Master Response 3.1
Fish Protection

Overview

The types of organisms found within an aquatic ecosystem are determined largely by the conditions within that ecosystem, with other factors, such as migration barriers, also playing a role. For example, if a river has relatively constant flows during all seasons, with warm temperatures and low flow velocities, a certain composition of aquatic organisms will be present. If another river has higher, more variable, and seasonally timed flows of a more natural pattern with cold water temperatures and high flow velocities and volumes, a different composition of aquatic organisms will be present. This paradigm is well understood in aquatic ecology and other ecology disciplines. The hydrologic characteristics of the Lower San Joaquin River (LSJR) and its three major eastside tributaries, the Stanislaus, Tuolumne, and Merced Rivers (plan area), have been so dramatically altered that native fish species are struggling to survive and nonnative fish species are thriving. These nonnative fishes are species that do well in slower, warmer, and less variable environments similar to their native habitats (which are typically the Eastern United States). On the other hand, the native fishes found within the plan area are species that are adapted to high inter-annual and seasonal variability in flow, water temperatures, and other environmental parameters that characterize the natural climatic conditions of this region.

The plan amendments for the LSJR flow objectives would require that 40 percent of the unimpaired flow remain in the Stanislaus, Tuolumne, and Merced Rivers February–June, which could be adaptively implemented in a range of 30–50 percent unimpaired flow. The current level of unimpaired flows remaining in the three major eastside tributaries is, on average, approximately 20 percent but can drop below 10 percent in some years. The increased unimpaired flow requirement under the LSJR flow objective is intended to reasonably protect fish and wildlife by restoring more natural habitat conditions for native fish species. "More natural" conditions do not mean that the plan amendments propose to restore the environment of the LSJR and its major tributaries to pre–water-development levels. The SED acknowledges that the physical environment of the Stanislaus, Tuolumne, and Merced Rivers is highly modified. However, the plan amendments address key factors that have contributed to historic declines and continue to limit the success of native fish species, even in a modified environment. As such, the plan amendments would have a dramatic influence on which fish species are successful within the plan area.

The program of implementation for the proposed plan amendments also recognizes that the engagement of local water districts and others to implement the LSJR flow objectives can help maximize the functionality of the proposed unimpaired flows and increase reliability for all uses. To facilitate this engagement, the plan of implementation includes a Stanislaus, Tuolumne, and Merced working group (STM Working Group) to assist with the implementation, monitoring, and effectiveness assessment of the February–June LSJR flow requirements. The STM Working Group proposal seeks the participation of water users and others on the Stanislaus, Tuolumne, and Merced Rivers (Appendix K, *Revised Water Quality Control Plan*).

The State Water Board reviewed all comments related to fish, the protection of fish, potential environmental impacts on aquatic biological resources, and measurable benefits to aquatic biological resources from the plan amendments and developed this master response to address recurring comments and common themes. This master response also clarifies and amplifies the SED analyses and information. This master response includes, for ease of reference, a table of contents after the *Overview* to help guide the readers to specific subject areas. In particular, this master response addresses, but is not limited to, the following topics raised by commenters.

- Current fish decline, the need for increased flow, and the role of non-flow measures.
- Purpose of the Bay-Delta Plan Update and the narrative objective.
- Justification and description of the plan amendments for protecting fish and adaptive implementation and functional flows.
- Best available science and the consideration of other information.
- Adequacy of modeling to support the analyses, including comparative fish analyses and why the SED does not rely upon SalSim.
- Other stressors on fish besides flow.
- Plan amendment benefits.

Please refer to the following for additional responses to comments that are related to fish protection: see Master Response 1.1, *General Comments*, for additional description of the plan amendments and the purpose and goals of the water quality objective for fish and wildlife beneficial uses; refer to Master Response 2.1, *Amendments to the Water Quality Control Plan*, for clarification regarding changes to the plan amendments; see Master Response 2.2, *Adaptive Implementation*, for additional clarification and examples of adaptive implementation; see Master Response 2.3, *Presentation of Data and Results in SED and Response to Comments*, for information regarding how data and results are presented in the SED; and please refer to Master Response 3.2, *Surface Water Analyses and Modeling*, for a description of the methods and data used in the SED hydrologic modeling, including use of the Water Supply Effects (WSE) model.

The State Water Resources Control Board (State Water Board) also recommends a suite of non-flow actions complementary to the flow objectives for the reasonable protection of fish and wildlife. Please see Appendix K, *Revised Water Quality Control Plan*, for a list of the recommended non-flow measures, and Chapter 16, *Evaluation of Other Indirect and Additional Actions*, for a description of these actions and their associated costs and potential environmental impacts. Please also see Master Response 5.2, *Incorporation of Non-Flow Measures*, for a discussion of the role of non-flow measures and their relationship to the plan amendments.

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Current Fish Decline and the Need for Increased and More Variable Flows

As described in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives* (also known as the Scientific Basis Report), scientific evidence indicates that reductions in flows and alterations to the flow regime in the SJR Basin resulting from water development over the past several decades have negatively affected fish and wildlife beneficial uses. The magnitude of these hydrologic alterations caused by water development in the Stanislaus, Tuolumne, and Merced Rivers is summarized in Figures 3.1-1, 3.1-2, and 3.1-3. By comparing the unimpaired annual hydrograph to present-day observed conditions, these figures illustrate that wet season flows have become dramatically lower, and dry season flows have become higher in each of the three eastside tributaries.

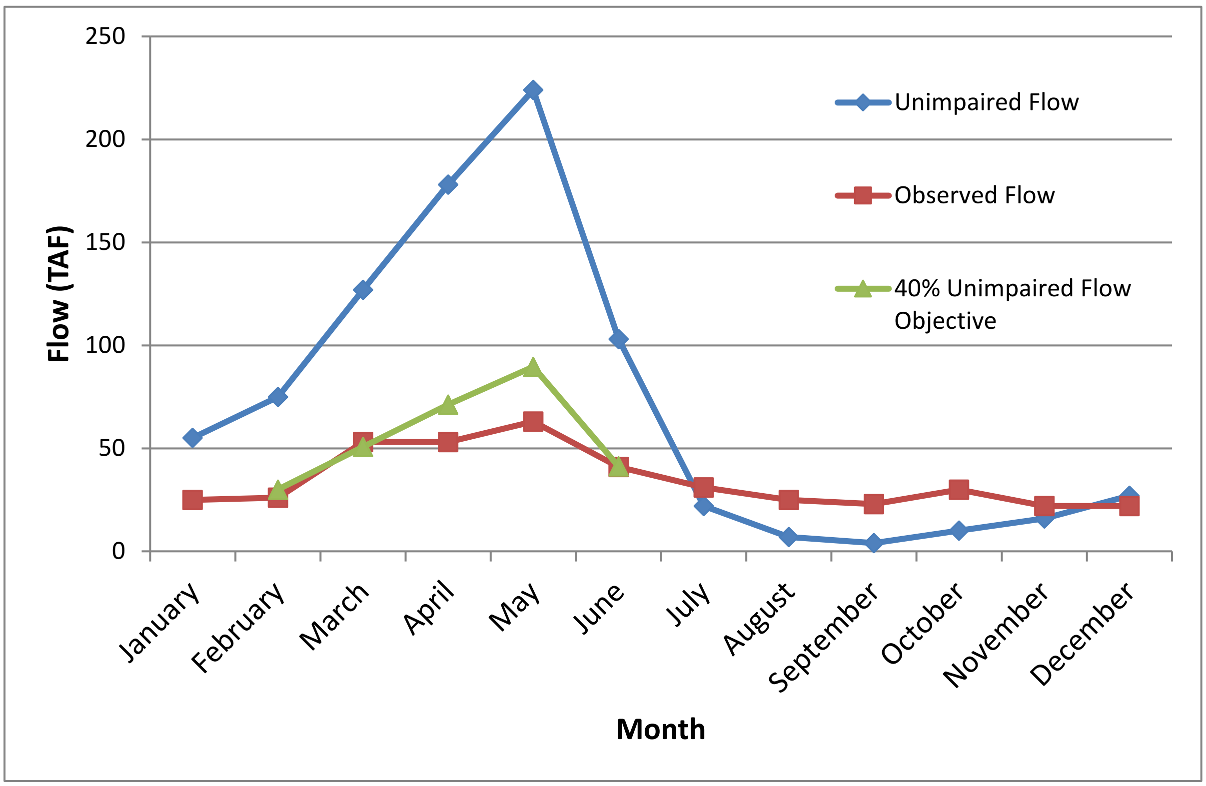

Figure 3.1-1. Stanislaus River Median Monthly Flow (Thousand Acre-Feet [TAF]) from 1984 to 2009 under Unimpaired, Observed, and 40% Unimpaired Flow Conditions. (Unimpaired and observed flow data are from Table 2.16 in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The 40% unimpaired flow objective points in the figure are 40% of the unimpaired flow points.)

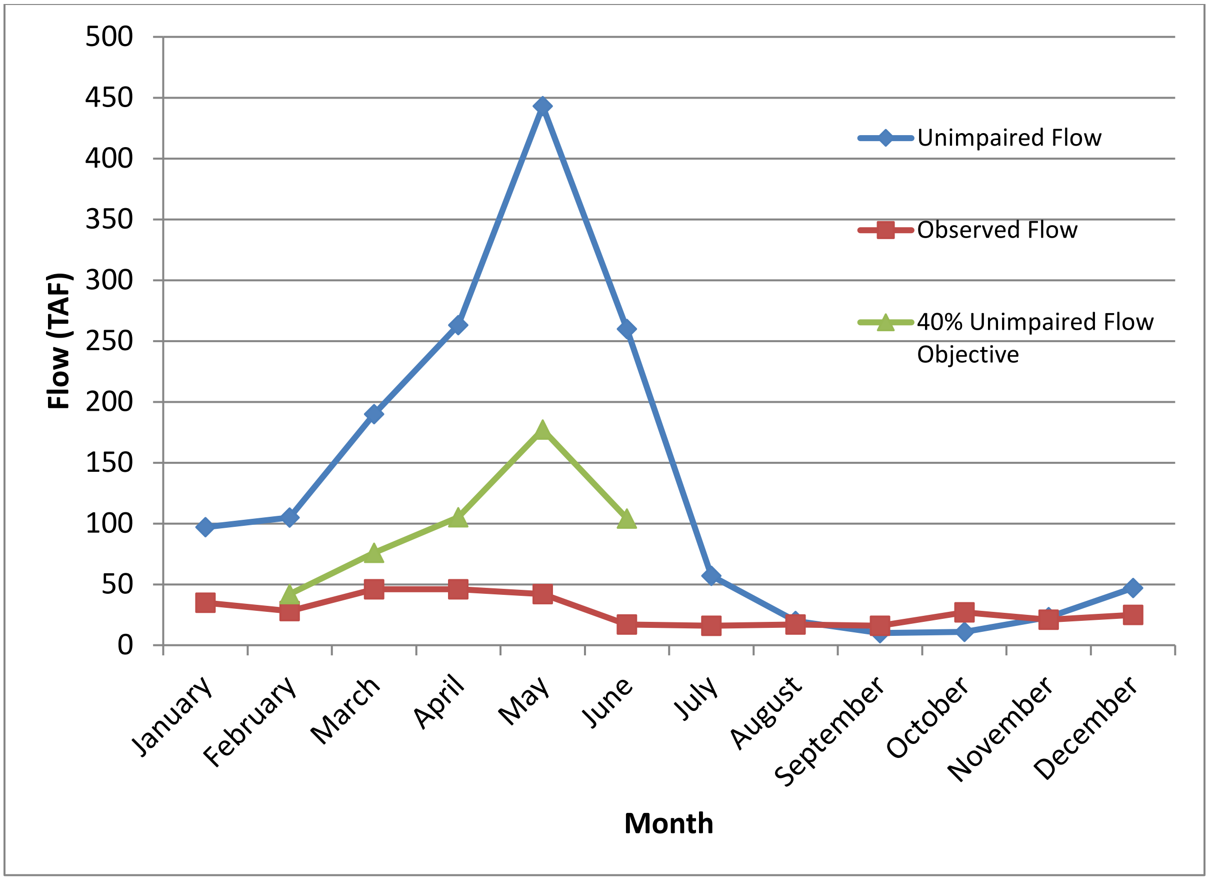

Figure 3.1-2. Tuolumne River Median Monthly Flow (Thousand Acre-Feet [TAF]) from 1984 to 2009 under Unimpaired, Observed, and 40% Unimpaired Flow Conditions. (Unimpaired and observed flow data are from Table 2.20 in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The 40% unimpaired flow objective points in the figure are 40% of the unimpaired flow points.)

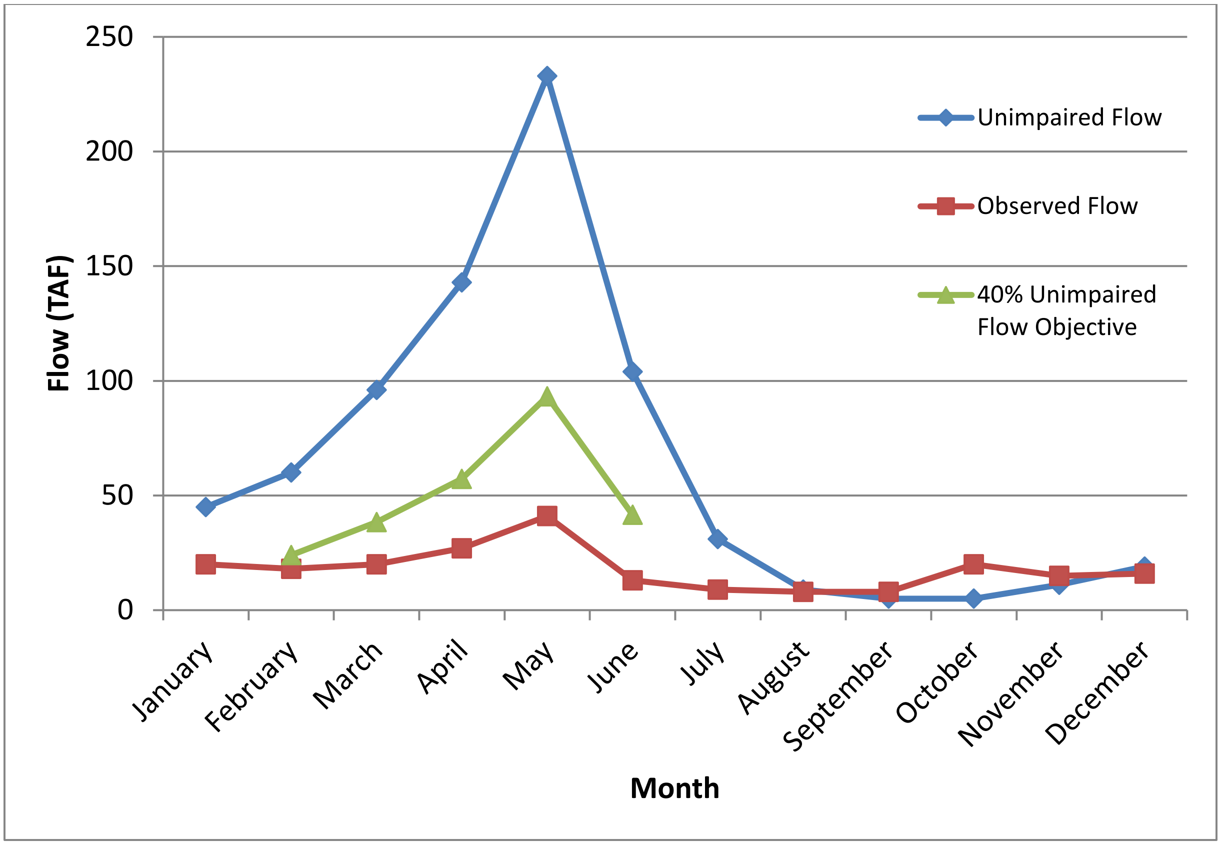

Figure 3.1-3. Merced River Median Monthly Flow (Thousand Acre-Feet [TAF]) from 1984 to 2009 under Unimpaired, Observed, and 40% Unimpaired Flow Conditions. (Unimpaired and observed flow data are from Table 2.24 in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The 40% unimpaired flow objective points in the figure are 40% of the unimpaired flow points.)

Water development in the SJR Basin has resulted in reduced annual flows, fewer peak flows, reduced and shifted spring and early summer flows, higher summer and early fall flows, reduced frequency of peak flows from winter rainfall events, reduced winter flows, shifted fall and winter flows, and a general decline in hydrologic variability over multiple spatial and temporal scales (see Appendix C, and Chapter 2, *Water Resources*). Currently, there is relatively little unregulated runoff from the SJR Basin with dams regulating at least 90 percent of the inflow (Cain et al. 2003). Dams and diversions in the SJR Basin have caused a substantial overall reduction of flows, compared to unimpaired hydrographic conditions, with a median reduction in annual flows at Vernalis of 54 percent and median reduction of spring flows of 74 percent, 83 percent, and 81 percent during April, May, and June, respectively.

The SJR Basin once supported large spring-run and fall-run (and possibly late fall-run) Chinook salmon populations; however, the basin now only supports fall-run Chinook salmon populations, and these populations are facing a high risk of extinction (Mesick 2009, 2010a, 2010b). The Stanislaus, Tuolumne, and Merced Rivers (individually or combined) have had larger reductions in the natural production of adult fall-run Chinook salmon than any of the other Sacramento River or SJR tributaries (or combination of other tributaries) when comparing the 1967–1991 and 1992–2011 time periods (Figure 3.1-4).

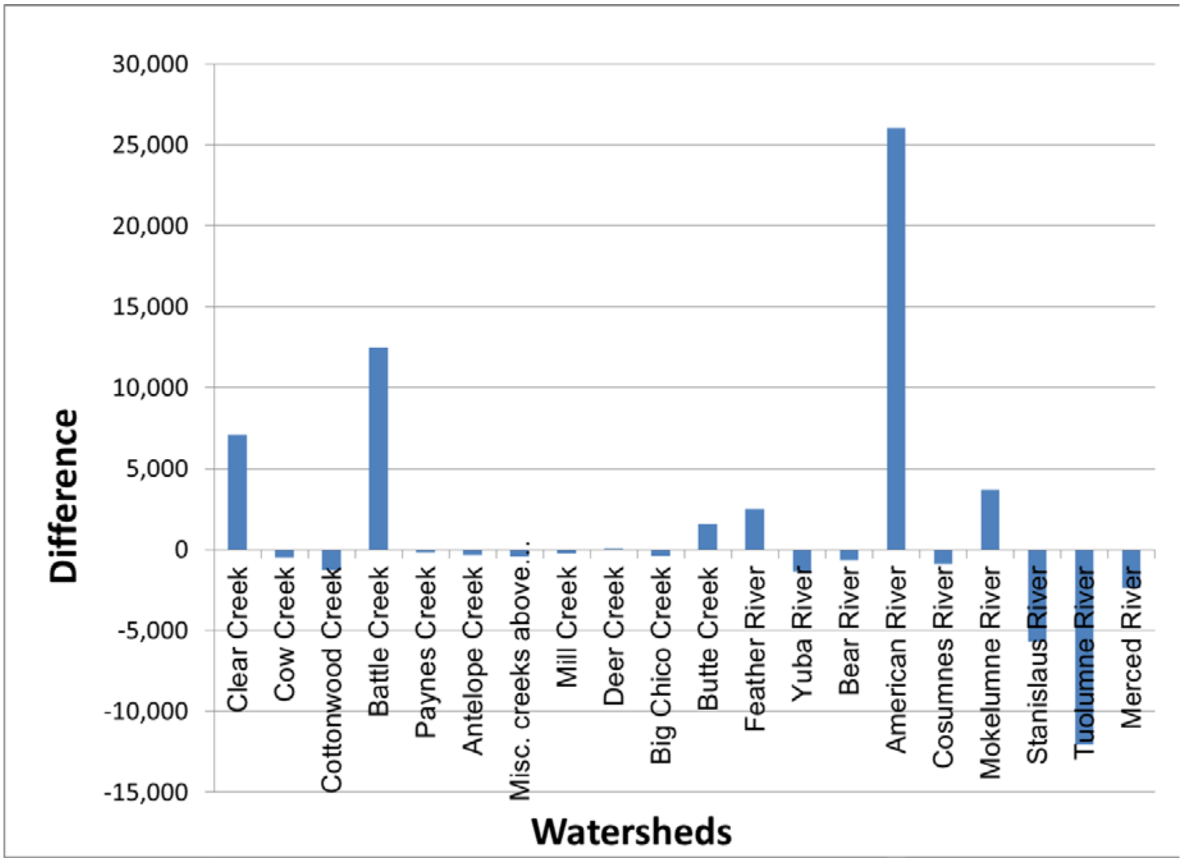

Figure 3.1-4. Difference in Natural Production of Adult Fall-Run Chinook Salmon when Comparing the 1967–1991 Average and the 1992–2011 Average in Tributaries to the Sacramento or San Joaquin Rivers, Showing that Salmon Declines in the Tributaries to the San Joaquin River are Greater Compared to other Watersheds in Recent Decades. (Difference = [1992–2011 time period average of estimated yearly natural production as reported in USFWS 2013a] minus [1967–1991 time period average of estimated yearly natural production as reported in USFWS 2013a] [repeated for each watershed].)

While aquatic resources in the SJR Basin have been adversely affected by numerous factors, including physical habitat alteration and passage barriers, flow during the spring time period remains a primary limiting factor (NMFS 2014a). In the *2014 Final Recovery Plan for the Evolutionarily Significant Units of Sacramento Winter-Run Chinook Salmon, and Central Valley Spring-Run Chinook Salmon, and the Distinct Population Segment of California Central Valley Steelhead*, the National Marine Fisheries Service (NMFS) acknowledges that salmon and steelhead recovery cannot be achieved without providing sufficient habitat.

> To help return the habitat capacity and diversity in the Central Valley to a level that will support viable salmon and steelhead, we have identified and prioritized recovery actions based on a comprehensive life stage specific threats assessment. Minimizing or eliminating stressors to the fish and their habitat in an efficient and structured way is a key aspect of the recovery strategy.

NMFS identifies flow as a key stressor affecting juvenile rearing and outmigration in the Stanislaus, Tuolumne, and Merced Rivers, and includes several actions for these rivers in its recovery strategy to improve flow conditions (NMFS 2014a:Tables 5-26, 5-27, and 5-28).

As described in Appendix C (see Section 3.6, *Analyses of Flow Effects on Fish Survival and Abundance*), studies that examine the relationship between fall-run Chinook salmon population abundance and flow in the SJR Basin generally indicate that: (1) additional flow is needed to significantly improve production (abundance) of fall-run Chinook salmon; and (2) the primary influence on adult abundance is flow 2.5 years earlier during the juvenile rearing and outmigration life stage (AFRP 2005; DFG 2005; Mesick 2008; DFG 2010; USDOI 2010). As referenced in Appendix C, many studies also report that the primary limiting factor for tributary abundances is reduced spring flow and that populations on the tributaries are highly correlated with tributary, Vernalis, and Delta flows (Kjelson et al. 1981; Kjelson and Brandes 1989; USFWS 1995; Baker and Mohardt 2001; Brandes and McLain 2001; Mesick 2001; Mesick and Marston 2007; Mesick 2009; Mesick 2010 a–d). Studies conducted more recently (after release of the Scientific Basis Report) also find that higher flow and the related habitat benefits during the February–June time period have a strong influence on juvenile survival and life history diversity, which are both important for population health and can result in more adult salmon returning approximately 2.5 years later (Figure 3.1-5) (Sturrock et al. 2015; USFWS 2014; Zeug et al. 2014).

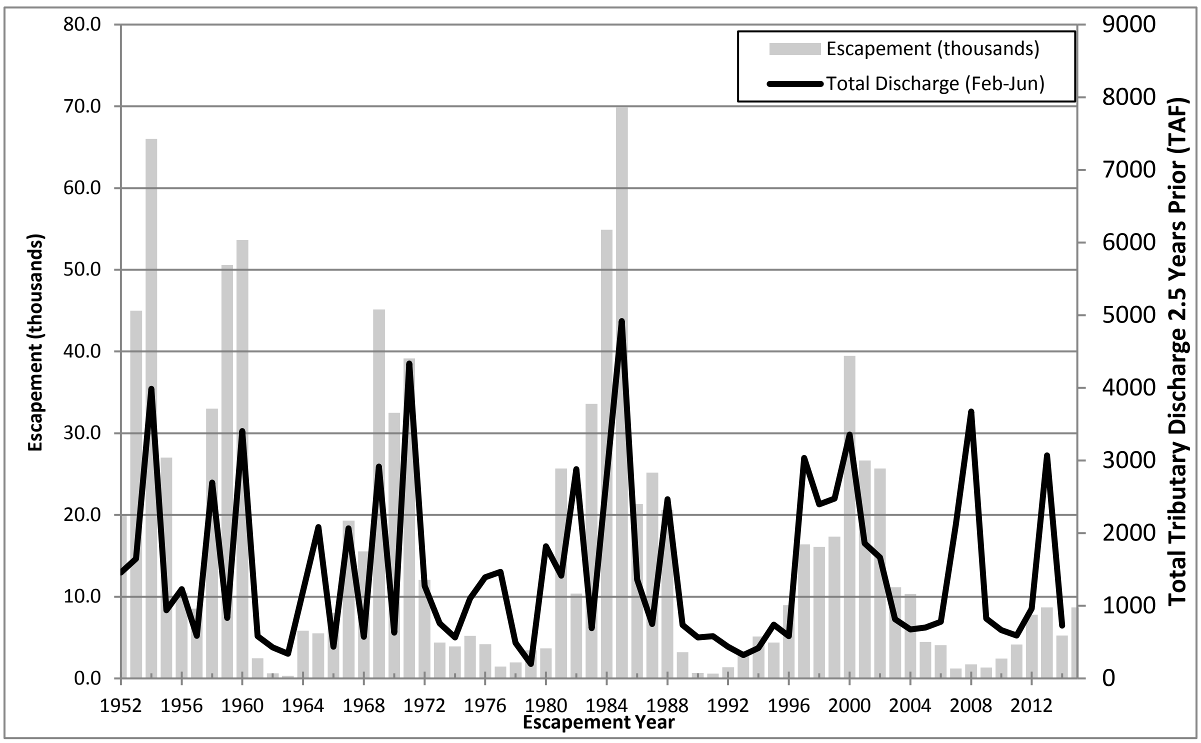

Figure 3.1-5. Relationship between Adult Salmon Returns to the San Joaquin River Basin and the River Flows they Experienced as Juveniles. (Fall-run Chinook salmon returns [escapement] to the Stanislaus, Tuolumne, and Merced Rivers combined from 1952–2014 relative to the total discharge [Thousand Acre-Feet] during the February–June outmigration period they experienced 2.5 years prior as juveniles. Salmon data from the California Department of Fish and Wildlife's [CDFW] GrandTab 2014.04.22 and GrandTab 2016.04.11. Flow data for the Stanislaus, Tuolumne, and Merced Rivers combined from USGS gages 11303000, 11290000, and 11270900 respectively. Note that adult abundance estimates have not been corrected for age distributions [it is assumed that all adults returned at age 3], or for out-of-basin straying. The large deviation in 2007 reflects poor returns that were attributed to poor ocean conditions [Lindley et al. 2009] and resulted in the closure of the fishery. Adapted from Sturrock et al. 2015.)

Scientific evidence indicates that in order to protect fish and wildlife beneficial uses in the SJR Basin, including increasing the populations of SJR Basin fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead (*Oncorhynchus mykiss*) to sustainable levels, the current flow regime of the SJR Basin needs to change. Specifically, a more natural flow regime consisting of higher and more variable flows from the salmon bearing tributaries (Stanislaus, Tuolumne, and Merced Rivers) is needed during the critical spring rearing and juvenile migration period from February through June (Appendix C, Chapter 3). A more recent study analyzing 14 years of rotary screw trap data on the Stanislaus River indicated that hydrology was a significant driver of several demographic characteristics of a Chinook salmon population and that incongruities between flow and life history traits can lead to reduced migration success and reduced diversity of migratory life history strategies. Results showed flows that were cumulatively greater and more variable elicited greater positive responses in survival, the proportion of pre-smolt migrants and the size of smolts (Zeug et al. 2014). Two studies by Sturrock et al. (2015) and Miller et al. (2010) found that all migratory phenotypes (fry, parr, and smolt) of the outmigrating population February–June contributed to the returning adult population. Furthermore, providing flow to manage and conserve life history diversity within this time period through the expression of all three phenotypes is necessary to support resilient salmon populations.

Other studies (Beechie et al. 2010; Yarnell et al. 2015) emphasize the need for river restoration to focus on retaining specific process-based components of the hydrograph (i.e., functional flows), rather than attempting to mimic the natural flow regime. As discussed in this master response under *Unimpaired Flow as Functional Flow*), the unimpaired flow approach to the plan amendments, when used with adaptive implementation, would essentially provide functional flows. Please also refer to Master Response 2.1, *Amendments to the Water Quality Control Plan*, and Master Response 2.2, *Adaptive Implementation*, for more information regarding functional flows.

Purpose of the Bay-Delta Plan Update and the Narrative Objective

As described more fully in Master Response 1.2, *Water Quality Control Planning Process*, the State Water Board protects water quality that affects beneficial uses of water in the Bay-Delta through the water quality control plan for the area, the Bay-Delta Plan, pursuant to its authorities under the Porter-Cologne Water Quality Control Act (Porter-Cologne Act) (Wat. Code, 13000 et seq.) and the federal Clean Water Act (33 U.S.C., § 1313). Water quality control plans designate the beneficial uses of waters that are to be protected (such as municipal and industrial, agricultural, and fish and wildlife beneficial uses), water quality objectives for the reasonable protection of the beneficial uses or the prevention of nuisance, and a program of implementation to achieve the water quality objectives. (Wat. Code, §§ 13241, 13050, subds. (h), (j).) The beneficial uses, together with the water quality objectives contained in the water quality control plans, and applicable federal anti-degradation requirements, constitute California's water quality standards for purposes of the Clean Water Act.

In formulating a water quality control plan, the State Water Board is vested with wide authority "to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." (§ 13000.) In fulfilling its statutory imperative, the State Water Board is required to "establish such water quality objectives ... as in its judgment will ensure the reasonable protection of beneficial uses ..." (§ 13241), a conceptual classification far-reaching in scope.

> 'Beneficial uses' of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves." (§ 13050, subd. (f).) Thus, in carrying out its water quality planning function, the Board possesses broad powers and responsibilities in setting water quality [objectives].' (State Water Resources Control Board Cases (2006) 136 Cal.App.4th 674, 697 quoting *United States v. State Water Resources Control Bd.* (1986) 182 Cal.App. 3d 82, 109-110.)

