Geotechnical Engineering Report

Fern Road Substation
Whitmore, Shasta County, California

August 23, 2021

Terracon Project No. NB215034

Prepared for:

LS Power Grid California, LLC
Chesterfield, Missouri

Prepared by:

Terracon Consultants, Inc.
Sacramento, California

Terracon GeoReport

August 23, 2021

LS Power Grid California, LLC
16150 Main Circle Drive, Suite 310
Chesterfield, Missouri 63017

Attn: Mr. Nick Tompkins – Project Engineer
P: (314) 346-5431
E: NTompkins@lspower.com

Re: Geotechnical Engineering Report
Fern Road Substation
Site Coordinates – 40.64329°N, 121.937703°W
Whitmore, Shasta County, California
Terracon Project No. NB215034

Dear Mr. Tompkins:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with the Work Authorization dated March 22, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

BEAU D. DONALDSON
No. 91954

GARRET S. H. HUBBART
No. 2588

Beau D. Donaldson, P.E. 91954
Project Engineer

Garret S.H. Hubbart, G.E. 2588
Principal

Reviewed by: Donald J. Kirker, PGp, Geophysical Subject Matter Expert

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	■ The project consists of construction of a new converter substation adjacent to the existing 500kV transmission line easement. ■ The proposed improvements are anticipated to consist of transformer dead-end A-frames, static mast, rigid bus steel support structures, equipment support stands which are anticipated to be supported on deep foundations. Other improvements such as power transformers, converter hall buildings, outdoor coolers, HVAC unit and other equipment are expected to be supported on shallow foundations.
Geotechnical Characterization	■ In general, the native soil and rock materials encountered at the site generally consisted of approximately 2 to 8 feet of surficial alluvium soil consisting of silty sand, clayey sand, clayey sand with gravel, and sandy lean clay underlain by Montgomery Creek Formation consisting of interbedded clayey sandstone and conglomerate bedrock. ■ Groundwater was not encountered at any time during our investigation at this site.
Earthwork	■ Cuts and fills ranging from 0 to 15 feet are anticipated to bring the site to grade. ■ Due to the presence of shallow rock at the site, we anticipate the need for heavy duty construction equipment, such as a ripping tooth or jack hammer for excavation methods. ■ The near surface clay soils encountered in the upper 2 feet at SB-2 and SB-8 locations on the site exhibit low to medium plasticity and are not suitable for use as engineered fill for this project. ■ Native sandstone and conglomerate bedrock materials exhibit low to moderate plasticity and are not considered suitable for use as engineered fill for this project but may be used as general-purpose fill material for site grading operations. ■ Mat foundations and floor slabs should be underlain by non-expansive engineered fill material. Non-expansive engineered fill material for this project shall conform with the requirements for engineered fill presented in **Earthwork**.
Shallow Foundations	■ The proposed power transformers, outdoor coolers, HVAC unit and other equipment may be supported on either mat slabs or conventional shallow spread footing foundations. Due to the expansion potential of the native materials at the site, mat slab foundations should bear on a minimum of 12 inches of non-expansive engineered fill. Shallow spread footings may bear directly on native sandstone bedrock or compacted engineered fill. ■ Refer to **Shallow Foundations** and **Mat Foundations** for design parameters and recommendations for each shallow foundation type.
Deep Foundations	Deep foundations may be used to support the proposed transformer dead-end A-frames, static mast, rigid bus steel support structures, equipment support stands

Topic [1]	Overview Statement [2]
	(surge arrester, disconnect switches, potential transformer, etc.). Recommendations and design parameters for deep foundations are provided in the **Deep Foundations** section of this report.
Below-Grade Structures	Retaining walls up to heights of 15 feet may be constructed for this project. Recommendations for design of the retaining walls are presented in in the **Lateral Earth Pressure** section of this report.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report

Fern Road Substation

Site Coordinates – 40.64329°N, 121.937703°W

Whitmore, Shasta County, California

Terracon Project No. NB215034

August 23, 2021

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed substation to be located adjacent to the existing 500 kV transmission lines approximately 1.5 miles northwest of Whitmore, California. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressures
- Seismic site classification per 2019 CBC

The proposed geotechnical engineering Scope of Services for this project included the advancement of eight (8) test borings to depths of 61.5 feet below existing grades (bgs). However, rotary auger refusal was encountered within borings SB-1, SB-4, SB-5, SB-6 and SB-7 on conglomerate bedrock at depths ranging from 7 to 36 feet bgs. Upon encountering auger refusal in these borings, the borings were advanced a minimum of 10 additional feet by rock coring. Boring termination depths ranged from 19 to 61.2 feet bgs.

In addition, field electrical resistivity soundings (VESs) were performed at six (6) locations within the proposed substation area.

Maps showing the site, boring and VES locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil and rock samples obtained from the site during the field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project site is located approximately 1.5 miles northwest of Whitmore in Shasta County, California. The center of the site is located at the approximate coordinates 40.64329°N, 121.937703°W. The site area is approximately 6.2 acres in size. See **Site Location**
Existing Improvements	The project site is undeveloped. Two parallel 500 kV transmission lines run in the north-south direction and border the west side of the site.
Current Ground Cover	Earthen with native vegetation consisting of medium height grasses, shrubs, small trees. Cobble/boulder sized rocks are scattered across the site.
Existing Topography	Site topography is variable and generally slopes to the southwest at an approximate grade of 3 percent. There is approximately 15 feet of topographic relief across the site.
Geology	This project site is located in the Sierra Nevada Geomorphic Province of California and is mapped within the Montgomery Creek Formation, with Tuscan Formation mapped nearby. The Eocene age Montgomery Creek Formation consists of basal conglomerate, succeeded by feldspathic to lithic greywackes, conglomerates, shales, carbonaceous shales, and minor lignites. The late Pliocene Tuscan Formation consists of dominant tuff breccia and lapilli tuff, and minor lava flows, flow breccia, and tuff.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Email from Nick Tompkins of LS Power providing the following: ■ Geotechnical Study Scope of Work prepared by Siemens Energy, latest revision dated April 1, 2021. ■ Fern Rd site plan complete with proposed boring locations. Prepared by Siemens Energy, latest revision dated April 1, 2021. Email from Engin Reis of Siemens Energy on July 21, 2021 providing the following: ■ Preliminary foundation drawings for the Orchard Substation dated June 6, 2021 showing planned mat foundation dimensions. ■ Preliminary foundation loads for proposed power transformer mat foundations.
Project Description	The project will involve the construction of a converter substation.
Proposed Structures	The following structures will be included within the proposed substations: Founded on Deep Foundations: ■ Transformer dead-end A-frames ■ Static mast (60 feet tall) ■ Rigid bus steel support structures ■ Equipment support stands (surge arrester, disconnect switches, potential transformer, etc.) Founded on Shallow Foundations: ■ Power transformers (3) ■ Converter hall buildings (2) ■ Outdoor coolers ■ HVAC unit and other equipment foundations
Maximum Loads	Deep Foundations (Assumed): ■ Axial: 10-50 kips ■ Shear: 5-35 kips ■ Moment: 50-200 kip-feet Mat Foundation/Slabs-on-grade (Provided): ■ Up to 2 kips per square foot (ksf)
Grading/Slopes	Cuts and fills ranging from 0 to 15 feet are anticipated to be performed to bring the site to grade.
Free-Standing Retaining Walls	Retaining walls with heights up to 15 feet may be constructed for this project.
Stormwater Basins	None anticipated.
Access Roadways	Aggregate-surface access roadways and operation roads will be constructed at the site.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Surficial Alluvium**	Variable, sandy to silty to clayey soils, fine to coarse grained, low to medium plasticity, relatively stiff to hard, medium dense to very dense.
2	**Bedrock: Sandstone**	Montgomery Creek Formation, fine to coarse grained sand, moderate cementation, weak rock, completely weathered.
3	**Sand**	Poorly graded sand, silty sand, clayey sand; fine to coarse grained sand, low to medium plasticity, moderate to strong cementation.
4	**Clay**	Fat clay with sand; fine grained sand, medium to high plasticity
5	**Bedrock: Conglomerate**	Montgomery Creek Formation, fine to coarse grained sand, medium plasticity, weak rock, with boulders and cobbles, moderately to completely weathered, weak rock.

GROUNDWATER

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not encountered in our test borings while drilling, or for the short duration the borings could remain open.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than anticipated. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

SEISMIC CONSIDERATIONS

The seismic design requirements for the substation and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7.

Description	Value
2019 California Building Code Site Classification (CBC) [1]	C [2]
Site Latitude	40.64329°N
Site Longitude	121.937703°W
S_s – Spectral Acceleration Parameter for a Short Period[4]	0.908
S_1 – Spectral Acceleration Parameter for a 1-Second Period[4]	0.361
F_a – Site Amplification Factor for a Short Period[4]	1.200
F_v – Site Amplification Factor for a 1-Second Period[4]	1.500
S_{MS} – MCE[3] Spectral Acceleration Parameter for a Short Period[4]	1.090
S_{M1} – MCE[3] Spectral Acceleration Parameter for a 1-Second Period[4]	0.542
S_{DS} – Design Spectral Acceleration for a Short Period[4]	0.727
S_{D1} – Design Spectral Acceleration for a 1-Second Period[4]	0.361

1. Seismic site soil classification in general accordance with the *2019 California Building Code*, which refers to ASCE 7-16.
2. The 2019 California Building Code (CBC) uses a site profile extending to a depth of 100 feet for seismic site soil classification. The borings for this report extended to the maximum depth of approximately 61.2 feet and this seismic site class assignment considers that similar soils continue below the maximum depth of the subsurface exploration. Additional exploration to greater depths could be considered to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a more favorable seismic site class.
3. MCE refers to Maximum Considered Earthquake.
4. These values were obtained using online seismic design maps and tools provided by SEAOC and OSHPD (https://seismicmaps.org/).

Faulting and Estimated Ground Motions

The site is located in Northern California, which is a seismically active area. The type and magnitude of seismic hazards affecting the site are dependent on the distance to causative faults, the intensity, and the magnitude of the seismic event. Based on the OSHPD Seismic Design Maps Report, using the American Society of Civil Engineers (ASCE 7-16) standard, the peak ground acceleration (PGA_M) at the project site is expected to be 0.482g. Based on the USGS Unified Hazard Tool, the project site has a mean earthquake magnitude of 6.93. Furthermore, the site is not located within an Alquist-Priolo Earthquake Fault Zone based on our review of the State Fault Hazard Maps.[1]

LIQUEFACTION

Liquefaction is a mode of ground failure that results from the generation of high pore water pressures during earthquake ground shaking, causing loss of shear strength. Liquefaction is typically a hazard where loose sandy soils or non-plastic fine-grained soils exist below groundwater. The California Geologic Survey (CGS) has designated certain areas within California as potential liquefaction hazard zones. These are areas considered at a risk of liquefaction-related ground failure during a seismic event, based upon mapped surficial deposits and the presence of a relatively shallow water table. The project site is not located within a liquefaction hazard zone mapped by the CGS.

Based on the distance to causative faults, absence of groundwater encountered in our investigation, and presence of shallow sedimentary and volcanic bedrock encountered at the site, we conclude that the risk for liquefaction induced settlement at this site is considered negligible.

LANDSLIDES

Landslides are frequently triggered by strong ground motions in association with steep terrains. Topography at the site generally slopes to the southwest at a relatively constant slope of 3 percent. Due to the relatively gentle and constant slopes present at the site, a slope stability analysis was not requested or intended. If a slope stability analysis is desired, we are experienced in performing these analyses.

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[1] California Department of Conservation Division of Mines and Geology (CDMG), *"Digital Images of Official Maps of Alquist-Priolo Earthquake Fault Zones of California, Southern Region"*, CDMG Compact Disc 2000-003, 2000.

VES SOUNDING RESULTS

The results of the VES surveys are summarized in the **Exploration Results** found in in the Appendix of this report. The left four columns of the tables contain the a-spacing (a) and electrode depth (b). The right two columns of the tables comprise the associated electrical resistivity values in ohms and ohm-centimeters. The apparent resistivity is calculated as:

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

The overall range of values measured generally vary from approximately 640 Ω-cm to 4710 Ω-cm with the exception of ER-6 which had two anomalous readings at 40 feet and 100 feet (a) spacings. The measurements were taken several times to note variance, however a reasonable data point based on the surrounding surveys data points was not achieved. These data points were not plotted and should be considered outliers. Data obtained from locations ER-1, ER-3 and ER-5 produced graphs that are relatively smooth, indicating little to no outside interference when testing. Data obtained from the remaining locations are relatively scattered indicating likely outside interference. It is our opinion that this interference was due to loose cobbly/bouldery surface soils at the site.

GEOTECHNICAL OVERVIEW

Due to the presence of shallow bedrock or very dense/hard materials at the site, we anticipate the need for heavy duty construction equipment, such as a ripping tooth or pneumatic excavation methods, in order to grade the site. We recommend an experienced grading contractor that is familiar with the area be used and plan their work accordingly. The near surface sandy lean clay soils in the areas of borings SB-2 and SB-8, clayey sand soils in the areas of borings SB-4 and SB-6, and conglomerate bedrock materials encountered at the site exhibit moderate plasticity and are not considered suitable for use as non-expansive engineered fill for this project but may be used as general purpose fill material for site grading operations. Mat slab foundations and floor slabs should be underlain by non-expansive engineered fill material in accordance with the recommendations in the **Earthwork** section.

The proposed power transformers, outdoor coolers, HVAC unit and other equipment may be supported on mat foundations. The proposed converter hall buildings may be supported on a conventional shallow spread footing. The reactors may also be supported on shallow foundations bearing on undisturbed bedrock. Due to the mass grading that may be performed for this site, spread footing foundations should be designed separately for improvements bearing on the cut and fill areas respectively. Shallow spread footing foundations may bear on undisturbed sandstone or conglomerate bedrock, or engineered fill if required to raise grades. Mat foundations and floor slabs should be underlain by a minimum of 12 inches of non-expansive engineered fill material overlying undisturbed sandstone or conglomerate bedrock or engineered fill if required to raise grades. The **Shallow Foundations** section addresses support of the improvements bearing on undisturbed sandstone bedrock or compacted engineered fill material.

Floor slabs and mat foundations should be underlain by a minimum of 12 inches of non-expansive engineered fill and should be increased to 24 inches where bedrock is located within 2 feet of finished subgrade or bottom of slab/foundation whichever is lower. The **Floor Slabs** section addresses slab-on-grade support of the proposed control building.

Deep foundations may be used to support the proposed dead-end A-frames, static mast, rigid bus steel support structures, equipment support stands. Recommendations and design parameters for deep foundations are provided in the **Deep Foundations** section of this report.

Expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structures should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. Some of these options are discussed in this report such as complete replacement of expansive soils or a structural slab.

Retaining walls with heights up to 15 feet may be constructed for this project. Recommendations for design of the retaining walls are presented in in the **Lateral Earth Pressure** section of this report.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations and floor slabs.

Site Preparation

Strip and remove existing vegetation and other deleterious materials from proposed construction areas. Exposed surfaces should be free of mounds and depressions which could prevent uniform compaction. The site should be initially graded to create a relatively level surface to receive fill and provide for a relatively uniform thickness of fill beneath proposed structures.

We recommend stripping topsoil to depths that expose soils with less than 3 percent organics and no roots having a diameter greater than ¼ inch. While the depth of the unsuitable soils should be expected to vary, the thickness of the top soil layer may be estimated to range between 3 and 6 inches for construction budgeting purposes. The thickness of the top soil layer was not determined during our field exploration. Therefore, the actual depth of stripping should be verified by engineering observations made during the grading operations at the project.

Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations. If it is necessary to dispose of organic materials on site, they should be placed in non-structural areas, and in fill sections not exceeding 5 feet in height.

Once cuts have been made and prior to placing any engineered fill, the subgrade should be proofrolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. The proofrolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or moisture conditioned and recompacted. Such areas may also be modified by stabilizing with lime/cement or aggregate base with geogrids.

