To: Beth Christman, Truckee River Watershed Council
From: David Shaw and Peter Kulchawik
Date: August 21, 2018

RE: Design Basis Memorandum: Lower Perazzo Meadow Restoration, Sierra County, California

Introduction

The Truckee River Watershed Council (TRWC) has contracted with Balance Hydrologics (Balance) to conduct field investigations, analysis, and provide design services for restoration of Lower Perazzo Meadow in Sierra County, California. This memo describes findings of our investigations and background research, presents 95% design drawings, and documents the basis for the design.

Earlier work at the project site completed by Swanson Hydrology and Geomorphology (SH+G, 2008) concluded that significant morphological change has occurred in the Perazzo Meadows system, with significant impacts on the system's ecological value. Field observations, evaluation of historical aerial photography and analysis of high-resolution topographic data indicate that extensive historical disturbance took place in the Little Truckee River watershed, such that portions of the meadow have been directly and indirectly impacted by historical land uses, and the river channel is now incised into Lower Perazzo Meadow.

Based on this earlier work, the TRWC and U.S. Forest Service Tahoe National Forest (TNF) elected to implement a restoration approach to introduce annual flooding to the meadow surface by way of filling the incised channel, and contracted Balance to assist in developing restoration design plans for this selected restoration approach. The remainder of this memo provides a contextual overview of the site and watershed setting, outlines the design elements, and describes the analyses that our team has carried out to support and refine the proposed design concept. The 95% Restoration Design Plans are attached to this memo, and this memo should always accompany the restoration design documents.

Location

The Project is located at Lower Perazzo Meadow in Sierra County, California, Township 19 N, Range 15 E, Sections 16 and 17, also identified as 39° 29' 44" N, 120° 19' 37" W (NAD27), as shown in Figure 1. The Little Truckee River flows through Lower Perazzo Meadow, and is tributary to the Truckee River, a terminal river which flows to Nevada and ultimately Pyramid Lake.

The Project reach includes approximately 5,300 feet of the Little Truckee River through lands owned by the Truckee Donner Land Trust (TDLT) and TNF. Figure 2 shows the project area, land ownership, and the location of USGS- and Balance-operated streamflow gaging stations upstream and downstream of the project.

Setting

The Little Truckee River drains the eastern crest of the Sierra Nevada Mountains at elevations above 9,000 feet and is a major tributary to the Truckee River with a total watershed area of 172 square miles as measured from its confluence with the Truckee River. The watershed area at the upstream end of the project is approximately 32.8 square miles, as measured at Balance gaging station LTPM. The watershed area at the downstream end of the project reach is approximately 34.2 square miles, as measured at Balance gaging station LTLM, with limited significant side tributaries within the project reach. Large segments of the Little Truckee River through Upper and Middle Perazzo Meadows underwent “plug and pond” enhancements during the summers of 2009 and 2010.

Geology

The Project area is located in the transition between the Sierra Nevada and Basin and Range Geomorphic Provinces. This transition includes active faulting oriented in the north and northwest directions, which influences the locations of drainages and drainage patterns, springs, and other geomorphic expression. The study area is dominantly underlain by Tertiary volcanic rocks that are found in much of the Central Sierra Nevada- predominately andesitic breccias and associated mudflows (Saucedo and Wagner, 1992).

Glaciation and subsequent fluvial erosion formed much of the steeper terrain surrounding the meadow and provides an abundance of fine and coarse sediment to the Little Truckee River by erosion of moraines, outwash, and glacial till. As the glaciers retreated they left lateral and terminal moraines. The terminal moraines often formed lake basins that filled in slowly to form meadows as glacial deposits were reworked and transported by rivers and streams. During the Pleistocene geologic age there were numerous glacial advances where lake formation occurred, resulting in several alluvial and outwash terraces. The different terrace surfaces tend to define separate vegetative communities and elevation relationships to the channel. Throughout the region, the youngest glacial outwash terraces are observed to be 2 to 4 feet above the active floodplain. After disappearance of the glaciers, streamflow in the Little Truckee River declined significantly, resulting in the formation of meandering channels within a broad glacially-derived alluvial valley.

Figure 3 is a generalized geology map of the study area and surrounding watershed showing the distribution of geologic formations. Site-specific geomorphic features were mapped as part of our analysis of the site and are described in more detail below.

Soils

Lower Perazzo Meadow soils are mapped as Aquolls and Borolls, 0 to 5 percent slopes, and adjacent hillsides are mapped as the Celio-Gefo-Aquolls complex, 2 to 30 percent slopes. Aquolls and Borolls are wetland soils found along the stream corridor and at distal toes of alluvial fans. They are poorly drained (Hydrologic Soil Group D) soils and are noted as having a high-water table during much of the year. These soils also support wetland vegetation such as alder, willow, rush, and sedge.

Historical Land Use

A number of events and land-use themes in the watershed and at the site appear to play an important role in the current status of stream health and integrity. Livestock grazing has been documented as far back as the mid-1800s with heavy use documented upstream and downstream of the project site (Lindstrom, 2012; Hastings and others, 2014). The construction and intensive use of Henness Pass Road between 1860 and 1868 required a number of bridges and crossings, including road construction across a tributary meadow to the Little Truckee River within Lower Perazzo Meadow.

Industrial-scale logging began around the 1860s, and involved extensive construction of roads, railroads, and use of the Little Truckee River for the transport of logs ('river driving'). Erman (1991) suggested that splash dams may have been used in the Little Truckee River to move logs down the river during periods of low flow. Several railroad and road grades are present in the slopes adjacent to the meadow surface, and a linear feature across the meadow is interpreted as an abandoned railroad grade. This grade appears to have crossed the Little Truckee River at the upstream end of the project reach. Additionally, many rills and small drainages on the slopes north of the meadow are interpreted as skid trails, where logs would be moved several hundreds of feet down the slope with the aid of gravity, for collection onto rail cars or into the river to be driven downstream. Large colluvial deposits at the base of these drainages are interpreted to be historical deposits on top of the meadow surface (NV5, 2018, Appendix A), most likely resulting from excessive erosion induced by logging practices.

River driving required extensive widening and deepening of the river so that downstream movement of logs could be maintained. This practice also required conversion of multiple channel systems to a single-thread channel system. Repeated scouring of the streambed that resulted from river driving likely altered riparian habitat (Hastings and others, 2014).

Channel Form

Channel morphology appears to be influenced by historical land uses. Disturbances described above likely converted Lower Perazzo Meadow from a multiple-channel braided system to a single-thread system with an oversized single channel. SH+G (2008) estimated that an approximately 2- to 5-year flow is required to inundate floodplain surfaces in the Lower Meadow. As a result, high flows have become concentrated in the single channel, leading to channel incision and widening, while floodplain inundation occurs less frequently.

Within Lower Perazzo Meadow, the single channel form is dominated by a riffle-pool morphology. Reach-average channel slope is approximately 0.2 percent (0.002), and the average valley slope is approximately 0.3 percent (0.003). Channel sinuosity across the project area is approximately 1.59. Several nearly-continuous relict channels are present in lower portions of the meadow and cross the main channel in several locations. These features are interpreted as historical primary or secondary channels that were abandoned due to human disturbance. Relict channel sinuosity is generally greater than that in the main channel, and relict channel widths and depths are generally smaller than those of the main channel.

Groundwater

Balance and TRWC established a groundwater monitoring program upstream of the project site beginning in 2009. In Summer 2011, UC Merced researchers installed additional piezometers (shallow groundwater monitoring wells) in Lower Perazzo Meadow using similar methods and equipment to those in the Upper and Middle Meadow. Groundwater data at all locations is provided in annual hydrologic monitoring data reports and have consistently shown that groundwater levels in Lower Perazzo Meadow to be 3 to 6 feet below the ground surface during the summer months, which are comparatively lower to groundwater levels in the restored Upper and Middle Meadows, especially during the 2012-2015 drought. Winter and spring groundwater conditions are also lower in the Lower Meadow, with groundwater rarely reaching the ground surface (Trustman and others, 2018).

Hydrology

Streamflow in the Little Truckee River has been gaged by the USGS and Balance at multiple locations and with varying periods of record between 1947 and the present. Locations of gaging stations near the Project site are shown in Figure 2. Table 1 lists these gaging stations, periods of record, and includes a summary of streamflow statistics. The stations closest to the site have periods of record that are too short to be statistically reliable, so annual peak and daily flow means and minimums for the period of record are simply presented in Table 3.

Table 1. Summary of available streamflow gaging data, Little Truckee River near Lower Perazzo Meadow, Sierra County California

Station Name	Station ID	Period of Record	Watershed Area (sq. mi.)	Mean Daily Flow (cfs)	Minimum Daily Flow (cfs)	Peak flow of record (cfs) (year of peak)
Little Truckee River below Middle Perazzo Meadow	Balance Hydrologics LTPM	2009-present	32.8	86.3	1.0	2,039 (2017)
Little Truckee River below Lower Perazzo Meadow	Balance Hydrologics LTLM	2011-present	34.2	80.2	1.5	2,319 (2017)
Little Truckee River below Sierra Valley Diversion	USGS 10341950	1993-1998; 2013-2016	36.1	95.2	2.1	3,980 (1997)
Little Truckee River near Hobart Mills	USGS 10342000	1947-1972	36.5	89	0.7	7,910 (1963)

Gotvald and others (2012) developed regional regressions equations for watershed size, location, and elevation in portions of California. Application of these regression equations using the USGS StreamStats online tool (StreamStats, 2018) provides an estimate of flow frequencies on the Little Truckee River at the downstream end of Lower Perazzo Meadow. As shown in Table 2, the regression indicates that the 2-year flow is approximately 692 cfs, and the estimated 100-year flow is on the order of 5,000 cfs.

