TECHNICAL MEMORANDUM

DATE October 31, 2019 **Project No.** 179018601

TO Erika Guerra, Talia Flagan
Lehigh Permanente

CC Brent Zacharia, Waterways Consulting, Inc.

FROM Robert Humphries; William Fowler, PG 4401, CEG 1401 **EMAIL bfowler@golder.com**

GEOLOGIC AND GEOMORPHIC ASSESSMENT OF PERMANENTE CREEK, LEHIGH HANSON PERMANENTE QUARRY, SANTA CLARA COUNTY, CA

1.0 INTRODUCTION

This technical memorandum provides the results of our geologic and geomorphic assessment of the Permanente Creek Restoration Plan – 90% Level Submittal, Waterways Consulting, Inc., dated 11/15/18 and updated 10/31/19 (the Project). The focus of the study was to determine if there were any specific areas of the proposed project which require further subsurface geotechnical exploration and testing to refine the project restoration design, so as to respond to comments dated February 14, 2019 from the County of Santa Clara Planning Office ("County"). Specifically, this work focused on a field assessment of the proposed alignment and longitudinal gradient of the proposed stream channel and how it compares to existing conditions. Particular attention was placed on the Rock Pile and Material Removal Area and the proposed depth of excavations required and stability of the adjacent creek sideslopes.

The scope of work for our study included a desktop data review, and site reconnaissance and mapping of the project area to evaluate the geologic conditions in conjunction with the proposed restoration design. The work product from our investigation includes a geologic map and cross sections of the project area, along with this technical memorandum. This memorandum includes:

- A brief presentation of the methods applied in this assessment
- A summary of pertinent supporting data from our previous investigations throughout the facility
- A geologic map and a description of the earth materials encountered along Permanente Creek
- A geologic and geomorphic assessment of the Permanente Creek channel profile
- A discussion of these results and their significance to the proposed Permanente Creek Restoration Plan
- Golder Associates Inc.'s (Golder) conclusions and recommendations regarding this assessment

2.0 METHODS

2.1 Data Compilation and Review

Golder reviewed available existing data pertaining to the project including aerial photographs, historical USGS topographic and geologic maps, site boring logs, seismic data from previously completed work within the project area, the Waterways 90% plan set, and pertinent site and regional geologic data.

2.2 Site Reconnaissance

Golder conducted a site visit over three days from July 25 to 27, 2019. The field team consisted of three primary members, including a fluvial geomorphologist, a geohazards geologist, and a staff geologist. The field team was given a site orientation and tailgate safety briefing by a locally based senior technician with long term familiarity with the site and specific knowledge of creek access points and safety. Creek access is difficult, and locally hazardous, because of very steep terrain, heavy vegetation, and other obstacles such as loose rock, fallen trees, etc. This rugged terrain also severely limits access for drill rigs to many of the reaches of the creek.

Golder communicated with Waterways to discuss our initial opinions and received feedback as to what specific reaches or features needed further study, or have the most uncertainty, with respect to the 90% design effort to focus our field mapping efforts. The field mapping efforts focused on the reaches that include the following two areas: 1) Rockpile and 2) Material Removal Area. Note, however, that the entire project area was traversed on foot by the field reconnaissance team.

2.3 Field Mapping

The mapping focused on defining areas of mining disturbance, (e.g., overburden, roads, structures, etc.) versus native slopes and development of geologic cross sections in key locations (e.g., Rockpile and Materials Removal Area). The mapping also identified other pertinent geomorphic features such as native slope angles, natural shallow slides, areas of erosion, sediment accumulation, bedrock exposures, etc.

3.0 REGIONAL GEOLOGIC AND GEOMORPHIC SETTING

3.1 Bedrock Geologic Units

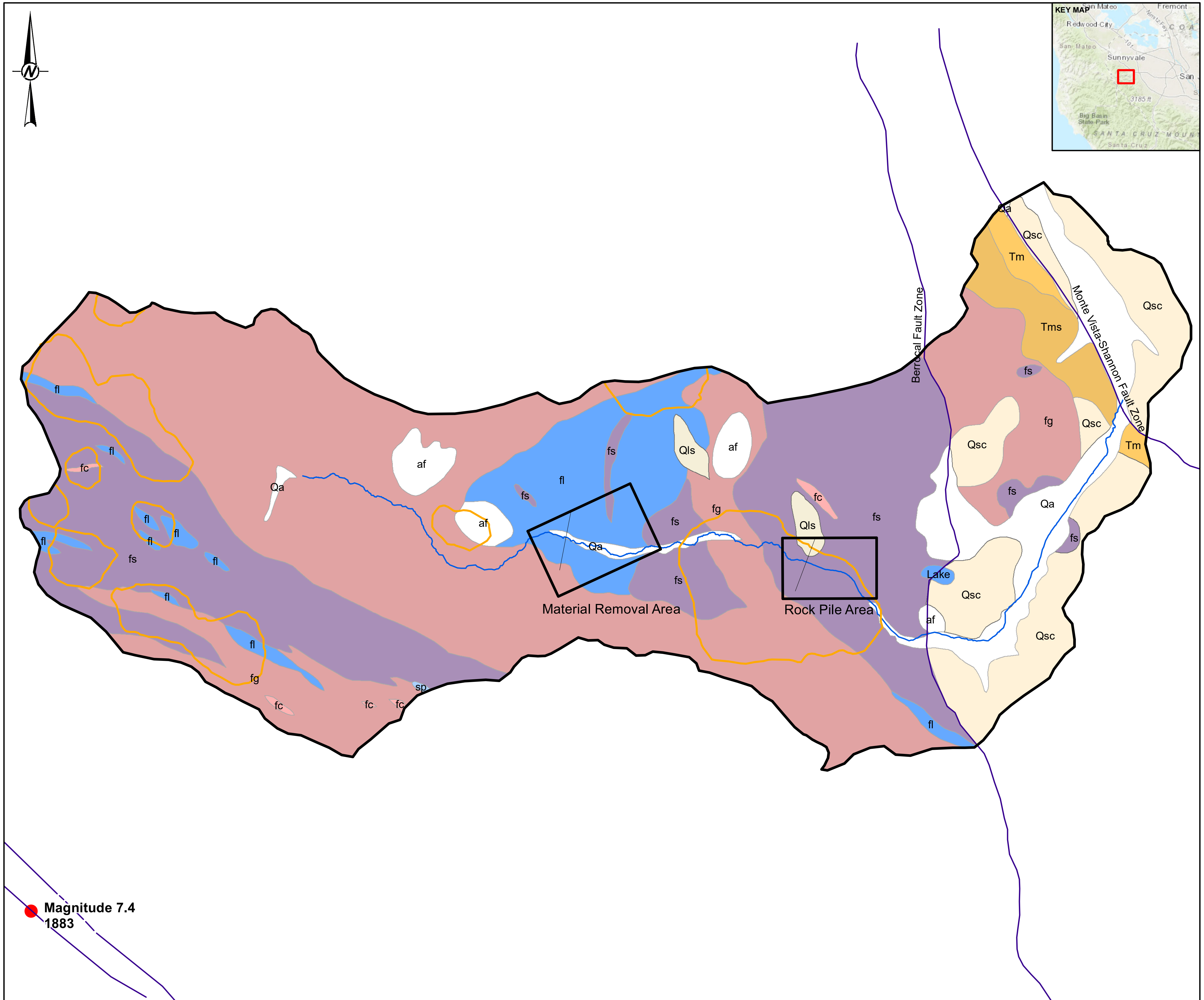
The bedrock materials exposed in the Quarry are part of the Permanente Terrane of the Franciscan Assemblage. The Franciscan Assemblage is comprised of highly deformed and variably metamorphosed, marine sedimentary rocks with submarine basalt (greenstone), chert, and limestone. The Franciscan is considered a tectonic mélange that was formed in the subduction zone between the Pacific tectonic plate and the North American plate. This plate boundary is now a transform, strike-slip plate boundary defined by the San Andreas Fault zone located about two miles southwest of the Quarry.

Golder has referenced two geologic map sources in our presentation of the geology of the Permanente Creek Basin (Figure 1). One set of maps comes from the Cupertino and Mindego Hills quadrangles (Dibblee and Minch 2007a and b), and the other comes from the San Francisco Bay Landslide Mapping Team (USGS 1997). Previous researchers have mapped the basin (Brabb 1970, Pulver 1979a and b).