The exposed subgrade soil should be scarified, moisture conditioned, and compacted. The depth of scarification of subgrade soils and moisture conditioning of the subgrade is highly dependent upon the time of year of construction and the site conditions that exist immediately prior to construction. If construction occurs during the winter or spring, when the subgrade soils are typically already in a moist condition, scarification and compaction may only be 8 inches. If construction occurs during the summer or fall when the subgrade soils have been allowed to dry out deeper, the depth of scarification and moisture conditioning may be as much as 18 inches or more. A representative of our office should be present to observe the exposed subgrade and specify the depth of scarification and moisture conditioning required subsequent to grading cuts and prior to placing fill.

Subgrade Preparation

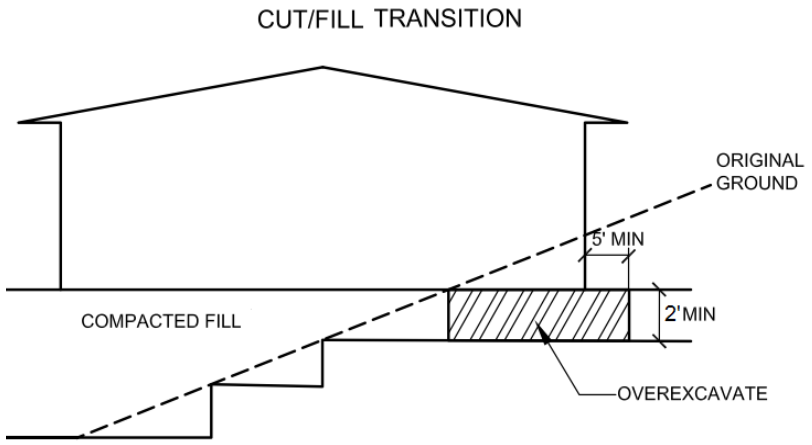
Shallow spread footing foundations may bear solely on undisturbed native sandstone or conglomerate bedrock materials or engineered fill if required to raise grades. Mat foundations and floor slabs should be underlain by a minimum of 12 inches of non-expansive engineered fill material overlying undisturbed sandstone or conglomerate bedrock or engineered fill if required to raise grades. Areas of loose soils may be encountered at foundation bearing depths. When such conditions exist beneath planned footing areas the subgrade soils should be compacted prior to placement of the foundation system. If sufficient compaction cannot be achieved in-place, the loose soils should be removed and replaced as engineered fill. The excavation should be widened laterally at least 8 inches for each 12 inches of fill placed below footing base elevations.

Conglomerate bedrock was encountered at several locations during our investigation. Therefore, large cobble sized materials may be encountered at foundation bearing depths. Such conditions could create point loads on the bottom of footings, increasing the potential for differential foundation movement. If such conditions are encountered, any cobbles or boulders should be removed from the upper 12 inches beneath foundations and be replaced with engineered fill.

The grading plans for the proposed improvement are not finalized at this stage of the project. However, minor to major rough grading operations may be required for this project. Based on the differences in elevation and existing topography on site, grading may include up to 15 feet of cut and/or fill. The site should be initially graded to create a relatively level surface to receive fill and provide for a relatively uniform thickness of fill beneath proposed structures.

Spread footings bearing on engineered fill are considered suitable for support of the proposed pad mounted equipment and control building structures. Engineered fill should extend to a minimum depth of 2 feet below the bottom of foundations, or 2 feet below existing grades, whichever is greater. Grading for the proposed pad mounted equipment and control building should incorporate the limits of these improvements plus a lateral distance of 5 feet beyond the outside edge of perimeter footings.

Mass grading operations should accommodate the placement of a minimum of 2 feet of engineered fill beneath foundations in the fill areas within the filled portion of the project site. See the sketch below for an approximate idea of how the grading at transitions should be performed.



Excavation

Excavation penetrating the bedrock may require the use of specialized heavy-duty equipment to facilitate rock break-up and removal. The use of ripping or jack-hammering may be needed to advance excavations penetrating the sandstone and conglomerate bedrock. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project. The contractor should be experienced with the local geology and plan their work accordingly. <u>If penetration and ripping is a concern, we can perform a seismic refraction study to determine the primary wave velocity which the contractor can use for equipment selection.</u>

Though groundwater was not encountered in our investigation, it is common for water to pond at the bedrock surface. Groundwater seepage should be anticipated for excavations approaching the level of bedrock. Pumping from sumps may be utilized to control water within the excavations. Well points may be required for significant groundwater flow, or where excavations penetrate groundwater to a significant depth. If construction occurs during or shortly after the rainy season, significant amounts of shallow groundwater could be encountered during grading operations.

Fill Material Types

All fill materials should be inorganic soils free of vegetation, debris, and fragments larger than three inches in size. Pea gravel or other similar non-cementitious, poorly-graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer.

Near surface native clay soils and sandstone to conglomerate bedrock exhibit low to moderate expansion potential and are not considered suitable for use as non-expansive engineered fill for this project. However, these materials may be used as engineered fill for the following.

- General purpose fill
- Foundation backfill

Approved non-expansive imported materials may be used as fill material for the upper 12 inches beneath the following:

- foundation areas
- exterior slab areas
- interior floor slab areas

Soils for use as non-expansive engineered fill material within the proposed building pad areas should conform to non-expansive materials as indicated in the following recommendations:

Gradation	**Percent Finer by Weight (ASTM C 136)**
3”	100
No. 4 Sieve	50-100
No. 200 Sieve	15-50

Liquid Limit	30 (max)
Plasticity Index	15 (max)
Maximum expansion index*	20 (max)

*ASTM D 4829

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill lifts should not exceed ten inches in loose thickness. The engineered fill should extend at least 5 feet beyond the perimeter of any foundations.

The contractor shall notify the Geotechnical Engineer of import sources sufficiently ahead of their use so that the sources can be observed and approved as to the physical characteristic of the import material. For all import material, the contractor shall also submit current verified reports from a recognized analytical laboratory indicating that the import has a "not applicable" (Class S0) potential for sulfate attack based upon current ACI criteria and is only "mildly corrosive" to ferrous metal and copper. The reports shall be accompanied by a written statement from the contractor that the laboratory test results are representative of all import material that will be brought to the job.

Fill Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows:

Material Type and Location	Per the Modified Proctor Test (ASTM D 1557)		
	Minimum Compaction Requirement (%)	Range of Moisture Contents for Compaction Above Optimum	
		Minimum	Maximum
Low volume change (non-expansive) imported fill:			
Beneath foundations:	90	0%	+3%
Beneath slabs:	90	0%	+3%
Engineered fill less than 5 feet in depth	90	0%	+3%
Engineered fill greater than 5 feet in depth	95	0%	+3%
Onsite native clayey sand soils:			
Engineered fill less than 5 feet in depth:	90	+2%	+4%
Engineered fill greater than 5 feet in depth:	95	+1%	+3%
Beneath aggregate surfaced roadway sections:	95	+1%	+3%
Utility trenches:	90	+2%	+4%
Bottom of native excavation receiving fill:	90	+1%	+3%

We recommend that compacted native soil or any engineered fill be tested for moisture content and relative compaction during placement. Should the results of the in-place density tests indicate the specified moisture content or compaction requirements have not been met, the area represented by the test should be reworked and retested as required until the specified moisture content and relative compaction requirements are achieved.

Utility Trench Backfill

For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

Grading and Drainage

All grades must provide effective drainage away from the structures during and after construction and should be maintained throughout the life of the structures. Water retained next to the structures can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks.

Exposed ground should be sloped and maintained at a minimum 5% away from the proposed improvements for at least 10 feet beyond the perimeter. After construction has been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted, as necessary, as part of the structures' maintenance program.

Slopes

For permanent slopes in compacted fill areas, recommended maximum configurations for on-site materials are as follows:

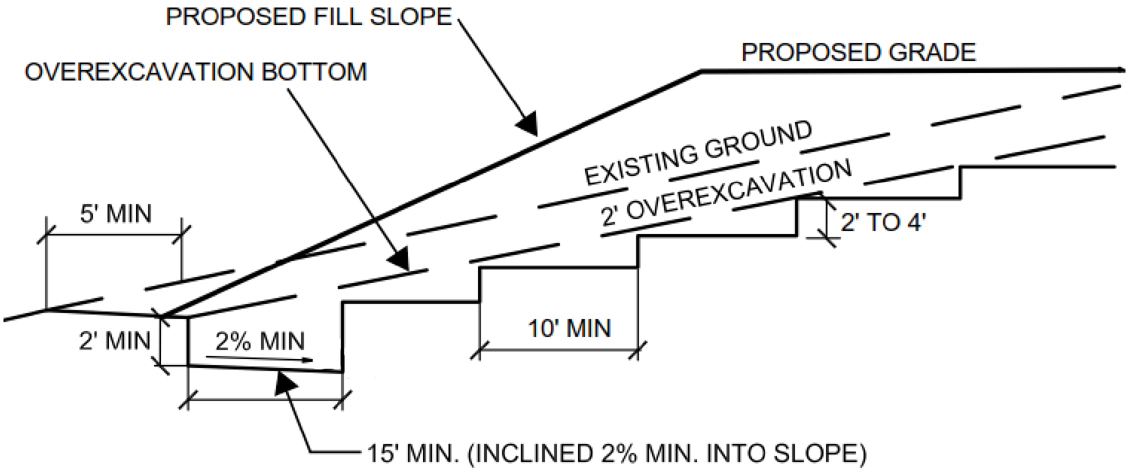
Maximum Slope Configuration

Inclination (horizontal: vertical)	Slope Treatment [1]
5:1 to less steep than 2:1	Re-vegetate
2:1 to less steep than 1.5:1	Rip-rap over filter fabric. Rip rap should be keyed into bottom of slope. Slope stability analysis may be required.
1.5:1 to 1:1	Grouted rip-rap or 6-inch thick shotcrete with integrated toe at base of slope having a minimum depth of 1/5 the total slope height. Slope stability analysis required.
Steeper than 1:1	Stability analysis or structural retaining wall required

1. Once initial grading plans are available, the geotechnical engineer shall be afforded the opportunity to review and deem if slope stability analysis and/or any additional recommendations are warranted.

We expect slopes with these configurations to be relatively resistant to erosion and stable against circular failure. The face of all slopes should be compacted to the minimum specification for fill embankments and over-built with compacted material and trimmed to final configurations. All exposed slopes should be covered immediately with some sort of erosion control measures to reduce the potential for erosion. If any slope in cut or fill will exceed 25 feet in height, the grading design should include mid-height benches to intercept surface drainage and divert flow from the face of the embankment. Terracon should be consulted for additional recommendations if slopes greater than 25 feet in height are anticipated.

If fill is placed in areas of the site where existing slopes are steeper than 5:1 (horizontal:vertical), the areas should be benched to reduce the potential for slippage between existing slopes and fills. Benches should be wide enough to accommodate compaction and earth moving equipment, and to allow placement and compaction of horizontal lifts of fill. See the detail below.



Earthwork Construction Considerations

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 1,500 square feet of compacted fill in the structure areas. One density and water content test should be performed for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, benches, and/or keys, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer’s evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

The proposed power transformers, outdoor coolers, HVAC unit and other equipment may be supported on either mat slabs or conventional shallow spread footing foundations. The proposed converter hall buildings may be supported on a conventional shallow spread footing. The reactors may be supported on spread foundations bearing on undisturbed bedrock.

Due to the mass grading that may occur for this site, spread footing foundations should be designed separately for improvements bearing on the cut and fill areas respectively. Shallow spread footing foundations may bear on undisturbed sandstone or conglomerate bedrock or engineered fill if required to raise grades. Design parameters for shallow spread footings bearing totally on undisturbed bedrock and totally on engineered fill are provided in the table below.

Foundations and structures should not be located along the daylight line with partial support from cut and fill areas. If this condition exists, cut areas should be over-excavated to a minimum depth of 2 feet to provide consistent and more homogenous support within the same foundation.

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Spread Footing Foundation Design Parameters – Compressive Loads

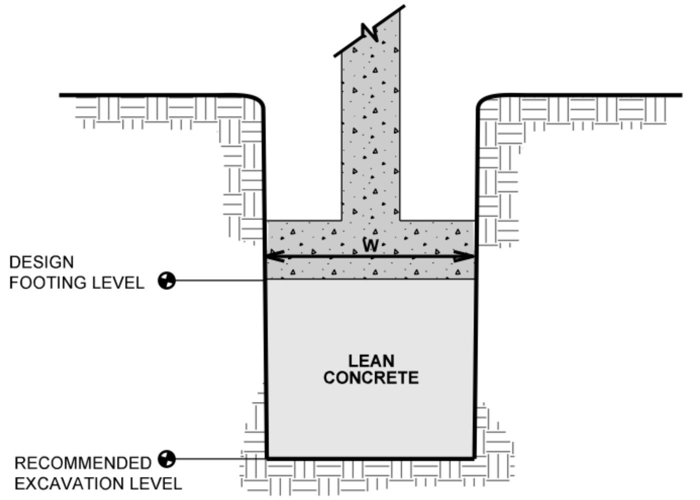
Item	Description
Maximum Net Allowable Bearing pressure [1, 2]	■ 4,000 psf for foundations bearing totally on undisturbed bedrock – **Cut Areas** ■ 2,500 psf for foundations bearing totally on engineered fill – **Fill Areas**
Required Bearing Stratum [3]	Compacted engineered fill in accordance with **Earthwork**, or undisturbed sandstone or conglomerate bedrock.
Minimum Foundation Dimensions	Columns: 18 inches Continuous: 12 inches
Ultimate Passive Resistance [4] (equivalent fluid pressures)	375 pcf
Ultimate Coefficient of Sliding Friction [5]	0.30
Minimum Embedment below Finished Grade [6]	12 inches
Estimated Total Settlement from Structural Loads [2]	■ Less than about 1/2 inch for foundations within **Cut Areas** ■ Less than about 1 inch for foundations within **Fill Areas**
Estimated Differential Settlement [2, 7]	About 2/3 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are relatively flat around the structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork** section.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. If passive resistance is used to resist lateral loads, the base friction should be reduced by 25 percent.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.
6. Embedment necessary to minimize the effects of seasonal water content variations. Finished grade is defined as the lowest adjacent grade within five feet of the foundation for perimeter (exterior) footings.
7. Differential settlements are as measured over a span of 50 feet.

Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

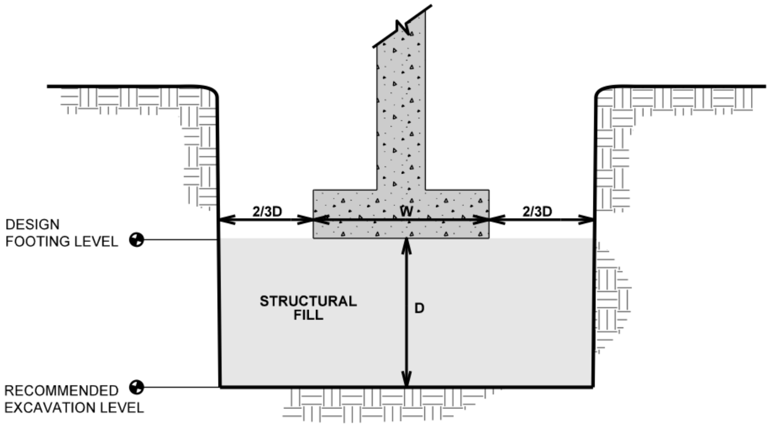
If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with engineered fill placed, as recommended in the **Earthwork** section.



OVER-EXCAVATION / BACKFILL ZONE

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

To ensure foundations have adequate support, special care should be taken when footings are located adjacent to trenches. The bottom of such footings should be at least 1 foot below an imaginary plane with an inclination of 1.5 horizontal to 1.0 vertical extending upward from the nearest edge of the adjacent trench.

