LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT D

EFFECTS OF THE PROJECT AND RELATED ACTIVITIES ON THE LOSSES OF MARINE-DERIVED NUTRIENTS IN THE TUOLUMNE RIVER STUDY REPORT

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LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Prepared for:
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Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River
Study Report

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List of Acronyms

ac-ft ....acre-foot
BLM...........................Bureau of Land Management
BOR ....Bureau of Reclamation
CCSF..........................City and County of San Francisco
CDFG.........................California Department of Fish and Game, now CDFW
CDFW........................California Department of Fish and Wildlife
cfs...............................cubic feet per second
CG..............................Conservation Group
Districts......................Turlock Irrigation District and Modesto Irrigation District
FERC..........................Federal Energy Regulatory Commission
FLA ....Final License Application
FPA ....Federal Power Act
GIS ....geographic information system
ILP..............................Integrated Licensing Process
ISR ....Initial Study Report
LGDD ....La Grange Diversion Dam
LP...............................Licensing Participant
M&I............................municipal and industrial
MID............................Modesto Irrigation District
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
O&M..........................operation and maintenance
PAD............................Pre-Application Document
PSP.............................Proposed Study Plan
QA/QC.......................quality assurance/quality control
RM ....river mile
RSP ....Revised Study Plan
SD2 ....Scoping Document 2
SPD ....Study Plan Determination
TAF ....thousand acre-feet
TID.............................Turlock Irrigation District
TM..............................technical memorandum
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
USR............................Updated Study Report

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four upstream reservoirs: Hetch Hetchy, Lake Eleanor, Cherry Lake, and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

Figure 1.1-1. **La Grange Hydroelectric Project location map.**

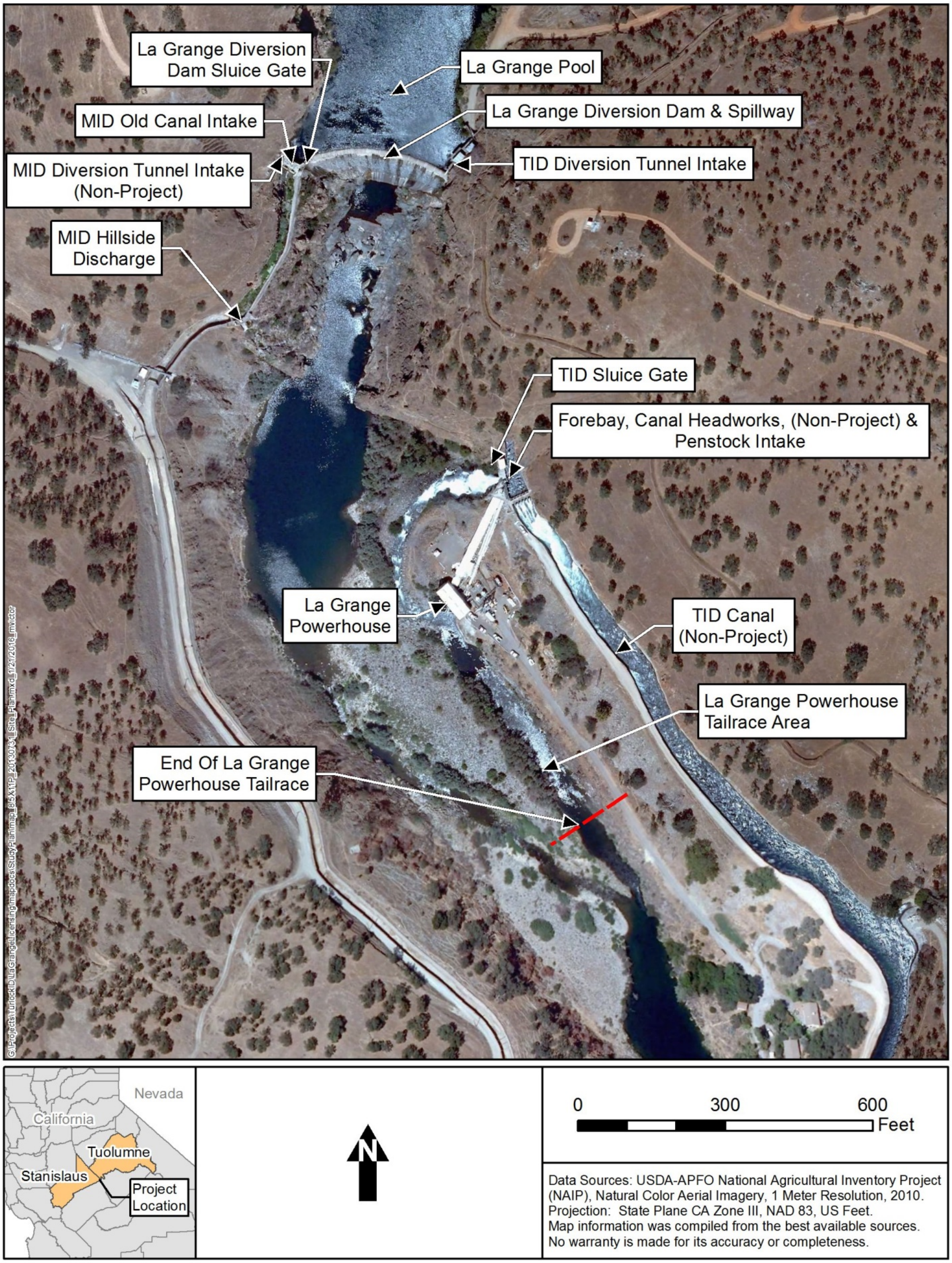

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

On January 29, 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document (PAD) with FERC[1]. The Districts' PAD included descriptions of the Project facilities, operations, and lands as well as a summary of existing information available on Project area resources.

On September 5, 2014, the Districts filed their Proposed Study Plan (PSP) to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On October 6, 2014, the Districts held a PSP meeting at MID's offices in Modesto, California. Based on discussion at the PSP meeting, the Districts prepared an Updated Study Plan document that went to licensing participants (LP) for review and comment on November 21, 2014. On December 4, 2014, the National Marine Fisheries Service (NMFS), the Conservation Groups (CG), and the California Department of Fish and Wildlife (CDFW) filed comments on the PSP and/or Updated Study Plan.

On January 5, 2015, in response to comments from LPs, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2]. Comments on the RSP were received from CDFW on January 16, 2015, and from NMFS, the CGs and the City of Modesto on January 20, 2015.

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by NMFS in its July 22, 2014 comment letter. Of the eight studies requested by LPs, FERC approved only the NMFS study noted above.

Although FERC's SPD did not require the Districts to undertake the Upper Tuolumne River Basin Habitat Assessment studies contained in the RSP, the Districts are voluntarily conducting the Upper River Barriers Study and the Water Temperature Monitoring and Modeling Study. Regarding the third component of the Upper Tuolumne River Basin Habitat Assessment, the ongoing upstream habitat characterization work being completed by NMFS, the Districts anticipate the results of this work becoming available for consideration in this licensing proceeding.

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).

[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."

[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the Project's powerhouse draft tubes and to determine the potential for injury or mortality from contact with the turbine runners. Per the SPD, the Districts developed a study plan in consultation with NMFS and other LPs. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

This study report describes the objectives, methods, and results of the Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River being implemented by the Districts in accordance with FERC's February 2, 2015 SPD. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's February 2, 2015 Study Plan Determination for the La Grange Project stated that FERC approved as filed NMFS' Request for Information or Study #5 - Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, dated July 22, 2014.

In its information request, NMFS stated that it was presenting an information request and not a specific study methodology (preferred data collection and analysis techniques, or objectively quantified information). The information presented in this report is responsive to the request by NMFS and is consistent with other studies of the same subject prepared for NMFS in other FERC proceedings.

2.0 STUDY GOALS AND OBJECTIVES

The goals and objectives for this study as provided below are taken from NMFS' study request dated July 22, 2014.

The goal or purpose of this study, as cited by NMFS, is to evaluate the potential effects of the Project and Project-related activities on the degree of reduction or loss in nutrient replenishment to the upper and lower Tuolumne River. The nutrients in question are those that are marine-derived, and then transported and deposited in freshwaters by migrating anadromous fishes. The mass of nitrogen (N) is addressed in this study for simplicity, although carbon and phosphorus are also transported and deposited by returning anadromous salmon.

The information to be obtained is:

(1) An estimate of a range of the historical mass of marine-derived N that was transported annually by Chinook salmon (all runs) to the Tuolumne River. For this study, this is considered to be a historical estimate.

(2) An estimate of the historical mass of marine-derived N that was transported annually by spring-run Chinook salmon to the upper Tuolumne River. For this study, this is considered to be a historical estimate.

(3) An estimate of the current annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River. This is existing information, for comparison with historical conditions.

(4) An estimate of annual losses, from historical to current levels, of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River. This compares existing conditions with historical conditions.

(5) An estimate of the annual loss, from historical to current levels, of marine-derived N to the upper Tuolumne River. This compares historical conditions with existing conditions (extirpated spring-run Chinook population).

3.0 STUDY AREA

Based on NMFS' study request (July 22, 2014), the study area includes the upper and lower Tuolumne River. Some components of the study request address estimated historical Chinook salmon escapement to the lower Tuolumne River, while some components address estimated historical Chinook salmon escapement to the upper Tuolumne River, or the combined upper and lower Tuolumne River. According to Yoshiyama et al. (2001), the historical natural upstream limit of anadromous fish is likely to have been Preston Falls on the mainstem Tuolumne River, approximately one mile above the mouth on the North Fork Tuolumne River, while the Middle Fork and South Fork Tuolumne rivers were presumably not used by salmon. Therefore, these are assumed to be the upstream limits of the study area for the purposes of this study. The lower limit of the study area is the confluence of the Tuolumne and San Joaquin rivers.

4.0 METHODOLOGY

4.1 NMFS Request Element #1: Estimate a range of the historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River

Element #1 of the study requires derivation of three primary variables: (1) estimated historical total annual escapement of all runs of Chinook salmon (i.e., fall-run and spring-run) to the Tuolumne River; (2) estimate of average mass of individual adult Chinook salmon; and (3) estimated average N content per individual fish.

4.1.1 Historical Total Annual Escapement of All Runs of Chinook Salmon (i.e., Fall-run and Spring-run) to the Tuolumne River

In its study request, NMFS (2014) acknowledges that information is not available regarding the actual, pre-European settlement, historical escapement ranges for Chinook salmon in the Tuolumne River.

NMFS (2014) provided references and quotes from some historical accounts for use in the development of this study. Empirical data of historical annual escapement estimates are not available; therefore, some anecdotal accounts must be used to approximate roughly historical quantities. To augment the information provided by NMFS (2014), a literature review was conducted to locate potential historical escapement estimates for spring-run Chinook salmon, as well as for fall-run Chinook salmon and total Chinook salmon escapement to the Tuolumne River. Based on the information provided by NMFS (2014) and this literature review, neither of which identified actual counts, the following methods were developed to provide a rough approximation of historical spring-run Chinook salmon, fall-run Chinook salmon and total Chinook salmon escapement to the upper Tuolumne River watershed.

4.1.1.1 Estimation of Potential Historical Spring-run Chinook Salmon Escapement to the upper Tuolumne River

Review of available literature did not reveal any readily available estimates of historical escapement of spring-run Chinook salmon specific to the Tuolumne River. Three anecdotal accounts of spring-run Chinook salmon escapement to the Tuolumne River were identified through the literature review. Each of these anecdotal accounts is addressed below in three different approaches to develop rough approximations of historical spring-run Chinook salmon escapement to the Tuolumne River.

First Approach

NMFS (2014) provided the following information.

> *"The former spring salmon run of the San Joaquin River has been described as one of the largest Chinook salmon runs anywhere on the Pacific Coast, possibly in the range of 200,000 to 500,000 spawners annually (CDFG 1990, in Yoshiyama et al. 2001, p. 91). It*

> *is not clear what proportion of this estimated run was contributed by the Tuolumne River, the largest San Joaquin tributary."*

The proportional distribution of reported historical habitat used by spring-run Chinook salmon in the upper San Joaquin River and the major tributaries to the San Joaquin River (Stanislaus, Merced and Tuolumne rivers) was used in an effort to allocate the above-referenced total annual spring-run Chinook salmon escapement among the San Joaquin River and its tributaries, including the Tuolumne River. Yoshiyama et al. (2001) provides information regarding the potential upstream extent of salmon passage and habitat utilization in the various rivers, but little information regarding the downstream extent. Given that spring-run Chinook salmon historically ascended their natal streams into the upper portions to hold and spawn, for this study it is generally assumed that the lower boundary of historical spawning habitat was located in the reaches above existing impassible dams.

Yoshiyama et al. (2001) reports that spring-run Chinook salmon in the mainstem Tuolumne River historically were most likely restricted to below Preston Falls, located four miles above Early Intake near the boundary of Yosemite National Park (about 50 miles upstream of the existing Don Pedro Dam). Steep reaches and natural impediments in the Clavey River and the South and Middle forks of the Tuolumne River just above their mouths most likely prevented passage of adult Chinook salmon, suggesting that spring-run Chinook salmon did not utilize the South or Middle forks of the Tuolumne River (T. Ford, personal communication, as cited in Yoshiyama et al. 2001), nor the Clavey River. In the North Fork Tuolumne River, a 12-foot waterfall approximately one mile upstream of the mouth reportedly also likely limited upstream access to salmonids (Yoshiyama et al. 2001). Therefore, it is assumed that access by spring-run Chinook salmon to the upper Tuolumne River Basin was primarily limited to approximately 50 miles of the mainstem Tuolumne River upstream of the existing Don Pedro Dam, and approximately one mile of the North Fork Tuolumne River. Overall, Yoshiyama et al. (2001) estimates that a total of about 52 miles of the historically available 104 miles remain available to Chinook salmon in the Tuolumne River.

In the upper San Joaquin River, Yoshiyama et al. (2001) reports that spring-run Chinook salmon historically ascended past the present site of Kerckhoff Power House to upstream spawning grounds (CFGC 1921b, as cited in Yoshiyama et al. 2001). Although a natural barrier shortly upstream of Willow Creek near present-day Redinger Lake may have obstructed passage of Chinook salmon (E. Vestal, personal communication, as cited in Yoshiyama et al. 2001), there is reportedly evidence that Chinook salmon traveled much further upstream at least to the vicinity of present-day Mammoth Pool Reservoir. Although Yoshiyama et al. (2001) estimate that a total of 173 miles were historically available to spring-run Chinook salmon in the upper San Joaquin River, based on accounts of historical spring-run Chinook salmon adult holding and spawning in the San Joaquin River (Yoshiyama et al. 2001), spring-run Chinook salmon appear to have primarily utilized the Friant area and areas upstream for holding and spawning. Therefore, for the purposes of this analysis, it is assumed that approximately 55 miles were historically available to spring-run Chinook salmon spawning in the upper San Joaquin River (i.e., RM 267 (Friant Dam) upstream to RM 322 (Mammoth Pool Reservoir)).

Yoshiyama et al. (2001) provides additional information on the potential historical distribution of spring-run Chinook salmon in the Stanislaus and Merced rivers. One ethnographic account stated that on the Middle Fork Stanislaus River, salmon went upstream as far as a waterfall at Baker's Bridge (Barrett and Gifford 1933 in Yoshiyama et al. (2001)), located about two miles below present-day Beardsley Reservoir. The practical upstream limit of historical salmon distribution on the North Fork Stanislaus River is McKay's Point (about eight miles above the confluence with the Middle Fork). Yoshiyama et al. (2001) found no suggestions of salmon having occurred in the South Fork Stanislaus River, and do not include it as a former salmon stream. Overall, Yoshiyama et al. (2001) estimates that a total of about 66 miles of the historically available 124 miles remain available to Chinook salmon in the Stanislaus River. Yoshiyama et al. (2001) also estimates that a total of about 56 miles of the historically available 107 miles remain available to Chinook salmon in the Merced River.

A rough approximation of spring-run Chinook salmon escapement to the upper Tuolumne River can be made assuming that: (1) the San Joaquin river system, including the upper San Joaquin, Stanislaus, Merced and Tuolumne rivers, may have produced from 200,000 to 500,000 spring-run Chinook salmon annually; (2) historical densities of spawning spring-run Chinook salmon were proportionally distributed among the upper San Joaquin River and major tributaries to the lower San Joaquin River; and (3) spring-run Chinook salmon spawning habitat generally was located in the reaches above existing impassible dams. Based on Yoshiyama et al. (2001), approximately 55, 66, 56 and 52 miles were historically available to Chinook salmon in the upper portions of the upper San Joaquin, Stanislaus, Merced and Tuolumne rivers. Applying these lengths of habitat as proportions of the total length (229 miles) of habitat in the upper portions of these rivers, the Tuolumne River could have experienced historical maximum annual returns ranging from about 45,000 to 114,000 spring-run Chinook salmon.

Second Approach

Regarding spring-run Chinook salmon historical escapement, NMFS (2014) stated that Moyle (2002) suggested that spring-run Chinook salmon in the upper San Joaquin River probably exceeded 200,000 fish at times, and further stated that "*it is likely that an equal number of fish were once produced by the combined spring runs in Merced, Tuolumne, and Stanislaus Rivers. However, early historical population levels were never measured*." (p. 260).

Based on Moyle's (2002) statement, for this study we used a historical estimate of 200,000 spring-run Chinook salmon as a combined annual run to the Stanislaus, Merced and Tuolumne rivers. Using the same methodology employed in the first approach, a rough approximation of spring-run Chinook salmon escapement to the upper Tuolumne River can be made. Based on Yoshiyama et al. (2001), approximately 66, 56 and 52 miles were historically available to Chinook salmon in the upper portions of the Stanislaus, Merced and Tuolumne rivers, respectively. Applying these lengths of habitat as proportions of the total length (174 miles) of habitat in the upper portions of these rivers, the Tuolumne River might have potentially experienced historical maximum annual returns approximating 60,000 spring-run Chinook salmon.

Third Approach

According to Reynolds et al. (1993), large runs of salmon in the San Joaquin River near Fresno during the 1940s were predominantly spring-run Chinook salmon. They stated that Chinook salmon total production (ocean harvest plus spawning escapement) in the San Joaquin River drainage historically approached 300,000 adults but probably averaged nearer 150,000 adults. Although no direct reference to spawning escapement was specifically made by Reynolds et al. (1993), a rough approximation of escapement contribution to total production can be made using information presented in the Final Restoration Plan for the Anadromous Fish Restoration Program (AFRP) (USFWS 2001). Information provided in USFWS (2001) for the major tributaries of the San Joaquin River indicated that for the doubling goal baseline period (1967-1991), spawning escapement in the Stanislaus, Merced and Tuolumne rivers averaged 4,800, 4,500 and 8,900 adult fall-run Chinook salmon. For this same period, total production in the Stanislaus, Merced and Tuolumne rivers averaged 11,000, 9,900 and 19,000 adult fall-run Chinook salmon. The percentage of escapement to total production averaged 44 percent, 46 percent and 47 percent, respectively, for a combined average of about 46 percent. Given the absence of information regarding spring-run Chinook salmon, and the lack of applicable data prior to the AFRP doubling goal baseline period, as a surrogate for this study we applied this average percentage of escapement to total production for fall-run to the major tributaries of the San Joaquin River.

Based on Reynolds et al. (1993) statement, for this approach we used a historical approximation of 69,000 (150,000 x 46 percent) to 138,000 (300,000 x 46 percent) of spring-run Chinook salmon as a combined annual run to the San Joaquin river system, including the upper San Joaquin, Stanislaus, Merced and Tuolumne rivers. Using the same methodology employed in the previous approaches, approximately 55, 66, 56 and 52 miles were historically available to Chinook salmon in the upper portions of the upper San Joaquin, Stanislaus, Merced and Tuolumne rivers. respectively. Applying these lengths of habitat as proportions of the total length (229 miles) of habitat in the upper portions of these rivers, the Tuolumne River could have experienced historical maximum annual returns approximating 16,000 to 31,000 spring-run Chinook salmon.

Based on the approximations of potential historical spring-run Chinook salmon annual escapement to the Tuolumne River discussed above, the Tuolumne River may have experienced maximum annual runs associated with the three different approximation approaches as follows:

- 45,000 to 114,000
- 60,000
- 16,000 to 31,000

4.1.1.2 Estimation of Historical Fall-run Chinook Salmon Escapement to the Tuolumne River

Review of available literature did not reveal any available estimates of historical escapement of fall-run Chinook salmon to the Tuolumne River prior to about 1940. As reported by Yoshiyama et al. (2001), historical fall-run Chinook salmon spawning escapements in the Tuolumne River during some years were larger than in any other Central Valley streams except for the mainstem Sacramento River, reaching as high as 122,000 spawners in 1940 and 130,000 in 1944 (CDFG 1946; Fry 1961, both as cited in Yoshiyama et al. 2001). According to NMFS (2014), Reynolds et al. (1993) stated that the Tuolumne River historically supported up to 12 percent of the total fall-run Chinook salmon spawning escapement in the Central Valley. Fisher (1994) developed historical (i.e., pre-1900) maximum Chinook salmon run-specific estimates for the Central Valley, including up to approximately 900,000 fall-run Chinook salmon. If it is assumed that maximum historical fall-run Chinook salmon escapement to the Central Valley was 900,000, and the Tuolumne River supported 12 percent of this escapement, then up to a maximum of approximately 108,000 fall-run Chinook salmon may have historically returned to the Tuolumne River. Based on this approximation, as well as the peak estimates reported for 1940 and 1944, for the purposes of this study, up to approximately 108,000 to 130,000 fall-run Chinook salmon may have historically returned annually to the Tuolumne River.

4.1.1.3 Estimation of Historical Chinook Salmon (all runs) Escapement to the Tuolumne River

Based on the approximations of potential maximum historical spring-run and fall-run Chinook salmon annual escapement to the Tuolumne River discussed above, the Tuolumne River may have experienced maximum annual Chinook salmon runs (spring- and fall-run combined) associated with the three different approximation approaches as follows:

- 153,000 to 244,000
- 168,000 to 190,000
- 124,000 to 160,000

Hence, in order to address study Request Element #1 (Estimate a range of the historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River), a range of historical annual escapement from about 124,000 to 244,000 will be used in the calculations.

4.1.2 Average Mass and Nitrogen (N) Content of Individual Adult Chinook Salmon

NMFS (2014) stated that a 10 kilogram (kg) (22 lbs) average mass for adult Chinook salmon and a 5.62 percent average N content per fish should be applied to the calculation method provided in Merz and Moyle (2006), which is described as follows.

> Transport of N = *nut%t* x *SW* x *SP*
>
> where *nut%* is the average percentage of N, *SW* is the average mass of an adult Chinook salmon, and *SP* is Chinook salmon escapement.

4.1.2.1 Average Mass of Individual Adult Chinook Salmon

Presumably, NMFS obtained the average Chinook salmon mass of 10 kg (22 lbs) from Merz and Moyle (2006), who also calculated estimates of marine-derived nutrients using this mass. Merz and Moyle (2006) include Moyle (2002) as a citation for the use of 10 kg (22 lbs) as an average mass for adult Chinook salmon in California. Moyle (2002) generally states that spawning Chinook salmon have a mass of 9-10 kg (19.8-22 lbs). However, Moyle (2002) also states that late fall-run Chinook salmon are the largest run of salmon in California, commonly with a mass of 9-10 kg (19.8-22 lbs). Moyle (2002) does not provide a mass specifically for fall-run or spring-run Chinook salmon. Therefore, a mass of 19.8-22 lbs potentially could be somewhat high for fall-run Chinook salmon.

The use of 10 kg (22 lbs) for an average adult Chinook salmon returning to the Tuolumne River may be an overestimation, particularly if the focus of this analysis is on marine-derived nutrients associated with historical Chinook salmon escapement. Review of Yoshiyama et al. (1998) indicates that Chinook salmon commercially caught in the Central Valley and San Francisco Bay during the mid- to late-1800s were variously reported to average 12-23 lbs (i.e., 5.4-10.4 kg), with an average weight of approximately 16 lbs (i.e., 7.3 kg).

In order to address study Request Element #1 (Estimate a range of the historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River), a range of the average mass of an adult Chinook salmon from 12 lbs (5.4 kg) to 23 lbs (10.4 kg) will be used in the calculations.

4.1.2.2 Average Nitrogen (N) Content Per Individual Fish

NMFS (2014) appears to have obtained the 5.62 percent average N content per fish from Merz and Moyle (2006), who reported that the average N content of Mokelumne River Chinook salmon carcasses and eggs that they sampled was 5.62 percent. This percentage of N was based on 26 Chinook salmon eggs collected from a spawning bed in the Mokelumne River and only nine Chinook salmon adults, including one hatchery-origin adult captured by angling in the Mokelumne River, and four post-spawned Chinook salmon collected from the Mokelumne River Fish Hatchery. It was not noted whether a difference in N content would occur between hatchery-origin and naturally produced Chinook salmon.

The 5.62 percent average N content per fish may be somewhat high, based on a review of additional sources, which indicates that percentage N of adult Pacific salmonids may be more in the range of approximately 2.5-3.0 percent. For example, Larkin and Slaney (1997) reported average N content of Pacific salmon carcasses, which included Chinook, coho, pink, sockeye and chum salmon, of 3.04 percent N. However, Merz and Moyle (2006) point out that species such as sockeye (*0. nerka*) have different dietary requirements than those of Chinook salmon, and that trophic level can have a significant effect on the distribution of N isotopes in animals. Nonetheless, Stansby and Hall (1965, as cited in Ashley and Slaney 1997) reported that salmon carcasses are approximately 3.0 percent N (wet weight), although species-specific composition was not referenced. Greene (1926) reported that wet muscle percentage N content of Chinook salmon was found to be 2.50 percent at sea, 2.70 percent at the “tide water” prior to the spawning run, and 2.30 percent while adults were on the spawning grounds. Kohler et al. (2013) applied the percent wet mass contents of 3.04 percent N reported by Larkin and Slaney (1997) to adult Chinook salmon in Idaho. Kohler et al. (2013) acknowledged potential spatial and temporal variation in the proximal composition of N in Chinook salmon adult populations, but stated that the values used in their analyses (e.g., 3.04 percent N) accurately represent Chinook salmon N concentrations in general.

To address study Request Element #1 (Estimate a range of the historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River), a range of the average N content of an adult Chinook salmon from 2.30 percent to 5.62 percent will be used in the calculations.

4.2 NMFS Request Element #2: Estimate the historical mass of marine-derived N transported annually by spring-run Chinook salmon to the upper Tuolumne River

In order to address study Request Element #2 (Estimate the historical mass of marine-derived N transported annually by spring-run Chinook salmon to the upper Tuolumne River), a range in the maximum annual runs associated with the three different escapement estimation approximation approaches discussed above will be used in the calculations. These ranges are:

- 45,000 to 114,000
- 60,000
- 16,000 to 31,000

A range of the average mass of an adult Chinook salmon from 12 lbs (5.4 kg) to 23 lbs (10.4 kg) will be used in the calculations.

A range of the average N content of an adult Chinook salmon from 2.30 percent to 5.62 percent will be used in the calculations.

The calculations will use the formula:

Transport of N = nut% x SW x SP

where nut% is the average percentage of N, SW is the average mass of an adult Chinook salmon, and SP is Chinook salmon escapement.

4.3 NMFS Request Element #3: Estimate the current annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River

NMFS (2014) requested that the current annual escapement of fall-run Chinook salmon be used to estimate the current annual mass of marine-derived N transported to the Tuolumne River. NMFS requested that current annual escapement be characterized by the recent peak and 10-year

(2001-2010) average Tuolumne River fall-run Chinook salmon escapement estimates. However, CDFW has updated escapement estimates as of April 15, 2015 with estimates extending through 2014. Thus, a more recent 10-year period of fall-run Chinook salmon escapement to the Tuolumne River extends from 2005 through 2014. Consequently, to comply with NMFS' (2014) request, current annual escapement characterized by the recent peak and 10-year average for both time periods (2001-2010 and 2005-2014) will be used in the calculation of transport of marine-derived N.

As shown in Table 4.3-1, the peak escapement over the 2001-2010 period was 8,782 (in 2001), and the average 10-year escapement was 2,261 fall-run Chinook salmon. By contrast, if the more recent 10-year average of fall-run Chinook salmon escapement is used (i.e., 2005-2014), peak and average escapement are both considerably lower (1,926 and 655, respectively).

In order to address study Request Element #3 (Estimate the current annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River), four different escapement values will be utilized in the calculations. These values are:

- 8,782 (peak 2001-2010)
- 2,261 (avg. 2001-2010)
- 1,926 (peak 2005-2014)
- 655 (avg. 2005-2014)

Table 4.3-1. Tuolumne River fall-run Chinook salmon escapement during 2001-2010 and during 2005-2014.

2001 - 2010		2005 - 2014	
Year	**Escapement**	**Year**	**Escapement**
2001	8,782	2005	668
2002	7,173	2006	562
2003	2,163	2007	224
2004	1,984	2008	388
2005	668	[2009]	124
2006	562	[2010]	540
2007	224	[2011]	893
2008	388	[2012]	783
[2009]	124	[2013]	1,926
[2010]	540	[2014]	438
Average	**2,261**	**Average**	**655**

Data reported for 2009 through 2014 are preliminary estimates.
Source: CDFW 2015.

A range of the average mass of an adult Chinook salmon from 12 lbs (5.4 kg) to 23 lbs (10.4 kg) will be used in the calculations.

A range of the average N content of an adult Chinook salmon from 2.30 percent to 5.62 percent will be used in the calculations.

The calculations will use the formula:

> Transport of N = nut% x SW x SP
>
> where nut% is the average percentage of N, SW is the average mass of an adult Chinook salmon, and SP is current fall-run Chinook salmon escapement.

4.4 NMFS Request Element #4: Estimate the annual losses, from historical to current levels, of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River

Study Request Element #4 involves the subtraction of estimates of marine-derived N transported to the Tuolumne River by fall-run Chinook salmon under recent conditions, from estimates of historically transported marine-derived N.

As described in Section 4.1.1.2, for the purposes of this study, up to approximately 108,000 to 130,000 fall-run Chinook salmon may have historically returned annually to the Tuolumne River. Thus, these two values represent a range in the maximum annual runs of fall-run Chinook salmon historically returning to the Tuolumne River and will be used in the calculations. As described in Section 4.3, four different escapement values will be utilized in the calculations to characterize estimates of marine-derived N transported to the Tuolumne River by fall-run Chinook salmon under recent conditions.

The range in values used to characterize both historical and current escapements of fall-run Chinook salmon to the Tuolumne River will be used in the calculations, along with a range in the average mass of an adult Chinook salmon (12 to 23 lbs) and a range of the average N content of an adult Chinook salmon (2.30 percent to 5.62 percent).

Each calculation will use the formula:

> Transport of N = nut% x SW x SP
>
> where nut% is the average percentage of N, SW is the average mass of an adult Chinook salmon, and SP is historical and current fall-run Chinook salmon escapement.

For each of the resultant permutations, estimates of existing marine-derived N transported to the Tuolumne River by fall-run Chinook salmon will be subtracted from estimates of historically transported marine-derived N.

In addition, although not presented as a request element, in its study request NMFS stated that the information to be obtained included an estimate of the annual loss, from historical to current levels, of marine-derived N to the upper Tuolumne River. This equates to the results of Request Element #2. This compares historical conditions with existing conditions (extirpated spring-run Chinook population).

5.0 RESULTS

Results of this study are provided below by study element, as described in NMFS' July 22, 2014 study request, consistent with FERC's February 2, 2015 Study Plan Determination for the La Grange Project.

5.1 NMFS Request Element #1: Estimate a range of the historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River

Consistent with the methodology and NMFS' (2014) study request, the transport of N is estimated using the calculation method provided in Merz and Moyle (2006), which is described as follows.

Transport of N = *nut%* x *SW* x *SP*

where *nut%* is the average percentage of N, *SW* is the average mass (lbs) of an adult Chinook salmon, and *SP* is Chinook salmon escapement.

As specified in the methodology (above), ranges of various parameters will be used in the calculations including:

- A range of historical annual escapement of Chinook salmon (all runs) to the Tuolumne River from 124,000 to 244,000 fish.
- A range of the average mass of an adult Chinook salmon from 12 lbs (5.4 kg) to 23 lbs (10.4 kg).
- A range of the average N content of an adult Chinook salmon from 2.30 percent to 5.62 percent.

Application of the calculation method results in the estimated historical mass of marine-derived N transported annually by Chinook salmon (all runs) to the Tuolumne River ranging from 34,000 to 315,000 lbs.

5.2 NMFS Request Element #2: Estimate the historical mass of marine-derived N transported annually by spring-run Chinook salmon to the upper Tuolumne River

As specified in the methodology (above) the estimated historical annual escapement of spring-run Chinook salmon to the upper Tuolumne River ranged from 16,000 to 114,000 fish.

Using the ranges of the average mass of an adult Chinook salmon and the average N content of an adult Chinook salmon specified above, application of the calculation formula results in the estimated historical mass of marine-derived N transported annually by spring-run Chinook salmon to the upper Tuolumne River ranging from 4,400 to 147,000 lbs.

Although not presented as a Request Element, NMFS stated in its study request that the information to be obtained included an estimate of the annual loss, from historical to current levels, of marine-derived N to the upper Tuolumne River. This equates to the results of Request Element #2. This compares historical conditions with existing conditions (extirpated spring-run Chinook population).

5.3 NMFS Request Element #3: Estimate the current annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River

As specified in the methodology (above), there are four different values used in the calculations to estimate current annual escapement of fall-run Chinook salmon to the Tuolumne River. The estimated historical mass of marine-derived N transported annually by fall-run Chinook salmon to the Tuolumne River, associated with these four different values and using the ranges of the average mass of an adult Chinook salmon and the average nitrogen (N) content of an adult Chinook salmon specified above, are presented below.

Estimated Escapement	Low Value of Mass (12 lbs) and N Content (2.30 percent)	High Value of Mass (23 lbs) and N Content (5.62 percent)
▪ 8,782 (peak 2001-2010)	2,400	11,400
▪ 2,261 (avg. 2001-2010)	600	2,900
▪ 1,926 (peak 2005-2014)	500	2,500
▪ 655 (avg. 2005-2014)	200	800

The current annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River across the estimated escapements above ranges from 200 to 11,400 lbs.

5.4 NMFS Request Element #4: Estimate the annual losses, from historical to current levels, of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River

Request Element #4 involves the subtraction of estimates of marine-derived N transported to the Tuolumne River by fall-run Chinook salmon under recent conditions, from estimates of historically transported marine-derived N.

As described Section 4.1.1.2, an estimated range of 108,000 to 130,000 maximum annual runs of fall-run Chinook salmon may have historically returned annually to the Tuolumne River, and are used in the calculations. Also, as described in Request Element #3, four different values (see above) are utilized in the calculations. This results in 16 different combinations (Table 5.4-1). The estimated range of differences in mass of marine-derived N transported annually by fall-run Chinook salmon to the Tuolumne River, for all combinations from historical to current escapement levels, are presented below.

Table 5.4-1. The estimated range of differences in mass of marine-derived N transported annually by fall-run Chinook salmon to the Tuolumne River, for all combinations from historical to current escapement levels. The specific differences result from the highlighted cells. Low value of N is defined as calculations using a mass of 12 lbs and N content of 2.30 percent. High value of N is defined as calculations using a mass of 23 lbs and a N content of 5.62 percent.

Historical Conditions		Current Conditions		Historical - Current Difference
Low Value of N (lbs)	High Value of N (lbs)	Low Value of N (lbs)	High Value of N (lbs)	Value of N (lbs)
29,800	168,000	2,400 (peak 2001-2010)	11,400 (peak 2001-2010)	27,400
29,800	168,000	600 (avg. 2001-2010)	2,900 (avg. 2001-2010)	29,200
29,800	168,000	500 (peak 2005-2014)	2,500 (peak 2005-2014)	29,300
29,800	168,000	200 (avg. 2005-2014)	800 (avg. 2005-2014)	29,600
29,800	168,000	2,400 (peak 2001-2010)	11,400 (peak 2001-2010)	18,400
29,800	168,000	600 (avg. 2001-2010)	2,900 (avg. 2001-2010)	26,900
29,800	168,000	500 (peak 2005-2014)	2,500 (peak 2005-2014)	27,300
29,800	168,000	200 (avg. 2005-2014)	800 (avg. 2005-2014)	29,000
29,800	168,000	2,400 (peak 2001-2010)	11,400 (peak 2001-2010)	165,600
29,800	168,000	600 (avg. 2001-2010)	2,900 (avg. 2001-2010)	167,400
29,800	168,000	500 (peak 2005-2014)	2,500 (peak 2005-2014)	167,500
29,800	168,000	200 (avg. 2005-2014)	800 (avg. 2005-2014)	167,800
29,800	168,000	2,400 (peak 2001-2010)	11,400 (peak 2001-2010)	156,600
29,800	168,000	600 (avg. 2001-2010)	2,900 (avg. 2001-2010)	165,100
29,800	168,000	500 (peak 2005-2014)	2,500 (peak 2005-2014)	165,500
29,800	168,000	200 (avg. 2005-2014)	800 (avg. 2005-2014)	167,200

The difference from historical to current escapement levels in the annual mass of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River is estimated to range from 18,400 to 167,800 lbs.

6.0 DISCUSSION AND FINDINGS

The goal or purpose of this study request from NMFS dated July 22, 2014 is to evaluate the degree of reduction or loss in marine-derived nutrient replenishment to the upper and lower Tuolumne River. Although carbon and phosphorus are transported and deposited by returning anadromous salmon, the study request only addressed the mass of N. This study report met the goal or purpose of the NMFS study request, and provided all of the information that NMFS requested be obtained in the conduct of this study.

The information that NMFS requested included estimates of the historical mass of marine-derived N that was transported annually by Chinook salmon (all runs) to the Tuolumne River, as well as that which was transported by spring-run Chinook salmon to the upper Tuolumne River. That information was requested in order to try to estimate annual losses, from historical to current levels, of marine-derived N transported by fall-run Chinook salmon to the Tuolumne River, in addition to losses to the upper Tuolumne River transported by spring-run Chinook salmon.

The goal of the study request, as well as the specific information requested by NMFS, is dependent upon estimates of annual escapement of historical populations of spring-run and fall-run Chinook salmon to the Tuolumne River. However, in its study request, NMFS acknowledges that actual counts of salmon runs are not available regarding the historical escapement ranges for Chinook salmon in the Tuolumne River for pre-European settlement. Although NMFS provided references and quotes from some historical accounts, empirical data of historical annual escapement estimates are not available. Consequently, historical annual escapement estimates, and resultant estimates of marine-derived N, are highly speculative. The speculative nature of the estimates and necessary assumptions in the estimation methodology are reflected in the extremely broad range of the results.

In addition to the speculative nature of historical annual escapement estimates, current escapement estimates of fall-run Chinook salmon to the Tuolumne River are influenced by numerous non-Project related factors. A few of these include ocean conditions (e.g., annual variability in coastal upwelling and food availability), Bay-Delta conditions, harvest practices (e.g., commercial and sport fishing), historical and current industrial development, downstream water uses, habitat impacts, invasive species and predation by non-native fish. Consequently, differences between historical and current escapement estimates, and associated estimates of marine-derived N, cannot be completely attributed to the Project. Because of the speculative nature of historical annual escapement estimates and the influence of numerous non-project-related factors, use of the information provided in this study report should be undertaken in a very cautious manner.

7.0 STUDY VARIANCES AND MODIFICATIONS

The February 2, 2015 FERC Determination (pg. 2) states that…."*Of the eight requested studies by relicensing* [sic] *participants, one is approved as filed and seven are not required*". That one study request, filed by NMFS, was Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River. FERC recommended that "*the Districts conduct this NMFS study as recommended*" (B-17). Although FERC determined that the study request was approved as filed, and that the study be conducted as recommended by NMFS, FERC's Determination included an additional study item titled "*compare the difference of marine-derived nitrogen incorporated into periphyton and aquatic benthic macroinvertebrates collected in the upper and lower Tuolumne River*" that was not included in NMFS' July 22, 2014 study request. Because this study item is not included in NMFS' July 22, 2014 study request, and because FERC recommended that the study be conducted as recommended by NMFS, this item is not addressed in this study.

There were no variances or modifications in the implementation of this study. However, this study report provides the information requested by NMFS, with some additional detail in terms of identifying ranges of transported marine-derived N. The February 2, 2015 FERC Determination (pg. 2) states that "… *the Districts may choose to conduct any study, or portion of a study, not specifically required herein that they feel would add pertinent information to the record*." Thus, the additional detail provided in this study report estimating ranges of nutrient transport, adding to that requested by NMFS, is appropriate.

