DISTRICTS' REPLY TO COMMENTS

ATTACHMENT C

FEASIBILITY OF SUCCESSFULLY INTRODUCING ANADROMOUS FISH TO THE UPPER TUOLUMNE RIVER BASIN

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FEASIBILITY OF SUCCESSFULLY INTRODUCING ANADROMOUS FISH INTO THE UPPER TUOLUMNE RIVER BASIN

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

TID WATER & POWER
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MID Modesto Irrigation District
The Power to Grow

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

Prepared by:
HDR, Inc.

January 2018

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Feasibility of Successfully Introducing Anadromous Fish Into the Upper Tuolumne River Basin

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List of Acronyms and Abbreviations

CCSF	City and County of San Francisco
CCV	California Central Valley
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
cfs	cubic feet per second
CHTR	collect, handle, transport, and release
CV	Central Valley
EPA	U. S. Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
FRFH	Feather River Fish Hatchery
LGDD	La Grange Diversion Dam
LWD	large woody debris
MID	Modesto Irrigation District
NMFS	National Marine Fisheries Service
RM	river mile
TID	Turlock Irrigation District
WTI	Water Temperature Index

1.0 INTRODUCTION

1.1 Background

In 2015, the Districts collaborated with licensing participants, including the National Marine Fisheries Service (NMFS), to initiate an Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework (Framework) process.[1] The purpose of the Framework was to develop, through a collaborative process, information needed to evaluate the feasibility[2] of successfully introducing two anadromous salmonids listed as threatened under the Endangered Species Act (ESA), i.e., Central Valley (CV) Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) and California Central Valley (CCV) Steelhead (anadromous *O. mykiss*) (the "target species") to the Tuolumne River basin upstream of the Don Pedro Hydroelectric Project (Don Pedro Project) Boundary.

Introducing anadromous fish upstream of the Don Pedro Project could be considered successful only if it contributes to the recovery of the target species, as reflected in the reintroduction goal statement established and approved by the Framework's Plenary Group on May 18, 2017, i.e., *"Contribute to the recovery of ESA listed salmonids in the Central Valley by establishing viable populations in the Tuolumne River at fair and reasonable cost"* (La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group 2017). Fall-run Chinook are not addressed in this document because the Fall-Run Chinook Evolutionarily Significant Unit (ESU) in the Tuolumne River basin is not listed under the ESA. Issues pertaining to fall-run Chinook are related to productivity, and there is abundant suitable habitat for fall-run Chinook in the lower Tuolumne River, so there is no justification for introducing the run into the upper basin.

Assessing the likelihood that such an introduction would lead to the establishment of viable populations that would contribute to the recovery of the target species requires a comprehensive evaluation of technological and ecological feasibility, biological constraints, and economic, regulatory, and other considerations. It is currently unknown how productive the target species would need to be for the introduced populations to contribute to recovery. However, in its most recent Recovery Plan for listed anadromous salmonids in California's Central Valley, NMFS (2014) identified the following numerical criteria for considering a salmonid population to be at low risk of extinction: a census population size that exceeds 2,500 adults or an effective population size that exceeds 500 adults. NMFS notes that census population size can be used if direct estimates of effective population size are unavailable.

As demonstrated in the following sections of this document and the associated supporting reports and technical memoranda (see Section 2.0), the information available indicates that introducing

[1] Since all the available information regarding historical spring-run Chinook and steelhead distribution in the Tuolumne River is anecdotal, the Districts do not agree that these species have been shown to have consistently populated the river upstream of the Don Pedro Project, and as such, do not necessarily consider this potential action under consideration to be a "reintroduction." Detailed information on the Assessment Framework process is contained in the Final License Application (FLA) for the La Grange Hydroelectric Project (TID/MID 2017a).

[2] Feasibility is taken as its common usage: "possible to achieve" (Webster 1992). For a project to be determined feasible, it must be able to achieve the objectives established by the project developer(s) and the performance standards established for projects of a similar nature and purpose. In accordance with 40 CFR 450.11(b), the EPA defines infeasible as not technologically possible, or not economically practicable and achievable in light of best industry practices.

ESA-listed CV spring-run Chinook into the upper Tuolumne River basin or attempting to connect upper and lower basin *O. mykiss* populations would be unsuccessful and fail to contribute to the recovery of the species. A variety of factors, including habitat suitability in the upper basin, challenges associated with attempting to implement experimental downstream fish passage technologies, well-documented outmigrant survival issues in the lower Tuolumne River, San Joaquin River, and the Bay-Delta, among others, likely represent insurmountable obstacles to establishing sustainable populations of the target species in the upper basin at a reasonable cost. Any position to the contrary would require compelling information beyond what is currently available. In addition, it is the Districts' view that NMFS has not invested sufficiently in assessing a range of potential impediments to establishing populations of the target species in the upper Tuolumne River, and has failed to evaluate other potential recovery options for the target species, such as establishing populations in the lower Tuolumne River, where adequate habitat availability has been documented, or in other watersheds where candidate reaches as defined by the Recovery Plan (NMFS 2014) exist. It is the Districts' position that NMFS must fully discharge its responsibilities related to species recovery before any decision-making on anadromous fish introduction in the upper Tuolumne River can move forward.

1.2 Information Gathering and Planning Deficiencies

The NMFS Northwest Fisheries Science Center, in collaboration with others, authored an article titled *Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery* (Anderson et al. 2014), which emphasizes that intensive, structured information gathering and planning are critical for deciding whether a fish introduction program should be implemented, i.e., based on the likelihood that the introduction program will be successful. Anderson et al. (2014) point out that despite substantial cost and effort, reintroduction programs often fail to establish self-sustaining populations. Another recent evaluation, conducted by Bennett et al. (2016), states that there is "limited information regarding the population response of salmon and steelhead to restoration actions," despite the fact that well designed studies lasting eight years or more have been conducted for this purpose. Anderson et al. (2014) note that "Poorly planned reintroduction efforts might waste resources that would be better invested in other conservation approaches…" Anderson et al. (2014) point out that constraints other than removal of migration barriers will influence the success of an introduction program, including habitat quality, migratory and ocean survival, harvest, interactions with other species and populations, and changing environmental conditions. Anderson et al. (2014) also warn that "If reintroduced fish experience poor reproductive success, the new habitat may become a "sink" that depletes an extant population but fails to provide the benefit of a newly established self-sustaining population."

Anderson et al. (2014) identify a set of planning concepts to guide scoping efforts and determine if a proposed introduction has conservation merit and acknowledge that a socioeconomic cost-benefit analysis is crucial for making decisions about large-scale restoration projects. The authors note that it is important to establish the timeframe needed for realizing the introduction benefits, thereby setting reasonable expectations and benchmarks for monitoring. The authors state, "Some reintroductions may provide immediate benefits within a generation or two, but those requiring adaptation to new habitat will likely take decades."

The NMFS Recovery Plan (NMFS 2014) for the target species states that when considering reintroduction of anadromous fish, watersheds are categorized as primary, candidate, or unsuitable. The plan states that, "Watersheds with less potential, or where potential has not been assessed are classified as 'candidates.' NMFS considers the reaches of the Tuolumne River above Don Pedro Reservoir and below La Grange Diversion Dam (LGDD) to be candidate watersheds for spring-run Chinook (NMFS 2014) and the Tuolumne River above Don Pedro Reservoir to be a candidate watershed for steelhead (NMFS 2014). NMFS considers steelhead to be present in the lower Tuolumne River below LGDD[3]. The assigning of candidate status to the Tuolumne River above Don Pedro Reservoir indicates that the upper basin's potential to support viable anadromous fish has not been fully investigated. Recovery actions identified in NMFS (2014) for the Tuolumne River are described as follows: "Evaluate and, if feasible, develop and implement a steelhead and spring-run Chinook salmon passage program for La Grange and Don Pedro dams. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program." As noted above, the Districts studies to date have begun to address feasibility, and to date findings indicate that successful introductions of the target species are likely infeasible (as described in the following sections). Moreover, NMFS has only conducted three studies (see Section 2.0), and the Districts do not see these as in any way comprehensive enough to support a decision to move forward with introductions.

The NMFS West Coast Region website includes frequently asked questions related to anadromous fish passage in California[4]. The frequently asked questions responses state that, "Fish passage must be safe, timely, and effective. Risk of physical injury, stress to the fish, and passage delay must be minimal, and the system must be able to pass sufficient numbers of adults upstream and juveniles downstream to support a viable population." Based on converging lines of evidence derived from information collected to date, it appears unlikely that juvenile salmonids could be collected in the safe and effective manner identified by NMFS as necessary to support viable populations of the target species.

[3] NMFS classifies the Tuolumne River below LGDD as a Core 2 watershed for steelhead, which NMFS (2014) defines as follows: "Core 2 populations meet, or have the potential to meet, the biological recovery standard for moderate risk of extinction... These watersheds have lower potential to support viable populations, due to lower [than Core 1] abundance, or amount and quality of habitat. These populations provide increased life history diversity to the ESU/DPS and are likely to provide a buffering effect against local catastrophic occurrences that could affect other nearby populations, especially in geographic areas where the number of Core 1 populations is lowest."