3.2 Surficial Geologic Units

3.2.1 Overburden and Fill

Many of the south-facing slopes that flank Permanente Creek are mantled with varying thicknesses of overburden. These are generally described as side-cast fills that mantle existing canyon slopes and fill small



LEGEND

- Areas of Interest
- Cross Sections
- Permanente Creek
- PermCrkBasin_V2
- Mostly Landslides
- Faults
- Earthquake Epicenter Location

Geologic Units

UnitNam

- Lake
- af
- Qa
- Qls
- Qsc
- Tm
- Tms
- sp
- fg
- fs
- fc
- fl

0 2,000 4,000

1 IN = 1,667 FT FEET

NOTE(S)
1. LINE NOTES
2. LINE NOTES
3. LINE NOTES

REFERENCE(S)
1. USGS (LANDSLIDES, 1997; FAULTS, 2000, 2002)
2. CALIFORNIA DIVISION OF MINES AND GEOLOGY (EARTHQUAKES, 1982)
3. WATERWAYS CONSULTING, INC. (PERMANENTE CREEK, 2018)
4. CALIFORNIA DEPARTMENT OF FORESTRY (GEOLOGY AND LANDSLIDES, 1979)
5. COORDINATE SYSTEM: NAD 1983 STATE PLANE CALIFORNIA III (FT)
6. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC.

PROJECT
GEOLOGIC AND GEOMORPHIC ASSESSMENT OF PERMANENTE CREEK

TITLE
GEOLOGIC MAP OF PERMANENTE CREEK BASIN

CONSULTANT
GOLDER

YYYY-MM-DD	2019-10-02
DESIGNED	RPH/BVJ
PREPARED	RPH/BVJ
REVIEWED	BF/CJ/RPH
APPROVED	BF

PROJECT NO.	PHASE	REV.	FIGURE
179018601	100	0	1

drainages and swales that formerly reported to Permanente Creek. The overburden deposits are of highly variable thickness, starting at the Rock Pile Area and continuing up through the Material Removal Area. A large percentage of this material within the Project area will be removed as part of the restoration effort.

The Rock Pile area is comprised of stockpiled material for production. The character of the overburden is variable but generally consists of fine to coarse gravel to angular cobble sized rock fragments. Elsewhere, overburden is a heterogeneous mixture of fines, sand, gravel and cobble sized fragments (i.e., greenstone, graywacke, cherts, and soil materials) but with small percentages of limestone.

3.2.2 Alluvium

This includes modern unconsolidated alluvial deposits along the active stream channel of Permanente Creek. These deposits are comprised of a poorly sorted mixture of cobbles, gravels, sand, silt and clay. Deposits range from a few inches thick in the upper reaches of the watershed where erosion has cut the channel down into bedrock, to tens of feet thick where the channel widens and deepens as it approaches the flatter terrain of the Santa Clara Valley.

3.2.3 Colluvium

Colluvial and slope wash deposits are common throughout the steep terrain of the Santa Cruz Mountains. In general, the natural slopes in the region are overlain with approximately one to two feet of soil and colluvial materials, which thicken to several feet or more in the larger natural swales in the region. Colluvium is generally described as predominantly clayey sand with gravel to clayey gravel, with some gravelly clay.

3.2.4 Ancient Natural Landslide Deposits

Several large, ancient landslides have been mapped by various investigators in various areas of the 3,510-acre Lehigh property, and throughout the broader foothill's region (Figure 1). These landslides are generally described as possible old landslides and considered to be early Holocene or possibly late- Pleistocene features. These are naturally occurring landslides that are not related to any modern day mining activities. Along the south flank of Permanente Creek, two large landslides are identified by Sorg and McLaughlin (1975) while Rogers and Armstrong (1973) map only one of the landslide features.

The presence of these ancient landslides, as well as much smaller surficial slides that occur along the canyon walls, and in steep zero-order drainages that report to Permanent Creek, reflects the young, steep geologic terrain that comprises the Santa Cruz Mountains. The relatively thin surficial failures that are common in this terrain are to be expected going forward with this Project both from natural sources—like the zero-order drainages along the south canyon wall—and potentially from restored natural grades once overburden is removed as part of the Project. Note that one of the primary goals of the creek restoration program is to remove specified overburden and fill materials and restore, to the extent practicable, natural slope angles both along the longitudinal profile of the creek and transverse to the creek (i.e., the creek banks).

3.3 Faulting and Seismicity

The San Andreas Fault zone is located approximately two miles southwest of the Quarry (Figure 1). The Sargent-Berrocal Fault Zone (SBFZ), part of the Santa Cruz Mountains front-range thrust fault system, parallels the San Andreas to the east and forms the eastern-most structural boundary to the Permanente Terrain.

Near the Quarry, the SBFZ consists of two northwest-trending, sub-parallel faults, namely the northeastern-most Monta Vista Fault Zone and the southwestern-most Berrocal Fault Zone (Sorg and McLaughlin, 1975) (Figure 1).

The Monta Vista Fault Zone is located approximately 1 mile to the northeast of the Quarry. A strand of the Berrocal Fault Zone lies beneath the Permanente Cement Plant area to the south of the EMSA, and extends west to other portions of the Quarry (Mathieson, 1982; Sorg and McLaughlin, 1975).

Using the 2008 Update of the United States National Seismic Hazard Maps (Peterson, et.al., 2008), which incorporates the findings of the Next Generation Attenuation Relation Project, Golder estimates that design peak ground accelerations should be approximately 0.57g for the site.

4.0 BASIN GEOMORPHOLOGY

The geomorphology of the Permanente Creek basin is influenced by multiple active geologic processes. The highly active tectonics of the San Andreas Fault and other nearby faults and fault zones result in a high rate of uplift and relatively frequent, high magnitude earthquakes. The tectonic activity has modified both the headwater basins and offsets lower elevations of landscape in juxtaposition to each other. The relatively frequent occurrence of high magnitude earthquakes is likely to have increased magnitude and occurrence of ancient, naturally-occurring landslides within the basin. Additionally, the highly variable rock types, tectonic histories, and geomechanical properties of the accretionary island arc geology of the Franciscan mélange have resulted in highly differential rates of erosion. These differential erosion rates are expressed in the varying morphologic characteristics of the basin.

As an added complexity, the carbonate units of the Franciscan complex have resulted in carbonate-rich water precipitating travertine deposits on the bed and banks of Permanente Creek. These travertine deposits interact with the self-forming step-pools of the steeper portions of the channel and contribute to a repeating cycle of travertine dam formation and breaching (Fuller et al. 2010). Additionally, the subsurface precipitation of travertine in the interstitial voids between sediment grains in sediment deposits increases the intergranular bond strength, making the sediment more resistant to erosion and potentially decreasing the rippability of the material.

In addition to the natural processes interacting with the basin morphology, the long history of mining in the basin has also substantially interacted with the surface processes defining the basin morphology. The very high rate of sediment supplied to the channel, in the form of overburden and fill placed along the margin of the stream channel during the early history of mining (1940s and 1950s), has resulted in aggradation of the channel in lower gradient portions of the channel.

4.1 Fault Influence

The drainage basins of the northeast side of the Santa Cruz mountains are characterized by geomorphic features that are controlled by faulting. The features include right-lateral deflected and offset drainages, drainages that follow lineaments, sidehill benches, closed depressions, aligned benches, linear scarps, linear troughs, saddles, and linear vegetation contrasts (Smith 1981).

In the downstream portion of the basin, the Monte Vista-Shannon fault zone defines geomorphic features. These features are believed to have been formed during the Pleistocene and possible Holocene. They include the reverse displacement of lower elevation sediment to higher elevations than those of their original deposition, forming benches, saddles, linear valleys, faceted spurs, scarps, linear range fronts, linear depressions, and associated vegetation contrasts (Bedrossian 1980, Hitchcock et al. 1994).

Similarly, the Jurassic and Cretaceous aged rocks of the Franciscan Complex are thrust over Pliocene and Pleistocene alluvial sediment of the Santa Clara Formation and younger Quaternary deposits (Sorg and

McLaughlin 1975, Wesling and Helley 1989, McLaughlin et al. 1991, Hitchcock et al. 1994). On the site, colluvial deposits are thrust over fluvial gravel of Permanente Creek, indicating late Pleistocene and possible Holocene displacement (Hitchcock et al. 1994).

Hitchcock and Kelson (1999) noted that coseismic deformation associated with the 1989 Loma Prieta earthquake, was coincident with geomorphic features suggestive of faulting along the Monte Vista-Shannon fault zone (Haugerud and Ellen 1990, Hitchcock et al. 1994, Langenheim et al. 1997). This could indicate that repeated localized contraction is in part coincident with the occurrence of Loma Prieta-type earthquakes. This would suggest a recurrence interval of about 400 years (Working Group on California Earthquake Probabilities 1996). Hitchcock et al. (1994) reported a late Pleistocene displacement rate across the Monte Vista fault zone of 0.3 ±0.2 mm/yr.

4.2 Hillslopes and Landslide Processes

The Santa Cruz Mountains are a steep and rugged terrain with a long history of landslide activity. The geomorphology of the Permanente Creek basin exhibits a high rate of dynamic change. This high rate of change, termed morphodynamics, is driven by the complex interaction between the dual processes of rapid uplift associated with the compressional tectonics along the San Andreas Fault system (as discussed above) and the relatively weak, easily erodible, and highly variable rocks of the Franciscan Complex.