Swanson Hydrology and Geomorphology (2008) used a 53-year period of record from Sagehen Creek to develop a flood-frequency curve and then used a ratio of watershed sizes to scale peak flows to the Little Truckee River at Perazzo Meadows, a short distance upstream from Sierra Valley Diversion, also shown in Table 2. Since that work was completed however, several years of peak flow gaging data from the Little Truckee River and Sagehen Creek suggest that there is limited correlation between the two, likely because Sagehen Creek watershed is somewhat lower in elevation than the headwaters of the Little Truckee River and is located slightly east of the Sierra Crest. Peak flows have been measured by Balance for the TRWC since 2010, as presented in Table 3, and suggest that the 2-year (median) annual peak flow over the period of record is in the 900 to 1,100 cfs range, slightly higher than the estimates provided by both SH+G (2008) and StreamStats.

Streamflow gaging data indicate that late season (September) baseflow ranges from 0.4 to 11.8 cfs, as shown in Table 3. The variability in late season baseflow is a result of variability in timing of snowmelt, annual precipitation, snowpack, and the frequency of summer cloudbursts.

Table 2. Selected Flood Frequencies, Little Truckee River at Lower Perazzo Meadow, Sierra County, California

Probability of Exceedence (percent)	Recurrence Interval (years)	Streamflow (cfs)	Streamflow (cfs)
		SH+G (2008)	Regional Regression developed by Gotvald and others (2012)
99	1	24	
50	2	342	692
20	5	864	1380
10	10	1,418	2,060
4	25	2,418	2,990
2	50	3,429	4,040
1	100		4,960

Table 3. Measured peak flows and September low flows upstream and downstream of Lower Perazzo Meadow, Sierra County, California

	Little Truckee River Below Middle Perazzo Meadow (LTPM)				Little Truckee River Below Lower Perazzo Meadow (LTLM)		
Water Year	Peak flow (cfs)	Peak flow date	September baseflow (cfs)		Peak flow (cfs)	Peak flow date	September baseflow (cfs)
2010	1,052	6/6/2010	2.0				
2011	902	6/29/2011	11.2				11.8
2012	896	4/26/2012	1.0		1,137	4/26/2012	2.2
2013	1,166	12/2/2012	2.4		1,403	12/2/2012	4.0
2014	210	4/8/2014	1.4		247	2/9/2014	2.7
2015	708	2/8/2015	2.7		892	2/8/2015	1.8
2016	580	3/6/2016	0.5		763	3/5/2016	0.4
2017	2039	1/8/2017	8.4		2,319	1/9/2017	10.0

Summary of the Proposed Restoration Design Elements

Restoration Objectives

The TNF and TRWC propose to re-establish a multi-threaded channel system in Lower Perazzo Meadow by raising the bed of the main channel. As we understand it, the objectives of the overall Perazzo Meadows Restoration Project are as follows:

- Restore hydrologic functions that have been lost from the meadow and floodplain;
- Improve water quality through increased floodplain inundation frequency and duration;
- Eliminate excessive meadow and stream channel erosion;
- Increase groundwater storage;
- Increase the frequency of floodplain inundation; and
- Improve riparian and wetland ecosystem conditions

The selected restoration approach is intended to redistribute low flows into the abandoned but nearly continuous secondary relict channels and allow high flows to more frequently spread across a greater floodplain area. Filling the channel will rapidly aggrade the system, offsetting channel incision and widening and replacing material that the river has mined as a result of human disturbance. Balance has reviewed the proposed restoration approach and developed detailed design drawings and technical analysis to support the selected restoration approach. The following design elements are shown in the attached 95% Restoration Design Plans (Appendix B):

- **Channel Treatments.** Four primary channel treatment approaches will be employed where shown in Plans:

A. *Preserve Amphibian Habitat.* Portions of the existing channel are serving as functional aquatic habitat, especially in deep scour pools where natural wood structures have developed. The U.S. Fish and Wildlife Service have expressed a desire to maintain these areas as open pools so that functioning aquatic and amphibian habitat can be maintained.

B. *Channel Fill.* Where the existing channel does not intersect relict or secondary channels, fill material will be placed to aggrade the channel to an elevation approximately 0.5- to 1-foot higher than the adjacent meadow surface. Prior to filling, the channel will be over-excavated to clear the bed and banks of vegetation, which will be salvaged and stored for transplanting. The excavated surface will be scarified, and channel fill will be placed in lifts and nominally compacted to fill voids.

C. *Channel Fill at Relict Channel or Swale Crossing.* Where the existing channel crosses a small relict channel or swale, fill material will be placed to aggrade the channel to an elevation matching the relict channel elevation, and to maintain flow along the swale. Prior to fill placement, the sub-grade will be prepared as described above.

D. *Coarse Channel Fill at Relict Channel Crossing.* Where the existing channel crosses a major relict channel of substantial depth and flow capacity, fill material will be placed to aggrade the channel to an elevation matching the relict channel elevation, and to maintain flow along the relict channel. The sub-grade will be prepared as described above, and the upper 1- to 2-feet of fill will consist of coarse channel fill material harvested from the existing channel. The coarse channel fill will be placed in 10-inch lifts and compacted using normal methods (i.e. driving equipment across the fill). The coarse channel fill material is intended to provide an armored layer in areas of swift and/or deep water that is more resistant to excessive erosion than regular channel fill material.

- **Riffle Grade Control.** The grade control riffle is intended to prevent the lower meadow fill treatments from eroding by allowing streamflow to transition from the meadow surface to the native stream bed over a short distance along the Little Truckee River. It is critical that the grade control riffle be a persistent feature for the long-term stability of the restored meadow, and the gradation of the riffle mixture is designed to be immobile in more than a 100-year event.

The attached 95% plans (Appendix B) also show the proposed location of haul routes, borrow sites, and a diversion plan that maintains continuous flow to downstream water users and aquatic habitat. As per Balance's contracted scope of work on this project, revegetation plans are not included in the 95% design, but are anticipated to be provided by TNF staff or others.

Analysis for Design

<u>*Geomorphic Features*</u>

To develop a contextual understanding of dominant processes on-site, Balance developed a Geomorphic Features and Disturbance Map (Figure 5). Field-mapping indicates that the site is underlain by colluvium, floodplain deposits, slope wash, younger and older delta deposits, glacial drift, and volcanic bedrock. The prominent terraces located south of the Little Truckee River appear to be deltaic deposits that settled in standing water. Field reconnaissance observations, desktop topographic analysis, and subsurface investigations by NV5 (2018; Appendix A) suggest that colluvial deposits on the north side of the meadow are historical material that was deposited during or after logging activity in the area and on the order of 2 to 4 feet thick. Excavation of these deposits for use as channel fill is anticipated to re-expose meadow soils and the meadow surface, which was buried due to human disturbance.

Borrow Material for use as Channel Fill

A Draft Geotechnical Engineering Report has been completed by NV5 for this project (NV5, 2018; Appendix A). As part of their work, NV5 performed a site reconnaissance, literature review, and subsurface exploration of potential borrow sites involving test pits and dynamic cone penetrometer testing. Soils encountered in and near potential borrow sites north of the meadow were found to consist of loose to medium dense coarse-grained soil and small amounts of stiff fine-grained soil. These soils are suitable for use as channel fill material (NV5, 2018). Borrow areas in deltaic deposits south of the river consist of relatively clean fine sand and will be mixed with other soils or re-vegetated to reduce the potential for excessive erosion.

Excavation of borrow areas will use geomorphic grading approaches, which mimic natural slopes and geomorphic features mapped on site to minimize visual impacts and encourage successful revegetation. Prior to excavation, topsoil will be removed and stockpiled for reapplication to the site after the project is completed.

Connecting to Relict Channels

Figure 6 is a Relative Elevation Model (REM) of the meadow, showing elevation differences between the current Little Truckee River channel, secondary remnant channels, and upland areas within the meadow. The REM was created by generating a sloping surface that represents the channel bed elevation over the entire width of the lower meadow. The sloping surface was then subtracted from the digital elevation model (DEM) for the meadow topography to create the REM. The final REM shows heights above the river bed (referenced to the nearest point perpendicular along the Little Truckee River) and was used to evaluate the feasibility of re-activating remnant channels, probable flow directions across the meadow surface, and high points that may need to be overcome where extensive floodplain connectivity is sought.

Grade Control Riffle Mixture Sizing

A 1-dimensional hydraulic model of the Little Truckee River was compiled to estimate the tractive forces on the grade control riffle. The model extended from just upstream of the grade control riffle for more than 1,000 feet downstream of the riffle to fully account for tailwater effects. Several flow rates were evaluated, from the 5-year up to the 100-year event, as estimated by regional regression equations (Gotvald and others, 2012; Table 2).

Model output for shear stress within the channel banks (where the grade control riffle will be installed) was used to estimate the maximum size material that would mobilize over the range of flows using the Shields equation, assuming a Shields parameter of 0.03:

$$d_s = \frac{\tau_0}{(\gamma_s - \gamma_w)\tau_{*c}}$$

wherein ds is the maximum particle size mobilized; τ0 is the shear stress, as estimated by the 1D model; γs is the specific weight of sediment (assumed specific gravity of 2.65); γw is the specific weight of water; and τ*c is the Shields parameter. We acknowledge that selecting a threshold (critical) Shield parameter to define the beginning of motion is subject to debate and requires making a number of simplifying assumptions; 0.03 is a widely accepted value in the scientific literature for representing a small, but measurable amount of sediment movement.

The results of the analysis for selected flow rates are summarized in Table 4 and showed that the maximum particle size mobilized during a 100-year event is roughly 6-inches at both the riffle crest and at the sill, 75 feet downstream from the crest. The median clast size (D50) for the riffle mixture is designed to be 12 inches, based on these calculations with a factor of safety of 2 applied to account for uncertainty in the model results and selection of the Shields parameter. By this approach, the coarse fraction of the riffle is anticipated to be immobile during a 100-year event. It is possible that fine material of the riffle mixture will be winnowed from the grade control riffle during flood events, however, the riffle is expected to persist because the coarse material will control the overall morphology. Fine material will likely be replenished during the falling limb of a flood event as small particles are deposited along the riffle.