MAT FOUNDATIONS

The subgrade soils and rock at this site are comprised of low to moderate plasticity materials exhibiting the potential to swell or shrink with changes in water content. To reduce the swell potential, the upper 12 inches of subgrade soil below the mat slab foundation should consist of an approved non-expansive engineered fill material.

Due to the mass grading that may occur at this site, mat foundations should be designed separately for improvements bearing within the cut and fill areas respectively. Mat foundations and floor slabs shall be underlain by a minimum of 12 inches of non-expansive engineered fill material overlying undisturbed sandstone or conglomerate bedrock or engineered fill if required to raise grades.

The proposed slab mounted substation equipment may be supported on mat slab foundations, If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for foundations for general substation equipment with the exception of proposed power transformers.

General Mat Foundations

Mat Width (feet)[1]	Bearing Stratum	Allowable Bearing Capacity (psf) [2, 3]	Modulus of Subgrade Reaction, k_v1 (pci) [3]
Minimum 6	**Fill areas:** non-expansive fill over compacted fill	2,000	180
	Cut Area: non-expansive Fill over bedrock[4]	3,000	250
10 or more	**Fill areas:** non-expansive fill over compacted fill	1,000	180
	Cut Area: non-expansive Fill over bedrock[4]	2,000	250

1. Interpolate for mat width between 6 and 10 feet.
2. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions.
3. Allowable settlement of 1.0 inch for mat foundations bearing on a minimum of 12 inches of non-expansive engineered fill
4. Bedrock needs to be within 1 foot of bottom of mat foundations.

A transformer foundation load distribution was provided by Siemans Energy. We understand maximum loading for the transformer foundations will be up to 1,710 psf for dead plus live and up to 2,600 psf for dead plus live with seismic. Based on the load distribution, we understand the max loads will be observed in a concentrated area. The bearing capacities in the table below assume the load is consistent across the entire span of the associated dimensions. Bearing capacities can be tolerated provided the area of the load is contained to the dimensions specified.

Power Transformer Mat Foundations[4, 5]

Mat Width (feet)	Bearing Stratum	Allowable Bearing Capacity (psf) [1, 2, 3]	Modulus of Subgrade Reaction, k_v1 (pci) [2]
50-ft x 30-ft or smaller	**Fill areas:** non-expansive fill over compacted fill	2,000	180
	Cut Area: non-expansive Fill over bedrock[4]	3,000	250
30-ft x 30-ft or smaller	**Fill areas:** non-expansive fill over compacted fill	2,500	180
	Cut Area: non-expansive Fill over bedrock[4]	3,500	250
30-ft x 10-ft or smaller	**Fill areas:** non-expansive fill over compacted fill	3,000	180
	Cut Area: non-expansive Fill over bedrock[4]	4,000	250

10-ft x 10-ft or smaller	**Fill areas:** non-expansive fill over compacted fill	4,000	180
	Cut Area: non-expansive Fill over bedrock[4]	5,000	250

1. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions.
2. Allowable settlement of 1.0 inch for mat foundations bearing on a minimum of 12 inches of non-expansive engineered fill
3. Values assume mat is embedded at least 5 feet below final design grades.
4. Bedrock needs to be within 1 foot of bottom of mat foundation
5. The transformer foundations will have a total embedment depth of 5 ft.

Since there are several factors that will control the design of mat foundations besides vertical load, Terracon should be consulted when the final foundation depth and width are determined to assist the structural designer in the evaluation of anticipated settlement.

Other details including treatment of loose foundation soils and observation of foundation excavations as outlined in the **Earthwork** section of this report are applicable for the design and construction of a mat foundation at the site.

The corrected subgrade modulus (k_c) for the mat is affected by the size of the mat foundation and would vary according the following equation:

$$k_v = k_{v1}((B+1)/2B)^2$$

Where: k_v is the modulus for the size footing being analyzed
B is the width of the mat foundation.

If using the pseudo-coupled method of mat design, the modulus of subgrade reaction (k_c) values for the perimeter should be twice the central values, and the integral of all the values over the area of the mat should be equal to the average. Terracon should be contacted if additional k_c recommendations are necessary for the pseudo-coupled method.

DEEP FOUNDATIONS

Transformer dead-end A frames, static mast (60 feet tall), rigid bus steel support structures, equipment support stands (surge arrester, disconnect switches, potential transformer, etc.). The reactors may be supported on cast in place drilled pier foundations.

Drilled Shaft Design Parameters

Due to the mass grading that may occur to balance the site, we have provided LPILE parameters for drilled shafts extending through compacted engineered fill and bearing into undisturbed bedrock materials. Drilled shafts shall not bear directly upon compacted fill.

Soil design parameters are provided below in the **Drilled Shaft Design Summary** table for the design of drilled shaft foundations. The values presented for allowable side friction and end bearing include a factor of safety.

Drilled Shaft Design Summary [1]

Approximate Elevation (feet) [5,6]	Stratigraphy [2]	Allowable Skin Friction (psf) [3]	Allowable End Bearing Pressure (psf) [4]
	Material		
2 to 6 (Fill Area only)	Compacted Engineered Fill	70	---
6 to 13 (Fill Area only)	Compacted Engineered Fill	140	8,000
2 to 13	Residual Sandstone	185	10,000
13 to 20	Sandstone/Conglomerate	235	20,000
20 to 61.2	Sandstone/Conglomerate	235	30,000

1. Design capacities are dependent upon the method of installation, and quality control parameters. The values provided are estimates and should be verified when installation protocol have been finalized.
2. See **Subsurface Profile** in **Geotechnical Characterization** for more details on stratigraphy.
3. Applicable for compressive loading only. Reduce to 2/3 of values shown for uplift loading. Effective weight of shaft can be added to uplift load capacity.
4. Shafts should extend at least one diameter into the bearing for end bearing to be considered.
5. Depth is from current elevations onsite. After the grading plan is finalized, these layers and parameters should be used based on the elevation of these layers after grading.
6. The axial capacity of the upper 2 feet should be neglected.

Tensile reinforcement should extend to the bottom of shafts subjected to uplift loading.

Drilled shafts should have a minimum (center-to-center) spacing of three diameters. Closer spacing may require a reduction in axial load capacity. Axial capacity reduction can be determined by comparing the allowable axial capacity determined from the sum of individual piles in a group versus the capacity calculated using the perimeter and base of the pile group acting as a unit. The lesser of the two capacities should be used in design.

A minimum shaft diameter of 12 inches should be used. Drilled shafts should have a minimum length of 7 feet and should extend into the bearing strata at least one shaft diameter for the allowable end-bearing pressures listed in the above table. For drilled shaft foundations extending through recompacted fill material, shafts shall penetrate through the fill and extend a minimum of 7 feet into competent bedrock materials.

Post-construction settlements of drilled shafts designed and constructed as described in this report are estimated to range from about ½ to ¾ inch. Differential settlement between individual shafts is expected to be ½ to ⅔ of the total settlement.

Drilled Shaft Lateral Loading

The following table lists input values for use in LPILE analyses. LPILE estimates values of k_h and ε_{50} based on strength; however, non-default values of k_h should be used where provided. Since deflection or a service limit criterion will most likely control lateral capacity design, no safety/resistance factor is included with the parameters.

Stratigraphy [1]		**L-Pile Soil Model**	**S_u (psf)** [2]	**ϕ** [2]	**γ (pcf)** [2]	**Initial Modulus of Rock Mass (psi)**	**RQD (%)**	**Uniaxial Compression Strength (psi)**
No.	**Material**							
0	Compacted Engineered Fill[3]	Sand (Reese)	---	32°	120	---	---	---
1	Residual Sandstone	Sand (Reese)	---	34°	120	---	---	---
2	Sandstone	Sand (Reese)	---	38°	135	---	---	---
3	Conglomerate	Weak Rock	---	---	140	22,000	35	100

1. See **Subsurface Profile** in **Geotechnical Characterization** for more details on Stratigraphy.
2. Definition of Terms:

   S_u: Undrained shear strength

Stratigraphy [1]		L-Pile Soil Model	S_u (psf) [2]	ϕ [2]	γ (pcf) [2]	Initial Modulus of Rock Mass (psi)	RQD (%)	Uniaxial Compression Strength (psi)
No.	**Material**							

ϕ: Internal friction angle,

γ: Effective unit weight

Strain Factors k and k_{rm}: can be left as 0 for default values determined by LPILE.

3. Use parameters for compacted engineered fill for drilled shafts extending through fill placed during mass grading of the site.

The load capacities provided herein are based on the stresses induced in the supporting soil strata. The structural capacity of the shafts/piles should be checked to assure they can safely accommodate the combined stresses induced by axial and lateral forces. Lateral deflections of shafts/piles should be evaluated using an appropriate analysis method, and will depend upon the pile's diameter, length, configuration, stiffness and "fixed head" or "free head" condition. We can provide additional analyses and estimates of lateral deflections for specific loading conditions upon request. The load-carrying capacity of shafts/piles may be increased by increasing the diameter and/or length.

Drilled Shaft Construction Considerations

A full-depth temporary steel casing may be required to stabilize the sides of the shaft excavations in the overburden. Difficult drilling conditions should be expected within the bedrock layers encountered in our investigation. These materials are dense and strong, and the potential for hard drilling conditions should be anticipated by the installation contractor. If casing is removed during concrete placement, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures present on a casing exterior. Water or loose soil should be removed from the bottom of the drilled shafts prior to placement of the concrete.

Care should be taken to not disturb the sides and bottom of the excavation during construction. The bottom of the shaft excavation should be free of loose material before concrete placement. Concrete should be placed as soon as possible after the foundation excavation is completed, to reduce potential disturbance of the bearing surface.

Concrete for "dry" drilled shaft construction should have a slump of about 5 to 7 inches. Concrete should be directed into the shaft utilizing a centering chute. Concrete for "wet" shaft construction would require higher slump concrete.

While withdrawing casing, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures acting on the casing exterior. Arching of the concrete, loss of seal and other problems can occur during casing removal and result in contamination of the drilled shaft. These conditions should be considered during the design and construction phases. Placement of loose soil backfill should not be permitted around the casing prior to removal.

The drilled shaft installation process should be performed under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions encountered, consistency with expected conditions, and details of the installed shaft.

FLOOR SLABS

The subgrade soils and rock at this site are comprised of low to medium plasticity materials exhibiting the potential to swell and shrink with changes in water content. To reduce the swell potential to less than about 1 inch, the upper 12 inches of subgrade soil below the floor slabs should consist of an approved non-expansive engineered fill material.

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	■ Minimum 4 inches of: ○ Free-draining crushed aggregate in areas with floor coverings or in areas sensitive to moisture vapor[2] ○ Aggregate base course in areas not sensitive to moisture vapor[3] ■ At least 12 inches of non-expansive soils
Estimated Modulus of Subgrade Reaction [4]	150 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Free-draining granular material should have less than 5% fines (material passing the No. 200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

Item	Description

3. Aggregate base course should meet the requirements for Class 2 Aggregate Base Course within the Current Caltrans Standard Specifications, latest edition.
4. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

CORROSIVITY

The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary

Boring	Sample Depth (feet)	Soil Description	Soluble Sulfate (%)	Sulfides (ppm)	Soluble Chloride (%)	Red-Ox Potential (mV)	Electrical Resistivity (Ω-cm)	Total Salts (ppm)	pH
SB-2	1-4	CL	0.0060	nil	0.0006	+399	3,098	126	7.4
SB-3	1-4	SM	0.0062	nil	0.0016	+400	2,994	149	7.0

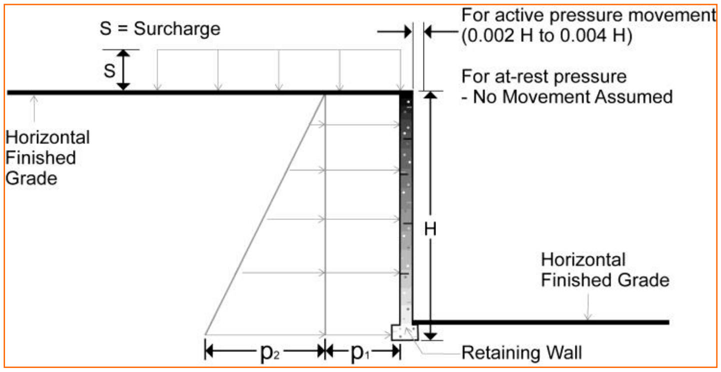
The sulfate test results indicate that the soil from boring SB-2 and SB-3 classifies as Class S0 according to Table 19.3.1.1 of ACI 318-14. This indicates that the sulfate level is negligible when considering corrosion to concrete. ACI 318-14, Section 19.3 does not specify the type of cement or a maximum water-cement ratio for concrete for sulfate Class S0. For further information, see ACI 318-14, Section 19.3.

The chloride test results indicate that the soils have a relatively low chloride content present. According to Table 19.3.1.1 of ACI 318-14, the soil should not be considered an external source of chloride (i.e. sea water, etc.) to concrete foundations. Consequently, chloride classes of C0 and C1 should be used where applicable. C0 is defined as, “Concrete dry or protected from moisture” and C1 is defined as, “Concrete exposed to moisture but not to an external source of chlorides”. For the amount of chlorides allowed in concrete mix designs, Table 19.3.2.1 of ACI 318-14 shall be adhered to as appropriate.

LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



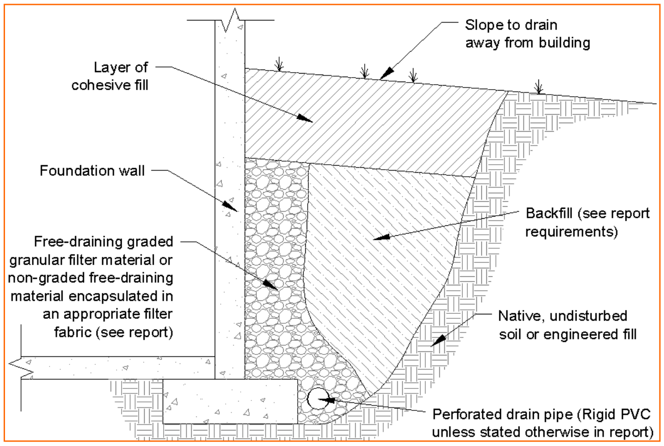
Lateral Earth Pressure Design Parameters			
Earth Pressure Condition [1]	**Coefficient for Backfill Type**[2]	**Surcharge Pressure** [3, 4, 5] **p_1 (psf)**	**Effective Fluid Pressures (psf)** [2, 4, 5]
Active (Ka)	Granular - 0.31	(0.31)S	(40)H
At-Rest (Ko)	Granular - 0.53	(0.53)S	(65)H
Passive (Kp)	Granular - 3.25	---	(390)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the ASTM D 1557 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.

Backfill placed against structures should consist of granular soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

ACCESS ROADS

Aggregate Surfaced Roadway Design Recommendations

Aggregate surface roadway design was conducted in general accordance with the Army Corps of Engineers (ACOE) Technical Manual TM-5-822, Design of Aggregate Surface Roads and Airfields (1990). The design was based on Category III, traffic containing as much as 15% trucks, but with not more than 1% of the total traffic composed of trucks having three or more axles (Group 3 vehicles), and Road Class G (under 70 vehicles per day). Based on the Category and Road Class, a Design Index of 1 was utilized. Terracon should be contacted if significant changes in traffic loads or in the characteristics described are anticipated.

One sample was obtained from SB-5 at a depth of 1 to 2.5 feet for the determination of California Bearing Ratio (CBR) value of the near surface soils. Laboratory test results indicated a CBR of 1.5. A CBR of 1.5 was used for determining the aggregate surfaced roadway section thicknesses provided below.

As a minimum, aggregate surface course should have a thickness of 12 inches and should be constructed over a minimum of 12 inches of scarified, moisture conditioned and compacted native soil to 95% of the maximum dry density using ASTM D1557. Aggregate materials should conform to the specifications of Class II aggregate base in accordance with the requirement and specifications of Class II aggregate base in accordance with requirements and specifications of the State of California Department of Transportation (CalTrans), or other approved local governing specifications. The recommended thicknesses should be measured after full compaction. The width of the roadway should extend a minimum distance of 1 foot on each side of the desired surface width.