The resulting topography forms narrow, steep sided, and actively eroding canyons. The Santa Cruz Mountains, and Permanente Creek canyon, are subject to both shallow (e.g., debris flows or “mudslides”) and deep landslides (e.g., large rotational slumps or translational block glides). Average slope angles in the canyon are approximately 25 degrees (or 2H:1V) which is reflective of the natural stability of the highly broken and sheared greenstone and mélange terrane. Steeper slopes, greater than 35 to 40 degrees, are locally observed in areas underlain by more competent limestone and graywacke bedrock but these are the exception.

4.3 Geotechnical Background and Considerations

Golder has a long history of geologic and geotechnical investigations at the Permanente Site starting in 2006 and continuing to present. The investigations include (but are not limited to) sector specific investigations of the quarry pitshell including existing landslides, both the EMSA and WMSA overburden stockpiles and foundation conditions, several investigations for updated storm water basins, a new crusher location and foundation, and a proposed water treatment plant location. In summary, we have an extensive library of material properties and corresponding stability analyses and therefore a good understanding of slope behavior for different types of materials and slope angles. Our geotechnical recommendations for slope design, discussed below, are based on this extensive background. A summary of material types and properties based on a number of our previous investigations is included in Appendix A.

From a geotechnical perspective, the proposed project primarily involves excavation and removal of man-made surficial deposits (i.e., overburden and artificial fills) to restore the creek channel and creek banks back to a more natural state. The intent is to remove the man-made surficial materials down to bedrock (or native soils) while minimizing excavations/cuts into bedrock or soil slopes. In general, excavations onto canyon slopes will only be done where the surfaces have been altered or affected by mining activities. Existing natural slopes will not be modified or excavated.

Our geotechnical recommendations for the Project include:

- Rock Slopes: Slopes greater than 20 feet in height in greenstone materials should not exceed slope angles of 2H:1V if possible. Slopes less than 20 feet should perform adequately at 1.5H:1V; however, localized areas of instability may be encountered. Cutslopes in limestone and graywacke greater than 20 feet in height should not exceed 1H:1V and slopes less than 20 feet should be limited to no steeper than 3/4H:1V.
- Fill or Soil Slopes: For planning purposes, permanent slopes comprised of overburden, alluvium, colluvium or other site-derived fill should not exceed 2H:1V.

Earlier versions of the Project included construction of retaining structures, or engineered structural elements, that warranted more detailed geotechnical investigations for design purposes. Retaining structures have been eliminated from the Project (with the exception of the Material Removal Area), and with other modifications, the main geotechnical considerations are limited to recommended slope angles for final slopes of previously filled or otherwise disturbed surfaces.

The Material Removal Area, and the Rock Pile Area, present the largest challenges due to depths of the cuts that are required, and the steep natural terrain underlying and comprising the hillslopes that are overlain by overburden. In some locations along creek banks, it is anticipated that cuts will expose natural surficial materials (i.e., colluvium and slope wash) as opposed to bedrock and may require localized cuts steeper than 2H:1V in order to daylight the cuts into natural slopes.

The Material Removal Area may require a retaining structure, depending on timing of the creek restoration project with respect to site operations, to preserve infrastructure and access associated with the Upper Water Treatment System (UTS). This is discussed in further detail in Section 6.2.

5.0 SITE RECONNAISSANCE AND GEOMORPHIC CHARACTERIZATION

The following section provides a summary of our geomorphic observations of the Project. All station references in this report are coincident with that used by Waterways on Sheets C2-C4 in their 90% restoration plan report (2019).

5.1 Overview of Permanente Creek Profile

The profile of Permanente Creek can broadly be classified into depositional reaches and bedrock reaches (delineated on Figure 2 as Reach A, Reach B, etc.). The processes that define these reaches are the rate that sediment is supplied to the channel and the rate at which the channel can convey the supplied sediment. The rate of sediment supply is controlled by hillslope processes and the rate that sediment is delivered to the channel. The rate of sediment transport is controlled by the channel geometry and the hydraulic characteristics of the reach. The channel hydraulics are directly coupled to the rate at which water is delivered to the channel.

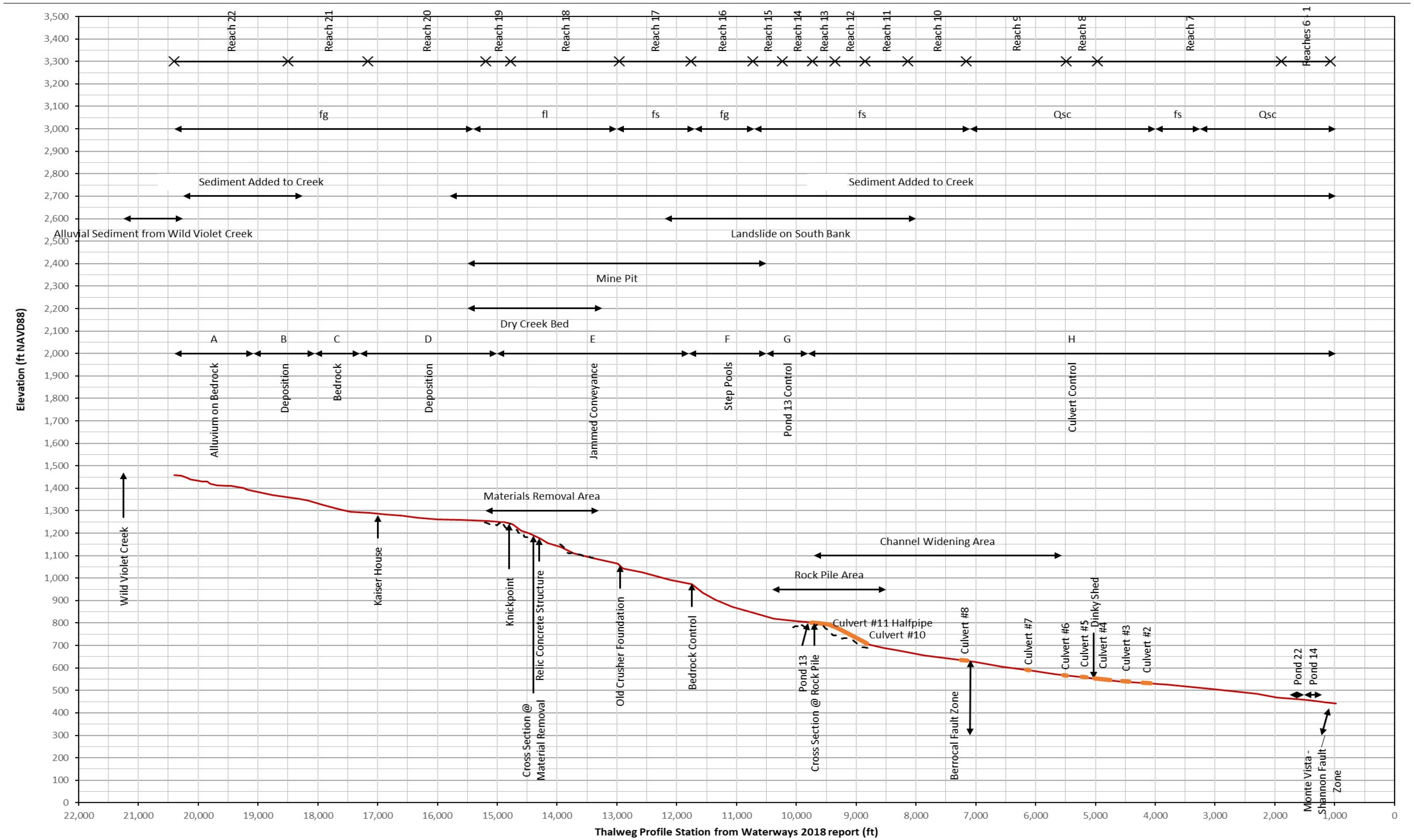


Figure 2: Permanente Creek Profile with geomorphic and geologic delineations. Stationing from Waterways (2019).

5.1.1 Reach A: Alluvium on Bedrock

The upstream most portion of the survey channel is characterized by alluvium in the form of travertine reinforced step pool morphology that partially covers a bedrock channel. The sediment supplied here is likely to come from natural processes and is likely partially supplied from an alluvial fan originating from Wild Violet Creek. Carbonate-rich water percolates from the south bank of the channel in this reach, indicating that the source of the carbonate-rich spring is likely within the Wild Violet drainage. Geologic maps (Dibblee and Minch 2007a and b) indicate that the limestone unit of the Franciscan complex outcrops within the Wild Violet drainage. The debris from this alluvial fan is being transported downstream and has deposited small terraces along both valley walls. These terraces are possibly abandoned by the modern hydraulic regime of the river and may be coupled to the debris flows originating from Wild Violet Creek.

