Geomorphology Monitoring Plan: Continuing Evaluation of Representative Channel Areas

Hydro License Implementation • April 2017

Upper American River Project

FERC Project No. 2101

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1.0 INTRODUCTION AND BACKGROUND

This Geomorphology Monitoring Plan for Continuing Evaluation of Representative Channel Areas (Plan) addresses monitoring set forth in the State Water Resources Control Board (SWRCB) Section 401 Water Quality Certification, Condition 8.H, and the U.S. Department of Agriculture Forest Service (USFS) section 4(e) Condition No. 31, located in Appendices A and B, respectively, of the Federal Energy Regulatory Commission's (FERC) Order issuing new License for the Upper American River Project (UARP or Project); (FERC 2014). Attachments 1 and 2 contain the language from these documents as applicable to this Plan.

The UARP is owned and operated by the Sacramento Municipal Utility District (SMUD) and is located within 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 Reservoir, and Ice House Reservoir), eight smaller regulating or diversion reservoirs, and eight powerhouses. The UARP has an authorized installed capacity of 637.3 megawatts. The UARP also includes recreation facilities containing over 700 campsites, five boat ramps, hiking paths, and bicycle trails at the reservoirs.

2.0 MONITORING OBJECTIVES

The primary objective of this Plan is to establish methods to evaluate geomorphological conditions of representative channel areas for potential changes resulting from operation of the UARP reservoirs and diversions that alter flow regimes, sediment supplies, and sediment transport. Additionally, conditions in the FERC license impose hydrologic changes (i.e. flow increases) relative to the previous license for all minimum streamflows in the bypass reaches of the UARP. Further, some reaches have required pulse flows and recreational streamflows. The rationale presented in the 2014 FERC license for the continuing geomorphic evaluation of representative channel areas is that monitoring at the end of each 5-year monitoring period will provide a measure of potential changes in channel conditions relative to changes in streamflow regime. If there is a need in the future to implement sediment management, as presented in the Adaptive Management Program described in WQC Condition 9.F (Attachment 3) and USFS 4(e) Condition 32 (Attachment 4), the monitoring results developed from this Plan may inform the sediment management decisions.

3.0 REPRESENTATIVE CHANNEL AREAS

Between 2002 and 2004 DTA and Stillwater Sciences conducted studies in support of UARP relicensing to characterize channel morphology and geomorphic function in streams affected by the Project. The study results were used to identify potential reaches most likely to show effects from alterations to hydrology or sediment supply and 12 sites within the UARP were selected for morphological description (DTA and Stillwater Sciences 2005, Section 3.2.2.1, p. 7). As described in the 2014 FERC license (WQC Condition 8.H and USFS 4(e) Condition No. 31) a subset of eight sites were

selected as representative channel areas for evaluating long-term geomorphic changes related to Project operations. Subsequent to the License being issued, the private landowner notified SMUD that legal access would not be provided to the site below Robbs peak Forebay (RPD-G1); consequently the site has been dropped from the list of sites for long-term monitoring under the License (Table 1 and Figure 1).

If it is determined in the future that reservoir dredging within the UARP is necessary, SMUD will consult with the SWRCB, USFS, U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Wildlife (CDFW), (collectively referred to as the resource agencies) to determine a plan for adding and monitoring cross sections downstream of the affected reservoir(s).

4.0 METHODS

The ultimate objective of the continuing evaluation of representative channel areas is to provide quantitative measurements of channel morphology that can be compared over time as a basis for identifying channel change, and relating these comparisons to changes in hydrology and sediment supply. Fundamental to this objective is establishing the methods used to monitor geomorphic condition; meaningful interpretation of geomorphic change, if any, depends on using established methods that are consistently applied during all monitoring events.

WQC Condition 8.H and USFS 4(e) Condition 31 (Attachments 1 and 2) require representative channel areas (Table 1) to be monitored as described in the *Channel Morphology Technical Report* (DTA and Stillwater Sciences 2005), which largely follows the Rosgen (1996) hierarchy of river inventory and assessment. The Rosgen hierarchical assessment provides the physical, hydrologic, and geomorphic context for linking the driving forces and response variables (Rosgen 1996). The framework of this hierarchy is stream classification, which (1) provides a consistent reference for communicating stream morphology and condition, and (2) sets categories of discrete stream types so that consistent, reproducible descriptions and assessments of condition can be developed (Rosgen 1996). The *Channel Morphology Technical Report* (Section 3.3.2, p. 12 through 14) describes application of the Rosgen Level III Channel Condition Assessment (Rosgen 1996, Chapter 6, p. 6-1 through 6-50) to the UARP. The Level III Channel Condition Assessment builds on a Geomorphic Characterization (Level I) and a Morphological Description (Level II). As presented in the *Channel Morphology Technical Report* (Section 3.3.1, p. 9 through 12, and Section 3.3.2, p. 12 through 14) and summarized below, Level II and Level III field data were collected using the following survey methodologies and protocols.

Table 1. Representative Channel Areas in the UARP for Continuing Geomorphic Evaluation.

Creek/River	Representative Channel Area	Site ID	Site Description	Length (ft.)	Upper Extent[1]		Lower Extent[1]	
					Northing	Easting	Northing	Easting
Rubicon River	Below Rubicon Reservoir Dam	RD-G1	--	500	2,132,934	7,065,172	2,133,296	7,065,103
Gerle Creek	Below Loon Lake Reservoir Dam	LL-G1	Upper Reach	400	2,133,750	7,038,643	2,133,921	7,038,248
Gerle Creek	Below Loon Lake Reservoir Dam	LL-G2	Middle Reach	700	2,134,709	7,030,706	2,134,677	7,030,030
S.F. Silver Creek	Below Ice House Reservoir Dam	IH-G1	Upper Reach	1,200	2,063,509	7,022,982	2,062,706	7,022,291
S.F. Silver Creek	Below Ice House Reservoir Dam	IH-G2	Lower Reach	1,300	2,071,195	7,005,700	2,072,082	7,005,510
Silver Creek	Below Camino Reservoir Dam	CD-G1	--	700	2,060,525	6,966,621	2,060,005	6,966,186
S.F. American River	Below Slab Creek Reservoir Dam	SC-G1	--	650	2,049,460	6,911,340	2,049,312	6,910,774

Note:
[1] Coordinates reference NAD83, State Plane, California Zone II, in units of feet (FIPS Zone 0402). Coordinates were converted from values (UTM NAD27 in meters) presented in DTA and Stillwater Sciences (2005), where the accuracy of the values is not reported. Thus, the accuracy of the values in this table is unknown.

