GEOTECHNICAL REPORT

Copper Ridge (Ruby Crossing) – Lennar

San Antonio, Bexar County, Texas

Prepared for:
Lennar
San Antonio, Texas

Prepared by:
TTL, Inc.
San Antonio, Texas

Project No. 00190901138.02
May 23, 2023

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May 24, 2023

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RE: ***Revised Geotechnical Engineering Report***
Copper Ridge (Ruby Crossing) - Lennar
Red Forest Land & Red Hill Lane
San Antonio ETJ, Bexar County, Texas
TTL Project No. 000190901138.02

Dear Mr. Mott:

TTL, Inc. (*TTL*) is pleased to submit this revised Geotechnical Engineering Report for the above-referenced project. If you have any questions regarding our report, or if additional services are needed, please do not hesitate to contact us.

The ***final*** pavement section design and ***preliminary*** foundation recommendations contained within this report are based on our understanding of the proposed development, the results of our field exploration and laboratory tests, and our experience with similar projects.

We appreciate the opportunity to provide these Geotechnical Services for your project and look forward to continuing participation during the design and construction phases of this project.

Respectfully submitted,
TTL, Inc.

June Potter, P.E.
Senior Project Engineer

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EXECUTIVE SUMMARY

This revised Geotechnical Feasibility and Pavement Report ("Report") has been prepared for the Copper Ridge (Ruby Crossing) -Lennar property to be developed as a residential subdivision, hereinafter referred to as either the "Project" or "Site." The Site is comprised of approximately 66 acres bounded by Red Forest Lane to the west and Red Hill Lane to the south in unincorporated Bexar County, Texas. The Copper Ridge (Ruby Crossing)-Lennar development will accommodate individual single-family residential lots, multiple interconnecting streets, and major utilities.

Based on the information provided to us for this study and from data developed as part of our engineering service, residential development and construction may be performed at the Site provided the site, streets, and utilities are prepared in accordance with the recommendations within this report. TTL is also providing preliminary foundation recommendations, which should only be used for planning and budgeting purposes and not used for the final foundation design. A general summary of our findings and conclusions are provided below:

- Subsurface conditions within the site consist primarily of CLAYEY SAND, LEAN CLAY with Sand (CL), SANDY LEAN CLAY (CL), and FAT CLAY (CH) to the borehole completion depths of approximately 15 feet. The upper 2½ feet of surficial CLAYEY SAND (SC) have a loose relative density and may require additional earthwork. Excavations in this upper 2½ feet material may require additional shoring for foundation beams as the sides of the foundation trenches may slough.
- Based on the results of our laboratory testing program, the existing lithology exhibits a moderate-to-high potential for volume changes (expansion and contraction) with fluctuations in their moisture contents. The subsoils, in their current state, yield a Potential Vertical Rise (PVR) ranging from less than 1 inch to approximately 1½ inches.
- As a part of the site improvement recommendations, the existing drainage/stock ponds should be drained and filled as specified in this report to match the desired final grade.
- Slab-on-grade foundations may be used to support the residences. Key preliminary design parameters are as follows:
    - The foundation beams shall bear no shallower than 18 inches below the exterior final grade.
    - The foundation beams may be sized for a net allowable total load-bearing pressure of 2,600 psf (pounds per square foot) or a net allowable dead plus gravity live load-bearing pressure of 1,700 psf if bearing below 2½ feet below existing grade or if bearing on a minimum of 1 foot of properly compacted select fill soils. For the foundation beams bearing in the upper 2½ feet of the natural soils, the foundation beams may be sized for a net

allowable total load-bearing pressure of 1,300 psf or a net allowable dead plus gravity live load-bearing pressure of 800 psf.
    - The width of foundation beams should not be less than 10 inches for post-tensioned slab foundations.
- Recommendations for site grading preparation and utility installation are provided in the Report.

This summary is provided for convenience only. For those individuals and entities that may need more details or technical information from this report for their use, it must be read in its entirety to fully understand the information and recommendations provided for the Project.

1.0 PROJECT INFORMATION

This revised Geotechnical Feasibility Report ("Report") has been prepared for the design and construction of the mass grading, pavements, utilities, and ***preliminary foundations*** in a proposed residential subdivision being referred to as the Copper Ridge (Ruby Crossing)-Lennar residential development (Project). The Site is bounded by Red Forest Lane to the west and Red Hill Lane to the south in unincorporated Bexar County, Texas. The planned development will accommodate individual lots, multiple interconnecting streets and major utilities.