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT E

LA GRANGE PROJECT FISH BARRIER ASSESSMENT PROGRESS REPORT

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LA GRANGE PROJECT
FISH BARRIER ASSESSMENT
PROGRESS REPORT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Prepared for:

Turlock Irrigation District – Turlock, California

Modesto Irrigation District – Modesto, California

Prepared by:

FISHBIO

February 2017

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List of Acronyms and Abbreviations

ac-ft ....acre-foot
BLM...........................Bureau of Land Management
BOR ....Bureau of Reclamation
CCSF..........................City and County of San Francisco
CDFG.........................California Department of Fish and Game, now CDFW
CDFW........................California Department of Fish and Wildlife
cfs...............................cubic feet per second
CG..............................Conservation Groups
Districts......................Turlock Irrigation District and Modesto Irrigation District
FERC..........................Federal Energy Regulatory Commission
FLA............................Final License Application
FPA ....Federal Power Act
GIS ....geographic information system
ILP..............................Integrated Licensing Process
ISR ....Initial Study Report
LGDD ....La Grange Diversion Dam
LPs ....licensing participants
M&I...........................municipal and industrial
MID............................Modesto Irrigation District
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
O&M..........................operation and maintenance
PAD............................Pre-Application Document
PSP.............................Proposed Study Plan
QA/QC.......................quality assurance/quality control
RM ....river mile
RSP ....Revised Study Plan
SD2 ....Scoping Document 2
SPD ....Study Plan Determination
TAF............................thousand acre-feet
TID.............................Turlock Irrigation District
TM..............................technical memorandum
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
USR............................Updated Study Report

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Lake Lloyd (known as Cherry Lake), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

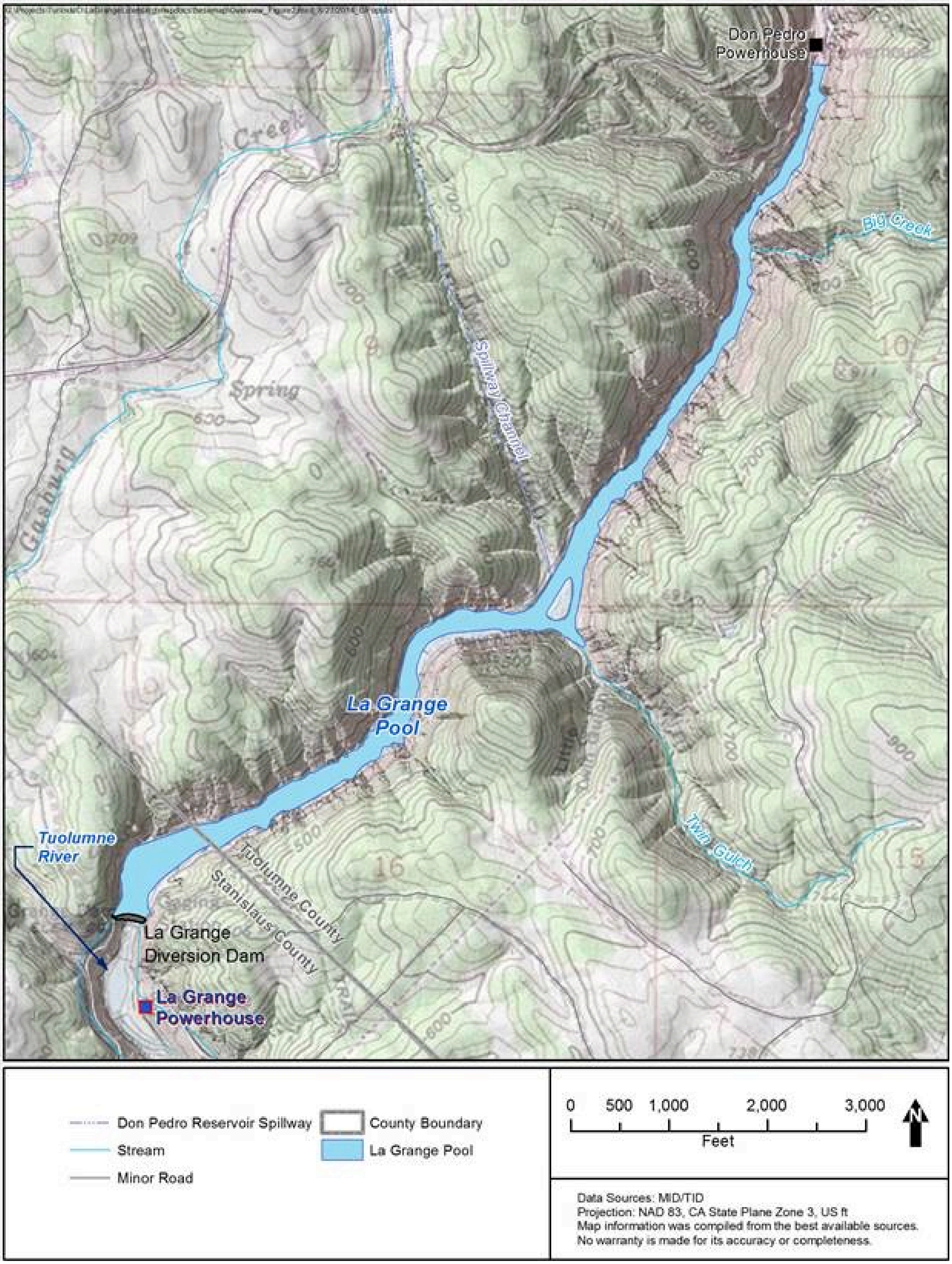

Figure 1.1-1. La Grange Hydroelectric Project location map.

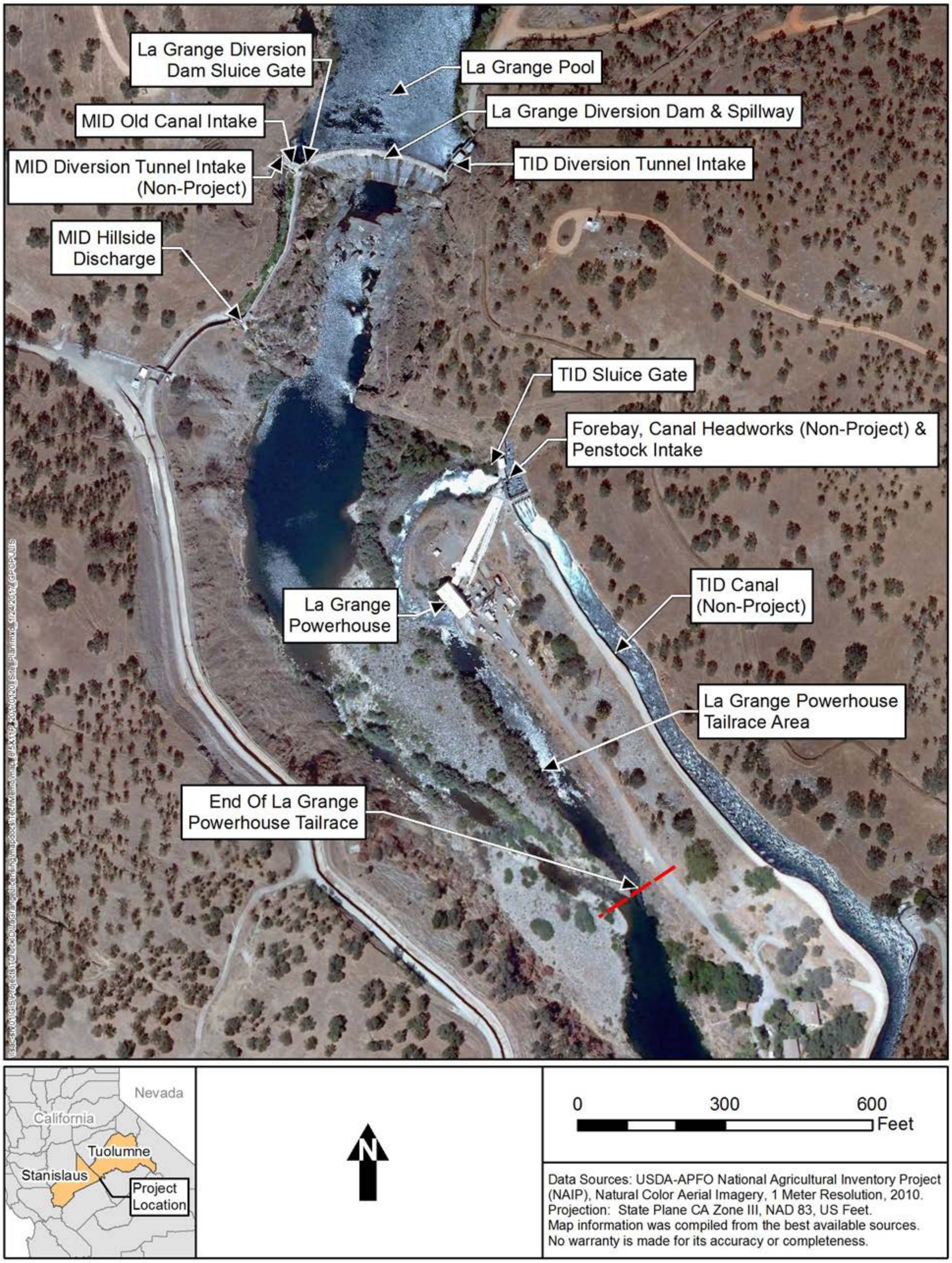

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."
[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).
[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish passage through Don Pedro Reservoir or La Grange pool. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study.

This progress report describes the objectives, methods, and results of the La Grange Project Fish Barrier Assessment (herein referred to as the Fish Barrier Assessment), which is one component of the Fish Passage Facilities Assessment as implemented by the Districts in accordance with the SPD. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified potential effects of Project operations on the upstream migration of anadromous fish.

FERC's SPD approved without modification the Districts' Fish Barrier Assessment as proposed in the RSP. In comments on the PAD, NMFS, CDFW, and the CGs state that LGDD and the La Grange powerhouse are barriers to upstream anadromous fish migration, and a study to evaluate whether the dam and powerhouse are barriers is not needed. However, FERC staff approved the study stating that the information collected in this study would help define the nature and degree to which the dam and powerhouse are barriers or impediments to the upstream migration of anadromous salmonids. No comments were filed in response to the Fish Barrier Assessment as proposed in the RSP.

2.0 STUDY GOALS AND OBJECTIVES

The purpose of the Fish Barrier Assessment is to evaluate the potential impact of LGDD and the La Grange powerhouse as barriers to the upstream migration of adult fall-run Chinook salmon and, if they occur, steelhead. This includes documenting the proportion of the fall-run Chinook salmon population that may migrate upstream to these facilities and evaluating potential impacts to the spawning of these fish. Objectives of this study are to:

- determine the number of fall-run Chinook salmon and steelhead migrating upstream to LGDD and the La Grange powerhouse during the 2015/2016 and 2016/2017 migration seasons;
- compare the number of fall-run Chinook salmon and steelhead migrating upstream to the LGDD and the La Grange powerhouse to total escapement during the 2015/2016 and 2016/2017 migration seasons;
- document carcass condition (egg retention) to evaluate pre-spawn mortality rates of fall-run Chinook salmon and steelhead migrating upstream to LGDD and the La Grange powerhouse, which do not move back downstream to spawn; and
- implement formal documentation of incidental fish observations in the vicinity of LGDD, La Grange powerhouse tailrace, and TID sluice gate channel. Note that this objective is being addressed as part of the Fish Presence and Stranding Assessment (TID/MID 2017).

3.0 STUDY AREA

The study area includes the Tuolumne River from LGDD (RM 52.2) downstream to the mainstem channel fish counting weir, and the La Grange powerhouse tailrace channel downstream to the tailrace channel fish counting weir (Figure 3.0-1). Daily boat surveys were conducted in both channels from LGDD to 0.3 miles downstream of the weir locations to document potential fish stacking or pre-spawn mortality issues. This study also includes data collected from monitoring conducted at a fish counting weir operated by the Districts at RM 24.5.

Figure 3.0-1. Location of main channel weir and tailrace channel weir.

4.0 METHODOLOGY

4.1 Weir Configurations

Two fish counting weirs were installed in the Tuolumne River on September 11, 2015. After a brief testing period, weir operation and monitoring began on September 23, 2015 and continued through April 14, 2016. One weir segment was placed downstream of the large pool below LGDD in the Tuolumne River main channel, and the second segment was placed just below the La Grange powerhouse in the tailrace channel (Figure 3.0-1). Each weir structure consisted of rigid weir panels that directed fish passage through a passing chute that was continuously monitored by a video system. Each weir panel was constructed of steel angle and horizontal pipe with 1 1/8-inch spacing and secured in-channel diagonal to the river flow.

The passing chute of the main channel weir (Figure 4.1-1) consisted of a 3-foot-wide by 4-foot-long white high-density polyethylene floor that was secured to the substrate. An overhead camera and an underwater side-view camera were positioned to view the entire passing chute. The tailrace weir (Figure 4.1-2) consisted of a 6-foot wide by 6-foot long high-density polyethylene passing chute equipped with an overhead camera and two underwater side-view cameras. Each passing chute was equipped with an infrared lighting system for 24-hour monitoring. Similar video systems have been operated by CDFW to monitor the passage of Chinook salmon and steelhead on Sacramento River tributaries (Killiam and Johnson 2008).

The overhead cameras at each weir provided full coverage of the passing chute area and were used to detect fish passage events. Underwater cameras were used to assist with species identification for each passage event. A multi-camera video surveillance application (SecuritySpy) was used to route footage to computers for storage. Hourly video files from each camera were saved to external hard drives and downloaded daily for data back-up. Additionally, motion detection settings in the video surveillance application were used to create five-second clips of all potential passage events.

Figure 4.1-1. Upstream view of main channel weir and passing chute.

Figure 4.1-2. Overhead view of tailrace channel weir and passing chute.

4.2 Weir Operations

The weirs were cleaned, weir performance was documented, and video footage was downloaded daily (generally between 8:00 am and 11:00 am each day). Environmental data collected during each weir check included dissolved oxygen (mg/L), stream stage (feet), turbidity (NTU), and water velocity at the opening of the fish passage chute. Provisional daily average flow data for the Tuolumne River at La Grange was obtained from U.S. Geological Survey (USGS) Gage 11289650 (http://waterdata.usgs.gov/ca/nwis). Hourly water temperature data were obtained from Hobo Pro v2 water temperature data loggers (Onset Computer Corporation) maintained at each weir site. Visual assessments were also conducted daily to ensure that fish were not stacking on either side of the weir. Boat surveys were conducted in both channels from LGDD to 0.3 miles downstream of the weir locations. Any spawning activity, live Chinook salmon (*Oncorhynchus tshawytscha*) or *Oncorhynchus mykiss* (*O. mykiss*), or carcasses observed upstream of the weir were recorded. Daily stacking counts were reported to CDFW three times per week ("stacking" was defined as 30 or more individuals on either side of the weir).

4.3 Video Review

A fisheries biologist or technician with prior video review experience reviewed digital video footage to determine passage events. Video review was limited to a group of five individuals in an attempt to ensure consistency through the review period. Video review consisted of viewing five-second motion detection clips from the overhead camera to determine fish presence, estimated length, and direction of passage. The underwater camera views were used for species identification, sex determination, and presence of an adipose fin. During periods when motion detection was ineffective, hourly overhead video files were reviewed at 10x speed to identify fish passage events. Passage date, time, direction of passage, species, and estimated fish size were recorded for each passage event. The certainty of each fish observation was recorded as high, medium, or low. A high certainty rating signified complete confidence in determining species and the presence or absence of an adipose fin; medium suggested confidence in determining species but sex and/or presence of an adipose fin was unknown; and low suggested uncertainty in determining species.

Video review quality assurance procedures consisted of an independent review of a subsample of video data by a separate fisheries biologist with extensive video review experience. Data selected for a second review included species identified as unknown, passages with a low observational certainty, and all recorded *O. mykiss* passages. Additionally, select hourly files were reviewed for passage events that were not captured by motion detection. Hourly files selected for second review were both hourly to evaluate video reviewer accuracy, and systematic to evaluate motion detection effectiveness (i.e. multiple upstream passages by an individual fish without subsequent downstream passages).

Raw data were summarized to determine daily upstream and downstream weir counts, the total numbers of individual fish moving through the weir (i.e., generating passage events), and the total number of fish exhibiting persistent upstream migration behavior (upstream counts minus downstream counts). The total number of fish exhibiting persistent upstream migration behavior was divided by total escapement determined at the lower weir (at RM 24.5) to estimate the extent to which the La Grange facilities are actually a barrier to upstream migration and spawning.

4.4 Lower Tuolumne River Weir

The Districts operate a fish counting weir at RM 24.5, which is located downstream of the Chinook salmon spawning reach. Monitoring objectives at this weir location include determining escapement of fall-run Chinook salmon and *O. mykiss* to the Tuolumne River through direct counts. This weir has been operated annually since 2009, and monitoring occurred continuously during the period that the La Grange weirs were operated (Becker et al. 2016).

4.5 Pre-spawn Mortality Evaluation

Salmon encountering barriers to migration may experience pre-spawn mortality. During carcass surveys conducted to estimate salmon escapement, CDFW examines female Chinook salmon carcasses for egg retention to estimate pre-spawn mortality. Assessments of pre-spawn mortality have been conducted in several Central Valley streams in some years; however, these assessments have been intermittent and inconsistent due to a lack of available funding and staff. CDFW has documented low levels of pre-spawn or partial-spawn mortality of fall-run Chinook in the Tuolumne River during surveys conducted in 1993, 1999, 2008, 2013, and 2014 (CDFW 2014). Of the years evaluated, the maximum annual occurrence of pre-spawn or partial-spawn mortality documented was five individuals (2013).

To evaluate the potential effect of LGDD and the La Grange powerhouse on the spawning of upstream migrants, daily surveys above the counting weir were conducted to assess the presence/absence of live Chinook salmon, spawning activity, or carcasses. Chinook carcasses were visually assessed for egg retention, and all fish carcasses observed were collected, frozen, and delivered to CDFW LA Grange staff.

5.0 RESULTS

This report summarizes all data collected during the 2015/2016 monitoring season. For the 2016/2017 migration season, sampling began on September 15, 2016 and is scheduled to continue through mid-April, 2017. Results of the 2016/2017 season will be provided in a final report after monitoring is completed and all data has been processed.

5.1 Weir Operations

During the 2015/2016 monitoring season, both weirs operated almost continuously between September 23, 2015 and April 15, 2016. Two high-debris flow events on October 17 and October 28 washed out a portion of the tailrace channel rigid weir structure. Sections of the rigid weir were temporarily removed and reinstalled resulting in the system being inoperable for 40.8 hours and 27.0 hours on October 17 and October 28, respectively. On eight other occasions the tailrace weir video monitoring system was inactive (i.e., video was not recorded due to camera or computer malfunctions), with outage times ranging from 3.3 hours to 30.7 hours (mean 14.1 hours). Overall the tailrace video system recorded video footage for 97.3 percent of the monitoring period. The main channel weir video system was inactive on 22 occasions, with outage times ranging from 2 hours to 35.6 hours (mean 15.7 hours) (Table 5.1-1). System outages at the main channel weir were associated with extended periods with minimal sunlight resulting in the computer turning off due to low battery voltage. Overall the main channel video system recorded video footage for 91.2 percent of the monitoring period.

During the monitoring period, average daily flow recorded at La Grange ranged from 91 to 175 cfs (Figure 5.1-1). River flow through the main channel weir came from the MID hillside discharge and was estimated to be approximately 25 cfs throughout the study period. Instantaneous water velocity recorded in the main channel fish counting weir passage chute ranged from 0.3 to 2.4 feet per second (ft/sec) (mean 0.9 ft/sec). The remainder of the flow recorded at La Grange originated from the powerhouse and/or TID sluice gate channel and flowed through the tailrace channel fish counting weir.[3] Instantaneous water velocity recorded at the tailrace channel fish counting weir passage chute ranged from 0.6 ft/sec to 4.7 ft/sec (mean 2.6 ft/sec).

Average daily water temperatures recorded at each weir site ranged from 50.1° F to 64.2° F (10.1° C to 17.9° C) in the tailrace channel and 48.7° F to 67.4° F (9.3° C to 19.7° C) in the main channel (Figure 5.1-1). Instantaneous turbidity ranged from 0.69 NTU to 14.06 NTU (mean 2.82 NTU) in the tailrace channel and from 0.54 NTU to 11.96 NTU (mean 2.44 NTU) in the main channel. Instantaneous dissolved oxygen ranged from 4.03 mg/L to 13.93 mg/L (mean 9.34 mg/L) in the tailrace channel and from 8.96 mg/L to 14.24 mg/L (mean 10.97 mg/L) in the main channel.

[3] During the 2015/2016 monitoring season TID maintained an 18-inch pipe in an open position that continuously delivers flow of approximately 5 to 10 cfs to the channel downstream of the sluice gates. This water flows into the tailrace just upstream of the powerhouse.

Table 5.1-1. Summary of video recording outage periods during the 2015/2016 monitoring season.

Weir	Date	Time Outage Began	Date	Time Outage Ended	Outage Duration (hrs)
Tailrace	10/17/15[1]	23:12	10/19/15	16:00	40.8
Tailrace	10/28/15[1]	13:00	10/29/15	16:00	27.0
Main Channel	11/24/15	3:13	11/24/15	8:40	5.5
Main Channel	11/24/15	23:23	11/25/15	8:44	9.4
Main Channel	11/25/15	8:53	11/26/15	9:18	24.4
Main Channel	12/2/15	21:48	12/4/15	9:23	35.6
Main Channel	12/5/15	7:05	12/5/15	9:37	2.5
Main Channel	12/5/15	22:18	12/6/15	11:21	13.1
Main Channel	12/11/15	23:42	12/12/15	9:09	9.5
Main Channel	12/13/15	6:52	12/13/15	9:16	2.4
Main Channel	12/13/15	12:23	12/14/15	10:11	21.8
Main Channel	12/19/15	9:33	12/20/15	10:58	25.4
Main Channel	12/20/15	18:49	12/21/15	11:59	17.2
Main Channel	12/21/15	17:24	12/22/15	9:04	15.7
Main Channel	12/22/15	20:39	12/23/15	10:52	14.2
Main Channel	12/24/15	6:13	12/24/15	10:29	4.3
Main Channel	12/24/15	23:26	12/25/15	9:41	10.3
Tailrace	1/3/16	19:51	1/4/16	11:25	15.6
Main Channel	1/4/16	20:13	1/5/16	11:45	15.5
Main Channel	1/5/16	15:32	1/6/16	9:44	18.2
Main Channel	1/17/16	11:19	1/18/16	14:38	27.3
Tailrace	1/19/16	5:00	1/19/16	11:55	6.9
Tailrace	1/24/16	6:00	1/24/16	9:20	3.3
Tailrace	1/31/16	6:00	2/1/16	12:39	30.7
Main Channel	2/2/16	10:19	2/3/16	10:15	23.9
Main Channel	2/6/16	12:49	2/7/16	9:59	21.2
Tailrace	2/27/16	3:47	2/27/16	10:52	7.1
Tailrace	2/27/16	11:29	2/28/16	10:19	22.8
Main Channel	3/11/16	9:07	3/12/16	11:07	26.0
Tailrace	3/20/16	13:00	3/21/16	9:53	20.9
Tailrace	4/10/16	5:00	4/10/16	10:50	5.8
Main Channel	4/14/16	8:32	4/14/16	10:33	2.0

[1] A portion of the weir was temporarily removed due to high-debris flow events.

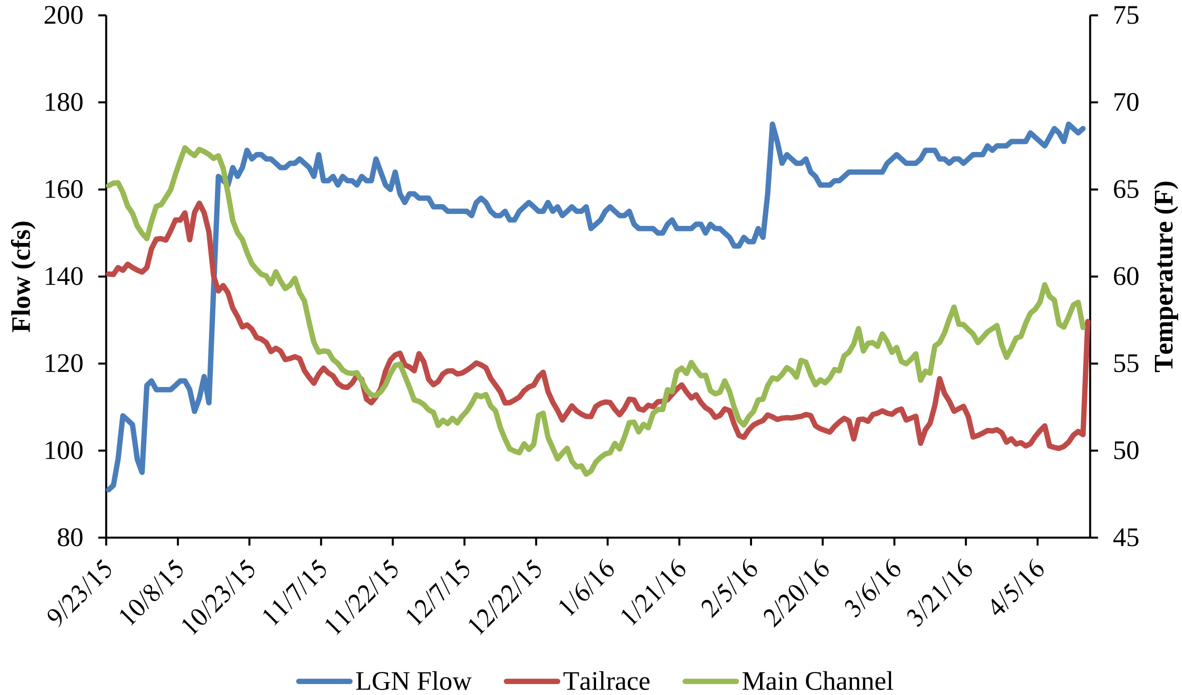

Figure 5.1-1. Mean daily flow (cfs) at the USGS gage (LGN) and daily mean water temperatures at the tailrace channel weir and the main channel weir during the 2015/2016 monitoring season.

5.2 Fish Passage

5.2.1 Chinook Salmon near La Grange Facilities

Based on data collected between September 23, 2015 and April 14, 2016, a total of 3,264 Chinook salmon passage events (1,617 upstream, 1,647 downstream) were detected at the tailrace and main channel weirs (Attachment A). The first Chinook salmon upstream passage was observed September 23, 2015, and the last Chinook salmon was observed February 15, 2016. The majority of passage events (89.7 percent) occurred during November and December accounting for 48.0 percent and 41.7 percent of Chinook salmon passages, respectively (Figure 5.2-1).

Individual fish were identified based on estimated fish length, sex, and general morphological characteristics. This classification resulted in a total of 105 individual Chinook salmon accounting for the 2,329 passages at the tailrace channel weir, and a total of 12 Chinook salmon accounting for the 935 passages at the main channel weir. Sex was determined for nearly all passages and consisted of 82 males and 35 females, with 28.2 percent (n=33) of the fish having a clipped adipose fin (ad-clipped). Based on morphological characteristics, it is likely that some individuals may have been detected at both weirs.

Individual Chinook salmon often made multiple, consecutive upstream and downstream passages. The mean number of upstream/downstream passage events for individual salmon at the tailrace weir was 10.8 (range: 1 to 54 passages), and at the main channel weir was 38.8

(range: 1 to 111 passages). The mean time from initial passage through final passage was 119 hours (4.98 days), and ranged from 0.37 hours to 823.89 hours (34.33 days) at the tailrace weir. The mean time from initial passage through final passage was 183.87 hours (7.66 days), and ranged from 4.83 hours to 491.28 hours (20.47 days) at the main channel weir.

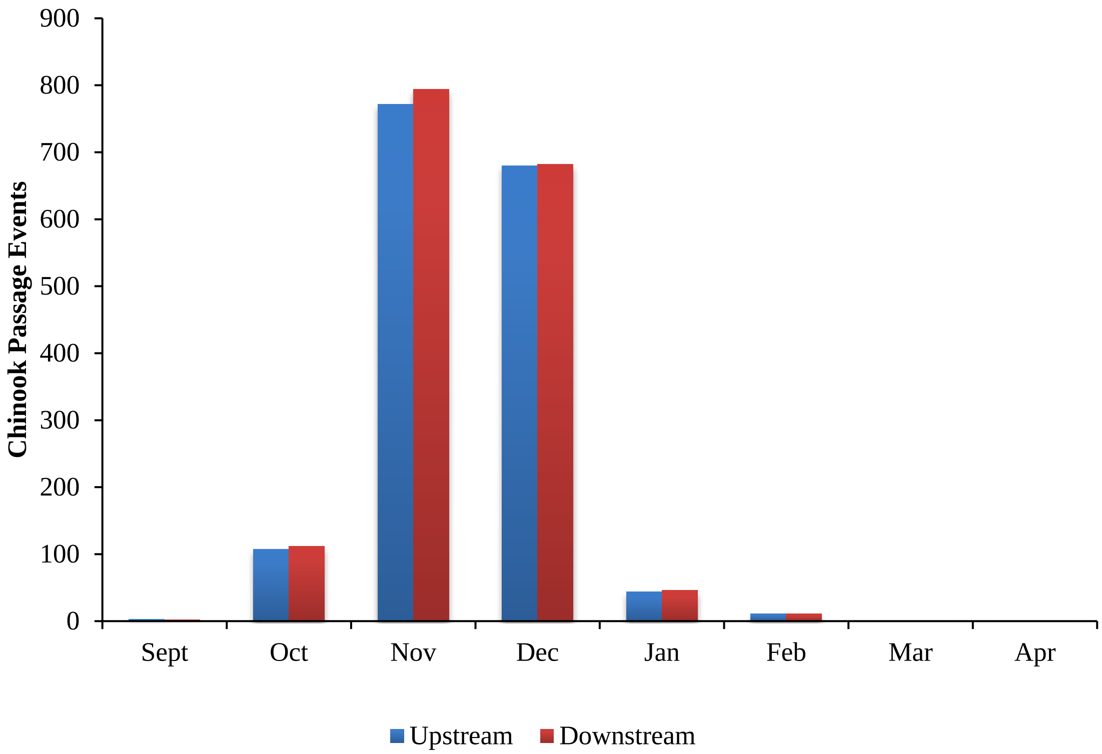

Figure 5.2-1. Chinook passage events by month at the tailrace and main channel weirs.

5.2.2 *O. mykiss* near La Grange Facilities

A total of 272 *O. mykiss* passage events (141 upstream, 131 downstream) were detected at the tailrace weir during the 2015/16 monitoring period. No *O. mykiss* were detected at the main channel weir. Estimated lengths of *O. mykiss* observed ranged from 10 cm to 60 cm. Adult-sized *O. mykiss* (>30 cm) accounted for 103 of these passages (45 upstream, 58 downstream) (Attachment A). Adult *O. mykiss* were first observed on October 6, 2015, and last observed on March 29, 2016 (Figure 5.2-2). The majority of adult *O. mykiss* detections occurred during the November through January period, accounting for 83.5 percent of the passage events. Unlike Chinook salmon, it was not possible to identify individual *O. mykiss* as there was much less variability in fish length, sex, and general morphological characteristics.

Two observations of ad-clipped *O. mykiss* were made on February 19 and February 24. Based on estimated length (~50 cm) and general morphological characteristics, these two observations were likely of a single fish. The absence of an adipose fin represents a hatchery-origin fish.

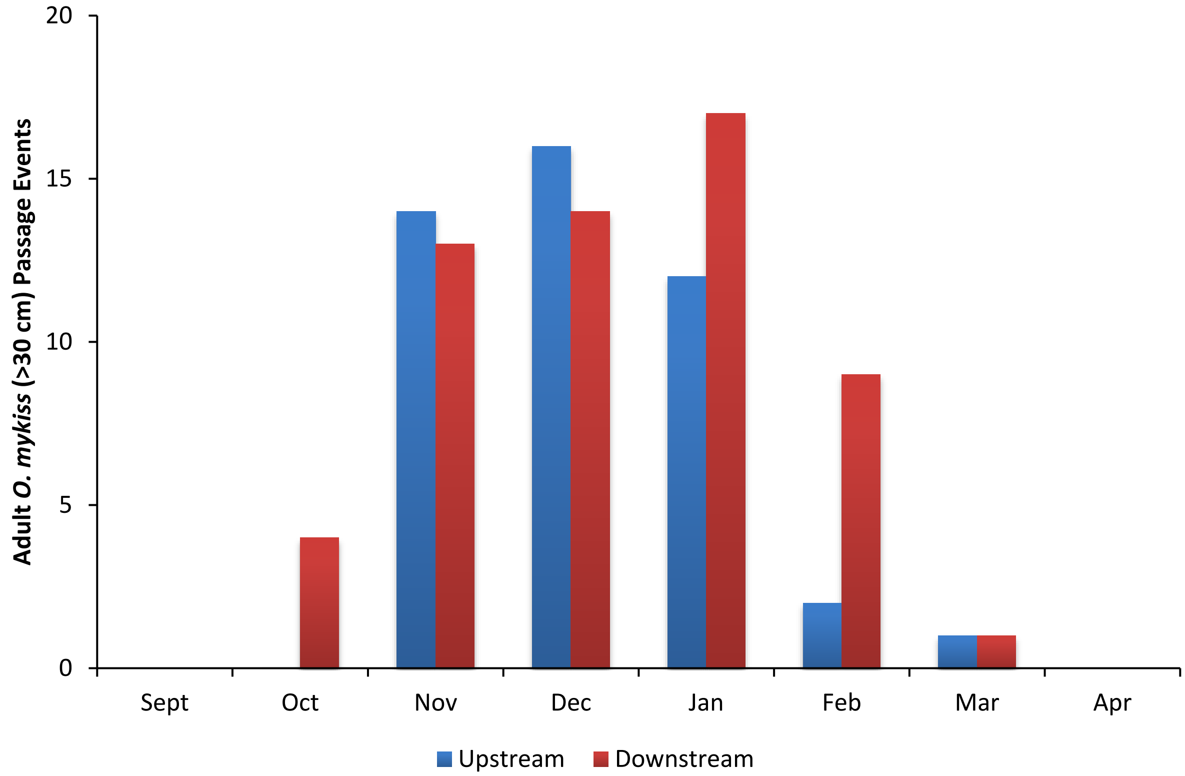

Figure 5.2-2. Adult *O. mykiss* (>30 cm) passage events at the tailrace channel weir.

5.2.3 Non-target Species near La Grange Facilities

Non-target fish species observed near the La Grange facilities during the 2015/2016 monitoring period included bluegill (*Lepomis macrochirus*), carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), largemouth bass (*Micropterus salmoides*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), and striped bass (*Morone saxatilis*) (Table 5.2-1). Mammals observed included beaver (*Castor canadenis*) and river otter (*Lontra canadenis*).

Table 5.2-1. Non-target fish species observed passing the tailrace and main channel weirs during the 2015/2016 monitoring season.

Species	Location	Estimated Length Range (cm)	First Passage Date	Last Passage Date	Passage Events	
					# Up	# Down
striped bass	tailrace	45-90	9/18/15	4/7/16	701	682
carp/goldfish	tailrace	20-90	12/24/15	4/11/16	645	407
Sacramento pikeminnow	tailrace	15-90	9/23/15	4/15/16	277	267
	main channel	20-40	9/27/15	2/25/16	9	5
bluegill/ sunfish	tailrace	5-20	9/21/15	2/21/16	67	13
	main channel	10-20	9/27/15	10/28/15	12	1
Sacramento sucker	tailrace	45-60	10/2/15	1/24/16	3	4
largemouth bass	tailrace	25-60	11/2/15	2/26/16	3	1
unidentified adult	tailrace	30-90	10/2/15	4/13/16	212	102
	main channel	30-50	10/21/15	10/31/15	7	5

Species	Location	Estimated Length Range (cm)	First Passage Date	Last Passage Date	Passage Events	
					# Up	# Down
unidentified juvenile	tailrace	10-25	9/22/15	3/25/16	57	36
	main channel	10-25	9/23/15	4/13/16	52	110

Previous monitoring on the Tuolumne River has documented non-native centrachids (bluegill and largemouth bass) below RM 48.0, with striped bass observed upstream to RM 51.8 (Stillwater 2012). This study provided the first formal documentation of these three species directly below La Grange powerhouse. On multiple occasions during the monitoring period, attempted predation events by striped bass were observed within the tailrace weir passing chute.

5.2.4 Passage at the Lower Tuolumne Weir

Total escapement into the Tuolumne River was determined to be 421 adult fall-run Chinook salmon based on weir counts at RM 24.5 between September 28, 2015 and December 31, 2015 (Becker et al. 2016). An additional 14 Chinook salmon passages were recorded during the winter/spring period (January 1, 2016 to May 13, 2016). Overall, 7.6 percent of passages (n=33) occurred during October, 49.7 percent (n=216) during November, and 39.5 percent (n=172) during December (Figure 5.2-3). Sex was determined for nearly all passages and consisted of 50 percent (n=212) males and 49 percent (n=207) females. Ad-clips were observed in 23.9 percent (n=104) of the Chinook salmon passages at the lower Tuolumne weir.

No *O. mykiss* were recorded passing the weir during the fall-run monitoring period, however three *O. mykiss* passages were recorded during the winter/spring period (January 1, 2016 to May 13, 2016) (Table 5.2-2).

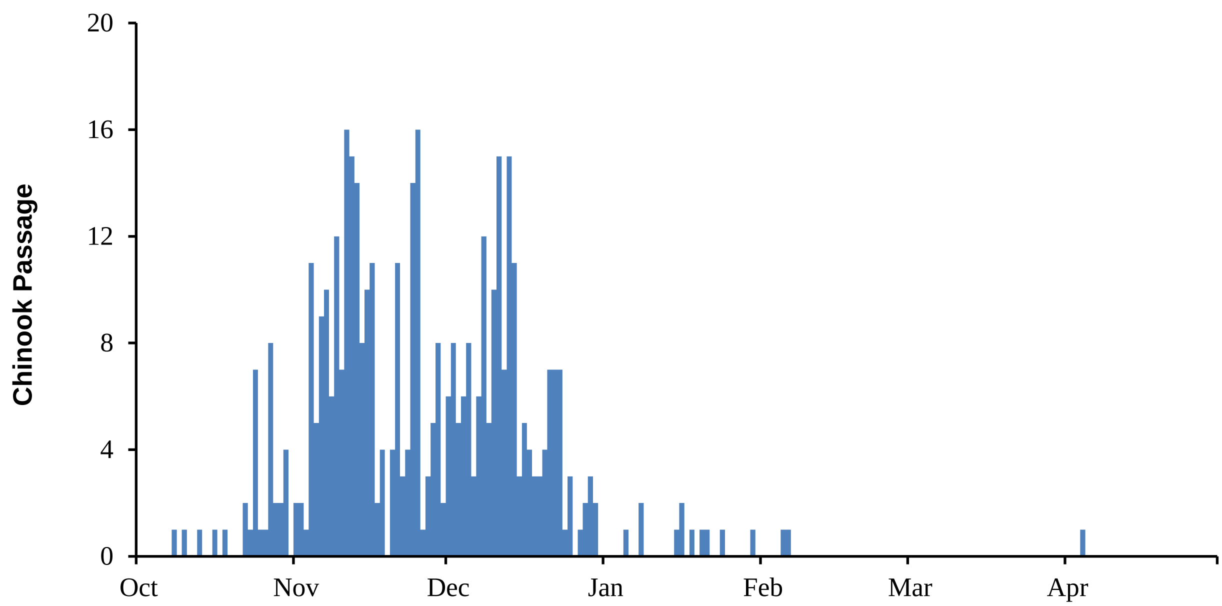

Figure 5.2-3. Count of daily upstream Chinook salmon passages at the Tuolumne River weir (RM 24.5).

Table 5.2-2. Lower Tuolumne weir (RM 24.5) *O. mykiss* passage information for the 2015/2016 monitoring season.

Sample Date	Passage Time	Passage Direction	Estimated Length (cm)	Ad Clip
1/27/16	14:37	Up	34	UNK
1/29/16	13:53	Up	42	Y
3/13/16	22:58	Up	40	N

5.3 Pre-spawn Mortality

Based on daily observations during the 2015/2016 monitoring season, there was no Chinook salmon or *O. mykiss* spawning activity upstream of the tailrace channel weir or the main channel weir. A single, unspawned Chinook salmon carcass was recovered in the sluice gate channel on December 25, 2015 (TID/MID 2017). After evaluation for egg retention, this carcass was frozen and delivered to CDFW La Grange staff. This fish likely entered the sluice gate channel during a powerhouse outage event, and became stranded and de-watered when the powerhouse came back online. CDFW escapement surveys conducted in the Tuolumne River did not document any pre-spawn or partial spawn Chinook mortalities during the 2015 fall-run monitoring period (Gretchen Murphey, CDFW pers. comm., January 2017).

6.0 DISCUSSION AND FINDINGS

6.1 Chinook Salmon Passage

Based on 2015/2016 weir counts, 117 adult Chinook salmon were observed at the La Grange counting weirs between September 23, 2015 and April 15, 2016. The proportion of the Chinook salmon escapement that was observed to be in the vicinity of the La Grange facilities was 26.9 percent (117/435). The maximum time observed between initial passage and final passage was a male Chinook salmon that made multiple upstream and downstream passages in the tailrace channel over a 34 day period between September 23, 2015 and October 27, 2015. Female salmon were not observed at the weirs until October 21, and within six days of arrival of the first female salmon, this male was no longer detected. It is likely that this fish was holding in the area below La Grange powerhouse in waiting of the arrival of a mate. As this fish was observed before the Tuolumne River weir (RM 24.5) was installed on September 28, 2015, it is unknown when this fish moved into the spawning reach.

Of the individual salmon observed during the 2015/2016 monitoring season, most (85.5 percent) spent less than 10 days near the La Grange facilities, with 21.4 percent (n=25) spending less than 24 hours near the La Grange facilities (Figure 6.1-1). This is consistent with typical observations of a lag of 1-2 weeks between arrival on the spawning grounds and spawning as documented by comparison of weir counts and redd mapping conducted by the Districts (Becker et al. 2016, FISHBIO, unpublished) and by live counts and redd counts reported by CDFW (O'Brien 2008).

The goal of this study was to determine the total number of fish exhibiting persistent upstream migration (i.e., as defined in the RSP, fish that move upstream to the La Grange facilities and don't return to downstream spawning habitat) to estimate the extent to which the La Grange facilities are actually a barrier to upstream migration and spawning. During the 2015/2016 monitoring season, only a single salmon met the criterion of exhibiting persistent upstream migration, a female that was likely stranded and dewatered in the sluice gate channel during an event when the powerhouse tripped offline. During the 2015/2016 monitoring period, 435 salmon moved upstream of the lower weir site (located at RM 24.5). Based on passages at the two monitoring locations, less than one percent of the total fall-run escapement exhibited persistent upstream migration as defined by the study criteria (1/435).

Considering that all but one of the Chinook salmon approaching the facilities moved downstream to spawn, and the relatively low rates of pre-spawn mortality observed in the lower Tuolumne River [4] (CDFW 2014, Gretchen Murphey, CDFW pers. comm., January 2017), it does not appear that the La Grange facilities affected Chinook production during the 2015/2016 study period.

[4] During the 2015 CDFW escapement surveys, CDFW did not observe any evidence of pre-spawn or partial spawn activity. A single pre-spawn mortality was observed in the sluice gate channel on December 25, 2015

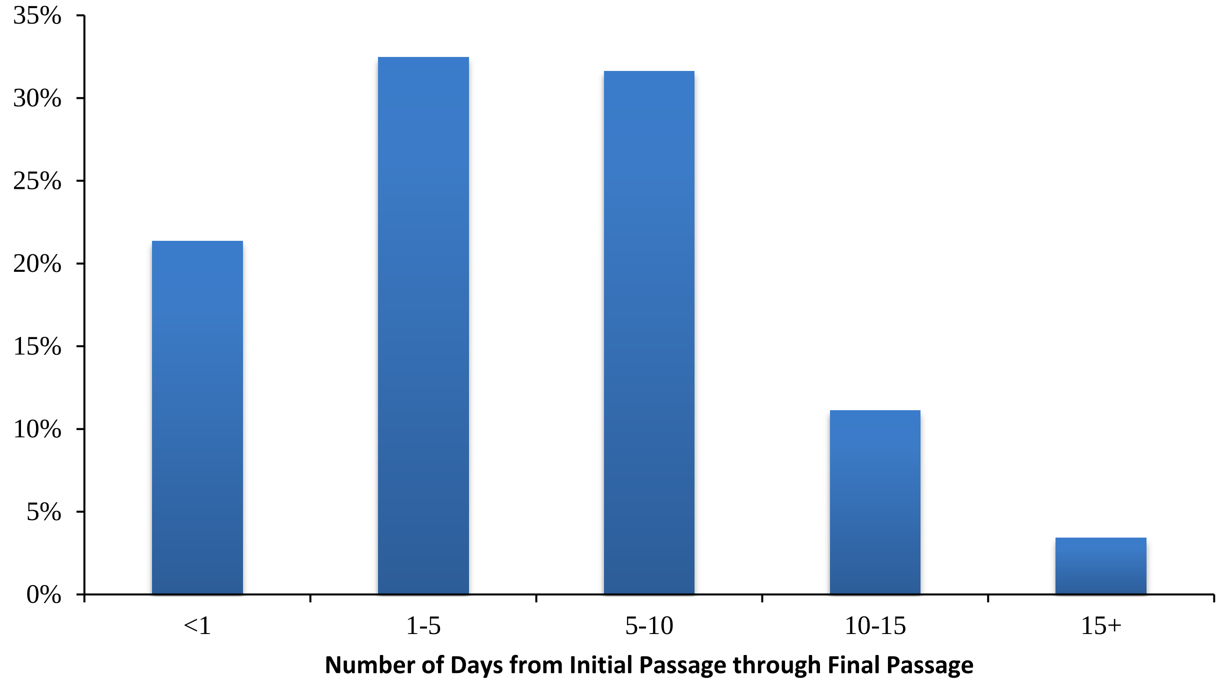

Figure 6.1-1. Proportional distribution of the number of days from initial weir passage through final passage for individual salmon at the tailrace and main channel weirs during the 2015/2016 monitoring season.

