INITIAL STUDY REPORT

APPENDIX E

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:
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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.

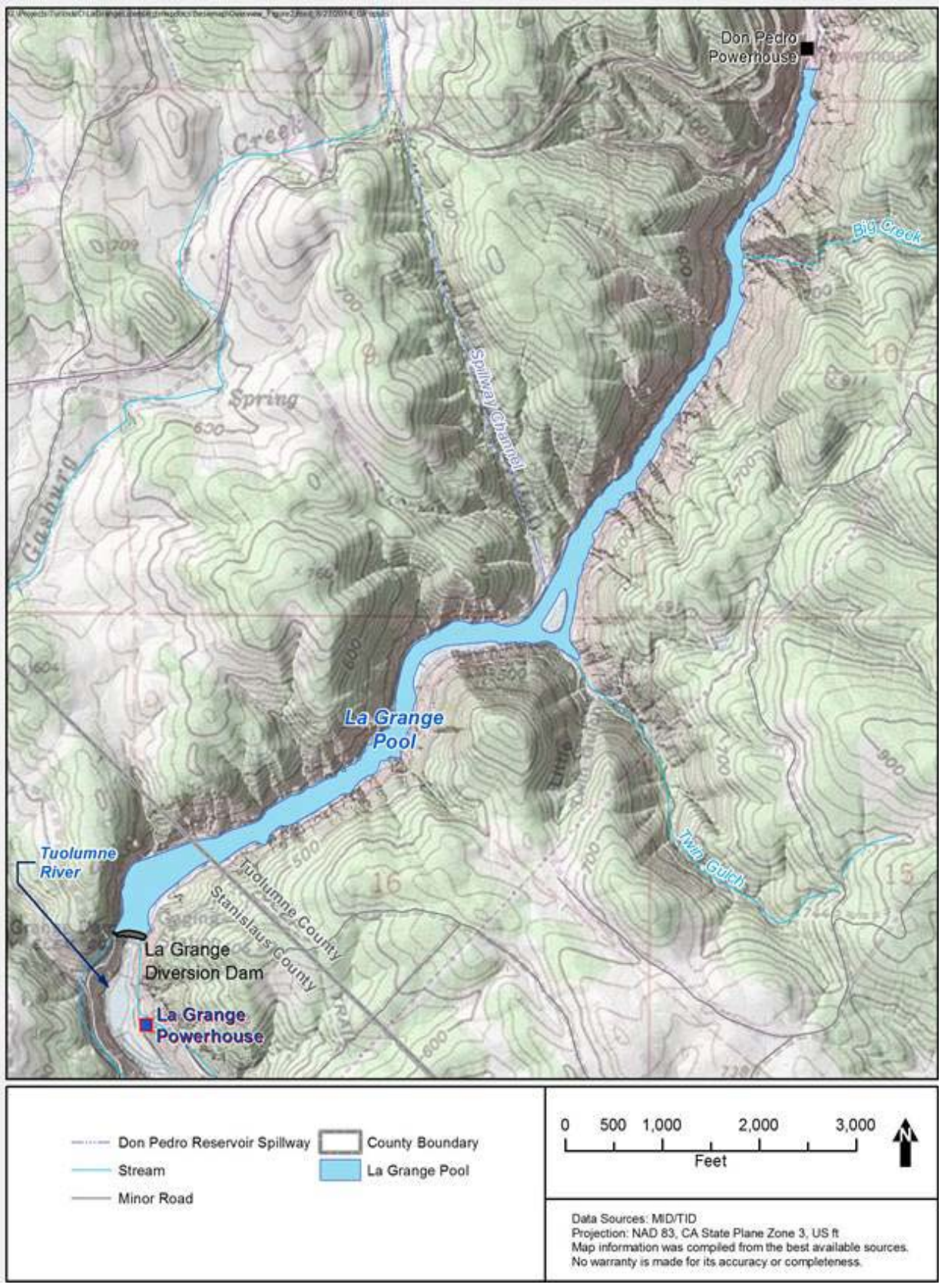

Figure 1.1-1. La Grange Hydroelectric Project location map.

