Findings Report: Gerle Creek Fish Passage Analyses

Sacramento Municipal Utility District

Hydro License Implementation • April 2017

Upper American River Project

FERC Project No. 2101

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1.0 INTRODUCTION

This *Findings Report: Gerle Creek Fish Passage Analyses* (*Findings Report*) addresses monitoring requirements set forth in the Sacramento Municipal Utility District's (SMUD) *Gerle Creek Fish Passage Plan* (*Plan*) (SMUD 2015). The requirements for this *Plan* are provided in Article 402 of the Federal Energy Regulatory Commission's (FERC) Order Issuing New License for the Upper American River Project (UARP), dated July 23, 2014 (License). State Water Resources Control Board (SWRCB) Condition No. 5, and U.S. Forest Service (USFS) 4(e) Condition No. 34, located in Appendices A and B, of the License, respectively, require SMUD to maintain Gerle Creek Reservoir at a level sufficient to provide fish passage from August through October, but only Article 402 required the *Plan*. The *Plan* was developed in consultation with the USFS, U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Wildlife (CDFW). FERC approved the *Plan* on August 5, 2015.

The *Plan*, to the extent needed, included provisions to modify the stream channel within the Gerle Creek Delta to maintain passage for brown trout. Because the extent of potential impairment of upstream passage of brown trout was unknown when SMUD prepared the *Plan*, the *Plan* details analyses that would yield valuable information SMUD would use to determine the necessity of (1) modifications to reservoir operations, or (2) channel alterations. This *Findings Report* documents the results of the analyses required by the *Plan* and SMUD's determination that neither modifications to reservoir operations nor channel alterations will be necessary to maintain upstream passage for brown trout from Gerle Creek Reservoir into Gerle Creek during the months of August through October.

SMUD owns and operates the UARP, which is licensed by FERC. The UARP (FERC Project No. 2101) is a series of hydropower generation facilities in El Dorado and Sacramento counties, primarily within lands of the Eldorado National Forest. The UARP consists of three major storage reservoirs: Loon Lake, Union Valley, and Ice House (with a combined capacity of approximately 379,000 acre-feet), eight smaller regulating or diversion reservoirs, and eight powerhouses. The UARP also includes recreation facilities containing over 700 campsites, five boat ramps, hiking paths, and bicycle trails at the reservoirs.

2.0 BACKGROUND

As part of the FERC relicensing of the UARP, FERC and the USFS agreed to participate as cooperating agencies in the preparation of the Environmental Impact Statement (EIS). The final EIS (FERC and USFS 2008) notes:

1) Gerle Creek has been identified as an important and unique brown trout fishery by sports anglers who recreate in the Crystal Basin.
2) Brown trout residing in Gerle Creek Reservoir travel upstream into Gerle Creek for their October and November spawning.

3) The confluence of Gerle Creek with Gerle Creek Reservoir is marked by an alluvium delta deposit in the stream channel, which varies in location and depth because of ongoing geomorphic processes.
4) Changes in the size and shape of the Gerle Creek Delta could cause possible passage barriers.

The *Fish Passage Barriers Technical Report* (DTA and Stillwater Sciences 2004), prepared during the relicensing studies, notes that although a passage barrier out of Gerle Creek Reservoir had been reported when reservoir levels are lower than current operating conditions, the reservoir levels maintained under previous license operations prevented exposure of any migration barrier.

Even though there is no documentation of historical barriers blocking passage of brown trout upstream to spawning grounds in Gerle Creek, the FERC-approved *Plan* required SMUD to analyze whether conditions in the new license could present barriers under (1) existing morphologic conditions of the delta, and (2) possible future morphologic conditions of the delta.

3.0 FINDINGS OF GERLE CREEK FISH PASSAGE ANALYSES

The FERC-approved *Plan* describes three analyses SMUD would carry out to more clearly define the potential for depth barriers to impede upstream passage of brown trout from Gerle Creek Reservoir into Gerle Creek from August through October. These analyses include (1) a topographic survey of Gerle Creek over the delta, (2) critical riffle analysis (CRA), and (3) numerical hydraulic analyses. The findings of each of these analyses are provided in the following sections.

3.1 Topographic Survey

On August 21, 2015 SMUD carried out the topographic survey of Gerle Creek through the delta where the creek flows into Gerle Creek Reservoir. Water year (WY) 2015 was a critically dry (CD) water year type as determined by the water year forecast of unimpaired runoff in the American River below Folsom Lake. The minimum streamflow required[1] was 5 cfs, and the USGS gage 11429500, located approximately 0.3-miles downstream of Loon Lake Dam, recorded flow of 5.74 cfs. SMUD's monitoring of pool elevations in Gerle Creek Reservoir show elevations of 5,226.5 feet[2] decreasing to 5,226.4 feet over the duration of the survey. These low-flow conditions facilitated identification of riffles on the delta. In accordance with the approved *Plan*, following the survey, SMUD identified potential critical riffles, shared the findings via a memo (Attachment 1) emailed on September 3, 2015 to the USFS, USFWS, CDFW, and the State Water Resources Control Board (SWRCB) (hereafter collectively referred to as

[1] Minimum streamflows in Gerle Creek below Loon Lake Dam are required by WQC Condition 1.C and USFS 4(e) Condition No. 27.
[2] All elevations in this report reference the National Geodetic Vertical Datum of 1929 (NGVD29).

the resource agencies), and provided the resource agencies an opportunity for a field visit to confirm (1) the critical riffle(s), (2) the survey alignments, and (3) the locations of monuments.

Staff from the USFS, CDFW, and SWRCB participated in a field meeting on the morning of September 9, 2015. As a result of this meeting, summarized in meeting minutes SMUD distributed by email on September 21, 2015 to the resource agencies (Attachment 2), SMUD and the resource agencies reached consensus that the upstream-most potential critical riffle was the most critical riffle and should be the focus of SMUD's study and monitoring. Even though during the meeting this riffle was upstream of the backwater influence of the reservoir pool (i.e., it was freely flowing and a downstream riffle also appeared to be freely-flowing), the group agreed that the observed conditions still appeared likely to allow brown trout to pass upstream. The group also agreed that a critical riffle analysis coupled with measured flow and a surveyed water-surface profile would determine if 5 cfs (the CD minimum streamflow) satisfies the minimum depth criteria for brown trout (see Section 3.2). If the calculations showed the minimum depth criteria were met, this result indicates the possibility that the passage criteria can be satisfied without need for channel modification or minimum pool elevations; if the criteria are not met, it indicates that SMUD will need to plan for more detailed analyses related to potential channel modification and management of reservoir operations.

3.2 Critical Riffle Analysis

As presented in the *Plan*, SMUD used the critical riffle analysis (CRA) to establish passage conditions. CDFG (2015) presents a standard operating procedure (SOP) for CRA to identify flows that support physical movement of salmon and trout through critical riffles; this SOP was applied for the CRA. The CRA SOP focuses on measurements of depth along a riffle's shallowest course from bank to bank. The measurements are compared to the following two depth criteria:

1) At least 10 percent of the entire length of the transect must be contiguous for the minimum depth established for the target fish, and
2) At least 25 percent of the entire transect length must be greater than or equal to the minimum depth established for passage for the target fish.

The flow that provides depth satisfying both criteria is the passage flow for the targeted fish at the critical riffle. Brown trout is the target fish for the Gerle Creek Delta, so according to CDFG (2015) the depth passage criterion is 0.4 feet. This criterion is based on a literature review conducted by R2 Resources (2008), and is intended to provide protective conditions for passage (CDFG 2015).

The SOP requires a minimum of three measurements over a range of discharges that adequately bracket expected passage flows.

3.2.1 CRA Measurement 1

The first CRA measurement was carried out on the afternoon of September 9, 2015, following the field meeting between SMUD and the resource agencies. SMUD's hydrographer measured flow of 5.5 cfs, within two percent of the 5.57 cfs reported at the USGS gage 11429500 located about 8.5 miles upstream. The surveyed water-surface elevation in Gerle Creek Reservoir was 5,226.3 feet, nearly matching the 5,226.4 feet SMUD monitored at the dam. These measurements confirmed the suitability of using the USGS flow and SMUD's reservoir pool elevation for future CRA measurements. As noted in the previous section, the reservoir did not appear to backwater the critical riffle. Figure 1 shows the alignment of the surveyed critical riffle, as well as the locations of the monumented endpoints. Figure 2 and Figure 3 show the monuments. The monuments consist of 2-foot-long, half-inch-diameter steel rebar with a stamped, aluminum cap. The caps are stamped "SMUD LPIN" and "SMUD RPIN", and their coordinates are provided in Table 1. The bank-to-bank views of the critical riffle are provided in Figure 4 and Figure 5.

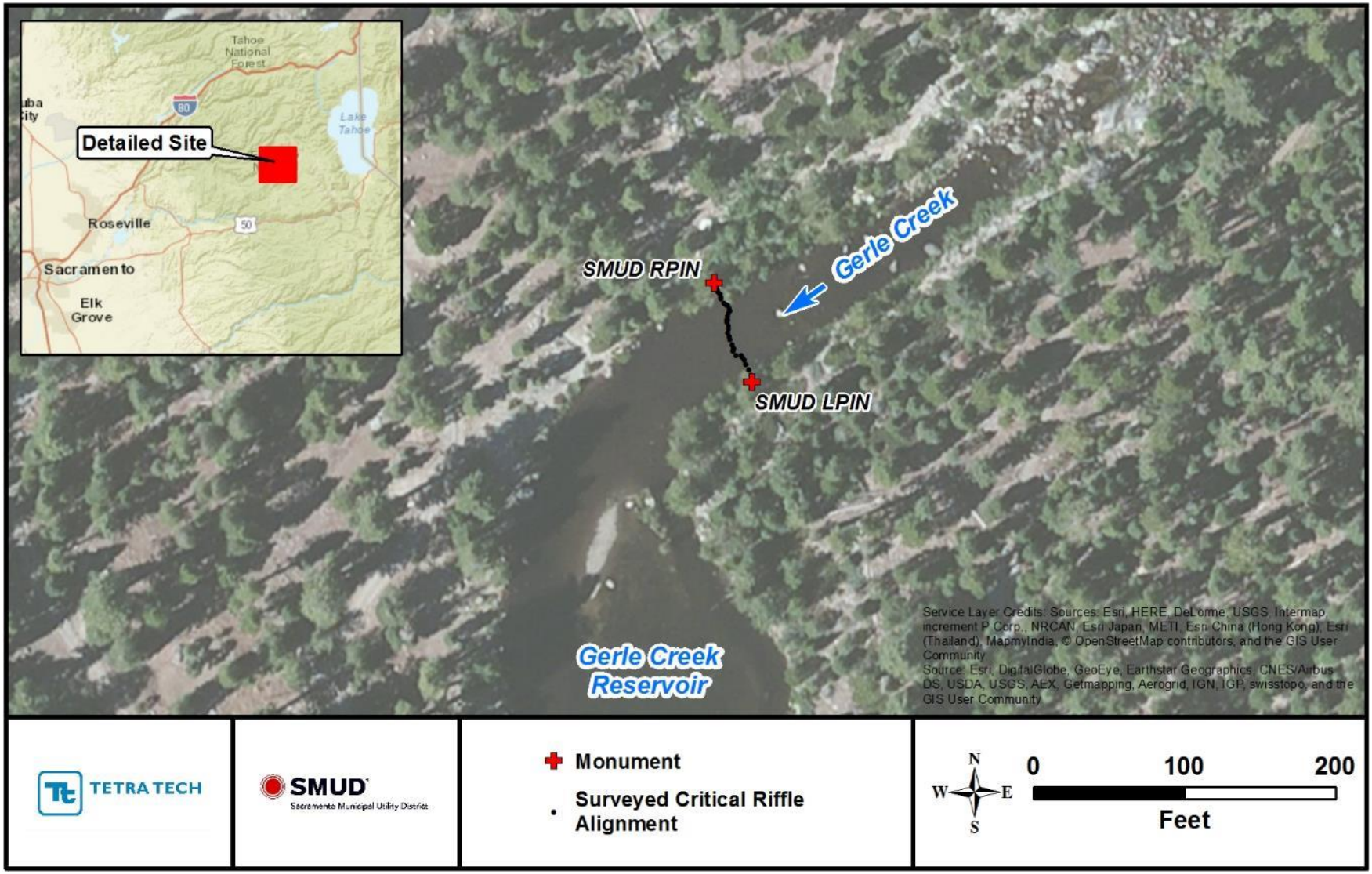

Figure 1. Location and alignment of the critical riffle on the Gerle Creek Delta

Figure 2. SMUD LPIN monument at the critical riffle (pink flagging is directly over LPIN)