U.S. Environmental Protection Agency 1994 Criteria and Approval of the 1995 Bay-Delta Plan

Under Section 303 of the Clean Water Act and the implementing regulations of the U.S. Environmental Protection Agency (USEPA), states are to establish designated uses for waterbodies and must adopt water quality criteria sufficient to protect those designated uses. The USEPA then reviews and approves or disapproves the state-adopted water quality standards. In 1991, USEPA disapproved part of the *1991 Bay-Delta Water Quality Control Plan* (1991 Bay-Delta Plan) finding that the state had not adopted criteria sufficient to protect the designated uses of the estuary. USEPA then prepared federal criteria "for the purpose of replacing the disapproved State plan." The federal criteria were proposed in December 1993 (59 F.R. 810) (January 6, 1994) and promulgated in December 1994 (60 F.R. 4664) (January 24, 1995) (USEPA 1995). USEPA criteria include salinity criteria of 0.44 milliMhos/centimeter (mmhos/cm) electrical conductivity (EC) on a 14-day running average in the LSJR in the reach from Jersey Point to Vernalis in wet, above normal, and below normal water years for the protection of estuarine spawning habitat using striped bass as the index species. In dry and critical water years, USEPA proposed the 0.44 mmhos/cm criteria for only the reach from Jersey Point to Prisoners Point. However, the federal criteria acknowledged that "it is [USEPA's] longstanding policy that the federal water quality standards will be withdrawn if a state adopts and submits standards that in the Agency's judgment meet the requirements of the Act" (60 F.R. 4664, 4668).

Multiple commenters have asserted that the State Water Board is bound by the USEPA criteria promulgated in 1994 and therefore should have included such criteria in the SED analyses. However, in the summer of 1994, the USEPA, the State Water Board "and other federal and state agencies involved in the [Bay-Delta] continued pursuing a cooperative approach to protecting the fish and wildlife resources of the estuary." This culminated in a framework agreement to "establish a process through which the government agencies would develop approvable water quality standards, coordinate water project operations, and develop long-term solutions to Delta water quality and management issues." This led to the signing of the Bay-Delta Accord on December 15, 1994. USEPA identified the Bay-Delta Accord as "an outline of the water quality measures that, if put into effect by the State Water Board following its required processes, would serve as the basis for water quality protection in the Bay/Delta…" Thereafter, USEPA praised the State Water Board for "following through on the Bay/Delta Accord, and in developing the 1995 Bay/Delta Plan."

In 1995, USEPA approved the 1995 Bay-Delta Plan as meeting the requirements of the Clean Water Act and its implementing regulations and setting the criteria for the Bay-Delta. USEPA then committed to withdrawing the federal rule as superseded but left the criteria in place as a backstop in case litigation challenging that the state standards resulted in neither state nor federal criteria applicable to the Bay-Delta (USEPA 1995). No such litigation was successful. As a result, the standards in the 1995 Bay-Delta Plan are the appropriate baseline criteria for purposes of the SED.

Delta Decline and the Need for Bay-Delta Plan Update

As discussed in the *Executive Summary*; Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*; Appendix C; Master Response 1.2, *Water Quality Control Planning Process*; and Master Response 2.1, *Amendments to the Water Quality Control Plan*, the Bay-Delta is in an ecological crisis. Fish species have not shown signs of recovery since adoption of the 1995 Bay-Delta Plan objectives intended to protect fish and wildlife. Several species of fish are listed as protected species under the state and federal endangered species acts. In particular, salmon and steelhead, including those that spawn and rear in the SJR's tributaries and migrate through the Delta to the Pacific Ocean, have steeply declined. As detailed above, scientific studies show that flow is a primary limiting factor in the survival of salmon. This plan update is part of a multi-pronged approach to address the ecological crisis and protect beneficial uses in the Bay-Delta and tributary watersheds. The LSJR narrative and numeric flow objectives are an expression of the desired flow and biological conditions in the LSJR and three eastside tributaries that would reasonably protect fish and wildlife, including requiring flows to be managed in a manner that avoids causing adverse impacts on fish. The LSJR numeric flow objectives apply in the February–June time period because the majority of yearly precipitation falls within these months, target fish species need in-stream habitat conditions to support early life stages during this timeframe, and conflicts with water needs for consumptive uses increase in the late spring and early summer months. However, the program of implementation for the flow objectives also includes the flexibility to shift a portion of the unimpaired flow outside of the February–June time period to prevent adverse effects on fisheries that would otherwise result from implementation of the February–June flow requirements. The program of implementation also requires carryover storage targets or other requirements to help ensure that providing flows to meet the flow objectives will not have adverse temperature or other impacts on fish and wildlife, including outside of the February–June time period.

Justification and Description of the Plan Amendments for Protecting Fish

Multiple commenters asserted that there will be no benefits to fish from the plan amendments or that the benefits are unclear. As discussed in Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*; Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*; and this master response, the plan amendments address key factors that have contributed to historic declines and continue to limit the success of native fish species and are anticipated to provide more natural habitat conditions (refer to the *Current Fish Decline and the Need for Increased and More Variable Flows and Section Benefits of Unimpaired Flow* section of this master response). The plan amendments are anticipated to also be beneficial to multiple ecosystem processes that are important for the environment as a whole (Appendix C, Section 3.7, *Importance of the Flow Regime*).

Other master responses that discuss the plan amendments in detail and clarify how they are designed to achieve the biological benefits discussed in the SED and this master response are Master

Response 2.1, *Amendments to the Water Quality Control Plan*; Master Response 2.2, *Adaptive Implementation*; and Master Response 5.2, *Incorporation of Non-Flow Measures*.

Other commenters asserted that the measurable benefits of the plan amendments do not justify the potential impacts. The State Water Board looked at a variety of factors necessary to reasonably protect fisheries, including flow and temperature, but also examined economic considerations (i.e., value of lost water to affected parties) of various approaches in relation to expected benefits. Please refer to Master Response 1.2, *Water Quality Control Planning Process*, regarding consideration of beneficial uses by the State Water Board. Refer to Master Response 1.1, *General Comments*, regarding general responses to economic-related comments.

Unimpaired Flow Approach

Unimpaired Flow is not Equivalent to the Natural Flow Regime

Multiple commenters asserted that unimpaired flow is not an appropriate representation of natural flow conditions because it does not incorporate landscape changes that have occurred (e.g., drainage of wetlands, alteration of floodplains, construction of levees, timber harvest, livestock grazing, etc.). Furthermore, multiple commenters asserted that simply increasing flow would not restore the natural conditions in which fish evolved. The analysis in the SED did not use unimpaired flow as a representation of natural flow conditions; unimpaired flow is not the same as restoring natural conditions. In the SED, distinctions between both types of flow (unimpaired flow and natural flow) are described in multiple locations (see Chapter 4, *Introduction to Analysis*, Section 4.2.1, *Hydrologic Modeling*; Appendix C, Section 3.1.1, *Terminology*; and Appendix F1, *Hydrologic and Water Quality Modeling*, Section 1.1, *Introduction*). *Unimpaired flow* represents the water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds, and uses the current configuration of channels, levees, floodplain, wetlands, deforestation, and urbanization. Refer to Master Response 3.2, *Surface Water Analyses and Modeling*, for clarification regarding the modeling and calculations involved in simulating unimpaired flow. On the other hand, *natural flow* (also referred to as the natural flow regime) represents the range of intra-and inter-annual variation of the hydrologic regime, and associated characteristics of magnitude, frequency, duration, timing and rate of change that occurred when human perturbations (i.e., the landscape changes identified previously) to the hydrologic regime were negligible. The intent of using the unimpaired flow approach is to capture the natural pattern of variability and retain the attributes of the natural flow regime to which native SJR Basin fish and wildlife adapted and that are important to support key ecosystem processes (Yarnell et al. 2015; Beechie et al. 2010).

The State Water Board recognizes that landscape changes have occurred and altered the hydrogeomorphology of rivers, making lasting impacts on the aquatic resources that depend on the riverine ecosystem. Chapter 7, *Aquatic Biological Resources*, Section 7.2, *Environmental Setting*, reviews historical and current fish communities and environmental stressors in the LSJR, three eastside tributaries, and the southern Delta, and includes descriptions of habitat alterations. Despite these landscape changes, the plan amendments address key factors that have contributed to historic declines and continue to limit the success of native fish species in a modified environment.

The State Water Board also recognizes that non-flow actions must be part of the overall effort to comprehensively address ecosystem needs in the Delta and tributaries, as a whole, and that results from the implementation of such actions can be used to inform adaptive implementation decisions under the plan amendments. For this reason, the State Water Board recommends a range of non-flow actions complementary to the flow objectives for the reasonable protection of fish and wildlife and describes those actions in Appendix K, *Revised Water Quality Control Plan*. Among these recommendations are actions intended to restore physical habitat, including floodplain, reduce vegetation-disturbing activities in floodplains and floodways, provide gravel augmentation, and enhance in-channel complexity. Chapter 16, *Evaluation of Other Indirect and Additional Actions*, Section 16.3, *Lower San Joaquin River Alternatives–Non-Flow Measures,* includes a description of these actions and their associated cost and potential environmental impacts. Refer to Master Response 5.2, *Incorporation of Non-Flow Measures*, for more information.

Benefits of Unimpaired Flow

Multiple commenters asserted there was no scientific evidence presented to justify the assumption that unimpaired flow would achieve the goals of the plan amendments to support and maintain the natural production of viable native fish population's migration through the Delta and achieve functions beneficial to native fishes (refer to Master Response 2.1, *Amendments to the Water Quality Control Plan*; Master Response 2.2, *Adaptive Implementation*; and the *Unimpaired Flow as Functional Flow* section of this master response). Multiple commenters also asserted that there will be no benefits to fish from the plan amendments, or that the plan amendment benefits to fish are minimal or unclear. Substantial evidence justifying the unimpaired flow approach can be found in Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*; Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*; and, this master response, which references and amplifies information in the SED. For information regarding the justification for the salinity objectives, please see Master Response 3.3, *Southern Delta Water Quality*.

As explained in Appendix C, higher and more variable flows are anticipated to improve conditions for fish, and other ecosystem attributes including, but not limited to, (1) native fish communities, (2) food web, (3) habitat, (4) geomorphic processes, (5) temperature, and (6) water quality. Chapter 19, *supplements* the information contained in Appendix C, by quantitatively evaluating the measurable benefits of the plan amendments for the LSJR flow objectives in terms of potentially available cold water and floodplain habitats, and associated population implications to native salmonids. Additional information regarding plan amendment benefits can be found in this master response in the following sections.

- Refer to the *Current Fish Decline and the Need for Increased and More Variable Flows* and *Weighted Useable Area* sections for a description of historical data and current studies supporting the need for higher and more variable flows.
- Refer to the *Temperature* and *Seasonal Flows from February through June* sections for a description of benefits to temperature conditions.
- Refer to the *Floodplain Habitat* section for a description of floodplain habitat benefits.
- Refer to *Elements of the Plan Amendments that Inform/Enhance Biological Benefits* section for a description of elements of the plan amendments that will facilitate flexible management and allow the incorporation of new science for even greater benefits.

Delta Flow Criteria Report

Multiple commenters asserted that 60 percent unimpaired flow is what the best available science indicates is needed to protect fish, citing the 2010 *Development of Flow Criteria for the Sacramento-*

San Joaquin Delta Ecosystem report (2010 Delta Flow Criteria Report). The 2009 Delta Reform Act (Wat. Code §§ 85000 et seq.) required the State Water Board, "for the purpose of informing planning decisions," to develop flow criteria as if the only goal was to protect public trust resources. The 2010 Delta Flow Criteria Report determined, among other things, that 60 percent of unimpaired SJR inflow February–June would preserve the attributes of a natural, variable system to which native fish species are adapted if there were no consideration of other beneficial uses. Stated another way, this report only presented a technical assessment of flow and operational requirements to provide fishery protection under existing conditions and, as such, its flow criteria determinations were limited to the protection of aquatic resources in the Delta. While setting flow objectives with regulatory effect (i.e., in a water quality control plan; see *The Purpose of the Bay-Delta Plan Update and Narrative Objective* section of this master response), the State Water Board reviews and considers all the effects of the flow objectives through a broad evaluation into all public trust and public interest concerns including, but not limited to, aquatic resources, economics, reservoir storage, power production, and groundwater. The SED provides such an evaluation. Please refer to Master Response 1.1, *General Comments*, and Master Response 1.2, *Water Quality Control Planning Process*, for more information regarding the separate process of developing the Delta Flow Criteria Report and the consideration of beneficial uses and the public trust when establishing objectives for the protection of competing uses.

Seasonal Flows from February through June

Temperature Improvements during June

Some commenters questioned the inclusion of June flows in the LSJR flow objective citing low detections of fish presence during some June periods. This is unsurprising as river flows have been highly altered during the month of June by water diversions and reservoir storage. In the Tuolumne River, for example, during half of the years (i.e., median value) between 1984 and 2009, monthly observed flows as a percentage of unimpaired flows were less than 9 percent during June. In other words, more than 91 percent of the unimpaired flow was diverted or stored in half of the years during June (see the *Current Fish Decline and the Need for Increased and More Variable Flows* section of this master response). In the Merced, Stanislaus, and San Joaquin (at Vernalis) Rivers, the median monthly observed flow as a percent of unimpaired flow was 15 percent, 40 percent, and 18 percent, respectively, in June during the 1984–2009 time period. These dramatic reductions in river flows within anadromous river reaches have had devastating effects on native fish populations as described in Appendix C and Chapter 19.

However, inclusion of the June period is important both for calculating the amount of water that can be adaptively implemented to achieve the narrative objective and, in some years, is key to increasing population resiliency (see the *Current Fish Decline and the Need for Increased and More Variable Flows* section of this master response). Water temperatures within the Stanislaus, Tuolumne, and Merced Rivers and LSJR are influenced by seasonal patterns in air temperature; however, water temperature in the Stanislaus, Tuolumne, and Merced Rivers and LSJR can be significantly improved for native fishes by increasing flow. Historical data from the month of June indicate that water temperatures can be reduced by 15 degrees Fahrenheit (°F) or more when flows are higher in each of the rivers (Figure 3.1-6 through Figure 3.1-9).

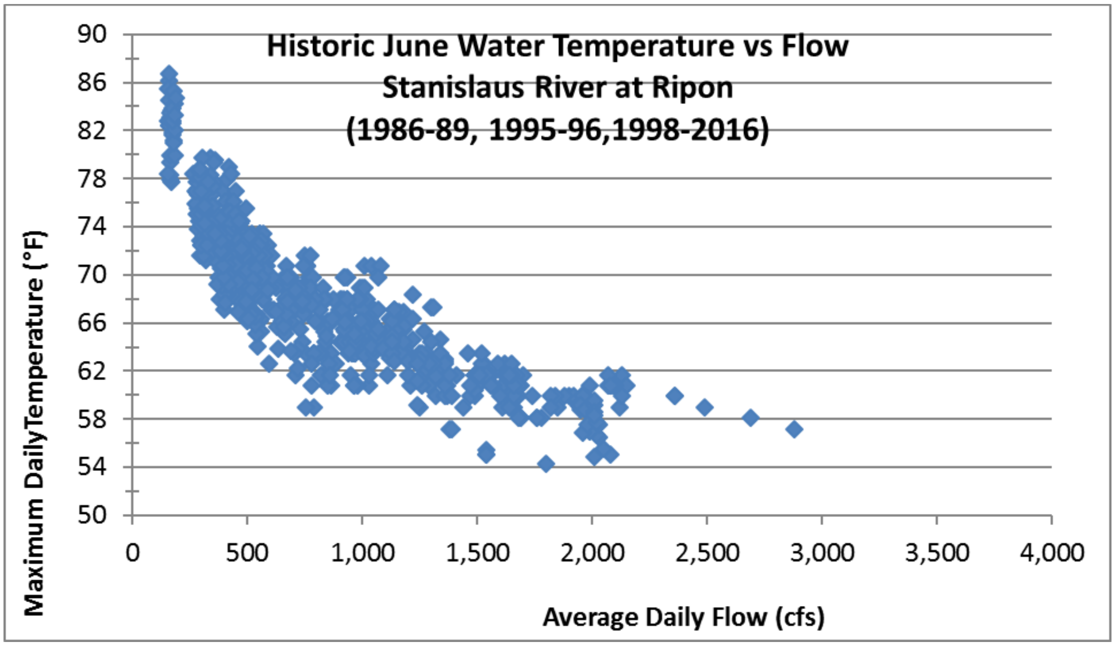

Figure 3.1-6. Historical June Maximum Daily Water Temperature (Fahrenheit) versus Average Daily Flow (cubic feet per second) on Stanislaus River at Ripon (Source: USGS Station 11303000 Stanislaus River at Ripon [1986-89, 1995-96, 1998-2016].)

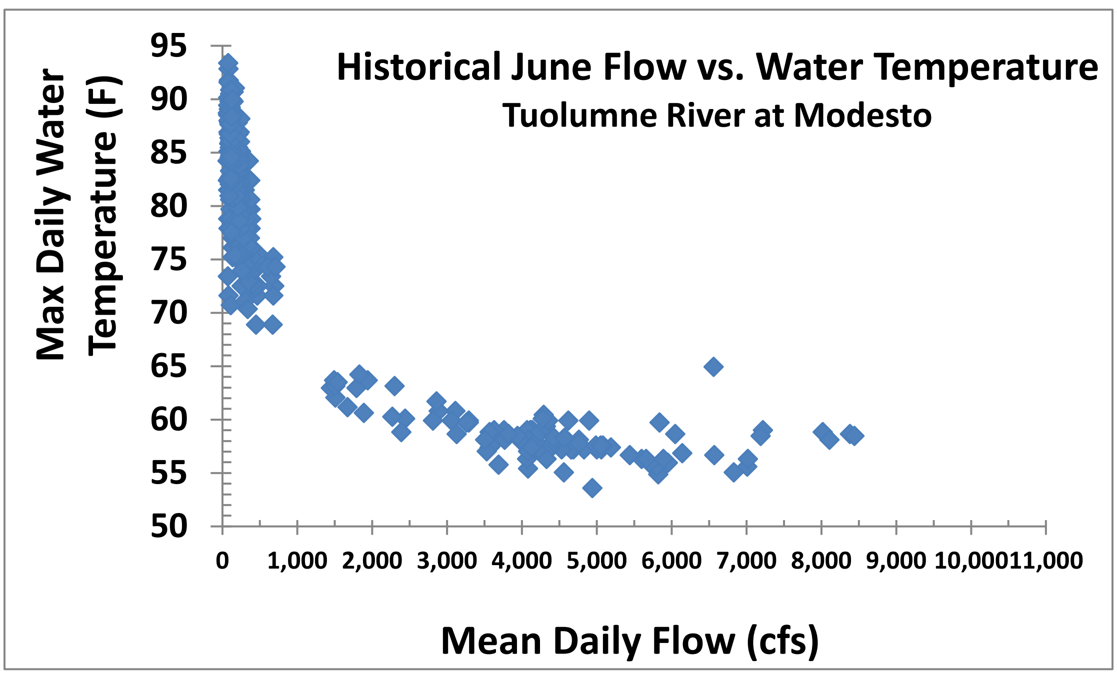

Figure 3.1-7. Historical (1989–1993, 2001–2003, 2005, 2007–2017) June Maximum Daily Water Temperatures (Fahrenheit) versus Average Daily Flow (cubic feet per second) on the Tuolumne River at Modesto (Source: USGS—Tuolumne River at Modesto [Site 11290000].)

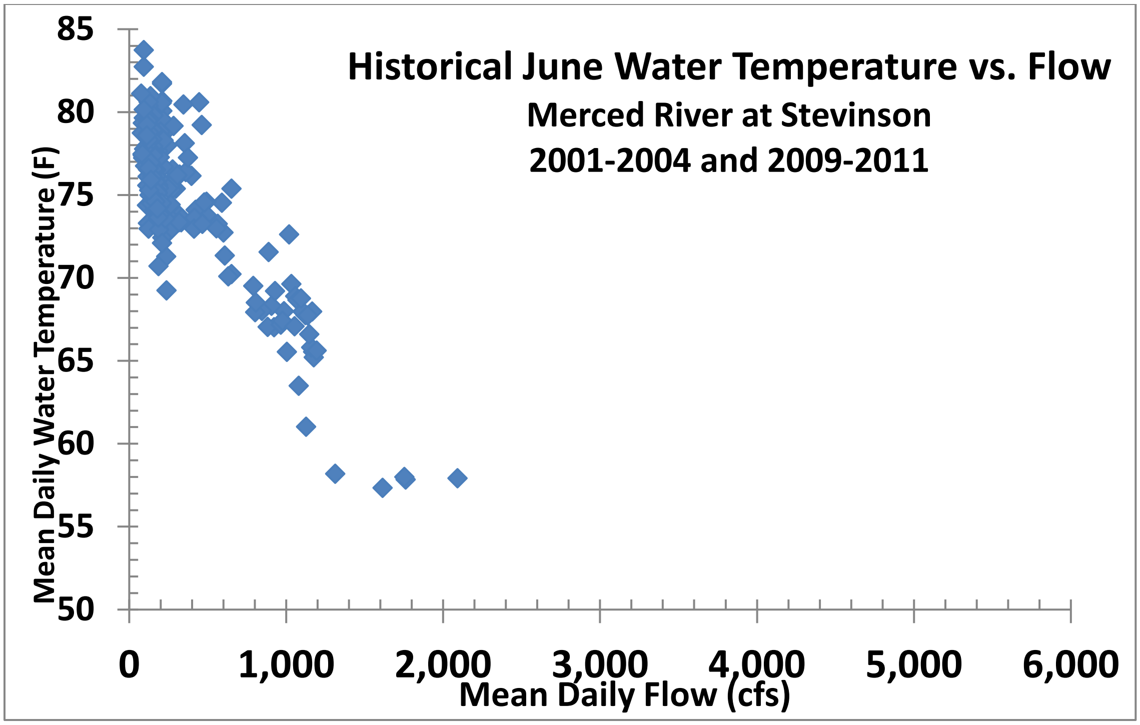

Figure 3.1-8. Historical June Average Daily Water Temperature (Fahrenheit) versus Average Daily Flow (cubic feet per second) on Merced River at Stevinson (2001–2004 and 2009–2011) (Source: California Data Exchange Center.)

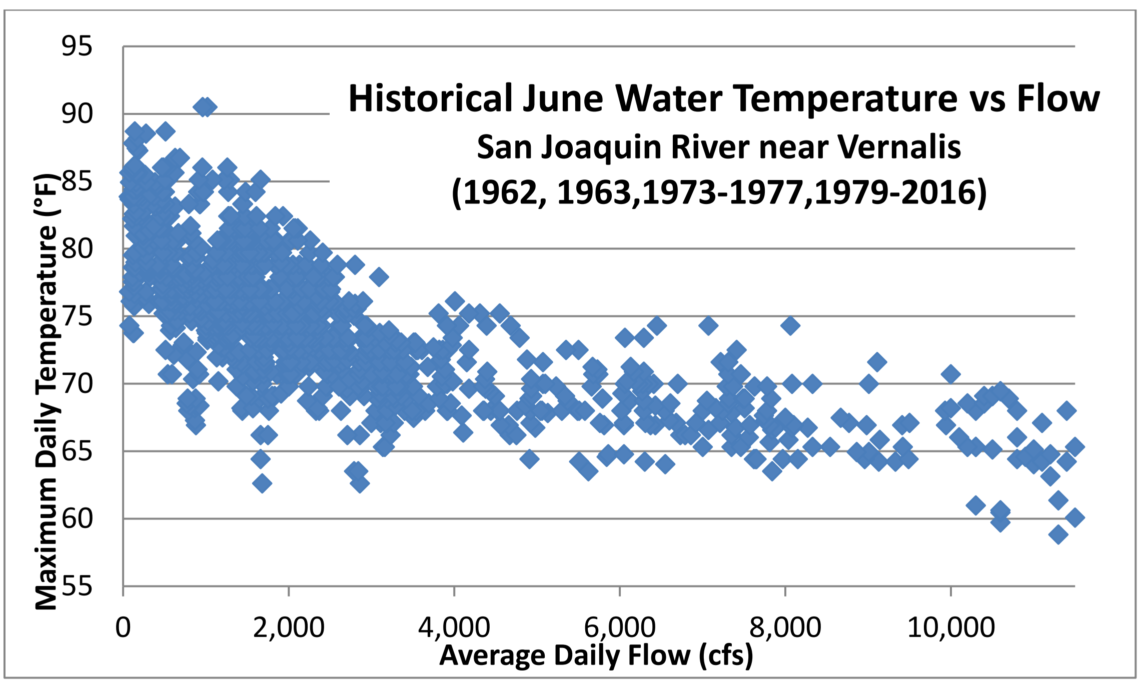

Figure 3.1-9. Historical June Maximum Daily Water Temperature (Fahrenheit) versus Average Daily Flow (cubic feet per second) on San Joaquin River near Vernalis (Source: USGS Station 11303500 San Joaquin River near Vernalis [1962, 1963,1973–1977,1979–2016].)

Under current low flow conditions that result from diversions and storage, water temperatures during the month of June are often unsuitable throughout many river reaches during many years. These unsuitable conditions have the effect of narrowing the window of opportunity that juvenile salmonids have during the spring time period to migrate to the Delta or Pacific Ocean, or to move upstream towards the dams to find colder water. Figure 3.1-10 through Figure 3.1-12 show that during water year 1991 the 40 percent unimpaired LSJR flow objective would extend the amount of time below 70°F (21.1° Celsius [C]) by approximately 1.5 months on the Tuolumne and Merced Rivers and by approximately 1 month on the Stanislaus River near the confluence of each river with the SJR. These figures also show that the number of days before water temperatures reach and stay above 65°F (18.3°C) would also be extended on each of the rivers, and on the Tuolumne River there is also a dramatic increase in the number of days near or below 60°F (15.6°C) under higher flows.

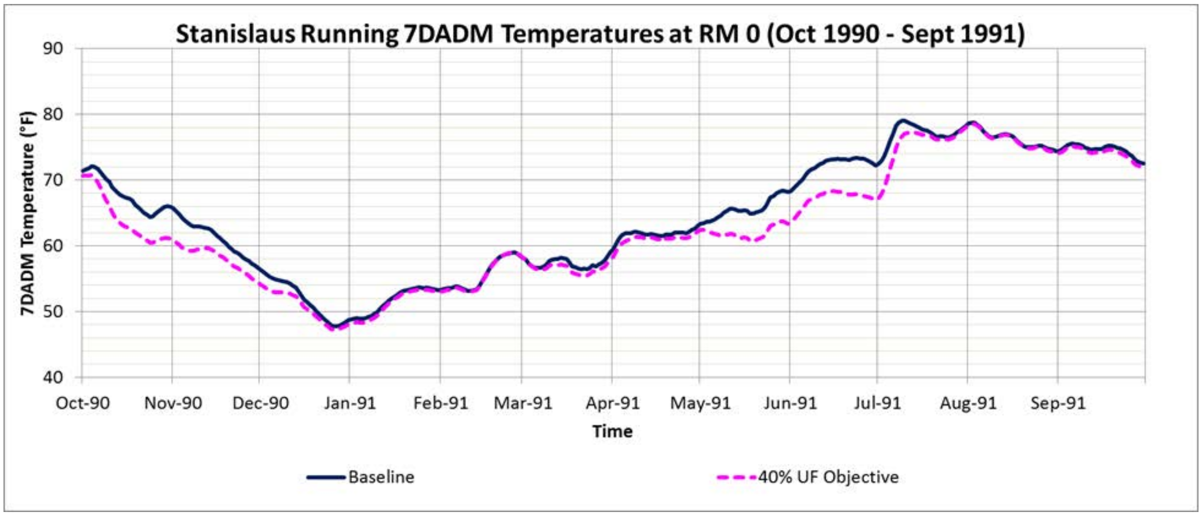

Figure 3.1-10. Stanislaus River Running 7-Day Average of the Daily Maximum (7DADM) Temperatures (Fahrenheit) under Baseline and 40% Unimpaired Flow Conditions at River Mile 0 from October 1990 through September 1991

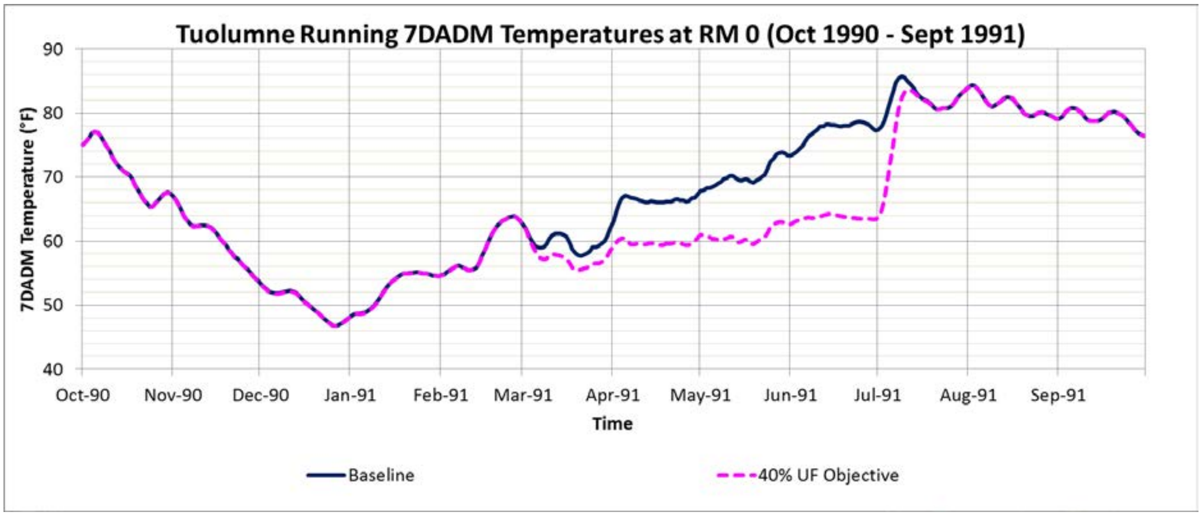

Figure 3.1-11. Tuolumne River Running 7-Day Average of the Daily Maximum (7DADM) Temperatures (Fahrenheit) under Baseline and 40% Unimpaired Flow Conditions at River Mile 0 from October 1990 through September 1991

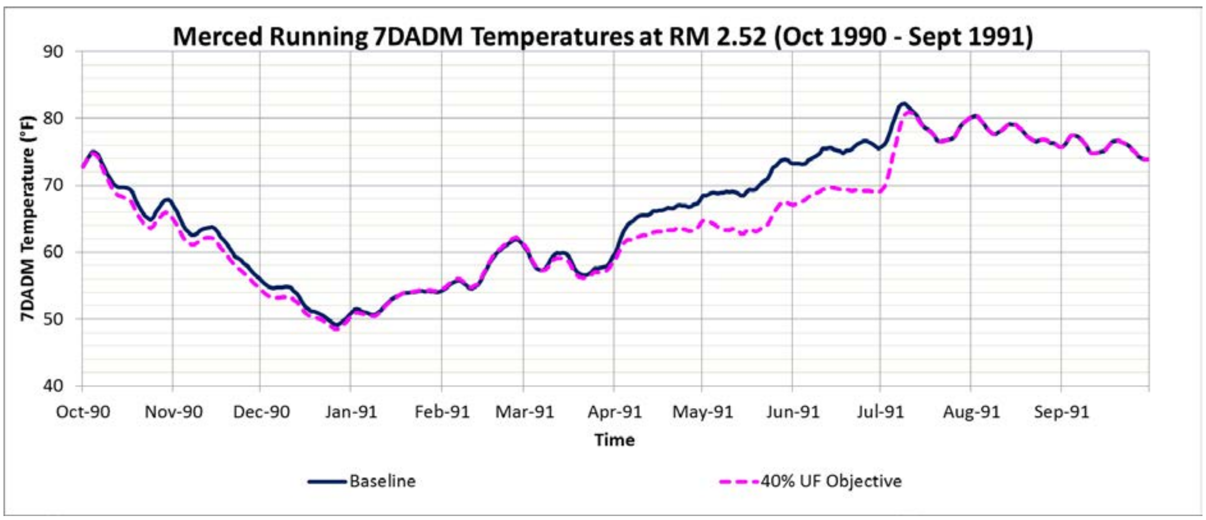

Figure 3.1-12. Merced River Running 7-Day Average of the Daily Maximum (7DADM) Temperatures (Fahrenheit) under Baseline and 40% Unimpaired Flow Conditions at River Mile 2.52 from October 1990 through September 1991.