The Constant Fractional Marking Program (CFM) was initiated in 2007 as a means of effectively estimating hatchery production (Buttars, 2013). Analysis of 2010-2012 recovered CWT's (Kormos et al. 2012, Palmer-Zwahlen and Kormos, 2013 and Palmer-Zwahlen and Kormos, 2015) found that hatchery-origin Chinook salmon comprised 49 percent, 73 perecent and 36 percent of the Tuolumne River fall-run spawning population, respectively. Overall, 28.5 percent (n=33) of Chinook salmon observed at the tailrace and main channel weirs were ad-clipped, suggesting hatchery origin, during the 2015/2016 monitoring season. Additionally, 23.9 percent of Chinook passing the lower Tuolumne weir (RM 24.5) were ad-clipped. Given that 25 percent of Central Valley fall-run Chinook salmon hatchery production is marked annually, and that there is no hatchery in the Tuolumne River, this suggests that nearly all Chinook salmon entering the lower Tuolumne River and in the vicinity of the La Grange facilities during the study period were hatchery strays.

6.2 *O. mykiss* Passage

An objective of this study was to enumerate potential steelhead migrating upstream to the La Grange facilities. During the 2015/2016 monitoring season, three upstream migrating adult *O. mykiss*, were detected passing the Tuolumne River weir (RM 24.5). Due to the low number of upstream migrating *O. mykiss* observed at the downstream weir, the total of 103 adult (>30 cm) *O. mykiss* passages detected at the tailrace weir during the 2015/16 monitoring period, are primarily believed to represent movement of "resident" *O. mykiss* rearing in and around the La Grange powerhouse tailrace. Although it was not possible to identify individual *O. mykiss* passing the La Grange weirs, 83.5 percent (n=90) of the adult *O. mykiss* passage events occurred prior to the first *O. mykiss* detection at the lower weir site. Additionally, snorkel surveys (Stillwater 2010, Stillwater 2012) have regularly identified adult *O. mykiss* (30-50 cm) in the upper reaches of the lower Tuolumne River.

An ad-clipped *O. mykiss* was detected passing the Tuolumne River weir at RM 24.5 on January 29, 2016 (FISHBIO, unpublished). Based on size and the adipose fin clip, this is believed to be the same individual that accounted for multiple passages observed in the tailrace weir between February 19 and February 24, 2016. Since weir monitoring began at RM 24.5 in 2009, only four ad-clipped *O. mykiss* (>30 cm) have been detected. Given that ad-clipped *O. mykiss*, representing a hatchery-origin fish, are relatively rare in the Tuolumne River, it is likely that this single fish was detected at both monitoring locations.

7.0 STUDY VARIANCES AND MODIFICATIONS

This study was conducted consistent with the FERC-approved study plan. No variances or modifications occurred.

8.0 REFERENCES

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LA GRANGE PROJECT FISH BARRIER ASSESSMENT
PROGRESS REPORT

ATTACHMENT A

WEIR FISH PASSAGE DATA FOR SEPTEMBER 23, 2015 THROUGH APRIL 14, 2016

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Table A-1. Tailrace channel weir Chinook passage information, 2015/2016 monitoring season.

Fish ID	Est. Length	Sex	Ad-clip	Initial passage	Final passage	Passage events	
						No. Up	No. Down
M1	60-75	Male	No	9/23/15 7:48	10/27/15 15:42	42	-42
F1	60-70	Female	No	10/21/15 22:08	10/29/15 9:33	15	-17
F3	50-70	Female	Yes	10/25/15 21:32	10/27/15 18:45	11	-11
F2	50-65	Female	No	10/25/15 22:10	10/29/15 16:30	4	-4
F1 or F2	60-70	Female	No	10/27/15 1:40	10/27/15 2:37	1	-2
F4	45-60	Female	No	10/27/15 10:40	10/28/15 10:58	2	-3
M2	60-80	Male	No	10/28/15 2:43	11/9/15 22:59	40	-42
F5	60-80	Female	Yes	10/28/15 7:34	11/2/15 18:35	11	-11
F6	60-80	Female	No	10/29/15 20:19	11/13/15 22:55	33	-31
F7	50-65	Female	No	11/1/15 0:40	11/3/15 17:31	3	-3
F8	70-80	Female	No	11/1/15 1:36	11/14/15 4:46	8	-6
M3	55-70	Male	No	11/2/15 2:21	11/11/15 14:31	15	-17
M4	60-80	Male	Yes	11/3/15 12:52	11/13/15 11:05	10	-10
F10	50-60	Female	No	11/8/15 3:46	11/9/15 0:00	2	-2
F9	60-70	Female	Yes	11/8/15 3:46	11/12/15 18:46	3	-4
M5	55-70	Male	No	11/8/15 5:06	11/9/15 15:29	16	-16
M6	70-80	Male	No	11/8/15 19:10	11/14/15 11:39	5	-5
F11	80	Female	No	11/8/15 19:36	11/8/15 22:42	1	-1
M7	80-100	Male	No	11/8/15 19:55	11/12/15 6:50	3	-3
M8	55-60	Male	No	11/9/15 12:53	11/15/15 17:20	2	-2
M9	60-80	Male	No	11/9/15 16:52	11/10/15 23:14	5	-5
M10	90-100	Male	Yes	11/10/15 7:53	11/14/15 4:05	3	-3
M11	50-70	Male	No	11/11/15 1:40	11/17/15 17:50	19	-19
M12	50-60	Male	No	11/11/15 3:19	11/21/15 8:52	26	-26
M13	80	Male	Yes	11/11/15 10:54	11/11/15 12:50	1	-1
F12	70-80	Female	Yes	11/12/15 18:17	11/17/15 1:41	4	-4
M14	70-85	Male	No	11/14/15 3:43	11/20/15 13:23	13	-13
F13	80	Female	No	11/14/15 6:32	11/15/15 0:15	2	-1
M15	60-70	Male	Yes	11/14/15 6:55	11/20/15 9:26	16	-17
M17	55-70	Male	No	11/14/15 8:18	11/20/15 1:16	17	-17
M16	60-70	Male	No	11/14/15 23:13	11/20/15 15:49	10	-11
F14	70-80	Female	No	11/15/15 2:10	11/19/15 21:54	6	-6
F15	60-70	Female	No	11/15/15 2:41	11/16/15 2:53	2	-2
M20	70-90	Male	No	11/15/15 6:23	11/28/15 9:01	28	-28
M18	70-75	Male	No	11/15/15 10:11	11/15/15 21:56	2	-2
M19	60-75	Male	No	11/15/15 11:19	11/23/15 8:17	24	-22
M21	50-60	Male	No	11/16/15 1:01	11/21/15 13:18	4	-4
F16	50-60	Female	No	11/16/15 13:55	11/26/15 23:33	8	-8
M23	50-70	Male	Yes	11/16/15 16:25	11/26/15 10:31	17	-14
M22	70-80	Male	Yes	11/16/15 19:19	11/20/15 22:22	5	-6
F17	60-70	Female	No	11/16/15 22:16	11/21/15 3:44	4	-4
M24	50-70	Male	No	11/18/15 6:22	11/26/15 16:41	14	-14
M25	50-60	Male	No	11/20/15 6:39	11/24/15 10:51	5	-5
M26	60-70	Male	Yes	11/22/15 23:47	11/26/15 14:55	4	-4
M27	60-80	Male	No	11/23/15 18:01	11/26/15 17:21	5	-5
M28	80	Male	No	11/24/15 2:54	11/30/15 14:14	9	-9
M29	120	Male	No	11/24/15 3:42	11/24/15 5:37	1	-1
M30	50-70	Male	No	11/24/15 8:14	11/30/15 20:01	27	-27
M32	50-60	Male	No	11/26/15 15:45	11/29/15 19:41	5	-5

Fish ID	Est. Length	Sex	Ad-clip	Initial passage	Final passage	Passage events	
						No. Up	No. Down
M31	70-85	Male	No	11/26/15 17:08	12/4/15 4:58	22	-22
F18	70-80	Female	Yes	11/26/15 20:39	11/27/15 6:05	3	-3
F19	60	Female	Yes	11/27/15 4:57	11/29/15 15:57	3	-3
M33	60-90	Male	No	11/27/15 6:12	12/7/15 22:45	54	-54
M34	60-80	Male	No	11/27/15 6:37	12/2/15 12:38	12	-12
F20	50-60	Female	Yes	11/27/15 12:58	11/29/15 14:04	4	-4
F21	70-80	Female	No	11/29/15 3:27	12/8/15 6:29	7	-7
M35	55-70	Male	Yes	11/29/15 14:04	12/13/15 16:42	10	-10
M36	60-70	Male	Yes	11/29/15 14:05	12/2/15 20:40	6	-6
F22	40-45	Female	No	11/30/15 20:23	11/30/15 21:07	2	-2
F23	60-75	Female	No	12/1/15 4:58	12/8/15 14:23	7	-7
M37	50-65	Male	No	12/1/15 7:11	12/6/15 15:32	23	-22
M38	55-70	Male	No	12/1/15 9:56	12/9/15 8:18	39	-41
M39	80-85	Male	Yes	12/1/15 14:34	12/8/15 12:26	8	-7
F24	60-70	Female	Yes	12/3/15 0:27	12/3/15 2:54	1	-1
M41	70-80	Male	No	12/3/15 4:58	12/7/15 7:03	13	-13
M42	55-65	Male	Yes	12/3/15 15:22	12/6/15 11:30	9	-9
M44	55-75	Male	No	12/4/15 2:04	12/21/15 13:46	42	-43
M43	90-100	Male	No	12/4/15 3:56	12/4/15 5:49	2	-2
M45	50-60	Male	No	12/5/15 8:09	12/12/15 11:55	8	-8
M46	60-65	Male	Yes	12/6/15 10:55	12/10/15 0:35	14	-14
M40	85-100	Male	Yes	12/8/15 13:46	12/10/15 1:16	12	-13
M47	50-60	Male	Yes	12/11/15 11:37	12/18/15 18:12	13	-14
F25	60-70	Female	Yes	12/11/15 16:26	12/12/15 12:41	7	-7
F26	50-70	Female	No	12/12/15 13:14	12/15/15 23:58	9	-9
M48	50-70	Male	No	12/12/15 13:47	12/22/15 19:56	35	-34
M49	50-70	Male	No	12/12/15 14:01	12/22/15 21:29	34	-34
M50	70-90	Male	Yes	12/13/15 9:26	12/18/15 2:39	5	-5
M51	60-90	Male	No	12/13/15 23:01	12/22/15 11:27	25	-24
M52	70-90	Male	No	12/14/15 14:14	12/19/15 14:57	13	-13
M53	50-70	Male	No	12/16/15 13:57	12/22/15 18:37	13	-13
M54	50-60	Male	No	12/18/15 8:56	12/22/15 18:37	34	-34
M55	60-70	Male	Yes	12/18/15 9:02	12/22/15 14:34	22	-22
M56	50-60	Male	No	12/22/15 11:11	12/22/15 15:05	3	-3
M57	50-60	Male	No	12/22/15 15:17	12/22/15 16:21	5	-5
M58	60	Male	No	12/22/15 15:47	12/22/15 20:37	4	-4
M59	70	Male	Yes	12/22/15 18:39	12/22/15 20:51	2	-2
M60	50-65	Male	Yes	12/22/15 18:45	12/24/15 22:09	14	14
M61	40-50	Male	No	12/23/15 8:01	12/24/15 15:24	2	2
M62	50-70	Male	No	12/24/15 17:08	1/4/16 16:51	10	-10
M63	50-70	Male	No	12/25/15 0:17	12/27/15 14:28	17	-17
F27	65	Female	No	12/25/15 4:01	--[1]	1	0
F28	70	Female	No	12/25/15 15:34	12/25/15 16:00	1	-1
F29	50-70	Female	No	12/28/15 5:06	1/3/16 8:14	16	-17
F30	70	Female	Yes	12/31/15 22:56	1/1/16 11:52	1	-1
M64	60-80	Male	No	1/7/16 0:54	1/15/16 17:05	6	-6
M65	50	Male	Yes	1/7/16 13:06	1/7/16 14:21	1	-1
M66	60-80	Male	No	1/19/16 21:45	1/25/16 11:36	3	-3
F31	60-70	Female	Yes	1/20/16 23:48	1/26/16 14:28	21	-20
M67	50-60	Male	No	1/21/16 13:42	1/21/16 14:04	2	-2
M68	60-70	Male	No	1/22/16 4:20	1/22/16 5:36	1	-1

Fish ID	Est. Length	Sex	Ad-clip	Initial passage	Final passage	Passage events	
						No. Up	No. Down
M69	60	Male	No	2/4/16 11:58	2/4/16 13:00	1	-1
M70	60-75	Male	No	2/8/16 3:31	2/9/16 8:08	3	-3
M71	50-55	Male	Yes	2/10/16 7:02	2/13/16 14:43	2	-2
M72	70	Male	No	2/13/16 5:06	2/13/16 11:40	2	-2
M73	50-70	Male	No	2/13/16 8:49	2/15/16 13:22	2	-2
M74	110	Male	No	2/14/16 15:27	2/14/16 16:15	1	-1
UNID	50-80	N/A	N/A	10/28/15 0:00	12/24/15 0:00	10	-25

N/A indicates data is not available.

[1] No downstream passage, unspawned Chinook carcass was recovered in the sluice gate channel on 12/25/15.

Table A-2 Main channel weir Chinook salmon passage information for the 2015/2016 monitoring season.

Fish ID	Est. Length (cm)	Sex	Ad-clip	Initial passage	Final passage	Passage Events	
						No. Up	No. Down
MC-F1	60-70	Female	No	11/3/15 19:27	11/14/15 20:37	20	-20
MC-M1	55-70	Male	No	11/10/15 9:55	11/16/15 13:08	26	-27
MC-F2	55-70	Female	Yes	11/13/15 18:47	11/16/15 12:52	7	-7
MC-M2	50-70	Male	No	11/14/15 20:36	11/20/15 12:21	71	-73
MC-F3	50-70	Female	No	11/15/15 1:51	11/21/15 17:53	107	-111
MC-F4	55-70	Female	No	11/15/15 12:29	11/18/15 7:36	5	-5
MC-M3	50-70	Male	No	11/15/15 12:34	11/23/15 23:37	31	-32
MC-M4	60-70	Male	No	11/16/15 23:05	11/18/15 13:46	33	-33
MC-M5	60-70	Male	No	11/24/15 3:07	12/14/15 14:24	48	-48
MC-M6	60	Male	Yes	11/27/15 19:32	11/28/15 0:22	1	-1
MC-M7	60	Male	No	11/28/15 19:39	12/12/15 16:56	54	-54
MC-M8	60	Male	No	12/11/15 8:24	12/23/15 14:15	58	-60
UNID	N/A	N/A	N/A	11/8/15 0:00	11/15/15 0:00	1	-2

N/A indicates data is not available.

Table A-3. Tailrace channel weir adult (>30 cm) *O. mykiss* passage information, 2015/2016 monitoring season.

Date	Time	Species	Est. Length (cm)	Sex	Ad-Clip	Passage Direction	Observational Certainty
10/6/15	14:07:18	RBT	40	Unknown	No	Down	Low
10/7/15	12:44:46	RBT	50	Female	No	Down	High
10/29/15	14:47:06	RBT	45	Unknown	No	Down	High
10/31/15	18:54:05	RBT	35	Unknown	Unknown	Down	Medium
11/1/15	1:04:53	RBT	40	Unknown	Unknown	Up	Low
11/1/15	1:13:48	RBT	40	Unknown	Unknown	Down	Low
11/7/15	23:01:36	RBT	40	Unknown	No	Down	Low
11/8/15	5:31:46	RBT	35	Unknown	Unknown	Up	Low
11/8/15	5:57:06	RBT	50	Unknown	No	Up	Low
11/8/15	6:00:52	RBT	50	Female	No	Down	High
11/8/15	12:45:53	RBT	40	Male	No	Up	High
11/8/15	15:43:03	RBT	35	Unknown	No	Up	High
11/9/15	8:08:40	RBT	35	Unknown	Unknown	Up	High
11/9/15	16:36:11	RBT	35	Unknown	Unknown	Down	Low
11/9/15	17:28:47	RBT	40	Unknown	Unknown	Down	Low
11/9/15	17:44:54	RBT	45	Unknown	Unknown	Down	Low
11/10/15	3:38:39	RBT	40	Unknown	Unknown	Down	Low

Date	Time	Species	Est. Length (cm)	Sex	Ad-Clip	Passage Direction	Observational Certainty
11/10/15	6:00:39	RBT	40	Unknown	Unknown	Up	Medium
11/10/15	6:25:23	RBT	40	Unknown	No	Up	High
11/10/15	17:24:21	RBT	35	Unknown	Unknown	Down	Low
11/11/15	12:47:08	RBT	50	Unknown	No	Up	High
11/13/15	18:10:44	RBT	45	Female	No	Down	High
11/13/15	20:20:44	RBT	45	Unknown	Unknown	Up	Low
11/15/15	16:31:57	RBT	50	Unknown	No	Down	Medium
11/16/15	18:34:50	RBT	40	Unknown	No	Up	Low
11/16/15	18:44:09	RBT	40	Unknown	No	Down	Medium
11/17/15	2:53:10	RBT	40	Unknown	Unknown	Up	Low
11/17/15	17:40:03	RBT	40	Unknown	Unknown	Down	Low
11/20/15	16:29:04	RBT	40	Unknown	No	Up	High
11/27/15	21:50:14	RBT	50	Unknown	Unknown	Down	Low
11/27/15	21:53:31	RBT	50	Unknown	Unknown	Up	Low
12/4/15	12:33:12	RBT	45	Unknown	No	Up	High
12/4/15	13:03:31	RBT	50	Unknown	Unknown	Down	High
12/5/15	14:19:10	RBT	45	Unknown	No	Up	High
12/5/15	14:44:44	RBT	45	Unknown	No	Down	High
12/7/15	6:46:12	RBT	40	Unknown	Unknown	Up	Medium
12/12/15	7:55:11	RBT	40	Unknown	No	Down	Medium
12/12/15	8:29:54	RBT	40	Unknown	No	Up	High
12/12/15	16:15:11	RBT	50	Unknown	No	Down	High
12/14/15	8:14:53	RBT	40	Unknown	No	Up	High
12/15/15	5:35:02	RBT	45	Unknown	Unknown	Down	Low
12/19/15	3:27:58	RBT	40	Unknown	No	Up	Medium
12/20/15	23:55:30	RBT	40	Unknown	Unknown	Up	Low
12/22/15	15:07:28	RBT	40	Unknown	No	Up	High
12/22/15	16:19:00	RBT	45	Unknown	No	Up	Low
12/22/15	20:14:11	RBT	40	Unknown	No	Down	Low
12/22/15	20:17:51	RBT	40	Unknown	Unknown	Up	Low
12/22/15	20:34:54	RBT	40	Unknown	Unknown	Down	Low
12/22/15	20:42:49	RBT	40	Unknown	No	Up	Low
12/25/15	19:52:36	RBT	40	Unknown	No	Down	High
12/26/15	0:40:46	RBT	45	Unknown	No	Down	Medium
12/26/15	2:09:00	RBT	50	Unknown	Unknown	Down	Low
12/26/15	2:10:20	RBT	50	Unknown	Unknown	Up	Low
12/26/15	2:10:23	RBT	50	Unknown	Unknown	Up	Low
12/26/15	2:16:48	RBT	50	Unknown	Unknown	Down	Low
12/26/15	6:57:40	RBT	50	Unknown	Unknown	Up	Low
12/27/15	18:50:55	RBT	50	Female	Unknown	Down	Medium
12/28/15	4:33:55	RBT	40	Unknown	Unknown	Up	Low
12/28/15	13:45:04	RBT	50	Unknown	No	Down	Low
12/30/15	15:48:23	RBT	50	Unknown	No	Down	Medium
12/31/15	1:52:41	RBT	50	Unknown	No	Up	Medium
1/9/16	14:05:35	RBT	50	Unknown	No	Down	Low
1/10/16	12:49:24	RBT	40	Unknown	No	Up	Low
1/11/16	8:09:57	RBT	50	Male	No	Down	Low
1/11/16	8:09:57	RBT	50	Female	No	Down	High
1/11/16	10:55:26	RBT	50	Male	No	Up	High
1/11/16	14:33:09	RBT	50	Unknown	No	Down	Medium
1/11/16	14:33:09	RBT	50	Unknown	No	Down	Low

Date	Time	Species	Est. Length (cm)	Sex	Ad-Clip	Passage Direction	Observational Certainty
1/11/16	14:57:14	RBT	50	Unknown	No	Up	Low
1/11/16	14:57:14	RBT	50	Unknown	No	Up	Low
1/12/16	7:55:07	RBT	50	Unknown	No	Down	Low
1/12/16	7:55:07	RBT	60	Female	No	Down	Medium
1/12/16	8:38:36	RBT	50	Unknown	No	Up	Medium
1/12/16	8:38:36	RBT	60	Female	No	Up	High
1/12/16	9:13:40	RBT	50	Male	No	Down	High
1/12/16	9:13:40	RBT	60	Female	No	Down	High
1/12/16	10:49:48	RBT	40	Male	No	Up	Medium
1/12/16	13:47:34	RBT	60	Unknown	No	Down	Low
1/16/16	13:33:48	RBT	50	Female	No	Up	High
1/16/16	23:43:53	RBT	60	Unknown	Unknown	Down	Low
1/17/16	13:51:33	RBT	50	Unknown	No	Up	Medium
1/20/16	12:38:53	RBT	50	Unknown	No	Down	Medium
1/21/16	10:49:13	RBT	40	Unknown	No	Down	Medium
1/21/16	15:48:45	RBT	40	Unknown	No	Up	High
1/21/16	16:12:57	RBT	40	Unknown	No	Down	High
1/22/16	2:49:45	RBT	40	Unknown	Unknown	Up	Medium
1/22/16	11:30:58	RBT	50	Female	No	Down	High
1/22/16	23:15:09	RBT	50	Unknown	Unknown	Up	Low
1/22/16	23:16:30	RBT	40	Unknown	Unknown	Down	Medium
1/23/16	15:58:34	RBT	50	Unknown	No	Down	High
2/19/16	3:43:06	RBT	50	Unknown	Yes	Down	Medium
2/19/16	21:09:23	RBT	40	Female	No	Down	High
2/20/16	7:14:15	RBT	40	Unknown	No	Down	High
2/23/16	20:38:12	RBT	50	Unknown	No	Down	High
2/24/16	22:09:59	RBT	35	Unknown	Unknown	Up	Medium
2/24/16	23:37:38	RBT	50	Unknown	Yes	Up	Medium
2/25/16	0:03:40	RBT	50	Unknown	Unknown	Down	High
2/25/16	0:03:40	RBT	50	Unknown	Unknown	Down	High
2/25/16	6:27:40	RBT	40	Unknown	Unknown	Down	Medium
2/25/16	6:27:40	RBT	40	Unknown	Unknown	Down	Medium
2/26/16	17:36:09	RBT	40	Unknown	No	Down	High
3/29/16	10:00:10	RBT	50	Unknown	Unknown	Up	Medium
3/29/16	10:15:21	RBT	50	Unknown	Unknown	Down	Medium

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT F

TOPOGRAPHIC SURVEY TECHNICAL MEMORANDUM

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TOPOGRAPHIC SURVEY
TECHNICAL MEMORANDUM

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

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

Prepared by:
HDR, Inc.

February 2017

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Lake Lloyd (known as Cherry Lake), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

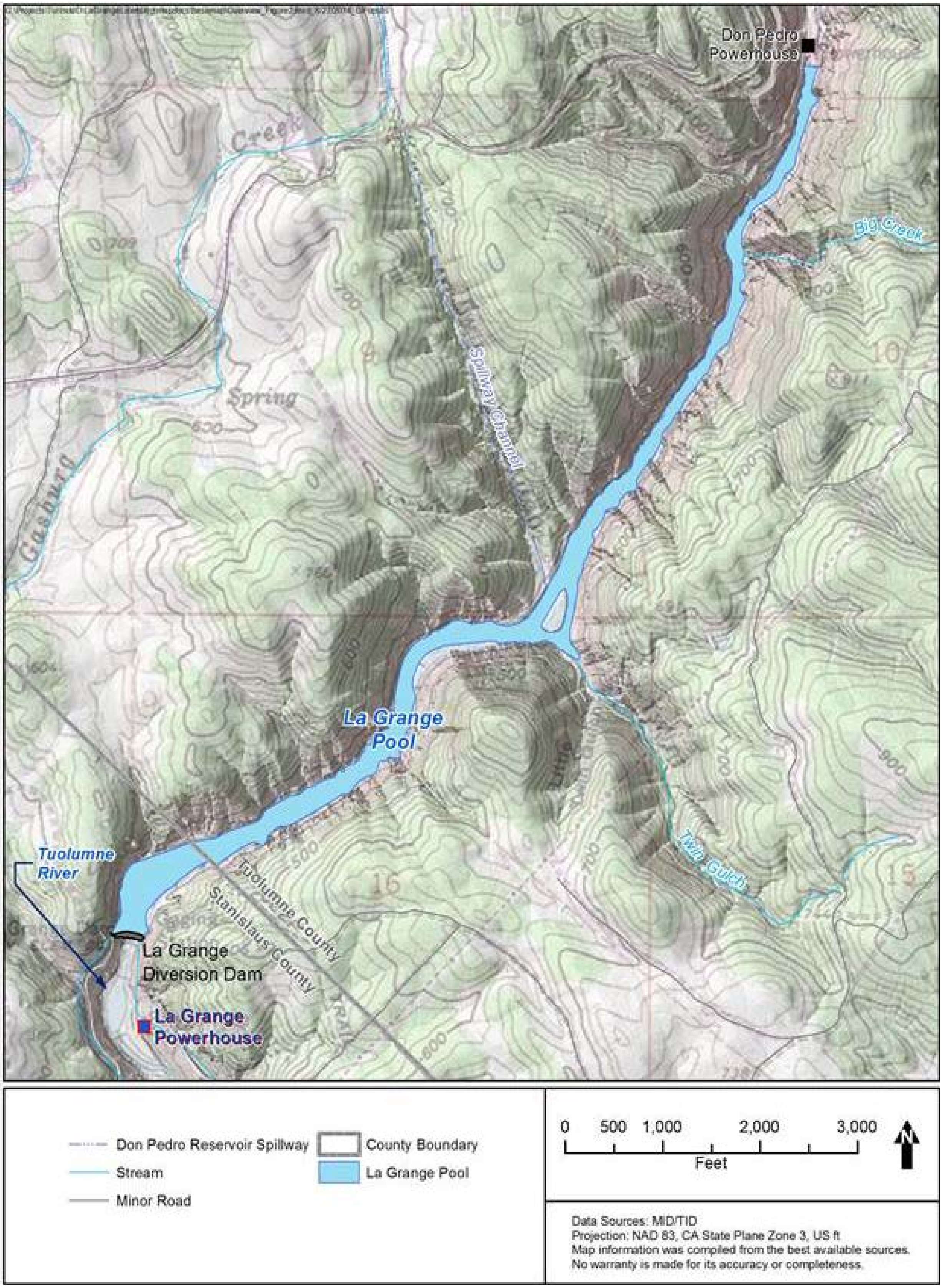

Figure 1.1-1. La Grange Hydroelectric Project location map.

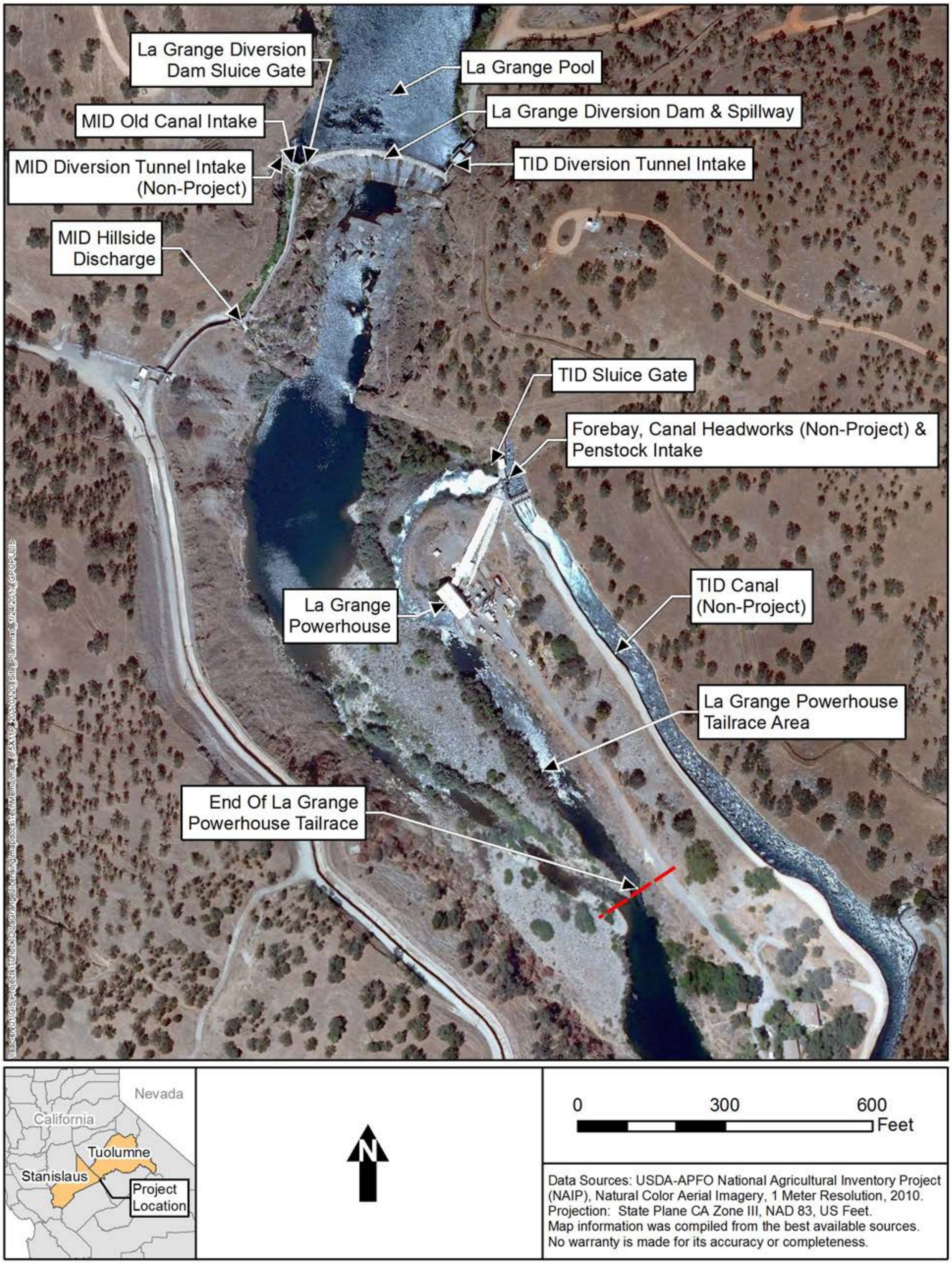

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

1 Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."
2 FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).

[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish passage through Don Pedro Reservoir or La Grange pool. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study.

During the ISR meeting held on February 25, 2016, NMFS requested that the Districts provide a copy of the LiDAR report for the LiDAR data referenced in the Topographic Survey Technical Memorandum. NMFS requested additional data pertaining to the study in the agency's April 4, 2016, comments on the ISR. In particular, NMFS requested a copy of the survey data (x, y, z coordinate data) as well as the longitudinal profile and water surface data.

In response to these requests, the Districts provided the LiDAR report as an attachment to the Districts' May 2, 2016 response to licensing participant comments on the ISR. Additionally, the Districts prepared a data package that included: (1) a shapefile depicting point LiDAR measurements of the island area between the lower Tuolumne River main channel below the La Grange Diversion Dam and the powerhouse tailrace channel; (2) a shapefile with survey points; (3) a shapefile with longitudinal profile routed line features that represent the thalweg of each surveyed channel; (4) a shapefile with all survey points utilized to develop the profile graphic included in the technical memo; and (5) a table summarizing depths by habitat unit and profile charts that show the water depth data. The Districts provided this data package, via CD, to

NMFS on May 23, 2016. On May 31, 2016, the Districts mailed a copy of this CD to FERC. This data is available upon request to the Districts (Attachment A).

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified the potential for Project effects on anadromous fish spawning habitat downstream of the LGDD. According to the SD2, such effects might possibly result from the retention of sediment in the La Grange pool, or if changes in Project outflows alter downstream spawning habitat suitability and thereby impact spawning due to stranding or displacement of fish or redds in either the main channel, the tailrace channel, or the sluice gate channel.

FERC's SPD approved with modifications the Districts' proposed Fish Habitat and Stranding Assessment below La Grange Diversion Dam. In its SPD, FERC ordered the Districts to: (1) continue monitoring existing flow conduits where flow monitoring is already occurring, conduct two years of flow monitoring at flow conduits not currently monitored (i.e., the Modesto hillside discharge and LGDD sluice gate), develop estimates of historical flows, data permitting, for each of the five flow conduits at the Project, and, based on existing information, to the extent available, characterize the magnitude and rate of flow and stage changes when Project conduits are shut down; (2) collect topographic, depth, and habitat data downstream of, and in the vicinity of, the Project; (3) assess fish presence and the potential for stranding; and (4) in consultation with NMFS and other interested parties, develop and implement a plan for monitoring anadromous fish movement into the powerhouse draft tubes.

The Topographic Survey reported herein describes the work associated with Item (2) above. Other components related to this study directive, including habitat typing, gravel mapping, and spawning habitat suitability in the reach immediately downstream of LGDD, are provided in a separate report entitled Salmonid Habitat Mapping Technical Memorandum (TID/MID 2016).

2.0 STUDY GOALS AND OBJECTIVES

The goal of the survey is to collect information to evaluate the effects of Project operation on stream flow and anadromous fish habitat in the Tuolumne River between LGDD and La Grange gage. Specific objectives of the survey include:

- surveying a longitudinal profile and transects along the channel thalweg in the La Grange powerhouse tailrace, TID sluice gate channel, and the mainstem river channel upstream of where it joins the tailrace channel, as depicted in Figure 1.1-2. Take survey measurements that characterize the large cobble and bedrock island that separates the La Grange powerhouse tailrace and the mainstem Tuolumne River below LGDD;
- taking survey measurements at geomorphic hydraulic control features in the channels below the LGDD and La Grange powerhouse. These include pool tailouts, rock outcroppings, ledges, and other immobile bed features that determine the stage-discharge relation. Note that this objective was added per FERC’s SPD; and
- measuring water depths at a flow of approximately 25 cubic feet per second (cfs) in the mainstem river channel upstream of where it joins the tailrace channel and at approximately 75 to 100 cfs in the La Grange powerhouse tailrace channel and the TID sluice gate channel.

3.0 STUDY AREA

The study area is depicted in Figure 1.1-2 and includes the La Grange tailrace channel, the TID sluice gate channel, and the mainstem Tuolumne River from where it joins the tailrace channel upstream to the LGDD plunge pool. The total length of stream channel to be assessed is approximately 0.5 miles.

4.0 METHODOLOGY

4.1 2015 Topographic Data Collection

The survey was completed over two days. The first day was June 23, 2015 and the second day was July 15, 2015. A Real Time Kinematic (RTK) GPS system was used to record topographic information. RTK GPS is capable of recording centimeter level accuracy for both horizontal and vertical positions. A licensed TID surveyor and survey crew were present and completed the topographic surveys on both days.

The day before data collection commenced, TID surveyors set up the RTK GPS base station and verified that the RTK data loggers were recording data by surveying several known points and validating the results. On June 23, traditional ground-based surveys along the longitudinal profile of both the mainstem Tuolumne River and the La Grange powerhouse tailrace channel were conducted. Each topographic measurement included a water depth measurement approximately every 10 feet with additional points recorded in areas of hydraulic control. Figure 4.1-1 shows surveyors recording position and depth along the thalweg of the La Grange powerhouse tailrace.

Figure 4.1-1. Traditional ground-based data collection along La Grange powerhouse tailrace channel.

Because the large plunge pool below LGDD and several areas along both channels were too deep to survey safely using traditional ground-based survey methods, it was determined that a bathymetric survey at a later date would be required for these areas. The bathymetric survey was completed on July 15, 2015 using a remote control platform combined with RTK GPS and sonar. Surveyors used a Hydrone™ Remote Control Vessel (RCV), a HydroLite-TM™ sonar system, and RTK GPS for position and elevation to complete the survey (Figure 4.1-2).

The HydroLite-TM™ system utilizes a 200-KHz four degree sonar beam to accurately record depths to 1 cm. Because the plunge pool's depth did not allow for a visual evaluation of the thalweg, position and depth were measured along transects perpendicular to the longitudinal extent of the large pool. Each transect was spaced at approximately 15 feet. The longitudinal profile and thalweg was then derived from the transect data by connecting the lowest sounding from each transect. There were several in-channel pools that were measured using the RCV as well. At these pools, the water was shallow enough for a visual evaluation of the thalweg and the RCV was piloted along the thalweg, recording position, and depth. These measurements were combined with the previous surveyed profile data to produce a seamless longitudinal profile along the thalweg of both the mainstem Tuolumne River and La Grange powerhouse tailrace channels.

Figure 4.1-2. Bathymetric survey of plunge pool below La Grange Diversion Dam.

At the time of the survey in 2015, no depths were recorded because the TID sluice gate channel was not inundated by water[3]. The Districts provided a LiDAR dataset that was collected while the sluice gate was closed. The LiDAR data was used to complete the longitudinal profile of the sluice gate channel and the topographic survey of the large cobble and bedrock island that separates the La Grange powerhouse tailrace and the mainstem channel. The LiDAR data was flown on March 30, 2012 and meets Federal Emergency Management Agency specifications for the generation of two-foot contours.

[3] In general, an 18-inch pipe supplies water to the sluice gate channel at all time. However, during a portion of the summer of 2015, the 18-inch pipe was closed to support study activities. The pipe was reopened in the fall of 2015.

4.2 Hydraulic Control

In addition to collecting topographic data along the river profile, surveyors collected additional topographic points along areas of hydraulic control within the inundated channels of both the mainstem Tuolumne River and the La Grange powerhouse tailrace channel.

4.3 Discharge Measurements

To ensure depth measurements were being taken at discharges identified in the RSP (i.e., approximately 25 cfs in the mainstem river channel upstream of where it joins the tailrace channel and at approximately 75 to 100 cfs in the La Grange powerhouse tailrace channel and the TID sluice gate channel), manual flow measurements of both the La Grange powerhouse tailrace channel and the mainstem Tuolumne River channel were completed using a Swoffer® velocity meter on June 23 to verify flow conditions were consistent with the requirements of the RSP. The model of Swoffer® velocity meter used is accurate at velocities ranging from 0.1 to 25.0 feet per second (fps). A photo of the flow measurement transect within the La Grange powerhouse tailrace channel is shown in Figure 4.3-1.

Figure 4.3-1. Velocity measurement transect on the La Grange powerhouse tailrace channel.

5.0 RESULTS

5.1 Topographic Data

The FERC-approved RSP states the results of the topographic study should include longitudinal profiles of the mainstem Tuolumne River, the TID sluice gate channel, and the La Grange powerhouse tailrace channel. These data are provided below (Figures 5.1-1, 5.1-2, and 5.1-3), along with a map showing the channel thalwegs (Figure 5.1-4). All elevations are reported in the North American Vertical Datum of 1988 (NAVD88).

The RSP additionally requires topographic points that characterize the large cobble and bedrock island that separates the La Grange powerhouse tailrace and the mainstem Tuolumne River below LGDD. These topographic points were available from the LiDAR data provided by the Districts and are characterized below in Figure 5.1-5. The elevations on the island at the time of the survey ranged from 176.9 to 193.0 feet. The average elevation was 186.9 feet and the average distance between points was approximately 1.4 feet.

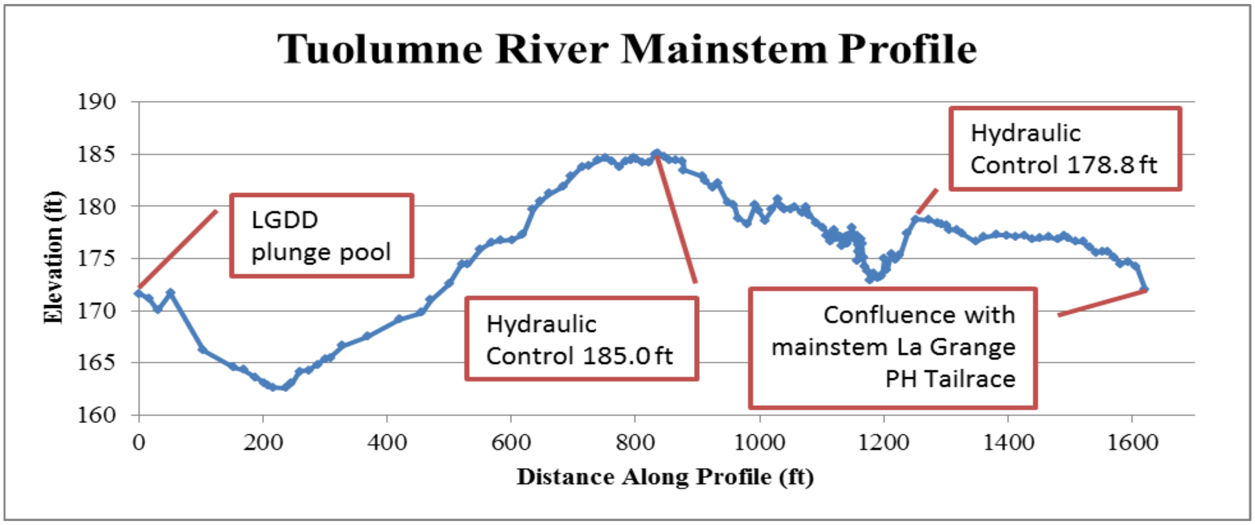

Figure 5.1-1. Longitudinal profile of the Tuolumne River mainstem channel.