1.1 Project Description

The following information was provided to us by the Client, design professionals working on the Project, or was collected by our firm:

Item	Description
Project Location	The Copper Ridge (Ruby Crossing) property is located on the south side of San Antonio, Texas in unincorporated Bexar County, Texas. The Project Site is south of S. Loop 1604 East and west of I-37. It is bounded by Red Forest Lane to the west and Red Hill Lane to the south.
Proposed Development	Based on a site layout generated by Cude Engineers ("*Ruby Crossing Subdivision Lot Count Exhibit*, E-1" August 16, 2022), the planned development will accommodate approximately 594 individual lots, multiple interconnecting streets and major utilities.
Site Description	The Site consists of approximately 66 acres of undeveloped ranch-type land with several drainage/stock ponds as indicated by the grading contours on the referenced Cude Engineers drawing and by available overhead imagery (GoogeEarth). Trees, low brush and grass cover the property. Dense vegetation is within the northern portion of the Site and within the areas of the drainage ponds. Several unpaved roads are present within the southern and eastern portions of the Site.
Project Objectives	This feasibility study provides preliminary design recommendations and construction guidelines with regard to geotechnical engineering aspects within the Site. Pavement design recommendations for the residential streets are also provided. The layout of the Site is illustrated in the Boring Location Plan (see Attachments) and in Figure 1.
Current Topography	The mass grading of the site had not been conducted prior to the drilling of TTL's exploratory borings. Based on visual observations, information from Google Earth imagery, and elevation contours provided on the Cude Engineers drawing, the Project Site gently slopes downward from the northeast to the southwest within the northern portion of the Site and generally downward from the east to the west on the southern portion of the Site.
Proposed Topography	Proposed grades and the finished floor elevations (FFE) were not available to us at the time this report was prepared. *For our recommendations, we have assumed that the FFE will be near (within 6 inches) the existing grade.* **Once the FFE becomes available; *TTL* should be contacted to reevaluate our recommendations.**
Geologic Formations	• Wilcox Group, undivided (Ewi Rock Unit Code) within the northern portion of the Site • Carrizo Sand (Ec Rock Unit Code), Tertiary Period, Eocene Epoch, Wilcox Group within the southern portion of the Site
USDA Soil Survey	Wilco loamy fine sand (HkC)

Pavements	Streets and residential driveways will be constructed. Streets will most likely be a flexible pavement system consisting of asphaltic concrete overlying granular base and moisture conditioned subgrade. The residential driveways will be concrete sections.

If the above information is not correct, please contact us so that we can make the necessary modifications to this document and our evaluation and recommendations, if needed.

1.2 Authorization

This Project was authorized by Mr. Richard Mott, P.E., with Lennar, on April 25, 2019 by acceptance of our Agreement for Services No. P00190901138.00, dated April 25, 2019.

2.0 EXPLORATION FINDINGS

2.1 Site Conditions

Item	Description
Site Location	The Copper Ridge (Ruby Crossing) Project Site is located in unincorporated Bexar County, San Antonio ETJ, Texas. The Site is south of S Loop 1604 E and west of I-37. It is bounded on the west by Red Forest Lane and to the south by Red Hill Lane.
Existing Improvements	The site was undeveloped ranchland-type property with several unpaved roadways traversing the southern and eastern portions of the Site.
Current Ground Cover	Trees, low brush and grass cover the property. Dense vegetation is within the northern portion of the Site and within the areas of the drainage ponds.
Existing topography	Based on visual observations, information from Google Earth imagery, and elevation contours provided on the Cude Engineers drawing, the Project Site gently slopes downward from the northeast to the southwest within the northern portion of the Site and generally downward from the east to the west on the southern portion of the Site.

2.2 Site Geology

The San Antonio Sheet (1976) of the Geologic Atlas of Texas published by the Bureau of Economic Geology of the University of Texas at Austin has mapped the Project Site as within the Wilcox Group, undivided of the Tertiary Period, Eocene age. The Wilcox consists mostly of mudstone with various amount of sandstone and lignite; in uppermost and lowermost parts the soils are commonly glauconitic. The deposit is massive to thin bedded with some silt and very fine sand laminae, pale brown to yellowish-brown in color, in the lower part of the formation the sands are very fine grained, yellowish brown to moderate brown. Lignite is present mostly near the middle of the formation.

Within the southern portion of the Site the geology is mapped as the Carrizo Sand Rock Unit within the Wilcox Group and consists of sandstone, medium to very coarse-grained up to the size of rice, finer grained toward top, poorly-sorted, friable to locally indurated, noncalcareous, thick bedded, light yellow to orange and brown; weathers yellowish-brown, locally iron-oxided banded.

2.3 Subsurface Lithology

Subsurface conditions within the project limits were evaluated by drilling 7 of the proposed 11 exploratory borings at the approximate locations shown on the Boring Location Plan in Appendix A. (Due to rainfall in the area and dense vegetation within the western portion of the Site, borings B-1, B-2, B-4, and B-10 were not accessible at the time of the field exploration.) Information from the exploratory borings is summarized below.