Positive drainage should be provided during construction and maintained throughout the life of the roadways. Proposed roadway design should maintain the integrity of the road and eliminate ponding.

Roadway Design Construction Considerations

Regardless of the design, aggregate surfaced roadways will display varying levels of wear and deterioration. Preventative measures should be applied as needed for erosion control and regrading.

Shoulder build-up on both sides of proposed roadways should match the aggregate surface elevation and slope outwards at a minimum grade of 10% for five feet.

Preventative maintenance should be planned and provided for through an on-going pavement management program to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment.

Materials and construction of pavements for the project should be in accordance with the requirements and specifications of the Caltrans, or other approved local governing specifications.

Base course or pavement materials should not be placed with the surface is wet. Surface drainage should be provided away from the edge of paved areas to minimize lateral moisture transmission into the subgrade.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

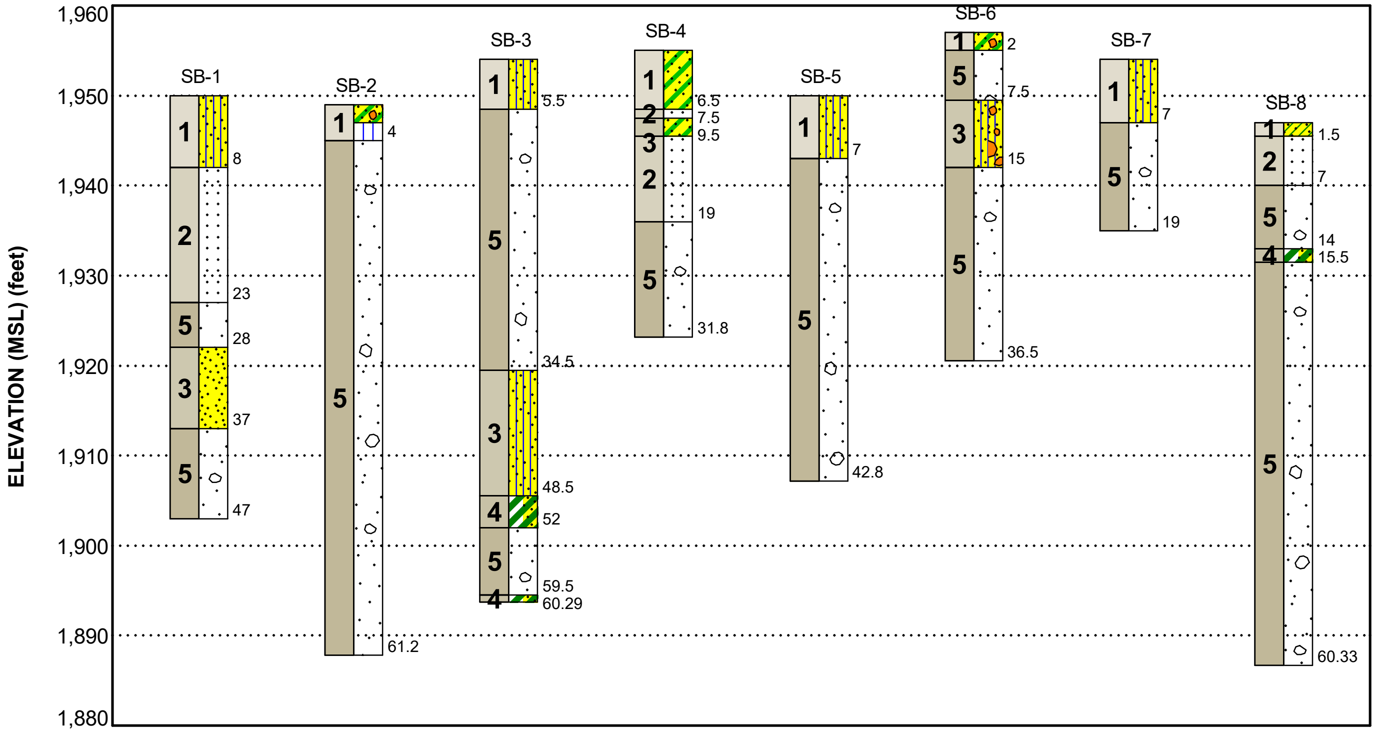
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

GEOMODEL

Fern Road Substation ■ Whitmore, CA
Terracon Project No. NB215034



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Surficial Alluvium**	Variable, sandy to silty to clayey soils, fine to coarse grained, low to medium plasticity, relatively stiff to hard, medium dense to very dense.
2	**Bedrock: Sandstone**	Montgomery Creek Formation, fine to coarse grained sand, moderate cementation, weak rock, completely weathered.
3	**Sand**	Poorly graded sand, silty sand, clayey sand; fine to coarse grained sand, low to medium plasticity, moderate to strong cementation.
4	**Clay**	Fat clay with sand; fine grained sand, medium to high plasticity
5	**Bedrock: Conglomerate**	Montgomery Creek Formation, fine to coarse grained sand, medium plasticity, weak rock, with boulders and cobbles, moderately to completely weathered, weak rock.

LEGEND

- ▨ Silty Sand
- ▨ Sandstone
- ☐ Gravel or Conglomerate 1
- ▨ Poorly-graded Sand
- ▨ Clayey Sand with Gravel
- ▨ Silt
- ▨ Fat Clay with Sand
- ▨ Clayey Sand
- ▨ Silty Sand with Gravel
- ▨ Sandy Lean Clay

NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.

Numbers adjacent to soil column indicate depth below ground surface.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
8	19 to 61.2	Proposed Improvements

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and approximate elevations were obtained by interpolation from Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rigs using continuous solid stem flight augers and HQ coring methods. We obtained 4 samples within the top 10 feet bgs and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. A 2.5-inch O.D. split-barrel sampling spoon with 2.0-inch I.D. tube lined sampler was also used for sampling. Tube-lined, split-barrel sampling procedures are similar to standard split spoon sampling procedure; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. For safety purposes, all borings were backfilled with neat cement grout in accordance with Shasta County guidelines after their completion.

Rock coring was performed in accordance with ASTM D2113 using HQ wireline coring methods, with rock logging performed in accordance with ASTM D5434. Coring was performed from for five (5) of our boring locations.

We collected VES data using a MiniRes Electrical Resistivity Meter manufactured by L&R Instruments. The MiniRes is a self-contained unit that transmits current at outputs ranging from 0.5 to 5.0 milliamps (mA). The instrument measures the potential drop (voltage) caused by the current influx and converts the data to values of resistance and apparent resistivity. The data are recorded for subsequent processing and archiving.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by an Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Engineer’s interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project geologist reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil and Rock
- ASTM D1140 Standard Test Method for Determining the Amount of Material Finer than No. 200 Sieve by Soil Washing
- ASTM D1883 Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

The laboratory testing program included examination of soil samples by an Engineer. Based on the material’s texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Fern Road Substation ■ Whitmore, Shasta County, California

Terracon Project No. NB215034

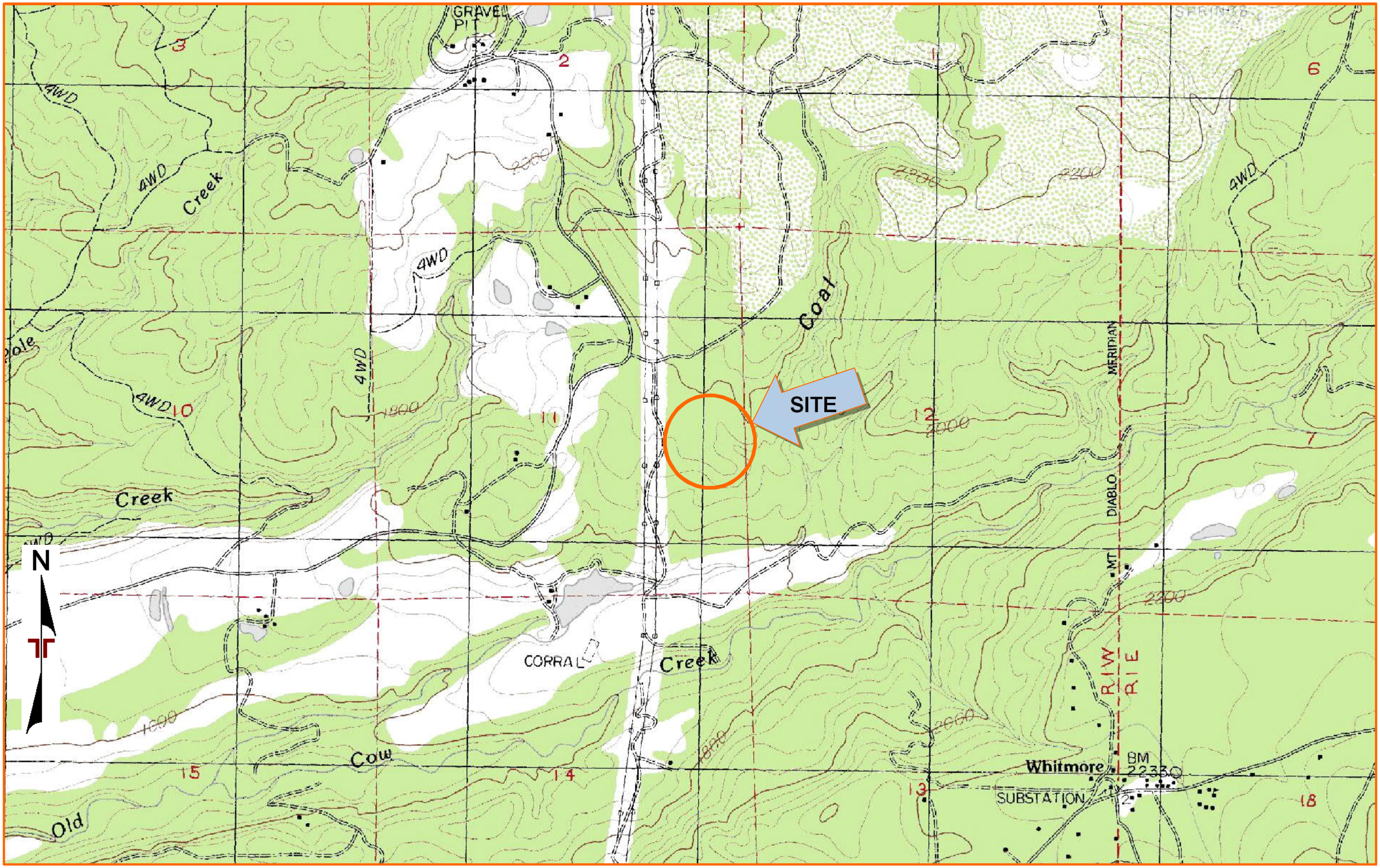


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: WHITMORE, CA (1/1/1986).

EXPLORATION PLAN

Fern Road Substation ■ Whitmore, Shasta County, California
Terracon Project No. NB215034

Terracon GeoReport

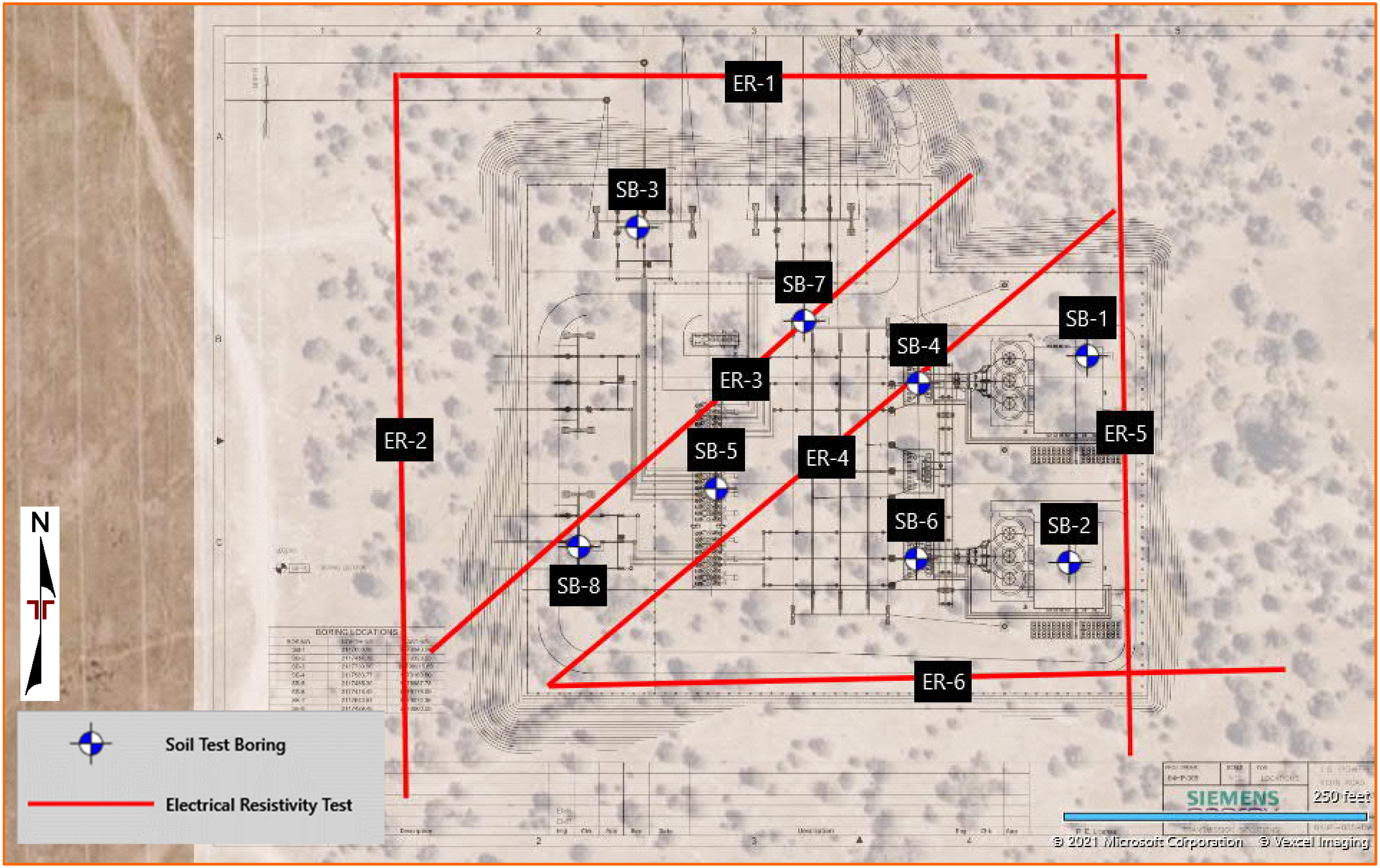


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (SB-1 through SB-8)
Atterberg Limits
Grain Size Distribution (3 pages)
California Bearing Ratio Test Results (2 pages)
Corrosivity
Field ER Testing Data (6 pages)

Note: All attachments are one page unless noted above.

