CE&G
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CAL ENGINEERING & GEOLOGY
785 Ygnacio Valley Road | Walnut Creek | CA94596
6455 Almaden Expwy., Suite 100| San José | CA 95120
23785 Cabot Blvd., Suite 321 | Hayward | CA 94545
www.caleng.com

GEOTECHNICAL DESIGN REPORT

SAN LORENZO VALLEY WATER DISTRICT
FOREMAN INTAKE GRADING AND EROSION CONTROL PROJECT

CE&G DOCUMENT NO.: 210450.001

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Prepared for:

Freyer & Laureta, Inc.
Jeffery Tarantino
144 San Mateo Drive
San Mateo, California 94401

Mark Myers, PE, GE
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
MARK W. MYERS
No. Geo GE 2580
No. Civil C 57494
CIVIL-GEOTECHNICAL
STATE OF CALIFORNIA

Rocio Briseno, PG
Project Geologist

PROFESSIONAL GEOLOGIST
ROCIO BRISENO
9859
EXP. 30 Nov 2023
STATE OF CALIFORNIA

Reviewed by:

Dan Peluso, PE, GE
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
DANIEL J. PELUSO
GE 2367
GEOTECHNICAL
STATE OF CALIFORNIA

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

1.1. GENERAL

Cal Engineering & Geology (CE&G) is providing geotechnical engineering services to Freyer & Laureta for the San Lorenzo Valley Water District (District) Foreman Intake Grading and Erosion Control Project, located northwest of the District's Lyon Water Treatment Plant (WTP) in Boulder Creek, California (Figure 1). This geotechnical design report presents recommendations for grading mitigation and erosion control design, incorporating the results of our field investigation, laboratory testing, and engineering analysis.

1.2. PROJECT DESCRIPTION

A pipeline access trail was constructed using emergency grading measures immediately after the 2020 CZU fires. The access trail was used to restore surface water diversion from Foreman Creek into the Lyon Water Treatment Plant (WTP). The grading for the access trail was completed with no geotechnical investigation or engineered design. Longitudinal cracks have occurred along the access trail since, along with other grading and erosional issues. The purpose of this report is to provide alternatives for mitigation of erosion potential and slope instability along the access trail.

1.3. SITE DESCRIPTION

The pipeline access trail is located northwest of the Lyon Water Treatment Plant (WTP) in Boulder Creek, California (Figure 1). The trail is approximately 1550 feet long and 8 to 12 feet wide. The foreman intake pipeline runs along the upslope edge of the trail. A survey of the location was completed in September of 2020 by SANDSIS and provided in AutoCAD format to CE&G. The survey uses an assumed datum and shows key features such as logs and stumps near the trail.

1.4. PURPOSE AND SCOPE OF SERVICES

Our scope of work included, but was not limited to:

- review of published soil and geologic maps;
- geologic site reconnaissance and marking of the site for Underground Service Alert;
- geologic mapping along the access trail;
- excavation and logging of three geotechnical borings;
- laboratory testing of materials recovered from the exploratory borings;
- engineering analysis;

- development of grading and erosion control mitigation measures;
- preparation of this geotechnical report.

CE&G's work has been specifically limited to evaluating the geologic and soil conditions in the vicinity of the access trail. Evaluation of the conditions in other areas was beyond the authorized scope of work. Evaluation or identification of the potential presence of hazardous materials at the site was not requested and is beyond the authorized scope of work.

2. GEOLOGIC CONDITIONS

2.1. REGIONAL SETTING

The project site lies within the Santa Cruz Mountains, within the Coast Ranges geomorphic province of California (Figure 1). This province is characterized by northwest-southeast trending mountain ranges and intervening valleys such as that occupied by San Francisco Bay and the Santa Clara Valley. The Santa Cruz Mountains are one such range, marking an area of regional uplift southwest of the San Andreas fault. The geologic setting is shown on our Regional Geologic Map (Figure 2).

2.2. SITE GEOLOGY

The general vicinity of the project site has been mapped several times, with geologic mapping having different emphases. For our report, the mapping completed by Graymer and others (2006); and Brabb and others (1997) is the most pertinent.

Brabb and others (1997) and Graymer and others (2006) maps are in agreement that the site is underlain by intrusive Cretaceous granitic rock. Brabb calls the geologic unit a gneiss granodiorite. Graymer refers to it as granite of the Salinian complex. Our mapping of the site is generally consistent with the regional data.

2.3. SURFICIAL SOILS

The surficial soils at the project site have been mapped by the USDA National Resource Conservation Service (NRCS) and USDA Soil Conservation Service. The project site has been mapped as belonging to the Ben-Lomond-Catelli-Sur complex for 30 to 75 percent slopes (NRCS, 2021).

Soils of the Ben-Lomond-Catelli-Sur complex are described as well-drained residuum weathered from granite and/or sandstone and have a plasticity index ranging from non-plastic to 10 percent.

2.4. LANDSLIDE GEOLOGY

Generalized regional landslide mapping (Cooper-Clark Associates, 1975; re-issued digitally as Roberts and others, 1998) shows a few "questionable landslide" deposits downslope of the Lyon Water Treatment Plant, but none along the pipeline access trail (see Figure 3).

2.5. ACTIVE FAULTS AND SEISMICITY

The project site is located within the greater San Francisco Bay Area, which is recognized as one of the more seismically active regions of California. The right-lateral strike-slip San Andreas fault system controls the northwest-southeast structural grain of the Coast Ranges and the Bay Area. The fault system marks the major boundary between two of earth's major tectonic plates, the Pacific Plate to the west and the North American Plate to the east. The Pacific Plate is moving north relative to the North American plate at approximately 40 mm/yr in the Bay Area (WGCEP, 2003).

The transform boundary between these two plates has resulted in a broad zone of multiple, subparallel faults within the North American Plate, along which right-lateral strike-slip faulting predominates. In this broad transform boundary, the San Andreas Fault accommodates less than half of the average total relative plate motion. Much of the remainder in the greater South Bay Area is distributed across faults such as the San Gregorio-Hosgri, Monte Vista-Shannon, Sargent, Berrocal, Hayward (southern segment), Calaveras, Zayante-Vergeles, and Greenville fault zones.

Since the project site is located in seismically active California, it will likely experience strong ground shaking from a large (Moment Magnitude [Mw] 6.7) or greater earthquake along one or more of the nearby active faults during the design lifetime of the project (WGCEP, 2014). Table 3-1 shows the approximate distances between the project site and various major surface fault traces, and their estimated magnitude, within approximately 50 km of the site (Caltrans, 2018). Other active seismogenic faults (capable of generating significant earthquakes) and their distances near the site are included in Table 3-1.

Table 3-1. Distances to Selected Active Fault Traces

Fault Name	Approximate Distance and Direction from Site to Surface Fault Traces	Estimated Mw
Zayante-Vergeles Upper	0.9 km northeast	7.0
Zayante-Vergeles Lower	3.5 km southwest	7.0
San Andreas	12.3 km northeast	8.0
San Gregorio fault (San Gregorio section)	14.5 km southwest	7.4
Sargent fault (southeastern section)	17. 3 km east	7.0
Monte Vista-Shannon	19.8 km northeast	6.4
Monterey Bay-Tularcitos (Monterey Bay section)	23.0 km south	7.2
Cascade fault	24.1 km northeast	6.7
San Gregorio fault zone (Sur Region section)	27.5 km southwest	7.4
Silver Creek fault	33.6 km northeast	6.9
Hayward (Southern extension)	39.9 km northeast	6.7
Calaveras	43.4 km northeast	6.9

A large magnitude earthquake on any of these faults or other active fault systems in the greater Bay area has the potential to cause significant ground shaking at the site. The intensity of ground shaking that is likely to occur at the property is generally dependent upon the magnitude of the earthquake and the distance to the epicenter.

2.5.1. Liquefaction and Seismic Densification

Soil liquefaction is a phenomenon in which saturated, cohesionless soils (generally sands) lose their strength due to the build-up of excess pore water pressure during cyclic loading, such as that induced by earthquakes. Soils most susceptible to liquefaction are saturated clean, loose, fine-grained sands and silts. The primary factors affecting soil liquefaction include: 1) intensity and duration of seismic shaking; 2) soil type and relative density; 3) overburden pressure; and 4) depth to groundwater.

No California Geological Survey (CGS) Seismic Hazard Zone Map has yet been prepared for the 7.5-minute quadrangle (Davenport 7.5' quadrangle) encompassing the site. These zones are established to trigger further evaluation (for certain projects) of the potential for seismically induced landsliding in hillside areas, and liquefaction potential in valley floor areas.

Dupre (1975) prepared an early liquefaction susceptibility map that includes the general site vicinity. At the scale mapped by Dupre, the site is shown as lying within a bedrock area lacking the materials and conditions needed for liquefaction.

The site is not mapped within a County of Santa Cruz Liquefaction Hazard Zone (County of Santa Cruz, gis.co.santa-cruz.ca.us/map_gallery, accessed September 2021).

Seismic densification is the densification of unsaturated, loose to medium dense granular soils due to strong vibrations resulting from earthquake shaking. We judge the potential for seismic densification of natural materials at the site to be low due to the depth of bedrock and lack of groundwater encountered.

3. FIELD INVESTIGATIONS

3.1. SITE RECONNAISSANCE

CE&G performed field reconnaissance of the site in June and August 2021 in advance of performing subsurface borings. Site reconnaissance consisted of photographic documentation of the project site, determining site access for drilling equipment, and identifying and marking boring locations. The markings were also used for utility clearance through USA (Underground Service Alert). CE&G subsequently made another site visit in October 2021 for geologic mapping. CE&G's preliminary geomorphology map and mapping along the trail are attached as Figures 4 and 5 described in Section 4. Details of post-fire, post-grading sloughing and ravelling downslope of the pipeline access trail are not shown.

Generalizing, the pipeline access trail was created by cut and sidecast fill, with cable-bundled logs placed parallel to contour in selected areas to help retain the unengineered sidecast fill. The granitic bedrock is locally exposed in the road cut, with rock quality varying from moderately hard, to nearly soil-like. Remnants of the previous above-grade pipeline support system are locally present. The cut slope varies considerably in height. Colluvium thickness varies from about 1.5 feet to over 4 feet. Rock quality varies widely, with rock quality generally highest at topographic spurs, and lowest in swale intervals.

3.2. SUBSURFACE EXPLORATIONS

3.2.1. Exploratory Borings

The subsurface conditions at the site were explored by drilling and sampling three geotechnical borings on August 17, 2021. The borings were drilled and sampled by Access Soil Drilling, using a minute-man drill rig and 4-inch-diameter solid-flight augers. Descriptions of the materials encountered in the borings are included on boring logs in Appendix A. The approximate locations of the borings are shown in Figure 5.

Upon completion, the borings were backfilled with cement grout. Drilling spoils were spread on-site in the vicinity of the borings.

3.2.2. Logging and Sampling

The materials encountered in the borings were logged in the field by a CE&G geologist. The soils were visually classified in the field, office, and laboratory according to the Unified Soil Classification System (USCS) in general accordance with ASTM D2487 and D2488.

During the drilling operations, soil samples were obtained using the following sampling methods:

- California Modified (CM) Sampler; 3.0-inch outer diameter (O.D.), 2.5-inch inner diameter (I.D.) (ASTM D1586)
- Standard Penetration Test (SPT) Split Spoon Sampler; 2.0-inch O.D., 1.375-inch I.D. (ASTM D1586)

The CM and SPT samplers were driven 18 inches (unless otherwise noted on the boring logs) with a 140-pound hammer using a cable drop, dropping 30 inches. The number of blows required to drive the samplers through each 6-inch interval was recorded for each sample. The results are included on the boring logs in Appendix A. The blow counts included on the boring logs represent the field values and are uncorrected.

Soil samples obtained from the borings were packaged and sealed in the field to reduce the potential for moisture loss and disturbance. The samples were taken to CE&G's local office for further analysis and storage.

3.2.3. Soil Conditions Encountered

The subsurface soils encountered in B-01 to B-03 consisted of granite-derived poorly graded sand with silt and gravel to silty sand. The poorly graded sand to silty sand was generally loose to medium dense and ranged in thickness between 4 and 9.5 feet. This was interpreted as the material cut and then placed to create a level pad for the access trail. Completely weathered to competent granite was encountered below the loose sands. The granite was interpreted as in-place; however, it is possible that the granite sampled was simply cobbles or boulders that were mixed in with the fill material.

For a more detailed description of the soils encountered in the borings, please see the boring logs and laboratory test results included in Appendix A.

3.2.4. Groundwater Conditions Encountered

Groundwater was not encountered during drilling. However, fluctuations in the groundwater due to rainfall, tide levels, and other factors not apparent at the time of exploration, can influence groundwater levels and may cause several feet of variation.

3.3. GEOTECHNICAL LABORATORY TESTING

Testing was performed to obtain information concerning the qualitative and quantitative physical properties of the samples recovered during the subsurface exploration program. Tests were performed by the CE&G Testing Laboratory in Hayward, California, in general conformance with applicable ASTM standards. The following tests were performed:

- Moisture Content and Dry Unit Weight (ASTM D2216)
- Atterberg Limits (ASTM D4318; dry method)
- Grain Size Analysis

The results of the laboratory testing program are presented in Appendix B and are summarized below.

3.3.1. Moisture Content and Dry Unit Weight

Moisture and density tests were performed on relatively intact samples recovered from the borings. The samples tested consisted primarily of poorly graded sand with silt had moisture contents between 3 and 14 percent. The dry densities of fill and shallow weathered bedrock was less than 100 pcf in two samples tested.

3.3.2. Atterberg Limits

An Atterberg Limits test was performed on a sample to determine the plasticity of the fine-grained materials. The sample resulted as non-plastic.

3.3.3. Grain Size Analysis

A grain size analysis was performed to determine the fines content of selected samples. The fines content of selected samples ranged from 6 to 21 percent.

4. DISCUSSION AND CONCLUSIONS

As noted in Section 1.2, the Foreman intake pipeline access trail was built using emergency grading measures immediately after the 2020 CZU fires. It is our understanding that the emergency trail was constructed by cutting into the upslope and pushing fill on the downslope side to create a bench for the installation of the new pipeline. The new pipeline is an HDPE pipeline installed approximately 3 feet below grade on the uphill side of the bench.

The emergency pioneered trail and pipeline successfully reconnected the Foreman intake to the treatment plant. Since installation, the cut and fill graded emergency trail has experienced distress. The distress consists primarily of fill creep, tension cracking and incipient sliding on the downslope side of the pioneered trail, and localized failure of the steep cut slopes in areas where rock quality is poorest. Since the original installation was not engineered, it is desired to design measures to return the site to a condition where stability is not exacerbated by the emergency installation.

4.1. ENGINEERED DESIGN

At the time of the CZU fire, the emergency response to reestablish the water supply did not allow for the pipeline installation to follow a normal design and construction process. A normal design process starts with 1) identification of project objectives, 2) identification of project constraints, 3) development of alternatives, 4) selection of a preferred alternative, and 5) design of the preferred alternative. A normal construction process would have included elements to address restoring the site after installation of the pipeline and would include slope stabilization measures as needed.

We assume that improvements to address slope instability and reduce erosion of the pioneered trail will follow the recommendations provided herein.

