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35 YEARS

TECHNICAL MEMORANDUM

To: Mr. Keith Herren
KW Petaluma Hill Road, LLC

Project No. E15229.003
15 July 2019

Cc: Mr. Sean O'Brien
KW Petaluma Hill Road, LLC

From: Devin Fielding
Staff Engineer

Reviewed By: Martha McDonnell, P.E.
Associate Engineer

REGISTERED PROFESSIONAL ENGINEER MARTHA A. McDONNELL NO. 042560 Exp. 3-31-20 CIVIL STATE OF CALIFORNIA

Subject: 38° NORTH PHASE 2
Petaluma Hill Road, Santa Rosa, California
FEASIBILITY OF SUBTERRANEAN CONSTRUCTION

References:
1. Geotechnical Engineering Study for Petaluma Hill Road and Kawana Springs Road, prepared by Youngdahl Consulting Group, Inc., dated 15 September 2015 (Project No. E15229.000).
2. Geotechnical Engineering Study for 38° North Phase 2, prepared by Youngdahl Consulting Group, Inc., dated 15 January 2019 (Project No. E15229.003).
3. Residential & Future Commercial Site Plan for 38° North Phase 2, prepared by TSD Engineering, Inc., dated 9 July 2019.

Based on the Reference 3 plans, we understand that subterranean parking is being considered for use within the future commercial development at the southwest corner of the project site. We anticipate that the subterranean parking will likely be one story, located beneath surface level parking and a commercial structure of approximate 20,000 square feet.

Clays with high potential for expansion in a medium stiff to stiff condition were generally encountered from ground surface to approximately 6 feet below ground surface in the vicinity of the proposed commercial site. Underlying the clays were cemented silts and sands in hard and dense to very dense conditions, respectively. Based on the soil conditions encountered at the site, we anticipate that construction of one-story subterranean parking is feasible at the proposed location.

We expect that mitigation for the highly expansive clays will be necessary for development of the project site. Additionally, we anticipate that drainage provisions will need to be installed due to the close proximity of the drainage/wetland area to the proposed commercial site and subterranean parking.

If there are any questions regarding these recommendations, please feel free to contact our office at your convenience.

GEOTECHNICAL ENGINEERING STUDY
FOR
38° NORTH PHASE 2
Petaluma Hill Road
Santa Rosa, California

Project No. E15229.003
January 2019

YOUNGDAHL
CONSULTING GROUP, INC.

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30 YEARS

KW Petaluma Hill Road, LLC
c/o Kent Mouton
151 South El Camino Drive
Beverly Hills, California 90212

Project No. E15229.003
15 January 2019

Attention: Mr. Keith Herren

Subject: **38° NORTH PHASE 2**
Petaluma Hill Road, Santa Rosa, California
GEOTECHNICAL ENGINEERING STUDY

References:
1. Geotechnical Engineering Study for Petaluma Hill Road and Kawana Springs Road, prepared by Youngdahl Consulting Group, Inc., dated 15 September 2015 (Project No. E15229.000).
2. Conceptual Site Plan, 38° North – Phase 2, prepared by BSB Design, dated 27 June 2018 (Project No. MR170465.00).
3. Proposal and Executed Contract for 38° North Phase 2, prepared by Youngdahl Consulting Group, Inc., dated 27 September 2018.

Dear Mr. Herren:

In accordance with your authorization, Youngdahl Consulting Group, Inc. has performed a Geotechnical Engineering Study for the project site located on the east side of Petaluma Hill Road in Santa Rosa, California. The purpose of this study was to perform a subsurface exploration and evaluate the surface and subsurface soil conditions at the site and provide geotechnical information and design criteria for the proposed project. Our scope was limited to a subsurface investigation, laboratory testing, and preparation of this report per the Reference 3 proposal.

Based upon our site reconnaissance and subsurface exploration program, it is our opinion that the primary geotechnical issues to be addressed consist of the presence of potentially highly expansive soils, overexcavation of soft and dry surface soils and recompaction as engineered fills, and drainage issues related to the low permeable soils present at the site. Due to the non-uniform nature of soils, other geotechnical issues may become more apparent during grading operations which are not listed above. The descriptions, findings, conclusions, and recommendations provided in this report are formulated as a whole; specific conclusions or recommendations should not be derived or used out of context. Please review the limitations and uniformity of conditions section of this report.

This report has been prepared for the exclusive use of KW Petaluma Hill Road, LLC and their consultants, for specific application to this project, in accordance with generally accepted geotechnical engineering practice. Should you have any questions or require additional information, please contact our office at your convenience.

Very truly yours,
Youngdahl Consulting Group, Inc.

Devin S. Fielding
Staff Engineer

Reviewed By:

Martha A. McDonnell, P.E.
Associate Engineer

REGISTERED PROFESSIONAL ENGINEER
MARTHA A. McDONNELL
NO. 042560
Exp. 3-31-20
CIVIL
STATE OF CALIFORNIA

Distribution: PDF to Client

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GEOTECHNICAL ENGINEERING STUDY
FOR
38° NORTH PHASE 2

1.0 INTRODUCTION

This report presents the results of our Geotechnical Engineering Study performed for the proposed multi-family development planned to be constructed along Petaluma Hill Road in Santa Rosa, California. An annotated vicinity map is provided on Figure A-1 to identify the approximate project location.

Purpose and Scope

The purpose of this study was to explore and evaluate the surface and subsurface conditions at the site, to provide geotechnical information and design criteria, and to develop geotechnical recommendations for the proposed project. The scope of this study includes the following:

- A review of geotechnical and geologic data available to us at the time of our study;
- A field study consisting of a site reconnaissance, followed by an exploratory boring program to observe and characterize the subsurface conditions;
- A laboratory testing program performed on representative samples collected during our field study;
- Engineering analysis of the data and information obtained from our field study, laboratory testing, and literature review;
- Development of geotechnical recommendations regarding earthwork construction including, site preparation and grading, soil moisture conditions, engineered fill criteria, underground improvements, and drainage;
- Development of geotechnical design criteria for seismic conditions, shallow foundations, slabs on grade, and pavements;
- Preparation of this report summarizing our findings, conclusions, and recommendations regarding the above described information.

Project Understanding

We understand that proposed development will consist of the construction of Phase 2 of an apartment complex at the project site. Final development plans were not available at the time of this proposal; however, based on the Reference No. 2 plans we anticipate the development will consist of 3 story wood frame structures supported by either conventional foundations with concrete slab on grade floors or post tension slab on grade foundations. Further, we anticipate appurtenant construction will include the associated utilities, paved drive aisles and parking areas, a pool, and a clubhouse. Due to the relatively flat nature of the site, site development will likely include shallow cuts and fills to generate the proposed building pads and promote positive site drainage.

Background

Based on a limited aerial review dating back to 1993, there has been previous activity at the project site. A structure was previously located at the northwest corner of the site before being demolished circa 2008. Following demolition of the structure, the site appears to have been used as grazing land for livestock. Throughout the observed history, there were signs of vehicular traffic throughout the project site which may have resulted in the disturbance of near-surface soils at the site.

If studies or plans pertaining to the site exist and are not cited as a reference in this report, we should be afforded the opportunity to review and modify our conclusions and recommendations as necessary.

2.0 FINDINGS

The following section describes our findings regarding the site conditions that we observed during our site reconnaissance and subsequent subsurface exploration. In addition, this section also provides the results of our laboratory testing, geologic review, and engineering assessment related to the project site.

Surface Observations

The project site is located on the east side of Petaluma Hill Road in Santa Rosa, California. The project site is bounded by Petaluma Hill Road to the west, Phase 1 under construction to the north, ongoing construction to the east, and a rural residential property to the south. Site topography is relatively flat. Vegetation throughout the project generally consisted of seasonal grasses with sparse trees. A drainage swale is present with an east/west orientation just south of the center of the site.

Subsurface Conditions

Our field study included a site reconnaissance by a representative of our firm followed by a subsurface exploration program conducted on 9 November 2018. The exploration program included the drilling of 4 exploratory borings under the direction of our representative at the approximate locations shown on Figure A-2, Appendix A. A description of the field exploration program is provided in Appendix A.

Subsurface soil conditions at the project site included clays, silts, and sands. The upper soil layers were generally observed to be loose or soft to depths up to 1 foot. Although not identified in our exploration, but given the history of the project site, fill soils may be present at various locations throughout the site. The encountered soils primarily consisted of clays to depths of approximately 5 to 8½ feet below ground surface. The clay soils were underlain by silts and sands in hard and dense to very dense conditions, often with varying levels of cementation.

A more detailed description of the subsurface conditions encountered during our subsurface exploration is presented graphically on the “Exploratory Boring Logs", Figures A-3 through A-6, Appendix A. These logs show a graphic interpretation of the subsurface profile, and the location and depths at which samples were collected.

Groundwater Conditions

Groundwater conditions were not observed at the boring locations. Based on our previous experience at the site, the depth to groundwater during our Reference 1 study was measured to be approximately 47 feet beneath the ground surface. According to the Department of Water Resources (DWR) well records, groundwater in the vicinity varies between 10 and 60 feet below the ground surface.

Geologic Conditions

The geologic portion of this report included a review of geologic data pertinent to the site and an interpretation of our observations of the surface exposures and our observations in our exploratory test pits excavated during the field study.

The site is located in the City of Santa Rosa, which is within the Great Valley geomorphic province. Sonoma County is located on the coast of the Pacific Ocean, north of the San Francisco Bay.

According to the Geologic Map of the Santa Rosa 7.5' Quadrangle (McLaughlin R.J. et al., 2008), the project site is primarily underlain by Quaternary Age alluvial fan and fluvial terrace deposits, which is poorly sorted stream and basin deposits of sand and silt. The site may also have pockets of Late Tertiary Sonoma Volcanics consisting of andesite and basalt and small areas containing diatomite and diatomaceous mudstone.

Seismicity

According to the Fault Activity Map of California and Adjacent Areas (Jennings, 2010) and the Alquist-Priolo Regulatory Maps, no active faults or Earthquake Fault Zones (Special Studies Zones) are located on the project site. Additionally, no evidence of recent or active faulting was observed during our field study. The nearest mapped potentially active and active faults pertinent to the site are summarized in the following table.

Table 1: Local Active and Potentially Active Faults

Activity	Fault Name	Distance, Direction
Active	Hayward - Rodgers Creek Fault	1 km E
Active	Maacama Fault Zone	18 km N
Active	San Andreas Fault Zone	30 km SW
Active	Napa Fault	36 km SE
Active	Green Valley Fault	46 km SE
Active	Hunting Creek Fault	48 km NE
Potentially Active	Bloomfield Fault	15 km SW
Potentially Active	Americano Creek Fault	18 km SW

Based on our literature review of shear-wave velocity characteristics of geologic units in California (Wills and Silva; August 1998: Earthquake Spectra, Volume 14, No. 3) and subsurface interpretations, we recommend that the project site be classified as Site Class D in accordance with Section 1613.3.2 of the 2016 CBC and Table 20.3-1 of ASCE 7-10.

Earthquake Induced Liquefaction, Surface Rupture Potential, and Settlement

Liquefaction is the sudden loss of soil shear strength and sudden increase in porewater pressure caused by shear strains, as could result from an earthquake. Research has shown that saturated, loose to medium-dense sands with a silt content less than about 25 percent and located within the top 40 feet are most susceptible to liquefaction and surface rupture/lateral spreading.

In the Reference 1 report, we evaluated the potential for seismically induced damage due to liquefaction, surface ruptures, and settlement to be considered low. Additionally, in our explorations for this study, cemented soils were encountered at shallower depths than our previous study for Phase 1. For the above-mentioned reasons, mitigation for these potential hazards is not required for the development of this project.

Laboratory Testing

Laboratory testing of the collected samples was directed towards determining the physical and engineering properties of the soil underlying the site. A description of the tests performed for this project and the associated test results are presented in Appendix B. In summary, the following tests were performed for the preparation of this report:

Table 2: Laboratory Tests

Laboratory Test	Test Standard	Summary of Results	
Expansion Index	ASTM D4829	B-102 @ 0-5'	EI = 130 (High)
		B-103 @ 1-5'	EI = 100 (High)
Atterberg Limits	ASTM D4318	B-102 @ 0-5'	LL = 68, PI = 47 (CH)
		B-103 @ 1-5'	LL = 57, PI = 39 (CH)
Hydrometer Analysis	ASTM D7928	B-102 @ 0-5'	See Appendix B
		B-103 @ 1-5'	
Unconfined Compression	ASTM D2166	B-102 @ 3.5'	q_u = 3,525 psf
		B-103 @ 1.5'	q_u = 5,468 psf
		B-104 @ 4'	q_u = 8,363 psf
		B-104 @ 5.5'	q_u = 5,026 psf
Moisture Content & Dry Density	ASTM D2216, Method B & ASTM D7263, Method B	See Boring Logs	
Moisture Content	ASTM D2216, Method B		
Corrosivity Suite	CA DOT Tests 417, 422 and 643	See Soil Corrosivity Section	

Soil Expansion Potential

The laboratory testing shows that the on-site clay soils exhibit a high potential for expansion. Expansive soils can undergo substantial volume changes (shrink and swell) with changes in moisture content. Changes in moisture content can result from seasonal variations in precipitation, perched groundwater, landscape practices, broken or leaking irrigation or utility lines or poor site drainage. The resulting soil volume change can cause unacceptable differential movements (settlement or heave) of building foundations, slabs-on-grade, or flatwork supported on these soils.

Special design considerations for expansive soils should be considered for the design and construction of the proposed improvements. These special design considerations include, but are not limited to, the construction of specialized foundation systems and moisture cut-off barriers for the foundation systems, focused attention to drainage and long-term moisture stability of the soils near the proposed improvements, and lime-treatment of the foundation and pavement supporting soils.

Soil Corrosivity

A corrosivity testing suite consisting of soil pH, resistivity, sulfate, and chloride content tests were performed on selected soil samples collected during our site exploration. We are not corrosion specialists and recommend that the results be evaluated by a qualified corrosion expert. The laboratory test results (provided by Sunland Analytical) are provided in Appendix B and are summarized in Table 3, below.

Table 3: Corrosivity Summary

Location	Depth (ft)	Soil pH	Minimum Resistivity ohm-cm (x1000)	Chloride (ppm)	Sulfate (ppm)	Caltrans Environment	ACI Environment
B-102	0-5	6.54	0.75	22.3	45.6	Potentially Corrosive	S0 (Not a Concern)

According to Caltrans Corrosion Guidelines Version 2.1, January 2015, the test results appear to indicate a potentially corrosive environment due to minimum resistivity. According to the 2016 California Building Code Section 1904.1 and ACI 318-14 Table 19.3.1.1, the test results indicate the onsite soils have a negligible potential for sulfide attack of concrete. Accordingly, Type I/II Portland cement is appropriate for use in concrete construction. A certified corrosion engineer should be consulted to review the above tests and site conditions in order to develop specific mitigation recommendations if metallic pipes or structural elements are designed to be in contact with or buried in soil.