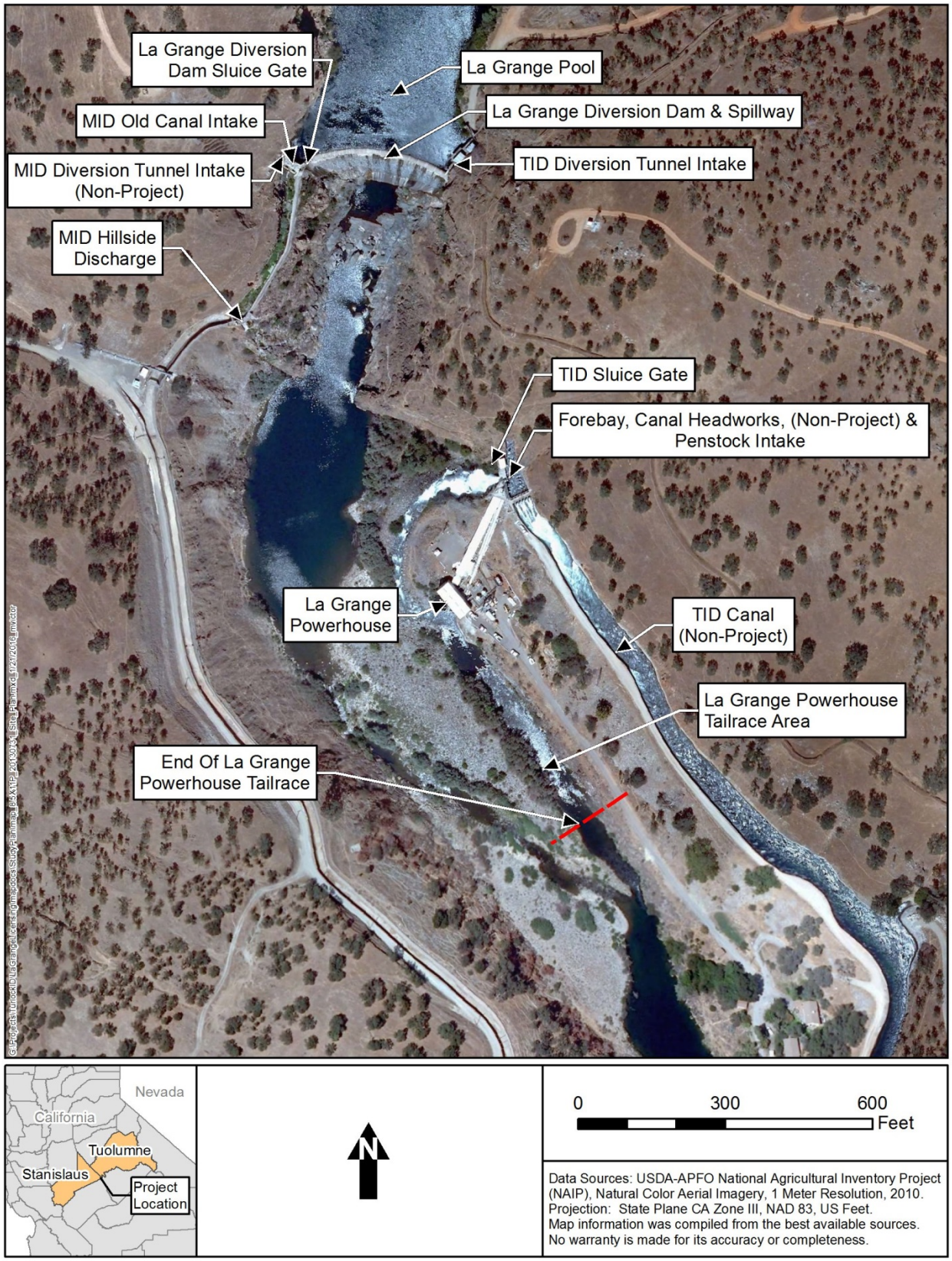

Figure 1.1-2. La Grange Hydroelectric Project site plan.

