Appendix G
Geology and Hydrology

G1. Geotechnical and Geomorphic Assessment of Permanente Creek (Golder Associates, October 21, 2019)

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

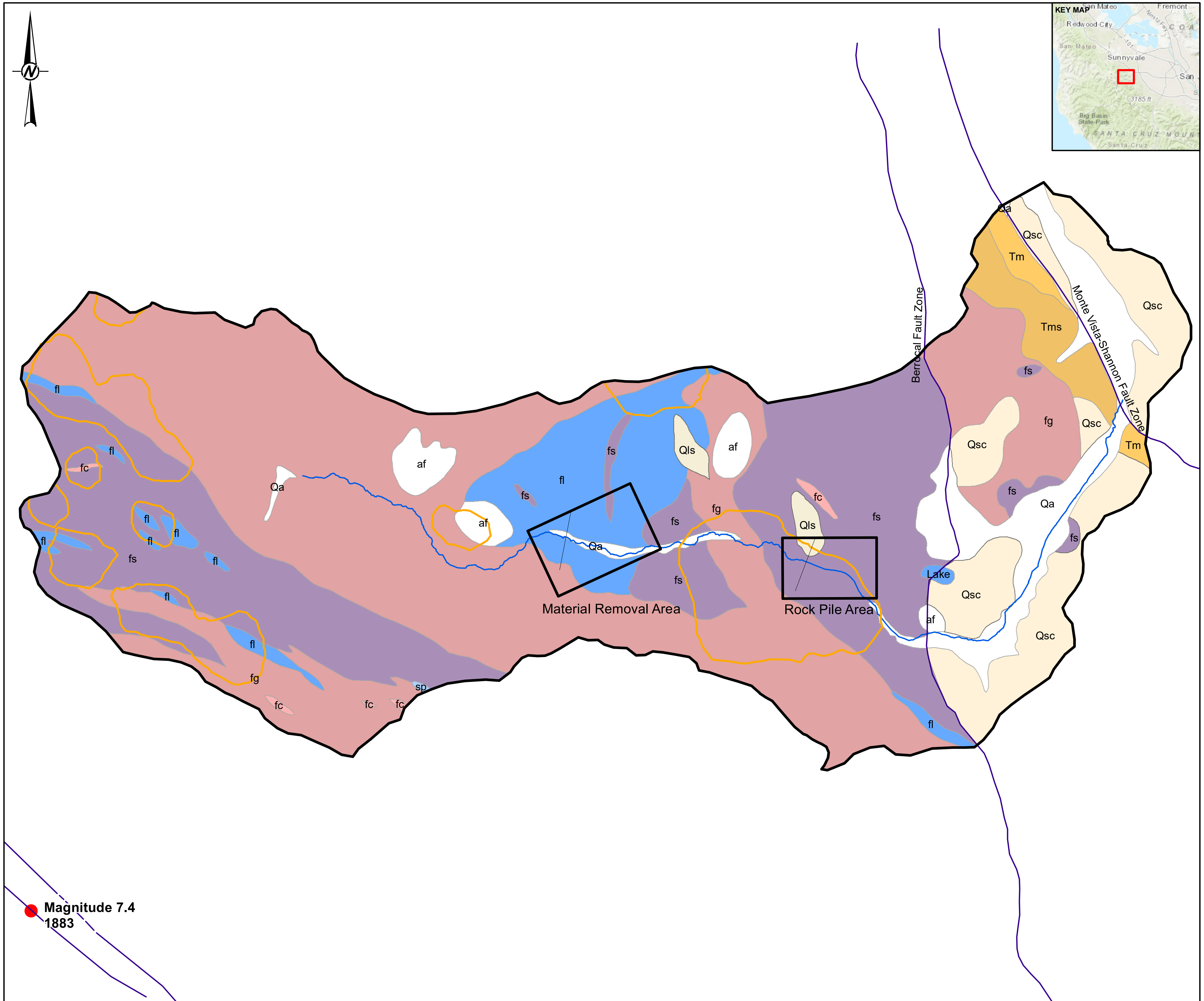
The bedrock materials exposed in the Quarry are part of the Permanente Terrane of the Franciscan Assemblage. The Franciscan Assemblage is comprised of highly deformed and variably metamorphosed, marine sedimentary rocks with submarine basalt (greenstone), chert, and limestone. The Franciscan is considered 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.

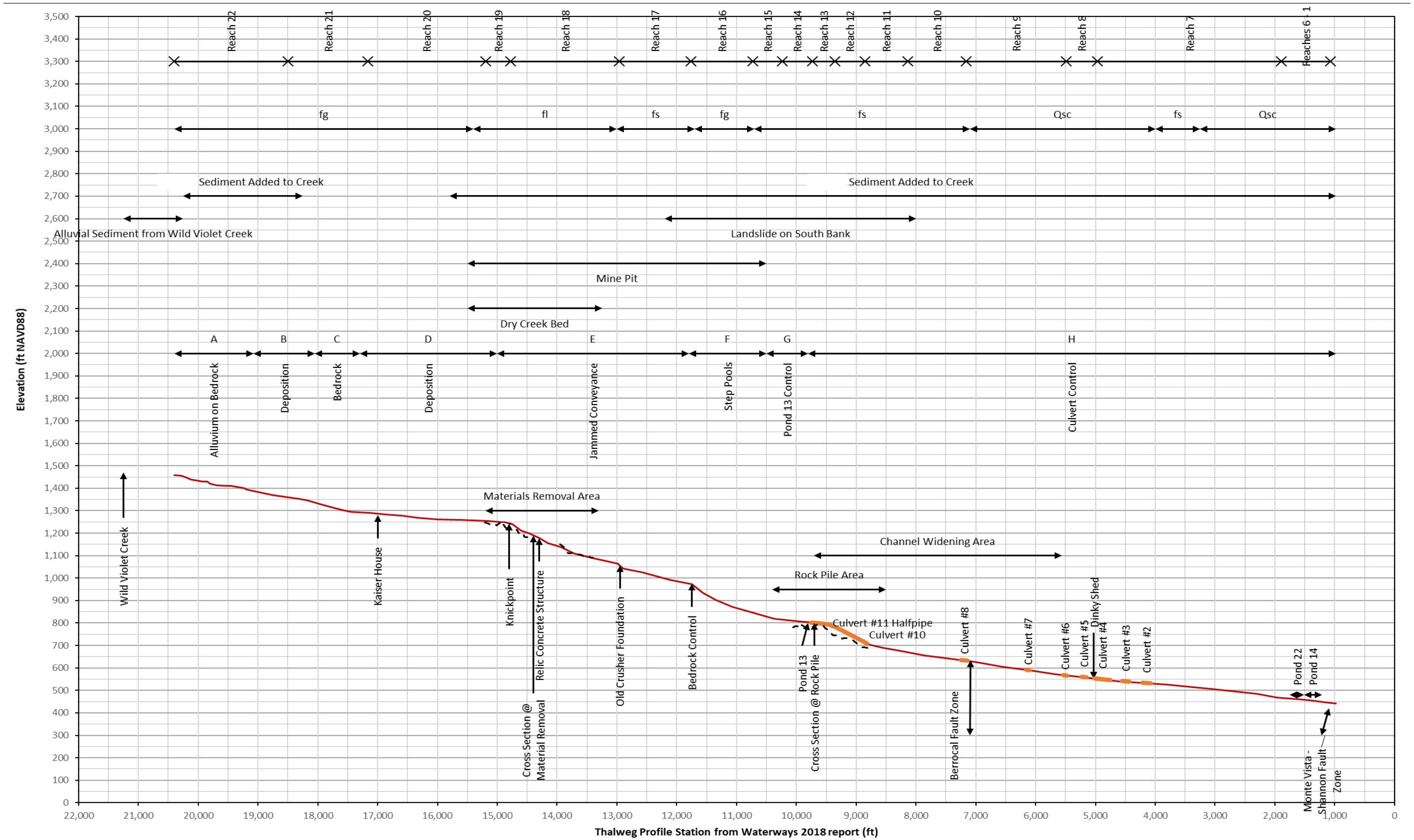


Figure 2: Permanente Creek Profile with geomorphic and geologic delineations. Stationing from Waterways (2019).

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).

Figure 3 - Travertine Deposits

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.

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.

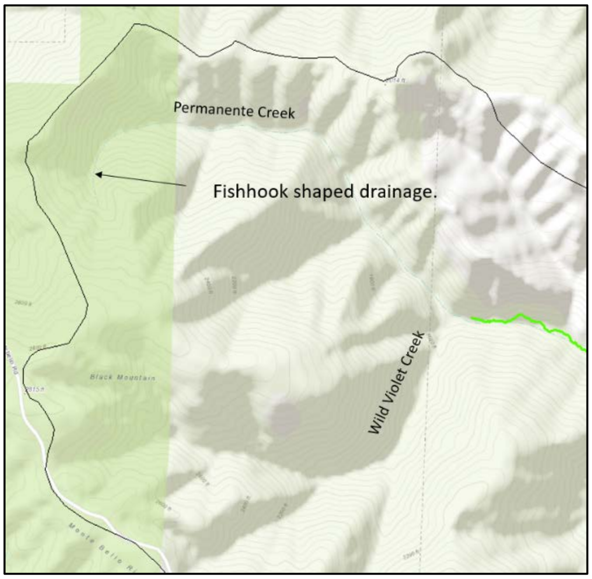


Figure 4 – Fishhook shaped headwaters

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

FEET

1 IN = 206 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: 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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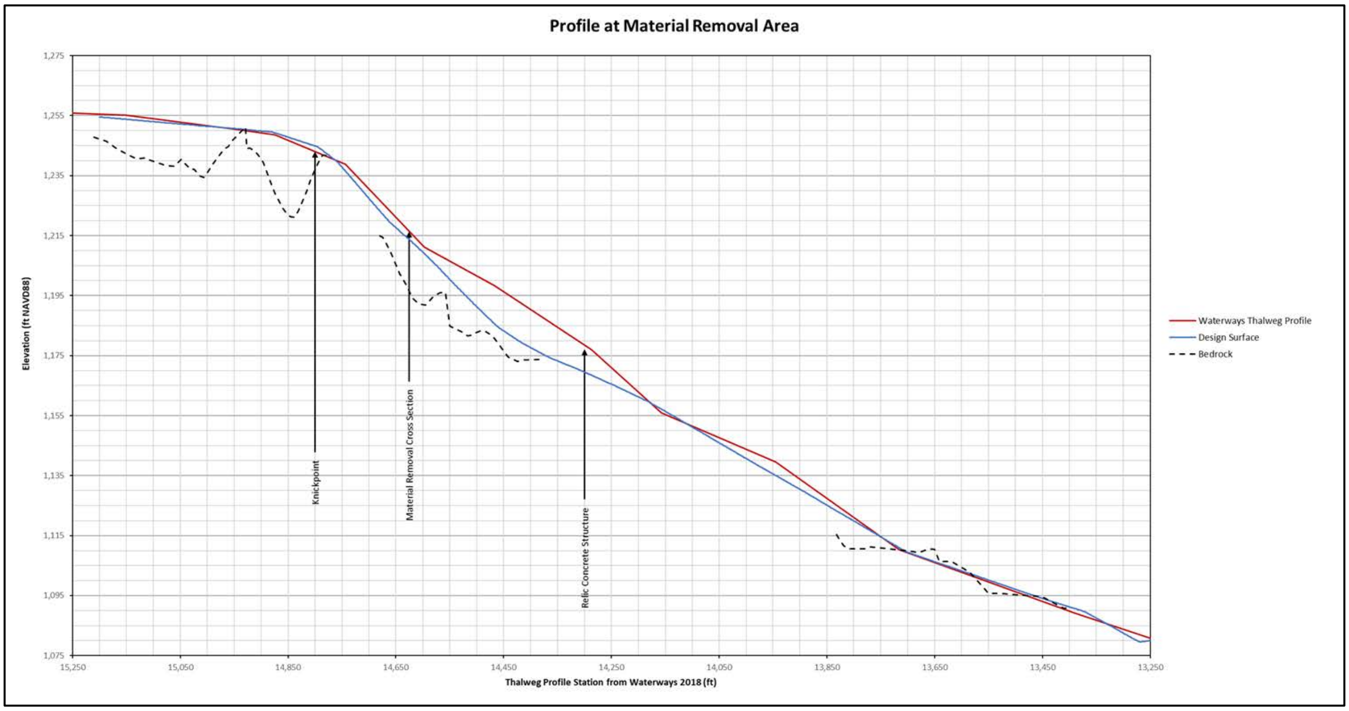


Figure 6: Profile of Material Removal Area from Station 152+50 to 132+50.

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.

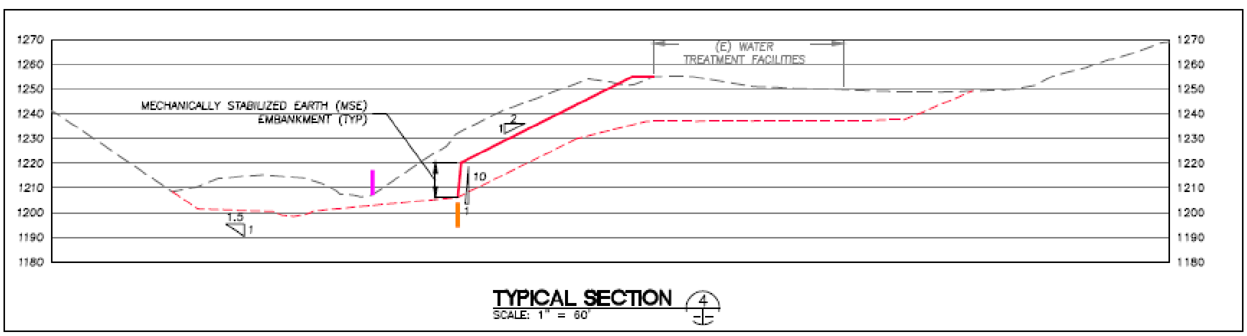


Figure 7: Typical Section of Potential MSE Wall to protect Water Treatment Facilities

- 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.

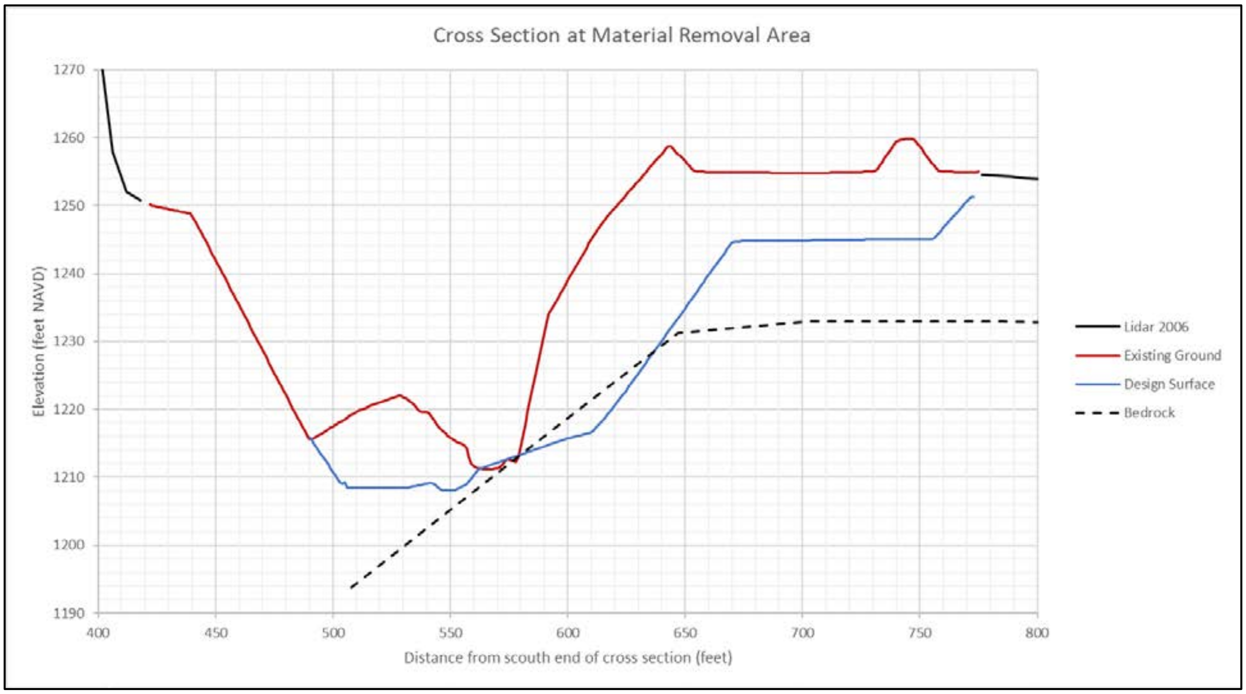


Figure 8: Cross section at Material Removal Area. Located at Thalweg Profile Station 146+00. Note depth to bedrock is approximate and estimated based on seismic refraction data.

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:

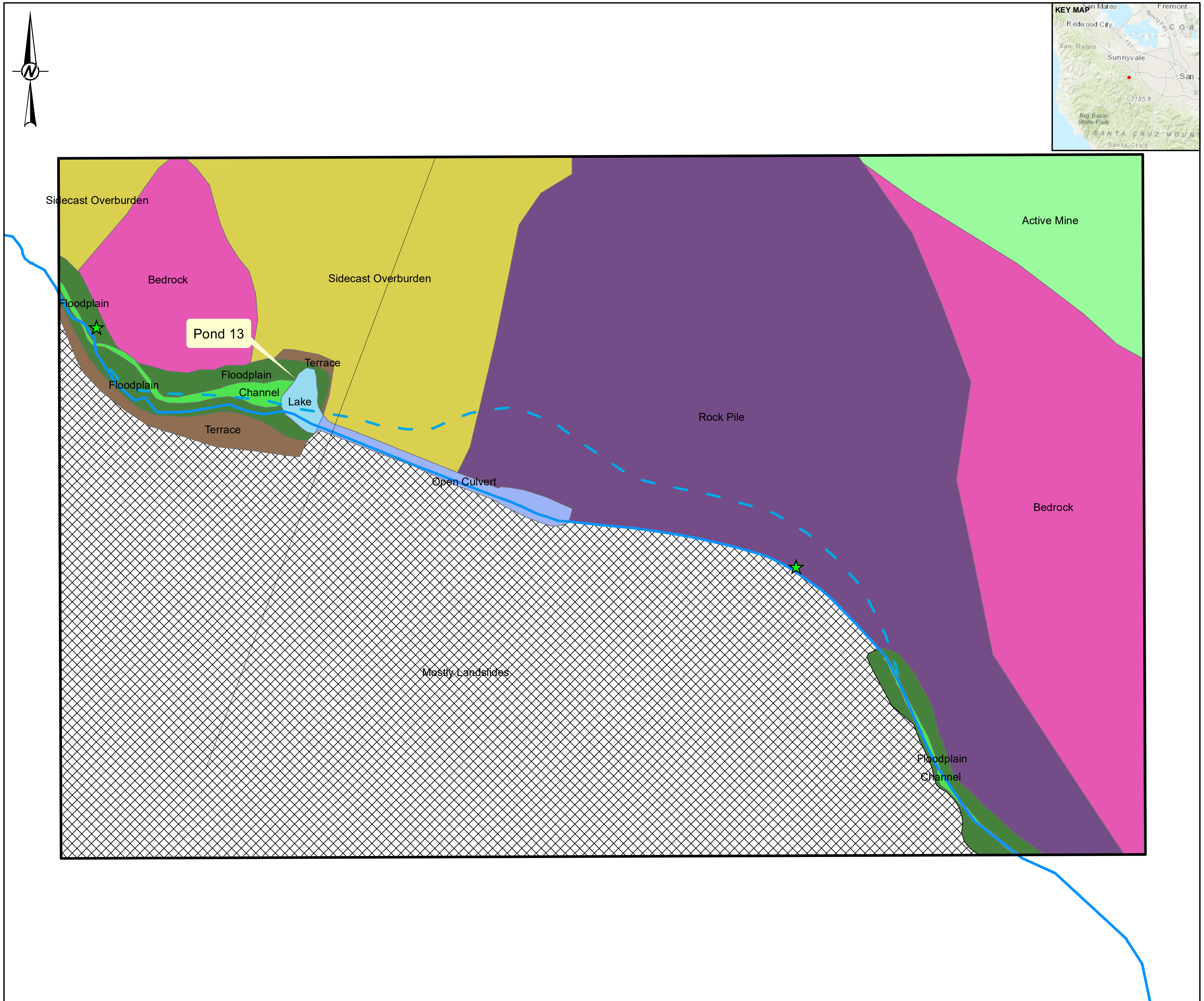
- Removal of concrete road segments and road-related fill material;
- Removal of 930 linear feet of culverts and daylighting of the creek that will help improve ecological complexity;
- Construction of a new channel with floodplain bench areas with habitat elements that will help improve ecological complexity;

- 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

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B bedrock topography and historic thalweg to the extent possible to meet the desired restoration outcomes.

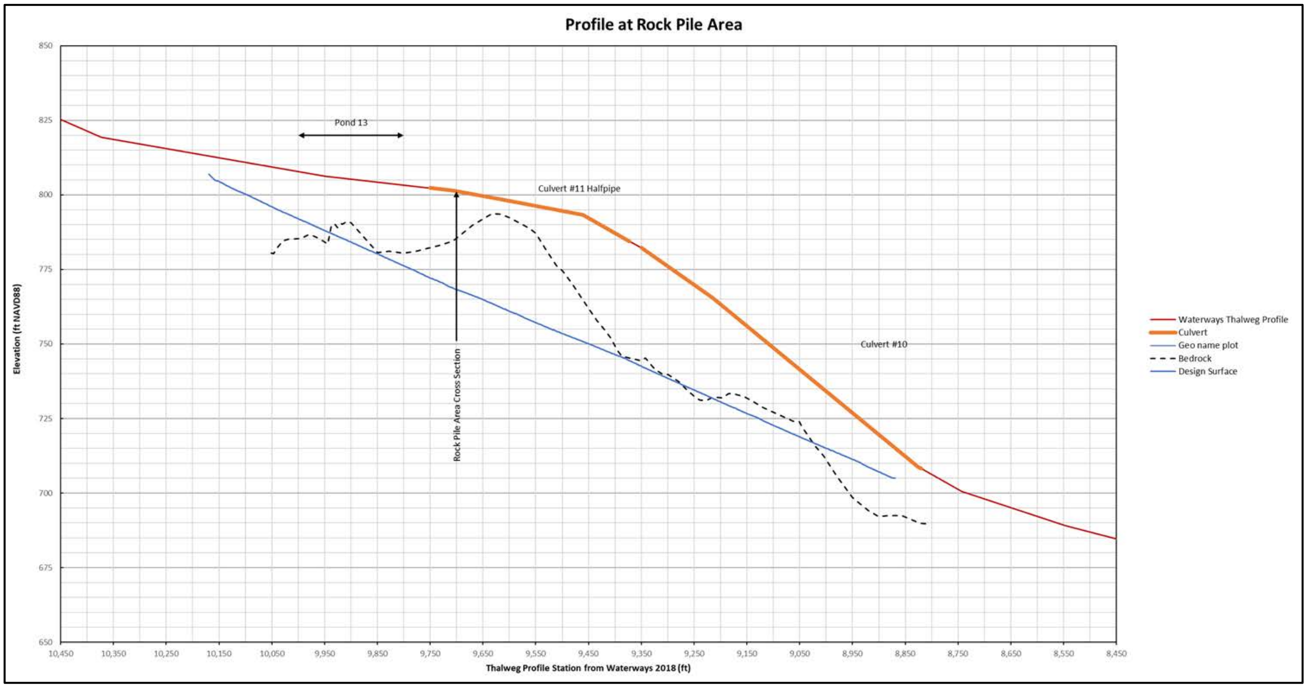


Figure 10: Profile of Rock Pile Area from Station 104+50 to 84+50.

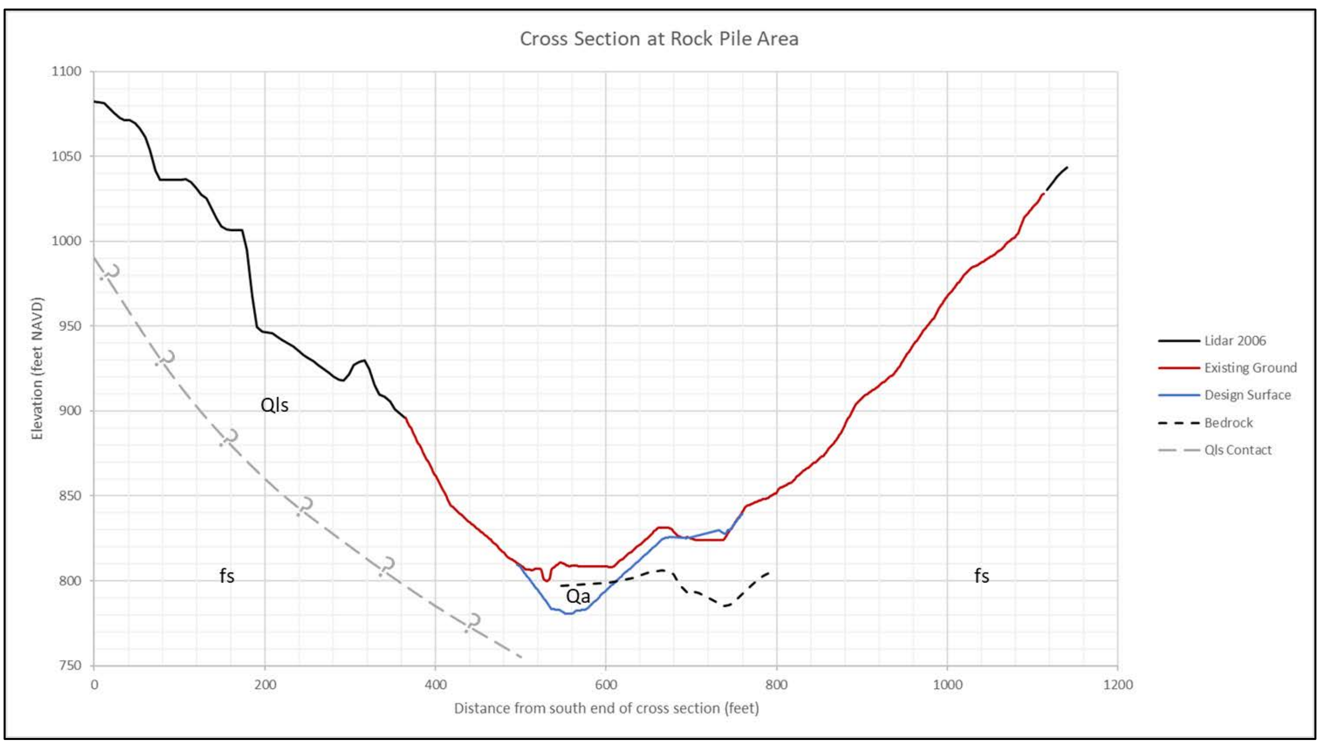


Figure 11: Cross section at the Rock Pile Area. Located at Thalweg Profile Station 97+00.

- 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

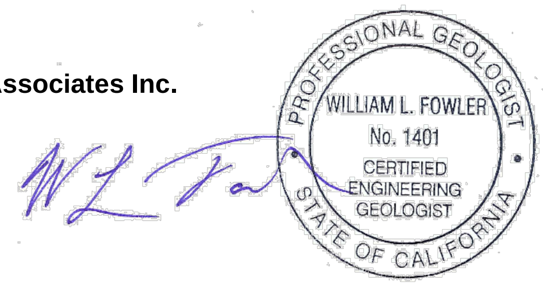
The main geotechnical challenge for the proposed project is likely related to the Rock Pile Area which entails a reach of the creek where culverts will be removed, and a large stockpile of aggregate materials placed along the margin of the creek and up onto the hillside to a height in excess of 200 vertical 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.



William L. Fowler, PG, CEG
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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Appendix A

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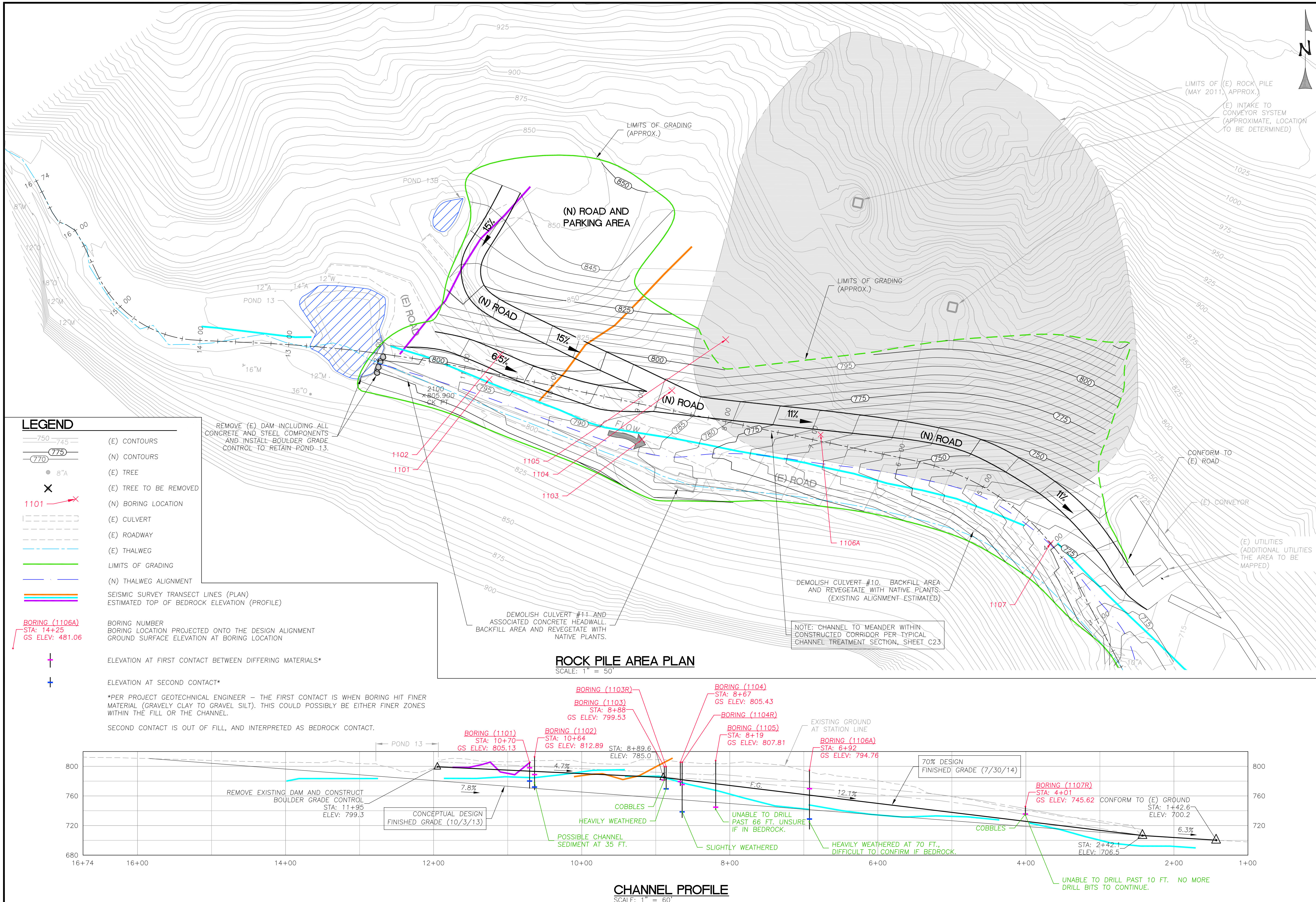
Appendix B



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PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
LEHIGH HANSON HEIDELBERG CEMENT GROUP

ROCK PILE AREA SEISMIC STUDY AND BORING RESULTS

PERMANENTE CREEK RESTORATION PLAN
SUBSURFACE BORING LOCATIONS

DESIGNED BY: B.Z.
DRAWN BY: B.M.S
CHECKED BY: M.W.W.
DATE: 03/10/15
JOB NO.: 13-016

BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALES FOR REDUCED PLOTS

FIG. 1

Golder Associates

Golder Associates, Inc.

Telephone:

BORING NUMBER 1101

PROJECT NUMBER	1302968-01	**DATE STARTED**	2/12/15
PROJECT NAME	Lehigh Rockpile Drill	**DATE COMPLETED**	2/12/15
LOCATION	Cupertino, CA	**CASING TYPE/DIAMETER**	----
DRILLING METHOD	HSA	**SCREEN TYPE/SLOT**	----
GROUND ELEVATION		**GRAVEL PACK TYPE**	----
TOP OF CASING	----	**GROUT TYPE/QUANTITY**	----
LOGGED BY	LF	**DRILLING COMPANY**	Gregg Drilling

REMARKS Borehole 1101 is located on road (furthest east location). Estimated depth of bedrock with seismic line is about 25 feet.

REMARKS CONTINUED Possible pond sediment at ~7 feet and weathered bedrock at ~25 feet.

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML	0–7		(FILL; ML) gravelly SANDY SILT, subangular to subrounded sand and gravel, low plastic fines; brown; moist.
		CH	7–25		(NATIVE possible pond sediment; CH) gravelly CLAY, medium to high plastic fines, fine subangular gravel, some coarse sand; dark brownish-gray; mosit.
			15		gravel decreases with depth
			25		at 25 feet: driller notice material is a little harder
SS	18/18	CL	25–32		(NATIVE; CL) gravelly CLAY, angular to subangular gravel, some FeOx staining, weathered Franciscan clasts; dark gray; moist.
		GM	32–35		(NATIVE; GM) SILTY GRAVEL, angular to subangular, low to medium plastic fines, weathered Franciscan bedrock; dark gray; moist to wet.
	12/18		35		Bottom of borehole at 35.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1102

PROJECT NUMBER 1302968-01
DATE STARTED 2/12/15
PROJECT NAME Lehigh Rockpile Drill
DATE COMPLETED 2/12/15
LOCATION Cupertino, CA
CASING TYPE/DIAMETER ----
DRILLING METHOD HSA
SCREEN TYPE/SLOT ----
GROUND ELEVATION
GRAVEL PACK TYPE ----
TOP OF CASING ----
GROUT TYPE/QUANTITY ----
LOGGED BY LF
DRILLING COMPANY Gregg Drilling
REMARKS Borehole 1102 is located on road above 1101. Drilled through fill and hit clay at ~19 feet and possibly weathered Franciscan at ~41 feet.
REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		SM	0–24		(FILL; SM) gravelly SILTY SAND, fine sand, subangular to subrounded gravel; brown; dry to moist.
			10		at 10-15 feet: increase in gravel, fine to coarse angular to subangular gravel; whitish-brown.
	0/18		19		at 19 feet: driller noticed softer material; attempted a drive sample (no recovery)
		CL	24–25		(FILL; CL) gravelly SILTY CLAY, fine subangular to subrounded gravel, some coarse sand; grayish-brown; moist.
		GM	25–35		(FILL; GM) SILTY GRAVEL, angular to subangular gravel, some sand; wet.
		CH	35–40		(NATIVE; CH) CLAY, possible channel sediment, medium to high plastic fines.
	18/18	GM	40–41		(NATIVE; GM) sandy SILTY GRAVEL, possible channel sediment.
		ML	41–45		(NATIVE; ML) sandy gravelly SILT, low to medium plastic fines, weathered Franciscan bedrock; brownish-gray.

Bottom of borehole at 45.0 feet.

Golder Associates

Golder Associates, Inc.

Telephone:

BORING NUMBER 1103

PROJECT NUMBER 1302968-01

PROJECT NAME Lehigh Rockpile Drill

LOCATION Cupertino, CA

DRILLING METHOD HSA

GROUND ELEVATION

TOP OF CASING ----

LOGGED BY LF

DATE STARTED 2/12/15

DATE COMPLETED 2/12/15

CASING TYPE/DIAMETER ----

SCREEN TYPE/SLOT ----

GRAVEL PACK TYPE ----

GROUT TYPE/QUANTITY ----

DRILLING COMPANY Gregg Drilling

REMARKS Borehole 1103 is located on road. Hit cobbles at 18 feet and unable to drill past.

REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML			(FILL; ML) gravelly SILT, low plastic fines, subangular to subrounded gravel, some fine sand; dark grayish-brown; moist.
		SM	5		(FILL; SM) gravelly SILTY SAND, fine sand, low plastic fines, subangular to subrounded gravel; brown; moist.
		ML	10		(FILL; ML) gravelly sandy SILT, low to medium plastic fines; dark brown; moist.
		GM	15		(FILL; GM) SILTY GRAVEL and COBBLES, angular to subangular; whitish-brown. unable to drill past 18 feet; possibly stuck on a boulder

Bottom of borehole at 18.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1103R

PROJECT NUMBER	1302968-01	**DATE STARTED**	2/12/15
PROJECT NAME	Lehigh Rockpile Drill	**DATE COMPLETED**	2/12/15
LOCATION	Cupertino, CA	**CASING TYPE/DIAMETER**	----
DRILLING METHOD	HSA	**SCREEN TYPE/SLOT**	----
GROUND ELEVATION		**GRAVEL PACK TYPE**	----
TOP OF CASING	----	**GROUT TYPE/QUANTITY**	----
LOGGED BY	LF	**DRILLING COMPANY**	Gregg Drilling

REMARKS Borehole 1103R is 3 feet east of 1103. Hit weathered Franciscan bedrock at ~25-30 feet.

REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML	0–8		(FILL; ML) gravelly SILT, low plastic fines, subangular to subrounded gravel, some fine sand; light brown to brown; moist.
		SM	8–20		(FILL; SM) gravelly SILTY SAND, fine sand, low to medium plastic fines, subangular to subrounded gravel; brown to dark brown; moist.
		ML	20–25		(FILL, ML) gravelly sandy SILT, angular to subangular gravel, weathered Franciscan clasts; brown.
		CL-ML	25–30		(NATIVE; CL-ML) gravelly SILT to gravelly CLAY, angular to subangular gravel, weathered Franciscan bedrock; reddish-orangish-brownish-gray; moist to wet.
			30		Bottom of borehole at 30.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1104

PROJECT NUMBER 1302968-01
PROJECT NAME Lehigh Rockpile Drill
LOCATION Cupertino, CA
DRILLING METHOD HSA
GROUND ELEVATION
TOP OF CASING ----
LOGGED BY LF
DATE STARTED 2/12/15
DATE COMPLETED 2/12/15
CASING TYPE/DIAMETER ----
SCREEN TYPE/SLOT ----
GRAVEL PACK TYPE ----
GROUT TYPE/QUANTITY ----
DRILLING COMPANY Gregg Drilling
REMARKS Borehole 1104 is located on rockpile. Hit cobbles at 32 feet and unable to drill past.
REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML	0–14		(FILL; ML) gravelly sandy SILT, low to medium plastic fines, subangular to subrounded gravel; gray; moist.
					color change to light grayish-brown
			10		color change to light brown
		CL-ML	14–20		(FILL; ML-CL) gravelly SILT to gravelly CLAY, medium plastic fines, subangular to subrounded gravel, trace coarse sand; brown; moist.
		GM	20–26		(FILL; GM-ML) SILTY GRAVEL to gravelly SILT, low plastic fines, angular gravel, some coarse angular sand; tannish-whitish-brown; moist.
					at 26 feet: driller noticed material became more stiff
		CL-ML	26–33		(FILL; ML-CL) gravelly CLAY to gravelly SILT, medium plastic fines, fine subangular to subrounded gravel, some fine sand, weathered; dark brownish-gray; moist.
	18/18		30		
	3/12				at 32 feet: hard material; unable to drill any further.
					Bottom of borehole at 33.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1104R

PROJECT NUMBER 1302968-01

PROJECT NAME Lehigh Rockpile Drill

LOCATION Cupertino, CA

DRILLING METHOD HSA

GROUND ELEVATION

TOP OF CASING ----

LOGGED BY LF

DATE STARTED 2/12/15

DATE COMPLETED 2/12/15

CASING TYPE/DIAMETER ----

SCREEN TYPE/SLOT ----

GRAVEL PACK TYPE ----

GROUT TYPE/QUANTITY ----

DRILLING COMPANY Gregg Drilling

REMARKS Borehole 1104R is 3 feet east of 1104. Possibly hit weathered Franciscan bedrock at about 67 feet.

REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML	0–15		(FILL; ML) gravelly sandy SILT, low plastic fines, angular to subangular gravel; grayish-brown; moist. at 9 ' color changes to light brown
		CL-ML	15–20		(FILL; ML-CL) gravelly SILT to gravelly CLAY, low to medium plastic fines; brown; moist.
		GM	20–30		(FILL; GM-ML) SILTY GRAVEL to gravelly SILT, low plastic fines, angular gravel; tanish-brown; moist.
		CL-ML	30–		(FILL: ML-CL) gravelly SILT to gravelly CLAY, subangular to subrounded gravel; brown to reddish-brown; moist. at 35' color changes to reddish-brown

Golder Associates, Inc.

Telephone:

BORING NUMBER 1104R

PROJECT NUMBER 1302968-01

PROJECT NAME Lehigh Rockpile Drill

DATE STARTED 2/12/15

DATE COMPLETED 2/12/15

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		CL-ML			(FILL: ML-CL) gravelly SILT to gravelly CLAY, subangular to subrounded gravel; brown to reddish-brown; moist. *(continued)*
		ML	45		(FILL; ML) gravelly SILT, low plastic fines, coarse subangular to angular gravel; brown; moist.
		CL-ML	50		(FILL; ML-CL) gravelly SILT to gravelly CLAY, low to medium plastic fines, angular to subangular gravel; brown; moist.
		GM	55 60 65		(FILL; GM) SILTY GRAVEL, low plastic fines, fine subangular gravel; light tanish-brown; moist. at 67 feet: driller notices a change in drilling
		GM	70		(NATIVE; GM-SM) sandy GRAVEL to gravely SAND, low plastic fines, weathered Franciscan clasts; brownish-gray to greenish-gray; moist to wet.
		CL	75		(NATIVE; CL) CLAY, slightly weathered Franciscan; dark gray; moist to wet.

Bottom of borehole at 75.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1105

PROJECT NUMBER 1302968-01
DATE STARTED 2/13/15
PROJECT NAME Lehigh Rockpile Drill
DATE COMPLETED 2/13/15
LOCATION Cupertino, CA
CASING TYPE/DIAMETER ----
DRILLING METHOD HSA
SCREEN TYPE/SLOT ----
GROUND ELEVATION
GRAVEL PACK TYPE ----
TOP OF CASING ----
GROUT TYPE/QUANTITY ----
LOGGED BY LF
DRILLING COMPANY Gregg Drilling
REMARKS Borehole 1105 is located on rockpile (most North on Figure). Hit clay at ~63 feet, unable to drill past 66 feet.
REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		GM	0–5		(FILL, GM) SILTY GRAVEL, angular to subangular; light to dark gray.
		CL-ML	5–10		(FILL; CL-ML) gravelly sandy CLAY to sandy SILT, medium plastic fines, medium to coarse sand, subangular gravel; dark gray; moist.
		ML	10–20		(FILL; ML) gravelly SILT, low plastic fines, fine to coarse subangular gravel, some coarse sand; brown; moist.
		GM	20–33		(FILL, GM) SILTY GRAVEL, fine to coarse angular to subangular gravel, low plastic fines; whitish-brown; moist.
		ML	33–35		(FILL; ML) gravelly SILT, low to medium plastic fines, subangular gravel; brown; moist.
		ML	35–		(FILL; ML) gravelly SILT, low plastic fines, angular to subangular gravel, some coarse angular to subangular sand, slightly weathered Franciscan clasts; reddish-orangish-brown; moist. at 35 feet: driller noticed material became more stiff; drill bit became hot and started smoking.

Golder Associates

Golder Associates, Inc.

Telephone:

BORING NUMBER 1105

PROJECT NUMBER 1302968-01

DATE STARTED 2/13/15

PROJECT NAME Lehigh Rockpile Drill

DATE COMPLETED 2/13/15

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML			(FILL; ML) gravelly SILT, low plastic fines, angular to subangular gravel, some coarse angular to subangular sand, slightly weathered Franciscan clasts; reddish-orangish-brown; moist. *(continued)*
		ML	45 50 55		(FILL; ML) gravelly SILT, low plastic fines, anuglar to subangular gravel; brown; moist.
		SM-ML	60		(FILL; ML-SM) gravelly sandy SILT, low plastic fines, fine to coarse sand, subangular to subrounded gravel; brown; moist.
		CH			(NATIVE; CH) gravelly CLAY, possible pond sediment, medium to high plastic fines, subangular to subrounded gravel, some coarse subangular sand; brown to dark brownish-gray to black; moist.
SS	3/6 5/6	CL-ML	65		(NATIVE; ML-CL) CLAYEY SILT to SILTY CLAY, possible pond sediment, low plastic fines, some fine sand, trace coarse subangular sand; light brownish-gray mottled dark gray.

Bottom of borehole at 66.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1106A

PROJECT NUMBER 1302968-01
PROJECT NAME Lehigh Rockpile Drill
LOCATION Cupertino, CA
DRILLING METHOD HSA
GROUND ELEVATION
TOP OF CASING ----
LOGGED BY LF
DATE STARTED 2/13/15
DATE COMPLETED 2/13/15
CASING TYPE/DIAMETER ----
SCREEN TYPE/SLOT ----
GRAVEL PACK TYPE ----
GROUT TYPE/QUANTITY ----
DRILLING COMPANY Gregg Drilling
REMARKS Borehole 1106A location is downslope on rockpile (east of previous boreholes). Driller notes gravel at ~18 feet.
REMARKS CONTINUED Possible pond sediment at ~25 feet. Possibly hit weathered Franciscan bedrock at ~66 feet.

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		GM	0–10		(FILL; GM) sandy SILTY GRAVEL, angular to subangular gravel, low plastic fines, fine to coarse sand; brown; moist.
		GP	10–15		(FILL; GP) poorly graded GRAVEL, coarse subangular gravel, some silt; brown; moist.
		GM	15–17.5		(FILL; GM-GC) SILTY GRAVEL to CLAYEY GRAVEL, low plastic fines, subangular gravel; brown; moist.
		SM	17.5–25		(FILL; SM) SILTY SAND, fine sand, low plastic fines, some medium to coarse subangular sand, some fine to coarse subangular gravel; brown; moist.
		CL-ML	25–		(FILL/COLLUVIUM (?); ML-CL) gravelly SILT to gravelly CLAY, low to medium plastic fines, fine to coarse subangular gravel; brown; moist.

Golder Associates

Golder Associates, Inc.

Telephone:

BORING NUMBER 1106A

PROJECT NUMBER 1302968-01 **DATE STARTED** 2/13/15

PROJECT NAME Lehigh Rockpile Drill **DATE COMPLETED** 2/13/15

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		ML			(FILL/COLLUVIUM (?); ML) gravelly SILT, low plastic fines, fine subangular gravel; brown; moist.
		ML	45		(FILL/COLLUVIUM (?); ML) gravelly SILT, low palstic fines, fine subangular gravel, some fine to coarse subangular sand; brown; moist.
		GM	50 / 55		(FILL/COLLUVIUM (?); GM) SILTY GRAVEL, fine angular to subangular gravel, low plastic fines, some coarse subangular gravel; brown; moist.
SS	12/18	ML	60 / 65		(FILL/COLLUVIUM (?); ML) gravelly SILT, low plastic fines, fine to coarse subangular gravel, some coarse subangular sand; brown; moist
		SM			(NATIVE; SM/GP) SILTY SAND and GRAVEL, heavily weathered; wet.
SS	6/18	CL-ML	70		(NATIVE; ML-CL) gravelly SILT to gravelly CLAY, heavily weathered, possibly Franciscan bedrock; wet.
		GM			(NATIVE; GM) sandy SILTY GRAVEL, fine to coarse angular to subangular gravel, possibly Franciscan bedrock; brown and dark green; wet.
SS	12/18	SM	75		(NATIVE; SM) gravelly SILTY SAND, fine to coarse sand, low plastic fines, angular to subangular gravel, weathered, possibly Franciscan bedrock; reddish-brown mottled brown; wet.
SS	3/80		80		Bottom of borehole at 80.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1107

PROJECT NUMBER	1302968-01	**DATE STARTED**	2/13/15
PROJECT NAME	Lehigh Rockpile Drill	**DATE COMPLETED**	2/13/15
LOCATION	Cupertino, CA	**CASING TYPE/DIAMETER**	----
DRILLING METHOD	HSA	**SCREEN TYPE/SLOT**	----
GROUND ELEVATION		**GRAVEL PACK TYPE**	----
TOP OF CASING	----	**GROUT TYPE/QUANTITY**	----
LOGGED BY	LF	**DRILLING COMPANY**	Gregg Drilling

REMARKS Borehole 1107 is located on rockpile (most East on Figure). Hit a burried retaining wall at 7 feet and can't drill further.

REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		GM	0–7		(FILL; ML-GM) gravelly SILT to SILTY GRAVEL, low plastic fines, fine to coarse angular to subangular gravel, some coarse angular to subangular sand; dark gray; moist.
			5		
					at 7 feet: hit retaining well; can't drill futher.
					Bottom of borehole at 7.0 feet.

Golder Associates, Inc.

Telephone:

BORING NUMBER 1107R

PROJECT NUMBER 1302968-01

PROJECT NAME Lehigh Rockpile Drill

LOCATION Cupertino, CA

DRILLING METHOD HSA

GROUND ELEVATION

TOP OF CASING ----

LOGGED BY LF

DATE STARTED 2/13/15

DATE COMPLETED 2/13/15

CASING TYPE/DIAMETER ----

SCREEN TYPE/SLOT ----

GRAVEL PACK TYPE ----

GROUT TYPE/QUANTITY ----

DRILLING COMPANY Gregg Drilling

REMARKS Borehole 1107R is 3 feet east of 1107. Hit cobbles 10 feet and unable to drill past.

REMARKS CONTINUED

SAMPLING METHOD	Recovery (ft)	USCS	DEPTH (ft. BGL)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
		GM	0–10		(FILL; GM) SILTY GRAVEL, coarse subangular gravel; dark gray; moist.
			5		
			10		at 10 feet: stuck on cobble; can't drill further.
					Bottom of borehole at 10.0 feet.

G2. Slope Stability Analyses (Golder Associates, July 22, 2021)

GOLDER
MEMBER OF WSP

TECHNICAL MEMORANDUM

DATE July 22, 2021 **Project No.** 179018610

TO Erika Guerra
Lehigh Hanson

FROM Robert Paul C. Erickson, PE; William L. Fowler, PG, CEG

EMAIL robertpaul_erickson@golder.com, bill_fowler@golder.com

RE: SLOPE STABILITY ANALYSES, PERMANENTE CREEK RESTORATION PLAN, LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC. PERMANENTE QUARRY, CUPERTINO, CALIFORNIA

Ms. Guerra,

Golder Associates Inc. (Golder) is submitting this technical memorandum to Lehigh Southwest Cement Company and Hanson Permanente Cement, Inc. (Lehigh) to present the results of our slope stability analyses of the proposed Rock Pile and mining overburden removal to the design finished grade related to Permanente Creek Restoration Plan, herein referred to as the Restoration Plan (Waterways, 2018)[1], at the Permanente Quarry in Cupertino, California. This work was performed in support of our response to comments dated June 25, 2021 compiled by ESA and submitted to the County of Santa Clara regarding the Permanente Creek Restoration Plan (PCRP).

The following sections provide a brief description of the analyses that were performed, the results and conclusions, and relevant slope stability analyses model outputs are provided as Attachment 1.

1.0 MODEL DEVELOPMENT

Golder analyzed cross-section C-C’, shown on Sheets 19 and 21 of the Restoration Plan, 90% design submittal (Waterways, 2019). This cross-section location is considered critical for slope stability because it consists of, nominally, the greatest height of the rockpile overburden material (250 feet measured from toe to crest) and captures the steepest inclinations of both the existing rockpile (approximately 1.1H to 1.2H:1V) and underlying native metabasalt (aka greenstone) (approximately 1H: 1V). The geometry of the existing site conditions is based on topographic data per a survey collected by Lehigh in May 2011. The Restoration Plan provides additional information regarding the interpretation of the depth to the underlying native bedrock. The topographic data provided to Golder was truncated at the existing haul road on the north side of the creek at approximately elevation 1070 feet (El. 1070), therefore, model geometry north of the haul road was estimated based on measurements from Google Earth.

In lieu of piezometer data along cross-section C-C’, Golder assumed a phreatic surface based on our understanding of the general subsurface water conditions along the south rim of the quarry as informed by long

[1] Waterways Consulting, Inc. 2019. Permanente Creek Restoration Plan Grading Plan 90% Design. Santa Clara County Grading Permit Submittal, October 31, 2019.

term installation and data collection from vibrating wire piezometers installed between the quarry and Permanente Creek. The analyses performed here assumed the depth to water is approximately 75 feet below the existing haul road and declines through the native bedrock to a depth of approximately 20 feet below the existing culvert in the creek (near original creek thalweg elevation).

2.0 ANALYSES

Golder performed 2-dimensional, limit equilibrium slope stability analysis along cross-section C-C' using Slide2 Modeler, Version 9.012[2]. The analyses presented here used Spencer's method of analysis because it satisfies static horizontal and vertical equilibrium as well as moment equilibrium. These analyses evaluated circular failures only because the interpretation of the subsurface conditions indicate a block type failure is unlikely (i.e., no weak horizontal stratum). Critical slip surfaces and corresponding FOS were evaluated for local failures through upper and lower portions of the respective slopes as well as global failures that span from the ultimate crest to ultimate toe of the final slope configuration.

Golder analyzed the following four cases for slope stability:

1. The existing rockpile overburden given existing conditions.
2. The interpreted native bedrock following excavation and removal of the rockpile overburden and underlying thin surficial deposits.
3. The interpreted native bedrock surface in the creek bottom following excavation to the expected upper limit of the design finished subgrade of the creek per the Restoration Plan.
4. The interpreted native bedrock surface in the creek bottom following excavation to the expected lower limit of the design finished subgrade of the creek per the Restoration Plan.

As a limited sensitivity analysis, Golder evaluated each of the above four cases considering the assume phreatic surface described in Section 1 as well as under dry conditions to bracket the range of factors of safety (FOS).

3.0 GEOTECHNICAL PARAMETERS

The geotechnical parameters used in slope stability analyses are summarized in Table 1 and described below.

Table 1: Summary of Geotechnical Parameters

Material	Unit Weight (pcf)	Cohesion (psf)	Effective Friction Angle (degrees)
Rockpile Overburden	125	0	40
Metabasalt/Greenstone	165	6,480	30

Notes: pcf = pounds per cubic foot
psf = pounds per square foot

[2] Rocscience Inc. 2020. Slide 2 Modeler, 2D Limit Equilibrium Analysis for Slopes. Build Version 9.012. Build date December 11, 2020.

Golder assumed the rockpile overburden has a unit weight of 125 pounds per cubic foot (pcf) with 0 cohesion and an effective friction angle (Φ') of 40 degrees. Its assumed friction angle corresponds to the rockpile's angle of repose and these assumed shear strength parameters yield a minimum static FOS of 1.0 which is reasonable considering the rockpile has performed well and appears stable since its placement.

Numerous previous analyses were performed by Golder[3] to back calculate, test, and develop shear strength parameters for the native greenstone at the site. These investigations and analyses determined the characteristics of the greenstone vary across the site with poorer quality greenstone generally observed in the northern portion of the quarry and better-quality rock located along the southern and southeastern portions of the site. The best geologic analog for the Rock Pile area is the nearby southern quarry rim which is located about 1500 feet west-northwest of the Rock Pile. The two areas are on trend with respect to the structural fabric of the quarry, and it is our opinion that they likely are underlain by the same general package of Franciscan bedrock comprised of a mixture of metabasalt and graywacke with associated interlayered limestone blocks.