3.0 DISCUSSION AND CONCLUSIONS

Grading Operation

Grading operations should include the processing of the surface materials down to a depth of approximately 3 to 4 feet. Regardless of the foundation design selected, continuous moisture conditioning of the clay soils may be needed to close and prevent desiccation cracking prior to the construction of foundations, slabs on grade, flatwork, and pavements.

Foundations

In our opinion, three foundation system alternatives are appropriate for the development of the proposed improvements.

Alternative 1: Deepened Continuous Foundations with Lime Treatment or Import Fill: Deepened conventional shallow foundations are appropriate for structures if they are founded a minimum of 48 inches below finished grade to bypass the soil most susceptible to seasonal moisture fluctuation and subsequent shrink and swell. Subgrades under slab-on-grade floors should consist of 18 inches of lime-treated native soils or select import soils meeting the requirements of engineered fill in Section 4.0 of this report.

Alternative 2: Continuous Shallow Foundations on Imported Fill: Conventional shallow foundations may also be used for support of structures if a minimum of 4 feet of the expansive soils are overexcavated and replaced with a non-expansive import soil meeting the requirements of engineered fill.

Alternative 3: Post-tension Slab-on-grade Foundation: Alternatively, post-tension slab-on-grade foundations can be considered for foundation support. The post tension slab-on-grade foundation system should also include a perimeter moisture cutoff barrier to reduce the potential for lateral moisture migration at the edge of the slab.

For use of the post-tension foundation parameters provided in this report, the site grades should be properly prepared as described in the Site Grading and Improvement section and the structures should be constructed using the minimum foundation and drainage recommendations provided in this report. Recommendations regarding each foundation design alternative are provided in Section 5.0 of this report.

Flatwork
Due to the potentially expansive clay soil anticipated at subgrade, mitigation measures are anticipated to be required to help minimize movement. The mitigation measures recommended in this report include lime-treatment, overexcavation and recompaction with non-expansive soil, and reinforced flatwork. Recommendations regarding flatwork improvements are provided in Section 5.0 of this report.

Drainage
Due to the potential of water to be perched on the clay soils, proper design and implementation of the site drainage practices are considered to be of paramount concern for effective development of the project site, as well as for providing long term stability of the structural improvements. Specific drainage recommendations are provided in Section 5.0.

4.0 SITE GRADING AND EARTHWORK IMPROVEMENTS

Site Preparation
Preparation of the project site should involve site drainage controls, dust control, clearing and stripping, expansive clay mitigation, and exposed grade compaction considerations. The following paragraphs state our geotechnical comments and recommendations concerning site preparation.

Site Drainage Controls: We recommend that initial site preparation involve intercepting and diverting any potential sources of surface or near-surface water within the construction zones. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and methods used by the contractor, final decisions regarding drainage systems are best made in the field at the time of construction. All drainage and/or water diversion performed for the site should be in accordance with the Clean Water Act and applicable Storm Water Pollution Prevention Plan.

Dust Control: Dust control provisions should be provided for as required by the local jurisdiction's grading ordinance (i.e. water truck or other adequate water supply during grading).

Clearing and Stripping: Clearing and stripping operations should include the removal of all organic laden materials including trees, bushes, root balls, root systems, and any soft or loose soil generated by the removal operations. Surface grass stripping operations are necessary based upon our observations during our site visit. Short or mowed dry grasses may be pulverized and lost within fill materials provided no concentrated pockets of organics result. It is the responsibility of the grading contractor to remove excess organics from the fill materials. **No more than 2 percent of organic material, by weight, should be allowed within the fill materials at any given location.**

General site clearing should also include removal of any loose or saturated materials within the proposed structural improvement and pavement areas. A representative of our firm should be present during site clearing operations to identify the location and depth of potential fills not disclosed by this report, to observe removal of deleterious materials, and to identify any existing site conditions which may require mitigation or further recommendations prior to site development.

Expansive Clay Mitigation: Typically, expansive soil mitigation alternatives consist of chemical treatment of the soils with lime, overexcavation and replacement with non-expansive materials, or specialized foundation systems such as post-tensioned slabs. The recommendations in this report present all of these approaches for various elements of site development. We have not been afforded an opportunity to review development plans but anticipate that expansive soils will be present at finished pad grade.

Exposed Grade Compaction: Exposed soil grades following initial site preparation activities should be overexcavated approximately 3 to 4 feet below surface grades, scarified to a minimum depth of 8 inches, moisture conditioned to 2 to 5 percent above optimum moisture content, and compacted to the requirements of engineered fill. Prior to placing fill, the exposed subgrades should be in a firm and unyielding state. Any localized zones of soft or pumping soils observed within a subgrade should either be scarified and recompacted or be overexcavated and replaced with engineered fill as detailed in the engineered fill section below.

Soil Moisture Considerations

The near-surface soils may become partially or completely saturated during the rainy season. Grading operations during this time period may be difficult since compaction efforts may be hampered by saturated materials. Therefore, we suggest that consideration be given to the seasonal limitations and costs of winter grading operations on the site. Special attention should be given regarding the drainage of the project site.

If the project is expected to work through the wet season, the contractor should install appropriate temporary drainage systems at the construction site and should minimize traffic over exposed subgrades due to the moisture-sensitive nature of the on-site soils. During wet weather operations, the soil should be graded to drain and should be sealed by rubber tire rolling to minimize water infiltration.

Compaction Equipment

In areas to receive structural soil fill, we anticipate that a sheepsfoot roller or approved equivalent will be capable of achieving the compaction requirements for engineered fill provided the soil is placed and compacted as recommended in the Engineered Fill Criteria section below.

Engineered Fill Criteria

All materials placed as fills on the site should be placed as “Engineered Fill" which is observed, tested, and compacted as described in the following paragraphs.

Suitability of Onsite Materials: We anticipate that a moderate amount of onsite soils will be generated during mass grading operations. We expect that soil generated from excavations on the site will consist of clay soils which are not expected to be suitable for reuse in the upper 4 feet of the site grades unless they are lime treated, or removed and replaced with a non-expansive import material.

Import Materials: If imported fill material is needed for this project, import material should be approved by our firm prior to transporting it to the project. It is preferable that import material meet the following requirements:

1. Plasticity index not to exceed 12;
2. "R"-value of equal to or greater than 20;
3. An angle of friction equal to or greater than 30 degrees;
4. Should not contain rocks larger than 6 inches in diameter;
5. Not more than 30 percent passing through the No. 200 sieve.

If these requirements are not met, additional testing and evaluation may be necessary to determine the appropriate design parameters for foundations, pavement, and other improvements.

Fill Placement and Compaction (Expansive Soils): Following the overexcavation of approximately 3 to 4 feet of the dry surface materials, all areas proposed to receive fill should be scarified to a minimum depth of 8 inches, moisture conditioned to 2 to 5 percent above the optimum moisture content, and compacted to 88 to 92 percent of the maximum dry density based on the ASTM D1557 test method. The fill should then be placed in thin horizontal lifts not to exceed 8 inches in uncompacted thickness. The fill should be moisture conditioned to 2 to 5 percent over the optimum moisture content and compacted to a relative compaction of 88 to 92 percent of the maximum dry density based on the ASTM D1557 test method. The upper 8 inches of fills placed under proposed pavement areas should be compacted to a relative compaction of not less than 95 percent based on the ASTM D1557 test method.

Fill Placement and Compaction (Non-Expansive Soils): Should non-expansive soils or lime-treated soils be used at the project site, the non-expansive fill should be moisture conditioned as necessary, and compacted to at least 90 percent of the maximum dry density and at 0 to 3 percent over the optimum moisture content based on the ASTM D1557 test method. The fill should be placed in thin horizontal lifts not to exceed 8 inches in uncompacted thickness. The upper 8 inches of fills placed under proposed pavement areas should be compacted to a relative compaction of not less than 95 percent based on the ASTM D1557 test method.

Testing of Engineered Fills: Fill soil compaction should be evaluated by means of in-place density tests performed during fill placement so that adequacy of soil compaction efforts may be evaluated as earthwork progresses.

Lime Treatment: If lime treatment of the site soils is selected for support of the flatwork and slab on grade, we recommend that the finish grade soils for structural improvements be treated using high calcium lime spread at a minimum of 5 percent, by dry weight, following completion of grading operations. The lime-treated section should be a minimum of 18 inches thick and compacted to a minimum of 95 percent relative compaction based on the ASTM D1557 test method. Due to the potential for gas generation by chemical reactions with lime, the soil should be mixed with lime and allowed to rest for a minimum of 18 hours before use as engineered fill. Once site grading has been initiated, and we can better ascertain the soil composition of the proposed building pad fills, we should be afforded the opportunity to perform additional laboratory testing of these materials to determine the optimum lime treatment percentage.

Underground Improvements

Trench Excavation: Trenches or excavations in soil should be shored or sloped back in accordance with current OSHA regulations prior to persons entering them. The potential use of a shield to protect workers cannot be precluded.

Backfill Materials: Backfill materials for utilities should conform to the local jurisdiction's requirements. It should be realized that permeable backfill materials will likely carry water at some time in the future. When backfilling within structural footprints, compacted low permeability materials are recommended to be used a minimum of 5 feet beyond the structural footprint to minimize moisture intrusion.

Backfill Compaction: All backfill, placed after the underground facilities have been installed, including site utilities and lateral connections should be moisture conditioned to 2 to 5 percent over the optimum moisture content and compacted between 88 to 92 percent of the maximum dry density based on the ASTM D1557 test method for potentially expansive soils. Select import materials consisting of non-expansive soils should be moisture conditioned to 1 to 3 percent over the optimum moisture content and compacted to a minimum of 90 percent relative compaction based on the ASTM D1557 test method. Compaction should be accomplished using lifts which do not exceed 12 inches. However, thickness of the lifts should be determined by the contractor. If the contractor can achieve the required compaction using thicker lifts, the method may be judged acceptable based on field verification by a representative of our firm using standard density testing procedures. Lightweight compaction equipment may require thinner lifts to achieve the required densities.

5.0 DESIGN RECOMMENDATIONS

Seismic Criteria

Based on the 2016 California Building Code, Chapter 16, and our site investigation findings, the following seismic parameters are recommended from a geotechnical perspective for structural design. The final choice of design parameters, however, remains the purview of the project structural engineer.

Table 2: Seismic Design Parameters

2016 CBC	ASCE 7-10	Seismic Parameter	Recommended Value
	Table 20.3-1	Site Class	D
Figure 1613.3.1(1)		Short-Period MCE at 0.2s, S_S	2.189g
Figure 1613.3.1(2)		1.0s Period MCE, S_1	0.904g
Table 1613.3.3(1)		Site Coefficient, F_a	1.000
Table 1613.3.3(2)		Site Coefficient, F_v	1.500
Equation 16-37		Adjusted MCE Spectral Response Parameters, $S_{MS} = F_a S_s$	2.189g
Equation 16-38		Adjusted MCE Spectral Response Parameters, $S_{M1} = F_v S_1$	1.356g
Equation 16-39		Design Spectral Acceleration Parameters, $S_{DS} = \frac{2}{3} S_{MS}$	1.459g
Equation 16-40		Design Spectral Acceleration Parameters, $S_{D1} = \frac{2}{3} S_{M1}$	0.904g
Table 1613.3.5(1)		Seismic Design Category (Short Period), Occupancy I to III	E
Table 1613.3.5(1)		Seismic Design Category (Short Period), Occupancy IV	F
Table 1613.3.5(2)		Seismic Design Category (1-Second Period), Occupancy I to IV	F
	Figure 22-7	Maximum Considered Earthquake Geometric Mean (MCE_C) PGA	0.841g
	Table 11.8-1	Site Coefficient F_{PGA}	1.000
	Equation 11.8-1	$PGA_M = F_{PGA}$ PGA	0.841g

*Based on the online calculator available at http://earthquake.usgs.gov/designmaps/us/application.php

Foundation Design

We offer the following comments and recommendations for purposes of design and construction of foundations. The provided minimums do not constitute a structural design of foundations which should be performed by the structural engineer. Our firm should be afforded the opportunity to review the project grading and foundation plans to confirm the applicability of the recommendations provided below. Modifications to these recommendations may be made at the time of our review. In addition to the provided recommendations, foundation design and construction should conform to applicable sections of the 2016 California Building Code.

Alternative 1: Deepened Continuous Foundations with Lime Treatment or Import Fill

Bearing Capacities: An allowable dead plus live load bearing pressure of 2,500 psf may be used for design of conventional shallow foundations embedded at least 48 inches below lowest adjacent soil grade into competent materials. The allowable pressures are for support of dead plus live loads and may be increased by 1/3 for short-term wind and seismic loads.

Lateral Pressures: Lateral forces on structures may be resisted by passive pressure acting against the sides of shallow footings and/or friction between the soil and the bottom of the footing. For resistance to lateral loads, a friction factor of 0.30 may be utilized for sliding resistance at the base of conventional shallow foundations in firm native materials and engineered fill. A passive resistance of 300 pcf equivalent fluid weight may be used against the side of conventional shallow footings in firm native soil and engineered fill. If friction and passive pressures are combined, the lesser value should be reduced by 50 percent.

Foundation Static Settlement: A total settlement of less than 1 inch is anticipated; a differential settlement of ½ of the total is anticipated where foundations are bearing on like materials. This settlement is based upon the assumption that foundation will be sized and loaded in accordance with the recommendations in this report.

Foundation Configuration: Under this alternative, continuous shallow foundations should be a minimum of 12 inches wide and founded a minimum of 48 inches into lowest adjacent soil grade and competent materials. Isolated pad footings are not recommended.

Foundation Reinforcement: Foundation reinforcement should be provided by the structural engineer. The reinforcement schedule should account for typical construction issues such as load consideration, concrete cracking, and the presence of isolated irregularities. At a minimum, we recommend that continuous footing foundations be reinforced with four No. 5 reinforcing bars, two located near the bottom of the footing and two near the top of the stem wall.

All footings should be founded below an imaginary 2H:1V plane projected up from the bottoms of adjacent footings and/or parallel utility trenches.

Foundation Subgrade Conditions: Footing should never be cast atop soft, loose, organic, slough, debris, nor atop subgrades covered by ice or standing water.

