# Appendix 12B
# Fisheries Impact Assessment Methodology

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# APPENDIX 12B
# Fisheries Impact Assessment Methodology

This appendix describes the impact assessment methodology and impact indicators used to evaluate the potential impacts on aquatic species occupying waterbodies in the Extended and Secondary Study Areas that may be affected by changes in the operation of the State Water Project (SWP) and Central Valley Project (CVP) facilities as a result of implementing the Sites Reservoir Project (Project) and alternatives.

Several fish species are sensitive to changes in both river flows and water temperatures throughout the year. Because the Project is anticipated to result in changes in water temperatures and river flows, the fisheries impact assessment focused on these and other habitat-based elements. Taking into account species- and life stage-specific habitat requirements, the construction, maintenance, and operational components of the Project alternatives were assessed to evaluate potential impacts on identified fish species and associated aquatic habitat.

For the DEIR/EIS, the impact assessment of aquatic biological resources consisted of three primary elements, including: (1) temporary and localized impacts associated with construction of the Project facilities; (2) ongoing impacts associated with the operation and maintenance of the Project facilities; and (3) impacts associated with changes in SWP and CVP Operations due to operation of the Project facilities. The potential impacts due to construction, operation, and maintenance of Project facilities in the Primary Study Area are described in Chapter 12 Aquatic Biological Resources. The analytical framework used to assess the potential impacts of ongoing hydrologic changes in SWP and CVP Operations is described below. The results of this analysis for impacts on aquatic species in the Extended and Secondary Study Areas is presented in Appendix 12C Fisheries Impact Summary.

## 12B.1 Extended Study Area

The Extended Study Area consists of the SWP/CVP water service areas, San Luis Reservoir, and the Level 4 wildlife refuges located throughout the water distribution system. Because no Project facilities would be constructed or maintained within the Extended Study Area, only operational impacts associated with Alternatives A, B, C, and D are discussed in the impacts analysis for the Extended Study Area. The impact assessment for aquatic resources in the Extended Study Area relied primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations.

### 12B.1.1 Agricultural Water Use

Potential changes to fisheries and aquatic resources associated with any changes in agricultural water deliveries were addressed by evaluating SWP and CVP CALSIM II water operations modeling in the Secondary Study Area, below. Therefore, no further evaluation of potential effects on fisheries and aquatic resources in the Extended Study Area associated with agricultural water use was conducted.

### 12B.1.2 Municipal and Industrial Water Use

Potential changes to fisheries and aquatic resources associated with any changes in municipal and industrial water deliveries were addressed by evaluating SWP and CVP CALSIM II water operations modeling in the Secondary Study Area, below. Therefore, no further evaluation of potential effects on fisheries and aquatic resources in the Extended Study Area associated with municipal and industrial water use was conducted.

### 12B.1.3 Wildlife Refuge Water Use

Potential changes to fisheries and aquatic resources associated with any changes in wildlife refuge water deliveries were addressed by evaluating SWP and CVP CALSIM II water operations modeling in the Secondary Study Area, below. National Wildlife Refuges and Wildlife Areas in the Extended Study Area that receive Level 4 water deliveries from the CVP are anticipated to have more reliable water deliveries, particularly during drier water years, with Project implementation.

An alternate source of Level 4 wildlife refuge water supply could potentially affect fisheries resources in the wildlife refuges or in the water distribution systems within the refuges. However, potential changes in water deliveries to individual refuges is not currently known and not provided as part of the CALSIM II model output. Therefore, the alternate supply of Level 4 wildlife refuge water to these refuges was evaluated qualitatively under the Project alternatives, relative to the bases of comparison.

### 12B.1.4 San Luis Reservoir

San Luis Reservoir provides habitat for both coldwater and warmwater fish species. To assess potential impacts of the Project alternatives on coldwater fisheries resources in San Luis Reservoir, end-of-month storage during the April through November period was evaluated as an indicator of available habitat for coldwater fishes. To assess potential impacts on the warmwater fisheries resources in San Luis Reservoir, the number of times that reservoir reductions of six feet or more per month could occur each month of the primary spawning period for nest-building fish (March through June) under the Project alternatives was determined and compared to the number of occurrences that were modeled under the Existing Conditions/No Project/No Action Condition. A more detailed description of the methodology used to assess impacts to aquatic resources in San Luis and other CVP/SWP reservoirs is provided in the assessment of impacts for the Secondary Study Area (Section 12B.2.1.2).

## 12B.2 Secondary Study Area

The Secondary Study Area consists of the SWP and CVP water bodies and the waterways within the Sacramento River Watershed, the Feather River Watershed, the Trinity River Watershed, and the American River Watershed. Specifically, the Secondary Study Area includes Shasta Lake, Sacramento River downstream of Keswick Dam, Trinity Lake, Trinity River, Klamath River downstream of the Trinity River, Clear Creek, Lake Oroville, Feather River, Sutter Bypass, Yolo Bypass, Folsom Lake, lower American River, the Sacramento-San Joaquin Delta, and Suisun, San Pablo, and San Francisco bays.

### 12B.2.1 Assessment Approach for Impacts Related to Hydrologic Changes Due to Project Operations

The aquatic biological resources impact assessment relied on hydrologic modeling to provide a quantitative basis from which to assess the potential impacts of the Project alternatives on fish species of primary management concern and aquatic habitats within the SWP/CVP system. Specifically, the hydrological modeling and post-processing applications were utilized to simulate operations expected to occur in SWP/CVP reservoirs, rivers, bypasses, and the Delta as a result of implementation of the Project alternatives, relative to the bases of comparison. Detailed information about specific modeling tools, the modeling assumptions used to characterize Project operations, and the appropriate use of model output results is presented in Appendix 6A Modeling of Alternatives and Appendix 6B Water Resources System Modeling.

Hydrologic simulation results of monthly river flows and end-of-month reservoir storage and elevations provided a quantitative basis to assess the potential impacts of operations on fish species, relative to the bases of comparison, for the period of simulation extending from water year 1922 through 2003 (82-year simulation period). These simulated results were used as inputs to the Bureau of Reclamation's (Reclamation's) Water Temperature Models (Appendix 7E River Temperature Modeling), which simulate monthly water temperature of the main river systems (Trinity, Sacramento, Feather, and American rivers) for the same simulation period. The water temperature results were used as inputs to Reclamation's Early Lifestage Chinook Salmon Mortality Model to estimate annual mortality rates for the early life stages of Chinook salmon. Flows and water temperatures were also utilized as inputs to other analytical tools including IOS, SALMOD, and the SacEFT to estimate potential population-level impacts on various life stages and habitat for some Sacramento River fishes.

Changes in flows, in and of themselves, generally do not constitute an effect on aquatic resources but can affect the quantity and quality of aquatic habitats in rivers, their floodplains, and bypasses (e.g., Sutter and Yolo bypasses) and have direct effects on fish species through stranding or dewatering events that occur when flows are reduced. In addition, changes in flows can affect ecologically important geomorphic processes such as gravel movement, sedimentation, and seed dispersal. The evaluation of potential impacts to aquatic resources included the use of the models listed above to identify anticipated impacts associated with changes in flows, habitat availability, river temperatures, and mortality with respect to anticipated presence and life stage of Chinook salmon and other native species.

#### *12B.2.1.1 Application of Model Output*

Computer simulation models and post-processing tools were used to assess potential changes in reservoir storage and water surface elevation, river flows and water temperatures, and other parameters (e.g., salinity) that could occur under the Project alternatives, relative to the bases of comparison. Model assumptions and results were used for comparative purposes, rather than for absolute predictions, and the focus of the analysis was on differences in the results among comparative scenarios (e.g., a comparison of simulated conditions under Project Alternative A, relative to the Existing Conditions/No Project/No Action Condition). All of the assumptions were the same for both the with-Project and No Project/No Action model runs, except assumptions associated with the Project alternatives, and the focus of the analysis was the differences in the results between the alternatives and the Existing Conditions/No Project/No Action Condition. Results from a single simulation may not necessarily correspond to actual system operations for a specific month or year, but are representative of general hydrologic conditions. Model results are best interpreted using various statistical measures such as long-term and year-type average, and probability of exceedance.

The models used in the analyses, although mathematically precise, should be viewed as having inherent uncertainty because of limitations in the theoretical basis of the model and the scope of the formulation and function for which the model is designed. Additionally, the accuracy of the models is unknown and unquantifiable because of the speculative nature under which the assumptions of the projected conditions were established. Nonetheless, the models developed for planning and impact assessment purposes represent the best available information with which to conduct evaluations of proposed changes in SWP and CVP operations.

### 12B.2.1.2 Potential Mechanisms for Impact and Analytical Methods

The following sections present a summary of the potential mechanisms for impact and the analytical methods used in the aquatic biological resources impact assessment for the Secondary Study Area.

#### CVP and SWP Reservoirs

Changes in CVP and SWP operations under the alternatives could result in changes in reservoir storage volumes, water surface elevations, and water temperatures in the primary water supply reservoirs (i.e., Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake). Variation in reservoir storage, elevation, and water temperature is a function of water demand, water quality requirements, and inflow; these attributes also change based on the water year type.

To evaluate changes in operation, changes in reservoir storage and elevation were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II for the entire 82-year period under the operations defined for each alternative, as described in Appendix 6B Water Resources System Modeling. The output of CalSim II served as input to the quantitative procedures described below for evaluation of changes in fish habitat and bass nesting success in CVP and SWP reservoirs.

##### *Changes in CVP and SWP Reservoir Storage Volume*

The effects analysis in Chapter 6 Surface Water Resources, includes a summary of the monthly storage in each major upstream reservoir in combination with a frequency of exceedance analysis for each month. Reservoir storage values are characterized based on results of CalSim II hydrologic modeling and presented as average monthly storage by water year type. Although aquatic habitat within the CVP and SWP water supply reservoirs is not thought to be limiting, and reservoir coldwater fish species are not considered state or federal special-status species, storage volume is presented as an indicator of how much habitat may be available to fish species inhabiting these reservoirs. Because the storage values are output from the monthly time step CalSim II model, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in reservoir storage of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

##### *Changes in CVP and SWP Reservoir Elevation*

Seasonal temperature stratification is a dominant feature of these reservoirs. There are relatively distinct fish assemblages within the upper (warm water) and lower (cold water) habitat zones, with different feeding and reproductive behaviors. Flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold water species. Drawdown of reservoir storage from June through October can diminish the volume of cold water, thereby reducing the amount of habitat for cold water fish species within these reservoirs during these months. Reservoir storage and surface water elevations in the reservoirs from the CalSim II model were used to analyze potential effects on reservoir fishes. Water surface elevation in each reservoir was calculated from storage values and is presented as average end-of-month elevation by water year type.

