# Geotechnical Engineering Report

**Multi-Family Community**

**Santa Rosa, Sonoma County, California**

Revised May 29, 2018

Terracon Project No. NB185057

**Prepared for:**

Wolff Enterprises II, LLC
Scottsdale, Arizona

**Prepared by:**

Terracon Consultants, Inc.
Sacramento, California

Revised May 29, 2018

Wolff Enterprises II, LLC
6710 E. Camelback Road, Suite 100
Scottsdale, Arizona 85251

Attn: Mr. Bret Hardison
P: (602) 751-6278
E: bhardison@awolff.com

Re: Geotechnical Engineering Report
Multi-Family Community
325 Yolanda Avenue
Santa Rosa, Sonoma County, California
Terracon Project No. NB185057

Dear Mr. Hardison:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PNB185057 dated April 16, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

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

Sincerely,
**Terracon Consultants, Inc.**

ROBERT HOLMER
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Environmental ■ Facilities ■ Geotechnical ■ Materials

# REPORT TOPICS

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

# ATTACHMENTS

## APPENDIX A – FIELD EXPLORATION

| | |
|---|---|
| Exhibit A-1 | Location Diagram |
| Exhibit A-2 | Exploration Plan |
| Exhibit A-3 | Field Exploration Description |
| Exhibits A-4 thru A-15 | Boring Logs |

## APPENDIX B – LABORATORY TESTING

| | |
|---|---|
| Exhibit B-1 | Laboratory Test Description |
| Exhibit B-2 | Atterberg Limits Test Results |
| Exhibit B-3 | Grain size Analysis |
| Exhibit B-4 thru B-5 | Unconfined Compression |
| Exhibit B-6 | R-Value Test Results |
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## APPENDIX C – SUPPORTING DOCUMENTS

| | |
|---|---|
| Exhibit C-1 | Unified Soil Classification |
| Exhibit C-2 | Description of Soil Properties |
| Exhibit C-3 | Seismic Design Maps Detailed Report |
| Exhibit C-4 | Liquefaction Analysis Figures |

# REPORT SUMMARY

| Topic [1] | Overview Statement [2] |
|---|---|
| **Project Description** | ■ The project will consist of a garden style multi-family community development consisting of multiple one to three-story apartment structures, a clubhouse, pavements, and landscaping areas. |
| **Geotechnical Characterization** | ■ Surface materials encountered at the site generally consisted of 6 to 12 inches of aggregate pavement base course. Aggregate base course was underlain by fill material consisting of silty sand with variable gravel throughout the site to depths of approximately 1.5 to 3.0 feet below ground surface (bgs).<br>■ Native subsurface materials encountered at the site generally consisted of medium stiff to very stiff lean clay with variable sand and medium dense clayey sand to a depth of approximately 3.5 to 16 feet, where it transitioned into medium dense to dense clayey sand with gravel and poorly graded to clayey gravel with interbedded very stiff to hard lean clay the total depth of exploration of 51.5 feet.<br>■ Groundwater was encountered at depths of approximately 4.5 to 15.0 feet bgs during our investigation. |
| **Liquefaction** | Site Specific liquefaction analysis has determined that the subgrade soils at this site possess a marginal risk of liquefaction with a corresponding differential settlement on the order of less than 1 inch. |
| **Earthwork** | ■ Earthwork for this project will include over-excavation of existing gravel pavement course and fill materials, demolition of the existing structure onsite, and fill placement.<br>■ Existing fill materials consisting of silty sand with variable gravel were encountered across the site to depths of approximately 1.5 to 3.0 feet bgs. No documentation has been presented showing that these materials have been placed in a controlled manner. Therefore, these materials are considered undocumented and are not suitable to support the proposed structures at this site.<br>■ Near surface native clays and clayey sands are expansive and sensitive to changes in moisture variation. These materials are not suitable for use as non-expansive engineered fill for this project. |
| **Shallow Foundations** | ■ The structures at this site may be supported on either a traditional spread footing foundation system or a post-tensioned slab.<br>■ The post tensioned slab foundation will provide additional protection against expansive soil related distress and also settlement due to potential liquefaction. |
| **Pavements** | With subgrade prepared as noted in **Earthwork**<br>Pavement thicknesses based on anticipated traffic Index (TI) is as follows:<br>Concrete:<br>■ TI of 4.5 – 6.0" PCC over 4.0" AB<br>■ TI of 5.5 – 6.0" PCC over 6.0" AB |

| **Topic** [1] | **Overview Statement** [2] |
|---|---|
| | ■ TI of 6.5 – 6.0” PCC over 6.0” AB<br>Asphalt:<br>■ TI of 4.5 – 3.0” ACC over 8.0” AB<br>■ TI of 5.5 – 4.0” ACC over 10.0” AB<br>■ TI of 6.5 – 4.5” ACC over 12.5” AB |
| **General Comments** | This section contains important information about the limitations of this geotechnical engineering report. |

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

# Geotechnical Engineering Report

**Multi-Family Community**
**325 Yolanda Avenue**
**Santa Rosa, Sonoma County, California**
**Terracon Project No. NB185057**
**Revised May 29, 2018**

## INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Multi-Family Development to be located at 325 Yolanda Avenue in Santa Rosa, Sonoma County, California. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Demolition considerations
- Excavation considerations
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC
- Lateral earth pressures
- Pavement design and construction

The geotechnical engineering scope of services for this project included the advancement of twelve (12) test borings to depths ranging from approximately 5 to 51.5 feet below existing site grades.

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

# SITE CONDITIONS

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

| Item | Description |
|---|---|
| **Parcel Information** | The project is located at 325 Yolanda Avenue in Santa Rosa, Sonoma County, California.<br>The parcel is approximately 8.4 acres in size<br>Approximate Latitude/Longitude: 38.4143°, -122.7110°<br>See **Site Location** |
| **Existing Improvements** | ■ The south-central portion of the site is currently developed with an existing pre-fabricated metal warehouse structure with associated storage yard and multiple small, metal storage structures.<br>■ The eastern portion of the site is developed with a gravel paved parking lot, hosting multiple semi-trucks and trailers. |
| **Current Ground Cover** | The site is currently covered by aggregate pavement base course and native vegetation. |
| **Existing Topography** | The site is relatively flat and gently slopes to the west. |
| **Geology** | ■ The project area is situated within the Coast Range Geomorphic Provence of California. The native materials underlying the site are considered to be alluvial fan deposits ($Q_{yfo}$ & $Q_{of}$), as described in the geologic map of the area[1]. According to the map, the alluvium is Quaternary in age (duration about 2.6 million years ago to present) and consists of the following units:<br>■ ($Q_{yfo}$) – Fluvial deposits at the outer edge of alluvial fans. Characterized by fine but variable grain size, composed mainly of fine sand, silt, and silty clay.<br>■ ($Q_{of}$) – alluvial fan deposits bordering uplands. Outer margins of fans are overlapped by younger alluvial deposits. Also includes deposits on stream terraces in narroy canyons cut in to uplands. Composed mainly of deeply weathered, poorly sorted, coarse sand and gravel.<br>■ The subsurface materials encountered in our investigation are generally consistent with the mapped geology. |

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[1] *Fox, K.F., Sims, J.D., Bartow, J.A., and Helley, E.J., 1973,Prelliminary Geologic Map of the Eastern Sonoma County and Western Napa County, California: United States Geological survey, MF-483, Scale 1: 62,500*

# SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-13.

| DESCRIPTION | VALUE |
|---|---|
| **2016 California Building Code Site Classification (CBC)** [1] | D [2] |
| **Site Latitude** | N 38.4139° |
| **Site Longitude** | W -122.7107° |
| **$S_S$ Spectral Acceleration for a Short Period** [3] | 2.092g |
| **$S_1$ Spectral Acceleration for a 1-Second Period** [3] | 0.858g |
| **$S_{MS}$ Maximum Considered Earthquake (MCE) Spectral** [3] | 2.092g |
| **$S_{M1}$ Maximum Considered Earthquake (MCE) Spectral** [3] | 1.287g |
| **Design Spectral Acceleration Value (Short Period), $S_{DS}$** [3] | 1.395g |
| **Design Spectral Acceleration Value (1-Second Period), $S_{D1}$** [3] | 0.858g |
| **$F_a$ Site Coefficient for a Short Period** [3] | 1.000 |
| **$F_v$ Site Coefficient for a 1-Second Period** [3] | 1.500 |

1. Seismic site classification in general accordance with the 2016 *California Building Code*, which refers to ASCE 7-13
2. The 2016 California Building Code (CBC) requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 51.5 feet, and this seismic site class definition considers that similar soils continue below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be necessary to confirm and/or modify the above site class.
3. These values were obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).

The site is located in Northern California, which is a seismically active area. The type and magnitude of seismic hazards affecting the site are dependent on the distance to causative faults, the intensity, and the magnitude of the seismic event. The table below indicates the distance of the fault zones and the associated maximum credible earthquake that can be produced by nearby seismic events, as calculated using the USGS Earthquake Hazard Program Unified Hazard tool.

**Characteristics and Estimated Earthquakes for Regional Faults**

| Fault Name | Percent Contribution (%) | Approximate Distance to Site (kilometers) | Maximum Credible Earthquake (MCE) Magnitude |
|---|---|---|---|
| Rogers Creek – Healdsburg [5] | 34.04 | 3.00 | 7.22 |
| Bennett Valley [6] | 3.98 | 6.24 | 6.57 |
| San Andreas (North Coast) [9] | 2.35 | 30.01 | 7.95 |
| Maacama [1] | 1.45 | 14.80 | 7.37 |

Based on the ASCE 7-10 Standard, the peak ground acceleration ($PGA_M$) at the subject site approximately 0.804g. Based on the USGS 2008 interactive deaggregations, the project site has a mean magnitude of 7.04.

The site is not located within an Alquist-Priolo Earthquake Fault Zone based on our review of the State Fault Hazard Maps.[2]

## LIQUEFACTION

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

As part of our evaluation of the liquefaction potential at this site, we extended boring B-6 to a depth of 51.5 feet during this investigation. Subsurface materials encountered consisted of medium stiff to hard lean clay to sandy lean clay to depths of 16 feet bgs underlain by interbedded medium dense to dense clayey sand with gravel and medium stiff to hard lean clay with gravel to a depth of 34 feet. These units were underlain by medium dense clayey gravel to poorly graded gravel with clay to a depth of 48 feet, which in turn were underlain by very stiff lean clay with sand to the maximum depth of exploration of 51.5 feet.

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

We performed a liquefaction analysis for this site using the data collected from our borings. Our liquefaction study utilized the Simplified Procedure originally developed by Seed and Idriss (1971) and most recently refined by Idriss and Boulanger (2014). This analysis was based on the soil data from Boring B-6 of our investigation. A Maximum Credible Earthquake (MCE) magnitude of 7.50 and a Peak Ground Acceleration ($PGA_M$) of 0.804g was used. Our calculations utilized a ground water depth of 10.0 feet. A summary of liquefaction analysis is attached in Appendix C of this report.

Our analysis concludes that there is a marginal risk of liquefaction in two stratigraphic units consisting of medium dense clayey sand to poorly graded gravel units encountered at depths of 25 to 30 feet and 45 to 48 feet respectively. Based on our analysis, the anticipated liquefaction induced settlement could be up to 2.3 inches total with differential settlement on the order of 1.2 inches over approximately 40 linear feet. However, the consequences of one-dimensional settlement may be largely mitigated by the presence of the thick non-liquefiable layer above the potentially liquefiable soils (Ishihara 1985, Naesgaard et al. 1998, Bouckovalas and Dakoulas, 2007). It is our opinion that the presence of stiff clay soils and medium dense to dense clayey sand soils (non-liquefiable layer) found beneath the existing ground surface to a depth of approximately 25 feet will act as a bridging layer that redistributes stresses and therefore results in more uniform ground surface settlement if there is a deeper liquefiable soil beneath the site. Therefore, it is our opinion that surficial expression of differential liquefaction induced settlement at the site would likely be a maximum of 1.5 inches total and 0.8 inches differential.

## CORROSIVITY

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

**Corrosivity Test Results Summary**

| Boring | Sample Depth (feet) | Soil Description | Soluble Sulfate (ppm) | Soluble Chloride (ppm) | Electrical Resistivity (Ω-cm) | pH |
|---|---|---|---|---|---|---|
| B-3 | 2.0’ | CL | 194 | 73 | 1,067 | 7.89 |

Results of soluble sulfate testing indicate samples of the on-site soils tested possess negligible sulfate concentrations when classified in accordance with Table 4.3.1 of the ACI Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

# PROJECT DESCRIPTION

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

| Item | Description |
|---|---|
| **Project Description** | The project will consist of a garden style multi-family community development consisting of multiple one to three story apartment structures, a clubhouse, asphalt and/or concrete pavements and drives, and landscaping areas. |
| **Proposed Structures** | The project includes a total of eleven (11) multi-story apartment structures and one (1) clubhouse structure with pool area. |
| **Building Construction** | The buildings are anticipated to be constructed of wood framing. These structures will be founded on either a shallow spread footing foundation system with slab-on-grade flooring, or a uniform thickened post-tensioned slab. |
| **Maximum Loads (Assumed)** | ■ Columns: 100 kips<br>■ Walls: 5 kips/ft.<br>■ Slabs: 100 psf |
| **Grading/Slopes** | Based on site topography, cuts and fills on the order of 1 to 2 feet are anticipated to provide a level building pad. |
| **Pavements** | A paved driveway and parking area will be constructed at the site.<br>We assume both rigid (concrete) and flexible (asphalt) pavement sections should be considered.<br>Anticipated traffic Index (TI) is as follows:<br>■ Auto parking: 4.5<br>■ Auto and light truck drives: 5.5<br>■ Heavy truck drives: 6.5 |

# GEOTECHNICAL CHARACTERIZATION

## Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the geologic setting and planned construction. The following table provides our geotechnical characterization.