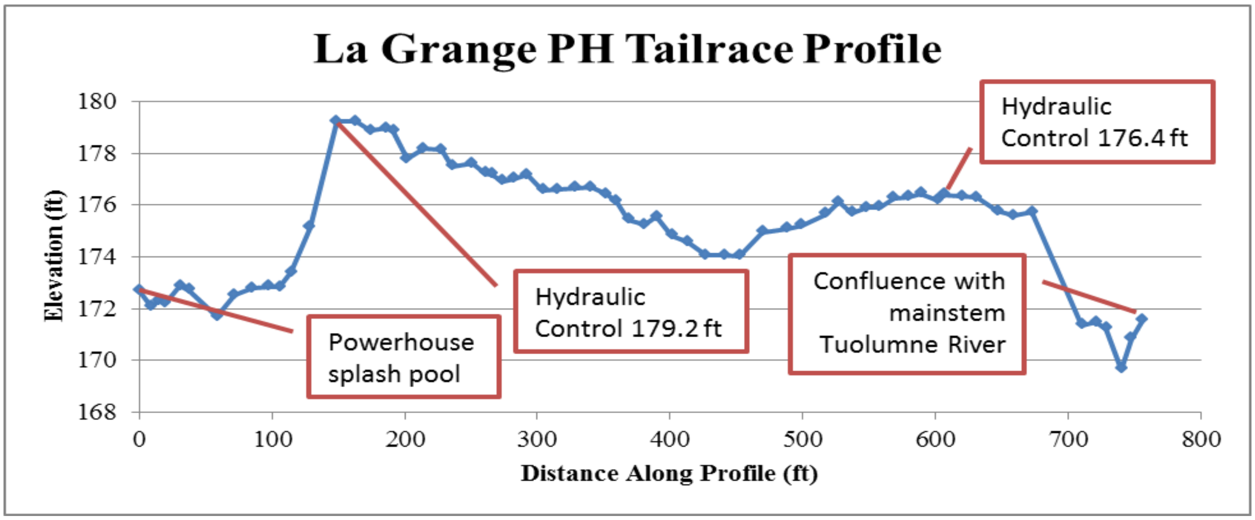

Figure 5.1-2. Longitudinal profile of the La Grange powerhouse tailrace channel.

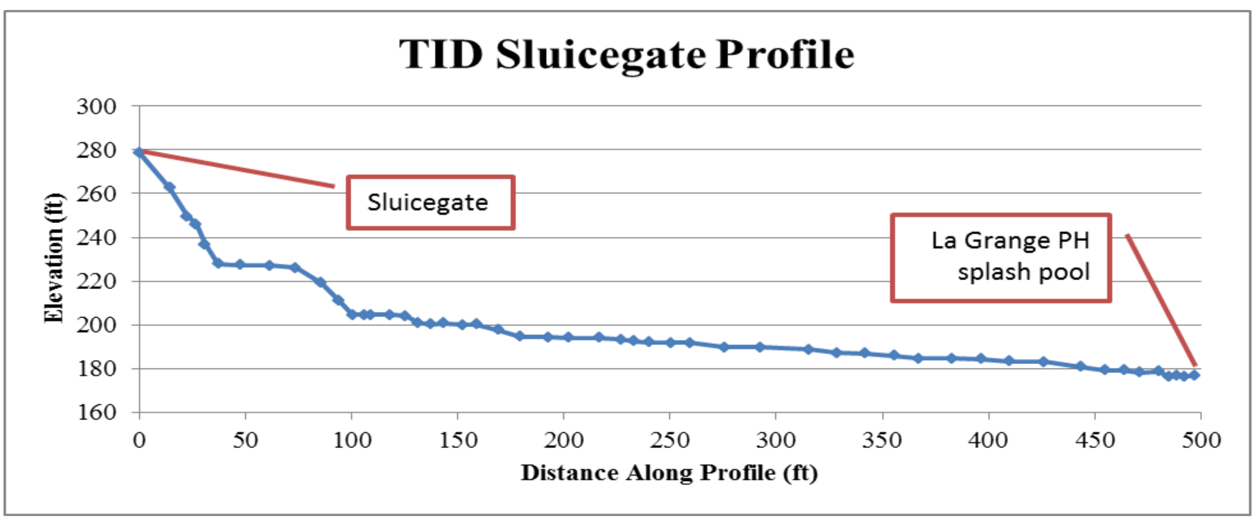

Figure 5.1-3. Longitudinal profile of the TID sluice gate channel.

Figure 5.1-4. Channel thalwegs and hydraulic control locations with distances along profile identified.

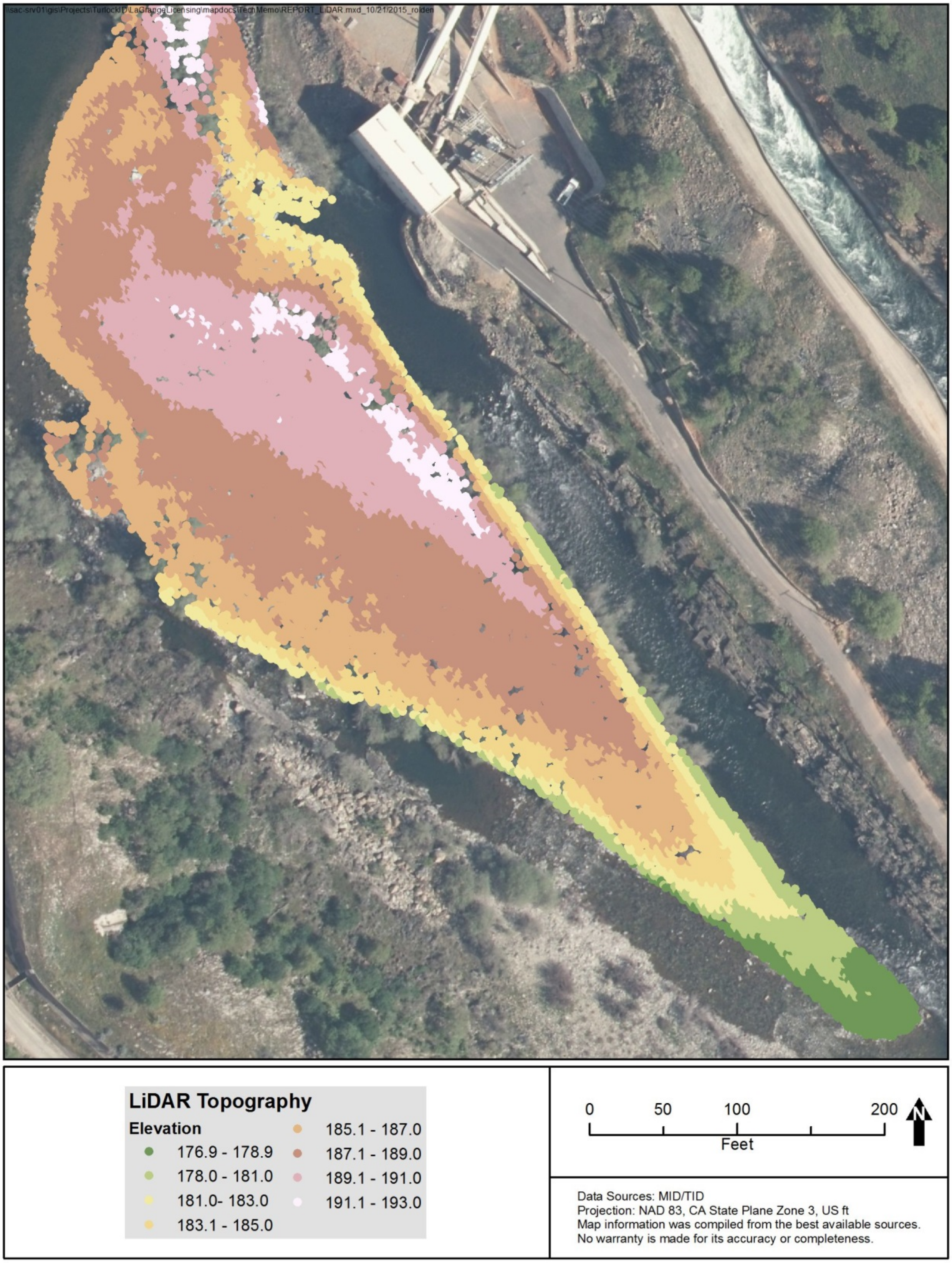

Figure 5.1-5. Mid-channel island LiDAR topography.

5.2 Hydraulic Control

Surveyors identified two points of hydraulic control on each of the both the mainstem Tuolumne River and the La Grange powerhouse tailrace channel. The topographic measurements at areas of hydraulic control are identified in Figures 5.1-1, 5.1-2, and 5.1-4.

5.3 Discharge and Depth Measurements

Mainstem Tuolumne River channel flow measurements were difficult to complete due to the low flow conditions and the lack of a suitable flow measurement location. However, the combined flow for both channels is captured by the U.S. Geological Survey (USGS) gage just downstream of the study area, thus mainstem channel flow measurements can be inferred by subtracting the flow measurement within the La Grange powerhouse tailrace channel.

Flow measurements for each of the channels were not measured on July 15, 2015 as they were similar to June 23, 2015 according to both the USGS gage immediately downstream of the study area and a visual assessment by survey staff. The RSP states that flows should be approximately 75 to 100 cfs in the La Grange tailrace channel and approximately 25 cfs in the main channel. As shown below in Table 5.3-1, the flow measurement results are consistent with this requirement.

Table 5.3-1. Flow measurements below La Grange Diversion Dam and powerhouse.

Date	Manual – La Grange PH Tailrace (cfs)	USGS 11289650 (cfs)	Inferred – Main Channel (cfs)
6-23-2015	81	~100	19
7-15-2015	NA	~90	NA

Depth measurements along the surveyed longitudinal profiles were recorded under discharges identified in the RSP. A summary of these data is provided below (Table 5.3-2). A range of depths is provided along with the average and median depths for each of the channel profiles. The median depth may be more representative of the most common depths by length as the deep pool depths are an order of magnitude larger than the most prolifically observed depths. The complete dataset of depth measurements is available upon request to the Districts.

As noted above, depths in the TID sluice gate channel were not available during the time of the 2015 survey as the sluice gate was closed and no water was in the channel. Additionally, existing LiDAR data of the sluice gate channel provided by the Districts was conducted when the TID sluice gate was closed. In 2016, a hydraulic study of the TID sluice gate channel was completed, the data from which is available upon request (Attachments A and B).

Table 5.3-2. Summary of depth measurements collected in 2015 for each channel below LGDD.

Channel	Depth Range (ft)	Average Depth (ft)[1]	Median Depth (ft)
Tuolumne River Mainstem	0.3-23.1	6.2	2.9
La Grange PH Tailrace	0.7-9.1	3.4	2.2
TID Sluice Gate[2]	NA	NA	NA

[1] Average and median depth calculated along the longitudinal profile measurements.
[2] The TID sluice gate was closed during the survey.

6.0 STUDY VARIANCES AND MODIFICATIONS

There was one variance and no modifications to the study plan. At the time of the survey in 2015, there were no flows in the TID sluice gate and thus no depth measurements were taken. The Districts collected this information in 2016 (Attachment B).

7.0 REFERENCES

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2016. Salmonid Habitat Mapping Technical Memorandum. Prepared by Stillwater Sciences. Attachment to La Grange Hydroelectric Project Initial Study Report. February 2016.

TOPOGRAPHIC SURVEY
TECHNICAL MEMORANDUM

ATTACHMENT A

LIDAR AND SPATIAL DATA AVAILABLE UPON REQUEST

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A CD containing LiDAR data and spatial data used by or developed during the Topographic Survey is available upon request. The CD contains: (1) a shapefile depicting point LiDAR measurements of the island area between the lower Tuolumne River main channel below the La Grange Diversion Dam and the powerhouse tailrace channel; (2) a shapefile with survey points; (3) a shapefile with longitudinal profile routed line features that represent the thalweg of each surveyed channel; (4) a shapefile with all survey points utilized to develop the profile graphic included in the technical memo; (5) a table summarizing depths by habitat unit and profile charts that show the water depth data; and (6) a LandXML file containing data from the 2016 sluice gate channel survey. The CD is available upon request to Jenna Borovansky (jenna.borovansky@hdrinc.com).

TOPOGRAPHIC SURVEY
TECHNICAL MEMORANDUM

ATTACHMENT B

2016 SLUICE GATE CHANNEL SURVEY

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1.0 INTRODUCTION

As part of the La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) Topographic Survey, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) were required to conduct a survey of the sluice gate channel. At the time of the Topographic Survey fieldwork in 2015, there were no sluice gate flows and thus no water depth measurements were taken. In January 2016, the Districts filed with the Federal Energy Regulatory Commission (the Commission or FERC) the Topographic Survey Technical Memorandum, which stated that the Districts would collect water depth data in the sluice gate channel in 2016. FERC staff approved this modification per the May 27, 2016 Determination on Requests for Study Modifications and New Study for the La Grange Project. This technical memorandum presents the results of the 2016 hydraulic study of the sluice gate channel.

If the La Grange powerhouse trips off line, the sluice gate(s) located adjacent to the penstock intakes (see Figure B-1) is immediately opened to maintain discharge in the tailrace channel. When powerhouse operation is restored, the sluice gate(s) closes. An 18-inch pipe delivers approximately 5 to 10 cfs from the forebay structure to the sluice gate channel continuously, maintaining flowing water to the sluice gate channel at all times [1].

Figure B-1. Aerial photo of sluice gate channel area, forebay, penstock intakes, powerhouse and upper end of tailrace channel.

[1] In general, an 18-inch pipe supplies water to the sluice gate channel at all time. However, during a portion of the summer of 2015, the 18-inch pipe was closed to support study activities. The pipe was reopened in the fall of 2015.

The Districts performed field survey measurements of topography and water surface elevation in the channel below the sluice gate at the constant flow from the 18-inch pipe which was measured to be approximately 8 cfs and at a sluice gate flow of 80 cfs. This field survey information and water surface elevation data were used to develop a hydraulic model and plot cross-section and longitudinal depth profiles as well as to quantify the stage changes associated with flow changes during operation of the sluice gates to enable the evaluation of the potential for fish stranding.

2.0 SITE DATA

Site data for the study was provided in the form of a detailed 1-foot contour interval topographic survey performed in October 2016. The topographic survey covered the area of the sluice gate channel between the discharge gates and the powerhouse tailrace, as shown in Figure B-2 and provided in Attachment 1. Figure B-2 shows the shaded area of the survey with the individual survey points overlaid on the aerial image of the study area.

Figure B-2. Topographic survey coverage.

3.0 HEC-RAS MODEL

HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The Hydrologic Engineering Center (HEC) in Davis, California, developed the River Analysis System (RAS) to aid hydraulic engineers in channel flow analysis and floodplain determination. HEC-RAS is capable of simulating steady and unsteady flows, including calculations for cross-sections, bridges, culverts, dams, gates, and other hydraulic structures.

HEC-RAS version 5.0.3 was used to evaluate the hydraulic characteristics of the sluice gate channel.

3.1 Setup

The HEC-RAS model is based on the field survey data compiled into HEC-GeoRAS and ArcGIS, then processed into a HEC-RAS model geometry. Figure B-3 presents the HEC-RAS model cross-section locations along the bypass channel.

Figure B-3. HEC-RAS model geometry superimposed on aerial photo.

Normal depth was set for the downstream boundary condition with a 1.7 percent slope approximated using the furthest downstream sections provided in the channel geometry. The calibration region was selected to be sufficiently upstream of the normal depth condition, ensuring that the channel's water surface was not affected by the boundary condition.

3.2 Geometry

Figure B-4 shows the generalized channel profile, illustrating the steep pitch directly below the gates, the shallow pool at the base of the steep pitch, and the run leading from the pool to the powerhouse tailwater. Representative cross sections are provided in Figures B-5 through B-7 for the pool, run, and a location just upstream of the powerhouse tailwater. The locations of these representative cross sections are shown in Figure B-4.

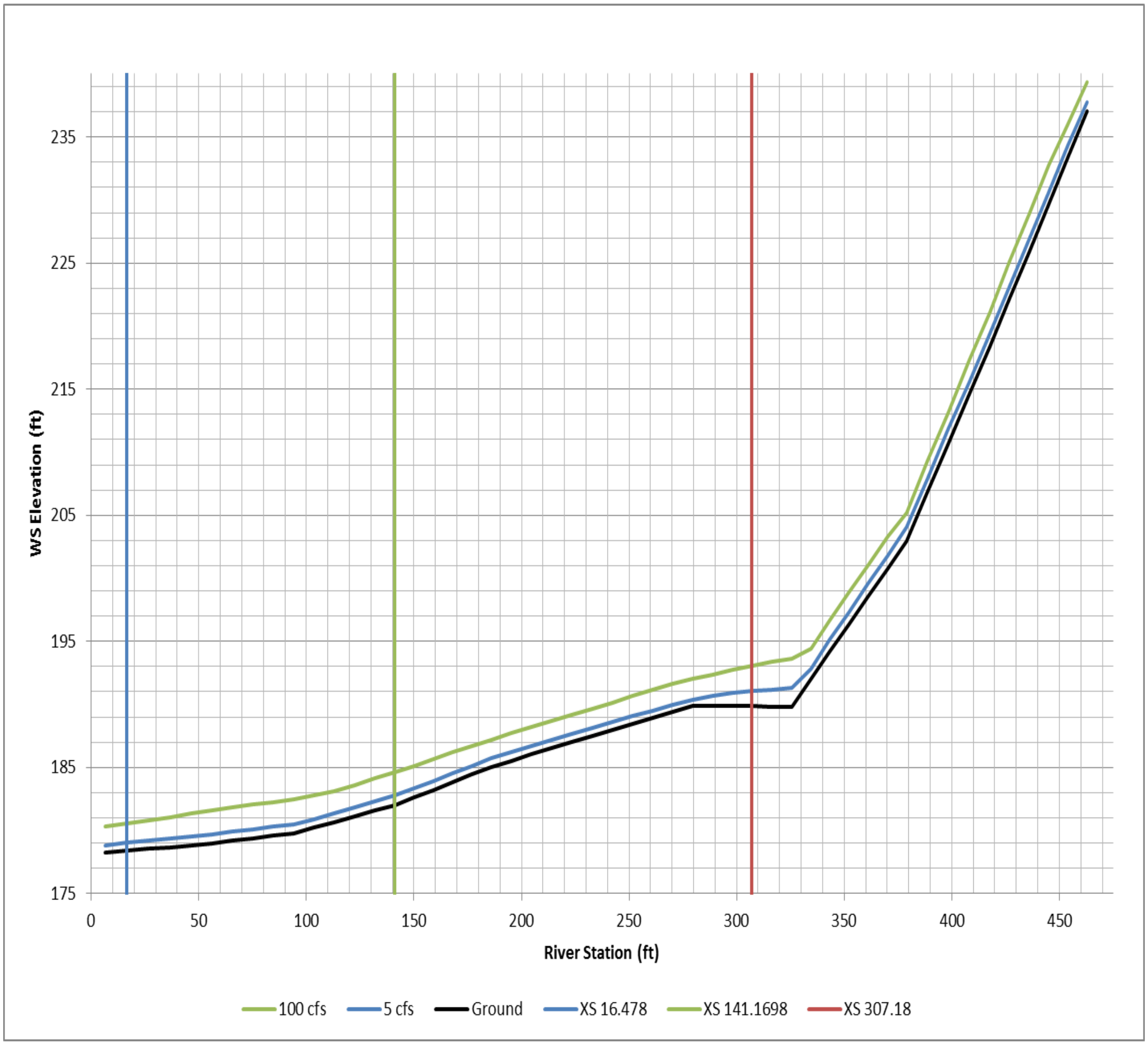

Figure B-4. Generalized channel profile with representative cross sections. Note the difference in the horizontal and vertical scales.

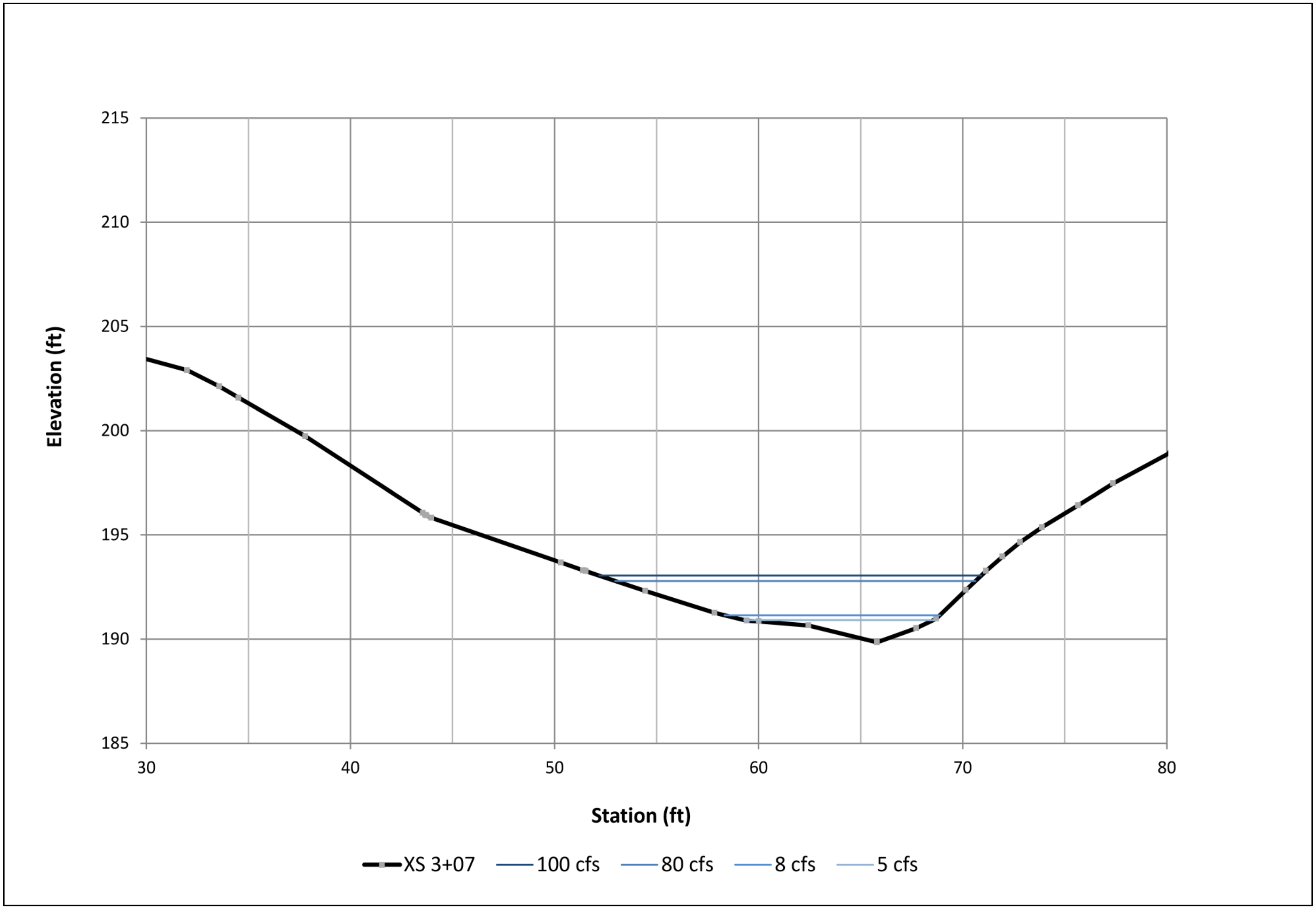

Figure B-5. Cross section at Station 3+07 in shallow pool area.

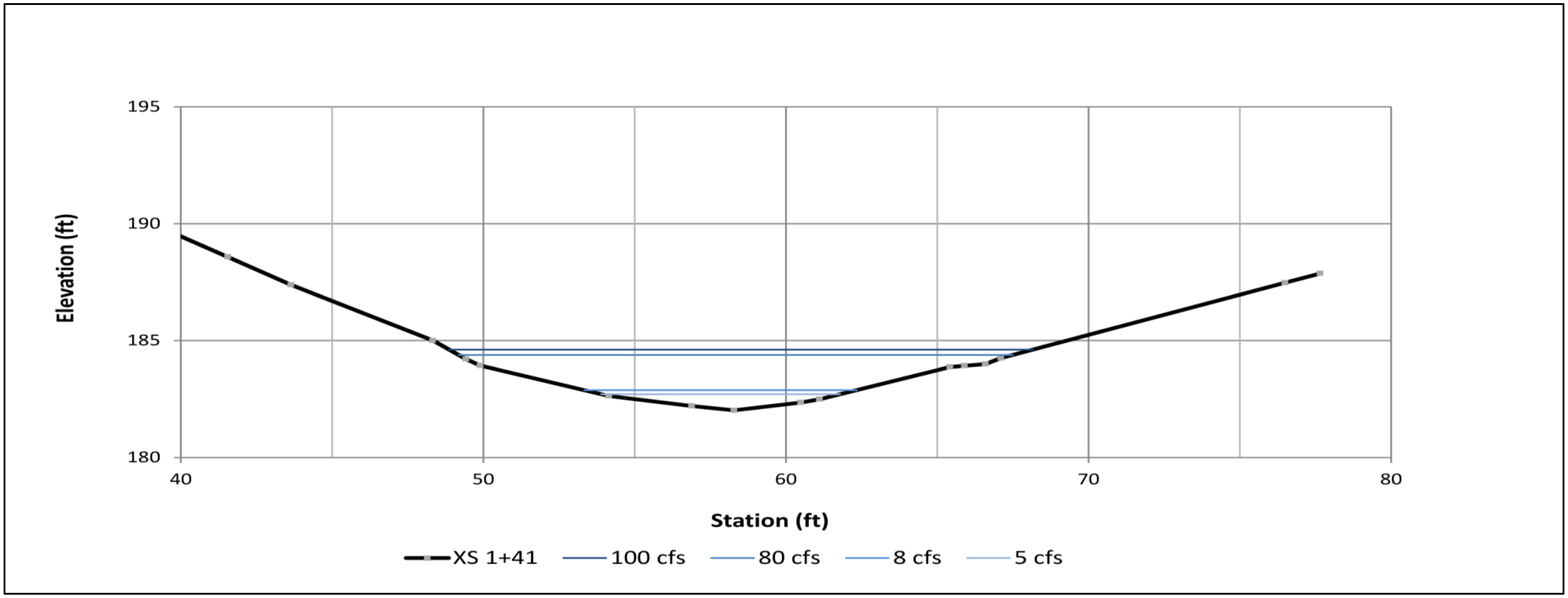

Figure B-6. **Cross section at Station 1+41 in run area.**

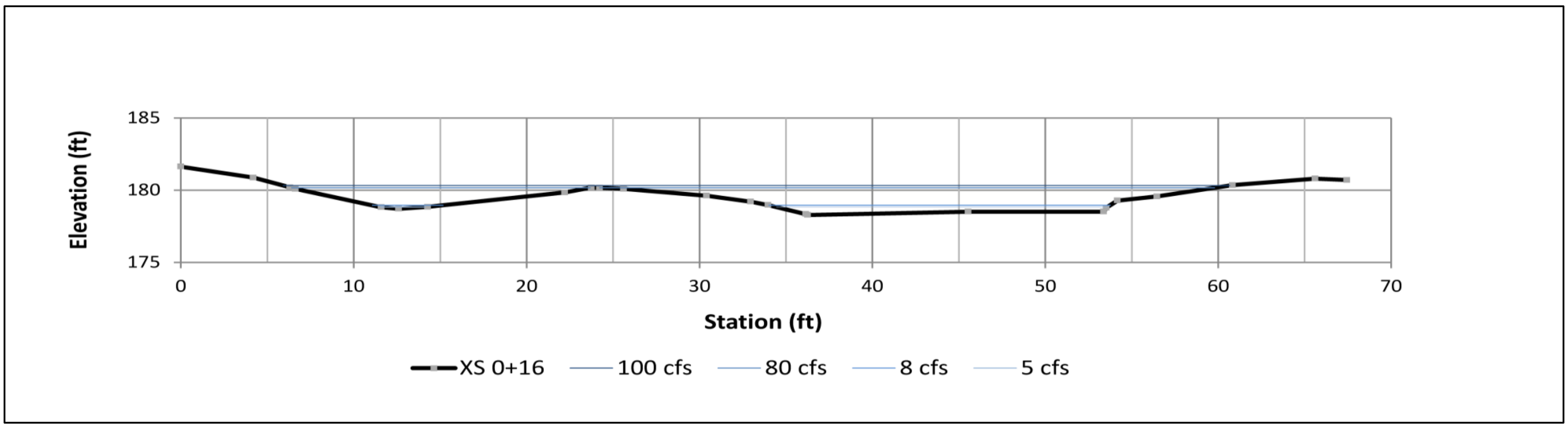

Figure B-7. **Cross section at Station 0+16 upstream of tailwater.**

3.3 Calibration

Calibration was performed using the field survey data obtained during the 2016 field survey, where flows of 8 and 80 cfs were released, and survey data was obtained along the channel edge of water for the two flows. TID estimated the flow rates in the sluiceway channel during the survey based on standard hydraulic formulae for submerged gates and orifices.

The HEC-RAS model was calibrated by varying the channel roughness, Manning's "*n*", in HEC-RAS to best match the surveyed 8 cfs and 80 cfs water surface elevations. For calibration, a range of *n* values of 0.08 to 0.20 were considered with calibration values of 0.15 and 0.12 determined for 8 and 80 cfs respectively.

A mean section roughness *n* value of 0.135 was selected to represent the general roughness in the stream reach, with resulting water surface profiles compared to survey data as shown in Figure B-8 and Figure B-9. The reach between model station 0+75 and station 3+25 was used in the calibration. For the mean *n* value of 0.135, the computed water surface elevation for 8 cfs was compared to the 8 cfs field survey elevation data, and the computed elevations were generally within 0.03 feet of the field survey water surface elevation data along the area of calibration. For the flow of 80 cfs, the modeled water surface was generally within 0.15 feet of the field survey elevation data, which is within 6 percent of the average depth for the measured 80 cfs water surface. HDR considers this to be reasonable fit for the model to the observed data.

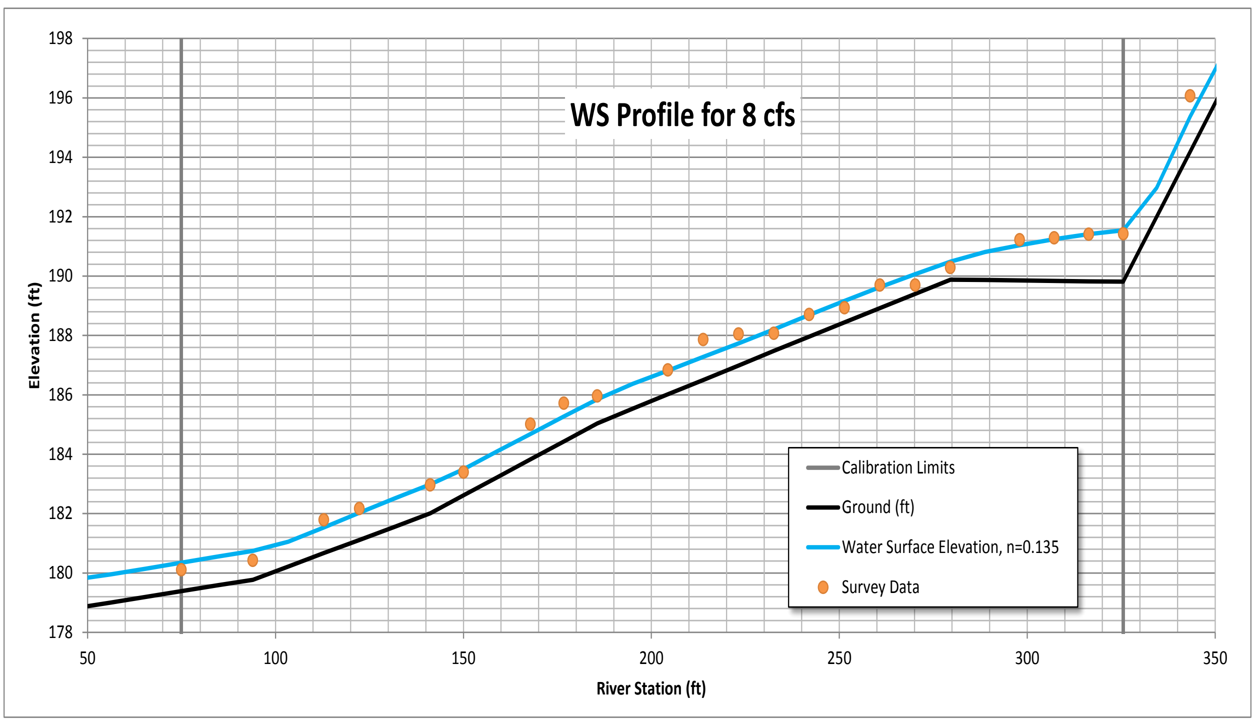

Figure B-8. Water surface profile for 8 cfs showing field survey calibration data.

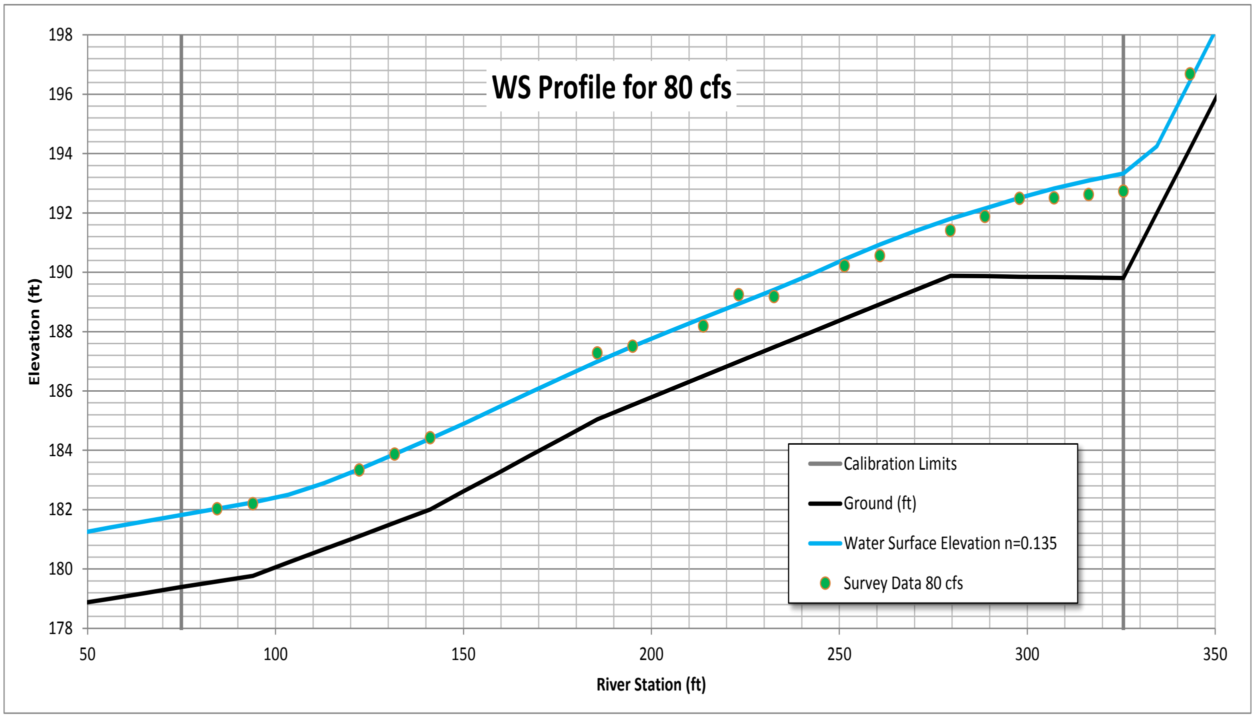

Figure B-9. Water surface profile for 80 cfs showing field survey calibration data.

3.4 Model Runs

Following calibration of the water surface profile for the surveyed 8 cfs and 80 cfs water surface profiles, the model was executed to simulate a gate closure event in which the inflow to the model was transitioned from a constant gate discharge of 100 cfs to a flow of 5 cfs, simulating a gate closure over a closure time of two minutes. The model was run at a 10-second time interval and ran 10 minutes past the end of the gate closure event to capture the attenuation of flow at the downstream end of the model.

4.0 RESULTS AND CONCLUSIONS

Within the sluice gate channel, there is a shallow watered pool located below the gates at model station 2+80 to 3+20. As shown in the profile on Figure B-3, a minimum flow of 5 cfs provides an average modeled channel depth of 0.7 feet (8 ¼ inches) with a minimum depth of 0.5 feet (6 inches) at the downstream end of the pool. From the pool downstream to the tailrace, the average depth for the channel is 0.65 feet (7 ¾ inches). It is important to note that the substrate composition for this channel is mainly large cobble with boulders, which provide localized flow resistance and localized irregular variation in water surface elevations. The HEC-RAS model utilizes the roughness value (Manning's "*n*") to uniformly approximate channel roughness and does account for the localized three-dimensional turbulence, although it is likely that these local effects create local variations in depths and velocity.

The HEC-RAS unsteady flow model runs demonstrated that a change in water surface, during a gate closure event from 100 cfs gate discharge to 5 cfs, would result in an average water surface drop along the flow channel of 1.7 feet starting within 6 minutes of the beginning of gate closure. The drop is relatively uniform across the lower reach length, demonstrating flow connectivity between the upstream pool area and the downstream tailrace as shown in Figure B-10.

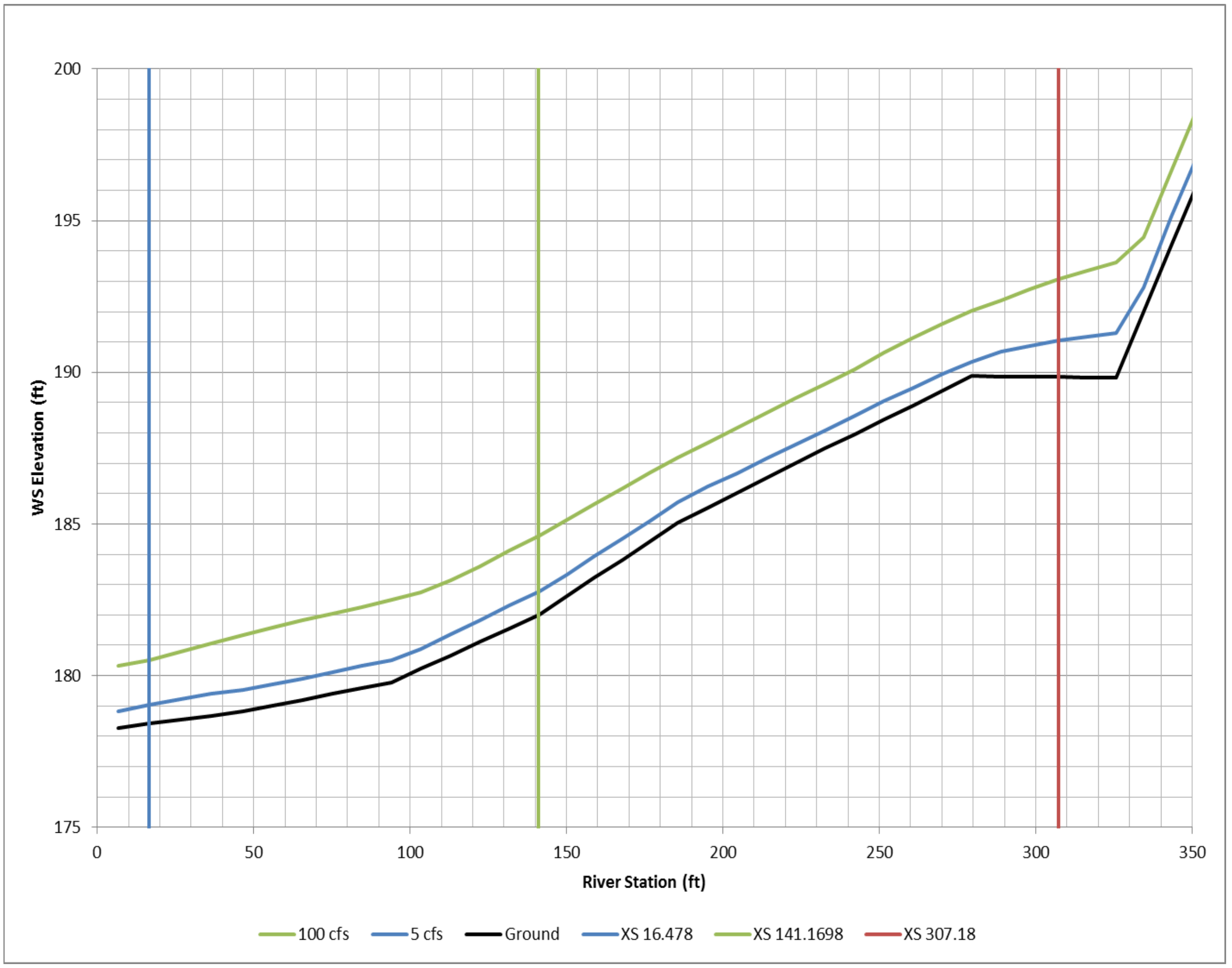

Figure B-10. Modeled water surface profiles under flows of 100 cfs and 5 cfs.

For the representative cross-section locations identified in Figure B-10, stage and discharge hydrographs are provided to demonstrate the modeled variation in water surface with discharge in Figures B-11, B-12 and B-13. Note the modeled two-minute gate closure begins on the second minute of modeling and the modeled lag between gate closure and change in downstream hydrograph is approximately one minute as shown in Figure B-13.