Golder performed a detailed investigation and analyses of the south quarry area for the purpose of final pitslope design in 2008. The results of this work are included as Chapter 9 of our geotechnical report published in support of the updated 2011 Reclamation Plan. Four coreholes were installed in the south quarry rim and approximately 1500 feet of core were recovered and analyzed. Rock mass properties used for the pitslope design were developed from geotechnical core logging, point load testing, and laboratory testing of the core. Mohr-Coulomb strengths for the rock units were estimated from Hoek-Brown strengths using the computer program RocData, by Rocscience. Based on this previous work, Golder assumed the metabasalt/greenstone unit has a unit weight of 165 pounds per cubic foot (pcf) with 45 psi cohesion and an effective friction angle (Φ') of 30 degrees.

4.0 RESULTS

The results of slope stability analyses are summarized in Table 2 and relevant model outputs are provided as Attachment 1.

[3] Golder Associates Inc. 2011. Geotechnical Evaluations and Design Recommendations (Revised), Permanente Quarry Reclamation Plan Update, Santa Clara County, California. December 2011.

Table 2: Summary of Slope Stability Analyses

Case	Failure Mode	FOS	
		Hypothetical Dry Conditions	Assumed Phreatic Surface
1 – Existing Conditions	Upper Slope	1.13	1.13
	Lower Slope	1.15	1.15
	Global	1.37	1.37
2 – Excavate Rockpile	Local (Upper Slope)	2.09	1.98
	Global	2.32	2.05
3 – Excavate to Upper Limit of Finished Grade	Local (Upper Slope)	2.09	1.97
	Lower Slope	5.58	5.13
	Global	2.14	1.87
4 – Excavation to Lower Limit of Finished Grade	Local (Upper Slope)	2.09	1.98
	Lower Slope	4.92	4.37
	Global	2.13	1.83

5.0 CONCLUSIONS AND CONSIDERATIONS

The results of the analyses presented here indicate the proposed excavation of the existing rockpile as well as excavation to both the upper and lower limits of the finished subgrade of the creek per the Restoration Plan will exceed a static FOS of 1.8. These conclusions are based on the interpreted extent of the native metabasalt/greenstone beneath the rockpile as described in the Restoration Plan, the condition (and corresponding geotechnical parameters) of the native metabasalt/greenstone Golder assumed for the analyses, and the phreatic surface Golder assumed for the analyses.

As outlined in our response to comments, and our previous documents published in support of the Permanente Creek Restoration Plan, a qualified professional engineer or geologist is required to inspect and map the native bedrock that is exposed beneath the rockpile overburden to confirm, or modify, the assumptions made to perform these analyses. If the observed conditions are different than those assumed here, additional analyses may be required.

6.0 CLOSING

Please contact the undersigned if you have questions or require clarifications regarding the information provided in this memorandum.

Golder Associates Inc.

Robert Paul C. Erickson, PE
Senior Consultant
RPCE/WLF/rpce

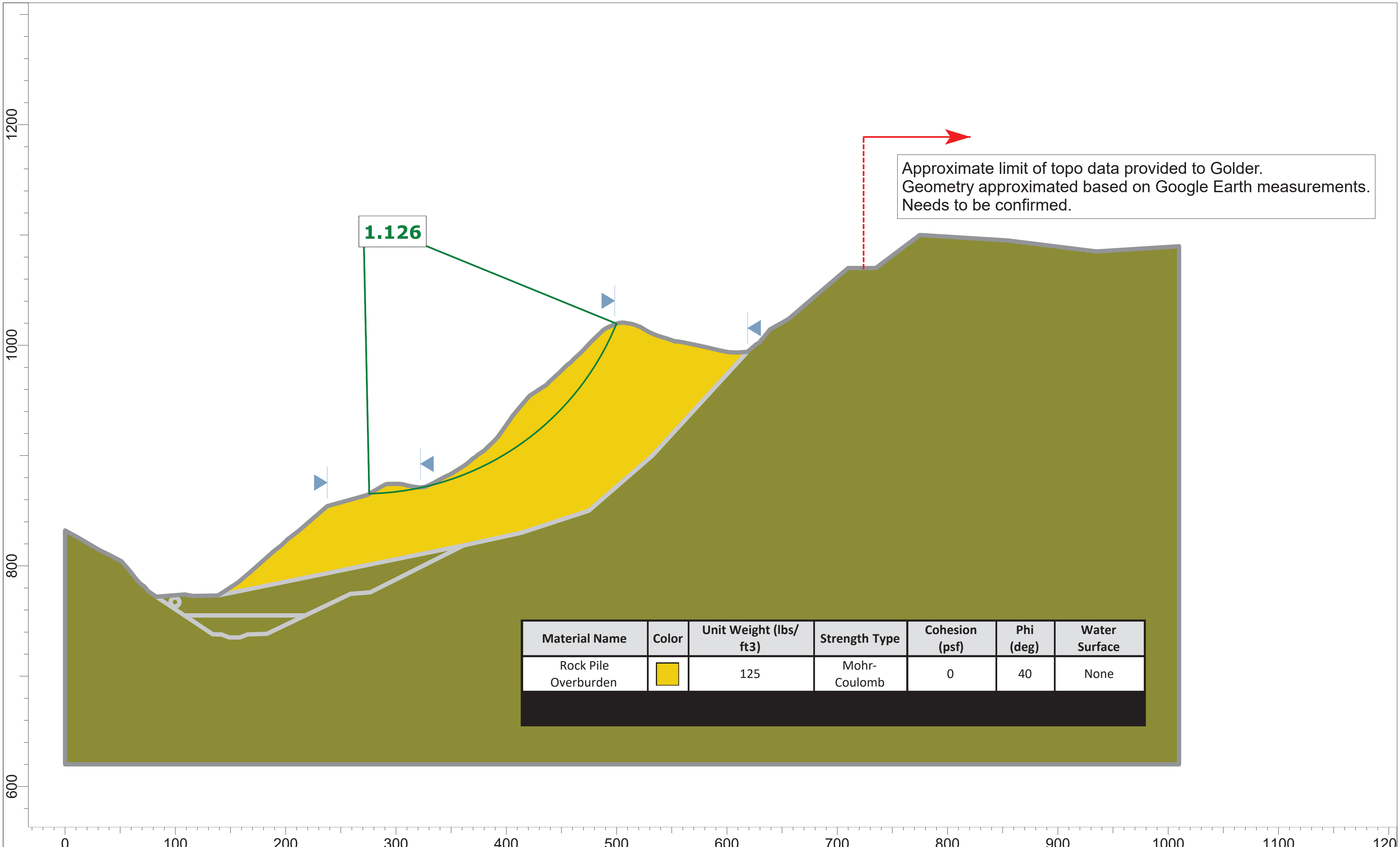
William L. Fowler, PG, CEG
Principal Engineering Geologist

Attachments: Attachment 1 – Slope Stability Analyses Model Outputs

https://golderassociates.sharepoint.com/sites/0637109940-lehighpermgwmonitoring-ca/shared documents/creek restoration/lehigh permanente creek restoration slope stability memo - 20210722.docx

ATTACHMENT 1

Slope Stability Analyses Model Outputs



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None

GOLDER

SLIDEINTERPRET 9.012

Project
SLIDE - An Interactive Slope Stability Program

Analysis Description

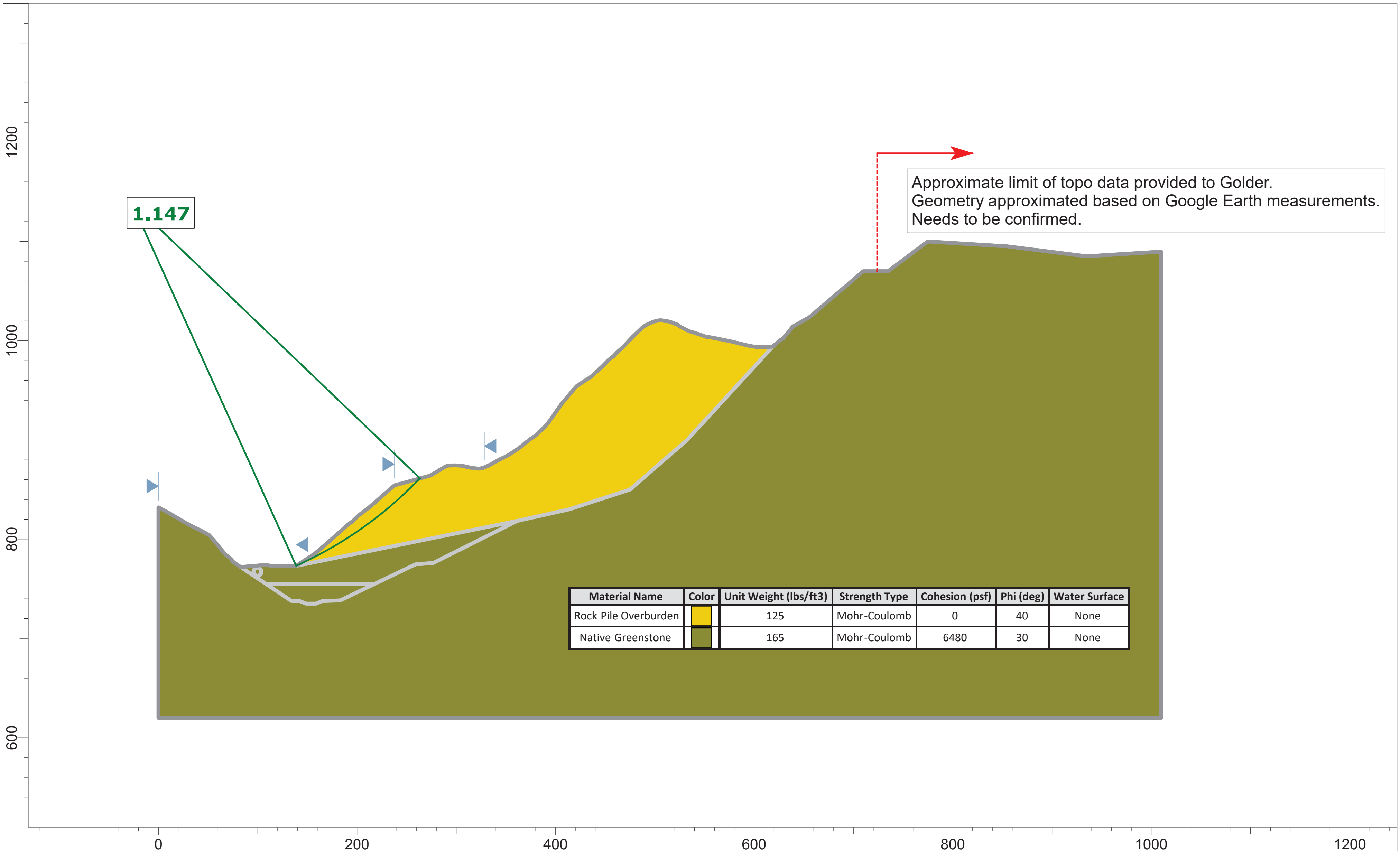
Drawn By

Scale 1:1444

Company

Date 7/9/2021, 4:25:49 PM

File Name Section C-C'_20210715.slmd

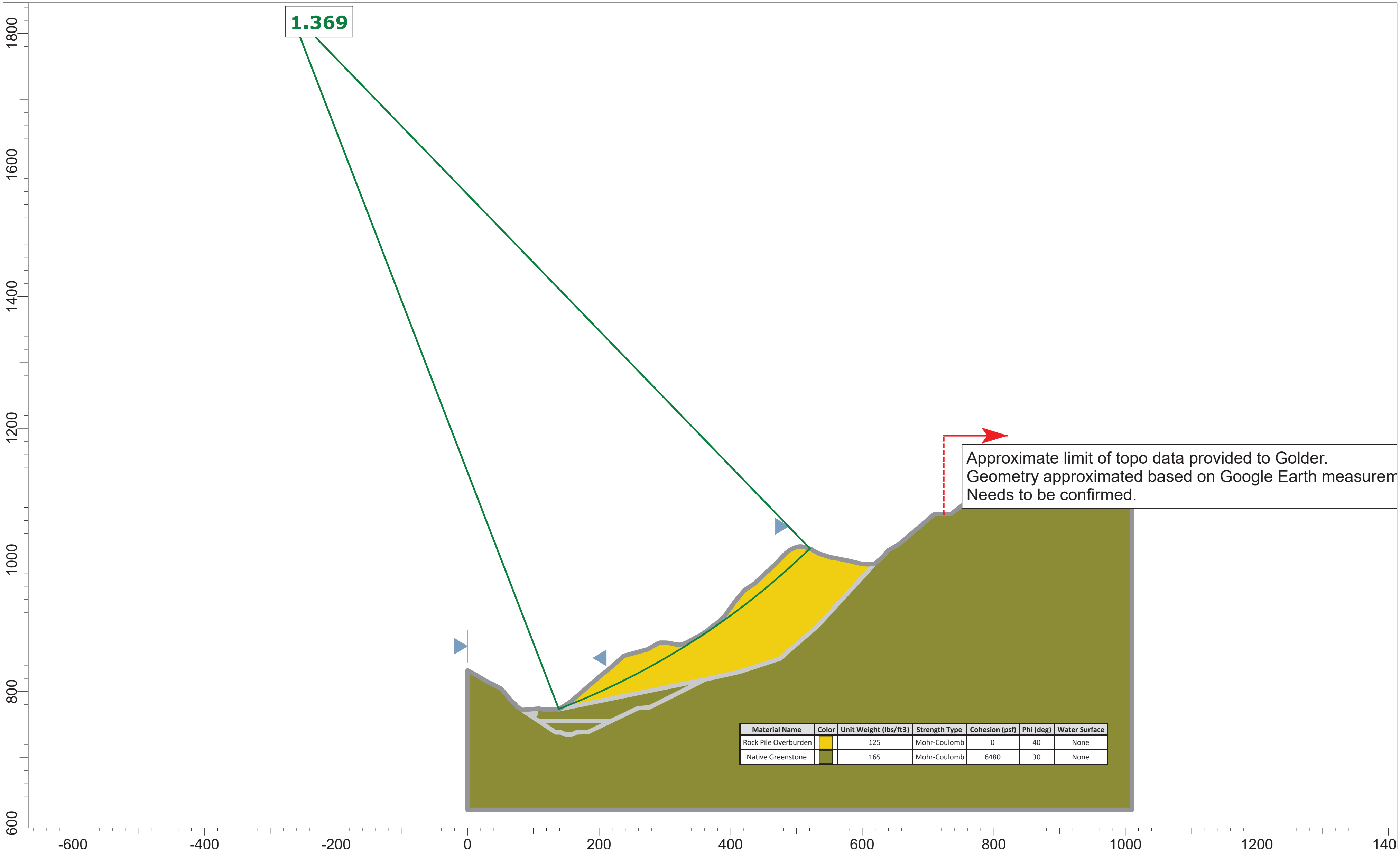


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None
Native Greenstone		165	Mohr-Coulomb	6480	30	None

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:1605	*Company*
Date 7/9/2021, 4:25:49 PM			*File Name* Section C-C'_20210715.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None
Native Greenstone		165	Mohr-Coulomb	6480	30	None

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
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Date	7/9/2021, 4:25:49 PM
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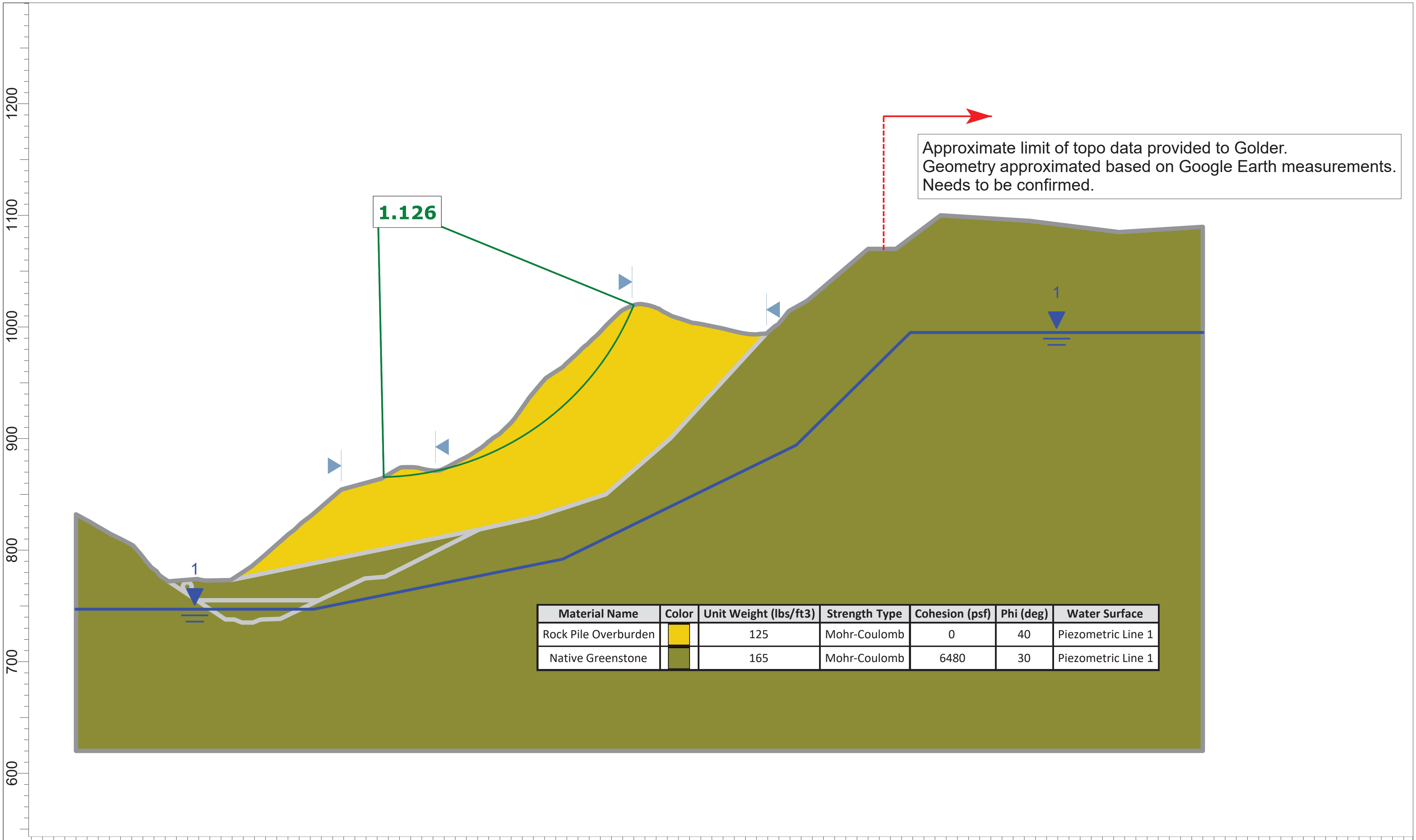

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
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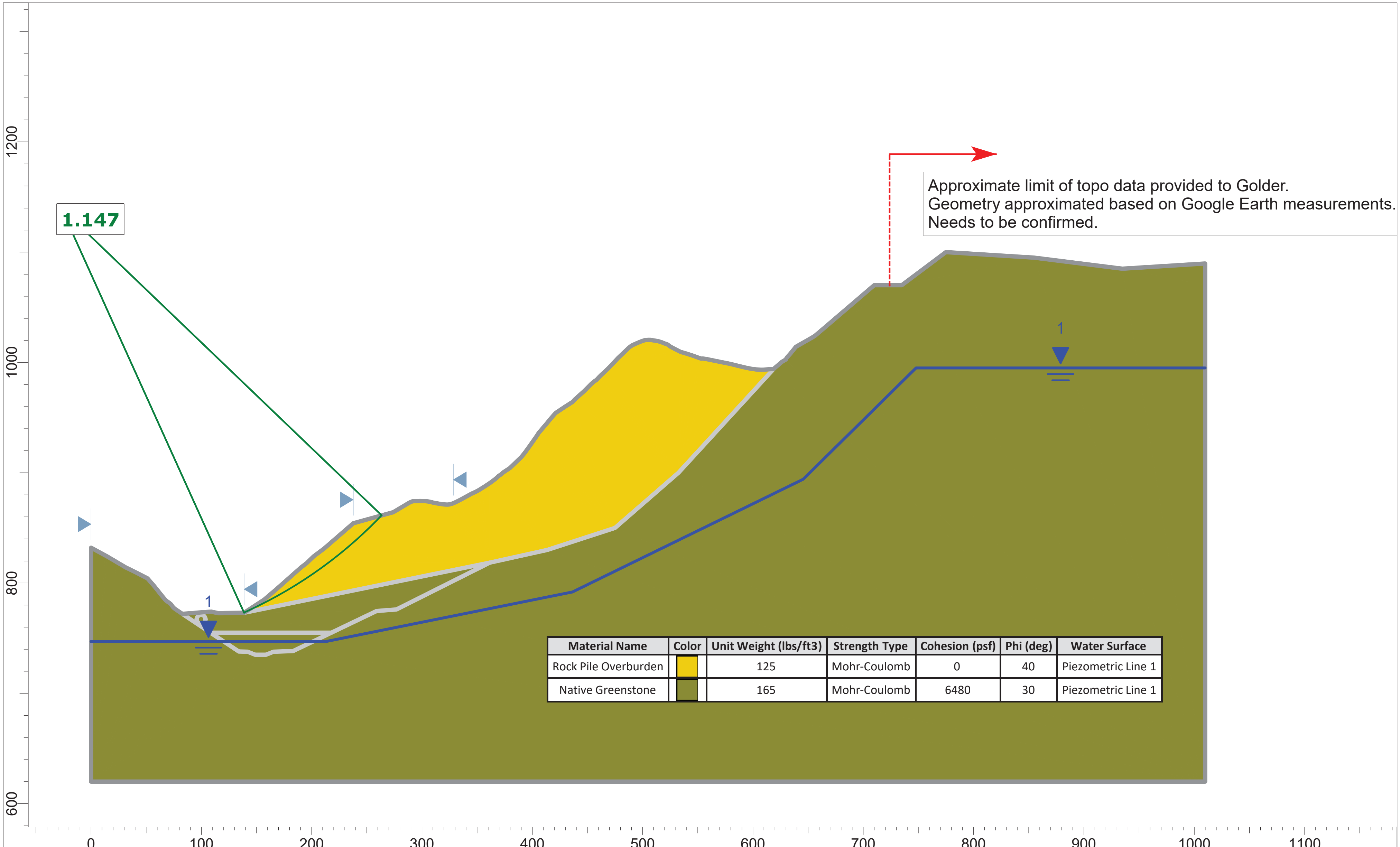

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
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Company	
Date	7/9/2021, 4:25:49 PM
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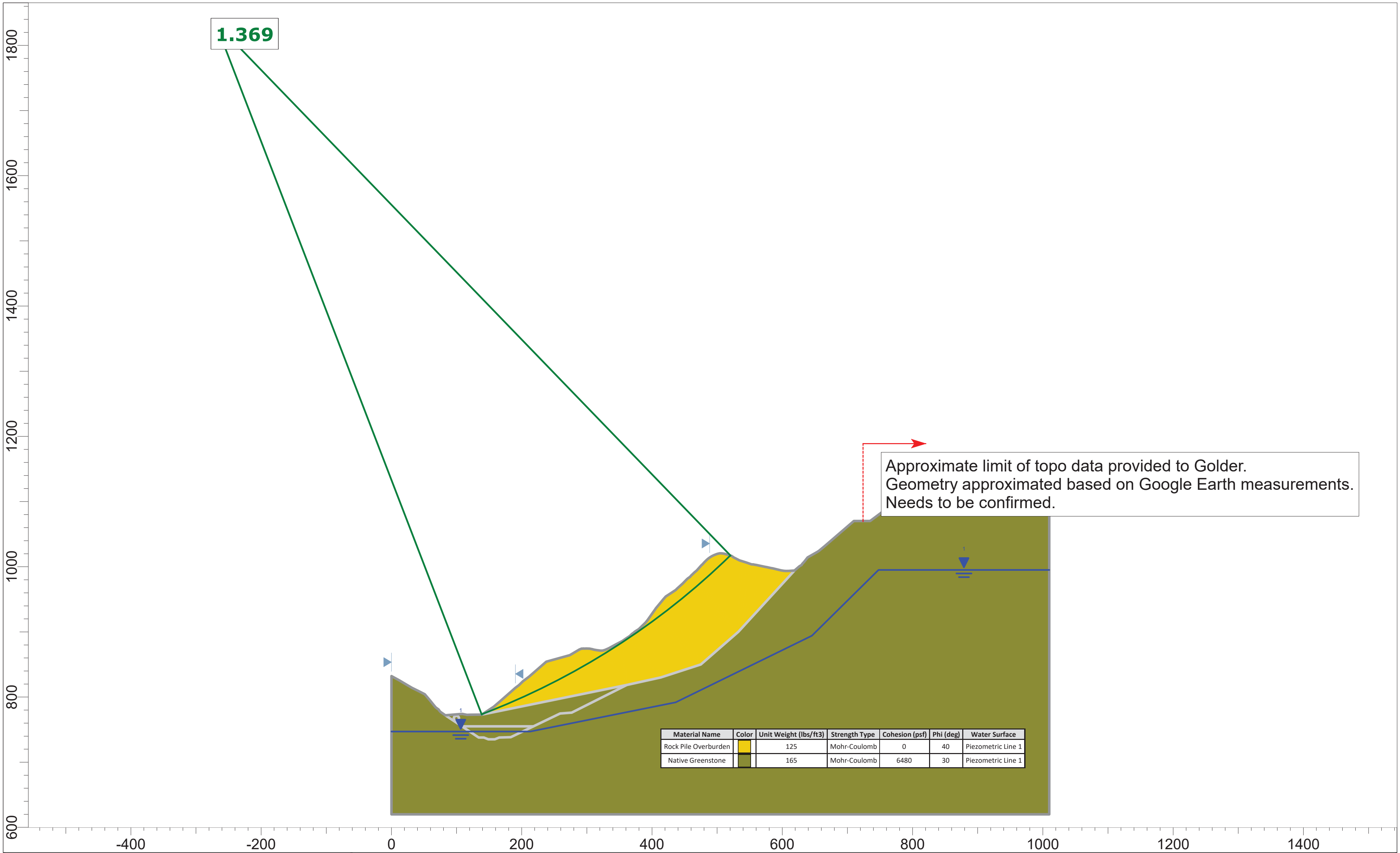

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
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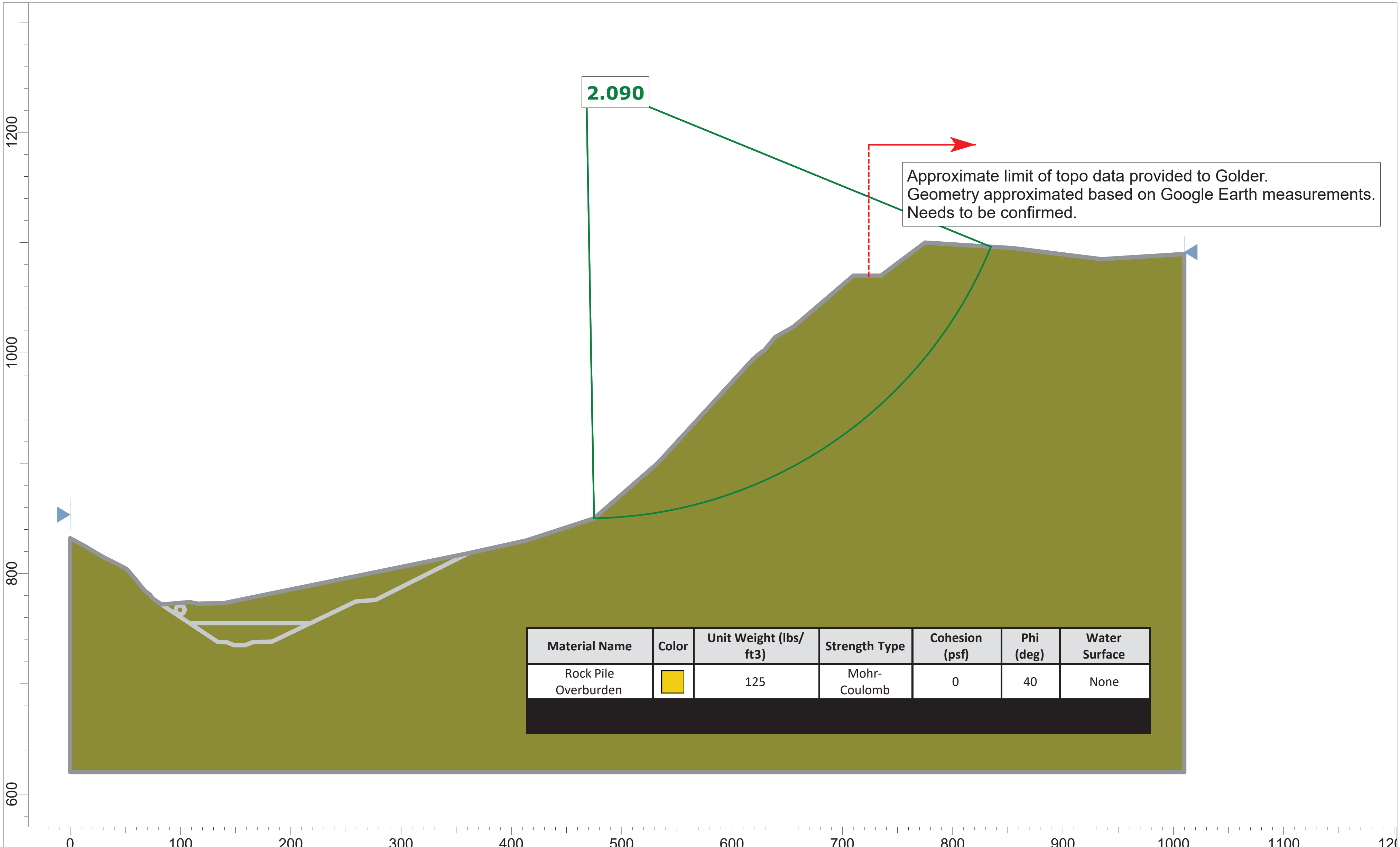

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
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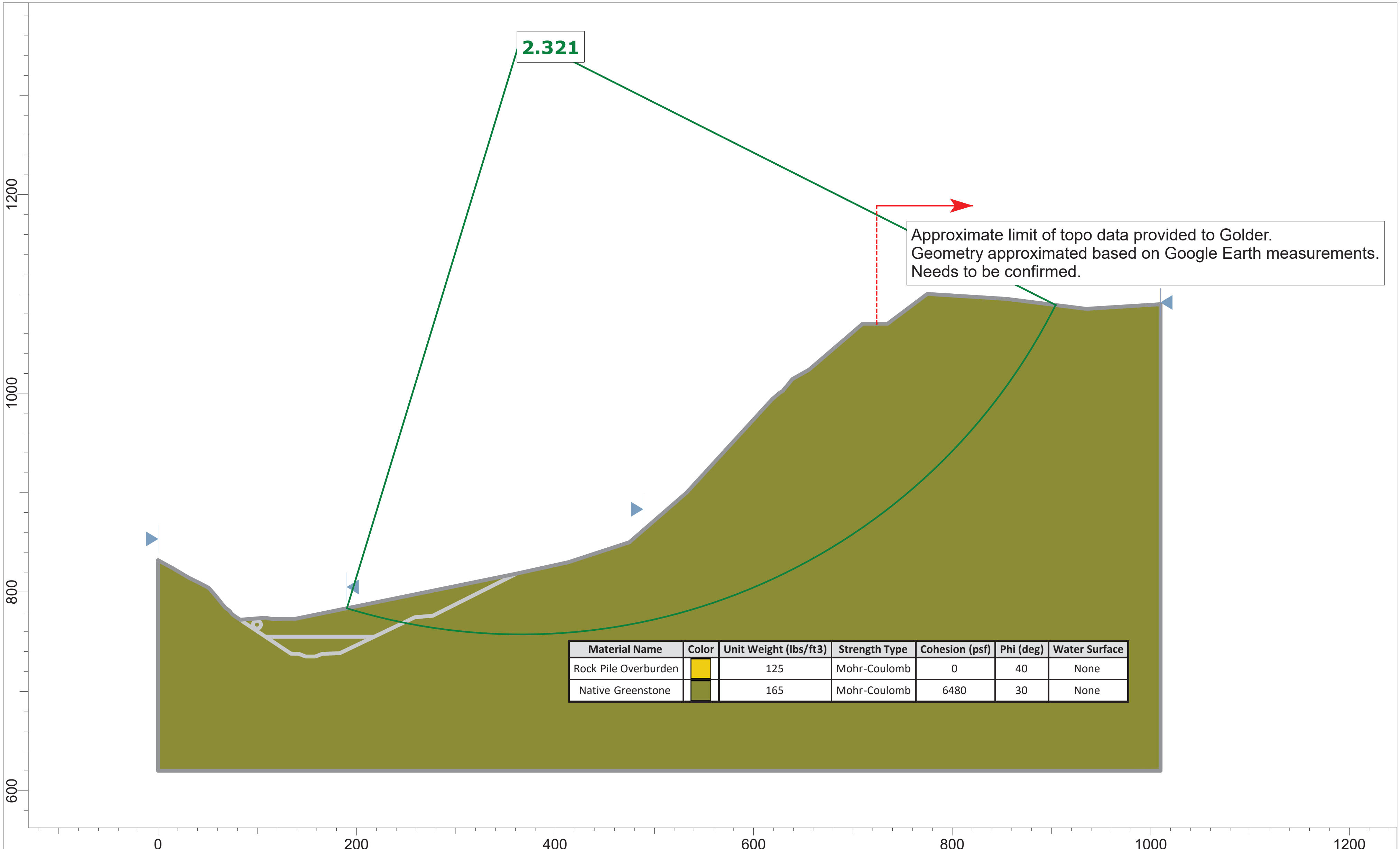
Date 7/9/2021, 4:25:49 PM		*File Name* Section C-C'_20210715.slmd	

GOLDER

SLIDEINTERPRET 9.012



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None
Native Greenstone		165	Mohr-Coulomb	6480	30	None

GOLDER

SLIDEINTERPRET 9.012

Project
SLIDE - An Interactive Slope Stability Program

Analysis Description

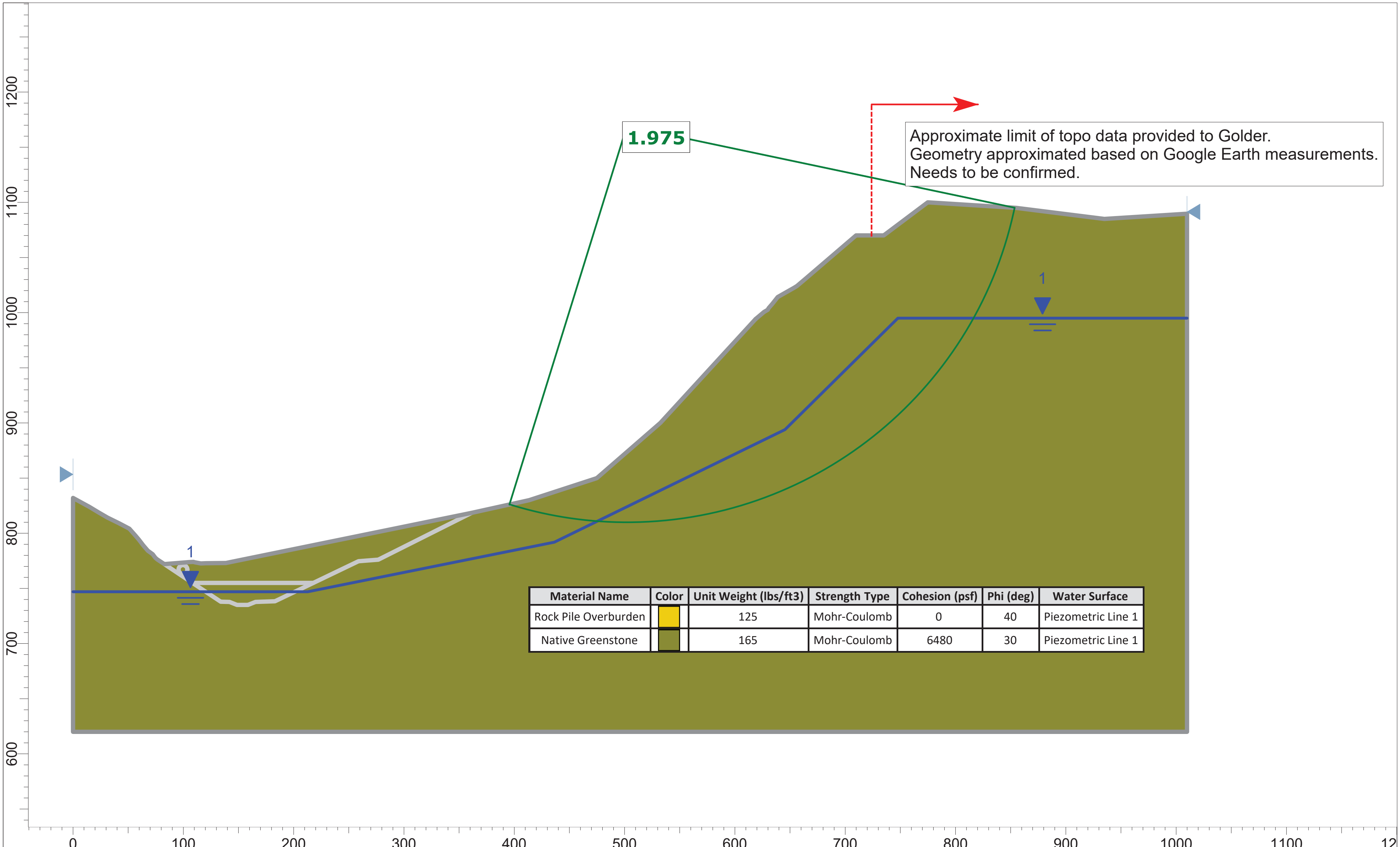
Drawn By

Scale 1:1605

Company

Date 7/9/2021, 4:25:49 PM

File Name Section C-C'_20210715.slmd

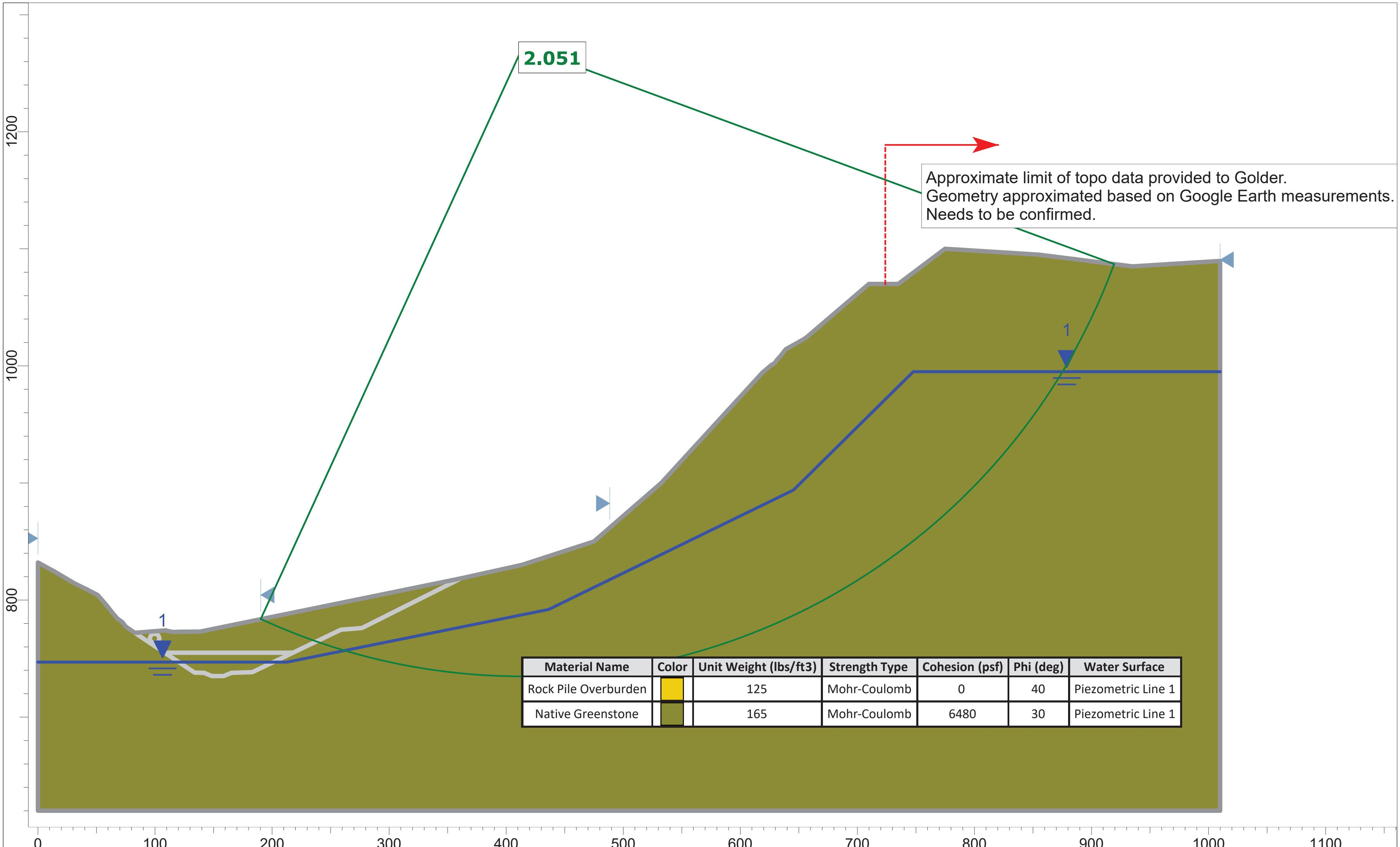


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:1444
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
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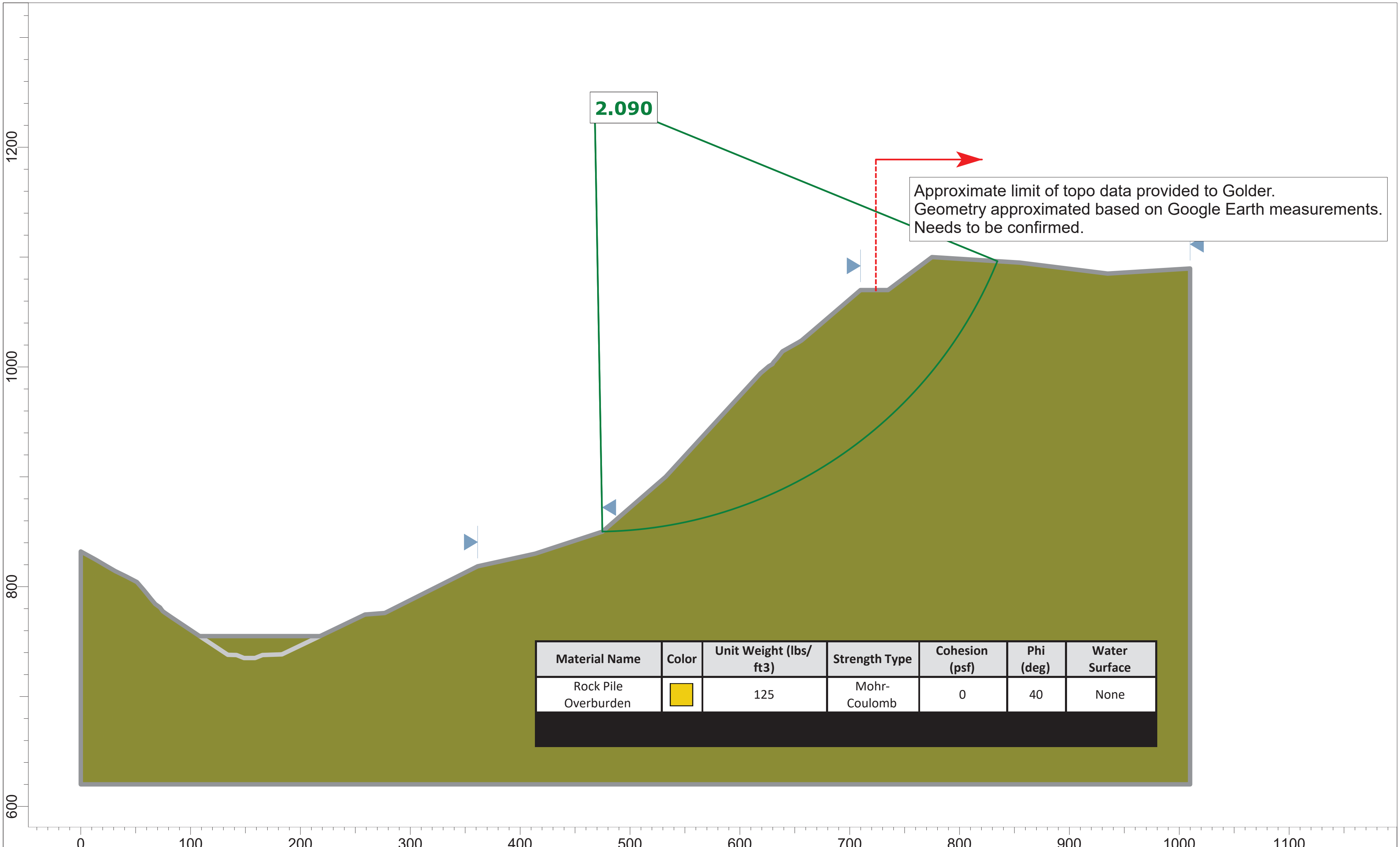
Date 7/9/2021, 4:25:49 PM		*File Name* Section C-C'_20210715.slmd	



GOLDER

SLIDEINTERPRET 9.012

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Analysis Description	
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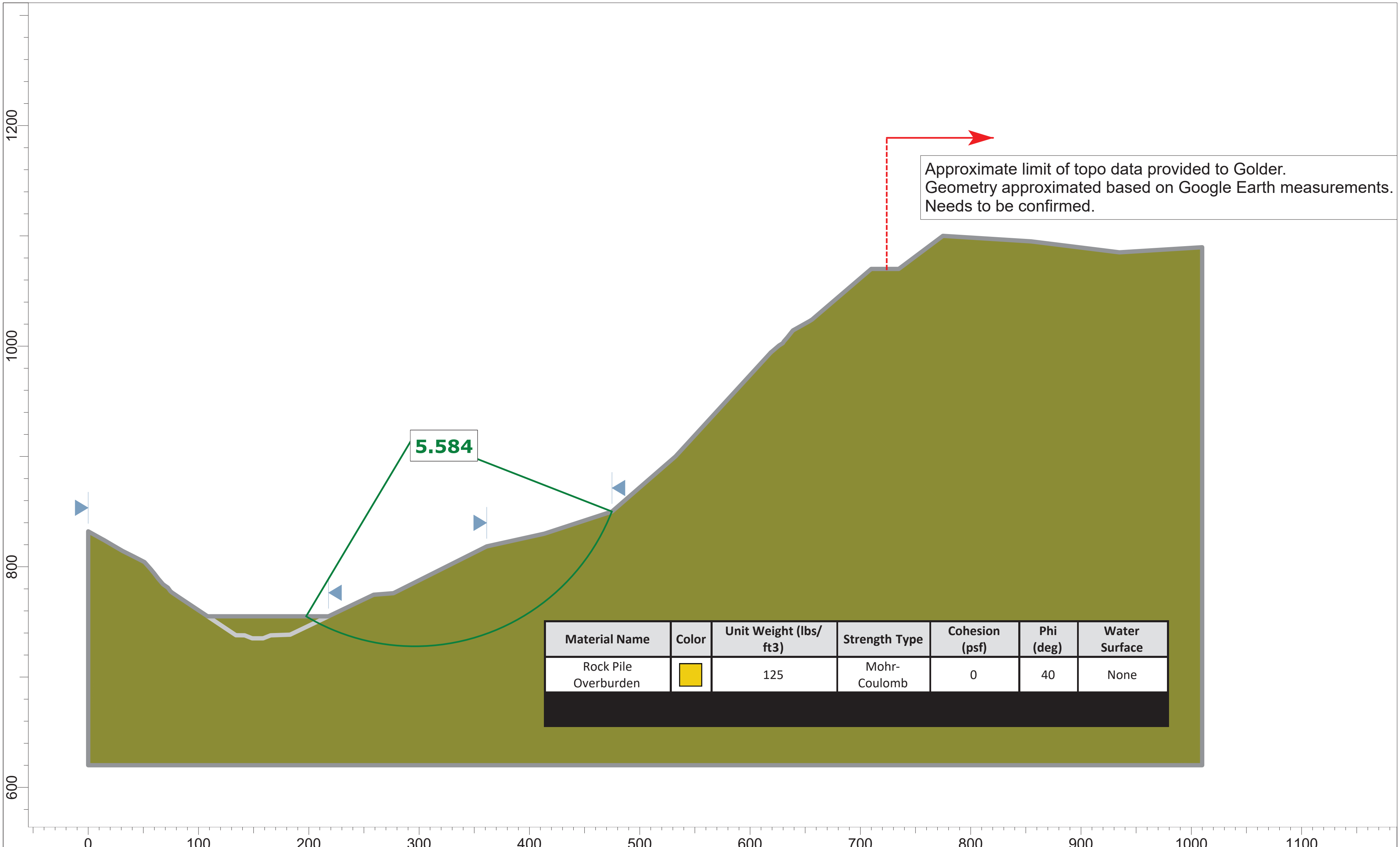
Company	
Date 7/9/2021, 4:25:49 PM	*File Name* Section C-C'_20210715.slmd

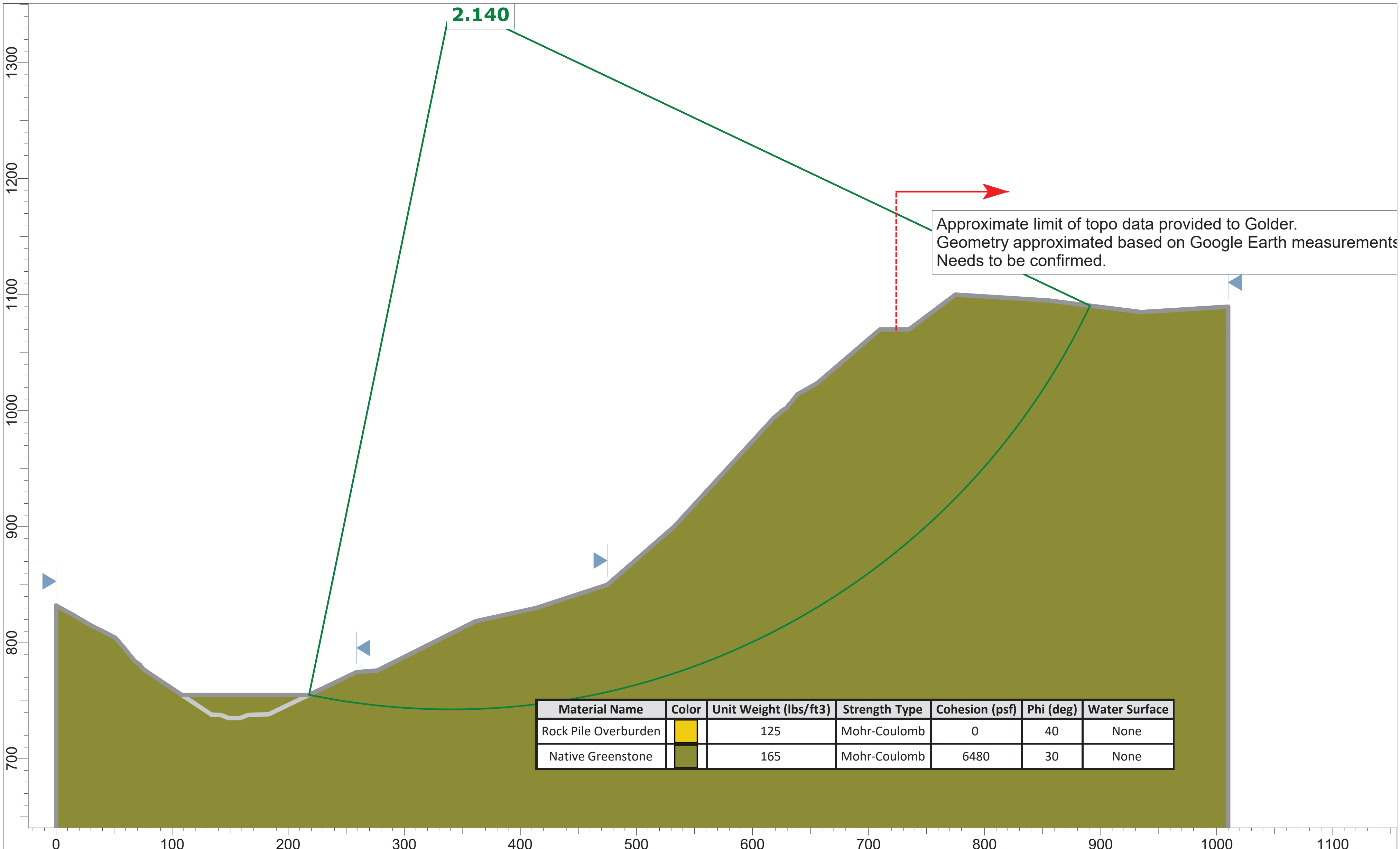


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:1444	*Company*
Date 7/9/2021, 4:25:49 PM		*File Name* Section C-C'_20210715.slmd	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None
Native Greenstone		165	Mohr-Coulomb	6480	30	None

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
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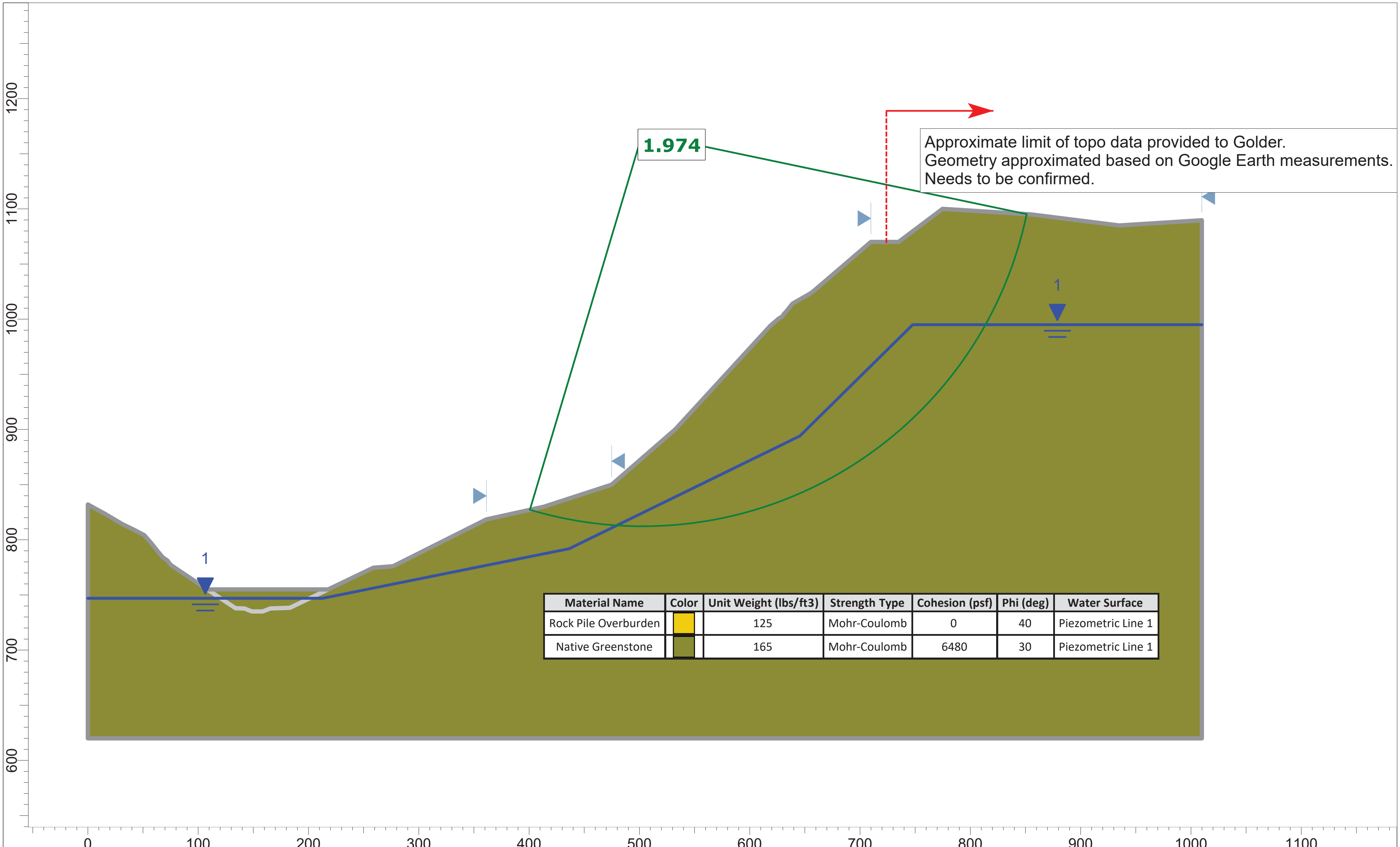
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd

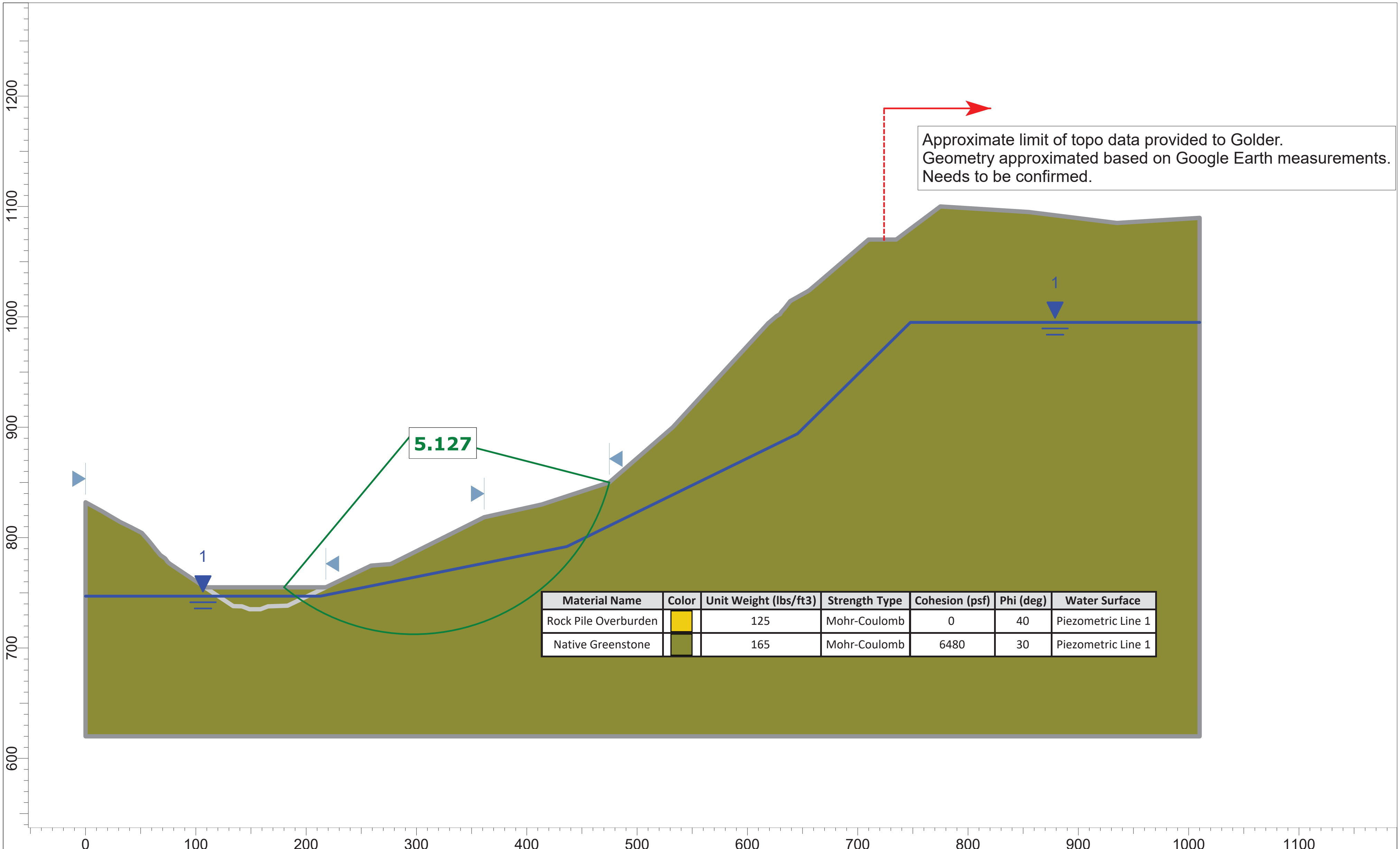


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:1444
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
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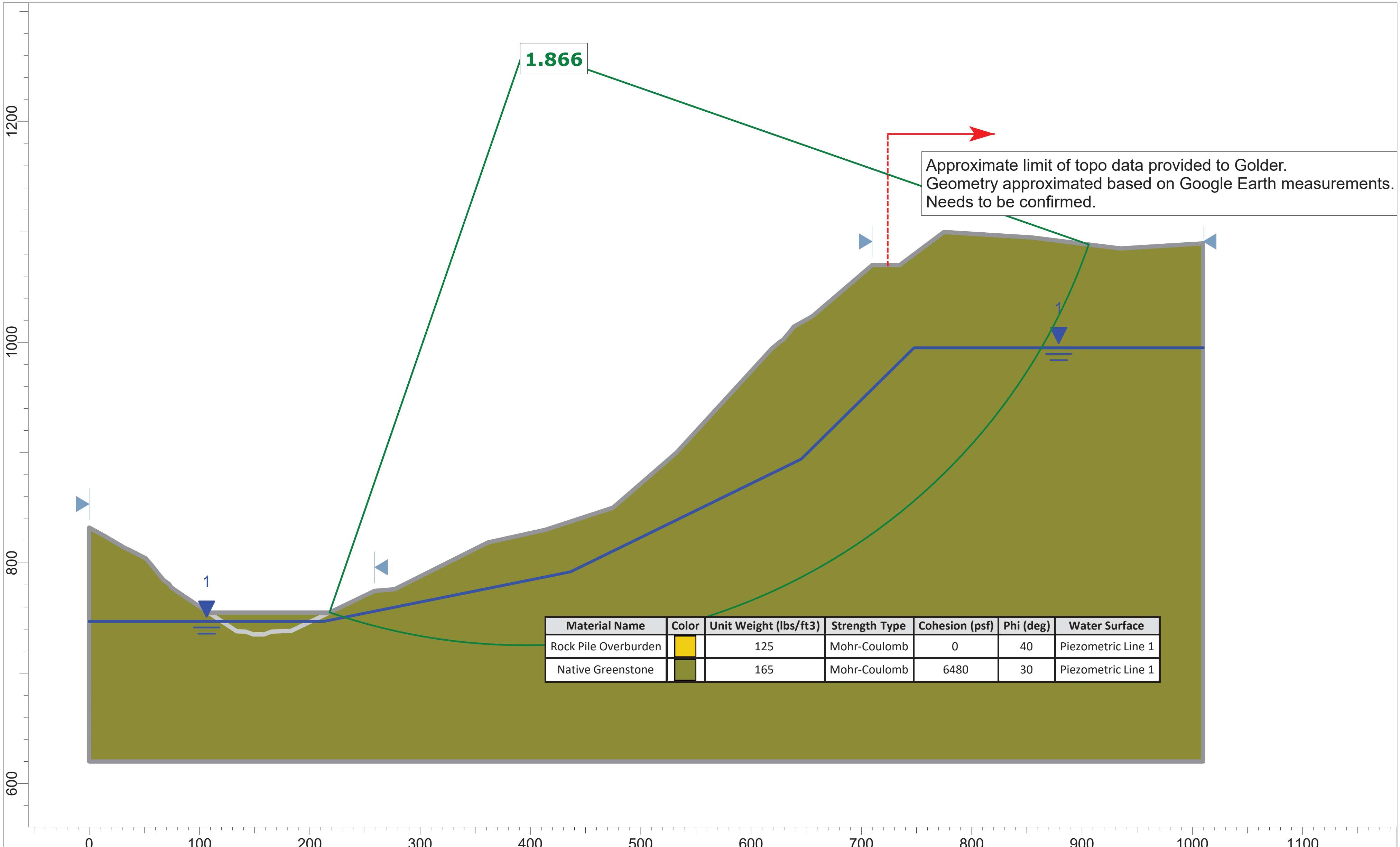
Date 7/9/2021, 4:25:49 PM		*File Name* Section C-C'_20210715.slmd	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
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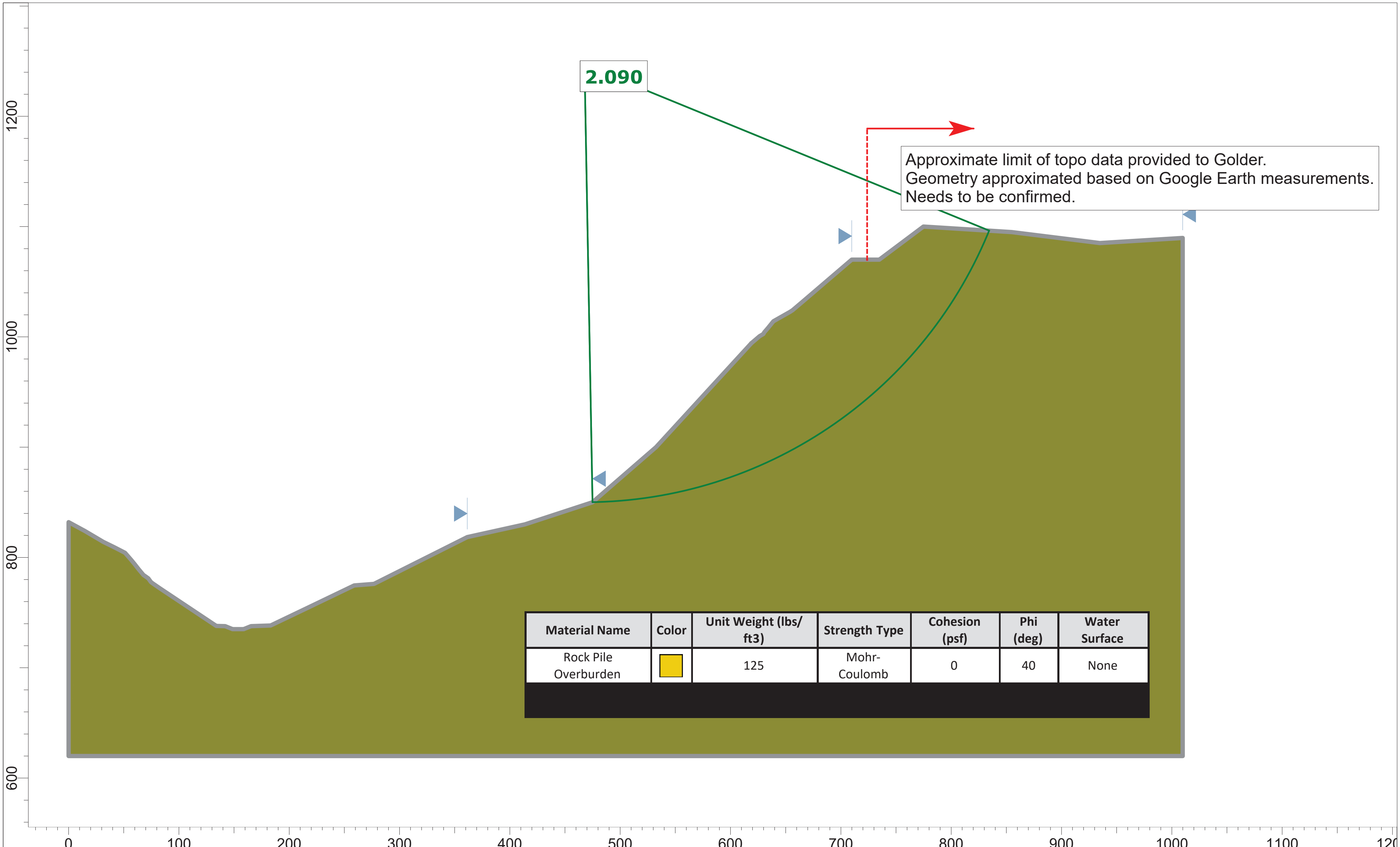
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd



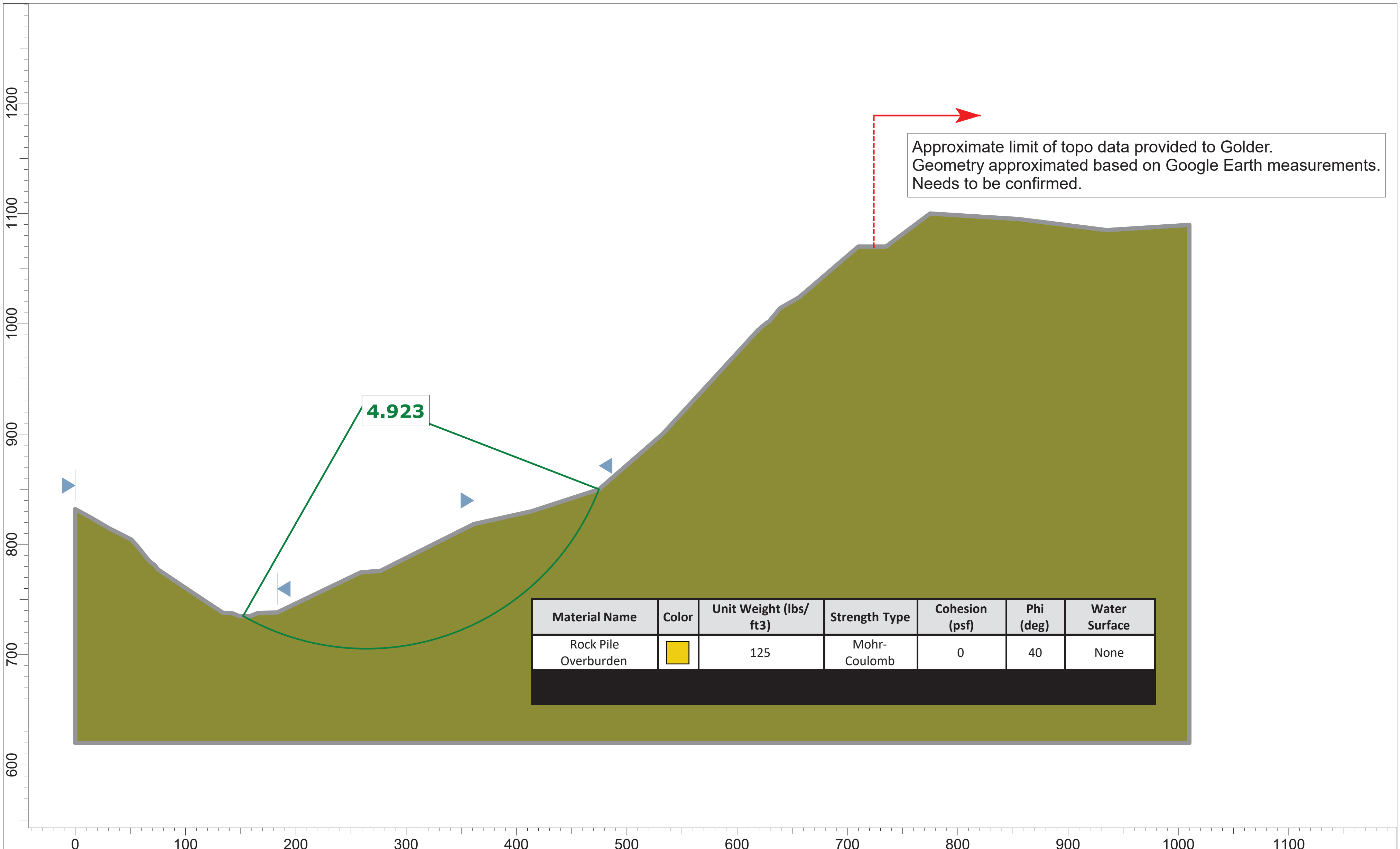
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None

[redacted]

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:1444
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None

[redacted]

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
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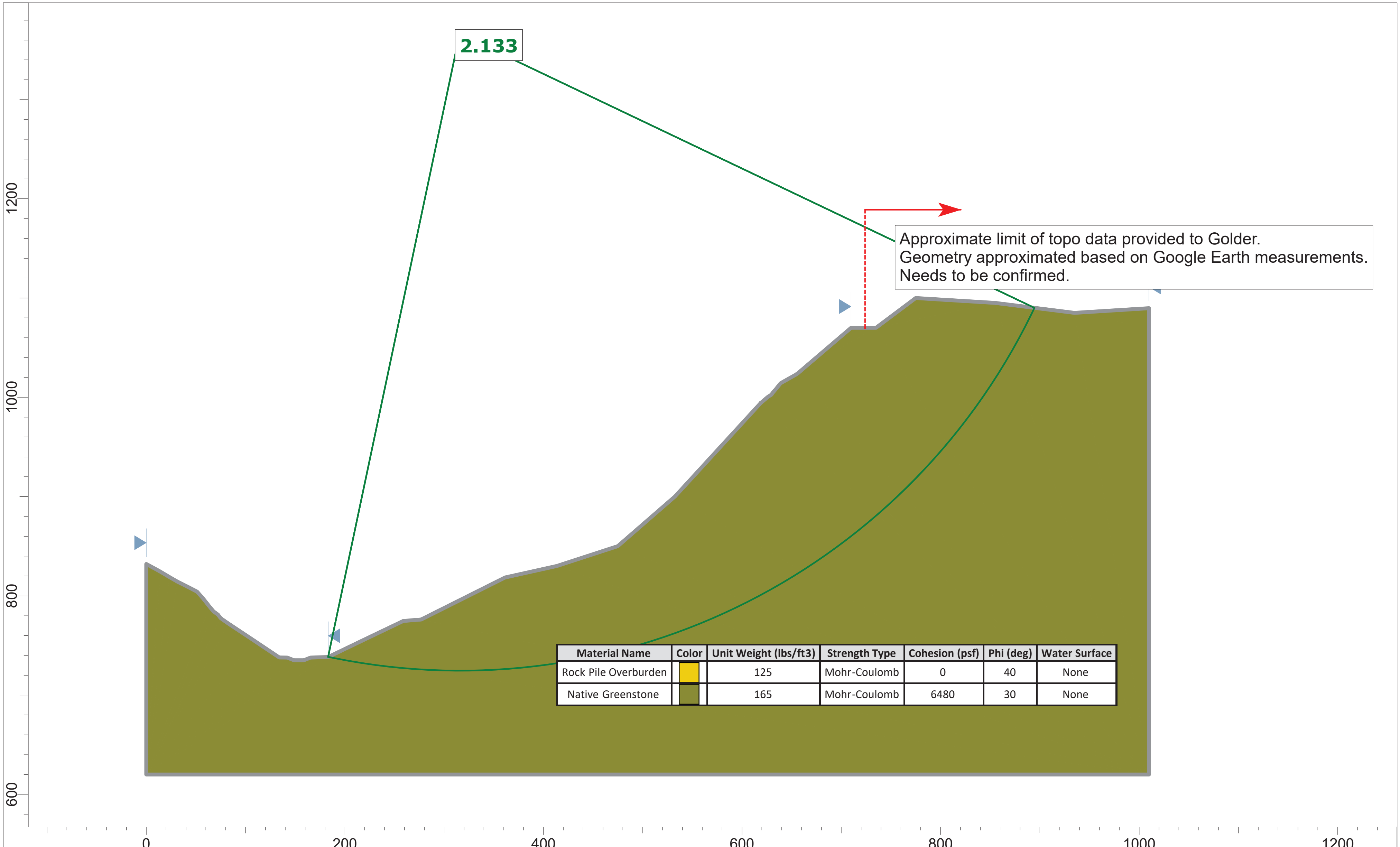
Company			
Date	7/9/2021, 4:25:49 PM	*File Name*	Section C-C'_20210715.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	None
Native Greenstone		165	Mohr-Coulomb	6480	30	None

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program		
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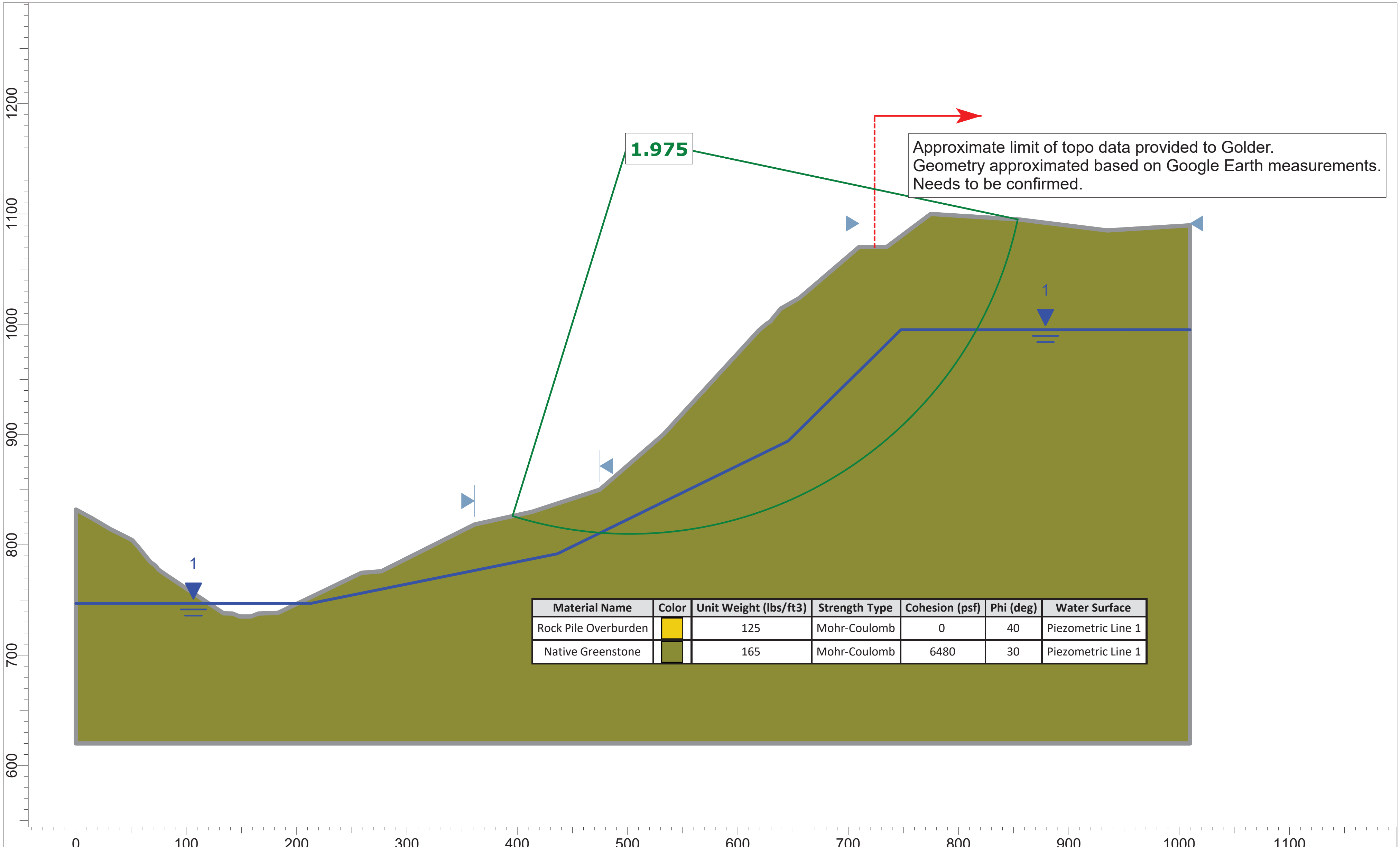
Date 7/9/2021, 4:25:49 PM		*File Name* Section C-C'_20210715.slmd	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
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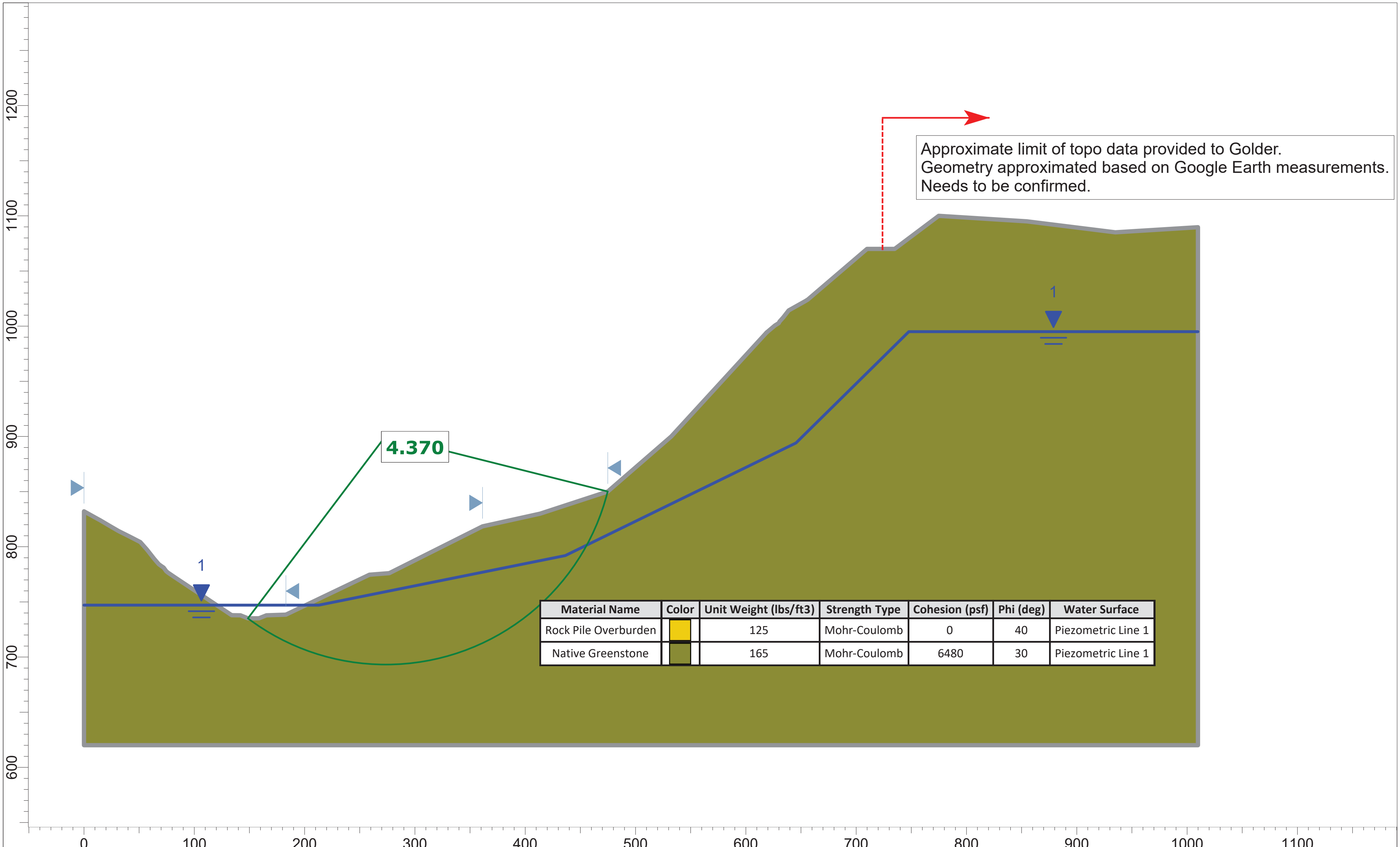

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER	*Project* SLIDE - An Interactive Slope Stability Program		
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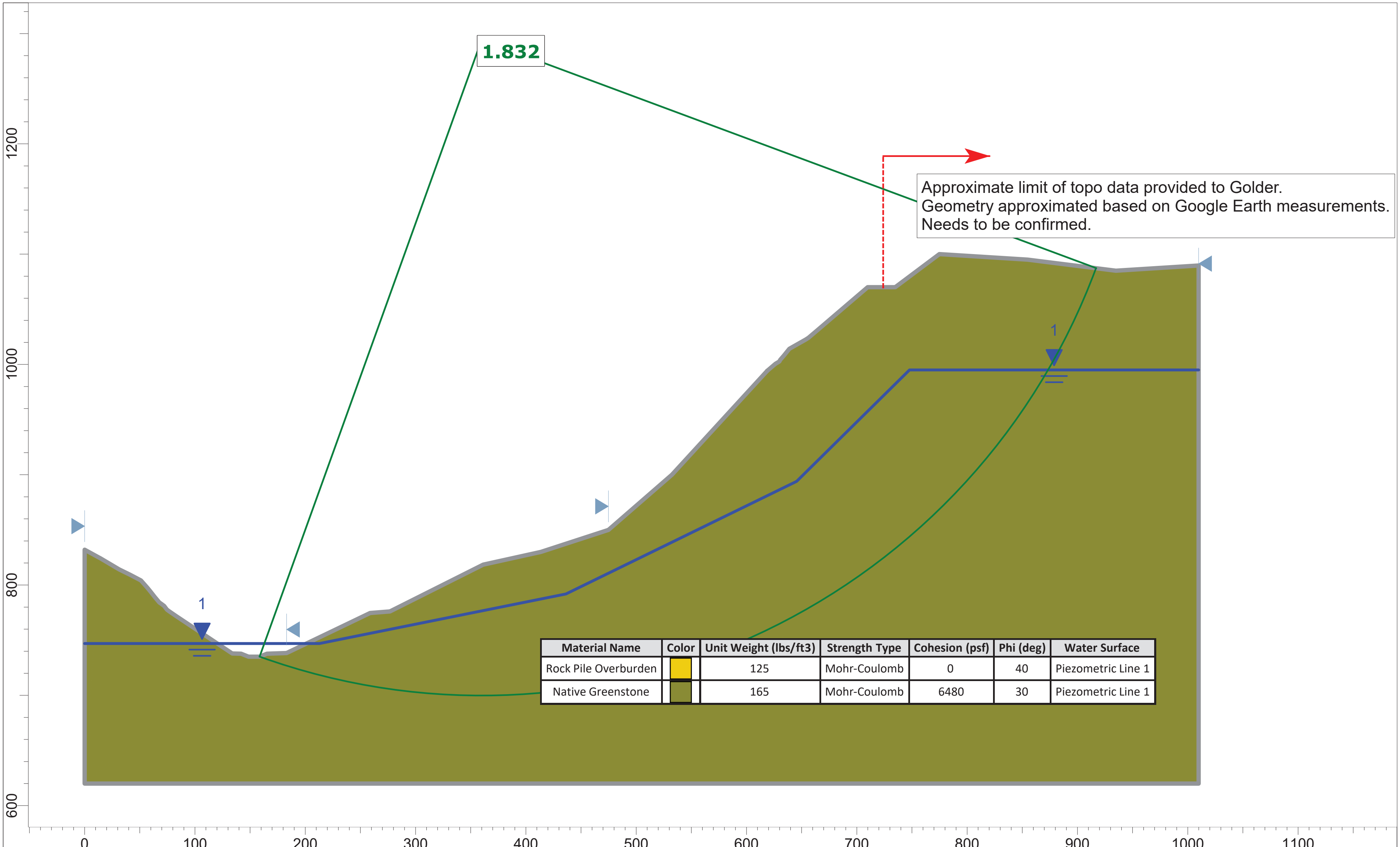

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Rock Pile Overburden		125	Mohr-Coulomb	0	40	Piezometric Line 1
Native Greenstone		165	Mohr-Coulomb	6480	30	Piezometric Line 1

GOLDER

SLIDEINTERPRET 9.012

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:1444
Company	
Date	7/9/2021, 4:25:49 PM
File Name	Section C-C'_20210715.slmd

Sampling, Analysis, and Management Plan for Soil and Sediment Material from Maintenance Projects

Description:
Soil and sediment material that is generated from maintenance projects conducted at the Lehigh Permanente Facility (Site) will be sampled, analyzed, and managed according to this standard operating procedure (SOP). This document is intended to provide instructions to adequately manage soil and sediment from maintenance operations by specifying screening guidelines, testing requirements, and placement to conform to applicable Federal, State and Local regulations.

Regulatory Framework:
The San Francisco Bay Regional Water Quality Control Board (Water Board) issued Waste Discharge Requirements, Order No. R2-2018-0028, (WDRs) to Lehigh for the Permanente Facility. The WDR regulates discharges to land and governs wastes and activities that generate waste at the site that have the potential to impact groundwater and hydrogeologically connected surface waters. Operations and maintenance of Waste Management Units (WMUs) at the Facility, including the Eastern Material Storage Area (EMSA) and Western Material Storage Area (WMSA), must be conducted in accordance to California Code of Regulations (CCR) 27 (Title 27), section 13263 of the California Water Code (CWC) and the approved plans required by Waste Discharge Requirement Order No. R2-2018-0028. The purpose of the procedures set forth herein is to ensure that material placement resulting from soil and sediment removal from maintenance operations is consistent with the requirements established by the WDRs.

- **Responsibility**— Environmental Department
- **Applicability**— Sampling and sediment of creek sediment originated from culvert cleanout activities
- **Affected Area**— Culverts in Permanente Creek
- **Frequency**— As needed
- **Attachments**— Attachment A – Environmental Screening Levels
- **Safety**—Basic Plant mandated PPE is required

Procedure:
Soil or sediment samples will be collected by Lehigh personnel and sent to laboratory for analysis. Samples will be analyzed for parameters listed on Table 1 and results compared against the most recent, applicable Water Board's Tier 1 Environmental Screening Levels (ESLs) for soils and groundwater as modified (Attachment A contains the 2019 ESLs for metals, the primary constituents of concern), as described below.

The documentation required includes:
1. Reports of removed material volume, date of removal, and location
2. Field data sheets and testing results
3. Temporary storage location, including survey coordinates, if needed
4. Final placement location, including survey coordinates

5. Report with December Self-Monitoring Report.

Sampling Guidelines:

Samples will be collected and analyzed in a manner sufficient to characterize the material. Sampling and laboratory analysis will be conducted in compliance with the following requirements:

1. All analysis will be performed in accordance with EPA and California approved methods
2. Analysis of samples will be completed and reported by an analytical laboratory accredited by the California State Environmental Laboratory Accreditation Program and the National Environmental Laboratory Accreditation Program;
3. The laboratory detection limits for Modified Waste Extraction Test (WET) results must be below the applicable Tier 1 ESLs for groundwater;
4. The laboratory reporting limits will be reported on a dry-weight basis; and
5. The results of the laboratory analysis will be reported in a standard laboratory data package, including a summary of the quality control and quality assurance sample results and chain of custody documentation.

Discrete soil samples will be collected unless regulatory approval is obtained for collection of composite samples for a specific project or if the project is greater than acres (Table 2). Samples will be collected with dedicated sampling equipment (e.g., plastic scoops) when possible. Any non-dedicated sampling equipment will be decontaminated between sampling locations. Field data sheets documenting sampling collection date, time, location, personnel, weather conditions, and sample identification will be completed. Each sample will be logged on a chain-of-custody record, which will accompany the samples through collection and delivery to the analytical laboratory. Table 1 includes the analytical parameters and sampling schedule.

Table 1: Laboratory Analytical Parameters

Analysis	EPA Analytical Method	Frequency
California Title 22 Metals (TTLC)	USEPA 6010B, 6020B, and/or 7471A	All
Modified WET California Title 22 Metals with DI Water	USEPA 6010B, 6020B, 1631E and/or 7471A	As necessary per TTLC results; minimum 1 out of 4 samples
VOCs	USEPA 82600/624	1 of 10 samples; minimum 1 sample per project

Analysis	EPA Analytical Method	Frequency
SVOCs	USEPA 8270/625/SIM	1 of 10 samples; minimum 1 sample per project
PCBs and Pesticides (surface water only)	USEPA 8080/8081/608	1 of 10 samples; minimum 1 sample per project
TPH as diesel, motor oil, and gasoline	EPA 8015	1 of 10 samples; minimum 1 sample per project
Cyanide	EPA 335.4/10-204-00	1 of 10 samples; minimum 1 sample per project

All samples will be analyzed for total metals via TTLC and a subset for leachability per the modified WET procedure. The WET results will be used to determine if metal concentrations in the soil or sediment have the potential to leach to groundwater. The WET results will be compared to the modified Tier 1 ESLs for groundwater. An additional subset of samples will be analyzed for other potential constituents of concern. These parameters, as well as the TTLC metal results, will be compared to the Tier 1 ESLs for soil.

The sampling schedule varies depending on the volume of soil or sediment to be displaced as part of the maintenance project. The frequency is listed on Table 2 and is based on the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) Information Advisory Clean Imported Fill Material Fact Sheet (https://dtsc.ca.gov/information-advisory-clean-imported-fill-material-fact-sheet).

Table 2: Sampling Frequency for Evaluation of Material

Area of Individual Area	Sampling Requirements per Area
2 acres or less	Minimum of 4 samples
2 to 4 acres	Minimum of 1 sample every ½ acre
Greater than 10 acres	Minimum of 8 samples with 4 subsamples per location
Volume of Stockpiled Material	**Samples per Volume**
Up to 1,000 cubic yards	1 sample per 250 cubic yards
1,000 to 5,000 cubic yards	4 samples for first 1000 cubic yards +1 sample per each additional 500 cubic yards

Greater than 5,000 cubic yards	12 samples for first 5,000 cubic yards + 1 sample per each additional 1,000 cubic yards

Results Evaluation and Material Placement:

The sampling results will be tabulated and reviewed. Based on the findings, the following scenarios will be followed.

1. If the results are below applicable Tier 1 ESLs, the removed soil and sediment material may be considered for backfill or cover material on site with regulatory notification and approval.
2. If the metal concentrations do not meet the applicable Tier 1 ESLs, but are below TTLC and/or STLC thresholds, additional characterization may be completed to determine the appropriate placement based on the following:
    a. If the material is determined to be a Group B mining waste similar to the material already present in the WMUs, the material will be placed and managed within a WMU (e.g., WMSA) in accordance with the Operations, Maintenance, and Contingency (OM&C) Plan.
    b. If the material is characteristically distinct from the Group B waste present in the WMUs, contains concentrations above applicable Tier 1 ESLs, and concentrations below TTLC and/or STLC thresholds, Lehigh will consult with the Water Board regarding the management and potential on and offsite disposal of these materials.
3. While not anticipated, if the results are above TTLC and/or STLC thresholds, the WATER BOARD will be notified and additional characterization will be completed to confirm the results and aid in determining appropriate management and disposal options. Upon completion of the additional characterization, Lehigh will seek the Water Board's concurrence on the management and disposal of these materials.

Dewatering Analysis and Placement Requirements:

1. Dewatering – If dewatering is conducted, additional characterization of the material may be conducted after dewatering has been implemented and soil is no longer saturated.
2. The water from the dewatering operations will be collected and sent to the on-site water treatment system(s) via the reclaim water system.
3. The soil or sediment will be moved to a selected dewatering location if necessary. Once the material is dewatered and characterized, the material will be managed and disposed of as appropriate based on this SOP.

Attachment A: Screening Values

Metal	CAS No.	Tier 1 ESL Soil (mg/kg)	TTLC (mg/kg)	Tier 1 ESL Groundwater (µg/L)*	STLC (µg/L)
		Total Metal		WET Results	
Antimony	7440-36-0	11	500	6.0	1500
Arsenic	7440-38-2	0.067****	50	10****	500
Barium	7440-39-3	390	10000	1000	100000
Beryllium	7440-41-7	5.0	75	2.7	75
Cadmium	7440-43-9	1.9	100	0.25	1000
Chromium	7440-47-3	160	2500	50.0	5000***
Cobalt	7440-48-4	23	8000	3.0	80000
Copper	7440-50-8	180	2500	3.1	25000
Lead	7439-92-1	32	1000	2.5	5000
Mercury	7439-97-6	13	20	0.025	200
Molybdenum	7439-98-7	6.9	3500	100	350000
Nickel	7440-02-0	86	2000	8.2	20000
Selenium	7782-49-2	2.4	100	5.0**	1000
Silver	7440-22-4	25	500	0.19	5000
Thallium	7440-28-0	0.78	700	2.0	7000
Vanadium	7440-62-2	18	2400	19	24000
Zinc	7440-66-6	340	5000	81	250000

Notes:

ESLs based on January 2019 (Rev. 1) Water Board ESL Workbook Tier 1 values for soil and groundwater unless otherwise noted.

* DI WET results to be compared to Tier 1 GW ESL.

** Freshwater Ecotox used instead of Saltwater Ecotox for the Aquatic Habitat Goal that comprises the GW Tier 1 ESL for selenium.

*** If the soluble chromium as determined by the TCLP is less than 5mg/L, and the soluble chromium as determined by the STLC test equals or exceeds 560mg/L, and the waste is not otherwise identified as a RCRA hazardous waste, then the waste is a non-RCRA hazardous waste.

**** Arsenic background levels are known to be above these screening levels.

G3. Water Quality Evaluation (Golder Associates, August 26, 2022)

TECHNICAL MEMORANDUM

DATE August 26, 2022 **Project No.** 31405507

TO Carolina Addison
Lehigh Hanson, Inc.

FROM George Wegmann, PG, CHg;
Bill Fowler, PG, CEG **EMAIL gwegmann@wsp.com**

WATER QUALITY EVALUATION, PERMANENTE CREEK RESTORATION PROJECT, LEHIGH SOUTHWEST CEMENT COMPANY AND HANSON PERMANENTE CEMENT, INC., PERMANENTE QUARRY, CUPERTINO, CALIFORNIA

1.0 INTRODUCTION

Golder Associates USA Inc. (Golder), a member of WSP, prepared this memorandum for Lehigh Southwest Cement Company and Hanson Permanente Cement, Inc. (Lehigh) to present the results of our assessment regarding the significance of potential water related impacts associated with specific elements of the proposed Permanente Creek Restoration Project (PCRP) adjacent to the Permanente Cement Plant and North Quarry (Permanente Site). The specific elements include:

- The type of onsite material(s) used for backfill or other restoration-related activities where those materials that may come in contact with the Permanente Creek watercourse, and recommendations related thereto;
- Expected geology of the restored creek channel that will come in contact with the Permanente Creek watercourse.

This evaluation is based on available geochemical characterization data and the conceptual site geochemical model prepared in accordance with applicable permits for the Permanente Site (*e.g.,* San Francisco Regional Water Quality Control Board (Water Board) Order No. R2-2018-002 (WDRs), and additional information or studies prepared in response to Water Code section 13267 Orders or as part of, site operations and reclamation-related activities. The scope of work for this evaluation included (1) a desktop data review of previous studies, (2) summarizing more recent rock unit characterization and creek sediment sampling, and (3) completing a site reconnaissance of the project area to evaluate the geologic conditions in conjunction with the proposed restoration design.

1.1 Background

The Permanente Site is located in Santa Clara County, California, west of the City of Cupertino. In response to a Cleanup and Abatement Order issued by the Water Board (Order No. 99-018) and as a result of a 2016 Amended Consent Decree entered into by Lehigh and the Sierra Club, Lehigh has committed to undertake the PCRP. Details regarding the scope of the PCRP are set forth in 2016 Amended Consent Decree and the 90% design documents prepared by Lehigh's consultant, Waterways, which were recently updated to incorporate regulatory agency and Santa Clara County comments to date, and submitted to the County on August 26, 2022 (90% Design drawings). The portion of Permanente Creek involved in the PCRP is located south/southeast of the Permanente Site, and the project involves, among other activities, removing material/sediment from Permanente Creek, laying back slopes, widening reaches, and ensuring stream bank stability and ecological/geomorphic function.

The headwaters of Permanente Creek are located approximately 2 miles west/southwest of the Permanente Site. Approximately 4.2 miles of Permanente Creek are adjacent or traverse through Lehigh's Permanente Site in a south/south-eastern/eastern "L" shaped direction, portions of which are included in the PCRP, including stretches of the Creek upstream of the Cement Plant that have been re-aligned into an open culverted channel or placed in underground culverts, or are subject to dam infrastructure (Pond 13). Flow in Permanente Creek continues in an eastern direction as it leaves the Permanente Site, flowing through the highly urbanized area Cities of Los Altos and Mountain View and into Mountain View Slough or Stevens Creek through the Stevens Creek Diversion Channel operated by the Santa Clara Valley Water District, which ultimately can reach the San Francisco Bay. The downstream hydrology of the Permanente Creek watershed has been substantially altered for flood protection purposes.

The Cement Plant and North Quarry at the Permanente Site have been operational since 1939 and has been a major source of cement for Santa Clara County. The facility contains two mining waste rock (also called "overburden") storage areas, the East Material Storage Area (EMSA) and West Material Storage Area (WMSA), largely comprised of soil and rocks excavated from the North Quarry, some of which may be accessed for onsite use as part of the PCRP as backfill. The North Quarry sits between the two storage areas, while the Cement Plant is located southwest of the EMSA (Attachment A, Figure 1).

1.2 Regional Geologic Setting

Most of the Site is underlain by complexly deformed and faulted rocks of the Franciscan Assemblage. The eastern portion of the Site, including portions of the Cement Plant and the EMSA, are underlain by Plio-Pleistocene rocks of the Santa Clara Formation, which in turn overlie the Franciscan bedrock. Overlying the bedrock are modern alluvial deposits associated with Permanente Creek, and relatively shallow surficial deposits comprised of soil and colluvium. The Miocene-age Monterey Formation lies just east of the Site in fault contact with the Franciscan basement rocks along the Monte Vista Fault System.

1.2.1 Bedrock Geologic Units

The bedrock materials exposed in the North 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) and limestone and, to a lesser extent, graywacke. 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 North Quarry. The Franciscan Complex contains complexly deformed marine sedimentary rocks and basalt, which were metamorphosed and altered during subduction and subsequent thrust faulting. The Santa Clara Formation, a late Tertiary-Pleistocene assemblage of conglomerate, sandstone, siltstone, and claystone sits unconformably on the Franciscan Complex in the eastern portion of the site. Surficial deposits of unconsolidated alluvial deposits, fill material, colluvium, landslide deposits, and surface soils overlie the bedrock units.

The geology of the Permanente Creek Basin is shown on Figure 2 (Attachment A) based on our site reconnaissance and two main geologic map sources: Cupertino and Mindego Hills quadrangles (Dibblee and Minch 2007a and b); and the San Francisco Bay Landslide Mapping Team (USGS 1997). Previous researchers have also mapped the basin (Brabb 1970, Pulver 1979a and b).

1.2.2 Surficial Geologic Units

Some of the south-facing slopes that flank Permanente Creek are mantled with varying thicknesses of overburden, which is a heterogeneous mixture of fines, sand, gravel and cobble-sized fragments (*i.e.,* greenstone, graywacke, and soil materials) but with small percentages of limestone. This same overburden comprises most of the WMSA and EMSA. Regarding the south-facing slopes, they are generally described as side-cast fills that mantle existing canyon slopes and fill small drainages and swales that formerly reported to Permanente Creek. The overburden deposits are of highly variable thickness and exist adjacent to the Rock Pile Area[1] (see 90% Design drawings at Sheet C19) and Material Removal Area (see 90% Design drawings at Sheets C23 & C24); this material will be removed and relocated as part of the PCRP.

Modern unconsolidated alluvial deposits are present 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 over thousands of years, to tens of feet thick where the channel widens and deepens as it approaches the flatter terrain of the Santa Clara Valley.

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. The alluvial and colluvial deposits contain a mixture of fines, sand, gravel and cobble-sized fragments (*i.e.*, greenstone, graywacke, and soil materials) but with small percentages of limestone.

1.2.3 Creek Bed Geology Summary

Most of the PCRP area is underlain by complexly deformed and faulted rocks of the Franciscan Assemblage as depicted on Figure 2 (Attachment A). The eastern portion of the project area, including portions by the Cement Plant and the EMSA, are underlain by Plio-Pleistocene rocks of the Santa Clara Formation. Overlying the bedrock are modern alluvial deposits associated with Permanente Creek (restricted to the eastern portion of the property), and relatively shallow surficial deposits comprised of soil and colluvium.

Figure 3 (Attachment A) depicts the profile of Permanente Creek, which can broadly be classified into depositional reaches and bedrock reaches (delineated 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 furthest upstream portion of Permanente Creek, upstream of the PCRP area, is characterized by alluvium in the form of travertine reinforced step pool morphology that partially covers a bedrock channel that is comprised of greenstone and limestone. The sediment supplied here is likely to come from natural processes and is 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) 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 Creek and may be coupled to the debris flows originating from Wild Violet Creek.

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

[1] The Rock Pile area is comprised of stockpiled material for aggregate production, which is ongoing. The character of the Rock Pile is variable but generally consists of fine to coarse-grained gravel to angular cobble-sized rock fragments of limestone.

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 formed step-pools were reinforced by travertine deposition to form travertine dams (Attachment A, 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.

The primary geologic units within the PCRP area are mainly greenstone (including shear zones) and the Santa Clara Formation. Greenstone bedrock is present at Reaches 10-17 and 20-22 and Santa Clara Formation bedrock along reaches 1-9 (Attachment A, Figure 3). Limestone bedrock is present along Reaches 18 and 19, including south of the creek, and comprises less than 15% of the bedrock present along the PCRP area. Importantly, with regard to the material removal activities planned to occur in Reach 18, the bedrock surface within the creek channel has been unaltered by historical site activities (*i.e.,* no mining activities have occurred in the creek), and the PCRP activities will follow the contours of natural bedrock, and will not alter or change the bedrock surface or its profile as part of restoration construction activities (see 90% Design drawings at Sheet C23). The focus of the Project along the limestone bedrock reaches will be to remove loose material mantled on top of the bedrock.

2.0 DATA SUMMARY

2.1 Material Characterization

Historical mining activities have contributed surficial materials to Permanente Creek in addition to deposition from naturally occurring geologic and geomorphic processes. As part of site operations, regulatory efforts, and reclamation-related activities, a geochemical dataset has been compiled since 2008 to characterize the predominate Permanente Quarry rock types. The data includes work completed as part of the development of National Pollutant Discharge Elimination System (NPDES) permitting[2] and WDRs[3,4] as follows: (1) analysis on acid rock drainage (ARD) potential by acid base accounting (ABA) testing methods, (2) chemical and mineralogical composition by quantitative X-Ray Diffraction (XRD) and, (3) Total Threshold Limit Concentration (TTLC) and leaching potential via the California modified waste extraction test (WET) with deionized water and wall washing samples. The results have been previously summarized in several reports, including the Permanente Site's Conceptual Site Model (CSM) Update prepared in accordance with the WDRs,[5] and are discussed below along with supplemental information.

Golder previously completed sampling and testing of the following major units: limestone, greenstone, graywacke, Santa Clara Formation, and undisturbed soil/colluvium as summarized in the CSM Update.[6] In summary:

[2] NPDES No. CA0030210, Regional Water Board Order No. R2-2019-0024, previously Order No. R2-2014-0010, as amended by Order No. R2-2017-0030.

3 SLR, 2014, EMSA and WMSA Material Characterization, Permanente Quarry, Santa Clara, California.

4 Golder Associates, August 2014, WMSA and EMSA Runoff and Seep Investigation Report, Lehigh Southwest Cement Company and Quarry, 24001 Stevens Creek Boulevard, Cupertino, CA

5 Golder Associates, 2020, CSM Update and Proposed SMP, Lehigh Southwest Cement Company and Quarry, 24001 Stevens Creek Boulevard, Cupertino, CA. June 2020.

[6] Golder Associates, 2020 CSM Update and SMP, Lehigh Permanente. December 2020.

- No acid rock drainage potential was identified in the tested samples as would be expected based on the carbonate nature of the rock.
- The leachate testing indicates that greenstone and graywacke are not a significant source of metals.
- Greenstone samples reported higher leachate nickel concentrations as compared to limestone; however, the concentrations are below the San Francisco Bay Regional Water Quality Control Board Environmental Screening Levels (ESLs) based on the California primary maximum contaminant for Freshwater Aquatic levels.
- Molybdenum and selenium leachate concentrations were generally greater in limestone samples compared to the other samples from greenstone and graywacke. Selenium leachate from the limestone has been detected above the Freshwater Aquatic ESL of 5 µg/L consistent with limestone wall washing results.[7]
- The selenium data supports the premise that the oxidation of sulfides in the limestone is the primary mechanism of generating leachable selenium.[8,9]

2.1.1 Sequential Leach Testing via Modified WET Method

In 2020, rock samples were analyzed using the modified WET method and were then subjected to four additional cycles of sequential leaching repeating the same method for a total of five leaching cycles to aid in evaluating long-term leachability. Limestone and greenstone, the predominate rock units, were selected for this analysis. The test results were compared to STLC thresholds and ESLs. Full tabulated leaching results are included as Table 1, Attachment B and time-series plots of the sequential leachate concentrations of the different materials is included as Attachment C. The results of the sequential leach testing are summarized as follows:

Limestone Samples

- STLC limits were not exceeded for any of the samples.
- Limestone leachate concentrations decreased over the leaching sequence for the following constituents: sulfate, chloride, total alkalinity, bicarbonate, antimony, calcium, magnesium, molybdenum, selenium, and vanadium.
- Limestone leachate concentrations were stable or at detection limits over the leaching sequence for the following constituents: carbonate, hydroxide, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, potassium, silver, sodium, thallium, and zinc.
- Sulfate, calcium, and magnesium concentrations were elevated in leachates from the medium-grade non-weathered limestone sample during leaches 1-3 compared to the other limestone samples.
- Barium leachate concentrations gradually increased for all limestone samples over the leaching period.

Greenstone Samples

- STLC limits were not exceeded for any of the samples.
- Greenstone leachate concentrations decreased over the leaching sequence for the following constituents: total alkalinity, bicarbonate, antimony, magnesium, potassium, selenium, and sodium.

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[7] Golder Associates, 2011 Hydrogeologic Investigation, Lehigh Permanente. 2011.

8 Diener, A., Neuman, T., Kramar, U., Schild, D. 2012. Structure of Selenium Incorporated in Pyrite and Machinawite as Determined by XAFS Analysis. Journal of Contaminant Hydrology: 133 (30-39).

9 Presser, T. S. 1994. Geologic Origin and Pathways of Selenium from the California Coast Ranges to the West-Central San Joaquin Valley. Selenium in the Environment.

- Greenstone leachate concentrations were stable or at detection limits over the leaching sequence for the following constituents: chloride, sulfate, carbonate, hydroxide, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, thallium, vanadium, and zinc.
- Total alkalinity, bicarbonate, arsenic, barium, magnesium, potassium, and sodium concentrations were higher in the non-weathered greenstone sample leachate compared to the weathered greenstone sample.
- The vanadium concentration was higher in the weathered greenstone leachate compared to the non-weathered greenstone sample across all leaching cycles.
- Aluminum concentrations in the weathered greenstone sample leachate increased between leaches 1-4 and plateaued after leach 4.

Overall, concentrations generally decrease with each leaching cycle, indicating that readily leachable parameters are depleted within a few flushing cycles and that the short-term metal leaching potential for the materials is low, and below regulatory thresholds. Furthermore, the greenstone samples exhibited less leachable concentrations than the limestone samples.

2.1.2 Material Characterization Summary

The leachate results indicate that greenstone and graywacke are not a significant source of metals to water. Limestone material is a potential source of selenium, though the potential is lesser in combined quantities and in a dynamic environment of a moving stream/creek. Specific observations include:

- Greenstone samples reported higher leachate nickel concentrations compared to limestone; however, the concentrations are below ESLs.
- Molybdenum and selenium leachate concentrations were predominantly greater in limestone samples as compared to the samples from greenstone and graywacke.
- Selenium leachate from the limestone was detected several times slightly above the Freshwater Aquatic ESL of 5 µg/L. The generation of leachable selenium decreases with subsequent leach tests.