Figure 3. SMUD RPIN monument at the critical riffle (pink flagging is affixed below the cap)

Table 1. Coordinates of monumented endpoints for the critical riffle

Monument	Northing (feet)	Easting (feet)	Elevation (feet)
SMUD LPIN	2,120,556.12	7,018,915.42	5,228.51
SMUD RPIN	2,120,621.50	7,018,890.50	5,229.31

Note:
Coordinates reference NAD83, State Plane, California Zone II (FIPS Zone 0402)

Figure 4. **Critical riffle facing the right bank viewed from the LPIN, September 9, 2015**

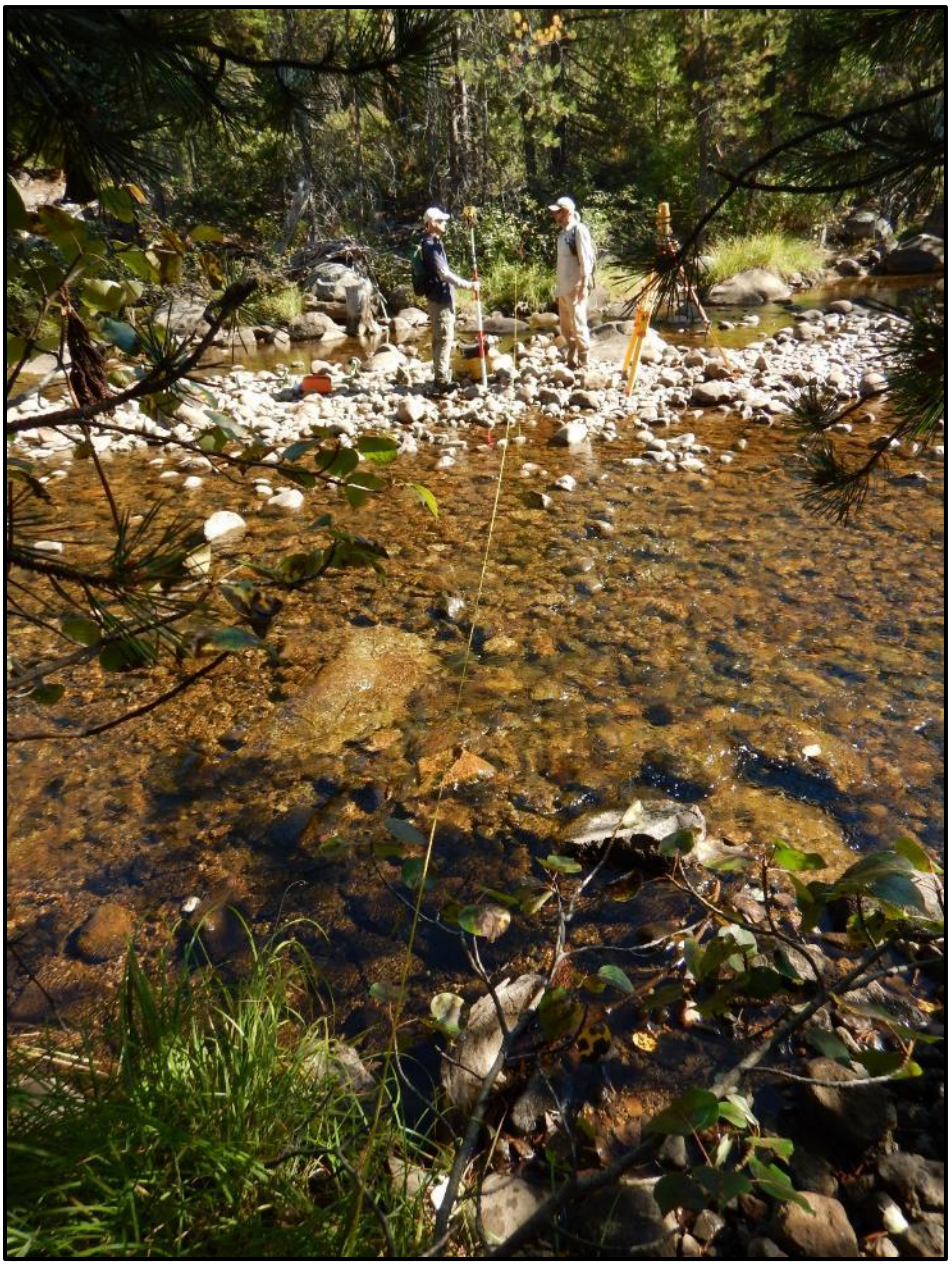

Figure 5. Critical riffle facing the left bank viewed from the RPIN, September 9, 2015

The depth measurements were transferred into CDFW's *CRA for Fish Passage* Microsoft Excel® worksheet to evaluate the two depth criteria (Attachment 3). The contiguous width with depth at least 0.4 feet was 23 percent of the maximum wetted width (based on CRA measurement 3, Section 3.2.3), and the total width with depth at least 0.4 feet was 38 percent of the maximum wetted width. Consistent with the observations made earlier in the day, these conditions were confirmed to provide protective conditions for upstream passage of brown trout. Consequently, the passage flow for this delta morphology is less than 5.5 cfs.

3.2.2 CRA Measurement 2

CRA measurement 2 was attempted on the afternoon of June 24, 2016, during the peak flow of the pulse flow test (described in SMUD 2016). The flow reported at the USGS gage 11429500 located about 8.5 miles upstream was 387 cfs. The water-surface elevation SMUD measured at the Gerle Creek Reservoir Dam was 5,225.9 feet. Flow velocity at the critical riffle was estimated to be 6 to 7 feet per second. Because of these high velocities and the flow depths, the riffle could not be safely waded across. Approximately 20 feet riverward from the RPIN monument, flow depth was measured at about 2 feet. The high velocity created a wave at the upstream side of the stadia rod, so the water-surface fluctuated by a few tenths of a foot. While the measurement could not be safely completed, flow depths were clearly in excess of the 0.4-foot criterion (Figure 6) and the measured depth provided a useful reference for calibrating the hydraulic model.

Figure 6. Critical riffle facing the left bank, June 24, 2016, flow depths of approximately 2 feet

3.2.3 CRA Measurement 3

The third CRA measurement occurred on the morning of August 23, 2016. WY 2016 was an Above Normal water year type so the minimum streamflow in August for Gerle Creek below Loon Lake Dam was 17 cfs. The flow measured at the USGS gage 11429500 was 17.8 cfs. SMUD measured the Gerle Creek Reservoir pool elevation at 5,225.7 feet. The observation of free-flow over a downstream riffle indicated that the reservoir was not backwatering the critical riffle. Figure 7 illustrates conditions as viewed from the LPIN monument toward the right bank; Figure 8 shows the perspective from the RPIN monument toward the left bank.

Figure 7. Critical riffle facing the right bank viewed from the LPIN, August 23, 2016

Figure 8. Critical riffle facing the left bank viewed from the RPIN, August 23, 2016

The depth measurements were transferred into CDFW's *CRA for Fish Passage* Microsoft Excel® worksheet to evaluate the two depth criteria (Attachment 3). The contiguous width with depth at least 0.4 feet was 14 percent of the maximum wetted width, and the total width with depth at least 0.4 feet was 40 percent of the maximum wetted width. As expected based on the results of CRA Measurement 1, the higher flow conditions during CRA Measurement 3 continued to provide protective conditions for upstream passage of brown trout.

It is noteworthy that the contiguous width with depth at least 0.4 feet decreased at 17.8 cfs (14 percent) relative to 5.5 cfs (23 percent). The shallowest course across the riffle varied between the two measurements because of inundation of the mid-channel bar as flow increased from 5.5 cfs to 17.8 cfs, and the natural variability in channel geometry. However, if the straight line distance between the two monuments is used to represent the maximum wetted width (i.e., 70.0 feet), the depth criteria remain satisfied for both CRA measurements.

3.2.4 CRA Summary

As coordinated with the resource agencies, CRA measurement 1 was carried out during the CD water year type minimum streamflow that represents the worst-case condition for upstream passage of brown trout over the critical riffle. Under these conditions the minimum depth criteria were met, indicating the possibility that the passage criteria can be achieved without need for channel modification or changes to reservoir operations (i.e., maintaining minimum pool elevations). However, as described in the *Plan*, the results of the CRA measurements are valid for the morphology of the critical riffle at the time of measurement, but future delta morphology could change through sedimentation or channel degradation. The *Plan* describes how hydraulic analyses would be used to establish how the passage flow should change in the event of appreciable morphologic change of the Gerle Creek Delta.

3.3 Numerical Hydraulic Analyses

The *Plan* specifies (1) that the topographic survey will be the basis for developing a numerical hydraulic model using HEC-RAS software, and (2) that the model will be calibrated using measurements collected during the CRA. The calibration of the model to current conditions was carried out to confirm it can provide the same evaluation of passage criteria as calculated by following CDFG's (2015) CRA SOP. Consequently, the simulated water-surface profiles (and thus flow depths) for changes in delta morphology can be trusted to appropriately analyze passage conditions at the critical riffle.

3.3.1 HEC-RAS Model Development

The HEC-RAS model was developed to simulate existing hydraulic conditions using the summer 2015 topographic survey to quantify required geometric inputs. Cross section geometry was initially only based on surveyed geometry (Figure 9); but to improve model stability and accuracy, the geometry was refined using HEC-RAS to interpolate cross sections between surveyed cross sections. Friction losses were specified using equivalent roughness *k* values instead of Manning's *n* because using *k* values reflects changes in energy loss as a function of stage (USACE 2016). Equivalent roughness is a measure of the linear dimension of roughness elements, but is not necessarily equal to the actual, or even the average, "height" of these elements (USACE 2016). Chow (1959) provides approximate *k* values for a variety of bed materials, including values of 0.1 to 3.0 for natural river bed material. Initially a value of 3.0 was selected under the expectation that the because of the coarse-gravel and cobble dominated bed surface (pebble count results provided in Attachment 4) and the relatively shallow flow depths, energy losses caused by grain roughness would be relatively high.