Lastly, we note that the gradation of the riffle mixture has a similar composition as naturally occurring coarse riffles observed during field investigations, as well as the engineered riffle at the lower end of the middle meadow, which was installed in 2010 and has remained stable.

Table 4. Particle Size Mobility Evaluation Results, Lower Perazzo Meadow Grade Control Design, Sierra County, California.

Location	**Maximum particle size mobilized (inches)**	
	10-year event (2,100 cfs)	100-year event (5,000 cfs)
Riffle crest	6.1	6.4
Sill (mid-riffle, 75 ft downstream of crest)	4.8	6.6

Construction Considerations

Haul Road Considerations

Meadow area soils are anticipated to quickly become unstable if wet or saturated, so access and haul roads have been designed to avoid the meadow surface as much as possible. Within the meadow, the channel itself will serve as the primary haul route, allowing for moderate compaction of the channel fill material and minimal disturbance of meadow soils. Where haul roads must cross the meadow, a temporary encapsulated road will be constructed. The encapsulated road will consist of geotextile fabric laid over the meadow surface, then 12 inches (minimum) of soil placed on the fabric, then compacted to create a firm, drivable surface. The encapsulated road will spread the vehicle loading over a large area and will prevent compaction of meadow soils. Localized decompaction and rehabilitation of meadow soils may be needed where the encapsulated road was not 100-percent effective.

Dewatering

To maintain clean and continuous flow to downstream habitat and water users, the Little Truckee River will be diverted, dewatering and bypassing the project area. The dewatering plan for the project is shown in the Revised 95% Design drawings (Appendix B). Prior to dewatering, fish exclusion screens will be installed just upstream and downstream of the project reach, and a fish rescue effort will be completed.

All flow in the Little Truckee River will be diverted by pumping into a closed conduit around the entire project reach. The pumping rate will be adjusted to match the incoming flow rate, and flows will be directed to an approximately 4,100-foot section of 12-inch diameter HDPE pipe. The pipeline will follow the alignment of the construction access route along the north margin of the lower meadow. A temporary cofferdam will be installed at the upstream end of the dewatered reach. The downstream end of the pipe will be located several hundred feet downstream of the project reach to prevent backwatering of the work area. Although not part of the dewatering system, sediment control features will be required at the downstream end of the project reach to prevent uncontrolled releases of sediment from the work area.

The entire dewatering system will be installed before turning on the pumps to avoid any lapse in streamflow to downstream reaches.

Limitations

This report was prepared in general accordance with the accepted standard of practice existing in Northern California at the time the investigation was performed. No other warranties, expressed or implied, are made. It should be recognized that interpretation and evaluation of geomorphic and ecologic conditions is a difficult and inexact art. Judgment leading to conclusions and recommendations presented above were based on existing information and personnel communications, which in total represent an incomplete picture of the site. More extensive studies can reduce some of the uncertainties associated with this study.

The following work could help form a more comprehensive basis for design of the project:

- Detailed topographic surveys of the channel and relict channels;
- Additional subsurface investigations;
- Preparation of a reach-scale hydraulic model;
- Vegetation mapping or surveys.

Balance Hydrologics has prepared this report for the Truckee River Watershed Council's exclusive use on this project. Analyses and information included in this report are intended for use at Lower Perazzo Meadow in Sierra County, California. Information and interpretations presented in this report should not be applied elsewhere without the expressed written permission of the authors, nor should they be used beyond the area to which we have applied them.

References

Erman, D., 1991, Historical background of long-term diversion of the Little Truckee River, In History of water: Eastern Sierra Nevada, pp. 415-426.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl.

Hastings, Shaw, Lass, Henery, Purdy, and Fesenmeyer, 2014, Little Truckee River Assessment: Sierra Valley Diversion Ditch Downstream to Stampeded Reservoir, Sierra County, California: Balance Hydrologics consulting report prepared for Trout Unlimited Feather River Chapter, 102 p.

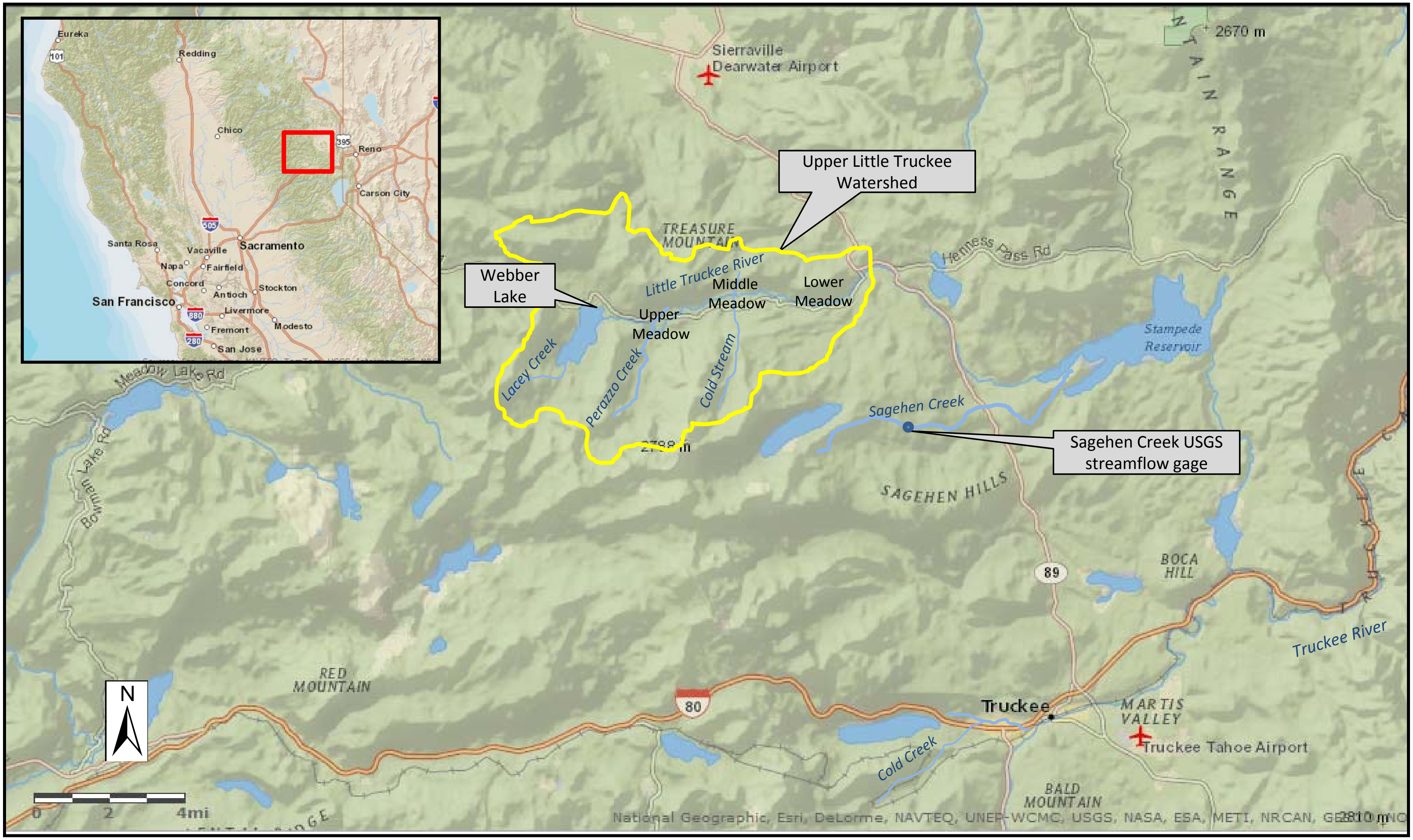
Lindstrom, S.G., 2012, Lacey Meadow/Webber Lake work book: A contextual overview of human land use and environmental conditions, consulting report prepared for Balance Hydrologics, multi-page document. Swanson Hydrology and Geomorphology, 2008.

Saucedo, G.J., and Wagner, D.L., 1992, Geologic Map of the Chico Quadrangle, California Department of Conservation Division of Mines and Geology Regional Geologic Map Series Map No. 7A, scale 1: 250,000.

Trustman, B., Shaw, D., and Hastings, B., 2018, DRAFT Perazzo Meadows Restoration hydrologic monitoring data report: Perazzo Meadows, Sierra County, California, Water Year 2017: DRAFT consulting report prepared for the Truckee River Watershed Council, 32 p. + forms, tables, and figures.