The data supports the premise that the oxidation of sulfides in the limestone is the primary mechanism of generating leachable selenium—the primary constituent of concern. Following sulfide oxidation, water flow and/or infiltration is the primary transport mechanism for selenium transport. Greenstone and graywacke do not generate leachable materials at levels that would negatively affect groundwater or surface waters. Sampling and geochemical analysis of the greenstone and graywacke indicates a low potential to leach selenium and other metals at levels above surface or ground water quality standards, and that it is suitable to be used as fill material consistent with Water Board/WDR standards.

2.2 Background Water Samples and Bedrock Influence on Creek Water Quality

Water quality from the upstream headwaters has been monitored as part of the National Pollutant Discharge Elimination System (NPDES) permit sampling program. The upstream surface water results for selenium are consistently less than 1 ug/L. As noted in Section 1.2, bedrock limestone and associated travertine deposits are present in these areas. The results further support the premise that selenium production from oxidized limestone already present in the creek channel is finite. For this reason, we expect that the PCRP as designed, which proposes to remove material and follow the existing bedrock contours for the restored creek channel grade and elevation, will not contribute to increased in-stream concentrations of constituents of concern.

3.0 DISCUSSION AND RECOMMENDATIONS

For areas of the project where fill material is needed, it is recommended that onsite material comprised predominantly of greenstone or graywacke be used where needed for backfill, as both exhibit a low metals leaching potential under natural site conditions. Furthermore, greenstone is the prevalent native material at the Site and already encompasses the majority of the Permanente Creek basin. Based on the available data, we do not expect detrimental water quality impacts from the creek restoration activities (causing exceedance of applicable water quality standards) provided on-site materials adhere to the recommendations herein.

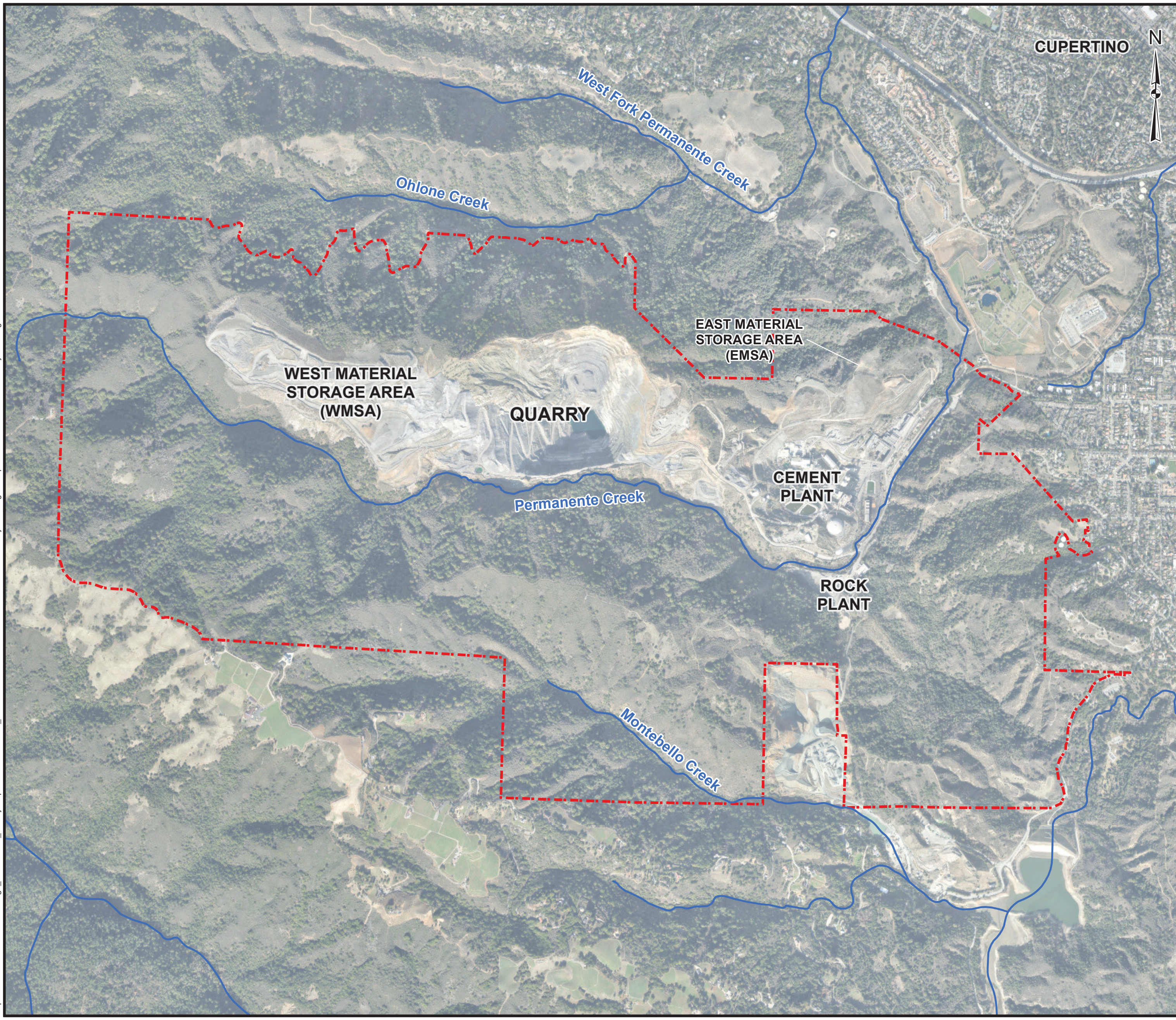
Further, the predominant areas where limestone is to naturally remain, e.g., Reach 18, will consist of non-disturbed bedrock, which, as demonstrated by upstream conditions, is not expected to contribute metals to the water column. Therefore, significant changes in the natural system will not occur and new source material will not be exposed to potentially undergo oxidation and mobilization of selenium based on the limestone bedrock present. As noted in Section 2.3, the water quality upstream of the PCRP is not impaired even though limestone bedrock and travertine deposits are present. As the bedrock surface in Reach 18 is inferred to have been exposed and undisturbed for a similar timeframe as the reaches upstream of the PCRP, impairment to water quality is not expected from the limestone bedrock section. Furthermore, as noted above, the production rate of leachable selenium from limestone decreases as the mobile fraction of selenium is depleted from the system. This process will be further expedited by removing potential sources (e.g., limestone material) via the PCRP, and the PCRP is not expected to interfere with those gains.

Attachments A: Figures 1-3
B: Data Summary Table 1
C: Time-Series Graphs

PCRP_Golder_creek_memo_fnl

ATTACHMENT A

Figures 1-3



LEGEND

- Stream
- Property Boundary

NOTES

1) Locations based on conversion from local coordinates or Google Earth placement.

REFERENCES

1)Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
2)Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
3)

1,200 0 1,200
Feet

PROJECT

PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

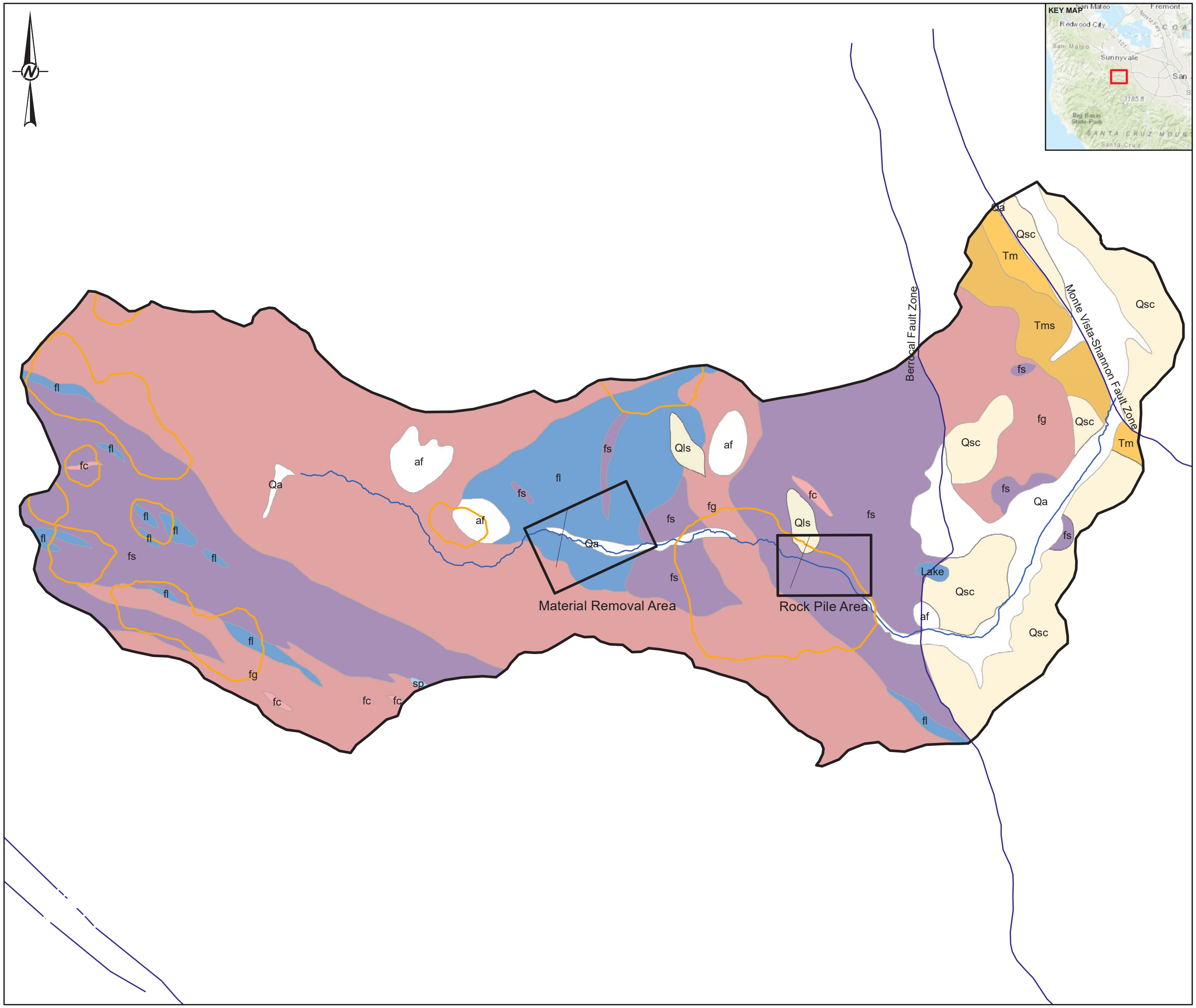
TITLE

SITE OVERVIEW

WSP GOLDER

PROJECT No.		063-7109	FILE No.	SitePlan_March2019.mxd
DESIGN	SHL	10/31/2013	SCALE: AS SHOWN	REV. 0
GIS	SHL	3/27/2019	**FIGURE 1**	
CHECK	GW	3/27/2019		
REVIEW	GW	3/27/2019		

Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\General\SitePlan_March2019.mxd / Modified 3/27/2019 10:45:14 AM by SLeidinger / Exported 8/23/2022 1:50:33 PM by SLeidinger



LEGEND

- Areas of Interest
- Cross Sections
- Permanente Creek
- PermCrkBasin_V2
- Faults

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)

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
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

PROJECT

TITLE
GEOLOGIC MAP OF PERMANENTE CREEK BASIN

CONSULTANT

wsp 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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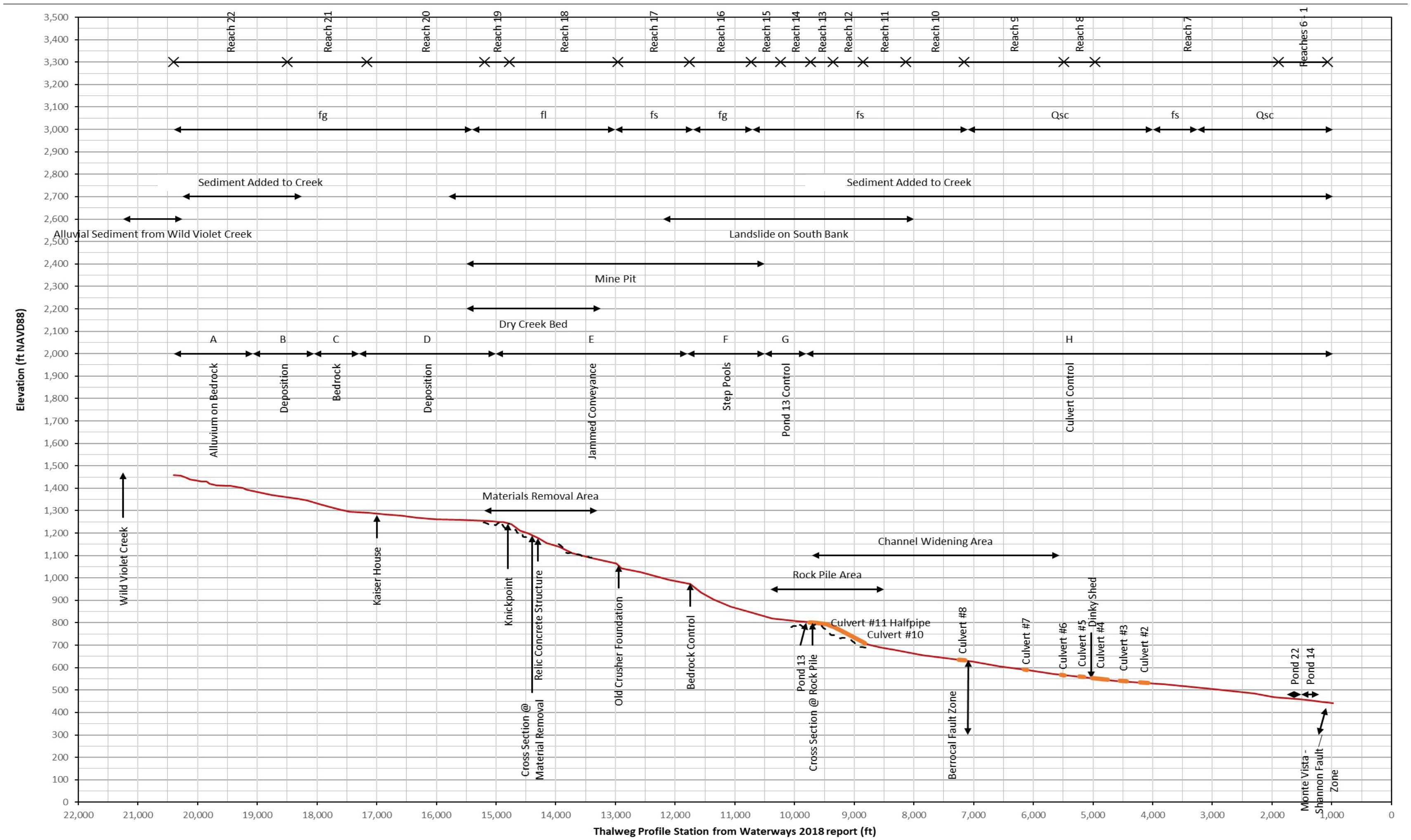


Figure 3: Permanente Creek Profile with geomorphic and geologic delineations. Stationing from Waterways (2019).

ATTACHMENT B

Data Summary Table 1

Table 1: Sequential WET Extraction Chemistry

Analyte	Units	STLC Regulatory Limit	ESL	B-1: High-Grade Limestone, Non-Weathered					B-2: Medium-Grade Limestone, Non-Weathered					B-3: Low-Grade, Limestone Non-Weathered				
				Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4	Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4	Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4
Dissolved Metals																		
Antimony	mg/l	15	0.006	0.0042	0.0025	0.0018 B	0.00123 B	0.0012 B	0.0057	0.0040	0.0032	0.0026	0.0027	0.013	0.0078	0.0052	0.0052	0.0040
Arsenic	mg/l	5	0.01	0.00022 B	0.00047 B	0.0003 B	0.00029 B	<0.001	0.00066 B	0.00088 B	0.00073 B	0.00091 B	0.00080 B	0.0013	0.0011	0.00065 B	0.00073 B	0.00062 B
Barium	mg/l	100	1	0.41	0.70	0.42	0.70	0.96	0.0288 B	0.11	0.13	0.27	0.45	0.15	0.29	0.17	0.32	0.45
Beryllium	mg/l	0.75	0.0027	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Cadmium	mg/l	1	0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	0.00011 B	<0.00025	<0.00025	<0.00025	<0.00025
Chromium	mg/l	5	0.05	<0.002	0.00157 B	0.0007 B	0.00079 B	0.00079 B	<0.002	0.0031	0.00062 B	0.00077 B	0.0017 B	<0.002	0.0028	0.00059 B	0.00138 B	0.00121 B
Cobalt	mg/l	80	0.003	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	0.000209 B	0.000062 B	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Copper	mg/l	25	0.009	0.0012 B	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0011 B	<0.002	<0.002	<0.002	<0.002
Lead	mg/l	5	0.0025	<0.0005	<0.0005	<0.0005	<0.0005	0.00028 B	<0.0005	<0.0005	<0.0005	<0.0005	0.0001 B	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Mercury	mg/l	0.2	0.000025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/l	350	0.1	0.14	0.024 B	0.020 B	<0.1	<0.1	0.27	0.070 B	0.048 B	0.026 B	0.021 B	1.1	0.21	0.10	0.038 B	<0.1
Nickel	mg/l	20	0.052*	<0.001	<0.001	<0.001	<0.001	<0.001	0.0017	0.00042 B	<0.001	<0.001	<0.001	0.00099 B	0.00069 B	<0.001	<0.001	<0.001
Selenium	mg/l	1	0.005*	0.0017	0.0019	0.0011	0.00086	0.00080	0.0062	0.0051	0.0044	0.0049	0.0044	0.0085	0.0051	0.0043	0.0039	0.0033
Silver	mg/l	5	0.00019	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Thallium	mg/l	7	0.002	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00011 B	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium	mg/l	24	0.019	0.041	0.016	0.0098	0.0097	0.0098	0.0092	0.012	0.014	0.019	0.019	0.37	0.13	0.083	0.083	0.076
Zinc	mg/l	250	0.081	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Wet Chemistry																		
Chloride	mg/l			1.4 B	2.5	0.77 B	0.58 B	0.85 B	<2	0.53	0.56 B	<2	<2	2.3	3.6	<2	<2	0.78 B
Sulfate	mg/l			9.0	5.9	7.9	4.4 B	3.3 B	212	31	26	9.2	7.9	22	12	16	9.1	4.8 B
Total Alkalinity	mg/l			14 B	17 B	15 B	14 B	14 B	16 B	24	20	16 B	17 B	18 B	23	18 B	18 B	17 B
Bicarbonate (CaCO$_3$)	mg/l			14 B	17 B	15 B	14 B	14 B	16 B	24	20	16 B	17 B	18 B	23	18 B	18 B	17 B
Carbonate as CaCO$_3$	mg/l			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Hydroxide as CaCO$_3$	mg/l			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Notes:

Soluble Threshold Limit Concentrations (STLC) as per California Code of Regulations Title 22, Section 66261.24(2)(A) ESL listed is lower of freshwater aquatic or primary MCL;

As is based on background level.

* = the ESL and surface water quality objective (California Toxics Rule, 40 CFR section 131.38) are the same.

B = estimated value, below laboratory reporting limit; mg/l = milligrams per Liter

Table 1: Sequential WET Extraction Chemistry

Analyte	Units	STLC Regulatory Limit	ESL	B-4: Non-Cement Grade Limestone, Non-Weathered					B-5-9: High-Grade Limestone, Weathered					B-6: Greenstone, Non-Weathered				
				Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4	Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4	Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4
Dissolved Metals																		
Antimony	mg/l	15	0.006	0.0030	0.0018 B	0.0014 B	0.0012 B	0.0011 B	0.0065	0.0038	0.0025	0.0026	0.0021	0.0030	0.00128 B	0.00085 B	0.00054 B	0.00043 B
Arsenic	mg/l	5	0.01	0.0002 B	0.00031 B	<0.001	0.00023 B	<0.001	0.00047 B	0.00069 B	0.00039 B	0.00054 B	0.00046 B	0.0026	0.0029	0.0021	0.0021	0.0017
Barium	mg/l	100	1	0.13	0.40	0.26	0.44	0.60	0.20	0.38	0.21	0.39	0.63	0.11	0.11	0.099	0.11	0.10
Beryllium	mg/l	0.75	0.0027	0.000082 B	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Cadmium	mg/l	1	0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Chromium	mg/l	5	0.05	<0.002	0.0007 B	<0.002	<0.002	<0.002	<0.002	0.0026	<0.002	0.00111 B	0.00108 B	<0.002	<0.002	<0.002	0.00114 B	<0.002
Cobalt	mg/l	80	0.003	<0.00025	0.00005 B	0.000092 B	<0.00025	<0.00025	0.000057 B	<0.00025	<0.00025	<0.00025	0.000059 B	<0.00025	0.000051 B	0.000063 B	0.00027	0.000066 B
Copper	mg/l	25	0.009	<0.002	0.0017 B	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Lead	mg/l	5	0.0025	<0.0005	<0.0005	0.00086	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00015 B	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Mercury	mg/l	0.2	0.000025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/l	350	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.23	0.067 B	0.044 B	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/l	20	0.052*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00071 B	<0.001	<0.001	0.0012	<0.001
Selenium	mg/l	1	0.005*	0.0013	0.0011	0.00092	0.00082	0.00077	0.0040	0.0035	0.0029	0.0028	0.0027	0.00054	0.00017 B	0.00018 B	<0.00025	<0.00025
Silver	mg/l	5	0.00019	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Thallium	mg/l	7	0.002	0.00011 B	<0.0005	0.0005 B	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium	mg/l	24	0.019	0.0046	0.00161 B	0.0022	0.0022	0.0023	0.036	0.016	0.012	0.014	0.015	0.013	0.012	0.0095	0.0095	0.0090
Zinc	mg/l	250	0.081	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Wet Chemistry																		
Chloride	mg/l			2.1	3.5	0.88 B	1.1 B	1.1 B	1.35 B	2.8	<2	<2	0.84 B	<2	<2	<2	<2	<2
Sulfate	mg/l			25	9.3	12	7.4	5.2	16	9.0	13	7.8	4.4 B	12	6.6	4.9 B	2.7 B	1.7 B
Total Alkalinity	mg/l			15 B	22	16 B	16 B	16 B	17 B	22	17 B	16 B	17 B	27	22	21	18 B	17 B
Bicarbonate ($CaCO_3$)	mg/l			15 B	22	16 B	16 B	16 B	17 B	22	17 B	16 B	17 B	27	22	21	18 B	17 B
Carbonate as $CaCO_3$	mg/l			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Hydroxide as $CaCO_3$	mg/l			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Notes:

Soluble Threshold Limit Concentrations (STLC) as per California Code of Regulations Title 22, Section 66261.24(2)(A) ESL listed is lower of freshwater aquatic or primary MCL; As is based on background level.

* = the ESL and surface water quality objective (California Toxics Rule, 40 CFR section 131.38) are the same.

B = estimated value, below laboratory reporting limit; mg/l = milligrams per Liter

Table 1: Sequential WET Extraction Chemistry

Analyte	Units	STLC Regulatory Limit	ESL	B-7-10: Greenstone, Weathered				
				Leach Initial	Leach 1	Leach 2	Leach 3	Leach 4
Dissolved Metals								
Antimony	mg/l	15	0.006	0.00065 B	<0.002	<0.002	<0.002	<0.002
Arsenic	mg/l	5	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/l	100	1	0.029 B	0.0247 B	0.028 B	0.026 B	0.0226 B
Beryllium	mg/l	0.75	0.0027	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Cadmium	mg/l	1	0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Chromium	mg/l	5	0.05	<0.002	<0.002	<0.002	0.00058 B	<0.002
Cobalt	mg/l	80	0.003	<0.00025	0.000067 B	0.000051 B	0.00011 B	0.000087 B
Copper	mg/l	25	0.009	0.00133 B	<0.002	<0.002	0.0013 B	<0.002
Lead	mg/l	5	0.0025	<0.0005	<0.0005	<0.0005	<0.0005	0.00018 B
Mercury	mg/l	0.2	0.000025	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/l	350	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/l	20	0.052*	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/l	1	0.005*	0.00021 B	0.00013 B	<0.00025	<0.00025	0.00014 B
Silver	mg/l	5	0.00019	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Thallium	mg/l	7	0.002	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium	mg/l	24	0.019	0.016	0.019	0.013	0.014	0.013
Zinc	mg/l	250	0.081	<0.015	<0.015	<0.015	<0.015	<0.015
Wet Chemistry								
Chloride	mg/l			<2	<2	<2	<2	<2
Sulfate	mg/l			4.8 B	1.4 B	1.3 B	<5	<5
Total Alkalinity	mg/l			24	22	22	21	20
Bicarbonate ($CaCO_3$)	mg/l			22	20 B	21	18 B	18 B
Carbonate as $CaCO_3$	mg/l			2.3 B	2.5 B	<20	2.4 B	2.2 B
Hydroxide as $CaCO_3$	mg/l			<20	<20	<20	<20	<20

Notes:

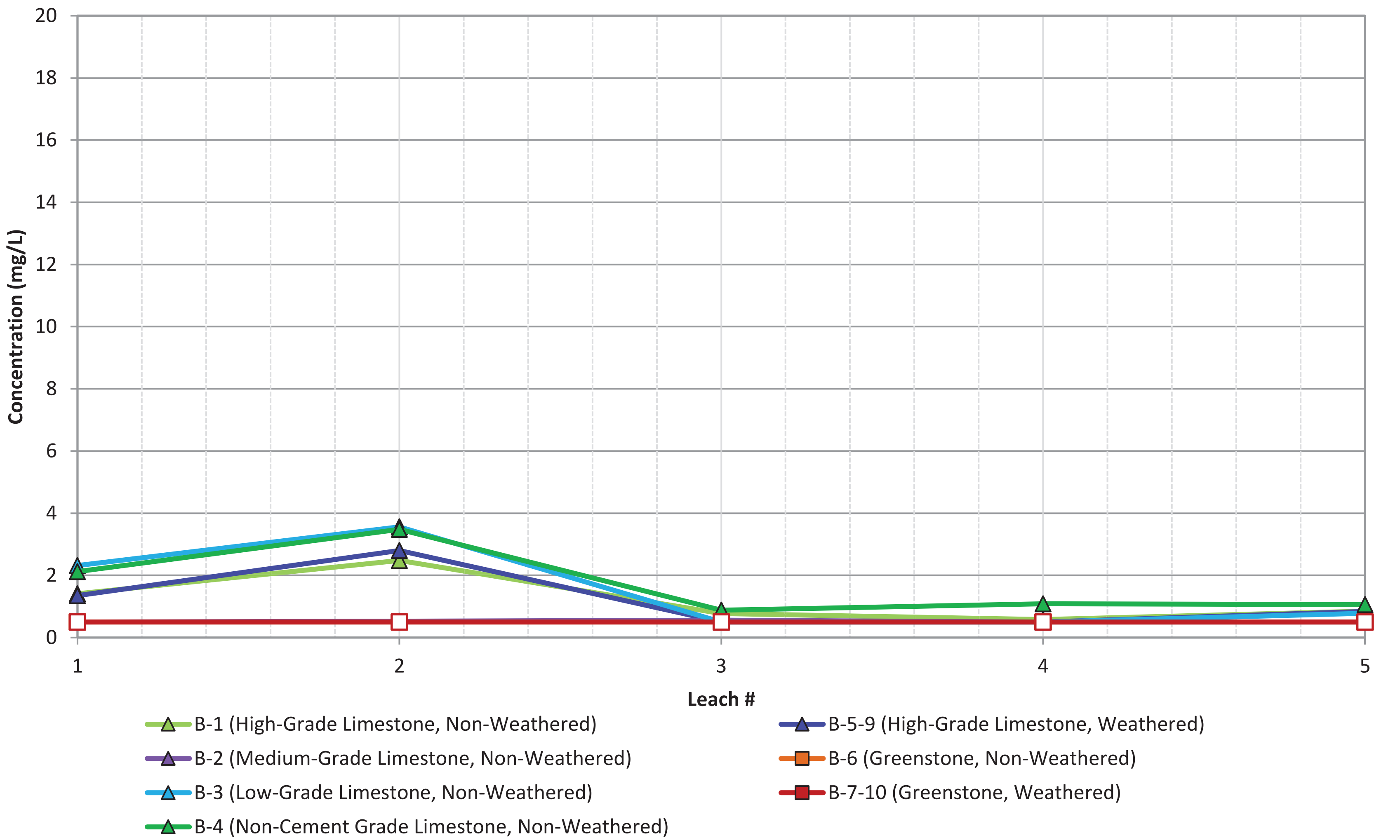
Soluble Threshold Limit Concentrations (STLC) as per California Code of Regulations Title 22, Section 66261.24(2)(A) ESL listed is lower of freshwater aquatic or primary MCL; As is based on background level.

* = the ESL and surface water quality objective (California Toxics Rule, 40 CFR section 131.38) are the same.

B = estimated value, below laboratory reporting limit; mg/l = milligrams per Liter

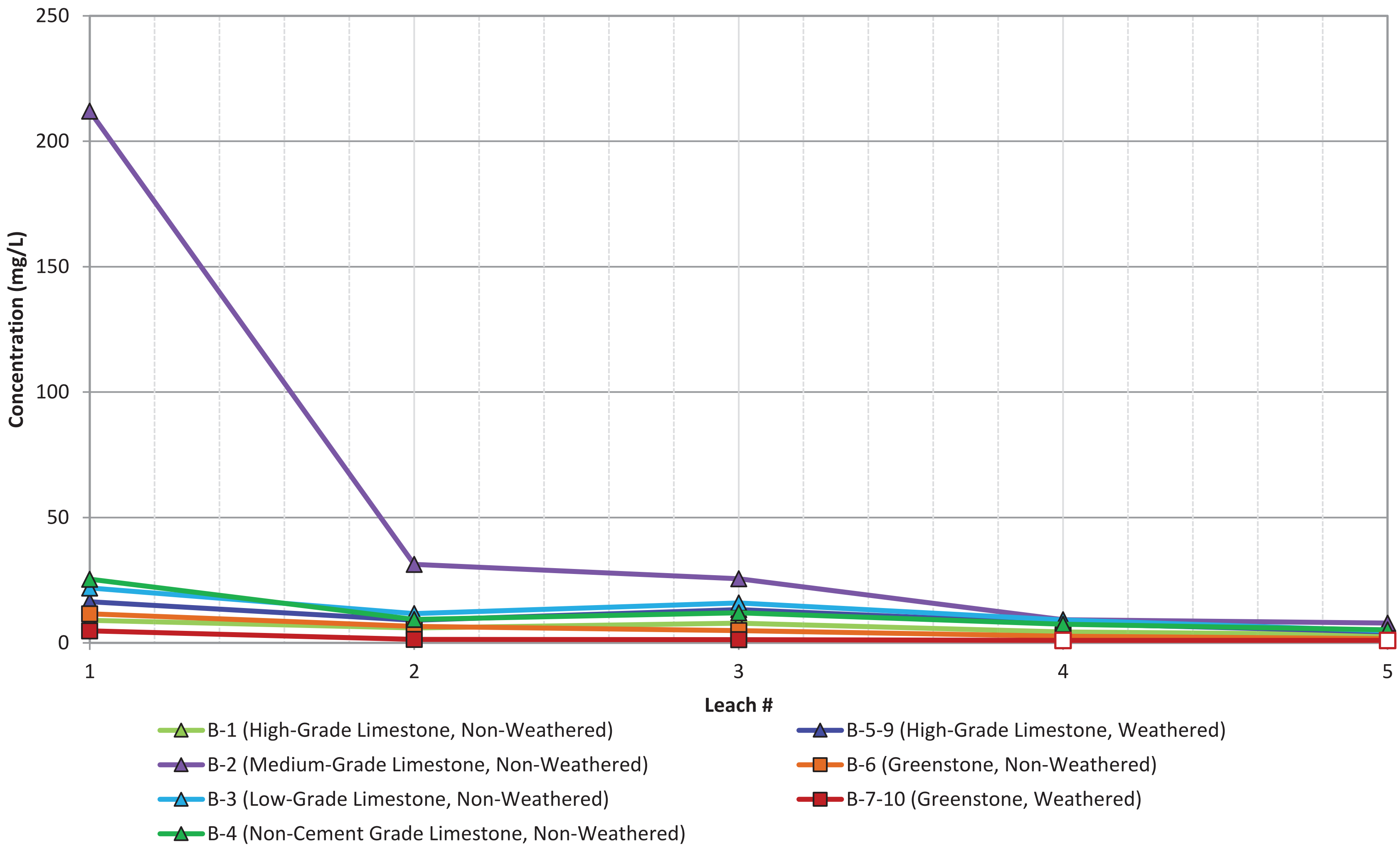
ATTACHMENT C

Time-Series Graphs



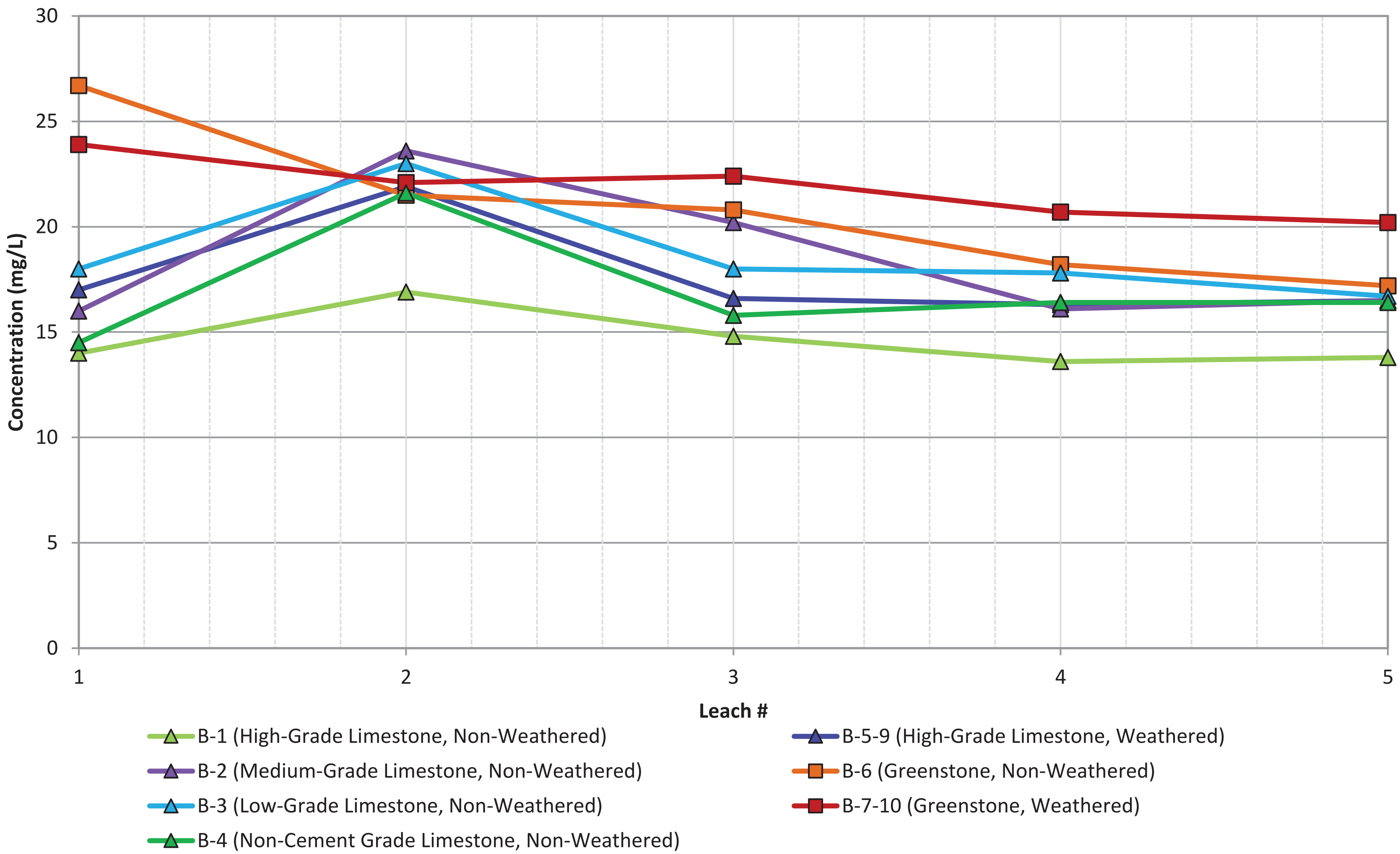
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Chloride**		
	Project Name	Project No. 31405507	FIGURE C-1
	Client Name: Lehigh Permanente	Date: 8/4/2022	



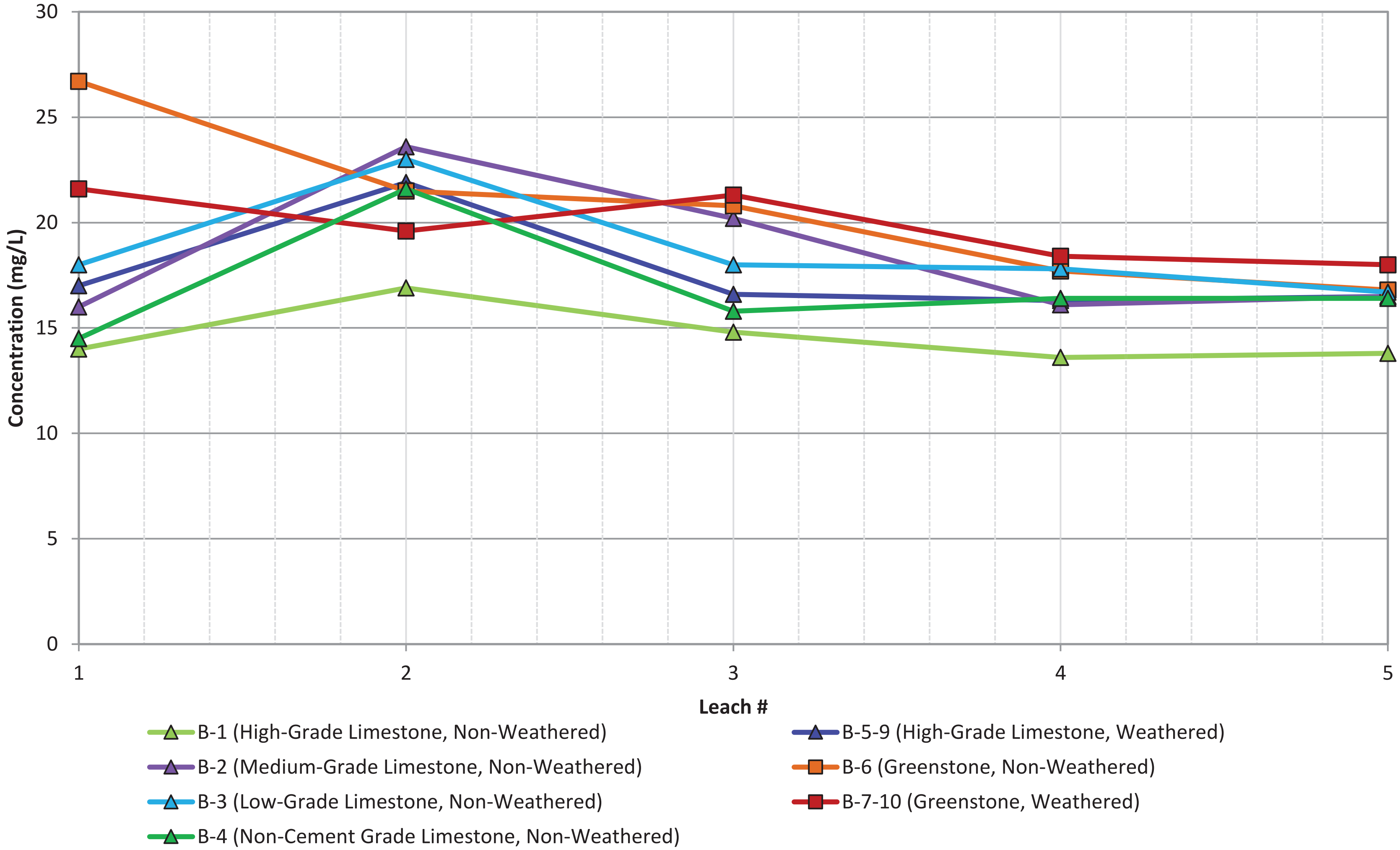
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Sulfate**		
	Project Name	Project No. 31405507	FIGURE C-2
	Client Name: Lehigh Permanente	Date: 8/4/2022	



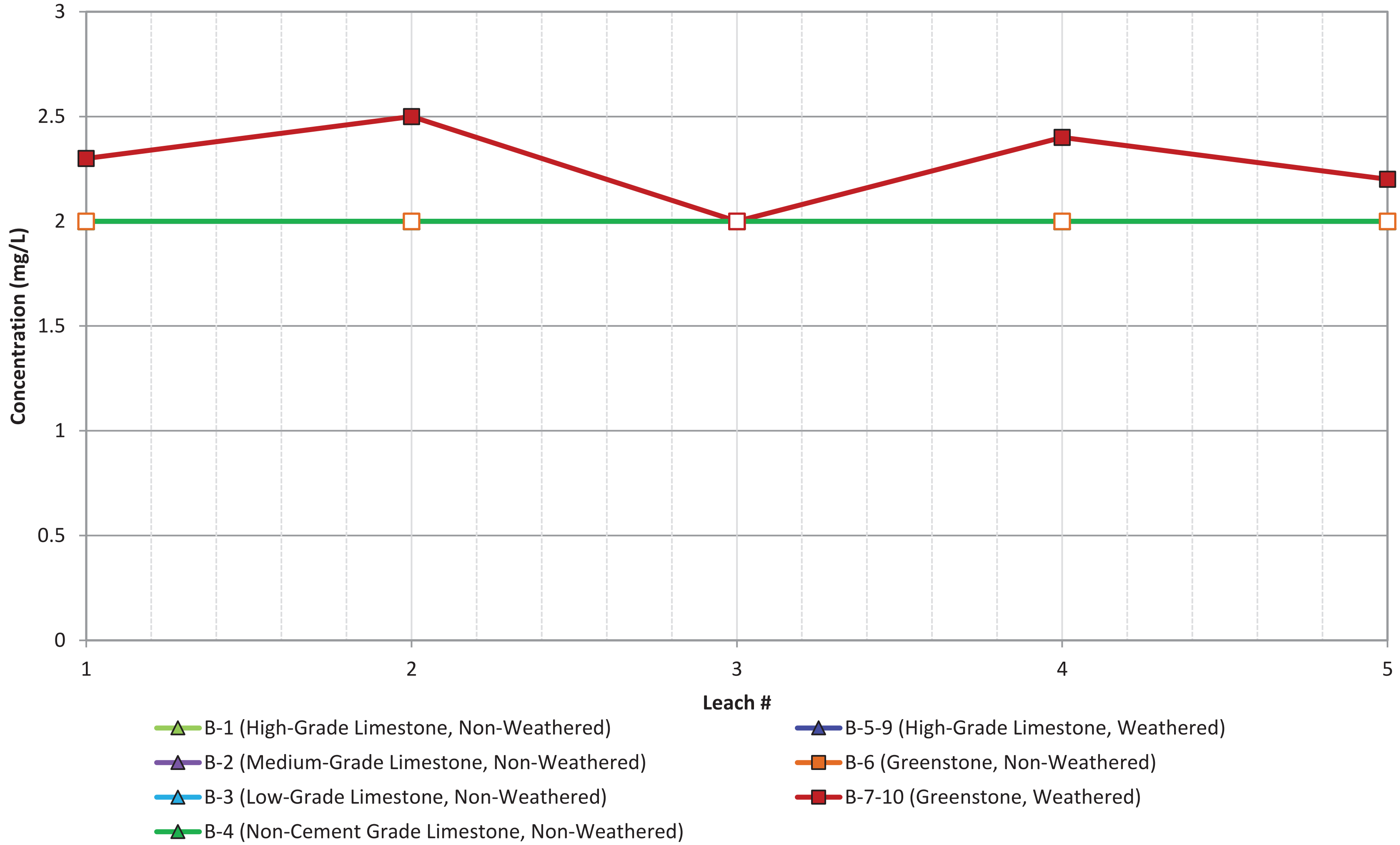
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title **Sequential Modified WET- Total Alkalinity**		
	Project Name	Project No. 31405507	FIGURE C-3
	Client Name Lehigh Permanente	Date 3/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Bicarbonate as CaCO3**		
	Project Name	Project No. 31405507	FIGURE C-4
	Client Name: Lehigh Permanente	Date: 8/4/2022	

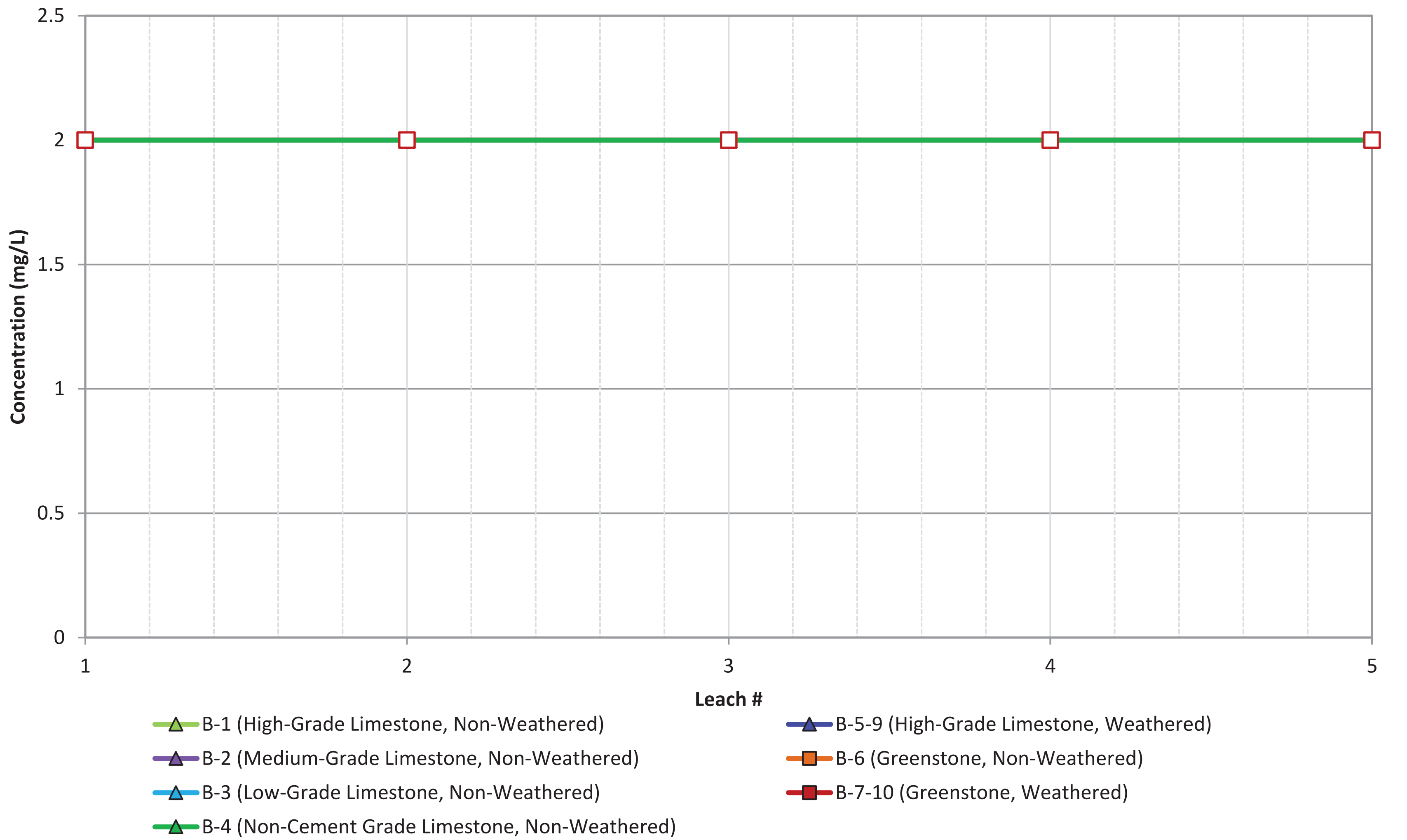


*Open symbols denote values at or below the method detection limit

WSP GOLDER

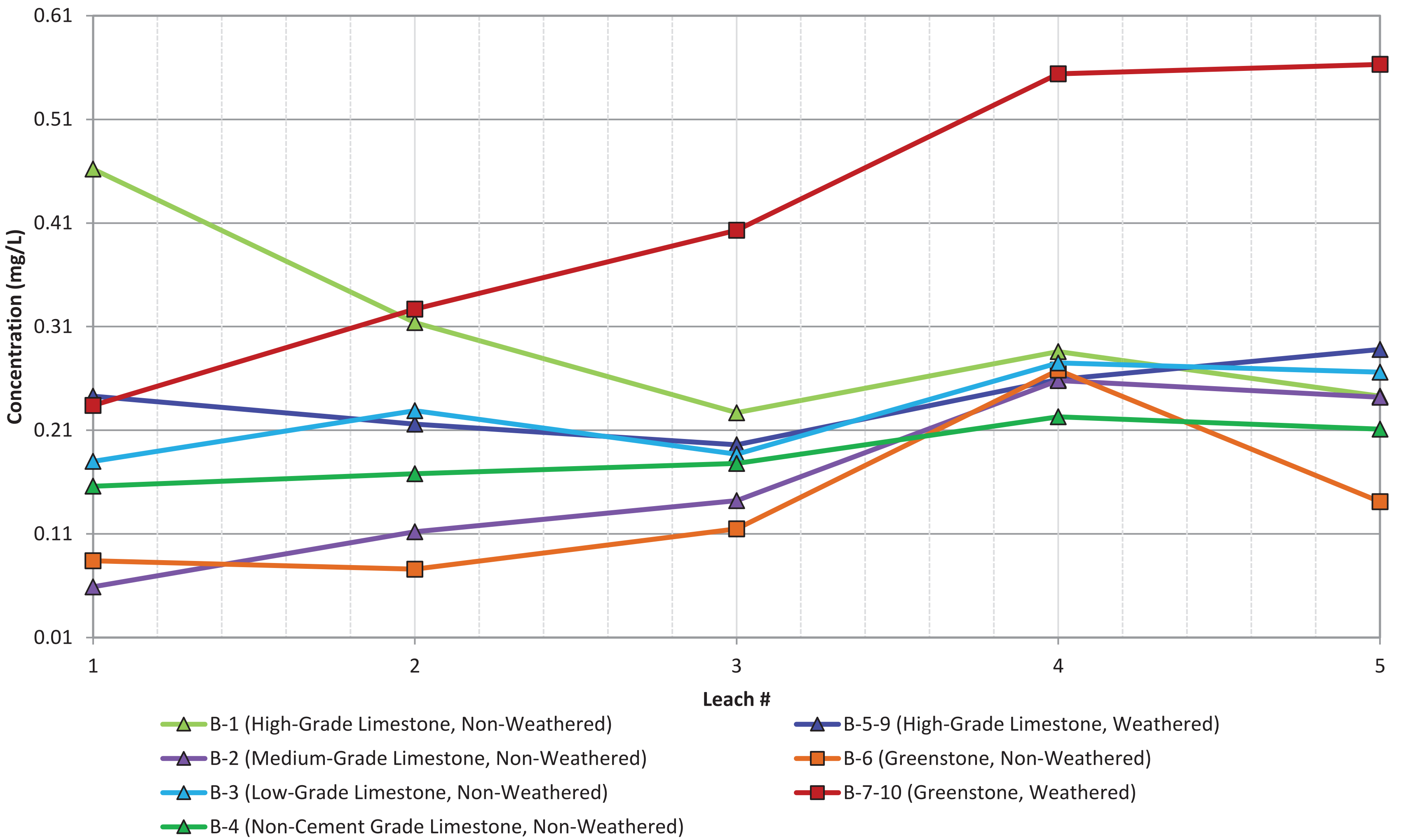
Title: **Sequential Modified WET- Carbonate as CaCO3**

Project Name	Project No. 31405507	FIGURE C-5
Client Name: Lehigh Permanente	Date: 8/4/2022	



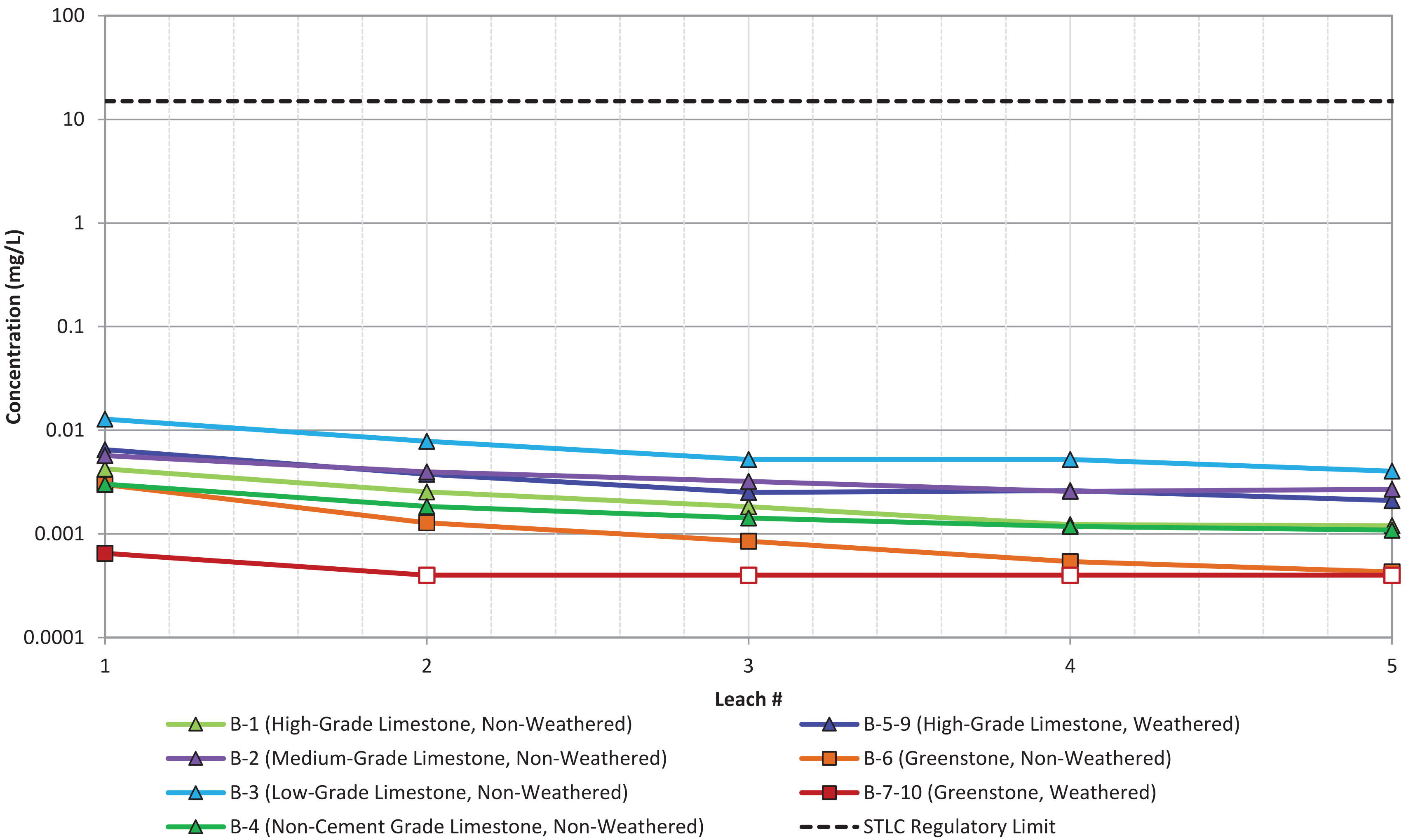
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Hydroxide as CaCO3**		
	Project Name	Project No. 31405507	FIGURE C-6
	Client Name: Lehigh Permanente	Date: 8/4/2022	