Warm water fish species that inhabit the upper layer of these reservoirs may be affected by fluctuations in storage through changes in reservoir water surface elevations (WSELs). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm water species, including the black basses. Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding behaviors. Increases in WSEL are not thought to result in adverse effects on these species unless there is a corresponding decrease in water temperatures that can result in nest abandonment.

Review of the available literature suggests that bass nest failure is highly variable between water bodies and between years but it is not uncommon to have up to 40 percent of bass nests fail (approximately 60 percent nesting success) (Scott and Crossman, 1973). Many self-sustaining black bass populations in North America experience a nest success (i.e., the nest produces swim-up fry) rate of 21 to 96 percent, with many reporting survival rates in the 40 to 60 percent range (Forbes, 1981; Friesen, 1998; Goff, 1986; Hunt and Annett, 2002; Hurley, 1975; Knotek and Orth, 1998; Kramer and Smith, 1962; Latta, 1956; Lukas and Orth, 1995; Neves, 1975; Philipp et al., 1997; Raffetto et al., 1990; Ridgway and Shuter, 1994; Steinhart, 2004; Turner and MacCrimmon, 1970; Steinhart, 2004). This would suggest that much less than 100 percent survival is required to have a self-sustaining population. Based on the literature review, bass nest survival probability in excess of 60 percent is assumed to be sufficient to provide for a self-sustaining bass fishery.

A conceptual approach was used to evaluate the effects of water surface elevation fluctuations on bass nests, based upon a relationship between black bass nest success and water surface elevation reductions developed by California Department of Fish and Wildlife (Lee, 1999) from research conducted on five California reservoirs. Lee (1999) examined the relationship between water surface elevation fluctuation rates and nesting success for black bass, and suggested that a reduction rate of approximately six feet per month or less would result in 60 percent nest success for largemouth bass and smallmouth bass. Therefore, a decrease in reservoir water surface elevation of six feet or more per month was selected as the threshold beyond which an adverse impact on spawning success of nest-building, warmwater fish could occur. To evaluate impacts on largemouth bass, smallmouth bass, and ultimately warmwater fish in general, the net number of times that simulated reservoir reductions of six feet or more per month would occur under the Project alternatives was compared to the number of occurrences that would occur under the Existing Conditions/No Project/No Action Condition (Appendix 12F Reservoir Water Surface Elevation Summary Tables).

Criteria for reservoir water surface elevation increases (nest flooding events) have not been developed by California Department of Fish and Game (CDFG). Because of overall reservoir fishery benefits (e.g., an increase in the availability of littoral habitat for warmwater fish rearing), greater reservoir elevations that would be associated with rising water levels would offset negative impacts due to nest flooding (Lee, 1999). Therefore, the likelihood of spawning-related impacts from nest flooding is not addressed for reservoir fisheries.

Although black bass spawning may begin as early as February, or as late as May, in southern and northern California reservoirs, respectively, and may possibly extend to July in some waters, the majority of black bass and other centrarchid spawning in California occurs from March through May (Lee, 1999; Moyle, 2002). However, given the geographical and altitudinal variation among the SWP/CVP and non-Project reservoirs, in order to examine the potential of nest dewatering events to occur, the warmwater fish-spawning period was assumed to extend from March through June. This period encompasses the majority, if not the entire, primary warmwater fish spawning and rearing period for the reservoirs included in this impact analysis.

CalSim II reports end-of-month (EOM) water surface elevations; therefore, water surface elevations from February to June were used in this analysis (i.e., March fluctuation rate = March EOM elevation – February EOM elevation). Water surface elevations used in this analysis are outputs from the monthly CALSIM model and incremental changes of 5 percent or less are related to the uncertainties in the model processing; therefore, changes in the number of years that have monthly drawdowns of 6 feet or more of less than 2 years are considered to be not substantially different, or "similar" in this comparative analysis. Changes in the frequency of drawdown exceeding 4 years are considered substantial and may have a potentially significant impact on warmwater fish species in the reservoirs.

### *Changes in CVP and SWP Reservoir Temperatures*

Water temperatures in the reservoirs potentially impacted by the Project alternatives could change as a result of altered operations. However, the small changes in lake temperatures that could occur would not be expected to adversely affect the lakes' warmwater fisheries. Any changes in water temperatures in the reservoirs are not anticipated to affect spawning warmwater game fish nesting success due to the wide water temperature ranges in which they spawn. For example, black basses reportedly spawn between approximately 55 and 75 degrees Fahrenheit (Graham, and Orth, 1986; Moyle, 2002). Due to their wide range in water temperature tolerance, it is anticipated that during the nesting season (March through June) there would be an adequate amount of habitat with suitable water temperatures in which warmwater game fish could successfully spawn and no evaluation of water temperatures in the SWP and CVP reservoirs was conducted for warmwater game fishes.

## Rivers

By altering reservoir storage and releases, changes in CVP and SWP operations under the Project alternatives would change flow and temperature regimes in downstream waterways. In turn, these alterations could affect fishery resources and important ecological processes on which the aquatic community depends.

### *Changes in Flows*

The effects analysis in Chapter 6 Surface Water Resources, includes a summary of the average monthly flows at various points downstream of the reservoirs in each major stream affected by Project operations and in the Sutter and Yolo bypasses. Post-processing tools utilized CALSIM output (i.e., monthly flow data) to calculate the long-term average flows, by month, occurring over the 1922 through 2003 simulation period under the bases of comparison and Project alternatives. Monthly average simulated flows by water year type were used to compare differences between the bases of comparison and the alternatives. Presented in tabular format, the data tables for the long-term average flows by month, and the monthly average flows by water year type demonstrate the changes that could be expected to occur as a result of the implementation of the Project alternatives, relative to Existing Conditions and the No Project/No Action Alternative (Appendix 6B Water Resources System Modeling). Because the CalSim II model uses a monthly time step, it was determined that incremental flow changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, flow changes of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis. A change in flow exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., water temperature), the context in which the change occurs (e.g., time of year, location, and species/life stage present), and professional judgement.

As described above, changes in flows, in and of themselves, do not constitute an effect on aquatic resources but can affect the quantity and quality of aquatic habitats in rivers and have direct effects on fish species through stranding or dewatering events that occur when flows are reduced. Changes in the quantity of suitable aquatic habitat potentially available for some fish species of management concern (e.g., Chinook salmon) were analyzed using a weighted-usable-area approach (described below and in Appendix 12L Weighted Useable Area Analysis). Changes in flow also can influence the availability of off-channel habitat in floodplains through changes in the frequency and duration of inundation. Changes in flows in the Sacramento River associated with the various Project alternatives could alter the flows entering the Yolo and Sutter bypasses and change the amount of rearing habitat available to salmonids and other native fish species. These changes were evaluated by comparing the frequency and duration that certain flows would be present in the bypasses as described below and in Appendix 12N Yolo and Sutter Bypass Flow and Weir Spill Analysis. It also was recognized that water temperature changes often exhibit a greater influence on fisheries resources and aquatic habitat utilization. Thus, the flow analyses were supplemented by separate species-specific water temperature analyses (described below and in Appendix 12E Fisheries Impact Assessment Summary Tables).

### *Flow-Dependent Habitat Availability*

To compare the operational flow regime and evaluate the potential effects on habitat for fish species inhabiting streams, it was necessary to determine the relationships between streamflow and habitat availability for each life stage of these species in the rivers in which flows may be altered by CVP and SWP operations. Two general indicators of flow-dependent habitat availability were used to assess potential changes in habitat conditions as a result of Project operations: (1) Weighted-Usable-Area (WUA); and (2) Floodplain inundation in the Yolo bypass.

#### **Weighted-Usable-Area**

A number of studies have been conducted using the models and techniques contained within the Instream Flow Incremental Methodology (IFIM) to establish these relationships in streams within the study area. The analytic variable provided by the IFIM is total habitat, in units of WUA, for each life stage (fry, juvenile and spawning) of each evaluation species (or race as applied to Chinook salmon). Habitat (WUA) incorporates both macro- and microhabitat features. Macrohabitat features include changes in flow, and microhabitat features include the hydraulic and structural conditions (depth, velocity, substrate or cover) affected by flow which define the actual living space of the organisms. The total habitat available to a species/life stage at any streamflow is the area of overlap between available microhabitat and macrohabitat conditions. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow differ substantially for the species and life stages evaluated.

WUA-flow relationships were available only for anadromous salmonids (salmon and steelhead) in some reaches of the rivers for which simulated flows were available. Therefore, flow dependent habitat availability was evaluated quantitatively only for Chinook salmon and steelhead in Clear Creek and the Sacramento, Feather, and American rivers, and was not reported for other rivers evaluated in this DEIR/EIS. Tables of the spawning habitat-discharge relationships used in the calculations of spawning WUA for these rivers are provided in Appendix 12L Weighted Useable Area Analysis. Because the WUA-flow relationships developed by the most recent IFIM studies present WUA values within particular flow ranges at particular variable steps, it was often the case that the monthly flow for a particular reach fell between two flows for which there were WUA values. In these cases, the value was determined by linear interpolation between the available WUA values for the flows immediately below and above the target flow. When the target flow was lower than the lowermost flow for which a WUA value exists, the corresponding WUA value was determined by linear interpolation between a flow of zero and the lowermost flow for which a WUA value exists. When the target flow was higher than the highest flow for which a WUA value exists, the corresponding WUA value was determined by assuming the WUA value for the highest flow.

WUA values are calculated and presented only on a monthly time-step, and not as seasonal or annual values. WUA values based on the monthly CalSim II flows were prepared for detailed evaluation of the alternatives. Monthly WUA values are presented as the average total WUA in each river segment, for the entire 82 year simulation period and the average total WUA in each of five water year types for each alternative. Differences between the alternatives and the two bases of comparison are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river. These comparisons were made only for the months in which the species and life stage are anticipated to be present in each river/reach based on the life history timing presented in Appendix 12A Aquatic Species Life Histories.

The ability to estimate sub-monthly WUA values is limited due to the monthly time-step of the CalSim II results. The monthly time-step is most limiting during the fall through spring seasons in areas downstream of tributaries, when flows can vary significantly on a daily basis due to hydrologic conditions. Hydrologic variability in the runoff and tributary flows cause significant variability of flows in the areas of interest for the WUA computations. During the periods of low flows, regulated flows from reservoir releases dampen the impact of daily variability of flows on WUA estimates. Because the WUA analysis uses output from the monthly time step CalSim II model, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in WUA values of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis. A change in WUA exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., water temperature), and professional judgement.