While Figure 3.1-10 through 3.1-12 show reduced temperatures near the confluence of each tributary, reductions in water temperature are also possible at most of the river reaches on the Stanislaus, Tuolumne, and Merced Rivers (Figure –3.1-13 through Figure 3.1-15). In addition, temperatures in the SJR can also be dramatically reduced (Figure 3.1-16 through Figure 3.1-21).

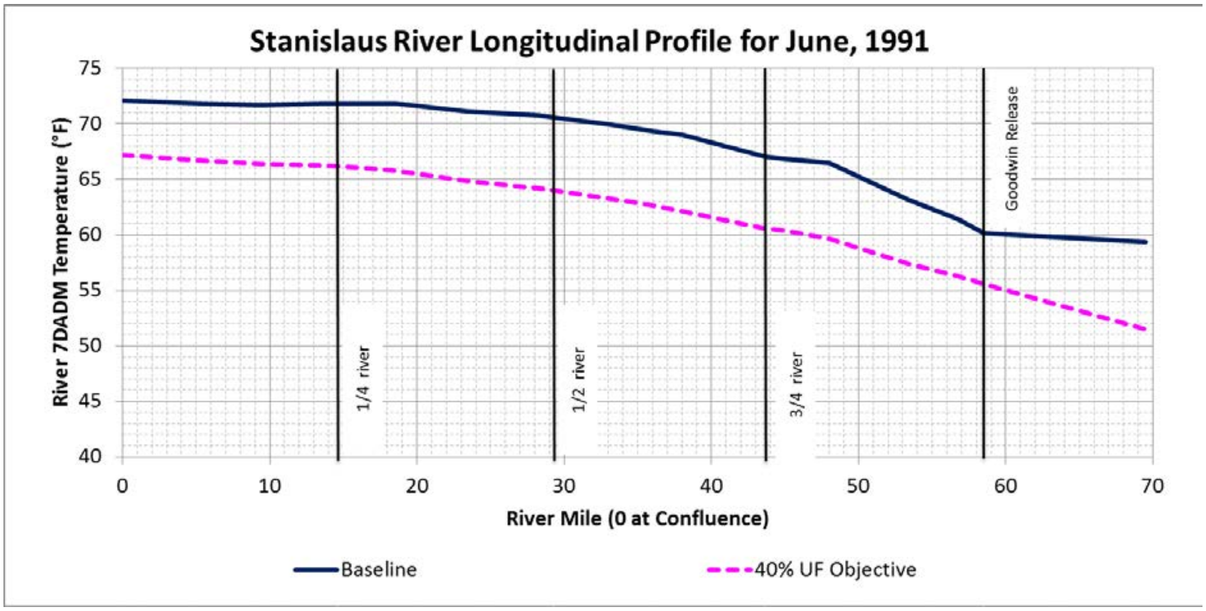

Figure 3.1-13. Average Stanislaus River Longitudinal Profile during June of 1991 under Baseline and 40% UF Conditions. (Fahrenheit) (Temperature reductions under the 40% unimpaired flow are from a combination of higher flows and higher storage.)

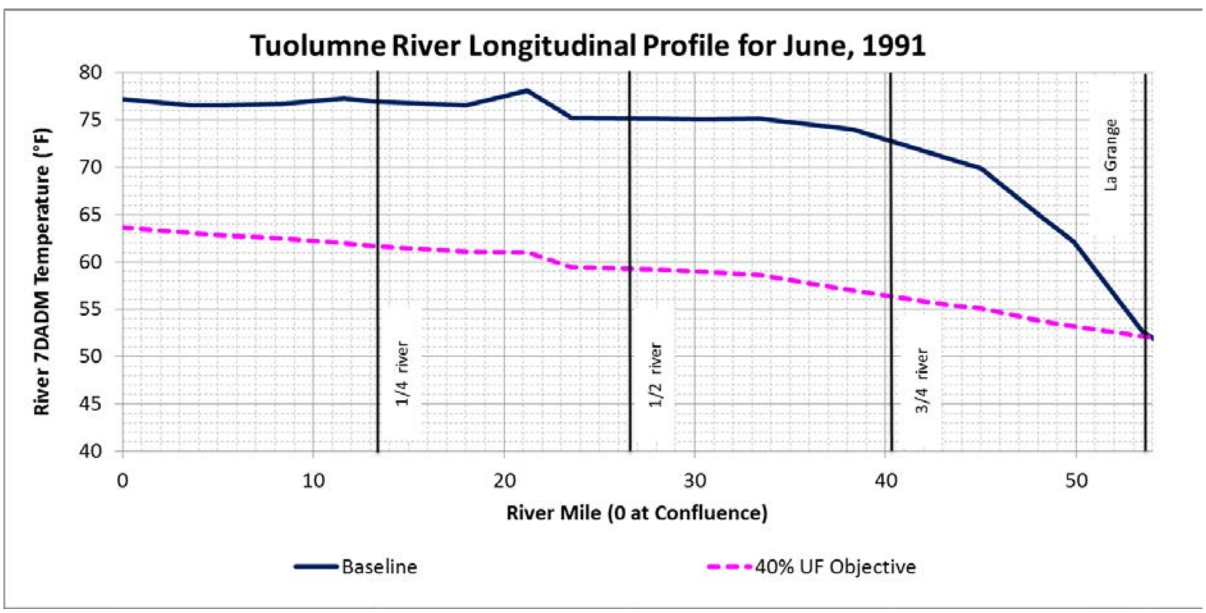

Figure 3.1-14. Average Tuolumne River Longitudinal Profile during June of 1991 under Baseline and 40% Unimpaired Flow Conditions. (Fahrenheit)

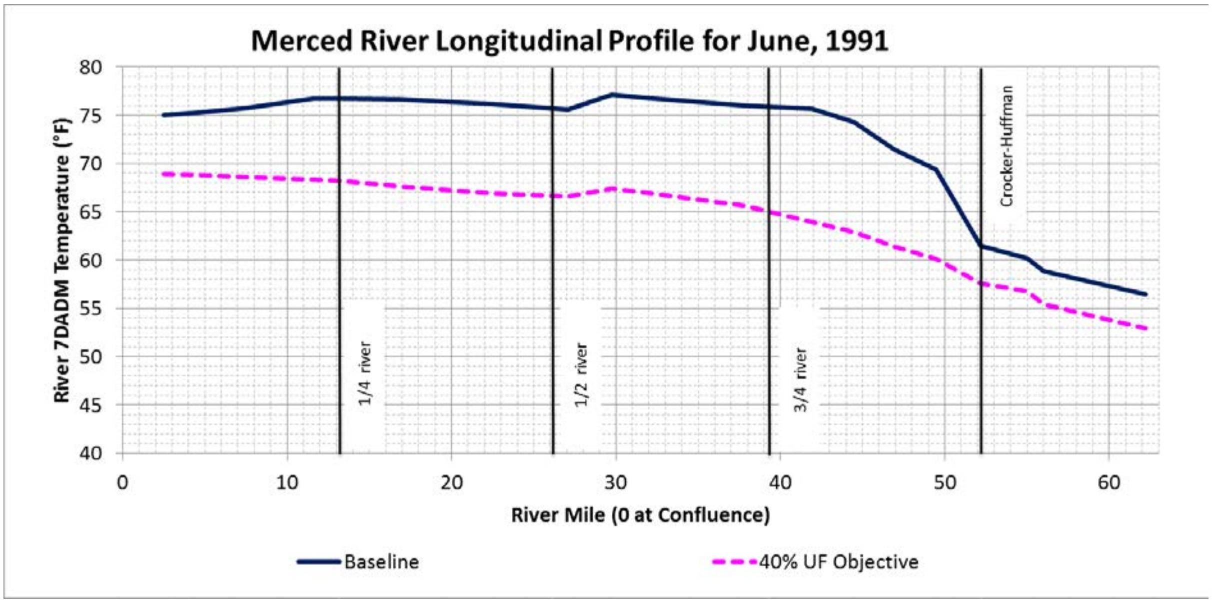

Figure 3.1-15. Average Merced River Longitudinal Profile during June of 1991 under Baseline and 40% Unimpaired Flow Conditions. (Fahrenheit)

These temperature reductions are expected during June in years when 40 percent unimpaired flow is substantially greater than baseline flow. All 34 years of June temperature modeling data are shown in exceedance plots in Figures 3.1-16, and 3.1-17, which show that the plan amendments would dramatically improve temperature conditions in the Tuolumne and Merced Rivers during June. These figures show dramatic reductions in water temperatures exceeding 70°F (21.1°C) and 75°F (23.9°C) for 40 percent unimpaired flow on both the Tuolumne and Merced Rivers, and on the Tuolumne River there is a dramatic reduction in temperatures exceeding 65°F (18.3°C) and 80°F (26.7°C).

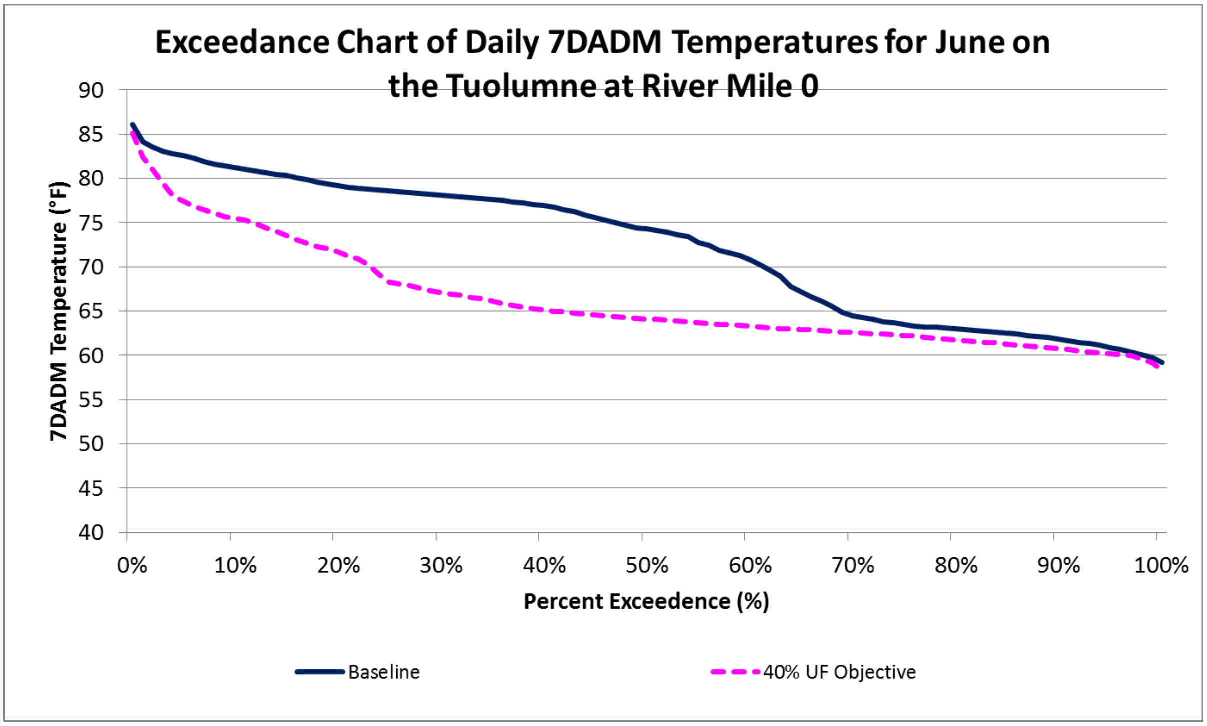

Figure 3.1-16. Tuolumne River Temperature Exceedance Chart (Fahrenheit) for the 7-Day Average of the Daily Maximum (7DADM) at River Mile 0 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

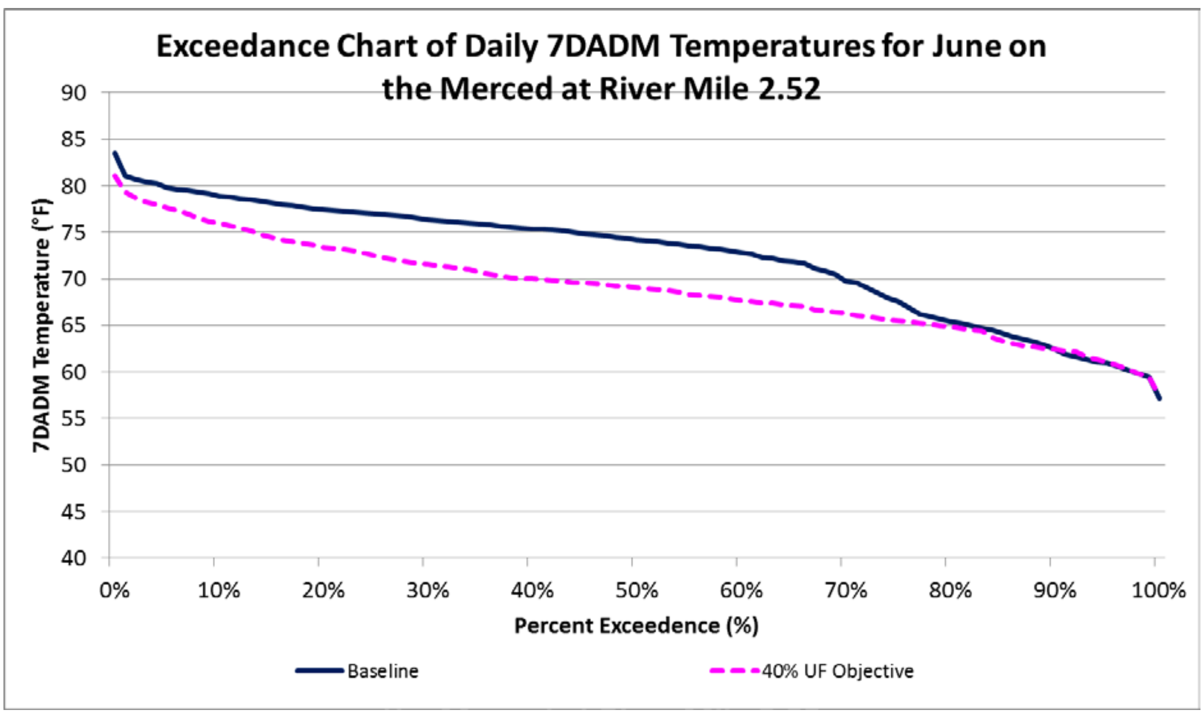

Figure 3.1-17. Merced River Temperature Exceedance Chart (Fahrenheit) for the 7-Day Average of the Daily Maximum (7DADM) at River Mile 2.52 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

The Stanislaus River does not see dramatic improvements on average (Figure 3.1-18) during June under 40 percent unimpaired flows (as mentioned previously, the median flow during June between 1984 and 2009 was 40 percent unimpaired flow). However, in years when the 40 percent flow requirement would result in substantially more flow during June, there are meaningful improvements in water temperatures (Figure 3.1-6 and Figure 3.1-13).

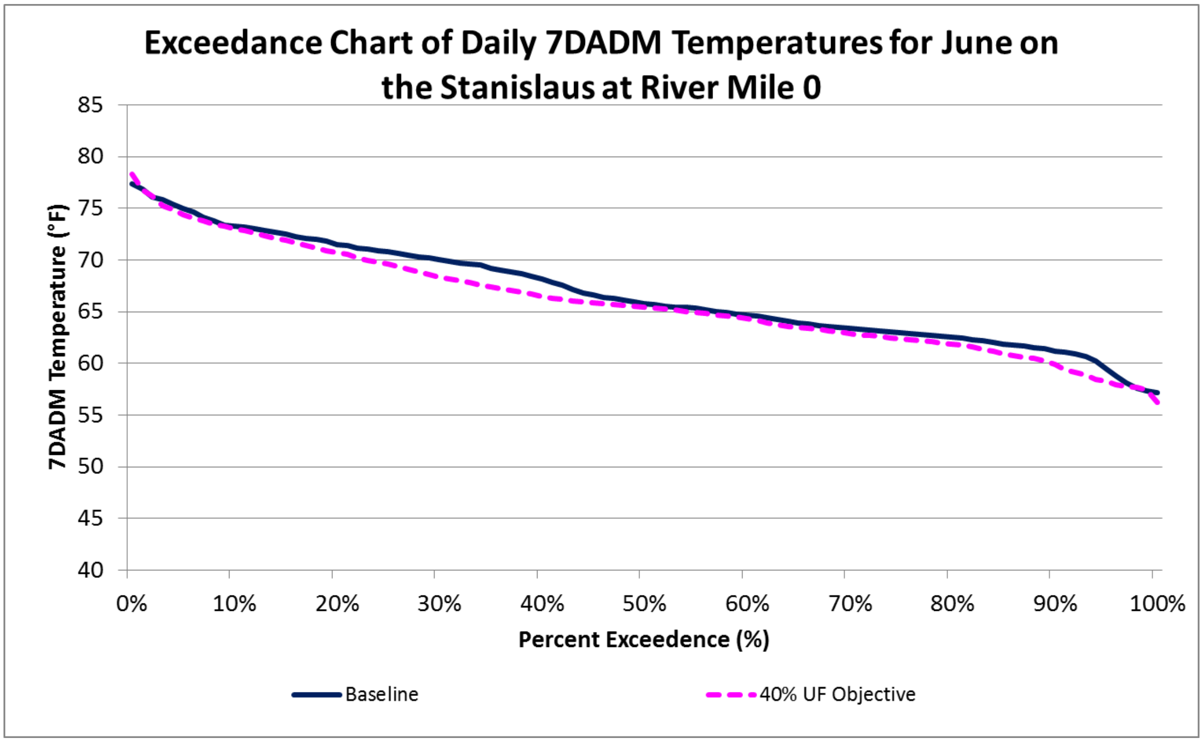

Figure 3.1-18. Stanislaus River Temperature Exceedance Chart (Fahrenheit) for the 7-Day Average of the Daily Maximum (7DADM) at River Mile 0 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

San Joaquin River Temperature Improvements during June

In the SJR, water temperature evaluations become more complicated because there are multiple tributaries that discharge different amounts of water into the LSJR. The longitudinal profile below (Figure 3.1-19) illustrates how temperatures change in the SJR during June as a result of inflow from the Stanislaus, Tuolumne, and Merced Rivers and as a result of additional water provided by 40 percent unimpaired flow. In years when substantially more water is added to the SJR from the three eastside tributaries, meaningful temperature improvements are expected as illustrated below in Figure 3.1-19 through Figure 3.1-21.

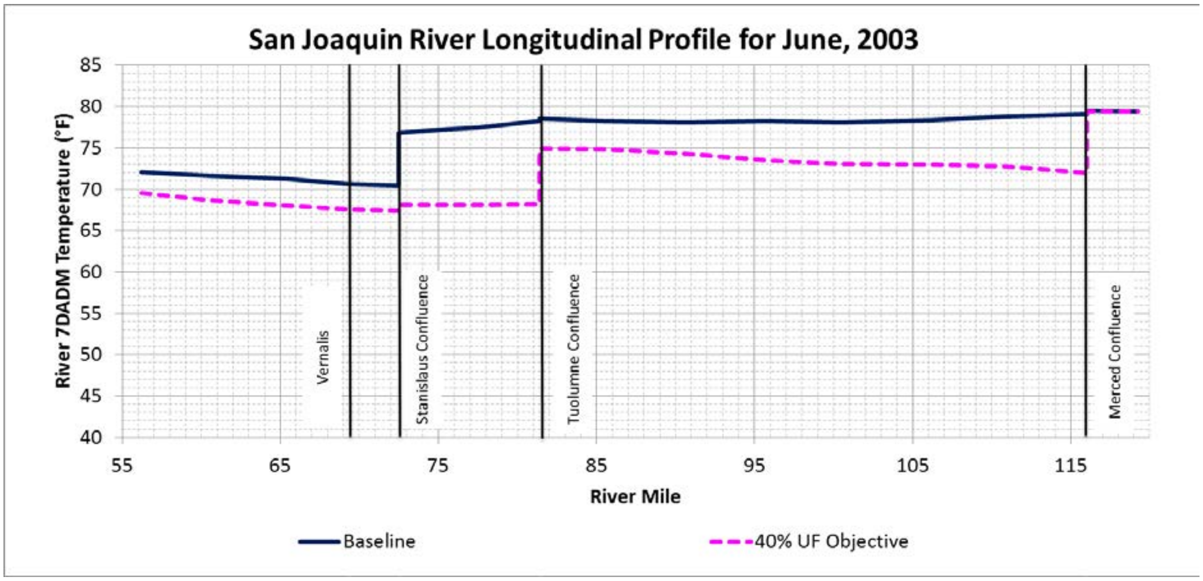

Figure 3.1-19. Average San Joaquin River Longitudinal Profile during June of 2003 under Baseline and 40% Unimpaired Flow Conditions (Fahrenheit)

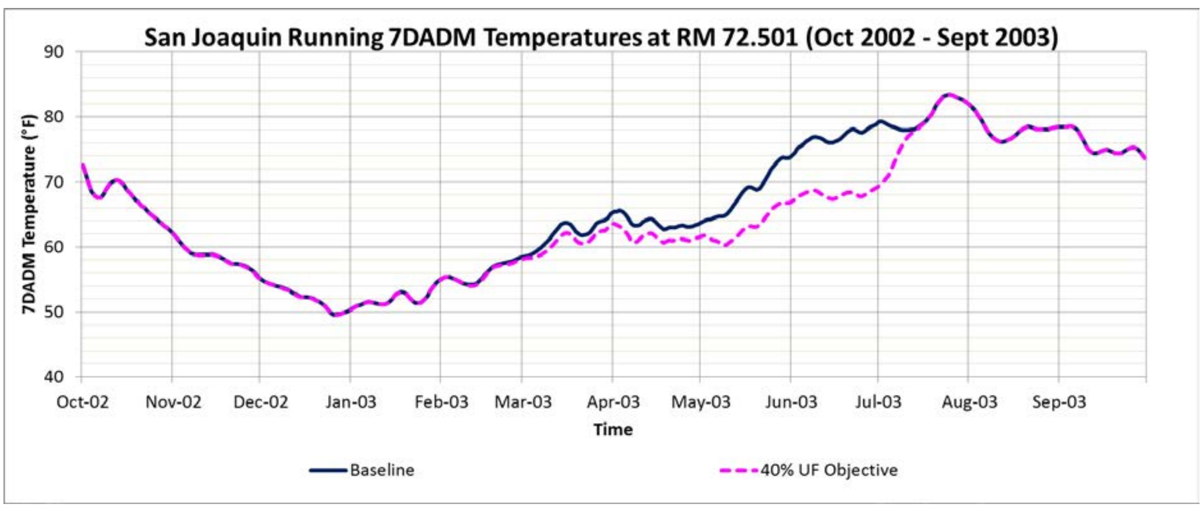

Figure 3.1-20. San Joaquin River Running 7-Day Average of the Daily Maximum (7DADM) Temperatures (Fahrenheit) under Baseline and 40% Unimpaired Flow Conditions at River Mile 72.501 from October 2002 through September 2003

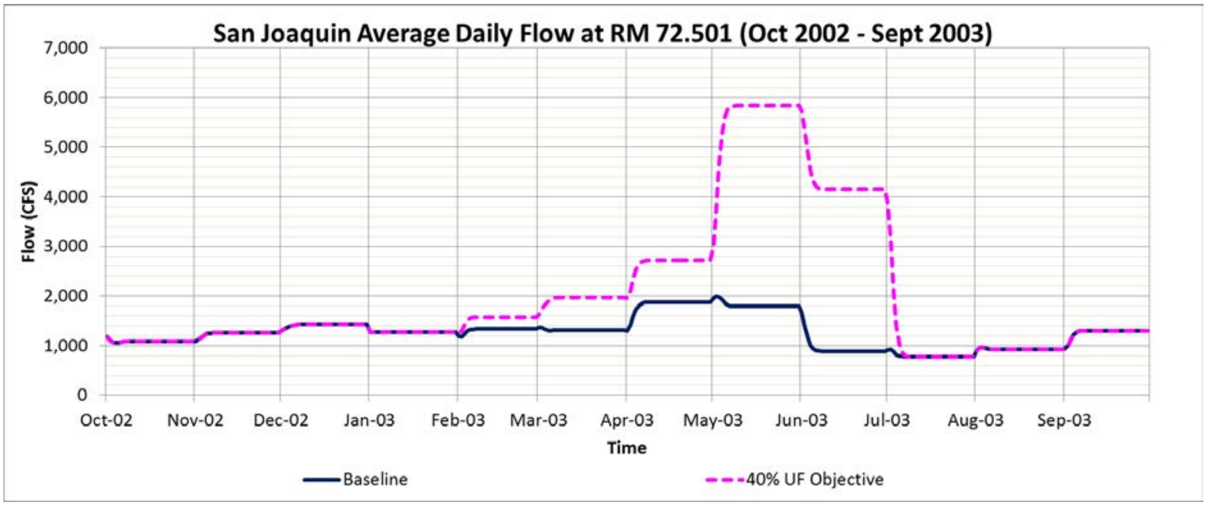

Figure 3.1-21. San Joaquin River Flow (cubic feet per second) under Baseline and 40% Unimpaired Flow Conditions at River Mile 72.501 from October 2002 through September 2003

Figure 3.1-22 through Figure 3.1-24 show daily temperature exceedances during June for all 34 years of temperature modeling at different locations in the LSJR. The LSJR reach between the Stanislaus and Tuolumne River confluences experiences large temperature reductions as a result of increased inflow from the Tuolumne and Merced Rivers under 40 percent unimpaired flow. The SJR at Vernalis and upstream of the Tuolumne confluence sees smaller temperature reductions on average, but these can be significant during years when 40 percent unimpaired flow adds substantially more water as seen in the longitudinal profile in Figure 3.1-21.

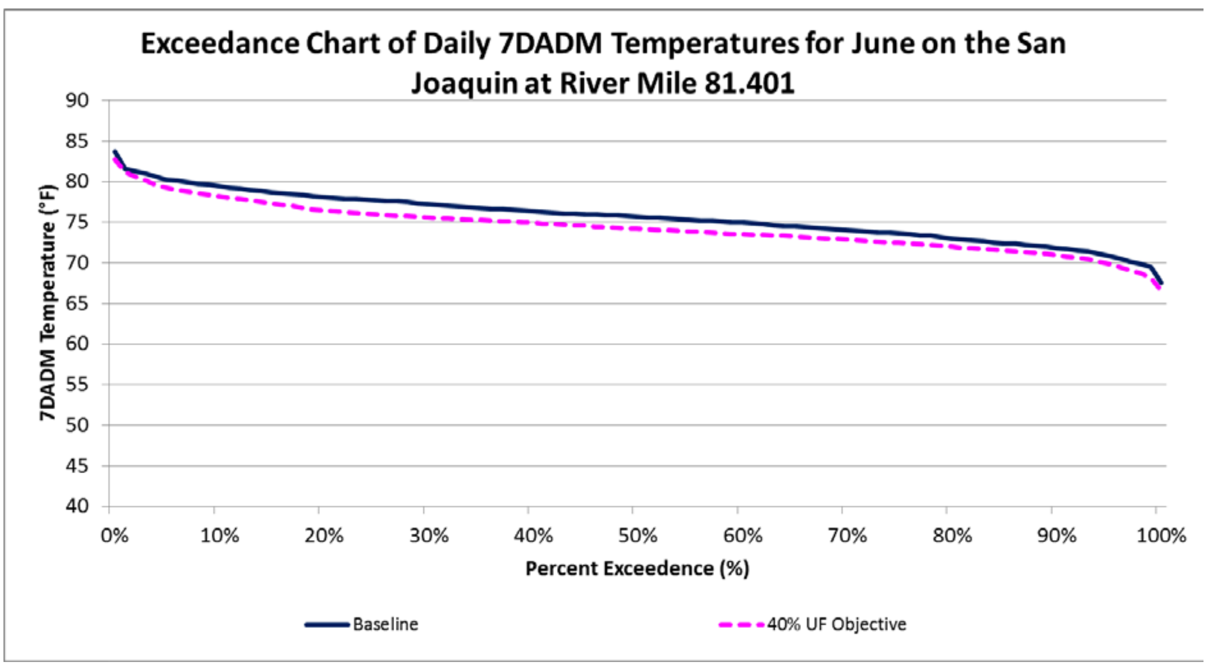

Figure 3.1-22. San Joaquin River Temperature (Fahrenheit) 7-Day Average of the Daily Maximum (7DADM) Exceedance Chart at River Mile 81.401 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

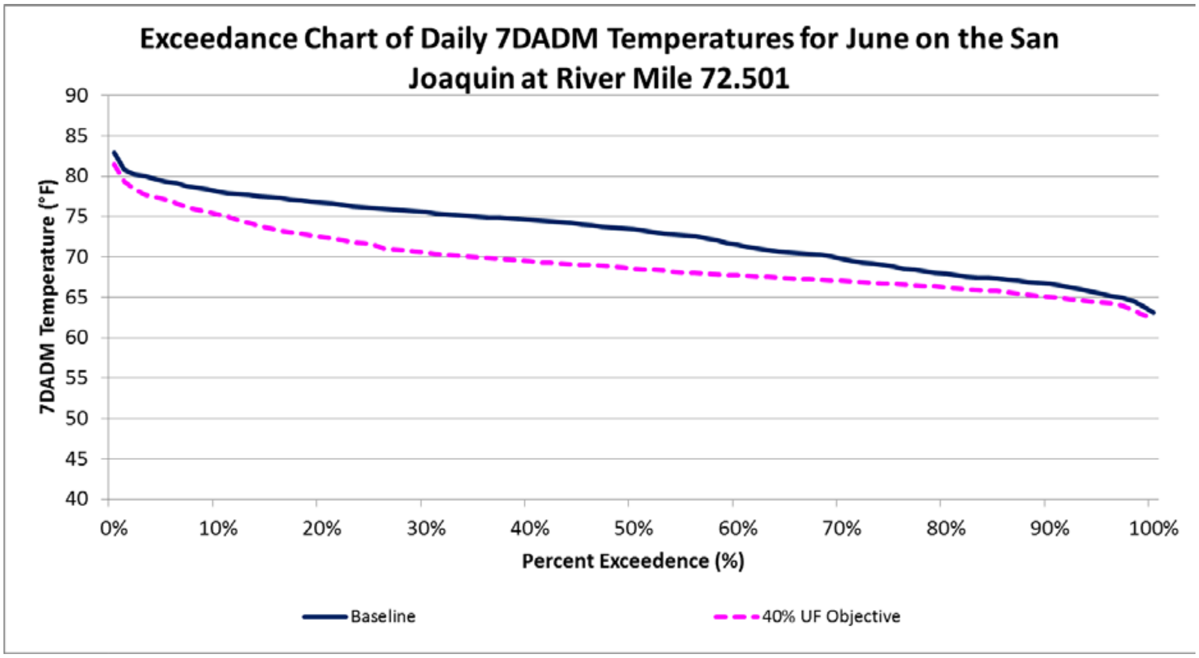

Figure 3.1-23. San Joaquin River Temperature (Fahrenheit) 7-Day Average of the Daily Maximum (7DADM) Exceedance Chart at River Mile 72.501 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

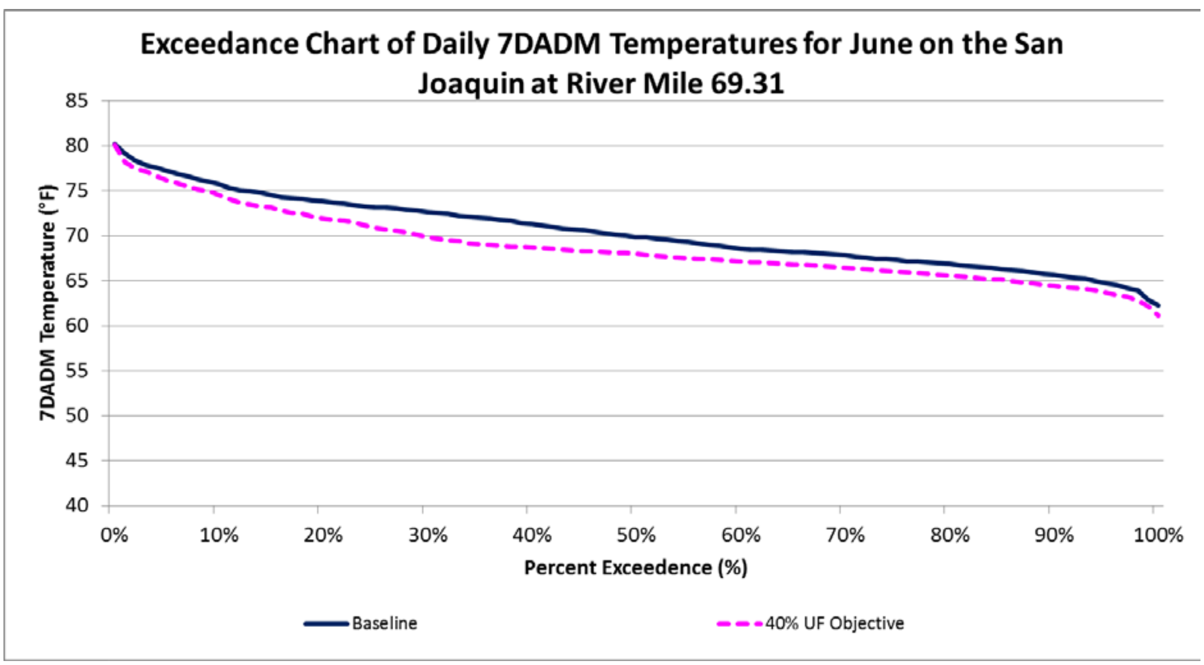

Figure 3.1-24. San Joaquin River Temperature (Fahrenheit) 7-Day Average of the Daily Maximum (7DADM) Exceedance Chart at River Mile 69.31 for All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions

To further summarize all temperature data during June on each river, daily longitudinal profiles during June are averaged over the 34-year model period and provided below to display average expected temperature conditions for all locations under baseline and 40 percent unimpaired flow (Figure 3.1-25 through Figure 3.1-28).