4.2. PROJECT OBJECTIVES

Based on our understanding of the project, the primary objective is to reduce erosion and offsite sediment transport as well as to address known areas of significant slope instability. It is also our understanding that it is not necessary to maintain a vehicle-width trail along the alignment. This segment of the pipeline can be accessed from both ends due to existing roads that access the Foreman Intake and the Treatment Plant. It is also our understanding that a 3- to 6-foot-wide walking trail that would provide access to the valves by District staff would be desirable but is not a requirement of the project.

4.3. PROJECT CONSTRAINTS

4.3.1. Offsite Safety

During our site walk with Freyer & Laureta and the District, we learned that reconstruction of private properties that were damaged in the 2020 CZU wildfire is in progress downslope of the east end of the trail. The project must consider slope instability and erosion that may impact safety for properties downslope of the access trail.

4.3.2. Environmental Considerations

Although we are not currently aware of specific environmental concerns, we know that work within tree-covered terrain does require consideration of the environment and we anticipate that an arborist will need to evaluate the condition of trees within the work area.

4.3.3. Site Geology and Site Soil Conditions

The current pioneered trail follows slope contours and crosses multiple times from spur ridge to colluvial/landslide ravines or swales. CE&G used existing geologic mapping of landslide features, geomorphic analysis of Lidar-derived topography, and fieldobservations to prepare a preliminary geomorphology map (Figure 4). The map shows the areas of sliding and debris flows that extend substantially beyond the limits of the pioneered trail and pipeline alignment. Figure 5 is a more detailed map that shows mapped cracks and conditions along the alignment. It should be understood that stabilization of areas along the access trail that exhibit slope instability or pose an erosion hazard will not address stability of the entire hillside, which is beyond the scope of this current project. Our understanding is that the project goal is to restore the condition along the trail alignment to a pre-pioneered trail slope stability condition.

4.4. CONCEPTUAL STABILIZATION ALTERNATIVES

Four conceptual stabilization methods that could be used are:

Alternative 1 - Return Slope to Pre-Installation Condition
Alternative 2 - Removal of Side Cast Fill and Construction of a Debris Catchment Wall
Alternative 3 - Removal of Side Cast Fill and Stabilization of Cuts using Tecco Mat;
Alternative 4 - Removal of the side cast fill and construction of walls to retain fill and buttress the cut slopes.

4.4.1. Alternative 1 - Return Slope to Pre-Installation Condition

This alternative (see Figure 6A) would require the construction of a keyway to bench engineered fill into competent bedrock. A concern with this method is that based on our limited subsurface investigation, the depth to competent material ranges from near the surface along spur ridges to about 8 feet, with changes in depth potentially occurring over a short distance. Assuming that fills would be keyed 3 feet into competent material would result in keyways ranging up to 10 feet deep. The steep topography greatly complicates staging to facilitate temporary stockpiling of fill, and increases the potential for steep cuts to fail and/or require extensive shoring. The steep topography can be addressed through the use of geogrid reinforcement in the reconstructed fill slope. Using geogrid, CE&G has designed slopes steeper than the existing conditions. However, excavation of keyways will necessitate removal of many trees and other vegetation, which may not be permitted due to environmental concerns. Additionally, the depth to bedrock would result in portions of the keyway conflicting with the recently installed water line.

4.4.2. Alternative 2- Removal of Side Cast Fill and Construction of a Debris Catchment Wall

This alternative (see Figure 6B) would mitigate the erosion hazard of side cast fill by removing it from the site. If a nearby site could be located and/or fill were needed for a nearby site, this would be the least expensive method to mitigate the hazard related to the side cast fill.

The upslope cut would be allowed to degrade and slump onto the bench being retained by a catchment wall. It is possible that debris flows upslope of the existing pioneered trail cut could fill and/or overwhelm over top the wall. As a result, the wall would require maintenance to remove debris if the wall became filled by debris.

This approach would likely be pursued progressively from one (or both) ends of the alignment. Removal of the existing fill, and construction of the wall, could be pursued in segments, with each completed segment facilitating access to the next.

4.4.3. Alternative 3 - Removal of Side Cast Fill and Stabilization of the Cut using Tecco Mat

This alternative (see Figure 6C) would mitigate the erosion hazard of side cast fill by removing it from the site, as in Alternative 2. If a nearby site could be located and/or fill was needed for a nearby site, this would be the least expensive method to mitigate the hazard related to the side cast fill when maintenance costs are considered.

The upslope cut would be stabilized using anchored Tecco Mat. A relatively narrow version of the existing trail would be preserved for access. The trail would also not be subject to debris since the cut would be stabilized by the Tecco Mat. The trail would could be a benefit to downslope properties by serving as a debris catchment bench for debris shed from areas upslope of the pioneered road cut.

4.4.4. Alternative 4 - Removal of Side Cast Fill and Reuse with Walls to Buttress Cut Slopes

This alternative (see Figure 6D) could use several different wall types. We would recommend that the side cast fill be removed and cleaned of vegetation and other debris to make it suitable for placement as engineered fill along the pioneered trail. CE&G has designed many mechanically stabilized earth retaining walls (MSEW). In areas where downslope conditions contain a significant thickness of creeping soils, the MSEW wall can be further stabilized by a pier-supported grade beam constructed below the wall. This method results in less extensive excavation than would be required for keyways. Additionally, using geogrid reinforced retaining walls or slopes results in substantially lower lateral loads on the piers, resulting in less costly piers when compared to a typical cantilever design. Additionally, if space constraints permit the use of a retaining structure that is closer to the original slope gradient (1H:1V, horizontal:vertical) or flatter, the design could use a geogrid-reinforced slope. For portions of the alignment that are steeper, welded wire forms could be used. Figure 6D shows a steel beam and lagging alternative, and a geogrid reinforced slope alternative.

4.4.5. Preferred Alternative

It is our opinion that the depth and configuration of keyways needed to construct Alternative 1 likely makes it unfeasible. If a site can be located for disposal of the side cast fill to be removed from the site, Alternatives 2 and 3 are likely the easiest and fastest to implement. Alternative 2 is also likely the most cost-effective alternative.

If a disposal location for the side cast fill to be removed from the site does not exist, Alternative 4 becomes the most feasible. *Alternative 4 - Removal of Side Cast Fill and Reuse with Walls to Buttress Cut Slopes* is the most flexible alternative. In a sloped configuration, Alternative 4 is similar to Alternative 1 but without large keyway excavations. In a more conventional wall configuration, Alternative 4 provides a wider path/trail for District staff.

Alternative 4 could use reinforced slopes, welded wire form-faced reinforced slopes, MSEW, or steel beam and lagging walls. There are also options where some material is disposed of outside of the pipeline alignment.

4.5. OTHER DESIGN CONSIDERATIONS

The Foreman intake pipeline is the only segment of pipeline replaced to date following the CZU fires. The CZU wildfire also destroyed a 5-mile-long District pipeline, taking it out of service. It may be desirable to look at the relatively short Foreman Intake Pipeline segment as an opportunity to test several designs and methods of construction in order to develop the most cost-efficient and appropriate mitigation suite for segments of the 5-mile pipeline that also flow to the Treatment Plant.

5. DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following design and construction recommendations assume Alternative 4 but are largely applicable to alternatives 1 through 3. Detailed recommendations for the geotechnical aspects of the proposed access road realignment project are presented in the subsequent sections of this report. Our evaluations and recommendations are based upon the previously discussed information collected for this investigation and our engineering analyses. The following recommendations may need to be modified if there are any changes in the proposed alignment that arise out of the design process.

5.1. DESIGN GROUNDWATER LEVEL

Groundwater was not encountered during the drilling of three borings along the pioneered trail. The borings were primarily located in areas of deeper soil based on visual observation and interpretation. If groundwater is encountered, it is most likely perched or within a more permeable layer within the bedrock. Groundwater may fluctuate depending on the time of year and winter rainfall.

5.2. EARTHWORK

5.2.1. Clearing

Clearing should include the removal of all vegetation within the limits of work and also any loose side cast soils below the pioneered pipeline trail. Depending on the final alignment layout, some portion of the existing slope may require scaling of colluvium exposed in cuts, and/or weak, disaggregating bedrock.

Site clearing should also include the removal of deleterious materials, debris, and obstructions that are designated for removal. Depressions, voids, and holes that extend below the proposed finish grades should be cleaned and backfilled with engineered fill compacted to the recommendations in this report.

5.2.2. Excavations

Excavations for this project will include excavation to firm and unyielding weathered rock and/or soil as determined by Cal Engineering & Geology. In some cases, some over-excavation may be required where competent materials are encountered at depth. Additionally, some excavation into the existing cut slopes will be needed to create intermittent benches for fill placement.

Excavations should be constructed in accordance with the current CAL-OSHA safety standards and local jurisdiction. The stability and safety of excavations, braced or unbraced, are the responsibility of the contractor.

If areas of adversely oriented bedrock are exposed in excavations, supplemental recommendations may need to be developed to reduce the potential for localized instability.

5.2.3. Slopes

The project will entail the construction of temporary cut and fill slopes and a permanent slope. Cut slopes in the existing slope appear to have been made at close to 1H:1V. In general, it is our understanding that the cuts were successful for the duration of construction but not for permanent conditions.

The slope below the pioneered trail should be returned to its pre-emergency slope inclination by removal of side cast fill.

5.2.4. Site Preparation

As discussed previously in "Clearing," the proposed alignment is underlain by the debris of variable thickness to depths of up to approximately 9.5 feet below the existing grade. To reduce the risk associated with these soils, they should be removed and replaced as engineered fill where shallow enough to do so. In deeper locations, a pier-supported foundation will be required.

After site preparation and before placement of compacted fills, the excavation bottom should be observed and approved by the geotechnical engineer or their representative. After approval, the subgrade should be scarified to a minimum depth of 8 inches, moisture conditioned to about 1 to 3 percent above optimum moisture content and compacted to 90 percent of the maximum dry unit weight as measured by ASTM D1557.

Prepared soil subgrades should be non-yielding when proof-rolled. If the equipment is lightweight, smaller lifts may be required to provide a non-yielding surface for the placement of fill. Moisture conditioning of subgrade soils should consist of adding water if the soils are too dry and allowing the soils to dry if the soils are too wet. After the subgrades have been prepared, the areas may be raised to design grades by the placement of engineered fill.

If unstable, wet, or soft soil is encountered, the soil will require processing before compaction can be achieved. When the construction schedule does not allow for air-drying, other means such as lime or cement treatment, over-excavation and replacement, geotextile fabrics, etc. may be considered to help stabilize the subgrade. The method to be used should be determined at the time of construction based on the actual site conditions. We recommend obtaining unit prices for subgrade stabilization during the construction bid process.

5.2.5. Material for Engineered Fill

In general, on-site soils with an organic content of less than 3 percent by weight, free of any hazardous or deleterious materials, and meeting the gradation requirements below may be used as general engineered fill to achieve project grades, except when special material (such as aggregate base or subbase material) is required.

In general, engineered fill material should not contain rocks or lumps larger than 3 inches in greatest dimension, should not contain more than 15 percent of the material larger than 1½ inches, and should contain at least 20 percent passing the No. 200 sieve. Due to the presence of side cast fill, import fill is not anticipated.

5.2.6. Engineered Fill Placement and Compaction

Engineered fill should be placed on soil subgrades that are prepared as recommended in this report. Engineered fill should be placed in horizontal lifts each not exceeding 8 inches in thickness and mechanically compacted to the recommendations below at the recommended moisture content. Relative compaction or compaction is defined as the in-place dry density of the compacted soil divided by the laboratory maximum dry density as determined by ASTM Test Method D1557, latest edition, expressed as a percentage. Moisture conditioning of soils should consist of adding water to the soils if they are too dry and allowing the soils to dry if they are too wet.

Engineered fills consisting of on-site soils and imported soils should be compacted to a minimum of 90 percent relative compaction with moisture content about 1 to 3 percent above the laboratory optimum value.

5.2.7. Trench Excavation and Backfill (Not anticipated to be needed)

Trenches less than 4 feet in depth in the near-surface soil materials should be able to stand near vertical in weathered bedrock. In areas where the bedrock has completely weathered to a sand, bracing may be needed to reduce raveling/caving of the granular soils. Based on the emergency grading, we estimate that excavations should be able to be accomplished with conventional excavating equipment, such as backhoes and excavators. Excavations should be constructed in accordance with the current CAL-OSHA safety standards and local jurisdiction. The stability and safety of excavations, braced or unbraced, are the responsibility of the contractor.

Pipe zone backfill, extending from the bottom of the trench to about 1 foot above the top of the pipe, should consist of free-draining sand (at least 90% passing a No. 4 sieve and less than 5% passing a No. 200 sieve) compacted to a minimum of 90 percent relative compaction unless concrete or cement slurry is specified.

Above the pipe zone, underground utility trenches may be backfilled with free-draining sand, on-site soil, or imported soil that is free of deleterious and hazardous material. The trench backfill should be compacted to the requirements given in Section 5.2.6, "Engineered Fill Placement and Compaction." Trench backfill should be capped with at least 12 inches of compacted, on-site soil similar to that of the adjoining subgrade. The upper 12 inches of trench backfill in areas to be paved should be compacted to a minimum of 95 percent relative compaction. Compaction should be performed by mechanical means only. Water jetting or flooding to attain compaction of backfill should not be permitted.

5.2.8. Wet Weather Construction

If site grading and construction are to be performed during the rainy winter months, the owner and contractors should be fully aware of the potential impact of wet weather. Rainstorms can cause delays to construction and damage to previously completed work by saturating compacted pads or subgrades, or flooding excavations.

Earthwork during rainy months will require extra effort and caution by the contractors. The grading contractor should be responsible for protecting their work to avoid damage by rainwater. Standing pools of water should be pumped out immediately. Construction during wet weather conditions should be addressed in the project construction bid documents and/or specifications. We recommend the grading contractor submit a wet weather construction plan outlining procedures they will employ to protect their work and to minimize damage to their work by rainstorms.

5.3. REINFORCED SLOPES AND RETAINING WALLS

CE&G will need to provide final design parameters when the alignment is determined. CE&G has already performed preliminary analyses using the following design values:

- PGA=0.48 g (10 percent chance of exceedance in 50 years.

- Active equivalent fluid earth pressure of 34 pcf for level backfill and 48 pcf for 2:1 (horizontal:vertical) backfill based on a friction angle of 35 degrees for weathered bedrock-derived soils.

- Walls taller than 6 feet will require a seismic increment. We recommend checking global stability for seismic conditions to address external stability along with adding 15 pcf to the recommended active pressure equivalent fluid pressures for the retaining wall design calculations.

- Soil resistance to lateral loads will be provided by passive pressures acting against twice the width of the CIDH piers. An allowable passive lateral bearing pressure equal to an equivalent fluid pressure of 200 psf/ft for piers located on a descending slope.

For piers constructed within 10 feet of slopes, the active pressure should be extended to the lesser of the depth of bedrock or 5 feet. Passive pressure should begin below the depth of active pressure. Where loads are extended below ground and below a footing or lagging, the active pressure can be applied on one pile diameter.

Concrete should be placed only in excavations that are clean and free of loose soils or debris. Foundation excavations should be maintained in a moist condition before the placement of concrete. A member of our staff should observe foundation excavations to verify that adequate foundation-bearing soils have been reached.

5.4. SURFACE DRAINAGE

The proposed grading should be designed to promote sheet flow. Sheet flow will reduce the potential for concentrated flows resulting in damage to downslope improvements. Additionally, positive drainage should be maintained to provide for the rapid removal of surface water runoff. Ponding of water in the vicinity of the slope should be avoided.