The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of site preparation, foundation options and pavement options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

| Stratum | Approximate Depth to Bottom of Stratum (feet) | Material Description | Consistency/Density |
|---|---|---|---|
| Surface | 6 to 12 inches | **GRAVEL PAVEMENTS:**<br>Aggregate Pavement Base Course | --- |
| Surface | 1.5 to 3.0 | **FILL MATERIAL:**<br>Silty Sand | --- |
| 1 | 3.5 to 16 | Lean Clay with Variable Sand | Medium Stiff to Very Stiff |
| | | Clayey Sand | Medium Dense |
| 2 | Undetermined: Borings terminated within this stratum at the planned depth of approximately 51.5 feet | Clayey Sand with Gravel - Clayey Gravel<br>Interbedded Poorly Graded sands and Gravels | Medium Dense to Dense |
| | | Lean Clay with Sands and Gravels | Medium Stiff to Very Stiff |

Conditions encountered at each boring location are indicated on the individual boring logs shown in **Appendix A**. Stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

## Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. In addition, delayed water levels were also obtained in some borings. The water levels observed in the boreholes can be found on the boring logs in **Appendix A**, and are summarized below.

| Boring Number | Approximate Depth to Groundwater while Drilling (feet) [1] | Approximate Depth to Groundwater after Drilling (feet) [1] |
|---|---|---|
| B-1 | 15 | 13.5 |
| B-2 | 14 | 15 |
| B-3 | 10 | 8.5 |
| B-4 | 5 | 4.5 |
| B-5 | 10 | --- |
| B-7 | 15 | 12.5 |
| B-8 | 13.5 | 13 |

2. Below ground surface

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

## GEOTECHNICAL OVERVIEW

The near surface, medium plasticity lean clay and clayey sands could become unstable with typical earthwork and construction traffic once gravel pavements and surficial fills are removed, especially after precipitation events. The effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier time of the year. If grading is performed during the winter months, an increased risk of unstable subgrade will persist. Near surface native clay soils are expansive and are not suitable for use as engineered fill for this project. Additional site preparation recommendations including subgrade improvement and fill placement are provided in the **Earthwork** section.

The soils which form the bearing stratum for shallow foundations are plastic and exhibit potential for shrink-swell movements with changes in moisture. The **Shallow Foundations** section addresses support of the building bearing on native stiff to hard lean clay. Slab on grade floor slabs, if selected, should be underlain by a minimum of 12 inches of non-expansive engineered fill. The **Floor Slabs** section addresses slab-on-grade support of the building.

The structures at this site may be supported on either a traditional spread footing foundation system, or a post-tensioned slab. The post-tensioned slab foundation will provide additional protection against expansive soil related distress, and also settlement due to liquefaction.

Both rigid and flexible pavement systems are provided for this site. The **Pavements** section addresses the design of pavement systems.

Fill material consisting of silty sand with variable gravel was encountered across the site to depths of approximately 1.5 to 3.0 feet bgs. No documentation has been provided demonstrating that these materials were placed in a controlled manner. We consider this material to be undocumented and unsuitable to support the proposed structures at this site.

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

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

# EARTHWORK

Earthwork will include clearing and grubbing, demolition of the existing structures, removal of existing foundations and utilities, over-excavation of undocumented fill, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

## Site Preparation

Site preparation will include demolition of the existing structure on site. All pavements, foundations, and slabs should be completely removed within the proposed building area. Undocumented fill material was encountered across the site to depths of approximately 1.5 to 3.0 feet bgs. Undocumented fills should be completely over-excavated down to native soil within the proposed building areas. Over-excavated undocumented fill materials may be stockpiled for reuse.

After demolition of the existing structure, over-excavation of undocumented fill, and any required cuts are made, the subgrade should be proof-rolled with an adequately loaded vehicle such as a fully loaded tandem axle dump truck. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by stabilizing. Excessively wet or dry material should either be removed or moisture conditioned and recompacted.

## Existing Fill

As noted in **Geotechnical Characterization**, our investigation encountered existing fill to depths of approximately 1.5 to 3.0 feet across the site. We have no records to indicate the degree of placement and compaction of this fill. Footings, floor slabs, and pavements should not be supported on or above existing undocumented fill. Existing undocumented fill materials should be completely over-excavated from the proposed improvement areas. Over excavated materials may be recompacted as engineered fill provided they meet the requirements outlined in this report.

## Fill Materials and Placement

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

Approved imported materials or onsite fill materials with low volume change properties may be used as fill material for general site grading and pond area backfill and over-excavation and recompaction of the building pad.

Any imported or on site soils for use as fill material for the project should conform to low volume change materials as indicated as follows:

| **Gradation** | **Percent Finer by Weight (ASTM C 136)** |
|---|---|
| ■ 3” | 100 |
| ■ No. 4 Sieve | 40 to 100 |
| ■ No. 200 Sieve | 20 to 40 |
| ■ Liquid Limit | 30 (Max) |
| ■ No. 200 Sieve | 20 to 40 |
| ■ Plasticity Index | 15 (max) |
| ■ Maximum Expansive Index* | 20 (max) |

*ASTM D 4829

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill lifts should not exceed eight inches in loose thickness.

## Fill Compaction Requirements

Compaction requirements for other structural and general fill should meet the following compaction requirements.

| **Material Type and Location** | **Per the Modified Proctor Test (ASTM D 1557)** | | |
|---|---|---|---|
| | **Minimum Compaction Requirement** | **Range of Moisture Contents for Compaction Above Optimum** | |
| | | **Minimum** | **Maximum** |
| Approved On-site or approved import structural fill soils: | | | |
| Beneath foundations: | 90% | +1% | +4% |
| Beneath slabs: | 90% | +1% | +4% |
| Utility trenches (structural areas): | 95% | +1% | +4% |
| Bottom of excavation receiving fill: | 90% | +1% | +4% |

| Material Type and Location | Per the Modified Proctor Test (ASTM D 1557) | | |
|---|---|---|---|
| | Minimum Compaction Requirement | Range of Moisture Contents for Compaction Above Optimum | |
| | | Minimum | Maximum |
| Miscellaneous backfill: | 90% | +1% | +4% |
| Utility trenches (Landscape areas): | 90% | +1% | +4% |
| Beneath asphalt pavements: | 95% | +1% | +4% |
| Beneath concrete pavements: | 95% | +1% | +4% |
| Aggregate base (beneath pavements): | 95% | 0% | +4% |

## Grading and Drainage

All final grades must provide effective drainage away from the building improvements during and after construction. Water permitted to pond next to the building can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped at least 2 percent away from the building extending a minimum of 10 feet beyond the perimeter of the building. After building construction and landscaping, we recommend the Civil Engineer/Surveyor verify final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Planters located within 10 feet of the structure should be self-contained to prevent water accessing the building and pavement subgrade soils. Locate sprinkler mains and spray heads a minimum of 5 feet away from the building line. Collect roof runoff in drains or gutters. Discharge roof drains and downspouts onto pavements which slope away from the building or extend down spouts a minimum of 10 feet away from the structure.

Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving. Sprinkler systems should not be installed within 5 feet of foundation walls. Landscaped irrigation adjacent to the foundation system should be minimized or eliminated.

## Earthwork Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. At the time of our study, moisture contents of the surface and near-surface native soils ranged from 9 to 26 percent. Based on these moisture contents, some moisture conditioning may be needed for the project.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of the floor slab. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, frozen, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and re-compacted prior to floor slab and pavement construction.

Surface water should not be allowed to pond on the site and soak into the soil during construction. Construction staging should provide drainage of surface water and precipitation away from the building and pavement areas. Any water that collects over or adjacent to construction areas should be promptly removed, along with any softened or disturbed soils. Surface water control in the form of sloping surfaces, drainage ditches and trenches, and sump pits and pumps will be important to avoid ponding and associated delays due to precipitation and seepage.

Groundwater was encountered in our borings at depths of 4.5 to 15 feet during our exploration. Based on our understanding of the proposed development, we do not expect groundwater to affect construction. If groundwater is encountered during construction, some form of temporary or permanent dewatering may be required. Conventional dewatering methods, such as pumping from sumps, should likely be adequate for temporary removal of any groundwater encountered during excavation at the site. Well points would likely be required for significant groundwater flow, or where excavations penetrate groundwater.

All excavations should be sloped or braced as required by OSHA regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current Occupational Health and Safety Administration (OSHA) Excavation and Trench Safety Standards.

## Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. One density and water content test for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

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

## SHALLOW FOUNDATIONS

The structures at this site may be supported on either a traditional spread footing foundation system, or a post-tensioned slab. The post-tensioned slab foundation will provide additional protection against expansive soil related distress, and also settlement due to liquefaction.

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

### Design Parameters – Compressive Loads

| Item | Description |
|---|---|
| **Maximum Net Allowable Bearing pressure** [1, 2] | 2,500 psf |
| **Required Bearing Stratum** [3] | Undisturbed native soils or over-excavated and recompacted engineered fill. |
| **Minimum Foundation Dimensions** | Columns: 24 inches<br>Continuous: 12 inches |
| **Ultimate Passive Resistance** [4] **(equivalent fluid pressures)** | 350 pcf |
| **Ultimate Coefficient of Sliding Friction** [5] | 0.30 |
| **Minimum Embedment below Finished Grade** [6] | 24 inches |
| **Estimated Total Settlement from Structural Loads** [2] | Less than about 1 inch |
| **Estimated Differential Settlement** [2, 7] | About 2/3 of total settlement |

| Item | Description |
|---|---|
| 1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.<br>2. Values provided are for maximum loads noted in **Project Description**.<br>3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.<br>4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.<br>5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.<br>6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.<br>7. Differential settlements are as measured over a span of 50 feet. | |

## Post-Tensioned Slab Foundations

Foundation slabs should be post-tensioned so that they may act as a unit. Post-tensioned foundations should consist of a monolithic slab (California Uniformed Thickened Slab) with deepened areas for concentrated column loads. We anticipate the post tensioned foundation will include an 8” to 10” thick slab with a minimum 4-inch thick (measured from bottom of slab) continuous shovel footing around the perimeter of the building.

The post tensioned foundation engineer should be allowed to calculate the most feasible slab for the given soil conditions and design parameters presented herein. We are providing design parameters from the Third Edition of the Post Tensioning Institute manual for “Design and Construction of Post-Tensioned Slabs-on-Ground.” The foundation engineer should be allowed to choose which parameters and which design method with which to design the slab. In determining design soil parameters in accordance with the Third Edition recommendations, we used the VOLFLO 1.5 software to calculate the respective soil parameters.

### Post-Tensioned Soil Parameters:

| Item | Description |
|---|---|
| **Foundation Type** | Post-tensioned slab |
| **Percent of soil passing the No. 200 Sieve that is finer than 0.002mm** | 28% |
| **Constant Soil Suction, PF** | 3.9 |
| **Modulus of Subgrade Reaction** | 100 psf |
| **Thornwaite Moisture Index** | 20 |
| **Depth to Constant Soil Suction** | 3.0 ft. |

### Post-Tensioned Design Parameters:

| Item | Description |
|---|---|
| **Edge Moisture Distance, Em** | |
| Center Lift, $E_m$ | 8.70 ft. |
| Edge Lift, $E_m$ | 4.90 ft. |
| **Estimated Differential Swell, $y_m$** | |
| Center Lift, $y_m$ | 0.81 in. |
| Edge Lift, $y_m$ | -0.62 in |
| **Anticipated Differential Settlement** | Less than 1 inch over 40 linear feet |
| **Allowable Bearing Capacity (Total load, dead plus live)** | 3,000 psf |
| **Coefficient of Friction (between slab and subgrade)** | 0.30 |

### Post-Tensioned Construction Considerations:

Care should be taken by the owner, architect and engineer to understand that these soil parameters have been developed based on several site constraints that shall be followed during and after construction.

- All down spouts will be connected to tight lines connected to the site storm drainage system and the runoff water will be carried out away from the buildings.
- The subgrade soil shall be in an above optimum moisture condition prior to casting the foundations.
- Positive drainage away from the building perimeter is provided to limit any ponding adjacent to the foundations.
- Landscape irrigation next to the foundations shall be monitored so as not to over irrigate clay soils. Experience has shown that misters and drip systems tend to perform this function well when properly monitored.
- No vegetation over six feet in height shall be planted within 20 feet of the building perimeters unless a root barrier is provided between the structure and tree to limit roots within 5 feet of building. Roots can draw additional moisture from the soils and cause excessive volume changes in the soil.
- The site grading, drainage, and irrigation shall be maintained around the entire perimeter of the buildings during the useful life of the post-tensioned foundation. Landscape irrigation shall be uniform around the perimeter of the buildings i.e. non-landscaped back yards cannot be left to dry out during the summer while the remaining sides of the foundation are irrigated. Moisture conditions around the perimeter of the foundations must be maintained in a uniform manner.