[4] http://www.westcoast.fisheries.noaa.gov/fish_passage/about_dams_and_fish/ca_fish_passage_faq.html#q1

2.0 STUDIES CONDUCTED TO PROVIDE INFORMATION FOR ASSESSING FISH INTRODUCTION

To begin assessing the potential for successfully establishing viable populations of the target species in the upper Tuolumne River basin, the Districts conducted the Federal Energy Regulatory Commission- (FERC) required and voluntary studies identified in Table 2.0-1. The studies referred to in Table 2.0-1, and appended to this document, address components of a comprehensive assessment of the feasibility of introducing the target species to the upper Tuolumne River basin. Thus, the results of any individual component are integral to the overall assessment, and should not be singled out and interpreted out of context.

Table 1.2.0-1. Studies conducted by the Districts to begin evaluating the feasibility of a successful introduction of CV Spring-Run Chinook and CCV Steelhead in the Upper Tuolumne River basin.

Study Title	Study Goal
Fish Passage Facilities Alternatives Assessment Study Report (TID/MID 2017b) (Appendix A)	Identify, develop, and assess feasibility of concept-level alternatives for upstream and downstream passage of the target species.
Upper Tuolumne River Basin Fish Migration Barriers Study Report (TID/MID 2017c) (Appendix B)	Assess barriers to spring-run Chinook and steelhead upstream migration in the upper Tuolumne River basin.
Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study: Model Development Study Report (TID/MID 2017d) (Appendix C1)	Simulate thermal conditions in the Tuolumne River from Early Intake to the Don Pedro Project Boundary.
Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study: Temperature Indices Analysis Study Report (TID/MID 2017e) (Appendix C2)	Assess thermal suitability in the upper Tuolumne River for the introduction of spring-run Chinook and steelhead.
Hatchery and Stocking Practices Review Study Report (TID/MID 2017f) (Appendix D)	Assess stocking practices in the Tuolumne River basin and adjacent watersheds, and identify potential interactions between hatchery and introduced salmonids.
Upper Tuolumne River Spring-Run Chinook Salmon and Steelhead Spawning Gravel Study (Appendix E)	Characterize spawning gravel in the upper mainstem Tuolumne River.
Upper Tuolumne River Habitat Mapping Assessment (Appendix F)	Evaluate habitat distribution, quantity, and quality in the mainstem upper Tuolumne River.
Upper Tuolumne River Macroinvertebrate Assessment (Appendix G)	Characterize benthic and drifting macroinvertebrate assemblages in the upper Tuolumne River basin.
Upper Tuolumne River Instream Flow Study (Appendix H)	Evaluate habitat suitability for spring-run Chinook and steelhead in the mainstem upper Tuolumne River.
Socioeconomic Scoping Study (Appendix I)	Explore economic considerations associated with implementing an anadromous fish introduction program.
Regulatory Context for Potential Anadromous Salmonid Reintroduction into the Upper Tuolumne River Basin (Appendix J)	Explore regulatory considerations associated with implementing an anadromous fish introduction program.
Simplified Spreadsheet Model to Estimate Adult Replacement of Spring-run Chinook salmon from the Upper Tuolumne River Technical Memorandum (Appendix K)	Application of a simplified spring-run Chinook life-history model to simulate upper Tuolumne River carrying capacity and survival between freshwater and ocean life stages, and provide rough estimates of the number of emigrants successfully returning to the basin to spawn three years after ocean entry.

Study Title	Study Goal
Tuolumne River – Genetic Analysis Results of *Onchorhynchus mykiss* Samples Technical Memorandum (Appendix L)	Resolve the genetic relationship between *O. mykiss* in the Tuolumne River below La Grange Diversion Dam and above the Don Pedro Hydroelectric Project Boundary.
Continued Model Application to assess EPA (2003) Recommended Temperature Benchmarks in the Upper Tuolumne River from Early Intake to Wards Ferry Technical Memorandum (Appendix M)	Apply the District's Upper Tuolumne River Flow and Temperature Model to assess EPA's water temperature guidelines for spring-run Chinook and steelhead based on conditions in the upper Tuolumne River.

NMFS also conducted some studies of the upper basin and potential fish passage (Table 2.0-2). The Districts are not providing summaries or reviews of these NMFS documents in this technical memorandum. District reviews have been conducted and are summarized elsewhere.

Table 1.2.0-2. Studies conducted by NMFS to begin evaluating the feasibility of a successful introduction of CV Spring-Run Chinook and CCV Steelhead into the Upper Tuolumne River basin.

Study Title	Study Goal
Estimation of Steelhead and Spring-Run Chinook Salmon Habitat Capacity in the Upper Tuolumne and Upper Merced Rivers (Boughton et al. 2017).	The Districts have not yet received this report from NMFS.
Genetic Evaluation of *O. mykiss* Populations in the Upper Tuolumne and Merced Watersheds Rivers to Evaluate Ancestry and Adaptive Genetic Variation (Pearse and Campbell 2017)	• Evaluate how dams as fish passage barriers have affected the genetic makeup of Tuolumne River and Merced River *O. mykiss* by altering the gene flow between above-barrier and below-barrier populations. • Understand the baseline status and origin of steelhead in the lower Tuolumne and Merced Rivers. • Genotype resident rainbow trout in various locations in the upper Tuolumne River and upper Merced River and evaluate their relationships.
Conceptual Engineering Plans for Fish Passage at La Grange and Don Pedro Dams on the Tuolumne River (Anchor QEA 2017)	• Identify the amount and quality of habitat above Don Pedro Reservoir that could be accessed by anadromous salmonids. • Evaluate feasibility of facilities to allow adult and juvenile salmonids to pass La Grange and Don Pedro dams. • Describe and compare challenges, opportunities, and preliminary cost estimates involved with specific fish passage scenarios. • Provide conceptual-level engineering drawings, cost estimates, three-dimensional drawings of fishway alternatives, and descriptions of alternative fish passage schemes. • Provide aerial and site-specific digital photographs of major project features; habitat areas of interest; and potential fish handling and collection, counting, tracking, and/or transport locations. • Describe how an interim fish passage facility and operation might be transformed into a permanent fish passage operation with a high degree of compatibility and economic efficiency.

3.0 FACTORS THAT WOULD INFLUENCE THE SUCCESSFUL INTRODUCTION OF THE TARGET SPECIES INTO THE UPPER TUOLUMNE RIVER BASIN

3.1 Donor Stock and Approach to Colonization

Introducing the target species to the upper Tuolumne River basin would require identification of donor stocks. Major risks associated with introducing fish into an area where they do not exist include: (1) homogenized population structure and reduced fitness within the introduction site, (2) depletion of the source population via removal of adults or gametes (resulting in a "sink" as discussed below), (3) invasion by nonnative species and suppression of preexisting native species within the introduction site, and (4) the spread of pathogens (Anderson et al. 2014). In addition, use of hatchery fish to establish a population may be inadvisable. NMFS, as the agency responsible for management and recovery of the target species, has not yet made decisions regarding this most basic of variables, i.e., identifying the potential donor stocks or the agency's preferred approach to introducing the target species to the upper Tuolumne River.

3.1.1 Spring-Run Chinook

In its *Endangered and Threatened Species: Designation of a Nonessential Experimental Population of Central Valley Spring-Run Chinook Salmon below Friant Dam in the San Joaquin River*, (CA50 CFR Part 223 [Docket No. 121210693–3985–01] RIN 0648– BC68), NMFS states, "Initially we will be using FRFH [Feather River Fish Hatchery] fish for captive broodstock and direct release to the river. We would later consider diversifying the donor stock with fish from naturally spawning populations in other streams if and when those populations can sustain the removal of fish." NMFS also states, "The FRFH is planning to produce sufficient fish to allow for eggs or juveniles to be collected for the reintroduction, in addition to the hatchery production needed for the Feather River. The consistent availability of hatchery produced fish, combined with existing protections for wild populations, can allow collection of fish for reintroduction of CV spring-run Chinook salmon to the San Joaquin River with no adverse impact on the ESU."

It is likely that NMFS would also attempt to introduce FRFH Chinook to the upper Tuolumne River basin, for the reasons identified in the quotations provided above. However, in its *Hatchery and Genetic Management Plan for Feather River Hatchery Spring-run Chinook Salmon Program*, the California Department of Water Resources (CDWR) (2009) states that until 2004, "separation of spring-run and fall-run Chinook at FRH was based solely on arrival timing. Generally, fish arriving at FRH in September were spawned as spring-run, those arriving in October were spawned as fall-run. Subsequently, DWR studies documented there had been considerable mixing of fall- and spring-run Chinook salmon stocks in the hatchery." As a result, it is questionable whether individuals derived from FRFH are true spring-run Chinook.