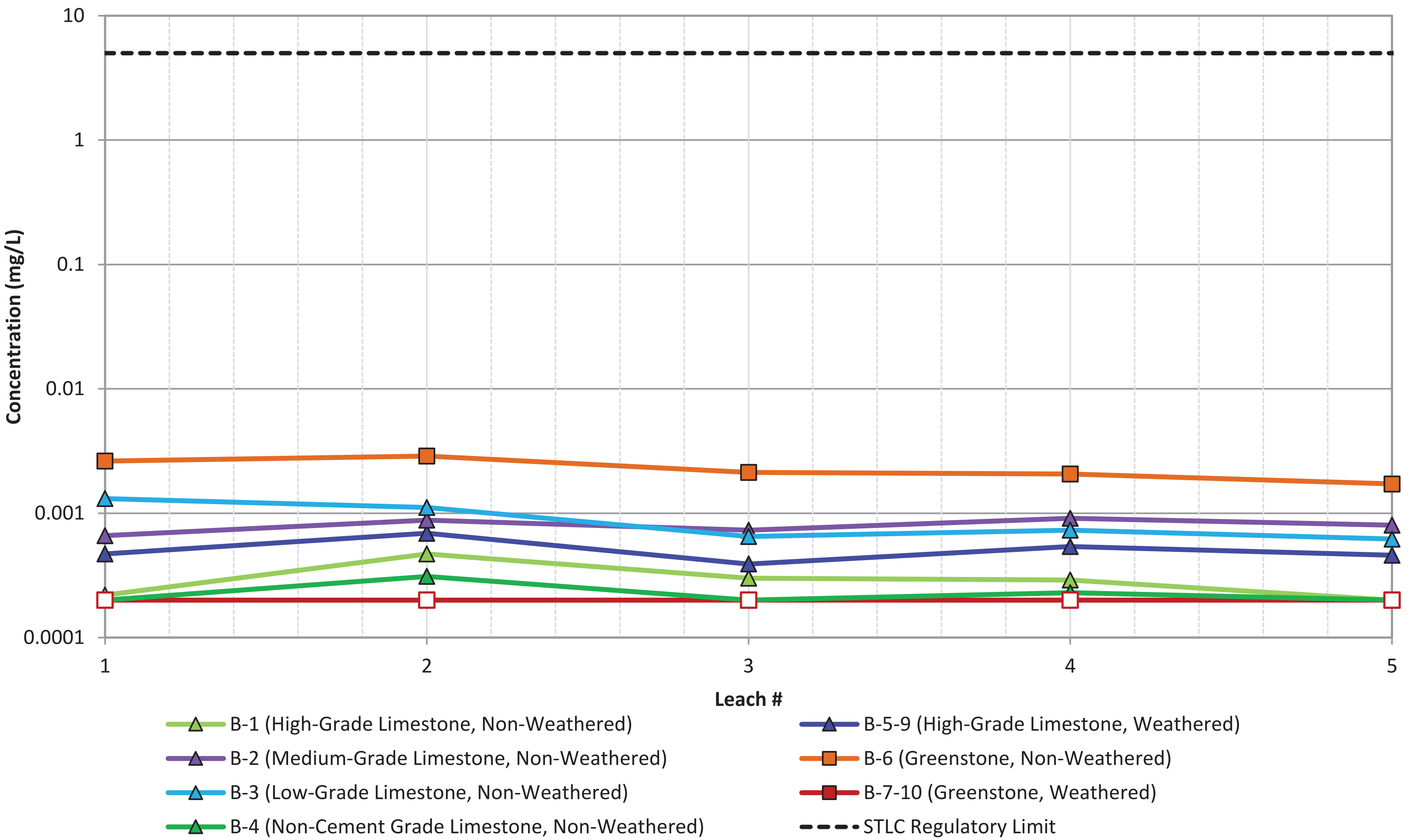
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Aluminum**		
	Project Name	Project No. 31405507	FIGURE C-7
	Client Name: Lehigh Permanente	Date: 8/4/2022	



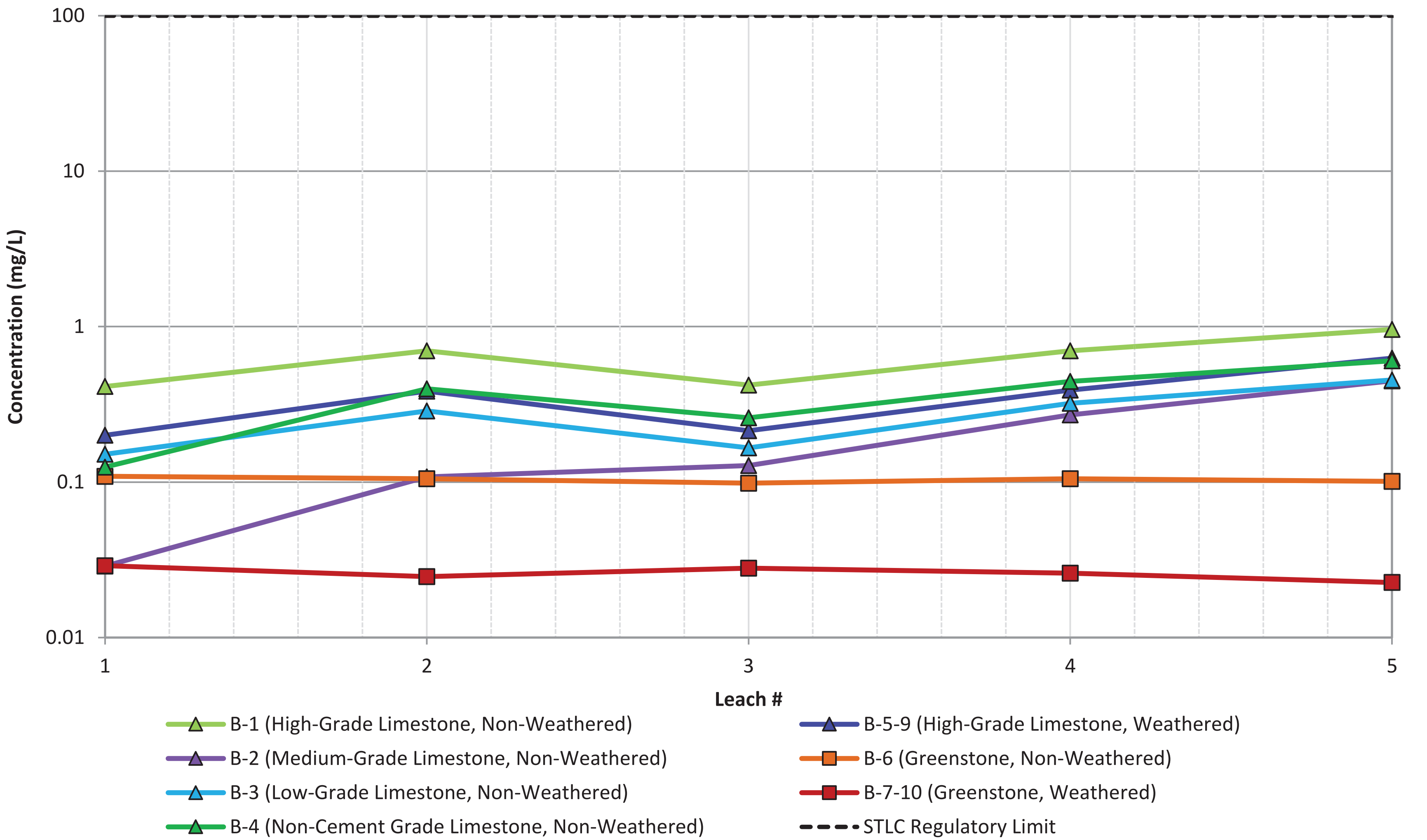
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Antimony**		
	Project Name	Project No. 31405507	FIGURE C-8
	Client Name: Lehigh Permanente	Date: 8/4/2022	



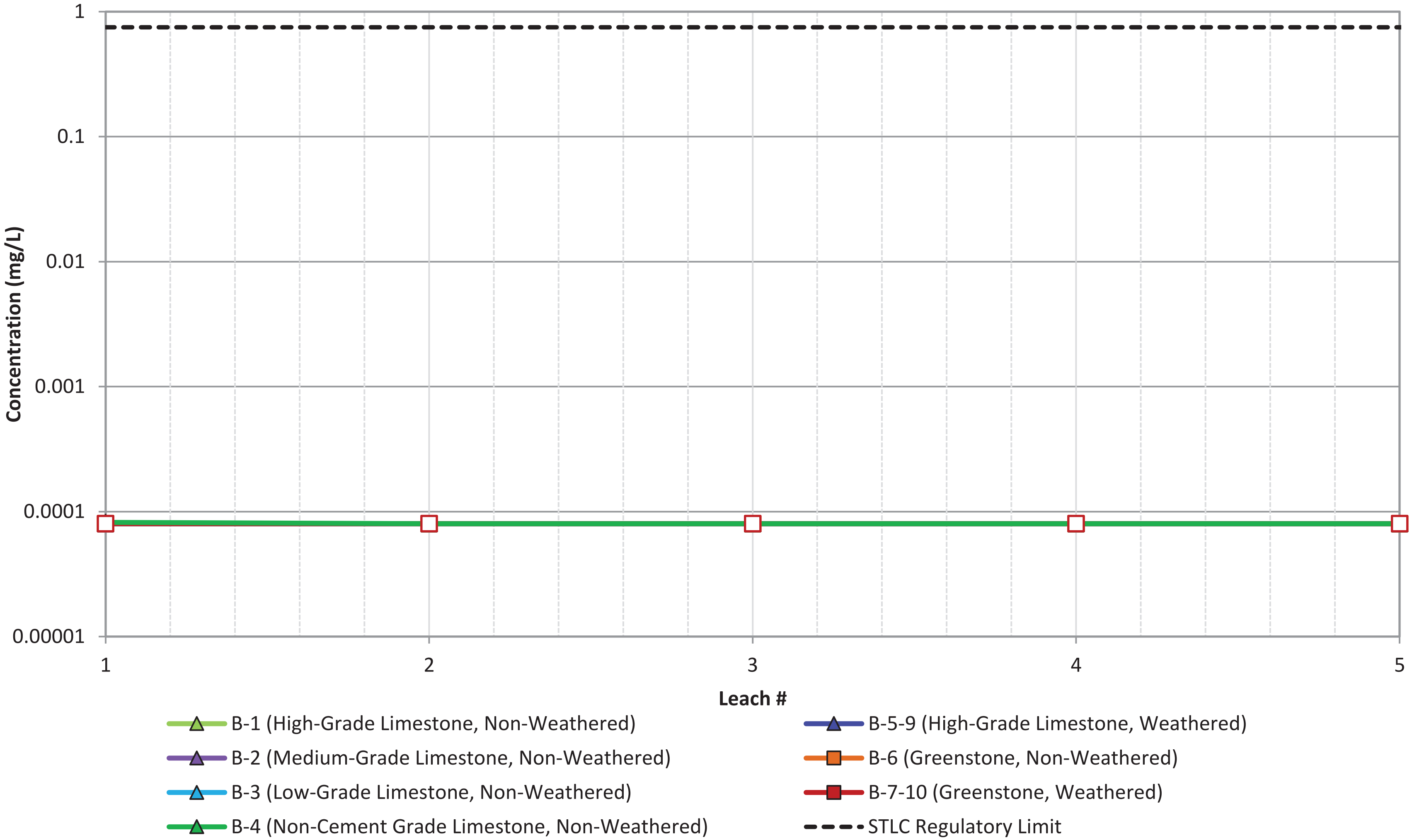
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Arsenic**		
	Project Name	Project No. 31405507	FIGURE C-9
	Client Name: Lehigh Permanente	Date: 8/4/2022	



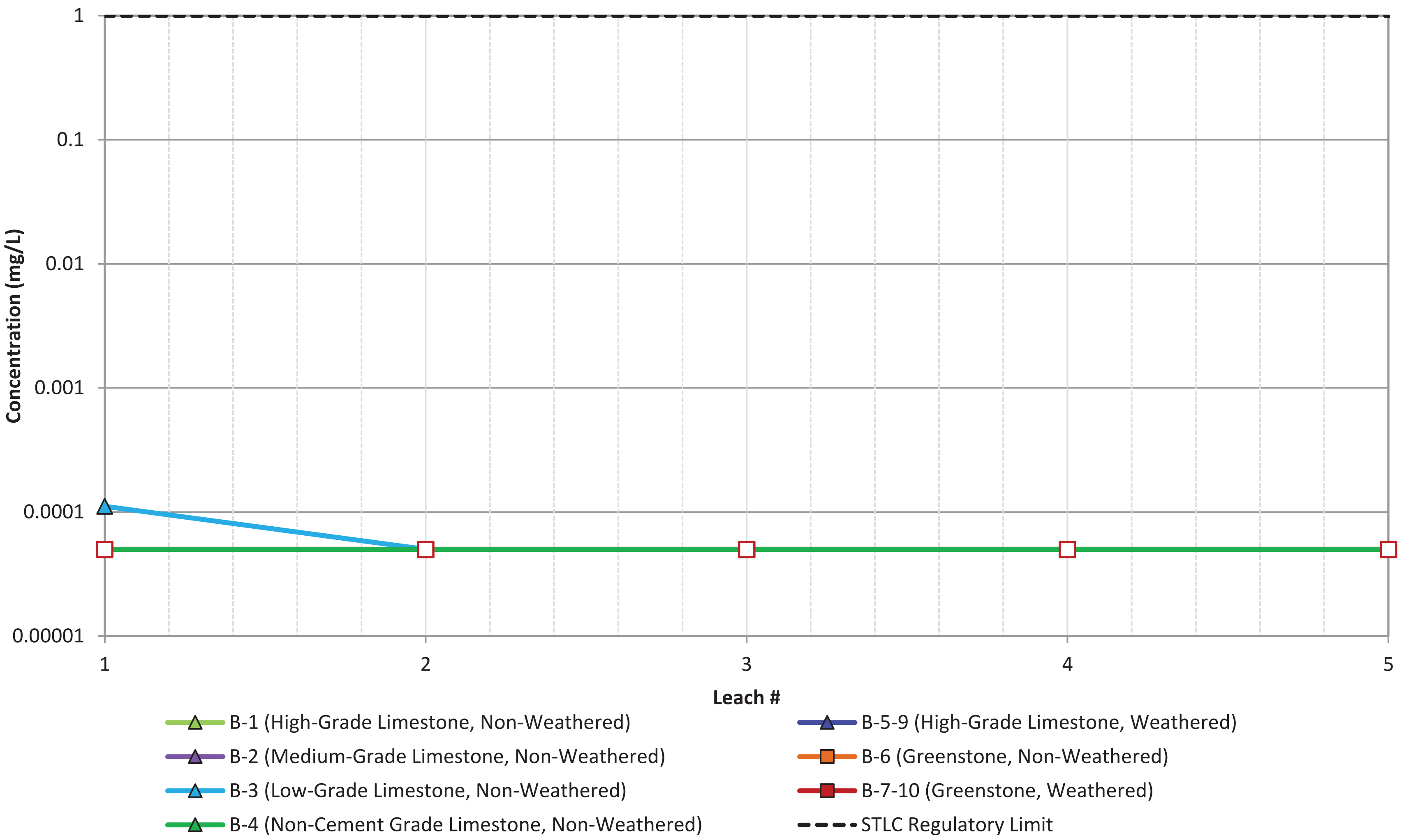
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Barium**		
	Project Name	Project No. 31405507	FIGURE C-10
	Client Name: Lehigh Permanente	Date: 8/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Beryllium**		
	Project Name:	Project No. 31405507	FIGURE C-11
	Client Name: Lehigh Permanente	Date 8/4/2022	

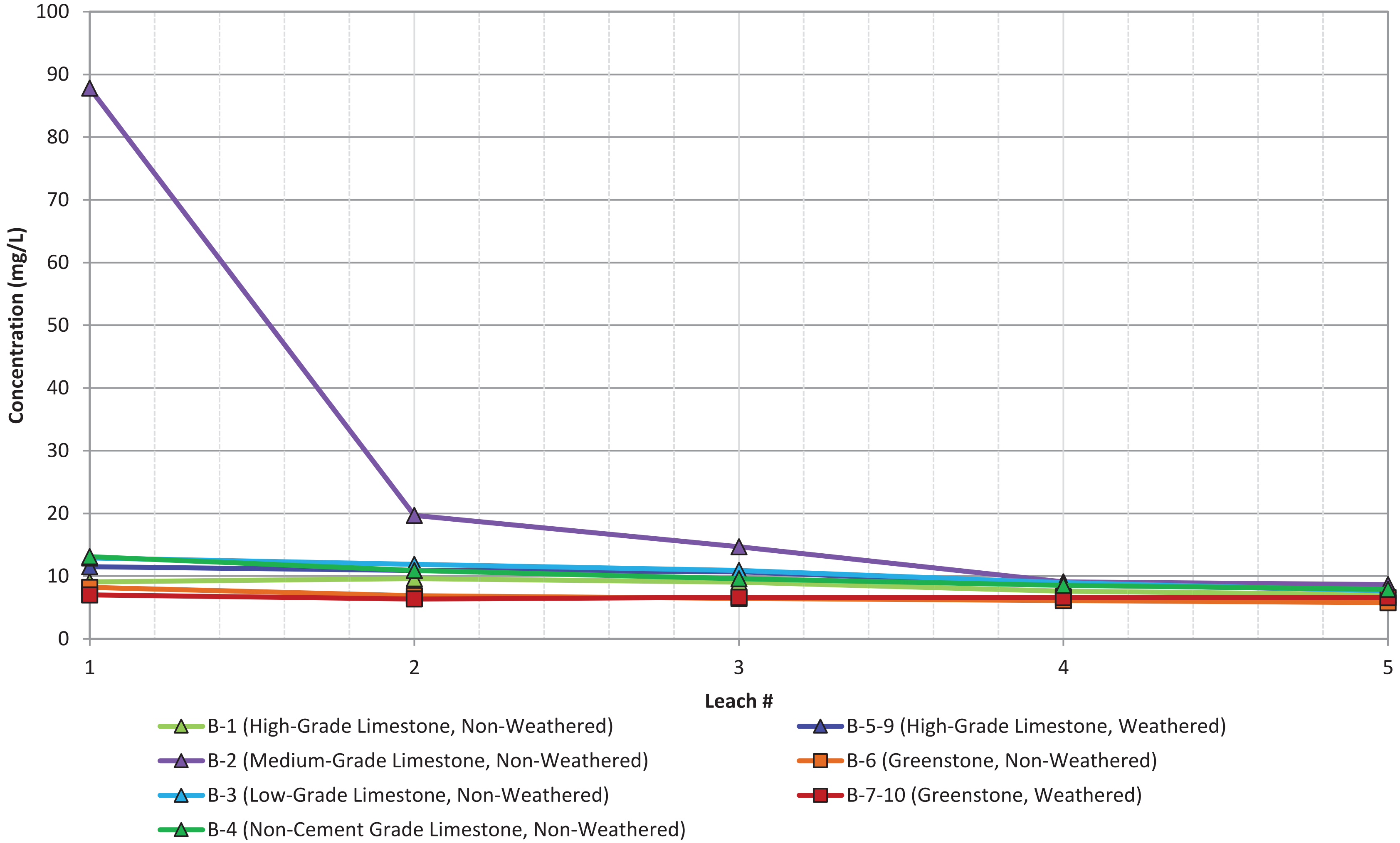


*Open symbols denote values at or below the method detection limit

WSP GOLDER

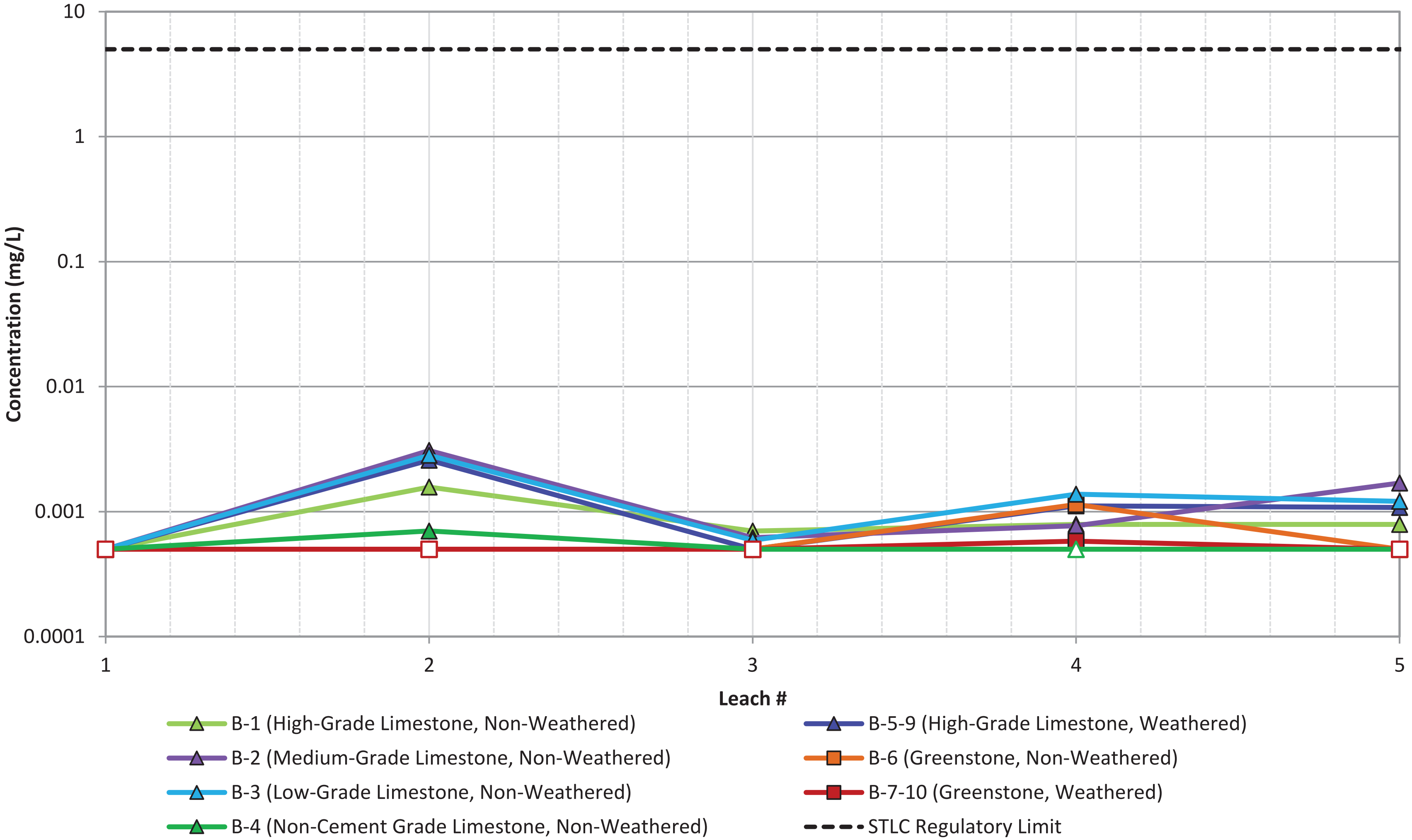
Title
Sequential Modified WET- Cadmium

Project Name	Project No. 31405507	FIGURE C-12
Client Name Lehigh Permanente	Date 8/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Calcium**		
	Project Name	Project No. 31405507	FIGURE C-13
	Client Name: Lehigh Permanente	Date: 8/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER

Title
Sequential Modified WET- Chromium

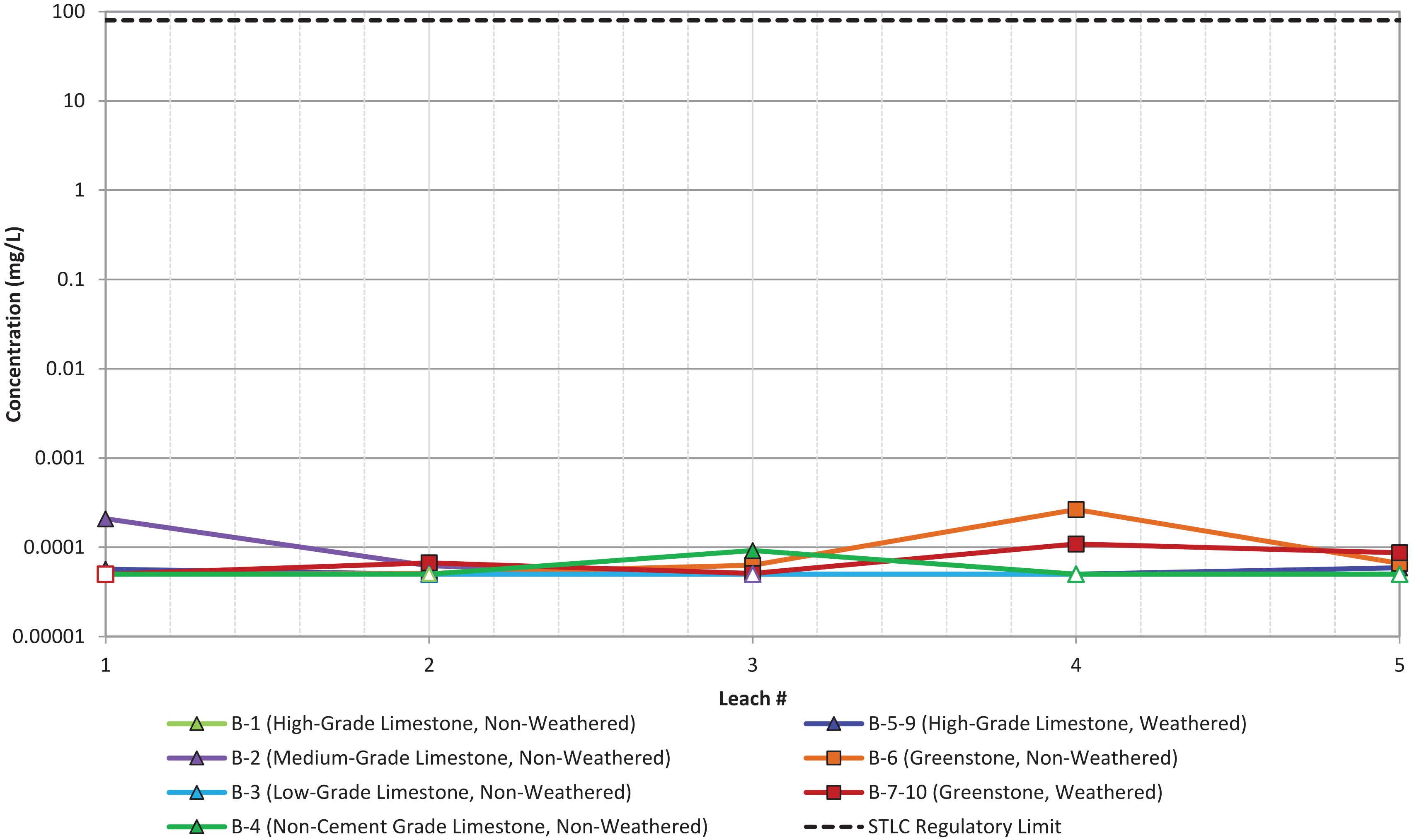
Project Name

Project No. 31405507

Client Name Lehigh Permanente

Date 8/4/2022

FIGURE C-14

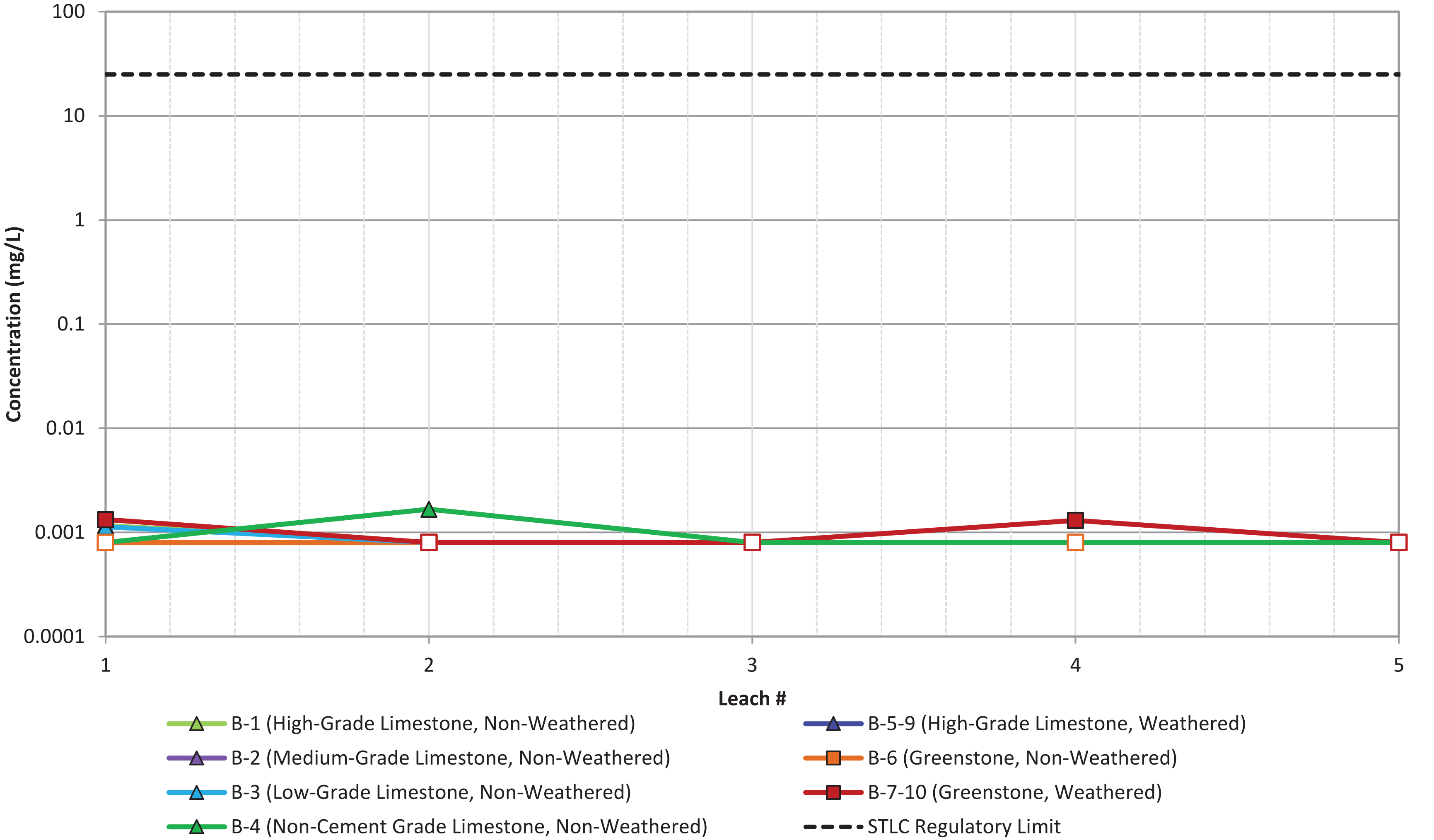


*Open symbols denote values at or below the method detection limit

WSP GOLDER

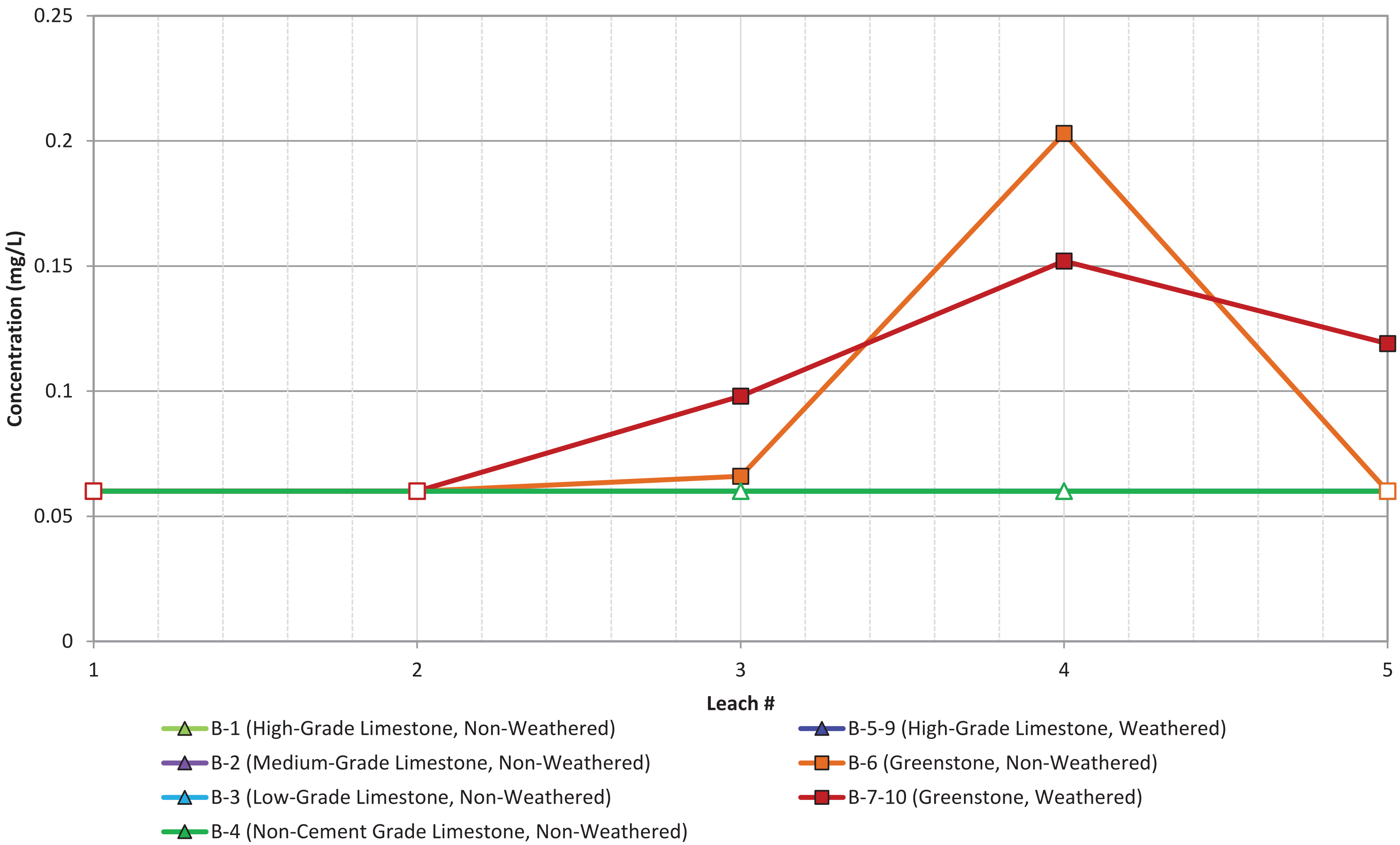
Title
Sequential Modified WET- Cobalt

Project Name	Project No. 31405507	FIGURE
Client Name Lehigh Permanente	Date 8/4/2022	C-15



*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Copper**		
	Project Name	Project No. 31405507	FIGURE C-16
	Client Name: Lehigh Permanente	Date: 8/4/2022	

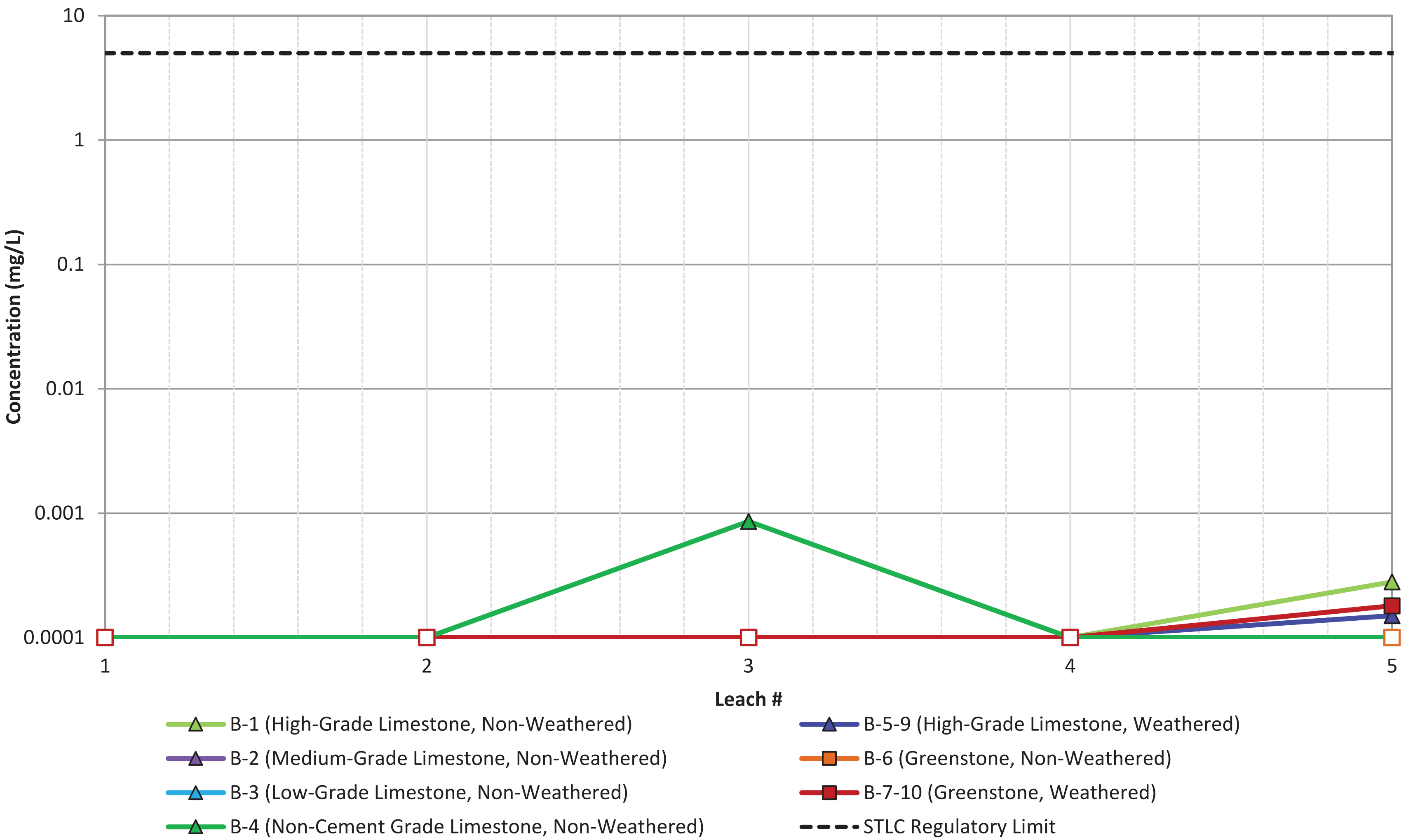


*Open symbols denote values at or below the method detection limit

WSP GOLDER

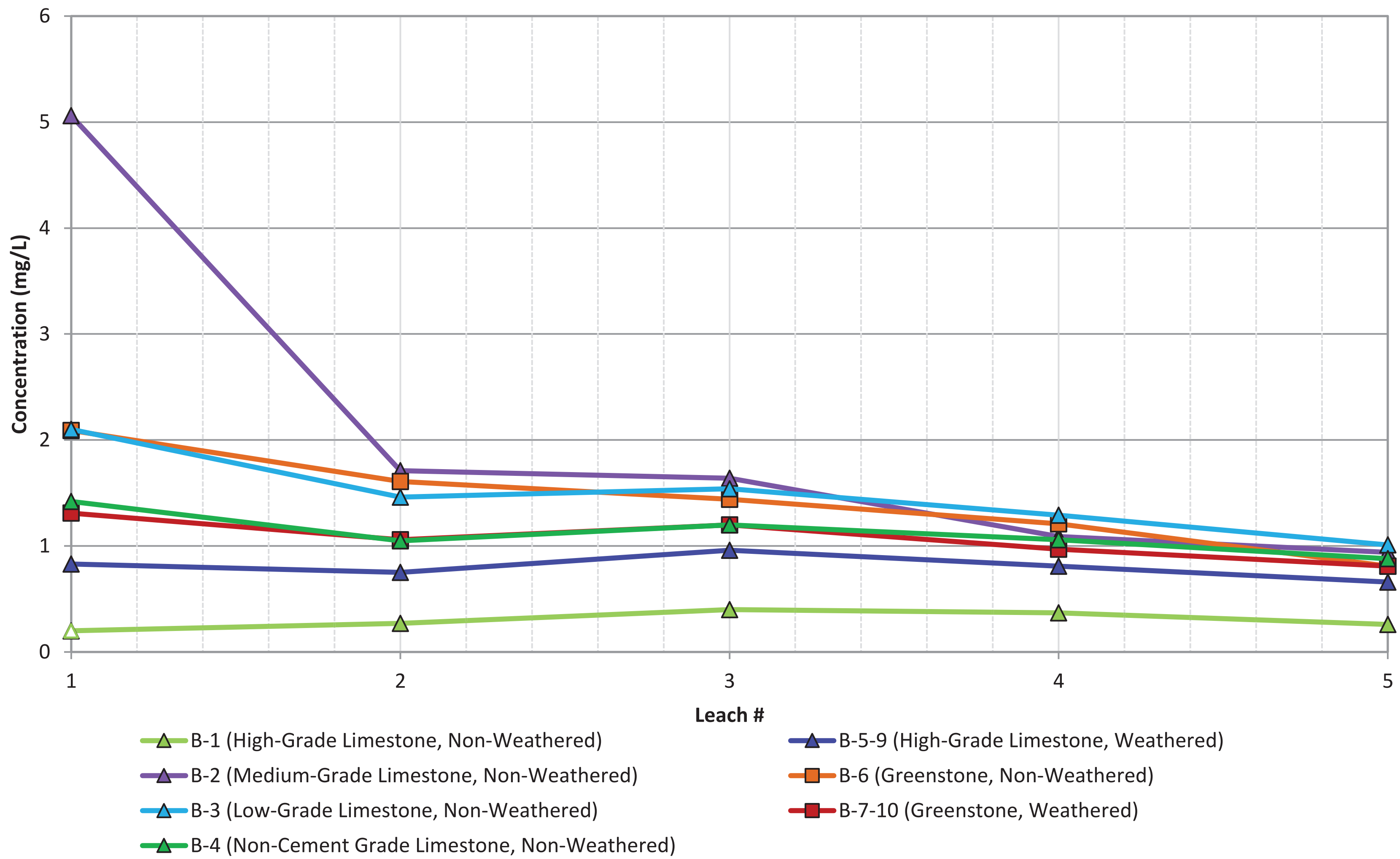
Title
Sequential Modified WET- Iron

Project Name	Project No. 31405507	FIGURE C-17
Client Name Lehigh Permanente	Date 8/4/2022	



*Open symbols denote values at or below the method detection limit

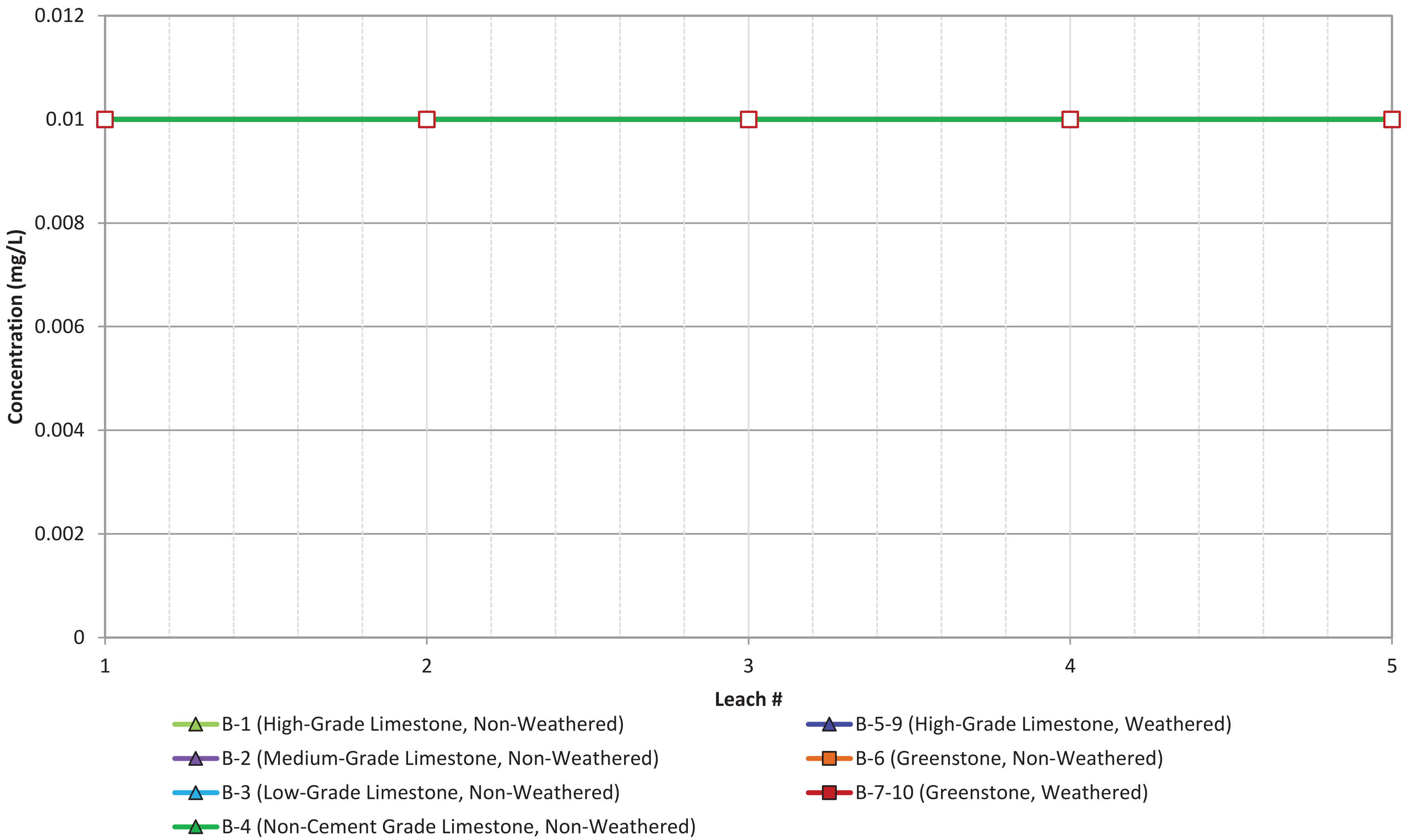
WSP GOLDER	Title: **Sequential Modified WET- Lead**		
	Project Name	Project No. 31405507	FIGURE C-18
	Client Name: Lehigh Permanente	Date: 8/4/2022	



*Open symbols denote values at or below the method detection limit

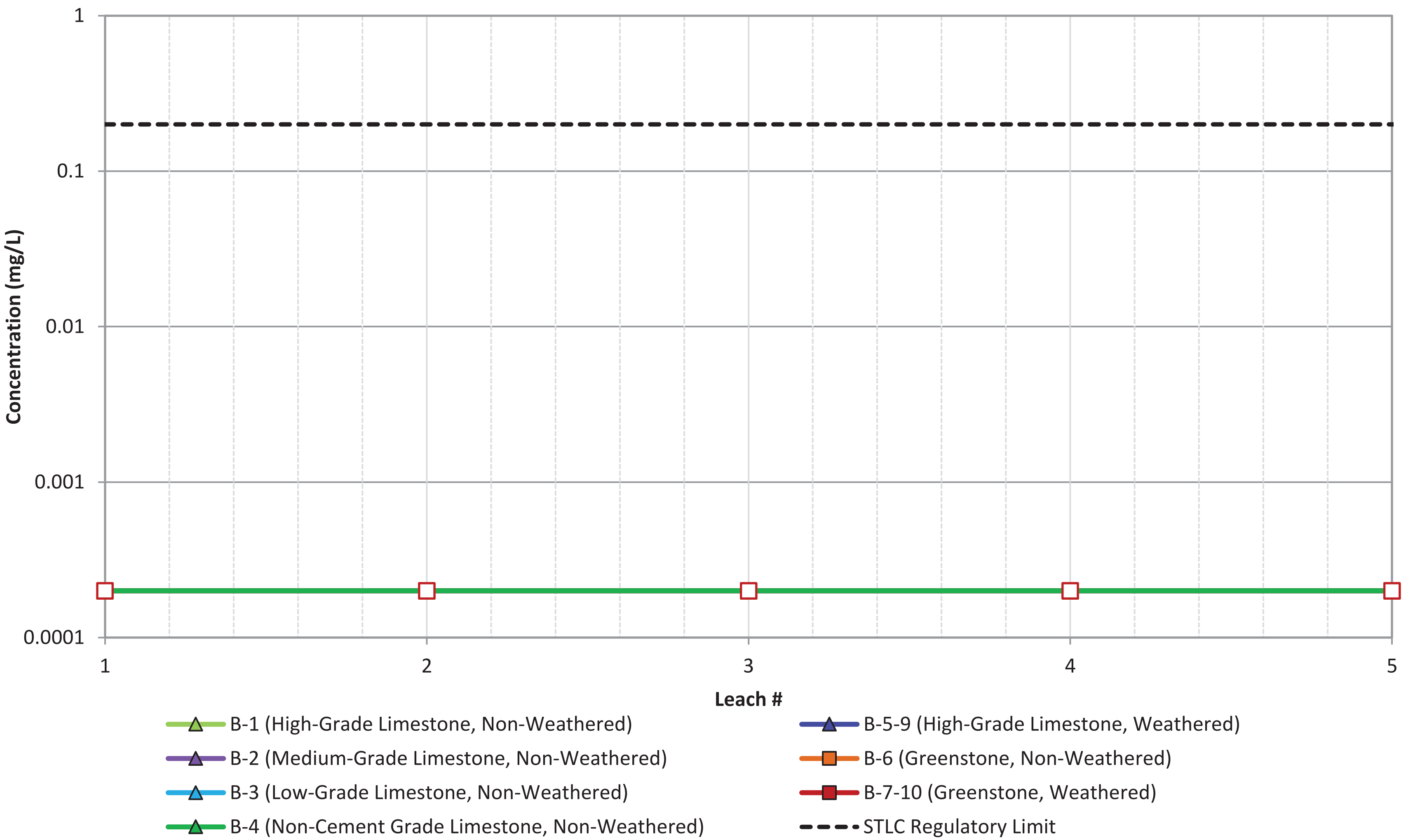
WSP GOLDER

Title		
Sequential Modified WET- Magnesium		
Project Name	Project No. 31405507	FIGURE C-19
Client Name Lehigh Permanente	Date 8/4/2022	



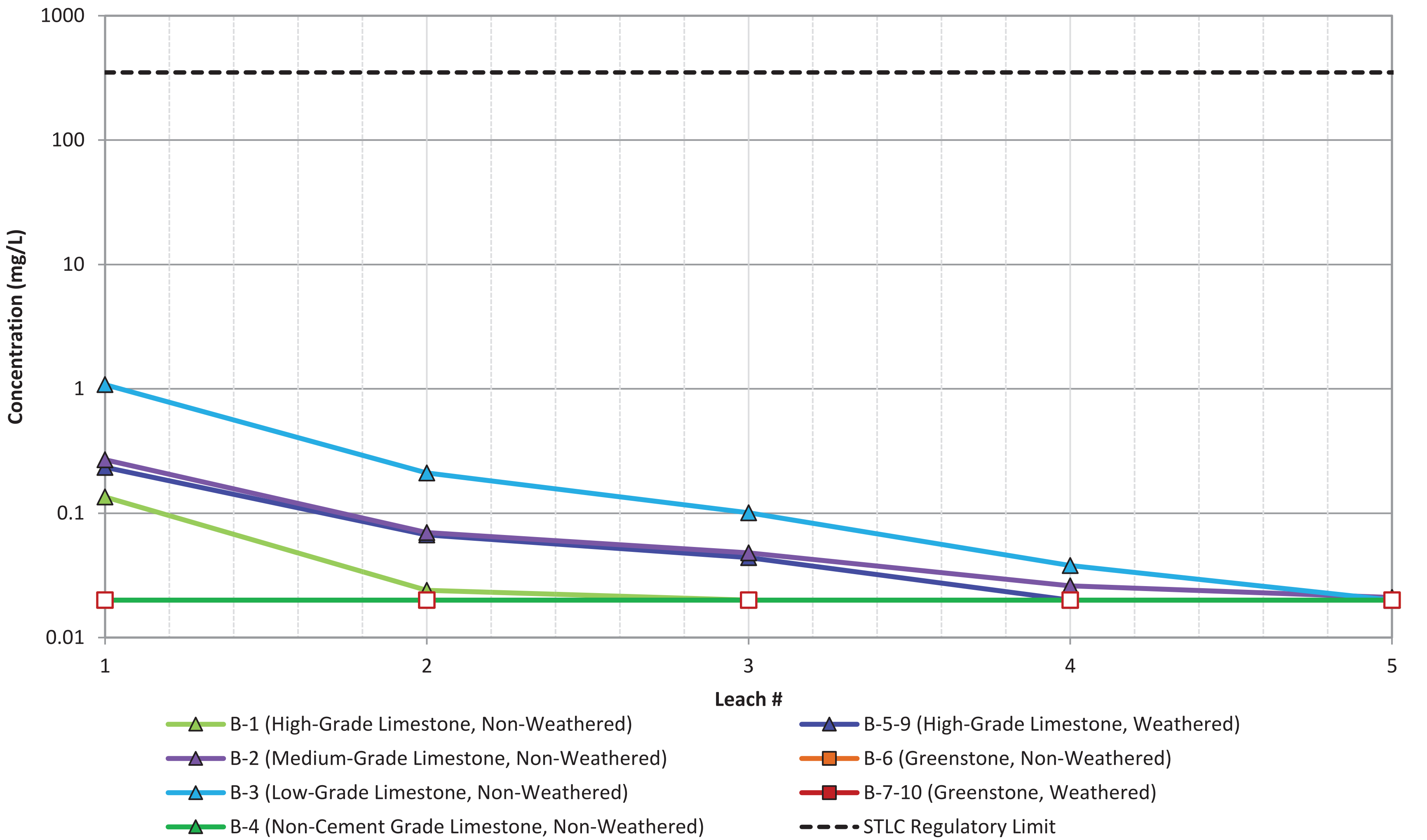
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Manganese**		
	Project Name	Project No. 31405507	FIGURE C-20
	Client Name: Lehigh Permanente	Date: 8/4/2022	