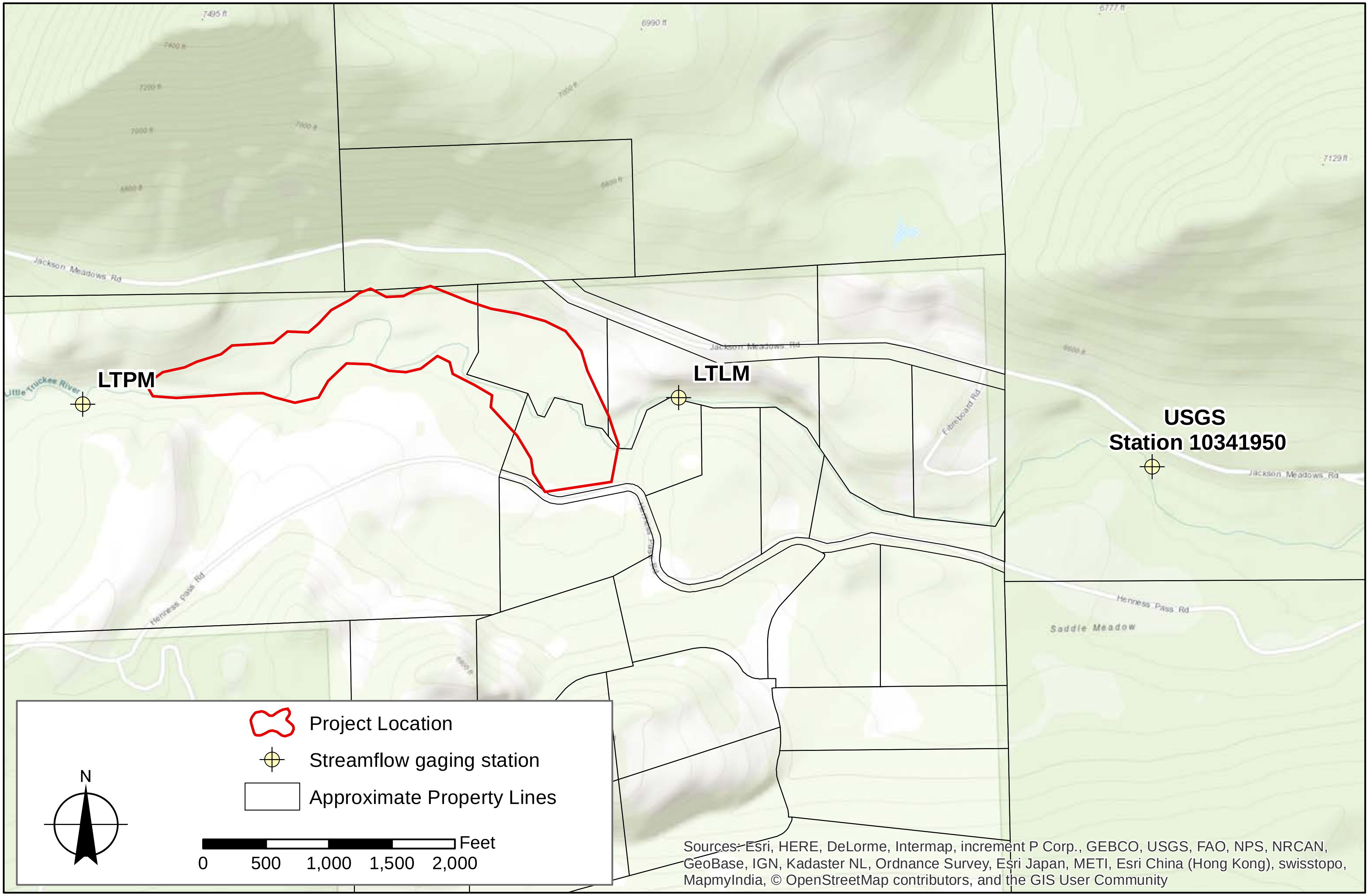
Enclosures: 218116 DBM Draft Figures
Appendix A Geotech Report
Appendix B Revised 95% Design Plans

FIGURES



Balance Hydrologics, Inc.

Figure 1 . Perazzo Meadows, Sierra County, California
Perazzo Meadows is part of the Upper Little Truckee watershed, in the headwaters of the Truckee River.

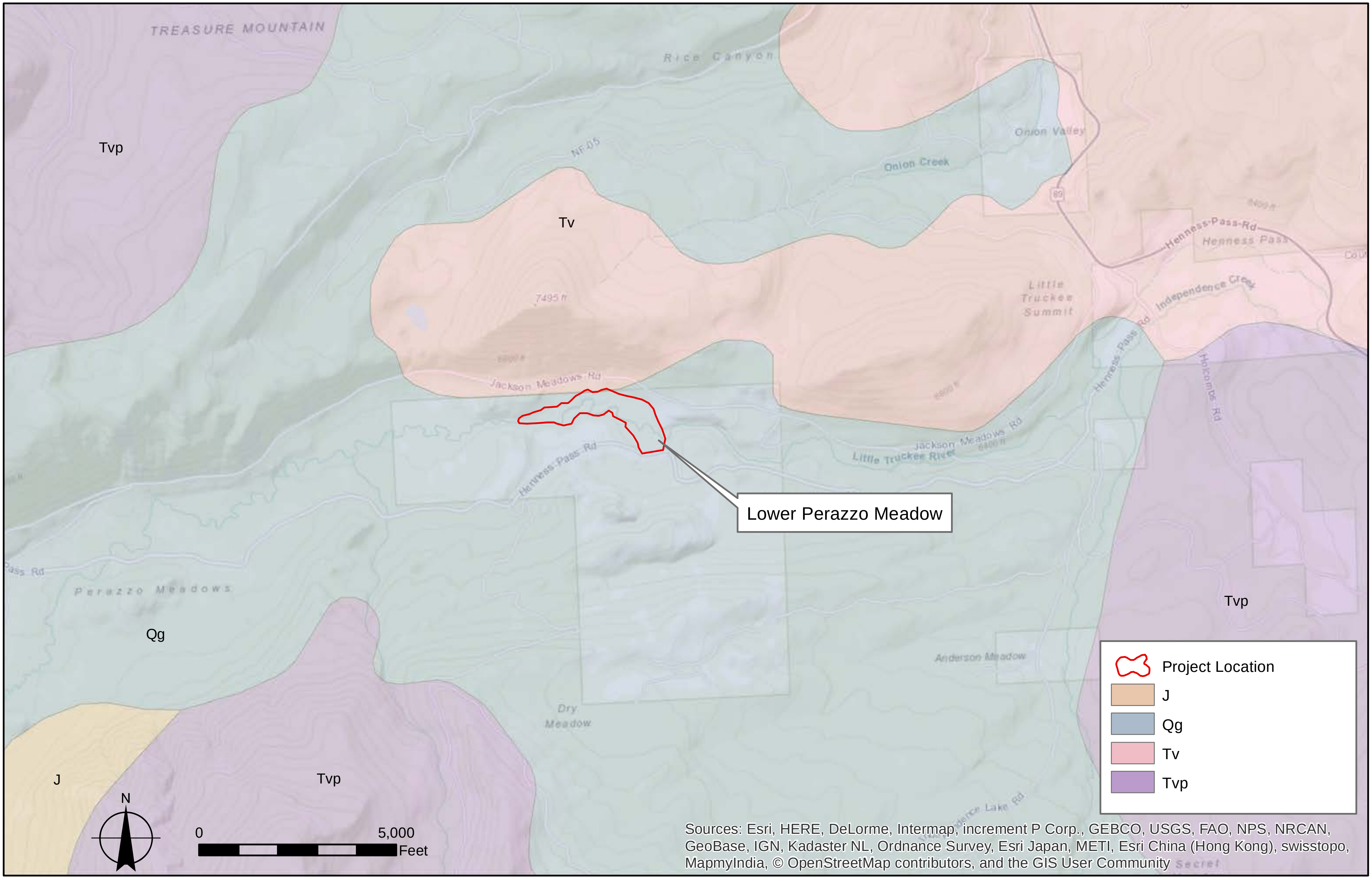


Balance Hydrologics, Inc.

Figure 2. Lower Perazzo Meadow Restoration Project Location. Sierra County, California

Stream gaging stations LTPM and LTLM operated by Balance Hydrologics.
USGS Station 10341950 Little Truckee River Below Diversion Dam was discontinued July, 31, 2016.

Y:\GIS\Projects\218116 Lower Perazzo Meadow\Project Location Map



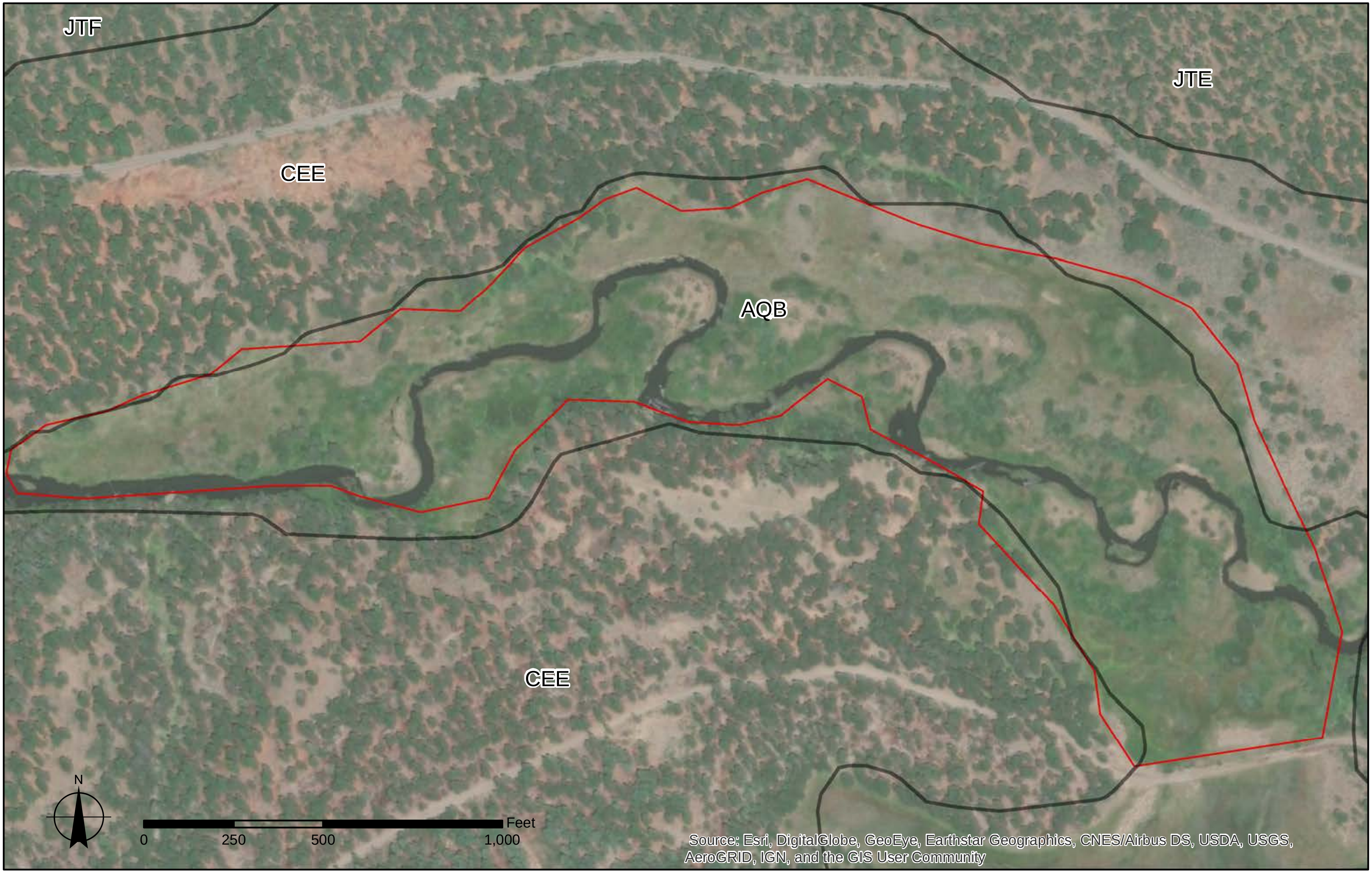
Balance Hydrologics, Inc.