The moistened subgrade should be covered by two layers of impervious vapor retarder such as 6 mil visqueen or equivalent, with seams and penetrations taped, in order to reduce subgrade friction when stressing and reduce the potential for moisture vapor traveling up though the slab. The vapor retarder should be covered by 1 to 2 inches of sand to protect it during construction and to aid in curing the concrete. However, we know from experience that most local sand will not meet these requirements. In our opinion, the sand should be a sand or silty sand containing no more than 20 percent passing the No. 200 sieve. Alternative materials must be approved by the geotechnical engineer prior to being brought to the site.

The sand should be moist but not saturated at the time of concrete placement. If the sand is saturated or free water is visible, the concrete should not be placed until the sand is dried sufficiently to only be moist or is replaced. Excessive moisture in the sand can lead to problems with excessive moisture vapor related problems with the concrete slab on grade.

If construction will take place in winter, sand may be substituted with ⅜ inch pea-gravel. The pea gravel may not be saturated. Free water must not be visible on the gravel. If the gravel is saturated, it must be dried sufficiently to only be moist or be replaced prior to placement of concrete.

Exterior finish grades should be at or below the floor subgrade level unless special drainage and waterproofing features are employed to reduce the potential for moisture migration under

### Foundation Construction Considerations

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

## SLAB-ON-GRADE FLOOR SLABS

The subgrade soils are comprised of moderately plasticity clays exhibiting the potential to swell with increased water content. Construction of the slab on grade floor slab and revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and damage the floor slab. To reduce the swell potential to less than about 1 inch, floor slabs shall be underlain by a minimum of 12 inches of non-expansive engineered fill.

Design parameters for slab on grade floor slabs, if selected, assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and. positive drainage of the aggregate base beneath the floor slab.

## Floor Slab Design Parameters

| Item | Description |
|---|---|
| **Floor Slab Support** [1] | Minimum 12 inches of non-expansive engineered fill. |
| **Capillary Break** | Minimum 6 inches of free-draining (less than 6% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of ASTM D 1557 [2, 3] |
| **Estimated Modulus of Subgrade Reaction** [2] | 100 pounds per square inch per inch (psi/in) for point loads |

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.
3. Free-draining granular material should have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

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

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

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

## Floor Slab Construction Considerations

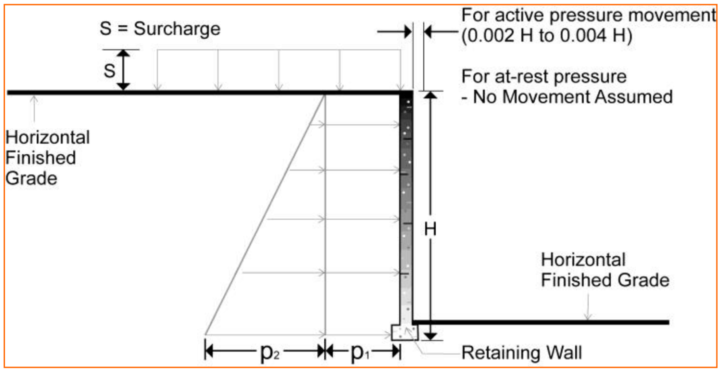
Finished subgrade within and for at least 10 feet beyond the floor slab should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor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

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

# LATERAL EARTH PRESSURES

## Design Parameters

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



| Lateral Earth Pressure Design Parameters | | | |
|---|---|---|---|
| Earth Pressure Condition [1] | Coefficient for Backfill Type [2] | Surcharge Pressure [3, 4, 5] $p_1$ (psf) | Effective Fluid Pressures (psf) [2, 4, 5] |
| Active (Ka) | 0.40 | (0.40)S | (50)H |
| At-Rest (Ko) | 0.60 | (0.60)S | (70)H |
| Passive (Kp) | 3.00 | --- | (325)H |

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95 percent of the ASTM D 1557 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.

**Lateral Earth Pressure Design Parameters**

| Earth Pressure Condition [1] | Coefficient for Backfill Type[2] | Surcharge Pressure [3, 4, 5] $p_1$ (psf) | Effective Fluid Pressures (psf) [2, 4, 5] |
|---|---|---|---|

4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.

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

# PAVEMENTS

## General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs, noted in this section, must be applied to the site, which has been prepared as recommended in the **Earthwork** section.

## Pavement Design Parameters

Design of Asphaltic Concrete (AC) pavements are based on the procedures outlined in the California Department of Transportation (CalTrans) Highway Design Manual. Design of Portland Cement Concrete (PCC) pavement sections were designed using PCA “Thickness Design for Concrete Highway and Street Pavements.”

A Design R-Value of 6 was used for the AC pavement designs, and a modulus of subgrade reaction of 100 pci was use for the PCC pavement designs. The values were determined through lab testing, and also empirically derived based upon our experience with the describe soil type subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**. A modulus of rupture of 600 psi was used for pavement concrete.

## Pavement Section Thicknesses

The following table provides options for AC and PCC Sections:

| Asphaltic Concrete Design | | | | |
|---|---|---|---|---|
| **Traffic Area** | **Traffic Index (TI)** | **AC (inches)** | **Aggregate Base (inches)** | **Total Thickness (inches)** |
| Auto Parking | 4.5 | 3.0 | 8.0 | 11.0 |
| Auto Drives | 5.5 | 4.0 | 10.0 | 14.0 |
| Delivery Truck | 6.5 | 4.5 | 12.5 | 17.0 |

| Portland Cement Concrete Design | | | | |
|---|---|---|---|---|
| **Traffic Area** | **Traffic Index (TI)** | **PCC (inches)** | **Aggregate Base (inches)** | **Total Thickness (inches)** |
| Auto Parking | 4.5 | 6.0 | 4.0 | 10.0 |
| Auto Drives | 5.5 | 6.0 | 6.0 | 12.0 |
| Delivery Truck | 6.5 | 6.0 | 6.0 | 12.0 |

The above sections represent minimum design thicknesses and, as such, periodic maintenance should be anticipated. The Portland cement concrete pavement should have a minimum 28-day compressive strength of 4,000 psi.

The estimated pavement sections provided in this report are minimums for the assumed design criteria, and as such, periodic maintenance should be expected. Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles. A maintenance program including surface sealing, joint cleaning and sealing, and timely repair of cracks and deteriorated areas will increase the pavement's service life. As an option, thicker sections could be constructed to decrease future maintenance.

Concrete for rigid pavements should have a minimum 28-day compressive strength of 4,000 psi, and be placed with a maximum slump of 4 inches. A minimum 4-inch thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its “green” state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system, longitudinal subdrains, or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Dishing in parking lots surfaced with ACC is usually observed in frequently-used parking stalls (such as near the front of buildings), and occurs under the wheel footprint in these stalls. The use of higher-grade asphaltic cement, or surfacing these areas with PCC, should be considered. The dishing is exacerbated by factors such as irrigated islands or planter areas, sheet surface drainage to the front of structures, and placing the ACC directly on a compacted clay subgrade.

## Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water.  Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Groundwater was encounter at depths as shallow as 4.5 feet bgs during our investigation. Based on the possibility of shallow and/or perched groundwater, we recommend installing a pavement subdrain system to control groundwater, improve stability, and improve long term pavement performance.

## Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

## GENERAL COMMENTS

As the project progresses, we address assumptions by incorporating information provided by the design team, if any. Revised project information that reflects actual conditions important to our services is reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

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

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

# APPENDIX A – FIELD EXPLORATION

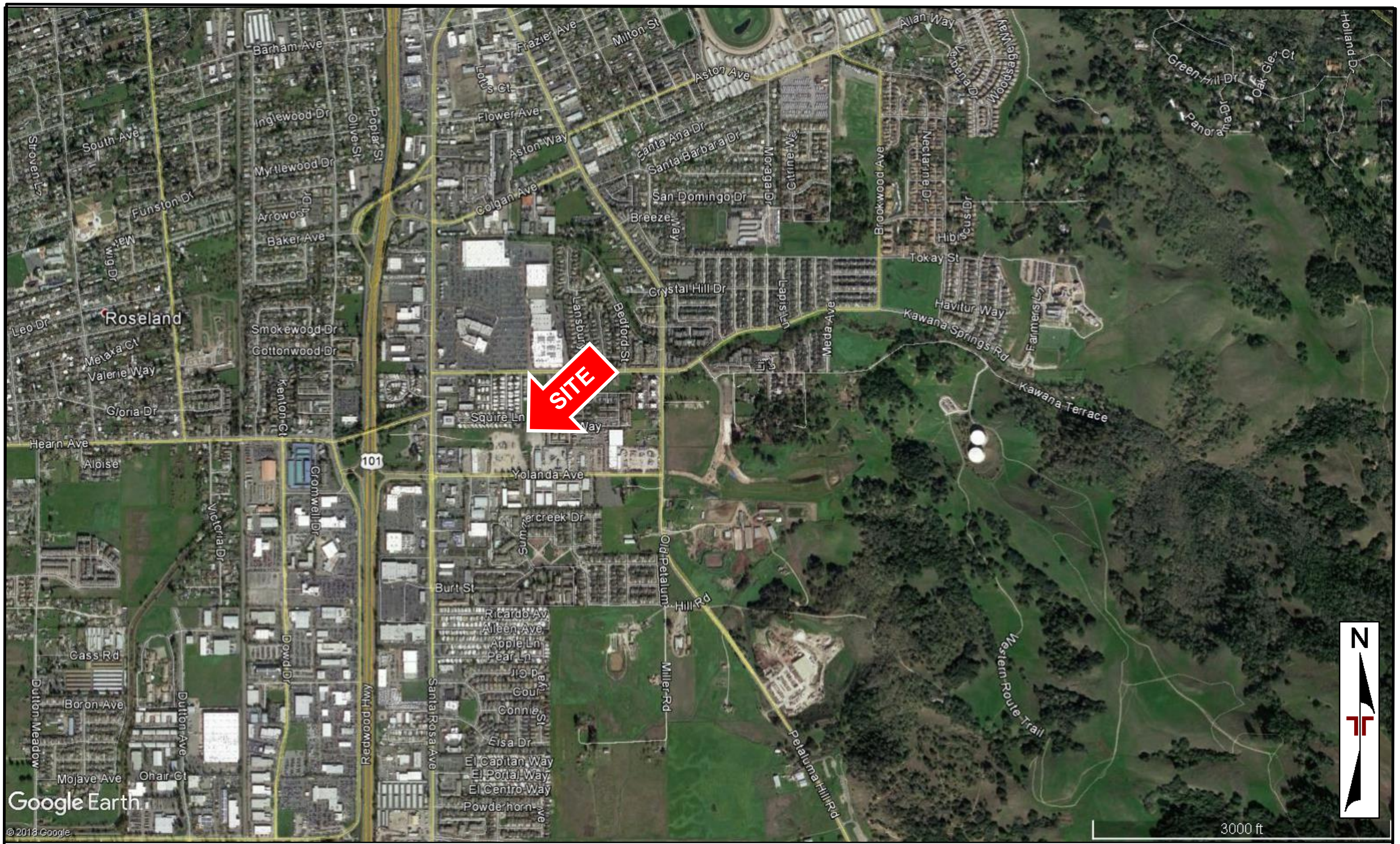


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

**Project Manager:** RH
**Drawn by:** NMN
**Checked by:** RH
**Approved by:** RH

**Project No.** NB185057
**Scale:** AS SHOWN
**File Name:** 185057.Exhibits
**Date:** MAY 2018

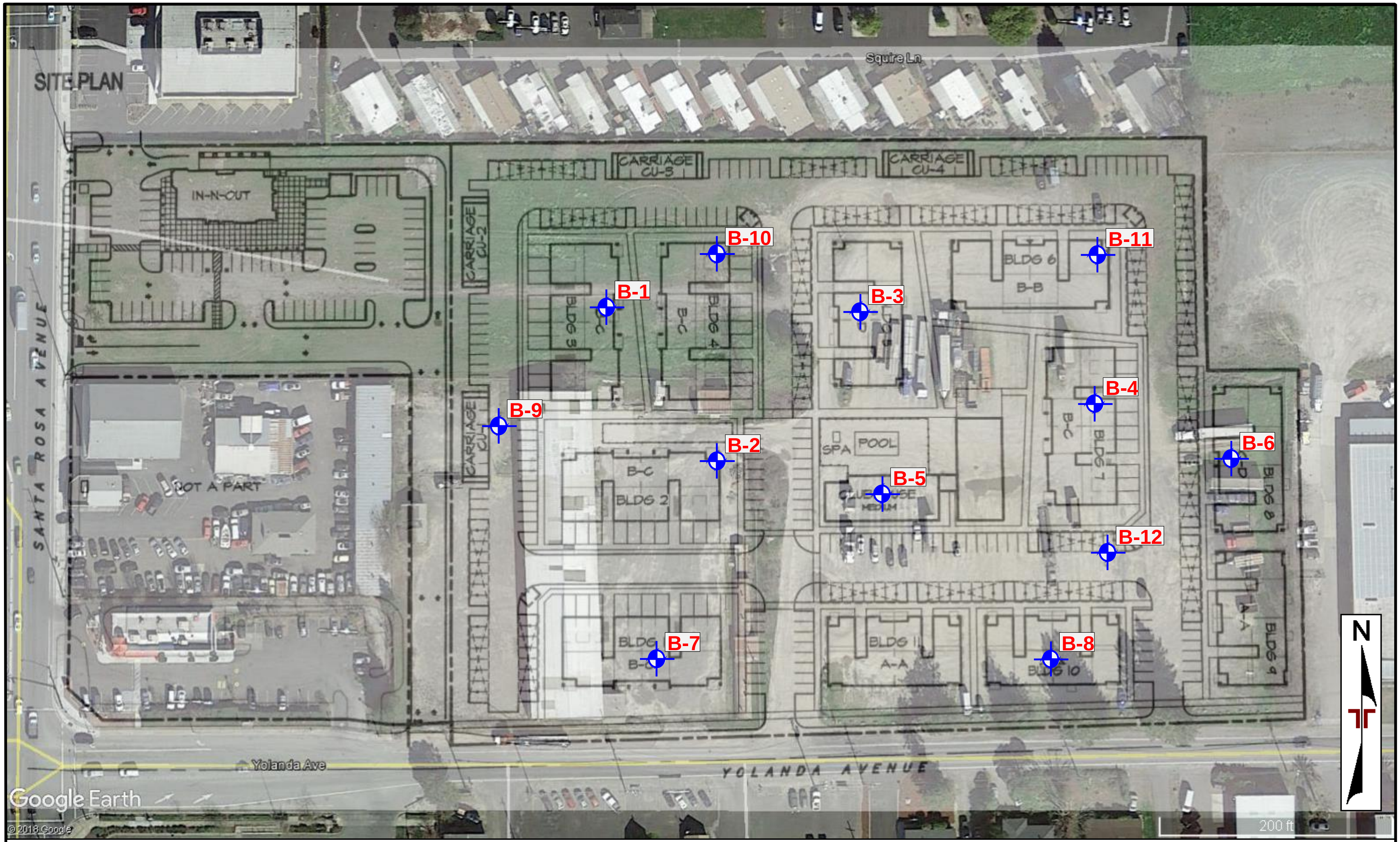
Terracon
Consulting Engineers & Scientists