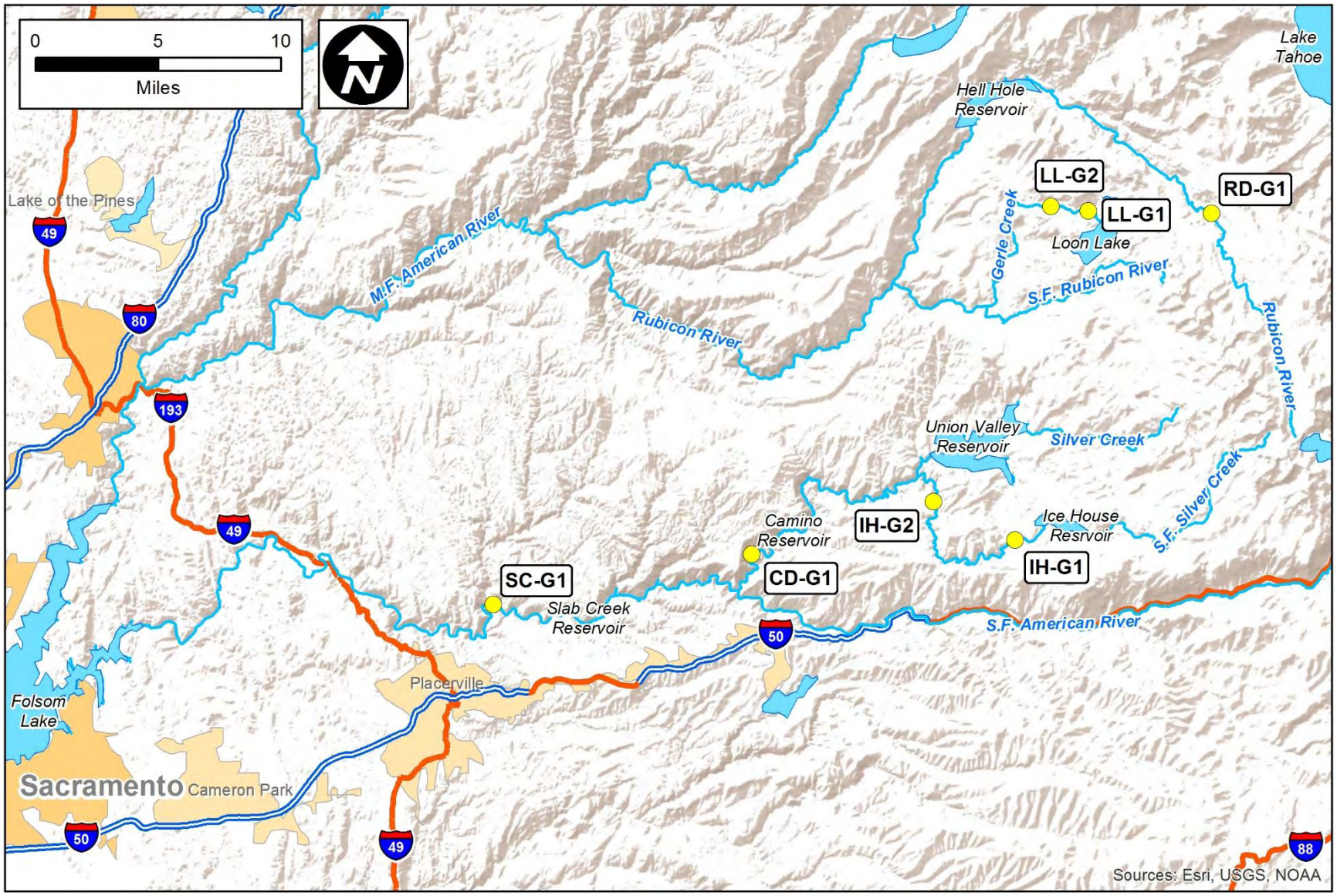

Figure 1. Representative Channel Areas in the UARP for Continuing Geomorphic Evaluation.

1) Level II field surveys included, but were not limited to, the following site-scale measurements:
   a. longitudinal profile (water surface and thalweg),
   b. approximately three monumented channel cross sections, each surveyed at intervals sufficient to clearly depict geometry (Harrelson et al. 1994),
   c. pebble counts of channel substrate at cross sections (Wolman 1954),
   d. delineation of bankfull indicators, thalweg, water's edge, and flood-prone areas, where identifiable,
   e. photo documentation at cross sections, and
   f. observations of potential anthropogenic influences on the channel, such as excess fine sediment, excessively coarse channel bed, or channel incision.

Sediment deposition in pools using the V^* method (Lisle and Hilton 1992; Hilton and Lisle 1993) was planned for the Level II field data collection, but because of the absence of measurable fine sediment deposits and the absence of well-defined pools, the data was not collected (DTA and Stillwater Sciences 2005, Section 4.1.1 p. 15, Section 4.1.2 p. 19, Section 4.1.5 p. 23, Section 4.1.7 p. 25, and Section 4.1.9 p. 27).

2) Level III field data collection included:
   a. bed surface texture based on facies mapping (stratification and delineation of channel bed features based on surface particle sizes and organization),
   b. streambank and channel condition and stability (Rosgen 1996; Pfankuch 1975),
   c. riparian vegetation type and density,
   d. depositional features, meander pattern, and debris jam condition (Rosgen 1996), and
   e. large woody debris (LWD) frequency.

4.1 Field Survey Methods

SMUD will use the same survey methodologies and protocols described in the *Channel Morphology Technical Report* (and detailed below) for the continuing evaluation of representative channel areas. These methodologies and protocols largely follow two levels of the four-level Rosgen (1996) hierarchy of river inventory and assessment (1) Level II Morphological Description, and (2) Level III Channel Condition Assessment. Before each monitoring event, the Level I Geomorphic Characterization Assessments presented in DTA and Stillwater Sciences (2005, Section 4.1.1 p. 15, Section 4.1.2 p. 18 – 19, Section 4.1.5 p. 22 – 23, Section 4.1.7 p. 25, and Section 4.1.9 p. 26 – 27) will be reviewed, along with any updated characterizations based on preceding monitoring.

1) Level II Morphological Description Assessments will include the following monitoring components.
   a. Survey the longitudinal profile (water-surface and thalweg) following Rosgen (1996, p. 5-27 and 5-29). If survey equipment other than a level and a tape (e.g., a total station or survey-grade GPS equipment) is used for the survey,

the referenced Rosgen method will be followed but the measurements will be made with the greater-precision equipment.

b. Survey the three monumented channel cross sections at lateral intervals sufficient to clearly depict geometry. The general surveying method will follow Harrelson et al. (1994, Chapter 6 Step 5, p. 27 - 28), allowing flexibility for use of greater-precision surveying equipment. To the extent feasible, the monuments set during the relicensing studies for the three cross sections at each of the seven representative channel areas will be recovered and used for continuing evaluation. Attachment 5 contains plan-view figures showing the positions of the monuments set during the relicensing study (DTA and Stillwater Sciences 2005). If the existing monuments cannot be recovered because the coordinates are incorrect or because of damage, SMUD will re-establish monuments consisting of capped rebar or equivalent. If elevations are not referenced to an established vertical datum, a relative datum will be used and site-specific benchmarks may be established as needed.

   During the sensitive site investigation along Gerle Creek (FERC License Article 401(b), WQC Condition 2.B, USFS 4(e) Condition No. 28), SMUD determined some of the monuments at LL-G2 were destroyed by fallen trees or were not recoverable; survey control for the recovered monuments is provided in SMUD (2016, Appendix A, p. A-1). As illustrated by this example, where monuments can be recovered, the relicensing measurements will serve as a baseline and monitoring measurements will follow the original alignments; where monuments cannot be recovered, attempts will be made to relocate new monuments as closely as possible to the original monuments, but the results from the first monitoring will serve as a baseline.

c. Characterize channel bed surface substrate at the monumented cross sections using the pebble count methodology of Wolman (1954).

d. Delineate bankfull indicators, thalweg, water's edge, and flood-prone areas, where identifiable, following Rosgen (1996, p. 5-8 through 5-20) and considering guidance in Harrelson et al. (1994, Chapter 7, p. 34 – 35) and DTA and Stillwater Sciences (2005, Section 3.3.1, p. 9 – 12).

e. Photo-document the monumented cross sections. No formal photo-documentation procedure was presented in DTA and Stillwater Sciences (2005). Baseline photographs are provided in Appendix F of DTA and Stillwater Sciences (2005). There is no photo documentation method presented in Rosgen (1996) for Level II or Level III assessments, and no purpose of the photo documentation is provided in the *Channel Morphology Technical Report*, but the photos provide general visual reference of geomorphic and riparian vegetation conditions at the monumented cross sections at the time of the surveys.

   The photos in Appendix F of DTA and Stillwater Sciences (2005) will be taken to the field for the first monitoring event so the photographer can reproduce as closely as possible the perspective. Once photograph positions are re-

established, the position will be (1) marked with capped rebar or other permanent marker, as inconspicuously as possible to minimize potential for vandalism, (2) surveyed (sub-meter accuracy), and (3) assigned an identifier to accompany the photographs. If a photograph position is within the channel, no marker will be established, and instead the position will be measured from and oriented relative to reference marks or other position markers at the cross section. With the photographer standing directly over the marker, the following information will be recorded: date and time, photograph number linked to the position identifier, and compass bearing. For photographs of the channel at a cross section, a tape stretched along the cross section alignment will be included in the view. At minimum, photograph positions will be established to provide views of each cross section as viewed from (1) downstream in the channel, (2) upstream in the channel, (3) the right top-of-bank facing the left top-of-bank, and (4) the left top-of-bank facing the right top-of-bank.

At least one reference point, such as a healthy, mature tree or a boulder, will be identified for each photo point position. This reference point should be within 200 feet of the photo point position. The distance and compass bearing from the reference point to the photo point position will be measured and recorded. A sketch will illustrate the relative position of the reference points and photo point positions; this information will be transferred to scaled overlays of aerial photographs/topographic mapping.

After the first monitoring event, if the photo point marker cannot be relocated, the reference point, mapping, and previous photographs will be used to re-establish the photo point marker as closely as possible to the original marker.

f. Observe and record potential anthropogenic influences on the channel, such as excess fine sediment, excessively coarse channel bed, or channel incision.
g. Attachment 6 will be followed to determine if detailed surveys are applicable for assessing fine sediment deposition in pools using the V^* method (Hilton and Lisle 1993), and if so, the methods for carrying out these surveys.