Geology Definitions

J Metamorphic rocks
Qg Glacial drift
Tv Andesite basalt
Tvp Andesite rhyolite

Figure 3. Perazzo Meadows Generalized Geology
Perazzo Meadows, Sierra County, California

Y:\GIS\Projects\218116 Lower Perazzo Meadow\Generalized Geology Map



Balance Hydrologics, Inc.

Soil Series

ABQ	Aquolls and Borolls
CEE	Celio-Gefo-Aquolls
JTE	Jorge-Tahoma
JTF	Jorge very stony sandy loam

Figure 4. Lower Perazzo Meadow General Soil Types Sierra County, California

Source: NRCS Web Soil Survey www.nrcs.usda.gov

Y:\GIS\Projects\218116 Lower Perazzo Meadow\Project Location Soils Map

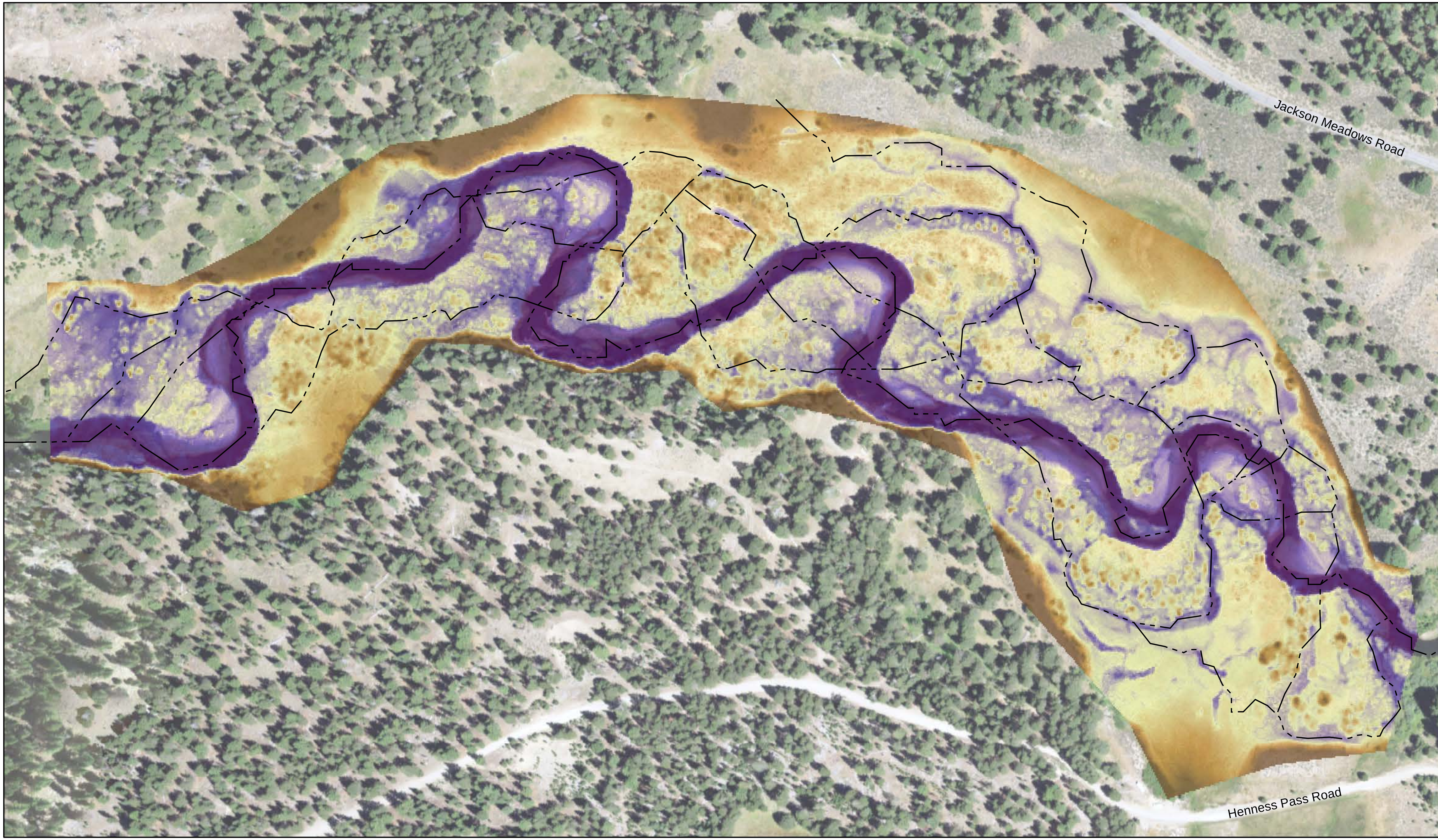
Legend

- Relict Channels
- Moraine Crest
- Existing Roads
- Abandoned Road, Railroad or Skid Trail
- Seeps/springs

Geomorphic Facet

Qch	Active channel
Qc	Colluvium
Qf.p.	Floodplain deposits
Qsw	Slope wash
Qd2	Younger delta deposits (sand and gravel)
Qd1	Older delta deposits (sand and gravel)
Qg	Glacial drift (poorly sorted sand, silt, gravel and boulders)
Tv	Volcanic bedrock

Figure 5 . Geomorphic Features and Historical Disturbance, Lower Perazzo Meadows, Sierra County, California
Source: Hillshade Source USFS 2013



Balance Hydrologics, Inc.

Relative Elevation Model
(height above channel bed, feet)
0 4 8

Current Channels
(mapped by USFS)

N
0 100 200 400 Feet

Figure 6. Little Truckee River Relative Elevation Model, Lower Perazzo Meadow, Sierra County, California

Basemap source: NAIP

APPENDICES

APPENDIX A

NV5 Geotechnical Engineering Report:

Lower Perazzo Meadow Restoration Project

GEOTECHNICAL ENGINEERING REPORT
LOWER PERAZZO MEADOWS RESTORATION PROJECT

SIERRA COUNTY, CALIFORNIA

AUGUST 22, 2018

PREPARED FOR:

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PROJECT NO. 42411.00

Project No. 42411.00
August 22, 2018

Balance Hydrologics, Inc.
12020 Donner Pass Road
PO Box 1077
Truckee, California 96160

Attention: Dave Shaw

Reference: ***Lower Perazzo Meadows Restoration***
Sierra County, California

Subject: ***Geotechnical Engineering Report***

This report presents the results of our geotechnical engineering investigation for the proposed stream restoration project at Lower Perazzo Meadows located in Sierra County, California. Project plans were in the Revised 95 percent Design stage at the time this report was prepared. We understand the proposed project will involve restoration of the stream and meadow by filling in much of the Little Truckee River channel. Appurtenant construction will likely include construction of temporary haul roads, excavation and restoration of barrow area excavations.

Several potential barrow areas have been identified by Balance Hydologics largely based on the expected geomorphic landform or geologic deposit present at the site. Our subsurface investigation involved excavation of seven test pits using a small excavator. The purpose of our subsurface investigation was to help characterize the soil material within the potential barrow areas and provide recommendations for temporary haul roads. Our subsurface investigation in the possible barrow areas on the north side of the river encountered silty Sand with gravel and numerous angular cobbles and small boulders overlying silty fine Sand that appeared to be indicative of near-surface meadow deposits. These deposits appear to be colluvium that appears to have been deposited during or subsequent to extensive logging that occurred at the site in the 1870's and 1880's. Our exploration on the south side of the river encountered well sorted Sand with some silt and gravel and interbedded Silt, Sand, and Gravel in areas mapped as Younger and Older delta deposits. In summary, the majority of soil encountered in our test pits consisted of granular soil and should be suitable for use as channel fill.

Tests in the wet meadow area indicated that very loose to loose material exists in the upper 8 to 10 feet of the meadow. We expect haul roads crossing the meadow soil may become unstable under construction traffic loads. We have provided recommendations for temporary haul roads in this report.

Our professional opinion is that the site is suitable for the proposed project using conventional earthwork grading techniques. No highly compressible or potentially expansive soil conditions were encountered during our subsurface exploration. Specific recommendations regarding the geotechnical aspects of project design and construction are presented in the following report.

The findings presented in this report are based on our subsurface exploration, laboratory test results, and our understanding of the proposed project. We recommend retaining our firm to provide construction monitoring services during earthwork to observe subsurface conditions and haul road conditions encountered with respect to our recommendations provided in this report.