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

[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.

anticipate the results of this work becoming available for consideration in this licensing proceeding.

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 Topographic Survey, which is one of 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 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.
- Take 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.
- Measure 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 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^{tm} Remote Control Vessel (RCV), a HydroLite-TM^{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, no depths were recorded because the TID sluice gate channel was not inundated by water. 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.

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.

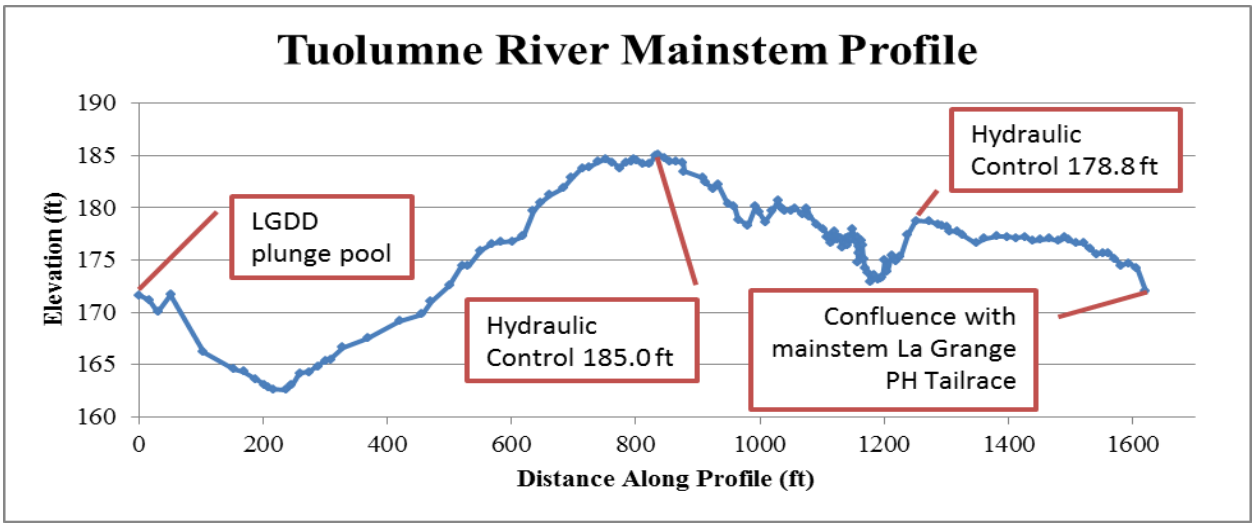

Figure 5.1-1. Longitudinal profile of the Tuolumne River mainstem channel.