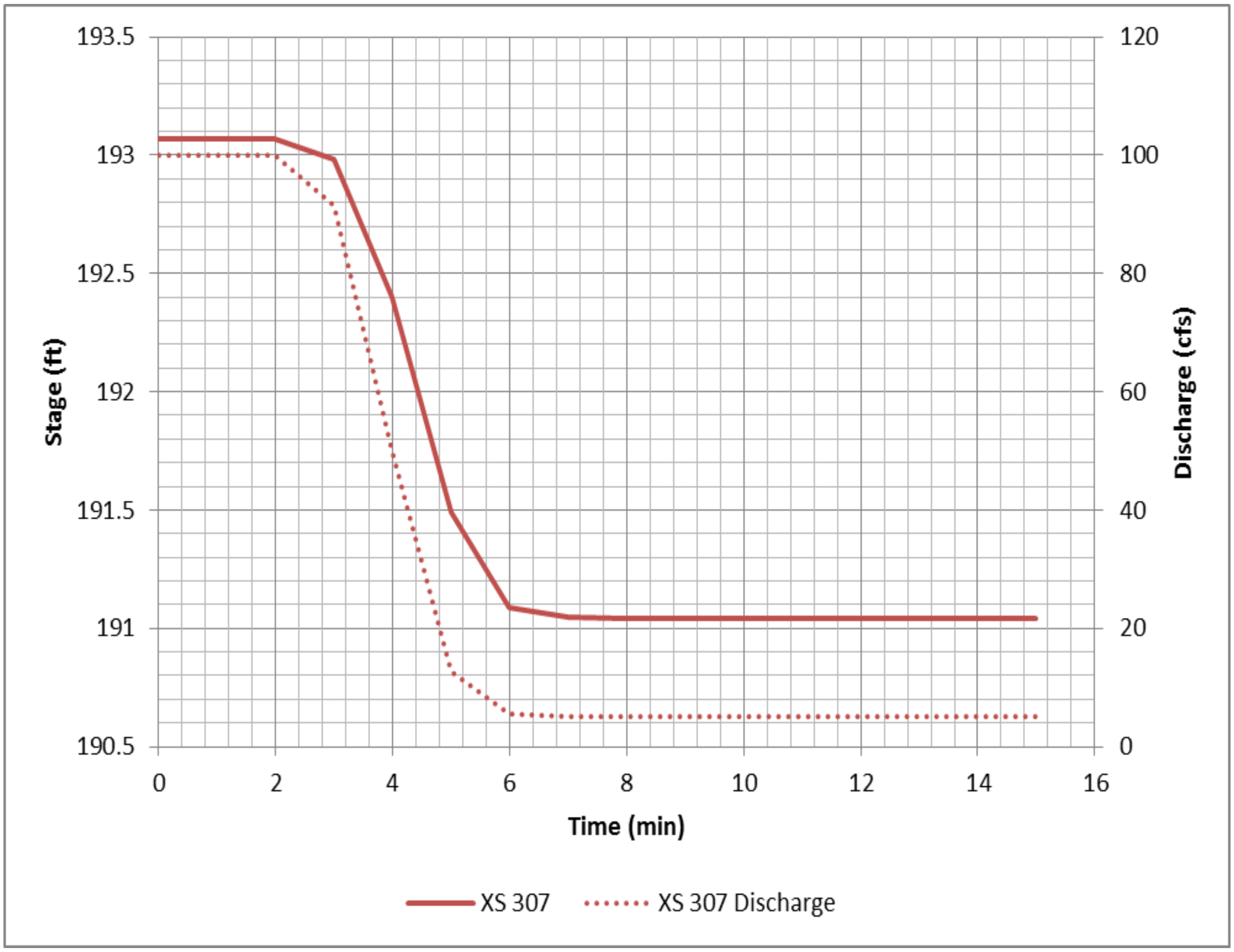

Figure B-11. Modeled stage-discharge hydrograph for representative pool cross section.

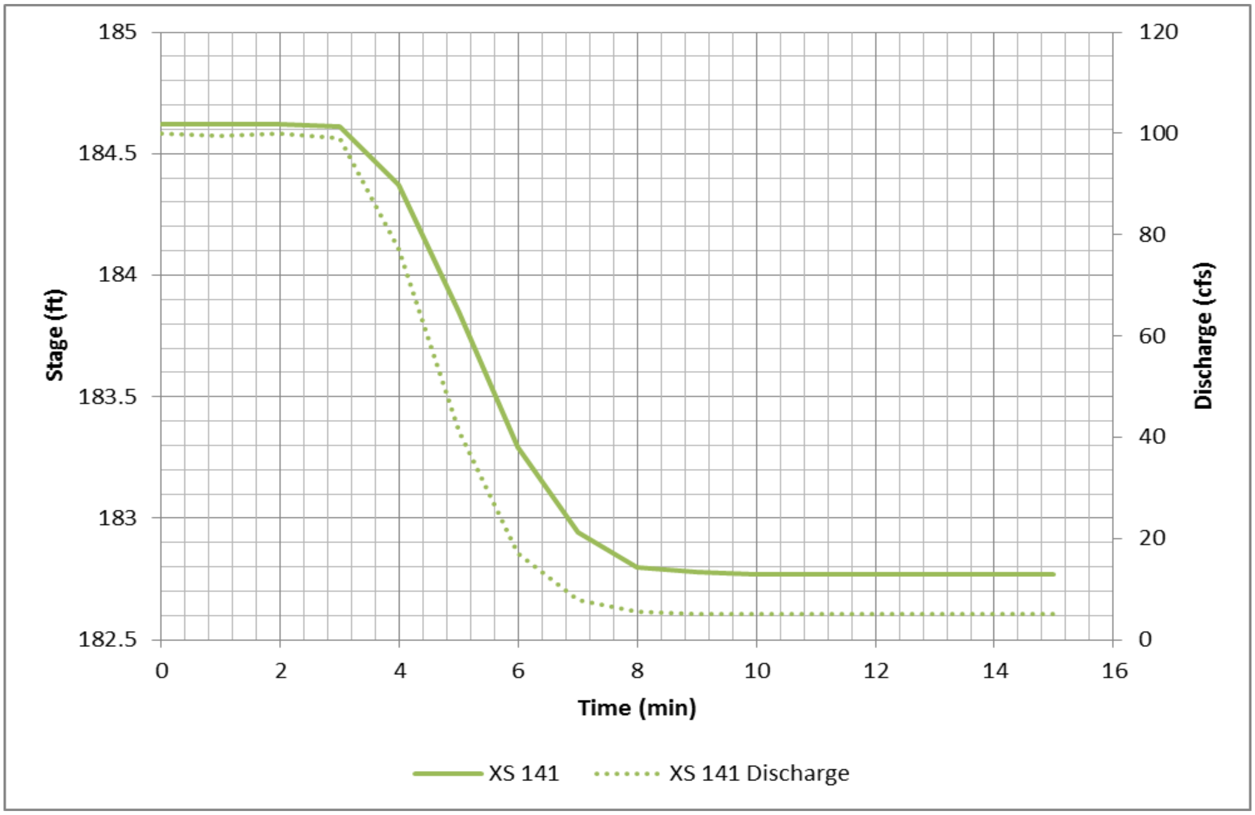

Figure B-12. Modeled stage-discharge hydrograph for representative run cross section.

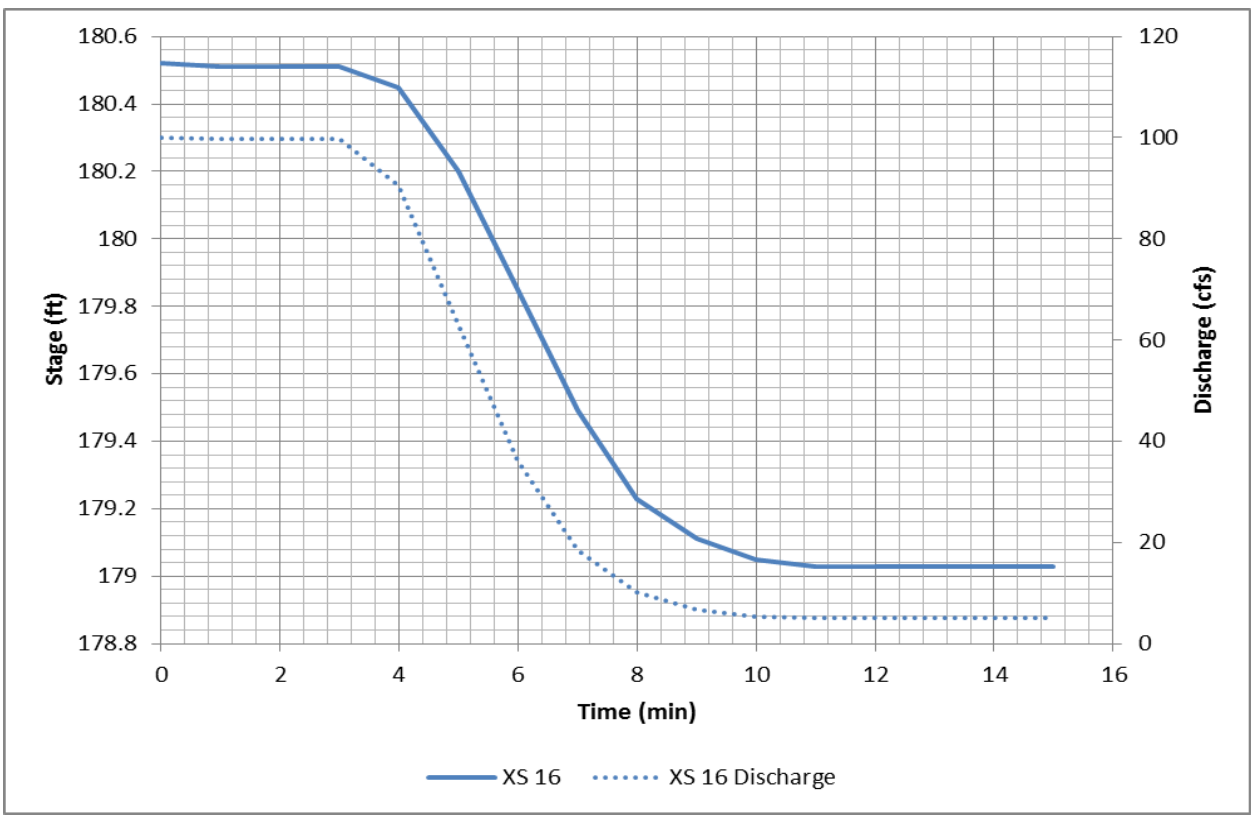

Figure B-13. Modeled stage-discharge hydrograph for representative terminal cross section.

Modeled HEC-RAS output was exported to GIS to provide a plan view of the modeled water surfaces and to examine the channel reach at various flow changes in the flow rates. Figure B-14 provides a plan view of modeled 80, 50, 25, and 8 cfs (colored polygons). For the section of the channel leading up from the tailrace to station 3+25.6, the modeled 8 and 80 cfs water surfaces match well with surveyed extents. Above station 3+25.6, topographic analysis shows that the average channel slope is 36 percent, demonstrating an extremely steep section. Note that the field survey did not locate edge of water surface in this steep reach.

Examination of Figure B-14 indicates zones of continuous water connectivity and absence of isolated pools during the changing flows upon gate closure. This matches field observations made during the La Grange study program after gate closure. Unsteady flow analysis of a two-minute gate closure event (in which the flow rate changes from 100 to 5 cfs) indicates the existence of a continuous flow channel as flow is reduced to the approximate minimum flow of 5 cfs.

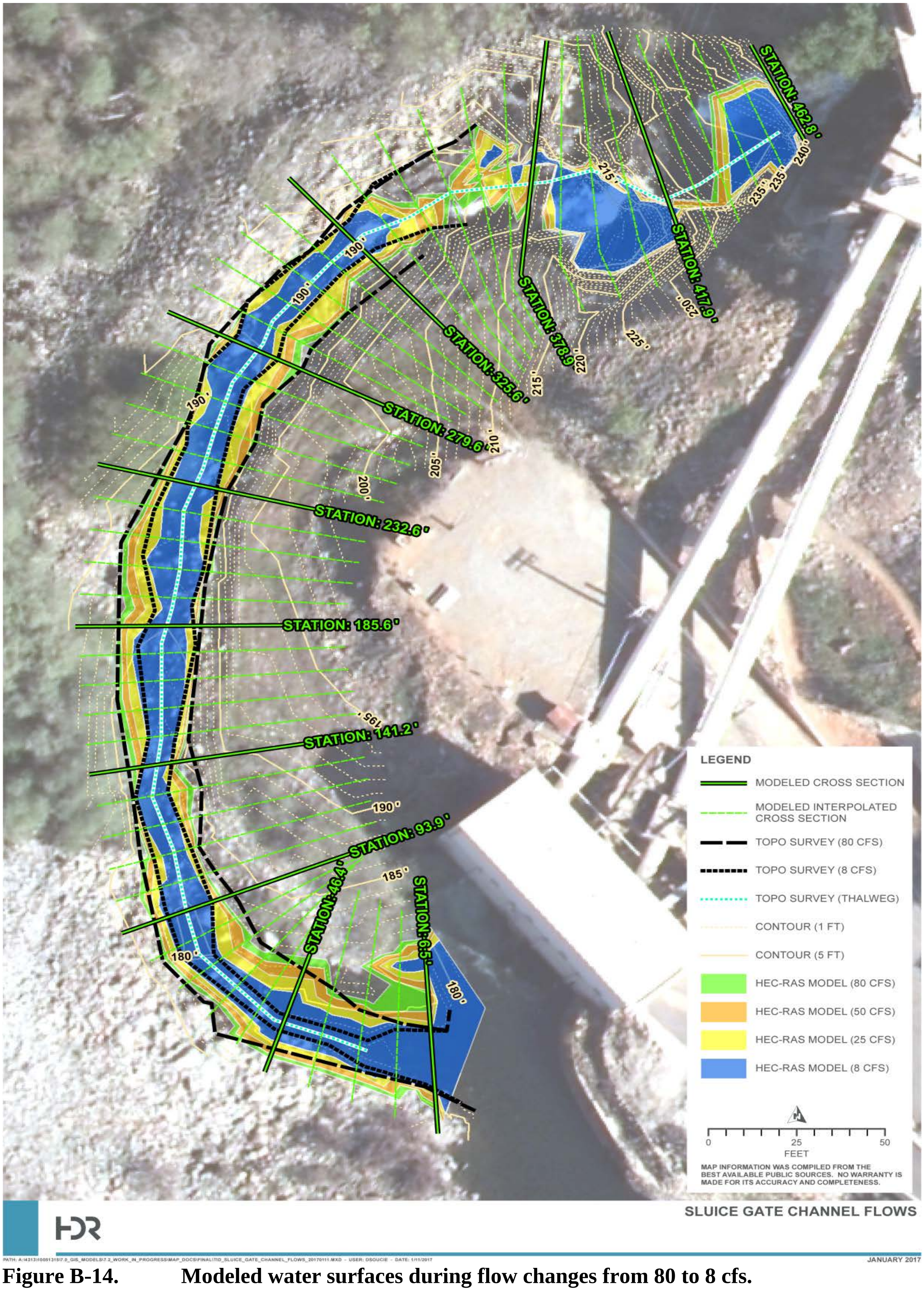

Figure B-14. Modeled water surfaces during flow changes from 80 to 8 cfs.

2016 SLUICE GATE CHANNEL SURVEY

ATTACHMENT 1

HDC-05 (2016 TID FIELD SURVEY)
REDUCED FROM 36X24

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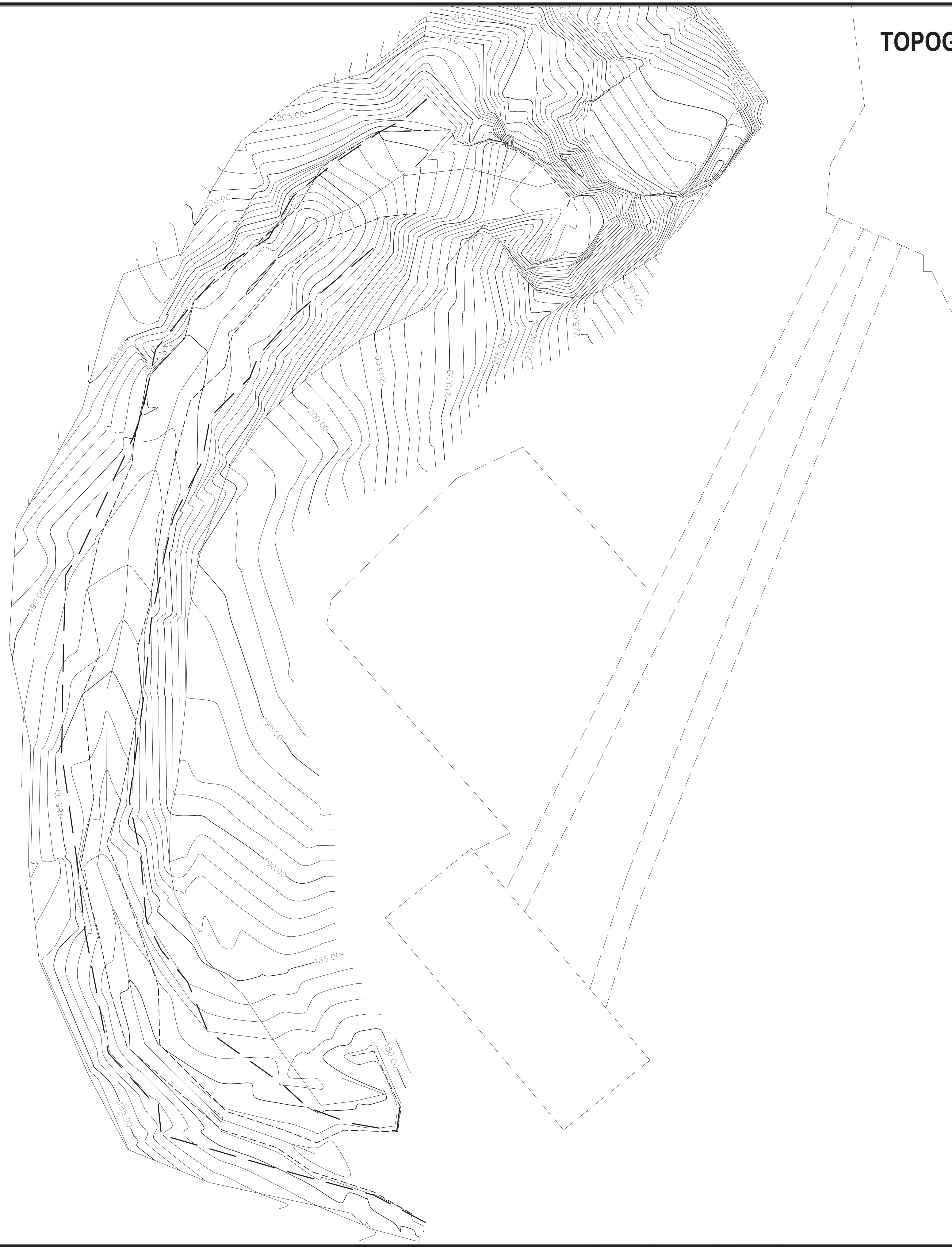
TOPOGRAPHIC SURVEY

BEING A TOPOGRAPHIC SURVEY OF A PORTION OF THE LA GRANGE SLUICE GATE CHANNEL AT VARIOUS DISCHARGE LEVELS



LEGEND

— —	APPROXIMATE WATER LEVEL @ 80 CFS
- - - - - -	APPROXIMATE WATER LEVEL @ 8 CFS
———	APPROXIMATE THALWEG
— — —	APPROXIMATE IMPROVEMENT LOCATIONS DERIVED FROM AERIAL PHOTOGRAPHS

REDUCED

SURVEYORS STATEMENT

THIS TOPOGRAPHIC SURVEY WAS PERFORMED BY ME AND OR UNDER MY DIRECTION IN OCTOBER OF 2016 AT THE REQUEST OF THE TURLOCK IRRIGATION DISTRICT.

TRISTAN S. HIGGINS, PLS #9048
(ONLY AN ORIGINAL SIGNATURE CONSTITUTES THIS SURVEY)

ADDITIONAL NOTES:

1. TREES HAVE NOT BEEN SHOWN ON THIS PLAN, AND LOCATIONS OF SUCH TREES SHOULD BE FIELD VERIFIED. TREE DIAMETERS IF ANY ARE APPROXIMATE AND ARE BASED ON MEASUREMENT TAKEN AT BREAST HEIGHT.

2. UTILITY INFORMATION AS SHOWN ON THIS PLAN, IF ANY, IS TAKEN FROM VISIBLE PHYSICAL EVIDENCE AND/OR RECORD INFORMATION AVAILABLE TO THE SURVEYOR DURING THE CREATION OF THIS SURVEY. NO ATTEMPT HAS BEEN MADE TO FURTHER LOCATE UNDERGROUND FACILITIES. LOCATION AND DEPTH OF ALL EXISTING UNDERGROUND UTILITIES TO BE VERIFIED BY CALLING 811 FOR UNDERGROUND SERVICE ALERT 72 HOURS PRIOR TO ANY EXCAVATION OR CONSTRUCTION.

3. SITE INFORMATION IS VALID AS OF OCTOBER 2016. PHYSICAL CHANGES MADE AFTER THIS DATE ARE NOT SHOWN AND ADDITIONAL SURVEY DATA SHOULD BE OBTAINED PRIOR TO ANY EXCAVATION OR CONSTRUCTION.

4. ELEVATION DATA IS BASED ON CURRENT TID DATUM, AND IS INTERPOLATED FROM GROUND ELEVATIONS OBSERVED DURING THE COURSE OF THIS SURVEY. INDIVIDUAL SPOT ELEVATIONS MEET NMAS STANDARDS FOR 5' CONTOURS. ADDITIONAL 1' CONTOURS ARE INTERPOLATED, DO NOT MEET NMAS STANDARD, AND ARE INTENDED FOR INFORMATIONAL PURPOSES ONLY.

ABBREVIATIONS

RW	RIGHT-OF-WAY
PL	PROPERTY LINE
CL	CENTER LINE
TL	TOP OF LINING
FL	FLOWLINE
EP	EDGE OF PAVEMENT
TC	TOP OF CURB
BSW	BACK OF SIDEWALK
EX	EXISTING
PROP	PROPOSED
GB	GRADE BREAK
AP	ANGLE POINT
PP	POWER POLE
UP	UTILITY POLE
GUY	GUY WIRE
ANC	ANCHOR
CB	CATCH BASIN
SD	STORM DRAIN
SS	SANITARY SEWER
W	WATER
ELEC	ELECTRICAL
OHE	OVERHEAD ELECTRICAL LINE
UGE	UNDERGROUND ELECTRICAL LINE
INV	INVERT
VT	VENT
CBX	CONCRETE IRRIGATION BOX
SSMH	SANITARY SEWER MANHOLE
SDMH	STORM DRAIN MANHOLE
SSCO	SANITARY SEWER CLEANOUT

SCALE: 1"= 15'

0' 15' 30'

ALL DISTANCES ARE IN FEET OR DECIMALS THEREOF

REVISIONS

NO.	DATE	REVISION

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SHEET 1 OF 1

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT G

SALMONID HABITAT MAPPING TECHNICAL MEMORANDUM

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SALMONID HABITAT MAPPING TECHNICAL MEMORANDUM

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

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

Prepared by:
Stillwater Sciences

February 2016

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1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four upstream reservoirs: Hetch Hetchy, Lake Eleanor, Cherry Lake, and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

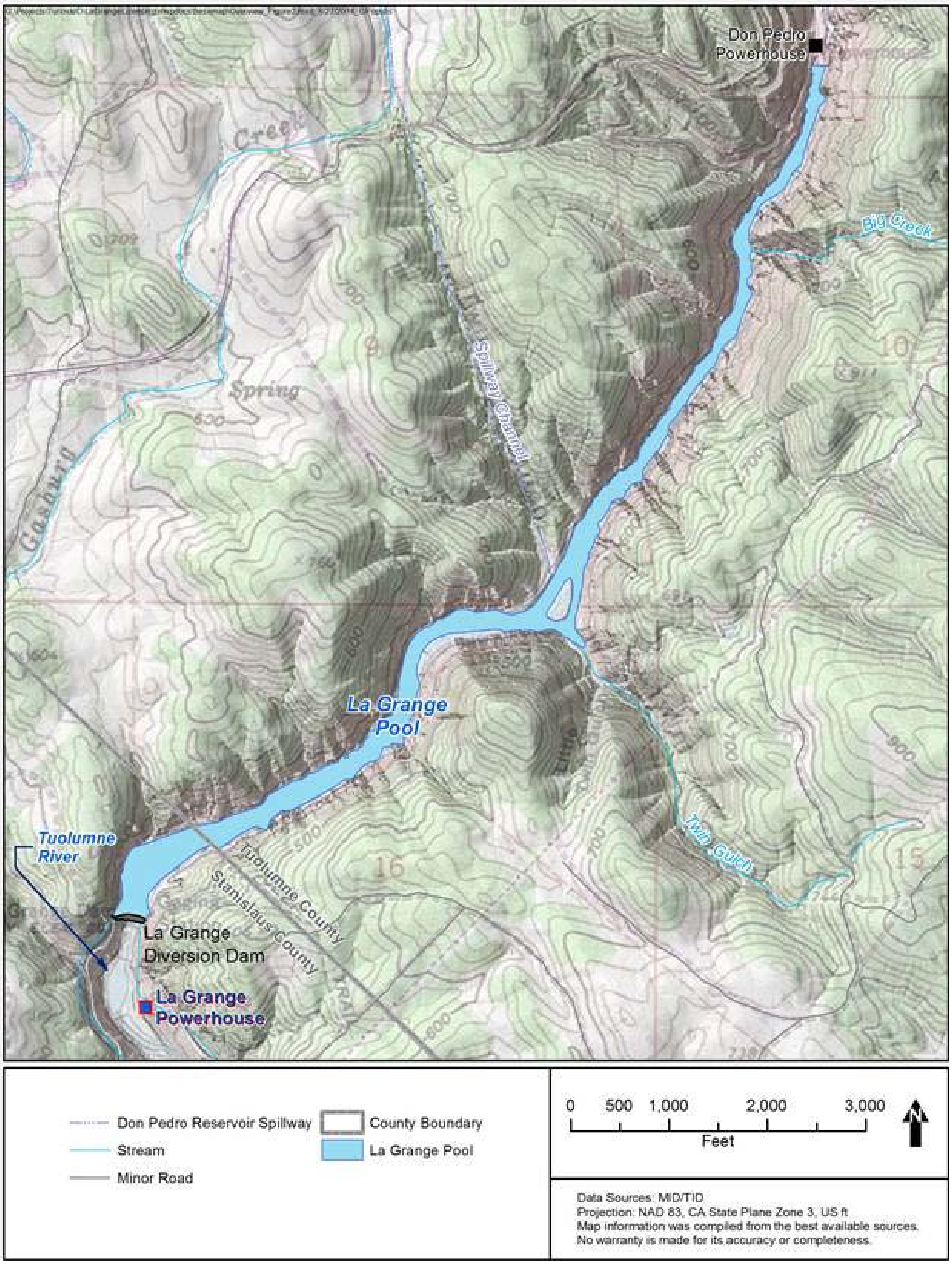

Figure 1.1-1. La Grange Hydroelectric Project location map.

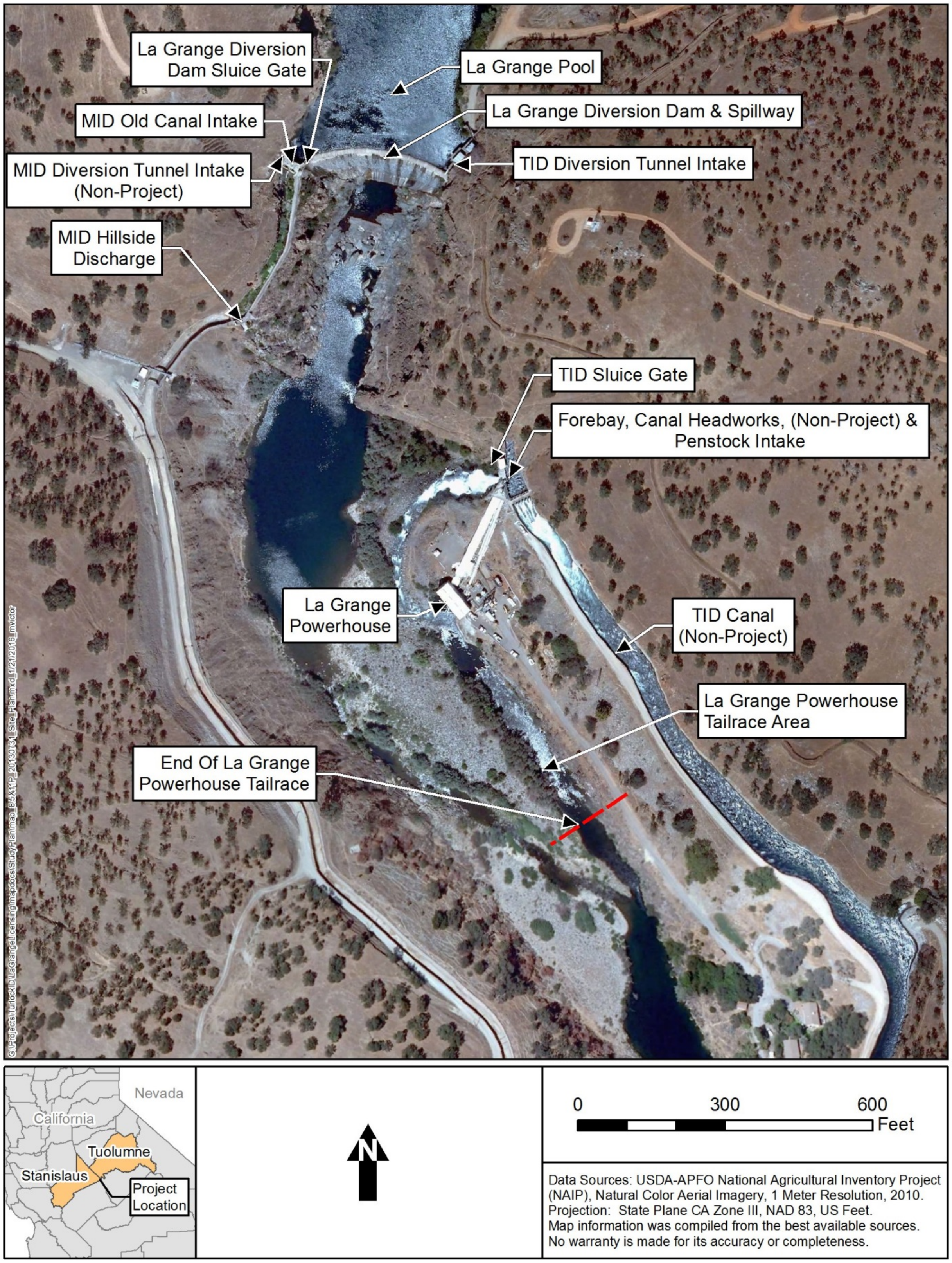

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

On January 29, 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document (PAD) with FERC[1]. The Districts' PAD included descriptions of the Project facilities, operations, and lands as well as a summary of existing information available on Project area resources.

On September 5, 2014, the Districts filed their Proposed Study Plan (PSP) to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On October 6, 2014, the Districts held a PSP meeting at MID's offices in Modesto, California. Based on discussion at the PSP meeting, the Districts prepared an Updated Study Plan document that went to licensing participants (LP) for review and comment on November 21, 2014. On December 4, 2014, the National Marine Fisheries Service (NMFS), the Conservation Groups (CG), and the California Department of Fish and Wildlife (CDFW) filed comments on the PSP and/or Updated Study Plan.

On January 5, 2015, in response to comments from LPs, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2]. Comments on the RSP were received from CDFW on January 16, 2015, and from NMFS, the CGs and the City of Modesto on January 20, 2015.

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by NMFS in its July 22, 2014 comment letter. Of the eight studies requested by LPs, FERC approved only the NMFS study noted above.

Although FERC's SPD did not require the Districts to undertake the Upper Tuolumne River Basin Habitat Assessment studies contained in the RSP, the Districts are voluntarily conducting the Upper River Barriers Study and the Water Temperature Monitoring and Modeling Study. Regarding the third component of the Upper Tuolumne River Basin Habitat Assessment, the ongoing upstream habitat characterization work being completed by NMFS, the Districts anticipate the results of this work becoming available for consideration in this licensing proceeding.

---

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).

[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."

[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the Project's powerhouse draft tubes and to determine the potential for injury or mortality from contact with the turbine runners. Per the SPD, the Districts developed a study plan in consultation with NMFS and other LPs. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

This technical memorandum describes the objectives, methods, and results of the Salmonid Habitat Mapping study, which is one of the four study components of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam being implemented by the Districts in accordance with FERC's SPD. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified the potential for Project effects on anadromous fish spawning habitat downstream of the LGDD. According to the SD2, such effects might possibly result from the retention of sediment in the La Grange pool, or if changes in Project outflows alter downstream spawning habitat suitability and thereby impact spawning due to stranding or displacement of fish or redds in either the main channel, the tailrace channel, or the sluice gate channel.

FERC's SPD approved with modifications the Districts' proposed Fish Habitat and Stranding Assessment below La Grange Diversion Dam. In its SPD, FERC ordered the Districts to: (1) continue monitoring existing flow conduits where flow monitoring is already occurring, conduct two years of flow monitoring at flow conduits not currently monitored (i.e., the Modesto hillside discharge and LGDD sluice gate), develop estimates of historical flows, data permitting, for each of the five flow conduits at the Project, and, based on existing information, to the extent available, characterize the magnitude and rate of flow and stage changes when Project conduits are shut down; (2) collect topographic, depth, and habitat data downstream of, and in the vicinity of, the Project; (3) assess fish presence and the potential for stranding; and (4) in consultation with NMFS and other interested parties, develop and implement a plan for monitoring anadromous fish movement into the powerhouse draft tubes.

The Salmonid Habitat Mapping effort reported herein describes the work associated with Item (2) above. Other components related to this study directive, including topographic surveying of longitudinal channel profiles to assess water depth and potential stranding in the main channel, tailrace channel, and sluice gate channel are provided in a separate report entitled Topographic Survey Technical Memorandum (TID/MID 2016).

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study is to collect information to aid in the evaluation of the potential for Project operations to affect anadromous fish habitat in the Tuolumne River in the vicinity of the LGDD and La Grange Project facilities. Specific objectives of the study include:

- Map substrate and habitat in the main channel and tailrace, delineating the presence of pools, runs, high- and low-gradient riffles, step-pools, and chutes.
- Map patches of spawning-sized gravels in the tailrace and main channel that are greater than two m^2.
- Conduct pebble counts in riffles, runs, and pool tailouts to document substrate particle size distribution in these habitats.

At the request of NMFS representatives during a May 5, 2015 telephone discussion of study implementation, data collection for this study element was expanded to provide complete gravel facies mapping of channel and bar features found within the study area and an expanded assessment of spawning gravel areas with an estimate of maximum potential spawning population sizes of Chinook salmon and *Oncorhynchus mykiss* (*O. mykiss*).

3.0 STUDY AREA

The study area included the main channel of the Tuolumne River from the base of the LGDD downstream to its confluence with the powerhouse tailrace channel near RM 51.8, the length of the tailrace channel, and the length of the TID sluice gate channel (see previous Figure 1.1-2). Gravel mapping included the large, exposed bar that separates the main channel from the tailrace channel along with associated bar features on the north side of the main channel near the confluence with the tailrace (RM 51.8).

4.0 METHODOLOGY

Habitat typing and gravel mapping were conducted on May 12, 2015. Flow measurements taken in the main channel (8.4 cfs) combined with the tailrace channel (165.5 cfs) closely reflected readings at the La Grange gage (USGS 11289650) located near RM 51.7, which recorded a discharge of 171 cfs. Methods implemented to characterize aquatic habitat and riverbed substrate in the study area are discussed below.

4.1 Habitat Typing

Habitat typing was based upon USFWS (2009) mesohabitat typing recommendations used in the *Instream Flow Incremental Methodology Study of the Lower Tuolumne River* (IFIM Study) implemented in accordance with the May 12, 2010 FERC Order (Stillwater Sciences 2013). Table 4.1-1 describes the mesohabitats used during the IFIM Study.

Table 4.1-1. Mesohabitat types used during the habitat typing surveys.

Channel form, Habitat Type	Description
Bar Complex	Submerged and emergent bars are the primary feature, sloping cross-sectional channel profile.
Flatwater	Primary channel is uniform, simple and without gravel bars or channel controls, fairly uniform depth across channel.
Pool	Primary determinant is downstream control - thalweg gets deeper going upstream from tail of pool. Fine and uniform substrate, below average water velocity, above average depth, tranquil water surface.
Glide	Primary determinants are no turbulence (surface smooth, slow and laminar) and no downstream control. Low gradient, substrate uniform across channel width and composed of small gravel and/or sand/silt, depth below average and similar across channel width (but depth not similar across channel width for Bar Complex Glide), below average water velocities, generally associated with tails of pools or heads of riffles, width of channel tends to spread out, thalweg has relatively uniform slope going downstream.
Run	Primary determinants are moderate turbulence and average depth. Moderate gradient, substrate a mix of particle sizes and composed of small cobble and gravel, with some large cobble and boulders, above average water velocities, usually slight gradient change from top to bottom, generally associated with downstream extent of riffles, thalweg has relatively uniform slope going downstream.
Riffle	Primary determinants are high gradient and turbulence. Below average depth, above average velocity, thalweg has relatively uniform slope going downstream, substrate of uniform size and composed of large gravel and/or cobble, change in gradient noticeable.

Habitat mapping was conducted by wading the channels using high resolution aerial imagery dated April 6, 2012 as a base map to record mesohabitat unit boundaries. Mesohabitat units were numbered consecutively extending from near the confluence of the main channel and tailrace channel (RM 51.8) upstream along the main channel to the LGDD, then back downstream from where the sluice gate channel enters the tailrace channel at the La Grange powerhouse to the confluence of the main channel and tailrace channel.

Field maps were then digitized into polygons corresponding to primary mesohabitats as well as any unique features present within the study area (e.g., step-pools which were not present in downstream habitats investigated as part of the IFIM Study).

4.2 Gravel Mapping

As noted in Section 2.0, data collection for this study element was expanded to include sediment-facies mapping throughout the study area. Gravel mapping activities were conducted in the field on May 17, 2015 by traversing the study area channels and gravel bars on foot using low-altitude aerial photographs of the study area to record distinct units of surface sediment mixtures on the field tiles at a scale of 1:2000 with a minimum recordable unit of approximately 100 ft^2. The facies mapping method used for this study was based on the methodology devised by Buffington and Montgomery (1999). The alluvial surface was classified according to the proportional occurrence of the five most prevalent substrate types: sand, gravel, cobble, boulder, and bedrock (see Table 4.2-1). The qualifying criterion for a substrate type to be included in a facies classification was a requirement that an individual substrate type represented $\geq$5 percent of all surface facies, or that the two sub-ordinate classes together represented $\geq$10 percent of all surface facies. Where the qualifying criterion was not met, the surface was classified according to the one or two most frequently observed substrate types, with the dominant substrate type being listed last. For example, the facies classification of "C" was applied if cobbles represented more than 95 percent of the material or "gC" if gravel represented at least 5 percent of the bed material and cobble represented the remaining bed material and no other substrate type represented more than 5 percent of the surface area.

Table 4.2-1. Particle size classes used for sediment facies mapping and pebble count measurements.

Size class	Grain size (mm)
Bedrock	>4,096
Boulder	
very coarse	2,048–4,096
coarse	1,024–2,048
medium	512–1,024
fine	256–512
Cobble	
coarse	128–256
fine	64–128
Gravel	
very coarse	32–64
coarse	16–32
medium	8–16
fine	4–8
very fine	2–4
Sand	0.0625–2

Source: Wentworth (1922).

Wolman (1954) pebble counts were conducted in selected areas using methods developed by Bunte and Abt (2001) to calibrate visual estimates of sediment facies and to chronicle the actual grain size distributions of individual facies. The intermediate (b) axis of 100 surface bed particles was measured at four locations in the study area (see Figure 4.2-1). The relative proportion of each grain-size class was calculated in the field to then guide the classification of facies units with the same visual characteristics. To provide an indication of gravel quality and suitability, an attempt was made where feasible to estimate grain size parameters (i.e., D_{84}, D_{50}, and D_{16}) for each sediment facies using methods employed in the *Spawning Gravel Study* (TID/MID 2013a) conducted as part of the Don Pedro Relicensing. Areas where grain size parameters could not be feasibly estimated included bedrock cascades and deep pools. All mapping and substrate measurements were conducted by the same field crew member to eliminate observer bias.

In the office, the sediment-facies mapping and pebble count data were compiled into an electronic database and transferred to a GIS format for graphical presentation. Sediment-facies maps with pebble-count sample locations were generated for the main channel, tailrace channel, and TID sluice gate channel. A map of the field-based polygons was produced using the April 6, 2012 aerial photography as a base map. The wetted perimeter captured in the imagery corresponds to a river discharge of approximately 320 cfs at the La Grange gage (USGS 11289650), with the majority of this flow contained within the La Grange powerhouse tailrace.

4.3 Spawning Habitat Suitability

Spawning habitat suitability was assessed using methods employed in the above-referenced *Spawning Gravel Study*. Suitable areas were delineated using binary habitat criteria for both water depth and water velocity previously developed as part of the IFIM Study (Stillwater Sciences 2013). Depth and velocity measurements were collected using a standard velocity meter (Marsh-McBirney Flo-Mate) and a top-set wading rod to delineate the areal extent of polygons hydraulically suitable for Chinook salmon and *O. mykiss* spawning over areas of suitable spawning gravel. Suitable gravel areas were determined for both Chinook salmon and *O. mykiss* based on the D_{50} size ranges of the mapped gravel areas. As described in Kondolf and Wollman (1993), a D_{50} size range between 16–78 millimeters (mm) was used to define suitable Chinook salmon spawning gravels and a D_{50} size range between 10–46 mm was used to define suitable *O. mykiss* spawning gravels.

Suitable spawning hydraulic conditions were defined as follows:

- Suitable depths ranging from 0.7–2.7 feet.
- Suitable velocity ranging from 1.0–3.1 feet per second (fps).

Based on spawning habitat suitability, the maximum spawning run size for the study area was estimated using methods described in Attachment D of the Spawning Gravel Study. This analysis uses the suitable spawning hydraulics data in combination with suitable substrate areas to derive a relationship between flow and spawning habitat area.

Areas of suitable spawning hydraulic conditions delineated over areas of suitable spawning gravels form the basis of the estimate. Suitable gravel areas were determined for both Chinook salmon and *O. mykiss* based on the D_{50} size ranges of the mapped gravel areas. As described in Kondolf and Wolman (1993), a D_{50} size range between 16–78 mm was used to define suitable

Chinook salmon spawning gravels and a D_{50} size range between 10–46 mm was used to define suitable *O. mykiss* spawning gravels. Because no suitable spawning substrates were identified in the main channel (Section 5.3), the estimate of total suitable spawning area in the reach was based on mapping of suitable substrates in the tailrace channel at a flow of 175 cfs. Beginning with the suitable spawning gravel areas digitized within the 320 cfs wetted perimeter, the following steps were applied from the *Spawning Gravel Study* (TID/MID 2013a) to estimate spawning habitat availability at any other flow “Y” in the range examined by the IFIM Study (Stillwater Sciences 2013)(100–1,000 cfs).

- Step 1. Delineate in GIS the total suitable spawning gravel area in wetted riffle habitats of at 320 cfs = A_{320} ft^2
- Step 2. Using PHABSIM results from the IFIM Study (Stillwater Sciences 2013) the proportion of spawning WUA at flow ‘Y’ cfs to spawning WUA at 320 cfs in riffle habitats is P_Y = (spawning WUA at flow ‘Y’)/(spawning WUA at 320 cfs)
- Step 3. Total suitable spawning habitat in wetted riffle habitats at flow Y is the product of the Step 1 area and Step 2 proportions, $A_Y = P_Y \times A_{320}$ ft^2.