5.5. IMPEDIMENTS TO FINAL DESIGN

For our work, CE&G was provided with an existing AutoCAD file of a survey along the Foreman Intake trail. The survey is not adequate for the preparation of plans for the following reasons:

- The survey does not extend sufficiently upslope and downslope of the pioneered tral;

- The survey uses an assumed datum and only includes a single control point. This is inadequate to locate the survey in California coordinates. (Our figure represents our best efforts to locate the surveyed trail on California coordinates to leverage existing publicly available Lidar data covering the area.)

It will be necessary to develop a proper base map on California coordinates with three or more control points for the creation of an alignment to locate proposed improvements. The baseman should include the location of the recently installed waterline.

5.6. TECHNICAL REVIEW AND CONSTRUCTION OBSERVATION

During the design process, CE&G, the geotechnical engineer, should be kept informed of the design and design process to make suggestions to the design and/or add supplemental recommendations, if needed. At the completion of the design, CE&G should review the project plans and specifications for conformance with the intent of the recommendations presented in this report and any future addenda. The geotechnical engineer should be contacted a minimum of 48 hours in advance of excavation operations to observe the subsurface conditions.

6. LIMITATIONS

The conclusions and recommendations presented in this report are based on the information provided regarding the proposed project, and the results of the site reconnaissance, geologic mapping, subsurface exploration, and laboratory testing, combined with interpolation of the subsurface conditions between boring locations. Site conditions described in the text of this report are those existing at the time of our last field reconnaissance and are not necessarily representative of the site conditions at other times or locations. This information notwithstanding, the nature and extent of subsurface variations between borings may not become evident until construction. If variations are encountered during construction, Cal Engineering & Geology, Inc. should be notified promptly so that conditions can be reviewed, and recommendations reconsidered, as appropriate.

It is the Owner's/Client's responsibility to ensure that recommendations contained in this report are carried out during the construction phases of the project. This report was prepared based on preliminary design information provided which is subject to change during the design process.

The findings of this report should be considered valid for a period of three years unless the conditions of the site change. After a period of three years, CE&G should be contacted to review the site conditions and prepare a letter regarding the applicability of this report.

This report presents the results of a geotechnical and geologic investigation only and should not be construed as an environmental audit or study.

The conclusions and recommendations contained in this report are valid only for the project described in this report. We have employed accepted geotechnical engineering procedures, and our professional opinions and conclusions are made in accordance with generally accepted geotechnical engineering principles and practices. This standard is in lieu of all other warranties, either expressed or implied.

7. REFERENCES

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Brabb, E.E., and others, 1997, Geologic map of Santa Cruz County, California: a digital database: U.S. Geological Survey Open-File Report 97-489.

California Department of Transportation, (2018), Caltrans fault database and Caltrans ARS online reports and data, http://dap3.dot.ca.gov/ARS_Online/technical.php

Cooper-Clark and Associates, 1975, Preliminary map of landslide deposits in Santa Cruz County, California: unpublished consultants' report to Santa Cruz County Planning Dept. (see Roberts and Baron, 1998).

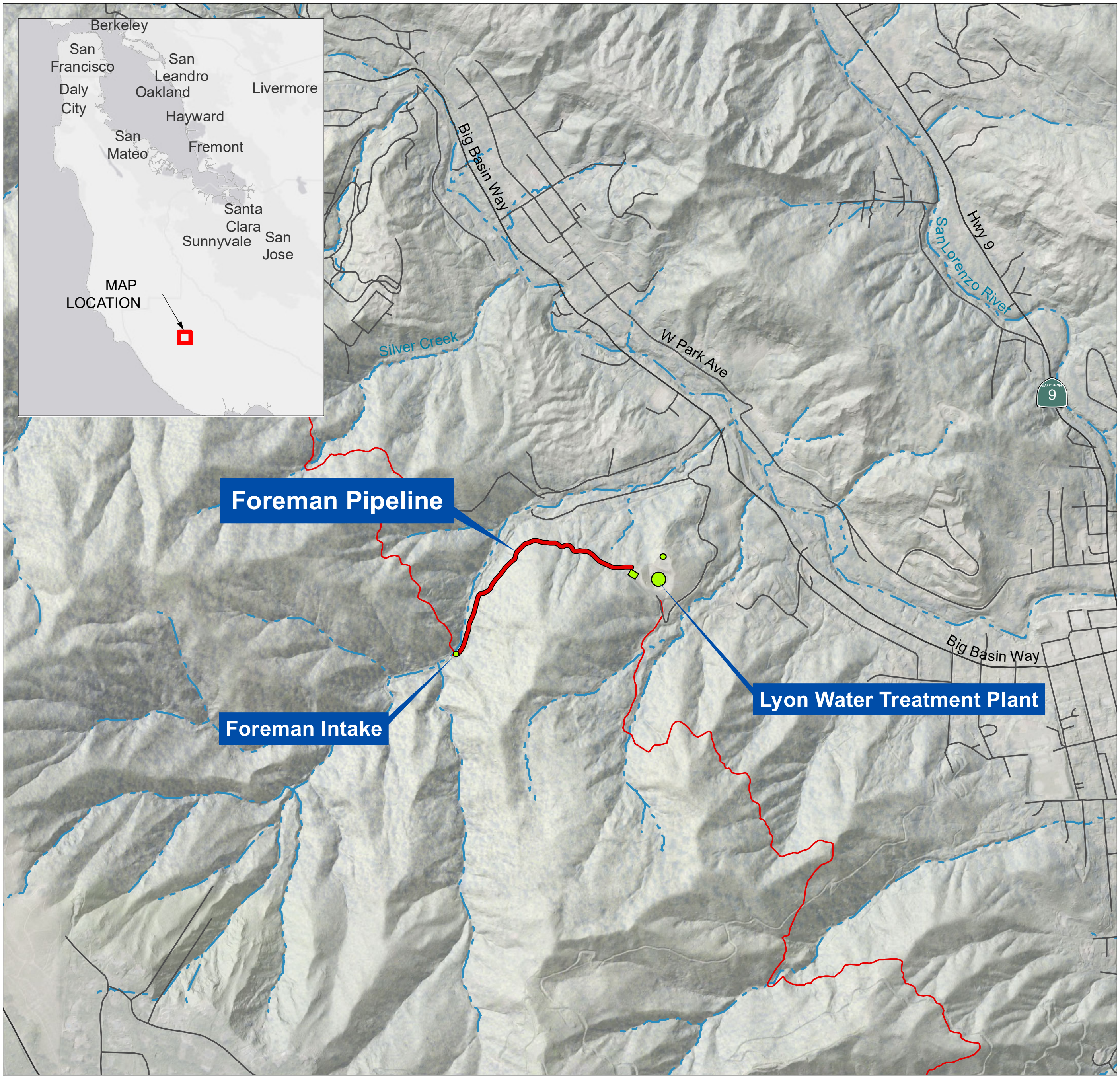
Dupre, William R., 1975, Maps showing geology and liquefaction potential of Quaternary deposits in Santa Cruz County, California: U. S. Geological Survey Miscellaneous Field Studies Map 648, scale 1:62,500.

Graymer, R.W., and 5 others, 2006, Geologic Map of the San Francisco Bay Region. U.S. Geological Survey, Scientific Investigations Map 2918.

U.S. Geological Survey and California Geological Survey, Quaternary fault and fold database for the United States, accessed June 2020, at: https://www.usgs.gov/natural-hazards/earthquake-hazards/faults

Working Group on California Earthquake Probabilities (WGCEP), 2014, Published as Field, E.H., Biasi, G.P., Bird, P., Dawson, T.E., Felzer, K.R. Jackson, D.D., Johnson, K.M., Jordan, T.H., Madden, C. Michael, A.J., Milner, K.R., Page, M.T., Parsons, T., Powers, P.M., Shaw, B.E., Thatcher, W.R., Weldon, R.J. II, and Zeng, Y., 2015, Long-term, time-dependent probabilities for the third uniform California earthquake rupture forecast (UCERF3), Bulletin of the Seismological Society of America. —Authors: Edward H. Field and members of the 2014 WGCEP

Figures



BASEMAP REFERENCE

1. STREET CENTERLINES FROM CALTRANS CALIFORNIA ROAD SYSTEM, DOWNLOADED ON 18 FEB 2020.
2. ORTHOIMAGERY FROM ESRI (MAXAR), 2017.

N

0 0.125 0.25 0.5
MILES

MAP UNIT DESCRIPTION

Foreman Segment Pipe Alignment by CE&G (DRAFT as on 9/28/2021), digitized over slopeshade raster (2018-2020 Lidar)

Remaining part of the 5-mile long Pipe Alignment by CE&G (DRAFT as on 9/28/2021), digitized over slopeshade raster (2018-2020 Lidar)

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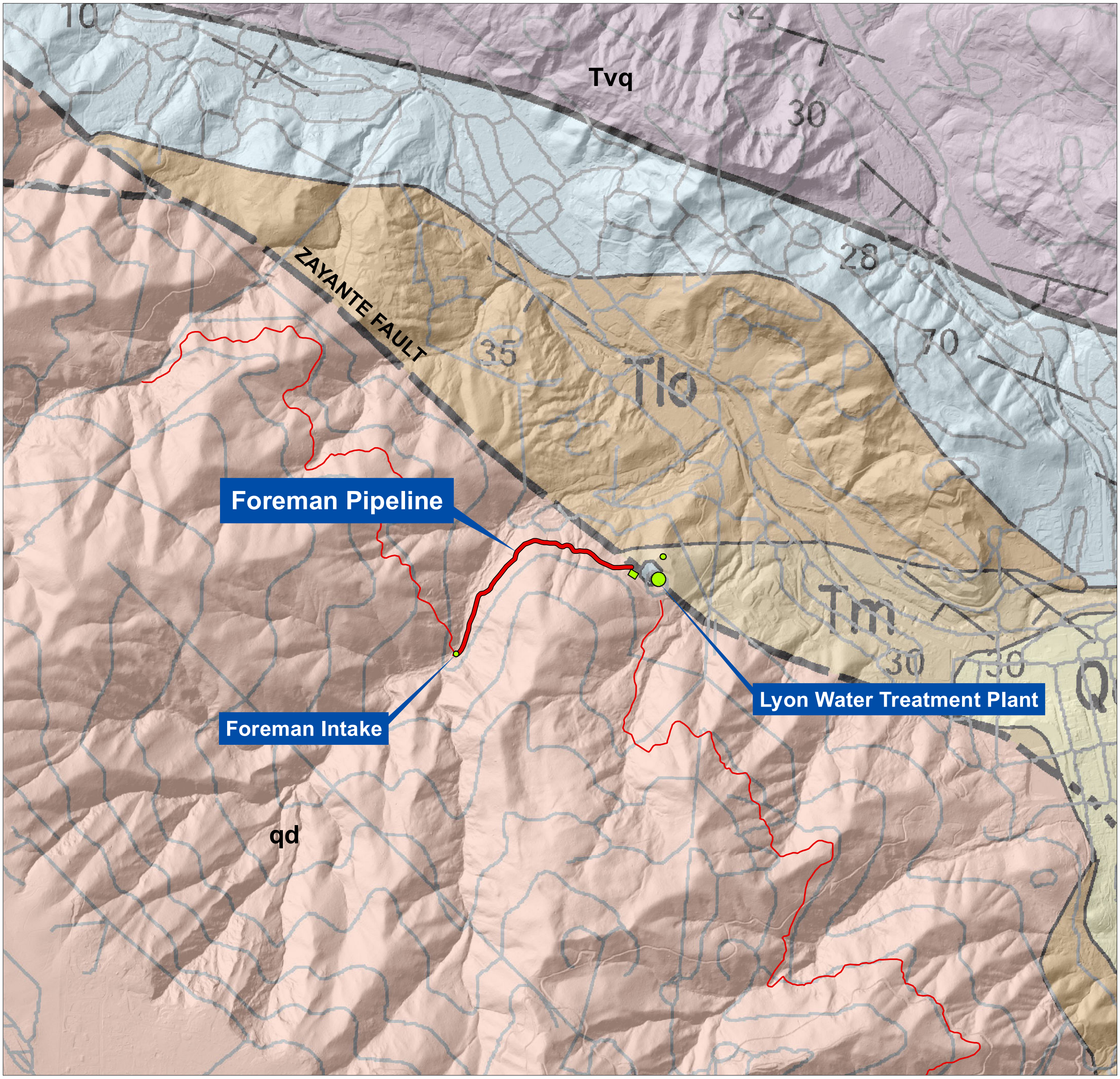
Walnut Creek, CA, 94596
www.caleng.com
Phone: (925) 935-9771

SAN LORENZO VALLEY WATER - FOREMAN INTAKE
SANTA CRUZ COUNTY
CALIFORNIA

SITE LOCATION MAP

210450	OCTOBER 2021	FIGURE 1

M:\2021\210460-FreyerLaureta-SLVWDCrossCountryPipelineStudy\GIS\ArcGIS\210450-Fig1-SiteLocation.mxd; 10/28/2021; kdrozynska



BASEMAP REFERENCE

1. REGIONAL GEOLOGY FROM BRABB, 1997.

N

0 0.125 0.25 0.5
MILES

MAP UNIT DESCRIPTION

Qal	ALLUVIAL DEPOSITS, UNDIFFERENTIATED (HOLOCENE)	Tvq	VAQUEROS SANDSTONE (LOWER MIOCENE AND OLIGOCENE)
Tm	MONTEREY FORMATION (MIDDLE MIOCENE)	Tbu	BUTANO SANDSTONE (EOCENE) UPPER SANDSTONE MEMBER
Tlo	LOMPICO SANDSTONE (MIDDLE MIOCENE)	qd	QUARTZ DIORITE (CRETACEOUS)