2) Level III Channel Condition Assessments will include the following monitoring components.
   a. Characterize bed surface texture based on facies mapping (stratification and delineation of channel bed features based on surface particle sizes and organization). The characterization will consist of scaled sketches and accompanying narrative (consistent with the level of detail provided in the facies maps presented in Appendix O of the *Channel Morphology Technical Report*) of each representative channel area. The objective of the facies mapping is to provide an easily understood record of channel conditions that may allow for associations between channel processes and morphologic responses (Buffington and Montgomery 1999, p. 1912).

b. Evaluate streambank and channel condition and stability (Rosgen 1996; Table 6-7, p. 6-29 through 6-30). The Rosgen method builds on the Pfankuch (1975) *Stream Reach Inventory and Channel Stability Evaluation*.
c. Generally describe riparian vegetation type and density, consistent with the level of detail provided in Section 4.1 of the *Channel Morphology Technical Report*, using the method of Rosgen (1996, Table 6-1, p. 6-14).
d. Evaluate depositional features (Rosgen 1996, Table 6-4, p. 6-18), meander pattern (Rosgen 1996, Table 6-5, p. 6-21), and debris and channel blockages (Rosgen 1996, Table 6-6, p. 6-25).
e. Tally large woody debris (LWD) frequency following the methodology of the USFS (2005[1], p. 19, 98 through 99), summarized as follows. Tally all LWD: (1) excluding beaver dams, (2) longer than one-half bankfull width (the minimum length criterion), and (3) downed with a portion lying within bankfull stage. There is no need to record the length or diameter of each piece. Aggregates are defined as four or more pieces of woody debris in contact where each piece meets the minimum length criterion and has some portion occurring within the bankfull width. Tally all pieces in the aggregate meeting the minimum size criterion that can be feasibly and safely identified. Tally root wads as single pieces whether they occur alone or are within an aggregate. A root wad is defined as the root mass of a tree whose trunk length is approximately equal to or shorter than the diameter of the root wad. Root masses with longer tree boles should be tallied as LWD. The purpose of the LWD tally is to provide a basis for assessing geomorphic and ecological function of the LWD.

4.2 Monitoring Frequency

Monitoring of the representative channel areas will occur during Years 5, 10, 15, and thereafter every 10 years through the term of the license, and any extensions. Each year is defined on a calendar year basis (i.e., January through December) and Year 1 is the first year during which all initial minimum streamflows required by the license are implemented by May 1 (2015 was Year 1). The monitoring methods presented in this Plan will thus be carried out in 2019, 2024, 2029, 2039, 2049, 2059, and possibly at additional 10-year intervals if the license is extended past 2064. To minimize the influence of varying seasonal conditions on the monitoring, the monitoring will be carried out during the late-spring (after spring runoff) through early-fall (before vegetation leaf-off), when flows are relatively low and snowpack does not impair site accessibility.

[1] The *Channel Morphology Technical Report* does not reference the version of the USFS's *Stream Channel Inventory* (*SCI*) used during the relicensing studies. *SCI* Version 5.0 is current (published in 2005), and *SCI* Version 4.0 was published in 1998. The LWD inventory methodology presented in the *Channel Morphology Technical Report* (Section 3.3.2, p. 13 through 14) matches the methodology in *SCI* Version 5.0 (p. 19, 98 through 99), so the baseline LWD tallies can be directly compared to future tallies collected following *SCI* Version 5.

4.3 Analysis

The analysis of the monitoring data will include two components: (1) hydrologic analysis, and (2) field data analysis. The analysis will consider the Level I geomorphic characterizations presented in DTA and Stillwater Sciences (2005), and subsequent updates if any, to inform potential drivers of change. The objective of the analyses will be to quantify geomorphic change using the Rosgen classification for natural rivers (1996, Figure 5-3, p. 5-6) and to interpret to what extent changes in hydrologic regime induced the geomorphic change. A secondary objective of the analyses will be to compare over time the indicators of stream condition, and interpret to what extent changes were driven by hydrologic changes. Starting with the analyses of monitoring data collected during the second monitoring event, evaluation of longer-term (i.e., across five-year and 10-year monitoring intervals) trends will be addressed in the monitoring reports.

4.3.1 Hydrologic Analysis

If the monitoring data indicate geomorphic change over time, interpretation efforts will focus on whether the hydrologic regime was the primary driver of the change. SMUD will use available flow gaging records to compile flow hydrographs for the period between monitoring events. Reference gaging stations will be as identified in the FERC-approved *Streamflow and Reservoir Elevation Gaging Plan* (SMUD 2015). Indicators of hydrologic regime will be calculated (e.g., number, timing, magnitude, and volume of floods; annual runoff volumes; annual maximum flow; freshet maximum flow; minimum instream flow releases; pulse flow releases; recreation flow releases). Indicators of recent historical hydrologic regime will also be calculated, to the extent historical gaging records are available, and appended as monitoring progresses. These indicators will serve to inform interpretations of the geomorphic change relative to the hydrologic regime over the monitoring period.

4.3.2 Geomorphic Field Data Analysis

The analysis of geomorphic field data will focus on quantifying change over time through application of the Rosgen stream classification and channel condition assessment. Some of this analysis will rely on graphical comparison, such as longitudinal profiles, cross- section geometry, bed surface gradation curves, and facies mapping; whereas, other data, such as streambank and channel condition and stability, bed surface gradation quantiles, riparian vegetation type and density, depositional features, meander pattern, debris and channel blockages, and LWD frequency will better be compared in tabular fashion. The graphical and tabular comparisons will be used to characterize geomorphic change, and where possible, relate the change to the hydrologic regime.

Rosgen Level II delineative criteria will be calculated from the monitoring measurements and observations as a basis for assigning a stream type classification (Rosgen 1996, Figure 5-2, p. 5-5, and Figure 5-3, p. 5-6). The key delineative criteria that will be determined include:

1) Whether the stream is a single-thread channel or multiple channel
2) Bankfull channel width (W_{bkf}) – the top width of the bankfull channel based on indicators identified in the field
3) Bankfull cross sectional area (A_{bkf}) – the cross sectional area of the bankfull channel
4) Bankfull maximum depth (d_{mbkf}) – the maximum depth of the bankfull channel as taken from the established bankfull stage
5) Bankfull mean depth (d_{bkf}) – the mean depth of the bankfull channel, calculated by dividing A_{bkf} by W_{bkf}
6) Flood-prone area width (W_{fpa}) – the top width at the elevation corresponding to twice the maximum depth of the bankfull channel ($2*d_{mbkf}$)
7) Entrenchment ratio (W_{fpa}/W_{bkf}) – the ratio of the flood-prone area width to the bankfull channel width
8) Width depth ratio (W_{bkf}/d_{bkf}) – the ratio of the bankfull channel width to the mean depth of the bankfull channel
9) Sinuosity – ratio of the valley length (measured from aerial imagery) to the channel length (measured during the Level II field surveys)
10) Dominant channel material (D_{50}) – the classification of the particle size for which 50 percent of the sampled particles is finer (Rosgen 1996 Table 5-4, p. 5-28)
11) Slope – change in water-surface elevation between consistent bed features, such as from the top of one riffle to the top of another riffle

5.0 REPORTING

SMUD will prepare monitoring reports following each monitoring event that fully describe the monitoring efforts, including the data collected and analyses of the data. SMUD will provide a draft report to the resource agencies by March 1 of the year following the year in which monitoring was conducted. SMUD will provide an opportunity for in-person discussion with the resource agencies of the draft report during the Annual Review of Ecological Conditions meeting held by April 1. SMUD will provide the resource agencies at least 30 days to review and comment on the draft report prior to filing the final reports with FERC. SMUD will file a final report, including copies of any comments and recommendations made by the resource agencies in connection with the report, with FERC by June 30 of the year following the year in which monitoring was conducted. SMUD will make copies of the final reports available to the resource agencies. FERC reserves the right to require changes to project operations or facilities based on the information contained in the report and any other information.

6.0 QUALITY CONTROL

The monitoring and analyses presented in this Plan will be carried out by qualified personnel (such as a senior fluvial geomorphologist) following industry standards regarding quality control. Quality control during the monitoring will be achieved through:

1. Understanding this Plan and appropriate sections of cited references.
2. Confirming survey equipment are properly calibrated according to manufacturer's specifications.
3. Maintaining roles of individuals and teams (consultation among field staff is encouraged) during monitoring activities at a representative channel area to minimize operator variability. This applies to longitudinal surveys; cross section surveys; pebble counts; delineation of geomorphic indicators (bankfull, thalweg, water's edge, and flood-prone areas); photo-documentation; facies mapping; evaluations of streambank and channel condition and stability; describing riparian vegetation type and density; evaluation of depositional features, meander pattern, and debris and channel blockages; and tallies of LWD frequency. Exceptions may be required for emergencies such as staff health or injury.
4. Checking topographic surveys in the field for errors during the survey, and confirming each instrument setup closes within 0.02 feet. If closure is not achieved, the survey will be repeated until closure is achieved.
5. Regularly checking for measurement or calculation errors while in the field. Where and when possible, duplicate measurements will be collected. Quality control for geomorphic monitoring data is not quantifiable in many applications, so professional judgment is required to assess reasonableness and representatives of the measurements and reporting.