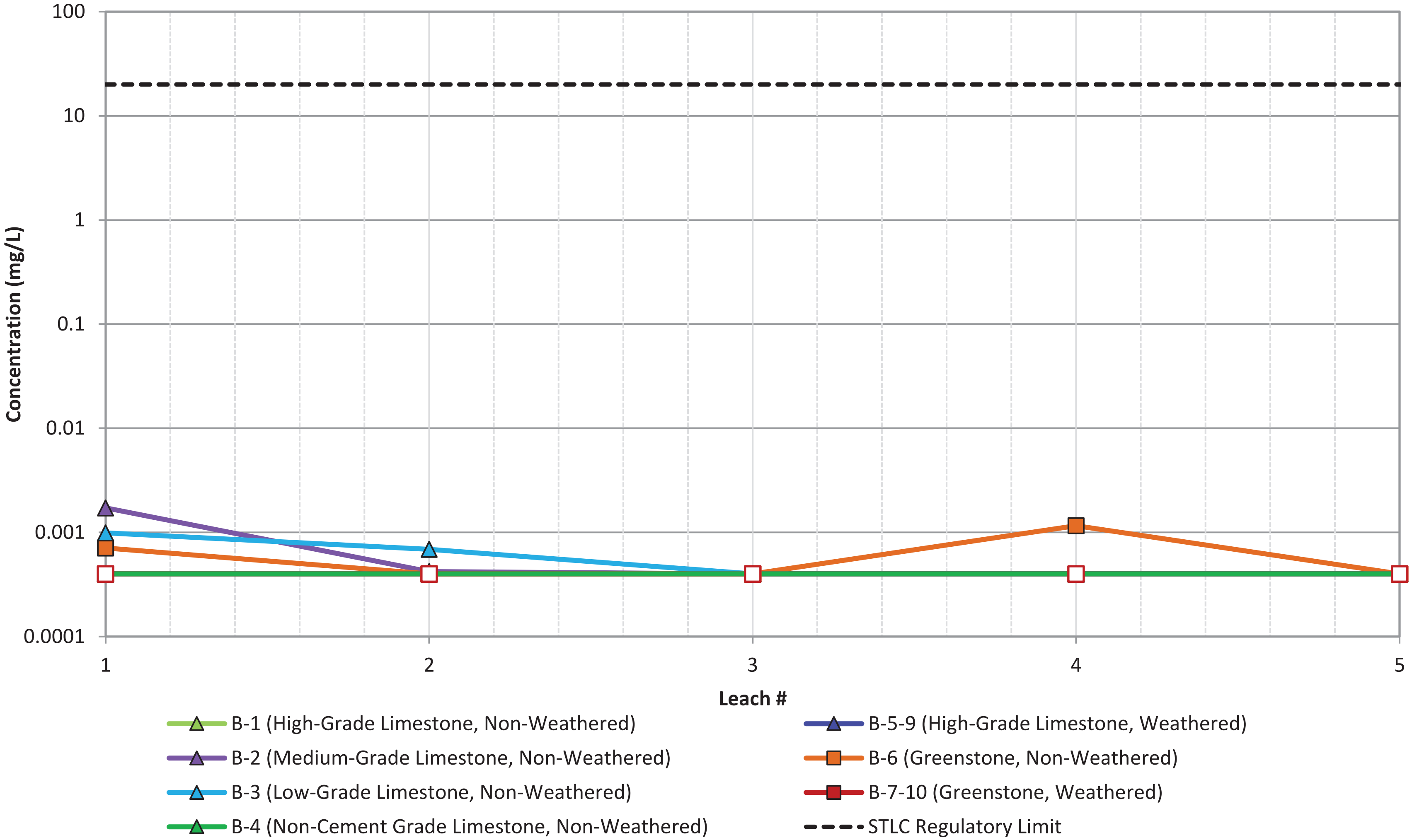
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Mercury**		
	Project Name:	Project No.: 31405507	FIGURE C-21
	Client Name: Lehigh Permanente	Date: 8/4/2022	



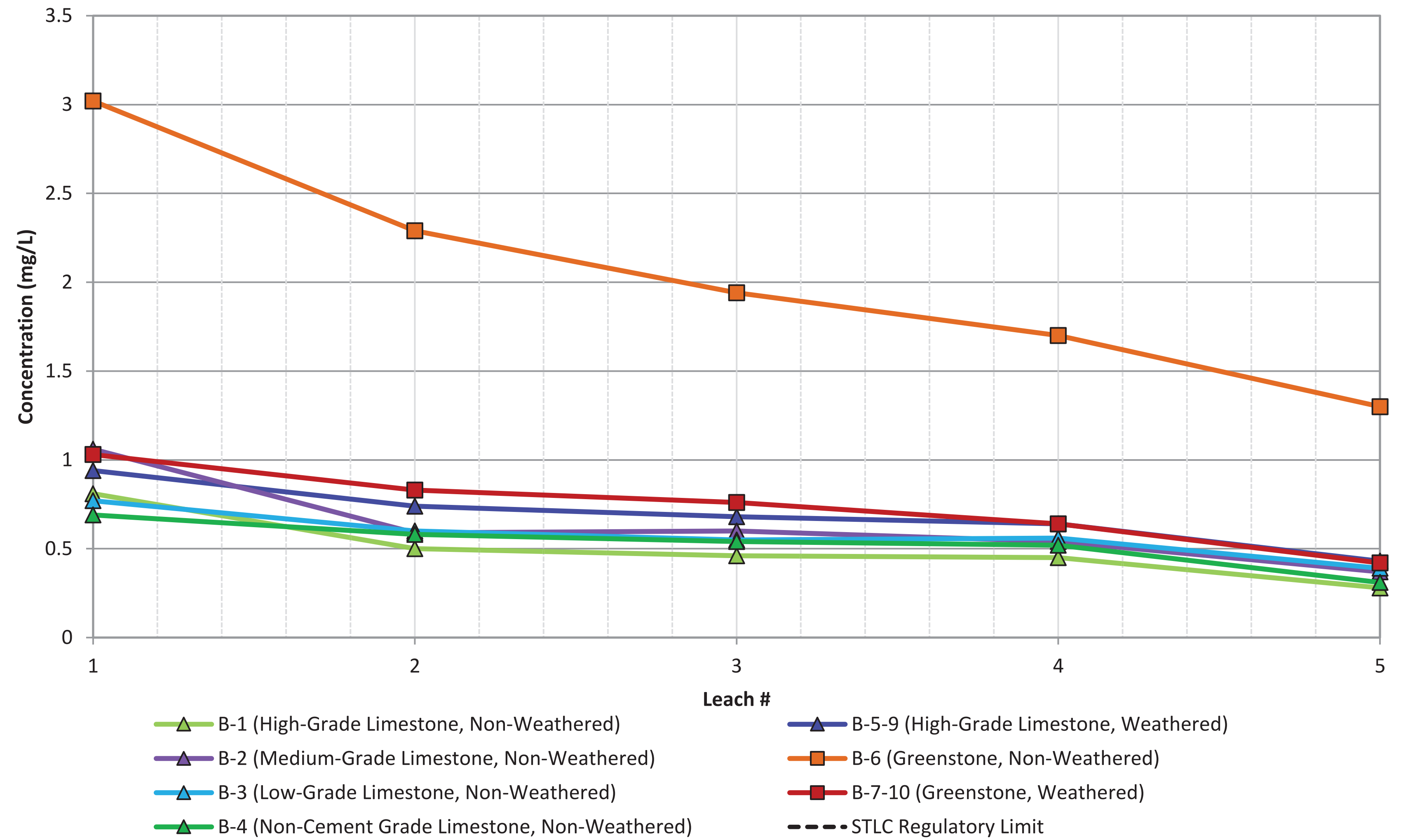
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Molybdenum**		
	Project Name	Project No. 31405507	FIGURE C-22
	Client Name: Lehigh Permanente	Date: 8/4/2022	



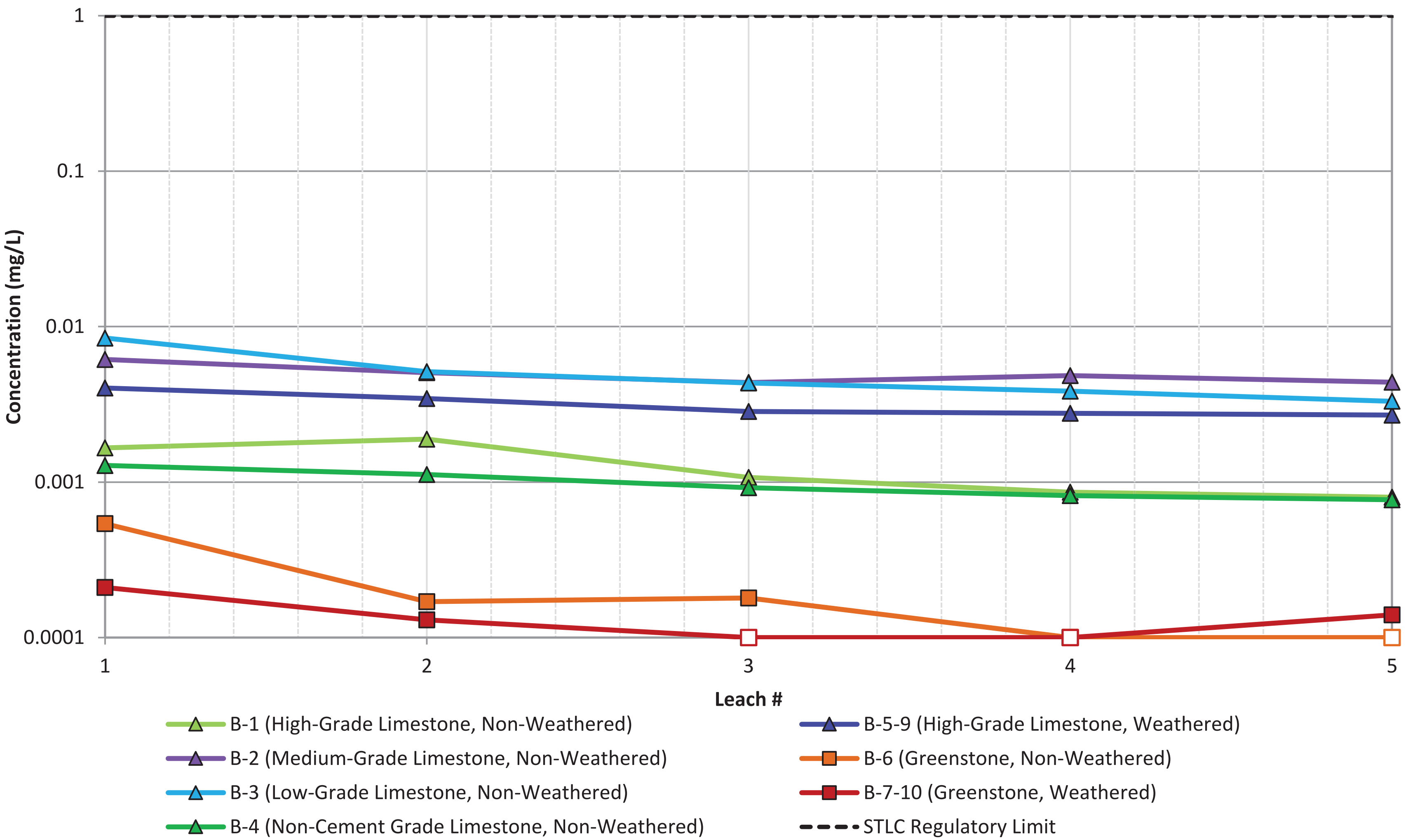
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Nickel**		
	Project Name	Project No. 31405507	FIGURE C-23
	Client Name: Lehigh Permanente	Date: 8/4/2022	



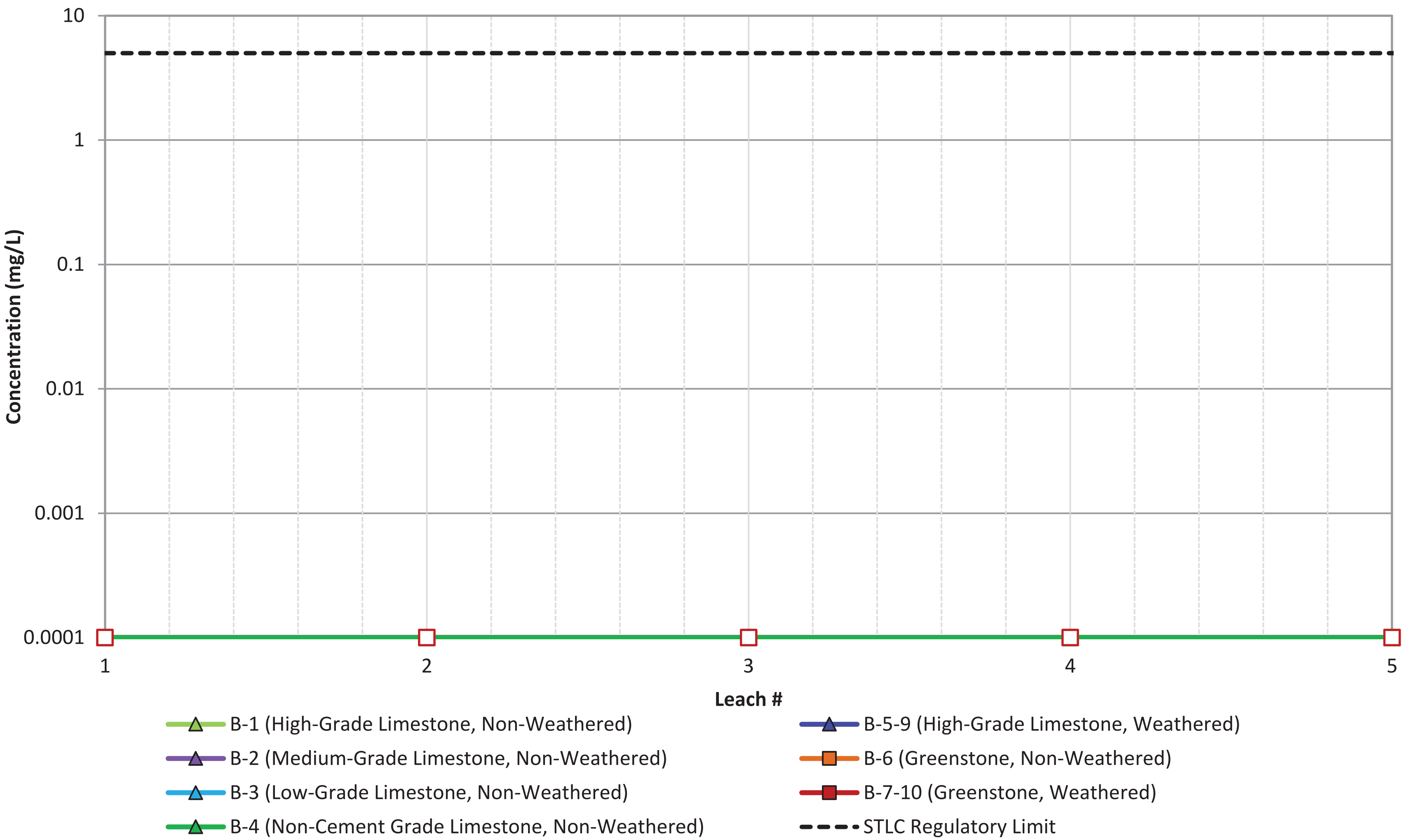
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Potassium**		
	Project Name	Project No. 31405507	FIGURE C-24
	Client Name: Lehigh Permanente	Date: 8/4/2022	



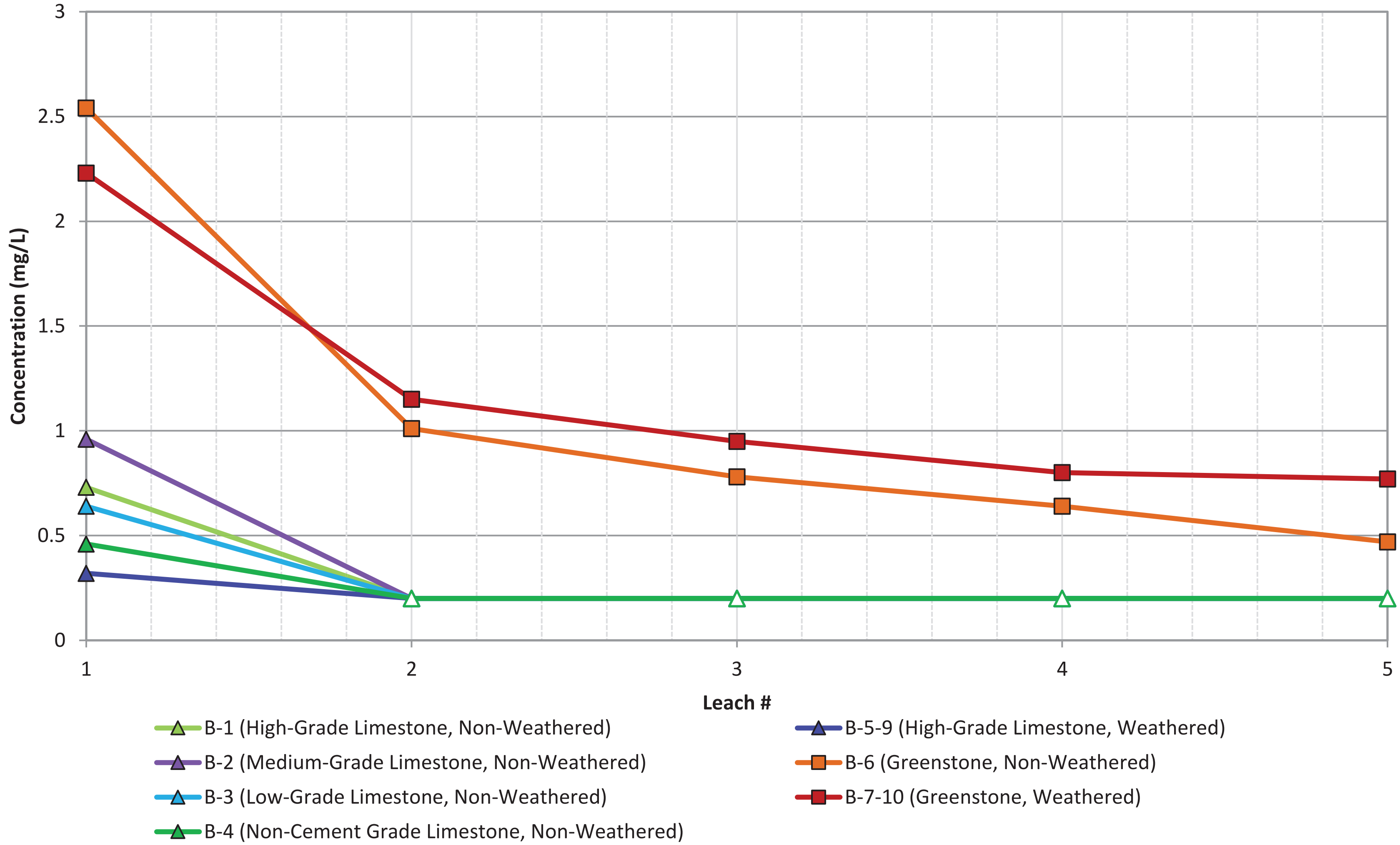
*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Selenium**		
	Project Name	Project No. 31405507	FIGURE C-25
	Client Name: Lehigh Permanente	Date: 8/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER	Title: **Sequential Modified WET- Silver**		
	Project Name	Project No. 31405507	FIGURE C-26
	Client Name: Lehigh Permanente	Date: 8/4/2022	



*Open symbols denote values at or below the method detection limit

WSP GOLDER

Title
Sequential Modified WET- Sodium

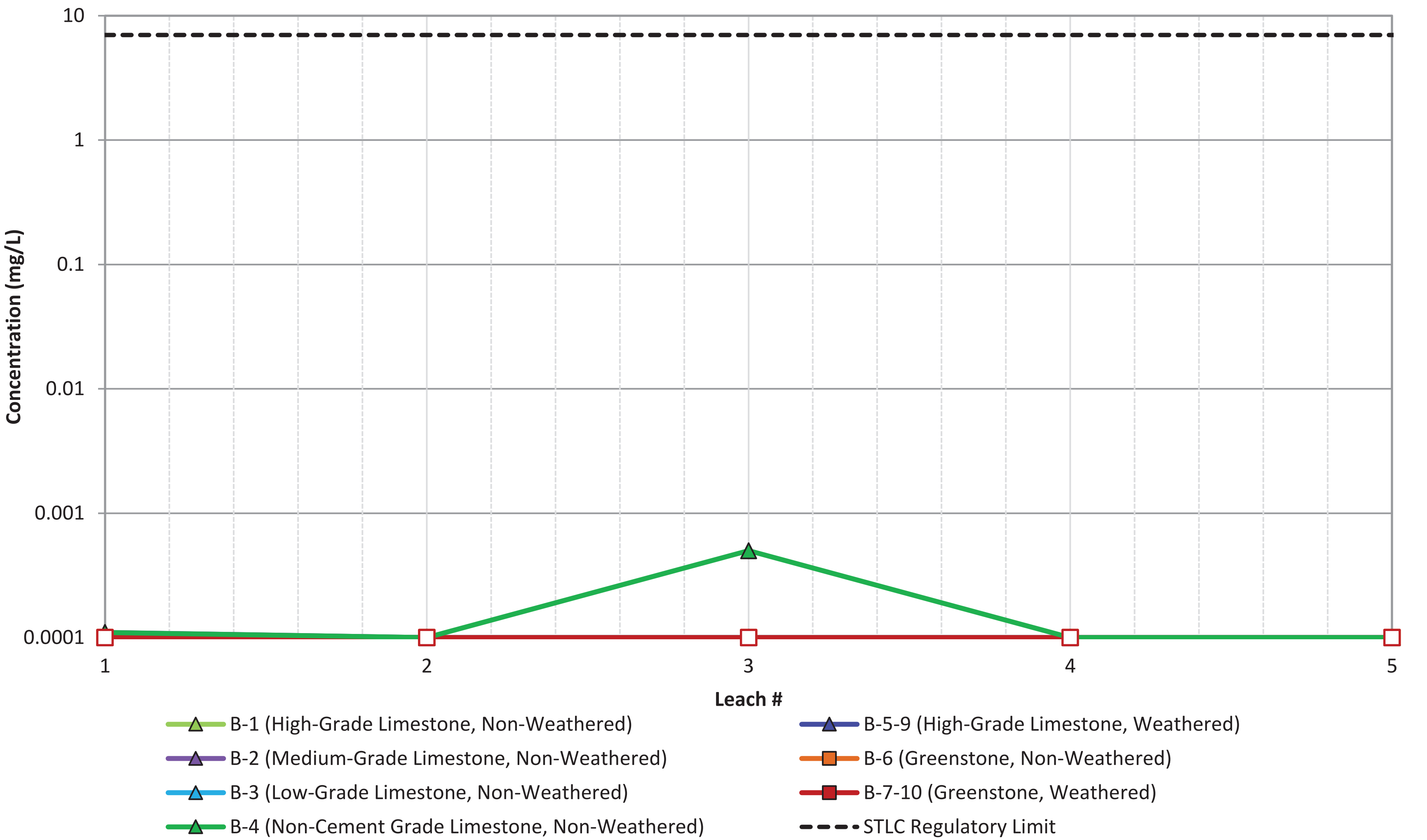
Project Name

Project No. 31405507

Client Name Lehigh Permanente

Date 8/4/2022

FIGURE C-27



*Open symbols denote values at or below the method detection limit

WSP GOLDER

Title
Sequential Modified WET- Thallium

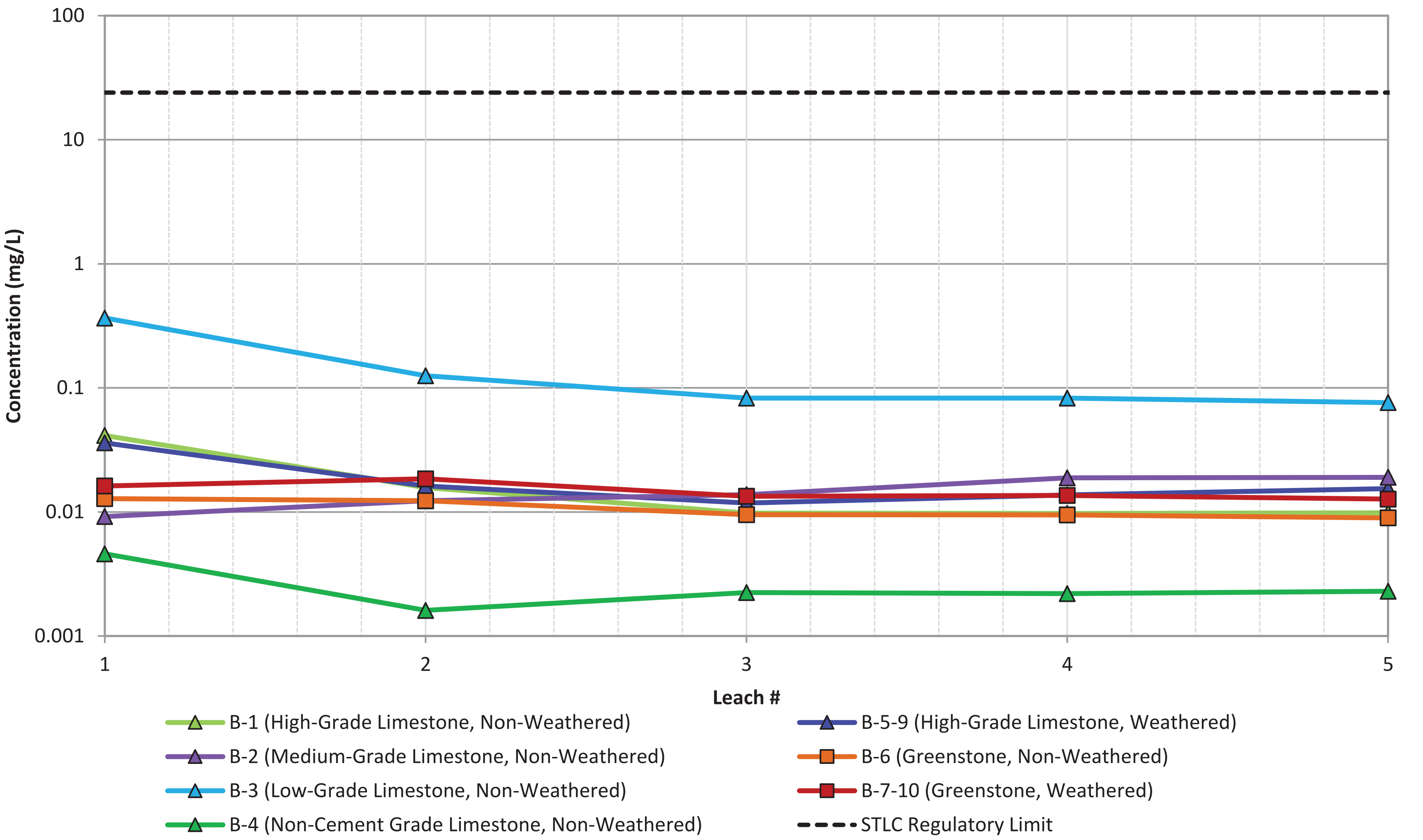
Project Name

Project No. 31405507

Client Name Lehigh Permanente

Date 8/4/2022

FIGURE C-28



*Open symbols denote values at or below the method detection limit

WSP GOLDER

Title		
Sequential Modified WET- Vanadium		
Project Name	Project No. 31405507	FIGURE C-29
Client Name: Lehigh Permanente	Date: 8/4/2022	

G4. Seismic Refraction Survey (NorCal Geophysical Consultants, Inc. May 22, 2014)

May 22, 2014

Golder Associates, Inc.
425 Lakeside Drive
Sunnyvale, CA 94085

Subject: Seismic Refraction Survey
Sites 4 and 11
Permanente Quarry
Cupertino, California

NORCAL Job #14-245.15B

Attention: George Wegmann,

This report presents the findings of seismic surveys performed by NORCAL Geophysical Consultants, Inc. for Golder Associates, Inc. at Permanente Quarry in Cupertino, California. The surveys were performed during the period March 4 through 11th, 2014 by NORCAL Professional Geophysicist William J. Henrich, PGp 893. Geologist Jeff Linder and Field Technician Dave Walter of Golder Associates, Inc. provided field assistance throughout the duration of the survey.

1.0 SITE DESCRIPTION AND PURPOSE

The seismic surveys were conducted at two locations referred to as Area 11 and Area 4, as shown on Plates 1A and 1B, respectively. Both areas encompass sections of Permanente Creek which drains in a general west to east direction. The area north of the creek has been subjected to accumulations of overburden materials related to quarrying operations. Particle sizes of the mine wastes ranged from sand and gravel size up to boulders that, on the surface, were several feet across. The local bedrock consisted of greywacke (sandstone), greenstone and limestone belonging to the Franciscan Complex.

The purpose of the seismic survey was to determine the thickness of alluvium and alluvium-rock fills at accessible select areas within the stream channel, along parallel haul roads and areas north of the stream channel. This data will be used by others to assess volumes of unconsolidated materials needed to be removed for restoration to the original stream channel grade and configuration as part of a reclamation plan for the quarry.

2.0 METHODOLOGY

We collected seismic data using two methods known as seismic refraction (SR) and multi-channel analysis of surface waves (MASW). The SR method was used to determine the compressional (P-) wave velocity of subsurface materials. The P-wave velocity (Vp) of fill, sediments, and rock are dependent on physical properties such as compaction, density, hardness, and induration. However, other factors such as bedding, fracturing, and saturation also affect Vp.

Typically, low Vp is indicative of loose, dry soils, poorly compacted fill material, poorly to semi-consolidated sediments, or alternatively, deeply weathered and/or highly fractured rock. Moderate Vp usually indicates dense and highly compacted or saturated sedimentary deposits or fill, and/or moderately weathered and fractured sedimentary rock. High Vp typically represent un-weathered sedimentary (i.e., sandstone, conglomerate, meta-sandstone or basalt) bedrock. A more detailed description of the SR methodology is provided in Appendix A.

The MASW method was used to determine both the P-wave and the shear (S-) wave velocity of subsurface materials in areas where limited access precluded the use of the SR method. S-waves typically propagate through earth materials at roughly one-half the velocity of P-waves. However, S-wave velocities are more directly related to the strength of fill, sediments, and rock than P-waves. Furthermore, unlike Vp, S-wave velocity (Vs) is not affected by saturation. Typically, low Vs is indicative of loose, dry soils, poorly compacted fill material, poorly to semi-consolidated sediments, or alternatively, deeply weathered and/or highly fractured rock. Moderate Vs usually indicates dense and highly compacted sedimentary deposits or fill, and/or moderately weathered and fractured sedimentary rock. High Vs typically represent un-weathered sedimentary (i.e., sandstone, conglomerate, meta-sandstone or basalt) bedrock. A more detailed description of the MASW method is provided in Appendix B.

3.0 DATA ACQUISITION

SR surveys were conducted in two locations referred to as the Rock Pile Area (Area 11) and the Material Removal Area (Area 4). The SR surveys were conducted according to the procedures described in Appendix A. MASW soundings were conducted in Area 11 according to the procedures described in Appendix B. The salient features of the data acquisition procedures used in each area are described in the following sections.

3.1 AREA 11

In Area 11 we collected SR data from 8-lines ranging in length from 75- to 250-ft. The locations of these lines, labeled Line 1 through Line 8, are shown on Plate 1A. We also conducted two MASW soundings. The locations of the soundings, labeled MASW-9 and MASW-10 are also shown on Plate 1A. Where possible, the SR lines and MASW soundings were located within the stream channel. However, there were some areas where the lines had to be placed on adjacent compacted gravel roads because of the presence of dense vegetation, concrete linings or steel culverts within the channel.

3.2 AREA 4

In Area 4, we acquired SR data from 13-lines ranging in length from 125- to 250-ft. The locations and orientations of the SR lines are shown on Plate 1B. The SR lines were positioned within the stream channel and on the northern portions (hill slopes, access roads and parking area) of the site.

4.0 DATA PROCESSING

4.1 SEISMIC REFRACTION (SR)

The refraction data were processed as described in Appendix A. Elevation data were provided by Waterways Consultants, Inc. at each shot point location within every seismic line. These elevation data were incorporated into the final processed seismic models. Further information regarding specific data input and sample compilations can be found in Appendix A.

4.2 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

The MASW data were processed according to the procedures described in Appendix B.

5.0 RESULTS

The results of the seismic refraction survey are illustrated by the seismic velocity cross-sections (profiles) shown on Plates 2 through 8. On each profile the vertical axis represents elevation above mean sea level (MSL) and the horizontal axis represents draped survey distance (Station) along each line. Color shaded areas represent the lateral and vertical extent of the seismic layers comprising each profile. Modelled layer depths (thicknesses) as described in the Appendix A were determined beneath each geophone. These data were interpolated/extrapolated beneath each shot point. The relationship between color and seismic velocity is indicated by the color scales plotted to the right of each seismic refraction profile. In order to indicate how velocity varies from line to line within each survey area, the same scale was used for every profile. The results obtained in each area are described in the following sections. Specific results are presented for areas where two or more seismic refraction profiles either cross each other or are in a local proximity. It was useful to group seismic lines in this manner because of common characteristics involving of topography, location or surface conditions.

5 .1 AREA 11

5.1.1 Lines 1 and 2 (Plate 2)

Lines 1 and 2 were located within the stream channel, just west of a retention pond, as shown on Plate 1A. During the survey, water from remote pumping was actively being discharged to the stream channel above the seismic lines. The profile for Line 1 indicates velocities (Vp) ranging from 1200- to 7200-ft/sec. Our interpretation of the data resolves this range into two seismic layers labeled V1 and V2 in order of increasing depth and velocity. We interpret V1as representing unconsolidated stream deposits and V2 as representing bedrock. The depth to rock ranged from 18- to 25-ft. The Profile for Line 2 indicates velocities (Vp) ranging from 1150- to 2550-ft/sec. Our interpretation of the data resolves this range into two seismic layers labeled V1 and V2 in order of increasing depth and velocity. Given the low velocities of these layers, we interpret both as representing unconsolidated stream deposits. The difference in velocity between the two layers is related to their relative degree of compaction. V2 has a higher velocity than V1 because it is more highly compacted, probably because of the overbearing weight of V1. Line 2 did not detect bedrock because it was a relatively short line length which limited the depth of exploration.

5.1.2 Line 3 – 6, MASW Soundings 9 and 10 (Plate 3)

Lines 3 through 5 were located on access roads that parallel the stream channel, as shown on Plate 1A. Line 6 was situated in open, gravel packed area that ranged from 40 to 60-ft north of a subsurface diversion channel. The profiles for Lines 3-6 indicate velocities (Vp) ranging from 2300- to 7800-ft/sec. Our interpretation of the data resolves this range into two seismic layers designated as V1 and V2 in order of increasing depth and velocity. We interpret V1 as representing unconsolidated materials, e.g. road fill and/or alluvium. Given the high velocity range of V2 (6850- to7800-ft/sec) we interpret it as representing bedrock. The depths to bedrock ranged from 8- to 35-ft bgs.

MASW Soundings 9 and 10 were located north of Seismic Refraction Line 3, as shown on Plate 1A. The MASW soundings were acquired for the purpose of assessing possible near surface high velocity layers and providing depth to bedrock information further north of the stream channel. The 1D MASW Velocity Models (9 and 10) shown at the top of Plate 3 indicate a near surface high velocity layer (Vs=1500- to 2000-ft/sec) that is 8- to 16-ft thick. We interpret this high velocity layer as representing compacted (by very heavy vehicle loads) road fill. The materials underlying the compacted fill have lower velocities (Vs=500- to1000-fps) and thus constitute a velocity inversion. This velocity inversion, which is typically about 8- to 9-ft thick, is characteristic of alluvium. It is underlain, at depths of 17- to 26-ft bgs by velocities (Vs) of about 1800-ft/sec. We interpret these velocities as being indicative of consolidated bedrock. The bedrock depth indicated by the MASW-9 model (about 17-ft) is more shallow than the depth indicated by the Line 3 profile (23-ft) at its point of closest approach. Conversely, the bedrock depth indicated by the MASW-10 model (26-ft) is significantly greater than the 5- to 10-ft depth indicated by the Line 3 and Line 4 profiles at their points of closest approach to MASW-10. These factors highlight the erratic nature of the bedrock surface and can be, in part, attributed to the fact that MASW-9 and MASW-10 are 25-ft north of Lines 3 and 4.

Additionally, the MASW soundings were undertaken to provide a constraint on the seismic refraction results in the general area (Seismic Refraction Lines 3 and 4) as the MASW techniques can accommodate shallow velocity inversions in processing. The MASW bedrock depths (17- to 26-ft bgs) derived from MASW analysis thus formed an approximate magnitude range of values. Our seismic refraction results indicated that bedrock depths ranged from 5- to 35-ft bgs which is in the same order of magnitude as the MASW estimate of depths to bedrock in the general area.

5.1.3 Lines 7, 8 and 11(Plate 4)

Lines 7, 8 and 11 trend northward, away from the stream channel, as shown on Plate 1A. Lines 7 and 8 cross an uphill section of accumulated mine waste and packed surficial gravel. The local topography was highly variable and steep. Line 11 crosses a gently sloping, open, gravel packed area from the edge of a metal culvert up to point 50-ft distant from the rock discharge pile (Rock Pile). The profiles for Lines 7, 8 and 11indicate velocities ranging from 1850- to 5700-ft/sec. Our interpretation of the data resolves this range into two seismic layers designated as V1 and V2, in order of increasing depth and velocity. Because of its relatively low velocity and highly variable thickness, we interpret V1 as representing mine wastes and/or alluvium. We interpret V2 as representing bedrock. Beneath Lines 7 and 8, the depth to rock ranges from less than 10- to over 50-ft. The Time-Distance plot for Line 11 indicated a relatively high velocity V1 layer associated with the road bed. No characteristic higher V2 bedrock velocity layer was detected. Therefore, no modeling results are presented for this line.

5.2 AREA 4

5.2.1 Lines 12, 13, 14 and 15 (Plate 5)

Lines 12, 13 and 14 were situated within a relative wide section of the stream channel, as shown on Plate 1B. Line 15 was located along a man-made bench that parallels the stream channel, about 20-ft upslope from the channel. The profiles for the four lines indicate velocities (Vp) ranging from about 900- to 3550-ft/sec. Our interpretation of the refraction data resolves this velocity range into three layers labeled V1 through V3 in order of increasing depth and velocity. We interpret the V1 and V2 layers as representing unconsolidated stream deposits and V3 as representing weathered bedrock. The depth to rock (V2/V3 interface) ranges from 7- to 23-ft bgs.

The relatively low velocity of V3 (2800- to 3450-ft/sec) suggests that it comprises a very weak rock like a meta-shale. The profile for Line 15 indicates that bedrock deepens to the east (downstream), reaching a maximum depth of 36-ft-bgs at the east end of the line. This puts it at an elevation of 1190-1192-ft MSL, which corresponds to the bedrock elevations at the west end of Line 12 and the east end of Line 13.

5.2.2. Lines 16 and 17 (Plate 6)

Lines 16 and 17 were situated on top of a gravel packed, level parking area, as shown on Plate 1B. The profiles for both lines indicate velocities (Vp) ranging from 1150- to 6200-ft/sec. Our interpretation of the Line 16 and Line 17 data resolves this range into two seismic layers labeled V1 and V2 in order of increasing depth and velocity. We interpret V1 as representing fill and alluvium and V2 as representing bedrock. The depth to rock ranges from17- to 23-ft bgs.

5.2.3 Lines 18, 19, 20 and 21 (Plate 7)

Lines 18 through 20 were located within the active stream channel, as shown on Plate 1B. However, there was no water in the channel at the time the survey was conducted. Line 21 extended north and upslope from the west end of Line 19. The profiles for these lines indicate velocities (Vp) ranging from 1100- to 4150-ft/sec. Our interpretation of the data resolves this range into three layers labeled V1 through V3 in order of increasing depth and velocity. V2 is absent beneath Line 18 and V3 is absent beneath Line 19. We interpret the combined V1 and V2 layers, with velocities ranging from 1050- to 2650-ft/sec, as representing unconsolidated stream and slope deposits. However, below Lines 19 and 20, the V2 layer could represent decomposed bedrock or dense gravel deposits. In addition, our field observations indicate that, beneath Line 21, V2 could represent mining waste that contains a high percentage of boulder size fill. We interpret theV3 layer as representing bedrock with velocities, where defined, ranging from 3400- to 4150-ft/sec. The depth to rock ranges from about 8- to 32-ft.

5.2.4 Lines 22, 23 and 24 (Plate 8)

Line 22 and Line 23 were located on an access road, as shown on Plate 1B. This road leads to Pond 4 (not shown). Line 24 extended southeast and down slope, from the access road towards the stream channel. The profiles for the three lines indicate velocities (Vp) ranging from 1200- to 6700-ft/sec. Our interpretation of the data resolves the velocity range into two layers labeled V1 and V2 in order of increasing depth and velocity. We interpret V1 as representing unconsolidated stream deposits. We interpret V2 as representing bedrock. Beneath Lines 22 and 23, the computed depths to bedrock ranged from 18- to 30-ft bgs. Beneath Line 24, the depths to bedrock decrease in the down slope direction; ranging from 18-ft bgs near the access road to only 8-ft bgs at the southeast edge of the profile.

6.0 STANDARD CARE

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate having the opportunity to provide you with this information.

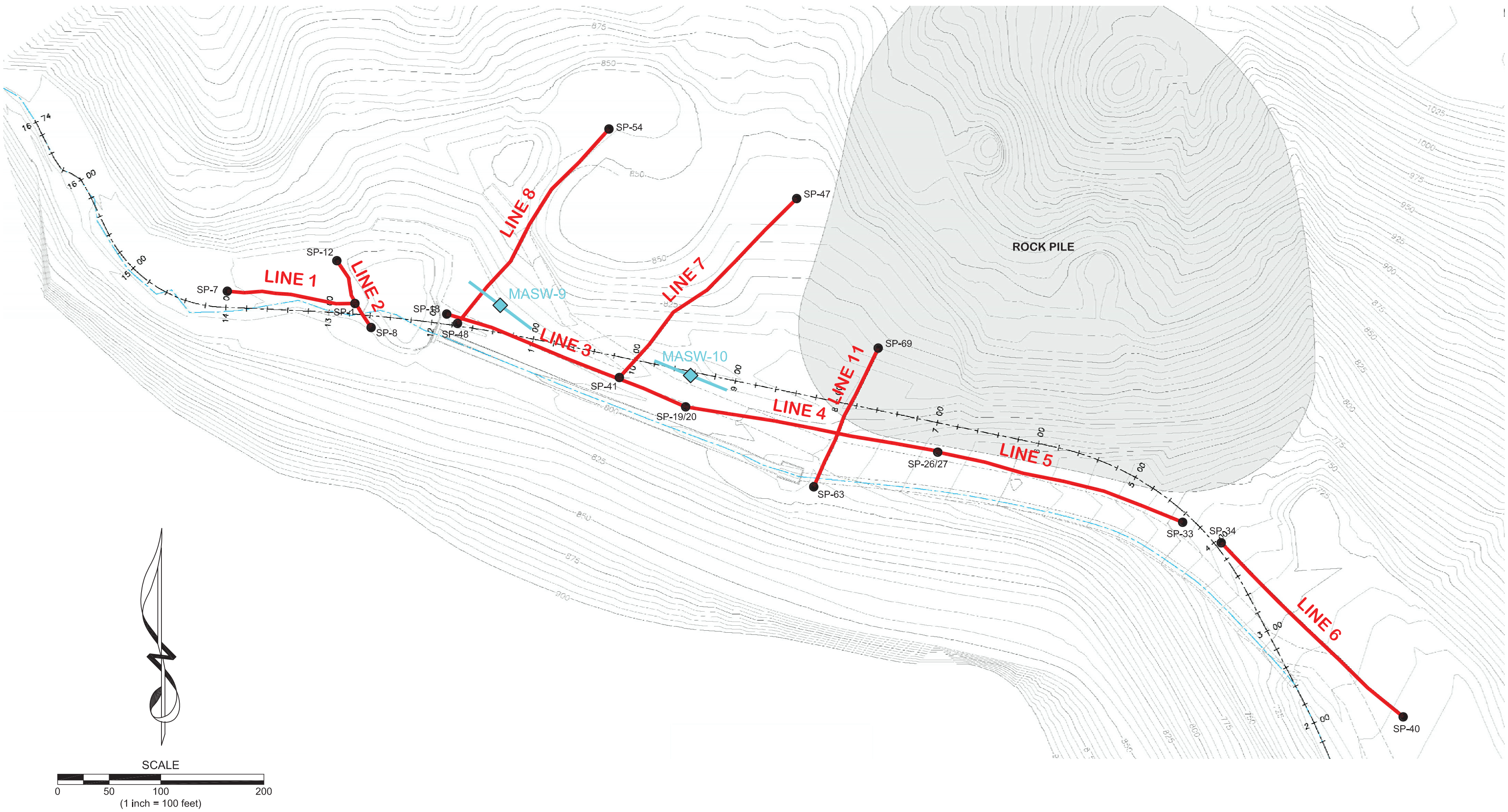
Respectfully,

NORCAL Geophysical Consultants, Inc.

William J Henrich
Professional Geophysicist PGp 893

WEB/tlt

Enclosures: Plates 1A, 1B and 2 through 8
Appendix A - Seismic Refraction (SR)
Appendix B – Multi-channel Analysis of Surface Waves (MASW)



LEGEND

(red line)	SEISMIC REFRACTION LINE
● SP-1	SHOT POINT LOCATION
(blue line with diamond)	CENTER POINT OF MASW LINE

NOTE: BASE MAP PROVIDED BY WATERWAYS CONSULTING, INC.

NORCAL

SITE LOCATION MAP
PERMANENTE QUARRY AREA 11
SEISMIC REFRACTION SURVEY

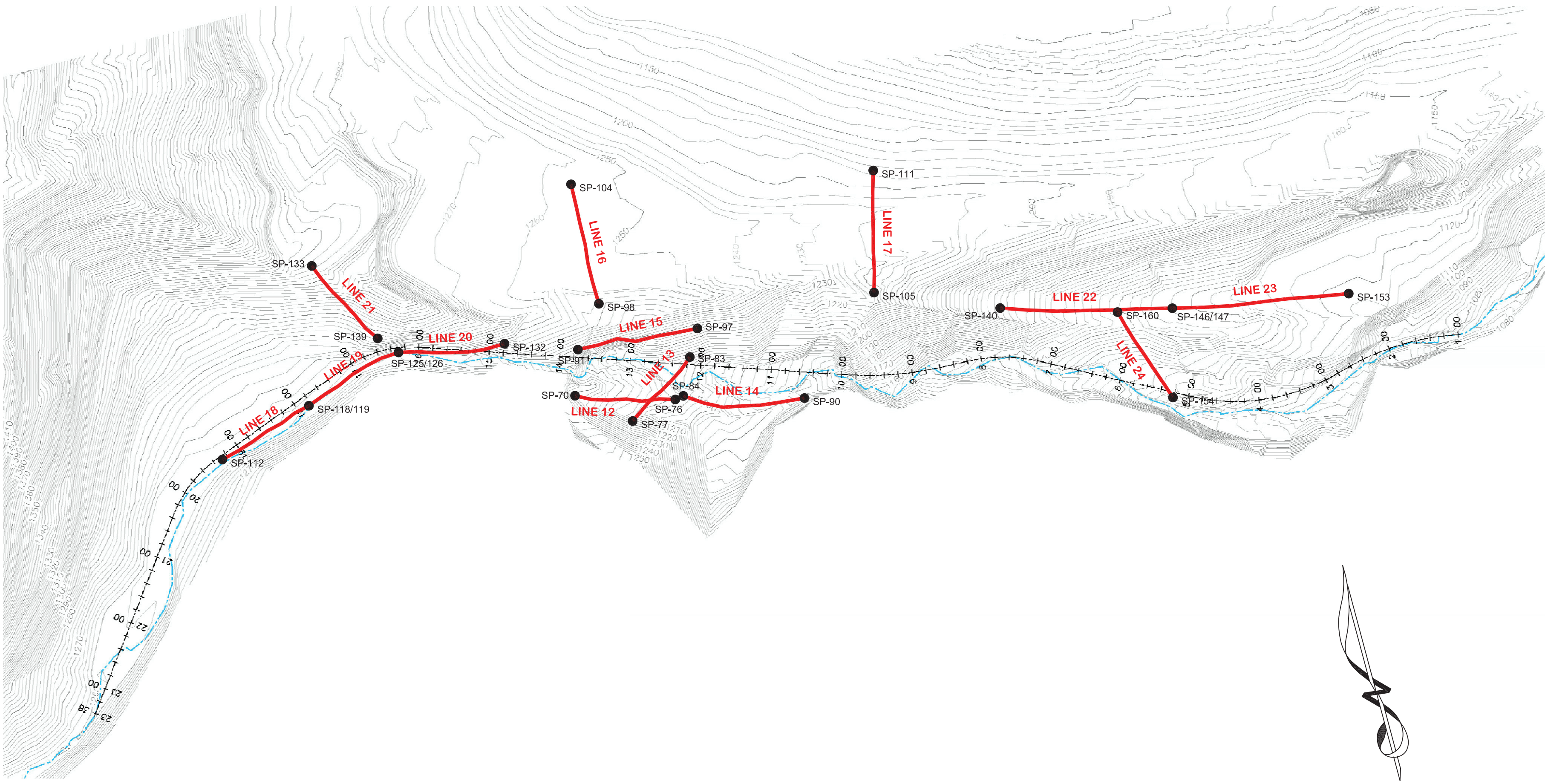
LOCATION: CUPERTINO, CALIFORNIA

CLIENT: GOLDER ASSOCIATES, INC.

JOB #: 14-245.15B | NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: MAY 2014 | DRAWN BY: G.RANDALL | APPROVED BY: WJH

PLATE 1A



SCALE

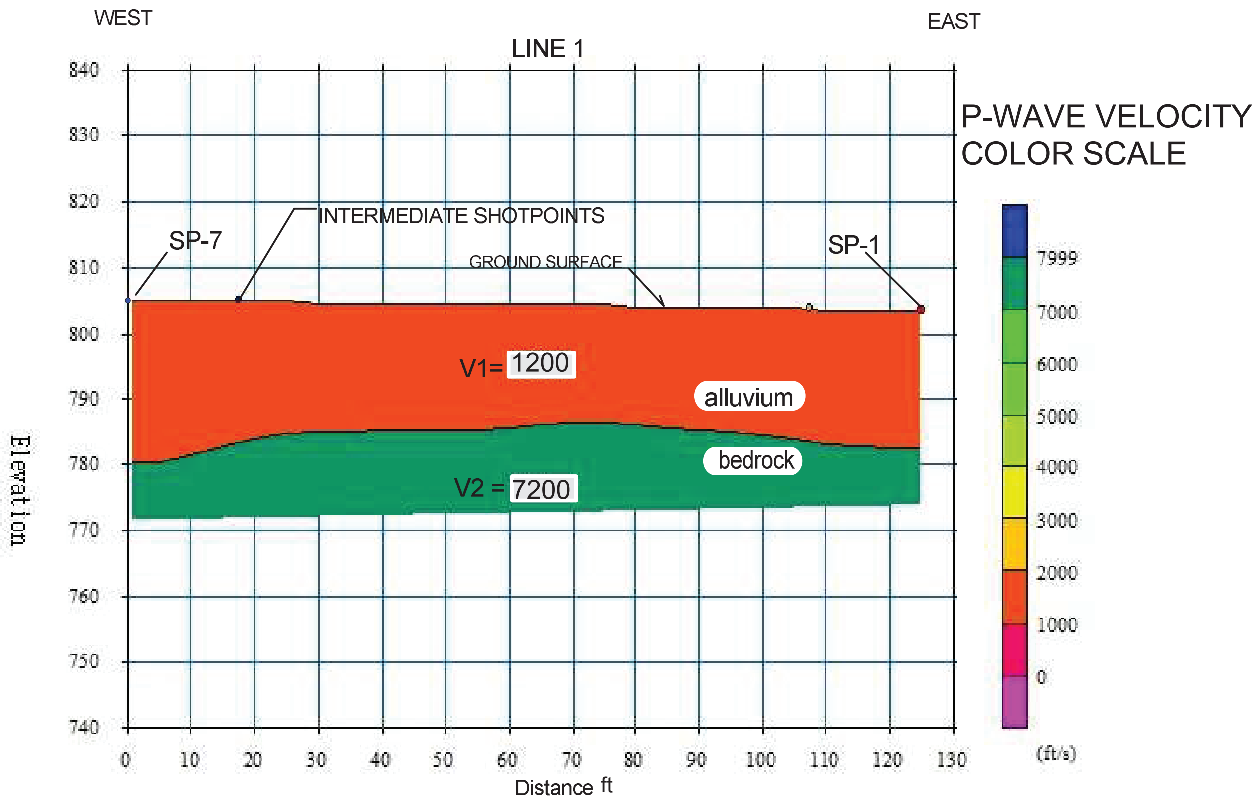
0 150 300

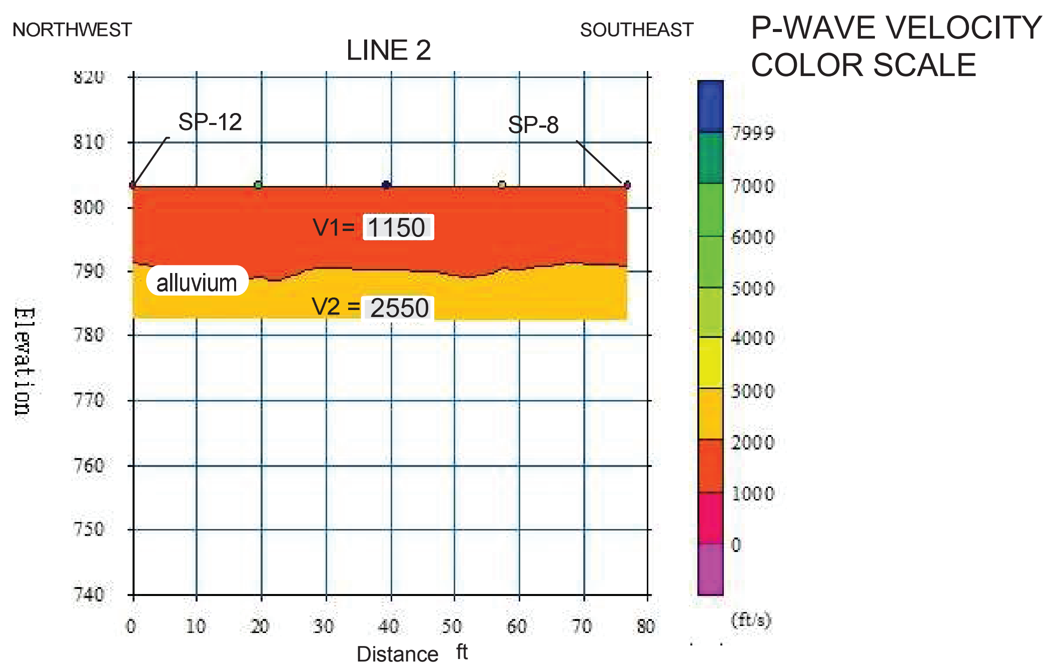
(1 inch = 150 feet)

LEGEND	
(red line)	SEISMIC REFRACTION LINE
● SP-1	SHOT POINT LOCATION

NOTE: BASE MAP PROVIDED BY WATERWAYS CONSULTING, INC.

NORCAL	SITE LOCATION MAP PERMANENTE QUARRY AREA 4 SEISMIC REFRACTION SURVEY		
	LOCATION: CUPERTINO, CALIFORNIA		
	CLIENT: GOLDER ASSOCIATES, INC.		PLATE
JOB #: 14-245.15B	NORCAL GEOPHYSICAL CONSULTANTS INC.		1B
DATE: MAY 2014	DRAWN BY: G.RANDALL	APPROVED BY: WJH	





EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

Horizontal/Vertical Scale 1' = 30 feet

NORCAL

SEISMIC REFRACTION PROFILES LINES 1 AND 2

LOCATION: PERMANENTE QUARRY, CUPERTINO, CA

CLIENT: GOLDER ASSOCIATES, INC.