5.1.2 Reach B: Deposition

This depositional reach is characterized by a relatively wide, low gradient, flat valley floor that extends for approximately 1,000 feet along the valley axis. In combination with downstream gradient controlled from the Bedrock reach, the sediment load is too great and too coarse for the local hydraulics to transport, resulting in deposition on the valley floor.

5.1.3 Reach C: Bedrock Control

The Bedrock controlled reach is relatively short (750 feet) and has a relatively low gradient (<2%), but the narrow bedrock channel maintains hydraulic and sediment continuity through this reach, resulting in a thin alluvial cover on a bedrock channel bed. It appears that this reach only receives sediment from the channel upstream and conveys almost all of this load through to the downstream reach.

5.1.4 Reach D: Deposition

This Deposition reach is characterized by the aggradation of sediment on the valley floor and relatively wide flat valley bottom that receives sediment from the upstream reach and the tributaries that confluence with Permanente Creek from the south. The downstream end of this reach is marked by the occurrence of a sharp change in channel gradient associated with a bedrock knickpoint. This portion of the landscape is within the Materials Removal Area. Further discussion of the implications of these features to the restoration plan are discussed in Section 6.

5.1.5 Reach E: Jammed Conveyance

The Jammed Conveyance is very steep (>9%), but due to the large quantity of material it receives, and the armoring effect of both the coarse sediment and the relict mining infrastructure within the channel, a large portion of this material remains within the reach. The geomorphic term ‘jammed’ describes steep channels that are clogged with debris (Zimmerman et al. 2010). Natural channels of this gradient are typically not depositional but rather erosional. The debris residing on the bed in this reach is immobile, and the modern channel alignment is constricted between the debris from the north and the south valley wall for much of this reach. The Material Removal Area is contained within the upstream portion of this reach.

5.1.6 Reach F: Step Pools

Downstream of the Jammed Conveyance, a large, mapped natural landslide borders the south bank of the river for the entirety of this reach. The large boulders from both mining and natural sources, as well as woody debris, form large, steep step-pools within this reach. Some of these step-pools appear to have been reinforced with travertine deposits, as evidenced by the relict abutment deposits on the channel margins.

5.1.7 Reach G: Pond 13 Control

The reach downstream of the Step Pools reach, appears to act as a gradient control. Although this gradient control may be driven by the back-water effect of the small reservoir at Pond 13, data from the Seismic survey indicates that this feature may be reinforced by naturally occurring bedrock ridges within the channel. A local bedrock ridge is present just downstream of Pond 13 (Figure 2).

5.1.8 Reach H: Culvert Control

Downstream from Pond 13 the channel is confined within culverts and canals that do not exhibit a morphologic connection to the adjacent landscape.

5.2 Geomorphic Observations

5.2.1 Knickpoints

In response to the dynamic changes driven by tectonic base level change, upstream propagating waves of erosion have migrated up Permanente Creek. The upstream most location of a given wave is marked by a distinct change in channel gradient, termed a knickpoint. Knickpoints characteristically migrate more rapidly through more easily erodible material, and more slowly through more erosion-resistant material (Whipple 2004). The upstream most knickpoint with the assessed channel is located at Station 148+00 within the Material Removal Area (Figure 2). This reach is characterized by a relatively low gradient reach upstream of this point and a steep reach downstream. The steep reach downstream is simultaneously receiving and conveying a large quantity of material, typically composed of the finer fraction of the total sediment load, and aggrading the coarser fraction, composed of large boulders.

Figure 3 - Travertine Deposits

5.2.2 Travertine

Travertine is a form of limestone precipitate that forms when calcium carbonate-rich water undergoes changes that cause the mineral to transition from solution to a solid state. This transition is largely controlled by physical processes, such as changes in pressure, temperature, or pH, but it can be influenced by biological processes and hydraulic variability as well (Fuller et al. 2010). Golder observed two types of travertine formation in Permanente Creek. One in which stalactites grew out of the southern stream bank downstream of the confluence with Wild Violet Creek, and the other along large portions of the channel where naturally forming step-pools were reinforced by travertine deposition to form travertine dams (Figure 3). These dams display a history of repeated formation and breaching, as evidenced by the clasts of travertine conglomerate from older dams being incorporated into modern dams, as well as the relict abutments of older travertine dams remaining on the channel margins. This natural process has been taking place throughout geologic time along Permanente Creek.

5.2.3 Basin Capture

A process termed basin capture can occur whereby drainage networks and flow paths are rearranged through landscape modifying influences of tectonics and surface processes. This process can result in characteristic landscape features like wind gaps, where valley geometry and upstream drainage are mismatched, and fishhooks, where headwater streams exhibit a significant curved alignment where the drainage meets the basin edge. The fishhook morphology is observable in the Permanente Creek basin, and adjacent basins (Figure 4). Evidence of basin capture is significant to the current investigation as the changes in basin area related to basin capture can be associated with a dis-equilibrium between the channel morphology and the sediment regime of the river. More straightforwardly, this implies that the basin used to be bigger, and the current hydrologic regime may not be sufficient to transport the former natural sediment load.

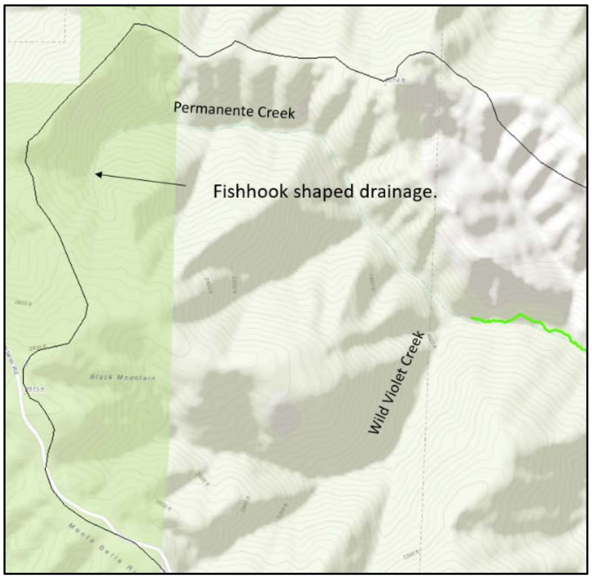


Figure 4 – Fishhook shaped headwaters

6.0 REVIEW OF RESTORATION DESIGN

This section provides an overview of the Waterways 90% design report (2019) with respect to the design basis and an evaluation of potential geotechnical issues for the Rock Pile and Material Removal Areas.

6.1 Geomorphic Design Basis

Waterways has based their geomorphic design on maintaining sediment transport continuity through the constructed reaches and proportionately distributing shear stresses across the channel bed and floodplain areas during floods to maintain a dynamic morphology without destabilizing the landscape. They optimized the design geometry by matching the hydraulics during flooding to the sediment size and transport rate of the channel. Additionally, design geometry incorporated the bankfull width and depth, and pool dimension and spacing relationships, of nearby reference watersheds and analog reaches (URS 2009). Waterways (2019) conducted hydrologic and hydraulic simulations of the restoration design and compared those results to fish passage capability, channel stability, flood conveyance, and sediment transport.

Waterways (2019) design specifications include the following primary elements:

- Engineered Streambed Material (ESM)
- Floodplain Armoring
- Vegetated Rock Slope Protection
- Vegetation Design
- Best Management Practices
- Engineered Woody Debris

- Slope Angle Guidance (Golder 2014)

6.2 Material Removal Area Design

Location: From Station 150+25 to 130+25

General Description (Waterways):

"This area has been modified by the placement of material within and adjacent to the channel… A seismic refraction analysis has been performed to estimate the depth to bedrock, in an effort to gain a clearer understanding of the pre-disturbance site geometry and allow a more informed evaluation of opportunities and constraints to enhancement.

Proposed cuts extend to depths of over thirty feet below existing ground, resulting in profile grades of 7.1% to 22.7%. These grades follow the peaks of the estimated subsurface bedrock profile. Final grades would be determined in the field to best fit bedrock exposures encountered during excavation."

Design Elements and Objectives:

- Removal of overburden/fill and a relic concrete structure, and moving the north toe of slope northward 25 feet along the majority of the project area, except near Pond 4A where it will move northward 16 feet;
- Construction of a new channel with floodplain bench areas with habitat elements that will help improve ecological complexity; and
- Installation of native vegetation.

6.2.1 Evaluation and Discussion of Materials Removal Area

A geologic and a geomorphic map of the Material Removal Area is presented in Figure 5. Longitudinal and thalweg profiles of this area are presented in Figures 6, 7 and 8. In general, both the cross section and long profile indicate that bedrock is close to the surface throughout the Material Removal Area with the exception of a few local areas where depths may be in the range of 15 to 20 ft bgs. The design approach used by Waterways notes that the estimated bedrock contacts as shown are approximate, and that the design will allow for the work to conform to and follow the bedrock surface as it uncovered during excavation.[1] Golder concurs with this general approach and doesn't believe any additional exploration would provide value to the design above and beyond the data provided by the seismic refraction surveys.