3.3.2 Boundary Conditions

The HEC-RAS model was used to simulate subcritical, steady-flow conditions, so an upstream flow and a downstream water-surface elevation were selected as boundary conditions. The upstream flows were based on the minimum streamflows for various water year types (WQC Condition 1.C and USFS 4(e) Condition No. 27) for the months of August, September, and October (Table 2). The hourly reservoir pool elevations monitored by SMUD between October 1, 2003 and October 31, 2016 (considering only measurements between August 1 and October 31, inclusive) were used to establish exceedance frequencies (Table 3) and to set the range of water-surface elevations.

Table 2. Minimum streamflow by water year type for Gerle Creek below Loon Lake Dam

	Water Year Type				
	CD	DRY	BN	AN	WET
Month	Minimum streamflow (cfs)				
August	5	10	14	17	20
September	5	10	14	17	20
October	7	11	16	20	23

Note:
CD = critically dry; BN = below normal; AN = above normal

Table 3. Gerle Creek Reservoir pool elevation non-exceedance, August 1 through October 31, based on October 1, 2003 through October 31, 2016 hourly observations

Percent of Time Not Exceeded	Water-surface Elevation (feet)
0.001	5,220.6
1.0	5,221.1
5.0	5,221.5
10.0	5,222.0
25.0	5,224.3
50.0	5,227.1
75.0	5,227.7
90.0	5,228.4
95.0	5,228.8
99.0	5,231.1
99.999	5,232.4

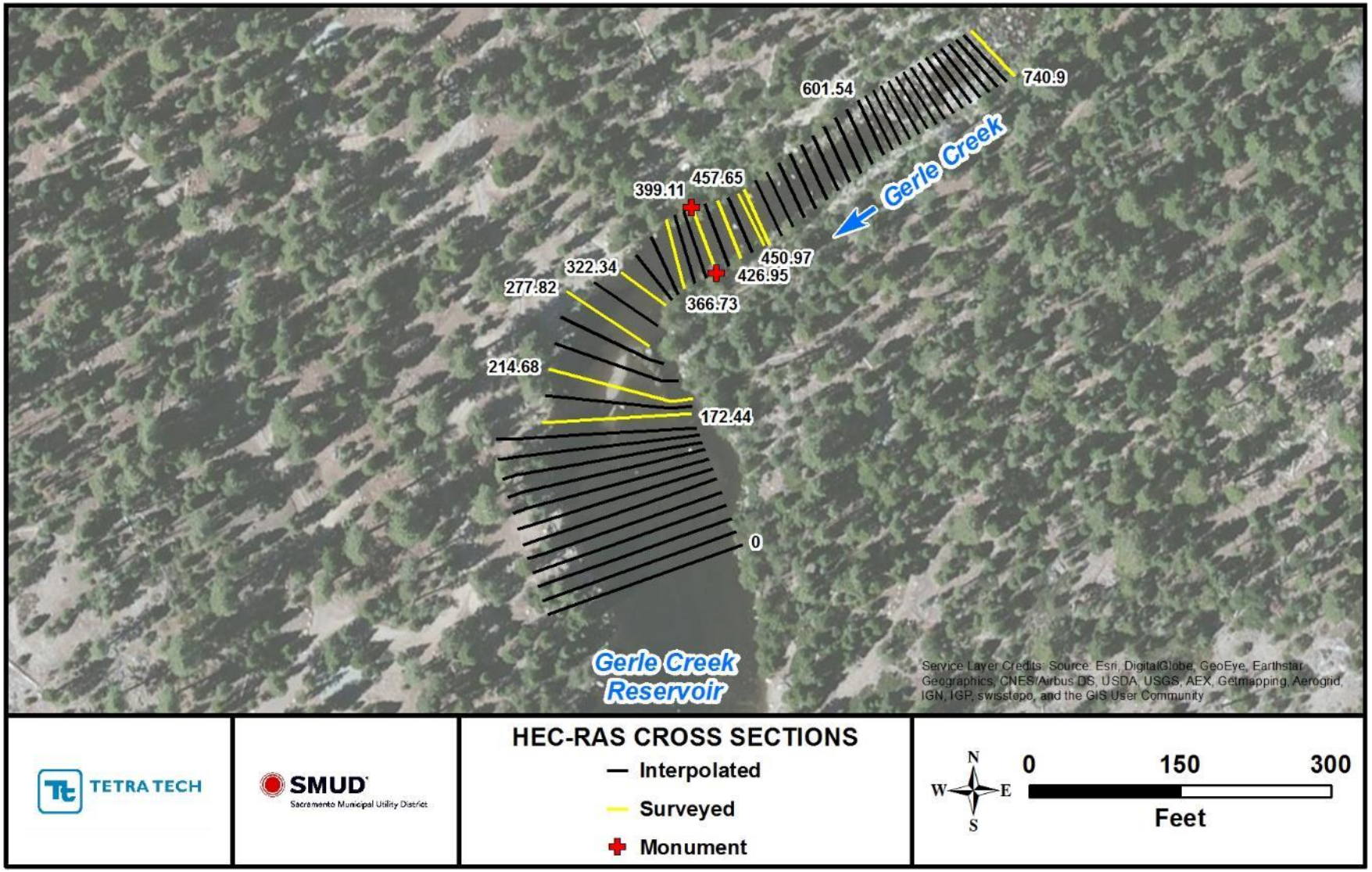

Figure 9. Cross sections delineated for input to the HEC-RAS model

3.3.3 Model Calibration

The focus of the calibration was to adjust the *k* values such that the simulated water-surface elevations at the critical riffle closely aligned with the measured elevations during the CRA measurements. Typically the calibration criterion would consider sources of uncertainty in the surveys and allowable error tolerance in the results; however, in this case, given the 0.4 foot depth criterion for brown trout passage, it was judged that a typical approach would allow for too much error. Instead, a narrower tolerance of 0.1 feet was set.

The initially-selected *k* values of 3.0 for the channel from section 601.54 through section 0 worked well, although the *k* values upstream of 601.54 were increased to 3.5. The reach upstream of 601.54 does not influence hydraulics at the critical riffle, so this adjustment to the *k* value was made based on observations of coarser bed material and more form roughness (i.e., steps and turbulence); the calibration focused on the reach from about 457.65 to 322.34. All overbank values were set to 4. The results of the calibration are provided in Table 4.

Table 4. HEC-RAS model calibration results at the critical riffle (ID 399.11)

CRA Measurement	Flow (cfs)	Surveyed Water-Surface Elevation (feet)	Simulated Water-Surface Elevation (feet)	Model Bias (feet)
1	5.5	5,226.55	5,226.59	0.04
3	17.8	5,226.81	5,226.75	-0.06

As shown in Table 4, the selected *k* values allow for successful calibration of the simulated water-surface elevations. Further, CRA measurement 2 established a depth of approximately 1.8 to 2.2 feet about 20 feet riverward of the RPIN monument. Simulated depths 15 to 25 feet riverward of the RPIN range from about 1.7 to 2.3 feet. While the accuracy of model cannot be deterministically evaluated using this measurement, the overlap between the measured depths and the simulated depths confirm that the selected *k* values are appropriate not just at the lowest flows, but across the full range of August through October minimum streamflows.

3.3.4 Model Simulations

As specified in the FERC-approved *Plan* the calibrated hydraulic model was used to evaluate how changes in delta morphology affect the passage conditions. The *Plan* specifies changes in delta morphology as average topset aggradation of 0.5, 1.0, 1.5, and 2.0 feet and average topset degradation of 0.5 and 1.0 feet. The delta is formed of deposited alluvium, so the morphology of the delta is governed by the sediment load and gradation and the reservoir pool elevations. The topset is the top surface of the delta and it is composed of coarser sediment that easily settles out of the flow. The foreset is the surface at the face of the delta advancing into the reservoir, and the foreset slope is typically steeper than the topset slope. The topset slope can be

calculated as a function of channel geometry and topset sediment gradation (USBR 1987); because these parameters are not expected to change appreciably in the future at the Gerle Creek Delta, it is logical to expect the topset slope remains similar to the current slope, even if the elevation of the topset changes in the future.

The morphologic changes to the delta were modeled by using HEC-RAS to apply a datum shift to each cross-section from the upstream head of the riffle reach (cross section ID 457.56) to the downstream boundary of the model. The datum shift tool in HEC-RAS applies a constant elevation adjustment to every station-elevation pair in the specified cross-section. In this way, the topset and foreset slopes of the delta were unchanged, and the channel hydraulics at the critical riffle could be evaluated for the effects of aggradation or degradation. Thalweg elevations for each of the modeled conditions are shown in Figure 10. Each morphology was used to simulate the range of flows presented in Table 2 and the range of pool elevations shown in Table 3.

Because the average topset slope does not change in any of the modeled simulations, and because the existing hydraulic conditions do not impede upstream passage of brown trout through the critical riffle, it was expected that the hydraulic conditions simulated for the varying aggradation and degradation would also maintain protective conditions for upstream passage of brown trout. The results also confirmed that it is unnecessary to consider the need to implement a passage pool elevation.

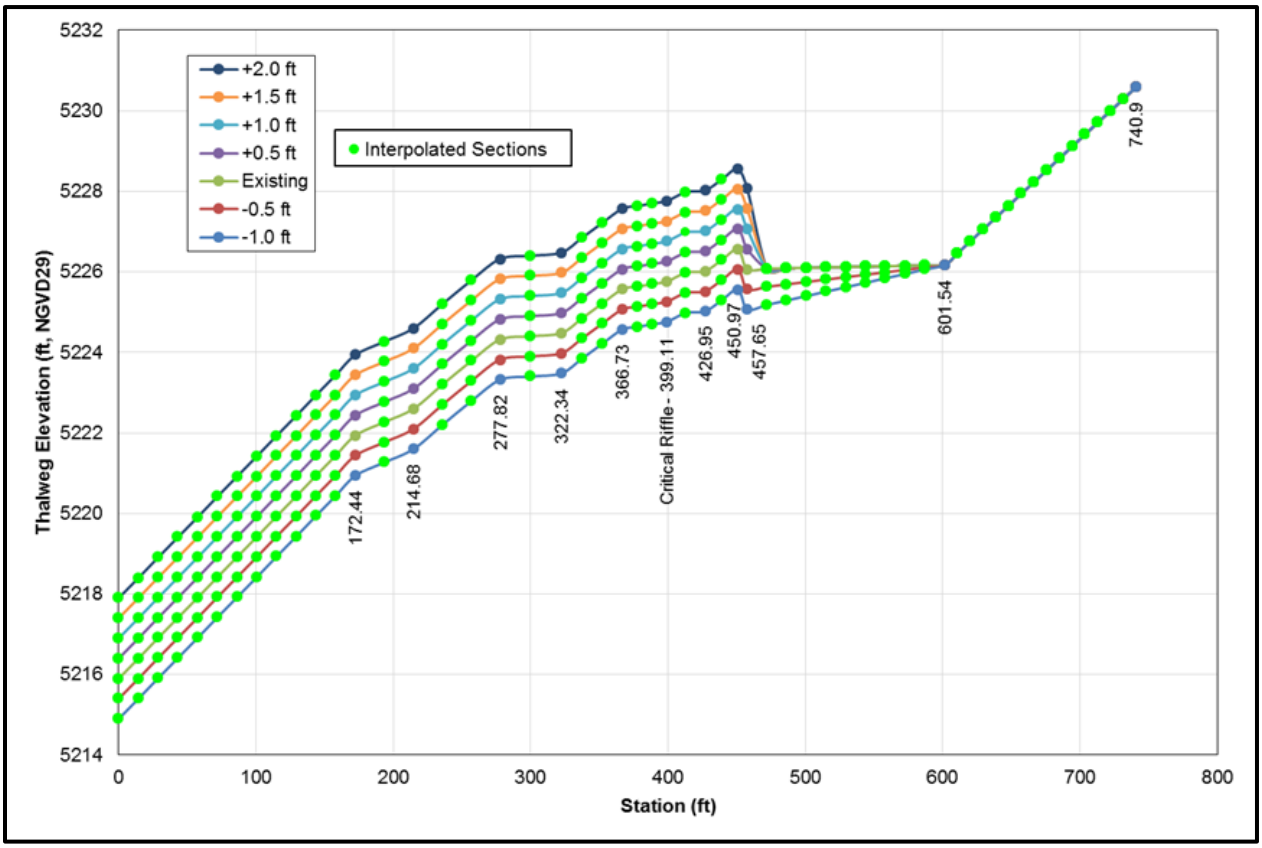

Figure 10. Comparison of channel thalweg profiles for simulated aggradation and degradation

3.3.5 Numerical Hydraulic Analysis Summary

The results of the model simulations (1) confirm the reliability of the HEC-RAS model for simulating passage conditions under existing conditions, and (2) provide a sound basis for evaluating passage conditions under potential future delta morphologic conditions. As established by the CRA, under existing conditions the passage flow is less than 5 cfs, so even under the worst-case conditions of minimum streamflows in a CD water year type, the current delta morphology maintains protective conditions for upstream passage of brown trout. The numerical hydraulic analyses confirmed these protective conditions are maintained for average topset aggradation of up to 2 feet and for average topset degradation of up to 1 foot. Should sedimentation or channel degradation occur, initiated by changes under the new license to hydrology and sediment supplies, the results of the numerical hydraulic analysis show no conditions that will impede upstream passage of brown trout out of Gerle Creek Reservoir into Gerle Creek from August through October.