Regardless of their source, if introduced fish experience low reproductive success, the habitat into which they have been released can become a sink that depletes an extant population without providing a newly established self-sustaining population (Anderson et al. 2014). Anderson et al. (2014) state, "Our review of the salmonid reintroduction literature…suggests that there are large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies. Despite the increased risks of methods such as transplanting adults and hatchery releases, we found no direct evidence that these approaches have established a demographically independent, self-sustaining natural population." The productivity of spring-run Chinook released into the upper basin would be low due to poor habitat quality in the upper basin, resulting primarily from the peaking operations of City and County of San Francisco's (CCSF) Holm Powerhouse (see Section 3.2.4), and low survival rates of outmigrating smolts (see Section 3.6). This would lead to depletion of the source population, without an accompanying increase in productivity, thereby resulting in a net loss of fish and their genetic material.

3.1.2 Steelhead

As noted above, NMFS conducted a genetics study (Pearse and Campbell 2017), which showed that the *O. mykiss* population upstream of Don Pedro Dam potentially supports adfluvial life history variants, and contains genomic variation for a major chromosomal polymorphism (single nucleotide polymorphisms on chromosome Omy5) associated with anadromy or adfluvial life-history expression. The authors conclude that the results of the study support the potential to reestablish anadromous *O. mykiss* in the upper Tuolumne River using fish from the locally-adapted gene pool. However, notwithstanding the genetics of the upper basin populations, environmental conditions have been shown to play a role in whether an anadromous or resident life history is expressed in *O. mykiss* (Sloat 2013, McMillan et al. 2012). There are no field data to indicate that rainbow trout in the upper basin are adfluvial or have a propensity to migrate downstream. Moreover, a genetic analysis of Tuolumne River *O. mykiss* tissue samples (Appendix L) showed that the migratory genetic variant is present in *O. mykiss* downstream of the La Grange Diversion Dam at comparable, if not higher, frequencies than what occurs upstream of the Don Pedro Project Boundary, and years of observations confirm that there is no steelhead run in the lower Tuolumne River (Zimmerman et al. 2008, Ford and Kirihara 2010, CDFW 2017). NMFS (2014) states that, "…reintegrating *O. mykiss* below and above barriers does not guarantee an increase in steelhead abundance, at least in the short-term while the selection regime favors residency."

As noted above, Pearse and Campbell (2017) suggest that *O. mykiss* currently occupying the upper basin could be used as a source of donor fish, i.e., releasing naturally produced juveniles taken from the upper basin (i.e., above-barrier fish) into the lower Tuolumne River. However, as noted above, the genetic analysis of Tuolumne *River O. mykiss* tissue samples (Appendix L) showed that the migratory genetic variant is present in *O. mykiss* downstream of the La Grange Diversion Dam at comparable, if not higher, frequencies than what occurs in the upper basin, and yet there is no steelhead run in the lower Tuolumne River (Zimmerman et al. 2008, Ford and Kirihara 2010, CDFW 2017), indicating that for the Tuolumne River *O. mykiss* populations genetic predisposition in less important than environmental conditions in determining whether fish engage in migratory behavior. As a result there is no justification for moving *O. mykiss* from the upper basin to the lower basin, or vice versa. In fact, as noted below, there are potential liabilities.

Listed below are potential liabilities associated with attempting to connect the *O. mykiss* populations currently occurring upstream and downstream of the Don Pedro and La Grange projects.

- Introduction of *O. mykiss* from the lower river or hatchery sources into the upper Tuolumne River basin would threaten the indigenous above-barrier population with non-native and domesticated genetic material.
- The above-barrier *O. mykiss* population contains a genetic migration variant that should be protected; passing these fish downstream would likely create a sink that will decrease the abundance of the migration variant.
- Initiating a transport program where fish from the lower river are introduced into upstream habitats would not lead to increased productivity because *O. mykiss* populations already in the upper Tuolumne River are likely at carrying capacity. Transferring fish would be an attempt to seed the habitat with more individuals than it can support.

3.2 Habitat Availability and Suitability in the Upper Tuolumne River Basin

3.2.1 Migration Barriers and Accessibility

TID/MID (2017c; report included as Appendix B) shows that the mainstem Tuolumne River would be reliably accessible to anadromous fish from the upper end of Don Pedro Project Boundary (River Mile [RM] 80.8) to Lumsden Falls (RM 97.3), and might be accessible from Lumsden Falls to Early Intake (RM 104.3) under some flow conditions (i.e., in some years). Only the lower reaches of the major upper basin tributaries would be accessible, including 1.69 miles of the North Fork Tuolumne River, 2.05 miles of the Clavey River, 1.9 miles of the South Fork Tuolumne River, 0 miles of the Middle Fork Tuolumne River, and 1.62 miles of Cherry Creek.

3.2.2 Mesohabitat Types

The Upper Tuolumne River Habitat Mapping Assessment (Appendix F) provides the following estimates of the relative abundances (percent length of river) of habitat types in the Tuolumne River from the upper end of Don Pedro Reservoir (RM 80.8) to Early Intake (RM 104.3): boulder garden (11.1 percent), cascade (7.8 percent), pool (15 percent), high-gradient riffle (9.8 percent), low-gradient riffle (17.5 percent), and run (38.8 percent). Sixty percent of the pools identified in this reach contained habitat suitable for adult anadromous fish holding. Abundant cover is available in some portions of this reach and would provide habitat for juvenile anadromous salmonids. Physical and thermal habitat suitability under the existing upper river flow regime are addressed in sections 3.2.4 and 3.2.5, respectively.

Average large woody debris (LWD) density from RM 80.8–RM 104.3 was 2.85 pieces/1,000 ft. The highest LWD density occurred above Lumsden Falls (7.72–9.41 pieces/1,000 ft). Densities below Lumsden Falls (the region that would be accessible at all flows to anadromous salmonids) were much lower (0–3.75 pieces/1,000 ft). Wood that collects on bars or islands is frequently out of contact with the low-flow channel and has a limited effect on channel morphology (Keller and Swanson 1979). Bilby and Bisson (1998) observed that wood has less effect on channel form in larger streams than it does in smaller streams. This is consistent with observations in the upper Tuolumne River from RM 80.8–RM 104.3, where average bankfull width is 149 ft, and LWD appeared to have little effect on channel morphology.

Habitat surveys conducted in the accessible portions of the Clavey River and South Fork Tuolumne River are described in the Upper Tuolumne River Basin Tributary Habitat Study Technical Memorandum (Attachment C to Appendix F). Results of the surveys show that the accessible reach of the Clavey River lacks spawning gravel suitable for the target species, particularly for spring-run Chinook, which would spawn during fall when flows are low. Also, summer water temperatures in the lower reach of the Clavey River (i.e., 25-27°C in summer 2015) would be unsuitable for salmonids during many years. Similarly, the accessible reach of the South Fork Tuolumne River is nearly devoid of spawning gravel, and although water temperatures were lower than those in the Clavey River, they were still in the range of 20–23°C during summer 2015.

3.2.3 Spawning Gravel

The amounts (area) of potentially suitable spawning gravel in the accessible reaches of the upper Tuolumne River that would be available during the spawning periods of spring-run Chinook and steelhead were estimated by scaling the spawning gravel area mapped at 130 cfs (Appendix E) to flows that would be encountered by spawning fish (based on estimated life-history periodicities for the upper river). Longitudinal increases in flow due to surface and groundwater accretion and variability in substrate composition together influence the amount of gravel inundated in a given reach during a species' spawning period. Therefore, results are provided on a reach-specific basis to reveal trends in gravel abundance along the length of the upper river. The areas of suitable spawning substrate during the lowest flow that would occur in each geomorphic reach over the spawning periods are summarized in Table 3.2-1. Flows for each species apply only to specific reaches within the study area. The actual area of suitable spawning habitat (beyond that based on substrate particle size) at a given flow would be governed by hydraulic conditions, as discussed in Section 3.2.4.

The relatively greater abundance of spawning gravel in these reaches, when compared to upstream reaches, is due to lower channel gradients, greater channel widths, greater bedload supply, and higher flows due to accretion. The tendency for gravel to be found disproportionately in the lower reaches curtails the suitability of upstream reaches for spawning, and because fry and juvenile rearing would occur downstream of spawning sites, also limits the longitudinal extent of salmonid rearing habitat.

Table 3.2-1. Suitable and available spawning gravel for spring-run Chinook salmon and steelhead in the upper Tuolumne River.[1]

Reach	Reach Length (mi)	Spring-run Chinook Salmon		Steelhead	
		Minimum Flow (cfs)	Available Gravel (ft²/mi)	Minimum Flow (cfs)	Available Gravel (ft²/mi)
7	6.91	100	2,186	60	739
6	5.89	125	3,890	200	1,699
5	2.30	165	4,464	500	38
4	1.69	165	33,738	500	19,496
3	1.36	165	288	500	290
2	0.95	165	19,986	500	456
1	4.68	165	18,566	500	4,822

1. Criteria used to determine gravel suitability for spring-run Chinook: D_{50}=10-46 mm, $D_{84}\leq$150 mm, quality $\geq$7. Criteria used to determine gravel suitability for steelhead: D_{50}=10-46 mm, $D_{84}\leq$150 mm, quality $\geq$6. Spawning gravel areas in Reaches 1 and 2 are calculated based on ratios developed in the Mohican instream flow study site. Spawning gravel areas in Reaches 3, 5, 6, and 7 are calculated based on ratios developed in the Tin Can Cabin instream flow study site. Spawning gravel area in Reach 4 is calculated based on ratios developed in the Wheelbarrow instream flow study site. Reach 8 does not contain suitable and available spawning gravel.