[1] It should be noted that where shown on included figures that the bedrock surface as interpreted from seismic refraction data is approximately located and will be field verified during construction.

LEGEND

- Areas of Interest
- Permanente Creek
- Design Thalweg
- Cross Section @ Material Removal Area
- BedrockPoints

Geomorphic Units

- Active Mine
- Bedrock
- Channel
- Floodplain
- Lake
- Mostly Landslides
- Open Culvert
- Pond 4 Fill
- Rock Pile
- Sidecast Overburden
- Terrace

0 200 400

1 IN = 206 FT FEET

NOTE(S)

1. LINE NOTES
2. LINE NOTES
3. LINE NOTES

REFERENCE(S)

1. WATERWAYS CONSULTING, INC. 2018. PERMANENTE CREEK RESTORATION PLAN INTERNAL DRAFT 90% LEVEL SUBMITTAL DESIGN BASIS TECHNICAL MEMORANDUM. PREPARED FOR LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC. NOVEMBER 5, 2018.
2. COORDINATE SYSTEM: NAD 1983 STATE PLANE CALIFORNIA III (FT)

CLIENT
LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC.

PROJECT
GEOLOGIC AND GEOMORPHIC ASSESSMENT OF PERMANENTE CREEK: MATERIAL REMOVAL AREA

TITLE
GEOMORPHIC MAP OF THE MATERIAL REMOVAL AREA

CONSULTANT
GOLDER

YYYY-MM-DD	2019-10-02
DESIGNED	RPH/BVJ
PREPARED	RPH/BVJ
REVIEWED	BF/CJ/RPH
APPROVED	BF

PROJECT NO.	PHASE	REV.	FIGURE
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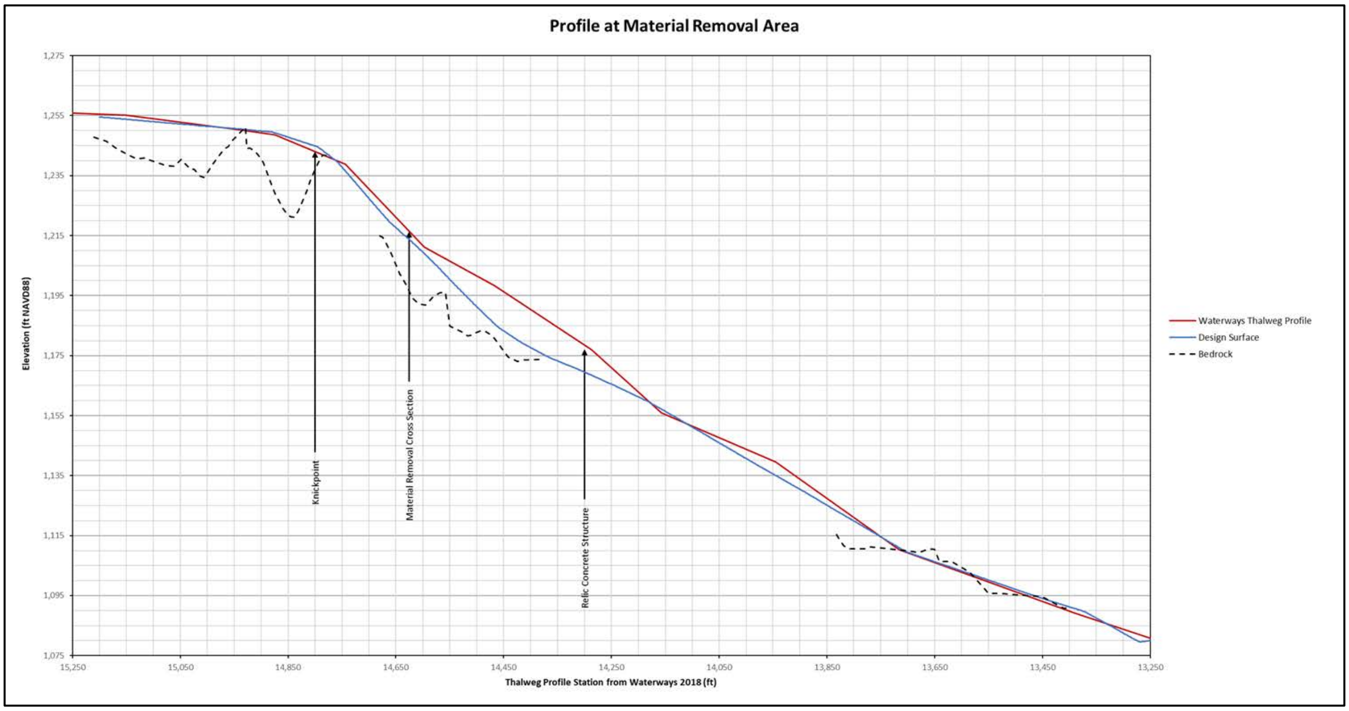


Figure 6: Profile of Material Removal Area from Station 152+50 to 132+50.

The following bullet points provide Golder's observations of the design as compared to conditions observed in the site reconnaissance and as informed by the seismic refraction survey data.

- At Station 148+00, bedrock close to the surface is likely the controlling feature of an upstream migrating knickpoint. The design shows the channel invert conforming to knickpoint and then potentially being established on exposed bedrock downstream of the knickpoint. We concur with this design approach. Additional design elements proposed including ESM and other profile control elements such as boulder weirs and sills should help to ensure stability of the knickpoint.
- Between Stations 146+50 and 142+50, the restoration design identifies a large quantity of material for removal from the channel. The relic mining infrastructure may play a role in defining the channel alignment and facilitating an armored surface on some of the debris. The result of the restoration efforts will increase the local gradient within this reach and extend the length of the high-gradient portion of the channel. Sheet C34 of the 2019 plan set provides additional details for Step-pool and cascade channel design segments in this reach to mitigate the local gradient. We concur with this approach and note that field engineering design modifications and follow on monitoring may be necessary to ensure that the post material removal channel geometry is stable.
- Between Stations 138+50 and 134+50, the seismic profiles indicate that bedrock may be encountered below design grade, but as the seismic profile lines were collected adjacent to the channel and not in the thalweg, Golder believes that bedrock may be exposed at relatively shallow depths along the thalweg. We understand that the intent of the design is to construct the channel on exposed bedrock

occurring within the proposed grading envelope and based on our reconnaissance we think this is generally achievable.

- There is a large relic concrete structure located in the left bank of the stream channel five to ten feet above the channel invert (143+00). There is a smaller relic concrete structure located in the channel further downstream. Golder understands that the removal of old mining infrastructure from the channel will increase the connectivity of the channel to the adjacent landscape and also that the relict structures may currently be contributing to the stability of this reach. We understand that weirs and steps will be constructed using material with a minimum size meeting the D50 of the specified material and a boulder sill w/ a minimum size meeting the D84. This design approach is intended to replace any potential stability relic structures are providing.
- The most challenging geologic and geotechnical issue in the Material Removal Area is the presence of the Upper Water Treatment System infrastructure, including the 1250 Pond and associated facilities located along the top of the creek bank and the access road to Permanente Creek. The lifetime of these facilities is uncertain at this time as they are required for on-going operations of the Facility. However, once reclamation is completed, they may no longer be necessary. If the facilities need to be protected during the creek restoration project, a retaining structure (e.g., Mechanically Stabilized Earth wall) will be necessary to maintain the road and the 1250 pond (as shown in Figure 4.0 of Waterways Updated Response Letter to the County dated 3-5-18 shown below). The retaining structure would be required as the design calls for pushing the north bank of the creek approximately 25 further north than current conditions.