4.0 NOMOGRAPH

The *Plan* includes development of a nomograph to show how the passage flow and passage pool elevation would need to change to maintain the passage criteria for the evaluated geomorphic change. The results of the CRA and numerical hydraulic analyses show that the passage flow under both existing conditions and the evaluated geomorphic change is less than the minimum streamflow of 5 cfs during a CD water year type. Thus, there is no passage flow or passage pool elevation needed to maintain protective conditions for upstream passage of brown trout. Consequently, there is no basis for developing a nomograph, and no need to have or use the nomograph.

5.0 RESERVOIR OPERATION PLAN

The *Plan* includes development of a reservoir operation plan if the results of the analyses determine passage pool elevations are required. Since passage pool elevations are not required, there is no need to develop a reservoir operation plan.

6.0 PROVISIONS TO MODIFY GERLE CREEK DELTA

Article 402 of the license, and the *Plan*, require, to the extent needed, provisions to modify the stream channel within the Gerle Creek Delta to maintain passage for brown trout. The results of the analyses documented in this *Findings Report* demonstrate that there is no need for such provisions.

7.0 LITERATURE CITED

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Attachment 1: Identification of possible critical riffles on the Gerle Creek Delta Memo SMUD transmitted by email on September 3, 2015 to the resource agencies

Identification of Possible Critical Riffles on the Gerle Creek Delta

The *Gerle Creek Fish Passage Plan* (*Plan*) (SMUD 2015) was approved by the Federal Energy Regulatory Commission (FERC) on August 5, 2015. The Plan requires SMUD in the summer of 2015 to survey the delta where Gerle Creek flows into Gerle Creek Reservoir. A primary purpose of the survey, as stated in the *Plan*, is to identify critical riffle(s), and inform the State Water Resources Control Board (SWRCB), U.S. Forest Service (USFS), California Department of Fish and Wildlife (CDFW), and the U.S. Fish and Wildlife Service (USFWS) (hereafter collectively referred to as resource agencies) of the identified critical riffle(s) and provide an opportunity for a field visit to confirm the critical riffle(s), the survey alignments, and the locations of the monuments.

SMUD contracted Tetra Tech, Inc. to survey the delta morphology, and the survey was carried out on August 21, 2015. Flows in Gerle Creek were approximately 5 cfs as recorded at the USGS gaging station near Loon Lake Dam. The pool elevation in Gerle Creek Reservoir was approximately 5,226.3 feet (all elevations are referenced to the National Geodetic Vertical Datum of 1929, NGVD29). As part of the survey, Tetra Tech photographed the delta and a few-hundred feet of Gerle Creek upstream of the delta. Based on the survey and site observations, four possible critical riffles (PCR) were identified, along with two human-placed rock (HPR) features that could affect upstream passage of brown trout from Gerle Creek Reservoir into Gerle Creek. SMUD has coordinated with the resource agencies to identify Wednesday September 9, 2015 as the time for a site visit, should the resource agencies determine the need for the visit.

Figure 1 identifies the locations of the four PCR and both HPR features. This figure also shows the extents of different reservoir pool elevations (assuming no flow in Gerle Creek) corresponding to various exceedance percentages. The exceedance percentages are based on SMUD's hourly measurements monitored in the months of August through October (inclusive) between October 1, 2003 and October 31, 2014. Subsequent figures show (1) the location of these features along the channel bed profile, (2) photographs of the PCR and HPR features, and (3) the surveyed cross section geometry near each feature.

Preliminary Interpretation

A key finding during the survey was the presence of HPR features spanning the channel. These features are not formed by fluvial processes, and their presence was not considered during the development of the Plan. Another key finding was the presence of the boulder clusters, located about 200 feet and 300 feet upstream of the HPR2 feature. The boulder clusters were observed to concentrate low flows in steep and narrow chutes that may affect upstream passage of brown trout that successfully pass the delta.

SMUD's monitoring of average daily pool elevations in Gerle Creek Reservoir show that pool elevations can drop below 5,221 feet (which is exceeded 99 percent of the August through October period), but that this has occurred only 4 times over the 11-year-monitoring-period for a median duration of 1.5 days (maximum duration of 3 days). Thus, while such low pool elevations could expose riffles that may affect upstream passage of brown trout, the exposure is of such short duration that these episodic incidents will not impact overall spawning success. Pool elevations have dropped below 5,225.5 feet

(which is exceeded 90 percent of the August through October period) 11 times over the 11-year-monitoring-period for a median duration of 9 days (maximum duration of 35 days). Therefore, riffles that may not support sufficient flow depths for brown trout passage under these pool elevations were considered as candidates for critical riffles. The downstream extent of the topographic survey was estimated to ensure the candidate riffles were included.

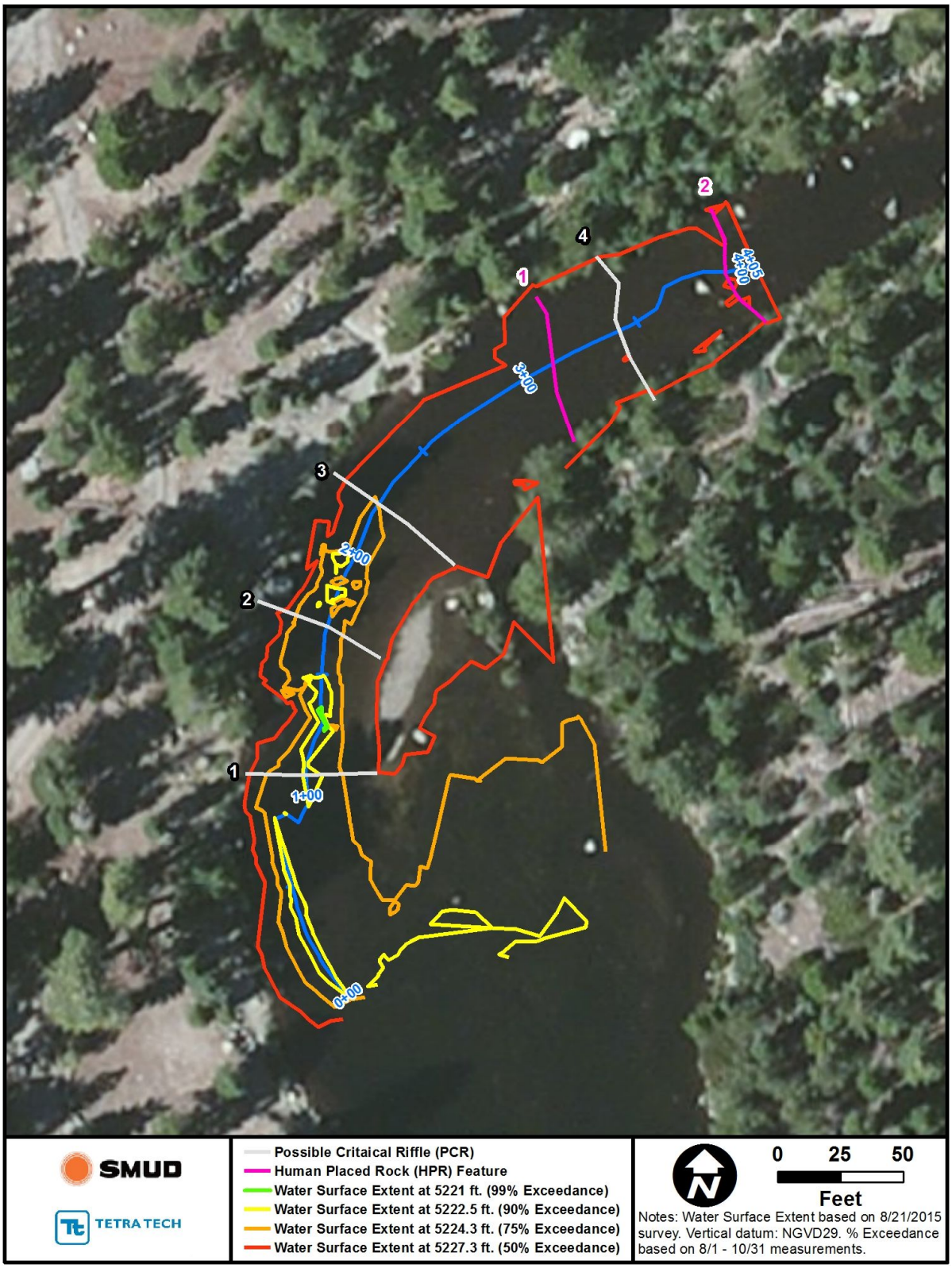

Figure 1. PCR and HPR features on the Gerle Creek delta, and water surface extents.