3.2.4 Instream Flow

Daily flows in the Tuolumne River upstream of Don Pedro Reservoir vary greatly due to San Francisco Public Utilities operation of CCSF’s Hetch Hetchy Project, primarily peaking operations at Holm Powerhouse. Hourly flows observed in the upper Tuolumne River often fluctuate widely, with peak-to-base-flow ratios up to 12:1 (RMC and McBain & Trush 2007). Flow changes of this magnitude and frequency can occur throughout the year and are likely to overlap the spawning and rearing life-history periods of the target species. To illustrate the extent of stage change, data are presented for June 30, 2014 (Figure 3.2-1), when flows decreased rapidly from 1,300 cfs to 150 cfs. At the Cherry Creek location near Holm Powerhouse, stage decreases associated with this operational change exceeded 30 in/hr. At the Ward’s Ferry location, about 24 miles downstream, observed stage decreases were approximately 4.5 to 5 in/hr. At the Tin Can Cabin location (RM 93.5, about 13 miles upstream of Ward’s Ferry), estimated stage change during the downramp period was approximately 16 in/hr.

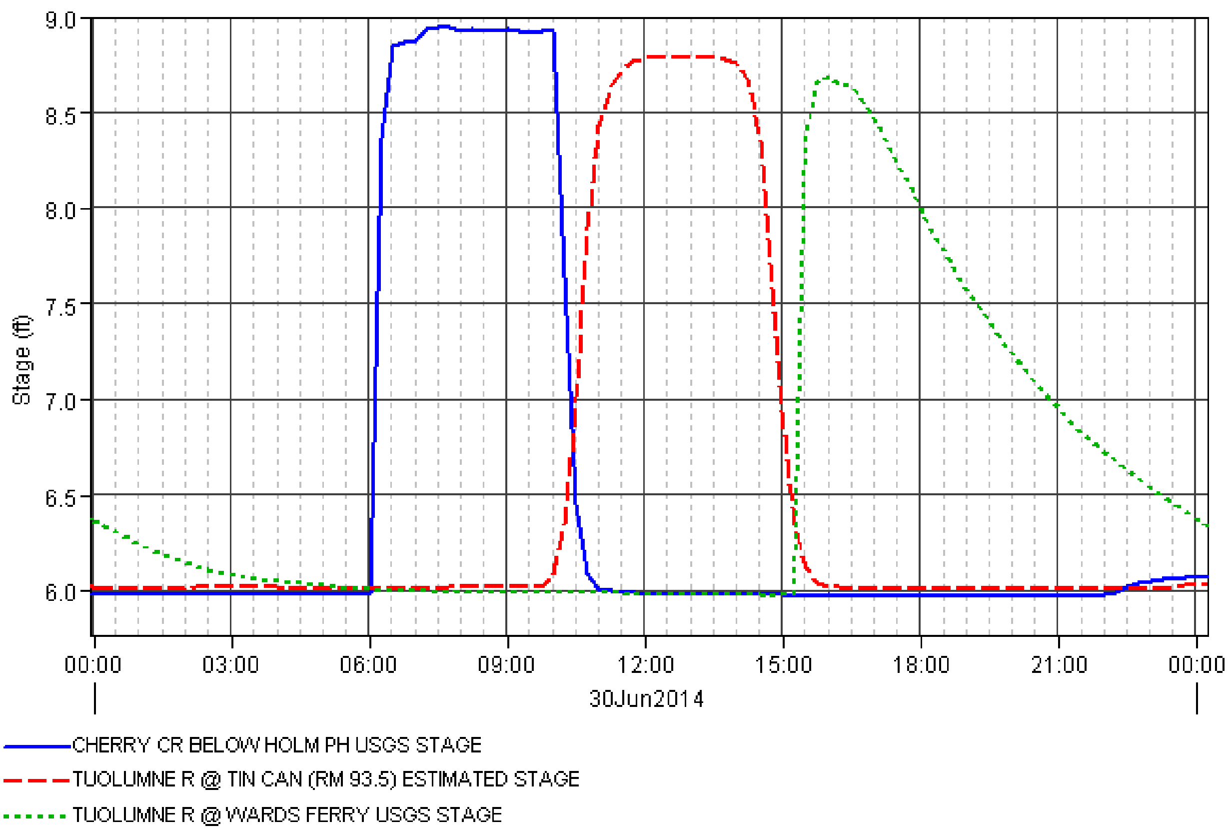

Figure 3.2-1. USGS stage data at Cherry Creek below Holm Powerhouse and at Ward's Ferry, and estimated stage information from Tin Can Cabin (RM 93.5) associated with a 1,300 to 150 cfs decrease in flows observed on June 30, 2014.

Accessible habitat in the upper Tuolumne River could only be used by the target species under suitable hydraulic conditions. Depths and water velocities vary dramatically on a daily basis in response to the flow changes described above. Egg incubation and fry emergence success would depend on redd location. Redds created in the channel margin during the high end of peaking flows would be susceptible to later dewatering, which would likely lead to desiccation of the incubating eggs. Fry would be forced to move laterally and longitudinally in response to flow fluctuations, which would impose a bioenergetic liability on the fish and subject them to increased predation. Fluctuating flows would also result in stranding and trapping of fry and juveniles, which would result in direct mortality and increased exposure to predators. Although hourly stage changes are attenuated with distance downstream (Figure 3.2.-1), the risk of stranding and trapping may be greatest closer to Don Pedro Reservoir, where the channel is wider and characterized by a lower gradient (Figure 3.2-2). Hunter (1992), a source widely cited by resource agencies, found that stage changes greater than 1 in/hr can result in significant stranding of salmon and steelhead fry. The stage changes in the upper river greatly exceed the rate identified by Hunter (1992) to minimize the risk of stranding. According to Hunter (1992), stranding risk is generally higher during daylight hours, which is when the effects of peaking in the upper river are most pronounced (Figure 3.2-1).

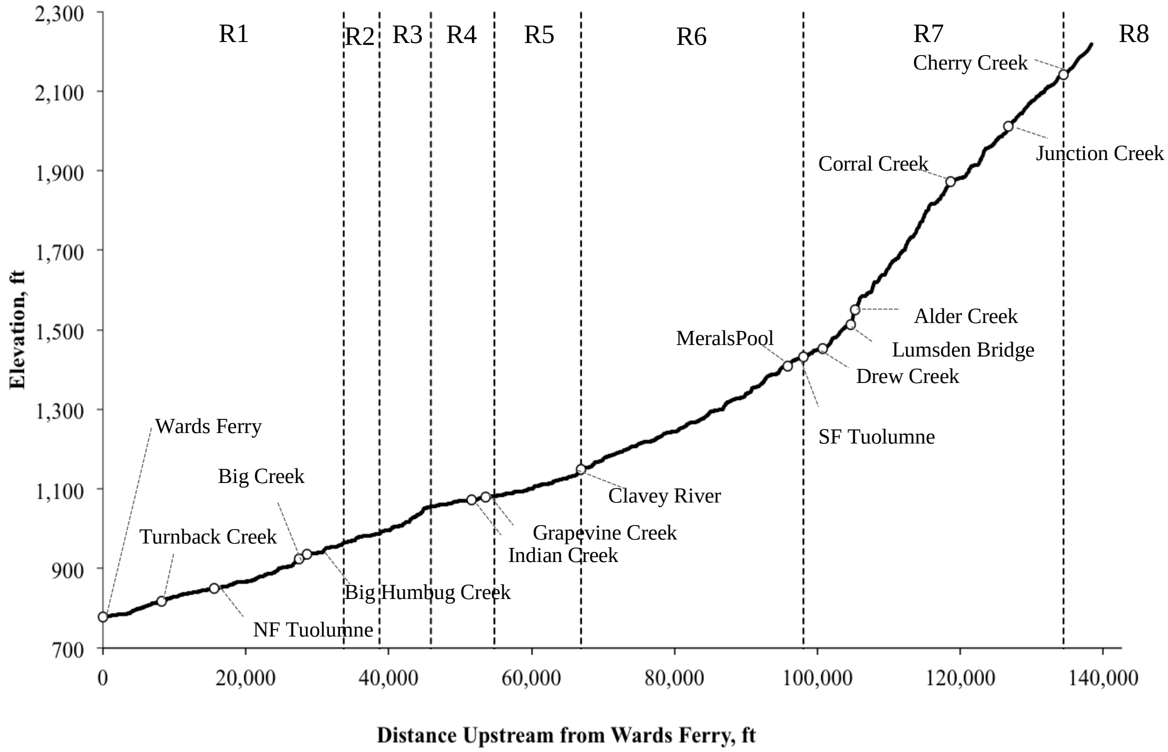

Figure 3.2-2. Changes in channel gradient by reach (R) in the mainstem upper Tuolumne River.