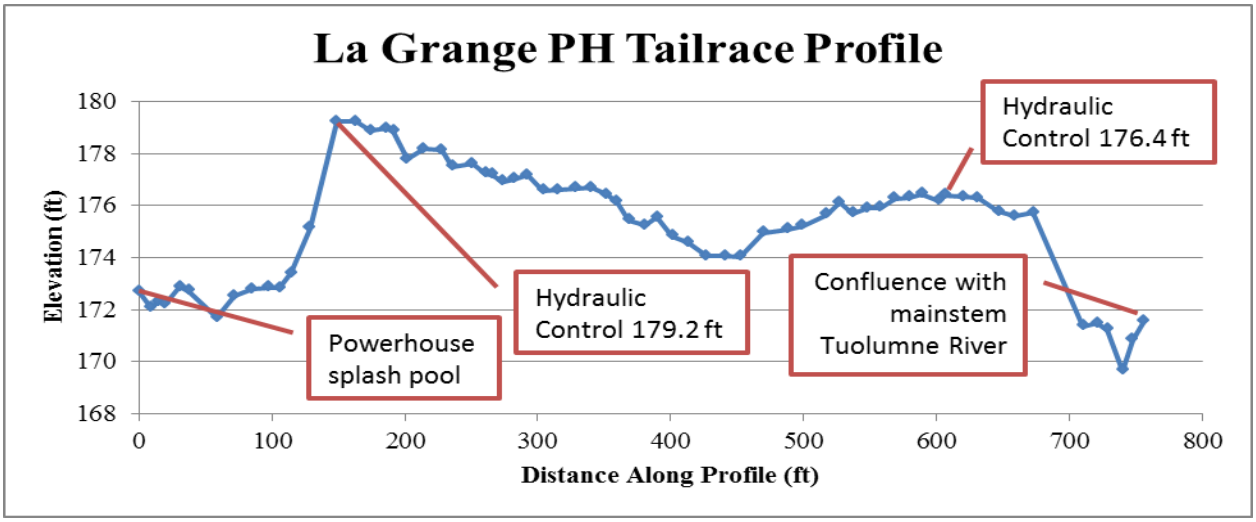

Figure 5.1-2. Longitudinal profile of the La Grange powerhouse tailrace channel.

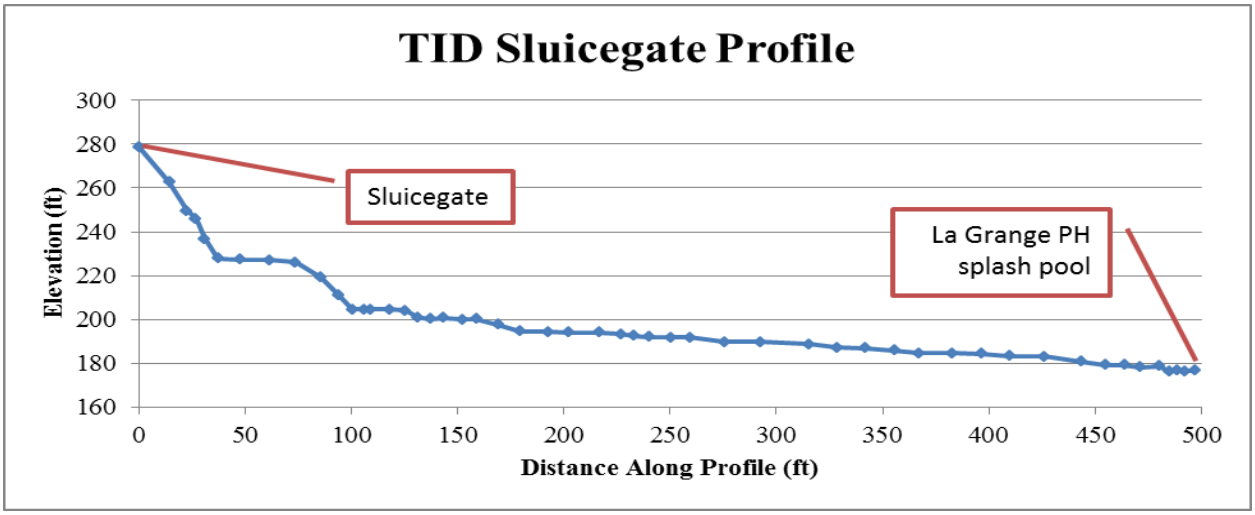

Figure 5.1-3. Longitudinal profile of the TID sluice gate channel.