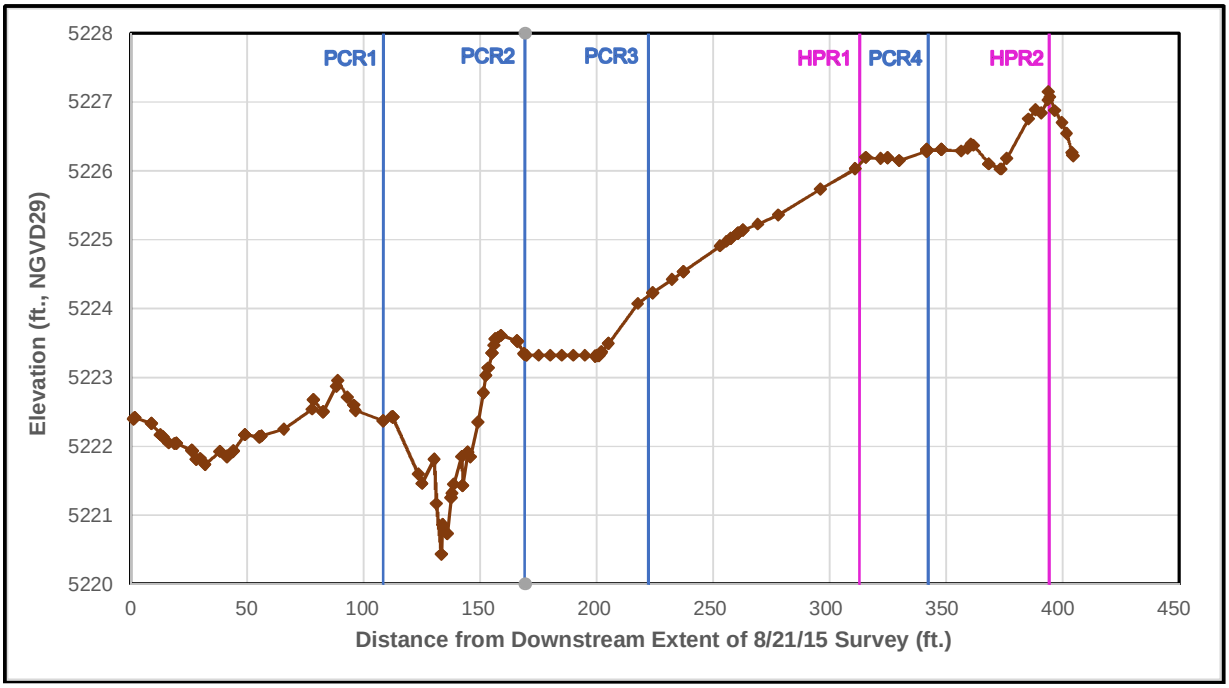

Figure 2. Longitudinal bed profile of Gerle Creek through the Gerle Creek delta.

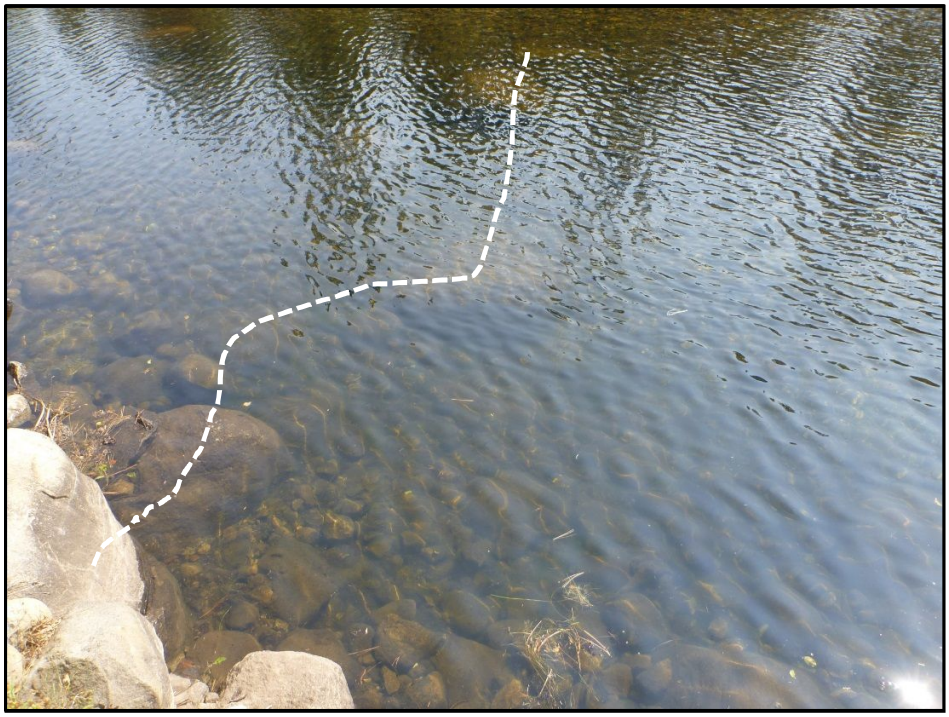

Figure 3. **PCR1 as observed from the right bank facing upstream (approximate alignment shown by dashed white line).**

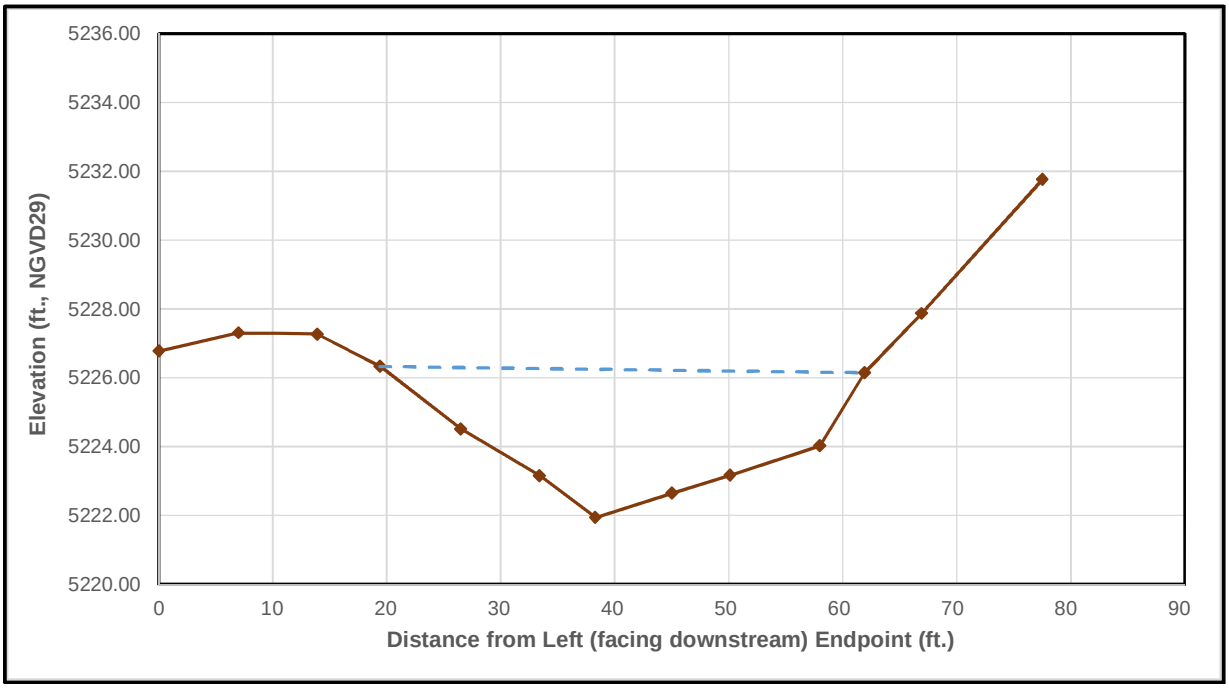

Figure 4. **Surveyed cross section geometry near PCR1 (as viewed facing downstream).**

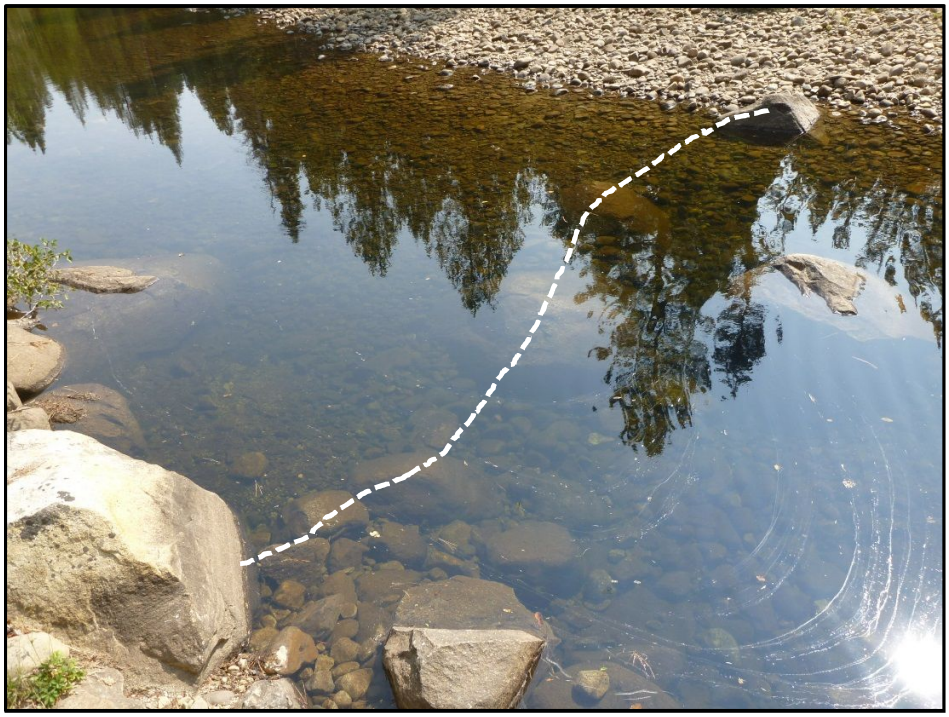

Figure 5. **PCR2 as observed from the right bank facing upstream approximate alignment shown by dashed white line).**

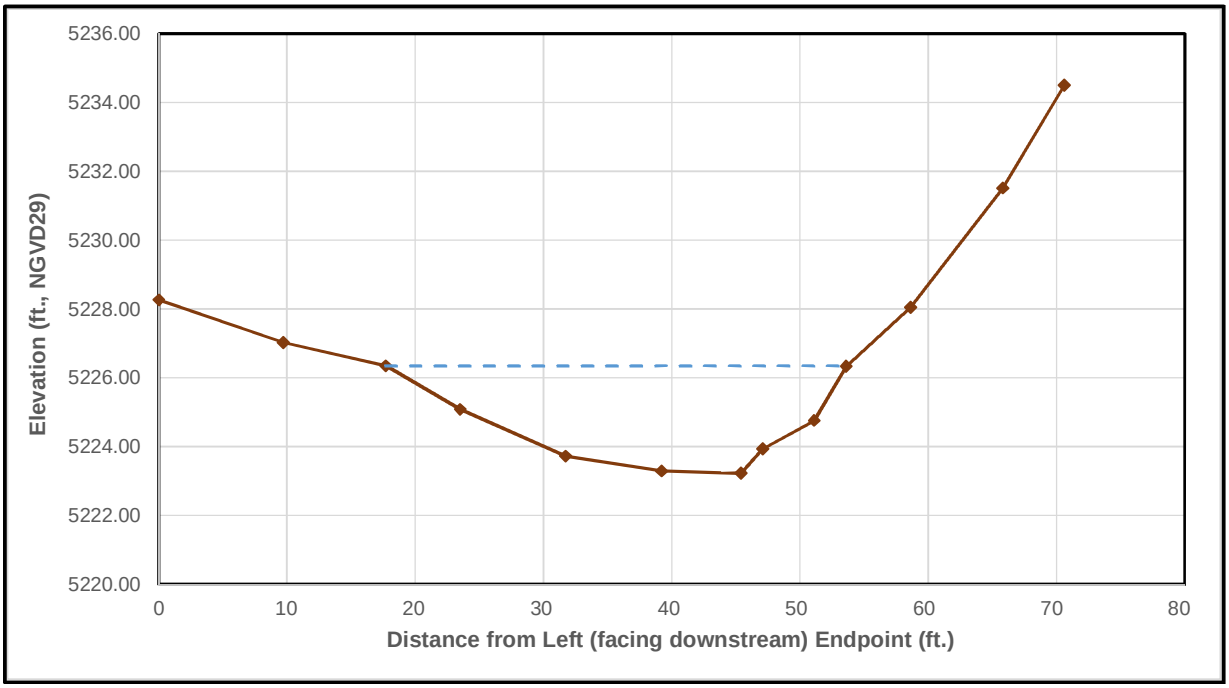

Figure 6. **Surveyed cross section geometry near PCR2 (as viewed facing downstream).**