For the Instream Flow Study (Appendix H), a Hydropeaking Analysis Tool was developed to examine how spring-run Chinook and steelhead spawning, incubation/emergence and fry rearing habitats are affected by rapidly changing river flows. These life-history stages were selected because they are the ones most susceptible to the adverse effects of power peaking in the upper Tuolumne River. Nevertheless, juveniles and adults would also be adversely affected by the extreme changes in river stage and velocity associated with frequent peaking operations.

Estimates of the number of potential spring-run Chinook and steelhead redds that could be supported in the upper basin, by year, are presented in Table 3.2-2. Estimates account for the effects of redd dewatering due to peaking operations, i.e., values in the table include only areas that would have remained wetted through the incubation period. Reach scaling of the site-specific spawning and incubation analysis to the 17-mile reach from the upper end of Don Pedro Reservoir to Lumsden Falls suggests that a maximum of 219 Chinook redds could have been created in 2013, and a minimum of 0 could have been created in 2011. For steelhead, a maximum of 766 redds could have been created in 2015, and a minimum of 226 could have been created in 2008.

Table 3.2-2. Estimates, by year, of the total number of potential spring-run Chinook and steelhead redds in the Upper Tuolumne River from the upper end of Don Pedro reservoir to Lumsden Falls, RM 81–98 (results extrapolated from Hydropeaking Analysis Tool results for three study sites; see Appendix H for a description of the study sites).

Year	Estimated Usable Area (m^2)	Estimated Number of Potential Redds
Spring-Run Chinook		
2009	312.42	52
2010	223.32	37
2011	0.00	0
2012	407.58	68
2013	1,313.09	219
2014	366.89	61
2015	167.45	28
2016	110.20	18
Median	**268**	**45**
Steelhead		
2008	1,358.68	226
2009	1,920.53	320
2010	2,378.06	396
2011	1,543.06	257
2012	1,643.22	274
2013	3,500.40	583
2014	1,715.98	286
2015	4,597.95	766
2016	2,013.60	336
Median	**1,920.53**	**320**

Estimates of fry stranding risk are shown in Table 3.2-3. The weekly stranding risk for both spring-run Chinook and steelhead fry is often high, making it almost certain that few fry would survive in many years, especially given the magnitudes of stage changes in the upper river (Figure 3.2-1). For steelhead, the risk of daily stranding is high in many years.

Table 3.2-3. Hydropeaking Analysis Tool estimates of stranding risk for spring-run Chinook and steelhead fry, by year, for all study sites combined (see Appendix H for explanation of study sites).

	Percent Stranding Risk			
Year	**Overall**	**Less than Once per Week**	**Weekly**	**Every Day**
Spring-Run Chinook				
2009	54%	54%	0%	0%
2010	58%	48%	10%	0%
2011	68%	61%	7%	0%
2012	44%	18%	26%	0%
2013	64%	38%	26%	0%
2014	48%	19%	29%	0%
2015	55%	18%	37%	0%
2016	69%	24%	45%	0%
Average	**57%**	**35%**	**23%**	**0%**
Steelhead				
2008	67%	37%	30%	0%
2009	76%	51%	24%	0%

	Percent Stranding Risk			
Year	**Overall**	**Less than Once per Week**	**Weekly**	**Every Day**
2010	87%	60%	27%	0%
2011	86%	70%	16%	0%
2012	65%	19%	32%	14%
2013	61%	5%	31%	26%
2014	53%	1%	21%	31%
2015	52%	4%	17%	31%
2016	79%	34%	21%	25%
Average	**70%**	**31%**	**24%**	**14%**

3.2.5 Water Temperature

The Upper Tuolumne River Flow and Temperature Model (TID/MID 2017d; report included as Appendix C1) was applied to the period 2008–2016 using life-stage-specific water temperature index (WTI)[5] values to assess thermal suitability in the upper Tuolumne River for spring-run Chinook and steelhead (TID/MID 2017e; report included as Appendix C2). WTI values and associated species periodicities were collaboratively developed and approved by the Framework Plenary Group. WTI values were based on literature review, which included up-to-date regional and site-specific information on the effects of water temperature on the growth and survival of salmon and steelhead.

Modeling results indicate that WTIs are exceeded in all years for at least one life-stage at one of the study locations for spring-run Chinook salmon, and in many years for at least one life-stage of steelhead (see TID/MID 2017e for detail; report included as Appendix C2). Peaking operations associated with the Holm Powerhouse reduce temperatures relative to what they would be in the absence of flow releases in the upper Tuolumne River; extended power outages (planned or unplanned) result in warmer water temperatures in the upper Tuolumne River during summer and early fall.

A supplemental analysis conducted by the Districts (Appendix M) expanded the assessment of water temperatures based on guidance recommended by the U. S. Environmental Protection Agency (EPA) (2003) for Chinook salmon and steelhead. EPA (2003) guidelines[6] were used to assess temperatures at the same locations where WTIs were assessed. Evaluation of modeled river temperatures for different fish life-history stages demonstrates that the EPA guidelines are often exceeded along the upper Tuolumne River mainstem, despite the cooling effects of flow releases in the upper basin (i.e., the guidelines would be exceeded even more often under natural conditions).

The percentages of days when EPA (2003) guidelines are exceeded, for each life-stage periodicity, are shown in Table 3.2-4. The values shown in the table represent the percentage of exceedances for an entire life-stage period. However, exceedances often occur during consecutive or near-consecutive days during shorter periods within the overall life-stage periods identified in the table. For example, the duration of the spring-run Chinook incubation/emergence period shown in

[5] Upper Optimum Water Temperature Index (UOWTI) and Upper Tolerable Water Temperature Index (UTWTI), see TID/MID 2017d, report included as Appendix C2)

[6] The EPA (2003) guidelines are based on the 7-day-average of daily maximum (7DADM) temperatures.

Table 3.2-4 (i.e., 139 days) represents the date range for the population. Individuals within the population complete incubation in significantly less time, so for embryos in a particular redd, the percentage of days when the EPA guidelines are exceeded can be much higher than the 40–45 percent reported in the table. To illustrate this, the percentages of days when 7DADM temperature exceeded EPA (2003) recommended benchmarks during high risk time periods are shown in Table 3.2-5.

Table 3.2-4. Percentage of days during which 7DADM exceeded EPA (2003) guidelines, by location and life stage, for spring-run Chinook salmon and steelhead, in representative year 2008[7].

Life Stage	Total Days	River Location Number										
		1	2	3	4	5	6	7	8	9	10	11
		Percentage of Days Exceeded										
Spring-Run Chinook												
Adult Upstream Migration (03/01–05/31)	92	9	0	0	0	0	0	0	0	0	0	0
Adult Holding (04/01–09/15)	168	55	43	39	41	41	42	43	44	44	46	46
Spawning (08/15–10/31)	78	80	72	72	73	73	73	73	73	81	80	81
Incubation/Emergence (08/15–12/31)	139	45	40	40	41	41	41	41	41	45	45	45
Fry Rearing (11/01–03/31)	152	0	0	0	0	0	0	0	0	0	0	0
Juvenile Rearing and Downstream Movement (01/01–12/31)	366	32	20	18	19	19	19	21	22	22	25	25
Smolt Outmigration (10/01–05/31)	244	3	0	0	0	0	0	0	0	0	0	0
Steelhead												
Adult Upstream Migration (11/01–03/31)	152	0	0	0	0	0	0	0	0	0	0	0
Adult Holding (11/01–12/15)	45	0	0	0	0	0	0	0	0	0	0	0
Spawning (12/15–4/30)	138	0	0	0	0	0	0	0	0	0	0	0
Incubation/Emergence (12/15–5/31)	169	13	0	1	4	4	4	5	7	7	10	10
Fry Rearing (02/01–07/15)	166	11	5	5	5	5	5	6	6	6	7	7
Juvenile Rearing and Downstream Movement (01/01–12/31)	366	19	11	9	10	10	9	12	14	15	16	16
Smolt Outmigration (12/01–04/30)	152	0	0	0	0	0	0	0	0	0	0	0

[7] Simulated temperatures in 2008 are presented because they are most representative (nearest to average) of normal annual runoff in the Tuolumne River above the Hetch Hetchy system, an area which is essentially unimpaired.

Table 3.2-5. Percentage of days during which 7DADM temperatures exceeded EPA (2003) recommended benchmarks during high risk time periods, by location for select life stages, of spring-run Chinook salmon and steelhead in representative year 2008[8].