Please contact us if you have any questions regarding this report or if we can be of additional service.

Sincerely,
NV5

Prepared by:

Austin L. Metz.
Staff Engineer

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
JOHN K. HUDSON
8/22/18
No. C 050923
CIVIL
STATE OF CALIFORNIA

John K. Hudson, P.E., C.E.G.
Principal Engineer

copies:

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APPENDICES

1 INTRODUCTION

This report presents the results of our geotechnical engineering investigation for the proposed Lower Perazzo Meadows restoration project in Sierra County, California. We performed our investigation in general accordance with our December, 27, 2017 proposal for the project. A copy of the proposal is included as Appendix A of this report. For your review, Appendix B contains a document prepared by the Geoprofessional Business Association entitled *Important Information about This Geotechnical-Engineering Report.* This document summarizes the general limitations, responsibilities, and use of geotechnical engineering reports.

1.1 PURPOSE

The purpose of our work was to explore and evaluate the subsurface conditions at the potential barrow sites to provide geotechnical engineering conclusions and recommendations for project design and construction.

Our findings are based on our subsurface exploration, laboratory test results, and our understanding of the planned project. We recommend retaining our firm to provide construction monitoring services during earthwork to observe subsurface conditions encountered with respect to our recommendations.

1.2 SCOPE OF SERVICES

To prepare this report we performed the following scope of services:

- We performed a site reconnaissance, literature review, and subsurface exploration involving test pits excavated with a mini-excavator and a dynamic cone penetrometer.
- We logged the subsurface conditions encountered and collected bulk soil samples for classification and laboratory testing.
- We performed laboratory tests on selected soil samples obtained during our subsurface investigation to evaluate material properties.
- Based on our subsurface exploration and the results of our laboratory testing, we performed engineering analyses to develop geotechnical engineering recommendations for project design and construction.

1.3 SITE DESCRIPTION

Lower Perazzo Meadows is located about 15 miles north of Truckee along the Little Truckee River in Sierra County, California. Perazzo Meadows consists of a series of wet meadow complexes located along the east slope of the Sierra Nevada mountain range. The meadow complexes are at an elevation of approximately 6,500 feet. The existing meadow is a riparian and wetland system that has been subject to a long history of human disturbance, including logging, grazing, and road and rail road construction. As a result, the meadow system has degraded, including streambank erosion and channel incision. The stream reach is in need of restoration. The approximate location of the site is shown on Figure 1, Site Vicinity Map. A plan view of the project site is shown on Figure 2, Test Pit Location Plan.

The project site is located on recently purchased Truckee Donner Land Trust property bounded by Fiberboard Road to Jackson Meadows Reservoir to the north, Henness Pass Road to the south, and is located in the south half Section 16, Township 19 North, Range 15 East. Vegetation at the site consists of wet meadow grasses, willows, conifer trees and bushes.

The site is located at 39°29'42"N latitude and 120°19'36"W longitude (WGS84 datum). Site elevations range from approximately 6451 feet above mean sea level (MSL) at the downstream end of the project to approximately 6,600 feet MSL in the southern part of the project.

1.4 PROPOSED IMPROVEMENTS

Information about the proposed project was obtained from our site visits, conversations with Balance Hydrologics and project plans provided by Balance Hydrologics Inc. As currently proposed, the project consists of restoration of the meadow by filling in the incised channel with locally sourced material. The fill material will come from several potential barrow areas, designated Alternate A through Alternate I. Construction will include construction of temporary haul roads, excavation at barrow pits, and stabilization of barrow pit cut slopes and revegetation.

We anticipate the fill depths will range up to about 10 feet in the channel. No structures are planned. Depending on the particular barrow area, cut depths may range up to 20 feet or more.

2 LITERATURE REVIEW

We reviewed available geologic and soil literature in our files to evaluate geologic and anticipated subsurface conditions at the project site.

2.1 SITE GEOLOGY

Perazzo Meadows is located on the eastern edge of the Sierra escarpment and is characterized by a dynamic geologic history of faulting and volcanic activity that is overlain by a more recent period of glaciation and erosion. The Lower Perazzo Meadows watershed is dominated by andesitic volcanic rock and mudflows. The meadows are primarily underlain by recent alluvial material. We reviewed the *Geology of the Independence Lake and Hobart Mills 7.5' Quadrangles, Nevada and Sierra Counties, California*, by Arthur Gibbs Sylvester and Gary L. Raines, California Geological Survey, 2017. The map shows the site is underlain by Tahoe age Glacial till and recent alluvium. As the glaciers retreated they left lateral and terminal moraines. The terminal moraines often formed lake basins that filled in slowly to form meadows as glacial deposits were reworked and transported by rivers and streams. During the Pleistocene geologic age there were numerous glacial advances where lake formation occurred, resulting in several alluvial terraces. After disappearance of the glaciers, streamflow in the Little Truckee River declined significantly, resulting in the formation of a meandering channel within a broad glacially derived alluvial valley.

In addition we reviewed an unpublished geologic map titled *Geomorphic Features and Disturbance, Lower Perazzo Meadows, Sierra County, California*, by Balance Hydrologics Inc., 2018. The Balance Hydrologics map indicates that the site is underlain by Colluvium, Floodplain deposits, Slope Wash, Younger and Older Delta deposits, Glacial Drift, and Volcanic Bedrock. Based on our subsurface investigation and review of LIDAR images, the prominent terraces located south of the Little Truckee River appear to be deltaic deposits that settled in standing water. The colluvial deposits mapped on the north side of the river appear to be largely historic material that was deposited during or subsequent to logging activity in the site area.

3 SUBSURFACE EXPLORATION

We performed our subsurface exploration to characterize typical geologic subsurface conditions at the site.

3.1 FIELD EXPLORATION

Subsurface conditions at the site were investigated on July 11, 2018 by excavating seven exploratory test pits to depths ranging from 5½ to 20 feet below the ground surface (bgs). Test pits were excavated with a CAT 305 CR mini-excavator equipped with a 24-inch bucket. Test Pit TP-6 was excavated within an existing barrow site, resulting in the 20-foot maximum depth. Test pit locations were selected based on locations of proposed barrow areas and site access.

An engineer from our firm logged the soil conditions exposed in the test pits, visually classified soil, and collected bulk soil samples for laboratory testing. Soil samples were packaged and sealed in the field to reduce moisture loss and were returned to our laboratory for testing. Upon completion, test pits were backfilled with the excavated soil. The approximate locations of our test pits are shown on Figure 2, Test Pit Location Plan.

3.2 SUBSURFACE SOIL CONDITIONS

We investigated the near-surface soil in the mapped geologic deposits in order to characterize the near surface soil material at potential barrow areas. The potential barrow areas were designated Alt A through Alt I on the Balance Hydrologics plans. Test Pit TP-1 was excavated approximately 100 feet west of barrow area Alt F in an area marked as Glacial drift (Qg). Test Pits TP-2 through TP-4 were excavated within barrow areas Alt G, H, and I, respectively, and all lie within the area outlined as Colluvium (Qfp). Test Pits TP-5 through TP-7 were excavated within an area mapped as Older delta deposits (Qd2) and were located within or near barrow areas Alt B, C, D, and E.

Test Pit TP-1 encountered about 9 inches of loose silty Sand (SM) containing organic material (topsoil) underlain by poorly graded Sand with gravel (SP) that appeared to be alluvial terrace deposits. Test Pit TP-1 was terminated at 6 feet below the ground surface (BGS) due to caving conditions.

Near-surface soil encountered in Test Pits TP-2 through TP-4 consisted of approximately 2½ to 4 feet of dark brown to black silty Sand with gravel (SM) with numerous angular cobbles and small boulders. This material was overlying silty fine Sand (SM) that was coincident with the adjacent meadow surface. The colluvium deposits on the north side of the river appear to be historic colluvium. Evidence of historic deposition of this material includes the lack of stratification or soil horizons, large cobbles and boulders in the meadow area well away from the slope, broken cobbles and scars on numerous cobbles and boulders, and a relatively high organic content in the colluvium. Below the historic colluvium, Test Pit TP-4 encountered 1½ to 2 feet of buried topsoil or paleosol consisting of olive brown to blue grey silty Sand with gravel (SM) and decomposed organic matter.

Test Pits TP-5 and TP-6 encountered interbedded loose to medium dense silty to clean Sand (SP to SM) and thin layers of clean Gravel (GP). Test Pit TP-5 encountered interbedded layers poorly graded Sand (SP) and stiff sandy Silt (ML) with glacial varves.

Test pit 6 was excavated within an existing barrow area and the test pit was logged from the original ground surface. We excavated a shallow trench down the approximately 15-foot high existing cut slope, and then a test pit at the bottom of the slope. Our test pit encountered medium dense silty Sand (SM) with discontinuous lenses of poorly graded Sand and poorly graded Gravel to the maximum depth explored.

Test Pit TP-7 encountered silty Sand with fine to course gravel (SM). The deposit appears to be alluvial material with maximum particle size up to small cobbles.

More detailed descriptions of the subsurface conditions observed are presented in our Test Pit Logs in Appendix C.

3.3 GROUNDWATER CONDITIONS

We observed groundwater during our subsurface exploration in Test Pit TP- 4 at a depth of 4½ feet bgs. Groundwater in the stream bottom will be nearly coincident with the water level of the Little Truckee River. Groundwater levels in the upland areas away from the river may consist of seasonally perched water. However, it is unlikely that significant quantities of water will be encountered in the summer or fall months at the barrow areas away from the stream course.