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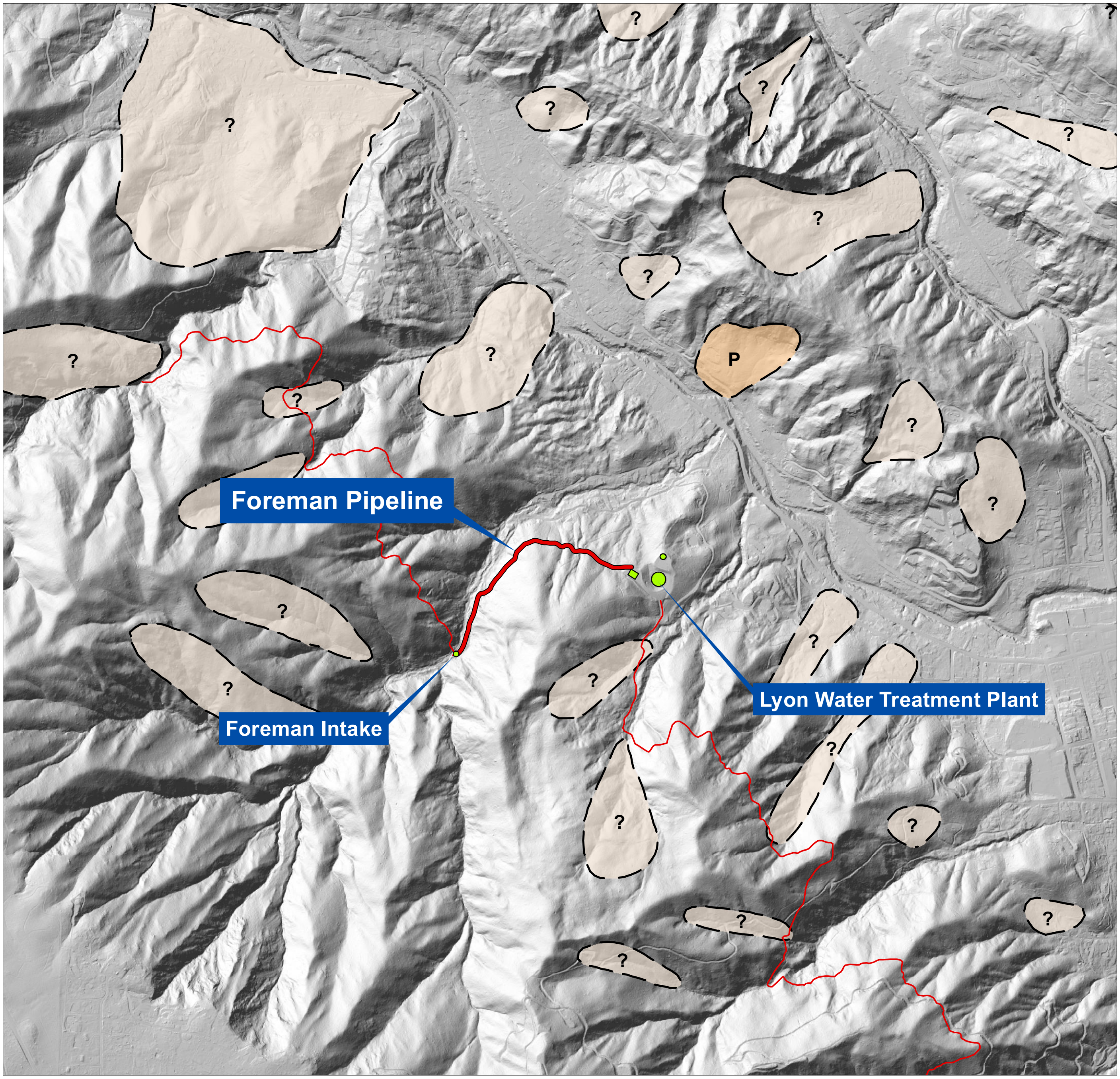
REGIONAL GEOLOGY MAP

210450	OCTOBER 2021	FIGURE 2

M:\2021\210460-FreyerLaureta-SLVWDCrossCountryPipelineStudy\GIS\ArcGIS\210450-Fig2-GeologyBrabb.mxd; 10/28/2021; kdrozynska



BASEMAP REFERENCE

1. LANDSLIDE MAPPING FROM COOPER-CLARK & ASSOCIATES, 1975.

N

0 0.125 0.25 0.5
MILES

MAP UNIT DESCRIPTION

Large Landslides:

- D — Definite Landslide Deposit
- DR — Definite Rapid Landslide Deposit
- P — Probable Landslide Deposit
- ? — Questionable Landslide Deposit
- Unattributed Landslide Deposit

Small Landslides:

- D - Definite Landslide Deposit
- DR - Definite Rapid Landslide Deposit
- ? - Questionable Landslide Deposit

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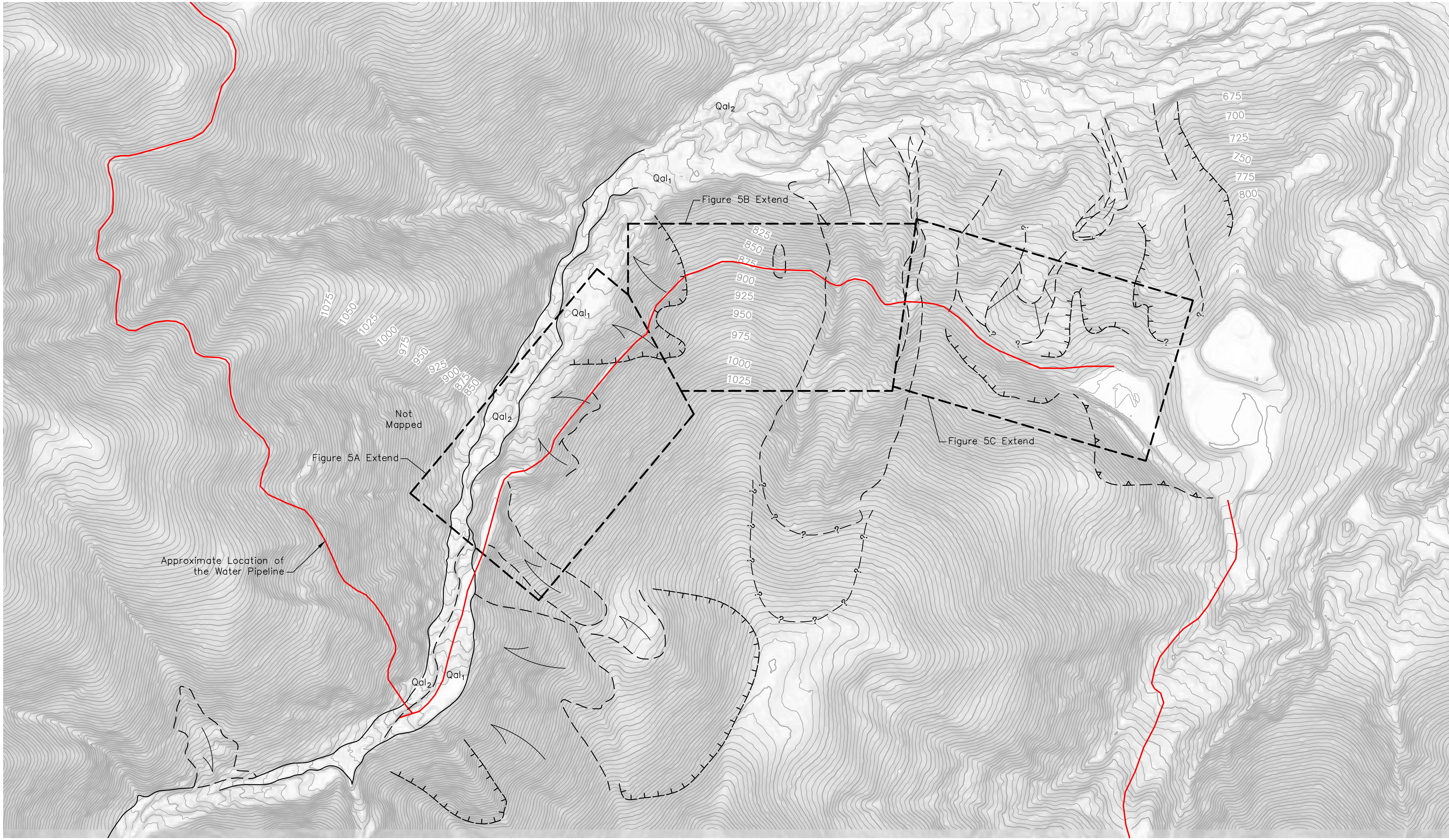
LANDSLIDE FEATURES

210450	OCTOBER 2021	FIGURE 3

M:\2021\210460-FreyerLaureta-SLVWDCrossCountryPipelineStudy\GIS\ArcGIS\210450-Fig3-Landslide.mxd; 10/28/2021; kdrozynska



REFERENCES

1. GEOLOGY MAPPING BY R. FISHER ON 10/8/2021.
2. 5-FTCONTOURS DERIVED FROM 2018-2020 COUNTY LIDAR DATA.
3. SLOPESHADE DERIVED FROM 2018-2020 COUNTY LIDAR DATA.

100 0 100 200
SCALE FEET

N

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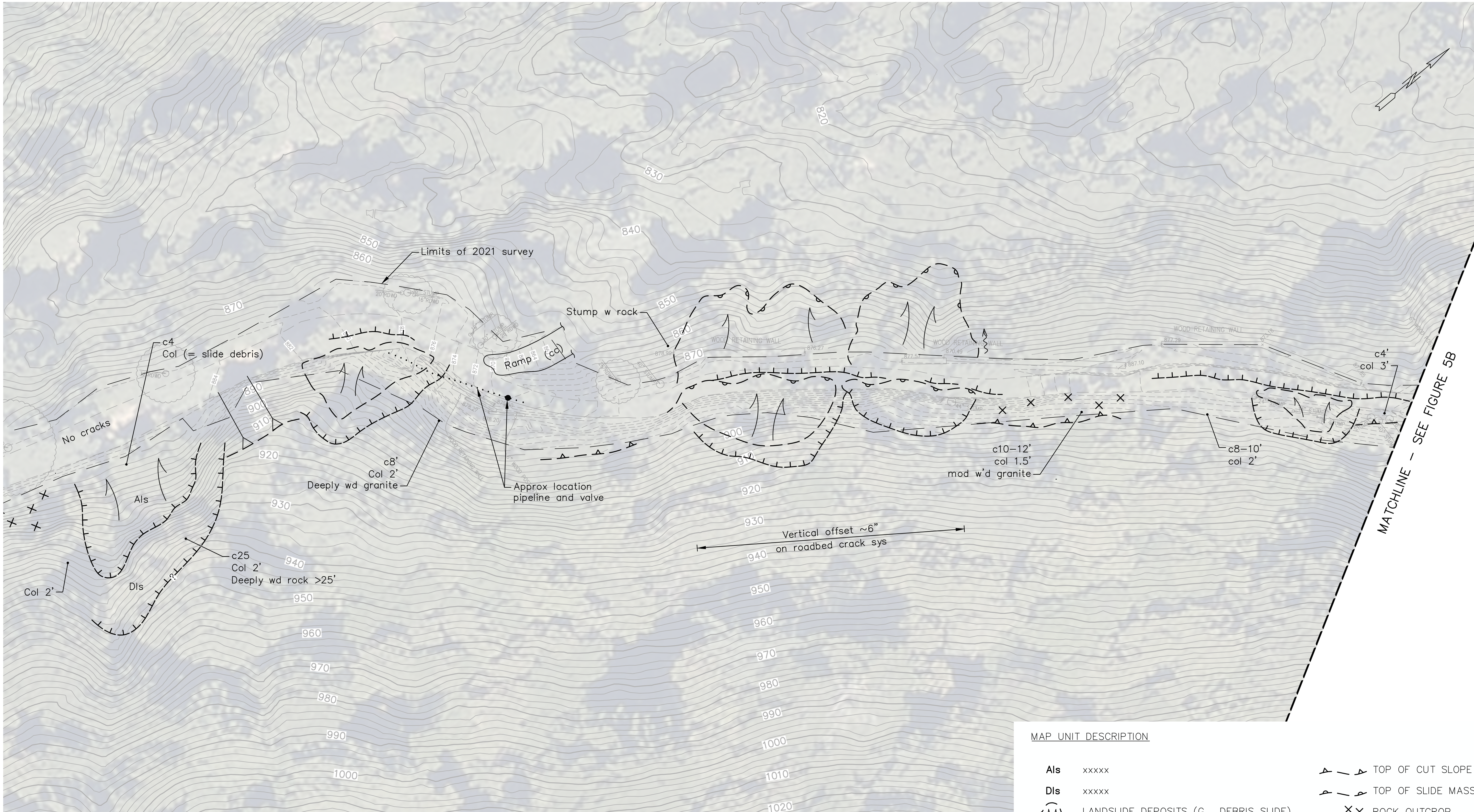
PRELIMINARY GEOMORPHOLOGY MAP

210450	OCTOBER 2021	FIGURE 4



MAP UNIT DESCRIPTION

Als	xxxxx
Dls	xxxxx
	LANDSLIDE DEPOSITS (G... DEBRIS SLIDE)
	TENSION CRACKS OR TOP OF SCARP
	TOP OF CUT SLOPE
	TOP OF SLIDE MASS
	ROCK OUTCROP
	XXXX

REFERENCES

1. SURVEY FOR "LITTLE LYON TANK TO BIG STEEL TANK TOPOGRAPHIC SURVEY" BY SANDIS, DATED 09/18/2020, CAD FILE RECEIVED ON 8/12/2021.
2. SUPPLEMENTAL CONTOURS DERIVED FROM 2018–2020 COUNTY LIDAR DATA.
3. ORTHOIMAGERY FROM SANTA CRUZ COUNTY, 2016.
4. SURVEY FILE WAS PREPARED IN ASSUMED COORDINATE SYSTEM; HENCE SUPPLEMENTAL CONTOURS AND ORTHOIMAGERY OVERLAY IS APPROXIMATE.

20 0 20 40
SCALE FEET

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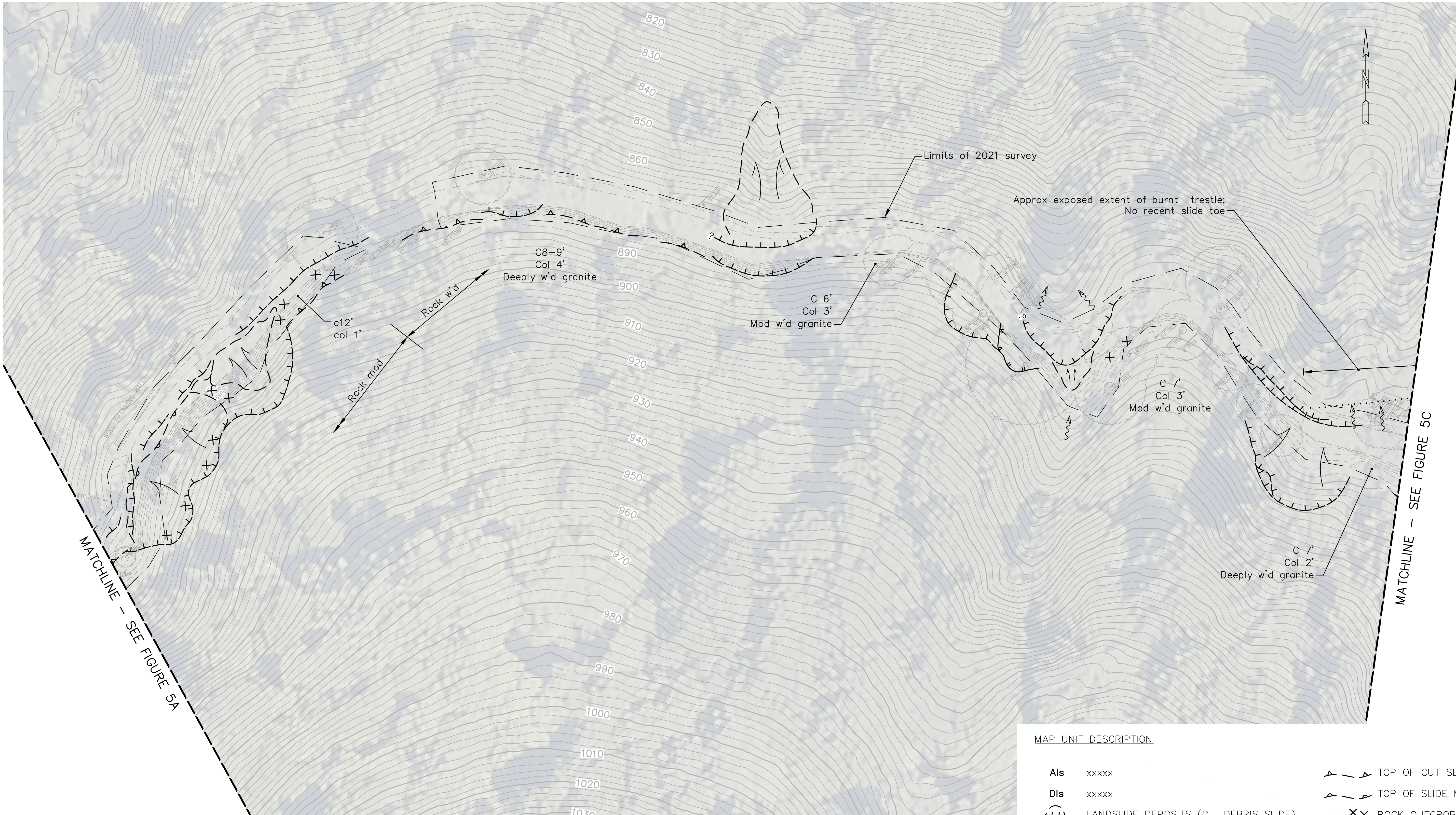
SITE PLAN (1 OF 3)

210450	OCTOBER 2021	FIGURE 5A



MAP UNIT DESCRIPTION

Als	xxxxx
Dls	xxxxx
	LANDSLIDE DEPOSITS (G... DEBRIS SLIDE)
	TENSION CRACKS OR TOP OF SCARP
	TOP OF CUT SLOPE
	TOP OF SLIDE MASS
	ROCK OUTCROP
	XXXX

REFERENCES

1. SURVEY FOR "LITTLE LYON TANK TO BIG STEEL TANK TOPOGRAPHIC SURVEY" BY SANDIS, DATED 09/18/2020, CAD FILE RECEIVED ON 8/12/2021.
2. SUPPLEMENTAL CONTOURS DERIVED FROM 2018–2020 COUNTY LIDAR DATA.
3. ORTHOIMAGERY FROM SANTA CRUZ COUNTY, 2016.
4. SURVEY FILE WAS PREPARED IN ASSUMED COORDINATE SYSTEM; HENCE SUPPLEMENTAL CONTOURS AND ORTHOIMAGERY OVERLAY IS APPROXIMATE.