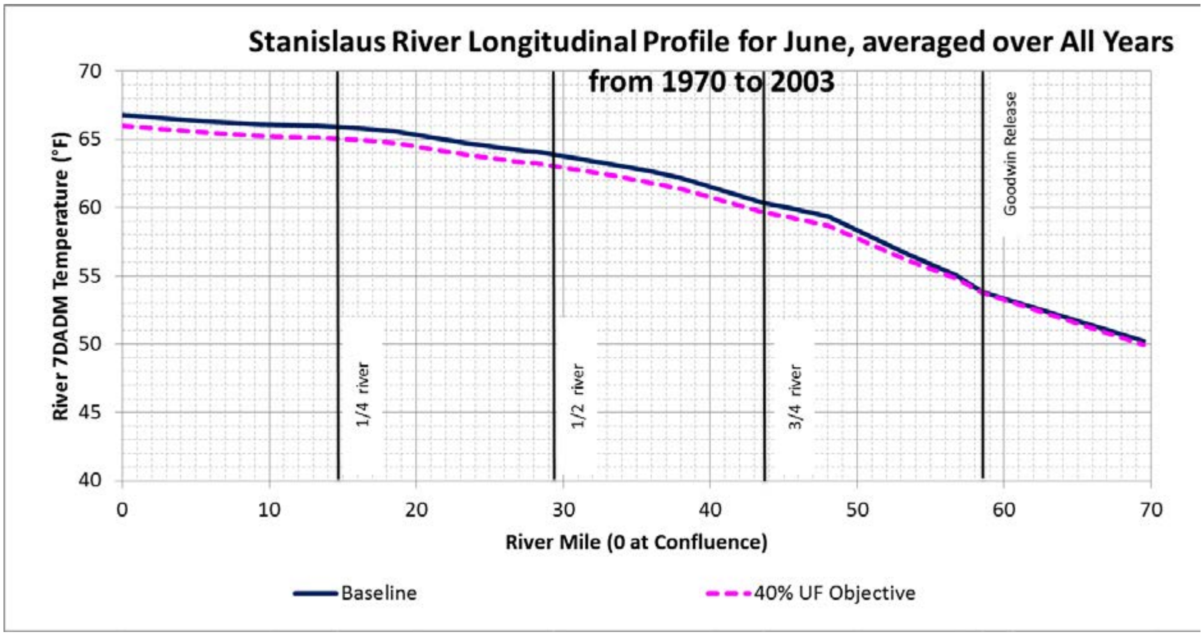

Figure 3.1-25. Average Stanislaus River Longitudinal Profile during All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions (Fahrenheit)

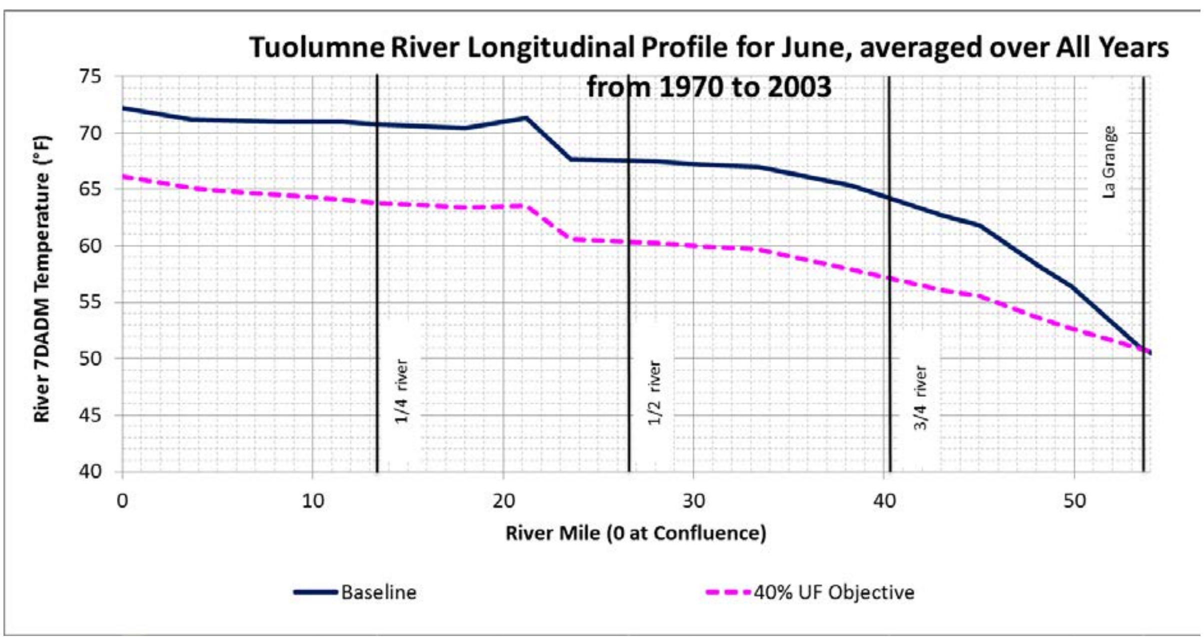

Figure 3.1-26. Average Tuolumne River Longitudinal Profile during All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions (Fahrenheit)

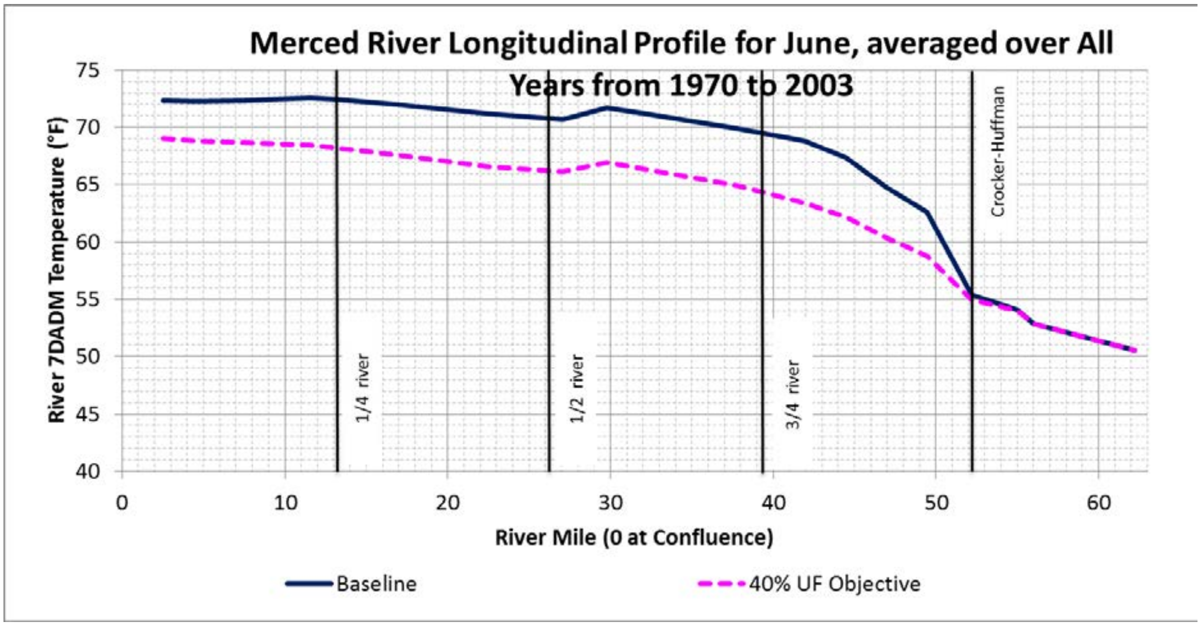

Figure 3.1-27. Average Merced River Longitudinal Profile during All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions (Fahrenheit)

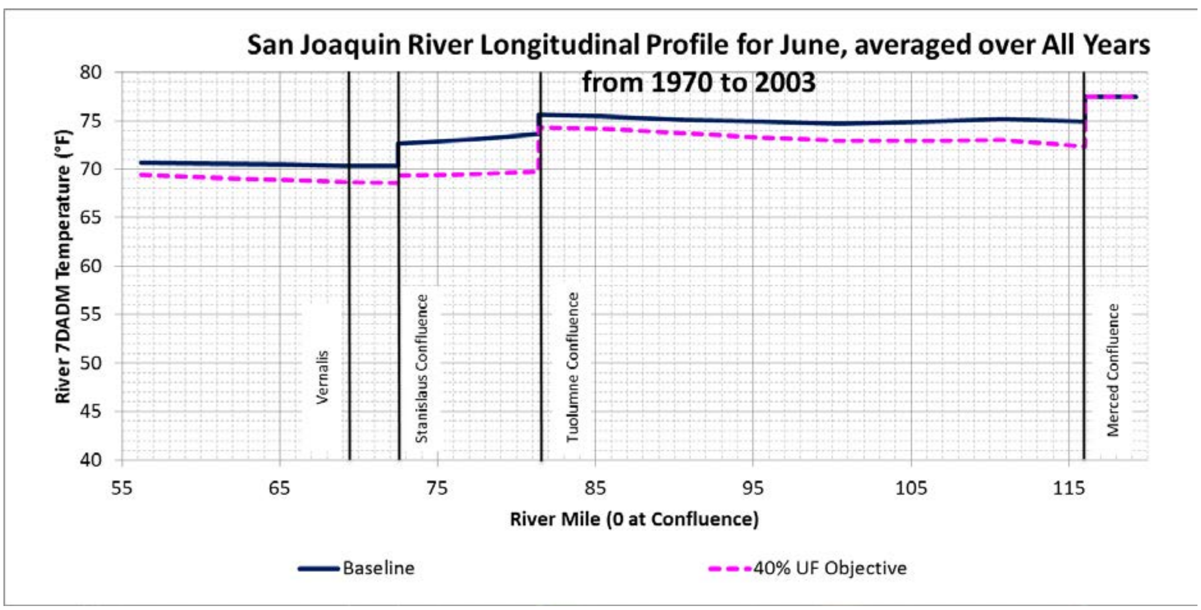

Figure 3.1-28. Average San Joaquin River Longitudinal Profile during All Days in June from 1970 to 2003 under Baseline and 40% Unimpaired Flow Conditions (Fahrenheit)

The modeling data presented in Chapter 7, *Aquatic Biological Resources*, Chapter 19, and Figure 3.1-10 through Figure 3.1-28 indicate that there is potential to significantly improve temperature conditions in June, particularly on the Tuolumne and Merced Rivers and the LSJR. Habitat improvements during June would provide anadromous fish with an extended window of opportunity to migrate to the Delta or Pacific Ocean by increasing suitable conditions and reducing harmful and lethal conditions (see the *Reductions in Harmful and Lethal Temperatures* section in this master response). When the June benefits are combined with the expected benefits earlier in the February–June period, it is expected that anadromous fish would be in better condition and would have improved odds of survival and success. It is also important to recognize that many other native fish species (e.g., sturgeon and splittail) would benefit from improved and extended habitat conditions during the February–June time period.

Salmon and Steelhead Presence in June

As previously discussed in this master response, multiple commenters questioned the importance of including June in the LSJR flow objective and asserted that no fish are present in June; therefore, there would be no benefits. The State Water Board's 2012 Scientific Basis Report (Appendix C) and the 2010 Flow Criteria Report both identified the February–June time period as being important and necessary for flow improvements to protect native fish. Under current conditions, which include large water diversions, river flows are often very low and water temperatures are often very high during June in the SJR Basin. These conditions are not suitable during many years for native fish, including juvenile salmonids migrating from the Stanislaus, Tuolumne, and Merced Rivers through the Delta to the Pacific Ocean. Despite poor historical flow and temperature conditions, historical fish monitoring data indicate the presence of important salmonid life stages emigrating during June in many years, including young-of-the-year (YOY) steelhead and fall-run Chinook salmon smolts.

Steelhead Outmigration Timing in the San Joaquin River Basin

In a report on *Oncorhynchus mykiss* (*O. mykiss*) monitoring covering a 10-year period, Ford and Kirihara (2010) provided information on the timing of downstream migration of *O. mykiss* in the Mokelumne, Calaveras, Stanislaus, and Tuolumne Rivers. YOY *O. mykiss* are caught during June in each of these rivers. YOY *O. mykiss* in particular (compared to *O. mykiss* older than 1-year-old) are captured in relatively large numbers in June, largely because adult steelhead have a later spawning period (spawning peaks between January and March) compared to fall-run Chinook salmon (which have a peak spawning time of November). Thus, steelhead offspring emerge later, and as YOY, leave later. Figure 3.1-29 through Figure 3.1-31 display information regarding the outmigration timing of *O. mykiss*. It is important to recognize the different sizes of *O. mykiss* shown in these figures. The smaller size *O. mykiss* (generally smaller than 100 millimeters [mm]) represent fish that are YOY (less than 1-year-old), while the larger size class (generally larger than 100 mm) represent fish that were born during previous years and are migrating to the ocean as 1+ year-olds. There is a distinct difference in migratory timing between individuals that migrate as YOY and individuals that migrate as 1+ years-olds. Protecting life history diversity, including migratory phenotypes (i.e., YOY and 1+ year-olds), is an important part of species management for Central Valley steelhead, which is federally listed as threatened under the Endangered Species Act (ESA) (NMFS 2014a).

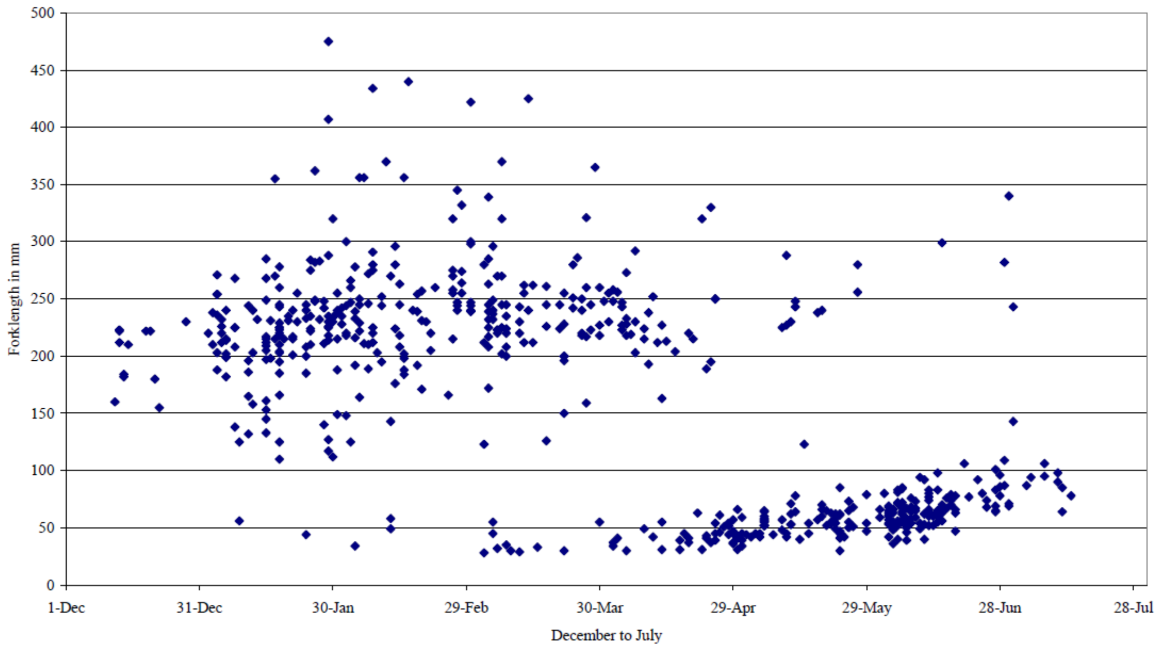

Figure 3.1-29. Stanislaus River Fork Length (millimeters) Distribution by Catch Date for *O. mykiss* Captured at the Oakdale Rotary Screw Trap (1995–2009) Indicating that Young-of-the-Year Steelhead Migrate in Relatively Large Numbers in June. (In many rotary screw trap seasons, trapping was terminated in early June, which results in fewer data collected during June than in many of the other months [Table 3.1-1]. (Source: Ford and Kirihara 2010.)

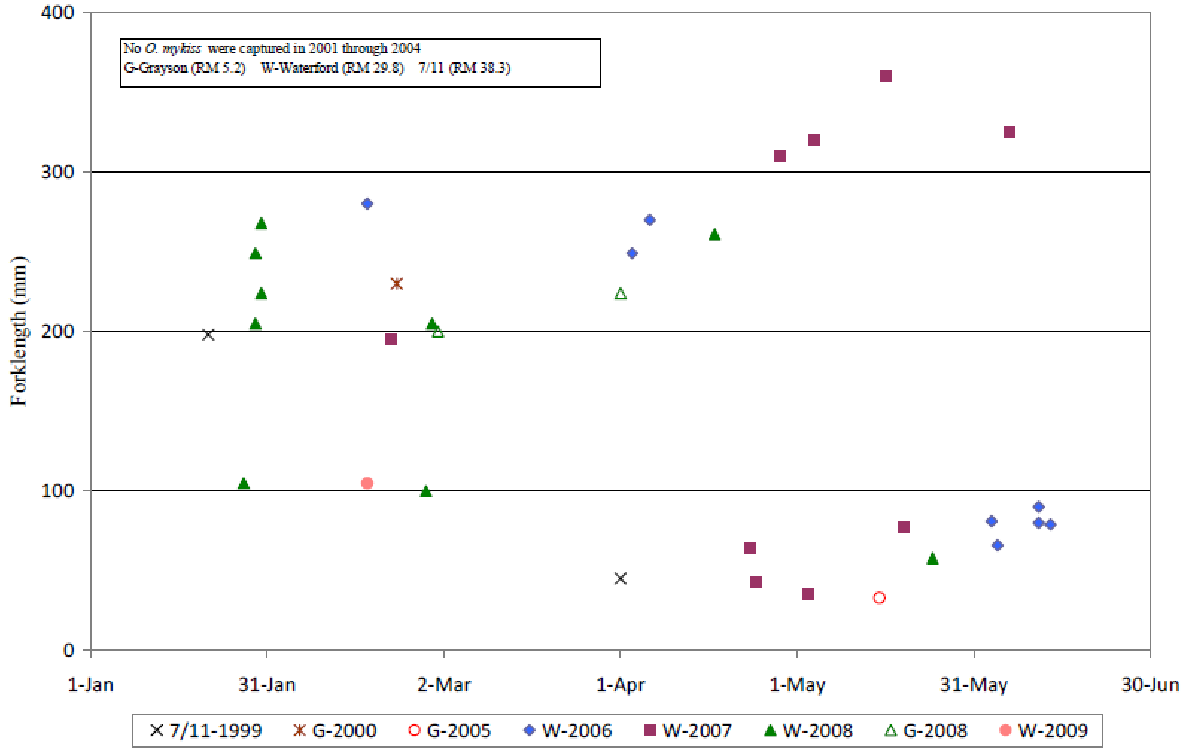

Figure 3.1-30. Tuolumne River Fork Length (millimeters) Distributions by Catch Date for *O. mykiss* Captured in Rotary Screw Traps from 1999 to 2009, Indicating that Young-of-the-Year Steelhead Migrate in Late May and June. (It is important to note that many Tuolumne River rotary screw trap seasons were terminated in late May or early June, which results in fewer data being collected during June compared to many of the other months, yet the data still indicate *O. mykiss* presence in June in relatively large numbers.) (Source: Ford and Kirihara 2010.)

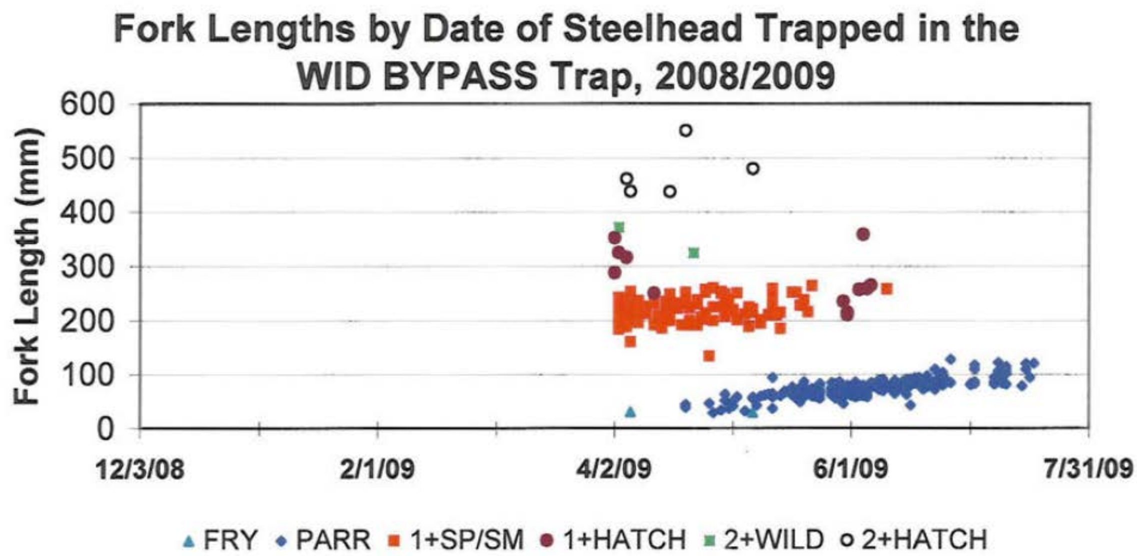

Figure 3.1-31. Fork Length (millimeters) Distributions by Catch Date for All Life Stages of Steelhead Passing the Bypass Trap Location on the Diversion Screen Bypass Line at Woodbridge Dam on the Mokelumne River (The Bypass trap was operated April 1, 2009 to July 21, 2009 during this year.) (Source: Boyd 2010)

While Figure 3.1-29 through Figure 3.1-31 show that juvenile steelhead migrate into June, it is important to recognize that the rotary screw traps on the Stanislaus and Tuolumne Rivers have historically been removed or disabled in late May or early June in many years. The multi-year data presented in Figure 3.1-29 through Figure 3.1-31 for the Stanislaus and Tuolumne Rivers include many years when data was not collected for the month of June. Tables 3.1-1 and 3.1-2 summarize the sampling periods for the rotary screw traps on the Stanislaus and Tuolumne Rivers.

Table 3.1-1. Summary of Sampling Periods for Rotary Screw Trapping on the Stanislaus River at Oakdale and Caswell, 1996–2005 (Source: Pyper and Justice 2006)

	Oakdale			Caswell		
Year	Start	End	Days Missed	Start	End	Days Missed
1996	2-Feb	9-Jun	13	6-Feb	2-Jul	5
1997	--	--	--	19-Mar	24-Jun	0
1998	27-Jan	16-Jul	25	8-Jan[a]	16-Jul	19
1999	18-Jan	30-Jun	11	18-Jan	30-Jun	12
2000	16-Dec	1-Jul	16	16-Dec	1-Jul	19
2001	12-Dec	29-Jun	14	22-Dec	28-Jun	10
2002	12-Dec	7-Jun	47	16-Jan	7-Jun	61
2003	20-Dec	5-Jun	31	18-Jan	5-Jun	38
2004	3-Jan	5-Jun	21	10-Jan	5-Jun	45
2005	4-Jan	17-Jun	24	6-Jan	17-Jun	44

[a] Traps wer operated briefly on Jan 8-9 and Jan 11-12 with a total estimated passage of 95 fry, followed by a period of days in which traps were not fished. Continuous sampling began on Jan 29.

Table 3.1-2. Summary of Sampling Periods for Rotary Screw Trapping on the Tuolumne River, 1995–2010

Year	Site (River Mile)	Period Sampled
1995	Shiloh (RM 3.4)	Apr 25–Jun 01
1996	Shiloh	Apr 18–May 29
1997	Shiloh	Apr 18– May 24
1998	Turlock Lake State Rec. (RM 42.0)	Feb 11–Apr 13
	7/11 (RM 38.5)	Apr 15–May 31
	Charles Road (RM 25.0)	Mar 27–Jun 01
	Shiloh	Feb 15–Jul 01
1999	7/11 (RM 38.5)	Jan 19–May 17
	Hughson (RM 23.7)	Apr 08–May 24
	Grayson (RM 5.2)	Jan 12–Jun 6
2000	7/11 (RM 38.5)	Jan 10–Feb 27
	Deardorff (RM 35.5)	Apr 09–May 25
	Hughson	Apr 09–May 25
	Grayson	Jan 09–Jun 12
2001	Grayson	Jan 03–May 29
2002	Grayson	Jan 15–Jun 6
2003	Grayson	Apr 01–Jun 6
2004	Grayson	Apr 01–Jun 9
2005	Grayson	Apr 02–Jun 17
2006	Waterford 1 (RM 29.8)	Jan 25–Apr 12
	Waterford 2 (RM 33.5)	Apr 21–Jun 21
	Grayson	Jan 25–Jun 22
2007	Waterford (RM 29.8)	Jan 11–Jun 5
	Grayson	Mar 23–May 29
2008	Waterford (RM 29.8)	Jan 8–Jun 2
	Grayson	Jan 29–Jun 4
2009	Waterford (RM 29.8)	Jan 7–Jun 9
	Grayson	Jan 8–Jun 11
2010	Waterford	Jan 5–Jun 11
	Grayson	Jan 6–Jun17

Source: Sonke et al. 2010.

Protecting the observed life history diversity of emigrating *O. mykiss* is important to the recovery of these populations (NMFS 2014a). Because YOY *O. mykiss* leave the tributaries later in the year compared to fall-run Chinook salmon, they are even more susceptible to low-flow conditions, which have the effect of creating high water temperatures, particularly in April, May, and June in the Stanislaus, Tuolumne, and Merced Rivers and LSJR. The plan amendments are expected to reduce the amount of time that native fishes are exposed to harmful and lethal temperatures in these rivers February–June (see the *Reductions in Harmful and Lethal Temperatures* section in this master response).

Juvenile Chinook Salmon Outmigration Timing in the San Joaquin River Basin

Multiple commenters have pointed out that a very small percentage of juvenile fall-run Chinook salmon leave the Stanislaus, Tuolumne, and Merced Rivers each year during June. These commenters are correct in terms of the overall percentage of juvenile fall-run Chinook salmon migrating to the ocean: rotary screw trap data indicates that very few juveniles leave the tributaries in June. However, there are several considerations to acknowledge: (1) smolts represent an important migratory phenotype and their migratory timing should be considered independent of fry and parr (see Figure 3.3 from Appendix C); (2) historical conditions in June have generally been unsuitable as a result of large surface water diversions (greater than 91 percent of unimpaired flow), which have the consequence of shortening the juvenile rearing and migration window (see the *Current Fish Decline and the Need for Increased and More Variable Flows* and the *Temperature Improvements during June* sections of this master response); (3) rotary screw traps are often not operated in June and, therefore, often do not collect data in June; (4) juvenile salmonids that emigrate from the tributaries in late May or June require suitable habitat conditions not just in the three eastside tributaries, but also in the LSJR (see the *Reductions in Harmful and Lethal Temperatures* section in this master response).