JOB #: 14-245.15B

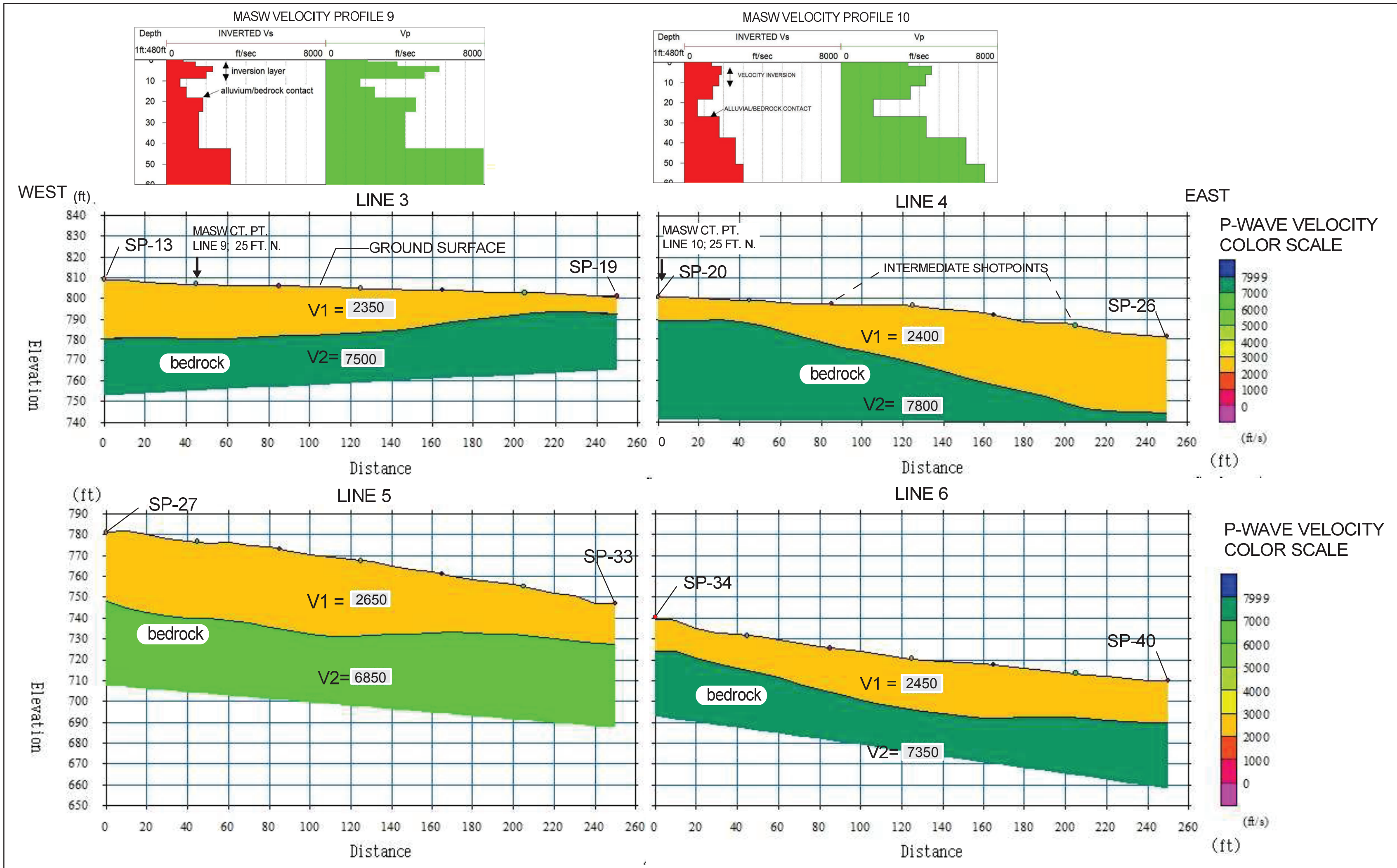
NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: APRIL, 2014

DRAWN BY: W HENRICH

APPROVED BY: WJH

PLATE 2

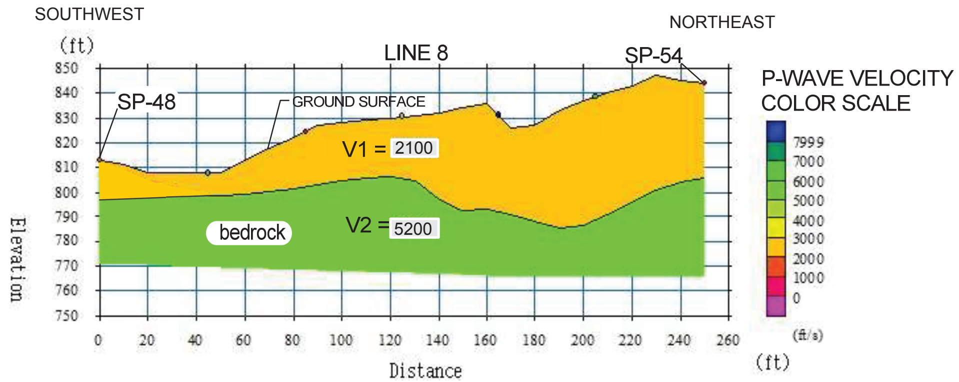


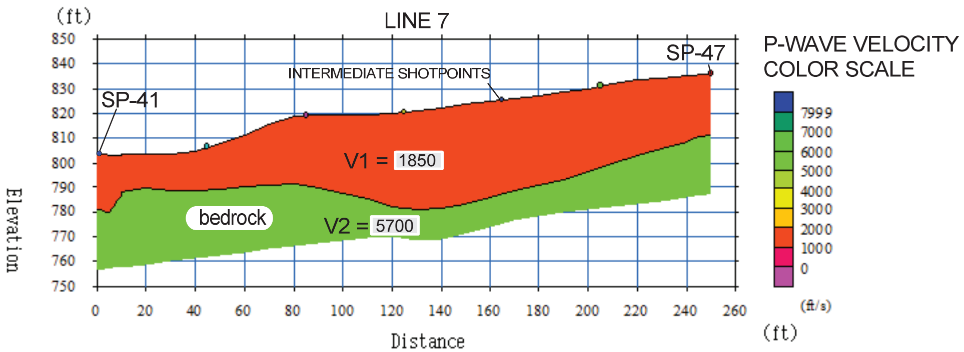
EXPLANATION

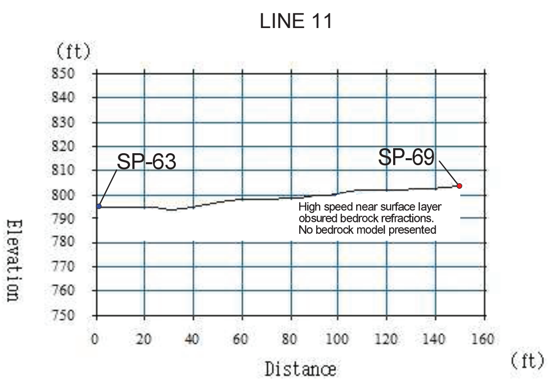
V2 = 7200 Velocity Layer in ft/sec

HORIZONTAL/VERTICAL SCALE: 1" APPROX. EQUALS 50 FEET

NORCAL	SEISIMC REFRACTION PROFILES LINES 3, 4, 5 AND 6; MASW PROFILES 9 AND 10	
	LOCATION: PERMANENTE QUARRY, CUPERTINO, CA	
	CLIENT: GOLDER ASSOCIATES, INC	PLATE 3
JOB #: 14-245.15B	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: APRIL, 2014	DRAWN BY: W. HENRICH / APPROVED BY: WJH	







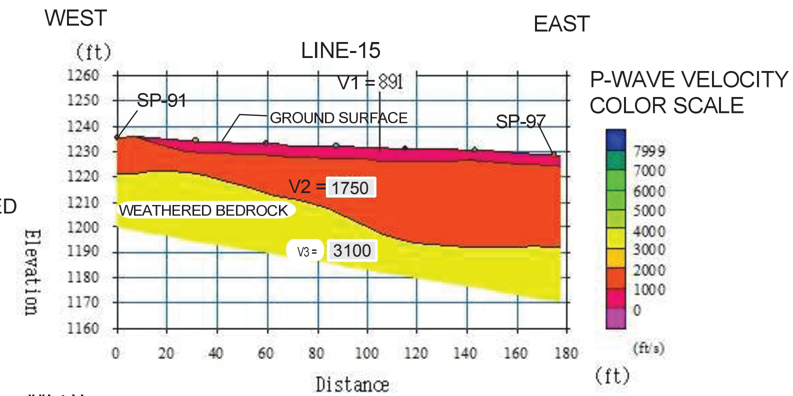
EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

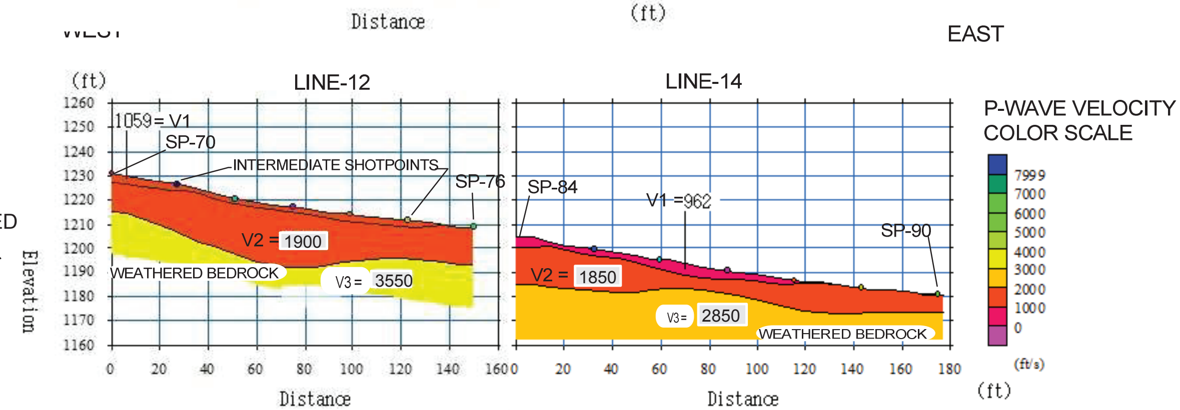
HORIZONTAL/VERTICAL SCALE: ONE INCH APPROX. EQUAL 50 FEET

NORCAL	SEISIMC REFRACTION PROFILES LINES 7, 8, AND 11		
	LOCATION: PERMANENTE QUARRY, CUPERTINO, CA		
	CLIENT: GOLDER ASSOCIATES, INC		PLATE 4
JOB #: 14-245.15B	NORCAL GEOPHYSICAL CONSULTANTS INC.		
DATE: APRIL, 2014	DRAWN BY: W. HENRICH	APPROVED BY: WJH	

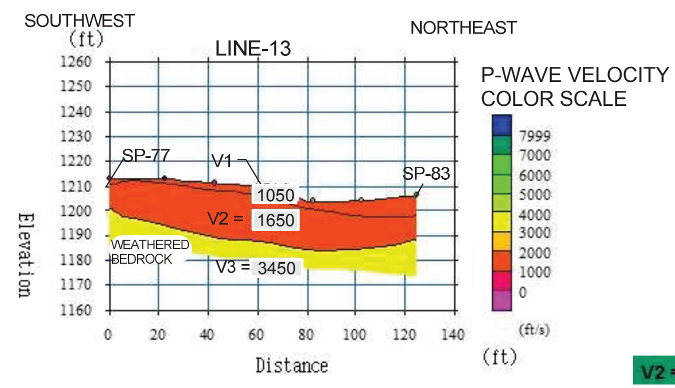
UPSLOPE
OF STREAM BED



ALONG
STREAMBED
DOWN STREAM



CROSS LINE
INTERSECTS
LINE 12



EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

HORIZONTAL/VERTICAL SCALE: ONE INCH APPROX. EQUAL TO 50 FEET

NORCAL

SEISIMC REFRACTION PROFILES
LINES 12, 13, 14, AND 15

LOCATION: PERMANENTE QUARRY, CUPERTINO, CA

CLIENT: GOLDER ASSOCIATES, INC

NORCAL GEOPHYSICAL CONSULTANTS INC.

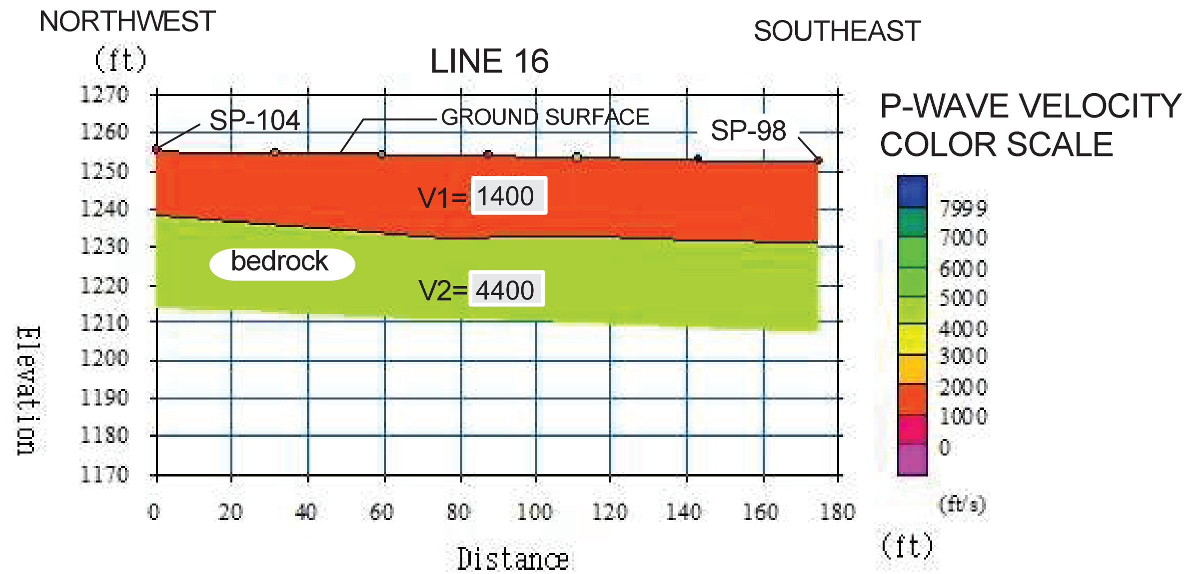
JOB #: 14-245.15B

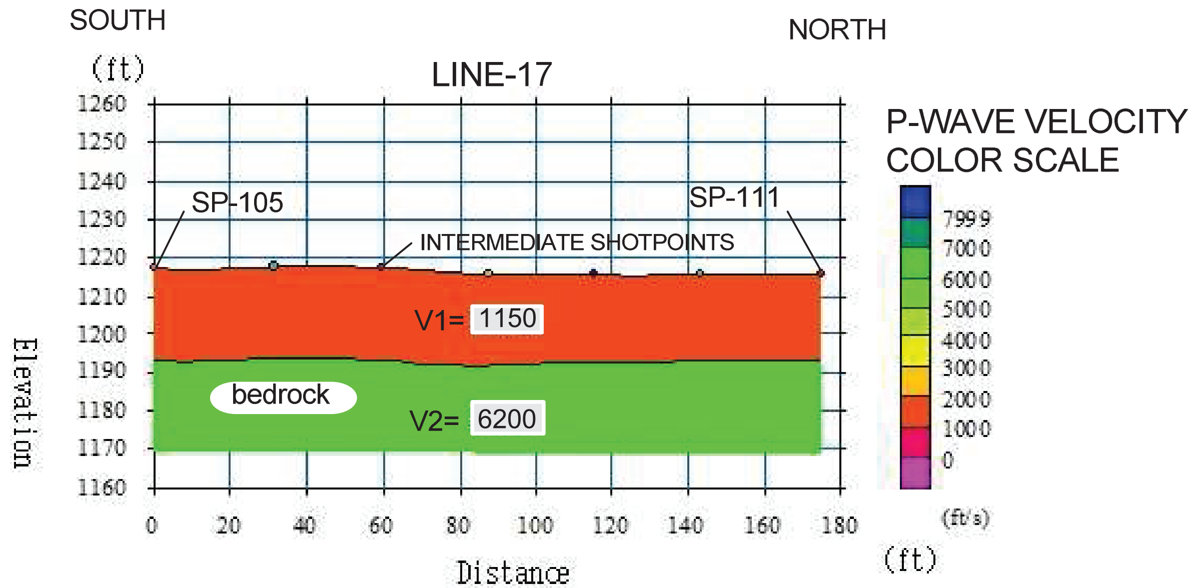
DATE: APRIL, 2014

DRAWN BY: W. HENRICH

APPROVED BY: WJH

PLATE
5





EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

HORIZONTAL/VERTICAL SCALE: ONE INCH APPROX. EQUAL TO 50 FEET

NORCAL

SEISMIC REFRACTION
PROFILES LINES 16 AND 17

LOCATION: PERMANENTE QUARRY, CUPERTINO, CA

CLIENT: GOLDER ASSOCIATES, INC.

NORCAL GEOPHYSICAL CONSULTANTS INC.

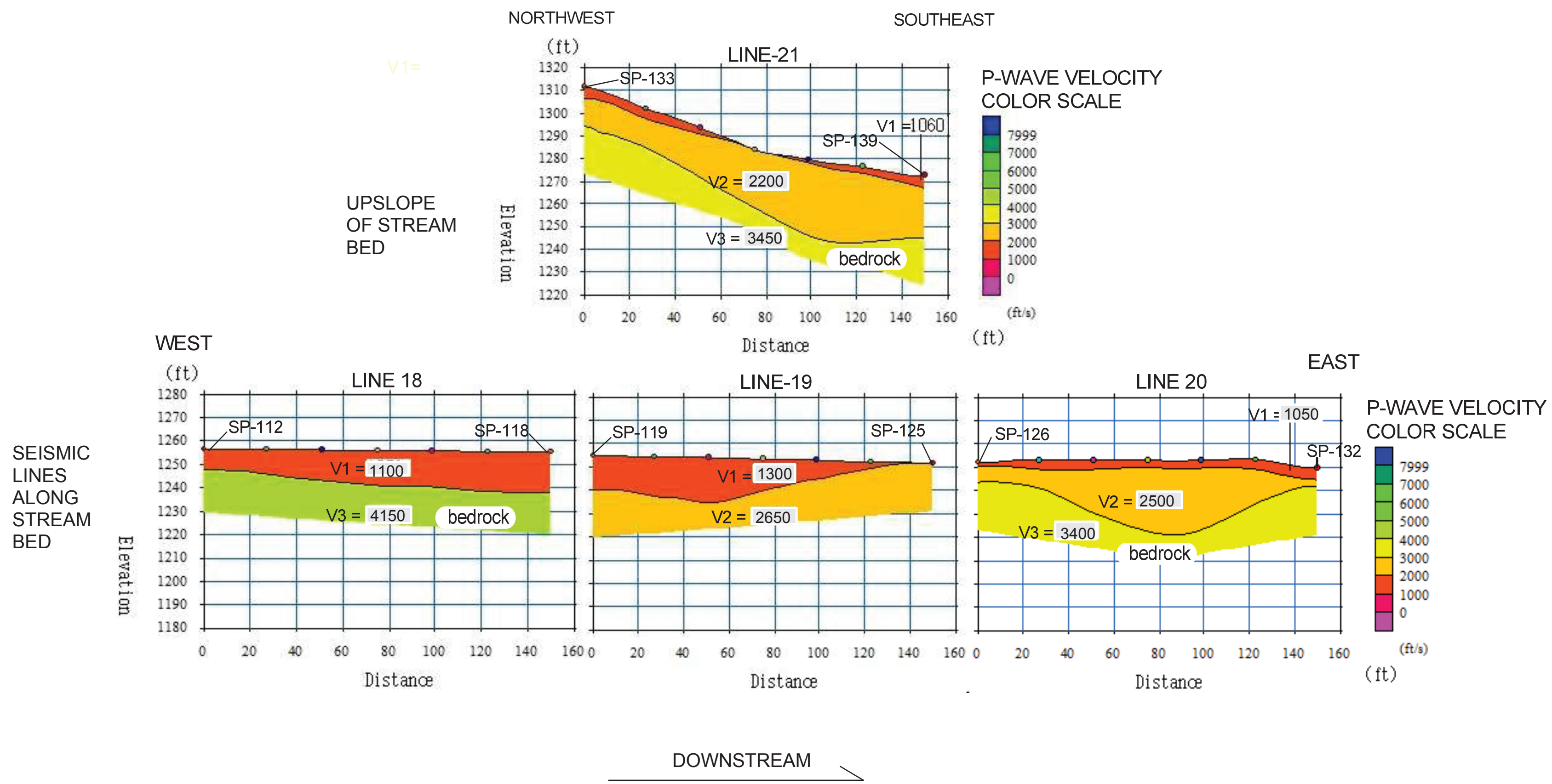
JOB #: 14-245.15B

DATE: APRIL, 2014

DRAWN BY: W HENRICH

APPROVED BY: WJH

PLATE 6

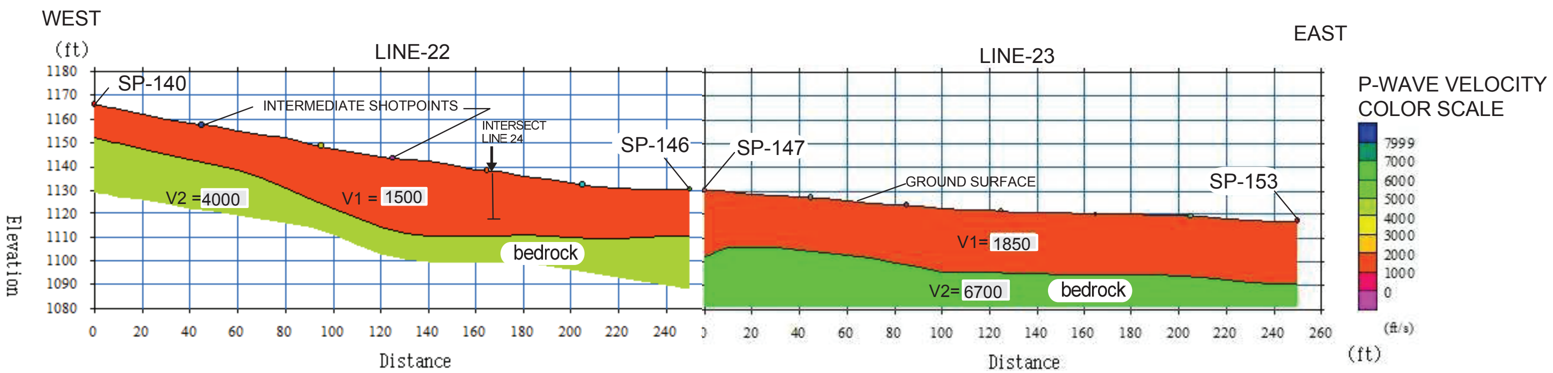


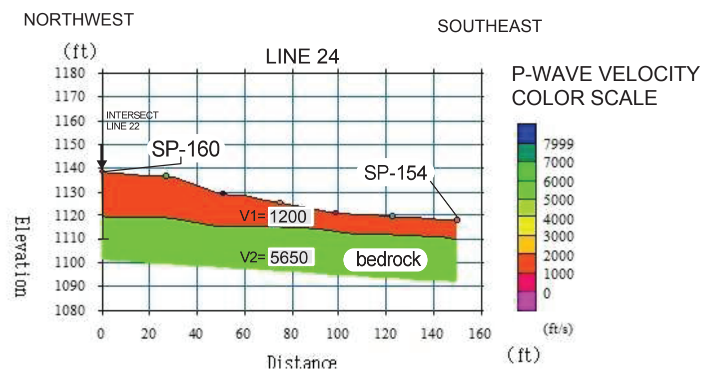
EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

HORIZONTAL/VERTICAL SCALE: ONE INCH APPROX. EQUAL 50 FEET

NORCAL	SEISIMC REFRACTION PROFILES LINES 18, 19, 20 AND 21	
	LOCATION: PERMANENTE QUARRY, CUPERTINO, CA	
	CLIENT: GOLDER ASSOCIATES, INC	PLATE 7
JOB #: 14-245.15B	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: APRIL, 2014	DRAWN BY: W. HENRICH / APPROVED BY: WJH	





EXPLANATION

V2 = 7200 Velocity Layer in ft/sec

NORCAL

SEISIMC REFRACTION PROFILES
LINES-22, -23 and -24

LOCATION: PERMANENTE QUARRY, CUPERTINO, CA

CLIENT: GOLDER ASSOCIATES, INC

JOB #: 14-245.15B

NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: APRIL, 2014

DRAWN BY: W. HENRICH

APPROVED BY: WJH

PLATE
8

Appendix A

SEISMIC REFRACTION (SR)

SEISMIC REFRACTION (SR)

1.0 METHODOLOGY

The seismic refraction method provides information regarding the seismic velocity structure of the subsurface. An impulsive (mechanical or explosive) source is used to produce compressional (P) wave seismic energy. The P-waves propagate into the earth and are refracted along interfaces caused by an increase in velocity. A portion of the P-wave energy is refracted back to the surface where it is detected by sensors (geophones) that are coupled to the ground surface in a collinear array (spread). The detected signals are recorded on a multi-channel seismograph and are analyzed to determine the shot point-to-geophone travel times. These data can be used along with the corresponding shot point-to-geophone distances to determine the depth, thickness, and velocity of subsurface seismic layers.

The seismic refraction technique is based on several assumptions. Paramount among these are that seismic velocity:

1) Increases with depth, and,
2) Is uniform within each layer over the length of the given spread.

In cases where these assumptions do not hold, the accuracy of the technique decreases. For example, if a low velocity layer occurs between two layers of higher velocity, the low velocity layer will not be detected and the depth to the underlying high velocity layer will be erroneously large. Also, if the velocity of a seismic layer varies laterally within a spread, those variations will be interpreted as fluctuations in the elevation of the underlying seismic layer.

2.0 DATA ACQUISITION/INSTRUMENTATION

Each SR line consisted of 24-geophones and 7-shot points distributed in a collinear array (spread). In most areas, the geophones were coupled to the ground surface by metal spike affixed to the bottom of each geophone case. In areas where the ground surface was too hard to penetrate (e.g. the road) the geophones were mounted on weighted pedestals that coupled them to the ground by their weight. The geophone intervals ranged from 3- to 10-ft depending on access. For each spread, the two end shot points were located one-geophone spacing beyond the end geophone at both ends of the spread. The remaining five shot points were evenly spaced along the spread. This distribution of shot points and geophones yielded total draped line lengths (end-geophone to end-geophone) ranging from 77- to 250-ft. The SR survey was designed to target the upper 15 to 50 feet of geologic material beneath each line, generally consisting of native soil, fill (mine waste) alluvium/stream deposits, weathered and un-weathered bedrock.

Data acquisition was initiated along each SR line by producing seismic energy using a mechanical source. Seismic energy was produced by impacting a metal strike plate on the ground surface with a 12-16 pound sledge hammer. The resulting seismic waveforms are recorded using a Geometrics ***Geode*** 24-channel engineering distributed array seismograph and Mark Products geophones with a natural frequency of 8-Hz. The seismic waveforms were digitized, processed and amplified by the Geode and transmitted via a ruggedized Ethernet cable to a field computer. There the data were archived for subsequent processing and displayed on the computers LCD screen in the form of seismograms. These were subsequently used to determine the time required for P-waves to travel from each shot point to each geophone in a given array (spread).

3.0 DATA ANALYSIS

The recorded seismic data were processed using the software package ***SeisImager*** which was written by Oyo Corporation (Japan) and distributed by Geometrics Inc. The first stage of seismic processing included compilation (7 shot points per line) and identification of first arriving P-wave energy. This process was conducted using ***Pickwin, Version 3.2.0.1*** (2004), which is part of the ***SeisImager*** package. A second interactive program ***Plotrefa, Version 2.8.0.1*** (2006) was used to assign geophone travel times, geophone/shot point surface elevations and velocity layer assignments to compute a 2D seismic velocity model based on these inputs. Example Time-Distance graph from a 7 shot point refraction line and inverted seismic layer model are presented in the following figures.

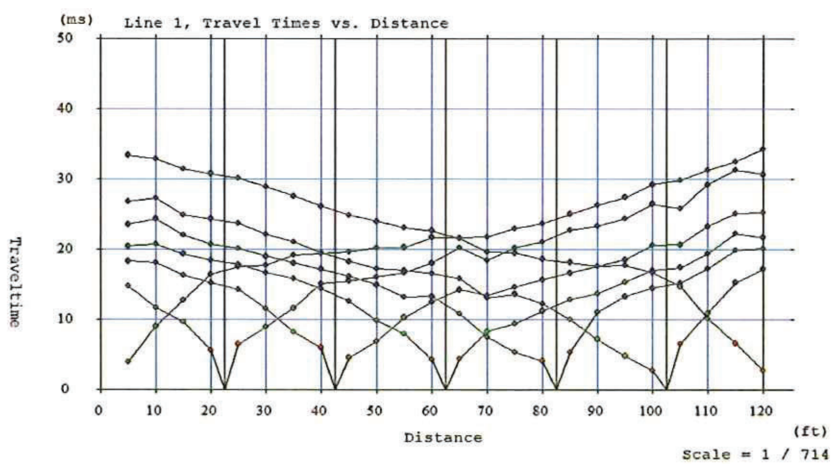


Figure 1 Example SR Time-Distance Graph, 24-geophones; 7 equal spaced shot points

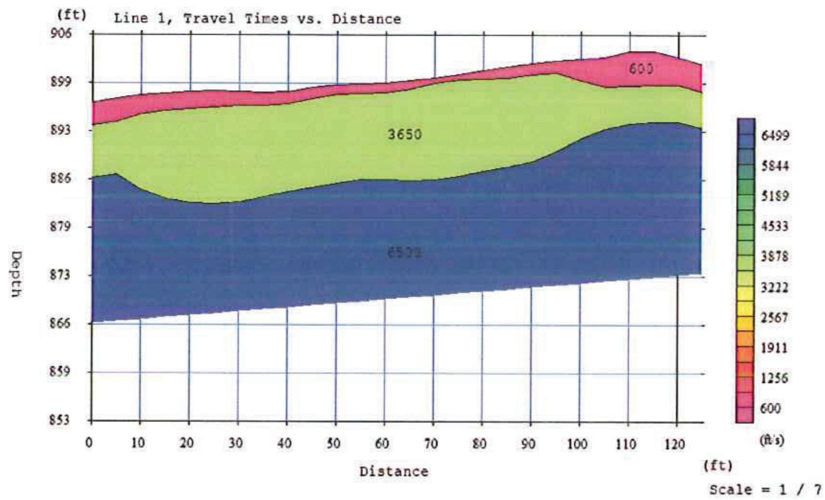


Figure 2 Time-Term Inverted Seismic Velocity Model

For this survey we have chosen an inversion routine that is based on the time-term method. The time-term method employs a combination of linear least squares and delay time analysis to invert the first arrivals into a velocity model. The model can consist of two or three velocity layers depending on the presence of significant line slopes that can be fitted to the first arrival times. Depths to the tops of the velocity layers are calculated below each geophone. For end and interior shot points the depths are extrapolated from the nearest geophone. This inversion as described above produces simplified velocity layers that, though generalized, will provide an adequate, useable characterization of the depth to bedrock.

4.0 LIMITATIONS

In general, there are limitations unique to the SR method. These limitations are primarily based on assumptions that are made by the data analysis routine. First, the data analysis routine assumes that the velocities along the length of each spread are uniform. If there are localized zones within each layer where the velocities are higher or lower than indicated, the analysis routine will interpret these zones as changes in the surface topography of the underlying layer. A zone of higher velocity material would be interpreted as a low in the surface of the underlying layer. Zones of lower velocity material would be interpreted as a high in the underlying layer.

Second, the data analysis routine assumes that the velocity of subsurface materials increase with depth. Therefore, if a layer exhibits velocities that are slower than those of the material above it, the slower layer will not be resolved. Also, a velocity layer may simply be too thin to be detected. Due to these and other limitations inherent to the SR method, the results of the SR survey should be considered only as approximations of the subsurface conditions. The actual conditions may vary locally. Other independent data (e.g., surface and borehole geology) should be integrated with SR data to enhance the subsurface interpretation.

NORCAL

Appendix B

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

1.0 METHODOLOGY

When seismic energy is generated at or near the ground surface, seismic waves are produced. Those that travel along the ground surface are referred to as ground roll or surface waves. Those that propagate into the earth are referred to as body waves. When a vertical impact seismic energy source is used, the resulting surface waves account for more than two-thirds of the energy that is produced. As a result, surface waves are the most prominent signal on multi-channel seismic records. In addition, surface waves have dispersion properties that body waves lack. That is, different wavelengths have different penetration depths and, therefore, propagate at different velocities. This is referred to as dispersion. Since surface waves travel at 0.9 times the velocity of S-waves, it is possible to determine subsurface Vs by analyzing the dispersion of surface waves. Furthermore, since S-wave velocities are directly proportional to shear modulus, this provides a direct indication in the variation of stiffness (or rigidity) of subsurface materials.

Computer software and processing techniques developed by researchers at the University of Kansas have made it possible to analyze surface waves using a large number of shot points and geophones. This is referred to as multi-channel analysis of surface waves (MASW). Surface wave data are gathered in much the same way as high resolution seismic reflection data. Seismic energy generated by vertical impacts on the ground surface is detected by an array of closely spaced geophones (spread). The energy source and the geophones are sequentially moved along a profile as the survey progresses.

The data gathered from each shot point are analyzed to determine the variation in surface wave velocity versus frequency (dispersion curve). Computer software then inverts the dispersion curve to determine the variation in Vs versus depth. The data gathered from multiple shot points and geophone locations can be collated to produce a two dimensional (2D) cross-section showing the variation in Vs with depth and distance beneath a line.

2.0 DATA ACQUISITION/INSTRUMENTATION

Soundings MASW-9 and -10 each comprised an array of 24-geophones distributed at 3-ft intervals in a collinear array (spread). Seismic energy was produced at four shot points on each spread through multiple impacts with a 12-pound sledge hammer against a metal strike plate placed on the ground surface. The shot points were positioned at distances of 3- and 12-ft beyond the end geophones at both ends of each spread. The resulting seismic waveforms were recorded using a Geometrics ***Geode*** 24-channel distributed array seismograph and Oyo ***Geospace*** geophones with a natural frequency of 8-Hz. The seismograph was networked to a field computer where the data were displayed on a LCD screen for QA/QC review and archived for subsequent processing.

3.0 DATA ANALYSIS

The MASW data were processed using the software package ***SurfSeis 2.05*** which was developed by the Kansas Geological Survey. Using this software, the data acquired from each shot point were processed to develop an overtone display. This is a color contoured plot that depicts phase velocity as a function of frequency and signal amplitude. The overtone display serves as a guide in nominating the dispersion curve that is used by the inversion routine. However, prior to nominating the dispersion curve, the four overtones were merged into one in order to increase the signal to noise ratio and maximize the continuity of the display. The merged and enhanced overtone was then used as a guide in nominating the dispersion curve used in the inversion process. At the onset of the inversion routine the software created a 1D model comprising 10-layers. Starting values of depth, thickness, Vp, Vs and Poisson's ratio (α) were assigned to each layer. The program then proceeded to refine the starting model through an iterative procedure in order to develop a 1D model that provided the best fit to the dispersion curve. In so doing, it was necessary that either Vp or α remain fixed during the inversion process. In this case, we opted to have α remain fixed, at a value of 0.4, so that the final model would provide the best indication of both Vp and Vs as a function of depth. The value of 0.4 was used for α because it is typical of most near surface earth materials.

G5. Regional Hydraulic Geometry and Analogue Channel Assessment (Waterways Consulting, Inc., October 30, 2018)

TECHNICAL MEMORANDUM - REVISED for 90% DESIGN

Prepared by: Waterways Consulting, Inc.

Date: October 30, 2018

Re: Permanente Creek Restoration – Regional Hydraulic Geometry and Analogue Channel Assessment

Introduction

Waterways Consulting, Inc. (Waterways) is developing engineering drawings to restore portions of Permanente Creek that flow through the Permanente Quarry (Quarry) property and have been impacted by past mining activities. The proposed approach at two locations (the Rock Pile Area and Material Removal Area[1]) focuses on restoring the channel form to an approximation of the pre-mining channel geometry and providing suitable aquatic habitat for local species, including resident rainbow trout. The Quarry is situated on lands owned by Lehigh Hanson Heidelberg Cement Group on the east side of the Santa Cruz Mountains to the west of Cupertino. Quarry operations over the past century have resulted in significant channelization, the installation of numerous culverts and sedimentation basins, and considerable sediment inputs to Permanente Creek. The altered channel form and high sediment loads resulted in the degradation of the instream aquatic habitat.

The proposed restoration will remove overburden sediment and several culverts, rebuild the affected channel reaches, and restore impacted riparian and aquatic habitats. Restoring Permanente Creek at the Rock Pile and Material Removal Areas requires a complete reconstruction of the streambed. Consequently, there is a need to estimate the appropriate channel morphology to support the restoration design, including active channel widths, depths and pool geometries and spacing.

Regional curves, relating channel dimensions to drainage area, exist for the San Francisco Bay region (Dunne and Leopold 1978) (Figure 1). However, these curves are regional in nature, incorporating data from a range of landscape settings and channel morphologies. For example, channel geometries of the low gradient bottomlands of the Santa Clara Valley will vary from bedrock-controlled streams in the Santa Cruz Mountains that are higher gradient and more influenced by hillslope processes. Given that much of the proposed restoration activities are in higher gradient, confined reaches of Permanente Creek, the appropriateness of the regional curves can be improved by focusing the data on sites with a similar geomorphic setting. Focusing the dataset on sites in the Santa Cruz Mountains could greatly improve the use of the hydraulic geometry curves to constrain expected channel morphologies in the impacted reaches of Permanente Creek. Furthermore, field-based measurements of channel geometry within less impacted reaches of Permanente Creek and in adjacent watersheds that exhibit similar characteristics to Permanente Creek could both provide a test for and improve the quality of the developed relationships.

[1] Although the analogue study was developed to support design efforts for the Rockpile and Material Removal Areas of the Permanente Restoration Project, the results are applicable to other locations within the project area including Culverts #7 and #8 within the Channel Widening Area.

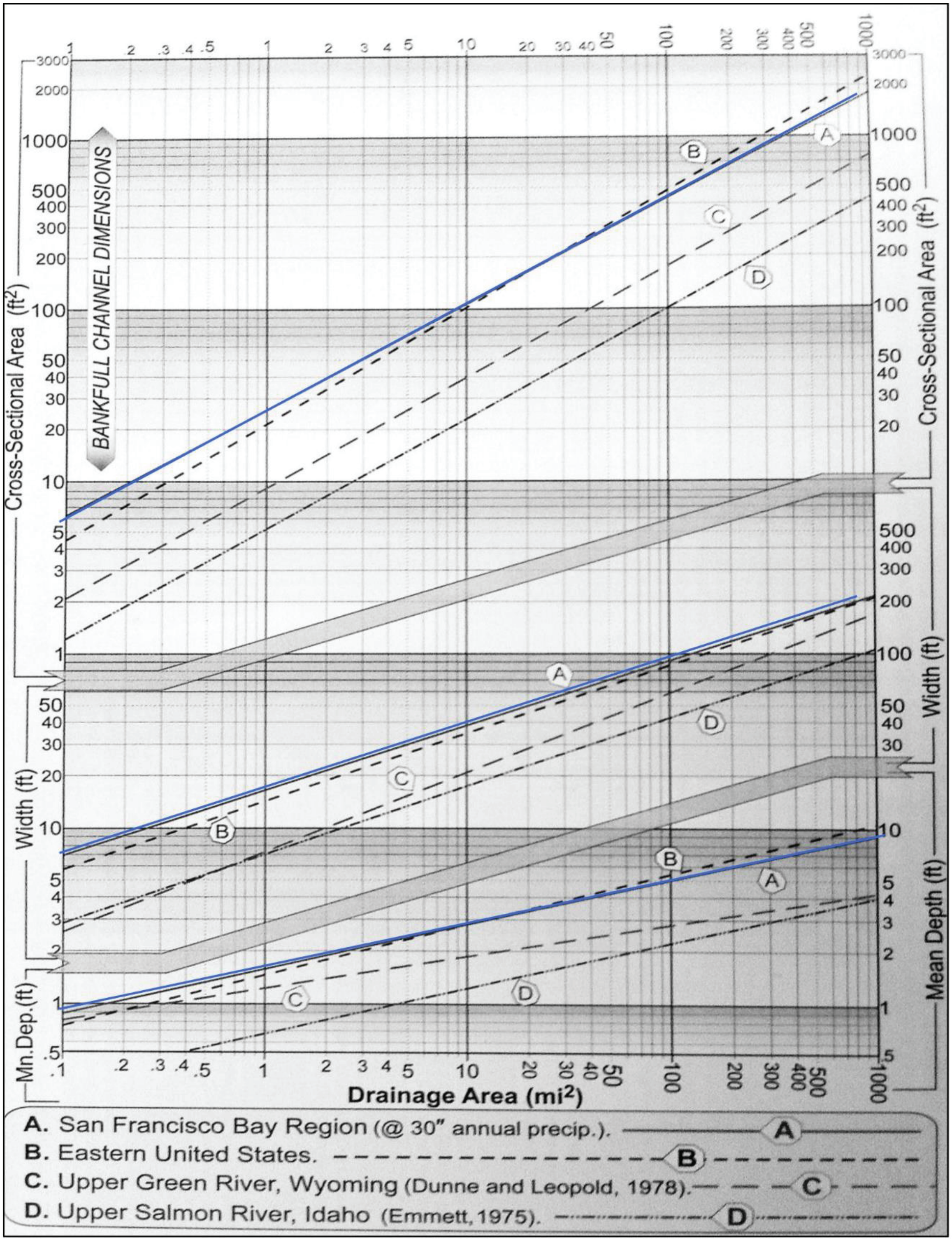


Figure 1. Regional hydraulic geometry curves produced by Dunne and Leopold (1978) relating drainage area to bankfull depth, width and cross-sectional area. The blue lines highlight the regional curves for the San Francisco Bay Area.

To create more site-specific curves, Waterways compiled data for the Santa Cruz Mountain sites that were included in the Dunne and Leopold (1978) curves for the San Francisco Bay region, surveyed two analogue stream channels close to the project area that were previously identified as having similar watershed and geomorphic characteristics as Permanente Creek (URS 2011)[2], and surveyed two segments of Reach 20 on Permanente Creek in what was considered a less impacted reach. These data were used to define reach-specific channel dimensions for the restoration effort. In addition, a longitudinal profile surveyed along portions of Permanente Creek where the channel morphology was determined to be more representative of natural conditions, was used to identify an appropriate size and spacing for pools to support the engineering design. This memorandum summarizes the findings of this work.

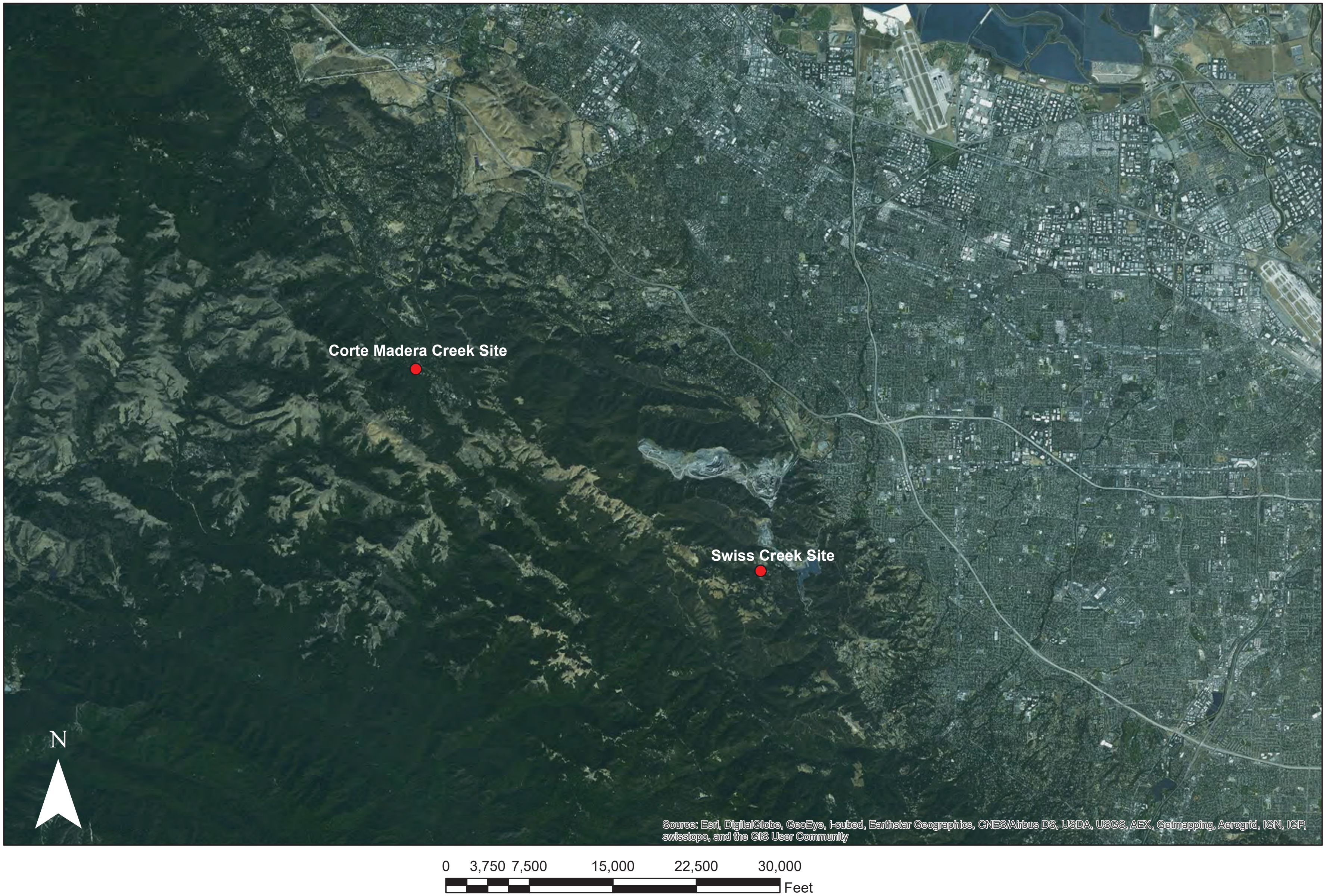
Study Area

Santa Cruz Mountains

The Santa Cruz Mountains have a complex geologic history, resulting in areas dominated by sandstone, limestone, igneous rocks (e.g., basalt), or metamorphic rocks (e.g., serpentine). The variable geologies result in different rates of erosion and the presence of different types of channel-forming sediment among streams that can be spatially close to each other. For example, Permanente Creek has abundant limestone that forms calcium carbonate precipitates that can bind rocks along the channel bed and banks. On the other hand, Stevens Creek is approximately one and one-half miles southeast of Permanente Creek and does not have limestone, and thus does not exhibit calcium carbonate precipitates.

Santa Cruz Mountain streams tend to be small headwater channels at the higher elevations and larger, alluvial streams at the lower elevations. The higher and mid-elevation streams generally flow through narrow valleys with steep hillslopes that restrict lateral channel movement. The steep hillslopes are susceptible to landslides and debris flows, especially following wildfire events. Entire reaches can be transformed during a debris flow and associated mudflow event. Debris flows can result in mobilization and deposition of sediment and debris across an entire valley bottom, leaving an aggraded valley consisting of an unsorted mix of materials. Subsequent high flows following a debris flow event reworks the aggraded material, with the active channel incising into the relatively uniform post-debris flow floodplain surface. Large roughness elements, including boulders and logs, become exposed as the channel incises into the debris flow surface, influencing the planform of the channel and providing local grade control for both the channel and floodplain. In higher gradient reaches, pools and riffles form in response to randomly spaced roughness elements. Along Permanente creek, debris flows prior to mining operations likely provided large wood and boulders that were incorporated into steep step-pool reaches and lower gradient riffle-pool reaches.

[2] The URS Plan was prepared to comply with the July 27, 1999 Cleanup and Abatement Order – 99-018 issued by the San Francisco Bay Regional Water Quality Control Board by preparation of a report that documented a field reconnaissance of Permanente Creek throughout the quarry facility identifying areas requiring stabilization, prioritizing stabilization activities at candidate sites, and preparing an implementation schedule.



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Map identifying the location of the surveyed reference reaches for Permanente Creek.

FIGURE

2

Field Sites

Waterways reviewed the URS Plan and studied published literature on the Santa Cruz Mountains to determine suitable reference reaches for Permanente Creek. We determined that a reach along Swiss Creek and a reach along Corte Madera Creek were the most appropriate reference reaches for Permanente Creek (Figure 2 and Table 1). The URS Plan described Corte Madera Creek and Swiss Creek as similar in drainage area, slope, and valley shape to Permanente Creek. Both creeks are in the Santa Cruz Mountains, relatively close to Cupertino, with precipitation regimes similar to the Permanente Creek watershed. Corte Madera Creek flows west and Swiss Creek flows east through confined, steep stream valleys, constrained on both sides by steep hillslopes prone to mass wasting and debris flow events. Both reference reaches are bedrock-controlled with a step-pool channel pattern formed by large boulders and other recently delivered colluvial deposits. Swiss Creek exhibited calcium carbonate precipitates within the active channel, similar to the calcium carbonate formations identified in Permanente Creek. In addition to the reference reaches in adjacent watersheds, a less impacted reach (Reach 20) within Permanente Creek was chosen to further support development of regional hydraulic geometries in support of the engineering design effort.

Table 1. Basin Characteristics for the Field Sites and Permanente Creek.

	Swiss Creek	Corte Madera Creek	Permanente Creek
Average annual precipitation (in)	33.8	38.6	34.2
Mean basin elevation (ft)	1,842	1,917	1,957
Dominant geology	limestone, sandstone	sandstone, shale	limestone, sandstone
Dominant hillslope process	landslide/debris flow	landslide/debris flow	landslide/debris flow
Average channel slope (%)	10.72	8.39	3.4 - 13.85
Drainage area (sq. miles)	0.8	1.4	2.7

Analysis Approach

To develop the regional hydraulic geometry relationships, information from the USGS streamflow gage database was compiled for streams in the Santa Cruz Mountains. The focus of this data mining effort was the 1.5-year[3] recurrence discharge because it approximates the channel forming, or bankfull, discharge (Dunne and Leopold, 1978). To evaluate the performance of the curve and provide data for smaller watersheds, which was missing from the USGS dataset, we collected field data from the two adjacent watersheds and within Reach 20 of Permanente Creek with a specific focus on measuring channel geometries at bankfull indicators that were identified in the field.

Hydraulic Geometry using existing USGS gage data

Waterways identified 33 USGS stream gages in the Santa Cruz Mountains, but only 14 of the 33 had sufficient peak flow records to be used in the hydraulic geometry analysis (Table 2). Ideally the gage sites would be limited to the eastern Santa Cruz Mountains near Cupertino and Santa Clara. However, since there are a limited number of gages with sufficient data, the 14 gages Waterways assessed are

[3] Previous iterations of this study focused efforts on the 2-year event. Results of that effort identified disparities between the gage-based analysis and the field-based analysis with the field-based analysis consistently under predicted bankfull widths and depths. This suggested that field-based bankfull indicators occurred at a discharge approximating the 1.5-year event rather than the 2-year event. These results, combined with comments from the reviewers prompted us to redo the analysis with a focus on the 1.5-year event rather than the 2-year event.

Table 2. USGS gage sites used to develop regional hydraulic geometry curves.

Site Name	Location	Period of Record	Drainage Area (sq. miles)	1.5-Year Flood Discharge (Bankfull) (cfs)	Estimated Bankfull Width (feet)	Estimated Bankfull Cross Sectional Area (sq. feet)	Estimated Bankfull Depth (feet)
Llagas Cr above Chesbro Reservoir	37.1483, -121.7672	1971-1982, 2004-2010	9.6	390	25.0	132.5	5.3
Aptos Creek near Aptos	37.0020, -121.9050	1972-1983	10.2	185	29.3	68.7	2.3
San Lorenzo River near Boulder Creek	37.2067, -122.1439	1969-1992, 1997	6.2	105	24.7	32.9	1.3
Bear Creek at Boulder Creek	37.1278, -122.1158	1978-1992, 1997	16.0	540	33.8	122.5	3.6
Boulder Creek at Boulder Creek	37.1267, -122.1217	1977-1992, 1997	11.3	680	47.4	305.2	6.4
Zayante Creek at Zayante	37.0861, -122.0458	1958-1992, 1997	11.1	480	28.0	103.0	3.7
San Lorenzo River at Big Trees	37.0444, -122.0714	1937-2017	106.0	3700	87.5	682.0	7.8
Carbonera Creek at Scotts Valley	37.0506, -122.0125	1985-2007	3.6	505	26.5	117.4	4.4
Scott Creek above Little Creek	37.0642, -122.2283	1937-1941, 1959-1973, 1982	25.1	600	43.5	145.0	3.3
Pescadero Creek near Pescadero	37.2608, -122.3278	1952-2017	45.9	1350	53.0	291.5	5.5
San Gregorio Creek at San Gregorio	37.3258, -122.3856	1955, 1970-2017	50.9	1900	61.5	402.5	6.5
Pilarcitos Creek at Half Moon Bay	37.4666, -122.4331	1967-2017	27.8	450	33.0	139.0	4.2
Redwood Creek at Redwood City	37.4494, -122.2325	1960-1997	1.8	170	13.0	41.5	3.2
San Francisquito Creek at Stanford University	37.4233, -122.1883	1931-1941, 1951-2017	37.4	1000	45.5	198.5	4.4
Saratoga Creek at Saratoga	37.2544, -122.0383	1934-2017	9.2	255	25.6	40.2	1.6

located throughout the eastern and western Santa Cruz Mountains. Despite the slightly wider than ideal geographic range, our gage analysis improves upon the current regional analyses by focusing on a smaller area and limiting gage sites to the Santa Cruz Mountains.

Waterways compiled the existing information available at each of the selected gaging sites, including drainage area, discharge, field measurements of channel width and cross-sectional area, and local channel slope near the gage. We imported the discharge data into HEC-SSP (U.S. Army Corps of Engineers 2010) and developed flood frequency curves (USGS, Bulletin 17b, 1982) for each gage site to estimate the 1.5-year recurrence interval discharge. We then reviewed measurements of channel width and cross-sectional area at each gage site to find measurements that were taken during a high flow event that approximated the 1.5-year recurrence interval discharge. Four of the gaging sites did not have channel width and cross-sectional area data recorded during a 1.5-year event, so we extrapolated based on the available data. We then estimated bankfull depth at each gage site by dividing channel cross-sectional area by channel width. Banfull width, bankfull depth, and the 1.5-year flood discharge were plotted separately against drainage area. One outlier was identified and removed from the study.

Analogue Site Assessment

Waterways surveyed a 200-foot reach of Corte Madera Creek, located downstream of the Alpine Road Trail culvert, a 171-foot reach of Swiss Creek, located approximately 500 feet upstream from the Peacock Court bridge, and two segments within Reach 20 of Permanente Creek totaling over 300 feet of channel. We chose reach locations that were beyond the influence of instream structures (e.g., culverts, bridges) and were representative of conditions within the reach. We used an auto-level to survey four channel cross section profiles at Corte Madera Creek, three channel cross section profiles at Swiss Creek, two sets of three channel cross-section profiles at Permanente Creek and a longitudinal profile at all four sites. Each channel cross section profile included the expanse of the valley floor and the identification of significant geomorphic features using field indicators, such as bankfull. In most cases, the field indicator used to estimate the bankfull width and depth was the base of mature trees.

Using the survey data, Waterways calculated the bankfull channel width and plotted each cross section to calculate their cross-sectional areas. We then divided each cross-sectional area by the surveyed bankfull width to determine average bankfull depth. We estimated drainage area for each field site using StreamStats (USGS 2012) and calculated channel slopes using the surveyed longitudinal profiles. Channel widths and hydraulic depths were determined for each cross-section and then averaged for each reach, or reach segment, to obtain a single channel width and depth for each creek at the estimated bankfull discharge. Two separate segments were surveyed in Reach 20 of Permanente Creek to identify differences in channel geometry based on differences in local channel slope with one segment having a local channel slope of 4.6% and the other a local channel slope of 8.2%.