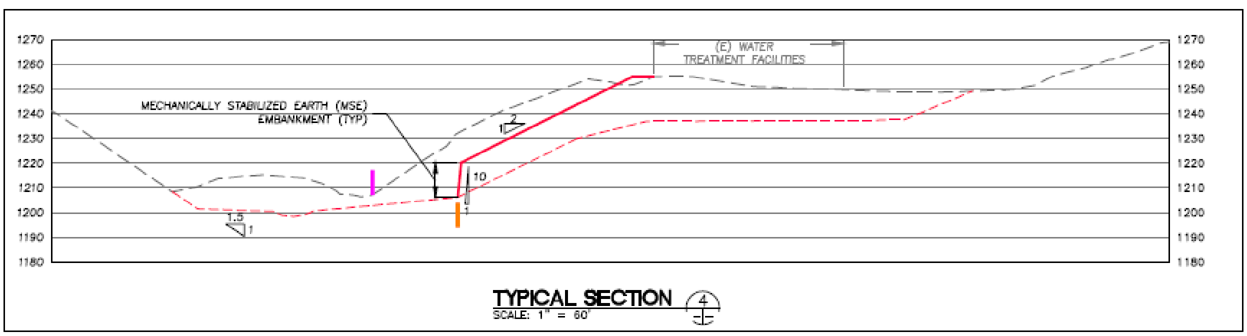


Figure 7: Typical Section of Potential MSE Wall to protect Water Treatment Facilities

- If a retaining structure is required, Golder recommends that a geotechnical investigation be performed along the alignment of the wall to verify depth to bedrock and to obtain appropriate design parameters for the design of the wall. However, depending on the timing of the restoration project, a retaining structure may not be necessary and therefore we recommend delaying any further investigation until such time it is needed. Figure 8 illustrates the design surface and bedrock conditions if the slope can be graded back at 2H:1V. This slope configuration meets Golder's general recommendations for cutslopes developed in surficial materials and is considered acceptable.

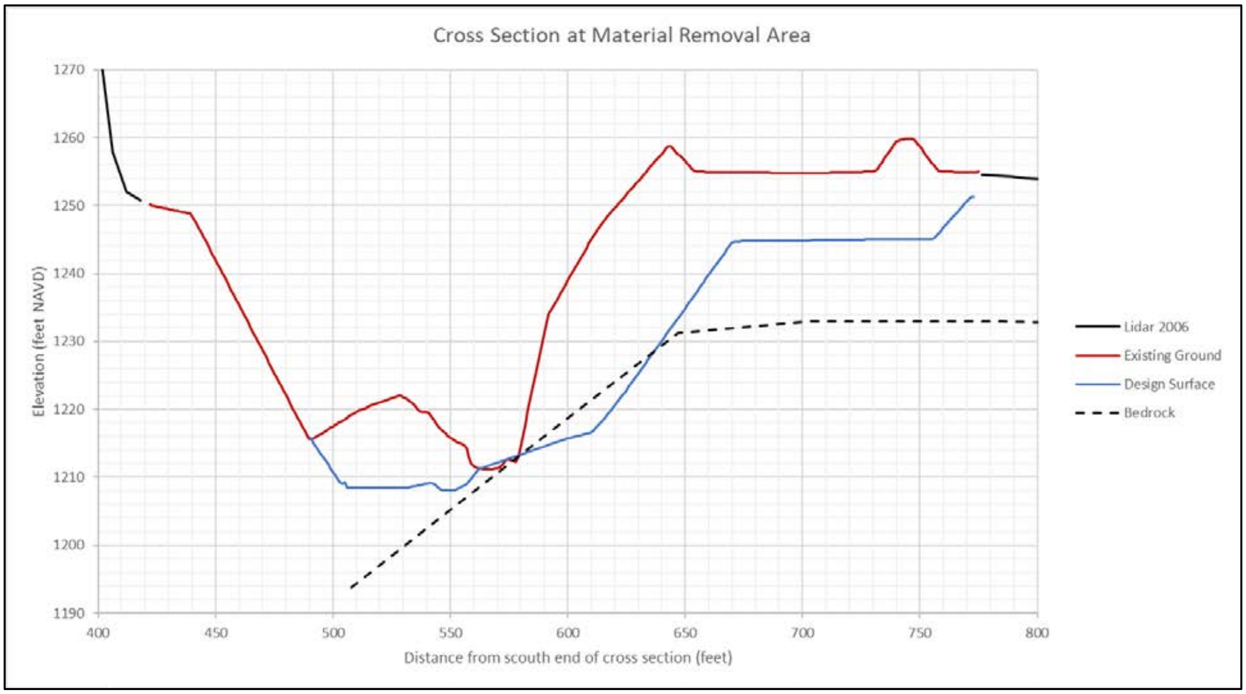


Figure 8: Cross section at Material Removal Area. Located at Thalweg Profile Station 146+00. Note depth to bedrock is approximate and estimated based on seismic refraction data.

6.3 Rock Pile Area Design

Location: From Station 104+50 to 85+50 within the Channel Widening Reach.

General Description (Waterways 2019):

"Extensive channel realignment and reconstruction is proposed throughout this area, including removal of Culverts #10 & #11 and the dam at Pond 13…. Cuts approximating thirty to forty feet of depth are required to accomplish this. The grading plan reflects the Lower Limit of Potential Design Channel Invert. The Upper Limit of Potential Design Channel Invert shown in profile has been established as a best fit to bedrock elevations that were estimated using a seismic refraction analysis and geotechnical borings. Final geometry will likely vary somewhat from that shown on the drawings, as necessary to conform to existing bedrock.

The rock pile and associated infrastructure will be removed to accommodate the lowered and widened channel…The slope exposed below the Rock Pile will be inspected by the Geotechnical Engineer or Project Engineering Geologist to evaluate the nature and stability of the exposed material and provide recommendations, as necessary, to ensure geotechnical stability of the slope and access road."

Design Elements and Objectives:

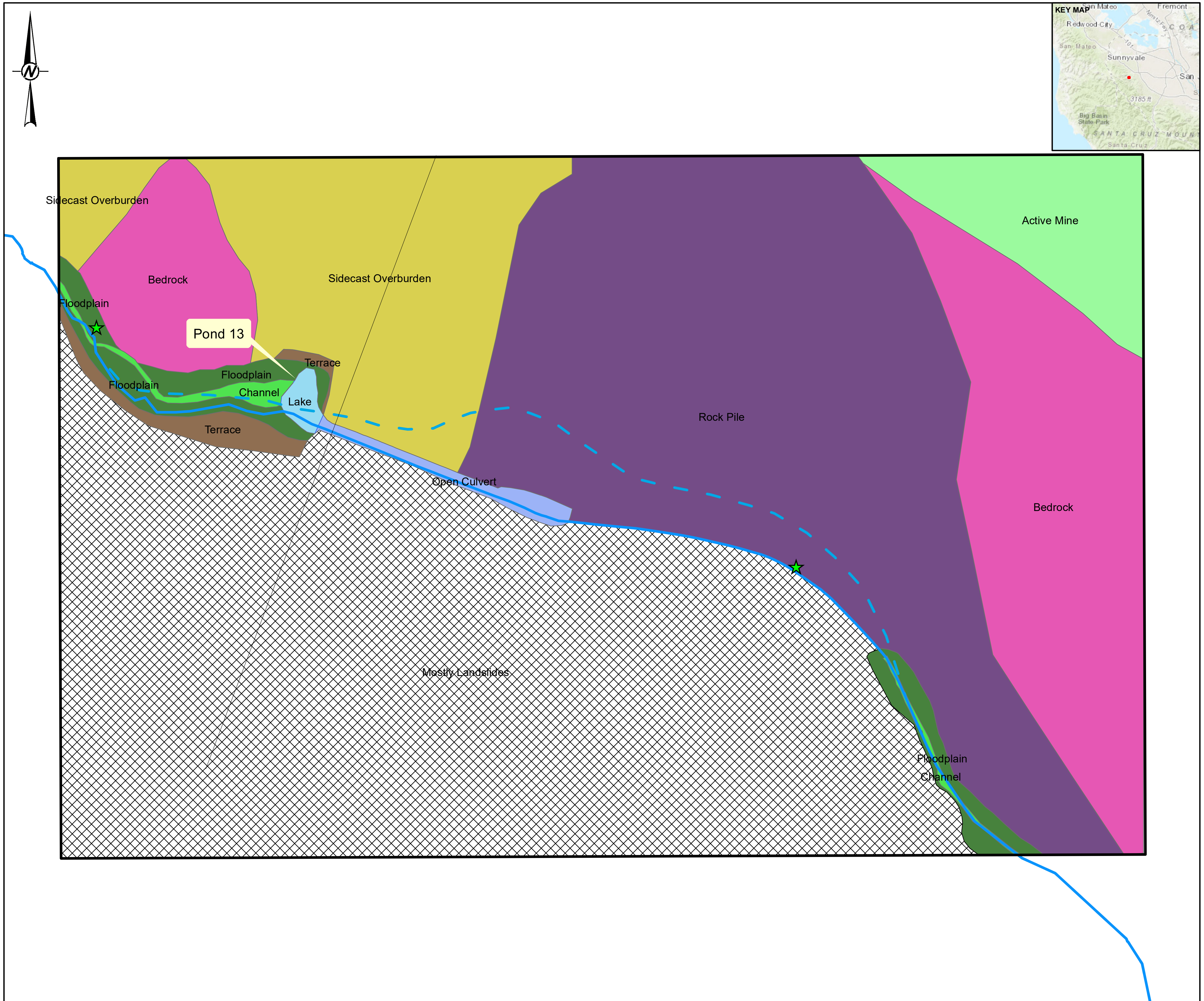
- Removal of concrete road segments and road-related fill material;
- Removal of 930 linear feet of culverts and daylighting of the creek that will help improve ecological complexity;
- Construction of a new channel with floodplain bench areas with habitat elements that will help improve ecological complexity;

- Removal of Rock Pile, retired Rock Plant conveyor system and associated infrastructure;
- Removal of Pond 13 dam/metal infrastructure; and
- Installation of native vegetation.