Figures 3.1-32 and 3.1-33 provide examples of the timing of juvenile fall-run Chinook salmon caught at the Oakdale and Caswell rotary screw traps on the Stanislaus River from 1996 to 2005. These figures illustrate that juvenile fall-run Chinook salmon migrating downstream towards the ocean are captured in rotary screw traps in June in many years. It is important to note that during many years, the rotary screw traps are pulled from the Stanislaus River in early to mid-June (see Table 3.1-1), which truncates the data on the tail end of the downstream migration period as can be seen in Figures 3.1-32 and 3.1-33. As discussed in Chapter 19, Appendix C, and this master response, protecting life history diversity, including migratory phenotypes, is an important part of species management for native salmonids in the Central Valley.

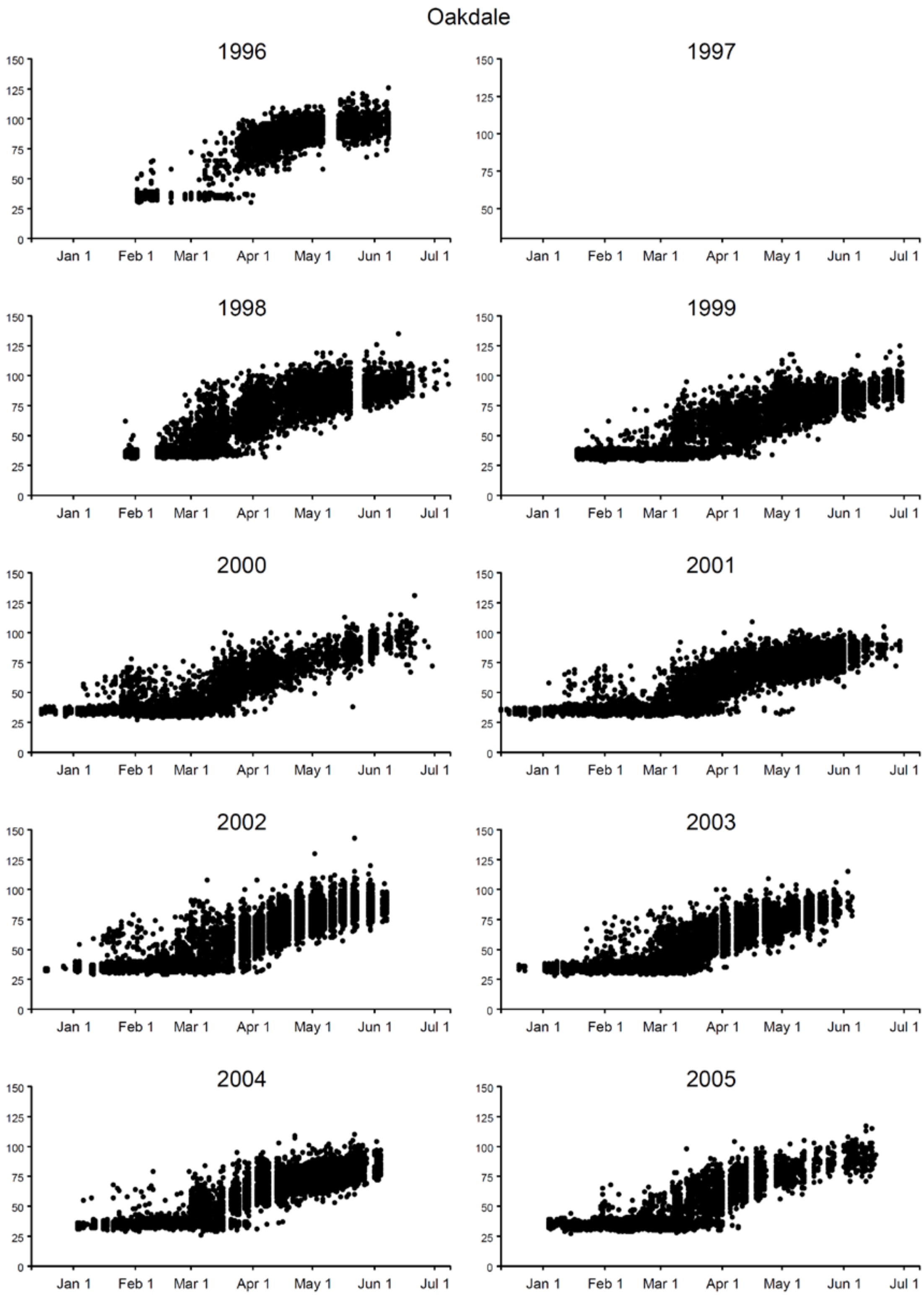

Figure 3.1-32. Lengths of All Sampled Juvenile Fall-Run Chinook Salmon by Day at the Oakdale Rotary Screw Trap Site (Source: Pyper and Justice 2006)

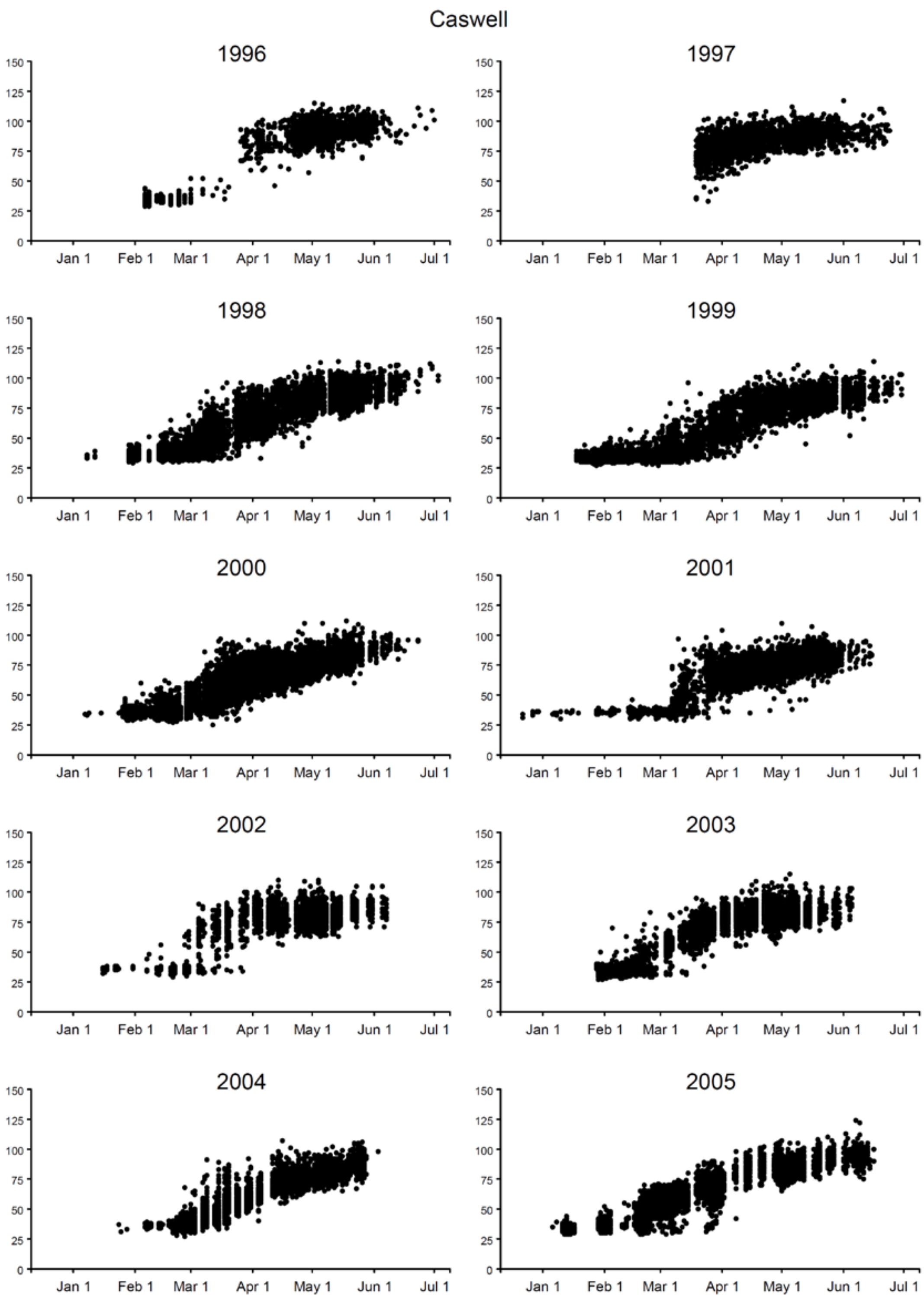

Figure 3.1-33. Lengths of All Sampled Juvenile Fall-Run Chinook salmon by Day at the Caswell Rotary Screw Trap Site (Source: Pyper and Justice 2006)

Elements of the Plan Amendments that Inform/Enhance Biological Benefits

Unimpaired Flow as Functional Flow

Multiple commenters asserted that the plan amendments should use a functional flows approach instead of an unimpaired flow percentage. As also explained in Master Response 2.2, *Adaptive Implementation*, the distinction between a functional flows approach and an unimpaired flow percentage approach is a matter of semantics as the program of implementation for the LSJR flow objectives (see Appendix K, *Revised Water Quality Control Plan*), includes four different adaptive adjustments for the unimpaired flow requirement. These adaptive adjustments allow the magnitude and timing of flows to be adjusted in a number of ways, within a prescribed range of flows, if best available scientific information supports that such changes would: (1) be sufficient to support and maintain the natural production of the viable native LSJR fish populations migrating through the Delta, and (2) meet any existing biological goals approved by the State Water Board. As described in the *Executive Summary*, those adaptive adjustments are included because the unimpaired flow objective is not intended to be implemented in a way that requires rigid adherence with a fixed percent of unimpaired flow. It is intended to be implemented in a flexible manner whereby a quantity of water can be shaped or shifted between February and June to provide more optimal flow patterns and more functionally useful flows to increase benefits to fish and wildlife. Functionally useful flows are designed to achieve a specific function, such as increased habitat, more optimal temperatures, or a migration cue. As allowed by adaptive adjustments, the unimpaired flows are not required to remain at one fixed percent, but rather to be adaptively implemented within a range of unimpaired flow in response to changing information and changing conditions. In addition, the program of implementation recognizes that each of the three eastside tributaries may need to be managed differently with respect to the percent of unimpaired flow and the specific adaptive implementation method or methods. The program of implementation provides the flexibility to do so as long as the flows remain within the adaptive range, and adaptive implementation among the three rivers is coordinated.

Because adaptive implementation allows the frequency, timing, magnitude, and duration of flows to shift in order to enhance the biological benefits, the plan amendments entail a virtually unlimited number of possible functional flow regimes within the analyzed range of flows. Please see Master Response 2.2, *Adaptive Implementation,* for a more detailed description of how adaptive implementation can respond to changing information and changing conditions; maximize the habitat, temperature, and other benefits achieved through the narrative and numeric objectives; and support scientific experiments that are intended to assess the benefits of different flow regimes.

Making Adjustments and Addressing Uncertainty

Multiple commenters asserted there is too much uncertainty with regard to any benefits the plan amendments would produce. The State Water Board acknowledges that uncertainty is inherent in any programmatic planning effort of this geographic and temporal scale. However, the plan amendments allow for maximum flexibility through the program of implementation to address scientific uncertainty and respond to changing conditions with adjustments that will be beneficial to fish and wildlife. As described in the previous section, adaptive adjustments are designed to provide greater benefits to fish and wildlife when compared to a strict adherence to a 40 percent flow requirement. Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between*

February 1 and June 30, demonstrates how these additional benefits can be achieved. For example, implementing flow shaping could help maximize temperature and habitat benefits by increasing flows to greater than 40 percent during critical periods. Please see Master Response 2.2, *Adaptive Implementation*, for clarifying descriptions of the elements of adaptive implementation, including, but not limited to, descriptions and examples of flow shaping (within the February–June time period) and flow shifting outside the February–June time period (also see the *Year-Round Flows* section of this master response).

Experiments, such as those that identify the optimal timing of migration flows, may also be conducted within the framework of the adaptive adjustments in order to address uncertainty by improving scientific understanding of needed measures for the protection of fish and wildlife beneficial uses. Any experiment will be coordinated with the San Joaquin River Monitoring and Evaluation Program (SJRMEP) and identify the scientific uncertainties to be addressed and the actions that will be taken to reduce those uncertainties, including monitoring and evaluation. Please see Master Response 2.1, *Amendments to the Water Quality Control Plan*, for additional clarification regarding elements of the program of implementation that can be used to inform decisions and address uncertainty, including the SJRMEP.

Biological Goals

Multiple commenters expressed concern regarding the need to have biological goals in order to determine the success of the flow requirements in providing fish protection or stated that the SED lacked a sufficient description and/or evaluation regarding how biological goals can be achieved with the plan amendments. It is important to note that the plan amendments are not self-implementing, so action to develop the biological goals can be occurring contemporaneously with other actions to facilitate implementation. As described in Appendix K, the program of implementation requires development of biological goals within 180 days of the Office of Administrative Law's approval of the plan amendments and mandates that the biological goals address certain indices of population trends. Providing a set period and certain minimum requirements allows flexibility for collaboration among the STM Working Group and others on the development of the biological goals, while at the same time providing explicit direction.

The program of implementation requires biological goals for salmonids as they are among the most sensitive species to flow modifications. McElhany et al. (2000) described four key parameters (defined below) for evaluating the population viability status of Pacific salmonids: (1) population abundance, (2) population growth rate, (3) population spatial structure, and (4) diversity. The program of implementation requires development of biological goals for these indicators. This is consistent with other actions, such as the recovery strategy developed as part of the final recovery plan for winter-run Chinook salmon, spring-run Chinook salmon and steelhead in the Central Valley (NMFS 2014a). That recovery strategy provides an example of these four key parameters being employed as a conservation principle to guide recovery because *population abundance* is an important parameter to determine whether a population is at risk and should be large enough for the population to survive environmental variation, provide resilience, and maintain genetic diversity. The second parameter, *population growth rate* (i.e., productivity), is an integral indicator of a population's performance in response to its environment and should be sufficient for the population to reproduce at a level that is viable. When assessing population status, any sustained trend in abundance and the associated population growth-rate are likely to provide the most useful information. The third parameter, *population spatial structure* refers to both the spatial distributions of individuals in a population and the processes that generate that distribution, such as risk factors that may not be readily apparent from observations of abundance and productivity. Lastly, *diversity* refers to the distribution of traits within and among populations, and is important for the maintenance of life history and genetic variation (McElhany et al. 2000; NMFS 2014a). Please refer to Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*, Section 3.7.1, *Effects on Fish Communities*, for more information regarding the importance of diversity.

Because salmonids are complex organisms with variable life histories, there can be uncertainty associated with monitoring populations and determining the effectiveness of restoration actions towards recovery. However, the indicators of viability, which are described in both the narrative objective and the program of implementation for the plan amendments, would facilitate the development of biological goals and a monitoring framework that is based on the best available science. Such a framework would allow the State Water Board to regularly evaluate the changing demographics of populations, and status toward meeting the overall goals for each population, including the salmon doubling objective established in state and federal law. In addition to biological goals for salmonids, the program of implementation also would allow for the development of biological goals for other LSJR species, as appropriate. Please refer to Master Response 2.1, *Amendments to the Water Quality Control Plan*, for clarifying descriptions regarding modifications to the plan amendments, and the program of implementation, including biological goals. Please refer to Master Response 2.2, *Adaptive Implementation*, regarding information needed for adaptive implementation to succeed, including biological goals.

Year-Round Flows

Multiple commenters questioned why the State Water Board did not include flow objectives for all months throughout the year instead of only February through June. As described previously in this master response and in Appendix C, scientific evidence indicates that higher and more variable flows indicative of the natural flow regime to which fish and wildlife have adapted and that are important for ecosystem processes are needed during the critical February–June time period for spring rearing and juvenile migration. However, the State Water Board also recognizes the importance of flows at other times and includes elements in the plan amendments that will allow protection of fish and wildlife outside the February–June time period.

As discussed above under *Unimpaired Flow as Functional Flow* section of this master response, the plan amendments include adaptive implementation, an adaptive adjustment framework. This adaptive adjustment framework allows the percentage of unimpaired flow to be managed as a total volume of water, including allowing a portion of the volume of water to be shifted into the July–January time period in order to prevent adverse effects on fisheries, such as elevated temperature conditions that cause poor or lethal instream habitat conditions. In this way, the February–June flow objectives, combined with adaptive implementation, are designed to provide a similar level of protection as a year-round flow schedule, while providing flexibility needed to achieve the greatest biological benefit with the block of water provided by the percent of unimpaired flow objective. Refer to Master Response 2.2, *Adaptive Implementation*, regarding clarification and examples of flow shifting outside the February–June time period.

In addition, the fall pulse flow objective to protect fish and wildlife beneficial uses from the 2006 Bay-Delta Plan remains unchanged, other than to clarify language regarding the amount of flow that is required under that objective. Whereas flows during the February–June time period are designed to protect juvenile outmigrating fish, the fall flow objective is designed to protect adult fish that are migrating upstream to their spawning grounds in the tributaries. The plan amendments for the LSJR flow objectives do not affect the fall objective. During October in critically dry years following critically dry years, a minimum monthly average flow rate of 1,000 cubic feet per second (cfs) is required at Vernalis on the SJR. In all other years, the flow requirement during October is 1,000 cfs, plus up to an additional 28 TAF pulse/attraction flow limited to the amount necessary to achieve a monthly average flow of 2,000 cfs.

Moreover, the program of implementation requires the State Water Board to include minimum reservoir carryover storage targets or other requirements to help ensure that providing flows to meet the flow objectives will not have adverse temperature or other impacts on fish and wildlife beneficial uses, including at other times of the year. For additional clarity, this requirement is now incorporated in Table 3 of Appendix K. Finally, the program of implementation for the LSJR flow objective requires the existence of the SJRMEP, discussed previously in this master response under *Making Adjustments and Addressing Uncertainty*. The Bay-Delta Plan is periodically updated, and the SJRMEP provides the framework for a comprehensive monitoring, special studies, evaluation and reporting program, which, among other things, will assess the potential need for future changes to the LSJR flow objectives, including flows needed during other times of the year to protect fish and wildlife beneficial uses. Refer to Master Response 2.1, *Amendments to the Water Quality Control Plan*, for additional clarification regarding carryover storage targets and the SJRMEP.

SED Use of Best Available Science

Multiple commenters asserted that the best available science was not used in the SED or that the SED did not provide sufficient evidence—information, data, and studies—for its conclusions related to how the plan amendments would reasonably protect fish. Several of these commenters made general unsupported assertions that there is no basis for increased flows or expressed general concerns regarding predation, food, temperature, and spawning habitat. Please refer to Master Response 1.1, *General Comments* (see *Scientific Basis*), for responses to general comments regarding these unsupported assertions.

As discussed in Volume 3, Chapter 1, *Introduction and Approach to Responses to Comments*; Master Response 1.1, *General Comments*; and as stated in State CEQA Guidelines, Section 15204, subdivision (a), lead agencies need only respond to significant environmental issues and do not need to provide all information requested by reviewers as long as a good faith effort at full disclosure is made in the environmental document. (Cal. Code Regs., tit. 14, § 15204, subd. (a).) For example, a number of commenters stated that information presented in the SED regarding species life history, distribution, and status was outdated, citing examples of recently published literature, status reports, or other published and unpublished sources. However, in most cases, this new information did not conflict with or contradict the key scientific information used to support the impact determinations or benefits assessments in the SED. In such cases, this new information is acknowledged but not included in the SED. For a more general discussion regarding CEQA requirements and the presentation of data, please refer to Master Response 2.3, *Presentation of Data and Results in the SED and Responses to Comments*.

The following discussions are specific to fish protection and provide a description of the comments, further clarification and support for each topic of concern, and reasoning for why the SED includes or does not include specific information, data, and studies. The discussion in this section provides responses to multiple commenters that provided specific comments regarding the use of fall-run

Chinook salmon as surrogates for steelhead in the analyses and particular concerns about Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives.* For responses to comments that specifically asserted that the State Water Board did not consider the most up-to-date scientific information with regard to predation as an additional stressor or that the temperature, weighted useable area (WUA), and floodplain analyses should have considered other studies and data, please see the following sections of this master response: *Other Stressors* and *Adequacy of Modeling to Support the Analyses*.

Use of Salmon as an Analysis Surrogate for Steelhead

Multiple commenters asserted fall-run Chinook salmon are not an appropriate surrogate for steelhead in evaluating the environmental needs of these fish species. However, the SED analyses identify where using fall-run Chinook salmon as a representative evaluation species for steelhead is appropriate and also distinguish where there are differences between the needs of the two species. More generally, anadromous salmonids are recognized as an indicator of the biological integrity of aquatic ecosystems (Willson and Halupka 1995, Mobrand et al. 1997), and serve as a focal species in evaluating ecosystem performance in a number of restoration planning and assessment tools (Blair et al. 2009, Alexander et al. 2014). In the SED analyses, while fall-run Chinook salmon are used as the principal evaluation species in cases where information for other species is lacking, conclusions are considered applicable to other species only where general similarities in species responses are evident from the literature. The statement in Appendix C, Section 3.1.4, *Approach*, "both species have somewhat similar environmental needs for river flows, cool water, and migratory corridors" refers to the general similarities in the migratory needs of both Chinook salmon and steelhead. For example, higher flows coinciding with the natural season of peak spring flows support juvenile outmigration for both species because of the key migratory functions of these flows and the co-occurrence of both species during this time period. In other words, both species will positively respond to increases in flows during the spring. This same paragraph in Appendix C, Section 3.1.4 also acknowledges the distinct differences in environmental needs between these species, citing specifically the year-round dependence of steelhead on suitable habitat conditions for rearing. In recognition of these differences (as described in Appendix C, Section 3.2, *Fall-Run Chinook Salmon*, and Appendix C, Section 3.3, *Central Valley Steelhead*), separate analyses were performed based on the specific timing, distribution, and habitat needs of individual species and life stages (e.g., July–August water temperature effects on summer rearing conditions for juvenile steelhead; see Impact AQUA-4 in Chapter 7, *Aquatic Biological Resources*, Section 7.4.3, *Impacts and Mitigation Measures*).

Appendix C, Scientific Basis Report

Multiple commenters specifically referred to the Scientific Basis Report (Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*), and questioned its sufficiency or use of best available science due to the report's inclusion of some literature that was not peer reviewed or was unpublished. However, during the water quality control planning process (please see Master Response 1.2, *Water Quality Control Planning Process*, for more information), the entire Scientific Basis Report was submitted for peer review, and peer reviewers concluded that the scientific information, data, and studies used in the report are based on sound scientific knowledge, methods, and practices.

The Scientific Basis Report was submitted for peer review in August 2011. In accordance with Health and Safety Code Section 57004, all organizations under the California Environmental

Protection Agency, including the State Water Board, must submit for external scientific review[1] the scientific portions of all policies, pursuant to the Porter-Cologne Water Quality Control Act, that have the effect of a regulation, such as the proposed plan amendments (please also refer to Master Response 1.1, *General Comments*, for information regarding development of LSJR Alternatives 1, 2, 3, and 4, and Master Response 1.2, *Water Quality Control Planning Process*, regarding the peer review process). The Scientific Basis Report includes scientific findings, conclusions, and analytical tools that provide the State Water Board with the best available scientific information upon which to base the plan amendments. The Scientific Basis Report fulfills a separate requirement than the programmatic-level evaluation of environmental impact presented in the SED to inform decision-makers about the potential environmental consequences of the plan amendments in compliance with CEQA. Please refer to the Scientific Basis section of Master Response 1.1, *General Comments*. Please refer to the *Modeling Purpose and Standards* section in this master response for more information regarding the adequacy of the evaluation that is performed in the SED.

The peer reviewer's responsibility is to determine whether the Scientific Basis Report's findings, conclusions, and assumptions are based upon sound scientific knowledge, methods, and practices. The areas of expertise[2] of the peer reviewers that conducted the peer review included, but were not limited to, the following.

- Aquatic ecology and fishery science—salmonids (Chinook salmon and Central Valley steelhead) and other riverine/migratory fish and aquatic resources, aquatic biology and ecology, flow requirements, instream flow evaluations, dam/reservoir management for fisheries, and resource/fisheries management.
- Hydrology, hydrodynamics, and water supply—unimpaired and actual hydrology of the SJR Watershed, evaluation of water supply and flow analyses based on post-processing of CALSIM II water resources system simulation modeling output, dynamics of water storage, diversion, and return flows in the San Joaquin Valley.

During the peer review, the independent experts convened to provide input on the adequacy of the Scientific Basis Report, including but not limited to the following.

- Appropriateness of the approach used to develop LSJR flow objectives for the reasonable protection of fish and wildlife beneficial uses and the associated program of implementation.
- Determination that more flow of a more natural spatial and temporal pattern is needed from the three salmon bearing tributaries to the SJR during the February–June period to protect SJR fish and wildlife beneficial uses.
- Appropriateness of using a percentage of unimpaired flow, ranging from 20 to 60 percent, during the February–June period, from the Stanislaus, Tuolumne, and Merced Rivers as the proposed method for implementing the narrative LSJR flow objective.

In general, the peer reviewers' comments indicated an overall agreement with the methodology in the report and asserted there was adequate evidence to support the conclusion that "flow of a more natural spatial and temporal pattern is needed from the three salmon bearing tributaries to the SJR during the February through June time frame to protect San Joaquin River fish and wildlife

[1] The external scientific peer review guidelines can be found on the State Water Board website at: http://www.swrcb.ca.gov/water_issues/programs/peer_review/docs/exhibit_f.pdf.

[2] The peer reviewers' curriculum vitae can be found on the State Water Board website at: https://www.waterboards.ca.gov/water_issues/programs/peer_review/sanjoaquin_river_flow.shtml.

beneficial uses." Peer reviewers agreed that the Scientific Basis Report was based on sound scientific knowledge, methods, and practices (See Appendix C, Attachment 2 for a detailed description of peer reviewers' comments).

The Scientific Basis Report, Chapter 3, *Scientific Basis for Developing Alternative San Joaquin River Flow Objectives*, provides the scientific justification that higher and more naturally variable flows are needed to protect fish and wildlife beneficial uses, and provides additional background information and technical support for the environmental setting description, and environmental impact analyses that are performed in the SED, Chapter 7, *Aquatic Biological Resources*. The Scientific Basis Report, Chapter 3, also provides the data and information that are the foundation for the quantitative evaluation of the measurable benefits of the plan amendments for the LSJR flow objectives with regard to potentially available cold water and floodplain habitats and associated population implications to native salmonids (see Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*). For information regarding the scientific justification for the salinity objectives, please see Master Response 3.3, *Southern Delta Water Quality*.

Adequacy of Modeling to Support the Analyses

Modeling Purpose and Standards

This SED evaluates the potentially significant environmental impacts and measurable benefits associated with LSJR Alternatives 1, 2, 3, and 4 (LSJR alternatives). The assessment of environmental effects in the SED is conducted at a programmatic level, which is a broader level than a project-specific analysis, but is a sufficient degree of analysis to inform decision-makers about the environmental consequences of the plan amendments in light of what is reasonably feasible when considering the magnitude of the plan amendments and their geographic scope. The Bay-Delta Plan does not in itself approve any water right or any particular project-specific construction activity. It provides a framework for the next steps in the regulatory process. Subsequent State Water Board activities in the program, such as discretionary actions to implement the plan amendments, will be examined in light of the SED to determine whether an additional environmental document must be prepared. Other actions taken in response to the plan amendments may also be subject to future project-specific CEQA review by those entities with authority over those projects once they are developed and proposed. For these reasons, the analysis does not attempt to show exactly how the system will respond because the specific response would depend on too many unknowable variables and would, therefore, be speculative. For more discussion regarding the programmatic nature of the document, please see Master Response 1.1, *General Comments*.

The State Water Board is not obligated to conduct an exhaustive analysis using every approach, modeling tool, and data set available. While there is always debate as to whether one model is better suited for a certain purpose than another model, the models used in this SED are all appropriate for the purposes of evaluating water operations under the LSJR alternatives. The State Water Board recognizes that there may be differing opinions as to how to approach an analysis for a given resource or which data sets should be used, but these differing opinions do not equate to inadequacy. A disagreement among experts does not make an environmental analysis inadequate. (*Town of Atherton v. California High-Speed Rail Authority* (2014, 228 Cal.App.4th 314.) The "relevant issue is only whether the studies are sufficiently credible to be considered as part of the total evidence that supports the agency's decision," not whether the studies "are irrefutable or whether they could have been better." (State Water Resources Control Board Cases (2006) 136 Cal.App.4th 674, 795.)

The State Water Board strived to use the best available science throughout the SED, and the modeling is credible because it is based on facts, reasonable assumptions predicated on facts, and expert opinion supported by facts that together allow comparative analyses between baseline and alternative conditions. Chapters 7, *Aquatic Biological Resources*, presents a comparative analysis of changes in river flows and reservoir operations that have the potential for quantifiable impacts on aquatic resources. Multiple commenters expressed concerns with the adequacy of the impact analysis with regard to changes in the quantity and quality of physical habitat for spawning and rearing resulting from changes in flow (e.g., for Impact AQUA-3, which used WUA and floodplain inundation criteria), and changes in exposure of fish to suboptimal water temperatures resulting from changes in reservoir storage and releases (e.g., Impact AQUA-4, which used USEPA-recommended water temperature criteria). Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30,* supplements the information in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*, and presents a comparative analysis by quantitatively evaluating the measurable benefits of the plan amendments in terms of potential cold water and floodplain habitats and associated population implications to native salmonids. These concerns, as well as the adequacy of the benefits analyses, are described in more detail and addressed below.

Multiple commenters also raised concerns regarding the information and methodology specific to hydrologic modeling. For information regarding modeling and the Water Supply Effects Model (WSE) and for information regarding the peer review as it relates to the WSE model, refer to Master Response 3.2, *Surface Water Analyses and Modeling*. Please refer to Master Response 3.2 and Master Response 2.3, *Presentation of Data and Results in SED and Response to Comments*, for a more detailed discussion regarding the purpose of modeling and the appropriate use of models and model results.