Stratum	Approximate Depth Stratum (ft.)	Material Description	Stratum Parameters
I	0 to 2	CLAYEY SAND (SC), loose, dark brown or brown or light brown with reddish-brown	PI=non-plastic -200 sieve: 29-40%
IIa	2 to (4-10)	LEAN CLAY with Sand (CL), stiff to hard, dark brown or mottled brown and gray or SANDY LEAN CLAY (CL), firm to stiff, yellowish-brown to light brown or dark brown with reddish-brown	PI=17-27 -200 sieve: 40-60%
IIb	4 to 10	SANDY FAT CLAY (CH), very stiff to hard, yellowish-brown or mottled brown and gray or dark brown with light brown or mottled yellowish-brown and gray	PI=34-35 -200 sieve: 66-70%
IIIa	(4-10) to 15	CLAYEY SAND (SC), dense, reddish-gray brown or light brown or light gray	PI=18 -200 sieve: 38-43%
IIIb	10 to 15	SANDY LEAN CLAY (CL), hard, light yellowish-brown with light reddish-brown or mottled yellowish-brown and gray	PI=23 -200 Sieve: 40-65%

Additional information about the subsurface lithology encountered at the exploratory boring locations is provided on the soil boring logs in Appendix A.

The Boring Logs presented in Appendix A represent our interpretation of the subsurface conditions based on tests and observations performed during the drilling operations at the test boring locations, visual examination of the soil samples by a geotechnical engineer, and laboratory tests conducted on the retrieved soil samples. The USCS classifications enclosed in parenthesis indicate a visual classification. The lines designating the interfaces between various strata on the Boring Logs represent the approximate strata boundary, however, the transition between strata may be more gradual than shown, especially where indicated by a broken line. All data should only be considered accurate at the exact test boring location.

2.4 Groundwater Conditions

Subsurface water was not encountered during drilling or upon completion of the exploratory borings. Observing boreholes for subsurface water the day after drilling or at later times was not in our scope of services. The exploratory borings were then backfilled with the spoils generated during drilling operations.

Subsurface water is generally encountered as a ‘true’ or permanent continuous water source surface that is generally present year-round or as a discontinuous, isolated “‘perched”’ or temporary water source surface that is temporary. Permanent subsurface water is generally present year-round, which may or may not be influenced by seasonal changes in climate, precipitation, vegetation, surface runoff, water levels in nearby water bodies, and other factors. The subsurface water level below the site may fluctuate up or down in response to such changes and may be at different levels than indicated on the exploration logs at times after the exploration. Temporary subsurface water generally develops as a result of seasonal and climatic conditions.

Based on the field exploration conducted for this study, subsurface water is not expected to affect or impact the planned construction activities. ***However, near-surface groundwater may be present in the vicinity of the existing ponds.*** The contractor or applicable subcontractors should be prepared to check for potential subsurface water conditions prior to excavating at the site.

3.0 GEOTECHNICAL CONSIDERATIONS

The following geotechnical considerations have been prepared based on the information developed during this Project, our experience with similar projects, and our knowledge of sites with similar surface and subsurface conditions.

3.1 Expansive Soil Considerations

Subsurface soils at the project site have a low-to-moderate potential for shrinking and swelling. Plasticity Index (PI) values range from 17 to 35. These soils experience volume changes by shrinking with a decrease in moisture content and swelling with an increase in moisture content. Based on our calculations, the subsoils at this site may yield a PVR ranging from less than 1 inch to approximately 1½ inches. The actual movement could be greater if inadequate drainage or other sources of water are allowed to infiltrate beneath the pavements after construction.

3.2 Corrosion Considerations

Laboratory testing was conducted on material samples recovered from the borings to assess the corrosivity risk of the soil at the boring locations. The soil samples were submitted to an analytical lab to determine the sulfate content. The results of the laboratory tests are presented in the following table.

Boring No.	Sample Depth (ft.)	Sulfate (ppm)
B-3	½ to 2	65.6
B-11	2½ to 4	38.1

According to the 2015 IBC, concrete that is exposed to sulfate-containing solutions should be designed in accordance with ACI 318. The sulfate test results indicate that the sulfate exposure level is Class S0. Therefore, Type I or II cement may be used.

4.0 EARTHWORK RECOMMENDATIONS

4.1 Subgrade Preparation and Stabilization

The intended performance of earth supported elements such as foundations and utilities are contingent upon following the earthwork recommendations and guidelines outlined in this section. Earthwork activities on the Project should be observed and evaluated by TTL personnel. The evaluation of earthwork should include observation and testing of all fill and backfill soils placed at the Site, subgrade preparation beneath the residential structures, utilities, and any load-bearing requirements within the Project.