SCALE 20 0 20 40 FEET

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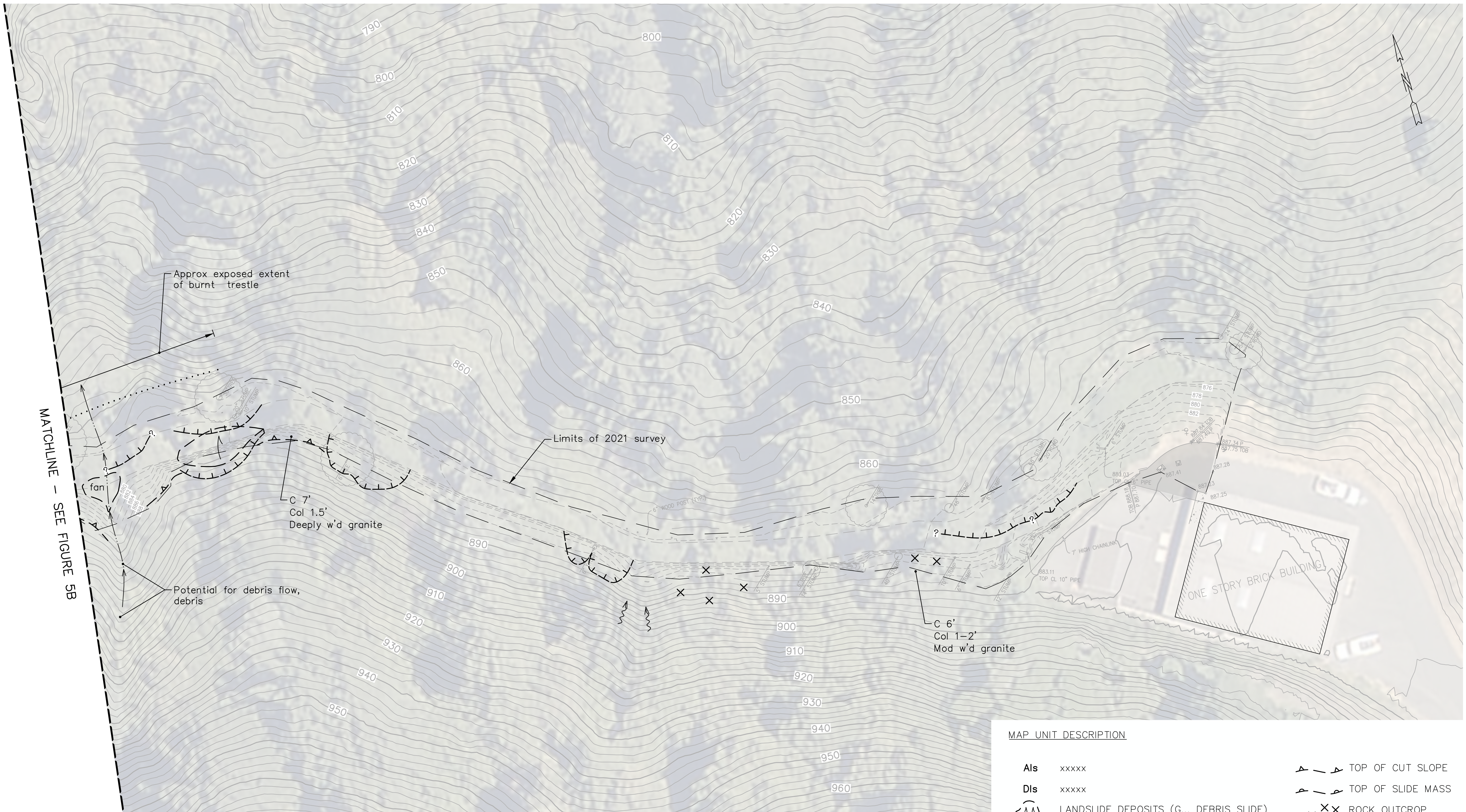
SITE PLAN (2 OF 3)

210450	OCTOBER 2021	FIGURE 5B



MAP UNIT DESCRIPTION

Als xxxxx
Dls xxxxx
LANDSLIDE DEPOSITS (G... DEBRIS SLIDE)
TENSION CRACKS OR TOP OF SCARP
TOP OF CUT SLOPE
TOP OF SLIDE MASS
ROCK OUTCROP
XXXX

REFERENCES

1. SURVEY FOR "LITTLE LYON TANK TO BIG STEEL TANK TOPOGRAPHIC SURVEY" BY SANDIS, DATED 09/18/2020, CAD FILE RECEIVED ON 8/12/2021.
2. SUPPLEMENTAL CONTOURS DERIVED FROM 2018–2020 COUNTY LIDAR DATA.
3. ORTHOIMAGERY FROM SANTA CRUZ COUNTY, 2016.
4. SURVEY FILE WAS PREPARED IN ASSUMED COORDINATE SYSTEM; HENCE SUPPLEMENTAL CONTOURS AND ORTHOIMAGERY OVERLAY IS APPROXIMATE.

20 0 20 40
SCALE FEET

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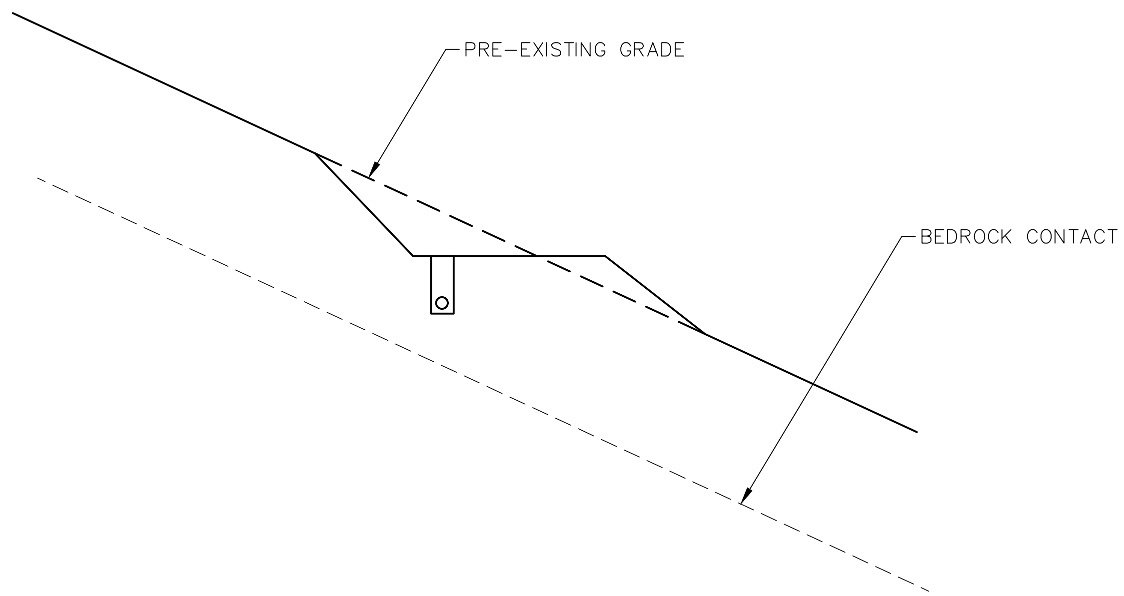
CALIFORNIA

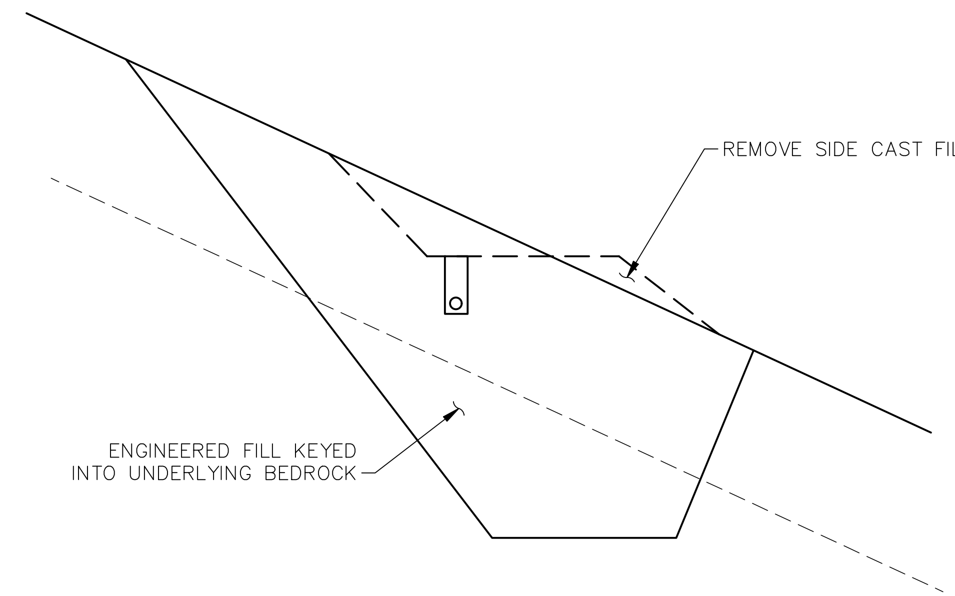
SITE PLAN (3 OF 3)

210450	OCTOBER 2021	FIGURE 5C



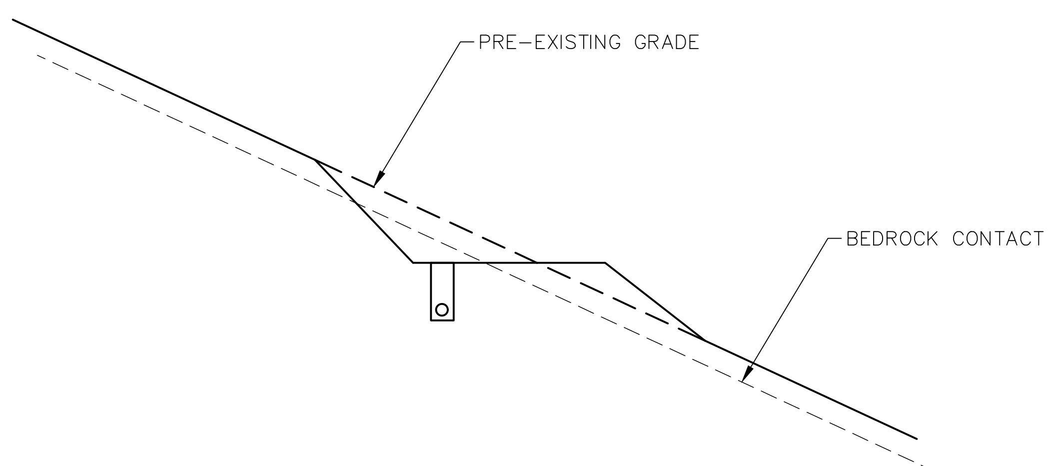
EXISTING CONDITIONS - DEEP SOIL PROFILE

NOT TO SCALE



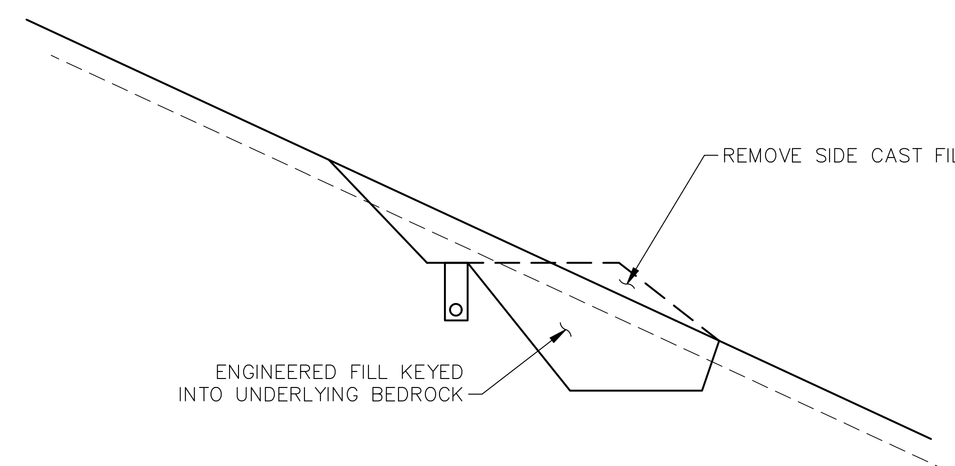
ALTERNATIVE 1 - DEEP SOIL PROFILE

NOT TO SCALE



EXISTING CONDITIONS - SHALLOW SOIL PROFILE

NOT TO SCALE



ALTERNATIVE 1 - SHALLOW SOIL PROFILE

NOT TO SCALE

DECRIPTION OF ALTERNATIVE

ALTERNATIVE 1 CONSISTS OF REBUILDING THE SLOPE USING ENGINEERED FILL KEYED INTO THE UNDERLYING BEDROCK.

COMMENTS

1. ALTERNATIVE 1 IS NOT FEASIBLE IN LOCATIONS WHERE DEEPER EXISTING SOILD EXIST BECAUSE THE KEYWAY EXCAVATION WOULD EXTEND INTO AND BEYOND THE RECENTLY INSTALLED PIPELINE.