BORING LOG NO. SB-1

Page 1 of 2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: **Site Coordinates: 40.64329°N, 121.937703°W**
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6432° Longitude: -121.9362°

Approximate Surface Elev.: 1950 (Ft.) +/-

MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	**SILTY SAND (SM)**, trace gravel, fine grained, angular, light brown-yellow, medium dense to very dense, weak to moderate cementation											
				⧗		12-12-18			16.4	86	36-32-4	46
		5		☒		33-40-50/5"			17.4			
				⧗		25-50/4"			15.4	103		
	8.0 — 1942+/-											
2	**SANDSTONE (SP-SC)**, brown gray with orange, very dense, completely weathered to residual soil											
		10		☒		14-34-46 N=80						32
		15		☒		24-50/6"			14.7			
		20		☒		25-34-38 N=72			14.9			
	23.0 — 1927+/-											
5	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay											
		25		☒		42-50/4"			11.5			
	28.0 — 1922+/-											
3	**POORLY GRADED SAND (SP)**, trace clay, fine to medium grained, subrounded, brown gray, very dense, moderate to strong cementation											
		30		☒		29-50/5"			14.9			
		35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-10-2021	Boring Completed: 06-11-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-1

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 40.6432° Longitude: -121.9362° Approximate Surface Elev.: 1950 (Ft.) +/- DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
3		37.0 1913+/-			☒		15-36-50/3"			11.7			
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, highly weathered to residual soil, lenses of medium plasticity red clay			▮	24		0					
			40		▮	28		34					
		47.0 1903+/-	45		▮	18		0					
		Boring Terminated at 47 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-10-2021	Boring Completed: 06-11-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: **Site Coordinates: 40.64329°N, 121.937703°W**
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6428° Longitude: -121.9363°

Approximate Surface Elev.: 1949 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	2.0	**CLAYEY SAND WITH GRAVEL (SC)**, medium plasticity, light brown	1947+/-
	4.0	**SILT (ML)**, brown gray with orange, hard	1945+/-
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		✋								
		⧗		29-50/4"			13.5	99	30-29-1	100
5		☒		34-42-50/6"						18
		⧗		50/6"						
10		☒		15-31-50/3"			15.0			
15		☒		25-50/5"			14.8			
20		☒		34-32-50/6"			10.6			
25		☒		43-38-50 N=88			12.2			
30		☒		50/4"			14.2			
35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-09-2021	Boring Completed: 06-10-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6428° Longitude: -121.9363°

Approximate Surface Elev.: 1949 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay *(continued)*			☒		18-27-34 N=61			24.8			
			40		☒		20-31-39 N=70			33.6			
			45		☒		16-22-50/5"			30.2			
			50		☒		30-50/5"			27.8			
			55		☒		33-50/6"			29.8			
		61.2 1888+/-	60		☒		31-48-50/2"			31.2			

Boring Terminated at 61.2 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-09-2021	Boring Completed: 06-10-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-3

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6435° Longitude: -121.9376°

Approximate Surface Elev.: 1954 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0–5.5	**SILTY SAND (SM)**, trace gravel, fine to coarse grained, elastic silt, light brown, medium dense to very dense, moderate cementation	1948.5+/-
5	5.5–34.5	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay	1919.5+/-
3	34.5		

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1–2		✋								
2.5–4		⧓		17-19-22			20.8	94	50-30-20	46
5–6.5		⧖		10-22-31 N=53			18.2			
7.5–9		⧓		12-34-50/5"			17.8	99		
10–11.5		⧖		16-22-46 N=68			18.9			
15		⧖		50			13.9			
20		⧖		46-50/3"			15.3			
25		⧖		36-50/5"			14.2			
30		⧖		19-26-50/5"						31

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-08-2021	Boring Completed: 06-08-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-3

Page 2 of 2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6435° Longitude: -121.9376°

Approximate Surface Elev.: 1954 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
3		**SILTY SAND (SM)**, fine to coarse grained, elastic silt, light brown with orange, very dense, weak cementation *(continued)*			☒		19-31-43 N=74			33.1			
			40		☒		23-26-38 N=64						38
			45		☒		15-23-33 N=56					68-53-15	48
		48.5 — 1905.5+/-											
4		**FAT CLAY WITH SAND (CH)**, fine to coarse grained, medium to high plasticity, gray and brown, hard, strong cementation	50				50/0"			32.9			
		52.0 — 1902+/-											
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay	55		☒		31-30-50 N=80			20.3			
		59.5 — 1894.5+/-											
4		**FAT CLAY WITH SAND (CH)**, fine to coarse grained, medium to high plasticity, brown gray, hard, moderate cementation	60		☒		50/3"			17.4			
		60.3 — 1893.5+/-											
		Boring Terminated at 60.29 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-08-2021	Boring Completed: 06-08-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL NB215034 FERN ROAD SUBSTAT.GPJ TERRACON_DATATEMPLATE.GDT 7/2/21

BORING LOG NO. SB-4

Page 1 of 1

PROJECT: Fern Road Substation

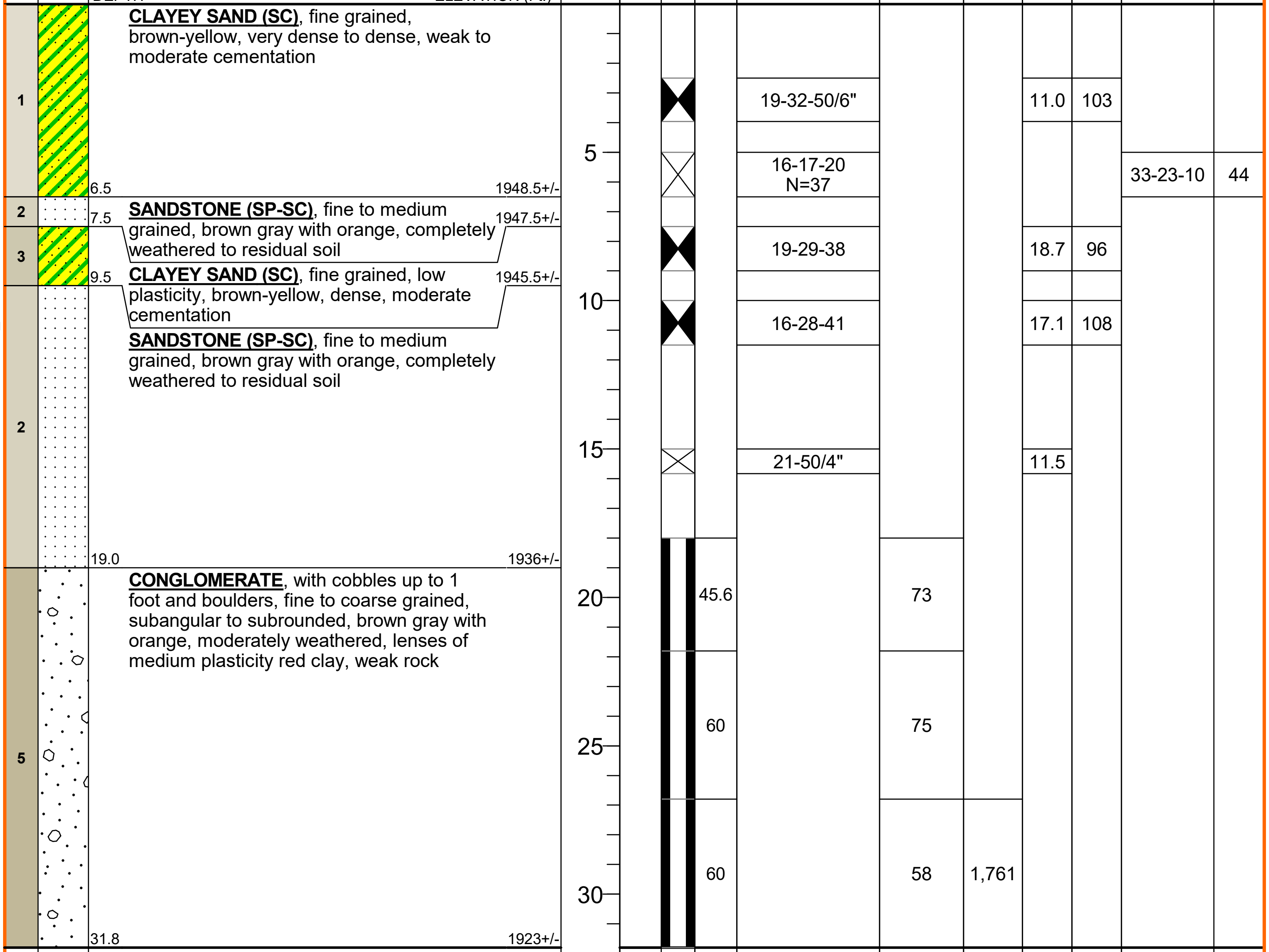
CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6432° Longitude: -121.9367°

Approximate Surface Elev.: 1955 (Ft.) +/-



MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	6.5	**CLAYEY SAND (SC)**, fine grained, brown-yellow, very dense to dense, weak to moderate cementation	1948.5+/-				19-32-50/6"			11.0	103		
				5			16-17-20 N=37					33-23-10	44
2	7.5	**SANDSTONE (SP-SC)**, fine to medium grained, brown gray with orange, completely weathered to residual soil	1947.5+/-										
3	9.5	**CLAYEY SAND (SC)**, fine grained, low plasticity, brown-yellow, dense, moderate cementation	1945.5+/-				19-29-38			18.7	96		
2	19.0	**SANDSTONE (SP-SC)**, fine to medium grained, brown gray with orange, completely weathered to residual soil	1936+/-	10			16-28-41			17.1	108		
				15			21-50/4"			11.5			
5	31.8	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, moderately weathered, lenses of medium plasticity red clay, weak rock	1923+/-	20		45.6		73					
				25		60		75					
				30		60		58	1,761				

Boring Terminated at 31.8 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-11-2021	Boring Completed: 06-11-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-5

Page 1 of 2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6429° Longitude: -121.9373°

Approximate Surface Elev.: 1950 (Ft.) +/-

MODEL LAYER	DEPTH / ELEVATION (Ft.)	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		**SILTY SAND (SM)**, with cobbles up to 1 foot and boulders, fine to medium grained, brown gray, very dense										
						28-50/4"			24.0		NP	6
			5			38-32-29 N=61			14.3			
	7.0 / 1943+/-											
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, moderately weathered, lenses of medium plasticity red clay, weak rock			7.6	50/2"	100					
			10		60		68					
			15		60		54	1,289				
			20		60		58					
			25		60		58					
			30		60		63					
			35									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-07-2021	Boring Completed: 06-07-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-5

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6429° Longitude: -121.9373°

Approximate Surface Elev.: 1950 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, moderately weathered, lenses of medium plasticity red clay, weak rock *(continued)*				60		77					
			40			60		74					
		42.8 1907+/-											
		Boring Terminated at 42.8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-07-2021	Boring Completed: 06-07-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-6

Page 1 of 2

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6428° Longitude: -121.9368°

Approximate Surface Elev.: 1957 (Ft.) +/-

MODEL LAYER	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	**CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, angular, brown 2.0	1955+/-											
5	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay						29-50/6"			11.4	105		
			5				40-50/1"			12.1			
	7.5	1949.5+/-											
3	**SILTY SAND WITH GRAVEL (SM)**, with gravel, fine to coarse grained, subangular to subrounded, brown gray with orange, very dense						50/6"			24.8			
			10				28-40-50/6"					37-32-5	17
	15.0	1942+/-											
5	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray, moderately weathered, lenses of medium plasticity red clay, weak rock		15				24-42-50/5"			32.2			
			20				19-28-38 N=66			34.5			
			25				50/3"			21.7			
						12		0					
			30			60		55					
			35			60		74	1,130				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-09-2021	Boring Completed: 06-09-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-6

PROJECT: **Fern Road Substation**

CLIENT: **LS Power Development LLC**
Chesterfield, MO

SITE: **Site Coordinates: 40.64329°N, 121.937703°W**
Whitmore, CA

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 40.6428° Longitude: -121.9368° Approximate Surface Elev.: 1957 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5		36.5 1920.5+/-											
		Boring Terminated at 36.5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-09-2021	Boring Completed: 06-09-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-7

PROJECT: **Fern Road Substation**

CLIENT: **LS Power Development LLC**
Chesterfield, MO

SITE: **Site Coordinates: 40.64329°N, 121.937703°W**
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6433° Longitude: -121.9371°

Approximate Surface Elev.: 1954 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		**SILTY SAND (SM)**, fine to coarse grained, brown with red, very dense, weak cementation				⧓		28-50/5"			14.1	96	30-29-1	20
				5		⊠		27-46-50/5"			17.4			
						⊠		50/5"						
		7.0	1947+/-											
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay				▮	16		25					
						⊠		9-44-48 N=92					31-22-9	30
				10		▮	18		0					
						⊠		22-36-41 N=77			22.4			
						▮	6		0					
				15		⊠		20-34-46 N=80			24.1			
						▮	30		40					
						⊠		20-18-24 N=42			29.1			
		19.0	1935+/-											
		Boring Terminated at 19 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Rotary auger advanced with 4" solid stem auger, coring advanced with 3" NQ/NX rock core barrel

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-07-2021	Boring Completed: 06-08-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-8

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6428° Longitude: -121.9378°

Approximate Surface Elev.: 1947 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	1.5	**SANDY LEAN CLAY (CL)**, fine to medium grained, medium plasticity, red brown	1945.5+/-
2	7.0	**SANDSTONE (SM)**, fine to medium grained, orange and red, very dense, completely weathered to residual soil	1940+/-
5	14.0	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, brown gray with orange, completely weathered to residual soil, lenses of medium plasticity red clay	1933+/-
4	15.5	**FAT CLAY WITH SAND (CH)**, fine grained, medium to high plasticity, hard, weak to moderate cementation	1931.5+/-
5		**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, medium plasticity, brown gray with orange, completely weathered to residual soil, lenses of red clay	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		⧗		9-17-30			25.2	80	46-35-11	16
5		☒		13-50/5"						
		⧗		44-41-50/6"			22.5	100		
10		☒		50/3"						
15		☒		22-50/3"			18.5			
20		☒		7-15-21 N=36			26.7			
25		☒		40-35-50/5"			17.6			
30		☒		26-50/4"			20.5			
35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-08-2021	Boring Completed: 06-09-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

BORING LOG NO. SB-8

PROJECT: Fern Road Substation

CLIENT: LS Power Development LLC
Chesterfield, MO

SITE: Site Coordinates: 40.64329°N, 121.937703°W
Whitmore, CA

LOCATION See Exploration Plan

Latitude: 40.6428° Longitude: -121.9378°

Approximate Surface Elev.: 1947 (Ft.) +/-

MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD%	ROCK UCC (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5	**CONGLOMERATE**, with cobbles up to 1 foot and boulders, fine to coarse grained, subangular to subrounded, medium plasticity, brown gray with orange, completely weathered to residual soil, lenses of red clay *(continued)*			☒		23-35-50/3"			27.7			
	lenses of medium to high plasticity red clay	40		☒		33-47-50/3"			27.9			
		45		☒		28-50/6"			22.0			
		50		☒		50/5"			17.9			
		55		☒		44-50/3"			26.1			
	60.3 1886.5+/-	60		☒		50			18.7			

Boring Terminated at 60.33 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4" solid stem auger