**Floodplain Inundation**

Salmonids and other fishes are reported to utilize the Yolo and Sutter bypasses for rearing, and it is believed that the bypasses provide high quality rearing habitat as a result of high nutrient and invertebrate production when it is inundated. All life stages of Sacramento Splittail may use the bypasses. To evaluate potential changes in habitat in the Yolo and Sutter bypasses, flows into and out of the bypass were used as an indicator of floodplain inundation. National Marine Fisheries Service’s (NMFS’) (2009) draft recovery plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley Steelhead recommends that the Yolo Bypass be inundated during the spring with at least 8,000 cfs to fully activate the floodplain. Flows through the Yolo Bypass of about 10,000 cfs reportedly may potentially provide the greatest area of shallow habitat in the Yolo Bypass (Fleenor et al., 2010). Recent work for the Central Valley Flood Management Planning Program (Resources Agency and California Department of Water Resources, 2016) confirms that as flows increase in the Yolo Bypass there is a rapid increase in inundated area up to around 40,000 cfs and then inundated area increases only marginally as flows increase up to modeled flows of 200,000 cfs. In the Sutter Bypass, the floodplain is well inundated at flows exceeding 4,000 cfs and increased flow does not inundate substantially more area, except in the northern portion where inundated area may increase by around 50 percent as flows exceed 50,000 cfs (Resources Agency and California Department of Water Resources, 2016).

Monthly flows in the bypasses are presented as the average monthly flow for the entire 82-year simulation period and the average monthly flow in each of five water year types for each alternative in combination with a frequency of exceedance analysis for each month (Appendix 6B Water Resources System Modeling). Differences between the alternatives and the Existing Conditions/No Project/No Action Condition are used to identify the effects of each alternative on floodplain habitat availability in the Yolo and Sutter bypasses.

Additional analysis using daily flows processed from the monthly CalSim II outputs was conducted to examine the frequency and duration of spills over the Fremont Weir as well as the total flows in the Yolo Bypass that would provide rearing habitat for salmonids and splittail. The number of years where there is at least one event of spill over the Fremont Weir into the Yolo Bypass of varying amounts (0, 2,000, 4,000, 6,000, 8,000, and 10,000 cfs) with a duration of 0-10 days, 11-20 days, 21-30 days, 31-45 days, and greater than 45 days was calculated from the daily results. Similarly, the number of years with at least one event where total Yolo flow exceeded these flows for frequency and duration was examined for the entire 82-year simulation period (Appendix 12N Yolo and Sutter Bypass Flow and Weir Spill Analysis). These comparisons were made only for the months in which juvenile salmonids and spawning splittail are anticipated to be present in the Yolo Bypass (October through April).

Of particular importance is the frequency of events in which the floodplain is fully activated for a duration that provides rearing opportunities. Therefore, the frequency of events where flows into (and through) the Yolo Bypass of greater than 8,000 cfs are maintained for at least 21 days was used an index of floodplain habitat availability. Because the floodplain inundation analysis uses daily flows downscaled from the from the monthly time step CalSim II model outputs, it was determined that incremental changes in frequency of events of 2 years or less were related to the uncertainties in the model processing. Therefore, changes in the frequency of events less than 2 years are considered to be not substantially different, or “similar” in this comparative analysis.

Similarly, modeled daily spill into the Sutter Bypass from the Sacramento River at Ord Ferry and the Moulton, Colusa, and Tisdale weirs is used to examine the frequency and duration of total spill into the Sutter Bypass that could provide rearing habitat for salmonids and splittail. Spill (flow) at Ord Ferry, Moulton Weir, and Colusa Weir were combined to assess potential changes in the northern portion of the Sutter Bypass; total spill at Ord Ferry, Moulton, Colusa, and Tisdale weirs were combined to assess potential impacts in the central portion of the bypass; and total flow through the bypass was used as an indicator of potential changes in floodplain habitat in the southern portion of Sutter Bypass. The number of years where there is at least one event of spill over the weirs into the Sutter Bypass of varying amounts (0, 2,000, 4,000, 6,000, 8,000, and 10,000 cfs) with a duration of 0-10 days, 11-20 days, 21-30 days, 31-45 days, and greater than 45 days was calculated from the daily results (Appendix 12N Yolo and Sutter Bypass Flow and Weir Spill Analysis). The frequency of events where flows into the Sutter Bypass of greater than 4,000 cfs are maintained for at least 21 days was used an index of floodplain habitat availability. Because the floodplain inundation analysis uses daily flows downscaled from the from the monthly time step CalSim II model outputs, it was determined that incremental changes in frequency of events of 2 years or less were related to the uncertainties in the model processing. Therefore, changes in the frequency of events less than 2 years are considered to be not substantially different, or “similar” in this comparative analysis.

### *Changes in Water Temperatures*

Water temperatures in the rivers and streams downstream of the CVP and SWP reservoirs are influenced by factors such as reservoir cold water pool, elevation of reservoir release outlets, and seasonal atmospheric conditions. The level of water storage in a reservoir has a strong effect on the volume of cold water (cold water pool) in the reservoir and, in combination with the elevation of reservoir release outlets, the temperature of water released downstream. Storage levels are often lowest in the late summer and early fall, resulting in warmer waters released from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. The summer and early fall are the times of year when river temperatures are most likely to rise above tolerance thresholds for steelhead and salmon.

The analysis of the effects of water temperature changes on fish was conducted using two approaches: (1) a comparison of average monthly water temperatures to various water temperature indices that are indicative of potential impacts on fish; and (2) application of Reclamation's salmon mortality model and the Sacramento River Ecological Flows Tool (SacEFT) model in certain water bodies to examine the effects of flow and temperature on mortality in the early life stages for Chinook salmon (Reclamation model) and steelhead and green sturgeon (SacEFT). These two approaches are described below.

#### Comparison to Established Water Temperature Indices

Hydrologic simulation results of monthly river flows and end-of-month reservoir storage and elevations from CalSim II provided a quantitative basis to assess the potential impacts of operations on fish species, relative to the bases of comparison, for the period of simulation extending from water year 1922 through 2003 (82-year simulation period). These simulated results were used as inputs to the Upper Sacramento River Water Quality Model (USRWQM), Reclamation's Water Temperature and the Folsom Reservoir CE-QUAL-W2 Models, which simulate monthly water temperature of the main river systems (Trinity, Sacramento, Feather, and American rivers) for the same simulation period.

The average monthly water temperature output from the water temperature models does not allow a direct comparison to the temperature indices identified in Appendix 12D Water Temperature Index Value Selection Rationale, and the effects of daily (or hourly) temperature swings are likely masked by the averaging process and likely effects from temperature on early life stages occur at a shorter temporal scale than can be captured in these models. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature indices would be exceeded. These indices are used in the temperature exceedance analysis where the frequency of exceeding specified indices (percent of years) is calculated over the 82-year CalSim II modeling period (Appendix 12E Fisheries Impact Assessment Summary Tables). For this monthly analysis that uses two cascading models, it was determined that incremental changes of one percent or less in the frequency of exceedance were related to the uncertainties in the model processing. Therefore, changes in the exceedance probability of one percent or less are considered to be not substantially different, or "similar" in this comparative analysis. A change in the probability of exceedance greater than one percent was considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., early life stage mortality), the context in which the change occurs (e.g., time of year, location, and species/life stage present), and professional judgement.

## Changes in Mortality

Water temperatures also affect the survival of various life stages of the focal species. Reclamation's Early Life-Stage Mortality model was used to estimate water temperature induced mortality in the early life stages Chinook salmon in four rivers. The Sacramento River Ecological Flows Tool (SacEFT) model was used to estimate flow and water temperature induced mortality in the early life stages of steelhead and green sturgeon in the mainstem Sacramento River.

SacEFT outputs for Chinook salmon were not utilized for impact assessment purposes for several reasons. First, the SacEFT is not yet widely used in environmental documents and has not been thoroughly reviewed by NMFS, U.S. Fish and Wildlife Service (USFWS), and CDFG, the degree to which it is appropriate to use SacEFT and potentially compare results to other existing models is unknown. Additionally, although the SacEFT provides outputs (e.g., index of juvenile stranding, redd scour, etc.) that are not provided by other Chinook salmon impact assessment models (IOS, SALMOD, Reclamation's Early Life-Stage Mortality Model) it does provide the same types of information provided by these models (e.g., egg-to-fry survival rate). Therefore, for impact assessment purposes Chinook salmon early life stage mortality was evaluated using Reclamation's Early Life-Stage Mortality Model. However, for disclosure purposes, SacEFT outputs for Chinook salmon are provided in Appendix 8B Sacramento River Ecological Flows Tool.

### *Chinook Salmon*

Reclamation's Early Life-Stage Mortality model (Appendix 12H Early Life-Stage Salmon Mortality Modeling) was used to estimate water temperature induced mortality in the early life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) of salmonids in the Trinity, Sacramento, Feather, and American rivers, based on output from the temperature models. The salmon mortality model is limited to temperature effects on early life stages of Chinook salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, entrainment or impingement at diversion structures, predation, and ocean harvest. Differences between alternatives are assessed based on changes in the overall mortality of all early life stages over the entire 82 year CalSim II simulation period and by water year type (based on 40 30 30 indexing). Because Reclamation's model uses output from the temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in egg mortality of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in egg mortality of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis. A change in mortality exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., WUA, water temperature), and professional judgement.

### *Steelhead and Green Sturgeon*

The Sacramento River Ecological Flows Tool (SacEFT) model (Appendix 8B Sacramento River Ecological Flows Tool) was used to estimate flow and water temperature induced mortality in the early life stages of steelhead and green sturgeon in the mainstem Sacramento River from Keswick downstream to Colusa. The Sacramento SacEFT system is a database-centered software system used for linking flow management actions to changes in physical habitats. The SacEFT is intended to illustrate the relative benefits of management alternatives, clarify ecological tradeoffs, identify critical uncertainties, and explore potential adaptive flow management experiments.

SacEFT uses daily flows provided by USRDOM and correlated water temperatures from USRWQM as inputs. Relevant performance measures (outputs) integrated into the SacEFT for steelhead include area of suitable spawning habitat, area of suitable rearing habitat, egg-to-fry survival rate, index of juvenile stranding, redd scour, and redd dewatering. The only performance measure integrated into the SacEFT for green sturgeon includes egg-to-larvae survival rate. Because the SacEFT provides the only source for estimating steelhead and green sturgeon egg survival, for impact assessment purposes, each of the relevant performance measures (model outputs) derived from the SacEFT for steelhead and green sturgeon under the Project alternatives were compared to output performance measure estimates under the bases of comparison (Appendix 8B Sacramento River Ecological Flows Tool).