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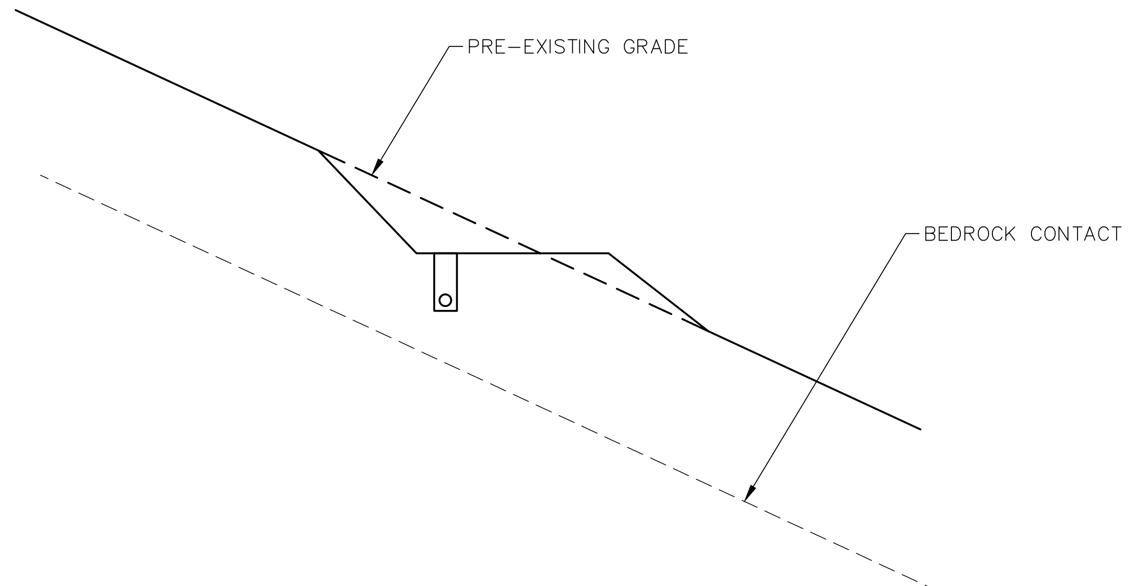
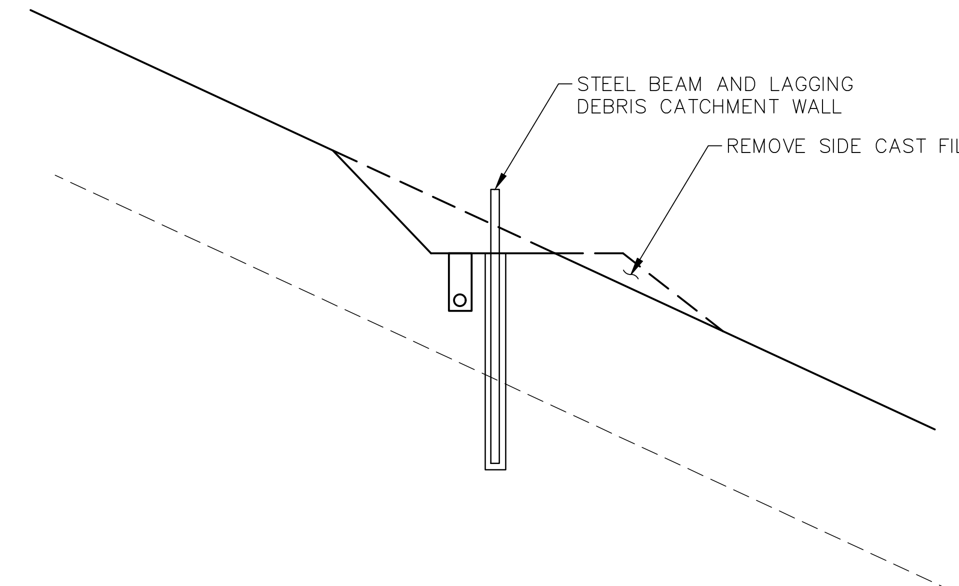
ALTERNATIVE 1

210450	OCTOBER 2021	FIGURE 6A



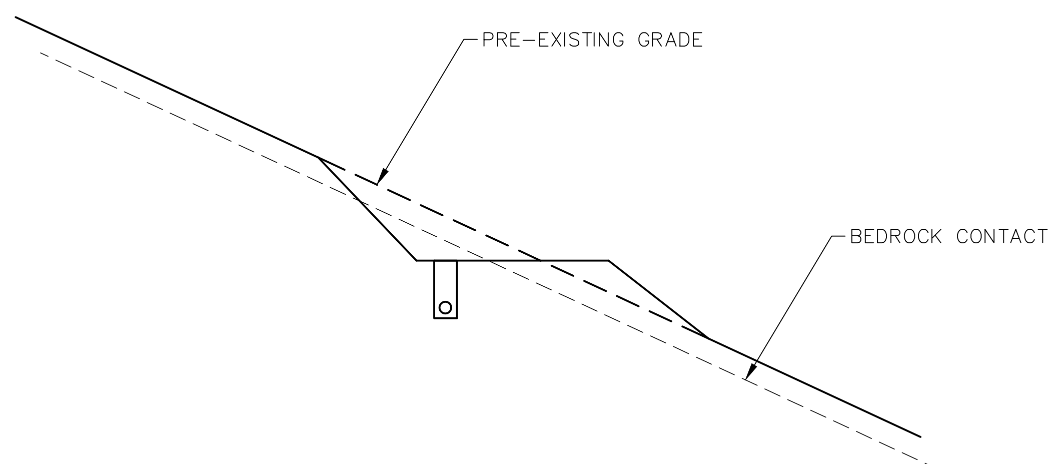
EXISTING CONDITIONS - DEEP SOIL PROFILE

NOT TO SCALE



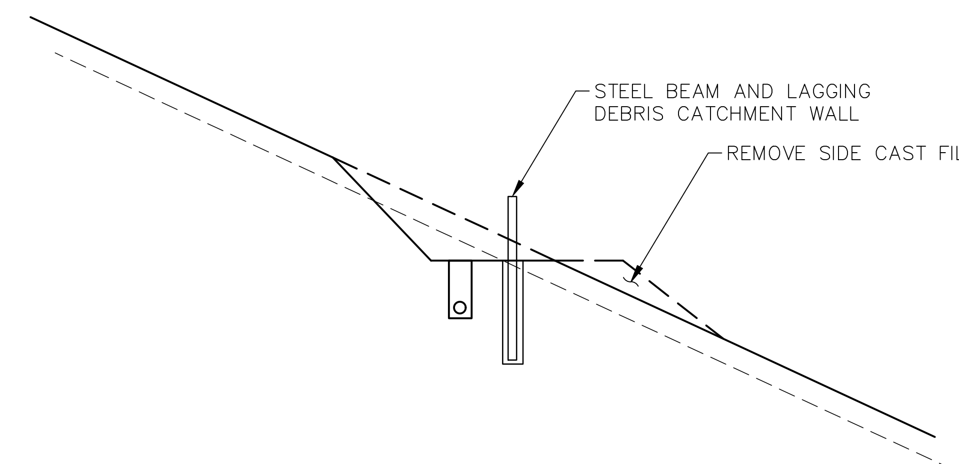
ALTERNATIVE 2 - DEEP SOIL PROFILE

NOT TO SCALE



EXISTING CONDITIONS - SHALLOW SOIL PROFILE

NOT TO SCALE



ALTERNATIVE 2 - SHALLOW SOIL PROFILE

NOT TO SCALE

DESCRIPTION OF ALTERNATIVE

ALTERNATIVE 2 CONSISTS OF REMOVAL OF SIDE CAST FILL AND THE INSTALLATION OF A STEEL BEAM AND LAGGING WALL DEBRIS CATCHMENT WALL.

COMMENTS

1. THE PILE DEPTHS WILL BE DEEPER IN AREAS OF DEEP SOIL WHEN COMPARED TO SHALLOW SOIL CONDITIONS.
2. SOME MAINTENANCE WILL BE REQUIRED TO REMOVE DEBRIS FOLLOWING RAVELING OF THE CUT OR POSSIBLY DEBRIS FLOWS FROM HIGHER UP THE SLOPE.

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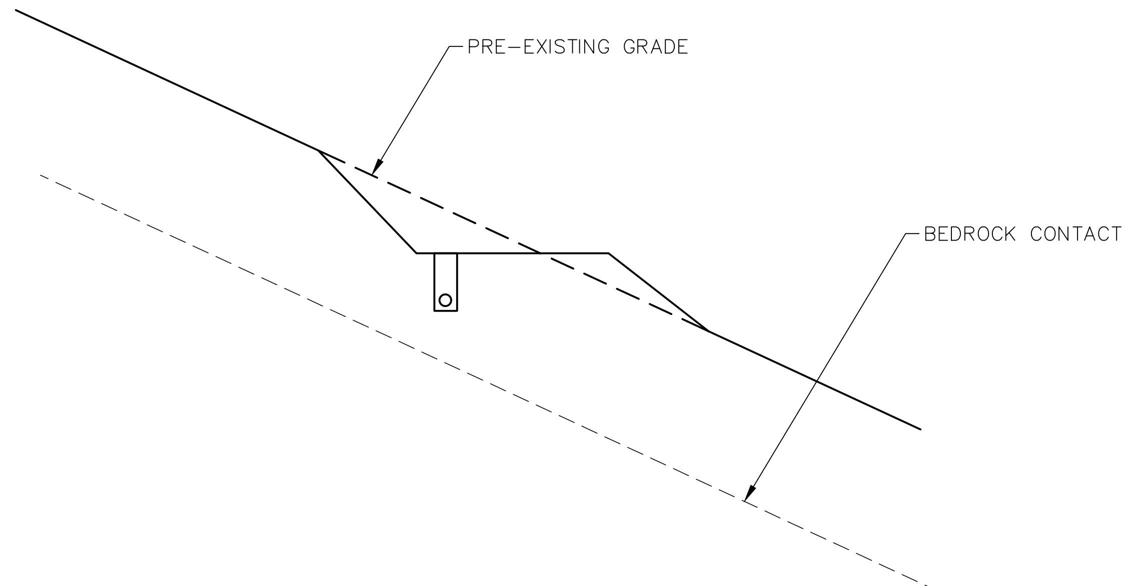
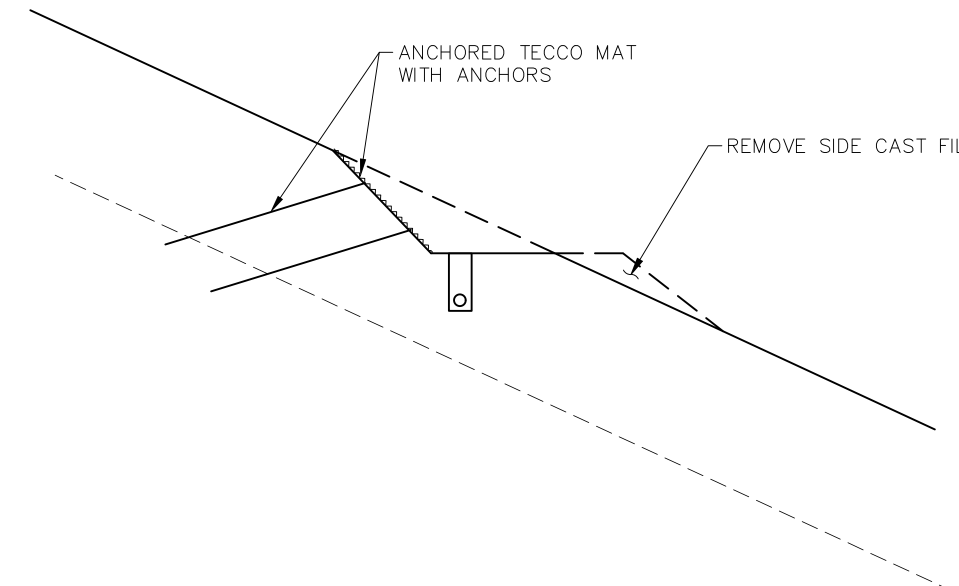
ALTERNATIVE 2

210450	OCTOBER 2021	FIGURE 6b



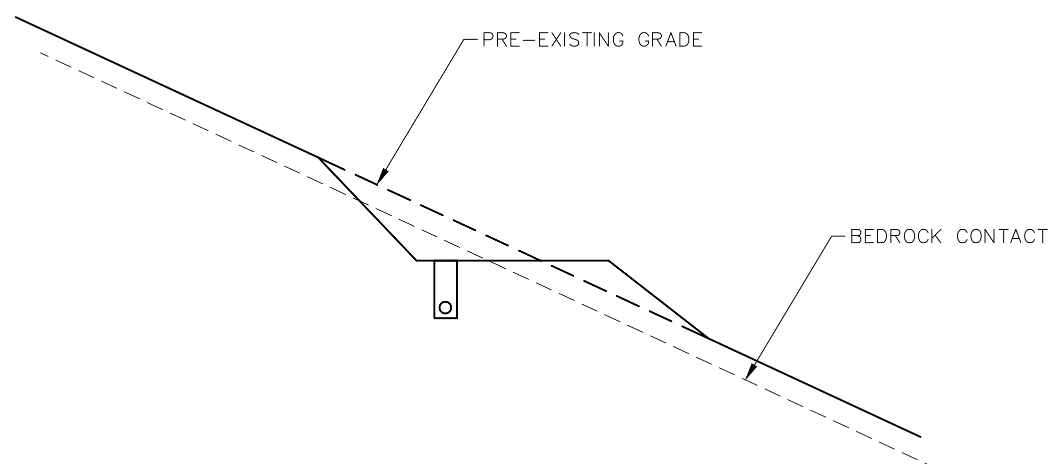
EXISTING CONDITIONS - DEEP SOIL PROFILE

NOT TO SCALE



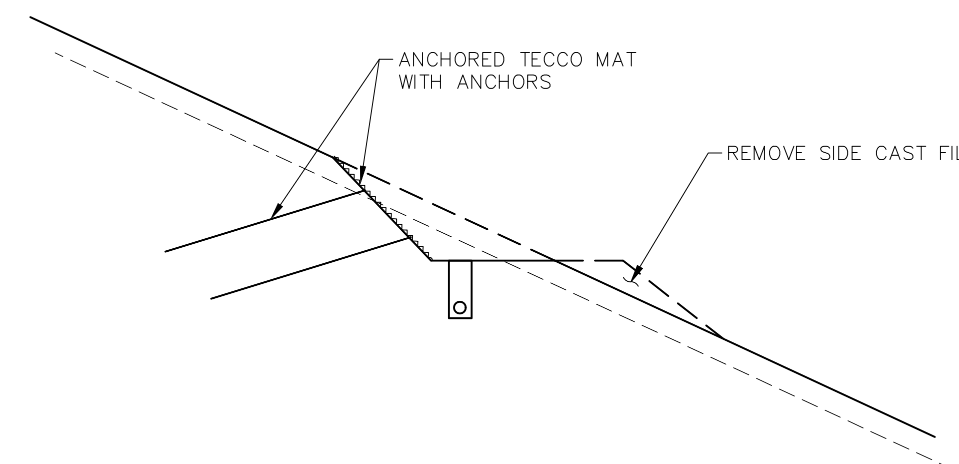
ALTERNATIVE 3 - DEEP SOIL PROFILE

NOT TO SCALE



EXISTING CONDITIONS - SHALLOW SOIL PROFILE

NOT TO SCALE



ALTERNATIVE 3 - SHALLOW SOIL PROFILE

NOT TO SCALE

DECRIPTION OF ALTERNATIVE

ALTERNATIVE 3 CONSISTS OF REMOVAL OF SIDE CAST FILL AND THE INSTALLATION OF ANCHORED TECCO MAT ON THE CUT SLOPE TO STABILIZE THE SLOPE.

COMMENTS

1. THE ANCHORS ARE GROUTED THREADED BARS. THEY CAN BE INSTALLED USING PORTABLE EQUIPMENT.

2. ONCE THE CUT IS STABILIZED THE REMAINING PATH WILL BE FREE OF DEBRIS WITH THE EXCEPTION BEING DEBRIS FLOWS FROM HIGHER UP THE SLOPE.