Shallow Footing Backfill: All footing backfill soil should be compacted to 88-92 percent of the maximum dry density (based on ASTM D1557).

Alternative 2: Continuous Shallow Foundations on Imported Fill

Bearing Capacities: The following bearing capacities are for foundations supported on a minimum of 4 feet of select engineered fill meeting the import fill criteria in Section 4.0 of this report. An allowable dead plus live load bearing pressure of 2,000 psf may be used for design of continuous shallow foundations with a minimum size of 12 inches wide and founded 18 inches below the lowest adjacent soil grade. The allowable pressures are for support of dead plus live loads and may be increased by 1/3 for short-term wind and seismic loads.

Lateral Pressures: Lateral forces on structures may be resisted by passive pressure acting against the sides of shallow footings and/or friction between the soil and the bottom of the footing. For resistance to lateral loads, a friction factor of 0.35 may be utilized for sliding resistance at the base of conventional shallow foundations in firm native materials, engineered fill, and for weathered rock. A passive resistance of 350 pcf equivalent fluid weight may be used against the side of conventional shallow footings in firm native soil and engineered fill. If friction and passive pressures are combined, the lesser value should be reduced by 50 percent.

Foundation Settlement: A total settlement of less than 1 inch is anticipated; a differential settlement of ½ of the total is anticipated where foundations are bearing on like materials. This settlement is based upon the assumption that foundation will be sized and loaded in accordance with the recommendations in this report.

Foundation Configuration: Under this alternative, continuous shallow foundations should be a minimum of 12 inches wide and founded a minimum of 18 inches below the lowest adjacent soil grade for one and two story structures. For three story structures, continuous foundations should be a minimum of 12 inches wide and founded a minimum of 24 inches below the lowest adjacent soil grade. Isolated pad footings are not recommended.

All footings should be founded below an imaginary 2H:1V plane projected up from the bottoms of adjacent footings and/or parallel utility trenches, or to a depth that achieves a minimum horizontal clearance of 6 feet from the outside toe of the footings to the slope face, whichever requires a deeper excavation.

Foundation Reinforcement: At a minimum, we recommend that continuous footing foundations be reinforced with four No. 4 reinforcing bars, two located near the bottom of the footing and two near the top of the stem wall.

Subgrade Preparation: Under this alternative, overexcavation of the onsite expansive soils down to firm native materials will be required. Replacement will consist of pre-approved import materials exhibiting low expansion potential compacted to the requirements of engineered fill.

Footings should never be cast atop soft, loose, organic, slough, debris, nor atop subgrades covered by ice or standing water. A representative of our firm should be retained to observe all subgrades during footing excavations and prior to concrete placement so that a determination as to the adequacy of subgrade preparation can be made.

Shallow Footing Backfill: All footing backfill soil should consist of non-expansive materials compacted to at least 90 percent of the maximum dry density (based on ASTM D1557).

Alternative 3: Post-Tensioned Slab-on-Grade Foundation System

Soil-supported post tension slab-on-grade floors could be used for the main floor of structures. Often the geotechnical issues regarding the use of post tension slab-on-grade floors include proper soil support and subgrade preparation, proper transfer of loads through the slab underlayment materials to the subgrade soils, and the anticipated presence or absence of moisture below, at, or above the subgrade level. We offer the following comments and recommendations concerning support of slab-on-grade floors. The slab design (concrete mix, reinforcement, moisture protection, and underlayment materials) is the purview of the project Structural Engineer.

Post Tension Slab-on-Grade Bearing Capacities: An average allowable dead plus live load contact pressure of 1,000 psf may be used for design of a post-tension slab-on-grade based on firm native soils or engineered fills. The perimeter foundation and localized footings (where required) may be designed for an allowable dead plus live load bearing pressure of 1,500 psf. The allowable pressures are for support of dead plus live loads and may be increased by 1/3 for short-term wind and seismic loads.

Geotechnical Design Parameters: A post-tension slab-on-grade foundation for expansive soil conditions may be used for support of the proposed structures. Based on the results of our laboratory testing and the methodology described in the Design of Post-Tension Slab-on-Ground, Ed 3 prepared by the Post-Tensioning Institute, we anticipate the following design parameters are suitable for use in designing the post tension slab.

Table 4: Expansive Soil Parameters for Post Tension Slabs

Parameter	Edge Lift	Center Lift
e_m	4.9 ft	6.8 ft
y_m	0.6 in	1.4 in

Foundation Settlement: A total settlement of less than 1 inch is anticipated; a differential settlement of ½ of the total is anticipated where foundations are bearing on like materials. This settlement is based upon the assumption that foundations will be sized and loaded in accordance with the recommendations in this report.

Slab Moisture Protection: Due to the potential for landscape to be present directly adjacent to the slab edge/foundation or for drainage to be altered following our involvement with the project, varying levels of moisture below, at, or above the pad subgrade level should be anticipated. The slab designer should include the potential for moisture vapor transmission when designing the slab. Our experience has shown that vapor transmission through concrete is controlled through slab thickness as well as proper concrete mix design. It should be noted that placement of the recommended plastic membrane, proper mix design, and proper slab underlayment and detailing per ASTM E1643 and E1745 will not provide a waterproof condition. If a waterproof condition is desired, we recommend that a waterproofing expert be consulted for slab design.

It is imperative that moisture be maintained at a constant level in the soils underlying the slab. **To reduce the potential for moisture related issues, we recommend that deepened perimeter edge footings be constructed to act as a cutoff wall and be founded approximately 24 inches below the site grade.**

Slab Thickness and Reinforcement: Geotechnical reports have historically provided minimums for slab thickness and reinforcement for general crack control. The concrete mix design and construction practices can additionally have a large impact on concrete crack control. All concrete should be anticipated to crack. As such, these minimums should not be considered to be stand alone items to address crack control, but are suggested to be considered in the slab design methodology.

It has been our experience that post tension slab-on-grade construction of similar types of construction consisted of an 8 to 10 inch thick slab with tensioning strands placed a minimum of 30 inches on-center. Thicker slabs may be required by the structural engineer based on the design loads of the proposed building. Thickness and reinforcement for expansive soils should be based on the design by a structural engineer. *The thickness and reinforcement of any constructed slab is the purview of the structural engineer.*

Slab Subgrade Preparation: All subgrades proposed to support slab-on-grade floors should be prepared and compacted to the requirements of engineered fill as discussed in the Site Grading and Improvements section of this report. Additionally, the post-tension slab foundation areas should be pre-saturated to a minimum of 15 inches for a minimum of 24 hours prior to the placement of concrete. Pre-saturation should be field evaluated by a representative of our firm by probing the soils with a ½ inch diameter steel rod prior to concrete placement.

Slab Underlayment: As a minimum for slab support conditions, the slab should be underlain by a minimum 10-mil thick moisture retarding plastic membrane. An optional 1 inch blotter sand layer above the plastic membrane is sometimes used to aid in curing of the concrete. If the blotter is omitted, special curing procedures may be necessary. The blotter layer can become a reservoir for excessive moisture if inclement weather occurs prior to pouring the slab, excessive water collects in it from the concrete pour, or an external source of water enters above or bypasses the membrane. The membrane may only be functional when it is above the vapor sources. The slab design and underlayment should be in accordance with ASTM E1643 and E1745.

If the blotter sand layer is omitted (as may be required if slab design and construction is to be performed according to the 2016 Green Building Code), special wet curing procedures will be necessary. In this case, development of appropriate slab mix design and curing procedures remains the purview of the project structural engineer.

Vertical Deflections: Soil-supported slab-on-grade floors can deflect downward when vertical loads are applied, due to elastic compression of the subgrade. For design of concrete floors, a modulus of subgrade reaction of k = 80 psi per inch would be applicable for native soils and engineered fills.

Moisture Maintenance: Maintaining uniformity in moisture content for the life of the structure is considered paramount to minimizing the potential for shrinkage and swell of the near surface soil and for optimum foundation and slab performance. In landscaping areas adjacent to the foundation and other improvements, it is suggested that the owner establish landscaping with an automated watering system around the foundation in order to reduce the fluctuation in moisture content of the foundation soils caused by wet and dry weather cycles. Some features which could be incorporated to promote a constant moist condition included the use of 4 to 6 inches of bark within planter areas and the avoidance of rock covered groundcover which tend to bake out moisture in high temperature seasons. Overwatering of landscape must be avoided. Additionally, planters should be constructed to slope to abundant area drainage inlets which should be installed flush to the drainage grade (not bark grade).

Slab-on-Grade Construction
It is our opinion that soil-supported slab-on-grade floors could be used for the main floors of the residential structures for foundation alternatives 1 and 2, contingent on proper subgrade preparation. Often the geotechnical issues regarding the use of slab-on-grade floors include proper soil support and subgrade preparation, proper transfer of loads through the slab underlayment materials to the subgrade soils, and the anticipated presence or absence of moisture at or above the subgrade level. We offer the following comments and recommendations concerning support of slab-on-grade floors. The slab design (concrete mix, reinforcement, joint

spacing, moisture protection, and underlayment materials) is the purview of the project Structural Engineer.

Slab Underlayment: As a minimum for slab support conditions, the slab should be underlain by a minimum 4 inch crushed rock layer and covered by a minimum 10-mil thick moisture retarding plastic membrane. An optional 1 inch blotter sand layer above the plastic membrane is sometimes used to aid in curing of the concrete in commercial structures. The blotter layer can become a reservoir for excessive moisture if inclement weather occurs prior to pouring the slab, excessive water collects in it from the concrete pour, or an external source of water enters above or bypasses the membrane. The membrane may only be functional when it is above the vapor sources. The bottom of the crushed rock layer should be above the exterior grade to act as a capillary break and not a reservoir, unless it is provided with an underdrain system. The slab design and underlayment should be in accordance with ASTM E1643 and E1745.

If the blotter sand layer is omitted (as may be required if slab design and construction is to be performed according to the 2016 Green Building Code), special wet curing procedures will be necessary. In all cases, development of appropriate slab mix design and curing procedures remains the purview of the project structural engineer.

Slab Moisture Protection: Due to the potential for landscape to be present directly adjacent to the slab edge/foundation or for drainage to be altered following our involvement with the project, varying levels of moisture below, at, or above the pad subgrade level should be anticipated. The slab designer should include the potential for moisture vapor transmission when designing the slab. Our experience has shown that vapor transmission through concrete is controlled through slab thickness as well as proper concrete mix design.

It should be noted that placement of the recommended plastic membrane, proper mix design, and proper slab underlayment and detailing per ASTM E1643 and E1745 will not provide a waterproof condition. If a waterproof condition is desired, we recommend that a waterproofing expert be consulted for slab design.

Alternative 1: Deepened Continuous Foundations with Lime Treatment or Import Fill

Slab Subgrade Preparation: Under this alternative, all subgrades proposed to support slab-on-grade floors should be lime treated to a depth of 18 inches below finished grade or consist of 18 inches of non-expansive import soils. The subgrades should then be prepared and compacted to the requirements of engineered fill as discussed in the Site Grading and Improvements section of this report.

Slab Thickness and Reinforcement: Geotechnical reports have historically provided minimums for slab thickness and reinforcement for general crack control. The concrete mix design and construction practices can additionally have a large impact on concrete crack control. All concrete should be anticipated to crack. As such, these minimums should not be considered to be stand alone items to address crack control, but are suggested to be considered in the slab design methodology.

In order to help control the growth of cracks in interior concrete from becoming significant, we suggest the following minimums. Interior concrete slabs-on-grade not subject to heavy loads should be a minimum of 4 inches thick and be reinforced. A minimum of No. 3 deformed reinforcing bars placed at 24 inches on center both ways, at the center of the structural section is suggested for slabs-on-grade supported on potentially expansive soils. Joint spacing should be provided by the structural engineer. Troweled joints recovered with paste during finishing or "wet sawn" joints should be considered every 10 feet on center. Expansion joint felt should be provided to separate floating slabs from foundations and at least at every third joint. Cracks will tend to occur at recurrent corners, curved or triangular areas and at points of fixity. Trim bars can be utilized at right angle to the predicted crack extending 40 bar diameters past the predicted crack on each side.

Vertical Deflections: Soil-supported slab-on-grade floors can deflect downward when vertical loads are applied, due to elastic compression of the subgrade. For design of concrete floors, a modulus of subgrade reaction of k = 150 psi per inch would be applicable for native soils and engineered fills.

Alternative 2: Continuous Shallow Foundations on Imported Fill

Slab Subgrade Preparation: All subgrades proposed to support slab-on-grade floors should be prepared and compacted to the requirements of engineered fill as discussed in the Site Grading and Improvements section of this report.

Slab Thickness and Reinforcement: In order to help control the growth of cracks in interior concrete from becoming significant, we suggest the following minimums. Interior concrete slabs-on-grade not subject to heavy loads should be a minimum of 4 inches thick and be reinforced. A minimum of No. 3 deformed reinforcing bars placed at 18 inches on center both ways, at the center of the structural section is suggested for slabs-on-grade supported on non-expansive soils. Joint spacing should be provided by the structural engineer. Troweled joints recovered with paste during finishing or "wet sawn" joints should be considered every 10 feet on center. Expansion joint felt should be provided to separate floating slabs from foundations and at least at every third joint. Cracks will tend to occur at recurrent corners, curved or triangular areas and at points of fixity. Trim bars can be utilized at right angle to the predicted crack extending 40 bar diameters past the predicted crack on each side.

Vertical Deflections: Soil-supported slab-on-grade floors can deflect downward when vertical loads are applied, due to elastic compression of the subgrade. For design of concrete floors, a modulus of subgrade reaction of k = 120 psi per inch would be applicable for engineered fills consisting of non-expansive soils.

Flatwork Construction

It is our opinion that soil-supported flatwork could be used contingent on proper subgrade preparation. We offer the following comments and recommendations concerning support of concrete flatwork. The slab design (concrete mix, reinforcement, and joint spacing) is the purview of the project Structural Engineer.

Flatwork Subgrade Preparation: In order to help minimize movement of flatwork, the flatwork areas should be prepared using the following risk based options in order of increasing risk of movement.

1. The flatwork area should be lime-treated to a depth of 12 inches below the bottom of flatwork using a minimum of 4 to 5 percent high calcium lime by weight. The treated subgrade should then be compacted to a minimum of 95 percent relative compaction at 0 to 3 percent over the optimum moisture content per the ASTM D1557 test method.

2. Overexcavate the flatwork areas to a depth of 12 inches and recompact with non-expansive soils in accordance with the engineered fill criteria of this report and to a minimum of 95 percent relative compaction at 0 to 3 percent over the optimum moisture content per the ASTM D1557 test method. Crushed rock or other gap graded select import materials are **not** recommended as backfill within the overexcavation area due to the ability to hold water in the void space of these materials.