## Delta

Changes in CVP and SWP operations under the alternatives would affect Delta conditions primarily through changes in the volume and timing of upstream storage releases and diversions, Delta exports and diversions, and Delta Cross Channel operations. Environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on aquatic resources in the Delta.

### *Changes in Volume and Timing of Flows through the Delta*

Operations of the CVP Delta Cross Channel and intake facilities owned by the CVP, SWP, local agencies, and private parties affect Delta hydrologic flow regimes. The largest effects of flow management in the Delta related to aquatic resources are the modification of winter and spring inflows and outflows of the Delta, and the introduction of net cross-Delta and net reverse flows in some Delta channels that can alter fish movement patterns. Seasonal flows play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, Striped Bass, American Shad, Delta Smelt, Longfin Smelt, and Sacramento Splittail. In addition, changes in Delta outflow influence the abundance and distribution of fish and invertebrates in the bay through changes in salinity, currents, nutrient levels, and pollutant concentrations. Altered flows through the Delta as a result of changes in CVP and SWP operations affect water residence time, an important physical property that can influence the ability of phytoplankton biomass to build up over time, with implications for higher trophic level consumers such as fish.

Hydrodynamic conditions in the interior Delta likely affect the quality and availability of juvenile salmonid rearing habitat. Two general indicators of habitat conditions within the interior Delta were used to assess potential changes in juvenile salmonid rearing habitat conditions, primarily for Steelhead: (1) Delta outflow; and (2) OMR reverse flows. Decreased flows through the Delta may decrease the migration rate of juvenile salmonids moving downstream, increasing their exposure time to unsuitable water temperatures, entrainment into the interior Delta, entrainment in water diversions, contaminants, and predation (CDFG, 2010). Changes in CALSIM II-simulated mean monthly Delta outflow and OMR flows were evaluated under the Project alternatives, relative to the Existing Conditions/No Project/No Action Condition. These changes are captured in the models used to estimate through-Delta survival of Chinook Salmon (Delta Passage Model [DPM]), escapement of Winter-run Chinook Salmon (IOS), and entrainment of Delta Smelt.

## Delta Outflow

Larval delta smelt may rely upon flow patterns to facilitate their movement from one area to another when conditions in their existing location become unsuitable. The importance of transport flows for larval delta smelt is dependent on the distribution of larvae in the Delta and ambient water temperature and food supply conditions. Although there is no known positive correlation between Delta outflow and delta smelt abundance, Delta outflow does reportedly have significant positive effects on several measures of delta smelt habitat (California State Water Resources Control Board [SWRCB], 2010), and spring outflow is positively correlated with spring abundance of *Eurytemora affinis* (SWRCB, 2010), an important delta smelt prey item. Therefore, potential impacts associated with changes in Delta outflow resulting from implementation of the Project alternatives could occur. Effects on the downstream transport of larval delta smelt are estimated by evaluating simulated average monthly Delta outflow during the latter portion (May and June) of the larval delta smelt evaluation period when water temperatures in the Central and South Delta begin to warm. Higher Delta outflow is generally assumed to be a result of greater inflow and increased movement of water through the Delta, thus resulting in increased transport and survival of larval delta smelt.

While there are no known statistical relationships between Delta outflow and juvenile steelhead survival or adult abundance, it was assumed that an increase in Delta outflow may contribute to improved rearing conditions and survival of juvenile steelhead in the Delta and Suisun Bay. Changes in CALSIM II-simulated mean monthly Delta outflow from October through July were evaluated under the Project alternatives, relative to the Existing Conditions/No Project/No Action Condition.

Because the CalSim II model uses a monthly time step, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, Delta outflow changes of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis. A change in Delta outflow exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., through-Delta survival, sturgeon year-class strength), and professional judgement.

## OMR Flows

Young longfin smelt are thought to be influenced by tidal and net currents while migrating downstream. High export pumping rates can cause reverse OMR flows, which can passively move all age groups of longfin smelt, particularly larvae, toward the export facilities (SWRCB, 2010). To evaluate the potential for entrainment of Longfin Smelt, the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities were compared for differences between the alternatives and the bases of comparison. For the purposes of this analysis it was assumed that a reduction in OMR reverse flows (making them more negative) may contribute to increased potential for entrainment of longfin smelt. The analysis was augmented with calculated Longfin Smelt abundance index values based on the position of X2 (see below).

The behavioral response and effects of reducing OMR reverse flows on juvenile steelhead migration, rearing, survival, and growth are not clearly known. However, for the purposes of this analysis it was assumed that a reduction in OMR reverse flows (making them more negative) may contribute to potentially adverse rearing and emigration conditions for juvenile steelhead in the interior Delta. Because the CalSim II model uses a monthly time step, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes of 5 percent or less in OMR flows are considered to be not substantially different, or "similar" in this comparative analysis. A change in OMR reverse flows exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., X2 position), and professional judgement.

#### *Changes in Aquatic Habitat (Position of X2)*

In the Delta, saline coastal oceanic water is mixed and diluted by flowing fresh water of rivers. This mix of fresh and oceanic water forms a salinity gradient that varies by area and location with seasonal variations in freshwater inflow and tidal action. This gradient drives the location of species that depend on salinity, such as estuarine vegetation, and delta smelt and longfin smelt. The location of this gradient reportedly varies on multiple time scales as a result of multiple processes — daily tides, monthly lunar cycle, intra-annual (seasonal) flow patterns, and interannual flow variation from interannual rainfall variation, and long-term global climate change (Kimmerer, 2004). During low-flow periods, the salinity gradient is maintained at locations that provide for freshwater in the Delta at levels that maintain human uses. Historically, the salinity gradient was generally farther downstream than it now occurs under similar hydrologic conditions.

Delta smelt, longfin smelt, and striped bass distribute themselves at different concentrations of salinity within the estuarine salinity gradient (Feyrer et al., 2007; Kimmerer, 2002a), indicating that at any point in time, salinity is a major factor affecting their geographic distributions. The term X2 is used to define the distance from the Golden Gate Bridge upstream to where salinity near the bottom of the water column is approximately 2.0 parts per thousand (ppt). The location of X2 reflects the physical response of the San Francisco Estuary to changes in flow and provides a geographic frame of reference for estuarine conditions (Kimmerer, 2002b). Because the location of X2 relies upon a number of physical parameters including river flows, water diversions and tides, its position shifts over many kilometers (km) on a daily and seasonal cycle. Over the course of a year, the location of X2 can range from San Pablo Bay during high river flow periods, up into the Delta during the summer. The position of X2 was used as an indicator of aquatic habitat quantity and quality for Delta smelt, Longfin smelt, Striped Bass, and American Shad and as an input for computing an abundance index for adult Longfin Smelt.

**Delta Smelt**

Changes in CVP and SWP operations under the alternatives could change the location of X2. Feyrer et al. (2010) used the fall (September-December) X2 location as an indicator of the extent of habitat available with suitable salinity and water transparency for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 65 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al., 2010). Because of the controversy surrounding the use of a habitat suitability index for delta smelt, the Project impact analysis utilized the principle that X2 location is an indicator of Delta Smelt distribution and evaluated changes in X2 location as an indicator of potential impact on delta smelt, but did not directly evaluate changes in the index of habitat suitability developed by Feyrer et al. (2010).

To evaluate habitat availability for Delta Smelt under the alternatives, X2 values (in km) simulated in the CalSim II model for each Project alternative were averaged over September to December, and compared for differences from the Existing Conditions/No Project/No Action Condition. Specifically, an increase in fall X2 location under an alternative, relative to the basis of comparison, was considered a negative impact while a decrease in fall X2 location was considered a benefit. Feyrer et al. (2010) concluded that, as X2 location increases, predicted delta smelt habitat declines, but the association is nonlinear and changes in X2 location mainly affect habitat suitability between about RKm 65 and RKm 80. Therefore, the evaluation focused on potential changes between RK 65 and RK 80.

Because CalSim II operations are simulated on a monthly basis and the DSM2 model would not be able to capture daily operations, it was determined that incremental changes in the position of X2 of less than 0.5 km are related to the uncertainties in the model processing. Therefore, changes of 0.5 km or less are considered to be not substantially different, or "similar" in this comparative analysis. Changes in the position of X2 exceeding 1.0 km are considered to represent a potentially meaningful difference. There are uncertainties and limitations associated with this approach, e.g., it does not evaluate other factors that influence the quality or quantity of habitat available for Delta Smelt (e.g., turbidity, temperature, food availability), nor does it take into account the relative abundance of Delta Smelt that might benefit from the available habitat in the simulated X2 areas, in any given year.

**Longfin Smelt, Striped Bass, and American Shad**

Kimmerer (2002b) noted that Striped Bass survival is negatively correlated with April – June X2 values, although the analysis was inconclusive on the mechanisms contributing to this relationship. Kimmerer et al. (2009) noted that Delta Smelt and Striped Bass had more negative slopes in the habitat-X2 relationship for surveys conducted in spring to early summer months than other surveys. They also noted that the slopes for the abundance–X2 and habitat–X2 relationships were similar for American Shad and for Striped Bass, and that the relationships of habitat to X2 appeared consistent with the relationships of abundance (or survival) to X2. Thus, Kimmerer et al. (2009) contended that this similarity provides some support for the notion that increasing habitat quantity as defined by salinity could be one mechanism to explain the X2 relationship for these species. Based on this relationship, position of X2 was used as general indicator of habitat for Longfin Smelt, Striped Bass and American Shad. Alternatives that resulted in a more westerly position of X2 relative to the bases of comparison were considered to have less potential for adverse effect, whereas those with a more easterly position would have a greater potential for adverse effect.

Because CalSim II operations are simulated on a monthly basis and the DSM2 model would not be able to capture daily operations, it was determined that incremental changes in the position of X2 of less than 0.5 km were related to the uncertainties in the model processing. Therefore, changes of 0.5 km or less are considered to be not substantially different, or "similar" in this comparative analysis. Changes in the position of X2 exceeding 1.0 km are considered substantial and may have a potentially significant impact on Longfin Smelt, Striped Bass and American Shad. In addition, the number of years across the 82-year simulation period where the modeled position of X2 is less than RK 75 is used as an indicator of potential effects on early life stages of Longfin Smelt and American Shad. Changes in the frequency that X2 <75 km of greater than 5 percent are considered substantial and may have a potentially significant impact on these species. A change in the frequency that X2 <75 km exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., abundance index [see below]), and professional judgement.