Life Stage	Month	River Location Number: 1	2	3	4	5	6	7	8	9	10	11
		Percentage of Days Exceeded										
Spring-Run Chinook												
Adult Holding	July	90	87	87	90	90	94	94	97	97	100	100
	Aug	100	100	100	100	100	100	100	100	100	100	100
Adult Spawning	Sep	100	100	100	100	100	100	100	100	100	100	100
Juvenile Rearing and Downstream Movement	Aug	100	100	100	100	100	100	100	100	100	100	100
	Sep	100	43	27	30	33	37	57	60	53	70	70
Steelhead												
Fry Rearing	Jun	0	0	0	0	0	0	0	0	0	0	0
	Jul	87	68	65	65	65	65	68	71	81	87	87
Juvenile Rearing and Downstream Movement	Aug	100	55	45	48	58	45	77	94	100	100	100
	Sep	10	3	0	0	0	0	0	0	0	0	3

3.3 Macroinvertebrate Populations in the Upper Tuolumne River

Results of Appendix G indicate that benthic macroinvertebrate populations are healthy at locations sampled in the upper Tuolumne River basin. All but one of the benthic macroinvertebrate samples collected from the upper Tuolumne River in summer 2016 had California Stream Condition Index scores that fell within the "likely intact" condition category. However, comprehensive investigations of macroinvertebrate abundance and diversity have not yet been conducted, so it is unknown how food availability for rearing anadromous salmonids might vary throughout the accessible reaches of the upper Tuolumne River basin.

3.4 Fish Species in the Upper Basin

The existing fish assemblage in the upper Tuolumne River and its tributaries consists mainly of resident rainbow trout, brown trout, Sacramento sucker, Sacramento pikeminnow, California roach, and hardhead (CCSF 2008). California Department of Fish and Wildlife (CDFW) has released, or continues to release, kokanee, brook trout, rainbow trout, coho salmon, Chinook salmon, brown trout, and Eagle Lake trout in the Tuolumne River watershed (CDFW 2016). Brown trout, which are aggressive piscivores, are common and grow large (>18 inches) in the upper mainstem Tuolumne River, as do resident *O. mykiss* (Weaver and Mehalick 2009). There is also evidence that kokanee and Chinook salmon stocked in Don Pedro Reservoir sometimes spawn in the upper basin (CCSF 2008, Bacher 2013, Perales 2015).

As noted in TID/MID (2017f; report included as Appendix D), salmonid species present in the upper Tuolumne River basin spawn and rear in habitats that overlap those preferred by the target species. Although direct competition for spawning habitat would typically favor the larger anadromous fish, redd superimposition by resident and adfluvial fish would result in at least some disturbance of the eggs and alevins of introduced anadromous salmonids.

[8] Simulated temperatures in 2008 are presented because they are most representative (nearest to average) of normal annual runoff in the Tuolumne River above the Hetch Hetchy system, an area which is essentially unimpaired.

Spring-run Chinook and steelhead fry and juveniles would be preyed upon by resident fish. Resident brown and *O. mykiss* would also prey on the eggs of introduced spring-run Chinook and steelhead. Johnson and Ringler (1979) found that Pacific salmon eggs accounted for 90 percent of the October diet of adult brook and brown trout in a tributary to Lake Ontario. Any fry or juveniles displaced downstream to Don Pedro Reservoir would encounter large numbers of predatory black bass and therefore be unlikely to survive.

3.5 Disease Transmission

Exposure of resident fish to novel pathogens could adversely affect their populations in the upper Tuolumne River basin, and donor fish could succumb to infections resulting from exposure to unfamiliar strains of pathogens established in the upper Tuolumne River. Anderson et al. (2014) identify the spread of pathogens as a risk associated with fish introduction and state that establishing baseline disease levels prior to introduction and screening individuals for pathogens prior to release are key elements of minimizing risks associated with an introduction program. McClure et al. (2011) identify the following disease-related "important components of reintroduction": establishing a pathogen profile within the receiving waters prior to an introduction to establish a baseline to which disease monitoring results can be compared during and following introduction, and screening hatchery-reared or translocated fish prior to release to minimize the risk of spreading disease. Also, although anadromy may not necessarily introduce novel pathogens, it can increase their prevalence in a river system (Warnock et al. 2016). Warnock et al. (2016) state that disease transmission pathways should be assessed to identify the fish introduction method with the lowest risk, and note that certain life stages are less likely than others to introduce novel pathogens.

Evaluation of the risk of disease transmission has been an important and thoroughly studied issue in other river basins where NMFS has participated in the planning of anadromous fish reintroductions. For example, as part of the anadromous fish reintroduction program associated with the Pelton Round Butte Project on the Deschutes River, Oregon, the potential for disease transfer resulting from the reestablishment of fish passage was identified as a major issue. Fish management agencies were concerned about: (1) the potential for significant disease-related losses in resident fish populations upstream of the Project dams and (2) adverse effects of diseases on the success of anadromous fish reintroductions. Portland General Electric (one of the co-applicants that applied for a new FERC license) contracted with the ODFW Fish Health Section to conduct a multi-year assessment of fish populations upstream and downstream of the Project to determine which fish disease agents not currently found above the Project had the potential to become established there as the result of fish passage (Engelking 2003). In addition, fish stocks from upstream of the Project were tested to determine their susceptibility to pathogens that might be transferred upstream as the result of reinitiating fish passage (Engelking 2003).

At this time, comprehensive disease profiles for potential donor sources and the upper basin fish community are not available, and the lack of such evaluations in the Tuolumne River represents a data gap that would need to be addressed by NMFS before any decision about fish passage can be reached. The limited research that has been done indicates that there is a low incidence of fish disease in the Tuolumne River downstream of La Grange Diversion Dam (e.g., Nichols and Foott

2002), so caution should be exercised when contemplating the release of any donor fish from out-of-basin sources into the Tuolumne River.

3.6 Life-Cycle Assessment

Juvenile anadromous fish produced in the upper basin would be passed around Don Pedro Reservoir and the La Grange headpond and then migrate downstream through the lower Tuolumne River, the lower San Joaquin River, and the Bay Delta, where their survival would be adversely affected by: (1) operation of the Central Valley and State Water projects, (2) water management in the San Joaquin, Merced, and Stanislaus rivers, (3) the Stockton Deep Water Ship Channel, (4 private diversions in the Delta, (5) levees in the San Joaquin River and Delta, (6) channel alterations due to in-channel mining, (7) agriculture and livestock grazing, (8) industrial and residential development, (9) fish hatchery practices, (10) introduced species, and (11) recreation. After surviving ocean rearing, adult fish would be affected by some of these same actions and conditions during their upstream migration.

The NMFS West Coast Region website acknowledges the many factors affecting successful life-cycle completion for anadromous fish in the Central Valley: "Fish passage is one consideration among many that inform salmon and steelhead recovery efforts. For example, in the Sacramento and San Joaquin river basins, over 94 percent of historical riparian habitat and over 95 percent of historical wetlands are no longer available to support healthy fish runs. Additionally, over 95 percent of the original 550 square miles of tidal wetlands in the Delta are gone... In addition, degradation of accessible habitat, altered stream flows, warm water temperatures, reduced Delta outflows, predation by non-native fish, and legacy effects of hatcheries all contribute to the current status of the Central Valley's listed species."

To assess whether a viable (i.e., at low risk of extinction) spring-run Chinook population could be successfully established in the upper Tuolumne River basin, Stillwater Sciences developed a life-history model[9] to simulate the number of adults returning to spawn three years after ocean entry (Appendix K). The model is structured to address the entire life-history of spring-run Chinook by accounting for fish survival at each life-stage and in the various environments that would be encountered during those life-stages, i.e., adults reaching holding areas, holding adults to spawners, effective redds to eggs, eggs to emergent fry, emergent fry to end of summer rearing, end of summer to end of winter rearing, end of winter to smolts collected at a hypothetical downstream passage facility in Don Pedro Reservoir, smolts collected in Don Pedro Reservoir to smolts reaching the La Grange Diversion Dam, smolts reaching La Grange Diversion Dam to smolts exiting the Tuolumne River, smolts exiting the Tuolumne River to smolts reaching Mossdale, smolts reaching Mossdale to smolts reaching Chipps Island, smolts reaching Chipps Island to smolts reaching the ocean, smolts reaching the ocean to adults attempting to return, and adults returning to the Tuolumne River.

Using the initial model formulation and parameterization, the ratio of adults returning to holding habitats below the La Grange Diversion Dam (i.e., those that could be transported upstream) to adults arriving three years earlier (i.e., adult replacement ratio) is about 68 percent, which would

[9] For the life-history model, an initial target population size of 2,500 adults was selected based on NMFS Recovery Plan criteria for a recovered spring-run Chinook salmon population at low risk of extinction (NMFS 2014, Lindley et al 2007).

be insufficient to maintain a self-sustaining salmonid population of spring-run Chinook originating in the upper Tuolumne River watershed. Results were based on high survival estimates for in-river life stages, that is, the simulated number of fish entering the river downstream of LGDD is unrealistically high. Based on this, it is clear that low emigration survival is the main contributor to the low simulated adult replacement ratio. The model did not address peaking operations in the upper basin, which, if accounted for, would dramatically reduce fish production (see Section 3.2.4) and further reduce the simulated number of returning adults, resulting in an adult replacement ratio well below that needed to sustain the population.