Temperature

Use of U.S. Environmental Protection Agency-Recommended Temperature Criteria

A number of commenters questioned the appropriateness of using the USEPA's (2003) recommended temperature criteria for protection of salmonids as a benchmark for evaluating temperature-related impacts or benefits of the LSJR alternatives on anadromous salmonids. The commenters are primarily concerned with the use of the USEPA (2003) temperature criteria because they were developed by USEPA Region 10 (Oregon, Idaho, Washington, and Alaska) for use in the Pacific Northwest, and commenters suggest that the temperature criteria are not applicable in California, which is located in USEPA Region 9 (California, Nevada, and Arizona). In the water quality control plan planning process and other planning and regulatory processes (e.g., Federal Energy Regulatory Commission (FERC) relicensing), the State Water Board has maintained that any supporting studies and impact evaluations for these actions should follow the 2003 USEPA guidance. The 2003 USEPA temperature guidance is the product of a collaborative process between states, tribes, and federal agencies to: (1) meet the biological requirements of native salmonid species for survival and recovery pursuant to the ESA; (2) provide for the protection and propagation of salmonids under the Clean Water Act, and (3) meet the salmonid rebuilding needs of federal trust responsibilities with treaty tribes (USEPA 2003). The 2003 USEPA guidance is based on a comprehensive review and synthesis of a large body of peer-reviewed studies and published papers, including temperature studies completed on Central Valley salmonids, and subsequent review by both an independent scientific panel and the public. The scientific basis for the 2003 USEPA guidance is presented in a series of technical summaries available at USEPA's Region 10 website.[3]

Evidence from a number of studies within California support the use of the USEPA water temperature criteria (based on the 7-day average of the daily maximum [7DADM]) as a benchmark for evaluating and establishing protective standards for anadromous salmonids (Welsh et al. 2001; Hines and Ambrose n.d.; Deas et al. 2004; Sacramento River Temperature Task Group 2016; USEPA 2011; North Coast Regional Water Board 2005). The 7DADM is recommended because it describes the maximum temperatures that fish are exposed to over weekly periods while protecting against acute effects, such as migration blockage, and harmful or chronic effects, such as temperature effects on growth, disease, smoltification, and competition (USEPA 2003). For example, the Sacramento River Temperature Task Group reported that USEPA's 2003 temperature maximum of 55°F (12.8°C) (7DADM) "captures conditions that winter-run eggs and fry are exposed to on a daily basis while reducing the potential that one extremely high daily maximum temperature would result in exceeding the temperature criterion" (Sacramento River Temperature Task Group 2016).

In 2011, USEPA transmitted the final list of waterbodies that were added to California's 2008–2010 list of water quality limited segments still requiring total maximum daily loads (TMDLs) pursuant to Clean Water Act, section 303(d), and 40 CFR 130.7(d)(2).[4] Within this letter, USEPA stated the following.

> EPA believes that EPA's Temperature Guidance values are appropriate for use in the Central Valley. The criteria have been used by California in their 303(d) list recommendations as well as selected as targets in Total Maximum Daily Loads (TMDLs) in the North Coast Region of California (Carter 2008). They have also been used by National Marine Fisheries Service ("NMFS") to analyze the effects of the long-term operations of the Central Valley Project and State Water Project, and to develop the reasonable and prudent alternative actions to address temperature-related issues in the Stanislaus River (NMFS 2009). Reviews of appropriate temperature criteria for use in the Stanislaus have yielded findings consistent with the EPA Temperature Guidance values (Deas et al. (2004) and Marston (2003)).

In that letter, USEPA also notes that a letter dated November 15, 2010 (pp 5-6) from Maria Rea, NMFS, to Alexis Strauss also supports the use of the Temperature Guidance values.

> The use of the US EPA 2003 criteria for listing water temperature impaired water bodies in the San Joaquin River basin is scientifically justified. It has been recognized that salmonid stocks do not tend to vary much in their life history thermal needs, regardless of their geographic location. There is not enough significant genetic variation among stocks or among species of salmonids to warrant geographically specific water temperature standards (US EPA 2001). Based upon reviewing a large volume of thermal tolerance literature, McCullough (1999) concluded that there appears to be little justification for assuming large genetic adaptation on a regional basis to temperature regimes. Prior to adoption of the revised water temperature standards for Oregon streams in 1996, there were separate water temperature standards assigned to salmon habitat in the western vs. the eastern

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[3] Available at https://yosemite.epa.gov/r10/water.nsf/Water+Quality+Standards/WQS+Temperature+Guidance.

[4] The Central Valley Regional Water Quality Control Board previously projected a completion date of 2027 for temperature TMDLs on the LSJR tributaries but does not have any current plans to develop such TMDLs. Moreover, EPA's action predates the release of the proposed plan amendments for the LSJR. Although the plan amendments do not include a temperature objective, as demonstrated above, the effect of implementation would be to substantially improve temperature conditions for salmonids. Therefore, the need for such TMDLs, if any, would have to be reevaluated in light of the plan amendments.

> portions of the state. Salmon-bearing streams in the western Cascades and Coast Range were assigned a standard of 14.4°C [57.9°F], but salmon-bearing streams in northeastern Oregon had a standard of 20.0°C [68.0°F], largely on the assumption that they would be adapted to the warmer air temperature regimes of the region. The large (5.6°C [10.1°F]) difference in adaptation that would be required, however, is not supportable by any known literature (McCullough 1999).
>
> Varying climatic conditions could potentially have led to evolutionary adaptations, resulting in development of subspecies differences in thermal tolerance. However, the literature on genetic variation in thermal effects indicates occasionally significant but very small differences among stocks and increasing differences among subspecies, species, and families of fishes. Many differences that had been attributed in the literature to stock differences are now considered to be statistical problems in analysis, fish behavioral responses under test conditions, or allowing insufficient time for fish to shift from field conditions to test conditions (US EPA 2001).
>
> Although many of the published studies on the responses of Chinook salmon and steelhead to water temperature have been conducted on fish from stocks in Oregon, Washington, and British Columbia, a number of studies were reported for the Central Valley salmonids. Myrick and Cech (2001, 2004) performed a literature review on the temperature effects on Chinook salmon and steelhead, with a focus on Central Valley populations…
>
> It is evident that the difference in thermal response is minimal in terms of egg incubation, growth, and upper thermal limit. Healey (1979 as cited in Myrick and Cech 2004) concluded that Sacramento River fall-run Chinook salmon eggs did not appear to be any more tolerant of elevated water temperature than eggs from more northern races. Myrick and Cech (2001) concluded that it appears unlikely that there is much variation among races with regard to egg thermal tolerance because data from studies on northern Chinook salmon races generally agree with those from California. They further concluded that fall-run Central Valley and northern Chinook growth rates are similarly affected by water temperature.

California Central Valley Salmonid Temperature Studies

Some commenters asserted that recent aerobic scope temperature studies of California Central Valley salmonids represent the best available science and that these studies should be used to modify or replace the 2003 USEPA-recommended temperature criteria used in the SED analysis. *Aerobic scope* is the capacity of an animal to increase its level of aerobic metabolism beyond that which is required for maintenance alone and thereby support activities such as muscular exercise, growth, or reproduction (Cech Jr. and Brauner 2011). Commenters asserted that findings from scientific investigations using aerobic scope to assess thermal tolerance in California Central Valley salmonids suggest increased tolerance to higher temperatures and that these studies should be used to modify or replace USEPA temperature criteria as a benchmark for evaluating temperature-related impacts or benefits on anadromous salmonids in the SED. While these highlight an opportunity to improve understanding of potential local thermal adaptation, they do not provide sufficient evidence to support modifying or abandoning the application of USEPA-recommended temperature criteria in the SED analysis.

Evaluations of hatchery fall-run Chinook salmon from the Mokelumne River Hatchery (Poletto et al. 2017) and wild steelhead from the lower Tuolumne River (Verhille et al. 2016) report that aerobic scope performance of rearing juveniles was maintained up to 73.4-77.0°F (23–25°C). USEPA temperature criteria for rearing juvenile salmonids is 60.8-64.4°F (16–18°C) and migration is 68.0°F (20°C). The USEPA temperature criteria values are substantially lower than the high-end of the temperature range reported for maintenance of aerobic scope in the Central Valley steelhead and fall-run Chinook salmon aerobic scope studies. These studies may suggest local adaptations to higher water temperatures. However, these two studies do not provide sufficient evidence to support use of a different temperature target in the SED analysis because they evaluated a single performance metric (aerobic scope) and were conducted in a short timeframe under highly controlled conditions. As discussed later in this section, these limitations and the need for additional research are acknowledged by the organizations that funded these studies.

USEPA funded the Mokelumne River Hatchery fall-run Chinook salmon aerobic scope study (USEPA 2017). Key study observations acknowledge the following.

> The metabolic performance of hatchery fish measured in this laboratory study under stable habitat and food supply conditions may vary substantially from the metabolic performance of wild fish in their actual habitat which includes variable oxygen levels and food availability and the increased metabolic costs of predator avoidance, foraging, and finding optimal habitat.
>
> Additional research on Central Valley Chinook salmon should be done to improve our understanding of how temperature affects survival. The upper limit of thermal tolerance of hatchery fish in laboratory conditions measured by aerobic scope in this study is considerably higher than recommended temperature criteria of 16 – 18 °C [60.8-64.4°F] for rearing and migration of juvenile salmon in the wild. Future studies should include more measurements such as heart rate, growth, and swimming performance and evaluate juvenile salmonids from different populations in their environment to measure effects in wild populations of fish.

Turlock Irrigation District and Modesto Irrigation District funded the wild steelhead study on the Lower Tuolumne River. In replying to the California Department of Fish and Wildlife's (CDFW's) comments on the draft report,[5] the team conducting the study emphasized eight points, including the following.

> 5) What our data should NOT be used for is to pick a new thermal criterion based solely on our aerobic scope curve. In fact, we do not suggest revising the 7DADM based solely on our AAS curve. We simply state that we believe our data are suggestive of local thermal adaptation in Central Valley fish and inconsistent with a blanket criterion for the population under consideration. Because the Tuolumne River O. mykiss fish outperform northerly populations at warm temperatures, the inference is that the current guidelines are overly conservative.

The 2003 USEPA temperature criteria guidance is based on an expert-reviewed synthesis of a large body of peer-reviewed studies and published papers. USEPA compiled multiple lines of evidence for the development of scientifically justified temperature guidance based on major physical and biological metrics, including: thermal effects on salmonid physiology, behavior, and distribution; interactions between multiple stressors (thermal and other); and spatial and temporal variation in patterns of stream temperature (USEPA 2001). Further, USEPA acknowledged in the guidance document that numeric criteria should be based on both laboratory experiments and studies determining where fish perform best in their natural environment considering food availability, competition, predation, and fluctuating temperatures (USEPA 2003). Aerobic scope studies are not based on multiple lines of evidence but are limited to the development of aerobic scope curves based on oxygen consumption of fish in a constructed swim-tunnel. Additionally, the findings of recent studies (Raby et al. 2016; Hvas et al. 2017) show that aerobic scope can be maintained or increased throughout meaningful temperature ranges in salmonids, which suggests that aerobic scope is not always the limiting factor in thermal stress.

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[5] *Thermal Performance of Wild Juvenile* Oncorhynchus mykiss *in the Lower Tuolumne River: A Case for Local Adjustment to High River Temperature. Appendix 6. Response to Comments on the Draft Study Report.* Provided as an attachment to comment letter 1344.

The use of USEPA-recommended temperature criteria in the SED analysis remains unchanged. Recent aerobic scope studies are recognized, but they do not provide enough information to justify changing the recommended temperature targets for analysis. Avoiding significant adverse temperature impacts on fish and wildlife is interpreted in the modeling process as meeting the USEPA-recommended temperature criteria within a 10 percent exceedance frequency of baseline conditions (Master Response 3.2, *Surface Water Analyses and Modeling*). Significance determinations for impacts on and benefits to fish were based on meeting USEPA-recommended temperature criteria within a 10 percent exceedance frequency of baseline and information describing the reductions in harmful and lethal temperatures expected from the plan amendments.

This analytical approach uses best available science, incorporates local temperature conditions into significance determinations, and is consistent with science describing the importance of water temperature for Chinook salmon survival.[6] Myrick and Cech (2001: iii) state that "water temperature is perhaps the physical factor with the greatest influence on Central Valley salmonids, short of a complete absence of water."

Reductions in Harmful and Lethal Temperatures

Multiple commenters asserted that under the plan amendments, USEPA (2003) optimal temperature criteria are not met at certain times and locations as shown in Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow between February 1 and June 30*. Multiple commenters suggest that when temperatures are not optimal, the habitat in those locations is not suitable for salmonids, and should therefore be considered useless to salmonids. Furthermore, under this scenario, the plan amendments do not provide a temperature benefit to salmonids. As described previously, meaningful benchmarks were used for evaluating temperature-related impacts or benefits of the LSJR alternatives based on well-documented and relevant literature. The SED primarily uses 2003 USEPA-recommended temperature criteria to evaluate changes in the amount of time that optimal temperature conditions are met at different locations in the LSJR and each of the three major eastside tributaries. The results in the SED analysis show the percentage of time different flow scenarios meet USEPA-recommended temperature criteria. In addition, supporting results are provided in the following locations in the SED.

- Exceedance tables are provided in Chapter 7, *Aquatic Biological Resources,* which provide the full range of temperature changes at multiple times and locations.
- Average temperature and 90th percentile temperature changes are also provided in Chapter 19.
- Additional temperature model results are shown in Appendix F.1, *Hydrologic and Water Quality Modeling*, Section F.1.6.2, *Temperature Model Results*.

While conclusions regarding temperature benefit and impact determinations are primarily based upon changes to the amount of time that USEPA-recommended temperature criteria are met under different flow scenarios, it is important to consider other temperature results, such as reductions to average and 90th percentile temperatures when the changes are in the range that is meaningful for salmonids. Together, all of the temperature results documented in the SED, along with the temperature model outputs, are used to reach conclusions about the measurable benefits or potential impacts on native fishes from different flow scenarios.

[6] Chapter 7, Chapter 19, and Appendix C, explain that water temperatures significantly affect the distribution, health, and survival of native salmonids.

USEPA also recommends a 68°F (20°C) maximum 7DADM numeric criterion for waterbodies that are used almost exclusively for migrating salmon and trout (typically in the lower reaches of major rivers) during the warmest periods of potential migration (USEPA 2003). While USEPA believes that this criterion would protect migrating juveniles and adults from lethal temperatures and prevent thermal blockages, USEPA also recommends that this criterion be accompanied by a narrative provision to protect (and where feasible, restore) the natural thermal regime. This additional provision is based on concerns that rivers with significant hydrologic alterations (e.g., rivers with dams and reservoirs, water withdrawals, and/or significant river channelization) may have lost much of the temperature diversity (e.g., coldwater refugia) that enabled fish to avoid prolonged exposure to water temperatures of this magnitude or higher during their migrations.

Field and laboratory studies compiled and reviewed by USEPA indicate that increasing exposure of migrating adults and juveniles to water temperatures above 68°F (20°C) can cause adverse effects in the form of increased disease, decreased swimming performance, and migration blockages in adults, and increased disease, impaired smoltification, reduced growth, and increased predation in juveniles. For example, water temperatures exceeding 70°F (21°C) have generally been cited as blocking migration of adult Chinook salmon and steelhead (McCullough et al. 2001). An upper limit of 68°F (20°C) 7DADM in migratory corridors is also consistent with studies of juvenile Central Valley Chinook salmon that show significant increases in the severity of harmful effects at temperatures ranging from 70–75°F (21–24°C) (Myrick and Cech 2001; Marine and Cech 2004). Additionally, survival studies of coded-wire-tagged juvenile Chinook salmon in the lower Sacramento River and Delta show that water temperature is an important factor in mortality at temperatures above 68°F (20°C) (Baker et al. 1995). Thermal tolerance studies indicate that juvenile Chinook salmon and steelhead can be expected to exhibit significant mortality at chronic temperatures exceeding 77°F (25°C), which approximates the upper incipient lethal temperature reported for individuals that have been acclimated to water temperatures greater than or equal to 68°F (20°C) (McCullough et al. 2001). Adults appear to have lethal tolerances 3.6–5.4°F (2–3°C) lower than that of juveniles (McCullough et al. 2001).

Additional tables are provided below (Table 3.1-3 through Table 3.1-10.) that amplify the information contained in the SED regarding potential temperature benefits to salmonids during the February–June time period by considering changes to harmful and lethal migratory temperatures.

Table 3.1-3. The Percentage of Time on the Merced River that Harmful Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (Base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Harmful Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that harmful temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that harmful temperatures are avoided. Expected changes in the amount of time that harmful temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

Merced River		Near Confluence (RM 2.52)						1/4 River (RM 13.5)						1/2 River (RM 27)						3/4 River (RM 37.8)						Below Crocker Huffman (RM 52.2)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
68.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Apr	**82%**	10%	15%	16%	16%	17%	**80%**	14%	18%	19%	19%	19%	**91%**	7%	7%	7%	7%	8%	**93%**	6%	6%	6%	6%	7%	**100%**	0%	0%	0%	0%	0%
68.0	May	**45%**	24%	36%	43%	46%	48%	**45%**	28%	39%	44%	48%	51%	**61%**	26%	34%	38%	39%	39%	**66%**	27%	32%	33%	34%	34%	**100%**	0%	0%	0%	0%	0%
68.0	Jun	**26%**	4%	9%	16%	23%	30%	**28%**	5%	13%	20%	31%	36%	**31%**	11%	29%	36%	39%	42%	**32%**	25%	37%	42%	43%	45%	**100%**	0%	0%	0%	0%	0%

Table 3.1-4. The Percentage of Time on the Merced River that Lethal Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (Base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Lethal Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that lethal temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that lethal temperatures are avoided. Expected changes in the amount of time that lethal temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

Merced River		Near Confluence (RM 2.52)						1/4 River (RM 13.5)						1/2 River (RM 27)						3/4 River (RM 37.8)						Below Crocker Huffman (RM 52.2)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
77.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Apr	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	May	**98%**	2%	2%	2%	2%	2%	**95%**	5%	5%	5%	5%	5%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Jun	**76%**	13%	15%	17%	20%	21%	**65%**	21%	24%	28%	31%	32%	**82%**	11%	15%	16%	17%	17%	**87%**	9%	12%	12%	13%	13%	**100%**	0%	0%	0%	0%	0%

Table 3.1-5. The Percentage of Time on the Tuolumne River that Harmful Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (Base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Harmful Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that harmful temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that harmful temperatures are avoided. Expected changes in the amount of time that harmful temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

Tuolumne River		Confluence (RM 0)						1/4 River (RM 13.2)						1/2 River (RM 28.1)						3/4 River (RM 38.3)						Below La Grange (RM 53.5)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
68.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Mar	**98%**	2%	2%	2%	2%	2%	**99%**	1%	1%	1%	1%	1%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Apr	**85%**	10%	12%	14%	14%	15%	**93%**	4%	6%	6%	7%	7%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	May	**63%**	17%	29%	36%	37%	37%	**71%**	17%	27%	29%	29%	29%	**97%**	3%	3%	3%	3%	3%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Jun	**36%**	10%	28%	37%	40%	43%	**38%**	22%	34%	38%	43%	48%	**47%**	29%	36%	44%	44%	46%	**59%**	26%	34%	35%	37%	40%	**100%**	0%	0%	0%	0%	0%

Table 3.1-6. The Percentage of Time on the Tuolumne River that Lethal Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (Base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Lethal Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that lethal temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that lethal temperatures are avoided. Expected changes in the amount of time that lethal temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

Tuolumne River		Confluence (RM 0)						1/4 River (RM 13.2)						1/2 River (RM 28.1)						3/4 River (RM 38.3)						Below La Grange (RM 53.5)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
77.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Apr	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	May	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Jun	**60%**	24%	28%	34%	35%	36%	**64%**	23%	28%	32%	33%	34%	**79%**	16%	18%	19%	20%	21%	**90%**	8%	8%	9%	10%	10%	**100%**	0%	0%	0%	0%	0%

Table 3.1-7. The Percentage of Time on the San Joaquin River that Harmful Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Harmful Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that harmful temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that harmful temperatures are avoided. Expected changes in the amount of time that harmful temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

San Joaquin River		Near Vernalis (RM 69.31)						Above the Stanislaus Confluence (RM 72.501)						Above the Tuolumne Confluence (RM 81.401)						Above the Merced Confluence (RM 116.001)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20	30	40	50	60		20	30	40	50	60		20	30	40	50	60		20	30	40	50	60
68.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Apr	**97%**	3%	3%	2%	3%	3%	**89%**	7%	8%	10%	10%	10%	**75%**	0%	6%	11%	13%	16%	**69%**	0%	0%	0%	0%	0%
68.0	May	**78%**	6%	12%	16%	18%	21%	**51%**	15%	29%	37%	42%	44%	**15%**	3%	10%	15%	19%	25%	**8%**	0%	0%	0%	0%	0%
68.0	Jun	**32%**	0%	9%	18%	32%	38%	**21%**	1%	12%	24%	35%	39%	**0%**	0%	0%	0%	1%	2%	**0%**	0%	0%	0%	0%	0%

Table 3.1-8. The Percentage of Time on the San Joaquin River that Lethal Juvenile Migratory Temperatures are Avoided Each Month under Modeled Baseline (Base) Conditions from 1970 to 2003, and the Expected Percent Change in the Amount of Time that Lethal Temperatures are Avoided under Modeled Unimpaired Flows of 20%, 30%, 40%, 50% and 60% at Different River Mile (RM) Locations. (Positive numbers under the unimpaired flows represent increases in the percentage of time [compared to baseline] that lethal temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time [compared to baseline] that lethal temperatures are avoided. Expected changes in the amount of time that lethal temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively [if applicable], and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.)

San Joaquin River		Near Vernalis (RM 69.31)						Above the Stanislaus Confluence (RM 72.501)						Above the Tuolumne Confluence (RM 81.401)						Above the Merced Confluence (RM 116.001)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20	30	40	50	60		20	30	40	50	60		20	30	40	50	60		20	30	40	50	60
77.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Apr	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	May	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**97%**	2%	3%	3%	3%	3%	**96%**	0%	0%	0%	0%	0%
77.0	Jun	**94%**	1%	1%	2%	4%	4%	**82%**	9%	10%	13%	15%	15%	**68%**	8%	14%	15%	18%	20%	**41%**	0%	0%	0%	0%	0%

Table 3.1-3 through Table 3.1-8 show that the plan amendments would substantially reduce the frequency of harmful and lethal temperatures during the February–June time period for migrating juvenile salmonids on the Merced and Tuolumne Rivers and the SJR. The frequency of the occurrence of harmful temperatures is reduced under 40 percent unimpaired flow during April, May, and June on each of these rivers. The frequency of the occurrence of lethal temperatures is reduced under 40 percent unimpaired flow primarily during June in each of these rivers. The 20 percent unimpaired flow scenario indicates substantially less benefit primarily in the SJR compared to the other unimpaired flow scenarios. Reductions in harmful and lethal temperatures from February through June is expected to help maintain usable migratory corridors and will reduce mortality rates and improve health and condition of emigrating juvenile salmon and steelhead. Reducing harmful and lethal temperatures in April, May, and June also helps to extend the window of opportunity needed during the spring time period for young salmonids and other native fish.

Improving and extending suitable conditions both temporally and spatially from February through June also has the benefit of shrinking the stressful time period that over-summering fish must endure and may help to improve the condition and health of fish as they enter into the stressful summer time period.

The Stanislaus River already functions near 40 percent unimpaired flow on average from February through June under existing conditions. Harmful migratory temperatures (Table 3.1-9) are typically avoided February through May on the Stanislaus River, but are avoided approximately 60 percent of the time during June near the confluence and ¼ River locations leaving room for improvement. The 50 percent and 60 percent unimpaired flow scenarios provide significant benefits by reducing the occurrence of harmful temperatures during June. Lethal temperatures (Table 3.1-10) for migrating juvenile salmonids are typically avoided under baseline conditions from February through June on the Stanislaus River. Although the Stanislaus River has historically operated near 40 percent unimpaired flow on average from February through June, it is important to note that flows were sometimes managed erratically from February through June during and between years (see Table 2.15 of Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*). Having more consistent flow management for fisheries purposes and the ability to adaptively manage flow and temperature is likely to create temperature benefits during certain years as shown in the temperature time series plot (refer to Figure 3.1-10 in the *Temperature Improvements during June* section of this master response). There are also likely to be synergistic benefits from having additional flow from all three major eastside tributaries managed in a comprehensive approach.

Table 3.1-9. The percentage of time on the Stanislaus River that harmful juvenile migratory temperatures are avoided each month under modeled baseline (base) conditions during 1970 to 2003, and the expected percent change in the amount of time that harmful temperatures are avoided under modeled unimpaired flows of 20%, 30%, 40%, 50% and 60% at different river mile (RM) locations. Positive numbers under the unimpaired flows represent increases in the percentage of time (compared to baseline) that harmful temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time (compared to baseline) that harmful temperatures are avoided. Expected changes in the amount of time that harmful temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively (if applicable), and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.

Stanislaus River		Confluence (RM 0)						1/4 River (RM 13.3)						1/2 River (RM 28.2)						3/4 River (RM 43.7)						Below Goodwin (RM 58.5)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
68.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Apr	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	May	**95%**	1%	2%	3%	4%	5%	**97%**	1%	1%	2%	3%	3%	**98%**	1%	1%	2%	2%	2%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
68.0	Jun	**59%**	-2%	4%	9%	12%	15%	**63%**	-1%	4%	9%	11%	16%	**75%**	2%	5%	6%	6%	8%	**96%**	2%	3%	3%	3%	3%	**100%**	0%	0%	0%	0%	0%

Table 3.1-10. The percentage of time on the Stanislaus River that lethal juvenile migratory temperatures are avoided each month under modeled baseline (base) conditions during 1970 to 2003, and the expected percent change in the amount of time that lethal temperatures are avoided under modeled unimpaired flows of 20%, 30%, 40%, 50% and 60% at different river mile (RM) locations. Positive numbers under the unimpaired flows represent increases in the percentage of time (compared to baseline) that lethal temperatures are avoided, and negative numbers under the unimpaired flows represent reductions in the percentage of time (compared to baseline) that lethal temperatures are avoided. Expected changes in the amount of time that lethal temperatures are avoided which are greater than positive 10% or less than negative 10% are highlighted green or red respectively (if applicable), and represent significant changes to juvenile salmon and steelhead migratory temperature habitat.

Stanislaus River		Confluence (RM 0)						1/4 River (RM 13.3)						1/2 River (RM 28.2)						3/4 River (RM 43.7)						Below Goodwin (RM 58.5)					
Temperature Criteria °F	Month	Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow					Base	Percent Unimpaired Flow				
			20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%		20%	30%	40%	50%	60%
77.0	Feb	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Mar	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Apr	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	May	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%
77.0	Jun	**99%**	0%	0%	0%	0%	1%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%

Multiple commenters asserted that if temperatures are a fraction over the optimal criteria then the habitat is useless and there are no benefits. While the SED and responses to comments provide a tremendous amount of relevant temperature information, it is important to consider that there is not one perfect temperature threshold or criterion that explains every temperature related effect for a specific species and life stage, and that works the same for every individual fish. For example, the thermal responses of fish to increasing water temperatures within the harmful range are often described as a continuum of effects as shown in Figure 3.1-33 below (also see Figure 19-6 in Chapter 19).

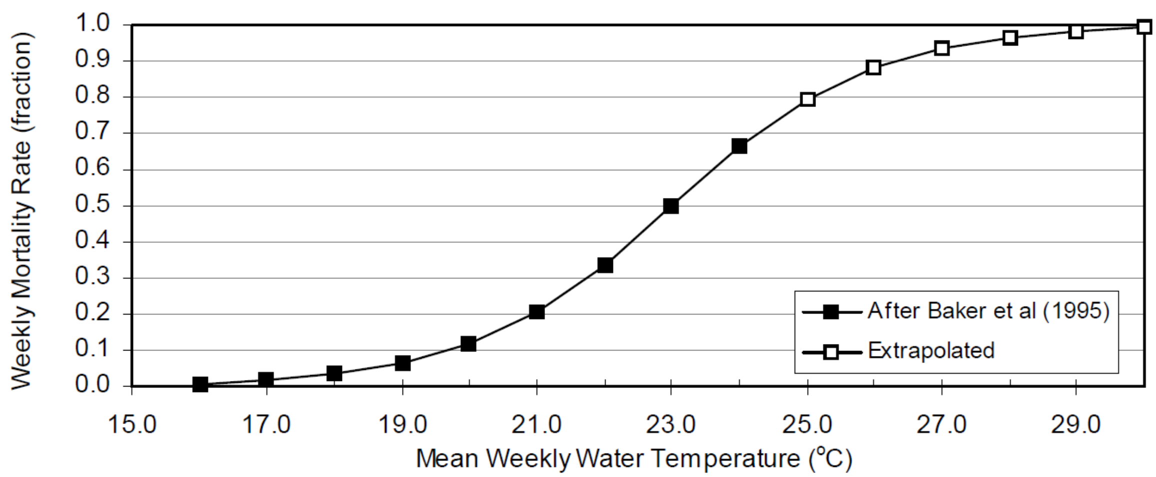

Figure 3.1-33. Weekly Morality Rate as a Function of Mean Weekly Water Temperature for Juvenile Chinook Salmon, used here to Illustrate the Continuous Effects of Temperature on Juvenile Chinook Salmon as Originally Described in Baker et al. 1995. (Note: the range of temperatures between 15.0°C to 30.0°C is equivalent to the range of temperatures between 59.0°F to 86.0°F) (Source: Deas et al. 2004.)

In addition, there are approximately 58.5 miles of the Stanislaus River, 53.5 miles of the Tuolumne River, 52.2 miles of the Merced River, and 59.8 miles of the LSJR that were modeled over a 34-year time period, and it is not possible to present every single temperature output in a reasonably lengthy document. Therefore, the temperature analyses in the SED do not show every modeled temperature result from each flow scenario. Those results are available in the temperature model output files. Instead, the SED presents some of the most relevant temperature results and describes why they are important. The overwhelming body of evidence presented in the SED and modeling files indicates that a reasonable water operation that is consistent with the requirements of the plan amendments will provide tremendous water temperature benefits for native fishes without unintended temperature consequences. Adaptive implementation as described in Master Response 2.2, *Adaptive Implementation*, will allow for real-time decision making to maximize the benefits using a limited quantity of water.

Using a Monthly Flow Model with a Sub-Daily Temperature Model

To model effects on temperature in the LSJR and three eastside tributaries for the SED, the State Water Board uses the San Joaquin River Basin-Wide Water Temperature and EC Model (SJR HEC-5Q model, or temperature model). Consultants under contract with the CALFED Bay-Delta Program between 2003 and 2008 developed the SJR HEC-5Q model through a process that included peer review and refinement (CALFED 2009). The temperature model was most recently updated by CDFW and released in June of 2013 (CDFW 2013a). Refer to Master Response 3.2, *Surface Water Analyses and Modeling*, for more information regarding the use of the HEC-5Q model and appropriate modifications made to the model.

The temperature model was designed to provide a SJR basinwide evaluation of temperature response at 6-hour intervals for alternative conditions, such as operational changes, physical changes, and combinations of the two. The extent of the model includes the Stanislaus, Tuolumne, and Merced River systems from their LSJR confluences to the upstream end of the major rim reservoirs (i.e., New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure, respectively). On the SJR, the upstream extent of the model is the Merced River confluence. The downstream extent of the model is the SJR at Mossdale. The model simulates the reservoir stratification, release temperatures, and downstream river temperatures as a function of the inflow temperatures, reservoir geometry and outlets, flow, meteorology, and river geometry. Calibration data is used to accurately simulate temperatures for a range of reservoir operations, river flows, and meteorology. For more information regarding the temperature model methods, see Appendix F1, Section F.1.6, *Temperature Modeling*.