3. The flatwork should be a minimum of 4 inches thick and reinforced with No. 3 reinforcing steel placed at 18 inches on center in both directions. The flatwork should be constructed on a 6 inch crushed rock layer which has been vibroplated for compaction.

Flatwork Moisture Protection: Due to the potential for landscape to be present directly adjacent to the flatwork or for drainage to be altered following our involvement with the project, varying levels of moisture below, at, or above the subgrade level should be anticipated. Soil grades should slope away from flatwork at a minimum gradient of 2 percent to an appropriate drainage device. If landscape slopes towards flatwork, an appropriate drainage device such as a subdrain and separate area drain collection system should be installed such as that detailed on Figure C-1.

Flatwork Thickness and Reinforcement: In order to help control the growth of cracks in interior concrete from becoming significant, we suggest the following minimums. Flatwork should be a minimum of 4 inches thick. Joint spacing should be provided by the structural engineer. Troweled joints recovered with paste during finishing or "wet saw" joints should be considered every 10 feet on center. Expansion joint felt should be provided at least at every third joint. Cracks will tend to occur at recurrent corners, curved or triangular areas and at points of fixity. Trim bars can be utilized at right angle to the predicted crack extending 40 bar diameters past the predicted crack on each side. Wire mesh reinforcement materials is not recommended.

Asphalt Concrete Pavement Design

We understand that asphalt pavements will be used for the parking areas and associated roadways. Our previous experience and testing for the Reference 1 report indicates that the near surface clay soils have very low subgrade support characteristics. Consequently, we evaluated and have provided a pavement support alternative, consisting of lime treatment of the upper 18 inches of the subgrade soils under the pavement sections. The lime treatment alternative allows winterized access to the site and aids in reducing the overall pavement structural section.

The following comments and recommendations are given for pavement design and construction purposes. All pavement construction and materials used should conform to applicable sections of the latest edition of the California Department of Transportation Standard Specifications.

Alternative 1: Standard Pavement Section

Subgrade Compaction: After installation of any underground facilities, the upper 18 inches of subgrade soils under pavements sections should be compacted to a minimum relative compaction of 95 percent for clay materials at a moisture content of 3 to 5 percent above optimum based on the ASTM D1557. Imported non-expansive fill materials should be compacted to a minimum of 95 percent within 0 to 3 percent over the optimum moisture content. Aggregate bases should also be compacted to a minimum relative compaction of 95 percent at a moisture content near optimum based on the aforementioned test method.

Alternative 2: Lime-Treated Subgrade

Lime-treated Subgrade Compaction: Lime-treatment may be considered an alternative to conventional pavement construction. If lime treatment is performed, after installation of any underground facilities, the upper 18 inches of subgrade soils under pavements sections should be lime-treated using high calcium lime and compacted to a minimum relative compaction of 95 percent based on the ASTM D1557 test method at a moisture content at least 2 percent above the optimum. Prior to final compaction of the subgrade soils, the lime-soil mixture should be treated and allowed to rest for a period of 18 hours, then scarified to the depth of the lime-treatment and should be compacted within 72 hours from the start of placement. Aggregate bases should also be compacted to a minimum relative compaction of 95 percent based on the aforementioned test method.

Lime Percentage: A site specific evaluation for lime treatment percentage was not performed at this time since grading operations can change the required percentage. Based on our experience, high calcium lime treatment should be anticipated to be on the order of 5 percent, by dry weight, to achieve a minimum required unconfined compressive strength of 300 psi. Additional laboratory testing will be required prior to the construction of asphalt pavements to determine the exact lime application percentage needed to achieve the required compressive strength.

Subgrade Stability: All subgrades and aggregate base should be proof-rolled with a full water truck or equivalent immediately before paving, in order to evaluate their condition. If unstable subgrade conditions are observed, these areas should be overexcavated down to firm materials and the resulting excavation backfilled with suitable materials for compaction (i.e. drier native soils or aggregate base). Areas displaying significant instability may require geotextile stabilization fabric within the overexcavated area, followed by placement of aggregate base. Final determination of any required overexcavation depth and stabilization fabric should be based on the conditions observed during subgrade preparation.

Design Criteria: Critical features that govern the durability of a pavement section include the stability of the subgrade; the presence or absence of moisture, free water, and organics; the fines content of the subgrade soils; the traffic volume; and the frequency of use by heavy vehicles. Soil conditions can be defined by a soil resistance value, or “R-Value,” and traffic conditions can be defined by a Traffic Index (TI).

Design Values: The following table provides recommended pavement sections based on our experience in the area and with soils with characteristics representative of the clay materials expected to be exposed at subgrade. An R-value of less than 5 is typical for the CLAYS at the project site. Based on the Caltrans design criteria, the R-value was defaulted to 5 for design purposes.

Design values provided are based upon properly drained subgrade conditions. Although the R-Value design to some degree accounts for wet soil conditions, proper surface and landscape drainage design is integral in performance of adjacent street sections with respect to stability and degradation of the asphalt.

The recommended design thicknesses presented in the following table were calculated in accordance with the methods presented in the Sixth Edition of the California Department of Transportation Highway Design Manual. A varying range of traffic indices are provided for use by the project Civil Engineer for roadway design.

Table 6: Asphalt Pavement Section Recommendations

Design Traffic Indices	Alternative Pavement Sections (Inches)		
	Asphalt Concrete *	Aggregate Base **	Lime Treatment***
4.5	2.5 3.0 2.5	9.5 8.5 4.0	— — 18.0
5.0	2.5 3.0 2.5	11.0 10.0 4.0	— — 18.0
5.5	3.0 3.5 2.5	12.0 11.0 4.0	— — 18.0
6.0	3.0 3.5 2.5	14.0 13.0 4.0	— — 18.0
6.5	3.5 4.0 2.5	14.5 13.5 4.0	— — 18.0

* Asphalt Concrete: must meet specifications for Caltrans Hot Mix Asphalt Concrete
** Aggregate Base: must meet specifications for Caltrans Class II Aggregate Base (R-Value = minimum 78)
*** Lime Treatment: if used, additional testing is recommended to verify required lime application percentage.

Due to the redistribution of materials that occurs during mass grading operations, we should review pavement subgrades to determine the appropriateness of the provided sections.

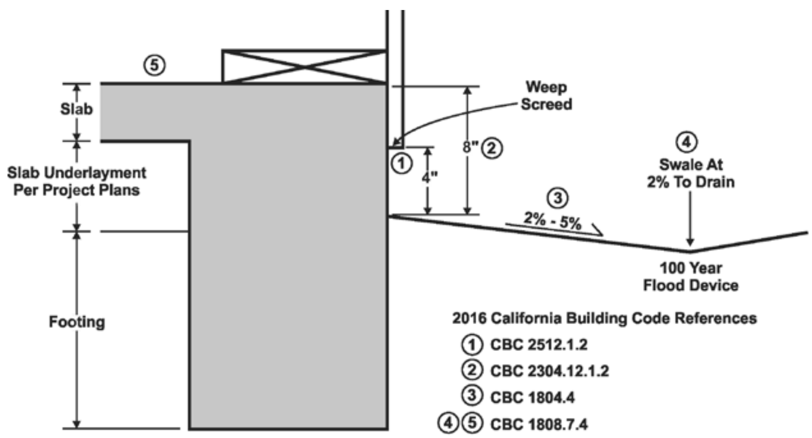
Drainage

In order to maintain the engineering strength characteristics of the soil presented for use in this Geotechnical Engineering Study, maintenance of the building pads will need to be performed. This maintenance generally includes, but is not limited to, proper drainage and control of surface and subsurface water which could affect structural support and fill integrity. A difficulty exists in determining which areas are prone to the negative impacts resulting from high moisture conditions due to the diverse nature of potential sources of water; some of which are outlined in the paragraph below. We suggest that measures be installed to minimize exposure to the adverse effects of moisture, but this will not guarantee that excessive moisture conditions will not affect the structure.

Some of the diverse sources of moisture could include water from landscape irrigation, annual rainfall, offsite construction activities, runoff from impermeable surfaces, collected and channeled water, and water perched in the subsurface soils on the bedrock horizon or present in fractures in the weathered bedrock. Some of these sources can be controlled through drainage features installed either by the owner or contractor. Others may not become evident until they, or the effects of the presence of excessive moisture, are visually observed on the property.

Some measures that can be employed to minimize the buildup of moisture include, but are not limited to proper backfill materials and compaction of utility trenches within the footprint of the proposed structures; grout plugs at foundation penetrations; collection and channeling of drained water from impermeable surfaces (i.e. roofs, concrete or asphalt paved areas); installation of subdrain/cut-off drain provisions; utilization of low flow irrigation systems; education to the proposed owners of proper design and maintenance of landscaping and drainage facilities that they or their landscaper installs.

Drainage Adjacent to Slabs: All grades should provide rapid removal of surface water runoff; ponding water should not be allowed on building pads or adjacent to foundations or other structural improvements (during and following construction). All soils placed against foundations during finish grading should be compacted to minimize water infiltration. Finish and landscape grading should include positive drainage away from all foundations. Section 1808.7.4 of the 2016 California Building Code (CBC) states that for graded soil sites, the top of any exterior foundation shall extend above the elevation of the street gutter at the point of discharge or the inlet of an approved drainage device a minimum of 12 inches plus 2 percent. If overland flow is not achieved adjacent to buildings, the drainage device should be designed to accept flows from a 100 year event. Grades directly adjacent to foundations should be no closer than 8 inches from the top of the slab (CBC 2304.12.1.2), and weep screeds are to be placed a minimum of 4 inches clear of soil grades and 2 inches clear of concrete or other hard surfacing (CBC 2512.1.2). From this point, surface grades should slope a minimum of 2 percent away from all foundations for at least 5 feet but preferably 10 feet, and then 2 percent along a drainage swale to the outlet (CBC 1804.4). Downspouts should be tight piped via an area drain network and discharged to an appropriate non-erosive outlet away from all foundations.



Typical 2016 California Building Code Drainage Requirements

The above referenced elements pertaining to drainage of the proposed structures is provided as general acknowledgement of the California Building Code requirements, restated and graphically illustrated for ease of understanding. Surface drainage design is the purview of the Project Architect/Civil Engineer. Review of drainage design and implementation adjacent to the building envelopes is recommended as performance of these improvements is crucial to the performance of the foundation and construction of rigid improvements.

It should be noted that due to the Americans with Disabilities Act (ADA) requirements, design and construction of alternative site drainage configurations may be necessary, particularly for multi-family and commercial developments. In this case, design and construction of adequate drainage adjacent to foundations and slabs are essential to preserving foundation support and reducing the potential for wet slab related issues. A typical example of this condition occurs in commercial developments where the landscape grades are situated at the same elevation as the parking areas so as to not create a drop off between the grades. This condition subsequently results in flat grades between the building, landscape area, and parking lot which do not meet building code requirements.

Subdrains: It has been our experience that sites with expansive clays and the potential for landscaping (i.e. lawns, enclosed planters, etc.) adjacent to flatwork have an increased potential for expansion related issues related to moisture migration from the landscape areas to the adjacent flatwork. To mitigate for the potential of these issues, in addition to the drainage provisions provide in the 2016 California Building Code, the construction of subdrains may be necessary depending on the landscape layout and design. The drain should be constructed as detailed in Figure C-1. The water collected in the subdrain pipe would be directed to an appropriate non-erosive outlet. We can provide consultation on appropriate drain locations at your request.

Post Construction: All drainage related issues may not become known until after construction and landscaping are complete. Therefore, some mitigation measures may be necessary following site development. Landscape watering is typically the largest source of water infiltration into the subgrade. Given the soil conditions on site, excessive or even normal landscape watering may contribute to groundwater levels rising, which could contribute to moisture related problems and/or cause distress to foundations and slabs, pavements, and underground utilities, as well as creating a nuisance where seepage occurs. In order to mitigate these conditions, additional subdrainage measures may be necessary.

6.0 DESIGN REVIEW AND CONSTRUCTION MONITORING

The design plans and specifications should be reviewed and accepted by Youngdahl Consulting Group, Inc. prior to contract bidding. A review should be performed to determine whether the recommendations contained within this report are still applicable and/or are properly reflected and incorporated into the project plans and specifications.

Construction Monitoring

Construction monitoring is a continuation of the findings and recommendations provided in this report. It is essential that our representative be involved with all grading activities in order for us to provide supplemental recommendations as field conditions dictate. Youngdahl Consulting Group, Inc. should be notified at least two working days before site clearing or grading operations commence, and should observe the stripping of deleterious material, overexcavation of existing fills or loose/soft soils and provide consultation to the Grading Contractor in the field.

Post Construction Monitoring

As described in Post Construction section of this report, all drainage related issues may not become known until after construction and landscaping are complete. Youngdahl Consulting Group, Inc. can provide consultation services upon request that relate to proper design and installation of drainage features during and following site development.

7.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. This report has been prepared for the exclusive use of KW Petaluma Hill Road, LLC and their consultants for specific application to the 38° North Phase 2 project. Youngdahl Consulting Group, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common to the local area. Youngdahl Consulting Group, Inc. makes no other warranty, expressed or implied.

2. As of the present date, the findings of this report are valid for the property studied. With the passage of time, changes in the conditions of a property can occur whether they be due to

natural processes or to the works of man on this or adjacent properties. Legislation or the broadening of knowledge may result in changes in applicable standards. Changes outside of our control may cause this report to be invalid, wholly or partially. Therefore, this report should not be relied upon after a period of three years without our review nor should it be used or is it applicable for any properties other than those studied.

3. Section [A] 107.3.4 of the 2016 California Building Code states that, in regard to the design professional in responsible charge, the building official shall be notified in writing by the owner if the registered design professional in responsible charge is changed or is unable to continue to perform the duties.

   WARNING: Do not apply any of this report's conclusions or recommendations if the nature, design, or location of the facilities is changed. If changes are contemplated, Youngdahl Consulting Group, Inc. must review them to assess their impact on this report's applicability. Also note that Youngdahl Consulting Group, Inc. is not responsible for any claims, damages, or liability associated with any other party's interpretation of this report's subsurface data or reuse of this report's subsurface data or engineering analyses without the express written authorization of Youngdahl Consulting Group, Inc.

4. The analyses and recommendations contained in this report are based on limited windows into the subsurface conditions and data obtained from subsurface exploration. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any variations or undesirable conditions be encountered during the development of the site, Youngdahl Consulting Group, Inc. will provide supplemental recommendations as dictated by the field conditions.