Using the approach described above, total suitable spawning area for Chinook salmon and *O. mykiss* will be used as a basis for estimating maximum spawning run size over a range of simulated flows by simply dividing the total spawning area available by the average redd size for each species.

Estimated maximum potential spawning population size for a specific flow was computed by dividing the total suitable spawning area (i.e., area with suitable substrate, depth, and velocity) by an estimate of the disturbed gravel area (i.e., the area of egg deposition) within completed redds for each species, and multiplying by a factor of two fish per redd. For Chinook salmon redds, an area estimate of 52 ft^2 (4.8 m^2) was calculated from detailed measurements (n=354) collected in 1988–1989 (TID/MID 1992, Appendix 6). A comparable estimate was made from Chinook salmon redd data collected in the fall of 2012 in the *Redd Mapping Study* for the Don Pedro Project Relicensing (TID/MID 2013b) using an average redd area of 43.1 ft^2 (4.0 m^2) for Chinook salmon based on redd measurements (n=286) in fall of 2012. Corresponding redd size estimates for *O. mykiss* were based on an average disturbed redd area of 3.1 ft^2 (0.3 m^2) calculated using measurements (n=36 redds) collected in spring 2013 as part of the *Redd Mapping Study*.

5.0 RESULTS

5.1 Habitat Typing

Habitat mapping results from the May 17, 2015 survey are shown in Figure 5.1-1 and summarized in Table 5.1-1. The main channel in the study area is dominated by pool habitat, including a plunge pool immediately downstream of the LGDD, a large mid-channel pool adjacent to the MID hillside discharge, and two smaller pools in the lower portion of the channel. There are a total of three small low-gradient riffles with no spawnable substrate in the lower portion of the main channel, along with one glide associated with the tailout of the large pool, and a bedrock outcrop separating the large pool from the plunge pool. The estimated average channel width downstream of the large mid-channel pool is approximately 35 feet, while the mid-channel pool width is estimated to be approximately 176 feet. Correspondingly, the aerial extent of the mid-channel pool was calculated as 134,483 ft^2, representing 74 percent of the total area comprising the main channel habitats. Depths of the habitats found in the main channel were generally described as being from 1–4 feet, with the mid-channel pool and plunge pool depths estimated as >10 feet. More precise depths of pool habitat can be derived from longitudinal channel profiles described in the Topographic Survey Technical Memorandum.

The tailrace channel includes two riffles, one of which include spawnable substrate, along with one run habitat in the lower portion of the channel (Figure 5.1-1). The upper portion of the tailrace channel includes a single pool with turbulent flow from the La Grange powerhouse discharge along with a glide associated with the tailout of this pool. Estimated average width of habitats in the tailrace channel is approximately 50 feet. The TID sluice gate channel is a high-gradient step-pool that originates at the TID canal (a non-Project feature) and empties into the pool at the upstream portion of the tailrace channel. Estimated average width of the sluice gate channel is approximately 30 feet.

Table 5.1-1. Summary of mesohabitat mapping results.

Mesohabitat	Total Number	Total Length (ft)	Percent of Channel
Main Channel			
Riffle	3	523	30%
Glide	1	122	7%
Pool	4	1,022	58%
Outcrop, bedrock	1	106	6%
Total	**9**	**1,773**	**100%**
Tailrace Channel			
Riffle	2	400	57%
Glide	1	49	7%
Pool	1	152	22%
Run	1	98	14%
Total	**5**	**699**	**100%**
Sluice Gate Channel			
Step-pool	1	383	100%
Total	**1**	**383**	**100%**

Figure 5.1-1. Habitat types downstream of La Grange Diversion Dam.

5.2 Gravel Mapping

Sediment–facies mapping results from the May 17, 2015 field survey are summarized in Tables 5.2-1 and 5.2-2, and shown in Figure 5.2-1. The pebble count data from the four samples collected in select facies units—PC1 in unit 2, PC2 in unit 5, PC3 in unit 6, PC4 in unit 10—are summarized in Table 5.2-3 and plotted in Figure 5.2-2. Overall, the study area was mapped predominately as gravel-boulder-Cobble (41 percent), sand-bedrock-Cobble (30 percent), and boulder-gravel-Cobble (11 percent) (see Table 5.2-2).

The sluice gate and tailrace channels, as mapped with facies units 1 through 7, are predominately cobble-bedded with varying proportions of gravel- and boulder-size substrates, along with some bedrock outcrops in the sluice gate channel. The three pebble-count samples collected here exhibited a well-graded (poorly sorted) texture, with measurable sizes varying between sand (~2 mm) and bedrock (>4,096 mm). The results also support the observation of a downstream-fining trend along the channels' total length. Substrates in the sluice gate channel (facies units 1 and 2) are the coarsest in the study area, being composed of cobbles, boulders, and bedrock with some coarse gravel. The La Grange powerhouse tailrace channel (facies units 4 through 7) is composed of cobble with varying proportions of gravel- and boulder-size substrates. A minor fraction of sand was observed in the lower-most facies unit of the tailrace channel (at sample PC3).

The thalweg of the Tuolumne River main channel, as mapped with facies units 10, 11, 13, 14, 17, 18, 20, 22, 24, and 25, is also predominately composed of cobble-sized sediments, with varying proportions of gravel- and boulder-size substrates, and some bedrock outcrops. The pebble-count sample collected along the thalweg near the confluence with the tailrace channel (in facies unit 10) exhibited a well-graded (poorly sorted) texture, with measurable sizes varying between fine gravel (~7 mm) and fine boulder (460 mm). Particle sizes did not appear to be correlated with longitudinal direction along the Tuolumne River main channel, as was observed and measured along the TID sluice gate and tailrace channels. The substrates within the large and deep pool unit downstream of LGDD, mapped as facies unit 22, appeared to be very well graded (i.e., very poorly sorted), with sizes ranging from sand (~2 mm) to bedrock (>4,096 mm).

The medial and lateral floodplain areas, as mapped with facies units 8, 12, 19, and 23, are composed of a mixture of sediment facies types similar to that present in the tailrace and main river channel.

Table 5.2-1. Summary of sediment-facies mapping results.

Sediment facies [1] Unit no.	Sediment facies [1] Type	Channel / feature	Corresponding mesohabitat [2]	Area (ft^2)	Grain size fractions (mm) [3] D_{84}	D_{50}	D_{16}
1	cobble-boulder-Bedrock (cbBr)	Sluice gate channel	Step-pool (unit 11)	8,813	N/A	N/A	N/A
2	gravel-boulder Cobble (gbC)			8,598	320	180	90
3	gravel-cobble-Boulder (gcB)	Sluice gate levee	N/A	17,603	800	400	200
4	boulder-gravel-Cobble (bgC)	Tailrace channel	Pool (unit 12)	9,624	300	110	50
5	boulder-gravel-Cobble (bgC)		Glide, Riffle, Run (units 13, 14, 15)	14,573	200	110	50
6	boulder-gravel-Cobble (bgC)		Riffle (unit 16)	11,606	150	70	23
7	gravel-boulder-Cobble (gbC)			2,039	250	150	50
8	boulder-gravel-Cobble (bgC)	River medial floodplain	N/A	2,583	150	70	25
9	unknown	River channel	Riffle and Pool (unit 1)	69,714	N/A	N/A	N/A
10	gravel-boulder-Cobble (gbC)		Riffle (units 1 and 2)	6,356	240	160	80
11	gravel-boulder-Cobble (gbC)		Riffle (unit 2)	5,932	240	170	90
12	gravel-boulder-Cobble (gbC)	River lateral floodplain	N/A	54,173	300	200	80
13	gravel-boulder-Cobble (gbC)	River channel	Riffle (unit 2)	4,061	300	150	50
14	gravel-cobble-Boulder (gcB)		Pool (unit 3)	5,337	800	500	200
15	bedrock-cobble-Boulder (brcB)	River lateral floodplain (talus slope)	N/A	8,662	N/A	N/A	N/A
16	Bedrock (Br)	River lateral floodplain (outcrop)		2,645	N/A	N/A	N/A
17	gravel-boulder-Cobble (gbC)	River channel	Riffle (unit 4)	2,628	300	200	80
18	bedrock-gravel-Cobble (brgC)		Pool (unit 5)	1,258	N/A	N/A	N/A
19	gravel-boulder-Cobble (gbC)	River medial floodplain	N/A	103,572	300	200	100
20	boulder-gravel-Cobble (bgC)	River channel	Riffle and Glide (units 6 and 7)	11,176	250	100	50

Sediment facies [1]		Channel / feature	Corresponding mesohabitat [2]	Area (ft^2)	Grain size fractions (mm) [3]		
Unit no.	Type				D_{84}	D_{50}	D_{16}
21	gravel-cobble-Boulder (gcB)	River lateral floodplain (talus slope)	N/A	6,911	800	500	200
22	sand-bedrock-Cobble (sbrC)	River channel	Pool (unit 8)	137,118	N/A	N/A	N/A
23	boulder-cobble-Gravel (bcG)	River lateral floodplain	N/A	20,822	200	50	20
24	gravel-boulder-Bedrock (gbBr)	River channel	Outcrop (unit 9)	7,919	N/A	N/A	N/A
25	Bedrock (Br)		Pool (unit 10)	6,648	N/A	N/A	N/A

1 See Figure 5.2-1 for location of sediment facies units.
2 See Figure 5.1-1 for location of mesohabitat units.
3 Size fractions: D_{84} and D_{16} represent the grain sizes for which 84 percent and 16 percent of the distribution is finer, respectively; D_{50} represents the median grain size.

Table 5.2-2. Summary of sediment-facies mapping results.

Sediment facies type [1]	Area (ft^2)	Percent of mapped Area
boulder-cobble-Gravel (bcG)	20,822	5%
boulder-gravel-Cobble (bgC)	49,562	11%
bedrock-gravel-Cobble (brgC)	1,258	0%
gravel-boulder Cobble (gbC)	187,359	41%
sand-bedrock-Cobble (sbrC)	137,118	30%
gravel-cobble-Boulder (gcB)	29,851	6%
bedrock-cobble-Boulder (brcB)	8,662	2%
gravel-boulder-Bedrock (gbBr)	7,919	2%
cobble-boulder-Bedrock (cbBr)	8,813	2%
bedrock (Br)	9,293	2%

1 List order based on smallest to largest sediment/bedrock sizes; does not include "unknown" facies type from Unit No. 9.

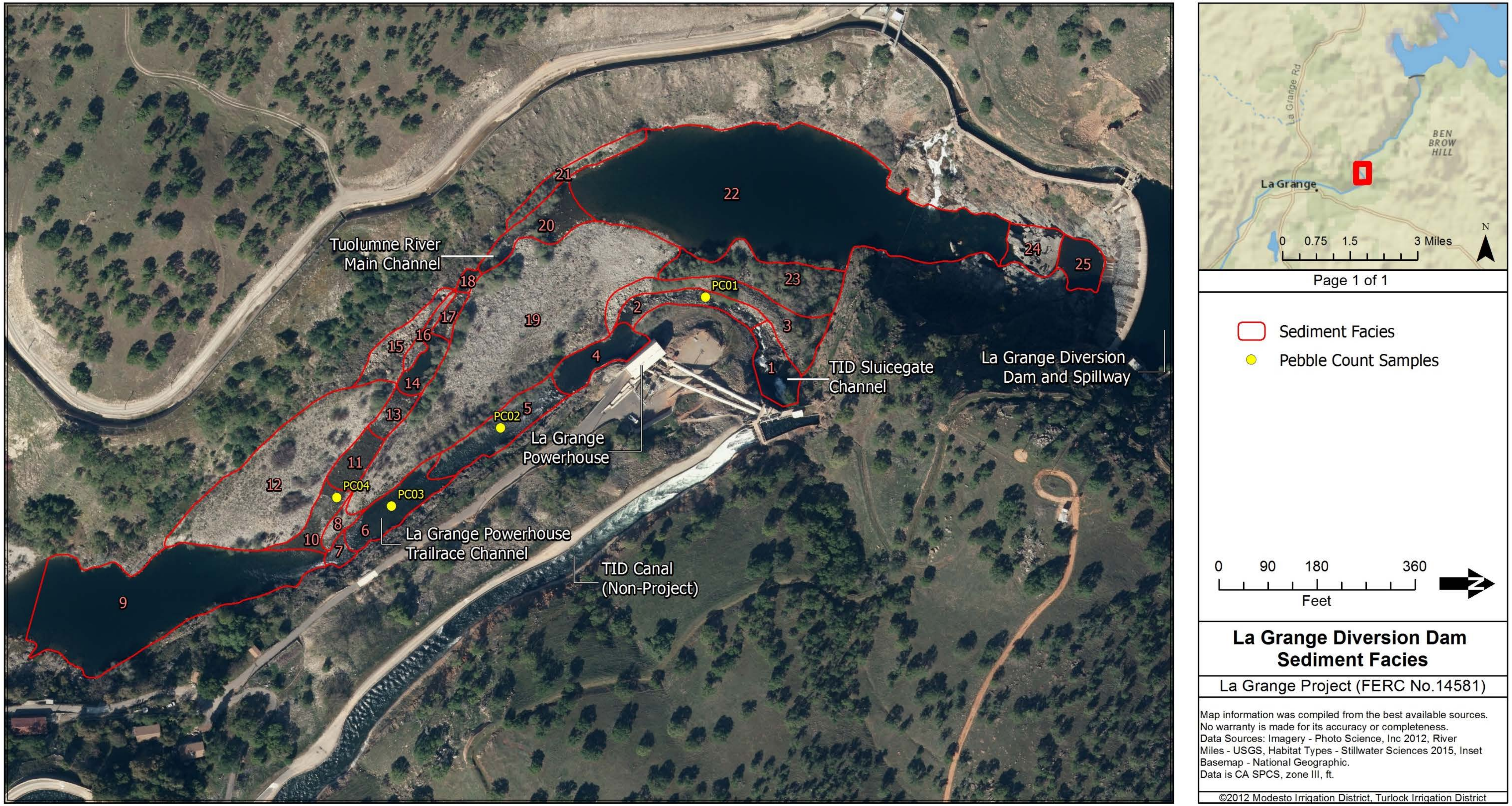

Figure 5.2-1. **Sediment facies mapped downstream of La Grange Diversion Dam.**

Table 5.2-3. Summary of pebble-count measurement results.

Pebble count sample [1]	Sediment facies unit no.	Grain size fractions (mm) [1]				Degree of bed sorting[2]
		D_{84}	D_{50}	D_{16}	D_G	
PC1	2	320	180	90	176	2.2
PC2	5	200	110	50	101	1.9
PC3	6	150	70	23	53	3.1
PC4	10	240	160	80	126	2.0

[1] Size fractions: D84 and D16 represent the grain sizes for which 84 percent and 16 percent of the distribution is finer, respectively; D50 represents the median grain size; DG represents the geometric mean of the distribution.

[2] Bed sorting describes the measure of non-uniformity of sediment mixtures (i.e., high values indicate well-graded [poorly sorted] conditions) and is computed as the geometric standard deviation: σG=(D84/D16)0.5 (Julien 2002).

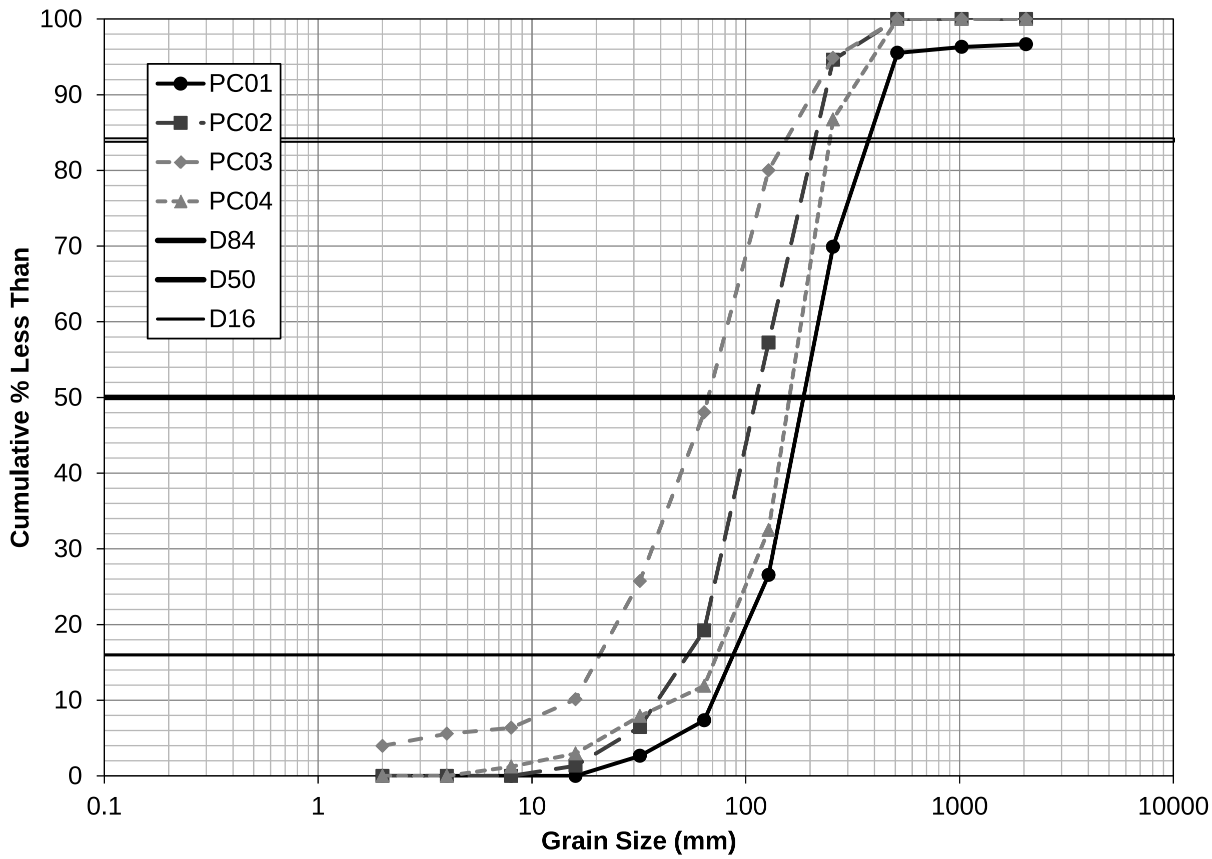

Figure 5.2-2. Particle-size distributions from the pebble-count samples collected in the study area.

5.3 Spawning Habitat Suitability

Only one of the two spawning gravel patches (facies unit 6, riffle habitat unit 16) mapped in the La Grange powerhouse tailrace channel was suitable for Chinook salmon spawning based on a pebble count D50 of 70 mm (Table 5.2-1 and Figure 5.2-1). The D_{50} of 112 mm, based on a pebble count within the other spawning gravel patch (facies unit 5, riffle habitat unit 14), exceeded the suitable range for Chinook (16–78 mm). Neither of the tailrace spawning gravel patches had suitable substrate for *O. mykiss* spawning, based on D_{50} values that exceeded the suitable range for *O. mykiss* (10–46 mm). In addition to falling outside the suitable substrate range; run habitat (unit 15) and pool habitat (unit 12) located in the La Grange powerhouse tailrace exceeded the depth criteria across the center of the channel with velocity measurements below the minimum criteria along the margins, while riffle habitat (unit 14) and glide habitat (unit 13) exceeded velocity criteria across the channel, with depths along the margin below the minimum criteria.

For Chinook salmon, the total area of suitable spawning gravel within the tailrace channel was estimated to be 13,610 ft^2. Of that area, a total of 9,014 ft^2 was estimated to meet the spawning depth and velocity criteria at approximately 175 cfs (Table 5.3-1). There was no suitable spawning gravel found in the Tuolumne River main channel or TID sluice gate channel, and no suitable spawning substrate found for *O. mykiss* at any location within the study area.

Table 5.3-1. Estimated suitable spawning area and maximum Chinook salmon population size in the tailrace channel.

FERC (1996) spawning flow requirement (cfs)	FERC (1996) Water Year type(s)	Suitable spawning area (ft^2)	Estimated maximum potential Chinook spawning population size[3]	
			1988-1989 redd size data[1]	2012 redd size data[2]
150	Critical and below through Median Dry	8,540	328	396
175	Median Below Normal	9,014	346	418
180	Intermediate Dry-Below Normal	9,086	350	422
300	Intermediate Below Normal-Above Normal through Median Wet/Maximum	8,839	340	410

[1] Based on average Tuolumne River Chinook salmon disturbed redd area of 52 ft^2 (4.8 m^2) (TID/MID 1992, Appendix 6).
[2] Based on average Tuolumne River Chinook salmon disturbed redd area of 43.1 ft^2 (4.0 m^2) from the *Redd Mapping Study* (TID/MID 2013b).
[3] Population size is a theoretical maximum based solely on spawning area divided by redd size.

The suitable spawning habitat area for Chinook salmon was extrapolated to current spawning flow requirements (October 16 – May 31) of the Don Pedro Project (FERC 1996) to estimate the maximum potential Chinook salmon spawning population sizes (Table 5.3-1). Maximum population sizes for Chinook salmon would range from approximately 328–422, dependent on redd size estimates. These maximum potential spawning population size estimates are based on the average redd size estimates from the Tuolumne River (Section 4.5) and do not take into account factors related to actual spawning site selection (i.e., non-uniform habitat selection at the site-scale) or superimposition of redds constructed by later arriving spawners upon previously constructed redds.

6.0 STUDY VARIANCES AND MODIFICATIONS

At the request of NMFS representatives during a May 5, 2015 telephone discussion of study implementation, the study was expanded to provide: (1) complete gravel facies mapping of channel and bar features found within the study area; and (2) an expanded assessment of spawning gravel areas with an estimate of maximum potential spawning population sizes of Chinook salmon and *O. mykiss*. Aside from these two additional objectives, there were no other variances or modifications to the study.

7.0 REFERENCES

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT H

FISH PRESENCE AND STRANDING ASSESSMENT TECHNICAL MEMORANDUM

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FISH PRESENCE AND STRANDING ASSESSMENT TECHNICAL MEMORANDUM

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

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

Prepared by:
FISHBIO

February 2017

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Lake Lloyd (known as Cherry Lake), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

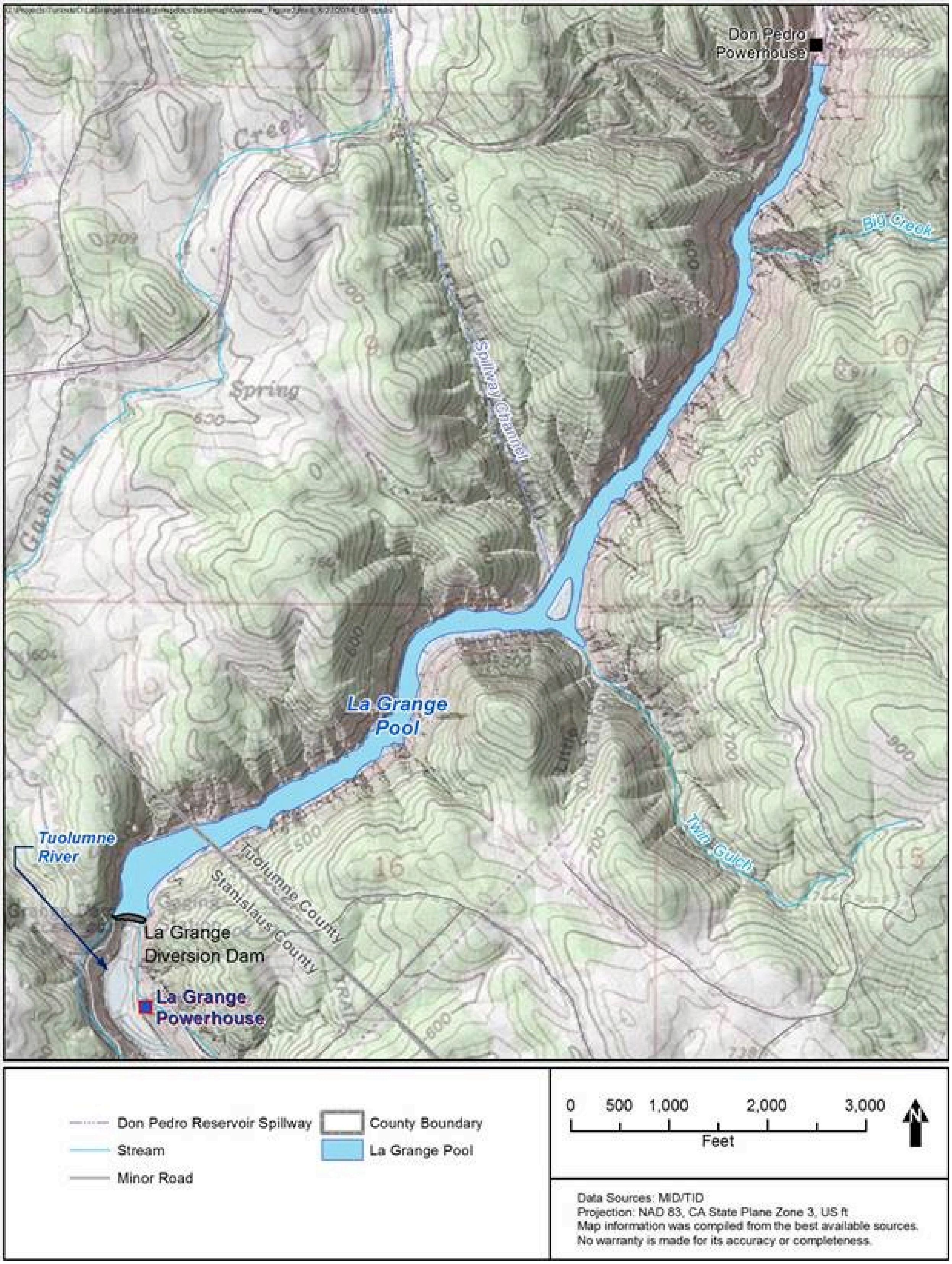

Figure 1.1-1. La Grange Hydroelectric Project location map.

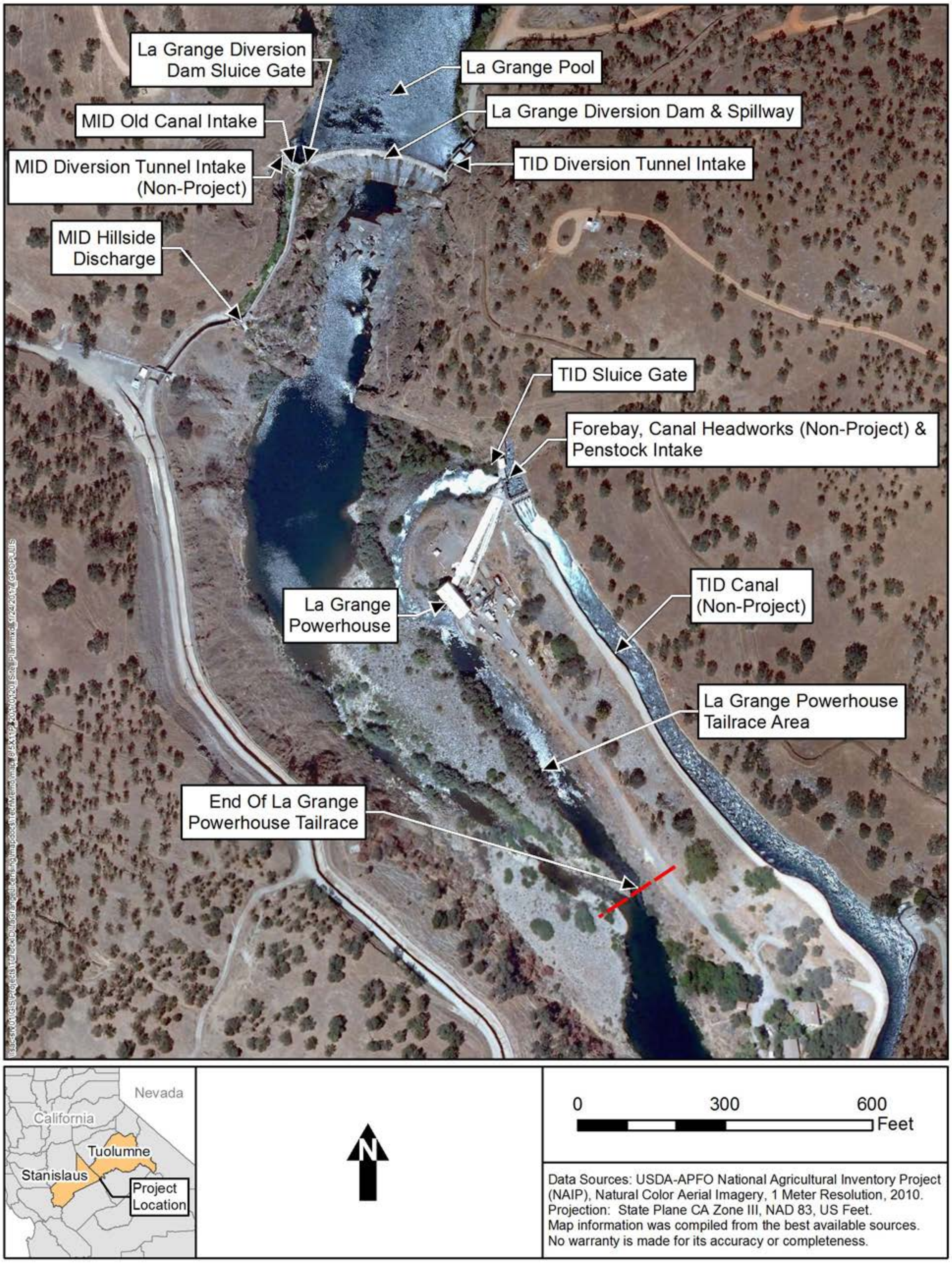

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."
[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).
[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish passage through Don Pedro Reservoir or La Grange pool. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study.

This technical memorandum describes the objectives, methods, and preliminary results of the Fish Presence and Stranding Assessment, which is one of four components of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam being implemented by the Districts in accordance with FERC's SPD. In addition to observations of fish presence and potential stranding during powerhouse outages, this technical memorandum reports daily fish observations and notation of any redds that may become dewatered. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified potential effects of Project operations on the stranding or displacement of fish.

FERC's SPD approved with modifications the Districts' proposed Fish Habitat and Stranding Assessment below La Grange Diversion Dam. In its SPD, FERC ordered the Districts to: (1)

continue monitoring existing flow conduits where flow monitoring is already occurring, conduct two years of flow monitoring at flow conduits not currently monitored (i.e., the Modesto hillside discharge and LGDD sluice gate), develop estimates of historical flows, data permitting, for each of the five flow conduits at the Project, and, based on existing information, to the extent available, characterize the magnitude and rate of flow and stage changes when Project conduits are shut down; (2) collect topographic, depth, and habitat data downstream of, and in the vicinity of, the Project; (3) assess fish presence and the potential for stranding; and (4) in consultation with NMFS and other interested parties, develop and implement a plan for monitoring anadromous fish movement into the powerhouse draft tubes.

The Fish Presence and Stranding Assessment reported herein describes the work associated with Item (3) above.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study is to implement formal documentation of incidental fish observations in the vicinity of LGDD, La Grange powerhouse tailrace, and TID sluice gate channel during the fall-run Chinook salmon and steelhead migration period for the 2015/2016 and 2016/2017 seasons. Specific objectives of the assessment include:

- daily observations of fish in the immediate vicinities of LGDD, La Grange powerhouse, and within the sluice gate channel;
- if the La Grange powerhouse trips offline, conduct sluice gate channel surveys to record fish presence and if necessary conduct relocation activities; and
- notation of redds that become dewatered and the duration of any dewatering, due to changes in powerhouse operations.

3.0 STUDY AREA

The study area includes the main channel of the Tuolumne River from the base of LGDD downstream to its confluence with the powerhouse tailrace channel near RM 51.8, the length of the tailrace channel, and the length of the TID sluice gate channel (Figure 3.0-1).

Figure 3.0-1 Map of the study area.

4.0 METHODOLOGY

4.1 Daily Fish Observations

Daily fish observation surveys in the immediate vicinities of LGDD, La Grange powerhouse, and within the TID sluice gate channel were conducted twice daily; morning surveys were conducted by FISHBIO fisheries biologists/technicians during daily operations and maintenance of the weir associated with the Fish Barrier Assessment (TID/MID 2017a). The weir is comprised of two sections located in the tailrace channel and in the mainstem Tuolumne River. Afternoon surveys were conducted by TID Project operators. A qualified biologist was present during the first five surveys to ensure that surveys were conducted effectively.

FISHBIO surveys included observation of the tailrace channel area above the weir, sluice gate channel, and the mainstem Tuolumne River channel from LGDD downstream to where it meets the tailrace channel. Surveys consisted of walking the length of the sluice gate channel, and floating both channels from LGDD to 0.3 miles downstream of the weir locations. Surveys conducted by TID project operators included the tailrace channel area above the weir and the sluice gate channel. These afternoon surveys consisted of walking the length of the sluice gate channel, and observing the tailrace channel from the road above the channel.

Observation surveys recorded on standardized datasheets included the following:

- observer;
- date and time of survey;
- approximate discharge and sluice gate conduit status at time of survey (flow observations were also post-processed using data from the Project);
- powerhouse output at time of survey;
- number of fish observed and their approximate size;
- identification of species, if possible; at a minimum each fish was identified as either a salmonid or non-salmonid;
- locations of fish (to be indicated on a previously-generated base map);
- description of general fish behaviors, such as moving upstream or downstream, spawning, holding in one specific location, or leaping/jumping;
- notation of any observations of fish swimming into the La Grange powerhouse tailrace; and
- notation of any observations of fish swimming into the TID sluice gate channel.

In addition to the observations listed above, surveys of the tailrace channel also included daily redd observations.

4.2 Sluice Gate Channel Stranding Surveys

In the event that La Grange powerhouse trips offline (i.e., unexpectedly stops operating) and water stops flowing through the powerhouse, the TID sluice gate opens immediately to bypass flows from the powerhouse and maintain river flow. In addition, TID currently maintains in an open position an 18-inch pipe that continuously delivers flow from the TID forebay to the sluice gate channel. The flow quantity is not measured and is unknown, but is roughly estimated to be 5 to 10 cubic feet per second (cfs) (TID/MID 2017b). Direct observations in the TID sluice gate channel downstream to the end of the La Grange powerhouse tailrace channel (i.e., to the confluence of the tailrace channel and the mainstem Tuolumne River) for the presence and potential stranding of salmonids were conducted during any flow transition from the time of maximum flow in the sluice gate channel through the subsequent closing of the sluice gate and until complete cessation of the sluice gate flow release. Once powerhouse operations were restored and the sluice gate had been closed, an additional survey was conducted to ensure fish were not stranded in the sluice gate channel.

Sluice gate channel stranding surveys were conducted by FISHBIO fisheries biologists/technicians. A qualified biologist was present during the first five surveys to ensure that surveys were conducted effectively.

Data collected during sluice gate channel stranding surveys included:

- presence of fish;
- species;
- fish location;
- estimated length;
- presence of adipose clip;
- general condition of fish;
- photo documentation; and, if appropriate,
- relocation time.

4.3 Redd Dewatering

To evaluate redd dewatering, and the duration of any dewatering, due to a change in powerhouse operations, a water level data logger (Onset Computer Corporation) was deployed in the tailrace channel on September 30, 2015. Water level data was recorded every 15-minutes and correlated with salmonid redd mapping data collected in the tailrace channel. Bi-weekly redd mapping surveys recorded Global Positioning System (GPS) redd coordinates and depth at the estimated egg pocket location of each redd. River stage was compared to the elevation of each documented redd to determine the frequency and duration of any potential dewatering events.

5.0 RESULTS

This report summarizes all data collected during the 2015/2016 monitoring season. The 2016/2017 monitoring season is on going. A final report will be issued at the end of the 2016/2017 monitoring season.

5.1 Daily Fish Observations

Twice daily fish observation surveys began on September 23, 2015 and continued through April 14, 2016.

Fish species observed in the tailrace during this period included Chinook salmon (*Oncorhynchus tshawytscha*), *Oncorhynchus mykiss* (*O. mykiss*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), and striped bass (*Morone saxatilis*). Fish observed in the main channel surveys included bluegill (*Lepomis macrochirus*), Chinook salmon, hardhead (*Mylophardon conocephalus*), sculpin (*Cottidae spp.)*, Sacramento pikeminnow, Sacramento sucker, and threespine stickleback (*Gasterosteus aculeatus*). No incidences of fish attempting to enter into the La Grange powerhouse or the TID sluice gate channel were observed. A summary of daily fish observations is included in Attachment A.

5.2 Sluice Gate Channel Stranding Surveys

On September 30, 2015, operators increased the opening of the 18-inch pipe to allow for a minimum channel maintenance flow of approximately 5 to 10 cfs to be provided in the sluice gate channel at all times. It was determined that this flow level would significantly reduce the risk of stranding or dewatering any fish that may enter the channel during a high flow event and would allow fish to volitionally exit the channel at all times, thereby minimizing the need for handling and relocating Chinook salmon or *O. mykiss*.

The La Grange powerhouse tripped offline, and the TID sluice gate opened, 18 times during the 2015/2016 monitoring season (September 23, 2015 through April 15, 2016). The duration of flow events in the sluice gate channel (above the minimum flow maintained at all times) ranged from 0.25 hours to 505.5 hours (median 40.5 hours) (Table 5.2-1).

Table 5.2-1. TID sluice gate operations and stranding survey events during the 2015/2016 monitoring season.

Event No.	Sluice Gate Opened		Sluice Gate Closed		Duration (hours)	Stranding Survey		Fish Observed
	Date	Time	Date	Time		Date	Time	
1	9/29	0:30	9/29	8:45	8.25	9/29	8:50	No
2	10/17	23:15	10/19	9:45	34.5	10/19	11:00	No
3	10/21	5:15	10/23	14:15	57.0	10/23	16:00	No
4	10/28	13:15	10/28	15:00	15.0	10/29	7:45	No
5	11/3	13:30	11/24	15:00	505.5	11/24	15:00	No
6	11/26	6:30	11/30	10:45	100.25	11/30	11:00	Yes
7	12/14	7:00	12/14	9:15	2.25	12/14	9:15	No
8	12/15	6:15	12/15	9:45	3.5	12/15	10:45	Yes
9	12/17	23:15	12/18	0:15	1.0	12/18	8:45	No

Event No.	Sluice Gate Opened		Sluice Gate Closed		Duration (hours)	Stranding Survey		Fish Observed
	Date	Time	Date	Time		Date	Time	
10	12/23	17:00	12/23	18:15	1.25	12/24	9:15	No
--	--	--	--	--	--	12/25	9:45	Yes
11	12/25	14:15	12/25	15:15	1.0	12/25	15:30	No
12	12/26	14:45	12/28	12:00	45.25	12/28	13:00	No
13	1/1	16:30	1/1	17:45	1.25	1/1	18:45	No
14	1/3	9:30	1/3	10:30	1.0	1/3	11:00	No
15	1/10	20:00	1/10	22:00	2.0	1/11	9:15	No
16	1/17	16:30	1/17	18:15	1.75	1/18	13:00	No
17	2/8	15:30	2/8	16:30	1.0	2/9	9:15	No
18	2/18	12:45	2/18	13:00	0.25	2/18	15:45	No

TID operators and a qualified biologist were on-site and surveyed the channel for stranded fish each time the sluice gate was closed and flow was reduced to the minimum flow of approximately 5 to 10 cfs. On three occasions during the 2015/2016 monitoring season fish were documented in the sluice gate channel during stranding surveys, with five adult Chinook salmon observed (Table 5.2-2). Three fish were relocated to the tailrace channel, one fish swam into the tailrace channel volitionally, and a single unspawned female salmon carcass was recovered on December 25 (Figure 5.2-1). This salmon mortality likely occurred after sluice gate event #10 (December 23). No fish were observed in the sluice gate channel during the December 24 stranding survey, however it is possible that this fish was near the channel margin under heavy vegetation. When the carcass was found on December 25 it showed signs of fresh predation, and had likely been moved into the center of the channel where it was discovered. The recovered salmon carcass was frozen and turned over to CDFW (La Grange field office). After this stranding event, minimum flow in the sluice gate channel was increased to a level which allowed fish to move volitionally between the tailrace and sluice gate channels.

Table 5.2-2. Fish observations during sluice gate channel stranding surveys during the 2015/2016 monitoring season.

Date	Species	Estimated Length (mm)	Ad-clip	Fish Condition	Relocation Time	Comments
11/30	CHN	700	No	Good	12:00	Relocated to the pool directly below powerhouse.
12/15	CHN	600	No	Good	11:00	Relocated to the pool directly below powerhouse.
12/15	CHN	800	No	Good	11:00	Relocated to the pool directly below powerhouse.
12/15	CHN	700	Unknown	Good	11:00	Swam volitionally to tailrace channel
12/25	CHN	780	No	Mortality	--	Unspawned female

Figure 5.2-1. Chinook salmon mortality recovered from the sluice gate channel on December 25, 2015.

5.3 Redd Dewatering

Bi-weekly salmonid redd mapping surveys began on October 14, 2015 and continued through April 6, 2016. A single Chinook salmon redd was identified in the tailrace channel on November 30, 2015 (Figure 5.3-1) during bi-weekly redd mapping surveys. Based on levelogger data, this redd was not dewatered during the monitoring period (Figure 5.3-2).

Figure 5.3-1. Location of Chinook salmon redd identified in the tailrace channel on November 30, 2015.

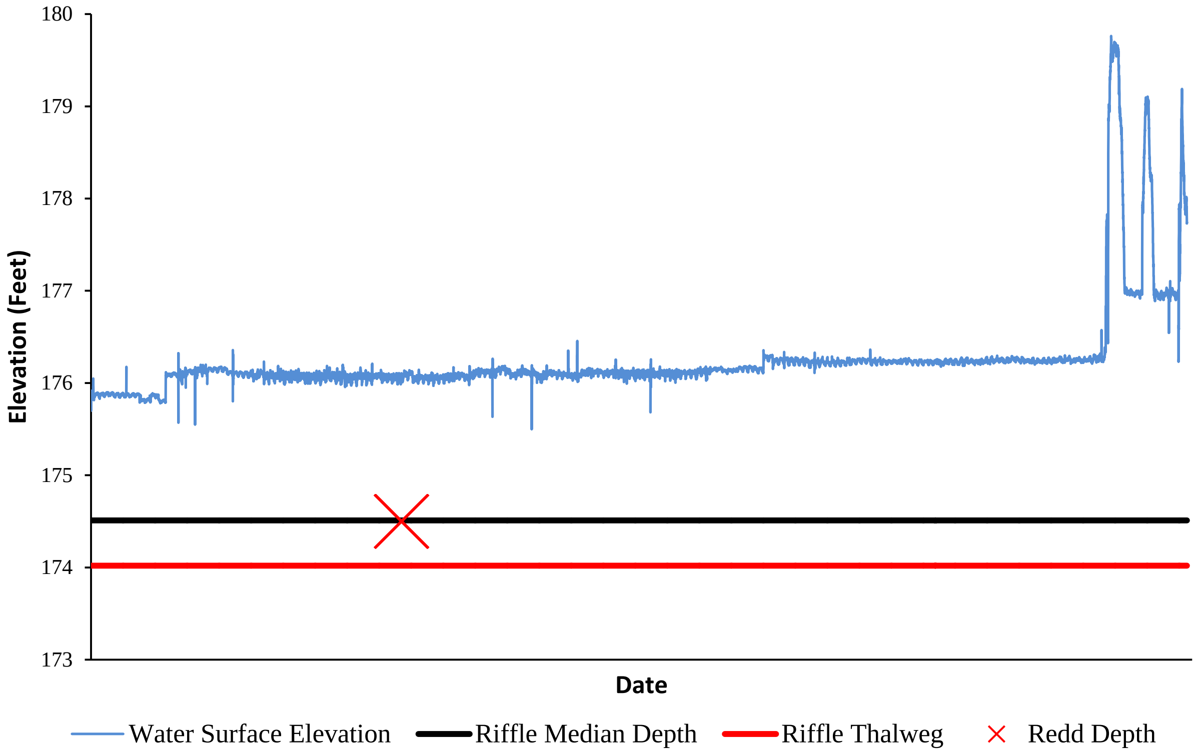

Figure 5.3-2. Tailrace channel water surface elevation levelogger data.