The analysis for Longfin Smelt was augmented with calculated Longfin Smelt abundance index values (Appendix 12G Smelt Analysis) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population. It was determined that incremental changes in the abundance index of less than 5 percent were related to the uncertainties in the model processing. Therefore, changes of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

### *Changes in Fish Entrainment*

Changes in CVP and SWP operations can affect survival of Delta and Longfin smelt through changes in the level of entrainment at CVP and SWP export pumping facilities. The south Delta CVP and SWP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle rivers.

In evaluating the potential for entrainment of adult Delta Smelt, as influenced by OMR flows under the alternatives, the USFWS (2008) regression model based on Kimmerer (2008) was used to estimate potential entrainment of Delta Smelt. The equation developed by Kimmerer (2008) is based on the average December through March OMR flow (in units of cfs) as predicted by the CalSim II model, and yields the percentage of adult Delta Smelt that may become entrained in the pumps. Further review by Kimmerer (2011) determined that the above equation has an upward bias, such that the results were reduced by 24 percent to correct this bias. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

Changes in CVP and SWP operations under the alternatives could also change entrainment of larvae and early juvenile Delta Smelt. Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. The USFWS (2008) regression model based on Kimmerer (2008) was used to calculate the percentage entrainment of larval and early juvenile Delta Smelt in Banks and Jones Pumping Plants. This regression is dependent on two variables: March through June average OMR flow (in cfs) and March through June average X2 position (in km). OMR and X2 values predicted by the CalSim II model for each alternative were used in estimating the entrainment loss. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

In this study, the percent entrainment values estimated for Delta Smelt are used as a tool to compare the alternatives, as one of the factors that would indicate conditions that might benefit or contribute to adverse effects on Delta Smelt. Because the regression analysis uses flow output from the monthly time step CalSim II model and the confidence intervals on the regression parameters are somewhat broad, it was determined that incremental changes in entrainment estimates of 5 percent or less were within the model uncertainty. Therefore, changes in entrainment of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis. A change in entrainment exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., OMR flows), and professional judgement. One limitation of this approach is that it does not reflect the benefit that some of the alternatives might realize through adaptive management of OMR flows to further reduce potential entrainment, based on input from the Smelt Working Group.

### *Changes in Fish Passage and Routing*

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in passage conditions and routing. Operation of the south Delta intake facilities, including facilities owned by the CVP and SWP and Contra Costa Water District, contribute to reverse flow conditions in Old and Middle rivers.

Changes in salmonid passage and routing were evaluated using the DPM. The DPM simulates migration and mortality of juvenile Chinook salmon entering the Delta from the Sacramento River, the Mokelumne River, and the San Joaquin River through a simplified Delta channel network, and provides quantitative estimates of relative juvenile Chinook salmon survival (or a survival index) through the Delta to Chipps Island (Appendix 12K Delta Passage Modeling). The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions.

For impact assessment purposes, the DPM was applied to all runs of Chinook salmon (the IOS module utilized to simulate through-Delta survival for winter-run Chinook salmon is identical to the DPM utilized for other Chinook salmon runs). Survival estimates derived from the model were then evaluated to identify potential impacts associated with implementation of the Project alternatives. Because the DPM uses output from the monthly time step CalSim II model and DSM2, it was determined that incremental changes in the median survival of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in through-Delta survival of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis. A change in through-Delta survival exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., salmonid production), and professional judgement.

### *Changes in Salmonid Production*

Collectively, factors such as flow, temperature, and habitat availability affect the population dynamics of anadromous fish species during their freshwater life stages. Two different models were used to assess changes in salmonid production potential: 1) SALMOD; and 2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook salmon.

**Comparison of Annual Production Using SALMOD**

The SALMOD model (Appendix 12I Salmonid Population Modeling) was used to assess changes in the annual production potential of four races of Chinook salmon in the Sacramento River. The primary assumption of the model is that egg and fish mortality is directly proportional to spatially and temporally variable habitat limitations, such as water temperatures, which themselves are functions of operational variables (timing and quantity of flow) and meteorological variables, such as air temperature (Reclamation, 2008). SALMOD characterizes fish habitat quality and carrying capacity using the hydraulic and thermal characteristics of individual mesohabitats (e.g., pools, riffles, or runs), categorized primarily by channel structure and hydraulic geometry, but modified by the distribution of features such as fish cover (Reclamation, 2008). Habitat area (quantified as weighted usable area or WUA) is computed from flow versus microhabitat area functions developed empirically or by using the Physical Habitat Simulation Model (PHABSIM) or similar physical habitat models (Reclamation, 2008).

SALMOD tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to the next until immature smolt, accounting for spawning (egg deposition), egg and alevin development and growth, mortality, and movement due to habitat limitation, freshets and seasonal stimuli as a function of local water temperature, typically concluding with fish that are physiologically “ready” (e.g., pre-smolts), and are swimming downstream toward the ocean (Reclamation, 2008). SALMOD accounts for mortality caused by (1) water temperature, (2) changes in flow and habitat (e.g., mortality associated with superimposition, mortality related to movement resulting from habitat limitation, and from sudden increases in streamflow), (3) seasonal movements, and (4) all other causes not directly modeled (i.e., base or background mortality). Detailed information and model results are included in Appendix 12I Salmonid Population Modeling.

The inputs to SALMOD include flows simulated by USRDOM, water temperatures simulated by the USRWQM, spawning distribution based on aerial surveys, spawning timing depending on the salmon run, and the number of spawners provided by the model user (e.g., recent average escapement).

Annual production potential or the number of outmigrants, annual mortality, length, and weight of the smolts are some of the reporting metrics available from SALMOD. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. For impact assessment purposes, juvenile Chinook salmon production estimates at Red Bluff Diversion Dam derived from SALMOD under each of the Project alternatives were compared to estimates under the bases of comparison. Specifically, annual production estimates were averaged over the entire 82-year simulation period and by water year type. Average annual production estimates were then evaluated under each Project alternative, relative to the bases of comparison. Because SALMOD uses flows and output from the water temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in production of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in production of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis. A change in production exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., water temperature, early life stage mortality), and professional judgement.

**Comparison of Annual Winter-run Chinook Salmon Escapement Using IOS**

The IOS model is a winter-run Chinook salmon life-cycle model that serves as a quantitative framework for estimating the long-term response of Sacramento River winter-run Chinook salmon populations to changing environmental conditions (e.g., river discharge, temperature, habitat quality at a reach scale) (Reclamation, 2008). Life cycle models integrate survival changes at various life stages, across multiple habitats, and through many years (Reclamation, 2008).

The IOS model tracks daily abundance of winter-run Chinook salmon for seven different life stage categories (eggs, alevins, fry, parr, smolts, subadults, and adults) in 22 reaches of the Sacramento River, in the Delta, and in the Pacific Ocean (Reclamation, 2008). IOS also tracks average fry and parr size in each reach using water temperature and density dependent growth functions (Reclamation, 2008).

Variables that influence simulated life cycle processes include flows, diversions, water temperatures, the status of migration barriers, spawning habitat capacity, in-river sport harvest, sex ratio of spawning adults, pre-spawn mortality, fecundity, egg deposition timing, redd dewatering, egg incubation time, base and thermal mortality for eggs and alevins, fry/parr growth and maturation rate, juvenile emigration rate, juvenile mortality in the Sacramento River, the Delta, and the Pacific Ocean, adult ocean harvest, and non-harvest-related adult mortality in the Pacific Ocean.

IOS model outputs were provided only for winter-run Chinook salmon and include: (1) egg–to-fry survival; (2) juvenile migration survival through the Sacramento River upstream of the Delta (e.g., fry-to-smolt survival); (3) juvenile migration survival through the Delta; and (4) adult female spawner escapement. Detailed information on the IOS model and model results are included in Appendix 12J Winter Run Chinook Salmon Life Cycle Modeling.

For impact assessment purposes, each of the IOS model outputs for each of the Project alternatives were compared to estimates under the Existing Conditions/No Project/No Action Condition. Because IOS uses output from the monthly time step CalSim II model or other models downscaled from CalSim II, as input, it was determined that incremental changes in escapement or survival estimates of 5 percent or less in were related to the uncertainties in the model processing. Therefore, changes in escapement and survival of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis. A change in escapement or survival exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., WUA, water temperatures), and professional judgement.

### *Changes in Sturgeon Year Class Strength*

Changes in CVP and SWP operations can affect sturgeon species through changes in flows through the Delta that, in turn, affect the year class strength of both Green Sturgeon and White Sturgeon. Estimated Delta outflow from the CalSim II model was used to analyze the potential effects on sturgeon using the hypothesized relationship between Delta outflow and the age-0 Year Class Index from the Bay Study in the presentation by Gingras et al. (2014). For this analysis, the mean Delta outflow during the March to July period for each year was calculated from the CalSim II output and used as an indicator of potential year class strength (Appendix 12M Sturgeon Analysis). Because the sturgeon analysis uses flow output from the monthly time step CalSim II model, it was determined that incremental changes in mean (March to July) Delta outflow of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in Delta outflow of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis. A change in Delta outflow exceeding 10 percent is considered to represent a potentially meaningful difference. Conclusions regarding whether the change would result in an impact on aquatic resources and whether that impact would be significant are determined through evaluation of the change in consideration of other available model outputs (e.g., year-class strength [see below]), and professional judgement.

Mean (March to July) Delta outflow was also used as an indicator of the likelihood of producing a strong year class of sturgeon by examining the number of years (over the 82-year CalSim II simulation) that mean (March to July) Delta outflow would exceed a threshold of 50,000 cfs. Changes in the frequency that mean (March to July) outflows exceed the threshold was considered to have a potential effect on sturgeon (Appendix 12M Sturgeon Analysis).

# 12B.3 Impact Indicators

The significance criteria described in Chapter 12 Aquatic Biological Resources do not provide quantitative thresholds against which construction-related actions and simulated hydrologic data can be compared to identify potential impacts. Therefore, impact indicators and evaluation guidelines were developed as a means to assess potential effects of the Project alternatives on aquatic biological resources. For the fisheries and aquatic resources impact assessment, indicators (e.g., water temperatures, flows) were used to evaluate whether the Project would have an impact on a fish species' habitat. The impact indicators and evaluation guidelines were developed based on an extensive review of fisheries literature, with special emphasis on research conducted in the Central Valley. Impact indicators for each of the study areas are provided below.

## 12B.3.1 Extended and Secondary Study Areas

Impact indicators used to evaluate the potential effects of implementation of the Project alternatives on fish species of management concern in the Extended and Secondary study area reservoirs are provided in Table 12B-1. Impact indicators used to evaluate the potential effects of implementation of the Project alternatives on fish species of management concern in the Trinity River, Clear Creek, Sacramento River, Feather River, American River, and the Sacramento-San Joaquin Delta within the Secondary Study Area are provided in Tables 12B-2 through 12B-63 below.