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

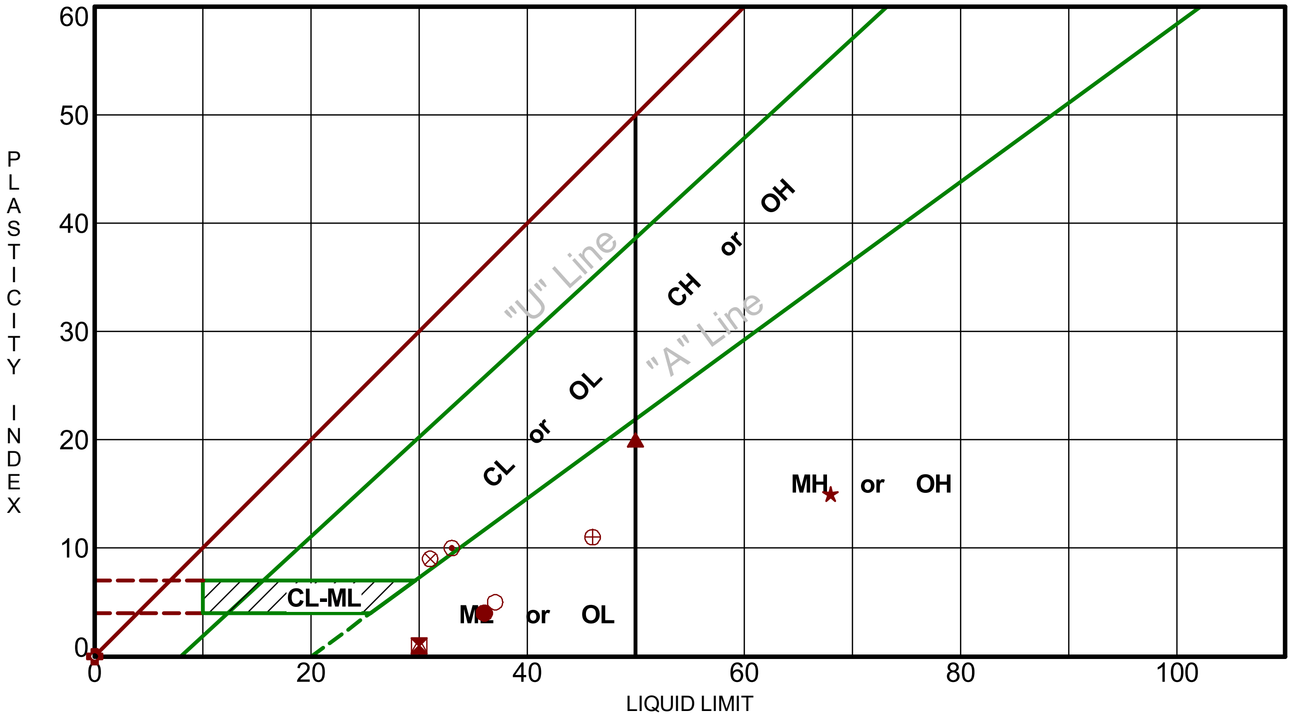
Groundwater not encountered

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 06-08-2021	Boring Completed: 06-09-2021
Drill Rig: CME-55 track	Driller: Taber Drilling
Project No.: NB215034	

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	USCS	Description
●	SB-1	2.5 - 4	36	32	4	46.4	SM	SILTY SAND
☒	SB-2	2.5 - 3.3	30	29	1	100.0	ML	SILT
▲	SB-3	2.5 - 4	50	30	20	46.0	SM	SILTY SAND
★	SB-3	45 - 46.5	68	53	15	48.1	SM	SILTY SAND
⊙	SB-4	5 - 6.5	33	23	10	44.0	SC	CLAYEY SAND
✿	SB-5	2.5 - 3.3	NP	NP	NP	6.5	SM	SILTY SAND
○	SB-6	10 - 11.5	37	32	5	17.3	SM	SILTY SAND
△	SB-7	2.5 - 3.4	30	29	1	20.5	SM	SILTY SAND
⊗	SB-7	8.5 - 10	31	22	9	30.3	SC	CLAYEY SAND
⊕	SB-8	2.5 - 4	46	35	11	15.8	SM	SILTY SAND

PROJECT: Fern Road Substation

SITE: Site Coordinates: 40.64329°N,
121.937703°W
Whitmore, CA

Terracon
50 Golden Land Ct, Ste 100
Sacramento, CA

PROJECT NUMBER: NB215034

CLIENT: LS Power Development LLC
Chesterfield, MO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS NB215034 FERN ROAD SUBSTAT.GPJ TERRACON_DATATEMPLATE.GDT 6/29/21

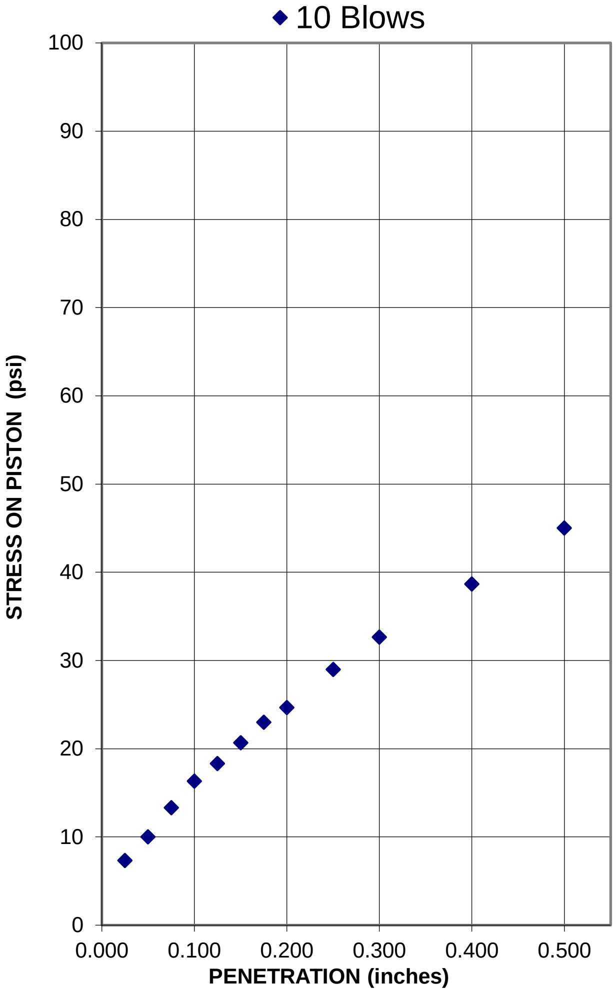
CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS
ASTM D1883 (SOAKED)

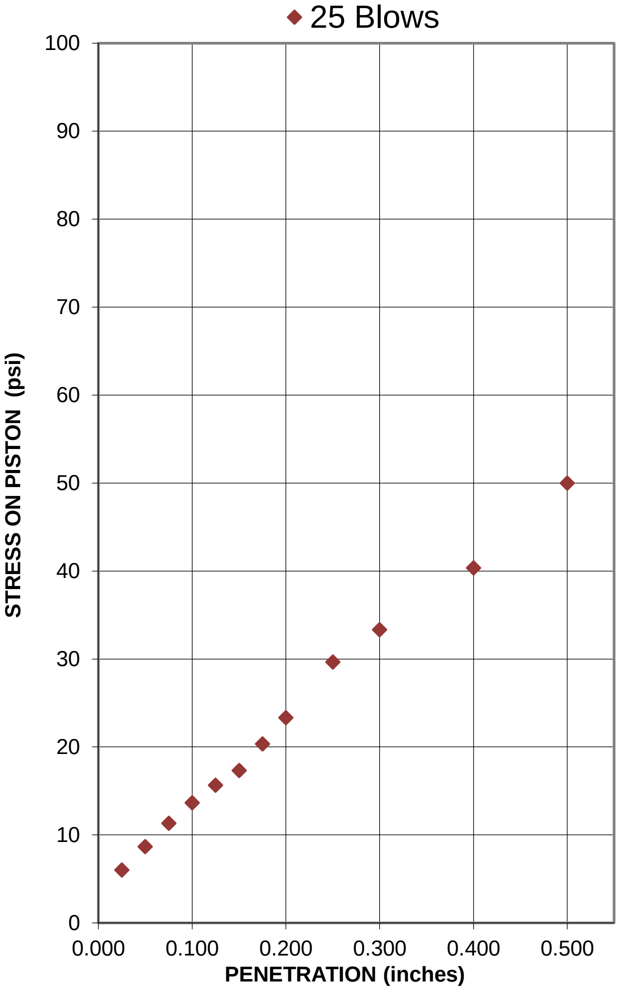
Terracon

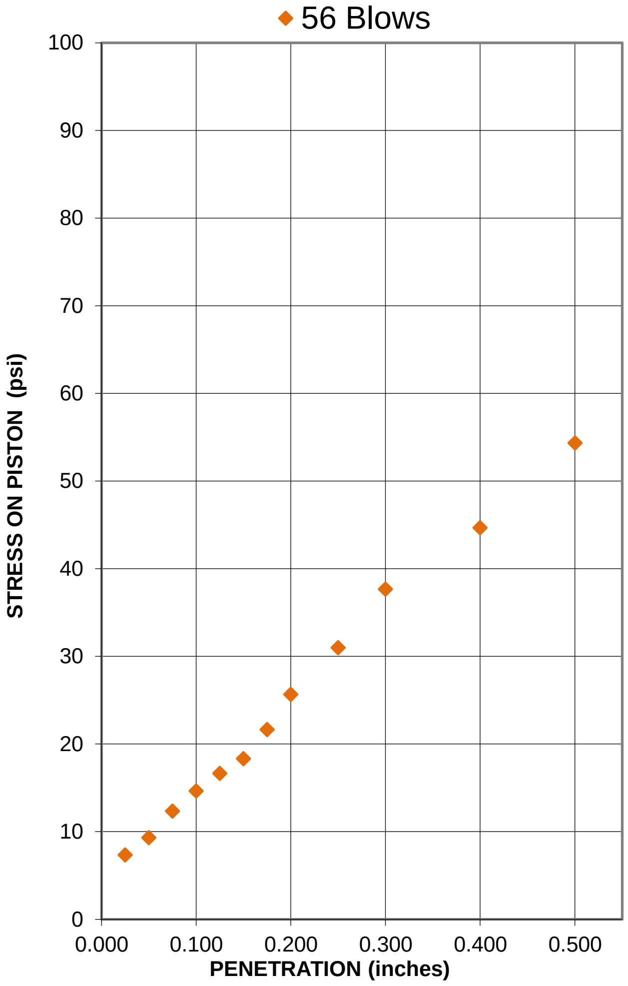
PROJECT: Fern Road Substation
LOCATION: SB-5 @ 1' - 2.5'
MATERIAL: Poorly Graded Sand W/ Silt (SP-SM)
SAMPLE SOURCE: Native

PROJECT NO: NB215034
WORK ORDER NO: --
LAB NO: --
DATE SAMPLED: --

	Blows per Lift	Compaction %	Compaction Method	Surcharge Weight (Lb.)	Sample Condition	Percent Swell	Before Soak		After Soak	
							Dry Density	Moisture %	Dry Density	Moisture %
Point 1	10	91.2	ASTM D1557	10	Soak	0.33	91.4	21.7	90.9	27.8
Point 2	25	94.2	ASTM D1557	10	Soak	0.41	94.4	21.6	91.2	27.7
Point 3	56	100.5	ASTM D1557	10	Soak	0.39	100.7	20.8	90.9	29.6







REVIEWED BY

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS
ASTM D1883 (SOAKED)

PROJECT: Fern Road Substation
LOCATION: SB-5 @ 1' - 2.5'
MATERIAL: Poorly Graded Sand W/ Silt (SP-SM)
SAMPLE SOURCE: Native

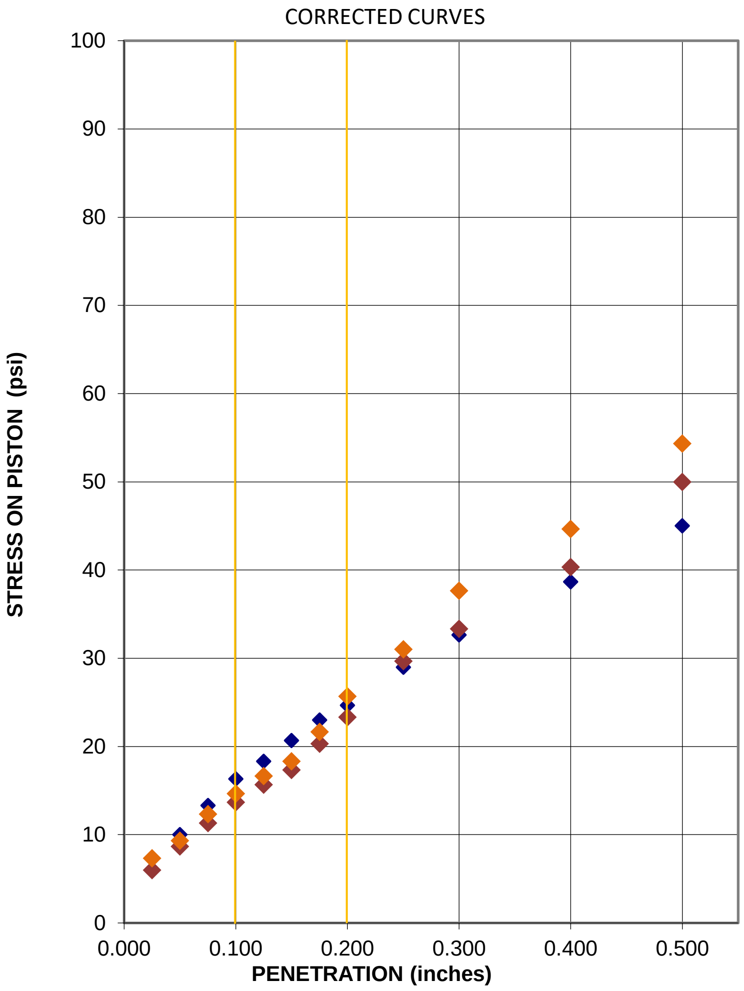
JOB NO: NB215034
WORK ORDER NO: --
LAB NO: --
DATE SAMPLED: --

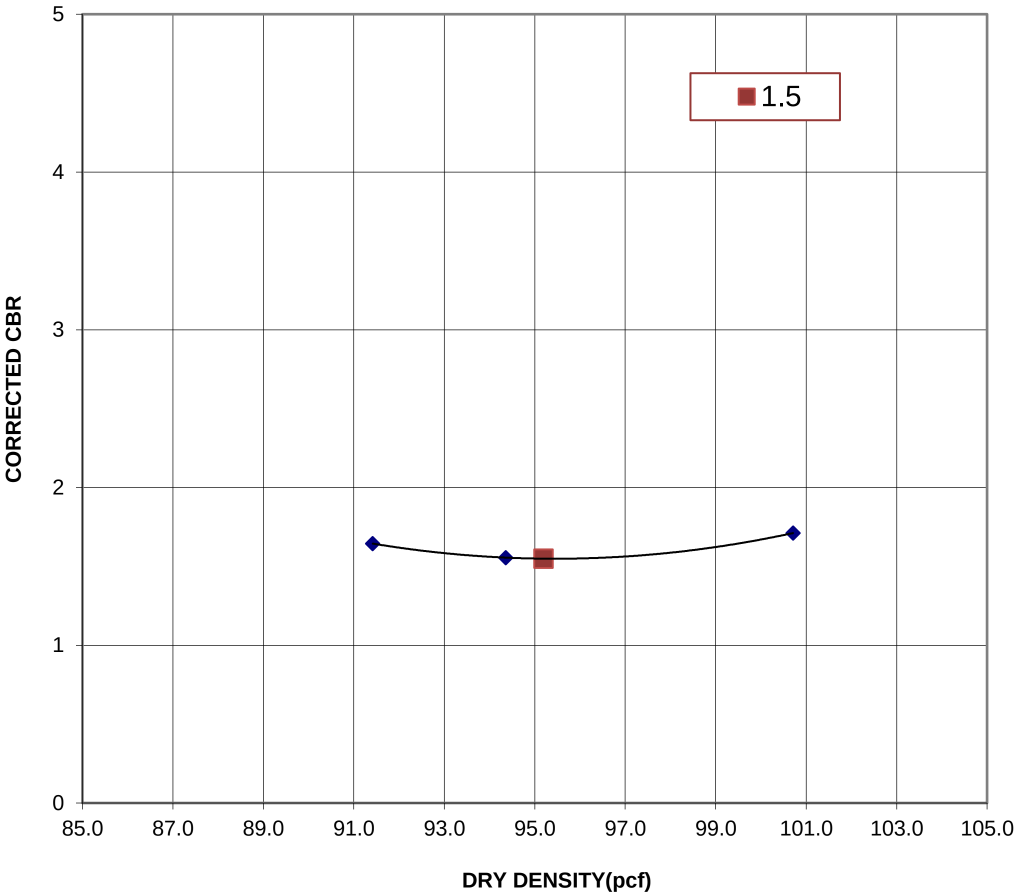
	Correction Factor		Corrected CBR		CBR
	0.1"	0.2"	0.1"	0.2"	
Point 1	0.00	0.00	1.6	1.6	1.6
Point 2	0.00	0.00	1.4	1.6	1.6
Point 3	0.00	0.00	1.5	1.7	1.7