50 Goldenland Court, Suite 100 Sacramento, CA 95834
PH. (916) 928-4690 FAX. (916) 928-4694

LOCATION DIAGRAM

**MULTI-FAMILY COMMUNITY**
325 YOLANDA AVE
SANTA ROSA, CALIFORNIA

Exhibit
A-1



**LEGEND:**

**B-1** ⊕ **APPROXIMATE BORING LOCATION**

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

| | |
|---|---|
| Project Manager: RH | Project No. NB185057 |
| Drawn by: NMN | Scale: AS SHOWN |
| Checked by: RH | File Name: 185057.Exhibits |
| Approved by: RH | Date: MAY 2018 |

Terracon
Consulting Engineers & Scientists
50 Goldenland Court, Suite 100 Sacramento, CA 95834
PH. (916) 928-4690 FAX. (916) 928-4694

EXPLORATION PLAN

**MULTI-FAMILY COMMUNITY**
325 YOLANDA AVE
SANTA ROSA, CALIFORNIA

Exhibit
A-2

# EXPLORATION AND TESTING PROCEDURES

## Field Exploration

| Number of Borings | Boring Depth (feet) | Planned Location |
|---|---|---|
| 7 | 18 to 21.5 | Building Areas |
| 1 | 51.5 | Building Areas - Liquefaction |
| 4 | 5 | Pavement Areas |

**Boring Layout and Elevations:** Unless otherwise noted, Terracon personnel provide the boring layout. Coordinates are obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and approximate elevations are obtained by interpolation from Google Earth$^{TM}$ imagery. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

**Subsurface Exploration Procedures:** We advance the borings with a truck-mounted, track-mounted, ATV-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem as necessary depending on soil conditions). Three to four samples are obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. Ring-lined, split-barrel sampling procedures are similar to standard split spoon sampling procedure; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. We observe and record groundwater levels during drilling and sampling. For safety purposes, all borings are backfilled with auger cuttings after their completion. Pavements are patched with cold-mix asphalt and/or pre-mixed concrete, as appropriate.

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

# BORING LOG NO. B-01

Page 1 of 1

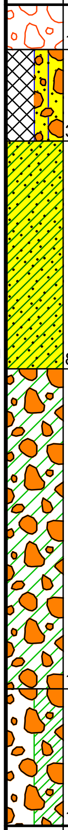
**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4142° Longitude: -122.712°



| GRAPHIC LOG DEPTH | DESCRIPTION | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **AGGREGATE BASE COURSE**, ~12 inches | | | | | | | | | | |
| 3.0 | **FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, angular, low to medium plasticity, brown to orange, medium dense, gravel to 1 inch in dimension, ~36 inch thickness | | | ⧗ | 5-9-12 | | | 18 | 104 | | 23 |
| 8.0 | **SANDY LEAN CLAY (CL)**, trace fine gravel, fine to coarse grained, low to medium plasticity, gray, very stiff | 5 | | ⧗ | 5-8-18 | | | 11 | 109 | 31-16-15 | 52 |
| 15.0 | **CLAYEY GRAVEL (GC)**, fine to coarse grained, subangular, orange to yellow, medium dense | 10 | | ⧗ | 10-16-23 | | | 13 | 117 | | |
| | | | ▽ | | | | | | | | |
| | | 15 | ▽ | | | | | | | | |
| 18.0 | **POORLY GRADED GRAVEL WITH CLAY (GP-GC)**, fine to coarse grained, subangular, brown to gray, dense | | | ☒ | 15-23-26 | | | 17 | 114 | | 7 |
| | | | | ⧗ | 15-24-36 | | | 9 | 123 | | |
| | ***Boring Terminated at 18 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-4 |

# BORING LOG NO. B-02

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4138° Longitude: -122.7114°

| DEPTH | DESCRIPTION | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **AGGREGATE BASE COURSE**, ~12 inches | | | | | | | | | | |
| 2.5 | **FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, low to medium plasticity, light brown to orange, medium dense | | | | | | | | | | |
| 5.0 | **SANDY LEAN CLAY (CL)**, fine to coarse grained, medium plasticity, brown, very stiff | | | ⧗ | 4-7-10 | 4.25 (HP) | 4.26 | 17 | 105 | | |
| 11.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, orange to yellow, medium dense | 5 | | ⧗ | 7-10-23 | 4.5 (HP) | | 23 | 95 | | |
| | | 10 | | ⧗ | 3-5-12 | | | 17 | 113 | | |
| 13.5 | **CLAYEY GRAVEL (GC)**, fine to coarse grained, subangular, brown to yellow | | | | | | | | | | |
| 16.5 | **GRAVELLY LEAN CLAY (CL)**, fine to coarse grained, subangular, light brown to gray, stiff to very stiff, gravel to 1 inch in dimension | 15 | ∇<br>∇ | ☒ | 5-8-12 | 3.75 (HP) | | 25 | 107 | | |
| 19.5 | **CLAYEY GRAVEL (GC)**, sandy, fine to coarse grained, subangular, brown to light bluish gray, medium dense | | | ⧗ | 4-8-13 | | | 20 | 106 | | 28 |
| | | | | ☒ | 7-8-9<br>N=17 | | | | | | |
| | ***Boring Terminated at 19.5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

∇ *While drilling*

∇ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-5 |

# BORING LOG NO. B-03

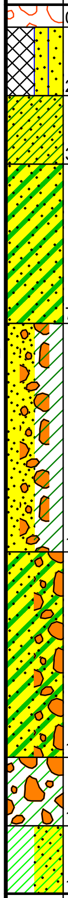
**PROJECT:** Multi-Family Community

**CLIENT:** Wolff Companies
Scottsdale, AZ

**SITE:** 325 Yolanda Ave
Santa Rosa, CA

LOCATION See Exhibit A-2

Latitude: 38.4142° Longitude: -122.7109°



| DEPTH | | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | **AGGREGATE BASE COURSE**, ~6 inch thickness | | | | | | | | | | |
| 2.0 | **FILL - SILTY SAND (SM)**, fine grained, brown to orange | | | | | | | | | | |
| 3.5 | **SANDY LEAN CLAY (CL)**, fine grained, medium plasticity, light brown, medium stiff | | | ⧗ | 3-5-7 | 2.25 (HP) | | 26 | 95 | | |
| 7.0 | **CLAYEY SAND (SC)**, with fine gravel, fine to medium grained, subrounded, brown to light brown, loose<br>fine to coarse grained, gray brown to orange | 5 | | ⧗ | 3-5-7 | | | 25 | 93 | | |
| 12.0 | **POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)**, coarse grained, subangular, brown to black, medium dense | 10 | ▽<br>▽ | ⧗ | 10-16-21 | | | 15 | 112 | | 8 |
| 16.5 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subrounded, brown to light brown, medium dense, gravel to 1/2 inch in dimension | 15 | | ⊠ | 9-14-17 | | | 30<br>27 | 101<br>91 | | |
| 18.0 | **CLAYEY GRAVEL (GC)**, fine to coarse grained, rounded, light brown, medium dense, gravel and cobbles to >3 inches in dimension | | | ⧗ | 6-9-9 | | | | | | |
| 19.5 | **LEAN CLAY WITH SAND (CL)**, fine to medium grained | | | ⊠ | 4-4-5<br>N=9 | 1.25 (HP) | | 23 | 98 | | |
| | ***Boring Terminated at 19.5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**
▽ *While drilling*
▽ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-6 |

# BORING LOG NO. B-04

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4141° Longitude: -122.7102°

| DEPTH | DESCRIPTION | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.7 | **AGGREGATE BASE COURSE**, ~8 inch thickness | | | | | | | | | | |
| 4.5 | **CLAYEY SAND (SC)**, fine to medium grained, medium plasticity, light brown to orange, medium dense | | | ⧗ | 7-11-13 | 2.5 (HP) | | 24 | 99 | 37-18-19 | 41 |
| | | 5 | ▽<br>▽ | | | | | | | | |
| 8.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, orange to brown, medium dense | | | ⧗ | 6-7-11 | | | 19 | 108 | | |
| 13.0 | **POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)**, fine to coarse grained, subangular, brown, medium dense | 10 | | ⧗ | 12-14-17 | | | 16 | 112 | | 9 |
| 18.5 | **CLAYEY GRAVEL (GC)**, fine to coarse grained, subrounded, light brown, medium dense | 15 | | ⧗ | 4-8-11 | | | 21 | | | |
| | | | | ☒ | 6-9-10<br>N=19 | | | 22 | 104 | | |

***Boring Terminated at 18.5 Feet***

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-7 |

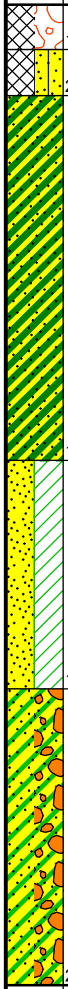
# BORING LOG NO. B-05

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**



| DEPTH | LOCATION See Exhibit A-2 | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **FILL - AGGREGATE BASE COURSE**, ~12 inch thickness | | | | | | | | | | |
| 2.0 | **FILL - SILTY SAND (SM)**, fine to medium grained, orange to brown | | | | | | | | | | |
| | **SANDY FAT CLAY (CH)**, fine grained, high plasticity, brown, medium stiff | | | ⋈ | 3-4-5 | | | 25 | | 58-39-19 | 70 |
| | fine to medium grained, stiff | 5 | | ⋈ | 5-8-10 | | | 23 | 93 | | |
| 10.0 | | 10 | ▽ | | | | | | | | |
| | **POORLY GRADED SAND WITH CLAY (SP-SC)**, fine to coarse grained, subangular, brown, dense | | | ⋈ | 9-21-25 | | | 17 | 100 | | 5 |
| 15.0 | | 15 | | | | | | | | | |
| | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, light brown to brown, medium dense | | | ⋈ | 7-9-12 | | | 22 | 92 | | |
| | fine to medium grained | 20 | | ⋈ | 5-12-11 | | | 16 | 100 | | |
| 21.5 | ***Boring Terminated at 21.5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" HSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *While drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 05-03-2018 | Boring Completed: 05-03-2018 |
| Drill Rig: D-50 | Driller: C. Nix |
| Project No.: NB185057 | Exhibit: A-8 |

# BORING LOG NO. B-06

**PROJECT:** **Multi-Family Community**

**CLIENT:** **Wolff Companies**
**Scottsdale, AZ**

**SITE:** **325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

| DEPTH | | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | **AGGREGATE BASE COURSE**, ~6 inch thickness | | | | | | | | | | |
| | **LEAN CLAY WITH SAND (CL)**, fine grained, medium to high plasticity, brown, medium stiff | | | ☒ | 4-3-3<br>N=6 | | | 18 | 97 | | |
| 5.0 | **SANDY LEAN CLAY (CL)**, fine to medium grained, medium plasticity, light brown to brown, hard | 5 | | ☒ | 8-14-19<br>N=33 | | | 22 | 94 | | |
| | medium stiff | 10 | | ☒ | 2-2-3<br>N=5 | | | 31 | 87 | | 53 |
| | | 15 | | ☒ | 3-8-20<br>N=28 | | | 28 | 88 | | 30 |
| 16.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, brown to light brown, medium dense | | | | | | | | | | |
| 20.0 | **LEAN CLAY WITH GRAVEL (CL)**, fine to coarse grained, subangular, light brown to orange, medium stiff | 20 | | ☒ | 3-4-5<br>N=9 | | | 40 | 83 | | 89 |
| 25.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, light brown, dense | 25 | | ☒ | 3-5-7 | | | 36 | 87 | | 43 |

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

Hammer Type: Automatic

Advancement Method:
4" Mud Rotary

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Water level not determined*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 05-03-2018 | Boring Completed: 05-03-2018 |
| Drill Rig: D-50 | Driller: C. Nix |
| Project No.: NB185057 | Exhibit: A-9 |