Quality control during the analyses will be achieved through:

1. Understanding this Plan and the appropriate sections of cited references.
2. Reviewing all field measurements for completeness and accuracy.
3. Spot-checking calculation results.
4. Documenting atypical conditions that affect analysis results, and documenting assumptions used in the analyses.
5. Having senior technical staff review calculations, analyses, and interpretations, as well as drafts of the periodic monitoring reports before they are distributed for review and comment.
6. Provide the USFS, SWRCB, CDFW, and USFWS at least 30 days to review and comment on the draft periodic monitoring reports.

7.0 LITERATURE CITED

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Attachment 1: SWRCB Section 401 Water Quality Certification, Condition 8.H Geomorphology: Continuing Evaluation of Representative Channel Areas

Within two years of license issuance, the Licensee, in consultation with USFS, CDFW, USFWS, and the State Water Board, shall develop a geomorphology monitoring plan that provides for the continuing evaluation of representative channel areas. The Licensee shall provide the Deputy Director with any comments provided by the agencies during the consultation process. The Licensee shall submit the plan to the Deputy Director for review and approval after agency consultation. The Licensee shall provide the Deputy Director with at least 90 days to review and approve the plan prior to submittal to the Commission, if applicable. The Deputy Director may require modifications as part of the approval. The Licensee shall file the Deputy Director's approval, together with any required plan modifications, with the Commission.

Method: Establishment and monitoring of permanent cross-section transects, longitudinal profiles, and channel properties in representative channel areas. Cross-section profiles shall be measured and substrate composition examined at each transect. Sites shall be evaluated as described in the *Channel Morphology Technical Report*[2].

Location: The following sites[3] shall be evaluated:

- 8.H.1 Rubicon River below Rubicon Reservoir Dam (RD-G1)
- 8.H.2 Gerle Creek below Loon Lake Reservoir Dam (LL-G1 and LL-G2)
- 8.H.3 S.F. Rubicon River below Robbs Peak Reservoir Dam (RPD-G1)
- 8.H.4 S.F. Silver Creek below Ice House Reservoir Dam (IH-G1 and IH-G2)
- 8.H.5 Silver Creek below Camino Reservoir Dam (CD-G1)
- 8.H.6 S.F. American River below Slab Creek Reservoir Dam (SC-G1)

In addition, prior to any reservoir dredging, additional downstream cross sections shall be surveyed as determined necessary by the Deputy Director after consultation with USFS, CDFW, and USFWS.

Timing: Years 5, 10, 15, and thereafter every 10 years for the term of the license and any extensions.

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[2] Monitoring shall be equivalent to a Rosgen Level III Channel Condition Assessment as described in the *Channel Morphology Technical Report* (January 2005) prepared as part of the relicensing proceeding.

[3] Study site designations and locations are described in the *Channel Morphology Technical Report* (January 2005) prepared for the relicensing proceeding.

Attachment 2: USFS Section 4(e), Condition 31 Geomorphology (Continuing Evaluation of Representative Channel Areas)

Within 2 years of license issuance, the licensee shall develop a geomorphology continuing evaluation of representative channel areas monitoring plan in consultation with FS, CDFG, FWS, and SWRCB. The licensee shall provide BLM, CDFG, FWS, and SWRCB a 90-day review and approval period for the monitoring plan prior to implementation. The licensee shall implement the plan upon approval.

Method: Establishment and monitoring of permanent cross-section transects, longitudinal profiles, and channel properties in representative channel areas (Rosgen Level 3). Measurement of cross-section profile and substrate composition at each transect. The following sites shall be evaluated:

Rubicon River below Rubicon Reservoir Dam (RD-G1)
Gerle Creek below Loon Lake Reservoir Dam (LL-G1 and LL-G2)
South Fork Rubicon River below Robbs Peak Reservoir Dam (RPD-G1)
South Fork Silver Creek below Ice House Reservoir Dam (IH-G1 and IH-G2)
Silver Creek below Camino Reservoir Dam (CD-G1)
SFAR below Slab Creek Reservoir Dam (SC-G1)

In addition, prior to any reservoir dredging, additional downstream cross sections shall be surveyed as determined necessary by FS, CDFG, FWS, and SWRCB.

Frequency: Years 5, 10, 15 and thereafter for every 10 years for the term of the license.

Rationale: Monitoring of permanent cross-sections, in combination with channel properties, provides the basis for evaluating changes in channel condition. Sampling as part of the relicensing process has provided baseline data prior to streamflow modification and/or measurable response to streamflow modification. Monitoring at the end of each 5-year period provides an index of changes in channel condition relative to changes in streamflow regime.

Attachment 3: SWRCB Section 401 Water Quality Certification, Condition 9.F Adaptive Management Conditions: Sediment Management

Based on results of geomorphology monitoring, if the Deputy Director, after consultation with USFS, BLM, USFWS, and CDFW, determines there is a need to place sediment downstream, and if there is a need to dredge reservoirs associated with the UARP, sediment that results from the dredging shall be placed downstream after the Licensee receives Deputy Director and any other necessary regulatory agency approvals. In the event it is necessary to conduct dredging activities, the Licensee shall also notify the State Water Board and Army Corps of Engineers (ACOE) to determine if a Clean Water Act Section 404 Permit (404 Permit) is required. If a 404 Permit is required, the Licensee shall apply to the State Water Board for water quality certification pursuant to Section 401 of the Clean Water Act.

Attachment 4: USFS Section 4(e), Condition 32 – Adaptive Management Program Sediment Management

Based on results of geomorphology monitoring, if FS, *BLM, SWRCB, FWS, and CDFG* determine there is a need to place sediment downstream, and if there is a need to dredge reservoirs associated with the Project during the license term, sediment that results from the dredging shall be placed downstream in consultation with FS, *SWRCB, BLM, FWS, and CDFG*, after approval by FS, *BLM, SWRCB, FWS, and CDFG*.

Attachment 5: Representative Channel Area Figures

Figure A.5-1. RD-G1, Rubicon River Below Rubicon Reservoir Dam

Figure A.5-2. LL-G1, Gerle Creek Below Loon Lake Reservoir Dam, Upper Reach

Figure A.5-3. LL-G2, Gerle Creek Below Loon Lake Reservoir Dam, Middle Reach

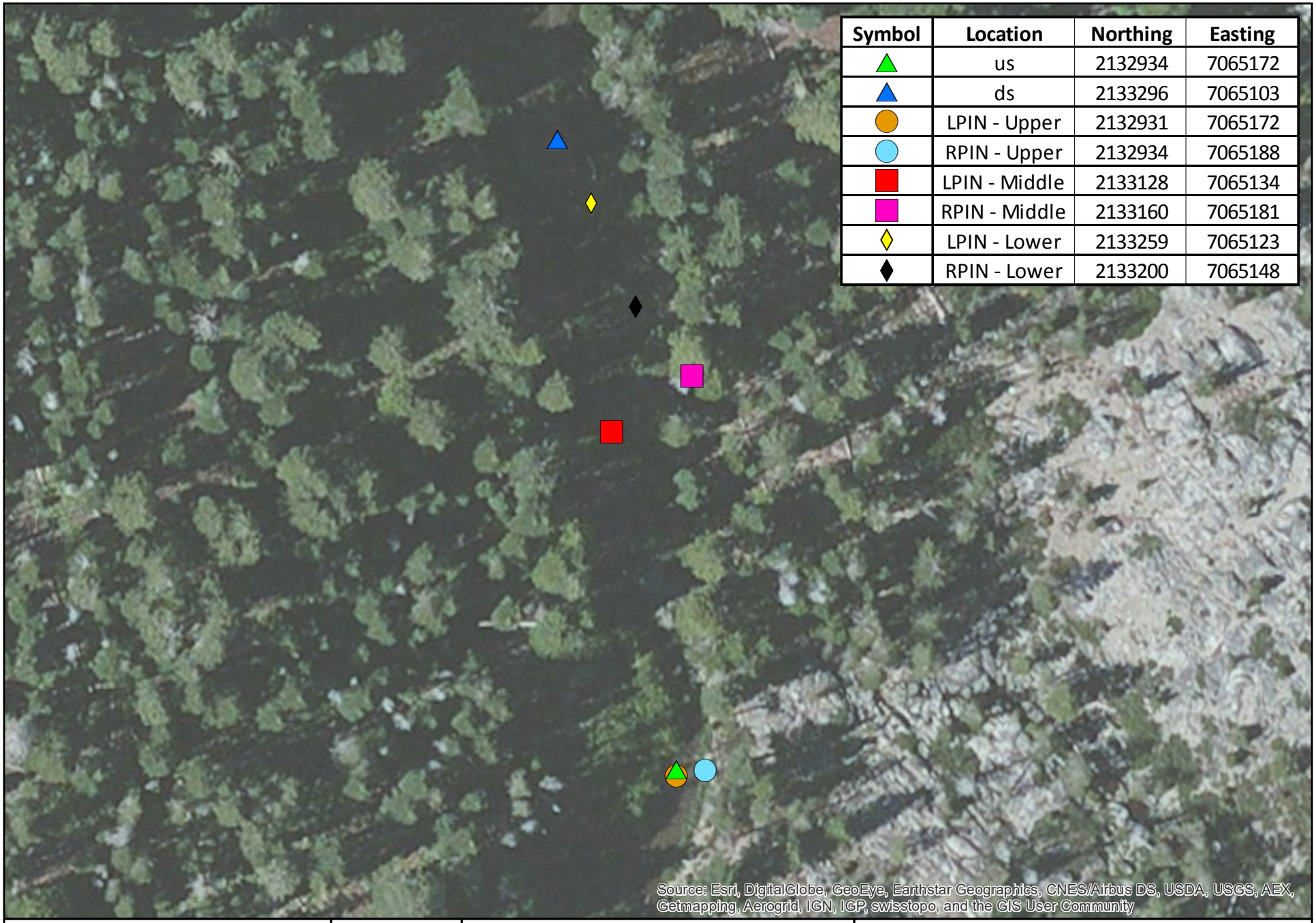
Figure A.5-4. IH-G1, South Fork Silver Creek Below Ice House Reservoir Dam, Upper Reach