Figure 7. **PCR3 as observed from the right bank facing upstream (approximate alignment shown by dashed white line).**

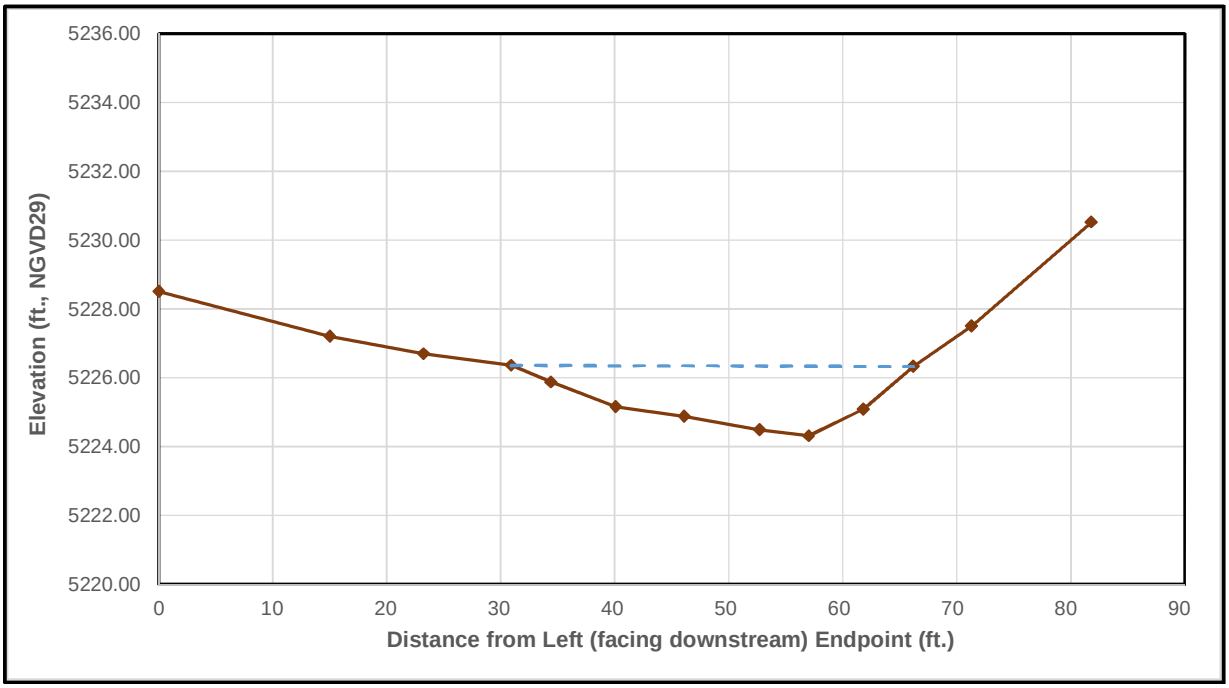

Figure 8. **Surveyed cross section geometry near PCR3 (as viewed facing downstream).**

Figure 9. **HPR1 as observed from the right bank facing downstream (approximate alignment shown by dashed white line).**

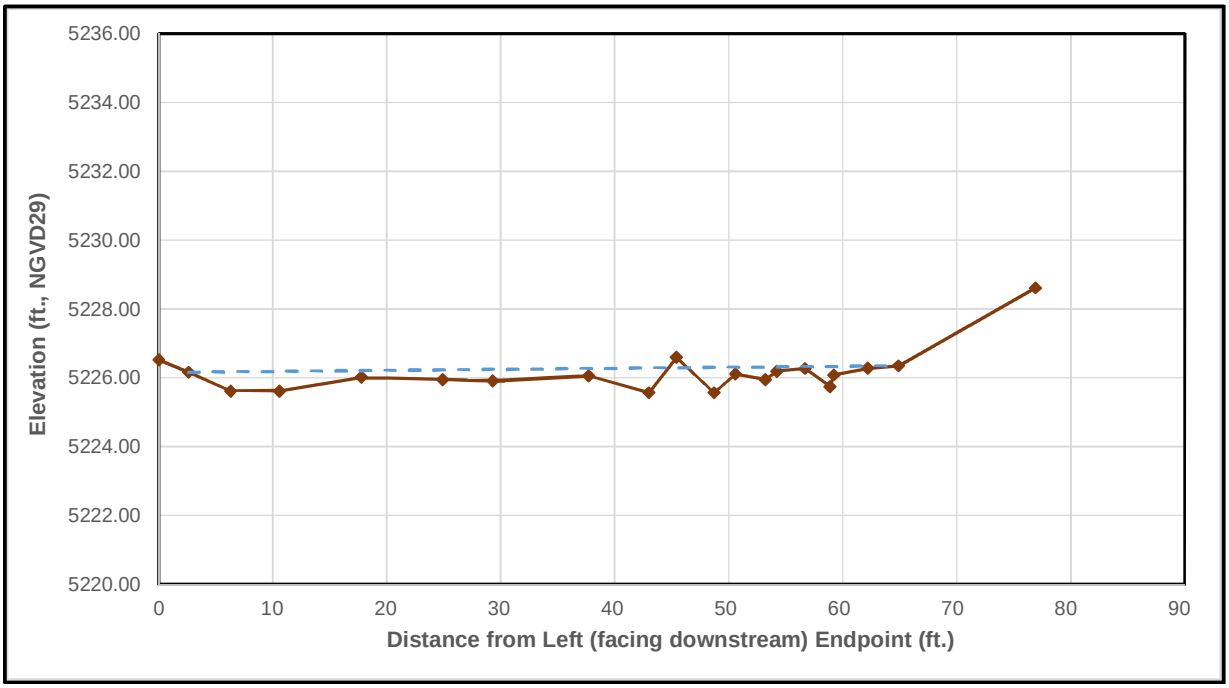

Figure 10. **Surveyed cross section geometry near HPR1 (as viewed facing downstream).**

Figure 11. **PCR4 as observed from the left bank facing across the channel.**

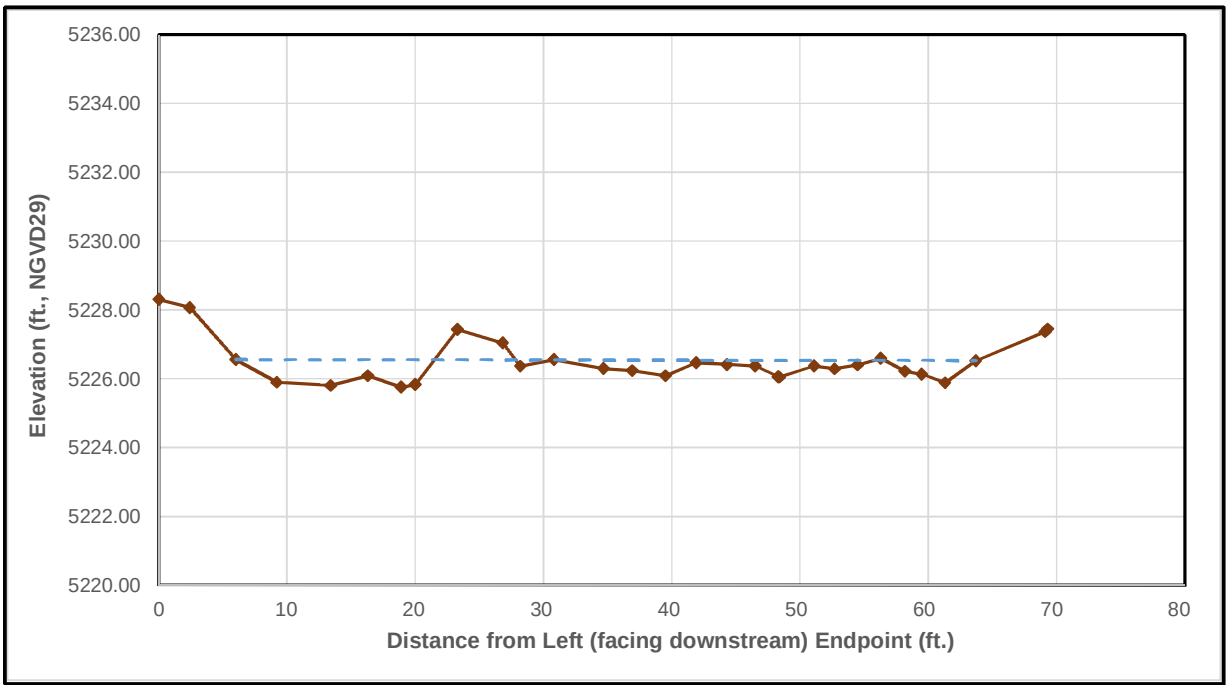

Figure 12. **Surveyed cross section geometry near PCR4 (as viewed facing downstream).**

Figure 13. **HPR2 as observed from the left bank facing across the channel.**

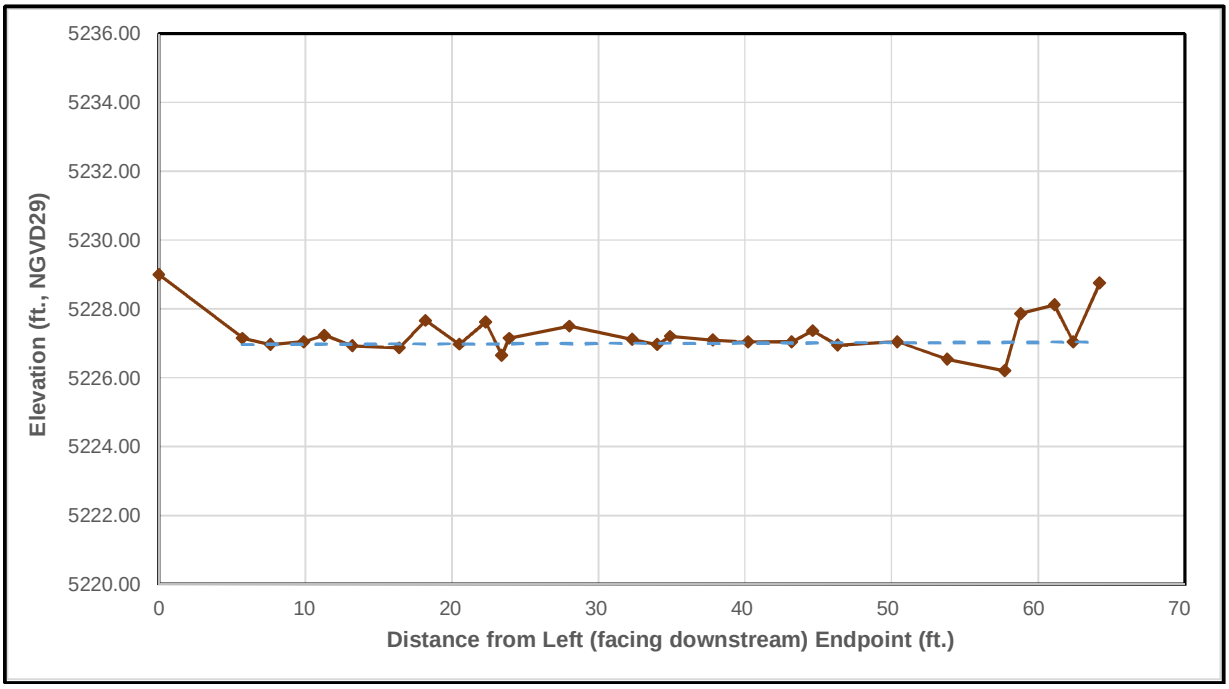

Figure 14. **Surveyed cross section geometry near HPR2 (as viewed facing downstream).**

Attachment 2: Meeting minutes for September 9, 2015 field discussion of possible critical riffles at the Gerle Creek Delta SMUD transmitted by email on September 21, 2015 to the resource agencies

On September 9, 2015, representatives from SMUD, SWRCB, USFS, and CDFW participated in a field meeting at the delta where Gerle Creek enters Gerle Creek Reservoir. The purpose of the meeting was to discuss the application of CDFW's Critical Riffle Analysis (CRA) SOP to the brown trout that migrate from the reservoir upstream into Gerle Creek to spawn. The participants are shown in **Table 1**.