6.0 DISCUSSION AND FINDINGS

Results from the daily fish observations in the tailrace and main channels in the immediate vicinities of LGDD and La Grange powerhouse have documented multiple species including bluegill, Chinook salmon, hardhead, *O. mykiss*, Sacramento pikeminnow, Sacramento sucker, sculpin, and threespine stickleback. For the 2015/2016 monitoring period, the majority of fish observations were juvenile Sacramento pikeminnow and juvenile Sacramento sucker, which accounted for 95 percent of observations. The majority of these fish observations occurred during the fall-run migration period, with very few fish observed after mid-December.

Adult Chinook salmon were documented to enter the sluice gate channel during periods when the sluice gates were opened. Given that a minimum flow of 5 to 10 cfs is maintained in the sluice gate channel, stranding of fish in this channel has been extremely rare.

During the 2015/2016 monitoring period, a single Chinook salmon redd was identified in the tailrace channel. Water surface elevation records confirmed that there were no redd dewatering events due to changes in powerhouse operations. Given that the sluice gates open immediately when the La Grange powerhouse trips offline, there is very little risk in dewatering the tailrace channel during these operational changes. Based on water level data recorded at 15-minute intervals, the maximum elevation change between readings was 0.57 feet.

7.0 STUDY VARIANCES AND MODIFICATIONS

This study was conducted consistent with the FERC-approved study plan. No variances or modifications occurred.

8.0 REFERENCES

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2017a. Fish Barrier Assessment Progress Report. Prepared by FISHBIO. Attachment to La Grange Hydroelectric Project Updated Study Report. February 2017.

_____. 2017b. Flow Records for Five Discharge Structures at the La Grange Project Technical Memorandum. Prepared by HDR, Inc. Attachment to the La Grange Hydroelectric Project Updated Study Report. February 2017.

FISH PRESENCE AND STRANDING ASSESSMENT TECHNICAL MEMORANDUM

ATTACHMENT A

DAILY FISH OBSERVATIONS SURVEY INFORMATION FOR THE 2015/2016 MONITORING SEASON

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Table A-1. Daily fish observation survey information for the 2015/2016 monitoring season.

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
9/23/15	9:15	25	Sacramento pikeminnow	Juvenile	MC Below Weir
		55	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Above Weir
9/23/15	12:00	0	N/A	N/A	N/A
9/24/15	9:30	50	Sacramento sucker	Juvenile	MC Below Weir
		30	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Above Weir
9/24/15	15:00	0	N/A	N/A	N/A
9/25/15	8:30	50	Sacramento sucker	Juvenile	MC Below Weir
		30	Sacramento pikeminnow	Juvenile	MC Below Weir
		10	Sacramento sucker	Juvenile	MC Above Weir
9/26/15	8:45	1	sculpin	Juvenile	MC Below Weir
		1	sculpin	Adult	MC Below Weir
		1	Sacramento sucker	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
		6	Sacramento pikeminnow	Juvenile	MC Above Weir
9/26/15	15:15	0	N/A	N/A	N/A
9/27/15	9:15	1	*O. mykiss*	Adult	TR Below Weir
		10	Sacramento pikeminnow	Juvenile	MC Below Weir
		5	Sacramento sucker	Juvenile	MC Above Weir
9/27/15	14:45	0	N/A	N/A	N/A
9/28/15	11:00	0	N/A	N/A	N/A
9/28/15	16:00	0	N/A	N/A	N/A
9/29/15	10:30	10	Sacramento pikeminnow	Juvenile	MC Below Weir
		25	Sacramento sucker	Juvenile	MC Below Weir
9/29/15	15:30	0	N/A	N/A	N/A
9/30/15	11:15	11	Sacramento sucker	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
9/30/15	12:30	0	N/A	N/A	N/A
10/1/15	9:00	9	Sacramento pikeminnow	Juvenile	MC Below Weir
		4	Sacramento pikeminnow	Juvenile	MC Above Weir
10/1/15	18:00	0	N/A	N/A	N/A
10/2/15	9:15	20	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
10/2/15	13:45	0	N/A	N/A	N/A
10/3/15	8:45	15	Sacramento sucker	Juvenile	MC Above Weir
		2	Sacramento pikeminnow	Juvenile	MC Above Weir
		40	Sacramento sucker	Juvenile	MC Below Weir
		14	Sacramento pikeminnow	Juvenile	MC Below Weir
10/3/15	14:45	0	N/A	N/A	N/A
10/4/15	8:30	6	Sacramento sucker	Adult	MC Above Weir
		50+	Sacramento sucker	Juvenile	MC Below Weir
10/4/15	14:30	0	N/A	N/A	N/A
10/5/15	9:45	50+	Sacramento sucker	Juvenile	MC Below Weir
		3	Sacramento pikeminnow	Juvenile	MC Above Weir
		1	bluegill	Juvenile	MC Above Weir
10/5/15	15:30	0	N/A	N/A	N/A
10/6/15	9:15	1	Sacramento sucker	Adult	TR Above Weir
		2	Sacramento pikeminnow	Juvenile	TR Above Weir
		50+	Sacramento sucker	Juvenile	MC Below Weir

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
		25	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Above Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
		1	bluegill	Adult	MC Above Weir
10/7/15	9:30	1	Sacramento pikeminnow	Juvenile	TR Above Weir
		50+	Sacramento sucker	Juvenile	MC Below Weir
		20	Sacramento pikeminnow	Juvenile	MC Below Weir
		6	Sacramento sucker	Juvenile	MC Above Weir
		10	Sacramento pikeminnow	Juvenile	MC Above Weir
		2	bluegill	Juvenile	MC Above Weir
10/7/15	13:30	0	N/A	N/A	N/A
10/8/15	9:00	1	Sacramento sucker	Adult	TR Below Weir
		25	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
		3	Sacramento pikeminnow	Juvenile	MC Above Weir
10/8/15	18:30	0	N/A	N/A	N/A
10/9/15	9:00	20	Sacramento sucker	Juvenile	MC Below Weir
		40	Sacramento pikeminnow	Juvenile	MC Below Weir
		6	Sacramento sucker	Juvenile	MC Above Weir
		4	Sacramento pikeminnow	Juvenile	MC Above Weir
10/9/15	17:30	0	N/A	N/A	N/A
10/10/15	9:00	50+	Sacramento sucker	Juvenile	MC Below Weir
		1	sculpin	Juvenile	MC Below Weir
		20	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Above Weir
10/10/15	12:45	0	N/A	N/A	N/A
10/11/15	8:45	75	Sacramento sucker	Juvenile	MC Below Weir
		25	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Above Weir
10/11/15	15:00	0	N/A	N/A	N/A
10/12/15	9:00	65	Sacramento sucker	Juvenile	MC Below Weir
		40	Sacramento pikeminnow	Juvenile	MC Below Weir
		25	Sacramento sucker	Juvenile	MC Above Weir
10/12/15	17:15	0	N/A	N/A	N/A
10/13/15	8:45	12	Sacramento sucker	Juvenile	MC Below Weir
		18	Sacramento pikeminnow	Juvenile	MC Below Weir
		6	Sacramento sucker	Juvenile	MC Above Weir
		6	Sacramento pikeminnow	Juvenile	MC Above Weir
10/13/15	15:45	0	N/A	N/A	N/A
10/14/15	9:15	125	Sacramento sucker	Juvenile	MC Below Weir
		60	Sacramento pikeminnow	Juvenile	MC Below Weir
		25	Sacramento sucker	Juvenile	MC Above Weir
10/14/15	18:00	0	N/A	N/A	N/A
10/15/15	8:45	50+	Sacramento pikeminnow	Juvenile	MC Below Weir
		30	Sacramento sucker	Juvenile	MC Below Weir
		4	Sacramento pikeminnow	Juvenile	MC Above Weir
		12	Sacramento sucker	Juvenile	MC Above Weir
10/15/15	17:15	0	N/A	N/A	N/A
10/16/15	8:45	2	Sacramento pikeminnow	Adult	TR Below Weir
		50+	Sacramento sucker	Juvenile	MC Below Weir

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
		50+	Sacramento pikeminnow	Juvenile	MC Below Weir
		2	Sacramento sucker	Juvenile	MC Above Weir
10/16/15	17:45	0	N/A	N/A	N/A
10/17/15	8:45	50+	Sacramento sucker	Juvenile	MC Below Weir
		30	Sacramento pikeminnow	Juvenile	MC Below Weir
		5	Sacramento sucker	Juvenile	MC Above Weir
10/17/15	14:30	0	N/A	N/A	N/A
10/18/15	11:00	50+	Sacramento sucker	Juvenile	MC Below Weir
		30	Sacramento pikeminnow	Juvenile	MC Below Weir
		5	Sacramento sucker	Juvenile	MC Above Weir
10/18/15	15:45	0	N/A	N/A	N/A
10/19/15	11:15	50+	Sacramento sucker	Juvenile	MC Below Weir
		40	Sacramento pikeminnow	Juvenile	MC Below Weir
		20	Sacramento sucker	Juvenile	MC Above Weir
10/19/15	16:00	0	N/A	N/A	N/A
10/20/15	10:00	50+	Sacramento sucker	Juvenile	MC Below Weir
		35	Sacramento pikeminnow	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
10/20/15	16:00	0	N/A	N/A	N/A
10/21/15	9:30	4	Sacramento sucker	Juvenile	MC Above Weir
		16	Sacramento sucker	Juvenile	MC Below Weir
		25	Sacramento pikeminnow	Juvenile	MC Below Weir
10/21/15	16:15	0	N/A	N/A	N/A
10/22/15	10:00	4	Sacramento pikeminnow	Juvenile	MC Above Weir
		1	Sacramento sucker	Juvenile	MC Above Weir
		37	Sacramento pikeminnow	Juvenile	MC Below Weir
		29	Sacramento sucker	Juvenile	MC Below Weir
10/22/15	17:45	0	N/A	N/A	N/A
10/23/15	8:30	16	Sacramento sucker	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
10/23/15	16:00	0	N/A	N/A	N/A
10/24/15	8:45	50+	Sacramento sucker	Juvenile	MC Below Weir
		25	Sacramento pikeminnow	Juvenile	MC Below Weir
		10	Sacramento sucker	Juvenile	MC Above Weir
10/24/15	15:15	0	N/A	N/A	N/A
10/25/15	8:45	30	Sacramento sucker	Juvenile	MC Below Weir
		20	Sacramento pikeminnow	Juvenile	MC Below Weir
10/25/15	15:45	0	N/A	N/A	N/A
10/26/15	8:45	2	Chinook salmon	Adult	TR Above Weir
		29	Sacramento sucker	Juvenile	MC Below Weir
		47	Sacramento pikeminnow	Juvenile	MC Below Weir
10/26/15	16:45	0	N/A	N/A	N/A
10/27/15	8:45	50+	sculpin	Juvenile	MC Below Weir
		5	threespine stickleback	Juvenile	MC Below Weir
		6	hardhead	Adult	MC Below Weir
10/28/15	9:15	39	Sacramento sucker	Juvenile	MC Below Weir
		17	Sacramento pikeminnow	Juvenile	MC Below Weir
10/28/15	17:30	0	N/A	N/A	N/A
10/29/15	8:00	1	striped bass	Adult	TR Below Weir
10/29/15	16:00	0	N/A	N/A	N/A
10/30/15	10:30	6	unidentified	Juvenile	MC Above Weir

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
10/30/15	17:45	0	N/A	N/A	N/A
10/31/15	9:15	50+	Sacramento sucker	Juvenile	MC Below Weir
10/31/15	9:15	20	Sacramento pikeminnow	Juvenile	MC Below Weir
10/31/15	9:15	2	Sacramento sucker	Juvenile	MC Above Weir
10/31/15	16:15	0	N/A	N/A	N/A
11/1/15	11:00	50+	Sacramento sucker	Juvenile	MC Below Weir
11/1/15	11:00	35	Sacramento pikeminnow	Juvenile	MC Below Weir
11/1/15	16:15	0	N/A	N/A	N/A
11/2/15	10:00	--[3]	N/A	N/A	N/A
11/2/15	16:00	0	N/A	N/A	N/A
11/3/15	8:45	1	Chinook salmon	Adult	TR Above Weir
11/3/15	8:45	1	Sacramento pikeminnow	Adult	MC Below Weir
11/3/15	8:45	50+	Sacramento pikeminnow	Juvenile	MC Below Weir
11/3/15	8:45	40	Sacramento sucker	Juvenile	MC Below Weir
11/3/15	8:45	1	Sacramento sucker	Juvenile	MC Above Weir
11/3/15	12:15	0	N/A	N/A	N/A
11/4/15	7:30	33	Sacramento pikeminnow	Juvenile	MC Below Weir
11/4/15	7:30	21	Sacramento sucker	Juvenile	MC Below Weir
11/4/15	7:30	6	threespine stickleback	Adult	MC Below Weir
11/4/15	12:00	0	N/A	N/A	N/A
11/5/15	9:15	50+	Sacramento sucker	Juvenile	MC Below Weir
11/5/15	9:15	50+	Sacramento pikeminnow	Juvenile	MC Below Weir
11/5/15	12:30	0	N/A	N/A	N/A
11/6/15	9:00	19	Sacramento sucker	Juvenile	MC Below Weir
11/6/15	9:00	27	Sacramento pikeminnow	Juvenile	MC Below Weir
11/6/15	12:30	0	N/A	N/A	N/A
11/7/15	9:30	50+	Sacramento sucker	Juvenile	MC Below Weir
11/7/15	9:30	15	Sacramento pikeminnow	Juvenile	MC Below Weir
11/7/15	12:15	0	N/A	N/A	N/A
11/8/15	9:45	50+	Sacramento sucker	Juvenile	MC Below Weir
11/8/15	9:45	20	Sacramento pikeminnow	Juvenile	MC Below Weir
11/8/15	12:15	0	N/A	N/A	N/A
11/9/15	9:30	50+	Sacramento sucker	Juvenile	MC Below Weir
11/9/15	9:30	25+	Sacramento pikeminnow	Juvenile	MC Below Weir
11/9/15	9:30	6	Sacramento sucker	Juvenile	MC Above Weir
11/9/15	12:00	0	N/A	N/A	N/A
11/10/15	9:00	1	Sacramento sucker	Juvenile	MC Below Weir
11/10/15	9:00	3	Sacramento sucker	Adult	MC Below Weir
11/10/15	9:00	50+	Sacramento pikeminnow	Juvenile	MC Below Weir
11/10/15	9:00	2	Sacramento pikeminnow	Adult	MC Below Weir
11/10/15	12:15	0	N/A	N/A	N/A
11/11/15	8:30	8	Sacramento sucker	Adult	MC Below Weir
11/11/15	8:30	50+	Sacramento sucker	Juvenile	MC Above Weir
11/11/15	11:45	0	N/A	N/A	N/A
11/12/15	11:00	50	Sacramento sucker	Juvenile	MC Below Weir
11/12/15	11:00	3	sculpin	Adult	MC Below Weir
11/12/15	11:00	1	Chinook salmon	Adult	MC Below Weir
11/12/15	12:00	0	N/A	N/A	N/A
11/13/15	9:15	50+	Sacramento sucker	Juvenile	MC Below Weir
11/13/15	9:15	10	sculpin	Adult	MC Below Weir
11/13/15	12:00	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
11/14/15	9:45	20	Sacramento sucker	Juvenile	MC Below Weir
		40	Sacramento pikeminnow	Juvenile	MC Below Weir
11/14/15	12:15	0	N/A	N/A	N/A
11/15/15	13:30	20	Sacramento sucker	Juvenile	MC Below Weir
		4	Sacramento pikeminnow	Juvenile	MC Below Weir
11/15/15	12:15	0	N/A	N/A	N/A
11/16/15	10:15	55	Sacramento pikeminnow	Juvenile	MC Below Weir
		40	Sacramento sucker	Juvenile	MC Below Weir
11/16/15	12:00	0	N/A	N/A	N/A
11/17/15	10:15	4	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Below Weir
11/17/15	12:00	0	N/A	N/A	N/A
11/18/15	10:15	50+	Sacramento pikeminnow	Juvenile	MC Below Weir
		10	Sacramento sucker	Juvenile	MC Below Weir
11/18/15	12:00	0	N/A	N/A	N/A
11/19/15	9:15	25	Sacramento sucker	Juvenile	MC Below Weir
		45	Sacramento pikeminnow	Juvenile	MC Below Weir
11/19/15	12:15	0	N/A	N/A	N/A
11/20/15	9:00	1	Chinook salmon	Adult	TR Below Weir
		15	Sacramento sucker	Juvenile	MC Below Weir
		23	Sacramento pikeminnow	Juvenile	MC Below Weir
11/20/15	11:45	0	N/A	N/A	N/A
11/21/15	9:15	2	Chinook salmon	Adult	TR Above Weir
		25	Sacramento sucker	Juvenile	MC Below Weir
		50+	Sacramento pikeminnow	Juvenile	MC Below Weir
11/21/15	12:00	0	N/A	N/A	N/A
11/22/15	9:00	20	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
11/22/15	12:00	0	N/A	N/A	N/A
11/23/15	10:30	3	Chinook salmon	Adult	TR Below Weir
		35	Sacramento sucker	Juvenile	MC Below Weir
		45	Sacramento pikeminnow	Juvenile	MC Below Weir
		1	unidentified	Unknown	MC Above Weir
11/23/15	11:30	0	N/A	N/A	N/A
11/24/15	10:00	1	Chinook salmon	Adult	TR Below Weir
		12	Sacramento pikeminnow	Juvenile	MC Above Weir
		3	Sacramento sucker	Juvenile	MC Above Weir
11/24/15	12:00	0	N/A	N/A	N/A
11/25/15	9:00	1	Chinook salmon	Adult	TR Below Weir
		25	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
11/25/15	16:30	0	N/A	N/A	N/A
11/26/15	8:45	20	Sacramento sucker	Juvenile	MC Below Weir
		1	Chinook salmon	Adult	MC Below Weir
11/26/15	11:50	0	N/A	N/A	N/A
11/27/15	9:45	20	Sacramento pikeminnow	Juvenile	MC Below Weir
		15	Sacramento sucker	Juvenile	MC Below Weir
11/27/15	16:50	0	N/A	N/A	N/A
11/28/15	9:15	10	Sacramento pikeminnow	Juvenile	MC Below Weir
		20	Sacramento sucker	Juvenile	MC Below Weir
11/28/15	12:00	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
11/29/15	9:30	15	Sacramento sucker	Juvenile	MC Below Weir
		5	Sacramento pikeminnow	Juvenile	MC Below Weir
11/30/15	9:30	12	Sacramento sucker	Juvenile	MC Below Weir
		3	Sacramento pikeminnow	Juvenile	MC Below Weir
11/30/15	12:00	5	Sacramento sucker	Juvenile	Upper sluice gate channel
11/30/15	12:00	1	Chinook salmon	Adult	Upper sluice gate channel
12/1/15	9:15	12	Sacramento pikeminnow	Juvenile	MC Below Weir
12/1/15	16:20	0	N/A	N/A	N/A
12/2/15	8:45	2	Sacramento pikeminnow	Juvenile	MC Below Weir
12/2/15	15:40	0	N/A	N/A	N/A
12/3/15	9:00	5	Sacramento pikeminnow	Juvenile	MC Below Weir
12/3/15	13:30	0	N/A	N/A	N/A
12/4/15	9:15	0	N/A	N/A	N/A
12/5/15	9:00	10	Sacramento sucker	Juvenile	MC Below Weir
12/6/15	9:00	7	Sacramento sucker	Juvenile	MC Below Weir
12/7/15	8:30	2	Chinook salmon	Adult	TR Above Weir
		30	Sacramento sucker	Juvenile	MC Below Weir
12/8/15	8:30	0	N/A	N/A	N/A
12/9/15	8:15	28	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
		1	Chinook salmon	Adult	MC Above Weir
12/10/15	8:45	10	Sacramento sucker	Juvenile	MC Below Weir
		15	Sacramento pikeminnow	Juvenile	MC Below Weir
		2	Chinook salmon	Adult	MC Above Weir
12/11/15	9:30	2	Chinook salmon	Adult	MC Above Weir
12/12/15	9:00	10	Sacramento sucker	Juvenile	MC Below Weir
12/12/15	16:20	0	N/A	N/A	N/A
12/13/15	9:00	0	N/A	N/A	N/A
12/14/15	8:45	7	Sacramento sucker	Juvenile	MC Below Weir
12/15/15	9:00	3	Chinook salmon	Adult	TR Above Weir
12/16/15	9:30	1	sculpin	Unknown	MC Below Weir
12/16/15	17:00	0	N/A	N/A	N/A
12/17/15	9:45	4	Sacramento sucker	Juvenile	MC Below Weir
12/17/15	16:30	0	N/A	N/A	N/A
12/18/15	9:00	3	Sacramento pikeminnow	Juvenile	MC Below Weir
12/18/15	16:00	0	N/A	N/A	N/A
12/19/15	10:00	--[3]	N/A	N/A	N/A
12/19/15	15:55	0	N/A	N/A	N/A
12/20/15	10:45	14	Sacramento sucker	Juvenile	MC Below Weir
		6	Sacramento pikeminnow	Juvenile	MC Below Weir
		4	Sacramento sucker	Juvenile	MC Above Weir
12/20/15	15:50	0	N/A	N/A	N/A
12/21/15	11:15	1	sculpin	Adult	MC Below Weir
12/21/15	15:45	0	N/A	N/A	N/A
12/22/15	8:30	1	Chinook salmon	Adult	TR Above Weir
12/22/15	15:15	0	N/A	N/A	N/A
12/23/15	10:30	11	Sacramento sucker	Juvenile	MC Below Weir
		28	Sacramento pikeminnow	Juvenile	MC Below Weir
12/23/15	16:15	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
12/24/15	10:00	--[3]	N/A	N/A	N/A
12/24/15	15:30	0	N/A	N/A	N/A
12/25/15	9:45	0	N/A	N/A	N/A
12/25/15	16:05	0	N/A	N/A	N/A
12/26/15	11:30	0	N/A	N/A	N/A
12/27/15	8:30	0	N/A	N/A	N/A
12/27/15	16:00	0	N/A	N/A	N/A
12/28/15	8:30	0	N/A	N/A	N/A
12/28/15	15:45	0	N/A	N/A	N/A
12/29/15	9:15	1	sculpin	Adult	MC Below Weir
12/30/15	8:45	0	N/A	N/A	N/A
12/30/15	16:30	0	N/A	N/A	N/A
12/31/15	11:30	0	N/A	N/A	N/A
12/31/15	16:30	0	N/A	N/A	N/A
1/1/16	14:50	0	N/A	N/A	N/A
1/2/16	8:45	1	sculpin	Juvenile	MC Below Weir
1/3/16	11:00	0	N/A	N/A	N/A
1/3/16	16:30	0	N/A	N/A	N/A
1/4/16	10:45	0	N/A	N/A	N/A
1/4/16	16:00	0	N/A	N/A	N/A
1/5/16	13:30	0	N/A	N/A	N/A
1/6/16	16:30	0	N/A	N/A	N/A
1/7/16	10:30	0	N/A	N/A	N/A
1/7/16	15:00	0	N/A	N/A	N/A
1/8/16	9:30	0	N/A	N/A	N/A
1/8/16	16:30	0	N/A	N/A	N/A
1/9/16	9:15	0	N/A	N/A	N/A
1/9/16	16:30	0	N/A	N/A	N/A
1/10/16	9:30	0	N/A	N/A	N/A
1/10/16	15:45	0	N/A	N/A	N/A
1/11/16	9:45	0	N/A	N/A	N/A
1/11/16	9:30	0	N/A	N/A	N/A
1/12/16	9:30	0	N/A	N/A	N/A
1/12/16	13:30	0	N/A	N/A	N/A
1/13/16	10:45	0	N/A	N/A	N/A
1/13/16	15:10	0	N/A	N/A	N/A
1/14/16	10:00	0	N/A	N/A	N/A
1/14/16	15:30	0	N/A	N/A	N/A
1/15/16	12:00	0	N/A	N/A	N/A
1/15/16	16:00	0	N/A	N/A	N/A
1/16/16	11:15	0	N/A	N/A	N/A
1/16/16	16:20	0	N/A	N/A	N/A
1/17/16	11:00	0	N/A	N/A	N/A
1/17/16	15:15	0	N/A	N/A	N/A
1/17/16	18:45	0	N/A	N/A	N/A
1/18/16	13:15	0	N/A	N/A	N/A
1/18/16	15:30	0	N/A	N/A	N/A
1/19/16	10:00	--[3]	N/A	N/A	N/A
1/19/16	16:00	0	N/A	N/A	N/A
1/20/16	10:00	0	N/A	N/A	N/A
1/22/16	8:00	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
1/23/16	14:00	0	N/A	N/A	N/A
1/24/16	8:30	1	Chinook salmon	Adult	N/A
1/24/16	14:30	0	N/A	N/A	N/A
1/25/16	9:15	0	N/A	N/A	N/A
1/25/16	15:30	0	N/A	N/A	N/A
1/26/16	12:30	0	N/A	N/A	N/A
1/26/16	16:00	0	N/A	N/A	N/A
1/27/16	11:00	0	N/A	N/A	N/A
1/29/16	11:00	0	N/A	N/A	N/A
1/30/16	10:00	0	N/A	N/A	N/A
1/30/16	14:30	0	N/A	N/A	N/A
1/31/16	10:00	0	N/A	N/A	N/A
1/31/16	16:00	0	N/A	N/A	N/A
2/1/16	11:30	0	N/A	N/A	N/A
2/1/16	13:00	0	N/A	N/A	N/A
2/2/16	10:00	0	N/A	N/A	N/A
2/2/16	17:00	0	N/A	N/A	N/A
2/3/16	9:45	0	N/A	N/A	N/A
2/3/16	16:40	0	N/A	N/A	N/A
2/4/16	9:30	0	N/A	N/A	N/A
2/4/16	17:05	0	N/A	N/A	N/A
2/5/16	12:30	0	N/A	N/A	N/A
2/5/16	17:00	0	N/A	N/A	N/A
2/6/16	12:30	0	N/A	N/A	N/A
2/6/16	16:35	0	N/A	N/A	N/A
2/7/16	9:45	0	N/A	N/A	N/A
2/7/16	14:00	0	N/A	N/A	N/A
2/8/16	9:30	0	N/A	N/A	N/A
2/8/16	15:30	0	N/A	N/A	N/A
2/9/16	9:30	0	N/A	N/A	N/A
2/9/16	13:00	0	N/A	N/A	N/A
2/10/16	10:00	0	N/A	N/A	N/A
2/10/16	17:05	0	N/A	N/A	N/A
2/11/16	9:15	0	N/A	N/A	N/A
2/11/16	16:30	0	N/A	N/A	N/A
2/12/16	9:00	0	N/A	N/A	N/A
2/12/16	10:00	--[3]	N/A	N/A	N/A
2/13/16	10:30	0	N/A	N/A	N/A
2/13/16	16:00	0	N/A	N/A	N/A
2/14/16	10:15	0	N/A	N/A	N/A
2/14/16	17:00	0	N/A	N/A	N/A
2/15/16	10:30	0	N/A	N/A	N/A
2/15/16	16:00	0	N/A	N/A	N/A
2/16/16	9:45	0	N/A	N/A	N/A
2/16/16	12:00	0	N/A	N/A	N/A
2/17/16	9:00	0	N/A	N/A	N/A
2/17/16	14:50	0	N/A	N/A	N/A
2/18/16	10:45	0	N/A	N/A	N/A
2/18/16	15:45	0	N/A	N/A	N/A
2/19/16	11:00	1	unknown bass	Adult	TR Below Weir
2/19/16	15:20	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
2/20/16	10:30	1	sculpin	N/A	MC Above Weir
2/20/16	14:00	0	N/A	N/A	N/A
2/21/16	10:15	0	N/A	N/A	N/A
2/21/16	15:50	0	N/A	N/A	N/A
2/22/16	9:45	0	N/A	N/A	N/A
2/22/16	17:30	0	N/A	N/A	N/A
2/23/16	10:00	0	N/A	N/A	N/A
2/23/16	17:00	0	N/A	N/A	N/A
2/24/16	9:15	0	N/A	N/A	N/A
2/24/16	16:30	0	N/A	N/A	N/A
2/25/16	9:30	0	N/A	N/A	N/A
2/25/16	14:20	0	N/A	N/A	N/A
2/26/16	9:15	1	unknown bass	Adult	TR Below Weir
2/26/16	16:50	0	N/A	N/A	N/A
2/27/16	9:45	0	N/A	N/A	N/A
2/27/16	15:00	0	N/A	N/A	N/A
2/28/16	9:30	0	N/A	N/A	N/A
2/28/16	17:30	0	N/A	N/A	N/A
2/29/16	10:00	--[3]	N/A	N/A	N/A
2/29/16	14:15	0	N/A	N/A	N/A
3/1/16	10:45	0	N/A	N/A	N/A
3/1/16	11:30	0	N/A	N/A	N/A
3/2/16	9:30	0	N/A	N/A	N/A
3/2/16	16:30	0	N/A	N/A	N/A
3/3/16	10:15	0	N/A	N/A	N/A
3/3/16	16:30	0	N/A	N/A	N/A
3/4/16	10:00	0	N/A	N/A	N/A
3/4/16	13:30	0	N/A	N/A	N/A
3/5/16	16:00	0	N/A	N/A	N/A
3/6/16	14:00	0	N/A	N/A	N/A
3/7/16	13:30	0	N/A	N/A	N/A
3/7/16	17:15	0	N/A	N/A	N/A
3/8/16	9:45	0	N/A	N/A	N/A
3/8/16	16:00	0	N/A	N/A	N/A
3/9/16	9:15	0	N/A	N/A	N/A
3/9/16	17:00	0	N/A	N/A	N/A
3/10/16	10:00	0	N/A	N/A	N/A
3/10/16	16:50	0	N/A	N/A	N/A
3/11/16	9:15	0	N/A	N/A	N/A
3/11/16	15:00	0	N/A	N/A	N/A
3/12/16	11:00	0	N/A	N/A	N/A
3/12/16	15:30	0	N/A	N/A	N/A
3/13/16	10:00	--[3]	N/A	N/A	N/A
3/13/16	17:00	0	N/A	N/A	N/A
3/14/16	11:00	0	N/A	N/A	N/A
3/14/16	12:15	0	N/A	N/A	N/A
3/15/16	12:00	0	N/A	N/A	N/A
3/15/16	12:30	0	N/A	N/A	N/A
3/16/16	9:15	0	N/A	N/A	N/A
3/16/16	16:30	0	N/A	N/A	N/A
3/17/16	13:30	0	N/A	N/A	N/A

Sample Date	Sample Time	Count	Species [1]	Life Stage [1]	Location [1,2]
3/17/16	16:00	0	N/A	N/A	N/A
3/18/16	9:15	0	N/A	N/A	N/A
3/18/16	18:00	0	N/A	N/A	N/A
3/19/16	10:30	0	N/A	N/A	N/A
3/19/16	13:10	0	N/A	N/A	N/A
3/20/16	10:15	0	N/A	N/A	N/A
3/20/16	14:00	0	N/A	N/A	N/A
3/21/16	8:30	0	N/A	N/A	N/A
3/21/16	15:00	0	N/A	N/A	N/A
3/22/16	9:15	0	N/A	N/A	N/A
3/22/16	17:00	0	N/A	N/A	N/A
3/23/16	10:00	0	N/A	N/A	N/A
3/24/16	8:45	0	N/A	N/A	N/A
3/25/16	9:30	0	N/A	N/A	N/A
3/26/16	9:45	0	N/A	N/A	N/A
3/27/16	9:00	0	N/A	N/A	N/A
3/27/16	16:00	0	N/A	N/A	N/A
3/28/16	8:45	0	N/A	N/A	N/A
3/28/16	15:00	0	N/A	N/A	N/A
3/29/16	13:30	0	N/A	N/A	N/A
3/29/16	15:15	0	N/A	N/A	N/A
3/30/16	13:15	0	N/A	N/A	N/A
3/31/16	13:45	0	N/A	N/A	N/A
4/1/16	9:15	0	N/A	N/A	N/A
4/2/16	9:00	0	N/A	N/A	N/A
4/3/16	9:00	0	N/A	N/A	N/A
4/3/16	16:00	0	N/A	N/A	N/A
4/4/16	9:45	0	N/A	N/A	N/A
4/4/16	12:45	0	N/A	N/A	N/A
4/5/16	10:45	0	N/A	N/A	N/A
4/5/16	12:30	0	N/A	N/A	N/A
4/6/16	9:45	0	N/A	N/A	N/A
4/7/16	11:15	0	N/A	N/A	N/A
4/8/16	10:30	0	N/A	N/A	N/A
4/9/16	10:00	--[3]	N/A	N/A	N/A
4/10/16	10:45	0	N/A	N/A	N/A
4/10/16	13:00	0	N/A	N/A	N/A
4/11/16	9:00	0	N/A	N/A	N/A
4/11/16	16:45	0	N/A	N/A	N/A
4/12/16	12:45	0	N/A	N/A	N/A
4/12/16	15:15	0	N/A	N/A	N/A
4/13/16	10:15	0	N/A	N/A	N/A
4/13/16	16:00	0	N/A	N/A	N/A
4/14/16	8:15	0	N/A	N/A	N/A

1 N/A – Data not applicable.
2 MC – Location is the main channel of the Tuolumne River; TR – Location is the tailrace channel.
3 Survey not conducted due to heavy rain causing low visibility condition.

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

DRAFT LICENSE APPLICATION

ATTACHMENT I

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

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INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

TID WATER & POWER
Serving Central California since 1887

MID Modesto Irrigation District
The Power to Grow

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

Prepared by:
FISHBIO and LGL Alaska Research Associates
February 2017

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List of Acronyms and Abbreviations

ac-ft ....acre-foot
BLM............................Bureau of Land Management
BOR ....Bureau of Reclamation
CCSF..........................City and County of San Francisco
CDFG.........................California Department of Fish and Game, now CDFW
CDFW........................California Department of Fish and Wildlife
cfs...............................cubic feet per second
CG ....Conservation Groups
Districts......................Turlock Irrigation District and Modesto Irrigation District
FERC..........................Federal Energy Regulatory Commission
FLA ....Final License Application
FPA ....Federal Power Act
GIS ....geographic information system
ILP..............................Integrated Licensing Process
ISR ....Initial Study Report
LGDD ....La Grange Diversion Dam
LPs ....licensing participants
M&I............................municipal and industrial
MID............................Modesto Irrigation District
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
O&M..........................operation and maintenance
PAD............................Pre-Application Document
PSP.............................Proposed Study Plan
QA/QC.......................quality assurance/quality control
RM ....river mile
RSP ....Revised Study Plan
SD2 ....Scoping Document 2
SPD ....Study Plan Determination
TAF............................thousand acre-feet
TID.............................Turlock Irrigation District
TM..............................technical memorandum
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
USR............................Updated Study Report

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Lake Lloyd (known as Cherry Lake), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.

Figure 1.1-1. La Grange Hydroelectric Project location map.

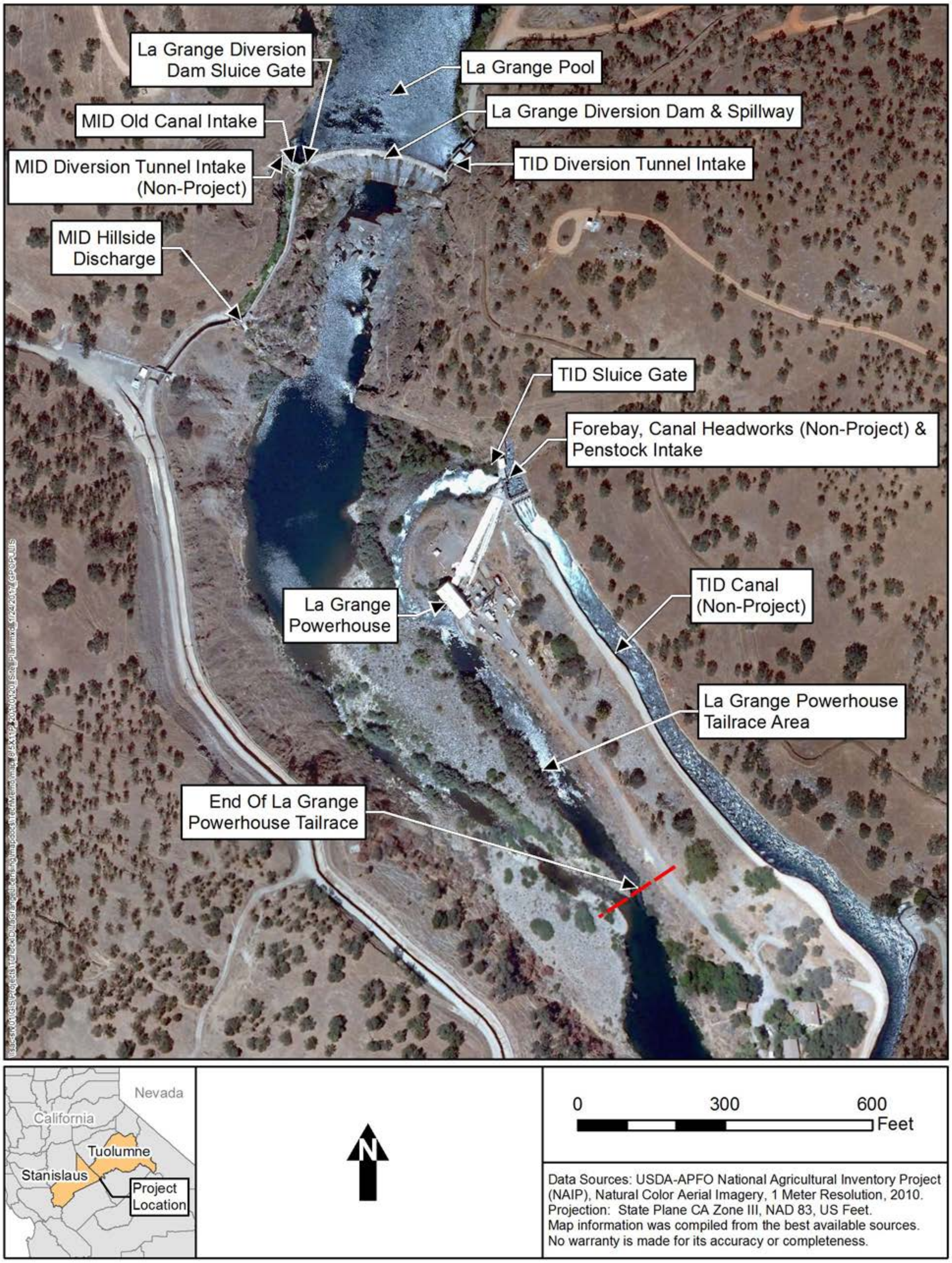

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."
[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).
[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

passage through Don Pedro Reservoir or La Grange pool. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study.

This study report describes the objectives, methods, and final results of the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes, which is one of five study components of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam being implemented by the Districts in accordance with FERC's SPD. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified potential for Project effects on upstream migration of anadromous fish.

FERC's SPD approved with modifications the Districts' proposed Fish Habitat and Stranding Assessment below La Grange Diversion Dam. In its SPD, FERC ordered the Districts: (1) to continue monitoring of existing flow conduits where flow monitoring is already occurring, conduct two years of flow monitoring at flow conduits not currently monitored (i.e., the Modesto hillside discharge and La Grange dam sluice gate), develop estimates of historical flows, data permitting, for each of the five flow conduits at the Project, and based on existing information, to the extent available, characterize the magnitude and rate of flow and stage changes when Project conduits are shut down, (2) collect topographic, depth, and habitat data downstream, and in the vicinity of, the Project, (3) assess fish presence and the potential for stranding, and (4) in consultation with NMFS and other interested parties, develop and implement a plan for monitoring anadromous fish movement into the powerhouse draft tubes.

As noted in FERC's SPD, the Districts' January 5, 2015, RSP did not include "protocols for monitoring anadromous fish movement into the powerhouse tailrace and the potential for injury or mortality by contact with the turbine runners." FERC therefore directed the Districts to develop a study plan to address a fourth directive of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam to monitor anadromous fish movement into the powerhouse draft tubes. The plan was to be developed in consultation with NMFS and other interested stakeholders and implemented beginning in 2015 for the anadromous fish migration. On May 4, 2015 the Districts provided a draft study plan to licensing participants for 30-day review. No comments were received and on June 11, 2015, the Districts filed the study plan with FERC. On August 12, 2015, FERC approved the study plan as filed.

The Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes Study Report summarizes the implementation of the FERC-approved study plan consistent with Item (4) described above.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study (hereinafter referred to as the Draft Tube Study) is to evaluate the potential impact of certain La Grange powerhouse facilities on adult fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*Oncorhynchus mykiss)*. Specific information obtained by this study will be used to:

- document adult resident *O. mykiss* and adult anadromous salmonid behavior in the vicinity of the La Grange powerhouse discharge during the fall 2015 (fall-run Chinook) to spring 2016 (*O. mykiss)* migration season;
- identify anadromous fish reaching the La Grange powerhouse;
- describe behavioral activities of fish in relation to La Grange powerhouse operations; and
- determine if fish are moving into the draft tube of operating units.

3.0 STUDY AREA

The study area includes the immediate vicinity of the discharge from La Grange powerhouse and the operating units (see previous Figure 1.1-2).