5. The recommendations included in this report have been based in part on assumptions about strata variations that may be tested only during earthwork. Accordingly, these recommendations should not be applied in the field unless Youngdahl Consulting Group, Inc. is retained to perform construction observation and thereby provide a complete professional geotechnical engineering service through the observational method. Youngdahl Consulting Group, Inc. cannot assume responsibility or liability for the adequacy of its recommendations when they are used in the field without Youngdahl Consulting Group, Inc. being retained to observe construction. Unforeseen subsurface conditions containing soft native soils, loose or previously placed non-engineered fills should be a consideration while preparing for the grading of the property. It should be noted that it is the responsibility of the owner or his/her representative to notify Youngdahl Consulting Group, Inc., in writing, a minimum of 48 hours before any excavations commence at the site.

6. Our experience has shown that vapor transmission through concrete is controlled through proper concrete mix design. As such, proper control of moisture vapor transmission should be considered in the design of the slab as provided by the project architect, structural or civil engineer. It should be noted that placement of the recommended plastic membrane, proper mix design, and proper slab underlayment and detailing per ASTM E1643 and E1745 will not provide a waterproof condition. If a waterproof condition is desired, we recommend that a waterproofing expert be consulted for slab design.

7. Following site development, additional water sources (i.e. landscape watering, downspouts) are generally present. The presence of low permeability materials can prohibit rapid

dispersion of surface and subsurface water drainage. Utility trenches typically provide a conduit for water distribution. Provisions may be necessary to mitigate adverse effects of perched water conditions. Mitigation measures may include the construction of cut-off systems and/or plug and drain systems. Close coordination between the design professionals regarding drainage and subdrainage conditions may be warranted.

Table 10: Checklist of Recommended Services

Item Description		Recommended	Not Anticipated
1	Provide foundation design parameters	Included	
2	Review grading plans and specifications	✓	
3	Review foundation plans and specifications	✓	
4	Observe and provide recommendations regarding demolition		✓
5	Observe and provide recommendations regarding site stripping	✓	
6	Observe and provide recommendations on moisture conditioning removal, and/or recompaction of unsuitable existing soils	✓	
7	Observe and provide recommendations on the installation of subdrain facilities	✓	
8	Observe and provide testing services on fill areas and/or imported fill materials	✓	
9	Review as-graded plans and provide additional foundation recommendations, if necessary	✓	
10	Observe and provide compaction tests on storm drains, water lines and utility trenches	✓	
11	Observe foundation excavations and provide supplemental recommendations, if necessary, prior to placing concrete	✓	
12	Observe and provide moisture conditioning recommendations for foundation areas and slab-on-grade areas prior to placing concrete	✓	
13	Provide design parameters for retaining walls	Included	
14	Provide finish grading and drainage recommendations	Included	
15	Provide geologic observations and recommendations for keyway excavations and cut slopes during grading		✓
16	Excavate and recompact all test pits within structural areas		✓

APPENDIX A
Field Study

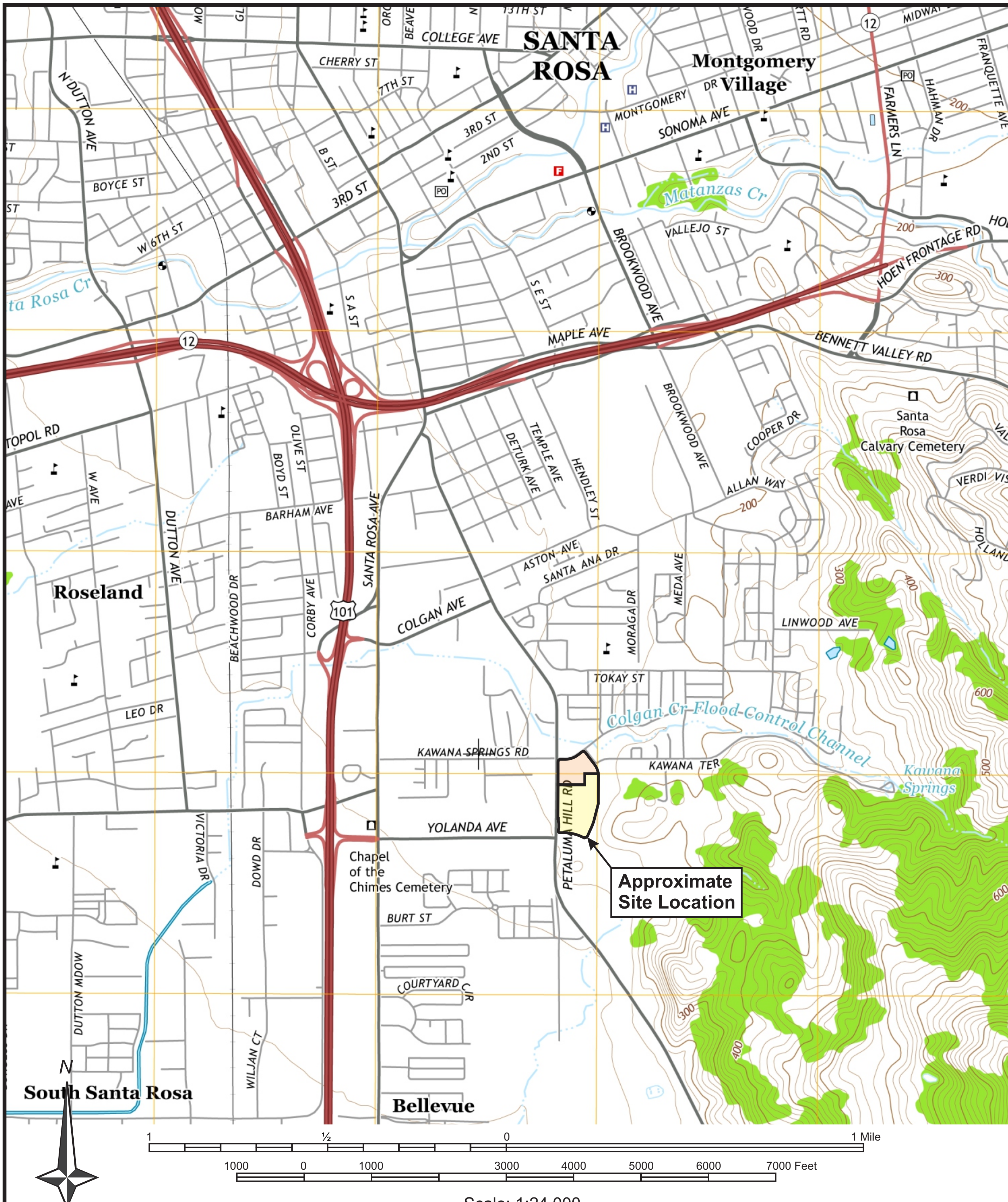
Vicinity Map
Site Plan
Logs of Exploratory Test Pits
Soil Classification Chart and Log Explanation

Introduction
The contents of this appendix shall be integrated with the Geotechnical Engineering Study of which it is a part. They shall not be used in whole or in part as a sole source for information or recommendations regarding the subject site.

Our field study included a site reconnaissance by a Youngdahl Consulting Group, Inc. representative followed by a subsurface exploration program conducted on 9 November 2018, which included the excavation of 4 borings under his direction at the approximate locations shown on Figure A-2, this Appendix. Drilling of the exploratory borings was accomplished with a DR5K truck mounted drill rig.

Throughout the drilling operation, soil samples were generally obtained at 5-foot depth intervals by means of a Modified California Sampler. This testing and sampling procedure consists of driving the steel sampler 18 inches into the soil with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded. If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance.

The soils encountered were logged during drilling and provide the basis for the "Exploratory Boring Logs," Figures A-3 through A-5, this Appendix. The enclosed Boring Logs describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples.



Scale: 1:24,000

BASE MAP REFERENCE: *U.S.G.S. 7.5 Minute Topographic Series, Santa Rosa Quadrangle, Dated 2015*

YOUNGDAHL CONSULTING GROUP, INC. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS TESTING	Project No.: E15229.003 **January 2019**	**VICINITY MAP** **38° North Phase 2** Santa Rosa, California	**FIGURE** **A-1**

B-1 = Approximate Boring Locations   B-101 = Approximate Boring Locations

0 80 160 320

Approximate Scale: 1" = 160'

REFERENCE: *Concept Site Plan, 38 North - Phase 2, BSB Design Inc., Dated 6/27/2018; Overlaid onto Google Earth, Aerial Data Dated 2/14/2018*

YOUNGDAHL CONSULTING GROUP, INC. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS TESTING	Project No.: E15229.003	**SITE PLAN**	**FIGURE**
	January 2019	**38° North Phase 2** Santa Rosa, California	**A-2**

Logged By: **DSF**	Date: **9 November 2018**	Lat / Lon: **N 38°24'47.83" / W 122°42'10.00"**	Boring No. **B-101**
Equipment: **Truck Mounted DR5K Drill Rig**		Elevation: **~**	

Depth (Feet)	Geotechnical Description & Unified Soil Classification	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
0	Brown sandy **SILT (ML)**, soft, slightly moist					**B-101** @ 0-5'
0.5	Olive brown **CLAY (CL)**, stiff, slightly moist					
1–2.5		19	4.5+ 4.5+ 4.5+			
3–4.5	*Grades olive grey, with sand*	23	4.5+ 4.5+ 4.5+			
5–6.5	*Grades medium stiff*	66	3.0 3.0 4.5+		49.4	
6	Olive yellow sandy **SILT (ML)**, moderately cemented, hard, slightly moist					
10	Olive silty **SAND (SM)**, moderately cemented, very dense, slightly moist	50/5		63.5	46.3	
15		50/3 50/2				
20		50/2				
20.5	Boring terminated at 20.5' No groundwater encountered					

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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EXPLORATORY BORING LOG

38° North Phase 2
Santa Rosa, California

FIGURE A-3

Logged By: **DSF**	Date: **9 November 2018**	Lat / Lon: **N 38°24'48.80" / W 122°42'14.30"**	Boring No. **B-102**
Equipment: **Truck Mounted DR5K Drill Rig**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
0			Olive brown **CLAY (CH)**, soft, slightly moist						**B-102** @ 0-5'
1			*Grades medium stiff*						79.7% < No. 200 PI = 47, LL =68
2					11	2.0			EI = 130
3						3.0 3.0			qu = 3,252 psf
4			*Grades olive, stiff*		27	4.5			
6			Olive yellow sandy **SILT (ML)**, moderately cemented, hard, slightly moist		55	4.5+ 4.5+	101.7	22.9	
7.5			Olive yellow silty **SAND (SM)** with gravel, dense, slightly moist		50/6		114.1	11.9	
12			*Grades olive, moderately cemented, very dense*		50/3				
17.5			*Grades strongly cemented*		50/3				
18			Boring terminated at 18' No groundwater encountered						

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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EXPLORATORY BORING LOG

38° North Phase 2
Santa Rosa, California

FIGURE **A-4**

Logged By: **DSF**	Date: **9 November 2018**	Lat / Lon: **N 38°24'51.81" / W 122°42'10.79"**	Boring No. **B-103**
Equipment: **Truck Mounted DR5K Drill Rig**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
0			Olive brown **CLAY (CH)**, soft, slightly moist						
1			*Grades stiff*						**B-103** @ 1-5' 84.7% < No. 200 PI = 39, LL =57 EI = 100 @1.5' qu = 5,468 psf
2					21	4.5 4.5			
4			*Grades olive, sandy*		26				
4.5			Olive silty **SAND (SM)**, moderately cemented, very dense, slightly moist						
5.5			Olive **CLAY (CL)** with sand, stiff, slightly moist			4.0			
6			Olive silty **SAND (SM)** with gravel, moderately cemented, very dense, slightly moist		61				
10					80				
15			*Grades with clay*		75				
20					50/4				
21.5			Boring terminated at 21.5' No groundwater encountered						

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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EXPLORATORY BORING LOG

38° North Phase 2
Santa Rosa, California

FIGURE A-5

Logged By: **DSF**	Date: **9 November 2018**	Lat / Lon: **N 38°24'55.05" / W 122°42'7.61"**	Boring No. **B-104**
Equipment: **Truck Mounted DR5K Drill Rig**		Elevation: **~**	

Geotechnical Description & Unified Soil Classification	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
Olive brown **CLAY (CL)**, soft, slightly moist					**B-104** @ 0-5'
Grades with sand and gravel, stiff					
		4.5			
	23	4.5+			
	22	4.5			qu = 8,363 psf
Grades with trace sand, without gravel					
Grades olive		4.0			
		4.0			qu = 5,026 psf
Grades with sand	28	4.5			
Grades sandy, with gravel		4.0			
		4.0	109.0	14.8	
Olive yellow silty **SAND (SM)** with gravel, dense, slightly moist	40				

Boring terminated at 9'
No groundwater encountered

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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EXPLORATORY BORING LOG

38° North Phase 2
Santa Rosa, California

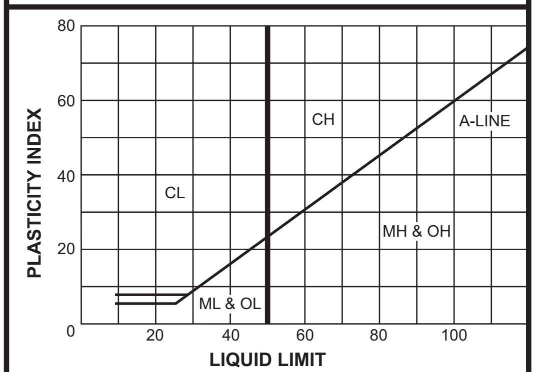
FIGURE **A-6**

UNIFIED SOIL CLASSIFICATION SYSTEMS

MAJOR DIVISION			SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS Over 50% > #200 sieve	GRAVELS Over 50% > #4 sieve	Clean **GRAVELS** With Little Or No Fines	GW	Well graded **GRAVELS**, **GRAVEL-SAND** mixtures
			GP	Poorly graded **GRAVELS**, **GRAVEL-SAND** mixtures
		GRAVELS With Over 12% Fines	GM	Silty **GRAVELS**, poorly graded **GRAVEL-SAND-SILT** mixtures
			GC	Clayey **GRAVELS**, poorly graded **GRAVEL-SAND-CLAY** mixtures
	SANDS Over 50% < #4 sieve	Clean **SANDS** With Little Or No Fines	SW	Well graded **SANDS**, gravelly **SANDS**
			SP	Poorly graded **SANDS**, gravelly **SANDS**
		SANDS With Over 12% Fines	SM	Silty **SANDS**, poorly graded **SAND-SILT** mixtures
			SC	Clayey **SANDS**, poorly graded **SAND-CLAY** mixtures
FINE GRAINED SOILS Over 50% < #200 sieve	**SILTS & CLAYS** Liquid Limit < 50		ML	Inorganic **SILTS**, silty or clayey fine **SANDS**, or clayey **SILTS** with plasticity
			CL	Inorganic **CLAYS** of low to medium plasticity, gravelly, sandy, or silty **CLAYS**, lean **CLAYS**
			OL	Organic **CLAYS** and organic silty **CLAYS** of low plasticity
	SILTS & CLAYS Liquid Limit > 50		MH	Inorganic **SILTS**, micaceous or diamacious fine sandy or silty soils, elastic **SILTS**
			CH	Inorganic **CLAYS** of high plasticity, fat **CLAYS**
			OH	Organic **CLAYS** of medium to high plasticity, organic **SILTS**
HIGHLY ORGANIC CLAYS			PT	PEAT & other highly organic soils

PLASTICITY CHART

USED FOR CLASSIFICATION OF FINE GRAINED SOILS



SAMPLE DRIVING RECORD

BLOWS PER FOOT	DESCRIPTION
25	25 Blows drove sampler 12 inches, after initial 6 inches of seating
50/7"	50 Blows drove sampler 7 inches, after initial 6 inches of seating
50/3"	50 Blows drove sampler 3 inches during or after initial 6 inches of seating

Note: To avoid damage to sampling tools, driving is limited to 50 blows per 6 inches during or after seating interval.