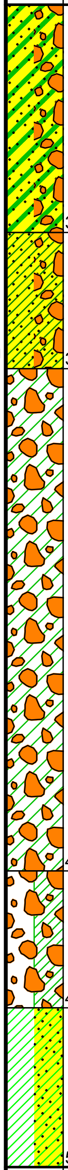
# BORING LOG NO. B-06

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2



| DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|
| **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, light brown, dense *(continued)* | | | ☒ | N=12 | | | | | | |
| | 30 | | ☒ | 7-14-20<br>N=34 | | | 25 | 92 | | |
| 31.0 | | | | | | | | | | |
| **SANDY LEAN CLAY WITH GRAVEL (CL)**, fine to medium grained, light brown | | | | | | | | | | |
| 34.0 | | | | | | | | | | |
| **CLAYEY GRAVEL (GC)**, fine to coarse grained, subrounded, brown to orange, dense | 35 | | ☒ | 7-13-19<br>N=32 | | | 32 | 88 | | 18 |
| | 40 | | ☒ | 3-11-34<br>N=45 | | | 15 | 99 | | 20 |
| 45.0 | | | | | | | | | | |
| **POORLY GRADED GRAVEL WITH CLAY (GP-GC)**, fine to coarse grained, subrounded, brown to light brown, medium dense | 45 | | ☒ | 4-7-12<br>N=19 | | | 14 | 98 | | 5 |
| 48.0 | | | | | | | | | | |
| **LEAN CLAY WITH SAND (CL)**, fine grained, medium plasticity, brown, very stiff | 50 | | ☒ | 8-12-11<br>N=23 | | | 29 | 94 | | 71 |
| 51.5 | | | | | | | | | | |
| ***Boring Terminated at 51.5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
4" Mud Rotary

Abandonment Method:
Boring backfilled with neat cement grout upon completion

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Water level not determined*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 05-03-2018 | Boring Completed: 05-03-2018 |
| Drill Rig: D-50 | Driller: C. Nix |
| Project No.: NB185057 | Exhibit: A-9 |

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL NB185057 MULIT-FAMILY COMM.GPJ TERRACON_DATATEMPLATE.GDT 5/22/18

# BORING LOG NO. B-07

Page 1 of 1

**PROJECT: Multi-Family Community**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

LOCATION See Exhibit A-2

Latitude: 38.4134° Longitude: -122.7114°

| DEPTH | | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **AGGREGATE BASE COURSE**, ~12 inch thickness | | | | | | | | | | |
| 3.0 | **FILL - CLAYEY SAND WITH GRAVEL (SC)**, coarse grained, subangular, medium plasticity, light brown, loose | | | ⧗ | 5-6-5 | 3.25<br>(HP) | | 9 | 117 | 37-15-22 | 32 |
| 5.0 | **LEAN CLAY (CL)**, medium plasticity, brown, medium stiff | 5 | | | | | | | | | |
| | **SANDY LEAN CLAY (CL)**, fine grained, medium plasticity, brown, very stiff | | | ⧗ | 6-10-12 | 4.5+<br>(HP) | | 19 | 102 | | 63 |
| 12.5 | | 10 | | ⧗ | 5-12-17 | 4.5+<br>(HP) | 3.03 | 20 | 102 | | |
| | **CLAYEY SAND (SC)**, fine to coarse grained, light brown to gray, medium dense | | ▽ | | | | | | | | |
| 16.0 | | 15 | ▽ | ☒ | 4-8-10 | 3.5<br>(HP) | | 23 | 102 | | |
| 18.0 | **SANDY LEAN CLAY (CL)**, fine to coarse grained, subangular, medium plasticity, gray to brown, stiff | | | ⧗ | 2-7-9 | | | | | | |
| | ***Boring Terminated at 18 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-10 |

# BORING LOG NO. B-08

Page 1 of 1

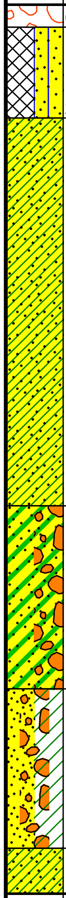
**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE:**
**325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4134° Longitude: -122.7102°



| DEPTH | | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | **AGGREGATE BASE COURSE**, ~6 inch thickness | | | | | | | | | | |
| 2.5 | **FILL - SILTY SAND (SM)**, fine grained, low plasticity, orange to brown, medium dense | | | | | | | | | | |
| | **SANDY LEAN CLAY (CL)**, fine grained, medium plasticity, light brown to gray, hard | | | ⧗ | 3-6-7 | | | 13 | 107 | | |
| | | 5 | | ⧗ | 13-20-27 | 4.5 (HP) | | 18 | 103 | 36-20-16 | 60 |
| 11.0 | fine to medium grained, very stiff | 10 | | ⧗ | 4-8-18 | | | 22 | 106 | | |
| 15.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, light brown to gray, medium dense, gravel to 1/4 inch indimension | | ▽<br>▽ | | | | | | | | |
| 18.5 | **POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)**, fine to coarse grained, subangular, light bluish gray, dense, gravel to 1/2 inch in dimension | 15 | | ☒ | 9-11-11 | | | 17 | 108 | | 11 |
| | | | | ⧗ | 16-34-35 | | | 23 | 99 | | |
| 19.5 | **SANDY LEAN CLAY (CL)**, fine grained, medium plasticity, brown, stiff | | | ⧖ | 14-5-7<br>N=12 | 3.5 (HP) | | 24 | 109 | | |
| | ***Boring Terminated at 19.5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-11 |

# BORING LOG NO. B-09

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4138° Longitude: -122.7121°

| DEPTH | DESCRIPTION | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.7 | **AGGREGATE BASE COURSE**, ~8 inch thickness | | | | | | | | | | |
| 1.5 | **FILL - SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, subangular, orange to brown | | | | | | | | | | |
| | **SANDY LEAN CLAY (CL)**, fine grained, medium to high plasticity, brown to orange, very stiff | | | | 4-7-20 | 2.5 (HP) | | 23 | 96 | 40-23-17 | 65 |
| 5.0 | light brown to gray | 5 | | | 10-15-19 | | | 18 | 106 | | |
| | ***Boring Terminated at 5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 04-23-0218

Boring Completed: 04-23-0218

Drill Rig: Mobile B-53

Driller: P. Pierson

Project No.: NB185057

Exhibit: A-12

# BORING LOG NO. B-10

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE:**
**325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4143° Longitude: -122.7113°

| GRAPHIC LOG | DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 **AGGREGATE BASE COURSE**, ~6 inch thickness | | | | | | | | | | |
| | 1.5 **FILL - SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, subangular, orange to brown | | | | | | | | | | |
| | 3.5 **SANDY LEAN CLAY (CL)**, fine grained, medium to high plasticity, brown to orange, stiff | | | ☒ | 4-7-11 | 2.5 (HP) | | 15 | 101 | | |
| | 5.0 **CLAYEY SAND (SC)**, fine grained, light brown to gray, very stiff | 5 | | ⧗ | 9-13-15 | | | 14 | 103 | | |
| | ***Boring Terminated at 5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-13 |

# BORING LOG NO. B-11

Page 1 of 1

**PROJECT: Multi-Family Community**

**CLIENT: Wolff Companies**
**Scottsdale, AZ**

**SITE: 325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4144° Longitude: -122.7101°

| DEPTH | | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.8 | **AGGREGATE BASE COURSE**, ~10 inch thickness | | | | | | | | | | |
| 1.5 | **FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, brown to orange | | | | | | | | | | |
| 3.5 | **SANDY LEAN CLAY (CL)**, fine grained, medium plasticity, light brown to brown, medium stiff | | | ☒ | 4-6-9 | 3.75 (HP) | | 24 | 93 | | 77 |
| 5.0 | **CLAYEY SAND WITH GRAVEL (SC)**, fine to coarse grained, subangular, orange to dark brown, dense, gravel to 1/2 inch in dimension | 5 | | ⧗ | 7-22-31 | | | 14 | 104 | | |
| | ***Boring Terminated at 5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

Boring Started: 04-23-0218

Boring Completed: 04-23-0218

Drill Rig: Mobile B-53

Driller: P. Pierson

Project No.: NB185057

Exhibit: A-14

# BORING LOG NO. B-12

Page 1 of 1

**PROJECT:** **Multi-Family Community**

**CLIENT:** **Wolff Companies**
**Scottsdale, AZ**

**SITE:** **325 Yolanda Ave**
**Santa Rosa, CA**

LOCATION See Exhibit A-2

Latitude: 38.4136° Longitude: -122.7102°

| GRAPHIC LOG | DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY HP (tsf) | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **AGGREGATE BASE COURSE**, ~12 inch thickness<br>1.0 | | | | | | | | | | |
| | **FILL - SILTY SAND (SM)**, fine grained, orange to brown<br>2.5 | | | | | | | | | | |
| | **CLAYEY SAND (SC)**, fine to medium grained, brown to gray, medium dense | | | | 3-5-21 | | | 16 | | | |
| | fine grained, light brown to gray, dense<br>5.0 | 5 | | | 22-31-42 | 4.5+<br>(HP) | | 18 | | | |
| | ***Boring Terminated at 5 Feet*** | | | | | | | | | | |

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

Hammer Type: Automatic

Advancement Method:
6" SSA

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

| | |
|---|---|
| Boring Started: 04-23-0218 | Boring Completed: 04-23-0218 |
| Drill Rig: Mobile B-53 | Driller: P. Pierson |
| Project No.: NB185057 | Exhibit: A-15 |

# APPENDIX B – LABORATORY TESTING

## Laboratory Testing

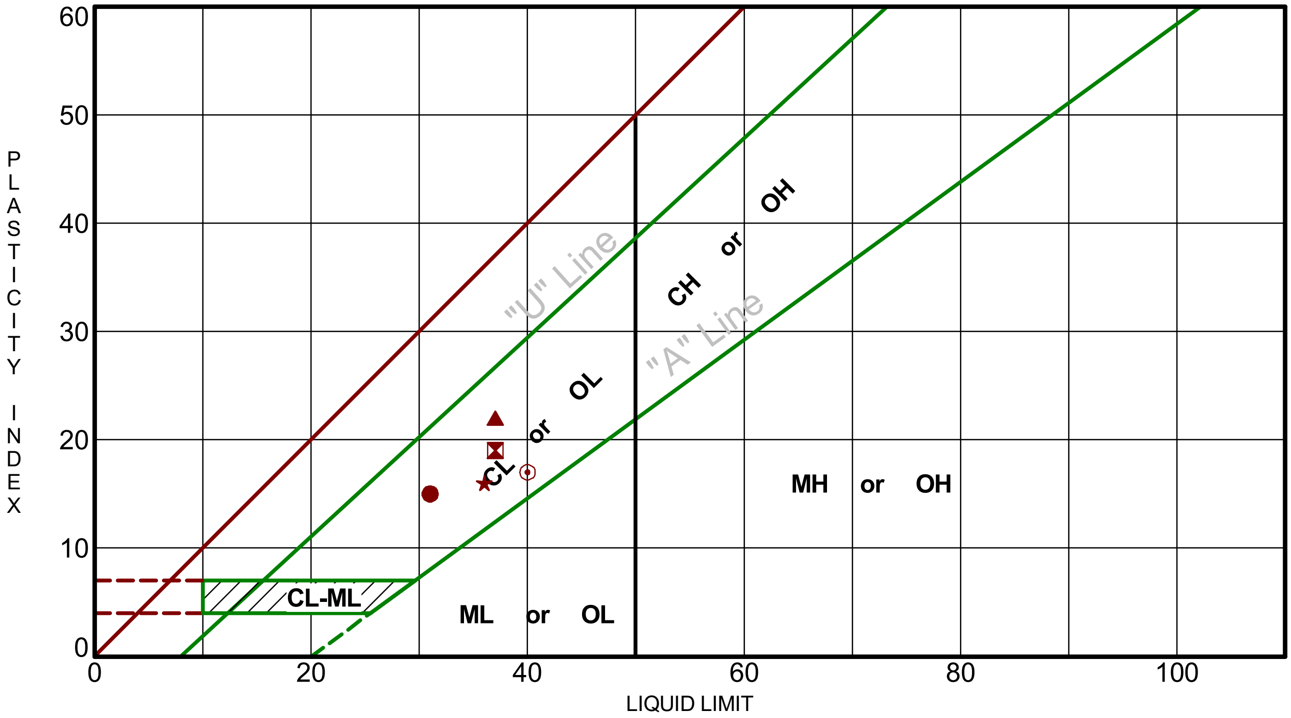
The project engineer reviews the field data and assigns various laboratory tests to better understand the engineering properties of the various soil strata as necessary for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods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

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
- ASTM D844 Standard Test Method for Resistance Value (R-Value)
- AWWA 4500H pH Analysis
- ASTM D516 Water Soluble Sulfate
- ASTM D512 Chlorides
- ASTM G57 Minimum Resistivity

The laboratory testing program often includes examination of soil samples by an engineer. Based on the material's texture and plasticity, we describe and classify the soil samples in accordance with the Unified Soil Classification System.