Please note that mass grading for the subdivision had not been performed before drilling of TTL exploratory borings at the site. Our ***preliminary*** *foundation recommendations are based on the in-place subsoil conditions, we encountered during our drilling operations.*

If possible, site development should be performed during seasonably dry weather (typically May through October), and excavation and site preparation should not be performed during or immediately following periods of heavy precipitation or freezing temperatures. Positive surface drainage should be maintained during grading operations and construction to prevent water from ponding on the surface. Surface water run-off from off-site areas should be diverted around the site using berms or ditches. The surface can be rolled smooth to enhance drainage if precipitation is expected but should then be scarified prior to resuming fill placement operations. Subgrades damaged by construction equipment should be promptly repaired to avoid further degradation in adjacent areas and water ponding. Our geoprofessional should provide recommendations for treatment if the subgrade materials become wet, dry, or frozen. When work activities are interrupted by heavy rainfall, fill operations should not be resumed until the moisture content and density of the previously placed fill materials are as recommended in this report. The following earthwork recommendations must be performed prior to pavement and utility construction.

4.1.1 Stripping

Subgrade preparation should begin with stripping the existing vegetation and any otherwise unsuitable materials from planned construction areas and mucking out the stock pond.

- Stripping should extend at least 3 feet (horizontal) beyond the construction limits or to the property lines, whichever is less. Due to the tree and brush vegetation at the Site, the stripping depth may need to be at least 12 to 18 inches to completely grub and remove the roots.
- Organic-laden strippings including root masses, loose topsoil, and muck from the pond areas, should be removed from the site or disposed of at designated on-site areas located outside the limits of current or future development.
- Strippings may be stockpiled for re-use as topsoil during landscaping if they are suitable for that purpose.
- Strippings should not be used to build permanent slopes.

4.1.2 Proofrolling

After stripping and excavating to the design subgrade elevation, the stability of exposed subgrades in areas to receive fill should be evaluated by proofrolling. The stability of subgrades exposed by cutting to final grades should also be evaluated by proofrolling.

- Perform proofrolling with a rubber-tired vehicle having a gross vehicle weight of at least 20 tons (such as a loaded tandem-axle dump truck, or similar size/weight construction equipment).
- Proofrolling equipment should make multiple closely-spaced overlapping passes in perpendicular directions over the subgrade at a walking pace.
- The subgrade should be relatively smooth and free of wheel ruts, sheepsfoot roller dimples, loose clods of soil, or loose gravel, and the subgrade should not be desiccated, cracked, wet, or frozen.
- A TTL geotechnical engineer or their representative should observe the proofrolling to identify, document, and mark areas of unstable subgrade response, such as pumping, rutting, or shoving, if any.

4.1.3 Subgrade Stabilization

Unstable subgrades should be stabilized as recommended below.

- Undercut soft, weak, and unstable soils by excavating below subgrade level to expose stable soils. The excavated soil can be used to restore the excavation subgrade, provided that the soils are relatively free and clean of deleterious material or materials exceeding three (3) inches in maximum dimension. The excavated soil, or imported fill soil, shall be placed in maximum 6-inch compacted lifts. Each lift of soil shall be moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content for clay subgrade and between minus two (2) and plus three (3) for granular subgrade. The moisture conditioned subgrade should then be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698 for clay subgrade and ASTM D 1557 for granular subgrade. If undercutting deeper than about three (3) feet is needed, contact TTL.
- Soil subgrade areas requiring fill placement should be scarified to a depth of about eight (8) inches and moisture conditioned between optimum and plus four (+4) percentage points of the optimum moisture content for clay subgrade and between minus two (2) and plus three (3) for granular subgrade. The moisture conditioned subgrade should then be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698 for clay subgrade and ASTM D 1557 for granular subgrade. The subgrade should be moisture conditioned just prior to fill placement so the subgrade maintains its compaction moisture levels and does not dry out.

- On-site soils (general fill), Select Fill or Granular Select Fill soil should be placed to achieve the desired elevation as described in Section 4.3 of this report.

4.2 Excavation Conditions

The initial soils observed at the boring locations consist of Clayey Sands (SC) with loose to medium dense relative densities to a depth of approximately 2 feet. Underlying these soils are Lean Clays with Sand (CL), Sandy Lean Clays (CL) and/or Sandy Fat Clays (CH) with firm to hard consistencies. The soils encountered at the borings can be excavated by conventional earthmoving equipment.

4.2.1 Temporary Slopes/OSHA Soil Types

Temporary construction excavations should be sloped or shored by the contractor in accordance with OSHA requirements. The OSHA regulations define short-term as a period of 24 hours or less. The on-site soils appear to be OSHA Type C soils. OSHA requires temporary excavation slopes no steeper than 1.5-horizontal to 1-vertical (1.5H:1V) through Type C soils. The contractor's "competent person" should evaluate temporary excavations daily and determine the specific soil types and temporary slope or shoring measures necessary according to OSHA requirements. TTL assumes no responsibility for excavations, shoring, or job site safety, which are the sole responsibility of the general contractor.