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

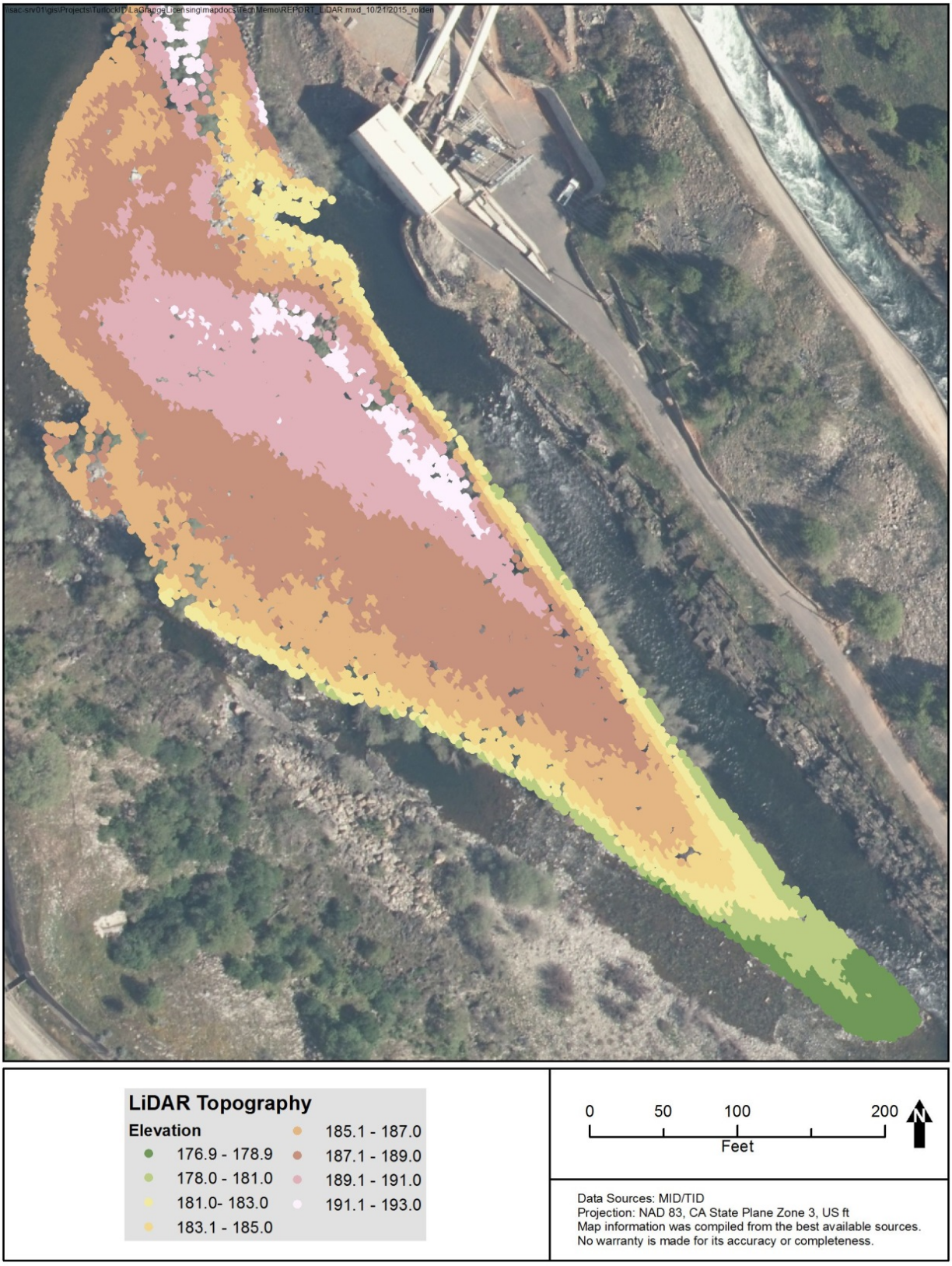

Figure 5.1-5. Mid-channel island LiDAR topography.

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 as the sluice gate was closed and no water was in the channel during the time of the survey. Additionally, existing LiDAR data of the sluice gate channel provided by the Districts was conducted when the TID sluice gate was closed.

Table 5.3-2. Summary of depth measurements 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, there were no flows in the TID sluice gate and thus no depth measurements were taken. The Districts will collect this information in 2016.

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.