Figure A.5-5. IH-G2, South Fork Silver Creek Below Ice House Reservoir Dam, Lower Reach

Figure A.5-6. Silver Creek Below Camino Reservoir Dam

Figure A.5-7. South Fork American River Below Slab Creek Reservoir Dam

Note – northing and easting coordinates shown on these figures are in units of feet referenced to NAD83, State Plane, California Zone II (FIPS Zone 0402). Values were converted from northing and easting values in meters referenced to NAD27, UTM Zone 10 presented in DTA and Stillwater Sciences (2005), where the accuracy of the values is not reported. Thus, the accuracy of the coordinates shown on these figures is unknown.



SMUD

A.5 - 1

RD-G1, Rubicon River
Below Rubicon Reservoir Dam

0 75 150
Feet

Symbol	Location	Northing	Easting
▲	us	2133750	7038643
▲	ds	2133921	7038248
●	LPIN - Upper	2133750	7038610
●	RPIN - Upper	2133793	7038617
■	LPIN - Middle	2133736	7038456
■	RPIN - Middle	2133784	7038476
◆	LPIN - Lower	2133743	7038413
◆	RPIN - Lower	2133788	7038440

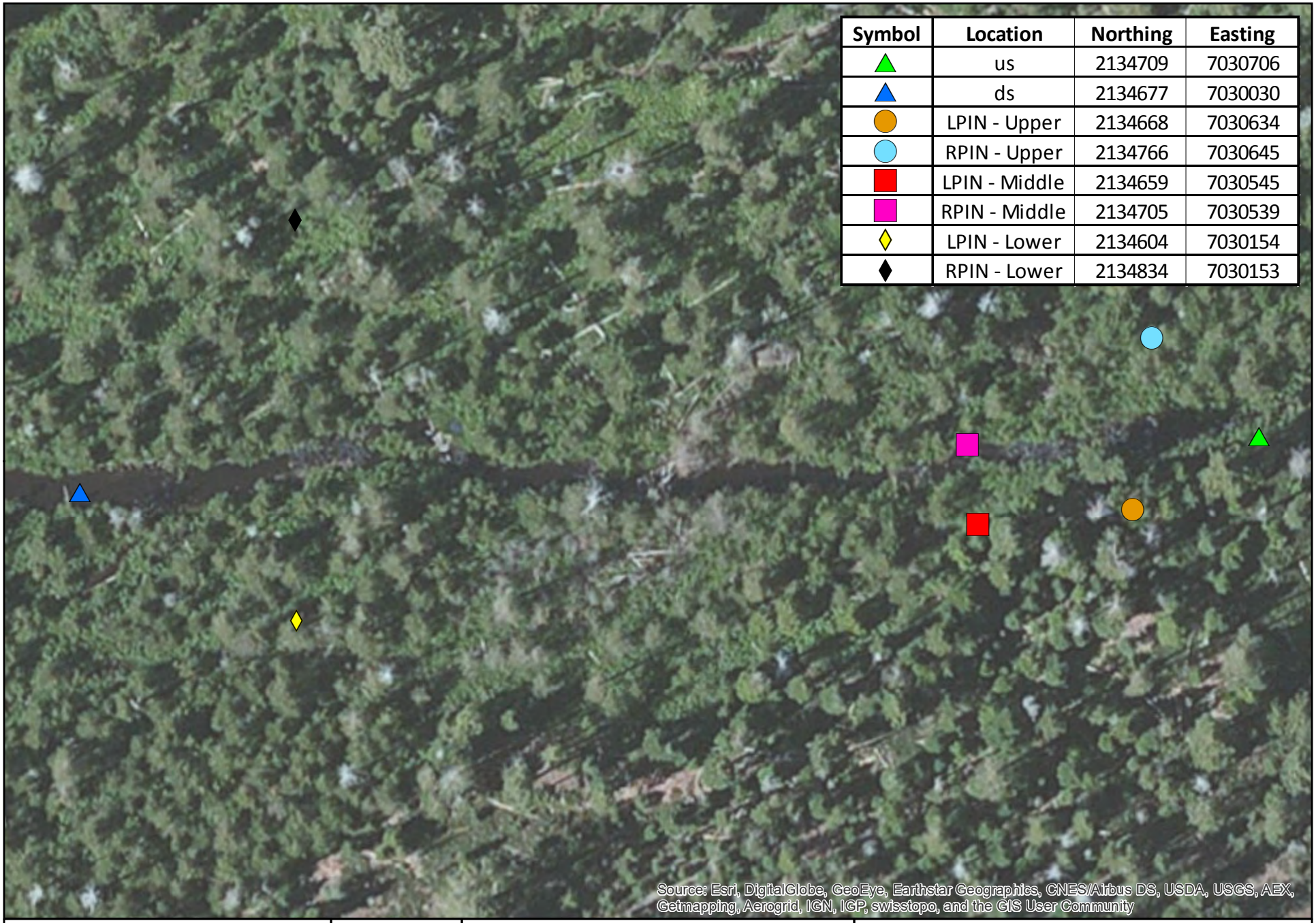
SMUD

A.5 - 2

LL-G1, Gerle Creek
Below Loon Lake Reservoir Dam,
Upper Reach

N

0 50 100
Feet



Symbol	Location	Northing	Easting
▲	us	2134709	7030706
▲	ds	2134677	7030030
●	LPIN - Upper	2134668	7030634
●	RPIN - Upper	2134766	7030645
■	LPIN - Middle	2134659	7030545
■	RPIN - Middle	2134705	7030539
◆	LPIN - Lower	2134604	7030154
◆	RPIN - Lower	2134834	7030153