# ATTERBERG LIMITS RESULTS

### ASTM D4318



| Boring ID | Depth | LL | PL | PI | Fines | USCS | Description |
|---|---|---|---|---|---|---|---|
| ● **B-1** | **5 - 6.5** | **31** | **16** | **15** | **52** | **CL** | **SANDY LEAN CLAY** |
| ⊠ **B-4** | **2 - 3.5** | **37** | **18** | **19** | **41** | **SC** | **CLAYEY SAND** |
| ▲ **B-7** | **2 - 3.5** | **37** | **15** | **22** | **32** | **SC** | **CLAYEY SAND** |
| ★ **B-8** | **5 - 6.5** | **36** | **20** | **16** | **60** | **CL** | **SANDY LEAN CLAY** |
| ⊙ **B-9** | **2 - 3.5** | **40** | **23** | **17** | **65** | **CL** | **SANDY LEAN CLAY** |

PROJECT: Multi-Family Community

SITE: 325 Yolanda Ave
Santa Rosa, CA

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

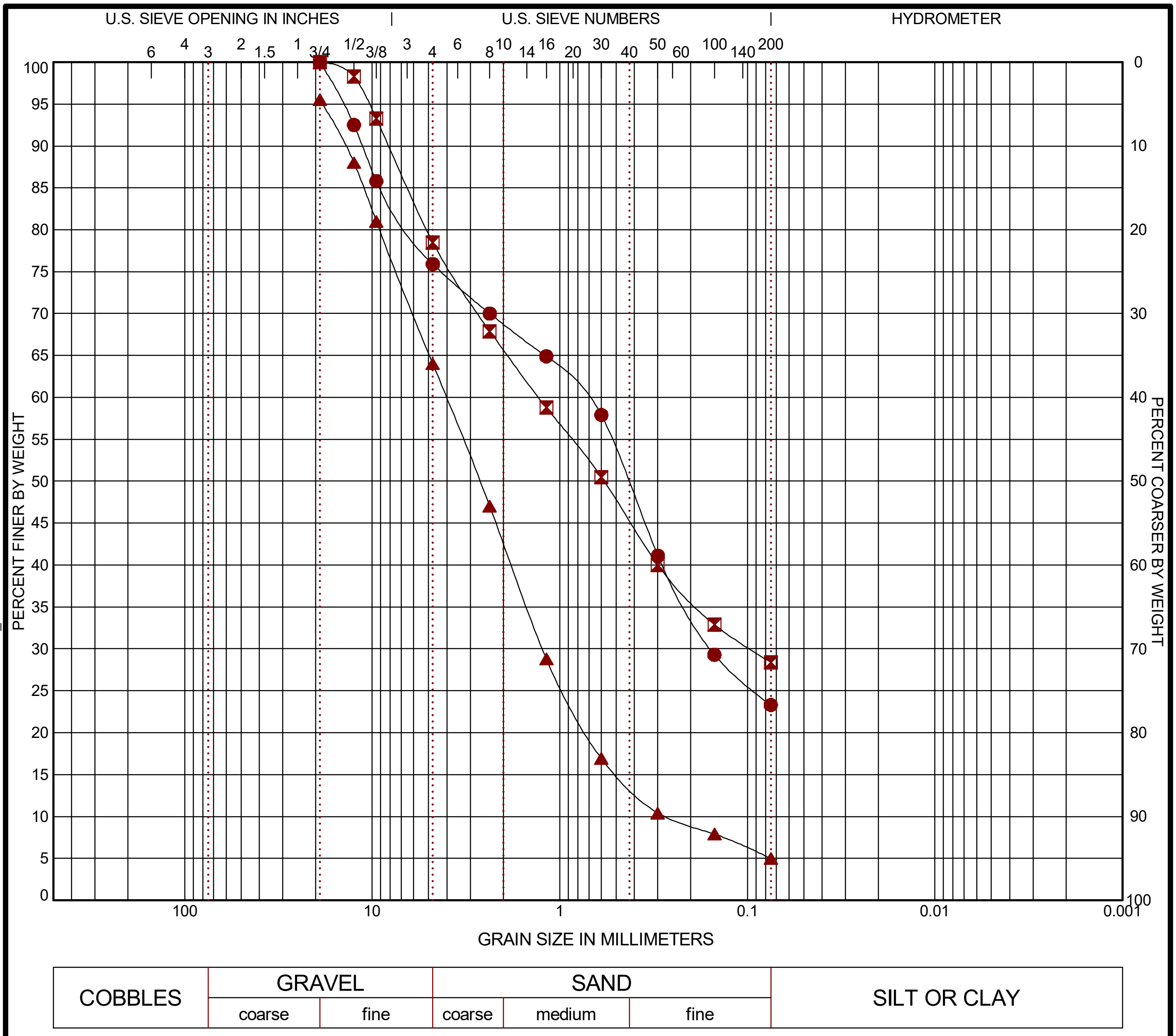
PROJECT NUMBER: NB185057

CLIENT: Wolff Companies
Scottsdale, AZ

EXHIBIT: B-2

# GRAIN SIZE DISTRIBUTION

## ASTM D422 / ASTM C136



| | BORING ID | DEPTH | % COBBLES | % GRAVEL | % SAND | % SILT | % FINES | % CLAY | USCS |
|---|---|---|---|---|---|---|---|---|---|
| ● | **B-01** | **2 - 3.5** | **0.0** | **24.1** | **52.6** | | **23.3** | | |
| ☒ | **B-02** | **16.5 - 18** | **0.0** | **21.5** | **50.1** | | **28.4** | | |
| ▲ | **B-05** | **10 - 11.5** | | **31.5** | **59.0** | | **5.0** | | |

| | GRAIN SIZE | | |
|---|---|---|---|
| | ● | ☒ | ▲ |
| $D_{60}$ | **0.735** | **1.293** | **4.029** |
| $D_{30}$ | **0.156** | **0.096** | **1.235** |
| $D_{10}$ | | | **0.269** |
| | COEFFICIENTS | | |
| $C_C$ | | | **1.41** |
| $C_U$ | | | **15.01** |

| ● | | ☒ | | ▲ | |
|---|---|---|---|---|---|
| Sieve | % Finer | Sieve | % Finer | Sieve | % Finer |
| **3/4"** | **100.0** | **3/4"** | **100.0** | **3/4"** | **95.5** |
| **1/2"** | **92.5** | **1/2"** | **98.3** | **1/2"** | **88.0** |
| **3/8"** | **85.8** | **3/8"** | **93.3** | **3/8"** | **81.0** |
| **#4** | **75.9** | **#4** | **78.5** | **#4** | **64.0** |
| **#8** | **70.0** | **#8** | **67.9** | **#8** | **47.0** |
| **#16** | **64.9** | **#16** | **58.8** | **#16** | **28.8** |
| **#30** | **57.9** | **#30** | **50.5** | **#30** | **16.9** |
| **#50** | **41.1** | **#50** | **40.0** | **#50** | **10.4** |
| **#100** | **29.3** | **#100** | **32.9** | **#100** | **7.9** |
| **#200** | **23.3** | **#200** | **28.4** | **#200** | **5.0** |

SOIL DESCRIPTION

●

☒

▲

REMARKS

●

☒

▲

PROJECT: Multi-Family Community

SITE: 325 Yolanda Ave
Santa Rosa, CA

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

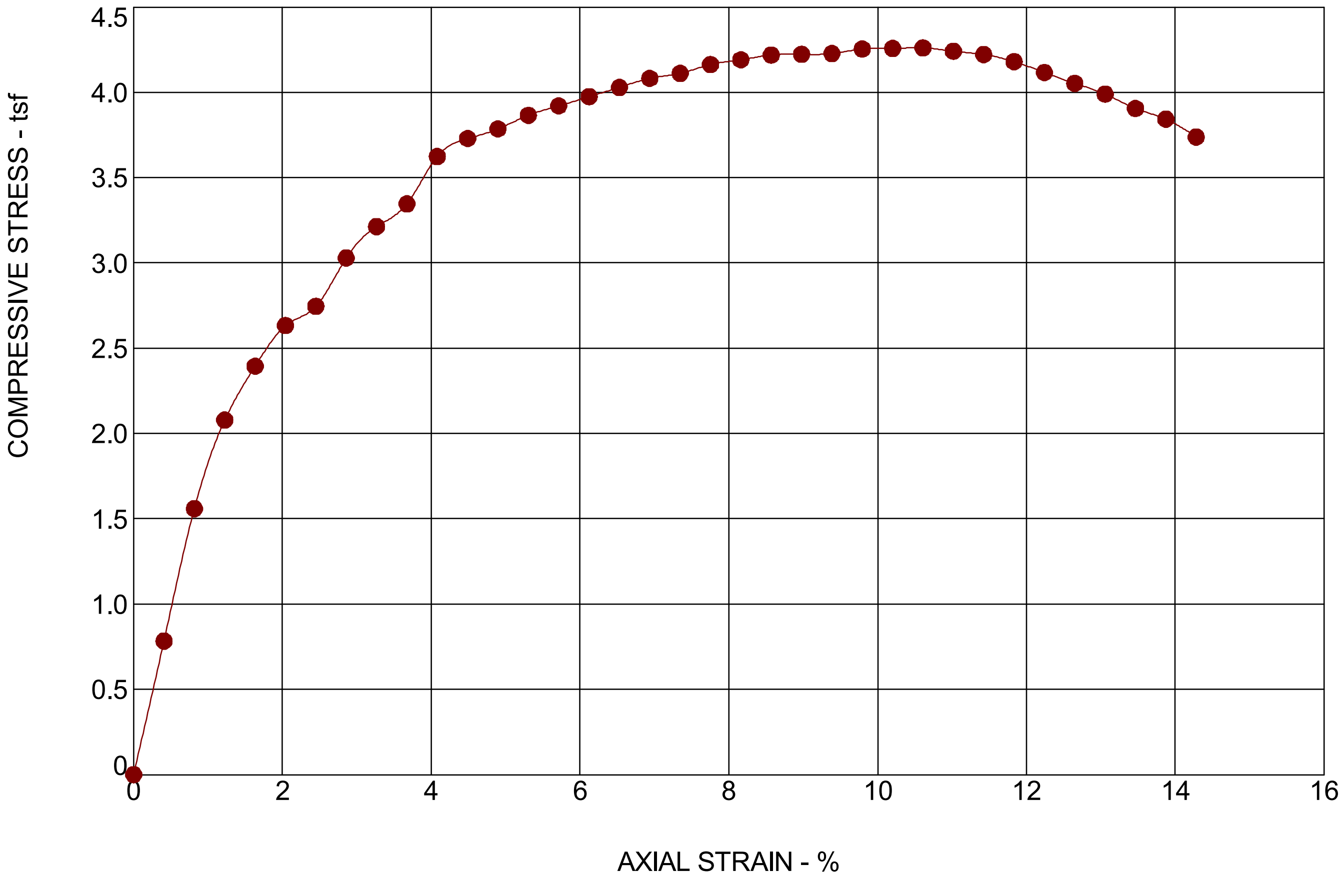
PROJECT NUMBER: NB185057

CLIENT: Wolff Companies
Scottsdale, AZ

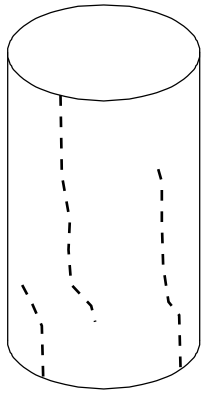
EXHIBIT: B-3

# UNCONFINED COMPRESSION TEST

## ASTM D2166



| SPECIMEN FAILURE MODE | SPECIMEN TEST DATA | | |
|---|---|---|---|
| | Moisture Content: | % | |
| | Dry Density: | pcf | |
| | Diameter: | in. | 1.90 |
| | Height: | in. | 4.90 |
| | Height / Diameter Ratio: | | 2.58 |
| | Calculated Saturation: | % | |
| | Calculated Void Ratio: | | |
| | Assumed Specific Gravity: | | |
| | Failure Strain: | % | 10.61 |
| | Unconfined Compressive Strength | (tsf) | 4.26 |
| | Undrained Shear Strength: | (tsf) | 2.13 |
| | Strain Rate: | in/min | |
| | Remarks: | | |



Failure Mode: (dashed)

SAMPLE TYPE: CA RING

SAMPLE LOCATION: B-2 @ 2.5 - 4 feet

| DESCRIPTION: | LL | PL | PI | Percent < #200 Sieve |
|---|---|---|---|---|
| | | | | |