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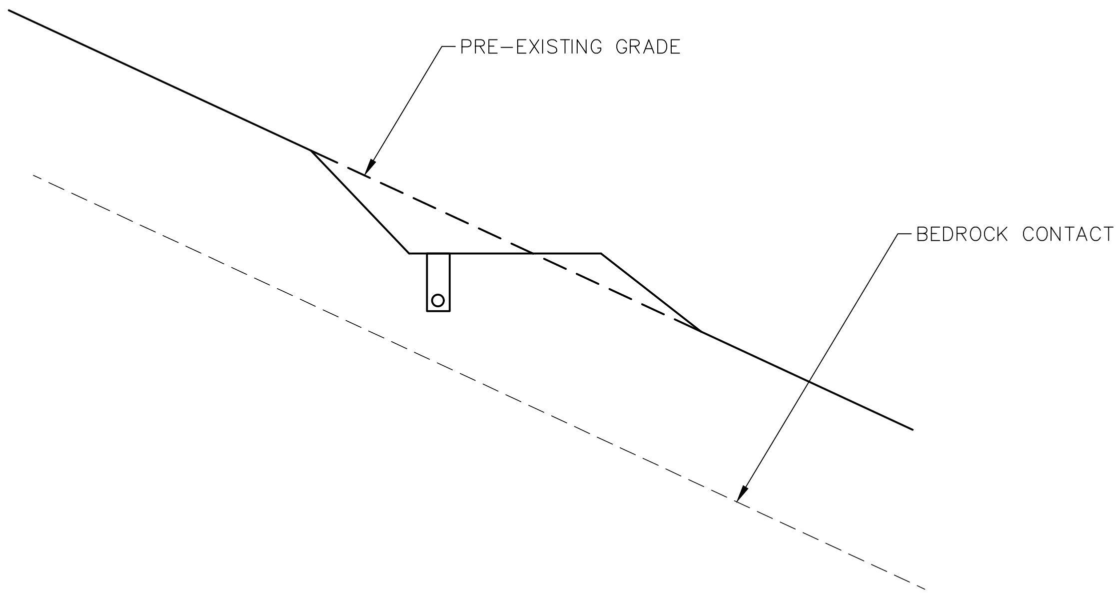
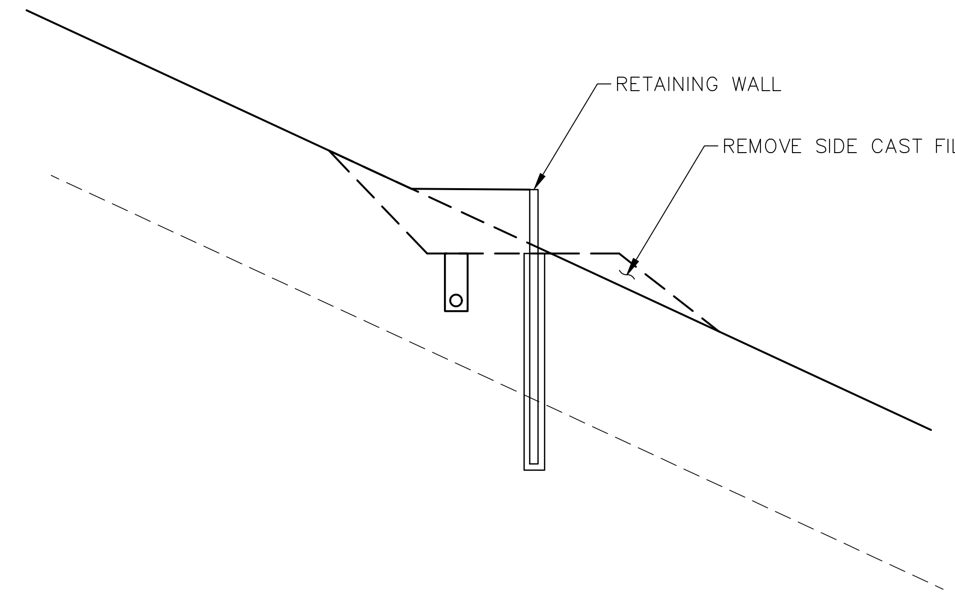
ALTERNATIVE 3

210450	OCTOBER 2021	FIGURE 6C



EXISTING CONDITIONS - DEEP SOIL PROFILE

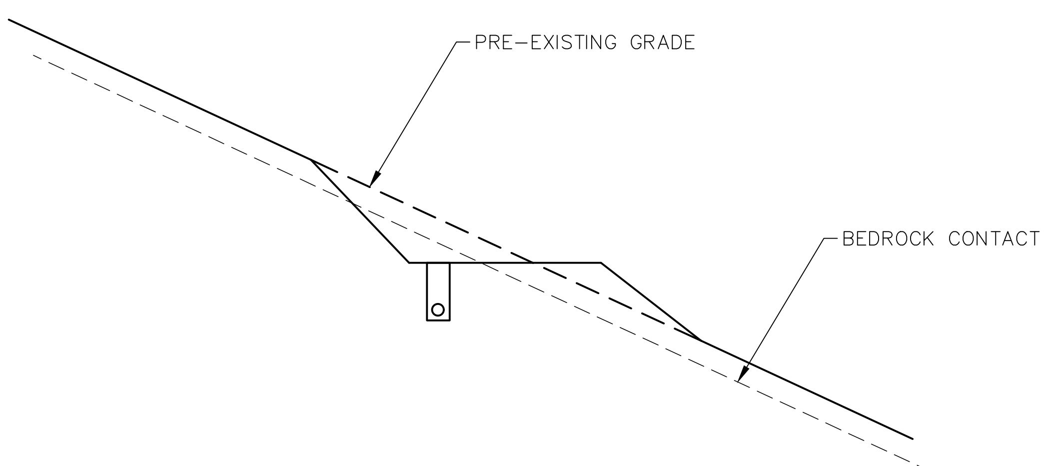
NOT TO SCALE



ALTERNATIVE 4 - DEEP SOIL PROFILE

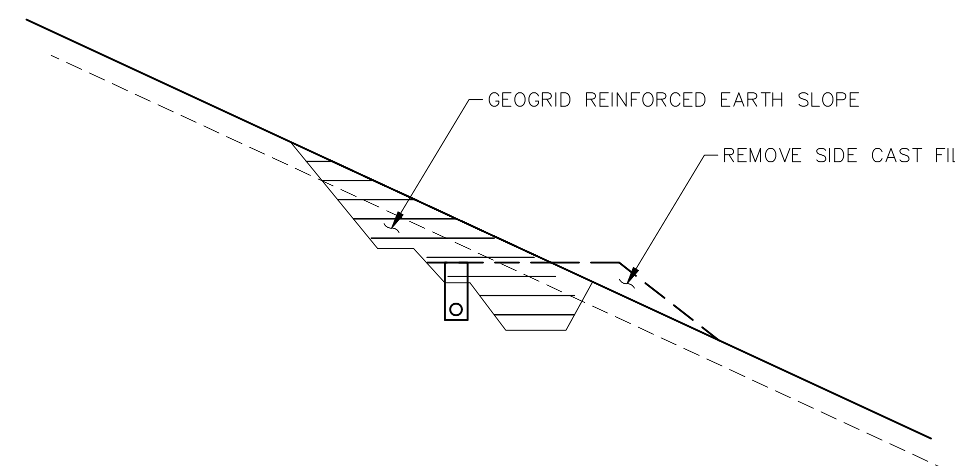
NOT TO SCALE

NOTE:
AT DEEPER SOIL LOCATIONS, DEEPER FOUNDATIONS SHOULD BE USED TO TRANSFER FILL LOADS TO COMPOTENT MATERIALS. THIS EXAMPLE USES A STEEL BEAM AND LAGGING WALL AND MAINTAINS A PATH.



EXISTING CONDITIONS - SHALLOW SOIL PROFILE

NOT TO SCALE



ALTERNATIVE 4 - SHALLOW SOIL PROFILE

NOT TO SCALE

NOTE:
AT SHALLOW SOIL LOCATIONS PILES OR KEYWAYS MAY BE FEASIBLE. THIS EXAMPLE SHOWS A GEOGRID REINFORCED EARTH SLOPE.

DESCRIPTION OF ALTERNATIVE

ALTERNATIVE 4 CONSISTS OF REMOVAL OF SIDE CAST FILL AND THE INSTALLATION OF EITHER A GEOGRID REINFORCED EARTH SLOPE OR RETAINING WALLS OR A COMBINATION OF BOTH ALONG THE ALIGNMENT TO CONSTRUCT A BUTTRESS TO STABILIZE THE CUT SLOPE.

COMMENTS

1. THIS ALTERNATIVE INTENDS TO PLACE THE SIDE CAST FILL ALONG THE PIONEERED ROAD AS ENGINEERED FILL.
2. THIS ALTERNATIVE CAN BE DESIGNED TO MAINTAIN A PATH OR TO RESTORE THE SLOPE.

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ALTERNATIVE 4

210450	OCTOBER 2021	FIGURE 6D

M:\2021\210450–FreyerLaureta–SanLorenzoValleyWater–ForemanIntake\AutoCAD\Figures\Fig6–Conceptual–Sections.dwg 10–28–21 04:17:29 PM kdrozynska

Appendix A. Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

Field Identification			Group Symbols	Typical Names	Laboratory Classification Criteria	
Coarse-Grained Soils More than 50% of material is retained on the No. 200 sieve.	**Gravels** More than 50% coarse fraction retained on the No. 4 sieve	**Clean Gravels** < 5% Fines	**GW**	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_U = D_{60} \div D_{10} \geq 4$ and $C_C = (D_{30})^2 \div (D_{10} \times D_{60}) \geq 1$ & ≤ 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	$C_U = D_{60} \div D_{10} < 4$ and/or $C_C = (D_{30})^2 \div (D_{10} \times D_{60}) < 1$ & > 3	
		Gravels with Fines >12% Fines	**GM**	Silty gravels, poorly graded gravel-sand-silt mixtures	Fines classify as ML or MH	If fines classify as CL-ML, use dual symbol GC/GM
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures	Fines classify as CL or CH	
	Sands More than 50% coarse fraction passes the No. 4 sieve	**Clean Sands** < 5% Fines	**SW**	Well-graded sands, gravelly sands, little or no fines	$C_U = D_{60} \div D_{10} \geq 6$ and $C_C = (D_{30})^2 \div (D_{10} \times D_{60}) \geq 1$ & ≤ 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	$C_U = D_{60} \div D_{10} < 6$ and/or $C_C = (D_{30})^2 \div (D_{10} \times D_{60}) < 1$ & > 3	
		Sands with Fines >12% Fines	**SM**	Silty sands, poorly graded sand-silt mixtures	Fines classify as ML or MH	If fines classify as CL-ML, use dual symbol SC/SM
			SC	Clayey sands, poorly graded sand-clay mixtures	Fines classify as CL or CH	

CLASSIFICATION OF GRAVELS & SANDS WITH 5% TO 12% FINES REQUIRES DUAL SYMBOLS

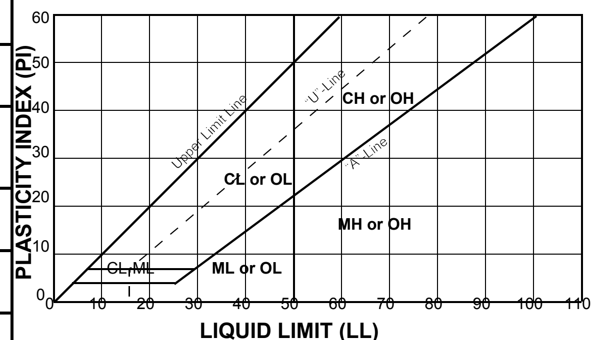
GW/GM or GP/GM: Gravel/Silty Gravel
GW/GC or GP/GC: Gravel/Clayey Gravel
SW/SM or SP/SM: Sand/Silty Sand
SW/SC or SP/SC: Sand/Clayey Sand

Field Identification		Group Symbols	Typical Names
Fine-Grained Soils More than 50% of material passes the No. 200 sieve.	**Identification Procedures on Percentage Passing the No. 40 Sieve**		
	Silts & Clays Liquid Limit less than 50%	**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly, sandy, and/or silty clays, lean clays
		OL	Organic silts, organic silty clays of low plasticity
	Silts & Clays Liquid Limit greater than 50%	**MH**	Inorganic silts, micaceous or diatomaceous fine sandy/-silty soil, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS		**PT**	Peat and other highly organic soils

PLASTICITY CHART

For Classification of Fine-Grained Soils and Fine-Grained Fraction of Coarse-Grained Soils

Equation of "A"-Line: PI = 4 @ LL = 4 to 25.5, then PI = 0.73 × (LL − 20)
Equation of "U"-Line: LL = 16 @ PI = 0 to 7, then PI = 0.9 × (LL − 8)



KEY TO SAMPLER TYPES AND OTHER LOG SYMBOLS

CS	California Standard Sampler
CM	California Modified Sampler
SPT	Standard Penetration Test Sampler
SHL	Shelby Tube Sampler
BU	Bulk Sample
LL	Liquid Limit of Sample (ASTM D-4318)
PI	Plasticity Index of Sample (ASTM D-4318)
Q_U	Unconfined Compression Test (ASTM D-2166)
▽	Depth at which Groundwater was Encountered During Drilling
▼	Depth at which Groundwater was Measured After Drilling
PP	Pocket Penetrometer Test
PTV	Pocket Torvane Test
-#200	% of Material Passing the No. 200 Sieve Test (ASTM D-1140)
PSA	Particle-Size Analysis (ASTM D-422 & D-1140)
C	Consolidation Test (ASTM D-2435)
TXUU	Unconsolidated Undrained Compression Test (ASTM D-2850)

KEY TO SAMPLE INTERVALS

CS	Length of Sampler Interval with a CS Sampler
☒	Length of Sampler Interval with a CM Sampler
	Length of Sampler Interval with a SPT Sampler
SHL	Length of Sampler Interval with a SHL Sampler
BU	Bulk Sample Recovered for Interval Shown (i.e., cuttings)
	Length of Coring Run with Core Barrel Type Sampler
NR	No Sample Recovered for Interval Shown

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UNIFIED SOIL CLASSIFICATION SYSTEM AND KEY TO BORING LOG

Rock Hardness Descriptions

Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimen requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to 1/4-inch deep can be excavated by hard blow of geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16-inch deep by firm pressure of knife or pick point. Can be excavated in small chips to pieces about 1-inch maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small tin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-inch or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Bedding Thickness & Joint/Fracture Spacing Descriptions

Centimeters	Inches	Bedding	Joints/Fractures
< 2	< ¾	Laminated	Extremely Close
2-5	¾-2	Very Thin	Very Close
5-30	2-12	Thin	Close
30-90	12-36	Medium	Moderate
90-300	36-120	Thick	Wide
> 300	> 120	Very Thick	Very Wide

Rock Weathering Descriptions

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very Slight	Rock generally fresh, joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 inch. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dulled and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes "clunk" when struck.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible. But mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil." Rock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers.

The above Bedrock Characteristics are based on the ASCE Manual No. 56, "Subsrface Investigation For Design And Construction Of Foundations Of Buildings," 1976.