6.3.1 Evaluation and Discussion of Rock Pile Area

A geologic and a geomorphic map of the Rock Pile Area is presented in Figure 9. Cross sections and thalweg profiles of this area are presented in Figures 10 and 11. Appendix B includes Figure 1 from Waterways Updated Response Letter to the County dated March 5, 2018 showing the locations of exploratory borings drilled previously by Golder in the area of the Rockpile restoration work and boring logs. The following discussion provides additional observations of specific design elements as compared to conditions observed in the site reconnaissance and as informed by the seismic refraction survey data.

- In the Rock Pile Area, Golder's comparison of the restoration design with seismic survey results indicates that bedrock ranges from about 5 feet to approximately 25 feet below ground surface with significant relief along the longitudinal profile (Figure 10). As with the Material Removal Area, the design intent will allow for the work to conform to and follow the bedrock surface as it is uncovered during excavation.
- The interpreted depth to top of native alluvium or bedrock for borings along the proposed thalweg (Borings 1101 and 1103) is approximately 25 feet although native surficial materials were likely encountered approximately 5 to 10 feet shallower. Boring 1107, also along the thalweg but near the downstream limit of the area, encountered a concrete structure at approximately 7 feet bgs interpreted as being near original ground surface along the channel thalweg. The remaining borings were drilled upslope of the thalweg to evaluate depths of fill along the toe of the proposed slope. In general, these borings indicate depths of overburden along the toe of the slope in the range of 60 to 70 ft bgs.
- The bedrock surface depicted on Figure 10 is close to the "Upper Limit of Potential Design Channel Invert" as defined by Waterways (based on seismic lines and verification borings), whereas the grading plan included on the design drawings represents the "Lower Limit of Potential Design Channel Invert" to show the maximum extent of potential grading. It is our opinion based on the review of available data that the constructed profile will be close to the "Upper Limit" upstream of Rock Pile Design. In summary, it is our opinion that the design is reasonable, and additional exploration will not provide value to the design above and beyond the data provided by the seismic refraction surveys and previous completed borings.
- The seismic data also identifies a potential former bedrock channel, which extends through the Rock Pile Area that in some locations is north of the proposed thalweg (Figure 11). Golder understands that Waterways has, to the extent possible, re-occupied the historic thalweg; however, extensive grading would be required in some areas to realign the channel and move it further to the north to occupy the historic channel thalweg. We understand that pushing the toe of the slope further north is not considered feasible given that this would require significant flattening of the slope which would impact the extensive infrastructure located at the top of slope including the main access road and the crusher facility. Golder recommends that field engineering design modifications be applied to utilize existing



LEGEND

- Areas of Interest
- Permanente Creek
- Design Thalweg
- Cross Section @ Rock Pile Area
- BedrockPoints

Geomorphic Units

- Active Mine
- Bedrock
- Channel
- Floodplain
- Lake
- Mostly Landslides
- Open Culvert
- Pond 4 Fill
- Rock Pile
- Sidecast Overburden
- Terrace

0 200 400
FEET
1 IN = 145 FT

NOTE(S)
1. LINE NOTES
2. LINE NOTES
3. LINE NOTES

REFERENCE(S)
1. WATERWAYS CONSULTING, INC. 2018. PERMANENTE CREEK RESTORATION PLAN INTERNAL DRAFT 90% LEVEL SUBMITTAL DESIGN BASIS TECHNICAL MEMORANDUM. PREPARED FOR LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC. NOVEMBER 5, 2018.
2. COORDINATE SYSTEM: NAD 1983 STATE PLANE CALIFORNIA III (FT)

CLIENT
LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC.

PROJECT
GEOLOGIC AND GEOMORPHIC ASSESSMENT OF PERMANENTE CREEK: ROCK PILE AREA

TITLE
GEOMORPHIC MAP OF THE ROCK PILE AREA

CONSULTANT
GOLDER

YYYY-MM-DD	2019-10-02
DESIGNED	RPH/BVJ
PREPARED	RPH/BVJ
REVIEWED	BF/CJ/RPH
APPROVED	BF

PROJECT NO.	PHASE	REV.	FIGURE
179018601	100	0	9

bedrock topography and historic thalweg to the extent possible to meet the desired restoration outcomes.

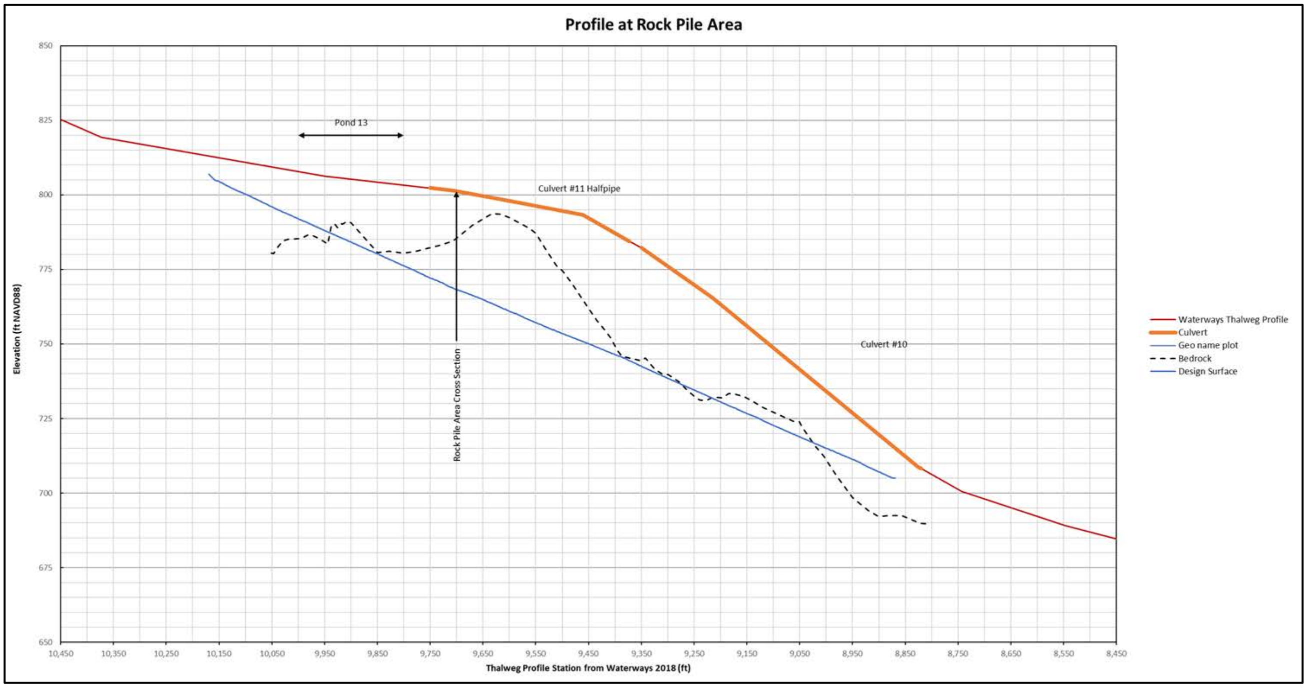


Figure 10: Profile of Rock Pile Area from Station 104+50 to 84+50.