4.2.2 Temporary Groundwater Control

The contractor should be prepared to remove groundwater seepage that may enter shallow excavations during construction. Although groundwater was not encountered by the borings, it is possible that groundwater could develop after periods of precipitation. We expect the quantity of seepage should be small enough that it can be managed by pumping from sumps within the excavation. If excessive seepage is encountered, then it will be necessary to consider other means for controlling the seepage.

4.3 Compacted Fill Materials

Compacted fill materials may consist of select or general fill depending upon its intended use. General fill materials may consist of onsite soils, select fill materials or clean imported fill soils that possess good compaction characteristics that will provide suitable, uniform support for pavements and other non-habitable facilities that are not extremely sensitive to movements. General fill material may be used in open areas where such facilities will not be constructed. Select fill material, on the other hand, is selected based on specific engineering characteristics and performance criteria for the proposed purposes. These selection characteristics and criteria typically depend on the requirements of the pavements, structures, or other facilities they are intended to support.

General and select fill materials should be clean and free of any vegetation, roots, organic materials, trash or garbage, construction debris, or other deleterious materials. These materials should contain stones no larger than two and one-half (2½) inches in maximum dimension. The following table provides more specific requirements for general and select fill materials.

Material Type	Characteristics	Compaction Procedures	Compaction Control [1, 2]
ON–SITE SOIL FILL (COMMON OR GENERAL FILL)	Shall consist of CH, CL, SM, SC, GM, GC, SW, or GW as defined by ASTM D 2487. Plasticity Index: Not more than 35. Maximum allowable organic content: 3 percent by weight. **This fill material type shall not be used in areas where select fill materials are specified. It is not the intent of this material to control differential soil movements and it shall not be used in areas where control of soil movements is required.**	Maximum loose lift thickness: 8 inches. Compaction requirement: Compaction should be to at least 95 percent of the standard Proctor maximum (ASTM D 698) dry density for non-roadway areas and TEX-114-E for roadway areas. Moisture content at time of compaction: within optimum to plus 4 percent of the material's optimum moisture content.	Building Areas: One field density test every 5,000 square feet per lift, with a minimum of two tests per lift. Pavement Areas and Slopes: One field density test every 10,000 square feet per lift, with a minimum of two tests per lift. Utility Trenches: One field density test per structure or one test per every 100 linear feet, per lift.
SELECT SOIL FILL (COMPACTED FILL)	Maximum particle size: 3 inches. Maximum gravel and oversize particle content: 15 percent retained on a ¾-inch sieve. No less than 30 percent of total material passing the No. 200 sieve Maximum allowable organic content: 3 percent by weight, but large roots are not allowed. Liquid Limit: Not more than 40. Plasticity Index: Between 8 and 20. Designation as a CL or SC in accordance with the Unified Soil Classification System (USCS).	Maximum loose lift thickness: 8 inches. Compaction requirement: Compaction should be to at least 95 percent of the standard Proctor maximum (ASTM D 698) dry density for non-roadway areas and TEX-114-E for roadway areas. Moisture content at time of compaction: within minus 2 to plus 3 percent of the material's optimum moisture content.	Building Area: One field density test every 5,000 square feet per lift, with a minimum of two tests per lift. Pavement Areas and Slopes: One field density test every 10,000 square feet per lift, with a minimum of two tests per lift. Utility Trenches: One field density test per structure or one test per every 100 linear feet, per lift.
SELECT GRANULAR MATERIALS (COMPACTED FILL)	Crushed stone (limestone) meeting Type A, Grades 1, 2, or 3; Crushed or uncrushed gravel meeting Type B, Grades 1, 2, or 3; Crushed concrete meeting Type D, Grades 1, 2, or 3; of the 2014 TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges. Designation as a GC or GM in accordance with the USCS Clayey gravel (may locally be referred to as "pit-run" material) or caliche having no particle sizes greater than 3 inches in any dimension, at least 50 percent of total material retained on the No. 200 sieve, a Liquid Limit (LL) no greater than 40, and a PI between 7 and 20. Designation as a GC in accordance with the USCS. Commercial Grade Base (may locally be referred to as "three-quarters to dust" material) that is produced by some local/regional quarries having nothing retained on the 2 inch sieve, at least 60 percent retained on the No. 40 sieve, at least 80 percent retained on the No. 200 sieve, an LL no greater than 30, and a PI of 7 or less. Designation as a GM in accordance with the USCS.	Maximum loose lift thickness: 8 inches. Compaction requirement: Compaction should be to at least 98 percent of the TEX-113-E dry density. Moisture content at time of compaction: within minus 2 to plus 3 percent of the material's optimum moisture content.	Building Area: One field density test every 5,000 square feet per lift, with a minimum of two tests per lift. Pavement Areas and Slopes: One field density test every 10,000 square feet per lift, with a minimum of two tests per lift. Utility Trenches: One field density test per structure or one test per every 100 linear feet, per lift.