ASTM D1557			
Moisture	Dry Density (pcf)		
%	100%	95%	90%
19.4	100.2	95.2	90.2

95% COMPACTION CBR (.2")

1.5





REVIEWED BY

CHEMICAL LABORATORY TEST REPORT

Project Number: NB215034
Service Date: 06/21/21
Report Date: 06/21/21

Terracon
10400 State Highway 191
Midland, Texas 79707
432-684-9600

Client

LS Power Development LLC
16150 Main Circle Drive
Chesterfield, MO 63132

Project

Fern Road Substation
Redding, CA

Sample Location	SB-2	SB-3
Sample Depth (ft.)	1-4	1-4
pH Analysis, ASTM - G51-18	7.40	7.00
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	60	62
Sulfides, ASTM - D4658-15, (mg/kg)	nil	nil
Chlorides, ASTM D 512 , (mg/kg)	6	16
RedOx, ASTM D-1498, (mV)	+399	+400
Total Salts, ASTM D1125-14, (mg/kg)	126	149
Resistivity, ASTM G187, (ohm-cm)	3,098	2,994

Analyzed By:

Nohelia Monasterios
Field Engineer

FIELD ELECTRICAL RESISTIVITY TEST DATA

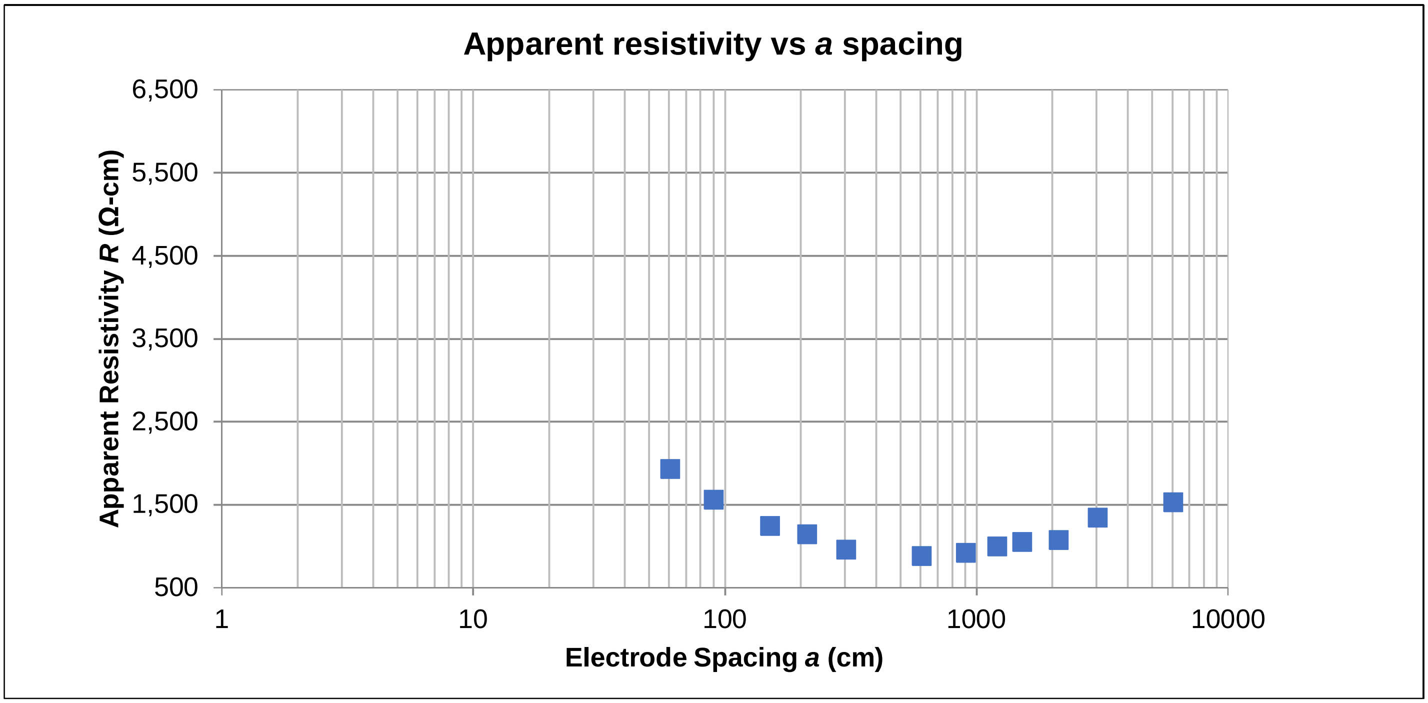
Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

Array Loc.	ER-1: 40.6438678, -121.9372754 (center of test)		
Instrument	Mini-Res Resistivity Meter, LRI	**Weather**	Sunny, 90°F
Serial #	SN-021	**Ground Cond.**	Earthen: moderate grasses, cobbles, trees
Cal. Check	June 22, 2021	**Tested By**	L. Guzman
Test Date	June 24, 2021	**Method**	Wenner 4-pin (ASTM G57-06; IEEE 81)
Notes & Conflicts	Test runs perpendicular to existing overhead transmission power lines along north end of the site.		

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		**Electrode Depth *b***		**Test**	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance *R* Ω	Apparent Resistivity *ρ* (Ω-cm)
2	61	4	10	4.82	1930
3	91	4	10	2.68	1560
5	152	4	10	1.29	1240
7	213	4	10	0.85	1140
10	305	4	10	0.50	960
20	610	4	10	0.23	880
30	914	4	10	0.16	920
40	1219	4	10	0.13	1000
50	1524	4	10	0.11	1050
70	2134	4	10	0.08	1070
100	3048	4	10	0.07	1340
200	6096	4	10	0.04	1530



FIELD ELECTRICAL RESISTIVITY TEST DATA

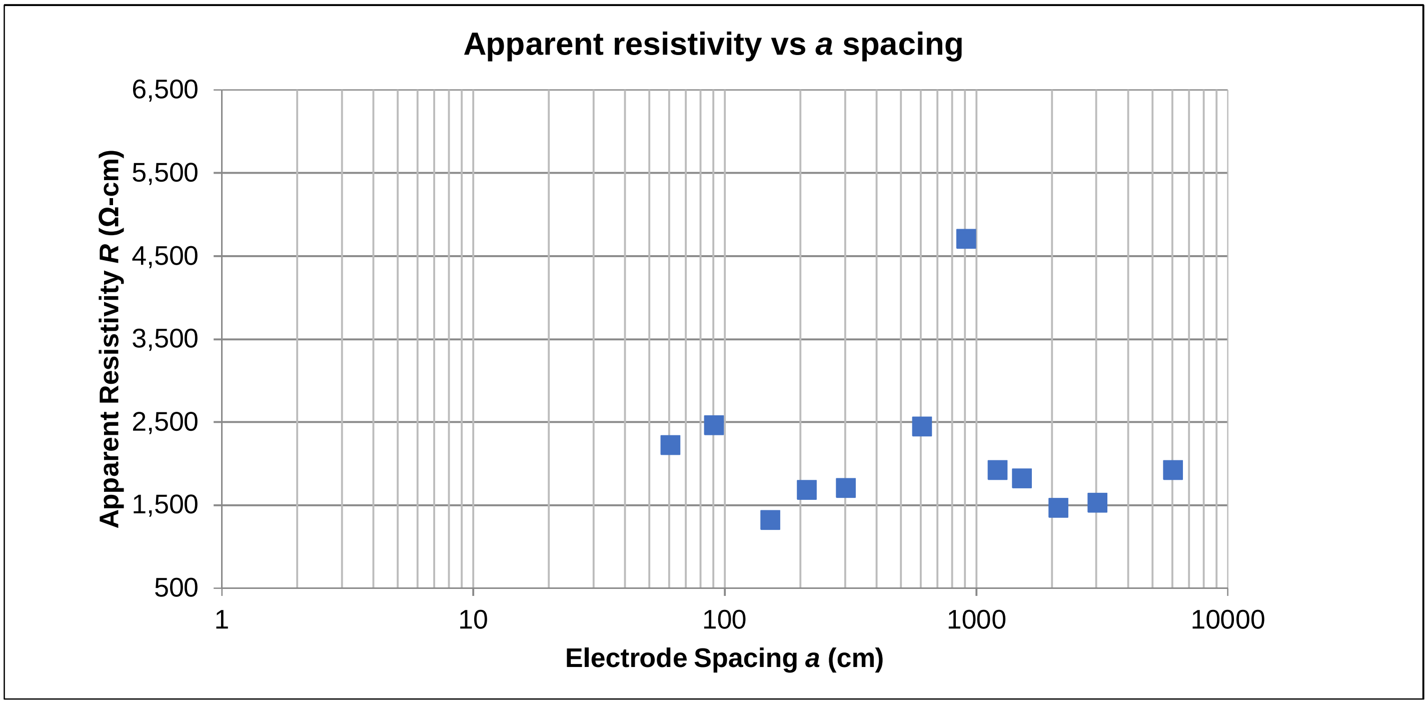
Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

Array Loc. ER-2: 40.6432075, -121.9382699 (center of test)
Instrument Mini-Res Resistivity Meter, LRI **Weather** Sunny, 90°F
Serial # SN-021 **Ground Cond.** Earthen: moderate grasses, cobbles, trees
Cal. Check June 22, 2021 **Tested By** L. Guzman
Test Date June 24, 2021 **Method** Wenner 4-pin (ASTM G57-06; IEEE 81)
Notes & Conflicts Test runs parallel to existing overhead transmission power lines along west end of the site.

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		Electrode Depth *b*		Test	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance *R*	Apparent Resistivity ρ
				Ω	(Ω-cm)
2	61	4	10	5.53	2220
3	91	4	10	4.22	2460
5	152	4	10	1.37	1320
7	213	4	10	1.25	1680
10	305	4	10	0.89	1710
20	610	4	10	0.64	2450
30	914	4	10	0.82	4710
40	1219	4	10	0.25	1920
50	1524	4	10	0.19	1820
70	2134	4	10	0.11	1470
100	3048	4	10	0.08	1530
200	6096	4	10	0.05	1920


Apparent resistivity vs *a* spacing

Terracon GeoReport

FIELD ELECTRICAL RESISTIVITY TEST DATA

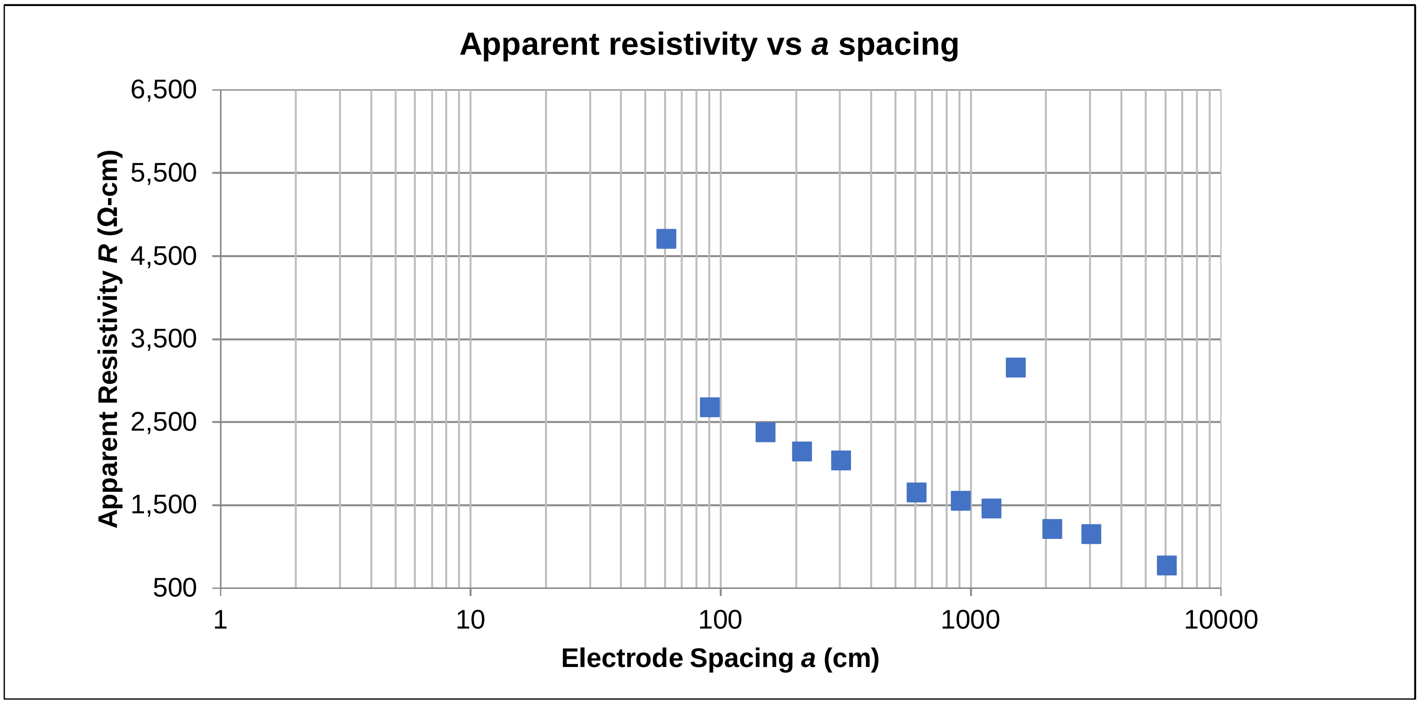
Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

Array Loc. ER-3: 40.6432075, -121.9372014 (center of test)
Instrument Mini-Res Resistivity Meter, LRI **Weather** Sunny, 90°F
Serial # SN-021 **Ground Cond.** Earthen: moderate grasses, cobbles, trees
Cal. Check June 22, 2021 **Tested By** L. Guzman
Test Date June 24, 2021 **Method** Wenner 4-pin (ASTM G57-06; IEEE 81)
Notes & Conflicts Test runs southwest to northeast and cuts diagonally through the site.