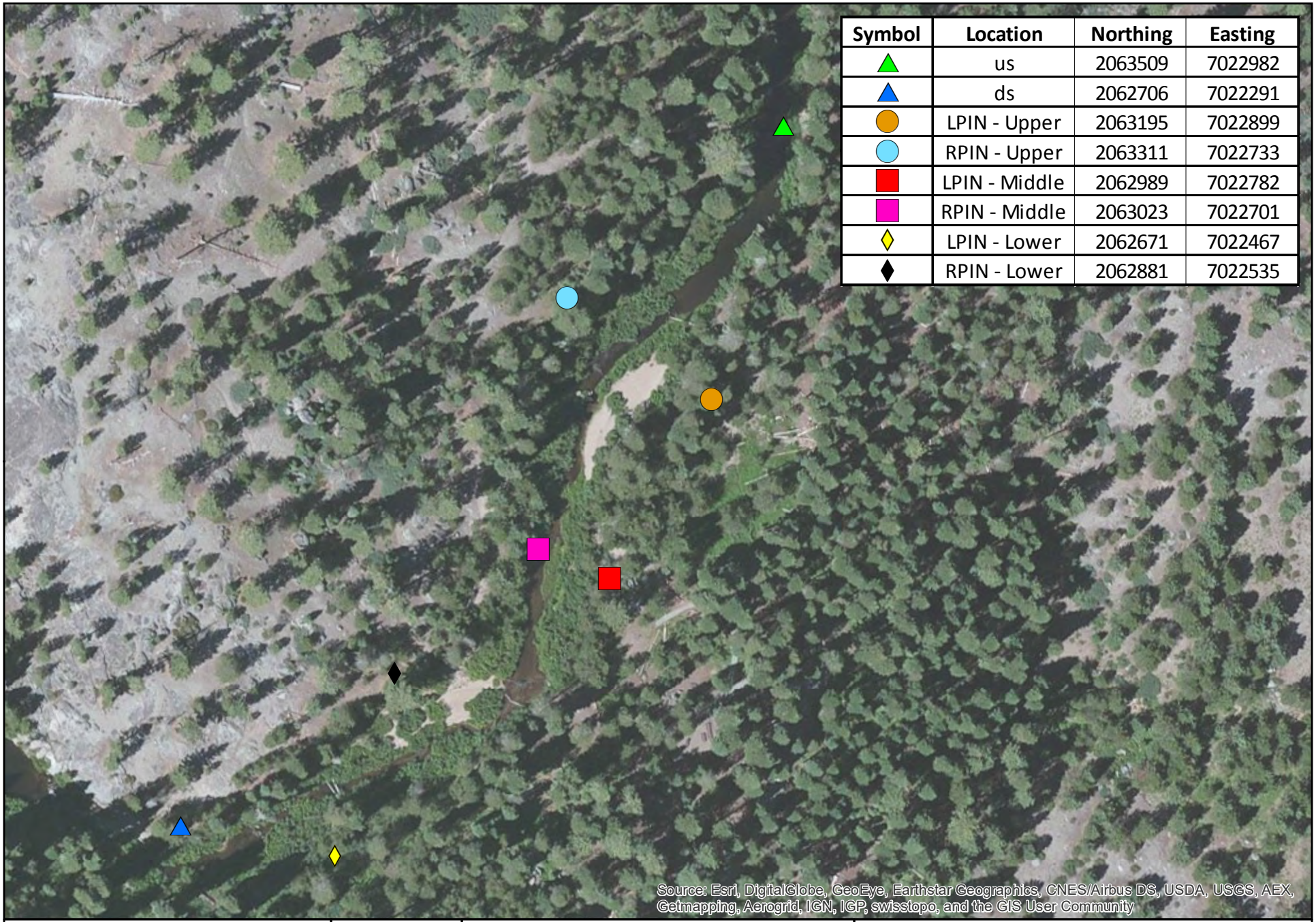
SMUD

A.5 - 3

LL-G2, Gerle Creek
Below Loon Lake Reservoir Dam,
Middle Reach

N

0 75 150
Feet



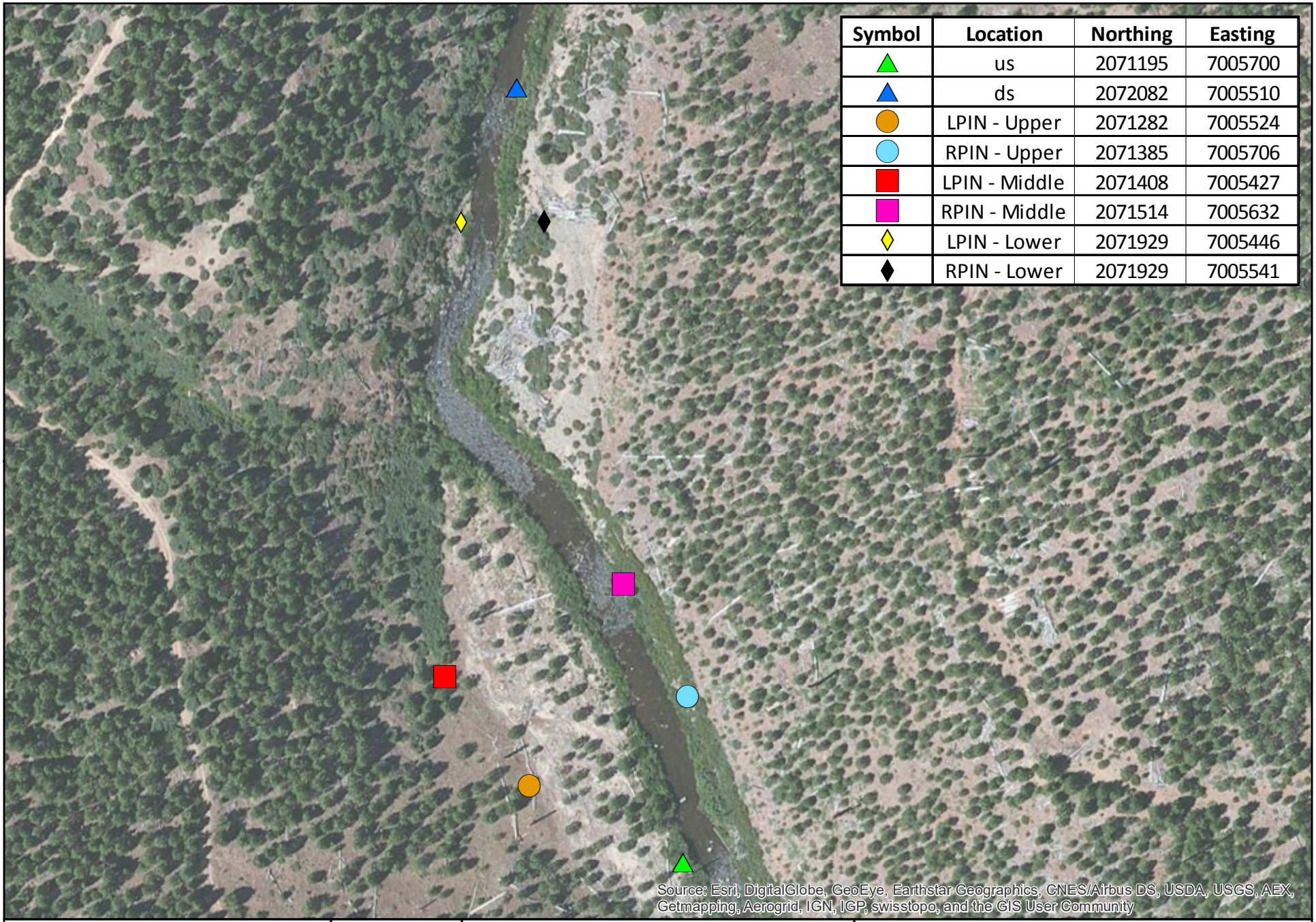
Symbol	Location	Northing	Easting
▲	us	2063509	7022982
▲	ds	2062706	7022291
●	LPIN - Upper	2063195	7022899
●	RPIN - Upper	2063311	7022733
■	LPIN - Middle	2062989	7022782
■	RPIN - Middle	2063023	7022701
◆	LPIN - Lower	2062671	7022467
◆	RPIN - Lower	2062881	7022535

SMUD

A.5 - 4

IH-G1, South Fork Silver Creek
Below Ice House Reservoir Dam,
Upper Reach

0 150 300
Feet



Symbol	Location	Northing	Easting
▲	us	2071195	7005700
▲	ds	2072082	7005510
●	LPIN - Upper	2071282	7005524
●	RPIN - Upper	2071385	7005706
■	LPIN - Middle	2071408	7005427
■	RPIN - Middle	2071514	7005632
◆	LPIN - Lower	2071929	7005446
◆	RPIN - Lower	2071929	7005541