3.7 Fish Passage Technology

The Districts conducted a Fish Passage Facilities Alternatives Assessment (TID/MID 2017b; report included as Appendix A) to gather information on potential passage facilities, including general biological and engineering design parameters and operational considerations, in a collaborative process with licensing participants, including NMFS. As part of this exercise, the Districts assessed functional site layouts, facility sizing, general design parameters, effects of environmental conditions, expected fish collection and survival efficiencies, construction costs, and operation and maintenance costs for select fish passage alternatives.

Conceptual designs for potential upstream and downstream fish passage facility alternatives were developed and assessed for feasibility based on the following criteria: (1) the facility could be engineered, constructed, and operated safely in the context of existing environmental conditions and site constraints, (2) the alternative could be implemented without undue adverse effects on existing facilities and uses, and (3) the alternative would need to be able to achieve usual and customary performance standards, such as collection efficiency, survival rates, and passage efficiency.

Five potential upstream fish passage alternatives were evaluated: (1) technical fish ladder–bypass, (2) two separate technical fish ladders, (3) fish lift with technical ladder at La Grange, (4) collect, handle, transport, and release (CHTR) facility, and (5) a Whooshh© fish transport tube. Of these, only the CHTR was determined to be technically feasible.

Four potential downstream fish passage alternatives were evaluated: (1) fixed multi-port collector with helical bypass near Don Pedro Dam, (2) floating surface collector near Don Pedro Dam, (3) floating surface collector near the head of Don Pedro Reservoir, and (4) fixed in-river collector. None of the downstream alternatives was determined to be technically feasible. Of the alternatives evaluated, only the floating surface collector near the dam is a facility type that is currently in operation. The remaining alternatives represent experimental technologies that have yet to be applied at a full scale, and it is unknown how or whether such a facility would work. None of the four alternatives would meet the anticipated agency-mandated reservoir passage and facility-specific performance standards required at other high dam facilities (e.g., in the Pacific Northwest).

Because the only feasible upstream passage option is CHTR, which bypasses the reservoirs, and all the downstream passage options were determined to be infeasible, the Districts are not conducting a study of juvenile anadromous salmonid movement through the reservoirs.

Regardless, the size, water temperature regime, and abundance of non-native piscivores would render Don Pedro Reservoir impassable to most, if not all, downstream migrating salmonids.

Estimated construction costs for upstream passage facility alternatives at La Grange Diversion Dam range from $33 to $294 million, with operations and maintenance costs up to $400,000 per year. Estimated construction costs for the infeasible downstream passage facility alternatives range from $49 to $285 million, with operations and maintenance costs up to $500,000 per year. These estimates do not include implementation costs or the inevitable costs associated with refinement, modification, and/or replacement of facility components to improve performance.

As noted above, collecting fish at the head of Don Pedro Reservoir would not be feasible. Moreover, because of the inhospitable conditions in the reservoir, any approach involving reservoir transit would be doomed to failure. Any juvenile fish trapped at a facility located at the head of the reservoir would have to be transported downstream and released into the lower Tuolumne River. The combination of this downstream transport with the use of CHTR for upstream passage would constitute a two-way trap-and-haul operation. As noted by Lusardi and Moyle (2017), "Capturing large numbers of outmigrating juveniles is the greatest management hurdle for two-way trap-and-haul operation programs…" As explained in Section 3.6, when the entire life cycles of the target species are considered, implementation of any form of successful passage/fish introduction program would be highly unlikely to succeed.

3.8 Regulatory Issues

A number of legal issues and a variety of management plans that apply in the upper basin would have to be considered when developing a plan to introduce the target species to the upper Tuolumne River basin (Appendix J). Among these, the ESA is the most significant. Any spring-run Chinook and steelhead introduced into the upper Tuolumne River would almost certainly be designated non-essential experimental populations[10]. Designating experimental population allows NMFS to advance its recovery objectives by attempting to establish self-sustaining populations while protecting private landowners, tribes, and governments from ESA-related liabilities, such as land and water use restrictions.

NMFS recently designated a non-essential experimental population of Central Valley Spring-Run Chinook Salmon below Friant Dam in the San Joaquin River (50 CFR Part 223 [Docket No. 121210693–3985–01] RIN 0648– BC68). In is designation NMFS stated, "…the unintentional take of CV spring-run Chinook salmon in the experimental population area that is caused by otherwise lawful activities is excepted from the take prohibitions under section 9. Examples of otherwise lawful activities include, but are not limited to, recreation, agriculture, municipal usage, flood control, water management, and other similar activities which are carried out in accordance with Federal, State, and local laws and regulations."

Attempting to establish viable populations of the target species in the upper Tuolumne River basin under current conditions would be unsuccessful, as explained in the preceding sections. One of the major limiting factors would be the power peaking operations of CCSF's Holm Powerhouse.

[10] Establishment of a non-essential experimental population would require a rulemaking by the Secretary of Commerce.

Exempting unintentional take associated with otherwise lawful activities, such as water management, from take prohibitions, as was done in the San Joaquin River, would mean that peaking would continue unhindered. Without limits on the current peaking regime, there is no chance of successfully establishing the spring-run Chinook and steelhead in the upper Tuolumne River basin at the levels considered by NMFS to represent a population at low risk of extinction (i.e., > 2,500 individuals of each species).

3.9 Socioeconomic Impacts

Construction and operation of the downstream passage facility could locally restrict access to and resource use at the upper end of Don Pedro Reservoir and/or in the upper Tuolumne River upstream to or beyond Ward's Ferry (Appendix I). Activities affected would include, but not necessarily be limited to, lake-based water activities that include houseboating and use by other types of powerboats and motorized watercraft, lake fishing, swimming, and effects on visual quality and conditions and aesthetic resources. Users of the Moccasin Point Recreation Area and dispersed campsites at the upper end of the reservoir would likely be most affected. The Moccasin Point Recreation Area has 96 campsites, a boat launch, and marina. If a downstream fish passage facility were to be located in the upper Tuolumne River channel, it would also affect riverine boating, potentially including whitewater rafting and kayaking. Anything affecting whitewater boating could adversely affect the commercial outfitters that offer upper river boating trips, which could alter use of the Wild and Scenic reach of the upper river.

Construction of fish passage facilities would lead to a small, temporary increase in demand for labor and materials, some perhaps procured locally. However, depending on the siting of a downstream passage facility, there could be adverse impacts during the construction phase if building the facility interrupts recreational use of the reservoir or upper Tuolumne River, or if the peaking operations of CCSF's Holm Powerhouse were curtailed. There would also be long-term adverse economic effects if the presence of ESA-listed species were to alter recreational use, boating and angling in particular, in the lower Tuolumne River, Don Pedro Reservoir, or the upper Tuolumne River basin. Expenses incurred by the Districts for implementation and maintenance of a costly fish passage program would be passed on to utility rate payers.

The biggest socioeconomic risk would be potential changes to water management in the upper Tuolumne River basin. As noted above, CCSF's peaking operations result in substantial flow variability that would severely limit the suitability of habitat for the target species. Fish would likely be initially introduced as part of nonessential experimental populations (as noted above), so flow fluctuations associated with peaking would continue unhindered. However, if designations for either spring-run Chinook or steelhead were to change, and full ESA protections were to take effect, San Francisco Public Utilities peaking operations would be dramatically curtailed. This in turn would limit whitewater boating in the upper Tuolumne River, which benefits substantially from the peaking operations of the Holm Powerhouse. The presence of an ESA-listed fish species in the upper Tuolumne River could also result in changes to release schedules to provide flows for physical habitat or temperature management, which, depending on their extent and timing, could interfere with CCSF's provision of drinking water to its Bay Area customers or curtail water availability for municipal and industrial uses.

4.0 LIKELIHOOD OF SUCCESSFUL INTRODUCTION OF THE TARGET SPECIES

Analysis of data collected by the Districts and evaluation of other sources of information demonstrate that attempts to introduce the target species into the upper Tuolumne River basin are unlikely to be successful. Specifically, the potential benefits to the recovery of CV spring-run Chinook and CCV steelhead are far outweighed by the liabilities. The direct and indirect costs of an introduction program would be exorbitant, and the likelihood of establishing viable populations is extremely low.