SOIL GRAIN SIZE

U.S. STANDARD SIEVE		6"		3"		¾"		4		10		40		200		
SOIL	BOULDER		COBBLE		GRAVEL COARSE		GRAVEL FINE		SAND COARSE		SAND MEDIUM		SAND FINE		SILT	CLAY
GRAIN SIZE IN MILLIMETERS		150		75		19		4.75		2.0		.425		0.075	0.002	

KEY TO PIT & BORING SYMBOLS

- Standard Penetration test
- 2.5" O.D. Standard California Sampler
- 3" O.D. Modified California Sampler
- Shelby Tube Sampler
- 2.5" Hand Driven Liner
- Bulk Sample
- Water Level At Time Of Drilling
- Water Level After Time Of Drilling
- P — Perched Water

KEY TO PIT & BORING SYMBOLS

- Joint
- Foliation
- Water Seepage

NFWE	No Free Water Encountered
FWE	Free Water Encountered
REF	Sampling Refusal
DD	Dry Density (pcf)
MC	Moisture Content (%)
LL	Liquid Limit
PI	Plasticity Index
PP	Pocket Penetrometer
UCC	Unconfined Compression (ASTM D2166)
TVS	Pocket Torvane Shear
EI	Expansion Index (ASTM D4829)
Su	Undrained Shear Strength

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SOIL CLASSIFICATION CHART AND LOG EXPLANATION
38° North Phase 2
Santa Rosa, California

FIGURE **A-7**

APPENDIX B

Laboratory Testing

Expansion Index Test
Atterberg Limit Test
Hydrometer Analysis
Unconfined Compression
Corrosivity Tests

Introduction
Our laboratory testing program for this evaluation included numerous visual classifications, expansion index, Atterberg limit, hydrometer analysis, unconfined compression, moisture content and dry density, and corrosivity tests. The following paragraphs describe our procedures associated with select tests. Graphical results of certain laboratory tests are enclosed in this appendix. The contents of this appendix shall be integrated with the Geotechnical Engineering Study of which it is a part. They shall not be used in whole or in part as a sole source for information or recommendations regarding the subject site.

Laboratory Testing Procedures
Visual Classification: Visual soil classifications were conducted on all samples in the field and on selected samples in our laboratory. All soils were classified in general accordance with the Unified Soil Classification System, which includes color, relative moisture content, primary soil type (based on grain size), and any accessory soil types. The resulting soil classifications are presented on the exploration logs in Appendix A.

Expansion Index Test: Expansion Index tests (ASTM D4829) were performed to provide an indication of swelling potential of a compacted soil. The results of these tests are presented on Figures B-1 and B-2, this Appendix.

Atterberg Limit Determination: Atterberg limits are used primarily for classifying and indexing cohesive soils. The liquid and plastic limits, which are defined as the moisture contents of a cohesive soil at arbitrarily established limits for liquid and plastic behavior, respectively, were determined for selected samples in general accordance with ASTM D-4318. The results of these tests are presented on the enclosed Atterberg limit graphs on Figures B-3 and B-4, this Appendix.

Hydrometer Analysis: The distribution of particle sizes smaller than 75 μm is determined by a sedimentation process (ASTM D7928) using a hydrometer. The results of these tests are presented on the Figures B-5 and B-6, this Appendix.

Unconfined Compression Strength: The strength parameters of the soils were evaluated using unconfined compression strength tests (ASTM D2166) performed on representative samples of the subsurface soils. The results of these tests are presented on Figures B-7 through B-10, this Appendix.

Corrosivity Tests: A corrosivity test typically comprises individual measurements of pH, electrical resistivity, sulfate content, and chloride content, which together indicate the corrosiveness of a soil. Corrosivity tests were performed on selected samples by an independent analytical laboratory working under subcontract to Youngdahl Consulting Group, Inc. The results of these tests are presented on the enclosed analytical certificates, this Appendix.

Expansion Index of Soils, ASTM D4829

Test Results

Expansion Index	130
Dry Density, as molded, pcf	92.3
Moisture Content, as molded, %	14.7
Final Moisture Content, %	36.4
Initial Saturation, as molded, %	48.4

Classification of Potentially Expansive Soil

Expansion Index, EI	Potential Expansion
0 - 20	Very Low
21 - 50	Low
51 - 90	Medium
91 - 130	High
Above 130	Very High

Material Description: **Olive Brown CLAY with Gravel**

Source:

Notes: Gravel removed from test sample.

Sample No./Depth:	B-102 @ 0-5'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	11/19/2018	CH	68	47	17	79.7

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Project:	**38° North, Phase 2**		
Project No.:	**E15229.003**		Figure
Reviewed By: JLC	Date: 1/7/2019		B-1

Expansion Index of Soils, ASTM D4829

Test Results

Expansion Index	100
Dry Density, as molded, pcf	96.0
Moisture Content, as molded, %	14.4
Final Moisture Content, %	28.6
Initial Saturation, as molded, %	51.8

Classification of Potentially Expansive Soil

Expansion Index, EI	Potential Expansion
0 - 20	Very Low
21 - 50	Low
51 - 90	Medium
91 - 130	High
Above 130	Very High

Material Description:	**Olive Brown CLAY with Sand**					
Source:						
Notes:						
Sample No./Depth:	B-103 @ 1-5'	USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled: 11/9/2018	Date Test Started: 11/19/2018	CH	57	39	0	84.7

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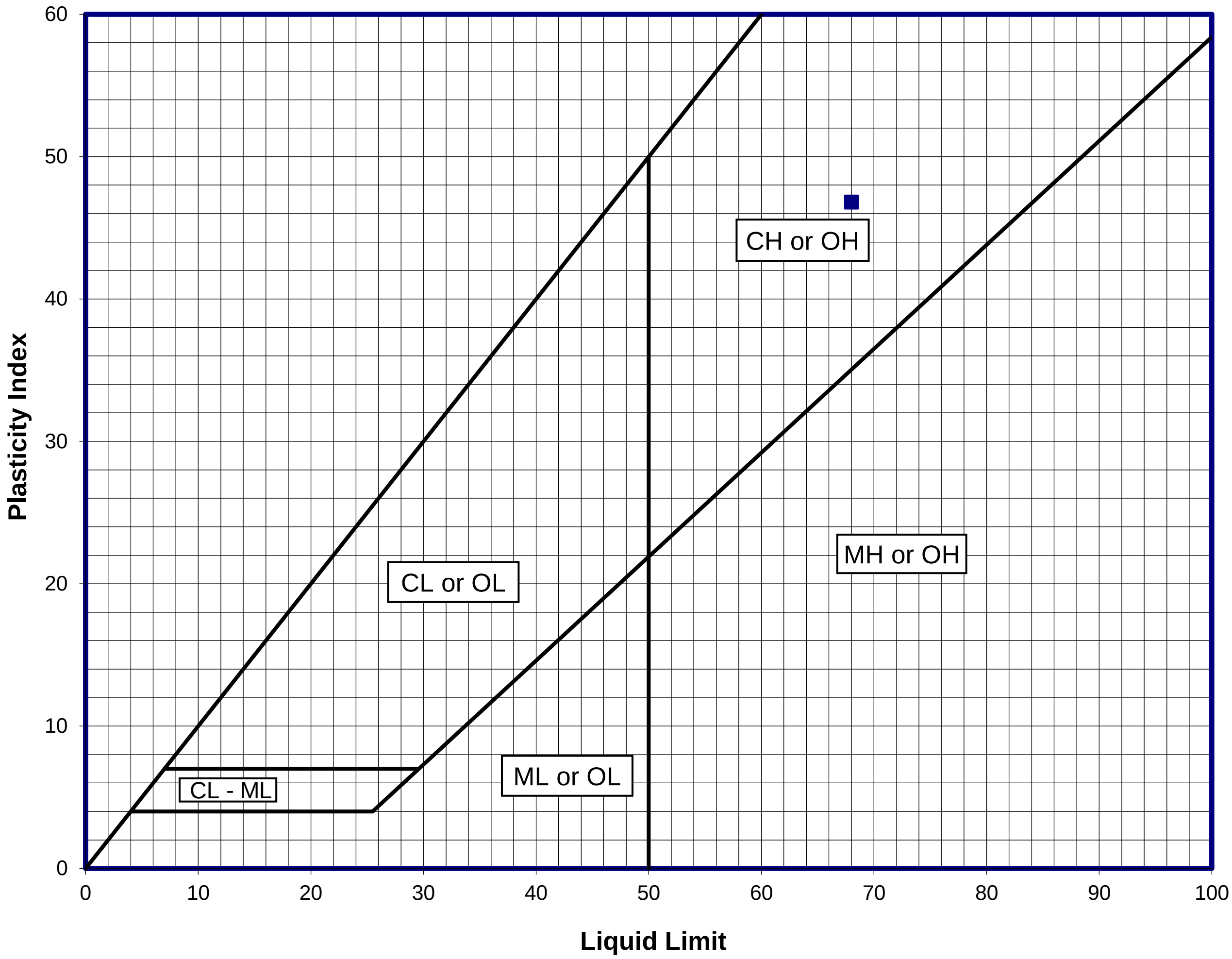
Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM D4318, Method A



Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification, ASTM D2487
68	21	47	CH

Material Description: **Olive Brown CLAY with Gravel**

Source:

Notes:

Sample No./Depth: B-102 @ 0-5'

Date Sampled: 11/9/2018 Date Test Started: 11/19/2018

USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
CH	68	47	17	79.7

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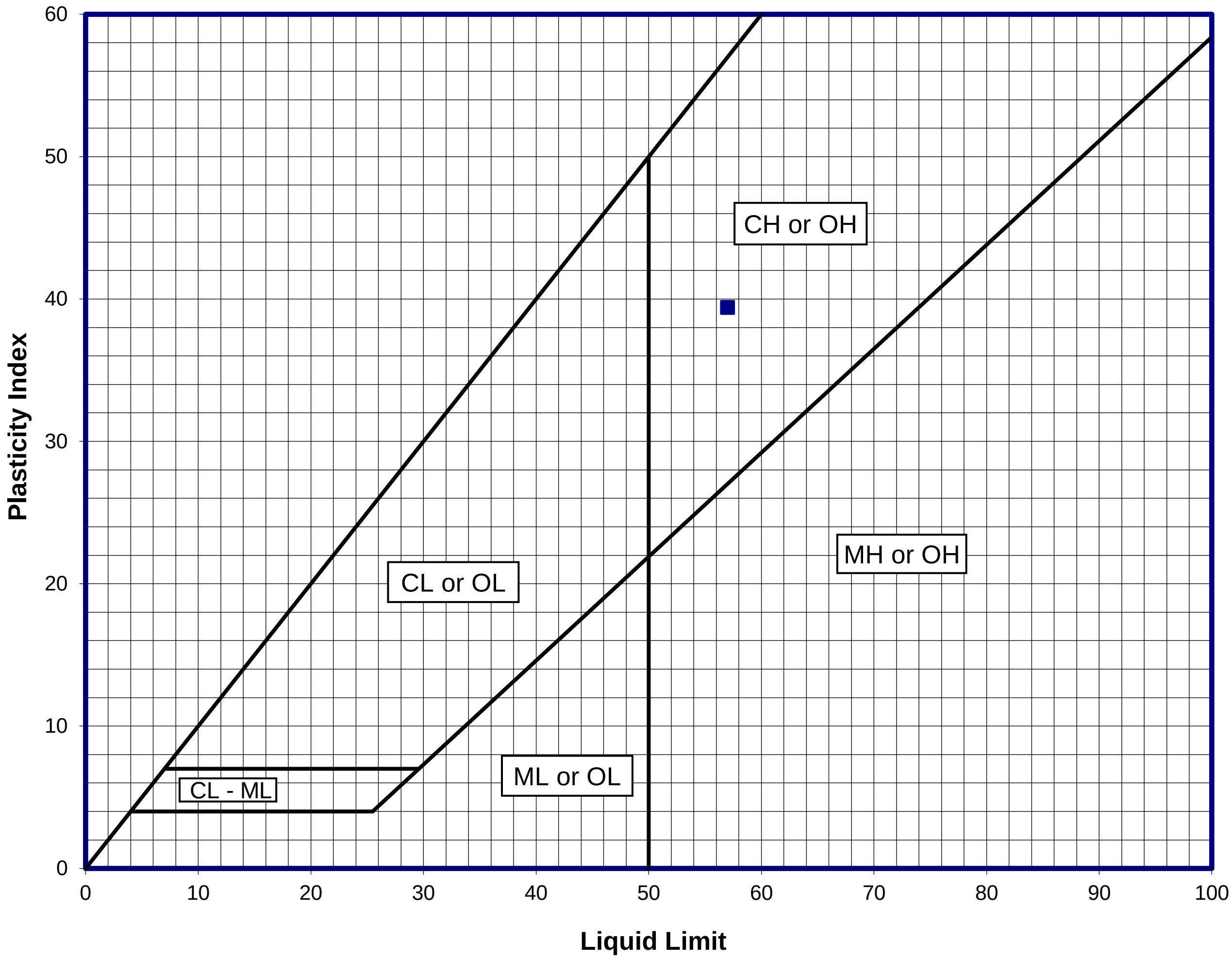
Figure B-3

Reviewed By: JLC Date: 1/7/2019

Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM D4318, Method A



Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification, ASTM D2487
57	18	39	CH