PROJECT: Multi-Family Community

SITE: 325 Yolanda Ave
Santa Rosa, CA

Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

PROJECT NUMBER: NB185057

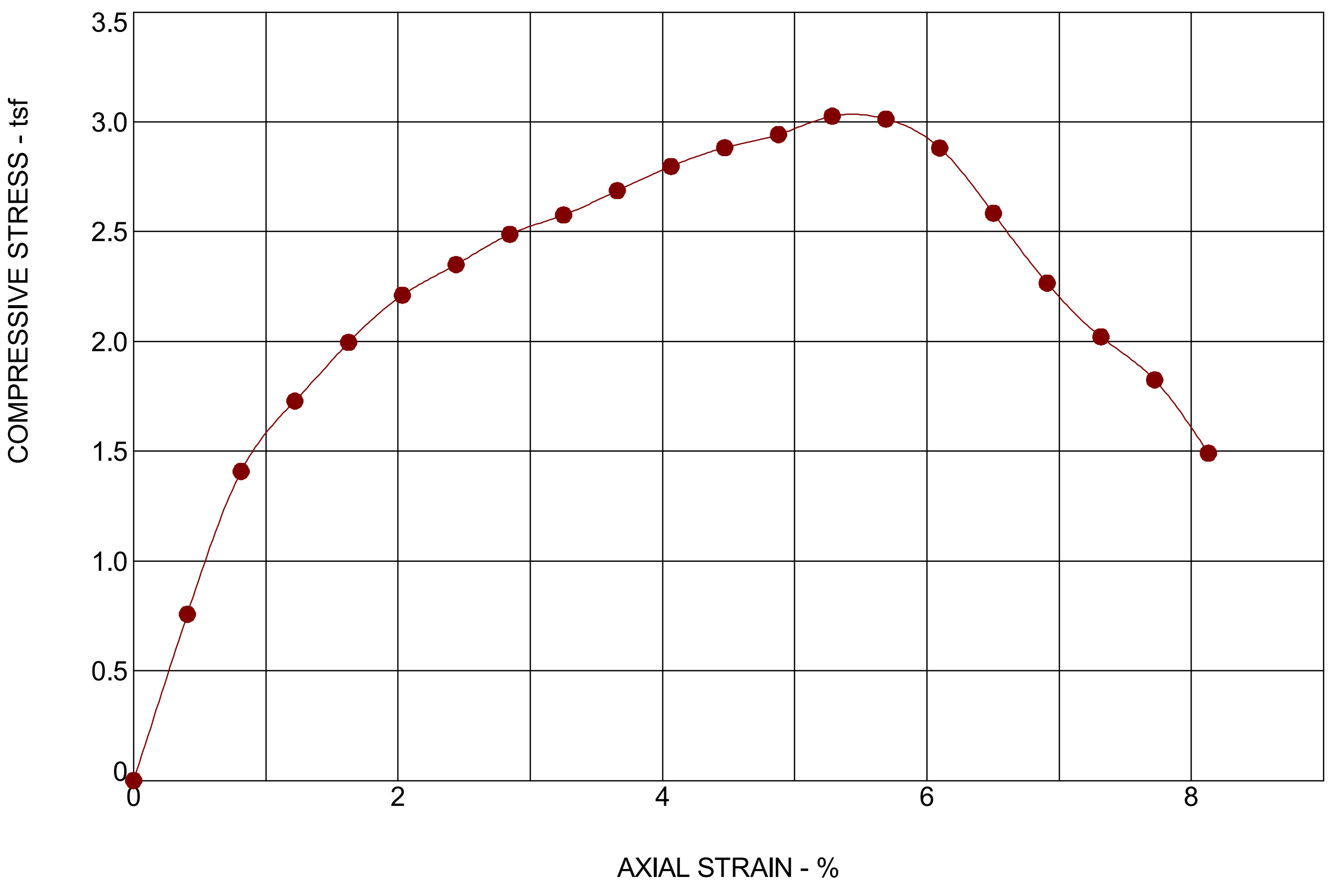
CLIENT: Wolff Companies
Scottsdale, AZ

EXHIBIT: B-4

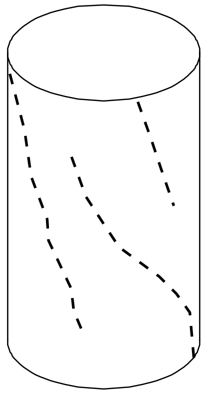
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED NB185057 MULIT-FAMILY COMM.GPJ TERRACON_DATATEMPLATE.GDT 5/4/18

# UNCONFINED COMPRESSION TEST

### ASTM D2166



## SPECIMEN FAILURE MODE



Failure Mode: (dashed)

## SPECIMEN TEST DATA

| | | |
|---|---|---|
| Moisture Content: | % | |
| Dry Density: | pcf | |
| Diameter: | in. | 1.90 |
| Height: | in. | 4.92 |
| Height / Diameter Ratio: | | 2.59 |
| Calculated Saturation: | % | |
| Calculated Void Ratio: | | |
| Assumed Specific Gravity: | | |
| Failure Strain: | % | 5.28 |
| Unconfined Compressive Strength | (tsf) | 3.03 |
| Undrained Shear Strength: | (tsf) | 1.51 |
| Strain Rate: | in/min | |
| Remarks: | | |

SAMPLE TYPE: CA RING

SAMPLE LOCATION: B-7 @ 10 - 11.5 feet

DESCRIPTION:

| LL | PL | PI | Percent < #200 Sieve |
|---|---|---|---|
| | | | |

PROJECT: Multi-Family Community

SITE: 325 Yolanda Ave
Santa Rosa, CA

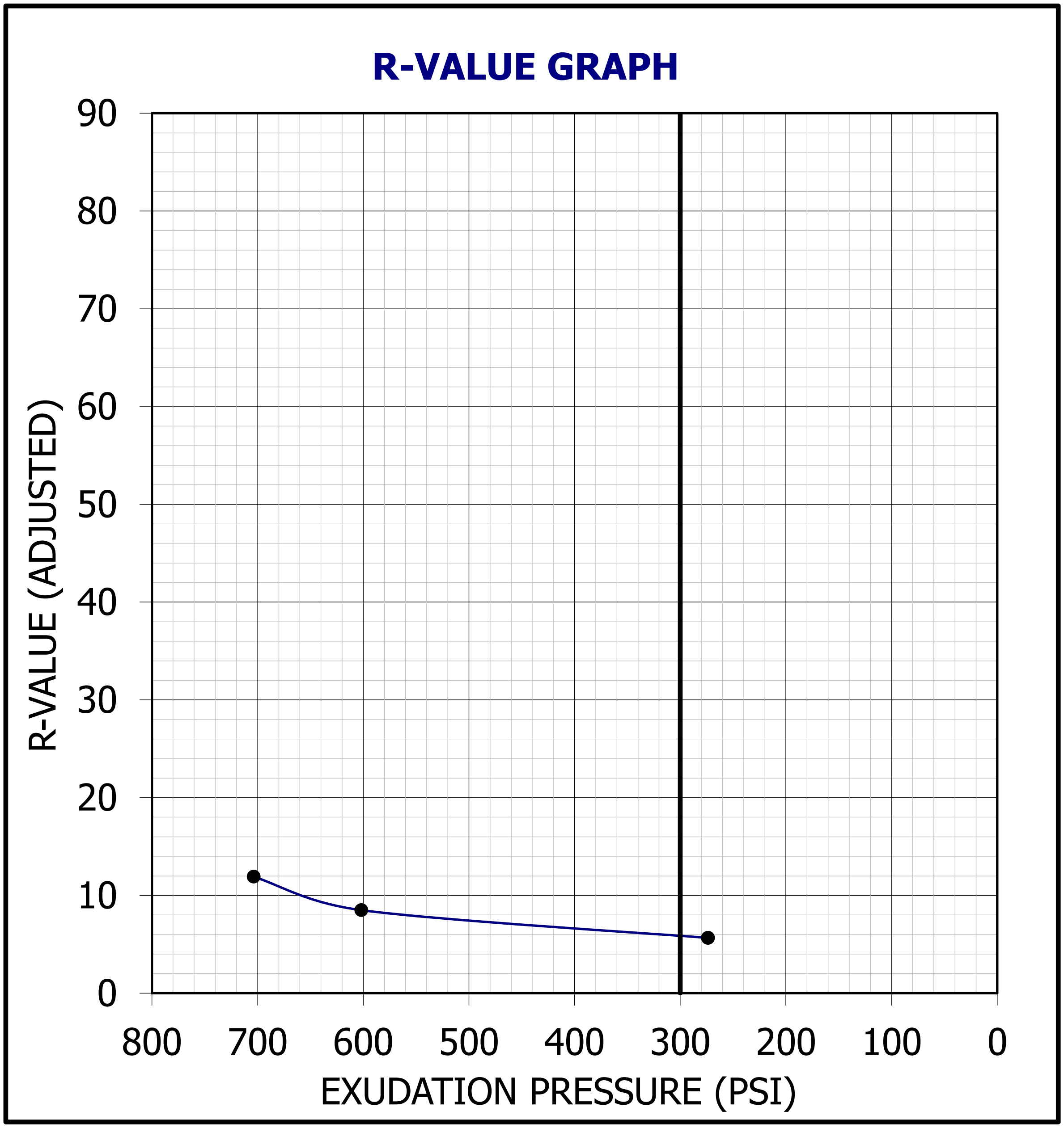
Terracon
50 Golden Land Ct Ste 100
Sacramento, CA

PROJECT NUMBER: NB185057

CLIENT: Wolff Companies
Scottsdale, AZ

EXHIBIT: B-5

JOB NAME: Multi-Family
JOB #: NB185057
SAMPLE NUMBER: B-9 (0-36")
Location: Native
SAMPLE CLASSIFICATION: Brown Clay



**R-VALUE AT 300 PSI EXUDATION PRESSURE:** 6

**NOTES:**
Exhibit: B-6

# CHEMICAL LABORATORY TEST REPORT

**Project Number:** NB185057
**Service Date:** 05/02/18
**Report Date:** 05/07/18
**Task:**

Terracon
750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

## Client

Wolff Companies

## Project

Mulit-Family Community

**Sample Submitted By:** Terracon (NB) **Date Received:** 4/30/2018 **Lab No.: 18-0504**

# *Results of Corrosion Analysis*

| | |
|---|---|
| ***Sample Number*** | B3-1-I |
| ***Sample Location*** | B3-1-I |
| ***Sample Depth (ft.)*** | 2 |
| pH Analysis, AWWA 4500 H | 7.89 |
| Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg) | 194 |
| Chlorides, ASTM D 512, (mg/kg) | 73 |
| Resistivity, ASTM G 57, (ohm-cm) | 1067 |

**Analyzed By:** Trisha Campo

Trisha Campo
Chemist

Exhibit: B-7

# APPENDIX C – SUPPORTING DOCUMENTS

# UNIFIED SOIL CLASSIFICATION SYSTEM

Multi-Family Community ■ Santa Rosa, Sonoma County, California

May 25, 2018 ■ Terracon Project No. NB185057

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[N] $PI \geq 4$ and plots on or above “A” line.

[O] $PI < 4$ or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.

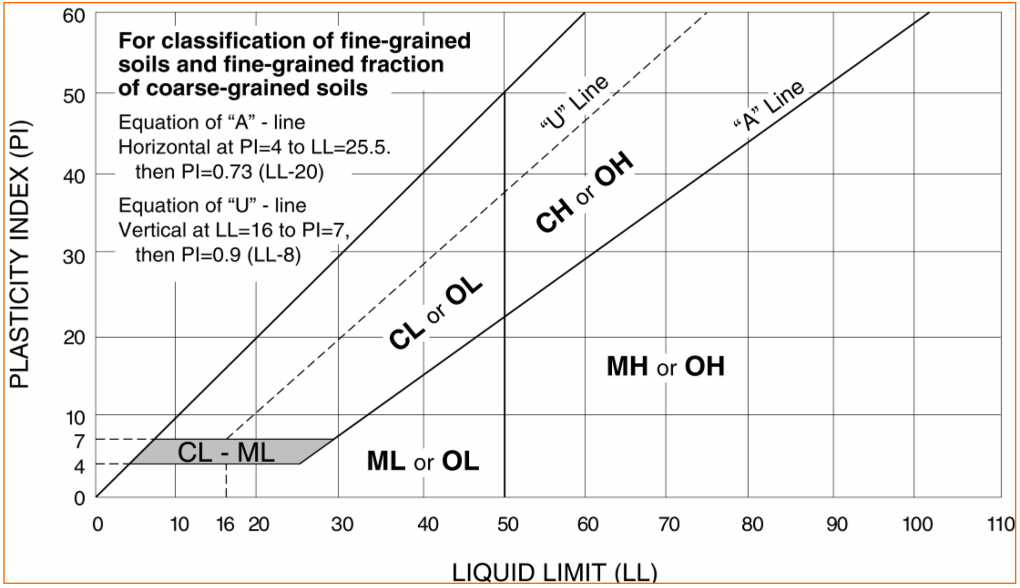


Exhibit: C-1

# DESCRIPTION OF ROCK PROPERTIES

Multi-Family Community ■ Santa Rosa, Sonoma County, California
May 25, 2018 ■ Terracon Project No. NB185057

## WEATHERING

| | |
|---|---|
| Fresh | Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline. |
| Very slight | Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline. |
| Slight | Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer. |
| Moderate | Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock. |
| Moderately severe | All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. |
| Severe | All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left. |
| Very severe | All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining. |
| Complete | Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers. |

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

| | |
|---|---|
| Very hard | Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick. |
| Hard | Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen. |
| Moderately hard | Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow. |
| Medium | Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick. |
| Soft | Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure. |
| Very soft | Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail. |

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

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

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

### Rock Quality Designator (RQD) [1]

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

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

### Joint Openness Descriptors

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

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

Exhibit: C-2

# Design Maps Detailed Report

## ASCE 7-10 Standard (38.4139°N, 122.7107°W)

Site Class D – “Stiff Soil”, Risk Category I/II/III

### Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain $S_S$) and 1.3 (to obtain $S_1$). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

| | |
|---|---|
| From Figure 22-1 [1] | $S_S$ = 2.092 g |
| From Figure 22-2 [2] | $S_1$ = 0.858 g |

### Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

| Site Class | $\bar{v}_s$ | $\bar{N}$ or $\bar{N}_{ch}$ | $\bar{s}_u$ |
|---|---|---|---|
| A. Hard Rock | >5,000 ft/s | N/A | N/A |
| B. Rock | 2,500 to 5,000 ft/s | N/A | N/A |
| C. Very dense soil and soft rock | 1,200 to 2,500 ft/s | >50 | >2,000 psf |
| D. Stiff Soil | 600 to 1,200 ft/s | 15 to 50 | 1,000 to 2,000 psf |
| E. Soft clay soil | <600 ft/s | <15 | <1,000 psf |
| | Any profile with more than 10 ft of soil having the characteristics:<br>• Plasticity index *PI* > 20,<br>• Moisture content *w* ≥ 40%, and<br>• Undrained shear strength $\bar{s}_u$ < 500 psf | | |
| F. Soils requiring site response analysis in accordance with Section 21.1 | See Section 20.3.1 | | |

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Exhibit: C-3

## Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake ($MCE_R$) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient $F_a$

| Site Class | Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period | | | | |
|---|---|---|---|---|---|
| | $S_S \leq 0.25$ | $S_S = 0.50$ | $S_S = 0.75$ | $S_S = 1.00$ | $S_S \geq 1.25$ |
| A | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| B | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| C | 1.2 | 1.2 | 1.1 | 1.0 | 1.0 |
| D | 1.6 | 1.4 | 1.2 | 1.1 | 1.0 |
| E | 2.5 | 1.7 | 1.2 | 0.9 | 0.9 |
| F | See Section 11.4.7 of ASCE 7 | | | | |

Note: Use straight–line interpolation for intermediate values of $S_S$

For Site Class = D and $S_S$ = 2.092 g, $F_a$ = 1.000

Table 11.4–2: Site Coefficient $F_v$

| Site Class | Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period | | | | |
|---|---|---|---|---|---|
| | $S_1 \leq 0.10$ | $S_1 = 0.20$ | $S_1 = 0.30$ | $S_1 = 0.40$ | $S_1 \geq 0.50$ |
| A | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| B | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| C | 1.7 | 1.6 | 1.5 | 1.4 | 1.3 |
| D | 2.4 | 2.0 | 1.8 | 1.6 | 1.5 |
| E | 3.5 | 3.2 | 2.8 | 2.4 | 2.4 |
| F | See Section 11.4.7 of ASCE 7 | | | | |

Note: Use straight–line interpolation for intermediate values of $S_1$

For Site Class = D and $S_1$ = 0.858 g, $F_v$ = 1.500

Exhibit: C-3

Equation (11.4–1): $S_{MS} = F_aS_S = 1.000 \times 2.092 = 2.092$ g

Equation (11.4–2): $S_{M1} = F_vS_1 = 1.500 \times 0.858 = 1.287$ g

## Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4–3): $S_{DS} = ⅔ S_{MS} = ⅔ \times 2.092 = 1.395$ g

Equation (11.4–4): $S_{D1} = ⅔ S_{M1} = ⅔ \times 1.287 = 0.858$ g

## Section 11.4.5 — Design Response Spectrum

From Figure 22-12 [3] $T_L$ = 8 seconds

Figure 11.4–1: Design Response Spectrum

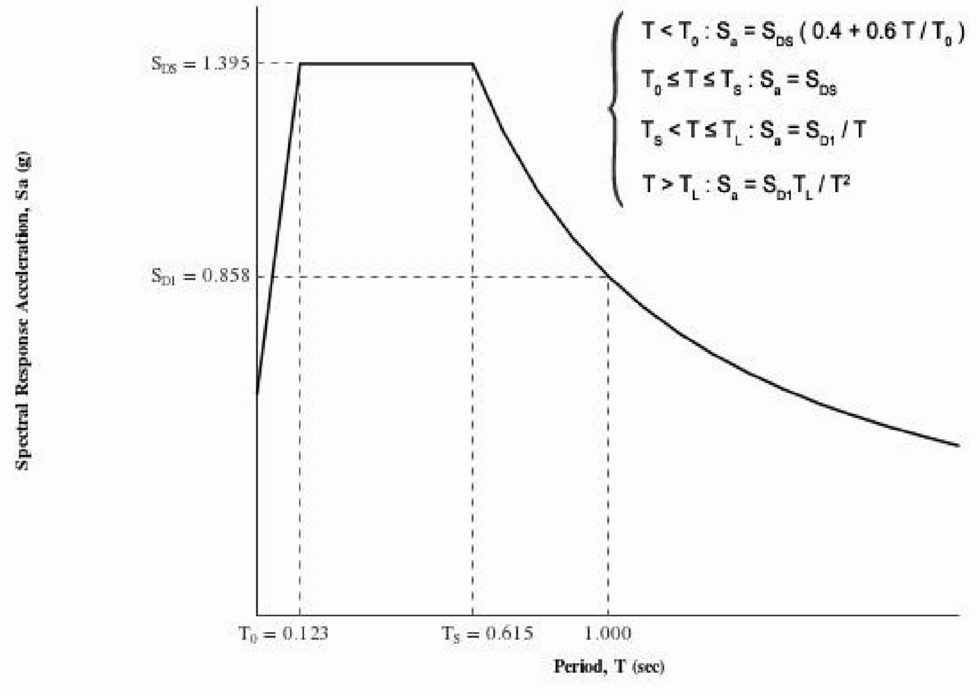


Exhibit: C-3

## Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake ($MCE_R$) Response Spectrum

The $MCE_R$ Response Spectrum is determined by multiplying the design response spectrum above by 1.5.

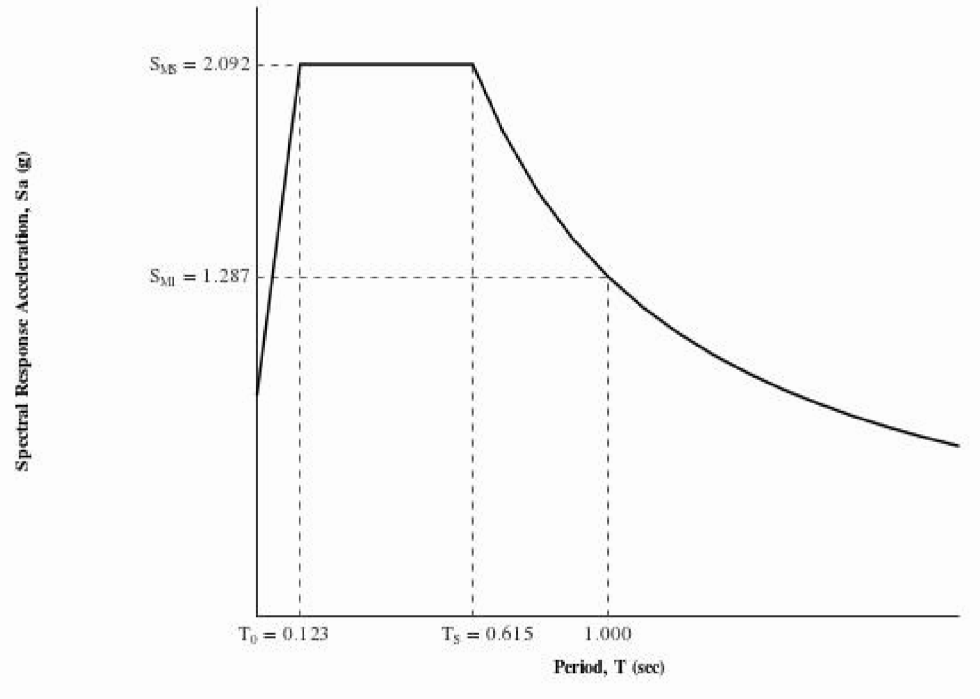


Exhibit: C-3

## Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.804

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Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.000 \text{ x } 0.804 = 0.804 \text{ g}$

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Table 11.8–1: Site Coefficient $F_{PGA}$

| Site Class | Mapped MCE Geometric Mean Peak Ground Acceleration, PGA | | | | |
|---|---|---|---|---|---|
| | PGA ≤ 0.10 | PGA = 0.20 | PGA = 0.30 | PGA = 0.40 | PGA ≥ 0.50 |
| A | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| B | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| C | 1.2 | 1.2 | 1.1 | 1.0 | 1.0 |
| D | 1.6 | 1.4 | 1.2 | 1.1 | 1.0 |
| E | 2.5 | 1.7 | 1.2 | 0.9 | 0.9 |
| F | See Section 11.4.7 of ASCE 7 | | | | |

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.804 g, $F_{PGA}$ = 1.000

## Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] $C_{RS}$ = 0.944

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From Figure 22-18 [6] $C_{R1}$ = 0.931

Exhibit: C-3

## Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

| VALUE OF $S_{DS}$ | RISK CATEGORY | | |
|---|---|---|---|
| | I or II | III | IV |
| $S_{DS} < 0.167g$ | A | A | A |
| $0.167g \leq S_{DS} < 0.33g$ | B | B | C |
| $0.33g \leq S_{DS} < 0.50g$ | C | C | D |
| $0.50g \leq S_{DS}$ | D | D | D |

For Risk Category = I and $S_{DS}$ = 1.395 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

| VALUE OF $S_{D1}$ | RISK CATEGORY | | |
|---|---|---|---|
| | I or II | III | IV |
| $S_{D1} < 0.067g$ | A | A | A |
| $0.067g \leq S_{D1} < 0.133g$ | B | B | C |
| $0.133g \leq S_{D1} < 0.20g$ | C | C | D |
| $0.20g \leq S_{D1}$ | D | D | D |

For Risk Category = I and $S_{D1}$ = 0.858 g, Seismic Design Category = D

Note: When $S_1$ is greater than or equal to 0.75g, the Seismic Design Category is E for buildings in Risk Categories I, II, and III, and F for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ “the more severe design category in accordance with Table 11.6-1 or 11.6-2” = E

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Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

### References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

Exhibit: C-3

## Multi-Family Community

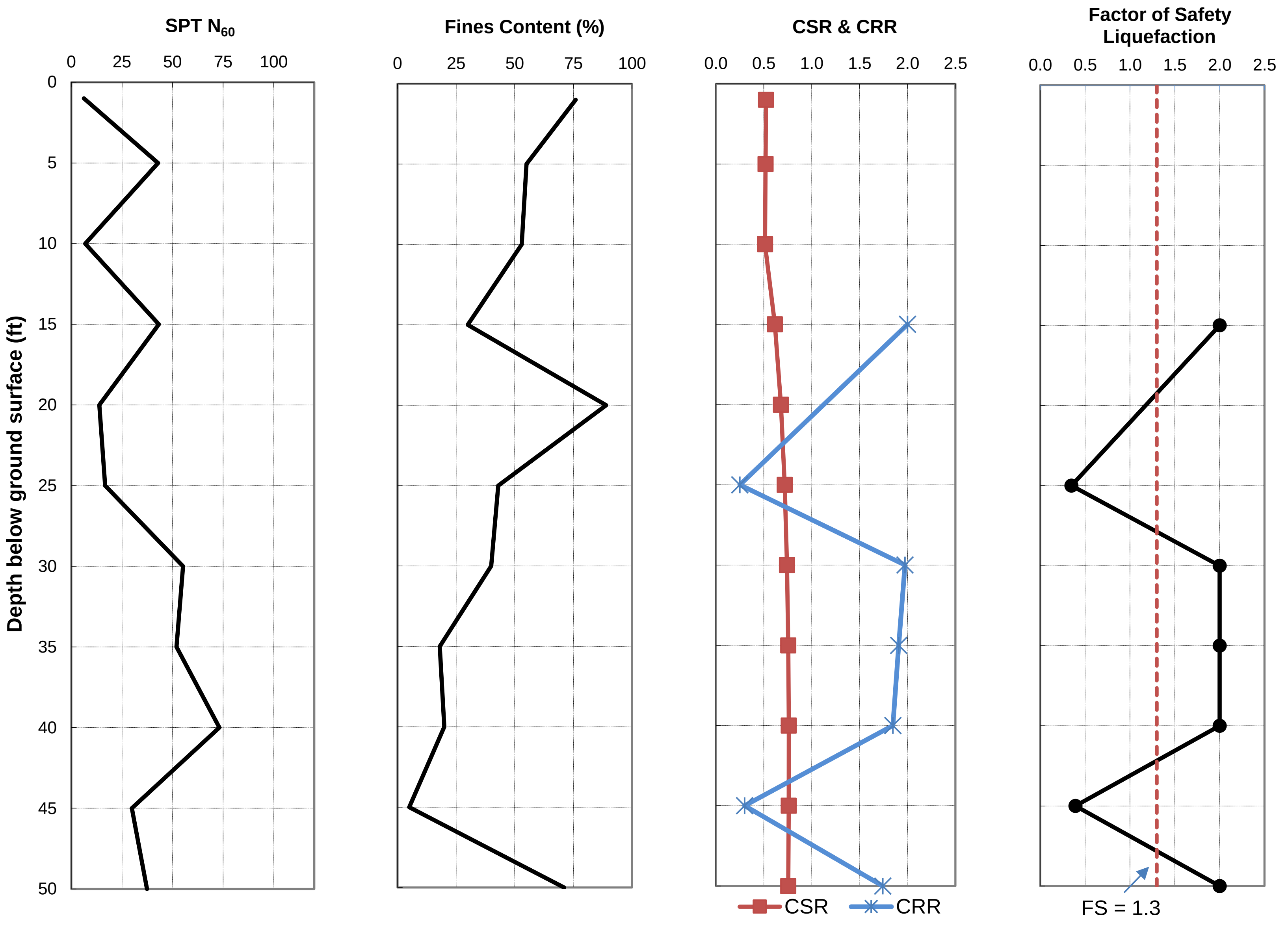

Exhibit: C-4