4 LABORATORY TESTING

We performed laboratory tests on bulk soil samples collected from our exploratory test pits to evaluate their engineering properties. We performed the following laboratory tests:

- Sieve Analysis (ASTM D422)
- Atterberg Limits / Plasticity (ASTM D4318)

Sieve analysis and Atterberg limits data resulted in Unified Soil Classification System (USCS) classifications of silty Sand (SM) and sandy silt (ML). More specific soil classification and laboratory test data is included in Appendix D. USCS classifications and Atterberg indices are summarized below.

Table 4.1 – Summary of Laboratory Test Results

Test Pit Number	Depth (feet)	USCS Classification	Percent Passing #200 Sieve	Liquid Limit	Plasticity Index
TP-2	2½ - 3	Silty Sand with Gravel (SM)	31.3	--	--
TP-4	5½ – 6	Silty Sand (SM)	44.6	34	8
TP-5	3 – 3½	Sand with silt (SP)	55	NP	NP
TP-5	6½ - 7 ½	Silt (ML)	96.8	NP	NP

5 CONCLUSIONS

The following conclusions are based on the results of our subsurface exploration, field observations, laboratory test results, and engineering analyses.

1. Soil conditions encountered during our field investigation generally consisted of loose to medium dense coarse-grained soil and small amounts of stiff fine-grained soil types of low to moderate plasticity. The colluvial deposits on the north side of the river appear to be historic colluvium that was deposited during or subsequent to extensive logging in the area. The colluvium consists of relatively thin (up to about 4 feet thick) layers of silty Sand (SM) with cobbles and small boulders. Numerous cobbles and boulders are scared, likely from mechanical movement of the material. There appears to be enough silt in the material to provide cohesion and reduce the potential for erosion. Although there are numerous small boulders in and on the colluvium, screening would likely be required to use the material as a source of clean boulders. Soil encountered within the colluvial deposits will be suitable for use as channel fill material.
2. The upland area soil should provide adequate haul road support. However, the meadow area soil may quickly become unstable if wet or saturated. Wet soil areas at the bottom of historical colluvium deposits that are used for barrow areas north of the Little Truckee River may become unstable under vehicle traffic. Due to the needed volume of fill, the number of loads with haul trucks will be significant and the hauling of barrow soil to the channel will be an important part of the project. One strategy to maintain access to barrow areas and haul routes to the channel will be to use several barrow sites, so a lesser number of trips is taken from the barrow area to the channel. The stream channel may provide a stable route for haul truck travel. We have provided a discussion and recommendations for haul road construction and routing in this report.
3. The potential barrow areas located in the delta deposits on the south side of the river contain relatively clean sand and fine gravel that may be susceptible to excessive erosion. Blending of these soil types with finer grained material may be beneficial to reduce potential erosion. If this material is used, fill areas should be graded and revegetated to reduce the potential for excessive erosion. A substantial source of boulders for grade control structures was not encountered at the barrow areas investigated.
4. The barrow areas will be relatively large and will require restoration. Landform/geomorphic grading attempts to mimic slopes, landform shapes and vegetation patterns for long-term, self-sustaining properties. The barrow areas should be shaped to blend with the adjacent landforms to provide a natural looking topography and vegetation pattern.

6 RECOMMENDATIONS

The following geotechnical engineering recommendations are based on our understanding of the project as currently proposed, our field observations, subsurface exploration, results of our laboratory tests, engineering analyses.

6.1 EARTHWORK

The following sections present our recommendations for excavating barrow material, landform grading of barrow areas, fill placement within the channel and stability of temporary haul roads.

6.1.1 Barrow Area Anticipated Excavation Conditions

Areas planned for excavation of barrow soil should be stripped of vegetation prior to excavation. Organic topsoil should be stockpiled for restoration placement back on barrow areas. Based on our subsurface exploration, we expect that 6 inches may be used as a reasonable estimate for average depth of stripping.

Potential barrow areas Alt F, G, H and I appear to be historical colluvium within a layer or lobe deposit approximately 2 ½ feet to 4 feet thick consisting of relatively well graded silty Sand with cobbles and small boulders. The soil is suitable from a geotechnical engineering standpoint for use as channel fill. These deposits may be excavated down to the original ground coincident with the adjacent meadow surface. We anticipate previously undisturbed native soil will be encountered at approximately 2 to 4 feet below the existing grade in these areas. Cobbles and boulders could be screened out or sorted and used in the downstream boulder and cobble grade control. Cut slopes within the colluvium should be stable at inclinations up to 2H:1V (horizontal to vertical); however, re-vegetating cut slopes at these inclinations may be difficult. Flatter slopes should be more susceptible to vegetation growth.

Barrow areas Alt A through D will likely encounter fluvial deposits consisting of interbedded layers of silty Sand (SM) to clean Sand (SP) with gravel, and lesser amounts of sandy Silt (ML) and fine to coarse poorly graded Gravel (GP). ~~These deposits are the result of an interesting geologic depositional environmental where the sediments were deposited in a fluvial environment.~~ Silt beds in the Older Delta deposits are thinly varved, representing seasonal sedimentation of summer (light colored) and winter (dark colored) beds within a single year. Although these soil types are suitable for use as fill material, the cleaner sand material may be more prone to erosion. Cut slope inclinations will again be stable at inclinations up to 2H:1V; however, re-vegetating cut slopes at these inclinations will be difficult.

Potential barrow area Alt E is located in a dense forest area and appears to be an alluvial terrace deposit consisting of silty Sand with gravel (SM).

6.1.2 Geomorphic Grading

Geomorphic Grading or Landform Grading is the attempt to mimic the natural slope, shape, and vegetation of a disturbed area. Grading plans at the site should include specifications for restoration of the barrow area and haul road cuts that mimic the landforms at the site. Slopes should curve convex at the top and concave at the bottom similar to adjacent slopes. The lateral extent of slopes should match pre-disturbed and adjacent landform slopes. These slopes should be self-sustaining and should revegetate easier than straight profile slopes. After revegetation they should appear like natural landforms.

The two primary landforms at the potential barrow areas consist of the historical colluvial aprons at Alt F – Alt I, and the delta lobes at Alt A – Alt D. We recommend the colluvial aprons be completely removed down to the former meadow surface that is present under the colluvial deposits. Provided there is meadow seed available and groundwater raises to the meadow surface, the resulting surface should revegetate to a wet meadow habitat. The delta deposits should be excavated down to the lower terrace level or to the meadow elevation. The constructed slope inclinations should mimic the adjacent slopes and the edges of the barrow excavations should be rounded into the remaining landform.

Cleared vegetation and topsoil from the site can be replaced after construction activity in order to expedite the restoration process. Cut slopes should be limited to inclinations of 2H:1V or less. However, as previously stated, these slopes will be difficult to revegetate. The upper two to five feet of cut slopes should be rounded into the existing terrain above the slope to remove loose material and produce a contoured transition from cut face to natural ground. The upper four to eight inches may be scarified to help promote revegetation.

6.1.3 Fill Placement

All fill placed for the project should be considered common fill as opposed to structural fill. Material used for fill may consist of site barrow soil or imported soil, however, imported soil may have strict weed free requirements. Areas proposed for fill placement, should be cleared and grubbed of larger vegetation. Organic surface soil may be stockpiled for future use in planting areas. We anticipate that the actual depth of stripping will vary across the site and may be greater in wooded areas. Processing or screening of the fill may be required to remove large rocks.

Where fill placement is planned, the near-surface soil should be scarified to a depth of about 8 inches. Channel fill should be placed in lifts and nominally compacted to fill voids to the lines and grade shown on the project plans. A compaction specification is not necessary for proper fill performance.

6.1.4 Temporary Haul Road Construction

We anticipate the total project fill volume to be on-the-order-of 47,000 cubic yards, resulting in approximately 170 haul-truck loads. Soil within the meadow may be loose and saturated, and may become unstable under construction traffic. The amount of precipitation prior to and during construction may significantly impact soil and haul road stability. If site grading is performed during periods of wet weather, near-surface site soil may be significantly above its optimum moisture content. These conditions could hamper equipment maneuverability. The upland area soil should provide adequate haul road support. However, the meadow area soil may quickly become unstable if wet or saturated. Wet soil areas at the bottom of historical colluvium deposits that are used for barrow areas north of the Little Truckee River may become unstable under vehicle traffic.

In order to reduce construction disturbance and constructability, multiple haul routes should be planned and trips on a single route through the meadow area should be minimized as much as possible. Several barrow areas should be utilized in order to reduce the traffic that each haul route supports. We recommend that the sod mat remain on all meadow routes to help reinforce the surface soil. Routes should minimize the distance crossing the meadow, and utilize the dewatered stream channel and gravel bars where possible. Areas that become unstable and exhibit pumping or rutting could be temporarily covered with a layer of filter fabric or geogrid and a 12 to 18 inch course of angular cobble to allow vehicle traffic, however, this is not practical for larger areas. We do not anticipate fill will be required for haul road construction. Cut slopes may be required to reach operational grades. Cut slopes should be restored in the same fashion outline in Section 6.1.2 Geomorphic Grading.

6.2 PLAN REVIEW AND CONSTRUCTION MONITORING

Construction monitoring includes review of plans and specifications and observation of onsite activities during construction. We recommend retaining our firm to provide construction monitoring services during earthwork to observe subsurface conditions encountered with respect to our recommendations provided in this report.

7 LIMITATIONS

Our professional services were performed consistent with generally accepted geotechnical engineering principles and practices employed in the site area at the time the report was prepared. No warranty, express or implied, is intended.

We are not responsible for the impacts of changes in environmental standards, practices, or regulations subsequent to performance of our services. We do not warrant the accuracy of information supplied by others or the use of segregated portions of this report. This report is solely for the use of our client. Reliance on this report by a third party is at the risk of that party.

If changes are made to the nature or design of the project as described in this report, then the conclusions and recommendations presented in the report should be reviewed by NV5 to assess the relevancy of our conclusions and recommendations.