[1]For preliminary planning only. Our technician/engineer should determine the actual test frequency.
[2] In addition, the fill must be stable under the influence of compaction equipment. Heavy construction traffic should not be allowed to travel on compacted fill areas, except on designated haul roads, to reduce the potential for damaging a previously compacted fill subgrade

If grading occurs during wet, cool weather, when drying soils is more difficult and time-consuming, the grading contractor may have difficulty achieving suitable moisture conditions for proper compaction of soil fill.

The surface of any filled area can experience settlement due to compression of the underlying soils, and sometimes additional settlement results from consolidation of thick soil fills due to their own self-weight.

4.3.1 Pavement Earthwork

The intended performance of roadway pavement is contingent upon following the earthwork recommendations and guidelines outlined in this section. Earthwork activities on the Project should be observed and evaluated by *TTL* personnel. The evaluation of earthwork should include observation and testing of all fill and backfill soils placed at the Site, and subgrade preparation beneath the streets.

The clay soils across the site have low to moderate potential to undergo expansion and contraction with fluctuations in their moisture content. Expansion and contraction of the clay subgrade can lead to cracking and undulating/corrugation in the pavement and curbs. Remedial methods to address this issue include: removing the expansive soils and replacing them with non-expansive cohesive soil; chemical injection of the expansive soils; a combination of moisture conditioning, lime or cement treatment, and installation of a vertical moisture barrier; other subgrade preparation methods are also available.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the pavements should be anticipated. The severity of cracking and other damage will probably increase if any 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 other measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request*. If additional earthwork preparation methods will be used or evaluated, please contact us.*

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.

The following earthwork recommendations must be performed prior to pavement construction.

- Strip vegetation, loose topsoil, vegetation and any otherwise unsuitable materials from the pavement area. The pavement area is defined as the area that extends at least 3 feet (horizontal) beyond the perimeter of the proposed pavement and any adjacent flatwork (sidewalks).
- Perform cut and fill to accommodate the design pavement subgrade elevation (also referenced as the bottom of the base course). Onsite soils can be used for grade

adjustments in fill areas. Refer to Section 4.0 of this report for requirements for the placement of onsite soils and select fill materials.

- After achieving the required excavation depth, and before placing any fill, the exposed excavation subgrade should be proof-rolled with at least a 20-ton roller, or equivalent equipment, to evidence any weak yielding zones. A technical representative of our firm should be present to observe the proof-rolling operations. If any weak yielding zones are present, they should be over-excavated, both vertically and horizontally, until competent soils are exposed. The excavated soil can be used to restore the excavation subgrade, provided that the soils are relatively free and clean of deleterious material or materials exceeding 3 inches in maximum dimension. The excavated soil or imported fill soil shall be placed in maximum 6-inch compacted lifts. Each lift of soil shall be moisture conditioned and compacted as described in Section 4.3.
- Upon completion of grading operations at the site, the index properties of the subgrade soils should be checked to determine whether or not lime treatment is required. Lean Clay/ Clayey Sand Subgrade with PI less than 20 does not require Lime Treatment. The Fat Clay subgrade (with PI more than 20) should be lime treated in accordance with TxDOT Item 260. The lime shall be in slurry form. It is anticipated that approximately four (4) percent hydrated lime will be required (approximately 22 pounds per square yard). The soil-lime mixture shall be placed between optimum and +4 percentage points of the optimum moisture content and shall be compacted to at least 95 percent of the maximum dry density determined in accordance with the Standard compaction effort (ASTM D 698).
- For pavement subgrades the earthwork described here should result in approximately six (6) inches of lime-treated soil or six (6) inches of moisture-conditioned soil below the design pavement subgrade elevation.
- For the pavements located in the flood hazard area or natural drainage path areas, one of the following additional measures should be constructed beneath the soil subgrade level:
    - Prepare the subgrade with 12 inches of moisture-conditioned soils beneath 6 to 8 inches of lime-treated soils, or
    - Prepare the subgrade with at least 12 inches of lime-treated soils.

4.3.2 Residential Pad Preparation

The subsurface soils at this Site generally exhibit a low-to-moderate potential to undergo expansion and contraction during fluctuations in their moisture contents. After mass grading, if the residential pads will be built up to achieve the finished lot elevations, select fill should be used to raise the residential pads above the mass grading elevation. Each lift of select fill should be moisture conditioned and properly compacted, as discussed in **Section 4.3 Compacted Fill Materials**.

4.4 Permanent Slopes

Experience with similar soil types in this area indicate cut and fill slopes for soil appear to be stable when constructed at 3H:1V or flatter. We recommend the top of compacted fill areas extend horizontally at least 5 feet beyond the outside edge of pavements and 10 feet beyond the edge of structures before sloping down. Any underground utilities planned near slopes should be constructed as far as practical from the slope edge because leakage can lead to slope instability. It is difficult to compact the edges of fill on a slope, often resulting in a weak zone along the slope face. If possible, we recommend that the slope be overbuilt and then cut back to the desired configuration with a bulldozer. If this is not feasible, a bulldozer should track up and down the slope to provide at least some level of compactive effort, but surface sloughs could still result from this approach.