KEY TO SYMBOLS

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CLIENT San Lorenzo Valley Water District
PROJECT NAME Foreman Intake, Grading, and Erosion Control
PROJECT NUMBER 210450
PROJECT LOCATION 365 Madrone Drive, Boulder Creek, CA

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

BEDROCK: Bedrock

SM: USCS Silty Sand

SP-SM: USCS Poorly-graded Sand with Silt

SAMPLER SYMBOLS

California Modified Sampler

Standard Penetration Test

WELL CONSTRUCTION SYMBOLS

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)

TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION
▽ Water Level at Time Drilling, or as Shown
▼ Water Level at End of Drilling, or as Shown
▼ Water Level After 24 Hours, or as Shown

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BORING NUMBER B-01

CLIENT San Lorenzo Valley Water District
PROJECT NAME Foreman Intake, Grading, and Erosion Control
PROJECT NUMBER 210450
PROJECT LOCATION 365 Madrone Drive, Boulder Creek, CA
DATE STARTED 8/17/2021 **COMPLETED** 8/17/2021
GROUND ELEVATION 879 ft **DATUM** WGS84 **HOLE SIZE** 4 in.
DRILLING CONTRACTOR Access Soil Drilling
COORDINATES: **LATITUDE** 37.127297 **LONGITUDE** -122.140331
DRILLING RIG/METHOD 4-in. Solid Flight Auger
GROUNDWATER AT TIME OF DRILLING --- Not Encountered
LOGGED BY R. Briseno **CHECKED BY** D. Burger
GROUNDWATER AT END OF DRILLING --- N/A
HAMMER TYPE 140 lb hammer with 30 in. cathead
GROUNDWATER AFTER DRILLING --- N/A

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS (FIELD VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	FINES CONTENT (%)
0		Poorly Graded SAND with Silt and Gravel (SP-SM): brown, dry to moist, loose, fine sand (ARTIFICIAL FILL)									
		Assumed Contact. Poorly Graded SAND with Silt and Gravel (SP-SM) grades to completely weathered bedrock: brown, dry to moist, loose, fine sand (COMPLETELY WEATHERED BEDROCK)	CM	9-8-8		96	7				12
			SPT	5-5-4							
5		GRANITE: brown, dry to moist, weak, friable, very intensely weathered, iron stains along fracture planes, becomes less weathered with depth (BEDROCK)	CM	7-13-15							
			SPT	8-9-11		62	10				
			CM	13-24-32							
10			SPT	8-9-11							
		GRANITE: dry, weak, very intensely weathered to completely weathered to Poorly Graded SAND with Silt	CM	22-25-29			4				6
15			SPT	17-16-17							

Bottom of borehole at 15.0 ft. Borehole backfilled with neat cement grout.

BORING NUMBER B-02

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CLIENT San Lorenzo Valley Water District
PROJECT NAME Foreman Intake, Grading, and Erosion Control
PROJECT NUMBER 210450
PROJECT LOCATION 365 Madrone Drive, Boulder Creek, CA
DATE STARTED 8/17/2021 **COMPLETED** 8/17/2021
GROUND ELEVATION 884 ft **DATUM** WGS84 **HOLE SIZE** 4 in.
DRILLING CONTRACTOR Access Soil Drilling
COORDINATES: LATITUDE 37.127152 **LONGITUDE** -122.140486
DRILLING RIG/METHOD 4-in. Solid Flight Auger
GROUNDWATER AT TIME OF DRILLING --- Not Encountered
LOGGED BY R. Briseno **CHECKED BY** D. Burger
GROUNDWATER AT END OF DRILLING --- N/A
HAMMER TYPE 140 lb hammer with 30 in. cathead
GROUNDWATER AFTER DRILLING --- N/A

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS (FIELD VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	FINES CONTENT (%)
0		Silty SAND (SM): dark brown, moist, very loose, fine sand (ARTIFICIAL FILL)	CM	4-3-2			14	NP	NP	NP	18
			SPT	2-3-8	1.25						
		GRANITE completely weathered to Poorly Graded SAND with Silt and Gravel (SP-SM)	CM	14-7-7							
5		GRANITE completely weathered to Poorly Graded Sand with Silt (SP-SM) to Silty Sand (SM) (WEATHERED BEDROCK) 3-inch granite rock fragment encountered at approximately 5 ft.	SPT	6-4-4			12				21
			CM	9-15-28							
10		GRANITE: greenish brown and brown, dry, weak, friable, very intensely weathered (BEDROCK)	SPT	32-22-25							
		hard	CM	50/3"							
			SPT	50							

Bottom of borehole at 11.8 ft. Borehole backfilled with neat cement grout.

BORING NUMBER B-03

CAL ENGINEERING & GEOLOGY

CLIENT San Lorenzo Valley Water District

PROJECT NAME Foreman Intake, Grading, and Erosion Control

PROJECT NUMBER 210450

PROJECT LOCATION 365 Madrone Drive, Boulder Creek, CA

DATE STARTED 8/17/2021 **COMPLETED** 8/17/2021

GROUND ELEVATION 879 ft **DATUM** WGS84 **HOLE SIZE** 4 in.

DRILLING CONTRACTOR Access Soil Drilling

COORDINATES: LATITUDE 37.126676 **LONGITUDE** -122.140824

DRILLING RIG/METHOD 4-in. Solid Flight Auger

GROUNDWATER AT TIME OF DRILLING --- Not Encountered

LOGGED BY R. Briseno **CHECKED BY** D. Burger

GROUNDWATER AT END OF DRILLING --- N/A

HAMMER TYPE 140 lb hammer with 30 in. cathead

GROUNDWATER AFTER DRILLING --- N/A

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS (FIELD VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	FINES CONTENT (%)
0		Silty SAND (SM): brown, slightly moist, very loose, fine sand, material derived from completely weathered bedrock (ARTIFICIAL FILL)	CM	3-2-3							
		granite block (1 in.) encountered within the Silty SAND	SPT	2-1-1			3				
5		Gradational Contact. Poorly graded Sand with Silt (SP-SM) (WEATHERED BEDROCK)									
		GRANITE: dry, weak, friable	CM	15-30-28							
		GRANITE pulverized to Poorly Graded SAND with Silt and Gravel (SP-SM)	SPT	20-31-27			5				11
		gray, dry, hard	CM	50/5"							
			SPT	50/5"							

Bottom of borehole at 9.8 ft. Borehole backfilled with neat cement grout.

Appendix B. Laboratory Testing

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SUMMARY OF LABORATORY RESULTS

CLIENT San Lorenzo Valley Water District

PROJECT NAME Foreman Intake, Grading, and Erosion Control

PROJECT NUMBER 210450

PROJECT LOCATION 365 Madrone Drive, Boulder Creek, CA

Borehole	Depth	Date Tested	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Screen Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-01	2.0	9/22/2021				19	12		6.5	96.4		
B-01	6.0	9/22/2021							9.9	62.1		
B-01	12.5	9/22/2021				9.5	6		4.3			
B-02	2.0	9/22/2021	NP	NP	NP	0.106	18	SM	13.7			
B-02	6.0	9/22/2021				19	21		12.2			
B-03	3.0	9/22/2021							2.6			
B-03	7.0	9/22/2021				19	11		4.9			

GRAIN SIZE DISTRIBUTION

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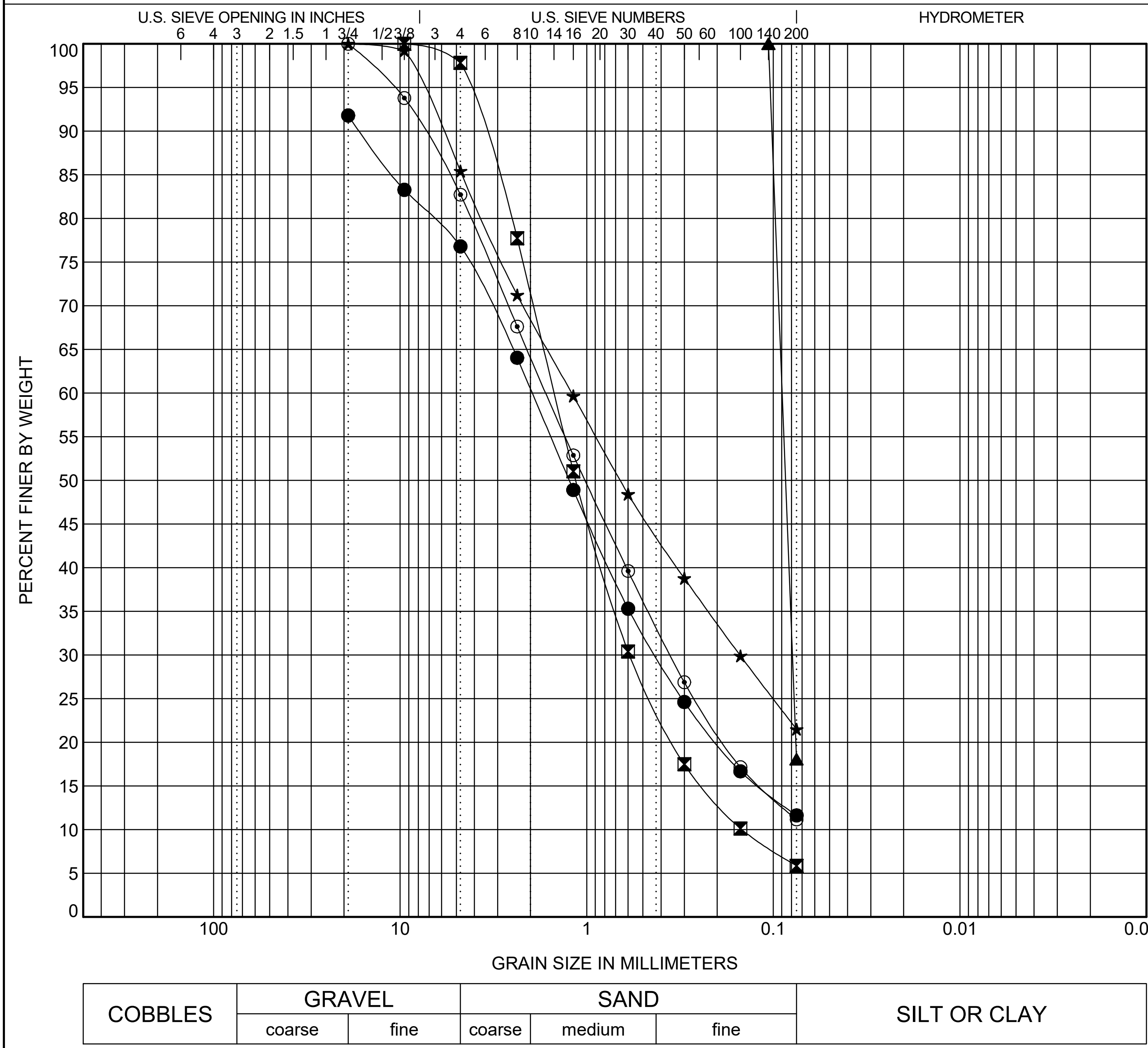
CLIENT San Lorenzo Valley Water District **PROJECT NAME** Foreman Intake, Grading, and Erosion Control

PROJECT NUMBER 210450 **PROJECT LOCATION** 365 Madrone Drive, Boulder Creek, CA



	BOREHOLE	DEPTH	DATE TESTED	Classification	LL	PL	PI	Cc	Cu
●	B-01	2.0	9/22/2021					1.54	32.72
⧗	B-01	12.5	9/22/2021					1.58	10.15
▲	B-02	2.0	9/22/2021	SILTY SAND(SM)	NP	NP	NP		
★	B-02	6.0	9/22/2021						
⊙	B-03	7.0	9/22/2021					1.17	25.15

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	B-01	2.0	19	1.962	0.425		15.0	65.2	11.6
⧗	B-01	12.5	9.5	1.49	0.587	0.147	2.2	92.0	5.9
▲	B-02	2.0	0.106	0.09	0.079		0.0	81.9	18.1
★	B-02	6.0	19	1.204	0.151		14.6	63.9	21.5
⊙	B-03	7.0	19	1.65	0.356		17.3	71.6	11.2

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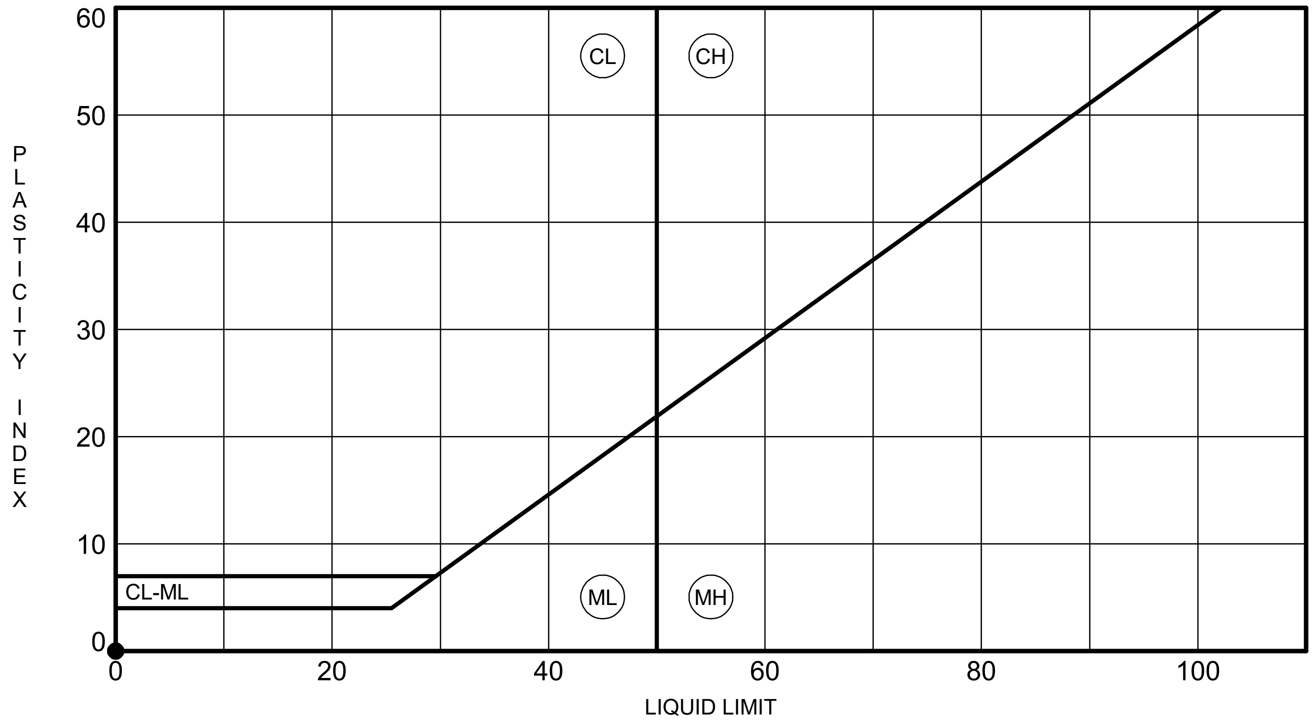
ATTERBERG LIMITS RESULTS

CLIENT San Lorenzo Valley Water District **PROJECT NAME** Foreman Intake, Grading, and Erosion Control

PROJECT NUMBER 210450 **PROJECT LOCATION** 365 Madrone Drive, Boulder Creek, CA



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification	Date Tested
●	**B-02**	**2.0**	**NP**	**NP**	**NP**	**18**	**SILTY SAND(SM)**	**9/22/2021**