Hydraulic Geometry Analysis

Waterway combined the USGS gage site data with the field survey data to determine trends in channel geometry as a function of drainage area. We developed relationships between drainage area and bankfull width, bankfull depth, and the 1.5-year recurrence interval discharge. Trend lines were fit to the data to provide a predictive tool to estimate these parameters at specific restoration sites, most specifically the Rock Pile and Material Removal Areas (Figures 3, 4, and 5). Using the equation for each trend line, we solved for the predicted channel width and depth for specific restoration areas within Permanente Creek based on a drainage area of 2.7 square miles (Culverts 7 and 8), 2.54 square miles (Rock Pile), and 2.02 square miles (Material Removal Area). Table 3 summarizes the results of this analysis.

Table 3. Channel Dimensions Calculated Using Hydraulic Geometry Relationships

Project Site	Drainage Area (mi^2)	Predicted Bankfull Width (ft)	Predicted Bankfull Depth (ft)	Cross Sectional Area (ft^2)
Culvert 7	2.70	17.9	2.3	31
Culvert 8	2.70	17.9	2.3	31
Rock Pile	2.54	17.5	2.3	29
Material Removal Area	2.02	16.0	2.1	25

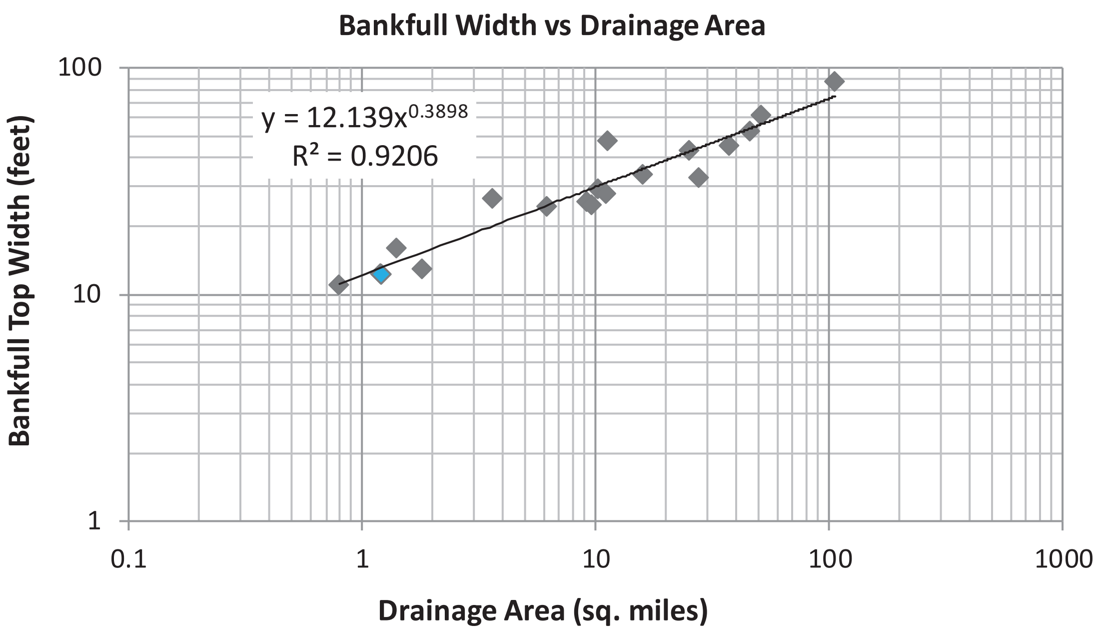

Figure 3. Bankfull Top Width as a Function of Drainage Area for the Santa Cruz Mountains. The blue marker represents the sites on Permanente Creek in Reach 20.

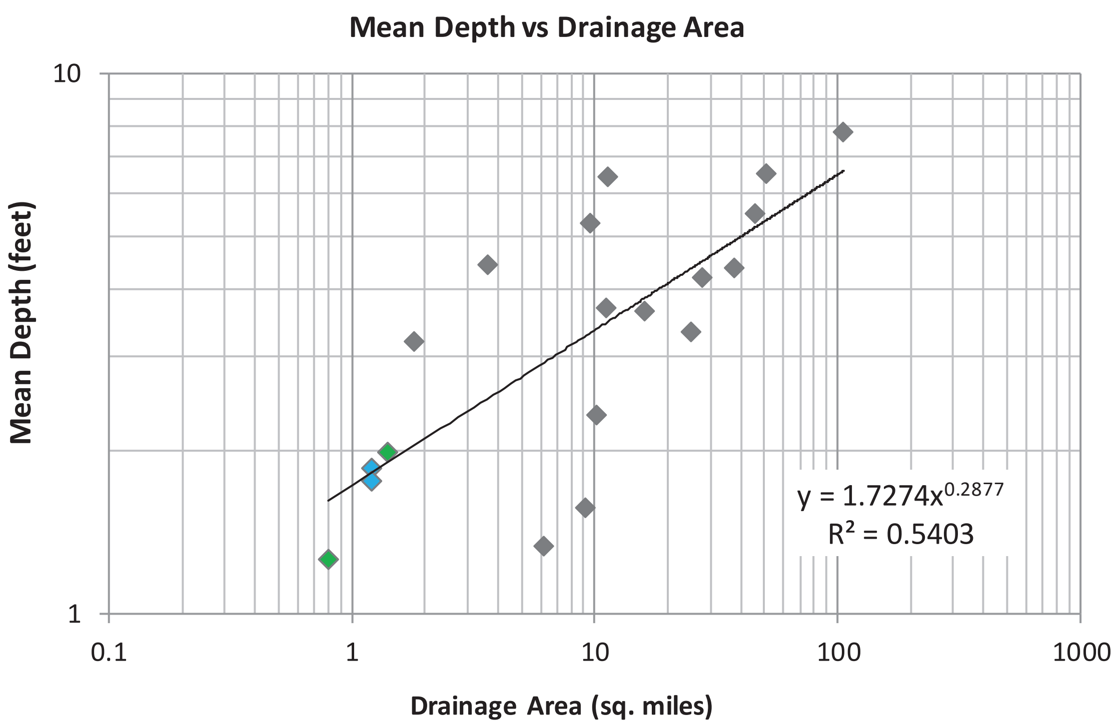

Figure 4. Bankfull Depth as a Function of Drainage Area for the Santa Cruz Mountains. The green data points are Swiss and Corte Madera Creeks. The blue data points are the sites on Permanente Creek.

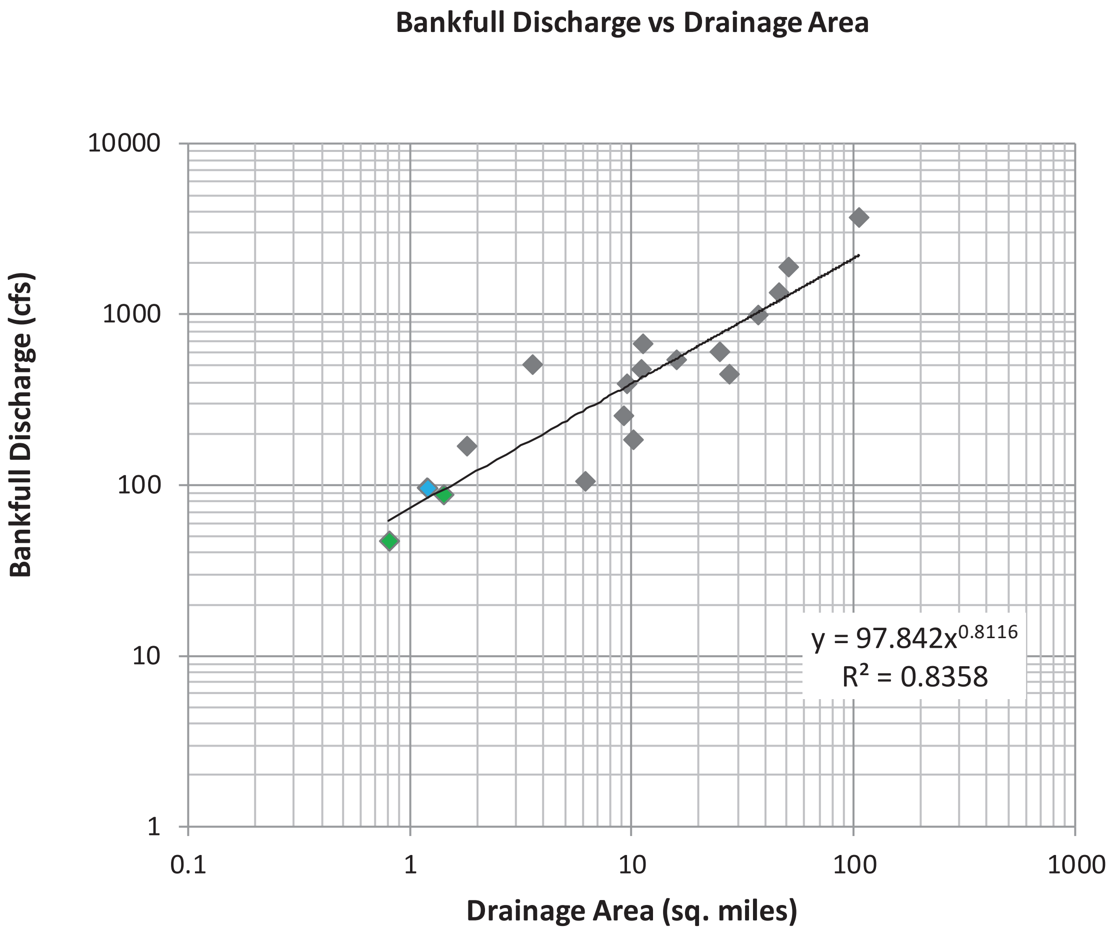

Figure 5. Bankfull Discharge as a Function of Drainage Area for the Santa Cruz Mountains. The green data points are Swiss and Corte Madera Creeks. The blue data points are the sites on Permanente Creek.

Pool Geometry

An important design parameter for reach-scale restoration of Permanente Creek is pool length and pool spacing. Despite the legacy of impacts to Permanente Creek, it was determined that several reaches (R14-R16 and R20-R21) continued to exhibit naturally formed pool and riffle geometries that encompass a range of channel slopes. These conditions provided an opportunity to measure pool and riffle geometries, locally, to support the design effort, rather than measuring those parameters in other adjacent watersheds which may lack specific characteristics found in Permanente Creek such as the prevalence of calcium carbonate precipitates. Given the inherent variability in pool geometries associated with the debris flow morphology of the channel, it was important to collect data along entire reaches and summarize the information to convey averages and ranges of natural conditions. To convey the range of natural variability, longitudinal profile data was collected along the entire length of the identified reaches within Permanente Creek to calculate pool length and spacing in relation to reach-scale channel gradients (Table 4). These data were then used to calculate pool statistics for each site-specific restoration area.

Table 4. Statistics on Pool Length, Depth and Spacing (in feet) By Reach of Permanente Creek.

Reach #	Reach Avg Slope	Avg Pool Length (ft)	Median Pool Length (ft)	St. Dev Pool Length (ft)	Avg Pool Depth (ft)	Median Pool Depth (ft)	St. Dev Pool Depth (ft)	Avg Pool Spacing (ft)	Median Pool Spacing (ft)	St. Dev Pool Spacing (ft)
21	5.1%	13.6	11.6	6.3	0.6	0.6	0.3	211	150	212
20	5.2%	11.4	11.0	4.1	0.9	1.0	0.4	106	92	57
16	7.1%	15.4	14.4	6.1	0.8	0.8	0.4	76	65	69
15	11.6%	10.5	9.4	2.5	0.7	0.7	0.4	58	39	50
14	6.4%	8.8	8.0	3.8	0.6	0.6	0.3	31	19	27
	4-8% Reaches	**12.0**	**10.3**	**5.7**	**0.7**	**0.7**	**0.4**	**94**	**55**	**124**
	8-12% Reaches	**10.5**	**9.4**	**2.5**	**0.7**	**0.7**	**0.4**	**58**	**31**	**50**

Results/Discussion

Dunne and Leopold's (1978) regional curves provide a predictive tool to estimate bankfull channel dimensions for Permanente Creek. Use of the Dunne and Leopold regional curves for the entire Bay Area estimated a bankfull width for the Permanente project area of approximately 17 to 25 feet and a bankfull depth of approximately 1.5 to 2.0 feet. Because these curves are regional and include a significant number of gage locations that are in a geomorphic setting that are different from the project area, regional curves that are more specific to the Permanente Creek project area were developed. Utilizing the more focused data set, which includes the USGS sites within the Santa Cruz Mountains and the field-based assessments sites on Permanente, Corte Madera and Swiss Creek, the curves predicted a bankfull width of 17.9 feet for Culverts 7 and 8, 17.5 feet for the Rock Pile Area, and 16.0 feet for the Material Removal Area and a bankfull depth of approximately 2.3 feet for Culverts 7 and 8, 2.3 feet for the Rock Pile Area and 2.1 feet for the Material Removal Area prior to mining-related impacts (Table 3). As expected, the Dunne and Leopold (1978) curves describe a wider and flatter channel, most likely due to the inclusion of lower gradient, unconfined, alluvial channels in the analysis. Table 5 includes ranges of bankfull channel dimensions for the areas where the channel will be reconstructed to provide for some variability and flexibility during construction since large non-uniform materials will be used in channel construction.

Measured channel slopes for Corte Madera and Swiss Creek, 8.4% and 10.7% respectively, are in the range of the design slopes at the Rock Pile and Material Removal Areas along Permanente Creek. Field observations of a step-pool channel morphology at these channel gradients suggest that Permanente Creek likely had a step-pool channel pattern in the steeper reaches prior to mining. This is supported by the observed conditions in the reaches of Permanente Creek that were identified as having pool and riffle geometry that were representative of natural conditions.

The pool analysis, utilizing the surveyed longitudinal profiles along the more intact reaches of Permanente Creek, suggest that there is an inverse relationship between pool length and spacing relative to channel gradient (Table 4). Furthermore, lower gradient reaches exhibit higher overall pool length and spacing variability than higher gradient reaches. This supports the idea that higher gradient reaches (>8% channel slope) are more characterized by a step-pool morphology, whereas lower gradient reaches (4% to 8% channel slope) exhibit more of a pool-riffle morphology. Pool depth was fairly consistent across all of the evaluated reaches with pools ranging between 0.5 and 2 feet, independent of channel slope. This is likely due to the fact that pool depth may be more a function of the presence of localized roughness elements, and the fact that there are limited opportunities to scour deeper pools due to the composition of the bed material and associated natural armoring.

Table 5. Proposed Channel Dimensions for Constructed Reaches

Project Site	Design Slope (%)	Design Slope Range (%)	Proposed Bankfull Width Min (ft)	Proposed Bankfull Width Max (ft)	Proposed Bankfull Depth Min (ft)	Proposed Bankfull Depth Max (ft)	Cross Sectional Area Min (ft^2)	Cross Sectional Area Max (ft^2)
Culvert 7	4.3%	4%-8%	16.5	20.5	2.1	2.5	28.2	34.2
Culvert 8	2.7%	<4%	18.0	22.0	1.9	2.3	28.2	34.2
Rock Pile Area	Varies	<4%	17.5	21.5	1.8	2.2	26.9	32.9
		4%-8%	16.0	20.0	2.0	2.4		
		>8%	15.5	18.5	2.4	2.8		
Material Removal Area	Varies	<4%	16.0	20.0	1.7	2.1	22.5	28.5
		4%-8%	14.5	18.5	1.9	2.3		
		>8%	14.0	17.0	2.3	2.7		

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G6. Stability Analysis – Draft
(Stantec, August 26, 2022)

Stantec **Memo**

To:	Carolina Addison Lehigh Permanente	From:	Paul Kos Denver
Project/File:	233001622	Date:	August 26, 2022

Reference: PCRP Stability Analysis- DRAFT

INTRODUCTION

Lehigh Southwest Cement Company (Lehigh), a subsidiary of Lehigh Hanson, Inc., engaged Stantec Consulting Services Inc. (Stantec) to provide professional engineering services for geotechnical analysis related to proposed grading associated with the Permanente Creek Restoration Project (PCRP) at the Permanente Facility in Cupertino, California. An element of the PCRP involves removing material from the creek corridor and adjacent slopes. The PCRP design and grading plans are presented in the associated report prepared by Waterways (90% Designs, dated August 26, 2022). The grading plans were provided to Stantec by Waterways, and Stantec performed geotechnical analyses of the proposed slopes in support of the environmental review and subsequent permit applications.

This PCRP Stability Analysis has been prepared to assist Lehigh with upcoming environmental review and subsequent permit applications to relevant regulatory agencies. This report documents the results of static and pseudo-static slope stability analyses of the reclamation surface. The report does not contain the creek restoration design details and shall be reviewed in conjunction with Waterways' 90% Designs.

BACKGROUND

The Permanente Facility is a limestone and aggregate mining operation, active since the late 1930's, in the unincorporated foothills of western Santa Clara County, approximately two miles west of the City of Cupertino, California. The Quarry occupies a portion of a 3,510-acre property (Permanente Property) owned by Hanson Permanente Cement, Inc. and operated by Lehigh.

The Permanente Property is situated in the rugged foothills along the eastern side of the Santa Cruz Mountains segment of the California Coast Ranges. This area of the Coast Ranges is characterized by moderately to steeply sloping hillsides ranging from approximately 500 to 2,000 feet (ft) above mean sea level (AMSL). The eastern side of the range is incised with eastern flowing drainages, including the Permanente Creek Drainage Basin, which flows through the central part of the Permanente Property, and flows through the Cities of Los Altos and Mountain View and into Mountain View Slough or Stevens Creek through the Stevens Creek Diversion Channel operated by the Santa Clara Valley Water District, which ultimately can reach the San Francisco Bay.

GEOLOGIC SETTING

The geology in the project area is complex due to the faulting and deformation associated with the Franciscan Complex. This geologic unit consists of faulted limestone and metabasalts (greenstone) and also contains basalt, diorite, shale, sandstone, chert, greywacke, and schist. Structure in the area includes numerous low- and high-angle faults. Low-angle faults separate limestone units from greenstone units and tend to follow the limestone bedding planes and typically dip to the southeast at 10° to 40°. High-angle faults, including the regional Berrocal Fault, are typically oriented in the northwest-southeast direction and dip at greater than 60°. The geology has been mapped several times by different geologists, and numerous drilling programs have been conducted. The results of these previous studies on the geologic units, structure, and interpretation were included in previous submittals (Golder 2011 and Foruria 2004).

PREVIOUS GEOTECHNICAL EVALUATIONS

The geologic and geotechnical properties of the rocks present at the Permanente Quarry have been evaluated several times by several companies. Each investigation included drilling, laboratory testing, assessment of strength parameters for the various rock types encountered, and slope stability calculations. The rock strength parameters were based on laboratory data, rock mass rating (RMR) calculations, and back-analysis of landslide areas. The strength parameters for soil, greenstone overburden, and limestone have been consistent through multiple geotechnical analyses performed by multiple consultants, and these values are listed in Table 1. The strength parameters for greenstone vary significantly depending on the condition of the bedrock and particularly, the amount of weathering and shearing, and lower-bound values have historically been used for design purposes to be conservative. These lower-bound values are based on back-analysis of the Main Slide in the North Quarry. Laboratory data suggest the in-place greenstone may have significantly higher strength, particularly at depths greater than approximately 50 feet, where the bedrock has not been weathered. Site observations also suggest that greenstone strengths are often under-reported as several areas of the highwall are constructed in weathered greenstone, and these areas have maintained their integrity with 50-foot high benches with face angles of 60° to 70° (Golder 2011).

Table 1: Historic Rock Strength Summary

Material	Unit Weight (pcf)	Cohesion (psf)	Φ' (°)
Limestone	165	12,500	30
Greenstone	155-165	1,400-1,880	19-23
Fault	155	0	20
Slide Debris	135	0-700	20-23
Greenstone Overburden	125	0	35
Soil	120	200	30

GEOTECHNICAL STABILITY EVALUATION

The slope stability analyses were modeled using the software Slide2 Modeler version 9 by rocscience, released in 2020. The software used limit equilibrium on slices of potential failure surface to calculate factor of safety (FoS). The models were evaluated under static and pseudo-static conditions, with horizontal ground acceleration, for the designed ramp configuration provided by the site using the Spencer method. The minimum FoS for each model evaluation is included in this report. The two types of analysis have been summarized in Table 2. The minimum acceptable factors of safety for the analyses are 1.3 for static conditions and 1.0 for pseudo-static conditions based on mining industry standards. For the pseudo-static model conditions, a horizontal seismic coefficient of 0.15 times the force of gravity (g) was applied to the static condition models to be consistent with previous studies and to follow recommendations for earthquakes with magnitudes up to 8.25 (Golder 2011). To evaluate the slope stabilities, cross-sections were analyzed for the reclamation surface.

Table 2: Stability Analyses

Analysis Type	Description	Minimum Acceptable Factor of Safety
Static Analysis	A limit equilibrium method of analysis which satisfies moment and force equilibrium to solve a slope stability problem. The output is a single FoS for the potential failure surface with the lowest FoS.	1.3
Pseudo-static Analysis	A limit equilibrium method of analysis which represents the effects of earthquake shaking by accelerations that create inertial forces. This is the simplest way to analyze the dynamic effects of earthquake loading of a soil or slope. The output is a single FoS for the potential failure surface with the lowest FoS.	1.0

Site specific geotechnical information is available for each rock type on the property, and strength parameters for the material have been established in previous geotechnical analyses (Golder 2011). These strength parameters are based on laboratory testing, back-calculation, and published values for soil properties. These strength parameters are listed in Table 3.

Table 3: Geotechnical Strength Parameters

Material	Unit Weight (pcf)	Cohesion (psf)	Phi' (Degrees)
Greenstone (Weathered)	165	1,800	27
Greenstone (Unweathered)	165	12,500	30
Limestone	165	12,500	30

As previously discussed, the greenstone strengths can vary significantly depending on the degree of weathering, and Stantec focused on evaluating the greenstone strengths as part of this geotechnical investigation. The greenstone strengths were re-evaluated based on RMR classifications. The historic greenstone strength (ϕ'=27° and cohesion=1,800 pounds per square foot [psf]) is suitable for areas that have been weathered and are near the surface. A stronger strength for greenstone is expected for bedrock at depths greater than 50 feet from the surface, which is "beyond" the surficial weathered zone. While this transition to competent bedrock has been demonstrated by drilling, Stantec has used the weathered greenstone strength values for all depths to be conservative. Similarly, there are likely areas with limestone that would exhibit greater strengths, and these have also not been included in the geotechnical analyses to be conservative.

Stability analyses are focused on areas with greater excavation volumes, particularly the rock pile removal area (Section A) and the 1250 Pond area (Sections C and E); the cross-sections modeled align with Waterway's sections and Waterway's naming conventions have been retained for clarity between the reports. Stantec modelled multiple cross-sections in the Pond 1250 area to evaluate the stability under different slope configurations and excavation depths. The cross-sections extend to the top of the surrounding slopes to evaluate any impacts that the grading may have on the global stability. Stantec adjusted the limits of the analyses to evaluate both the global slope stability and the stability in the area immediately adjacent to the PCRP grading.

The configurations modeled as part of this analysis exceed the minimum acceptable factor of safety, as defined in Table 3. Generally, the elevated geotechnical stability results are from the shallow cut slopes associated with the PCRP grading plan. Results from the stability analyses are shown in Table 4. Printouts of the slope stability sections are attached.

Table 4: Geotechnical Stability Analyses Results

Analysis Area	Analysis method	Section A	Section C	Section E
Cut Slope	Static	1.8	3.0	2.3
	Pseudo-Static	1.7	2.8	2.2
Global Slope	Static	1.5	2.8	1.5
	Pseudo-Static	1.5	2.7	1.4

CLOSURE

This report provides the analysis and supporting information needed to demonstrate that Lehigh Southwest Cement Company's plan for the PCRP meets design and performance requirements under static and seismic conditions. The PCRP will be excavated so that stable slopes remain. As mutual protection to Lehigh, the public, and Stantec, this report was submitted for exclusive use by Lehigh Southwest Cement Company. Our report and recommendations should not be reproduced in whole or in part without the supporting Waterways 90% Design report and our express written permission, other than as required in relation to agency review and submittals. A draft of this report was reviewed by personnel from Lehigh Southwest Cement Company.

Regards,

STANTEC CONSULTING SERVICES INC.

Reference: PCRP Stability Analysis

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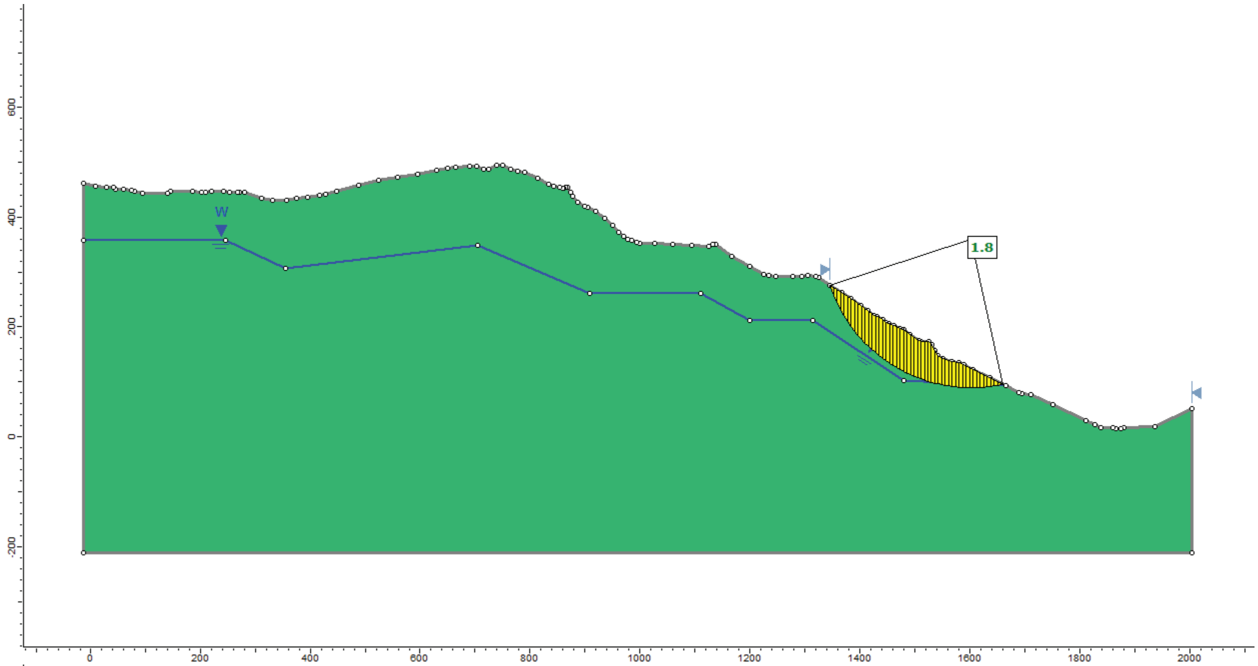
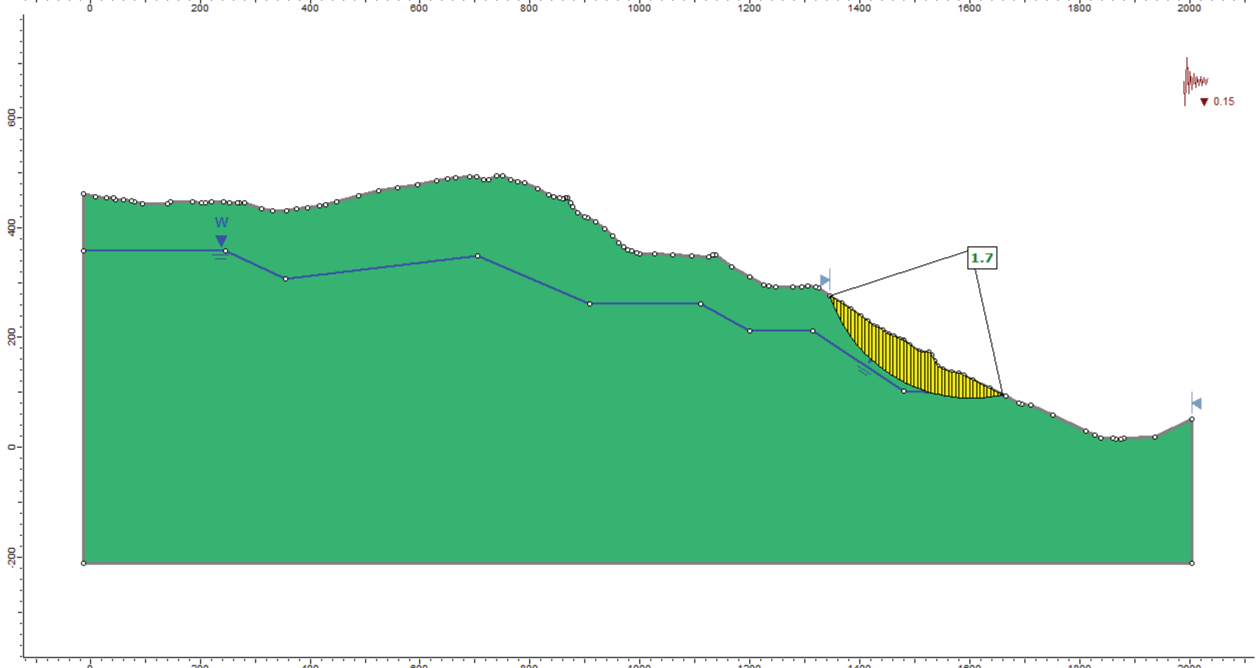
Attachment: Stability Model Reports

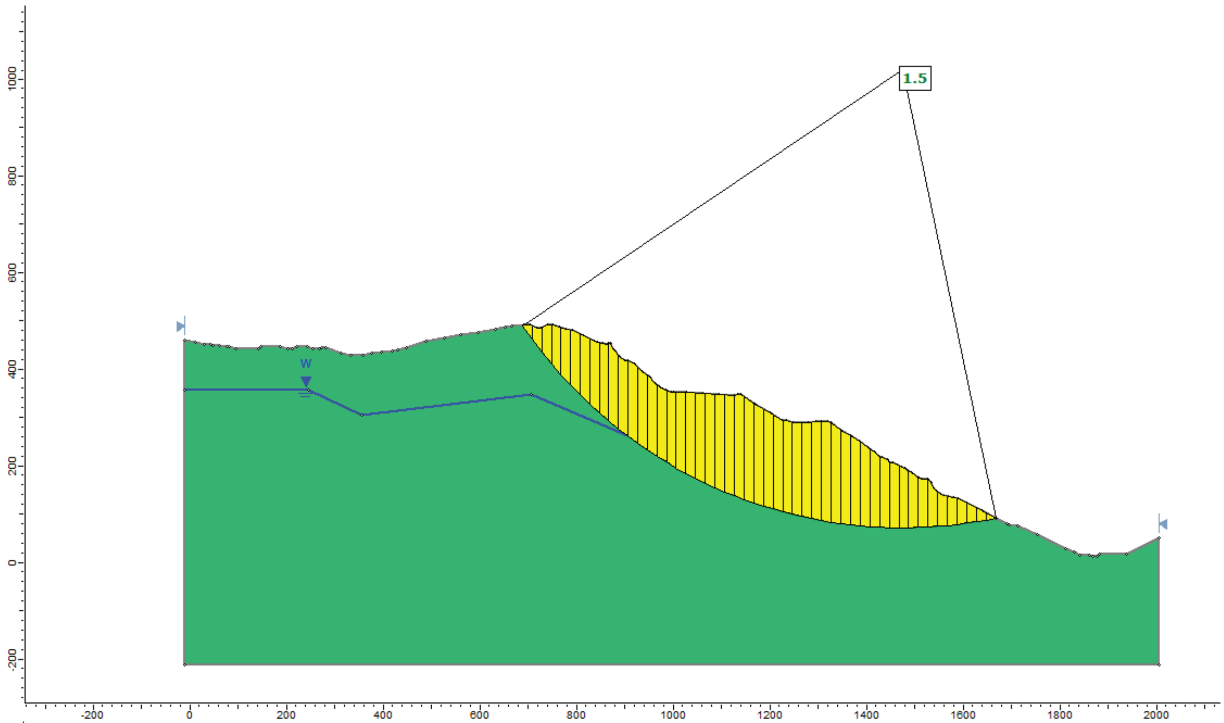
Attachment A

Stability Model Reports

SECTION A (Rock Pile Removal Area)



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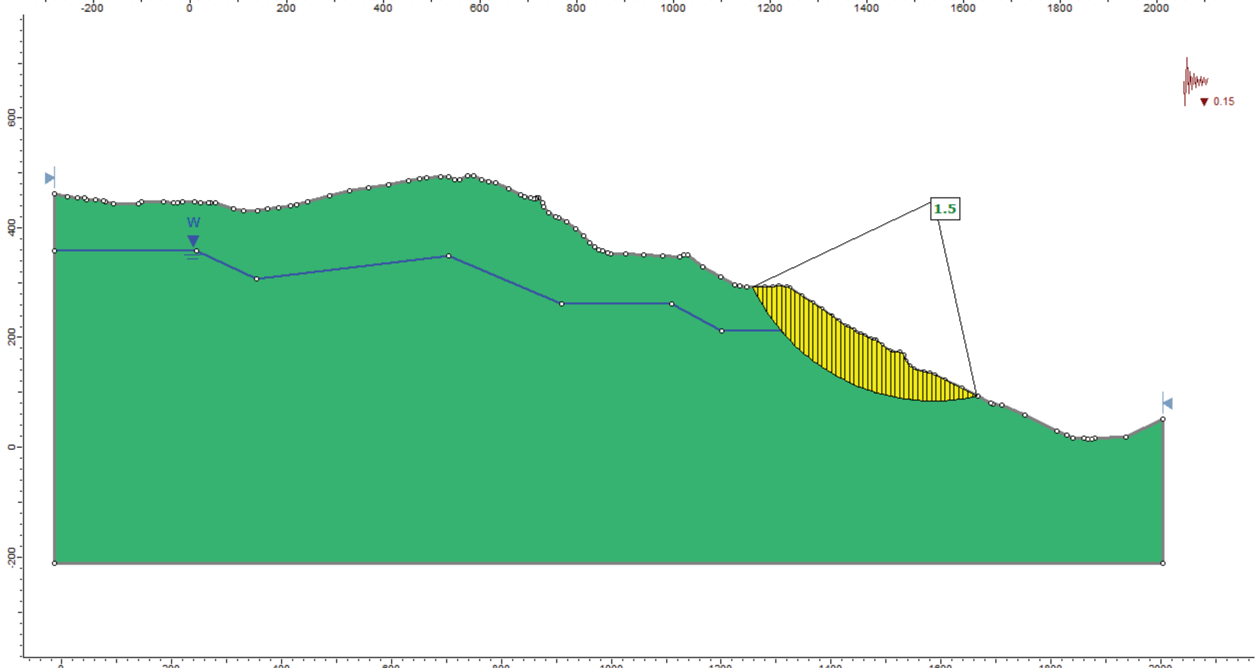
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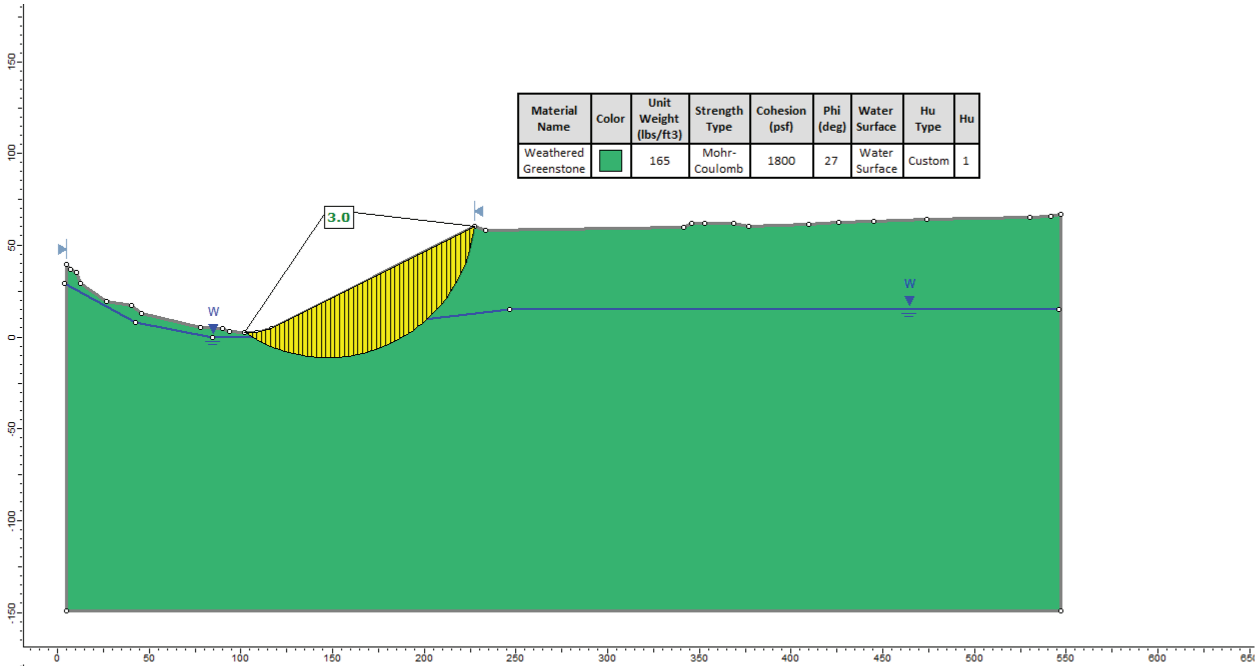
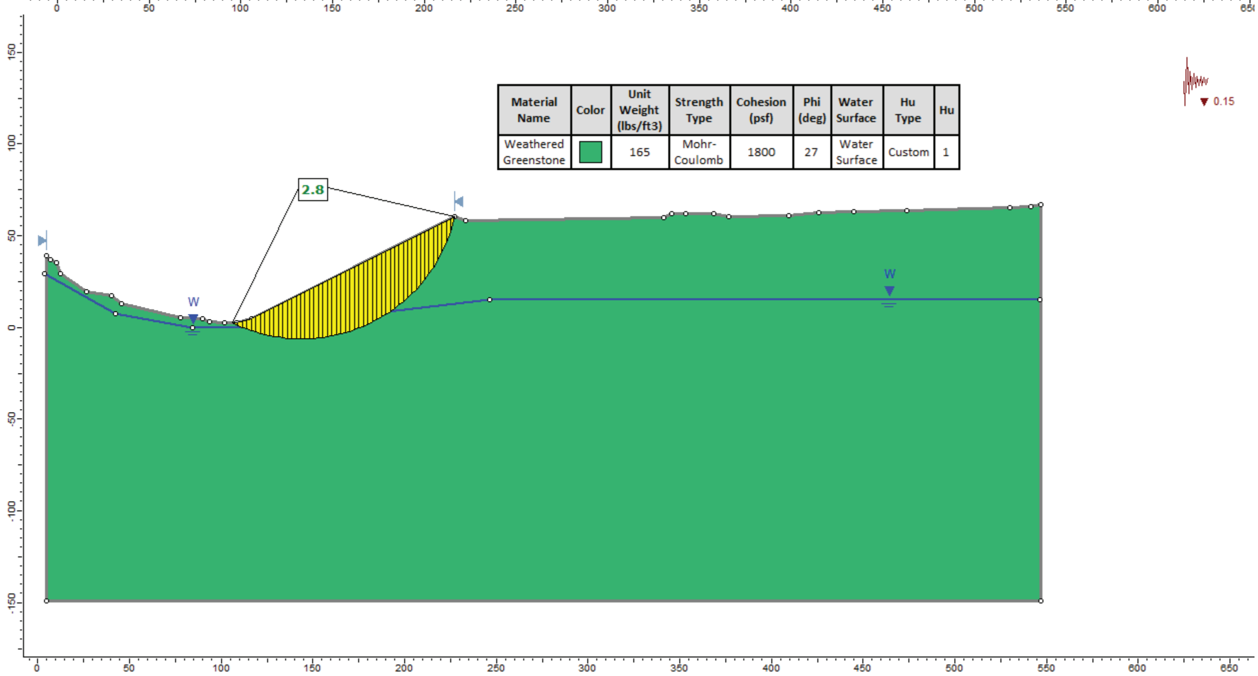
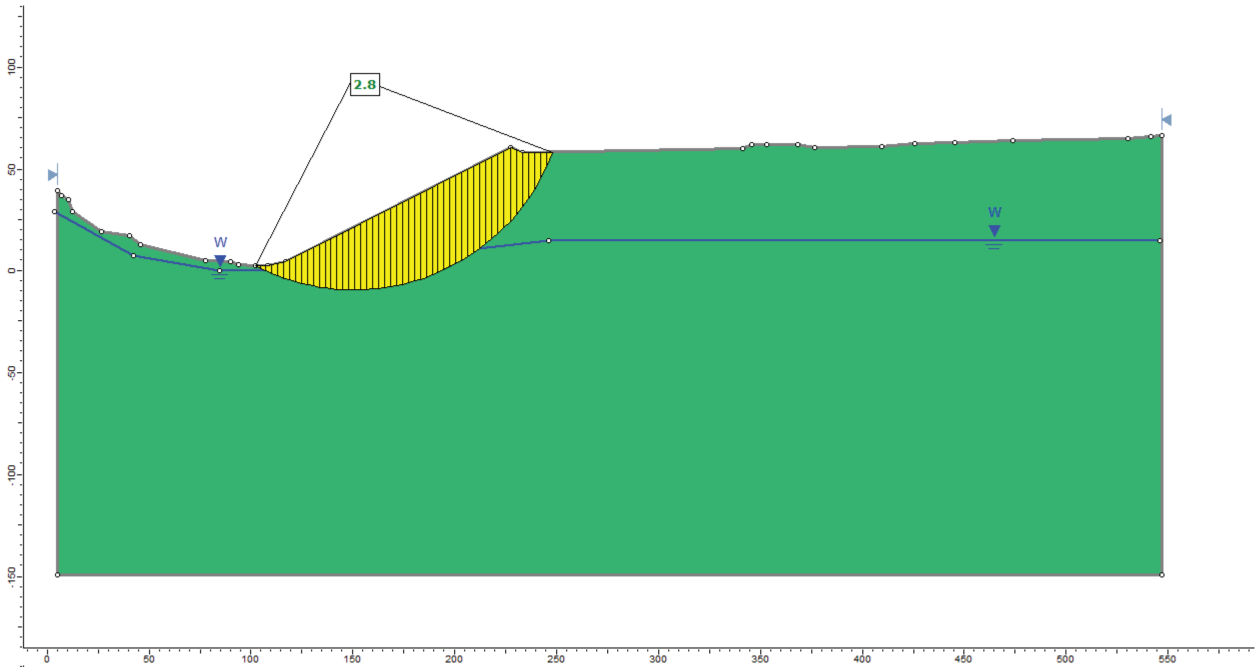
SECTION C (Pond 1250 Area)



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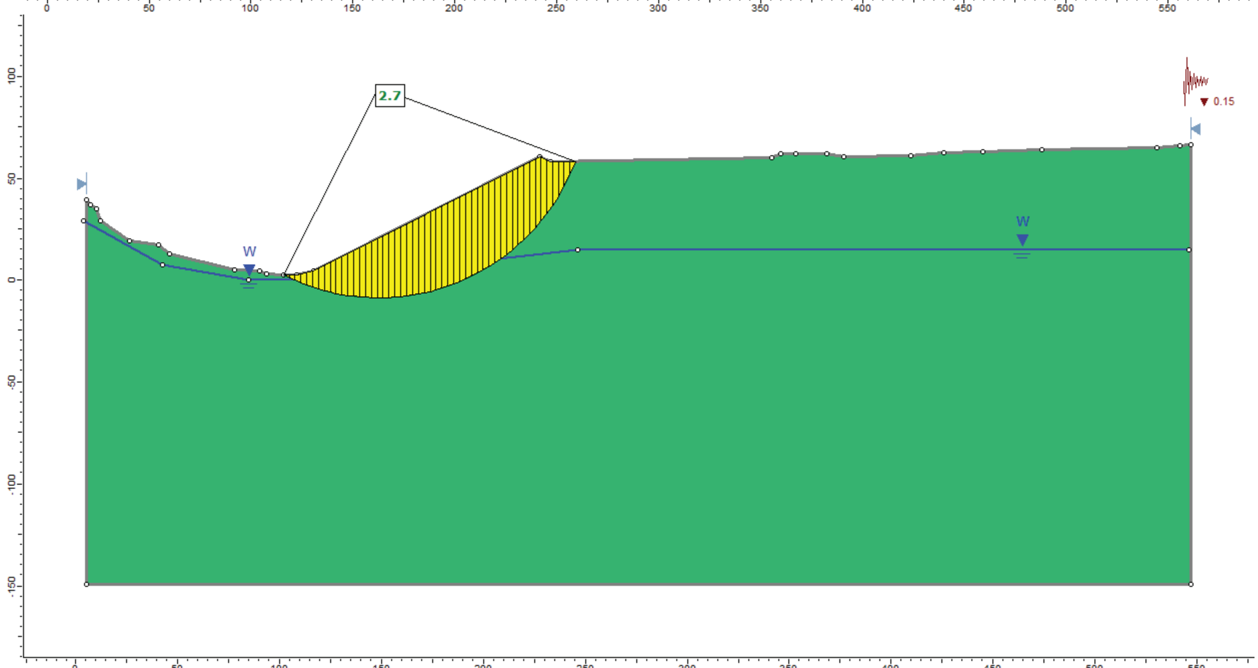
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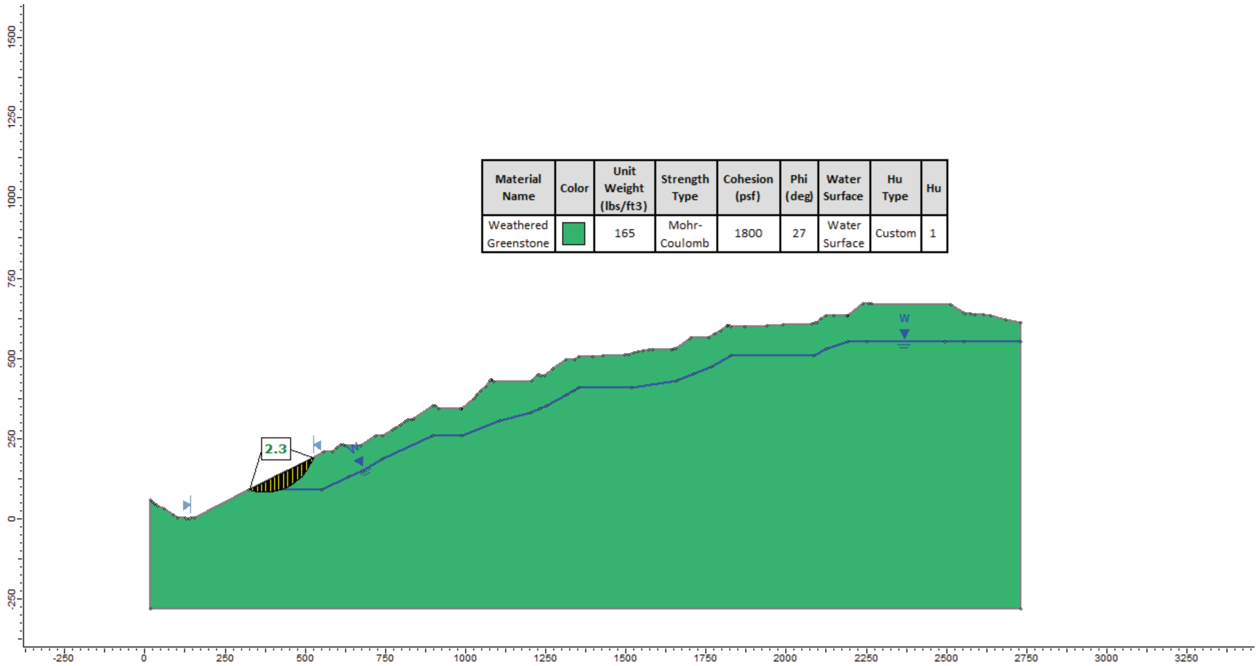

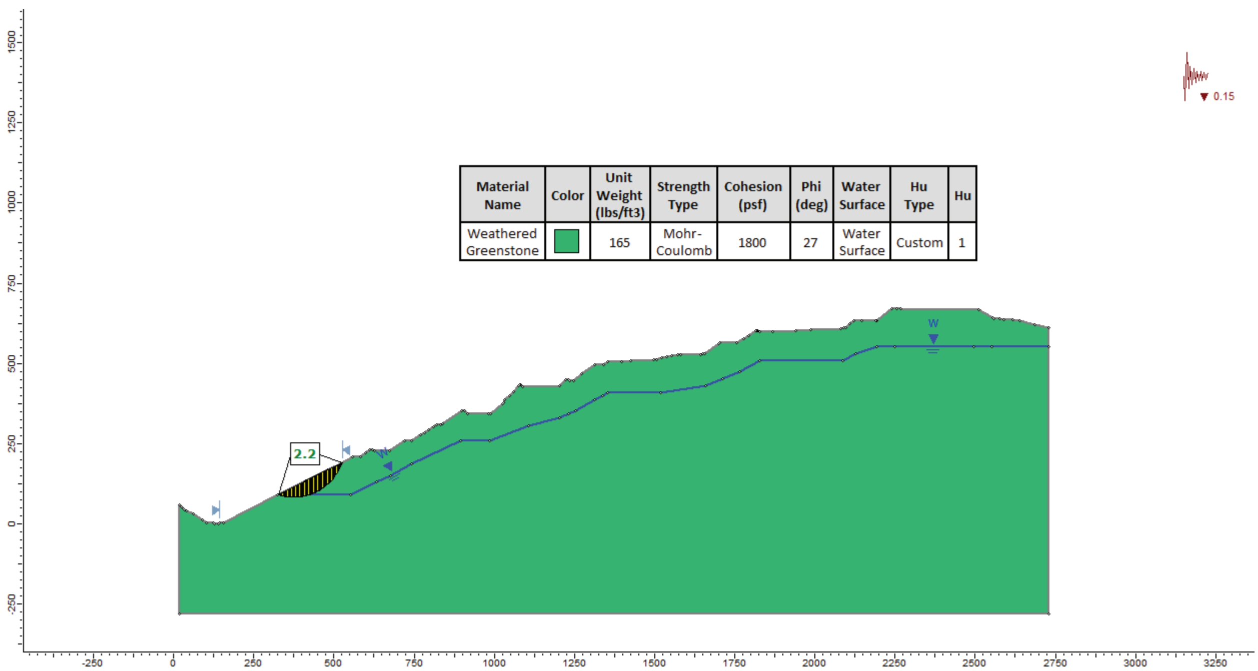

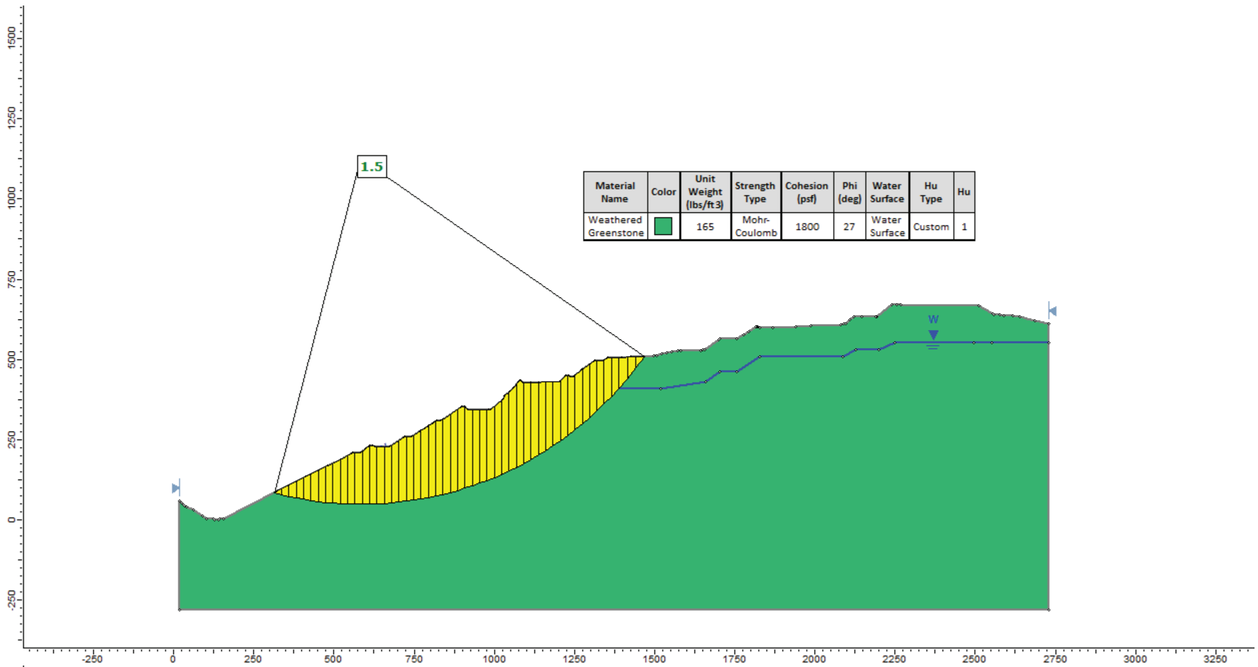

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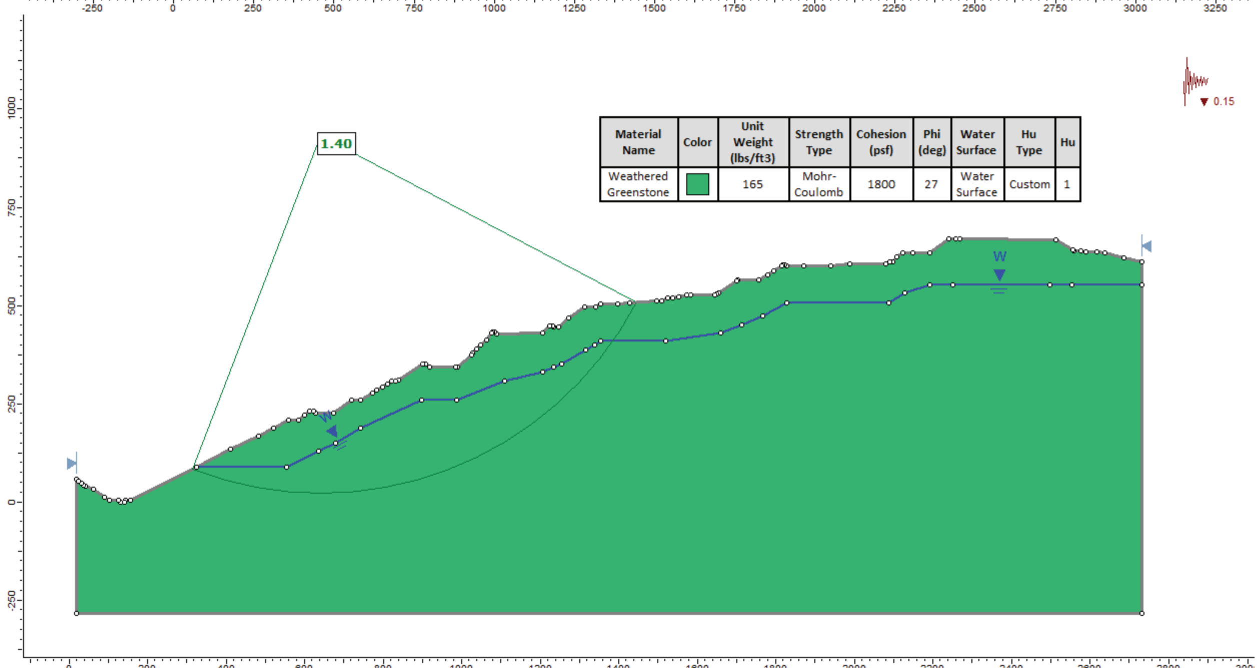

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0.15
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W