### *12B.3.1.1 Extended and Secondary Study Area Reservoirs*

**Table 12B-1**
**Impact Indicators Evaluated for Warmwater and Coldwater Fish Species in the Extended and Secondary Study Area Reservoirs**

| Life Stage | Evaluation Period | Impact Indicator | Criteria | | Range |
|---|---|---|---|---|---|
| | | | Value | % | |
| **Trinity, Shasta, Oroville, Folsom, and San Luis Reservoirs** | | | | | |
| **Warmwater Fish** | | | | | |
| Spawning Success | March through June | Water surface elevations | 2 years | | All Years |
| **Coldwater Fish** | | | | | |
| Coldwater Habitat Availability | April through November | Reservoir storage | | 10 | All Years |
| | | | | | By WYT |

## *12B.3.1.2 Trinity River*

**Table 12B-2**
**Impact Indicators Evaluated for Coho Salmon in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | September through January | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 40 | | All Years |
| | | | | 52 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| | | | Trinity River at Douglas City | 40 | | All Years |
| | | | | 52 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| | | | Trinity River at North Fork | 40 | | All Years |
| | | | | 52 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| Adult Spawning and Embryo Incubation | October through May | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 40 | | All Years |
| | | | | 43 | | All Years |
| | | | | 48 | | All Years |
| | | | | 50 | | All Years |
| | | | | 56 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning and Embryo Incubation (cont'd) | See above | See above | Trinity River at Douglas City | 40 | | All Years |
| | | | | 43 | | All Years |
| | | | | 48 | | All Years |
| | | | | 50 | | All Years |
| | | | | 56 | | All Years |
| | | | | 68 | | All Years |
| | | | Trinity River at North Fork | 40 | | All Years |
| | | | | 43 | | All Years |
| | | | | 48 | | All Years |
| | | | | 50 | | All Years |
| | | | | 56 | | All Years |
| | | | | 68 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 41 | | All Years |
| | | | | 48 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| | | | Trinity River at Douglas City | 41 | | All Years |
| | | | | 48 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| | | | Trinity River at North Fork | 41 | | All Years |
| | | | | 48 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration (cont'd) | See above | See above | See above | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 70 | | All Years |
| | | | | 77 | | All Years |
| Smolt Emigration | February through June | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 50 | | All Years |
| | | | | 59 | | All Years |
| | | | | 62 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at Douglas City | 50 | | All Years |
| | | | | 59 | | All Years |
| | | | | 62 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at North Fork | 50 | | All Years |
| | | | | 59 | | All Years |
| | | | | 62 | | All Years |
| | | | | 70 | | All Years |

Note:
cfs = cubic feet per second

**Table 12B-3**
**Impact Indicators Evaluated for Upper Klamath-Trinity River Spring-run Chinook Salmon in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | April through September | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Trinity River at North Fork | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Egg Incubation | August through November | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Trinity River at Douglas City | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Trinity River at North Fork | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at North Fork | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Smolt Emigration | February through July | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature(°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration (cont'd) | See above | See above | See above | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at North Fork | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-4**
**Impact Indicators Evaluated for Upper Klamath-Trinity River Fall-run Chinook Salmon in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | August through December | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Trinity River at North Fork | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Egg Incubation | October through June | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Early Lifestage Mortality | Trinity River below Lewiston Dam | | 10 | All Years |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Trinity River at Douglas City | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Trinity River at North Fork | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at North Fork | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Smolt Emigration | February through July | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at Douglas City | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration (cont'd) | See above | See above | Trinity River at North Fork | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-5**
**Impact Indicators Evaluated for Steelhead (Winter- and Summer-run) in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding (Winter-run) | August through April | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at Douglas City | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at North Fork | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| Adult Immigration and Holding (Summer-run) | June through August | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at Douglas City | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Trinity River at North Fork | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Spawning and Egg Incubation | October through June | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | Trinity River at Douglas City | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | Trinity River at North Fork | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at Douglas City | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Trinity River at North Fork | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration | February through July | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River below Lewiston Dam | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Trinity River at Douglas City | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Trinity River at North Fork | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-6**
**Impact Indicators Evaluated for Green Sturgeon in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | February through July | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 61 | | All Years |
| | | | Trinity River at North Fork | 66 | | All Years |
| Adult Spawning | May through August | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 68 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-7**
**Impact Indicators Evaluated for White Sturgeon in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | November through May | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 77 | | All Years |
| Adult Spawning | February through May | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 61 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River at North Fork | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-8**
**Impact Indicators Evaluated for Pacific Lamprey in the Trinity River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration | January through June | Monthly mean flow (cfs) | Trinity River Below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | January through August | Monthly mean flow (cfs) | Trinity River Below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River Below Lewiston Dam | 50-64* | | All Years |
| | | | Trinity River at Douglas City | 50-64 | | All Years |
| | | | Trinity River at North Fork | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Trinity River Below Lewiston Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Trinity River Below Lewiston Dam | 72 | | All Years |
| | | | Trinity River at Douglas City | 72 | | All Years |
| | | | Trinity River at North Fork | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

### *12B.3.1.3 Clear Creek*

**Table 12B-9**
**Impact Indicators Evaluated for Spring-run Chinook Salmon in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | April through October | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Embryo Incubation | August through March | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Clear Creek at Igo | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Mouth of Clear Creek | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing | August through April | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Juvenile Emigration | May through January | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Emigration (cont'd) | See above | See above | Clear Creek at Igo | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-10**
**Impact Indicators Evaluated for Fall-run Chinook Salmon in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | September through December | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Embryo Incubation | September through March | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Clear Creek at Igo | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Mouth of Clear Creek | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Juvenile Rearing | October through May | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | All Years |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Juvenile Emigration | January through June | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | All Years |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Emigration (cont'd) | See above | See above | See above | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-11**
**Impact Indicators Evaluated for Late Fall-run Chinook Salmon in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | December through April | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Embryo Incubation | January through April | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Clear Creek at Igo | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Mouth of Clear Creek | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| Juvenile Rearing | February through May | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing (cont'd) | See above | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Juvenile Emigration | April through June | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | All Years |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Emigration (cont'd) | See above | See above | See above | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-12**
**Impact Indicators Evaluated for Steelhead in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | August through March | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Clear Creek at Igo | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Mouth of Clear Creek | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| Adult Spawning and Embryo Incubation | December through May | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | Clear Creek at Igo | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | Mouth of Clear Creek | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning and Embryo Incubation (cont'd) | See above | See above | See above | 60 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Clear Creek below Whiskeytown Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Clear Creek below Whiskeytown Dam | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Clear Creek at Igo | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of Clear Creek | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-13**
**Impact Indicators Evaluated for River Lamprey in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration | September through June | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | February through July | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 50-64* | | All Years |
| | | | Clear Creek at Igo | 50-64 | | All Years |
| | | | Mouth of Clear Creek | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 72 | | All Years |
| | | | Clear Creek at Igo | 72 | | All Years |
| | | | Mouth of Clear Creek | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-14**
**Impact Indicators Evaluated for Pacific Lamprey in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration | January through June | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | January through August | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 50-64* | | All Years |
| | | | Clear Creek at Igo | 50-64 | | All Years |
| | | | Mouth of Clear Creek | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 72 | | All Years |
| | | | Clear Creek at Igo | 72 | | All Years |
| | | | Mouth of Clear Creek | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-15**
**Impact Indicators Evaluated for Hardhead in Clear Creek**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 65-82* | | All Years |
| | | | Clear Creek at Igo | 65-82 | | All Years |
| | | | Mouth of Clear Creek | 65-82 | | All Years |
| Adult Spawning | April through June | Monthly mean flow (cfs) | Whiskeytown Releases to Clear Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Whiskeytown Dam | 59-64 | | All Years |
| | | | Clear Creek at Igo | 59-64 | | All Years |
| | | | Mouth of Clear Creek | 59-64 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

### *12B.3.1.4 Sacramento River*

**Table 12B-16**
**Impact Indicators Evaluated for Winter-run Chinook Salmon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | December through July | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Feather River | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | Female Escapement (IOS) | Sacramento River | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning, Egg Incubation, and Initial Rearing | April through August | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Bend Bridge | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Ball's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Jelly's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Bend Bridge | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | Early Lifestage Mortality (Reclamation) | Keswick Dam to Princeton | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Early Lifestage Mortality (IOS) | Sacramento River | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | July through April | Monthly mean flow (cfs) | Below of Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Smolt Production SALMOD | Keswick Dam to Red Bluff Diversion Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration (cont'd) | See above | See above | Feather River | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-17**
**Impact Indicators Evaluated for Spring-run Chinook Salmon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | February through September | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Spawning, Egg Incubation, and Initial Rearing | September through April | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Bend Bridge | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Early Lifestage Mortality | Keswick Dam to Princeton | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning, Egg Incubation, and Initial Rearing (cont'd) | See above | Monthly mean water temperature (°F) | Below Keswick Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Ball's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Jelly's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Bend Bridge | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | RBDD | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |
| | | Smolt Production SALMOD | Keswick Dam to Red Bluff Diversion Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 63 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration (cont'd) | See above | See above | See above | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| Smolt Emigration | October through June | Monthly mean flow (cfs) | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-18**
**Impact Indicators Evaluated for Fall-run Chinook Salmon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | July through December | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Spawning, Egg Incubation, and Initial Rearing | October through April | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Bend Bridge | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Spawning, Egg Incubation, and Initial Rearing (cont'd) | See above | Scaled composite WUA | Keswick Dam to Deer Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Early Lifestage Mortality | Keswick Dam to Princeton | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Ball's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Jelly's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Bend Bridge | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Below RBDD | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| Juvenile Rearing and Emigration | December through June | Monthly mean flow (cfs) | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration (cont'd) | See above | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Smolt Production SALMOD | Keswick Dam to Red Bluff Diversion Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-19**
**Impact Indicators Evaluated for Late Fall-run Chinook Salmon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | October through April | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below RBDD | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning, egg incubation, and initial rearing | January through May | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Bend Bridge | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | | By WYT |
| | | Early Lifestage Mortality | Keswick Dam to Princeton | | 10 | All Years |
| | | | | | | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Ball's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Jelly's Ferry | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Bend Bridge | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Juvenile Rearing and Emigration | April through December | Monthly mean flow (cfs) | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Smolt Production SALMOD | Keswick Dam to Red Bluff Diversion Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Feather River Confluence | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Freeport | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-20**
**Impact Indicators Evaluated for Steelhead in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | August through March | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Below RBDD | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Feather River Confluence | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Freeport | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| Spawning and Egg Incubation | December through April | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | Scaled composite WUA | Keswick Dam to Battle Creek | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | See above | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Bend Bridge | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Ball's Ferry | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Jelly's Ferry | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Bend Bridge | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Below RBDD | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration | October through May | Monthly mean flow (cfs) | Below RBDD | See above | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Feather River Confluence | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Freeport | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |

**Table 12B-21**
**Impact Indicators Evaluated for Green Sturgeon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | February through December | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 61 | | All Years |
| | | | | 66 | | All Years |
| | | | Below Delevan Pipeline Intake | 61 | | All Years |
| | | | | 66 | | All Years |
| | | | Freeport | 61 | | All Years |
| | | | | 66 | | All Years |
| Spawning and Egg Incubation | March through September | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Wilkins Slough | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below RBDD | 64 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below RBDD | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 66 | | All Years |
| | | | Below Delevan Pipeline Intake | 66 | | All Years |
| | | | Freeport | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-22**
**Impact Indicators Evaluated for White Sturgeon in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | November through May | Monthly mean flow (cfs) | Hamilton City | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Rio Vista | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Hamilton City | 77 | | All Years |
| | | | Below the Delevan Pipeline Intake | 77 | | All Years |
| | | | Freeport | 77 | | All Years |
| Spawning and Egg Incubation | February through May | Monthly mean flow (cfs) | Hamilton City | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Hamilton City | 61 | | All Years |
| | | | | 68 | | All Years |
| | | | Below the Delevan Pipeline Intake | 61 | | All Years |
| | | | | 68 | | All Years |
| | | | Below the Feather River Confluence | 61 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Wilkins Slough | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Delevan Pipeline Intake | 66 | | All Years |
| | | | Knights Landing | 66 | | All Years |
| | | | Freeport | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-23**
**Impact Indicators Evaluated for River Lamprey in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | **Description** | **Value** | **%** | |
| Adult Immigration | September through June | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | February through July | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 50-64* | | All Years |
| | | | Below RBDD | 50-64 | | All Years |
| | | | Below the Delevan Pipeline Intake | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 72 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Ammocoete Rearing and Emigration (cont'd) | See above | See above | Below the Delevan Pipeline Intake | 72 | | All Years |
| | | | Freeport | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-24**
**Impact Indicators Evaluated for Pacific Lamprey in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration | January through June | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | January through August | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 50-64* | | All Years |
| | | | Below RBDD | 50-64 | | All Years |
| | | | Below the Delevan Intake | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 72 | | All Years |
| | | | Below the Delevan Pipeline Intake | 72 | | All Years |
| | | | Freeport | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.
Note:
cfs = cubic feet per second

**Table 12B-25**
**Impact Indicators Evaluated for Hardhead in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 65-82* | | All Years |
| | | | Below the Delevan Pipeline Intake | 65-82 | | All Years |
| | | | Freeport | 65-82 | | All Years |
| Adult Spawning | April through June | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below Keswick Dam | 59-64 | | All Years |
| | | | Below the Delevan Pipeline Intake | 59-64 | | All Years |
| | | | Freeport | 59-64 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-26**
**Impact Indicators Evaluated for Sacramento Splittail in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning | February through May | Monthly mean water temperature (°F) | Below the Delevan Pipeline Intake | 45-75* | | All Years |
| | | | Freeport | 45-75* | | All Years |
| Egg and Larval | February through May | Frequency of Floodplain Activation (years) | Sutter Bypass | 2 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-27**
**Impact Indicators Evaluated for American Shad in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | Below Red Bluff Diversion Dam (RBDD) | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below RBDD | 60-70* | | All Years |
| | | | Below the Feather River Confluence | 60-70 | | All Years |
| | | | Freeport | 60-70 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | July through November | Monthly mean flow (cfs) | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Delevan Pipeline Intake | 63-77 | | All Years |
| | | | Below the Feather River Confluence | 63-77 | | All Years |
| | | | Freeport | 63-77 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-28**
**Impact Indicators Evaluated for Striped Bass in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Delevan Pipeline Intake | 59-68* | | All Years |
| | | | Below the Feather River Confluence | 59-68 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Verona | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Delevan Pipeline Intake | 61-71 | | All Years |
| | | | Below the Feather River Confluence | 61-71 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-29**
**Impact Indicators Evaluated for Largemouth Bass in the Sacramento River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | Below Keswick Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Delevan Pipeline Intake | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Freeport | | 10 | All Years |
| | | | | | 10 | By WYT |
| Spawning | March through June | Monthly mean water temperature (°F) | Below Keswick Dam | 59-75* | | All Years |
| | | | Below the Delevan Pipeline Intake | 59-75 | | All Years |
| | | | Freeport | 59-75 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

### *12B.3.1.5 Feather River*

**Table 12B-30**
**Impact Indicators Evaluated for Spring-run Chinook Salmon in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | March through October | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of the Lower Feather River | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Embryo Incubation | September through April | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Spawning and Embryo Incubation (cont'd) | See above | See above | Below the Thermalito Afterbay Outlet | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration | October through June | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of the Lower Feather River | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-31**
**Impact Indicators Evaluated for Fall-run Chinook Salmon in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | July through December | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of the Lower Feather River | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning | October through December | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Spawning (cont'd) | See above | See above | Below the Thermalito Afterbay Outlet | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| Embryo Incubation | October through April | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | Early Lifestage Mortality | Fish Barrier Dam to Mouth | | 10 | All Years |
| | | | | | 10 | By WYT |
| Juvenile Rearing and Emigration | November through June | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration (cont'd) | See above | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of the Lower Feather River | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-32**
**Impact Indicators Evaluated for Steelhead in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration and Holding | August through April | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Mouth of the Lower Feather River | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| Adult Spawning and Embryo Incubation | December through May | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Scaled composite WUA | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 52 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning and Embryo Incubation (cont'd) | See above | See above | See above | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Smolt Emigration | October through May | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | By WYT |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |
| | | | Mouth of the Lower Feather River | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | | 59 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-33**
**Impact Indicators Evaluated for Green Sturgeon in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | February through December | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Feather River at Shanghai Bend | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 61 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 61 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of the Lower Feather River | 61 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning and Embryo Incubation | March through August | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 64 | | All Years |
| | | | | 68 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Juvenile Rearing | Year-round | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 64 | | All Years |
| | | | | 66 | | All Years |
| | | | Mouth of the Lower Feather River | 64 | | All Years |
| | | | | 66 | | All Years |
| Juvenile Emigration | May through September | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Feather River at Shanghai Bend | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 66 | | All Years |
| | | | Mouth of the Lower Feather River | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-34**
**Impact Indicators Evaluated for White Sturgeon in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | November through May | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Feather River at Shanghai Bend | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Fish Barrier Dam | 77 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 77 | | All Years |
| | | | Mouth of the Feather River | 77 | | All Years |
| Spawning and Egg Incubation | February through May | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Feather River at Shanghai Bend* | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Fish Barrier Dam | 61 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 61 | | All Years |
| | | | Mouth of the Feather River | 61 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Feather River at Shanghai Bend | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Fish Barrier Dam | 66 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 66 | | All Years |
| | | | Mouth of the Feather River | 66 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-35**
**Impact Indicators Evaluated for River Lamprey in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration | September through June | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | February through July | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 50-64* | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 50-64 | | All Years |
| | | | Mouth of the Lower Feather River | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Ammocoete Rearing and Emigration | See above | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 72 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 72 | | All Years |
| | | | Mouth of the Lower Feather River | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-36**
**Impact Indicators Evaluated for Pacific Lamprey in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Immigration | January through June | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | January through August | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 50-64* | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 50-64 | | All Years |
| | | | Mouth of the Lower Feather River | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Ammocoete Rearing and Emigration (cont'd) | See above | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 72 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 72 | | All Years |
| | | | Mouth of the Lower Feather River | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-37**
**Impact Indicators Evaluated for Hardhead in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adults and Juveniles | Year-round | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 65-82* | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 65-82 | | All Years |
| | | | Mouth of the Lower Feather River | 65-82 | | All Years |
| Adult Spawning | April through June | Monthly mean flow (cfs) | Low Flow Channel below the Fish Barrier Dam | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Lower Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Low Flow Channel below the Fish Barrier Dam | 59-64 | | All Years |
| | | | Below the Thermalito Afterbay Outlet | 59-64 | | All Years |
| | | | Mouth of the Lower Feather River | 59-64 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

## Table 12B-38
## Impact Indicators Evaluated for Sacramento Splittail in the Feather River

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning | February through May | Monthly mean flow (cfs) | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the Feather River | 45-75* | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-39**
**Impact Indicators Evaluated for American Shad in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 60-70* | | All Years |
| | | | Mouth of the Feather River | 60-70 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | July through November | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 63-77 | | All Years |
| | | | Mouth of the Feather River | 63-77 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-40**
**Impact Indicators Evaluated for Striped Bass in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 59-68* | | All Years |
| | | | Mouth of the Feather River | 59-68 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 61-71 | | All Years |
| | | | Mouth of the Feather River | 61-71 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-41**
**Impact Indicators Evaluated for Largemouth Bass in the Feather River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | Below the Thermalito Afterbay Outlet | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the Feather River | | 10 | All Years |
| | | | | | 10 | By WYT |
| Spawning | March through June | Monthly mean water temperature (°F) | Below the Thermalito Afterbay Outlet | 59-75* | | All Years |
| | | | Mouth of the Feather River | 59-75 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

### *12B.3.1.6 American River*

**Table 12B-42**
**Impact Indicators Evaluated for Spring-run Chinook Salmon in the American River**

| Lifestage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value (°F) | % | |
| Non-Natal Juvenile Rearing | November through April | Monthly mean flow (cfs) | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the American River | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Note:

cfs = cubic feet per second

**Table 12B-43**
**Impact Indicators Evaluated for Fall-run Chinook Salmon in the American River**

| Lifestage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value (°F) | % | |
| Adult Immigration and Holding | September through December | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| | | | Mouth of the American River | 60 | | All Years |
| | | | | 64 | | All Years |
| | | | | 68 | | All Years |
| Adult Spawning | October through December | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |
| | | Scaled Composite WUA | Sailor Bar (RM 21.8) through Rossmoor (RM 17.3) | | 10 | All Years |
| | | | | | 10 | By WYT |
| Embryo Incubation | October through March | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 56 | | All Years |
| | | | | 58 | | All Years |
| | | | | 60 | | All Years |
| | | | | 62 | | All Years |

| Lifestage | Evaluation Period | Impact Indicator | Location Description | Criteria Value (°F) | Criteria % | Range |
|---|---|---|---|---|---|---|
| Embryo Incubation (cont'd) | See above | Early Lifestage Mortality | Nimbus Dam to Mouth | | 10 | All Years |
| | | | | | 10 | By WYT |
| Juvenile Rearing and Emigration | January through June | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Nimbus Dam | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | American River at Watt Avenue | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of the American River | 60 | | All Years |
| | | | | 63 | | All Years |
| | | | | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 70 | | All Years |
| | | | | 75 | | All Years |