Material Description:	**Olive Brown CLAY with Sand**					
Source:						
Notes:						
Sample No./Depth: B-103 @1-5'		USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled: 11/9/2018	Date Test Started: 11/29/2018	CH	57	39	0	84.7

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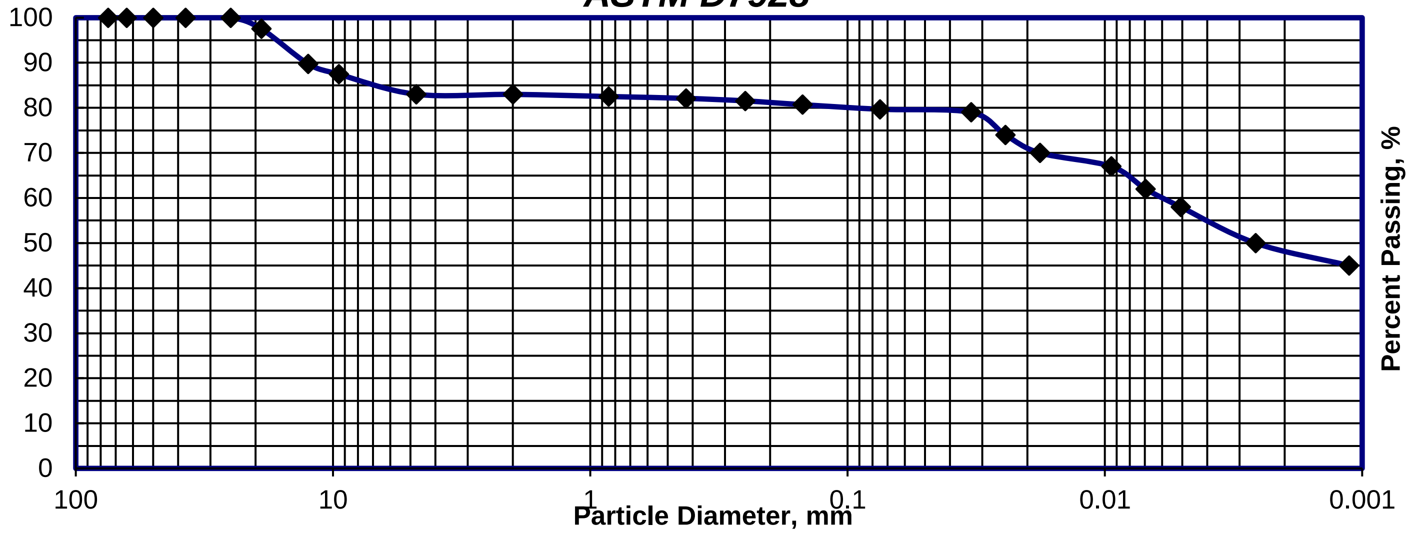
Project No.:	**E15229.003**		Figure
Reviewed By: DN		Date: 12/3/2018	B-4

Particle-Size Distribution of Fine-Grained Soils Using the Sedimentation Analysis, ASTM D7928



Sieve Analysis	
US Standard Sieve Size	Percent Passing
3 Inch (75 mm)	100
2 1/2 Inch (63.5 mm)	100
2 Inch (50 mm)	100
1 1/2 Inch (37.5 mm)	100
1 Inch (25 mm)	100
3/4 Inch (19 mm)	98
1/2 Inch (12.5 mm)	90
3/8 Inch (9.5 mm)	87
No. 4 (4.75 mm)	83
No. 10 (2 mm)	83
No. 20 (850 µm)	83
No. 40 (425 µm)	82
No. 60 (250 µm)	82
No.100 (150 µm)	81
No. 200 (75 µm)	79.7

Hydrometer Analysis	
Particle Diameter, mm	Percent Passing
0.033	79.0
0.024	74.0
0.018	70.0
0.009	67.0
0.007	62.0
0.005	58.0
0.003	50.0
0.001	45.0

Material Description: **Olive Brown CLAY with Gravel**

Source:

Notes:

Sample No./Depth:	B-102 @ 0-5'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	12/19/2018	CH	68	47	17	79.7

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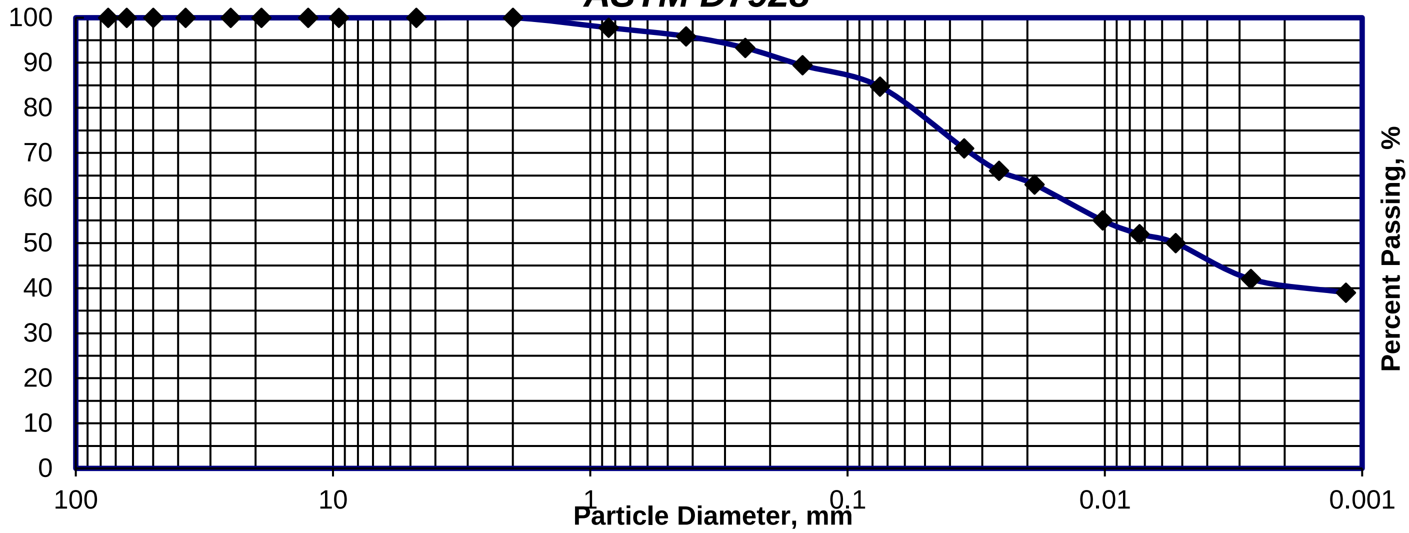
Project:	**38° North, Phase 2**		
Project No.:	**E15229.003**		Figure
Reviewed By: JLC	Date: 1/7/2019		B-5

Particle-Size Distribution of Fine-Grained Soils Using the Sedimentation Analysis, ASTM D7928



Sieve Analysis	
US Standard Sieve Size	Percent Passing
3 Inch (75 mm)	100
2 1/2 Inch (63.5 mm)	100
2 Inch (50 mm)	100
1 1/2 Inch (37.5 mm)	100
1 Inch (25 mm)	100
3/4 Inch (19 mm)	100
1/2 Inch (12.5 mm)	100
3/8 Inch (9.5 mm)	100
No. 4 (4.75 mm)	100
No. 10 (2 mm)	100
No. 20 (850 µm)	98
No. 40 (425 µm)	96
No. 60 (250 µm)	93
No.100 (150 µm)	89
No. 200 (75 µm)	84.7

Hydrometer Analysis	
Particle Diameter, mm	Percent Passing
0.035	71.0
0.026	66.0
0.019	63.0
0.010	55.0
0.007	52.0
0.005	50.0
0.003	42.0
0.001	39.0

Material Description: **Olive Brown CLAY with Sand**

Source:

Notes:

Sample No./Depth:	B-103 @ 1-5'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	12/19/2018	CH	57	39	0	84.7

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Project:	**38° North, Phase 2**			
Project No.:	**E15229.003**			Figure
Reviewed By:	JLC	Date:	1/7/2019	B-6

Unconfined Compressive Strength of Cohesive Soil, ASTM D2166

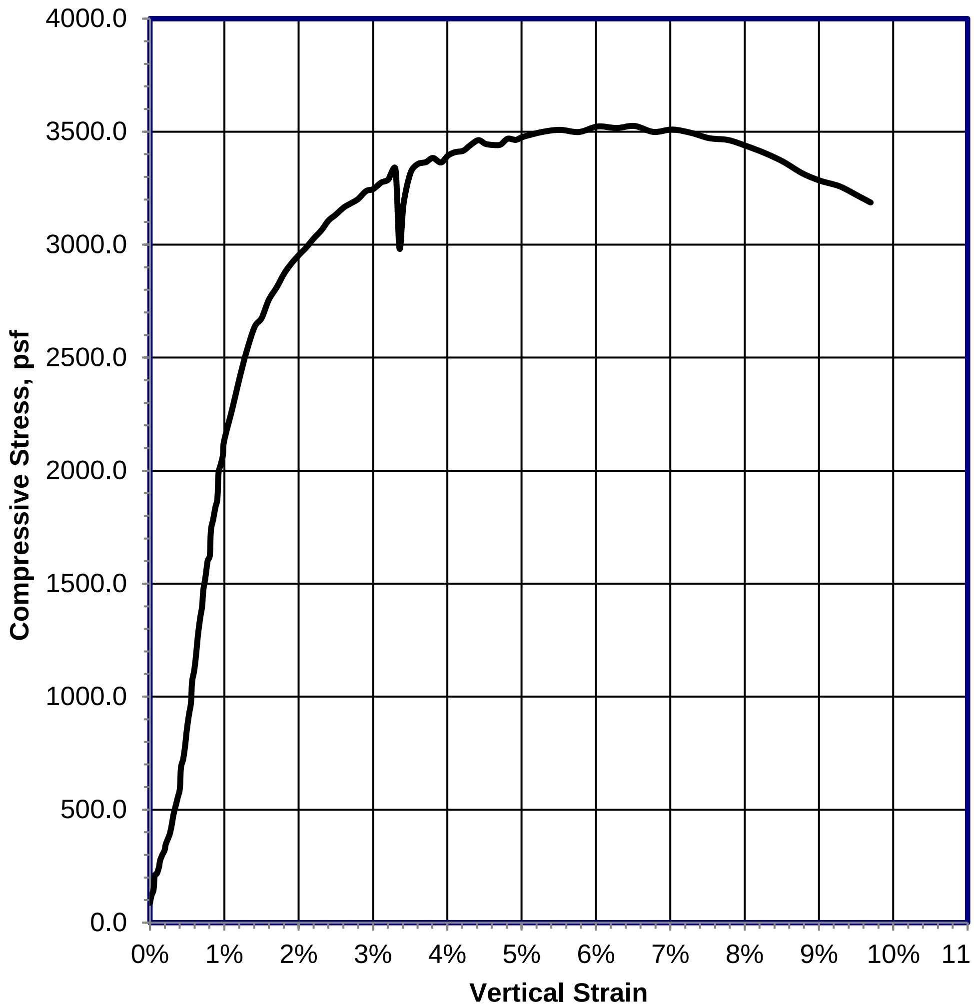

Image of Failed Specimen

Unconfined Compression Results			**Specimen Parameters**				
	Compression Strength	3525 psf		Wet Density, pcf	121.4	Diameter, in	2.42
				Dry Density, pcf	100.7	Height/Diameter	2.0330
	Shear Strength	1762.5 psf		Moisture Content, %	20.7	Strain Rate, %/min	1.5000
				Saturation, %	Not Evaluated	Sensitivity:	Not Evaluated
	Failure Strain, %	6.5 %		Void Ratio		Specimen Type:	Insitu
				Height, in	4.927		

Material Description: **Olive Brown CLAY**

Source:

Notes: *Moisture content based on after test sample.

Sample No./Depth:	B-102 @ 3.5'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	12/12/2018					

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Project:	**38° North, Phase 2**			
Project No.:	**E15229.003**			Figure
Reviewed By:	DN	Date:	12/13/2018	B-7

Unconfined Compressive Strength of Cohesive Soil, ASTM D2166

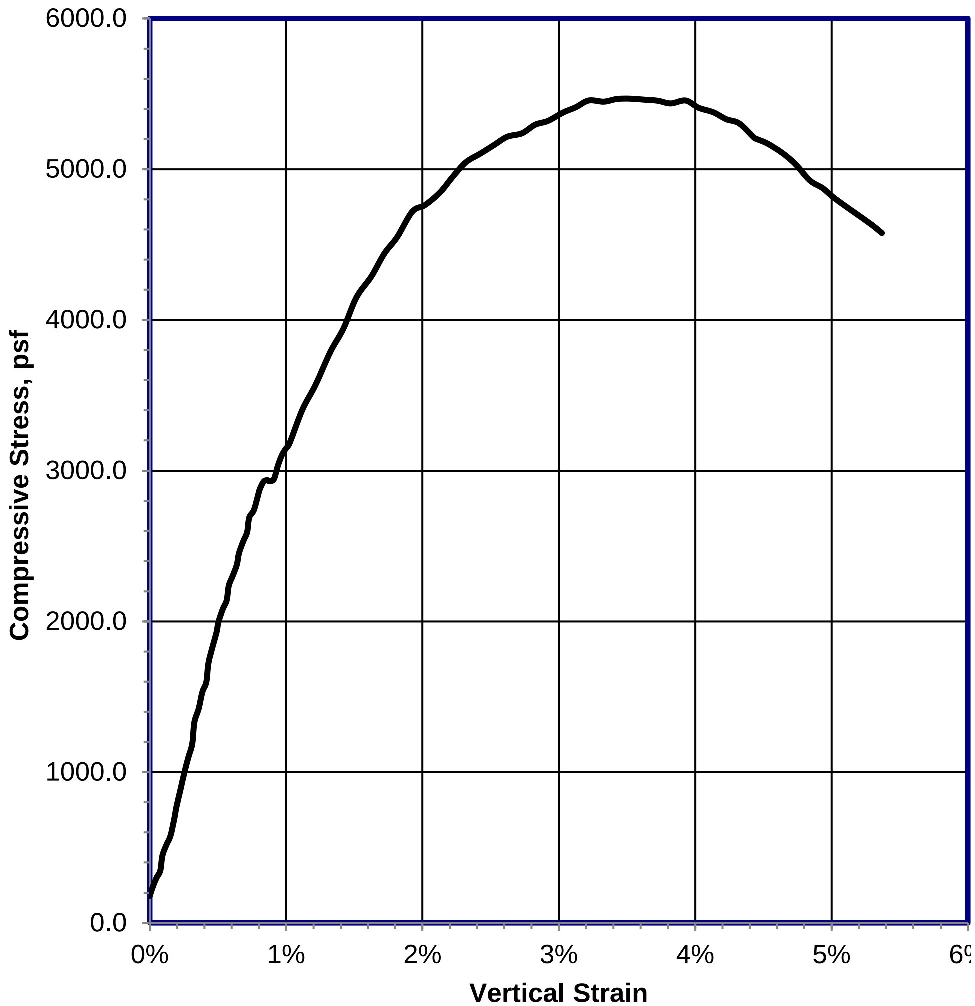

Image of Failed Specimen

Unconfined Compression Results	Compression Strength	5468 psf	**Specimen Parameters**	Wet Density, pcf	116.7	Diameter, in	2.38
				Dry Density, pcf	100.0	Height/Diameter	2.0686
	Shear Strength	2734 psf		Moisture Content, %	16.7	Strain Rate, %/min	1.5000
				Saturation, %	Not Evaluated	Sensitivity:	Not Evaluated
	Failure Strain, %	3.5 %		Void Ratio		Specimen Type:	Insitu
				Height, in	4.916		

Material Description: **Olive Brown Sandy CLAY**

Source:

Notes: *Moisture content based on after test sample.