Table 1. September 9, 2015 Meeting Participants

Agency	Representatives
SMUD	Darold Perry, Tyler Belarde
Tetra Tech (SMUD Contractor)	Mike Harvey, David Pizzi, Mike Brown
SWRCB	Mike Maher
USFS	Kim Morales
CDFW	Beth Lawson

The meeting began by reviewing the possible critical riffles identified during the topographic survey carried out by Tetra Tech on August 21, 2015. The four possible critical riffles and two human-placed rock (HPR) features were mapped and the resulting figure, including surveyed cross sections and preliminary interpretations, was distributed via email to participants a few days prior to the meeting.

The group was unsure how to handle the HPR features (**Figure 1**), particularly since the CRA SOP doesn't specifically address such features. Beth Lawson offered to follow-up with the downtown CDFW office to determine if and how others may have previously dealt with such features. In the meantime, the group reached consensus that the upstream-most possible critical riffle was the most critical riffle and should be the focus of SMUD's study and monitoring (**Figure 2**). The flow passing this location during the meeting was approximately 5.5 cfs, although the flow through the riffle was divided between two separate channels (**Figure 3** and **Figure 4**). Depth measurements made using a survey rod indicated that the flow in the right (facing downstream) channel – the larger of the two channels through the critical riffle – was unlikely to provide sufficient depth to meet the two CRA SOP depth-distribution criteria for upstream passage of brown trout. Even though the riffle was upstream of the backwater influence of the reservoir pool (i.e., it was freely flowing and a downstream riffle also appeared to be freely flowing), the group agreed that the observed conditions appeared likely to allow brown trout to pass upstream. In response, Beth Lawson offered to investigate whether CDFW has previously allowed flexibility in the criteria presented in the SOP (the required percentages of contiguous and total width meeting the minimum depth criteria) or application of the SOP (determination of the appropriate width in a divided channel, whether the entire wetted width or only one of the channels).

The group agreed that the upstream-most HPR feature affected flow through the critical riffle, so its presence would impact depths measured following the CRA SOP. To assist SMUD's planning, the group agreed that an initial measurement could be collected along with measured flow and a surveyed water-surface profile to determine if 5 cfs (the

Critically Dry water-year type minimum instream flow) satisfies the minimum depth criteria for brown trout. The measurements will be used to calibrate slope-area calculations using the surveyed geometry and Manning's equation. If the calculations show the minimum depth criteria are met, it will indicate the possibility that the passage criteria can be satisfied without need for channel modification or minimum pool elevations; if the criteria are not met, it will indicate that SMUD will need to plan for more detailed analyses related to potential channel modification and management of reservoir operations.

Follow-up Actions:

- Beth Lawson and Kim Morales will check with their respective agencies whether HPR features have been encountered in previous CRA, and share their findings with SMUD.
- Beth Lawson will follow up with downtown CDFW office regarding potential for flexibility in the depth passage criteria for brown trout, and the application of the CRA SOP to a critical riffle with divided flow. As part of this inquiry, she will ask about the importance of repeating future CRA measurements along the exact same critical riffle alignment, particularly if the morphology of the riffle changes. Beth will share her findings with SMUD.

Figure 1. **Upstream-most HPR feature on the Gerle Creek delta, as seen from the right bank.**

Figure 2. **Upstream-facing view of most critical riffle identified on the Gerle Creek delta. Critical section is approximately at the feet of the people in the upper right corner. The HPR feature in Figure 1 is between the two groups of people.**

Figure 3. **Upstream-facing view of flow (about 5.5 cfs) in two separate channels across the critical riffle (flow divided by the gravel- and cobble-dominated bar where the people are standing).**

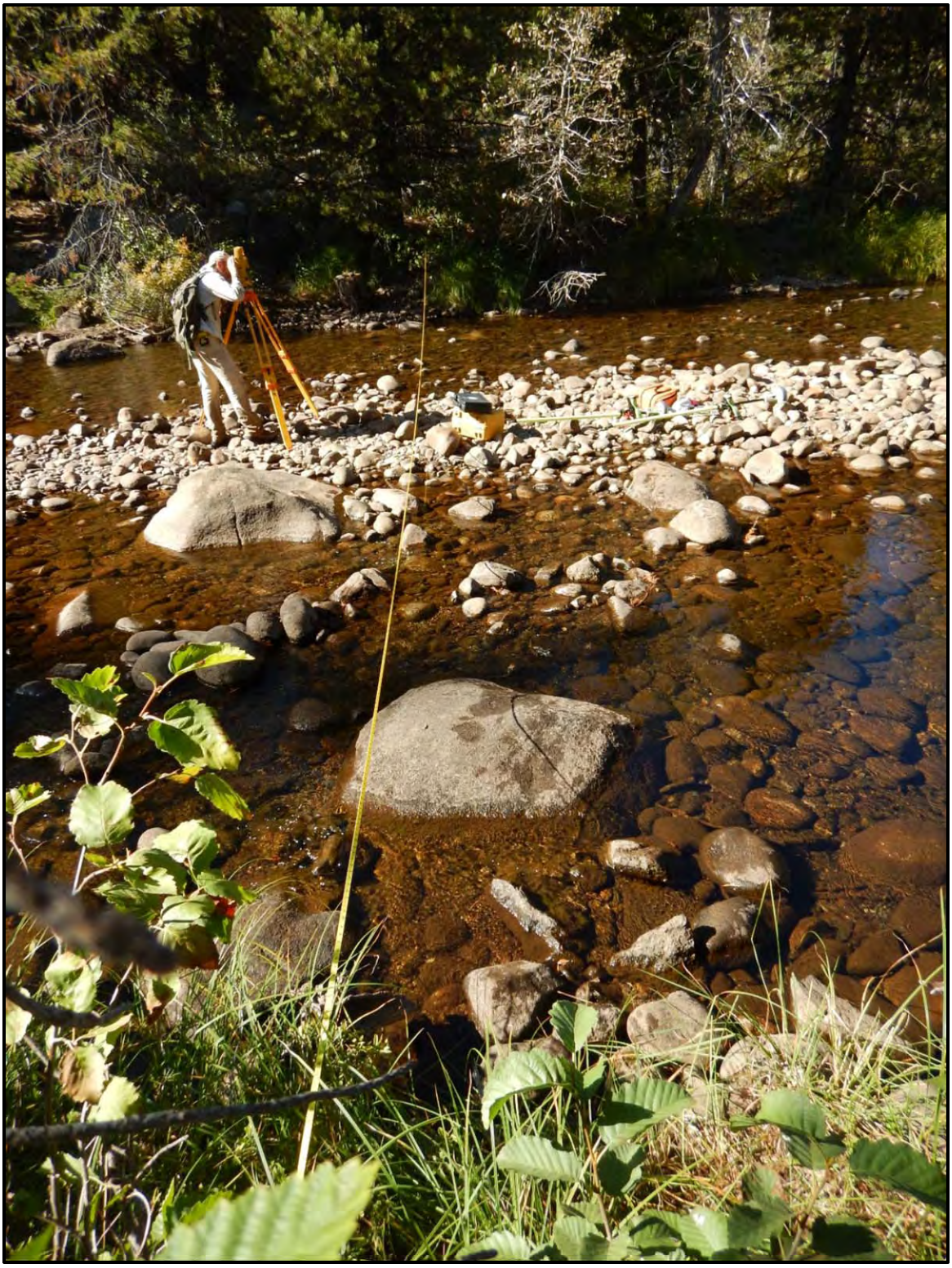

Figure 4. **View facing the right bank across the separate channels at the approximate alignment of the critical riffle (the stretched tape marks the location, but not the shallowest course defining the critical riffle).**

Attachment 3: CDFG critical riffle analysis passage forms

Critical Riffle Analysis for Fish Passage in California
Standard Operating Procedure DFG-IFP-001

Location: Gerle Creek
Site Name: Gerle Creek Delta
Riffle Name: Critical Riffle
Site Description: Critical Riffle Alignment
GPS Coordinates: N: 2,120,590 ft, E: 7,018,900 ft
Event No. (1-6) and targeted flow: 5.5 cfs, 5226.3 ft pool elevation
Critical Riffle Total Width hp to tp (ft): 70.0
Reference Discharge (cfs): 5.57 cfs USGS Loon Lake
Meter number:
Notes: Elevations to NGVD29 (ft.)

Date: Geometry.: 9/9/15, Flow: 9/10/15
Field Staff: MB, DP, MDH; TB (SMUD, flow)
Data Entry Staff: DP
Photo File Name: See fieldbook
Staff Gage Start: n/a End: n/a
Time Start: 13:00 Time Stop: 19:00
LBWE: 0.0 RBWE: 59.7

	Target Species 1		Target Species 2		Target Species 3	
Target Species Depth Criteria (ft):	0.4					
Species/Lifestyle Code:	Trout					
	Total	**Cont.**	**Total**	**Cont.**	**Total**	**Cont.**
% Usable:	**37.6%**	**23.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Station	Distance	Depth*	Width	Cell Width Meeting Criteria					
				Total	Cont.	Total	Cont.	Total	Cont.
1	0.0	0.00	1.95						
2	3.9	0.74	4.05	4.1	4.1				
3	8.1	0.83	3.55	3.6	3.6				
4	11.0	0.55	2.75	2.8	2.8				
5	13.6	0.88	1.85	1.9	1.9				
6	14.7	0.80	2.20	2.2	2.2				
7	18.0	*OW	3.40						
8	21.5	*OW	2.45						
9	22.9	0.27	0.70						
10	22.9	0.00	0.00						
11									
12									
13	31.6	0.00	0.00						
14	31.6	0.33	1.30						
15	34.2	0.48	2.50	2.5	2.5				
16	36.6	0.10	2.40						
17	39.0	0.15	2.30						
18	41.2	0.19	2.00						
19	43.0	0.50	0.95	0.9	0.9				
20	43.1	0.52	1.40	1.4	1.4				
21	45.8	0.19	2.15						
22	47.4	0.28	1.70						
23	49.2	0.17	1.80						
24	51.0	*OW	1.85						
25	52.9	0.35	1.60						
26	54.2	0.43	1.55	1.6	1.6				
27	56.0	0.68	2.75	2.8	2.8				
28	59.7	0.00	1.85						
29									
30									

Must manually select "COUNT" range for continuous cells

Wetted Width this Event:	51.0 (ft)	Width:	23.6	14.4	0.0	0.0	0.0	0.0
Maximum Transect Length**:	**62.6** (ft)	Percent:	38%	23%	0%	0%	0%	0%

*OW = Out of Water
**Must set "Maximum Transect Length" to the largest length of all measured discharges.