Notes:

cfs = cubic feet per second
RM = river mile

**Table 12B-44**
**Impact Indicators Evaluated for Steelhead in the American River**

| Lifestage | Evaluation Period | Impact Indicator | Location Description | Criteria Value (°F) | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration and Holding | November through April | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| | | | Mouth of the American River | 52 | | All Years |
| | | | | 56 | | All Years |
| | | | | 70 | | All Years |
| Adult Spawning | January through April | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |
| | | Scaled composite WUA | Sailor Bar (RM 21.8) through Rossmoor (RM 17.3) | | 10 | All Years |
| | | | | | 10 | By WYT |
| Embryo Incubation | January through May | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 52 | | All Years |
| | | | | 54 | | All Years |
| | | | | 57 | | All Years |
| | | | | 60 | | All Years |

| Lifestage | Evaluation Period | Impact Indicator | Location Description | Criteria Value (°F) | Criteria % | Range |
|---|---|---|---|---|---|---|
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Nimbus Dam | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | American River at Watt Avenue | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| | | | Mouth of the American River | 65 | | All Years |
| | | | | 68 | | All Years |
| | | | | 72 | | All Years |
| | | | | 75 | | All Years |
| Smolt Emigration | January through June | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 52 | | All Years |
| | | | | 55 | | All Years |
| | | | Mouth of the American River | 52 | | All Years |
| | | | | 55 | | All Years |

Notes:

cfs = cubic feet per second
RM = river mile

**Table 12B-45**
**Impact Indicators Evaluated for Green Sturgeon in the American River**

| Lifestage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value (°F) | % | |
| Adult Immigration and Holding | February through December | Monthly mean flow (cfs) | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the American River | 61 | | All Years |
| Adult Spawning and Egg Incubation | March through August | Monthly mean flow (cfs) | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the American River | 68 | | All Years |
| Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the American River | 66 | | All Years |

Notes:

cfs = cubic feet per second

**Table 12B-46**
**Impact Indicators Evaluated for River Lamprey in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration | September through June | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | February through July | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Nimbus Dam Release | 50-64* | | All Years |
| | | | American River at Watt Avenue | 50-64 | | All Years |
| | | | Mouth of the American River | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Nimbus Dam Release | 72 | | All Years |

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Ammocoete Rearing and Emigration (cont'd) | See above | See above | American River at Watt Avenue | 72 | | All Years |
| | | | Mouth of the American River | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-47**
**Impact Indicators Evaluated for Pacific Lamprey in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Immigration | January through June | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning and Egg Incubation | January through August | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Nimbus Dam Release | 50-64* | | All Years |
| | | | American River at Watt Avenue | 50-64 | | All Years |
| | | | Mouth of the American River | 50-64 | | All Years |
| Ammocoete Rearing and Emigration | Year-round | Monthly mean flow (cfs) | Nimbus Dam Release | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Nimbus Dam Release | 72 | | All Years |
| | | | American River at Watt Avenue | 72 | | All Years |
| | | | Mouth of the American River | 72 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-48**
**Impact Indicators Evaluated for Hardhead in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 65-82* | | All Years |
| Adult Spawning | April through June | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 59-64 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-49**
**Impact Indicators Evaluated for Sacramento Splittail in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Spawning | February through May | Monthly mean flow (cfs) | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | Mouth of the American River | 45-75* | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-50**
**Impact Indicators Evaluated for American Shad in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 60-70* | | All Years |
| | | | Mouth of the American River | 60-70 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | July through November | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 63-77 | | All Years |
| | | | Mouth of the American River | 63-77 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-51**
**Impact Indicators Evaluated for Striped Bass in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location Description | Criteria Value | Criteria % | Range |
|---|---|---|---|---|---|---|
| Adult Spawning, Embryo Incubation, and Initial Rearing | April through June | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 59-68* | | All Years |
| | | | Mouth of the American River | 59-68 | | All Years |
| Larvae, Fry, and Juvenile Rearing and Emigration | Year-round | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | | Mouth of the American River | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Monthly mean water temperature (°F) | American River at Watt Avenue | 61-71 | | All Years |
| | | | Mouth of the American River | 61-71 | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

**Table 12B-52**
**Impact Indicators Evaluated for Largemouth Bass in the American River**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adults and Other Life Stages | Year-round | Monthly mean flow (cfs) | American River at Watt Avenue | | 10 | All Years |
| | | | | | 10 | By WYT |
| Spawning | March through June | Monthly mean water temperature (°F) | American River at Watt Avenue | 59-75* | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note:

cfs = cubic feet per second

### *12B.3.1.7 Sacramento-San Joaquin Delta*

**Table 12B-53**
**Impact Indicators Evaluated for Delta Smelt in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult | December through May | Mean monthly water temperature (°F) | Sacramento River at Freeport | 59-68* | | All Years |
| | December through March | Mean monthly entrainment (regression) | SWP and CVP Export Facilities | | 10 | All Years |
| | | | | | | By WYT |
| Egg and Embryo | February through May | Mean monthly water temperature (°F) | Sacramento River at Freeport | 59-68 | | All Years |
| Larval | March through June | Mean monthly water temperature (°F) | Sacramento River at Freeport | 59-68 | | All Years |
| | | Mean monthly Delta outflow (cfs) | Delta | | 10 | All Years |
| | | | | | 10 | By WYT |
| Juvenile* | May through July | Mean monthly water temperature (°F) | Sacramento River at Freeport | 59-68 | | All Years |
| | | Mean monthly entrainment (regression) | SWP and CVP Export Facilities | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Mean monthly X2 location (RKm) | Changes in X2 location between RKm 65 and 80 | 1.0 Km | | All Years |

*Water temperature ranges were evaluated by calculating the net change in the probability of water temperatures occurring within the specified range.

Note: *Entrainment regression is for the larval and juvenile life stages

cfs = cubic feet per second

**Table 12B-54**
**Impact Indicators Evaluated for Longfin Smelt in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Adult | December through June | Mean monthly OMR flow (cfs) | Old and Middle Rivers | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Index of Abundance | Delta | | 10 | All Years |
| | | | | | 10 | By WYT |
| Larval and Juvenile | December through June | Mean monthly OMR flow (cfs) | Old and Middle Rivers | | 10 | All Years |
| | January through June | Mean monthly X2 location (RKm) | Changes in X2 location | | 1.0 Km | By WYT |
| | January through June | Mean monthly X2 location (RKm) | Changes in frequency that X2 location is less than or equal to RK 75 | | 5 | All Years |

**Table 12B-55**
**Impact Indicators Evaluated for Winter-run Chinook Salmon in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Outmigration | Year-round | Through-Delta survival | IOS | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |

Notes:

CVP = Central Valley Project
SWP = State Water Project

**Table 12B-56**
**Impact Indicators Evaluated for Spring-run Chinook Salmon in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and outmigration | Year-round | Through-Delta survival | Delta Passage Model | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |

Notes:

CVP = Central Valley Project
SWP = State Water Project

**Table 12B-57**
**Impact Indicators Evaluated for Fall- and Late Fall-run Chinook Salmon in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Outmigration | Year-round | Through-Delta survival | Delta Passage Model | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |

Notes:

cfs = cubic feet per second
CVP = Central Valley Project
SWP = State Water Project

**Table 12B-58**
**Impact Indicators Evaluated for Steelhead in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Outmigration | October through July | Mean monthly Delta outflow (cfs) | Delta | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Mean monthly OMR flow (cfs) | Old and Middle Rivers | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |

Notes:

cfs = cubic feet per second
CVP = Central Valley Project
SWP = State Water Project

**Table 12B-59**
**Impact Indicators Evaluated for Green Sturgeon in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Juvenile Rearing and Emigration | March through July | Mean monthly Delta outflow (cfs) | Delta | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Probability of Delta Outflow >50,000 cfs | Delta | | 10 | All Years |

Notes:

cfs = cubic feet per second
CVP = Central Valley Project
SWP = State Water Project

**Table 12B-60**
**Impact Indicators Evaluated for White Sturgeon in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | **Description** | **Value** | **%** | |
| Juvenile Rearing and Emigration | March through July | Mean monthly Delta outflow (cfs) | Delta | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Probability of Delta Outflow >50,000 cfs | Delta | | 10 | All Years |

Notes:

cfs = cubic feet per second
CVP = Central Valley Project
SWP = State Water Project

**Table 12B-61**
**Impact Indicators Evaluated for Sacramento Splittail in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Egg and Larval | February through May | Mean monthly flow (cfs) | Yolo Bypass | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |
| Juvenile Rearing and Emigration | April through July | Mean monthly flow (cfs) | Yolo Bypass | | 10 | All Years |
| | | | | | 10 | By WYT |
| Adult Spawning | February through May | Mean monthly flow (cfs) | Yolo Bypass | | 10 | All Years |
| | | | | | 10 | By WYT |
| | | Frequency of Floodplain Activation (years) | Yolo Bypass | 2 | | All Years |

Notes:

cfs = cubic feet per second
CVP = Central Valley Project
SWP = State Water Project

**Table 12B-62**
**Impact Indicators Evaluated for American Shad in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Egg and Larval | April through June | Mean monthly X2 location (RKm) | Changes in X2 location | 1.0 Km | | All Years |
| | | | | 1.0 Km | | By WYT |
| | April through June | Mean monthly X2 location (RKm) | Changes in frequency that X2 location is less than or equal to RK 75 | | 5 | All Years |

Notes:

CVP = Central Valley Project
RKm = river kilometer
SWP = State Water Project
X2 = the position of the two parts per thousand (ppt) salinity isopleth

**Table 12B-63**
**Impact Indicators Evaluated for Striped Bass in the Delta**

| Life Stage | Evaluation Period | Impact Indicator | Location | Criteria | | Range |
|---|---|---|---|---|---|---|
| | | | Description | Value | % | |
| Egg and Larval | April through June | Mean monthly X2 location (RKm) | Changes in X2 location | 1 Km | | All Years |
| | | | | 1.0 Km | | By WYT |

Notes:

CVP = Central Valley Project
RKm = river kilometer
SWP = State Water Project
X2 = the position of the two parts per thousand (ppt) salinity isopleth

# 12B.4 References


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