Soil surfaces on cut and fill slopes should be protected from erosion by seeding, sodding or other acceptable means. Shallow sloughing failures are possible during periods of high rainfall and should be promptly repaired to prevent the failure from spreading and causing a larger slide. We recommend that our geotechnical engineer observe slope conditions at the time of construction to check for seeps, soft soils or other unfavorable conditions. If any of these conditions are found, the slope geometry may have to be altered or other protective measures implemented.

If the general excavation is performed during the winter or spring, minor groundwater seeps should be anticipated, especially following periods of precipitation. However, we do not expect groundwater to significantly affect construction, and dewatering of any shallow excavations, if necessary, should be accomplished with conventional sumps and pumps.

The recommendations contained in this report section are based on our experience with similar conditions. Slope stability analysis was beyond the scope of this exploration.

Permanent slopes should be designed with a negative slope to prevent surface water from flowing over the crest and down the face of the slope. Only precipitation that falls on the slope should be allowed to flow down the slope. The surface of the slope should be protected against erosion with suitable vegetation or with engineered controls, such as erosion control matting or other measures. We recognize that permanent slopes are often considered by contractors as areas on site where excess topsoil and strippings can be placed, but we caution against this practice. Topsoil and strippings will settle differentially and lose strength over time, which can cause sloughs or slope failures.

4.5 Drainage Considerations

4.5.1 Surface Water

The soil at the site contains fat clays that are sensitive to changes in moisture content. When dry, they exhibit good strength characteristics and are relatively stable under moving rubber-tired equipment. However, when they are wet as a result of local precipitation and climatic conditions or exposure with depth of cut, they can become unstable, particularly under repeated loading from heavy construction equipment. This can occur even for soil that has been moisture conditioned and properly compacted. Protection of the prepared subgrades will be important with regard to the construction schedule and grading costs for this project. Drying the soil may not be practical during wet seasons of the year.

Clay soils will be exposed at the subgrade level during site work and after grading is completed. These soils can degrade after repeated passes of heavy, rubber tired equipment, particularly in wet weather. If possible, site development should be performed during seasonably dry weather (typically May through October), and excavation/site preparation should not be performed during or immediately following periods of heavy precipitation or freezing temperatures. Positive surface drainage should be maintained during grading operations and construction to prevent water from ponding on the surface. Surface water from off-site areas should be diverted around the site using berms or ditches. The surface can be rolled smooth to enhance drainage if precipitation is expected, but should then be scarified and moisture conditioned, as needed, prior to resuming fill placement. When work activities are interrupted by heavy rainfall, fill operations should not be resumed until the moisture content and density of the previously placed fill materials are as recommended in this report. Subgrades damaged by construction equipment should be promptly repaired to avoid further degradation in adjacent areas and water ponding. Our geoprofessional should provide recommendations for treatment if the subgrade materials become wet, dry, or frozen. Degradation of the near surface soils should be expected if they are subjected to freeze/thaw.

4.5.2 Drainage Adjacent to Pavements

The performance of the pavement system will not only be dependent upon the quality of construction but also upon the stability of the moisture content of the soils and base underlying the pavement surface. Proper drainage along or adjacent to the pavement edge or curbs is very important and should be provided so infiltration of surface water from unpaved areas surrounding the pavement is minimized. The Project Civil Engineer should design final grades so that there is positive drainage away from the pavement/curb edge. Also, surface slopes for asphaltic concrete pavement areas should be no flatter than 0.75 percent to reduce the potential for ponding of water on the asphaltic concrete surface. The importance of proper runoff and drainage cannot be overemphasized and should be thoroughly considered by the Project Civil Engineer. Post construction accumulation or ponding of surface runoff near structures must be avoided.

Since water penetration usually results in degradation of the pavement section with time as vehicular traffic traverses the affected area, we recommend that the curbs extend vertically through the aggregate base course and at least 6 inches into the pavement subgrade or install a vertical moisture barrier (VMB) behind the curb.

4.5.3 Groundwater Control

Groundwater was not encountered in the soil borings. Localized zones of “trapped” or “perched” water can sometimes develop in the soil, especially after extended periods of wet weather. If the general excavation for slope construction is performed during the winter or spring, minor ground water seeps should be anticipated, especially following periods of precipitation. However, we do not expect groundwater to significantly affect construction, and dewatering of any shallow excavations, if necessary, should be accomplished with conventional sumps and pumps.

Normally, groundwater inflow can be removed from construction excavations by pumping from a sump near the point of seepage. Our geotechnical engineer should be contacted for guidance if heavy seepage occurs or there is evidence of soil particle migration. Detailed design of the temporary groundwater control measures for construction is the responsibility of the contractor. We do not believe there will be a need for permanent groundwater control measures, since groundwater was not encountered by the borings.