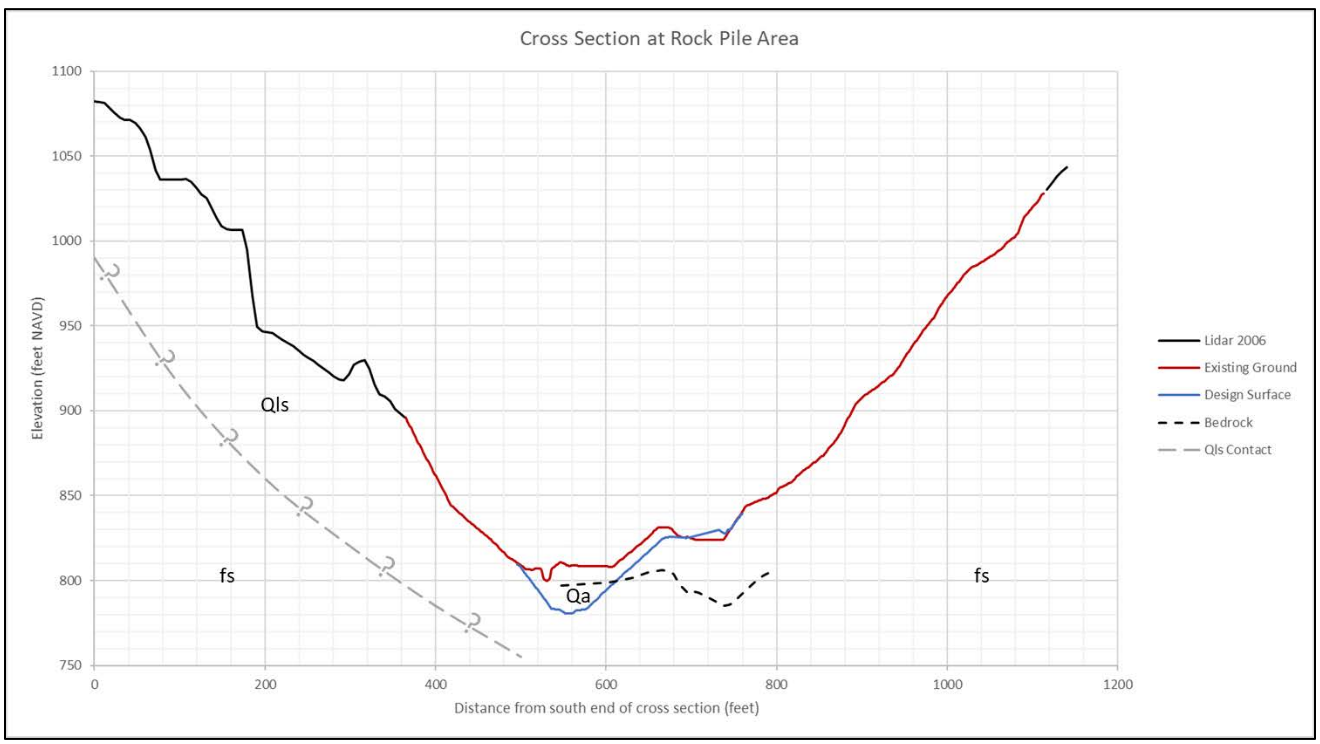


Figure 11: Cross section at the Rock Pile Area. Located at Thalweg Profile Station 97+00.

- The removal of the two culverts and creation of a floodplain with an inset channel in this reach will re-establish the lateral connectivity of the channel to the adjacent hillslopes. Reconnecting the channel to the adjacent landscape will have positive benefits as designed by Waterways, but it will also increase the potential for a laterally migrating channel to affect adjacent hillslopes. The north valley wall will consist of the excavated Rock Pile and the south valley wall is defined as a large, ancient landslide based on regional geologic mapping.
- The seismic data indicate that there is a bedrock ridge, oriented perpendicular to the valley axis, located just downstream of Pond 13. It appears that Pond 13, and/or the underlying more resistant bedrock, may be acting as a grade control structure on the reach upstream of Pond 13 (Figure 10).The channel morphology upstream of Pond 13 appears to have adjusted to this local gradient control and has resulted in the aggradation of sediment upstream of Pond 13. We understand that, the channel upstream of Pond 13 will be excavated into the stored sediment and depending on the depth to bedrock, a large proportion of these sediments will be removed as part of the restoration effort. In addition, we understand that grade control will be installed at the upstream limits of work under either Profile scenario.

7.0 CONCLUSIONS AND RECOMMENDATIONS

In this section, Golder summarizes the finding of our investigations and provides recommendations to facilitate the implementation of the Restoration Plan (Waterways 2018).

7.1 Adaptive Management and Monitoring

In our opinion, the most effective way to ensure a successful project is thorough engineering observation and field fitting of final profiles during excavation activities. This is the best way to achieve the goal of restoring natural profiles while minimizing excavation of native soils or bedrock materials. Note that this is a well-established concept first described and promoted by Karl Terzaghi as the “Observational Method” and was later described in detail by Ralph Peck (1969). The intent of the method is to balance the cost of investigation and design while still achieving a successful project through adaptive management in the field. The method entails designing to the most probable conditions rather than the most unfavorable conditions. Data gaps are filled by detailed observations during construction and designs are modified as needed.

It is important that stakeholders recognize that this is a restoration project, not an engineered stream channel, and this will by necessity entail restoration of new slopes to match previously existing slopes. This will require slope angles which, in some cases, may evidence stability just like the existing natural slopes. In our opinion, additional subsurface exploration will not alter this fundamental concept or improve the project outcome. Rather, it is understood by the Project team that shallow slides and/or erosion may occur on restored natural slopes.

7.2 Evolution of Design

The plan set is in general conformance with the applicable geotechnical recommendations as outlined in our “Preliminary Geotechnical Recommendations for Conceptual Level Permanente Creek Restoration Plans” dated April 28, 2014 (Golder 2014). We note that several structural construction elements that were part of the original project design in 2014 have been eliminated from the 2019 plan set. With the exception of a possible MSE wall in the Material Removal Area, structural elements such as gabions or retaining walls, which would warrant more detailed subsurface investigation and testing, are no longer part of the project.

7.3 Field Observations and Adaptive Management

As stated in the Field Engineering Notes section of the project plan notes (Sheet C28) stability of hillsides may necessitate:

- Field engineering and a field directed construction approach, i.e., field observations and adaptive design as discussed above
- Final geometries to be directed in the field by the Project Engineer to account for unanticipated subsurface conditions
- Flexibility with respect to final gradients and defined “grading envelopes” for channel gradients
- A narrowing of floodplain widths in areas where the final design profile approaches the lower limit of the grading envelope
- Slope benching to reduce slope angles and lengths in areas of disturbed terrain, and to control surface runoff and erosion while vegetation is established

We concur with the above recommendations, and the Field Engineering Notes in general, with respect to addressing and minimizing potential slope instabilities. We further recommend that the Project Geotechnical Engineer or Project Engineering Geologist inspect all interim and final cutslopes as the project progresses such that any potential areas of concern can be identified early in the process and remedial measures developed, if required.

7.4 Material Removal Area

The Material Removal Area may require a retaining structure, depending on timing of the creek restoration project with respect to site operations, to preserve infrastructure and access associated with the Upper Water Treatment System (UTS). Our understanding is that Waterways is recommending that work at the Material Removal Area is sequenced to occur after other portions of the project are constructed if the treatment facilities and Pond 1250 need to remain in place at the start of project implementation. Work would start with the Channel Widening Area and generally proceed upstream. The second phase of work would include the Rock Pile Area. The final stage of work would include the Material Removal Area.

If the MSE wall is required, then Golder recommends a geotechnical investigation be completed to prepare final design and construction plans. Based on the above construction sequence, there will adequate time to plan, permit and implement this investigation even after the project has started.

7.5 Rock Pile Area

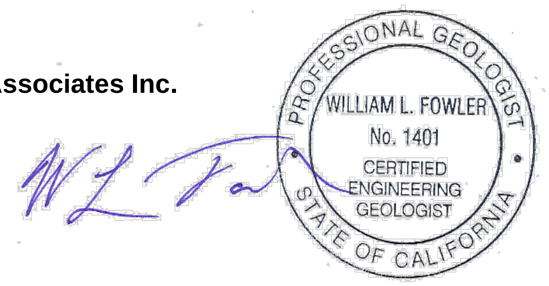
The main geotechnical challenge for the proposed project is likely related to the Rock Pile Area which entails a reach of the creek where culverts will be removed, and a large stockpile of aggregate materials placed along the margin of the creek and up onto the hillside to a height in excess of 200 vertical feet. The estimated thickness of the rock pile ranges up to 100 feet. Estimated natural slopes angles underneath and above the rock pile are shown as steep as 1H:1V. We recommend inspection of these slopes by the Project Engineering Geologist or Geotechnical Engineer following the removals to evaluate the geologic conditions and stability of the exposed materials. If the removals expose bedrock, stability of the slopes should be adequate. However, if the cut leaves significant thicknesses of overburden in place, potential localized slope instability may be encountered. Golder recommends that Lehigh and Waterways have contingency plans in place to design and implement remedial measures such as:

- Additional localized removals of loose or unstable materials
- Slope laybacks and benching
- Engineered drainage controls
- Buttresses or slope sections comprised of compacted rockfill

7.6 Travertine Deposits

The deposition of travertine between clasts in step-pools and dam-like structures, as well as deposited sediment that is accessed by the channel flow is likely to have increased the apparent strength of localized areas of alluvial materials along the channel. This cementation may make the removal of this material more difficult than anticipated and may play a role in long term channel stability. Golder recommends that this cemented material be left in place wherever possible to augment the restoration design.

Golder Associates Inc.



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Senior Program Leader/Principal

Dated: 10/31/19

https://golderassociates-my.sharepoint.com/personal/bfowler_golder_com/documents/permanente/creek restoration/perm creek recon_final_wlf_10-31-19 r4.docx

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