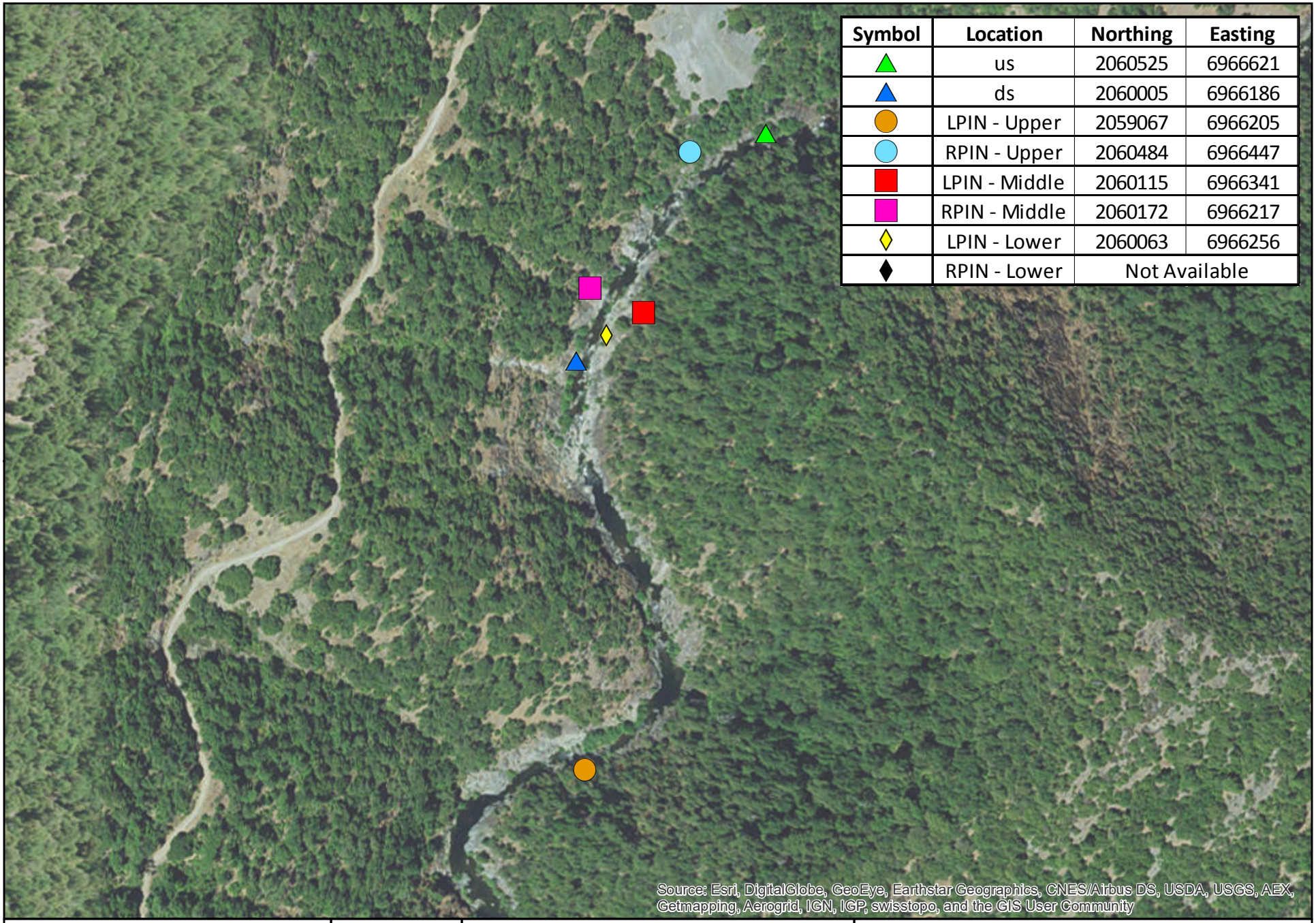
SMUD

A.5 - 5

IH-G2, South Fork Silver Creek
Below Ice House Reservoir Dam,
Lower Reach

N

0 150 300
Feet

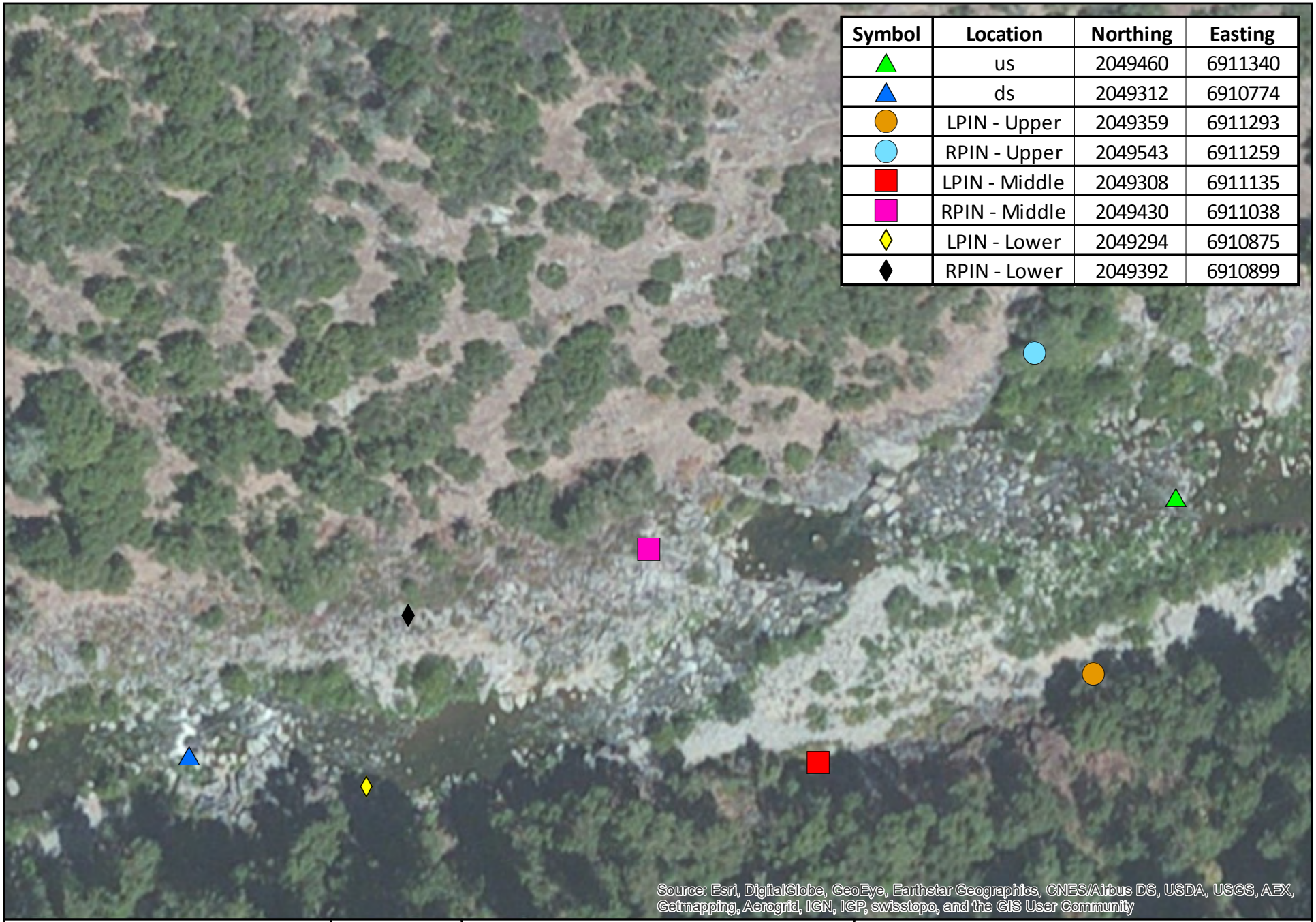


SMUD

A.5 - 6

Silver Creek
Below Camino Reservoir Dam

0 300 600
Feet



Symbol	Location	Northing	Easting
▲	us	2049460	6911340
▲	ds	2049312	6910774
●	LPIN - Upper	2049359	6911293
●	RPIN - Upper	2049543	6911259
■	LPIN - Middle	2049308	6911135
■	RPIN - Middle	2049430	6911038
◆	LPIN - Lower	2049294	6910875
◆	RPIN - Lower	2049392	6910899

SMUD

A.5 - 7

South Fork American River
Below Slab Creek Reservoir Dam

N

0 75 150
Feet

Attachment 6: V^* Method for Evaluating Fine Sediment Deposition in Pools

Observe fine sediment deposition in pools of representative channel areas (sites) with the following characteristics (Hilton and Lisle, 1993, p.1):

1. a wide-range in particle size between the bed surface and fine sediment deposition in pools,
2. stable banks of densely rooted alluvium, bedrock, or armored colluvium,
3. a single thread channel, and
4. gradient less than 5 percent.

Hilton and Lisle (1993, p. 2) define fine sediment as material that (1) is distinctly finer than the bed surface (median particle size of fine sediment approximately one-tenth or less of the median particle size of the bed surface), and (2) can be distinguished from underlying coarser sediment by probing with a rod. For sites satisfying the four characteristics listed above, pools are defined using the following criteria established by Hilton and Lisle (1993, p. 2):

1. the deepest part of the pool must be at least twice as deep as the water flowing out of the pool at the downstream end,
2. the water-surface slope during low flow is less than 0.05 percent,
3. the pool must include the thalweg and occupy at least half of the width of the low-flow channel, and
4. pool boundaries should be clearly defined.

All pools meeting these criteria will be identified. If a pool meets these criteria but flow patterns through the pool (and thus fine sediment deposition) are controlled by LWD, boulders, outcrops, or other obstructions, the pool will be excluded. Pools where outflow is controlled by LWD or other blockages will also be excluded. In the remaining pools visual estimates of V^*, the fraction of the scoured pool volume filled with fine sediment (Hilton and Lisle, 1993, p. 2-3), will be made for each pool using the *Fine Sediment Deposition in Pools – V^*_w Worksheet* that follows. The visual estimates will be supported by photographs or sketches to be provided in monitoring reports (Section 5.0). The V^* values for pools within a site will be used to estimate V^*_w, the site-averaged V^* weighted by pool volume. If the estimated V^*_w is less than or equal to 0.1, no surveys of fine sediment deposition will be carried out. If such conditions are met at a site for two consecutive monitoring events (including the monitoring carried out in support of the relicensing (DTA and Stillwater Sciences, 2005)), this will indicate that fine sediment loads are not problematic at this site, and fine sediment deposition in pools will not be monitored at this site for all remaining monitoring events. If the estimated V^*_w exceeds 0.1, the standard error of V^*_w will be calculated using the equation in Appendix B of Hilton and Lisle (1993, p. 11); this equations and the associated calculations of required input are described on the *Fine Sediment Deposition in Pools – V^*_w Worksheet* that follows. If the standard error of V^*_w exceeds 20 percent of the V^*_w (Hilton and Lisle,

1993, p. 7), which indicates (1) too few pools are available at the site, (2) the variability in V^* values for individual pools at the site is too great, or (3) a combination of (1) and (2), no surveys of the fine sediment deposition at the site will be carried out. If the estimated V^*_w exceeds 0.1 and the standard error of V^*_w is less than 20 percent of the V^*_w, the fine sediment deposition in pools at the site will be surveyed following the methods presented in Lisle and Hilton (1993).