For the temperature evaluations presented in Chapter 7 and Chapter 19, 34 years of monthly average flow outputs from the WSE model are disaggregated into average daily outputs, meaning that the average flow for any given month of a particular year is assigned to every day within that month. This disaggregation is appropriate because the monthly flow in the SED represents average flow within that month spread evenly throughout that entire month. Although there are many variations of how that quantity of water could actually flow down a river in a given month, what is important is that the water volume and source temperature is accurately estimated for each flow scenario. Based on daily average flows, the temperature model then determines temperature every 6 hours based on the balance of heating and cooling as a function of meteorological data for air temperature and seasonal trends in solar heating, among other factors. Therefore, a monthly flow model is capable of providing inputs to a model that calculates temperature on a sub-daily time step, and this approach is appropriate for the comparison of alternative management scenarios on a basin-wide and long-term scale. Temperature differences resulting from different flow scenarios are generally the result of differences in reservoir storage, diversion practices, and the amount of water flowing in the river.

There are innumerable ways within the boundaries of what is permissible under the plan amendments that a certain quantity of flow could be shaped over a given month. Modeling every possibility is not necessary because an alternative either provides more coldwater flow or less coldwater flow over a given month for a specific year, relative to baseline conditions. When these water temperature changes are within the range that is meaningful to native fish, they can be beneficial or detrimental. Please see Chapter 7 and Chapter 19 for additional information, including these evaluations. Please see Master Response 2.2, *Adaptive Implementation*, for more information on how the adaptive implementation framework of the plan amendments can use real-time information to inform decision-making in ways that maximize the benefits of a limited quantity of water.

Weighted Usable Area

Several commenters questioned conclusions regarding the significance of impacts of higher flows on WUA based on consideration of other factors (e.g., floodplain habitat availability and water temperature) in evaluating the overall response of Chinook salmon and steelhead populations to proposed changes in winter and spring flows under the plan amendments. *WUA* is an index of the quantity and quality of in-channel physical habitat available to individual Chinook salmon and steelhead life stages. WUA and flow form an empirical relationship (WUA versus discharge) that describes how WUA for individual life stages changes in response to flow. Although these relationships are useful for providing information regarding in-channel habitat availability, additional analysis is needed to provide insight into changes in habitat conditions and other environmental variables that determine the overall responses of the fish populations to higher winter and spring flows (see the floodplain habitat [Section 19.3, *Floodplain Inundation*] and water temperature analyses [Section 19.2, *Temperature*] in Chapter 19).

While the availability of suitable in-channel physical habitat can be an important variable affecting habitat selection and abundance, the relationships used in the impact analysis (see Chapter 7, Impact AQUA-3; WUA versus discharge relationships from USFWS 2008; USFWS 2011, 2012, 2013b; and cbec 2010) define only how flow affects physical habitat availability in the main channel of the river. WUA-discharge relationships do not provide a complete picture of the ecological benefits of alternative flow regimes because they are static relationships that do not consider biologically important differences in flow variation (e.g., timing and duration of flow pulses) and the dynamic responses of fish to variation in water temperature, food availability, turbidity, and other factors that vary in response to flow (Harvey and Railsback 2007; Railsback 2016). WUA considers the habitat variables of depth, velocity, and substrate (or cover) to define the amount of usable or suitable physical habitat for different life stages and does not consider the effects of other physical, chemical, and biological factors on life stage success. As described in Appendix C, the higher and more variable flows of the plan amendments are anticipated to improve a number of ecosystem attributes (not accounted for in the WUA analysis) that enhance survival, growth, and emigration success of juvenile salmonids (e.g., water temperature, food production, water quality, emigration timing, predator-prey dynamics, habitat connectivity, and geomorphic processes).

As described in Chapter 7, Section 7.4.2, *Methods and Approach (Physical Habitat Availability)*, the WUA-discharge relationships are limited to the range of flows within the bankfull width of the channel and, therefore, do not consider increases in available habitat associated with flows that exceed bankfull levels and inundate adjacent floodplains. In general, as flows increase up to the limits of the bankfull channel, WUA for juvenile salmonids decreases in response to reductions in suitable habitat resulting from increases in water velocities and reductions in shallow water. However, as flows increase above bankfull levels, the availability of suitable habitat for juveniles begins to increase as flows inundate the adjacent floodplain. These higher flows also increase the amount of suitable habitat for juvenile salmonids by extending the downstream extent of suitable water temperatures for rearing and outmigration. Consequently, potential impacts associated with higher flows on WUA are evaluated in the broader context of potential benefits associated with increases in floodplain habitat availability and improved water temperatures throughout the juvenile salmonid rearing and emigration period (February–June). Therefore, in addition to changes in habitat availability in the main channel, it is important to take into consideration the results from the evaluation of floodplain and temperature benefits provided in Chapter 19. For example, although increased flows in the Merced River in April and May under LSJR Alternatives 3 and 4 would reduce average WUA for juvenile rearing (potentially reducing in-channel rearing capacity) (Chapter 7, Table 7-14c), these same flows would increase the frequency and spatial extent of overbank flows (floodplain habitat) (Chapter 19, Table 19-24), and the longitudinal extent of suitable water temperatures for rearing and emigration through June (Chapter 19, Table 19-9). With increases in cumulative flow and lower water temperatures from each of the tributaries, the benefits of higher spring flows (measured in terms of increased floodplain habitat availability and reduced water temperatures) would extend to the LSJR between the Merced River confluence and the Delta, contributing to overall rearing and emigration success of juvenile salmonids (Chapter 19, Tables 19-25 through 19-27). (See also the *Reductions in Harmful and Lethal Water Temperatures* and the *Temperature Improvements during June* sections of this master response.)

Floodplain Habitat

In Chapter 7 and Chapter 19, changes in the frequency and magnitude of floodplain inundation in the Stanislaus, Tuolumne, and Merced Rivers and LSJR are quantified using modeled WSE flows and floodplain-versus-flow relationships developed by the U.S. Fish and Wildlife Service (USFWS) (2008, 2011, 2012, 2013b), cbec (2010), and the State Water Board. The results are used to evaluate potential effects of the LSJR alternatives on floodplain habitat availability for juvenile salmonids and other native fishes based on changes in inundated floodplain area (acres) and duration (acre-days) during the February–June period.

A number of commenters expressed concern regarding the appropriateness of using modeled monthly flows as a basis for the SED's floodplain habitat analysis, stating that monthly flows (i.e., effectively assuming constant daily flows) do not capture the daily variation in flows that would actually occur under the LSJR alternatives or the frequency and duration of floodplain inundation associated with key floodplain functions. For similar reasons, the use of acre-days to evaluate the potential benefits of floodplain inundation (Chapter 19,) was disputed. As discussed in Master Response 3.2, *Surface Water Analyses and Modeling,* the modeling of monthly flows using the WSE model provides an appropriate level of analysis that is sufficient to support a programmatic evaluation of the plan amendments and inform the public and decision makers on the range and magnitude of measurable benefits and potential impacts. In view of the limitations of using mean monthly flow to characterize floodplain inundation events, the SED uses reductions of 10 percent or more in the frequency of floodplain inundation areas of 50 acres or more to evaluate the significance of potential impacts on aquatic biological resources. These criteria are sufficient to differentiate the LSJR alternatives and determine the potential for changes in the frequency and magnitude of floodplain inundation events important to fish. Based on the unimpaired hydrograph, a mean monthly flow corresponding to 50 acres of floodplain inundation represents a daily hydrograph that potentially includes flows well above the average, resulting in floodplain inundation events that can exceed 50 acres for more than a week or two.[7] Through the adaptive implementation process (see Master Response 2.2, *Adaptive Implementation*), these flows could be further shaped (through adjustment of timing, duration, and magnitude of flows) to achieve specific inundation targets for fish or other aquatic resource needs.

Additional concerns were raised regarding the appropriateness of using floodplain inundation area (wetted area) as a measure of floodplain habitat because it does not consider other floodplain attributes that determine the extent of usable or suitable habitat for juvenile salmonids and other native fishes (e.g., water depths and velocities). Although floodplain inundation area generally overestimates the amount of optimal habitat for salmonid rearing, it was considered sufficiently robust as an indicator of floodplain habitat availability to differentiate the alternatives and determine the potential for significant changes in floodplain habitat availability for juvenile

[7] See Figure 19-3 in Chapter 19 for an example of seasonal and daily flow variation of the unimpaired hydrograph.

salmonids and other native fishes. This is supported by the close correspondence between increases in inundated floodplain area and suitable floodplain habitat (as indexed by WUA) as flows exceed bankfull elevations and inundate the adjacent floodplain. For example, in the Merced River, WUA for juvenile Chinook salmon, steelhead, and other native fishes (representing areas of suitable depths and velocities) between the Shaffer Bridge and Crocker-Huffman Dam (RM 32.8 to 52.0) peaks at flows between 50 and 200 cfs in the main channel, decreases as flow increase up to bankfull discharges between 1,000 and 1,500 cfs, and then increases continuously up to flows of 3,500 cfs or higher as flows inundate increasing amounts of floodplain area (Merced Irrigation District 2013:Figures 3.3-1 through 3.3-9). The increases in usable habitat with increasing overbank flows correspond closely to increases in inundated floodplain area as shown in the relationship developed by the Board for the SED analysis for the upper Merced River (see Chapter 19, Section 19.3.2, *Methods of Floodplain Inundation Evaluation*) and the relationship developed by USFWS for the lower Merced River (RM 0.0 to 25.0) (Gard pers. comm.) (Figure 3.1-34). A similar correspondence can be shown between overbank flows, floodplain inundation area, and usable habitat for juvenile salmonids in the Tuolumne River (USFWS 2008' HDR and Stillwater Sciences 2017).

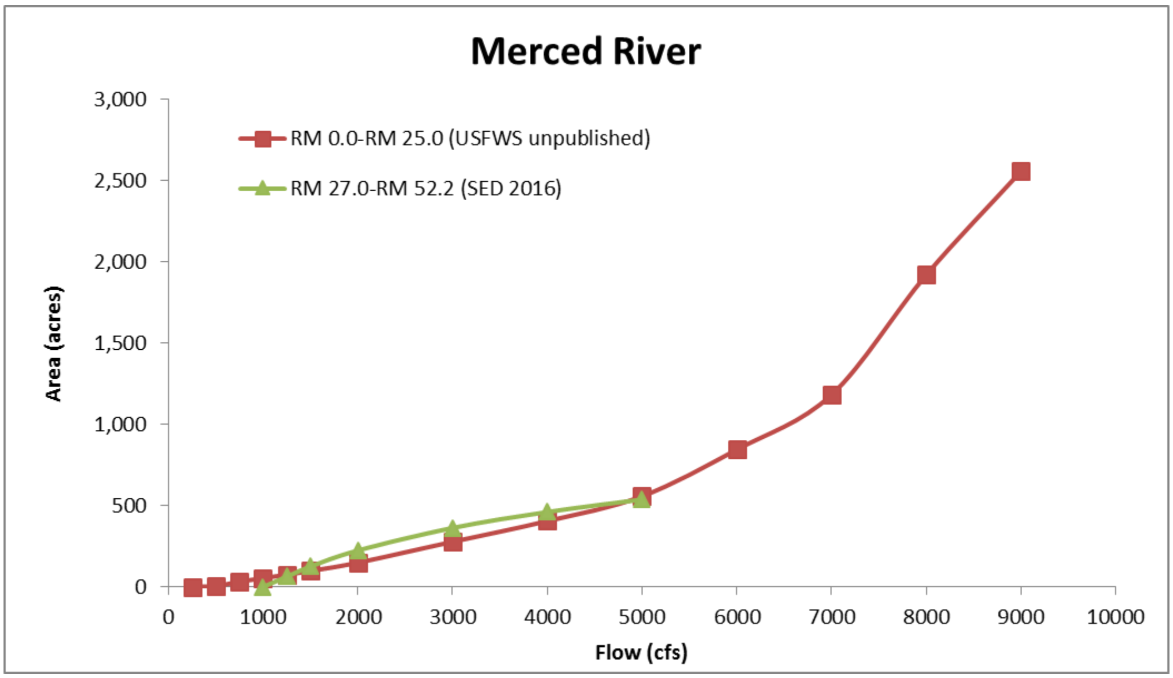

Figure 3.1-34. Floodplain Area Versus Flow for the Lower and Upper Reaches of the Merced River (Source of RM 0.0 to 25.0: Gard pers. comm.)

Several commenters questioned the validity of the conclusions of the SED regarding the beneficial effects of floodplain inundation on juvenile salmon and other native fishes (e.g., enhanced food production and growth opportunities) because of the reliance on evidence from other rivers and the lack of similar evidence from the LSJR and major eastside tributaries. While uncertainties exist regarding the relative importance of floodplain inundation on fish production in the tributaries and LSJR, the simplification of river channels and losses of floodplain and riparian habitat are recognized as major contributors to historical declines of Central Valley salmonids and other native fishes, and are among the key stressors that currently limit the recovery of these species (NMFS 2014a).

As discussed in Appendix C, successful rearing of juvenile Chinook salmon is associated with the magnitude, timing, and duration of natural peak winter and spring flows which seasonally expand available rearing habitat and provide access to productive riparian, floodplain, and wetland habitat (Mesick et al. 2007; Opperman 2006; Sommer et al. 2001; Williams 2006; USDOI 2010). Numerous studies of the habitat preferences and distribution patterns of juvenile salmon clearly demonstrate the importance of shallow, low-velocity nearshore, floodplain, and off-channel habitat for successful rearing (Garland et al. 2002; Beechie et al. 2005; Tiffan et al. 2006; FISHBIO 2015a, 2015b). For juvenile salmon, the benefits of such habitat derive not only from potential increases in food availability but reduced predation risk and energy expenditures associated with access to shallow, low velocity areas and cover. Although these benefits are most often associated with smaller, rearing individuals, good quality channel margin habitat is also considered important for migrating smolts because it provides protective cover from predators and velocity refuge during downstream migration (Williams 2006; Burau et al. 2007; Zajanc et al. 2012). With higher, more frequent overbank flows associated with the plan amendments, potential growth and survival benefits are expected to extend throughout the rearing and migration corridor for juvenile salmon, including tributary reaches where the active floodplain is narrow and such habitat is limited to narrow strips of riparian vegetation along the channel margins. Where low-lying floodplain and off-channel areas occur naturally or where floodplain restoration has been implemented, these benefits would be further enhanced. This is illustrated by the WUA-discharge relationships for juvenile salmon and other native fishes in the Merced River between the Highway 59 bridge and Snelling Road bridge (Merced Irrigation District 2013: Figures 3.3-4 through 3.3-6), which show a dramatic increase in suitable habitat (as measured by WUA) with increasing overbank flows (1,000 to 5,000 cfs) associated with channel restoration activities in this reach, including realignment of the main channel, isolation of a gravel pit from the main river by a setback berm, and revegetation of the engineered floodplain (Merced Irrigation District 2013).

A number of commenters also questioned the validity of conclusions regarding the benefits of floodplain inundation based on water temperatures that often exceed suitable ranges for juvenile salmonids, especially in the lower reaches of the tributaries and LSJR. As described previously (see the *Weighted Usable Area* section in this master response), increases in the frequency of overbank flows under the 40 percent and higher percent unimpaired flow scenarios not only increase the availability of floodplain habitat but also increase the longitudinal extent of suitable water temperatures through the spring rearing and emigration period. For example, in the Tuolumne River, overbank flows and floodplain inundation are initiated at flows of approximately 1,100 cfs (Chapter 19, Figure 19-12) and these same flows are associated with suitable rearing and emigration temperatures throughout much of the river through June (Figure 3.1-35 through Figure 3.1-37). While utilization of floodplain habitat by juvenile salmon diminishes through the spring as juveniles initiate their downstream migration, higher flows, cooler water temperatures, and increased floodplain habitat availability under the 40 percent unimpaired flow scenario would extend the longitudinal extent and seasonal duration of potential rearing opportunities, and expand the windows when juvenile salmon can successfully rear and emigrate from the tributaries to the Delta in many years (see also the *Reductions in Harmful and Lethal Water Temperatures* and *Temperature Improvements during June* sections of this master response).

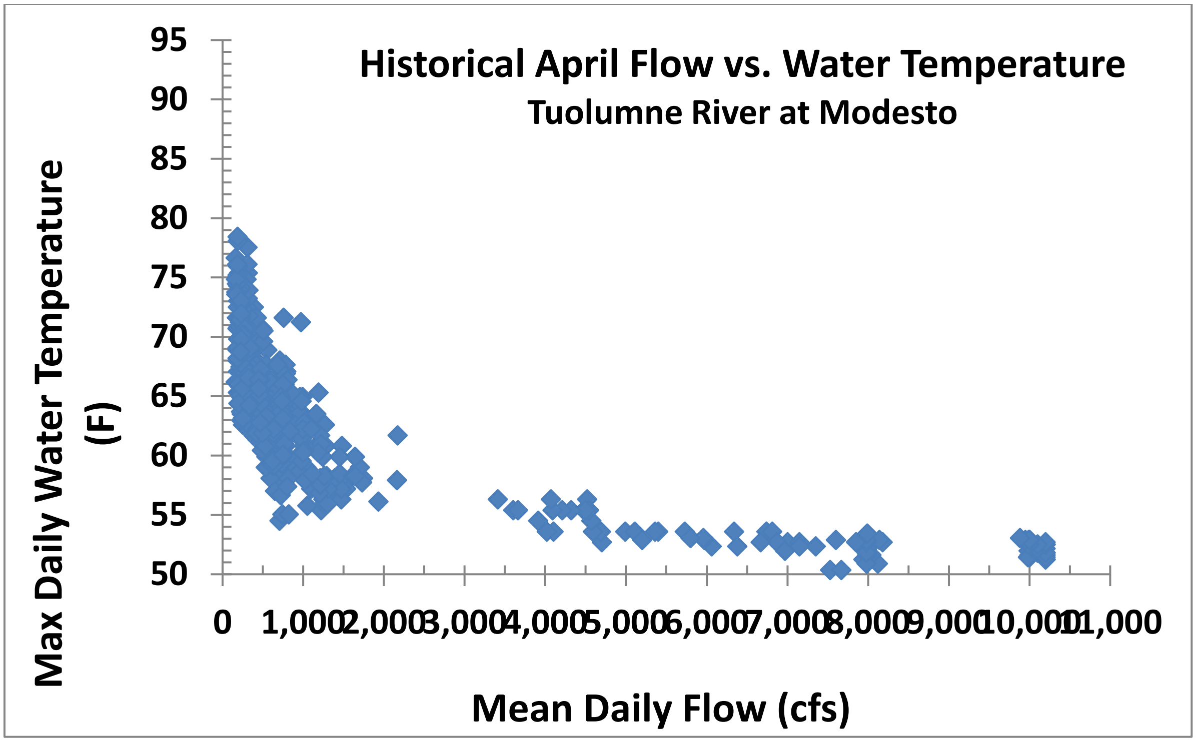

Figure 3.1-35. Historical (1989–1994, 2001–2003, 2005, 2007–2017) April Maximum Daily Water Temperatures (Fahrenheit) versus Average Daily Flow (cubic feet per second) on the Tuolumne River at Modesto (Source: USGS—Tuolumne River at Modesto [Site 11290000].)

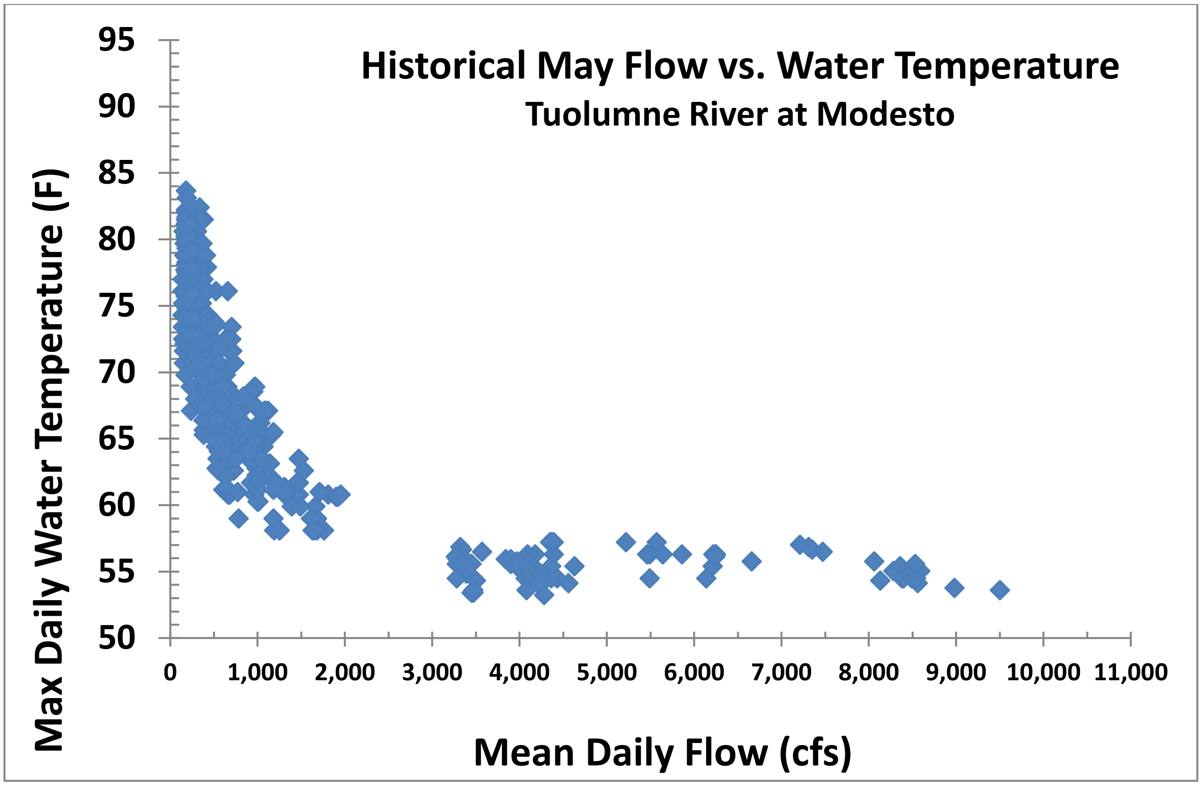

Figure 3.1-36. Historical (1989–1994, 2001–2003, 2005, 2007–2009, 2011–2017) May Maximum Daily Water Temperatures (Fahrenheit) versus Average Daily Flow (cubic feet per second) on the Tuolumne River at Modesto (Source: USGS—Tuolumne River at Modesto [Site 11290000].)

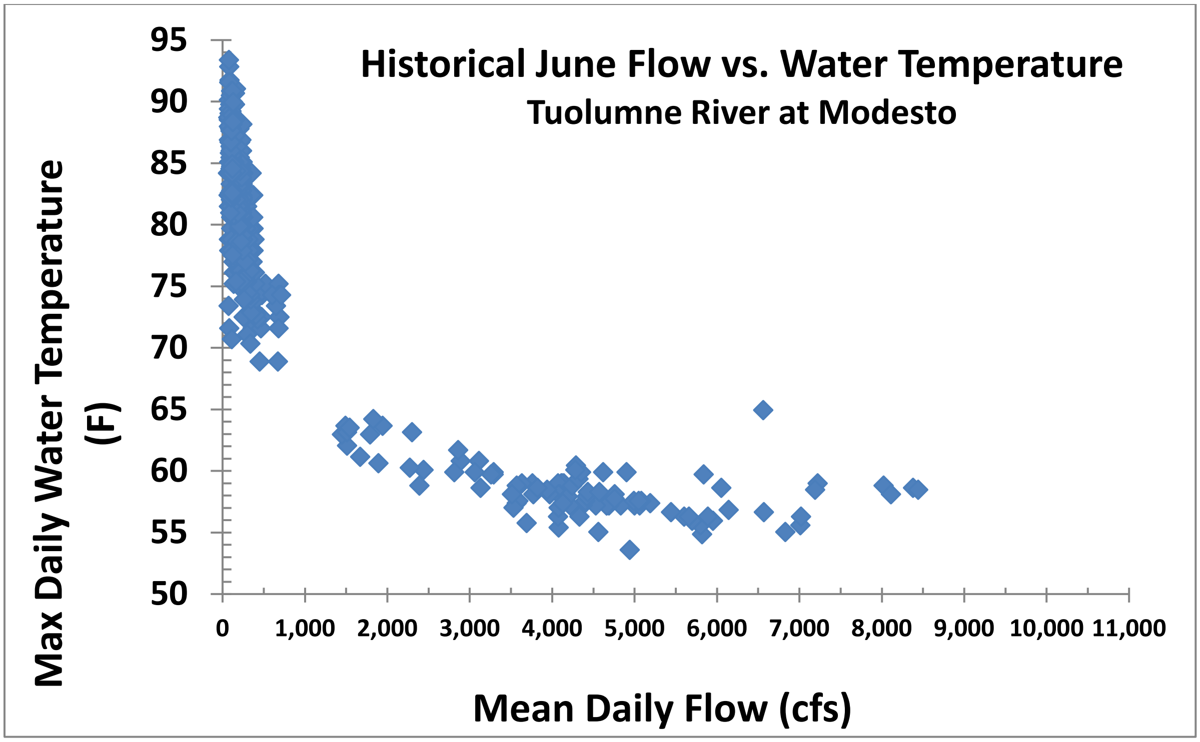

Figure 3.1-37. Historical (1989–1993, 2001–2003, 2005, 2007–2017) June Maximum Daily Water Temperatures (Fahrenheit) versus Average Daily Flow (cubic feet per second) on the Tuolumne River at Modesto (Source: USGS—Tuolumne River at Modesto [Site 11290000].)

SalSim

Multiple commenters submitted comments regarding the State Water Board's use of SalSim in the SED to inform the plan amendments. Commenters frequently asserted that implementation of the plan amendments would only yield a few thousand fish per year based on commenters' interpretations of the SalSim's results, which were presented for informational purposes in the SED. This master response addresses many of the SalSim-related comments received, by theme. However, the State Water Board did not rely upon SalSim, either for impact determinations in the SED or for its conclusions regarding fish benefits. This was due to limitations in the model, as explained in Chapter 19 and in more detail in this master response.

How the State Water Board Applied SalSim and Why

As described in Chapter 19, the State Water Board evaluated whether SalSim could provide insight into potential management decisions that could be implemented under this Bay-Delta Plan update. SalSim is a life-history population simulation model for fall-run Chinook salmon that originate from the SJR and its upper three east-side salmon bearing tributaries (the Stanislaus, Tuolumne, and Merced Rivers). SalSim was developed by the CDFW, AD Consultants, and a variety of other modeling and fisheries experts (CDFW 2013b; CDFW 2014a). The State Water Board applied SalSim in a variety of flow scenarios in order to evaluate whether it could help assess the response of fall-run Chinook salmon production from the Stanislaus, Tuolumne, and Merced Rivers. It is important to understand that this model cannot predict what is expected to occur in the future under the plan amendments, as is explained in more detail later in this section. Instead, the model backcasts how salmon populations may have responded under past hydrology and other conditions (1994–2010) if water management was different in the three eastside tributaries. The model is limited to fall-run Chinook salmon and does not consider other native species (e.g., sturgeon, splittail, and steelhead) that are expected to benefit from the plan amendments' improved flow and related habitat conditions during February–June time period.

SalSim is a useful model in that it forces the user to consider the many tradeoffs that exist between different salmon life stages. Although flaws with the model were identified during model use, the model still provided a platform for experimentation of different flow management scenarios, which are currently not conducted in the real world within the plan area. As noted previously, however, the SED did not rely upon SalSim for its impact conclusions or determinations of fish benefits. More generally, experimentation with the model informed some of the concepts behind the flow shifting paradigms that may occur through adaptive implementation.

SED Acknowledges the Limitations of SalSim

Multiple commenters have questioned why the State Water Board used a flawed model or showed results that are flawed. The State Water Board applied SalSim because it was the most comprehensive life-history population simulation model available for fall-run Chinook salmon originating from the SJR and its upper three east-side salmon bearing tributaries. During the exploration and use of this model, State Water Board staff discovered that the treatment of two of the most important salmon habitat attributes related to flow in the plan area, water temperature and floodplain inundation, are not represented by the model in a manner that is consistent with current scientific information. State Water Board staff acknowledges these limitations and provides a use advisory in the SED: refer to Chapter 19, Section 19.4.1, *Introduction of SalSim*, and Section 19.4.4, *Summary and Conclusions of the SalSim Evaluation*, for discussions of the issues, limitations, and interpretations of SalSim results.

Fish Produced from SalSim Runs

Multiple commenters have suggested that, according to SalSim, the plan amendments are only expected to produce approximately 1,103 salmon per year. This assertion is inaccurate and mischaracterizes the information presented in the SED. This number comes from Chapter 19, Table 19-32, which shows the total adult production of fall-run Chinook salmon by year for each year for 1994–2009, for a variety of flow scenarios input to SalSim. The difference between the baseline case (SBBASE) and the 40 percent unimpaired flow case (SB40%UF) in average annual total adult production for the entire simulation period is 1,103. While results are presented for the entire simulation period, the 1998–2004 time period is most appropriate due to model priming in early years (1994–1997), and the ocean crash in later years (2005–2009). If only looking at the 1998–2004 time period, the difference between the 40 percent unimpaired flow cases and baseline then becomes 2,059 for the SB40%UF case and 7,637 for the SB40%MaxFS case (Table 3.1-11 below), and these numbers are problematic if trying to forecast expected changes.

An average annual increase in production of approximately 2,059 to 7,637 adult Chinook salmon for all three tributaries combined during 7 years of comparison was an unsatisfactory result for many of the commenters. Putting limitations with SalSim aside, it is important to note that for a fish with a 2- to 4-year life cycle, an approximately 7-year time period is an extremely short time period to evaluate potential increases from what is an extremely small population size. The SalSim results presented in Chapter 19 show an increase over baseline of 12.7 percent for SB40%UF and 47.3

percent for SB40%MaxFS in the average annual total adult production during the 7-year comparison period. While 2,059 to 7,637 total adult salmon may seem like a small number, and does not factor in population benefits from temperature improvements and floodplain inundation, this represents a large percentage increase.

Table 3.1-11. SalSim Average Results for 1998–2004 and the Difference Compared to Baseline

SalSim Case	1998 to 2004 Annual Average Total Adult Production	Difference Compared to Baseline	Percent Change
SBBASE	16,151	NA	NA
SB20%UF	15,482	-668	-4.1%
SB30%UF	16,347	196	1.2%
SB40%UF	18,210	2,059	12.7%
SB40%MaxFS	23,788	7,637	47.3%
SB40%OPP	18,710	2,559	15.8%
SB50%UF	17,783	1,632	10.1%
SB60%UF	17,594	1,443	8.9%

As discussed in Chapter 19, it is difficult to make inferences about what these results mean in the long term. An increase of 12.7 or 47.3 percent during a 7-year time period does not provide any information about the new long-term average for adult salmon production or population size. Calculating long-term increases or long-term averages for salmon requires many more years of data. For example, the long-term adult escapement averaging periods used by USFWS (2013a) are calculated from the 1967–1991 and 1992–2011 time periods (Figure 3.1-38).