4.0 METHODOLOGY

4.1 Imaging Sonar Deployment and Monitoring

An imaging sonar unit (ARIS Explorer 1800, Sound Metrics) was installed at the outlet from the La Grange powerhouse on September 1, 2015 for operation during the 2015/2016 migration season to determine if fish were attempting to access the La Grange powerhouse or enter the powerhouse draft tubes, and to assess their behavior in relation to powerhouse operations. The Unit 1 draft tube was the focus of the evaluation given water availability and that the projected generation schedule anticipated the operation of only this unit during the study period.

The imaging sonar system consisted of a sonar head, data transmission cable, sonar control box, ethernet cable and laptop computer loaded with imaging sonar data acquisition software (ArisScope, Sound Metrics). Electronic components were housed in a ventilated box for protection from rain and heat. The system was powered with 110 VAC, and also had a surge-protected uninterruptable power supply to prevent loss of data during power surges or short-term power outages.

Imaging sonar resolution and quality can be affected by entrained air and turbulence created during power generation. Prior to deployment, feasibility testing of the imaging sonar system was conducted to identify deployment configurations and assess the issue of turbulence as a potential limitation for sonar sampling. With a discharge of 150 cfs at Unit 1 (Unit 2 was not operational during the field tests and was not expected to be operational during the proposed sampling periods), turbulence was noted to be fairly minor. Therefore, it was likely that sonar imagery would not be significantly degraded during similar operational conditions within the proposed sampling periods.

The imaging sonar unit was deployed approximately five feet outside of the pit and eight feet below the water surface, and was aimed with a positive 9.5 tilt angle to allow for imaging the bottom edges of the draft tube and the water volume below the Unit 1 draft tube (Figure 4.1-1). With this deployment, fish presence and behavior were assessed at the pit entrance and within the pit including directly below the draft tube.

The sampling design reasonably permitted the observation of fish that may enter the draft tube pit and the draft tube. The water volume directly below the draft tube was ensonified and any fish that entered that volume was detected (Figure 4.1-2). Any fish detected within the volume directly below the draft tube that swim up into the draft tube was shown to disappear from the field of view. Given that the water volume directly below the draft tube entrance was also ensonified, fish that exited the field of view without moving beyond the circumference of the bottom of the tube were assumed to have moved up into the draft tube.

Continuous data collection began on September 4, 2015 and continued through May 5, 2016. Data were ported directly to external hard drives, and backed up and archived daily to additional hard drives to ensure no data were lost.

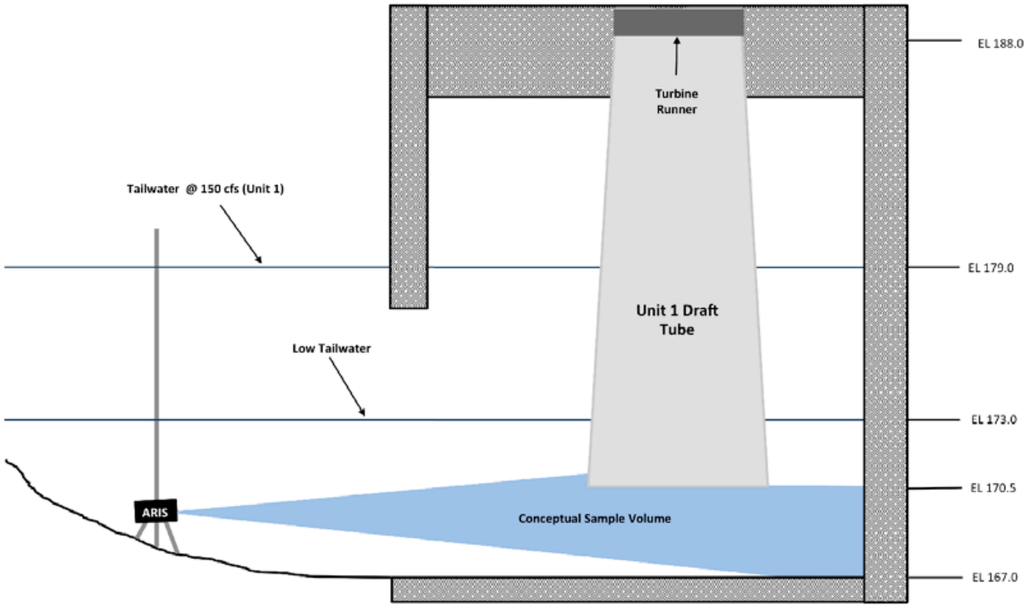

Figure 4.1-1. **Conceptual depiction of an imaging sonar deployment used to assess fish presence and behavior in the vicinity of and directly below the La Grange Unit 1 draft tube. Note that drawing is not to scale.**

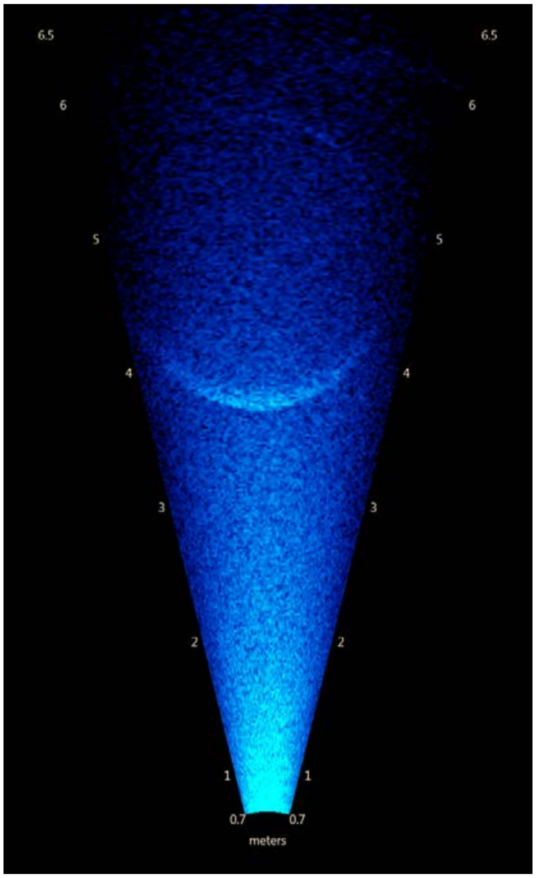

Figure 4.1-2. **Image of the field of view from the ARIS showing the entire circumference of the Unit 1 draft tube during operation of Unit 1.**

4.2 Data Processing and Analysis

The Districts processed and analyzed subsets of the imagery data to encompass periods during the fall-run Chinook salmon migration/spawning period (October through mid-December) and during the period after the fall-run Chinook salmon season (mid-December through May). Consistent with the FERC approved study plan, sub-sampled time periods were chosen based on observations of fish passing the tailrace monitoring weir (the Districts deployed a counting weir just downstream of the La Grange powerhouse in accordance with the La Grange Fish Barrier Assessment (TID/MID 2017a) concurrent in time with the Draft Tube Study). Weir count data from the Fish Barrier Assessment were reviewed to optimize the timing of the sonar imaging analysis (i.e., to determine when peak counts of fish are in the vicinity of the powerhouse). The sonar imaging monitoring periods chosen to be processed and analyzed were as follows: the consecutive five-week period from November 15 through December 19, 2015; and five three-day periods between December 20, 2015 and February 2016 (December 20 through 22, December 26 through 28, January 10 through 12, January 21 through 23, and February 24 through 26).

Initially, raw data were to be processed using a Convolved-Samples-Over-Threshold (CSOT) algorithm to filter out data that do not contain moving targets (i.e., all static imagery will be removed, resulting in a much smaller dataset to be manually processed). However, given that turbulence and debris were observed to confound the motion-sensing features of the CSOT algorithm, it was necessary to manually review all data files. Manual processing entailed reviewing the data files using playback software (ARISFish) that presents the data in both echogram and sonar display formats. When potential fish traces were observed in the echogram a short excerpt of data around the trace was then reviewed in sonar format to confirm whether or not the trace was a fish (the sonar format presents the data as a streaming view that allows for recognition of fish based on swimming movements and morphological features). Observed fish were then measured using the software's sizing tool. For all adult-sized (>30 cm) fish detected, the following data were documented: date, time, estimated total length, fish location relative to edge of draft tube (whether or not fish were observed to be within 0.6 m of the draft tube), whether or not the fish occupied the area below the draft tube or entered into and/or exited Unit 1 draft tube. If a fish were partially observed (i.e. its entire body was not in the field of view), but the portion of the body observed was > 30 cm, then the estimated total length assigned for the fish included a '+' sign to indicate that the length was a partial estimate. For example, if a fish was observed along the edge of the field of view and the portion of the body of the fish that was visible was 41 cm, then the fish was assigned an estimated total length of 41+ cm.

Imaging sonar is a passive method for sampling fish, as this technique relies on operational frequencies above the known hearing range of all species of fish (Fay and Simmons 1999). Imaging sonar is an accepted fisheries science data collection method and has been used for both fish passage investigations at hydropower dams (Johnson et al. 2013) and for estimating salmonid escapement in large rivers (Burwen et al. 2014). An important limitation of imaging sonar is that fish cannot be identified to species when similar species are present at the same time. In the context of this study this limitation is relevant since it was not possible to separate observations of Chinook salmon from observations of *O. mykiss* and other adult-sized fish (e.g., striped bass and Sacramento pikeminnow) based on imaging sonar data alone as those species are all generally similar in body shape (as opposed to for example lamprey or sturgeon which have distinctly different body shapes and as a result can be identified using imagery sonar). All adult-sized fish (including Chinook salmon and *O. mykiss)* observed in the ARIS system field of view during the sampling period were included in the analysis and overall fish observations are inclusive of both Chinook salmon and *O. mykiss* as well as other adult fish of other species that may have been present during the sampling periods. Another important note is that an individual fish cannot be identified and tracked from the imaging sonar. This is relevant to the study results since total observations identified does not necessarily equal numbers of fish present in the vicinity of the draft tube (i.e., one fish may be responsible for multiple observations).

All entered data were reviewed for quality assurance purposes. Finalized datasheets were entered into a Microsoft Excel database and then independently reviewed for accuracy. Database quality assurance and quality control consisted of a comparison of entered data to the original datasheet information to affirm appropriate database entry.

5.0 RESULTS

5.1 Sampling Effort and Operational Conditions

The ARIS system was configured to collect data continuously throughout the study period but on a few occasions data collection was interrupted due to technical difficulties and system malfunction. As a result some portions of the study period were not monitored. For the consecutive five-week sub-sampled period (November 15 through December 19) sampling effort was 87 percent (of 840 hours, 728 hours were sampled and processed; Attachment A). For the five three-day periods, the sampling effort was 94 percent (of 360 hours, 339 hours were sampled and processed; Attachment B)

Operation of Unit 1 was not consistent throughout the study periods (Attachment A and Attachment B). Throughout a large portion of the month of November, Unit 1 was not operational, due to maintenance issues. For the five-week sub-sampled period, Unit 1 was operational for 60 percent of all hours. Across all five three-day sub-sampled periods, Unit 1 was operational for 80 percent of all hours.

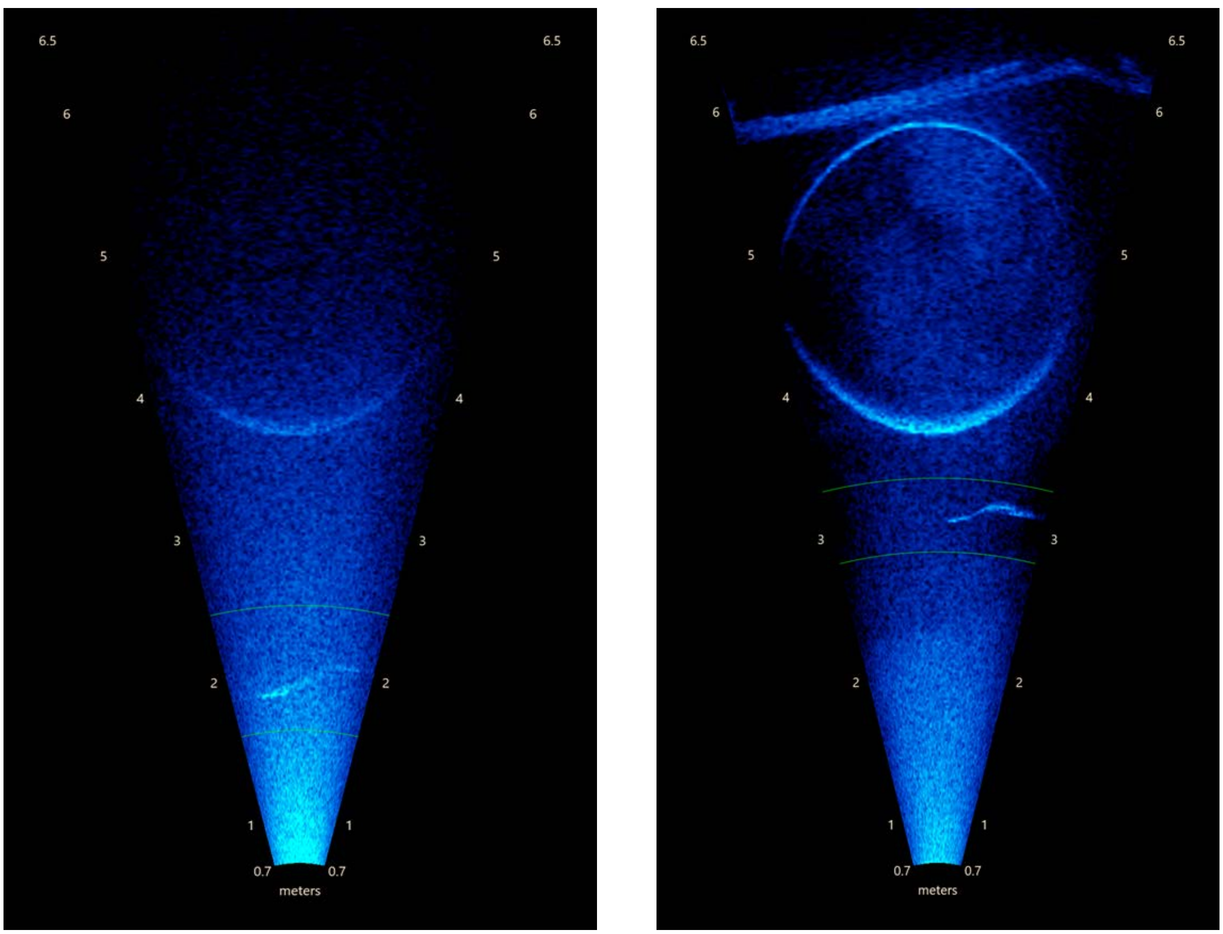

Figure 5.1-1. Still images from ARIS data with adult fish showing the differences in image quality during Unit 1 in operation (left panel) and Unit 1 not in operation (right panel).

5.1.1 Image Quality

The quality and clarity of ARIS imagery was not consistent across Unit 1 operational conditions (Figure 5.1-1, above). When Unit 1 was operational the imagery was characterized with less visible structural features in the field of view and lower resolution of fish images as compared with data collected when Unit 1 was off. When the unit was not operational the walls of the draft tube pit were visible and the entire circumference of the bottom of the draft tube could be clearly seen.

5.1.2 Adult Fish Observations

5.1.2.1 Overall Counts and Temporal Patterns

A total of 883 observations of adult fish were detected with ARIS during the consecutive five-week sampling period in 2015 (Figure 5.1-2). As noted above, these observation events do not represent individual fish, as an individual fish could pass through the ARIS field of view multiple times. Weir monitoring in the tailrace channel just downstream (~50 meters) of the ARIS monitoring location detected a total of 1,988 adult fish (>30 cm) passage events (1,016 upstream, 972 downstream) during this five-week period (Table 5.1-1). During this period, weir monitoring determined that 60 Chinook salmon were present in the vicinity of La Grange powerhouse, accounting for 67.3 percent of total weir passages (TID/MID 2017a).

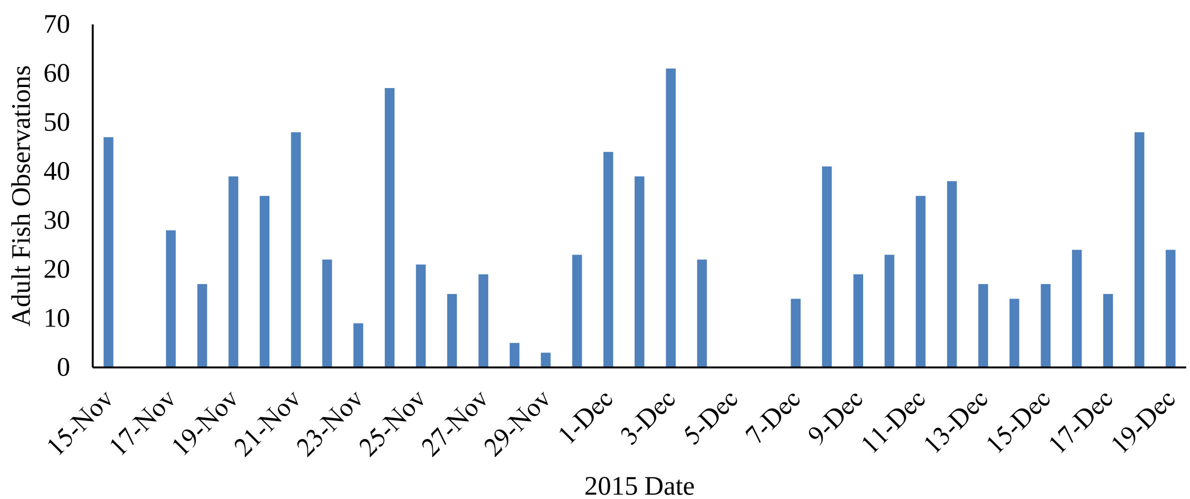

Figure 5.1-2. Number of adult fish observations detected with ARIS by date throughout the five-week sampling period (November 15 through December 19, 2015). Dates with missing bars were days in which sampling did not occur.

During the five three-day periods in 2015/2016 a total of 300 adult fish observations were detected (Figure 5.1-3). These periods (December 20 through 22, December 26 through 28, January 10 through 12, January 21 through 23, and February 24 through 26) were selected based on increase adult *O. mykiss* detections at the tailrace weir (TID/MID 2017a). During the five three-day periods, 630 adult fish (>30 cm) passage events (305 upstream, 325 downstream) were detected at the tailrace weir location. Striped bass accounted for 43.2 percent of the total passages during these periods, with Chinook salmon and *O. mykiss* accounting for 35.2 percent and 7.8 percent, respectively (Table 5.1-1). It was estimated that the numbers of salmon present during these five periods were 12, 2, 1, 3, and 0, respectively.

Table 5.1-1. Adult fish (>30 cm) weir passage events in the tailrace channel just downstream of the ARIS monitoring location.

Species	Weir Passage Events		Percent of Total Passage
	Up	Down	
Consecutive Five-week Period			
Chinook	662	676	67.3
O. mykiss	19	13	1.6
Striped Bass	228	241	23.6
Sacramento Pikeminnow	57	65	6.1
Unidentified	6	21	1.4
Five Three-day Periods			
Chinook	112	110	35.2
O. mykiss	22	27	7.8
Striped Bass	135	137	43.2
Sacramento Pikeminnow	16	22	6.0
Carp/Goldfish	14	12	4.1
Unidentified/Other[1]	6	17	3.7

[1] Passages classified as other included bass (two down passages) and Sacramento sucker (one up passage).

All adult fish observations detected during the study periods are listed in Attachments C and D. Assessing fish observations by hour indicates an increase of activity during the late morning and early afternoon hours throughout the five-week sampling period during both Unit 1 on and off conditions (Figure 5.1-4). The hourly pattern was less consistent throughout the five three-day sampling periods with generally more activity from 0600 to 1200 hours when Unit 1 was operating (Figure 5.1-5).

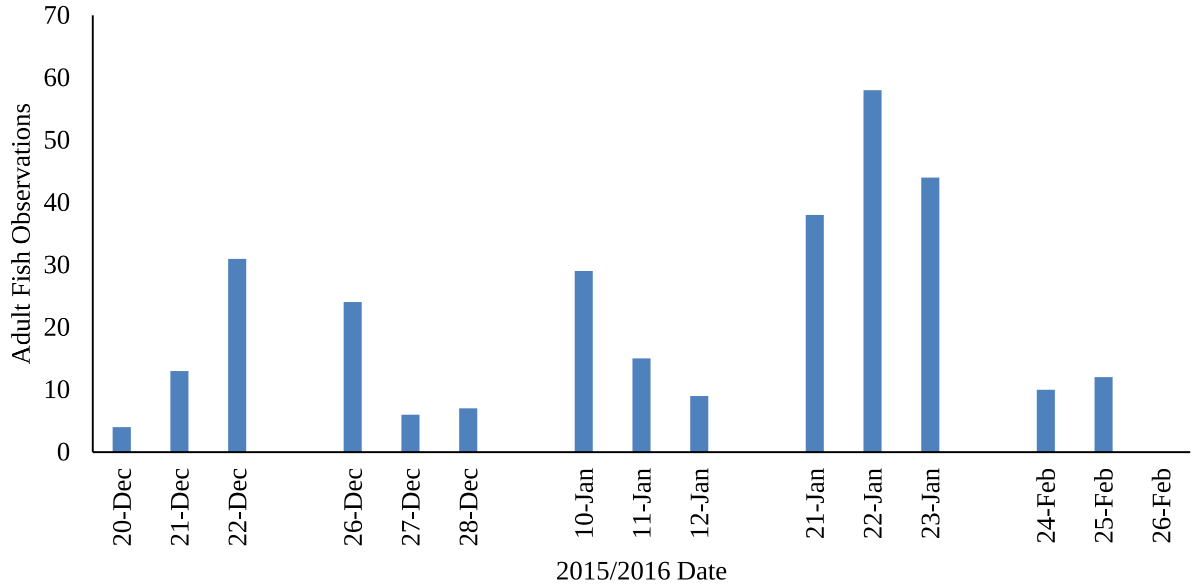

Figure 5.1-3. Number of adult fish observations detected with ARIS by date throughout the five three-day sampling periods (December 20 through December 22, 2015; December 26 through December 28, 2015; January 10 through January 12, 2016; January 21 through January 23, 2016; and February 24 through February 26, 2016). The missing bar for February 26 indicates that no fish were observed that day.

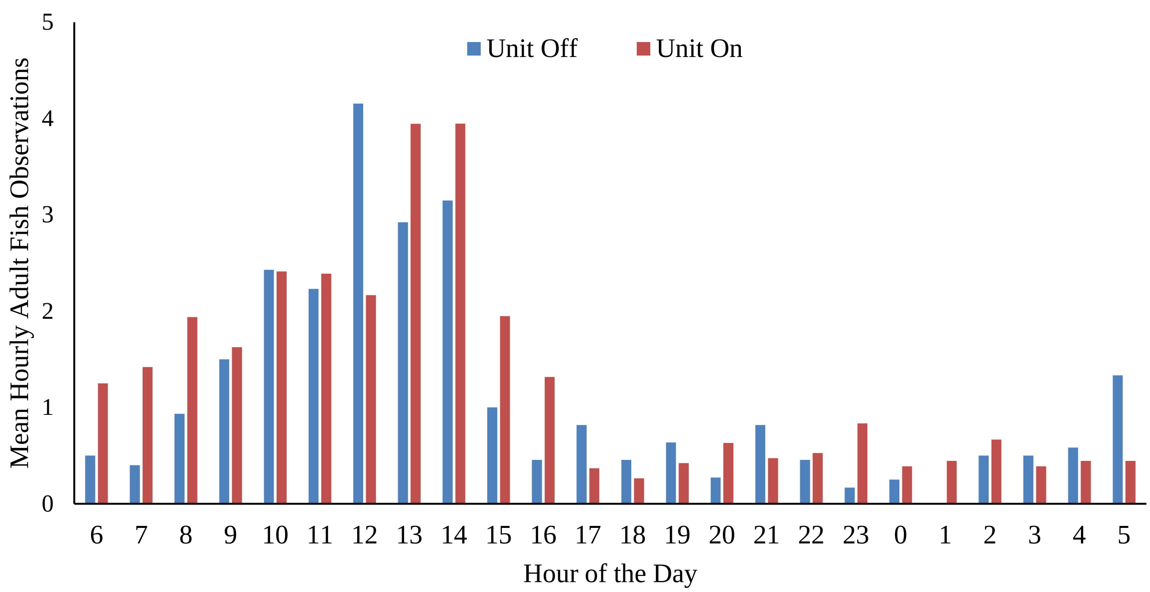

Figure 5.1-4. Mean hourly adult fish observations detected with ARIS throughout the five week sampling period (November 15 through December 19, 2015) during Unit 1 on and off conditions. Mean hourly counts are standardized by sampling effort. The missing bar for hour 1 indicates no fish were observed during that hour when Unit 1 was off.

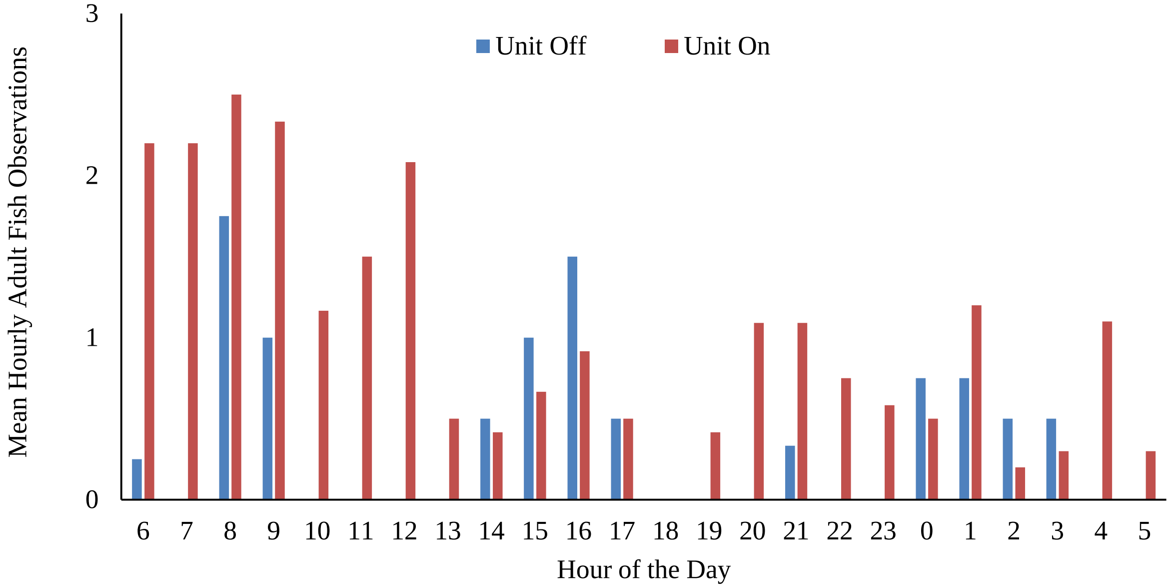

Figure 5.1-5. **Mean hourly adult fish observations detected with ARIS throughout the five 3-day sampling periods (December 20 through December 22, 2015; December 26 through December 28, 2015; January 10 through January 12, 2016; January 21 through January 23, 2016; and February 24 through February 26, 2016) during Unit 1 on and off conditions. Mean hourly counts are standardized by sampling effort. Hours with missing bars indicate that no fish were observed during those hours. Unit 1 on and off conditions occurred to some extent during each hour of the day through the five three-day study periods (see Figure 5.1-2).**

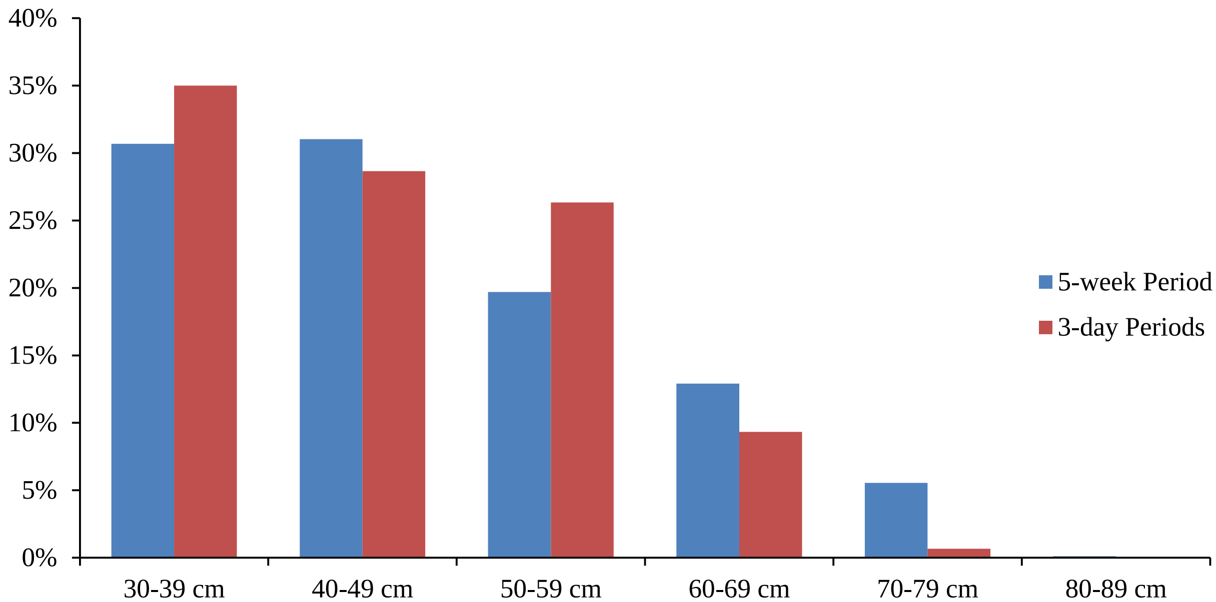

Figure 5.1-6. **Proportional distributions of adult fish observations by size classification for the consecutive five-week (left) and five three-day (right) sampling periods. Note there was one observation (0.11 percent) of a fish within the 80-89 cm size class (estimated total length 83 cm) during the consecutive five-week period and no fish observed in that size class during the five three-day periods.**

5.1.2.2 Size Estimates

Proportional distributions of fish observations by size class indicated that the majority of fish were between 30-39 cm and 40-49 cm in estimated total length (Figure 5.1-6). Fish within the 50-59 cm size class were also frequently observed.

5.1.2.3 Observations and Unit Operations

During the consecutive five-week sample period 62 percent of all observations occurred when Unit 1 was operational (Table 5.1-2). Ninety percent of all observations occurred when Unit 1 was operational during the five three-day sample periods.

Table 5.1-2. Number and percentage of adult fish observations detected during Unit 1 On and Off conditions in the five-week and five three-day sample periods. Numbers and percentages are also shown for observations that occurred near (within 0.6 m) and under the draft tube.

	Five-week Period			Five Three-day Periods		
	Total Observations	**Near Draft Tube (>0.6m)**	**Under Draft Tube**	**Total Observations**	**Near Draft Tube (>0.6m)**	**Under Draft Tube**
Unit 1 ON	546 (62%)	39 (7%)	0	271 (90%)	75 (28%)	0
Unit 1 OFF	337 (38%)	53 (16 %)	5 (1%)	29 (10%)	6 (21%)	0

The majority of observations throughout all sample periods and across operational conditions were of fish detected beyond 0.6 m from the edge of the draft tube. When Unit 1 was operational seven percent of observations were of fish detected near (within 0.6 m) the draft tube during the five-week study period and 28 percent during the five three-day sample periods (Table 5.0-3). No adult fish were detected under the draft tube when Unit 1 was on. When Unit 1 was off 16 percent and 21 percent of observations were of fish near the draft tube for the five-week and the five three-day sample periods, respectively. A total of five observations (one percent) were of adult fish detected below the draft tube when Unit 1 was off during the five-week sample period (e.g. Figure 5.1-7).

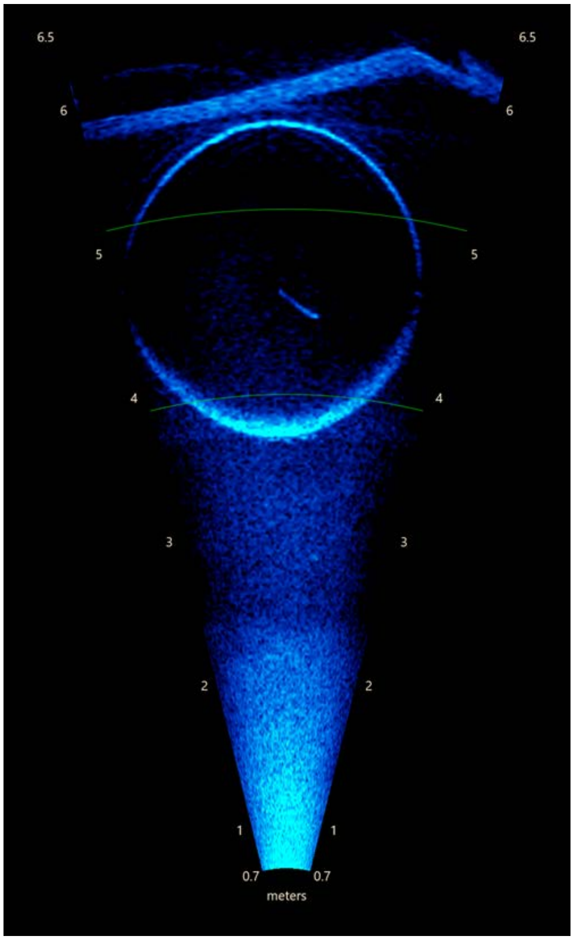

Figure 5.1-7. Still image of ARIS data showing an adult fish (estimated total length 35 cm) below the Unit 1 draft tube. This observation occurred at 0630 on November 19, 2015 (Unit 1 was not operating).

6.0 DISCUSSION AND FINDINGS

The quality of the ARIS imagery differed between periods when Unit 1 was operating and when Unit 1 was not operating. During non-operational conditions the ensonified volume was clear throughout the field of view which allowed for more defined and higher resolution images of fish as compared to when the unit was in operation. During operational conditions the ensonified volume was less clear due to turbulence associated with unit operation, which resulted in less defined and lower resolution images of fish as compared to non-operational conditions. However, despite the lower resolution imagery during operational conditions the quality was high enough to sufficiently assess adult fish presence throughout the field of view when the unit was operating.

Results from ARIS sampling out front of the La Grange Diversion Dam powerhouse indicated that the area in the vicinity of the draft tube pit was occupied frequently by adult fish. Weir counts from the Fish Barrier Assessment indicated that the majority of observations at the tailrace weir were of adult salmonids, although striped bass, Sacramento pikeminnow, common carp and goldfish were also observed (TID/MID 2017a). Therefore, it is likely that the observations based on ARIS sampling included individuals from each of these species that were observed passing up through the weir. It is also important to note that the observations of adult fish in the vicinity of the draft tube pit do not reflect the observation of separate individual fish but instead indicate the movement of individual fish continuously entering and exiting the ARIS field of view.

The frequent presence of adult fish in the vicinity of the La Grange powerhouse was observed during the fall-run Chinook 2015 migration period and the winter 2015/2016 migration season for *O. mykiss*. Adult fish observations during these periods often exceeded 30 per day. Weir count information (from the Fish Barrier Assessment) analyzed for this study's monitoring period indicate that a variety of fish species, including fall-run Chinook and *O. mykiss*, were present in the vicinity of the La Grange powerhouse. Though fish presence in the vicinity of the La Grange powerhouse was evident, they were detected most frequently in the foreground of the field of view and not close to the draft tube. It appears that adult fish often occupy the area in front of the powerhouse but do not approach the draft tube. This result was evident during both Unit 1 On and Unit 1 Off conditions. Adult fish were not observed to occupy the area under the draft tube when Unit 1 was operational. Furthermore, fish were rarely observed occupying the area under the draft tube when Unit 1 was not operational. The study results indicate that there is likely no risk of fish entering the draft tube and furthermore, swimming vertically up the draft tube and leaping into and being injured as a result of being in contact with the turbine runners in Unit 1 while it is in operation. Given that both units at La Grange Diversion Dam are vertically oriented Francis units with conical, straight-drop draft tubes (not elbow draft tubes) and the low steel of the turbine runner is significantly above tailwater elevation during normal operation, it is likely that the study results apply to both units. These results are also corroborated in the field where crews were on site daily (Fish Presence and Stranding Assessment [TID/MID 2017b]) throughout the study period and reported no observations of injuries or mortalities of adult fish that would have indicated evidence of fish being struck by turbine blades. The lack of adult fish observations below the draft tube when Unit 1 was operational and the absence of direct evidence of blade strike injuries support the notion that considering the vertical orientation of the draft tube (of both units) and the distance between the turbine runner and the tailwater elevation (Figure 4.1-1), there is a very low likelihood of fish entering the draft tube and leaping up towards a turbine runner while units are operating.

6.1 Summary of Findings

The following is a summary of study findings.

- Adult fish, including fall-run Chinook salmon and *O. mykiss* (as determined by weir counts), were frequently observed in the vicinity of the La Grange powerhouse (883 observations during the consecutive five-week study period; 300 observations during the five three-day study period). Note that these observation events do not represent individual fish. For example, weir monitoring in the tailrace channel just downstream of the ARIS monitoring location estimated 60 adult salmon present during the five-week study period (TID/MID 2017a).
- Mean hourly observations showed an increase of activity during the late morning and early afternoon hours throughout the five-week sampling period, and this pattern was consistent whether or not Unit 1 was operating. The hourly pattern was less consistent throughout the five three-day sampling periods with generally more activity from 0600 to 1200 hours, especially when Unit 1 was operating.
- Proportional distributions of fish observations by size class indicated that the majority of fish were between 30-39 cm and 40-49 cm in estimated total length through all sample periods. Fish within the 50-59 cm size class were also observed.
- The majority of observations occurred when Unit 1 was operational (62 percent during the consecutive five-week sample period and 90 percent during the five three-day sample periods).
- The majority of observations throughout all sample periods and across operational condition were of fish detected beyond 0.6 m from the edge of the draft tube.
- Five observations (one percent) of adult fish were detected below the draft tube when Unit 1 was off during the five-week sample period and no observations were detected below the draft tube when Unit 1 was off during the five three-day sample periods.
- No adult fish were observed under the draft tube when Unit 1 was operational throughout all sample periods.
- Study results (also corroborated by daily field observations from the Fish Presence and Stranding a [TID/MID 2017b]) indicate that there is no risk of fish entering unit draft tubes while in operation and furthermore, being injured as a result of being in contact with the turbine runners at La Grange Diversion Dam.

7.0 STUDY VARIANCES AND MODIFICATIONS

There was a single variance to this study. The study plan identified January through April as the period for five additional three-day sampling events after the fall-run Chinook season. Review of weir data in the tailrace immediately downstream of the ARIS monitoring location identified an increase in *O. mykiss* passages starting in mid-December. In order to better evaluate potential interactions of *O. mykiss* near the draft tubes, this monitoring period was shifted to mid-December through February, and three-day periods corresponded with peaks in *O. mykiss* passage.

8.0 REFERENCES

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INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT A

SAMPLING EFFORT AND UNIT 1 OPERATION FOR THE FIVE-WEEK PERIOD NOVEMBER 15 THROUGH DECEMBER 19, 2015

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Table A-1. Sampling effort and Unit 1 operation for the five-week period November 15 through December 19, 2015. Hourly sampling effort is shown using values 0 to 1 with 0 indicating that the hour was not sampled and 1 indicated that the full hour was sampled. Fractional values indicate the proportion of the hour that was sampled. Blue shaded hours denote when Unit 1 was off and yellow shaded hours denote when Unit 1 was on.

Hr of Day	11/15	11/16	11/17	11/18	11/19	11/20	11/21	11/22	11/23	11/24	11/25	11/26	11/27	11/28	11/29	11/30	12/1	12/2
0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	0.75	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-1. (cont.)

Hour of Day	12/3	12/4	12/5	12/6	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16	12/17	12/18	12/19
0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT B

SAMPLING EFFORT AND UNIT 1 OPERATION FOR THE FIVE THREE-DAY SUB-SAMPLED PERIODS

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Table B-1. Sampling effort and Unit 1 operation for the five three-day sub-sampled periods. Hourly sampling effort is shown using values 0 to 1 with 0 indicating that the hour was not sampled and 1 indicated that the full hour was sampled. Blue shaded hours denote when Unit 1 was off and yellow shaded hours denote when Unit 1 was on.

	Period 1			Period 2			Period 3			Period 4			Period 5		
Hour of Day	**12/20**	**12/21**	**12/22**	**12/26**	**12/27**	**12/28**	**1/10**	**1/11**	**1/12**	**1/21**	**1/22**	**1/23**	**2/24**	**2/25**	**2/26**
0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT C

DAILY COUNTS OF ADULT FISH OBSERVATIONS DURING THE FIVE-WEEK SAMPLE PERIOD NOVEMBER 15 THROUGH DECEMBER 19, 2015

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Table C-1. Daily counts of adult fish observations during the five-week sample period November 15 through December 19, 2015.

Date	Fish Observations		Estimated Size Range (cm)
	Away From Draft Tube (>0.6 m)	Near Draft Tube (<0.6 m)	
15-Nov	44	3	30-76
16-Nov	0	0	--
17-Nov	25	3	35-75
18-Nov	16	1	30-75
19-Nov	29	10	30-77
20-Nov	32	3	32-78
21-Nov	42	6	31-83
22-Nov	19	3	30-70
23-Nov	3	6	36-70
24-Nov	51	6	30-67
25-Nov	21	0	32-64
26-Nov	8	7	32-71
27-Nov	17	2	30-66
28-Nov	3	2	35-44
29-Nov	3	0	37-49
30-Nov	20	3	31-59
1-Dec	40	4	32-70
2-Dec	34	5	31-76
3-Dec	56	5	30-64
4-Dec	20	2	32-73
5-Dec	0	0	--
6-Dec	0	0	--
7-Dec	11	3	39-68
8-Dec	40	1	33-77
9-Dec	18	1	31-75
10-Dec	23	0	31-59
11-Dec	34	1	31-68
12-Dec	33	5	32-59
13-Dec	15	2	30-60
14-Dec	14	0	32-66
15-Dec	15	2	32-57
16-Dec	22	2	32-56
17-Dec	13	2	31-71
18-Dec	47	1	30-67
19-Dec	23	1	31-59

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT D

DAILY COUNTS OF ADULT FISH OBSERVATIONS DURING THE FIVE THREE-DAY SUB-SAMPLED PERIODS

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Table D-1. Daily counts of adult fish observations during the five three-day sub-sampled periods.

Date	Fish Observations		Estimated Size Range (cm)
	Away From Draft Tube (>0.6m)	Near Draft Tube (<0.6 m)	
20-Dec	2	2	35-47
21-Dec	6	7	29-55
22-Dec	29	2	32-61
26-Dec	21	3	30-56
27-Dec	5	1	32-50
28-Dec	7	0	32-47
10-Jan	23	6	30-57
11-Jan	15	0	30-53
12-Jan	7	2	34-47
21-Jan	26	12	31-67
22-Jan	36	22	31-71
23-Jan	24	20	34-73
24-Feb	9	1	32-61
25-Feb	9	3	31-52
26-Feb	0	0	--