As discussed in the preceding sections, physical habitat availability and water temperature would limit anadromous fish production in the upper Tuolumne River basin. Much of the riverine habitat, particularly in the tributaries, is inaccessible due to natural migration barriers. Dramatic flow fluctuations due to peaking operations associated with CCSF's Holm Powerhouse would greatly limit physical (i.e., hydraulic) habitat suitability in the mainstem Tuolumne River. Also, much of the habitat in the accessible portions of the tributaries is hydraulically and/or thermally unsuitable for salmonids. Competition with resident fish and predation would influence the productivity of any introduced anadromous fish. Selection of donor stocks would require careful consideration of genetics and impacts on the source populations and resident fish established in the receiving waters. Life-cycle modeling shows that survival of juvenile fish passed downstream would be low due to an array of factors, including introduced predators, habitat alteration, and water diversions, among others. The costs of constructing, operating, and maintaining fish passage facilities would be high, and successfully operating and maintaining an experimental downstream fish passage facility would be infeasible due to a variety of constraints. In addition, regulatory changes to how resources are managed in the Tuolumne River and Don Pedro Reservoir could result in substantial socioeconomic impacts, the most significant of these being potential constraints on the operation of CCSF's Hetch Hetchy Project. Moreover, as noted by Anderson et al. (2014), in the case of introductions requiring adaptation to new habitat (i.e., the upper Tuolumne River basin) it would likely require decades before populations could become established. The authors further state, "Combined with the multiple generations probably required to achieve potential benefits, this suggests that reintroduction will rarely be a quick fix for improving the status of an ESU or population at immediate risk of extinction."

As noted earlier, NMFS has not conducted sufficient research and planning to justify the introduction of spring-run Chinook into the upper Tuolumne River or to connect the *O. mykiss* population upstream of the Don Pedro Project with the one located downstream of La Grange Diversion Dam. Furthermore, NMFS has not given reasonable consideration to alternative recovery strategies for the Tuolumne River Basin. As Anderson et al. (2014) point out, "It is also important to remember that reintroduction is only one management option. In some cases, reintroduction may be essential for the conservation of a particular life history type or evolutionary lineage. In other cases, management strategies designed to improve the reproductive success, survival, and productivity of extant populations might offer a better return on the investment dollar than reintroduction. We suggest that evaluating the potential benefits, risks, and constraints is necessary to weigh reintroduction against other management options and ensure that reintroductions contribute to long-term population and ESU viability."

5.0 REFERENCES

Anchor QEA. 2017. Conceptual Engineering Plans for Fish Passage at La Grange and Don Pedro Dams on the Tuolumne River. Prepared for NOAA Fisheries California Central Valley Office. Sacramento, CA. Prepared by Anchor QEA, LLC, Seattle, WA.

Anderson J.H., G.R. Pess, R.W. Carmichael, M.J. Ford, T.D. Cooney, C.M. Baldwin, and M.M. McClure. 2014. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery, North American Journal of Fisheries Management, 34:1, 72-93.

Bacher, D. 2013. Triple Fishing Fun and Lake Don Pedro. The Fish Sniffer 32(14):6-7.

Bennett, S., G. Pess, N. Bouwes, P. Roni, R.E. Bilby, S. Gallagher, J. Ruzycke, T. Buehrens, K. Krueger, W. Ehinger, J. Anderson, and C. Jordan, B. Bowersox, and C. Greene. 2016. Progress and Challenges of Testing the effectiveness of stream restoration in the Pacific Northwest using intensively monitored watersheds. Fisheries 41:2.

Bilby, R.E. and P.A. Bisson. 1998. Function and distribution of large woody debris. In River Ecology and Management. Naiman R.J. and R. E. Bilby (Eds.). New York, Springer, p. 324-346.

Boughton, D.A., S. John, C.J. Legleiter, R. Richardson, and L.R. Harrison. (in progress). On the Capacity of upper Tuolumne and Merced Rivers for Reintroduction of Steelhead and Spring-run Chinook Salmon; Part 1: Hydraulic and Geomorphic Components of Habitat Capacity. Draft Report dated August 2017.

City and County of San Francisco (CCSF). 2008. Final PEIR Volume 3 of 8 for the San Francisco Public Utilities Commission's Water System Improvement Program. City and County of San Francisco. State Clearinghouse No. 2005092026.

California Department of Fish and Wildlife (CDFW). 2016. Fish Planting Schedule. Available at < https://nrm.dfg.ca.gov/fishplants/> Accessed August 25, 2016.

_____. 2017. California Department of Fish and Wildlife, Central Region's Comments on the Draft License Application for the La Grange Hydroelectric Project, Federal Energy Regulatory Commission Project No. P-14581, Tuolumne River, California. August 2017.

California Department of Water Resources (CDWR). 2009. Hatchery and Genetic Management Plan for Feather River Hatchery Spring-run Chinook Salmon Program. Prepared by B. Cavallo (Cramer Fish Sciences), R. Brown, and D. Lee. June 2009.

Engelking, H.M. 2003. Draft Fish Health Management Plan for the Pelton Round Butte Project. Prepared by the Oregon Department of Fish and Wildlife, Fish Health Section, Corvallis, OR. February 2003.

EPA (U.S. Environmental Protection Agency). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Ford, T., and S. Kirihara. 2010. Tuolumne River Oncorhynchus mykiss monitoring report. Prepared by Turlock Irrigation District/Modesto Irrigation District, California and Stillwater Sciences, Berkeley, California for Federal Energy Regulatory Commission, Washington, D.C.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes and options for mitigation. Department of Fish and Wildlife.

Johnson, J.H. and N.H. Ringler. 1979. Predation on Pacific salmon eggs by salmonids in a tributary of Lake Ontario. Journal of Great Lakes Research, Volume 5, Issue 2, 1979, Pages 177-181.

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4: 361–380.

La Grange Hydroelectric Project Reintroduction Assessment Framework Plenary Group. 2017. La Grange Reintroduction Assessment Framework – May 18, 2017 Final Meeting Notes.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lusardi, R. A., and P. B. Moyle. 2017. Two-way trap and haul as a conservation strategy for anadromous salmonids. Fisheries, 42:9, 478-487.

McClure, M., J. Anderson, G. Pess, T. Cooney, R. Carmichael, C. Baldwin, L. Weitkamp, D. Holzer, M. Sheer, and S. Lindley. 2011. Anadromous salmonid reintroductions: general planning principles for long-term viability and recovery.

McMillan, J. R., J. B. Dunham, G. H. Reeves, J. S. Mills, and C. E. Jordan. 2012. Individual condition and stream temperature influence early maturation of rainbow and steelhead trout, *Oncorhynchus mykiss*. Environmental Biology of Fishes 93:343–355.

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

Nichols, K., and J. S. Foott. 2002. FY2001 Investigation Report: Health Monitoring and Natural Fall-run Chinook Salmon Juveniles in the San Joaquin River and Tributaries, April-June 2001. U.S. Fish and Wildlife Service. California-Nevada Fish Health Center.

Pearse, D.E. and M.A. Campbell. 2017. Genetic analysis of Oncorhynchus mykiss in the Upper Tuolumne and Merced Rivers to evaluate ancestry and adaptive genetic variation. Prepared for National Marine Fisheries Service. Prepared for the West Coast Region California Central Valley Office, Federal Energy Regulatory Commission Branch. Prepared by National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA.

Perales, K. Martin. 2015. What Lies Behind the Dam? In Some Cases, Self-Sustaining Salmon. California Water Blog. Available at <https://californiawaterblog.com/2016/02/14/5714/> Accessed August 25, 2016.

RMC Water and Environment (RMC) and McBain & Trush, Inc. 2007. [Online] URL: Upper Tuolumne River: Description of River Ecosystem and Recommended Monitoring Actions. Prepared for the San Francisco Public Utilities Commission. April 2007 (revised January 2016).

Sloat, M. 2013. Born to Run? Integrating Individual Behavior, Physiology, and Life Histories in Partially Migratory Steelhead and Rainbow trout (*Oncorhynchus mykiss*). PhD dissertation, Oregon State University, Corvalis, OR. March. 148 pp.

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2017a. La Grange Hydroelectric Project Final License Application. September 2017.

_______. 2017b. Fish Passage Facilities Alternatives Assessment Study Report. Prepared by HDR, Inc. September 2017.

_______. 2017c. Upper Tuolumne River Basin Fish Migration Barriers Study Report. Prepared by HDR, Inc. February 2017.

_______. 2017d. Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study: Model Development Study Report. Prepared by Watercourse Engineering, Inc. September 2017.

_______. 2017e. Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study: Temperature Indices Analysis Study Report. Prepared by Watercourse Engineering, Inc. September 2017.

_______. 2017f. Hatchery and Stocking Practices Review Study Report. Prepared by HDR, Inc. February 2017.

Warnock, W.G., D.H.P Stroud, and J.E. Merz. 2016. Donor stock selection of Chinook salmon for reintroduction to the Transboundary Reach of the Columbia River. Report prepared for the Canadian Columbia River Inter-Tribal Fisheries Commission. 153 pp.

Weaver, J. and S. Mehalick. 2009. Tuolumne River 2009 Summary Report. Heritage and Wild Trout Program, CDFG.

New Webster's Dictionary and Thesaurus of the English Language (Webster). 1992. Definition of "Feasible." Lexicon Publications.

Zimmerman, C.E., G.W. Edwards, and K. Perry. 2008. Maternal origin and migratory history of *Oncorhynchus mykiss* captured on rivers of the Central Valley, California. California Department of Fish and Game.