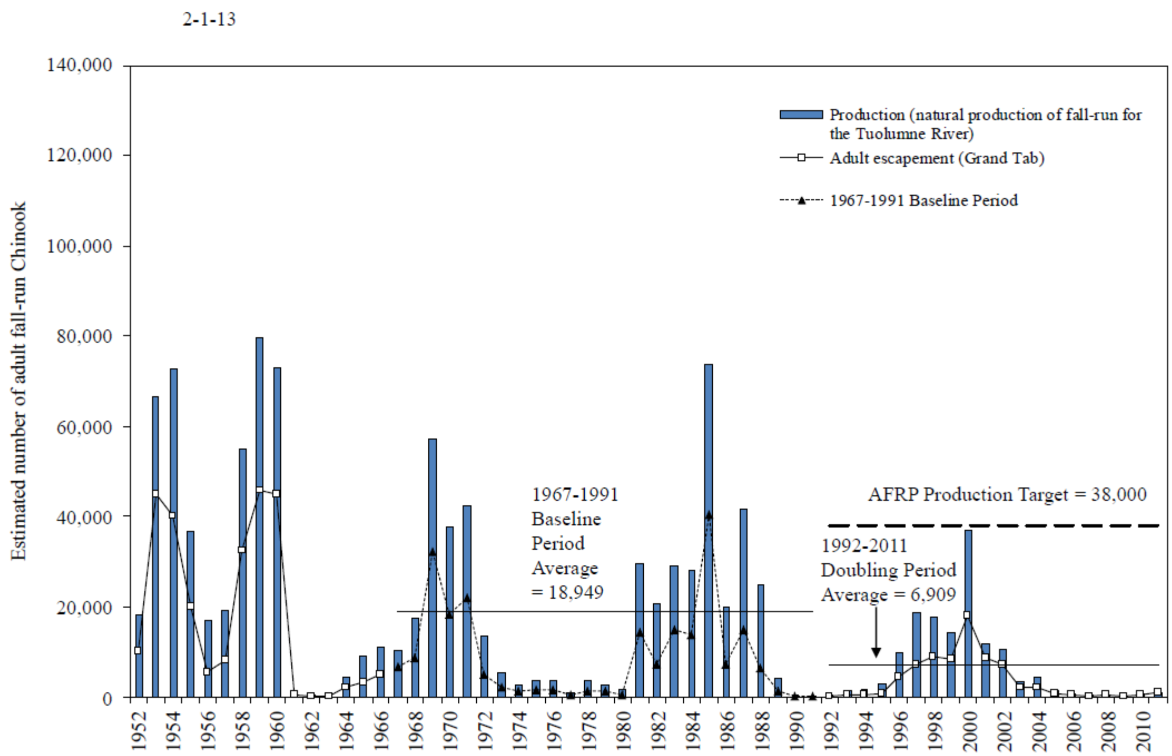

Figure 3.1-38. Long-Term Population Metrics for a Salmon Population that is in Decline in the Tuolumne River (Source: USFWS 2013a.)

Contrary to many commenters' assertions that only 1,103 addition salmon would be produced each year from the plan amendments, simulations in SalSim for a 7-year time period are extremely limited in providing information about changes to long-term averages. Asserting that 1,103 is the increase in the average annual production is out of context. Consider the plots provided in Newman and Hankin (2004), which show two artificial population increase scenarios (Figure 3.1-39).

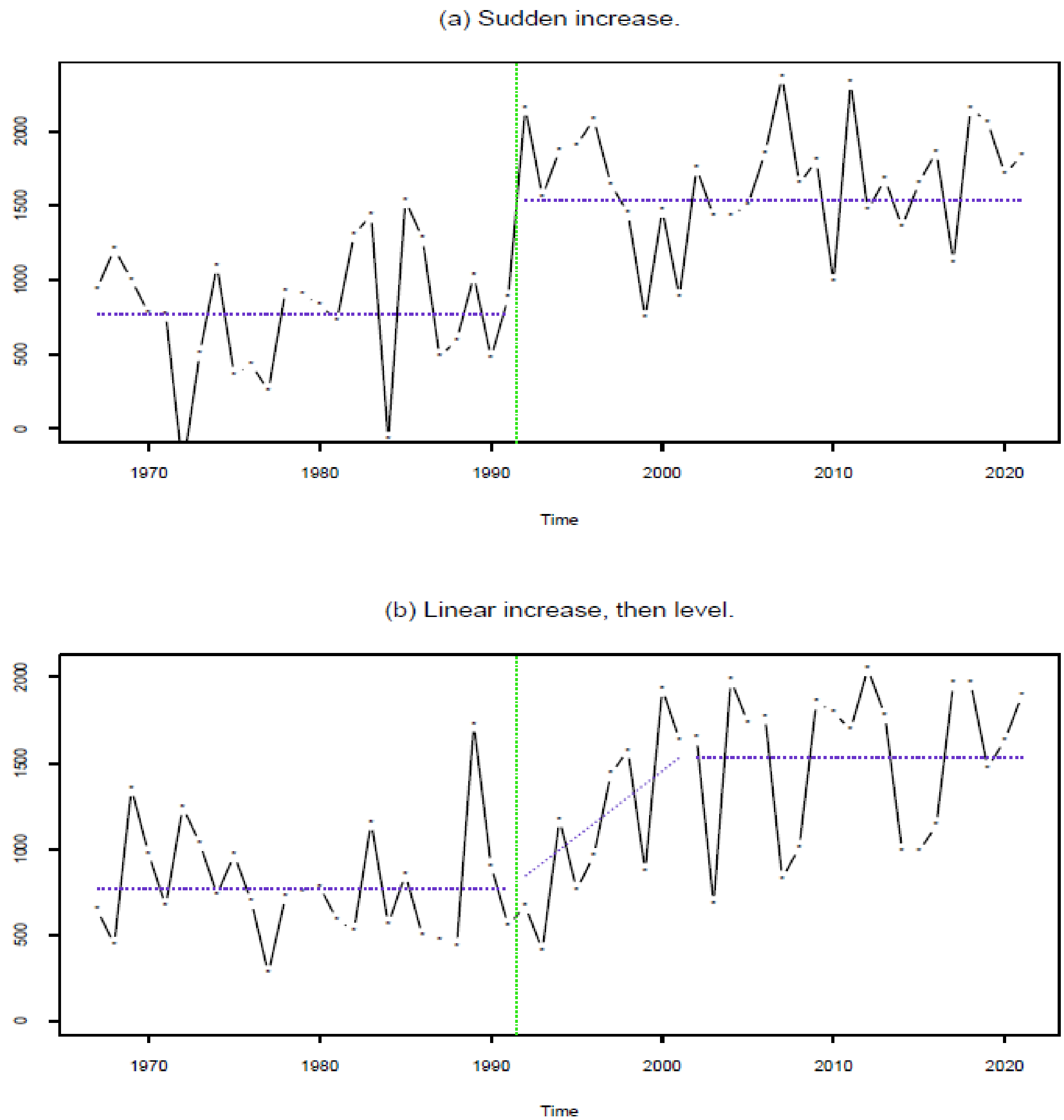

Figure 3.1-39a and b. Artificial Examples of Two Idealized Production Doubling Scenarios (The vertical line marks the division between the baseline and later management periods. The dashed lines are the underlying mean values.) (Source: Newman and Hankin 2004.)

Only looking at results for the first couple of years to the right of the green line in Figure 3.1-39b does not provide any information about where the new mean value will end up (beyond the year of 2001 [approximately]). Furthermore, only looking at the first couple of years to the right of the green line in Figure 3.1-39a would also not provide much information regarding the new mean value. Similarly, in evaluating the SalSim results, there is no way to determine the new long-term production or population averages.

Although the simulations in SalSim are not useful for providing information on long-term changes to numbers of salmon, these types of simulations can provide information about whether a management scenario is anticipated to affect the growth of salmon populations in a positive or negative direction and potentially may provide some information about the rate of increase or decrease (although that can change from density-dependent factors over time). As discussed in Chapter 19, this type of information should be interpreted with caution because of the identified imperfections in SalSim equations, such as responses to temperature and floodplain changes.

Use of Historical Flow versus Fish Data Instead of SalSim

The State Water Board considered many studies evaluating relationships between salmonids and flow conditions. Please see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*, Section 3.6, *Analyses of Flow Effects on Fish Survival and Abundance*, which summarizes much of the literature that was available during development of the Scientific Basis Report. Since the Appendix C, was finalized, consideration of newer literature has continued, and some of the new studies comparing fish and flow are cited in Chapter 19. Some of the recent studies that staff has considered include, but are not limited to, USFWS 2014, Zueg et al. 2014, and Sturrock et al. 2015 (see the *Current Fish Decline and the Need for Increased and More Variable Flows* section of this master response).

While past fish versus flow studies are valuable, they have limitations in making projections to population level effects resulting from future management scenarios. Past studies were conducted under conditions that are much different than the proposed flow conditions. The plan amendments will improve conditions in successive years. The synergistic effects of successive improved years make comparisons with the past years difficult because successive good years are rare in the period of record.

Use of SalSim February–June Data Instead of All SalSim Data

Multiple commenters have suggested that the State Water Board should have evaluated juvenile production data in SalSim. The State Water Board evaluated many of the more than 400 different types of outputs that SalSim produces in its summary file, and the information related to juvenile salmon during the February–June time period was of particular interest. However, only focusing on results from the spring time period can be very shortsighted because changes to reservoir levels, flows, and water temperature at other times of the year may change and can affect other life stages. A comprehensive view of the overall effect on a salmon population is important and is the reason why SalSim was created; however, SalSim's equations related to temperature for both egg and juvenile survival were flawed and limited the usefulness of evaluating changes to those life stages. Finally, CDFW (2014a) identified problems with rotary screw trap data that was used to build the model: large confidence intervals indicated a low reliability in the data. Comparatively, escapement data was more reliable; therefore, rotary screw trap data was only used in the initial calibration of the model and escapement data was used for the final calibration. Additionally, inland parameters were varied during the global calibration process making them even less reliable (CDFW 2014a). Therefore, the SalSim simulation results of adult salmon were given more weight compared to juvenile results.

Other Stressors

Multiple commenters claimed that the plan amendments did not address stressors on fish other than flow. The majority of the comments were focused on predation and the role of hatcheries, which are addressed in this master response in the following sections.

Multiple commenters also asserted that other stressors, including, but not limited to, historic landscape changes, pollutants, invasive species, and migratory blockage were not considered by the plan amendments. In addition to proposing amendments to the LSJR flow objectives, the State Water Board recognizes that non-flow measures have a complementary role to flow-based restoration. As described in Appendix K, *Revised Water Quality Control Plan*, and Chapter 16, *Evaluation of Other Indirect and Additional Actions*, non-flow measures may include floodplain and riparian habitat restoration, reduction of vegetation-disturbing activities in floodplains and floodways, gravel augmentation, enhancement of in-channel complexity, improvement of temperature conditions, fish passage improvements, predatory fish controls, and invasive aquatic vegetation control. Please see Master Response 5.2, *Incorporation of Non-Flow Measures*, for more information on non-flow measures that other entities could implement to address other stressors.

Predation

Consideration of Predation

The State Water Board considers and recognizes in multiple locations of the SED that predation affects salmonids. In Chapter 7, *Aquatic Biological Resources*, the State Water Board evaluates potential changes in predation risk resulting from changes in flow and water temperature under Impact AQUA-10. The Impact AQUA-10 analysis concluded that potential changes in predation risk are less than significant. Moreover, higher flows and cooler water temperatures in the three eastside tributaries, as a result of the plan amendments, would reduce predation impacts by: (1) improving growth opportunities and reducing temperature-related stress in juvenile Chinook salmon and steelhead; and, (2) limiting the distribution and abundance of largemouth bass and other nonnative species that prey on juvenile salmonids.

In addition, under the program of implementation Appendix K, *Revised Water Quality Control Plan*, Section C. *Recommendation to Other Agencies*, 10. *San Joaquin River Non-Flow Actions*, the State Water Board recommends that CDFW, NMFS, USFWS, FERC, FERC licensees, local water districts, conservation groups, landowners, water users, and other appropriate entities should reduce impacts that nonnative predators and competitors have on native fishes and modify habitats that currently favor nonnative fishes in the LSJR and its tributaries so that they favor native fishes. Specifically, these other agencies are recommended to take the following actions.

- Study and report the effects that predators and nonnative fishes have on native fishes.
- Identify gravel pits, scour pools, ponds, weirs, diversion dams, and other structures or areas that harbor significant numbers of nonnative fishes and predatory fish that may currently reduce native fish survival.
- Modify priority structures and areas to reduce predation and nonnative fish effects and to improve native fish success.

- Evaluate and implement changes to fishing regulations to reduce the impact that nonnative competitor and predator fishes have on native fishes.

The State Water Board also evaluated information prepared by fish and ecology experts, which indicates that predator reduction measures alone are insufficient to restore native fish populations within the Bay-Delta Watershed and that increased flow of a more natural pattern is needed. The most comprehensive review of predation within the Bay-Delta Watershed was sponsored by CDFW, the Delta Science Program, and NMFS. The sponsors assembled a panel of experts and held a multi-day workshop. The final product developed by the expert panel was the Post Panel Report which is titled, *Effects of Fish Predation on Salmonids in the Sacramento River-San Joaquin Delta and Associated Ecosystems* (Grossman et al. 2013). The expert panel reached the following conclusion.

> Habitat change and invasive species interact, because habitat change, especially degradation, may favor invasives and thus intensify interspecific competition and predation (Meffe and Carroll 1994; Moyle and Light 1996; Bunn and Arthington 2002). Focusing on habitat change or invasive species alone is not adequate for recovery of native salmonids in the Bay-Delta. Rather, both of these ecosystem stressors must be addressed in a coordinated fashion. The importance of a natural flow regime (Grossman et al. 1982; Poff et al. 1997) to the native flora and fauna, function, and resilience of lotic ecosystems is widely accepted. Restoration of natural hydrologic regimes is a large component of many regulated river rehabilitation programs (Richter and Thomas 2007) including the Colorado River Basin (Muth et al. 2000; McAda 2003; USBR 2011). However, in some cases restoration of natural hydrologic cycles alone is unlikely to benefit native fishes without concurrent management of invasives, especially predators (Tyus and Saunders 2000; Propst et al. 2008). Invasive predator management is now occurring in conjunction with flow restoration in both the Upper and Lower basins (Mueller 2005; Coggins et al. 2011) of the Colorado River. Salmonid conservation efforts in the Delta cannot focus on habitat restoration alone because 1) the physical structure of the system is highly constrained by domestic and agricultural water demands, and 2) invasive species, including predators, will continue to pose a threat to salmonid persistence. Nor is predator control likely to be effective on a broad scale without attention to the habitat conditions that make invasive predators successful.

In addition, leading experts from the University of California, Davis, have concluded that "The best long-term strategy for increasing populations of small fish (prey) is to improve the ability of the ecosystem to support them." (Moyle et al. 2016). Additionally, Moyle and Bennett (2010) from the University of California, Davis wrote a letter to the Fish and Game Commission when a change was proposed to the striped bass fishery regulations to allegedly decrease predation.[8] In that letter they concluded the following.

> Overall, the key to restoring populations of desirable species and to diminish populations of undesirable species (Brazilian waterweed, largemouth bass, etc.) is to return the Delta to being a more variable, estuarine environment… We stress that attempting to reduce striped bass and other predator populations is unlikely to make a difference in saving endangered fishes, and will serve only to distract attention from some of the real problems. However, efforts to reduce predation opportunities (not necessarily predators) in some locations with a focused effort may make a difference in the survival rates of depleted salmon and other species and provide some assistance to their recovery.

The State Water Board understands the need for a combined effort of habitat improvement and predator reduction, which is why the plan amendments identify predation reduction measures as an

[8] In a unanimous decision, Commissioners rejected the proposal, which would have increased striped bass bag limits and decreased size limits. (*See: https://cdfgnews.wordpress.com/tag/california-fish-and-game-commission/page/8/)*

important and necessary complementary action to flow. (See also Master Response 5.2, *Incorporation of Non-Flow Measures*.)

Moreover, when examining the primary factors that affect fish abundance, it is important to understand how much the hydrology in the SJR Basin has been altered and that this alteration has had dramatic impacts on native fishes and wildlife. For example, in half of the years between 1984 and 2009, observed flows as a percentage of unimpaired flows in the SJR at Vernalis have been less than 25 percent in April, 17 percent in May, and 18 percent in June. In the Tuolumne River, during half of the years between 1984 and 2009, observed flows as a percentage of unimpaired flows were less than 9 percent during June. Stated another way, more than 91 percent of the unimpaired flow is diverted or stored in half of the years during June (see the *Current Pattern of Fish Decline and the Need for Higher and More Variable Flows* section of this master response). The importance of higher and more variable flow conditions in the plan area during the February–June time period is widely recognized as one of the most important factors in juvenile survival and adult production of salmonids (AFRP 2005; Baker and Mohardt 2001; Brandes and McLain 2001; DFG 2005; DFG 2010; Kjelson et al. 1981; Kjelson and Brandes 1989; Mesick 2001; Mesick and Marston 2007; Mesick 2008; Mesick 2009; Mesick 2010 a-d; NMFS 2014a; Sturrock et al. 2015; USDOI 2010; USFWS 1995; USFWS 2014; Zueg et al. 2014).

Recent Tuolumne River Predation Study

Multiple commenters have suggested that the State Water Board did not consider a predation study conducted in the Tuolumne River and/or have referenced conclusions from a Tuolumne River study that allegedly shows that more than 90 percent of salmon or steelhead are eaten by predators before exiting the river. Commenters are presumably referring to the report, *Predation Study Report (W&AR-07) Don Pedro Project FERC NO. 2299*, conducted by FISHBIO for Turlock Irrigation District (TID) and Modesto Irrigation District (MID) in 2012 and reported in January of 2013 (FISHBIO 2013).

State Water Board staff submitted a letter to FERC on March 11, 2013 with comments and concerns regarding this study including that information regarding relative habitat use by juvenile salmon and predators was insufficient and lacked correlation and that predation rates were developed using sample sizes that were too small to be considered representative (State Water Board 2013). Additionally, State Water Board staff are participating in the FERC relicensing process and have considered concerns that were also expressed by CDFW, NMFS, and USFWS regarding this study. Because of the concerns raised during the FERC relicensing process, a second predation study was recommended by FERC to be conducted in 2014 by TID and MID. This study was never completed.

Although the 2013 predation report contains many shortcomings, which are well documented in the FERC record (CDFW 2013c; CDFW 2014b; NMFS 2014b; State Water Board 2013; TID and MID 2016; and USFWS 2013c), the report provides some information that may be useful for understanding predation in the Tuolumne River.

The 2013 predation report provides information indicating that flow conditions affect predation vulnerability. Specifically, Table 5.4-2 from TID and MID (FISHBIO 2013) shows that under high flow conditions, 43 tagged Chinook salmon (of 75 in Release Group #1) passed station SRP 10, but under much lower flow conditions, only 2 tagged Chinook salmon (of 73 in Release Group #3) passed station SRP 10. These high flow conditions would occur much more frequently under the plan amendments. For the 40 percent unimpaired flow objective, monthly average flows will exceed

2,000 cfs 51 percent more often during the month of May in the Tuolumne River, which is the month when the tagged salmon were released during the predation study.

The 2013 report also indicates that during existing low flow conditions, juvenile salmonids may be vulnerable to high predation rates. According to the authors, the results are based on the assumption "that the daily number of juvenile Chinook migrating was uniformly distributed (over a 60-day, or 90-day, or 120-day period) and that all were equally vulnerable to predation at the average rate." The authors also assumed it would be "plausible that most, if not all, losses of juvenile Chinook salmon in the lower Tuolumne River between Waterford and Grayson during 2012 could be attributed to non-native predatory species." State Water Board staff does not dispute that predation rates may be high under poor environmental conditions and during low prey densities. However, many assumptions within the predation study are problematic as documented in the FERC record (CDFW 2013c; CDFW 2014b; NMFS 2014b; State Water Board 2013; TID and MID 2016; and USFWS 2013c), such as the example provided above regarding uniform distribution of migratory juvenile salmon and equal vulnerability at the average rate of consumption. Migratory timing is not evenly distributed, and salmon use a strategy to migrate together to satiate predators, which has the effect of dramatically reducing predation vulnerability.

Additionally, estimated losses between these two rotary screw traps can vary dramatically by year. For example, between 2007 and 2012, estimates of juvenile salmon passing the downstream trap ranged from 76 to 98 percent less than estimates of passage at the upstream trap (FISHBIO 2013). Over a longer timeframe on the Stanislaus River (Pyper and Justice 2006), it was estimated that juvenile salmon survival between the Oakdale and Caswell trap sites was between 8 percent during a dry year and 95 percent during a wet year, which shows the dramatic variability in survival that can occur under different environmental conditions. Additionally, the FISHBIO (2013) predation study discussed previously indicates very low survival (3 percent) under low flow conditions, but much higher survival (57 percent) under higher flow conditions through the study area.

Effects of Higher Flows February–June on Juvenile Salmonid Survival

Multiple commenters have suggested that higher flows may encourage early emigration resulting in higher predation losses of the smaller juvenile salmonids or that increased floodplain inundation or temperature changes may increase predation vulnerability of juvenile salmonids. This is unsupported by historical data. In the past, when flows have been higher and more variable during the spring time period in the Stanislaus River, juvenile salmon survival was higher (Zeug et al. 2014), which has led to more adult returns 2.5 years later (Sturrock et al. 2015). USFWS (2014) evaluated the effects of floodplain inundation in the Stanislaus River on juvenile salmon survival and found that in years when there was higher flow and more floodplain inundation that juvenile salmon survival was higher with floodplain inundation explaining 77 percent of the year-to-year variation in juvenile survival. Sturrock et al. (2015) found that higher flows during the spring time period were important to the conservation of life history diversity, and provided evidence that the early emigration of fry can contribute significantly to adult spawning population approximately 2.5 years later. The authors reported the number of fry contributing to adult survivors was approximately twice as high during a wet year than a dry year (23 percent in 2000 versus 10 percent in 2003). Please refer to the *Current Fish Decline and the Need for Increased and More Variable Flows* section of this master response for more information regarding studies that support the need for higher and more variable flows.

Role of Hatcheries

Natural-Origin Fish

Multiple commenters asserted that the benefits to natural-origin fish are uncertain due to the presence of large quantities of hatchery fish in the population and that effects from hatcheries may hinder any benefits from the plan amendments. Regarding addressing uncertainty with the plan amendments for enhanced benefits, please refer to the *Making Adjustments and Addressing Uncertainty* section in this master response. The presence of hatchery-origin fish and effects from hatchery operations does not obviate the need for actions to improve anadromous fish populations, including increased and more variable flows (refer to the *Current Fish Decline and the Need for Increased and More Variable Flows* section in this master response).

Based on current hatchery operations, the large numbers of returning hatchery-origin adults and their propensity to stray are the result of current hatchery management practices (e.g., releases of large numbers of hatchery-reared smolts in the estuary) that decouple the survival and recruitment dynamics of these anadromous fish populations from the environmental conditions affecting freshwater rearing and emigration success. Consequently, the benefits of the proposed flow objectives will accrue mainly to naturally produced fish that will benefit not only from improved flow conditions during rearing and emigration but the broader range of rearing and emigration opportunities associated with a more natural flow regime. These benefits will likely shift the balance toward increasing proportions of naturally produced salmon, especially when combined with non-flow measures (Master Response 5.2, *Incorporation of Non-Flow Measures*), including efforts to move toward more conservation-based hatchery management practices.

Conservation of salmon is considered a high priority based on multiple species being listed as threatened or endangered under the ESA, and the contribution of hatcheries, “as currently operated” (Hatchery Reform Project), has contributed to their decline. To facilitate hatchery reform in the Pacific Northwest, Congress established the Hatchery Reform Project in 1999 with an independent scientific review panel, the Hatchery Scientific Review Group (HSRG) (Pacific Northwest Hatchery Reform Project 2017). HSRG was tasked with evaluating hatchery programs in the Pacific Northwest to determine whether the programs were providing fish for harvest, while reducing risks to natural populations and contributing to achieving conservation goals for Pacific salmon and steelhead (NOAA Fisheries West Coast Region 2017).

Hatchery program reviews were completed in Puget Sound, coastal Washington, and the Columbia River Basin, and implementation success led Congress to expand the program to encompass California. In 2010, funds were appropriated by Congress to conduct a scientific review of hatchery programs in California to ensure hatchery programs are managed and operated to meet one or both of the following purposes: (1) help to recover and conserve naturally spawning salmon and steelhead populations, and (2) support sustainable fisheries with little or no deleterious consequences to natural populations (California HSRG 2012).

The California Hatchery Scientific Review Group (California HSRG) acknowledged that hatchery reform will not, on its own, reverse the effects from accumulated degradation of salmonid habitats. Furthermore, in conjunction with the implementation of the California HSRG’s recommendations, major efforts to restore and/or protect habitat in California’s Central Valley need to continue. Among these other efforts, the California HSRG recognized the importance of instream flows.

> Protecting and increasing the quality and quantity of habitat (including stream flows) and the biotic community in holding, spawning, and rearing areas and throughout migration corridors must be a priority if natural reproduction of salmon and steelhead populations is desired and the abundance of natural-origin fish is expected to increase.

This statement provides additional support for the State Water Board's plan amendments for the LSJR flow objectives.

Multiple commenters expressed concern that the plan amendments may benefit hatchery-origin fish to the detriment of natural-origin fish, and that this impact should have been analyzed in the SED. As explained in Appendix K, *Revised Water Quality Control Plan*, and further clarified in Master Response 2.1, *Amendments to the Water Quality Control Plan*, the plan amendments have been developed to "support and maintain the natural production of viable native San Joaquin River watershed fish populations migrating through the Delta" (see the LSJR narrative flow objective). The term "natural production" specifically refers to the population of fish that is spawned and reared in nature. This term excludes the population of fish that is spawned and reared in a fish hatchery.

The process of updating the LSJR flow objectives in the Water Quality Control Plan has been ongoing for nearly 8 years and is based on the best available science on what actions would provide greater protection of fish and wildlife. Research and analysis into the habitat conditions that will contribute to achieving the LSJR narrative flow objective has culminated in the determination that natural fish populations in the San Joaquin River watershed need higher and more variable flows of a more natural pattern. See the *Current Fish Decline and the Need for Increased and More Variable Flows* section of this master response. In preparing the SED to support the plan amendments, the Board clearly acknowledged the concerns regarding the genetic and ecological impacts of hatchery production on wild stocks (see the *Consideration of Hatchery Effects* section below). While hatchery operations are recognized as a major stressor on the viability of natural salmon populations, the evidence is clear that achieving the narrative objective and moving toward recovery will require an ecosystem-based approach that addresses a broad range of stressors that currently limit natural production, life history diversity, and genetic diversity of these populations (Lindley et al. 2009, NMFS 2014b, HSRG 2015). For LSJR and other Central Valley tributaries, the restoration of a more natural flow regime and other actions to restore spawning and rearing habitat are high-priority recovery actions (NMFS 2014b). While changes in hatchery management are needed to fully address the risks posed by hatchery fish, ongoing efforts to increase natural salmon production by addressing altered flow conditions and other habitat limitations are essential to Central Valley conservation and recovery strategies (Lindley et al. 2009, NMFS 2014b).

Consideration of Hatchery Effects

Multiple commenters asserted that the role of hatcheries as a stressor to natural populations was not addressed. In the SED, Chapter 7, *Aquatic Biological Resources*, the State Water Board recognizes that hatchery operations have an influence on fall-run Chinook salmon and Central Valley steelhead in the plan area. Section 7.2, *Environmental Setting*, provides a description of these indicator species, and the environmental stressors (including hatchery operations) that affect these fish in each tributary. In Section 7.4.3, *Impacts and Mitigation Measures*, for impact AQUA-2 (changes in the availability of coldwater species reservoir habitat resulting from changes in reservoir storage), the State Water Board uses a significance criterion that "is considered a reasonable criterion given the large seasonal and annual fluctuations in reservoir storage experienced by fish in reservoirs and the dependence of the reservoir fisheries on hatchery trout and salmon stocking programs." For impact

AQUA-4 (changes in exposure of fish to suboptimal water temperatures resulting from changes in reservoir storage and releases), the State Water Board considers impacts to:

- Adult Migration: "…water temperature impacts on migrating adult salmon (including adults returning to Merced River Hatchery) and steelhead would be less than significant.";
- Spawning and Incubation: "…water temperature impacts on Chinook salmon and steelhead spawning and incubation life stages (including adult salmon and incubating eggs and fry in the Merced River Hatchery) would not be adverse and would be less than significant.";
- Juvenile Rearing: "…changes in the exposure of juvenile salmon and steelhead during the spring rearing period are not expected to result in significant impacts on natural or hatchery production compared to baseline conditions."; and
- Smoltification: "…represents a beneficial effect on spring outmigration conditions for juvenile salmon and steelhead in the Tuolumne and Merced Rivers (including juvenile salmon reared at the Merced River Hatchery and released in the Merced River)."

Throughout Appendix C, Chapter 3, *Scientific Basis for Developing Alternative San Joaquin River Flow Objectives*, the State Water Board acknowledges: (1) the high straying rates of hatchery produced fish, (2) the influence of hatchery numbers on escapement estimates, (3) availability of better information (from Constant Fractional Marking) in the future with regard to hatchery influence, (4) the high abundance of hatchery fish compared to wild fish leads to reduced diversity and weakened genetic integrity, (5) a more natural flow regime is anticipated to maintain/enhance genetic diversity for wild fish, and reduce the negative effects of hatcheries.

Moreover, the State Water Board is aware of, and has been aware of, potential hatchery-related effects as evidence by the existing language in the 2006 Bay-Delta Plan. The 2006 Bay-Delta Plan, Section C, *Recommendations to Other Agencies*, describes numerous complementary actions to the water quality control plan that can be taken under the authorities of other agencies to improve habitat conditions both inside and outside the Bay-Delta estuary. Among the actions listed, is (4), *Improve hatchery programs for species of concern*. In this recommended action, which applies to federal and federally funded salmon and steelhead hatcheries, the State Water Board recognizes that the viability of natural fish populations has been compromised due to the operation of hatcheries and recommends the implementation of studies to evaluate improvements to hatchery programs for species of concern. As described in the 2006 Bay-Delta Plan, the fisheries agencies should continue to take the following actions.

1) Carefully examine and periodically re-examine the role and contribution of existing hatchery production for salmon and steelhead, including a consideration of the need for genetic diversity and maintaining the integrity of different salmon runs; and
2) Evaluate strategies for improving the survival of hatchery fish, before and after release, including diet and pre-release conditioning, selection of the life stage and size of fish to be released, timing releases relative to the presence or absence of other species, and using multiple release locations.

In sum, Chapter 7 and Appendix C appropriately acknowledge that fish produced by the hatcheries have the potential to negatively affect natural fall-run Chinook salmon, and the 2006 Bay-Delta Plan recognizes hatchery reform as a complementary non-flow measure. In either case, however, neither the acknowledgement of hatchery fish nor the recognition for hatchery reform obviates the need for the plan amendments. On the contrary, both support the need for measures that increase populations of naturally produced fish, which is integral to the purpose of the plan amendments.

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Personal Communications

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