Critical Riffle Analysis for Fish Passage in California
Standard Operating Procedure DFG-IFP-001

Location: Gerle Creek
Site Name: Gerle Creek Delta
Riffle Name: Critical Riffle
Site Description: Critical Riffle Alignment
GPS Coordinates: N: 2,120,590 ft, E: 7,018,900 ft
Event No. (1-6) and targeted flow: 17.8 cfs, 5225.7 ft pool elevation
Critical Riffle Total Width hp to tp (ft): 70.0
Reference Discharge (cfs): USGS Gage below Loon Lake
Meter number:
Notes: Elevations to NGVD29 (ft.)

Date: 8/23/2016
Field Staff: SMUD
Data Entry Staff: DP
Photo File Name: See fieldbook
Staff Gage Start: n/a End: n/a
Time Start: ~10:00 Time Stop: ~12:00
LBWE: 0.0 RBWE: 62.6

	Target Species 1		Target Species 2		Target Species 3	
Target Species Depth Criteria (ft):	0.4					
Species/Lifestyle Code:	Trout					
	Total	Cont.	Total	Cont.	Total	Cont.
% Usable:	40.6%	14.2%	0.0%	0.0%	0.0%	0.0%

Station	Distance	Depth*	Width	Cell Width Meeting Criteria					
				Total	Cont.	Total	Cont.	Total	Cont.
1	0.0	0.00	1.50						
2	3.0	0.12	2.30						
3	4.6	0.09	1.80						
4	6.6	0.65	2.10	2.1	2.1				
5	8.8	0.51	2.15	2.2	2.2				
6	10.9	0.49	2.05	2.1	2.1				
7	12.9	0.39	2.05						
8	15.0	0.20	2.05						
9	17.0	0.35	2.00						
10	19.0	ow	2.05						
11	21.1	ow	2.35						
12	23.7	0.18	2.55						
13	26.2	ow	2.55						
14	28.8	ow	2.30						
15	30.8	ow	2.15						
16	33.1	0.16	2.15						
17	35.1	0.45	2.00	2.0	2.0				
18	37.1	0.28	2.00						
19	39.1	0.55	2.00	2.0	2.0				
20	41.1	0.48	2.05	2.1	2.1				
21	43.2	0.55	2.45	2.5	2.5				
22	46.0	0.50	2.40	2.4	2.4				
23	48.0	0.28	2.85						
24	51.7	0.68	4.50	4.5	4.5				
25	57.0	0.56	3.70	3.7	3.7				
26	59.1	0.26	2.80						
27	62.6	0.00	1.75						
28			0.00						
29			0.00						
30			0.00						

Must manually select "COUNT" range for continuous cells

Wetted Width this Event:	62.6 (ft)	Width:	25.4	8.9	0.0	0.0	0.0	0.0
Maximum Transect Length**:	**62.6** (ft)	Percent:	41%	14%	0%	0%	0%	0%

*OW = Out of Water
**Must set "Maximum Transect Length" to the largest length of all measured discharges.

Attachment 4: Results of September 9, 2015 pebble count at the Gerle Creek Delta critical riffle

Table Att.2-1. Bed surface gradation at the Gerle Creek Delta critical riffle

Gravelomenter Opening (mm)	Incremental Count, Retained On	Cumulative Percent Passing
362	0	100
256	2	98
180	2	96
128	8	88
90	24	64
64	20	44
45	17	27
32	6	18
22.5	8	10
16	4	6
11.3	2	4
8	3	1
5.7	0	1
4	1	0
	D_{84} (mm):	121
	D_{50} (mm):	70.9
	D_{16} (mm):	29.3

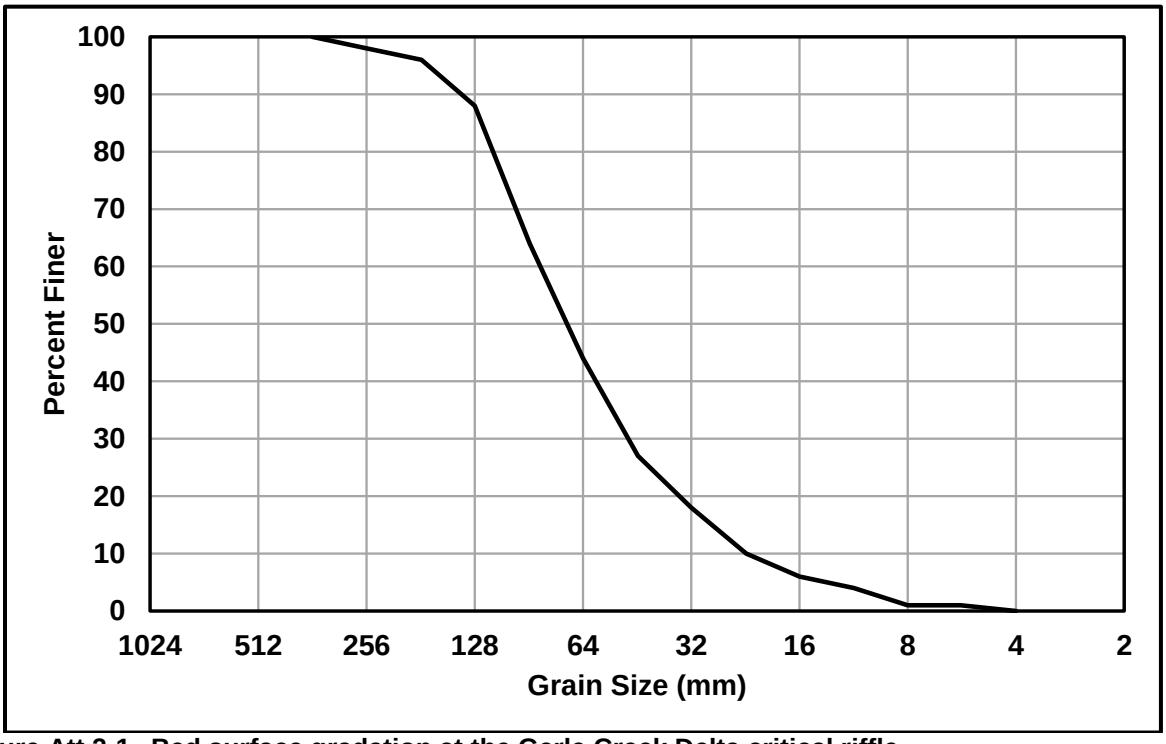

Figure Att.2-1. Bed surface gradation at the Gerle Creek Delta critical riffle

FEDERAL ENERGY REGULATORY COMMISSION
Washington D.C. 20426

OFFICE OF ENERGY PROJECTS

Project No. 2101-106 and 114 -- California
Upper American River Hydroelectric Project
Sacramento Municipal Utility District

June 27, 2017

Jon Bertolino
Sacramento Municipal Utility District
P.O. Box 1500
Pollock Pines, CA 95726

Subject: Robbs Peak Powerhouse entrainment study report and Gerle Creek fish passage plan report- Articles 402 and 401(a)

Dear Mr. Bertolino:

This letter acknowledges receipt of your Gerle Creek fish passage plan report (fish passage report) and Robbs Peak Powerhouse entrainment study report (entrainment study report), filed with the Commission on April 10 and 20, 2017, respectively, pursuant to Articles 402 and 401(a) of the Upper American River Project license FERC No. 2101.[1] The report is also required by the Commission's August 5, 2015 Order Modifying and Approving Gerle Creek Fish Passage Plan (Fish Passage Plan)[2] and July 30, 2015 Order Modifying and Approving Robbs Peak Powerhouse Entrainment Monitoring Plan (Entrainment Monitoring Plan).[3]

According to your Fish Passage Plan, you are to file a final report upon conducting three studies/analyses to understand the potential for depth barriers that impede upstream fish passage through the Gerle Creek Delta from August through October when brown trout migration is occurring. One study included conducting a topographic survey to establish baseline data on the Delta's geomorphology. Following this, you conducted a critical riffle analysis under three flow regimes, in order to establish current passage

[1] Order Issuing New License. 148 FERC ¶ 62,070 (issued July 23, 2014).
[2] 152 FERC ¶ 62,089
[3] 152 FERC ¶ 62,072

conditions that are independent of backwater influence from Gerle Creek Reservoir in the Delta and ultimately identify passage flow and passage depth. Finally, upon determining passage flow, you compared it to the minimum instream flow requirement from the August to October period to determine whether a change in the Gerle Creek Reservoir surface elevation is necessary to maintain passage. From these studies/analyses, you concluded in your April 10th report that there is no barrier to brown trout passage out of Gerle Creek Reservoir into Gerle Creek at any of the streamflows or reservoir elevations required by the license during the August-October spawning period. You also used the model to simulate morphological changes to the Delta, assuming potential aggradation and degradation scenarios in the future. You also concluded from the studies that there weren't any conditions that should impede brown trout passage upstream during the spawning period. Therefore, you deemed the development of a reservoir operations plan and nomograph, as referenced in your Fish Passage Plan as a potential follow-up action pending the results of the study, unnecessary and did not pursue it further.

You provided the results of your studies/analyses to the U.S. Forest Service (Forest Service), California State Water Control Board (Control Board), California Department of Fish and Wildlife (California DFW), and the U.S. Fish and Wildlife Service (FWS) on March 1, 2017 for review and comment. One comment was provided by California DFW, which requested that you perform additional analysis to determine whether downstream riffles not originaly classified as "critical" could become passage impediments to brown trout at the lowest reservoir level. You completed the analyses as requested and ultimately determined that the riffles in question were of sufficient depth and width to accommodate brown trout passage under the lowest reservoir level conditions. California DFW concurred with your determination that no further action is needed.

Your Entrainment Monitoring Plan requires you to conduct a study to determine at which flows fish migration is occurring and whether fish are being entrained at Robbs Peak Powerhouse, and if the entrainment is occurring, whether it's substantially impacting the South Fork Rubicon River fishery. In the event that entrainment is found to occur and it is negatively impacting the South Fork Rubicon River fishery, you must consult with the resource agencies identified in the Entrainment Monitoring Plan to develop adaptive management measures described in the water quality certification and Forest Service 4(e) conditions for the project license.

According to your April 20th report, you concluded that approximately 3.3 percent of fish are migrating from the South Fork Rubicon River into the forebay at Robbs Peak Powerhouse. These are typically younger fish, aged at 0+ years, based on fork length. You determined that that there is not a strong pattern of downstream migration from the South Fork Rubicon River into the forebay. Of the 1,000 individuals tagged, only nine

fish were entrained. You extrapolated this data to estimate an annual entrainment rate of less than 1 percent in the South Fork Rubicon River fishery, which is substantially lower than the natural mortality for this age class that would be considered compensatory. From this, you concluded that there is no substantial negative impact to the South Fork Rubicon River fishery from entrainment, and thus, no need for adaptive management measures.

You provided the report to Forest Service, FWS, California DFW, and the Control Board for review and comment on March 1, 2017 and then further discussed the results of the study at an annual meeting with these agencies on March 23, 2017. No outstanding comments remain.

Your April 10th and 20th reports fulfill the reporting requirements referenced here within. Thank you for your cooperation. If you have any questions regarding this letter, please contact me at (202) 502-6760.

Sincerely,

Joy M. Kurtz
Aquatic Ecologist
Division of Hydropower Administration and Compliance

cc: Mr. Darold Perry
Sacramento Municipal Utility District
P.O. Box 1500
Pollock Pines, CA 95726