Representative Channel Area:_____
Monitoring Date:_____

Fine Sediment Deposition in Pools - V^*_w Worksheet

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pool	f_i	w_i	V_i	$f_i - \bar{f}$	$w_i - \overline{w}$	$(f_i - \bar{f})^2$	$(w_i - \overline{w})^2$	(4)*(5)	V^*
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
SUM									
AVG.									
V^*_w									
σ_i^2									

Notes:
f_i = volume of fine sediment in the i^{th} pool
w_i = residual pool volume in the i^{th} pool
V_i = scoured pool volume, equal to $f_i + w_i$, columns (1) + (2)
$\bar{f}$ = arithmetic average volume of fine sediment
$\overline{w}$ = arithmetic average volume of residual pools
σ_i^2 = variance of the i^{th} variable
n = number of pools in a reach
Cov. = covariance of f_i and w_i, SUM of (8) / (n – 1)
$V^* = f_i / V_i$, columns (1) / (3)
AVG. = arithmetic average
V^*_w = reach-averaged V* weighted by pool volume, SUM of (1) / SUM of (3)
S.E. V^*_w = standard error of V^*_w

Equations on reverse side of this sheet

$$\sigma_{fi}^2 = \frac{\sum_{i=1}^{n}(f_i - \overline{f})^2}{(n-1)} \quad \text{(Equation 1)}$$

$$\sigma_{wi}^2 = \frac{\sum_{i=1}^{n}(w_i - \overline{w})^2}{(n-1)} \quad \text{(Equation 2)}$$

$$Cov. = \frac{\sum_{i=1}^{n}[(f_i - \overline{f}) * (w_i - \overline{w})]}{(n-1)} \quad \text{(Equation 3)}$$

$$S.E.V_w^* = \sqrt{n * \frac{\left[\left(\left(\sum_{i=1}^{n} f_i\right)^2 * \sigma_w^2 + \left(\sum_{i=1}^{n} w_i\right)^2 * \sigma_f^2\right) - 2 * Cov. * \sum_{i=1}^{n} f_i * \sum_{i=1}^{n} w_i\right]}{\left(\sum_{i=1}^{n} f_i + \sum_{i=1}^{n} w_i\right)^4}} \quad \text{(Equation 4)}$$

Fraction of the S.E. V^*_w relative to $V^*_w = \frac{S.E.V_w^*}{V_w^*}$ (Equation 5)

160 FERC ¶ 62,068

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Sacramento Municipal Utility District Project No. 2101-149

ORDER APPROVING GEOMORPHOLOGY MONITORING PLAN PURSUANT TO ARTICLE 401

(Issued July 25, 2017)

1. On May 23, 2017, and supplemented May 30, 2017, the Sacramento Municipal Utility District, licensee for the Upper American River Hydroelectric Project No. 2101, filed the Geomorphology Monitoring Plan (Plan) required by license Article 401, U.S. Forest Service 4(e) condition 31.8, and California State Water Resources Control Board's (California Water Board) Water Quality Certificate (WQC) condition 8.H.[1] The project consists of eight developments and is located on Silver Creek and the Rubicon and South Fork American rivers in El Dorado and Sacramento counties, California. The project occupies federal lands administered by the U.S. Bureau of Land Management and by the U.S. Forest Service within the Eldorado National Forest.

Background

2. License Article 401, U.S. Forest Service 4(e) condition 31.8, and WQC condition 8.H require the licensee to prepare and file the Plan, within 28 months of license issuance, to provide for monitoring of representative stream channels. The Plan is required to include provisions for monitoring transverse and longitudinal profiles, channel properties, and substrate composition at the following locations; the Rubicon River below Rubicon dam, Gerle Creek below Loon Lake dam, the South Fork Rubicon River below Robbs Peak dam, South Fork Silver Creek below Ice House dam, Silver Creek below Camino dam, and the South Fork American River below Slab Creek dam. The licensee is required to perform the monitoring 5, 10, 15, and every 10 years thereafter, following license issuance.

3. The licensee is required to develop the Plan in consultation with the U.S. Forest Service, the U.S. Fish and Wildlife Service (FWS), the California Water Board, and the California Department of Fish and Wildlife (California DFW).

[1] *Sacramento Municipal Utility District*, 148 FERC ¶ 62,070 (2014). The 4(e) conditions and WQC are attached to the license as appendices B and A, respectively.

4. On November 17, 2016, the licensee requested an extension of time to file the Plan with the Commission, which was granted by an unpublished order on December 9, 2016.

Licensee's Plan

5. In its Plan filed May 23, 2017, the licensee states the primary purpose of the Plan is to evaluate the effects of project operation on several representative stream channels. The licensee states the current license includes streamflow requirements which differ from the method of previous operation, and implementation of the Plan would provide data to be used to correlate changes in channel conditions with changes in the streamflow regime.

6. The licensee states the required monitoring sites were selected as a result of work during the licensing effort for the project. However, in the Plan, the licensee states a private landowner has denied permission to access the site below the Robbs Peak dam. The licensee also indicates it would monitor two different stream reaches on Gerle Creek below the Loon Lake dam, and on South Fork Silver Creek below the Ice House dam, resulting in a total of seven monitoring sites.

7. The licensee explains its methodology for conducting the monitoring including establishing survey monuments to locate transects, measurements of profiles, photo documentation, pebble counts, noting the presence of woody debris, and evaluation of anthropogenic influences. The Plan also states the licensee would conduct monitoring in the late spring through early fall season in 2019, 2024, 2029, and every 10 years thereafter. The licensee states it would review the data obtained from its monitoring surveys to help evaluate the influences on stream geomorphology at the project. Furthermore, the licensee states it would prepare a report and provide it to the U.S. Forest Service, the FWS, the California Water Board, and the California DFW for comment. According to the Plan, the licensee would provide this report and any agency comments to the Commission by June 30 of each year following the year in which it conducted monitoring.

Consultation

8. On May 31, 2016, July 22, 2016, February 15, 2017, and April 20, 2017, the licensee provided draft versions of the Plan to the U.S. Forest Service, the FWS, the California Water Board, and the California DFW that had been revised pursuant to agency comments. By letter dated May 19, 2017, and included in the May 23, 2017 filing, the U.S. Forest Service approved the Plan. The May 30, 2017 filing includes a letter dated May 26, 2017, in which the California Water Board also approved the Plan.

Discussion

9. The current license for the project, when compared to the previous license, included a significant number of changes to the flow regime below the developments. These changes were the result of newly required minimum flows, pulse flow events, and recreational flow releases. As a result of these changes, the parties to the licensing proceeding were concerned with how these new flows would affect the resources within the project area and proposed a substantial monitoring effort to quantify any effects the new flow requirements would have on the environment, including geomorphology. The licensee was required to develop the Plan as part of this monitoring effort to ensure flow release requirements were not resulting in any adverse unintended consequences.

10. The licensee's May 23, 2017 Plan adequately describes the criteria for selecting the representative stream channels, how monitoring would be conducted, and how results of that monitoring would be analyzed and presented to the Commission and resource agencies for review. The Plan also includes provisions for assessing man-made impacts on stream channels to help determine what effects project operation may have on the natural environment. We determine the licensee's Plan adequately fulfills the requirements of license Article 401, U.S. Forest Service 4(e) condition 31.8, and WQC condition 8.H, and therefore should be approved.

The Director orders:

(A) The Geomorphology Monitoring Plan filed on May 23, 2017, by the Sacramento Municipal Utility District, for the Upper American River Hydroelectric Project No. 2101, is approved.

(B) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the Federal Power Act, 16 U.S.C. § 825*l* (2012), and the Commission's regulations at 18 C.F.R. § 385.713 (2016). The filing of a request for rehearing does not operate as a stay of the effective date of this order, or of any other date specified in this order. The licensee's failure to file a request for rehearing shall constitute acceptance of this order.

Kelly Houff
Chief, Engineering Resources Branch
Division of Hydropower Administration
and Compliance

Document Content(s)