Analyses, conclusions, and recommendations presented in this report are based on site conditions as they existed at the time we performed our subsurface exploration. We assumed that subsurface soil conditions encountered at the locations of our subsurface explorations are generally representative of subsurface conditions across the project site. Actual subsurface conditions at locations between and beyond our explorations may differ. If subsurface conditions encountered during construction are different than those described in this report, we should be notified so that we can review and modify our recommendations as needed.

The elevation or depth to groundwater and soil moisture conditions underlying the project site may differ with time and location. The project site map shows approximate exploration locations as determined by a handheld GPS. Therefore, exploration locations should not be relied upon as being exact.

The findings of this report are valid as of the present date. Changes in the conditions of the property can occur with the passage of time. These changes may be due to natural processes or human activity, at the project site or adjacent properties. In addition, changes in applicable or appropriate standards can occur, whether they result from legislation or a broadening of knowledge. Therefore, the recommendations presented in this report should not be relied upon after a period of three years from the issue date without our review.

8 REFERENCES

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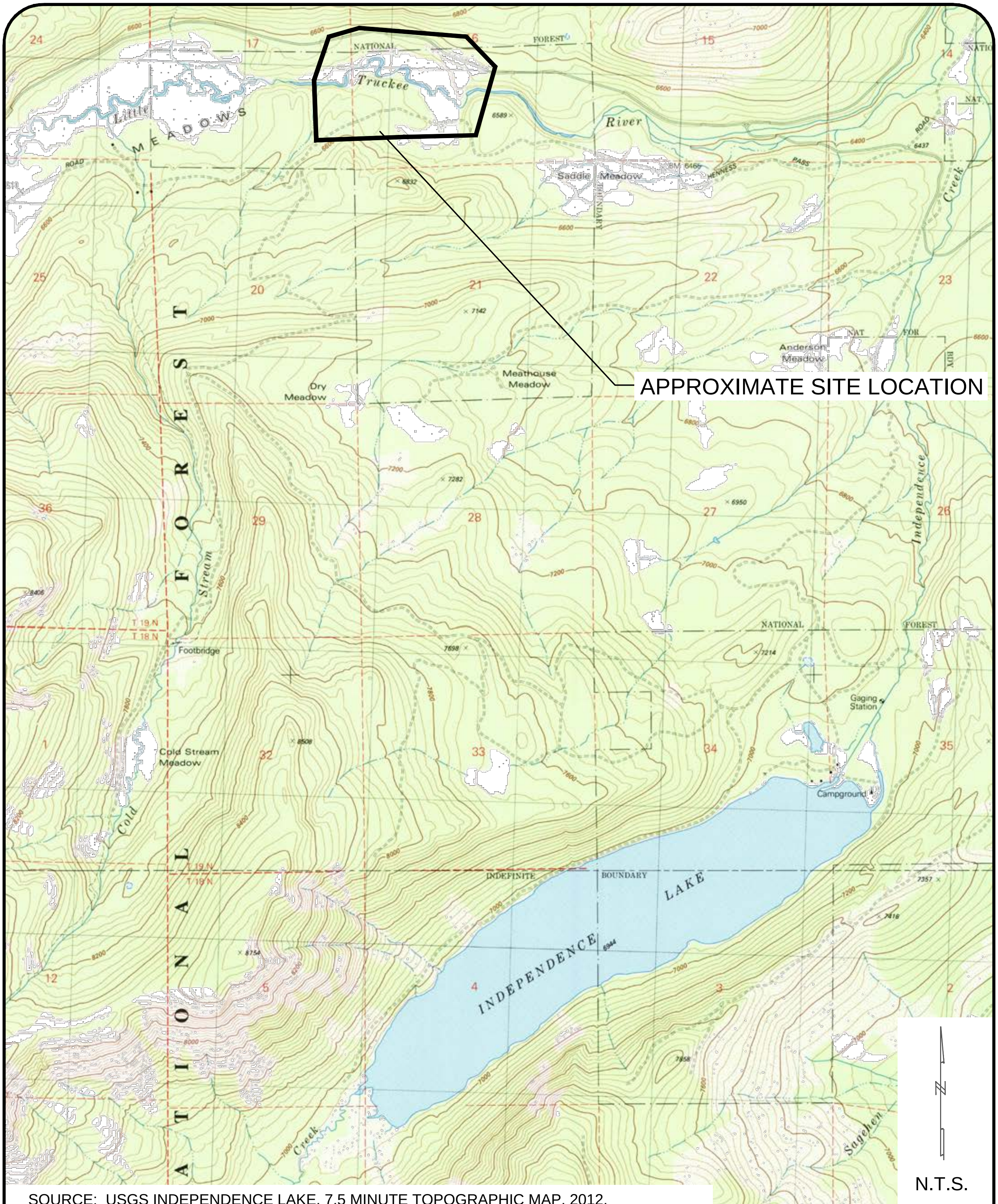
FIGURES

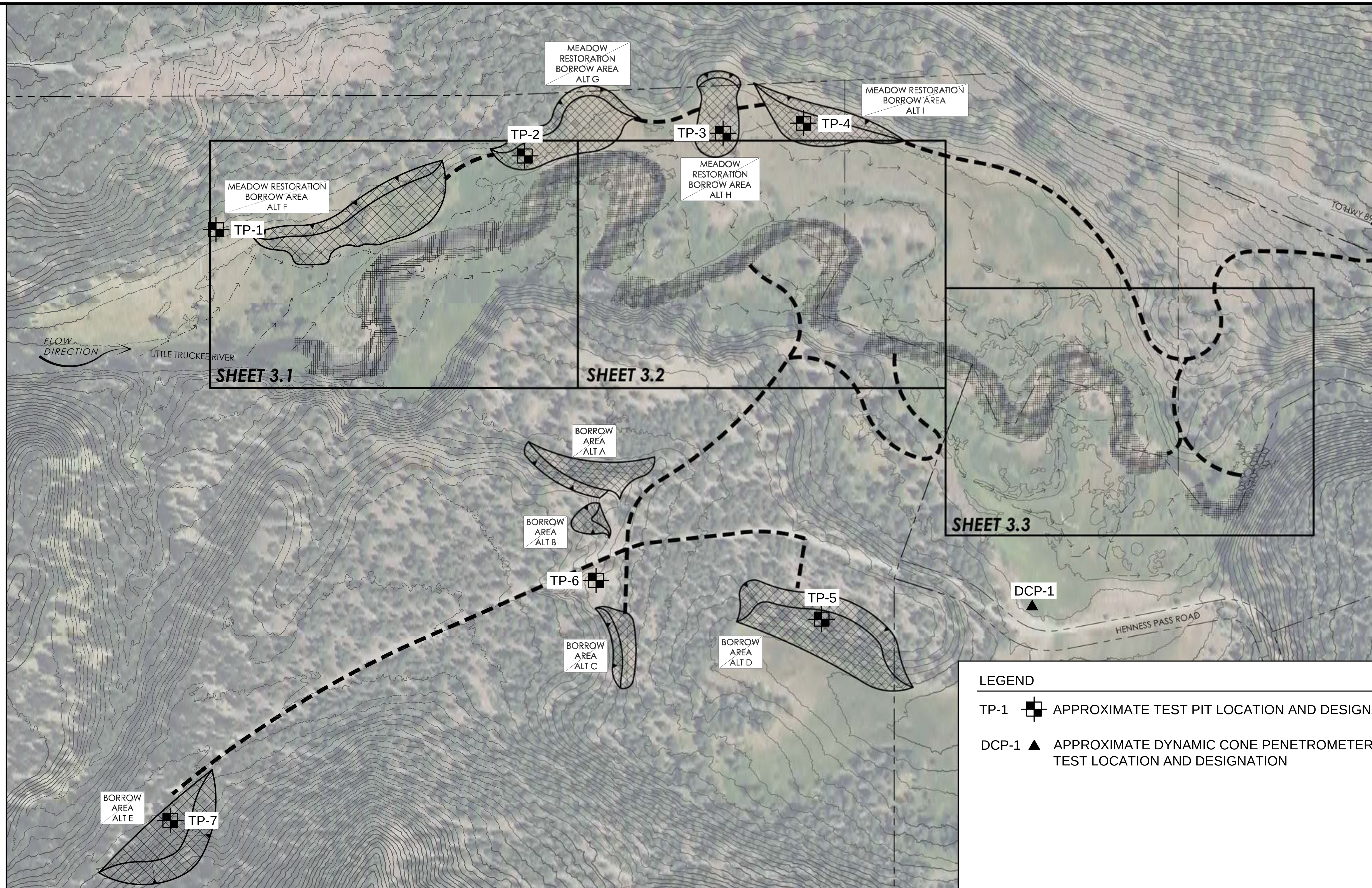


SOURCE: USGS INDEPENDENCE LAKE, 7.5 MINUTE TOPOGRAPHIC MAP, 2012.

N|V|5

SITE VICINITY MAP
LOWER PERAZZO MEADOWS
SIERRA COUNTY, CALIFORNIA

PROJECT NO.: 42411.00
DATE: AUGUST 2018
FIGURE NO.: 1



LEGEND

TP-1 APPROXIMATE TEST PIT LOCATION AND DESIGNATION

DCP-1 ▲ APPROXIMATE DYNAMIC CONE PENETROMETER TEST LOCATION AND DESIGNATION

NOT TO SCALE

MODIFIED OVERVIEW MAP AND ACCESS AND STAGING PLAN, LOWER PERAZZO MEADOW RESTORATION, PROVIDED BY BALANCE HYDROLOGICS, INC. DATED APRIL 6, 2018.

NV5

TEST PIT LOCATION PLAN
LOWER PERAZZO MEADOWS
SIERRA COUNTY, CALIFORNIA

DRAWN BY: ALM	CHECKED BY: JKH
PROJECT NO.: 42411.00	
DATE: AUGUST 2018	
FIGURE NO.: 2	