Sample No./Depth:	B-103 @ 1.5'		USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started: 12/12/2018					

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Project:	**38° North, Phase 2**		
Project No.:	**E15229.003**		Figure
Reviewed By: DN	Date: 12/12/2018		B-8

Unconfined Compressive Strength of Cohesive Soil, ASTM D2166

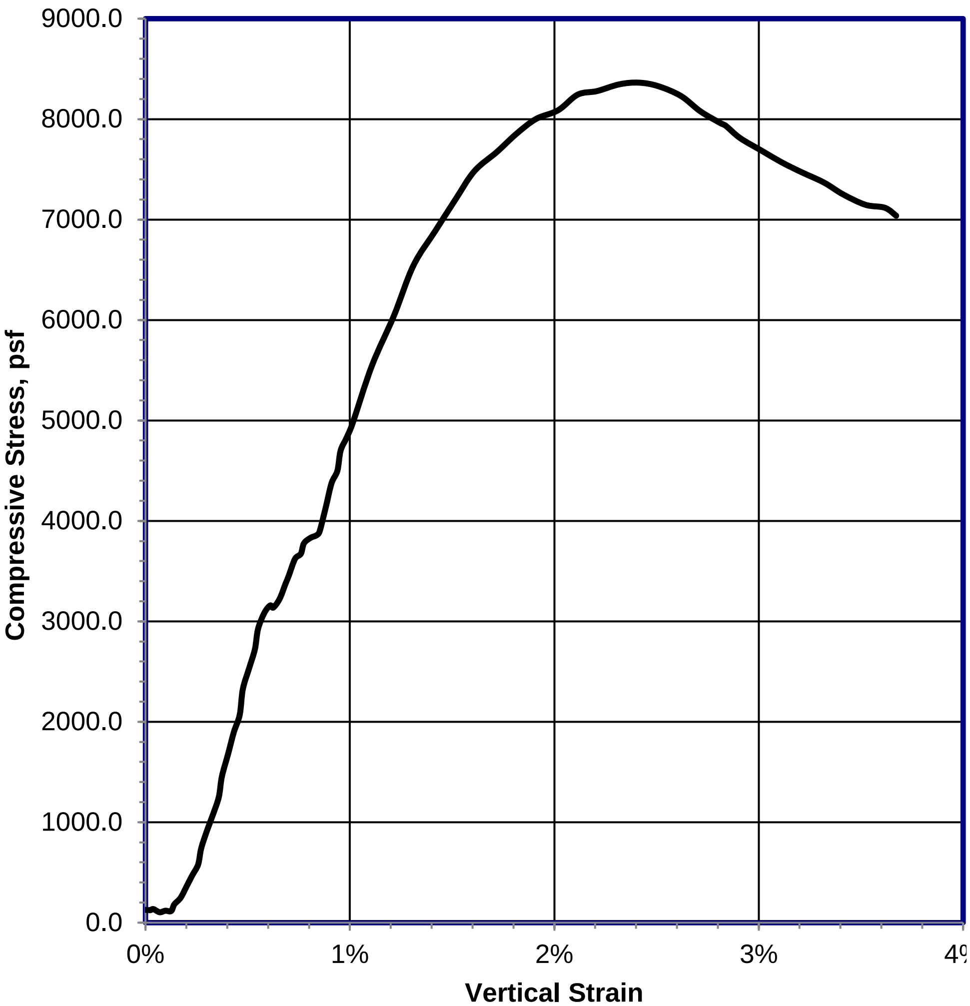

Image of Failed Specimen

Unconfined Compression Results	Compression Strength	8363 psf	**Specimen Parameters**	Wet Density, pcf	122.7	Diameter, in	2.38
	Shear Strength	4181.5 psf		Dry Density, pcf	102.4	Height/Diameter	2.0448
	Failure Strain, %	2.4 %		Moisture Content, %	19.8	Strain Rate, %/min	1.5000
				Saturation, %	Not Evaluated	Sensitivity:	Not Evaluated
				Void Ratio		Specimen Type:	Insitu
				Height, in	4.867		

Material Description: **Olive Brown CLAY**

Source:

Notes: *Moisture content based on after test sample.

Sample No./Depth:	B-104 @ 4'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	12/12/2018					

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Project:	**38° North, Phase 2**		
Project No.:	**E15229.003**		Figure
Reviewed By: DN	Date: 12/13/2018		B-9

Unconfined Compressive Strength of Cohesive Soil, ASTM D2166

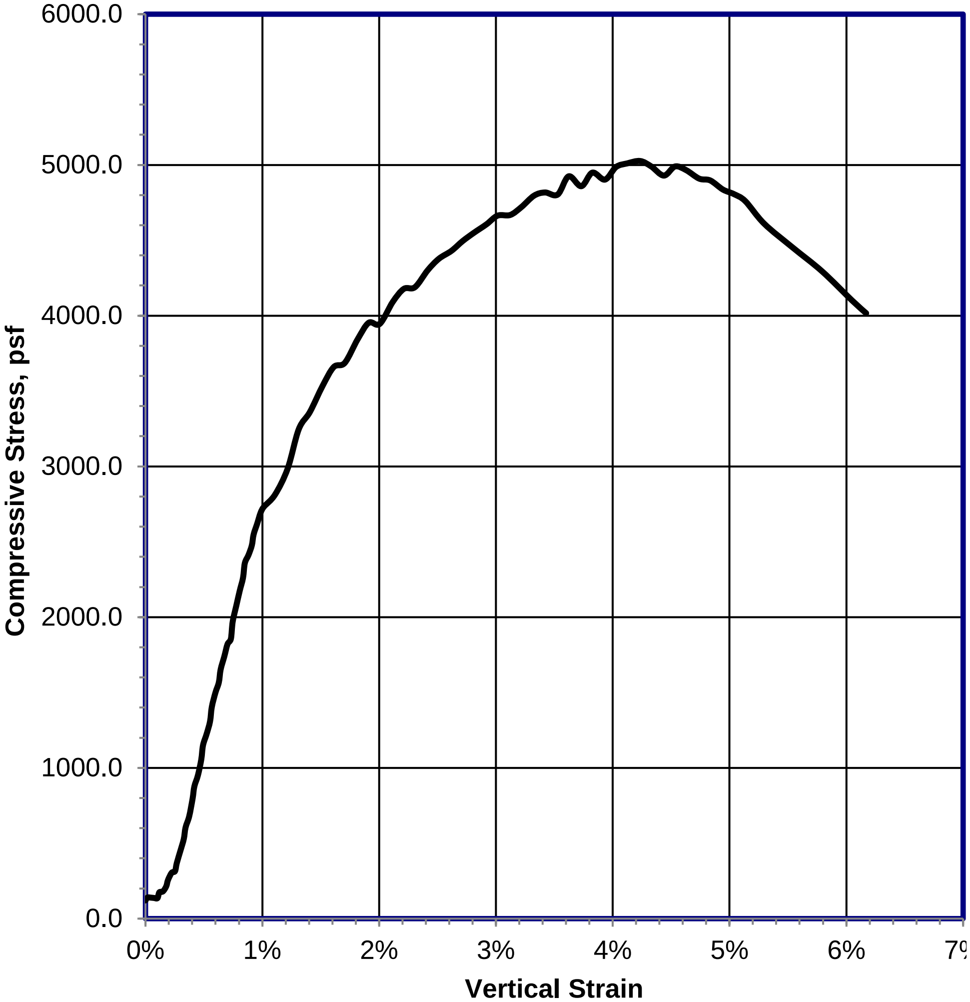

Image of Failed Specimen

Unconfined Compression Results	Compression Strength	5026 psf	**Specimen Parameters**	Wet Density, pcf	127.0	Diameter, in	2.37
				Dry Density, pcf	104.3	Height/Diameter	2.0197
	Shear Strength	2513 psf		Moisture Content, %	21.7	Strain Rate, %/min	1.5000
				Saturation, %	Not Evaluated	Sensitivity:	Not Evaluated
	Failure Strain, %	4.2 %		Void Ratio		Specimen Type:	Insitu
				Height, in	4.780		

Material Description: **Olive CLAY**

Source:

Notes: *Moisture content based on after test sample.

Sample No./Depth:	B-104 @ 5.5'			USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled:	11/9/2018	Date Test Started:	12/12/2018					

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Project:	**38° North, Phase 2**		
Project No.:	**E15229.003**		Figure
Reviewed By: DN	Date: 12/13/2018		B-10

Sunland Analytical
11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 11/16/2018
Date Submitted 11/13/2018

To: Jeffry Cannon
Youngdahl Consulting Group
1234 Glenhaven Ct.
El Dorado Hills, CA 95630

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : E15229.003 Site ID : B-2@0-5FT.
Thank you for your business.

* For future reference to this analysis please use SUN # 78499-164140.

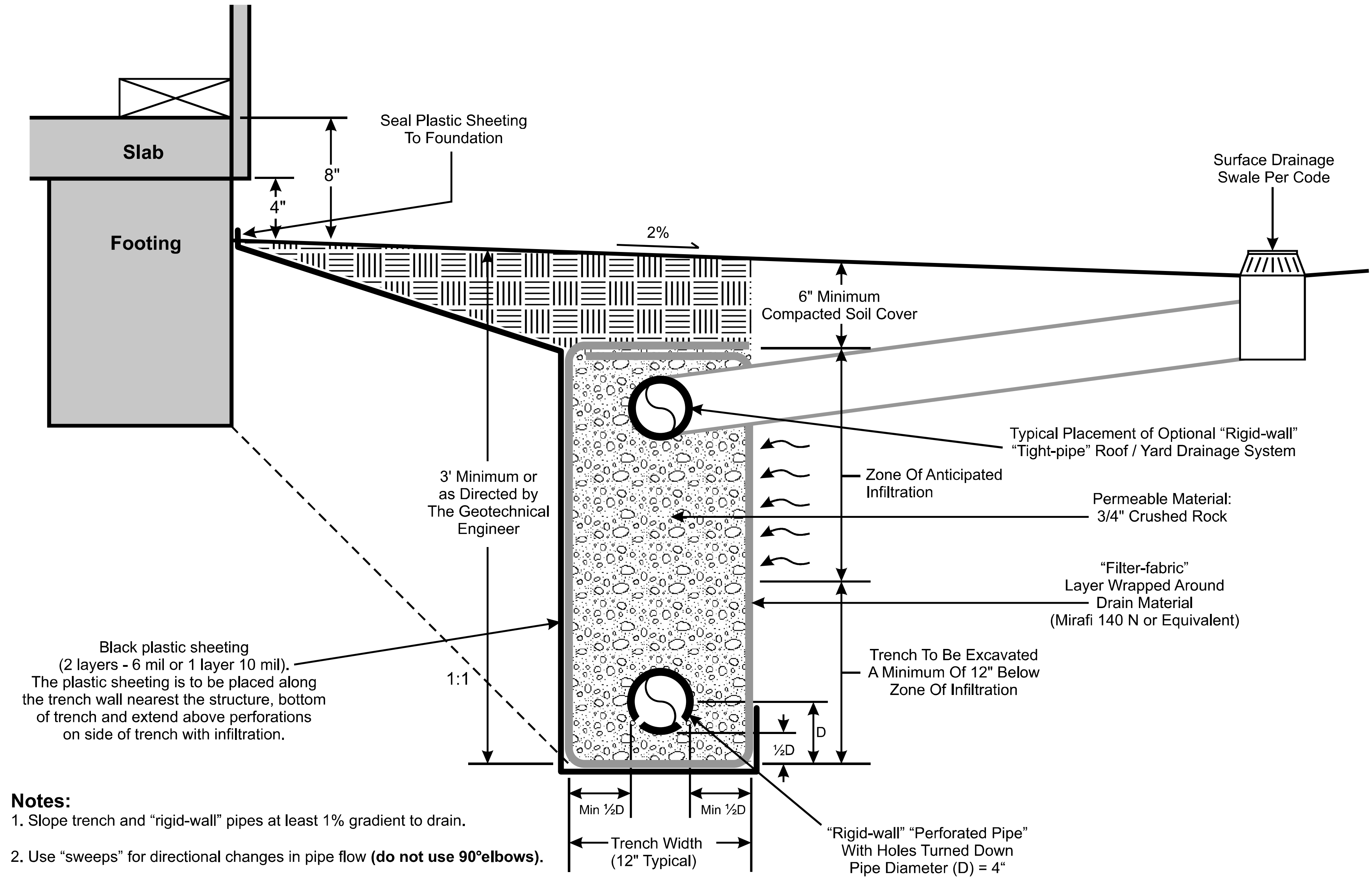
EVALUATION FOR SOIL CORROSION

Soil pH	6.54		
Minimum Resistivity	0.75	ohm-cm (x1000)	
Chloride	22.3 ppm	00.00223 %	
Sulfate	45.6 ppm	00.00456 %	

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422

APPENDIX C
Details

Subdrain



Notes:

1. Slope trench and "rigid-wall" pipes at least 1% gradient to drain.
2. Use "sweeps" for directional changes in pipe flow **(do not use 90°elbows)**.
3. Provide sweeps to periodic "clean-outs".
4. Washed clean permeable material.

YOUNGDAHL CONSULTING GROUP, INC. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS TESTING	Project No.: E15229.003 **January 2019**	**SUB-DRAIN DETAIL** **38° North Phase 2** Santa Rosa, California	**FIGURE** **C-1**