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		**Electrode Depth *b***		**Test**	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance *R*	Apparent Resistivity *ρ*
				Ω	(Ω-cm)
2	61	4	10	11.77	4710
3	91	4	10	4.60	2680
5	152	4	10	2.47	2380
7	213	4	10	1.60	2150
10	305	4	10	1.06	2040
20	610	4	10	0.43	1650
30	914	4	10	0.27	1550
40	1219	4	10	0.19	1460
50	1524	4	10	0.33	3160
70	2134	4	10	0.09	1210
100	3048	4	10	0.06	1150
200	6096	4	10	0.02	770



FIELD ELECTRICAL RESISTIVITY TEST DATA

Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

Array Loc. ER-4: 40.6429275, -121.9369364 (center of test)

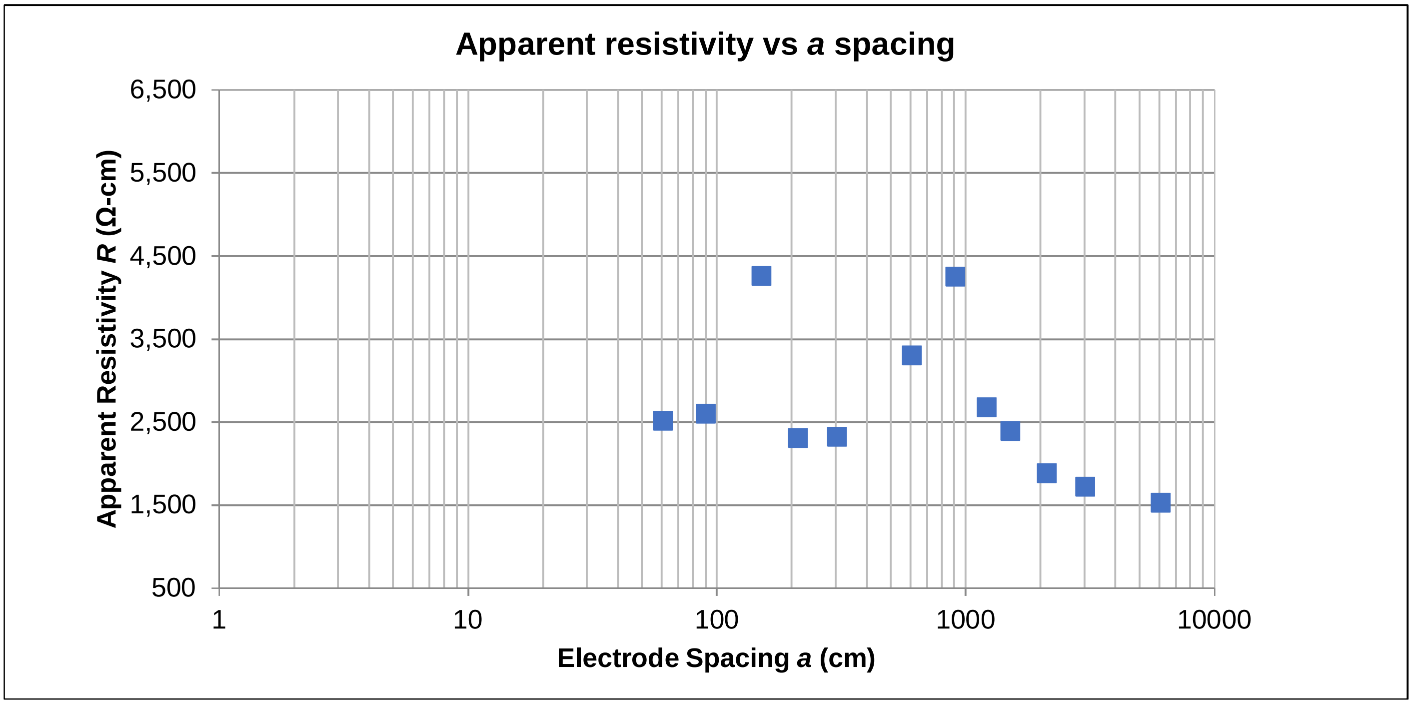
Instrument	Mini-Res Resistivity Meter, LRI	**Weather**	Sunny, 90°F
Serial #	SN-021	**Ground Cond.**	Earthen: moderate grasses, cobbles, trees
Cal. Check	June 22, 2021	**Tested By**	L. Guzman
Test Date	June 23, 2021	**Method**	Wenner 4-pin (ASTM G57-06; IEEE 81)

Notes & Conflicts Test runs southwest to northeast and cuts diagonally through the site.

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		**Electrode Depth *b***		**Test**	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance R Ω	Apparent Resistivity ρ (Ω-cm)
2	61	4	10	6.29	2520
3	91	4	10	4.46	2600
5	152	4	10	4.43	4260
7	213	4	10	1.72	2310
10	305	4	10	1.21	2320
20	610	4	10	0.86	3300
30	914	4	10	0.74	4250
40	1219	4	10	0.35	2680
50	1524	4	10	0.25	2390
70	2134	4	10	0.14	1880
100	3048	4	10	0.09	1720
200	6096	4	10	0.04	1530



FIELD ELECTRICAL RESISTIVITY TEST DATA

Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

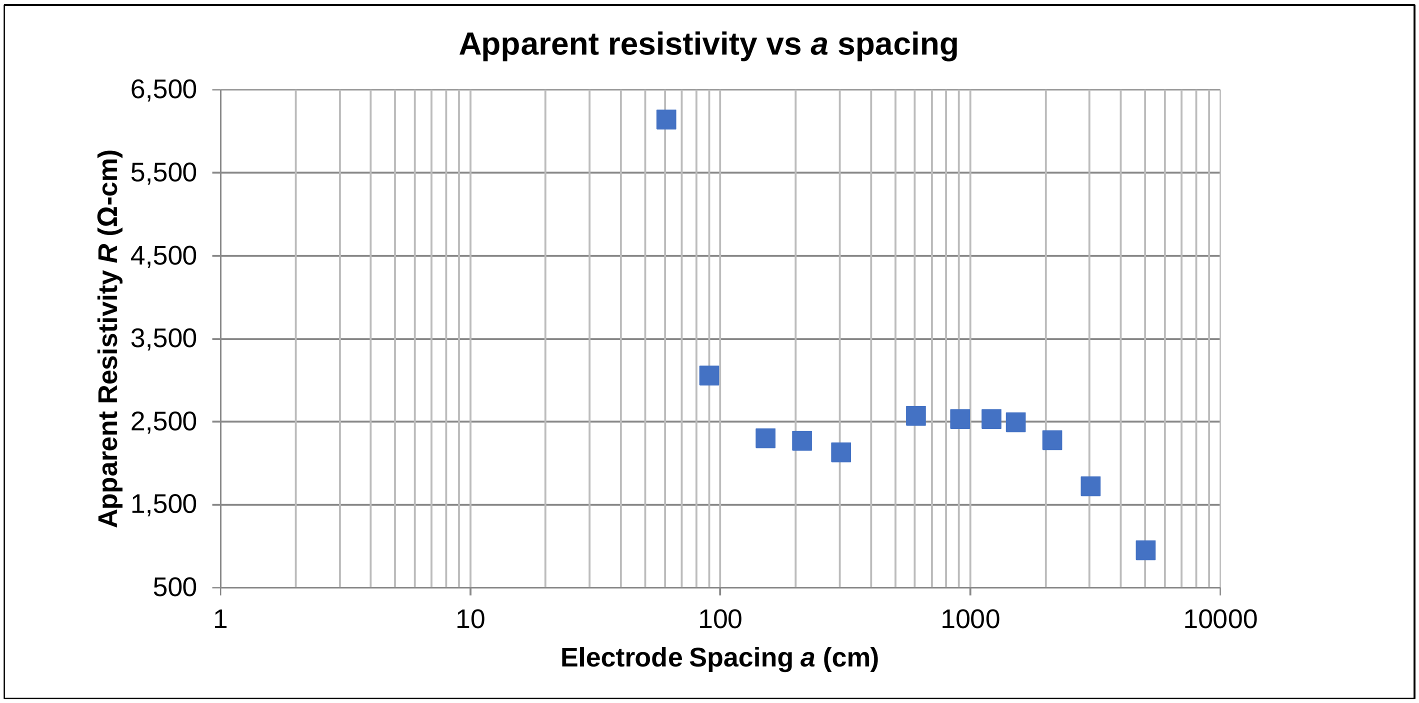
Array Loc.	ER-5: 40.6430593, -121.9363161 (center of test)		
Instrument	Mini-Res Resistivity Meter, LRI	**Weather**	Sunny, 70°F
Serial #	SN-021	**Ground Cond.**	Earthen: moderate grasses, cobbles, trees
Cal. Check	June 22, 2021	**Tested By**	S. Delgado
Test Date	June 10, 2021	**Method**	Wenner 4-pin (ASTM G57-06; IEEE 81)
Notes & Conflicts	Test runs parallel to existing overhead transmission power lines along east end of the site.		

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		**Electrode Depth *b***		**Test**	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance *R* Ω	Apparent Resistivity *ρ* (Ω-cm)
2	61	4	10	15.34	6140
3	91	4	10	5.25	3060
5	152	4	10	2.39	2300
7	213	4	10	1.69	2270
10	305	4	10	1.11	2130
20	610	4	10	0.67	2570
30	914	4	10	0.44	2530
40	1219	4	10	0.33	2530
50	1524	4	10	0.26	2490
70	2134	4	10	0.17	2280
100	3048	4	10	0.09	1720
* 166	5060	4	10	0.03	950

* - "a" spacing was reduced due to cultural interference with wire.



FIELD ELECTRICAL RESISTIVITY TEST DATA

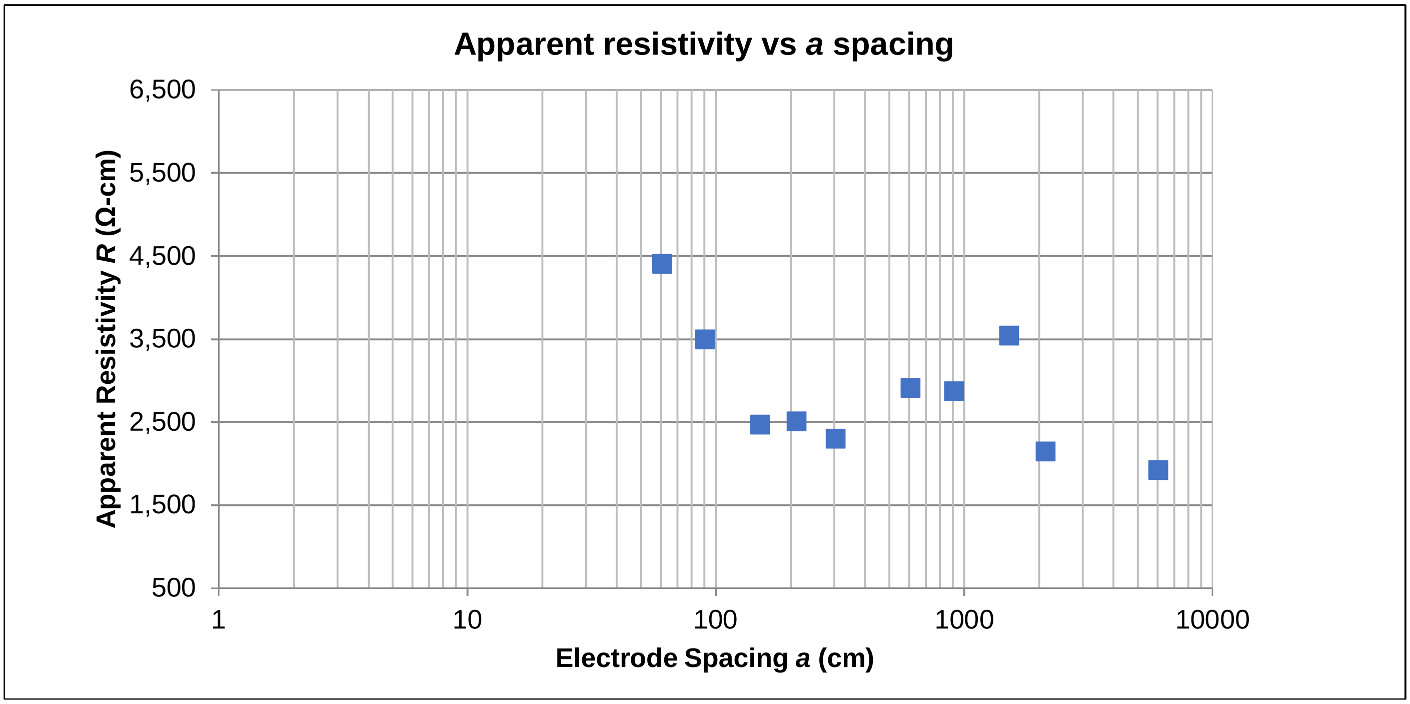
Fern Road Substation ■ Whitmore, Shasta County, CA
Terracon Project No. NB215034

Array Loc.	ER-6: 40.6425136, -121.9368522 (center of test)		
Instrument	Mini-Res Resistivity Meter, LRI	**Weather**	Sunny, 90°F
Serial #	SN-021	**Ground Cond.**	Earthen: moderate grasses, cobbles, trees
Cal. Check	June 22, 2021	**Tested By**	L. Guzman
Test Date	June 23, 2021	**Method**	Wenner 4-pin (ASTM G57-06; IEEE 81)
Notes & Conflicts	Test runs perpendicular to existing overhead transmission power lines along south side of the site. Outliers recorded at an "a" spacing of 40 feet and 100 feet.		

Apparent resistivity ρ is calculated as :

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Electrode Spacing *a*		**Electrode Depth *b***		**Test**	
(feet)	(centimeters)	(inches)	(centimeters)	Measured Resistance *R*	Apparent Resistivity *ρ*
				Ω	(Ω-cm)
2	61	4	10	11.00	4410
3	91	4	10	6.00	3500
5	152	4	10	2.57	2470
7	213	4	10	1.87	2510
10	305	4	10	1.20	2300
20	610	4	10	0.76	2910
30	914	4	10	0.50	2870
40	1219	4	10	1.27	9730
50	1524	4	10	0.37	3540
70	2134	4	10	0.16	2150
100	3048	4	10	2.00	38300
200	6096	4	10	0.05	1920



SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

- ⧗ Modified California Ring Sampler
- ☒ Standard Penetration Test

WATER LEVEL

- ▽ **Water Initially Encountered**
- ▽ **Water Level After a Specified Period of Time**
- ▼ **Water Level After a Specified Period of Time**
- ▨ **Cave In Encountered**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve) Density determined by Standard Penetration Resistance			Consistency of Fine-Grained Soils (50% or more passing the No. 200 sieve) Consistency determined by laboratory shear strength testing, field visual0manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**2.5-inch California Modified Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**2.5-inch California Modified Sampler Blows/Ft.**
Very Loose	0 to 3	0 to 5	Very Soft	less than 0.25	< 2	< 3
Loose	4 to 10	5 to 12	Soft	0.25 to 0.50	2 to 4	3 to 5
Medium Dense	10 to 30	19 to 58	Medium Stiff	0.50 to 1.00	5 to 8	6 to 11
Dense	31 to 50	36 to 60	Stiff	1.00 to 2.00	9 to 15	12 to 21
Very Dense	> 50	> 60	Very Stiff	2.00 to 4.00	16 to 30	22 to 42
			Hard	> 4.00	> 30	> 42

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	**Group Name** [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A”		CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

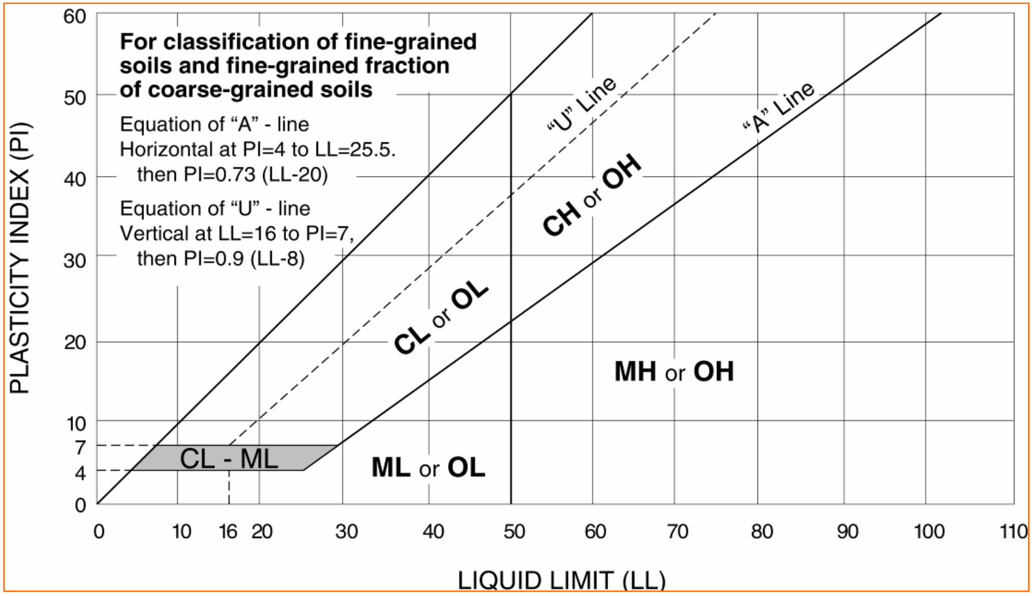
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



UNIFIED SOIL CLASSIFICATION SYSTEM

WEATHERING

Term	Description
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS

Description	Field Identification	Uniaxial Compressive Strength, psi (MPa)
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION

Fracture Spacing (Joints, Faults, Other Fractures)		Bedding Spacing (May Include Foliation or Banding)	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]

Description	RQD Value (%)
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

[1] The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some 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 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull 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.
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" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens 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 ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. 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 thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.