5.0 INFRASTRUCTURE RECOMMENDATIONS

5.1 Utilities

Various utilities will be installed to develop this site. The utilities may include sanitary sewer lines, storm drainage (i.e., sewer lines, concrete drainage channels, culverts, etc.), electrical lines, gas lines, and telecommunication lines. Installation of these utilities should conform to the applicable specifications of the local utility entity.

Utilities not referenced above, such as security, small water lines, or sanitary sewer laterals, should meet the following minimum installation guidelines.

- The bottom of the utility trench excavation should be clean of loose soils and debris prior to placement of the utility pipe or cable.
- Backfill above the utility pipe or cable should be as follows:
    - Traversing Non-Pavement or Non-Load Bearing Areas
        - The backfill soils may be the excavated soils.
        - Place the backfill soils in loose lifts not to exceed 8 inches in thickness to achieve compaction thickness no greater than 6 inches.
        - Add water as applicable so that the soil moisture content after compaction is between minus 2 and plus 3 percent of the optimum moisture content.
        - Compact the backfill soil lift to at least 95 percent of standard moisture-density relationship (ASTM D 698).
    - Traversing Pavement or Load Bearing Areas
        - Place 12 inches of backfill soils, which may be the excavated soils, above the utility pipe or cable. The backfill soils should be placed as follows:
        - Place the backfill soils in loose lifts not to exceed 8 inches in thickness to achieve compaction thickness no greater than 6 inches.

- Add water as applicable so that the soil moisture content after compaction is between minus 2 and plus 3 percent of the optimum moisture content.
- Compact the backfill soil lift to at least 95 percent of standard moisture-density relationship (ASTM D 698).
- Place flowable fill in the utility trench, terminating at a depth to accommodate the applicable pavement section or slab.
- The flowable fill should have a 28-day compressive strength between 25 and 100 psi.

5.1.1 Utility Trenches

Utility trenches that traverse beneath the structures or through foundation members are potential avenues for subsurface water to migrate beneath the structure. One of the following design recommendations should be considered by the Project Civil or MEP Engineers:

- If the utility trench traverses beneath the structure, a 'clay soil plug' should be used for the bedding and backfill. The clay soil plug should have a plasticity index (PI) between 18 and 25. The clay soil plug should be at least 5 feet in length, extend equally across the structure perimeter, and extend full depth of the trench. Granular materials, unless specifically required by the utility company or local codes, should not be used for bedding or backfill along the clay soil plug. If granular bedding or backfill is to be used, we must be contacted to address this issue. Backfill material placement should follow the recommendations in **Section 4.3 Compacted Fill** of this Report.
- If the utility pipes/cables traverse through the foundation member, the hole should be filled with flowable fill or concrete. The pipes/cables traversing through this zone should be designed with some flexibility if they are sensitive to movement. In lieu of this approach, a 'pipe sleeve' can be installed through the foundation member for the utility lines to pass through. The pipe sleeve should have a clearance that is at least 6 inches larger than the outer edges of the utility pipes/cables. The annulus within the pipe sleeve should be filled with a flexible but water-proof material such as sealants or asphaltic mastics.

5.2 Pavements

TTL has not been provided with specific pavement loading information or design criteria for the project. Our recommendations are therefore based on our expectation that pavement areas will most likely be subjected to traffic from passenger cars, sport-utility vehicles (SUVs), and pickup trucks, with only occasional truck traffic for deliveries, moving, or waste management. The recommendations below are minimum pavement sections for this type of development. TTL understands that a flexible pavement system will be considered for the proposed streets developments. The following flexible pavement sections were designed in general accordance with the American Association of State Highway and Transportation Officials (AASHTO) and the

Bexar County guidelines. TTL is providing recommendations for street classifications of Local Type A without bus traffic and Local Type A with bus traffic.

Pavement recommendations in this report do not account for construction traffic. We recommend construction traffic not be allowed on asphalt pavement layers. If desired, construction traffic can use crushed stone base layers as long as the crushed stone base is re-evaluated and repaired prior to placement of asphalt. Repair may require removal of some, or all, of the crushed stone base if it has become contaminated with soil. The soil subgrade may also require repair consisting of undercutting and replacing with compacted fill or additional crushed stone base. Subgrade repairs needed as a result of construction traffic on the crushed stone base should not result in extra charges to the owner as the use of pavement subgrades for construction traffic falls under the contractor's means and methods of construction.

5.3 Pavement Design Considerations

Based on the Bexar County design guidelines, the following design parameters were used for design of the pavement sections:

	Local Type A	Local Type B
Reliability, %	70	90
Initial Serviceability Index, po	4.2	4.2
Terminal Serviceability Index, pt	2.0	2.0
Standard Deviation, So	0.45	0.45
Design Life, years	20	20
18-kip ESALs	100,000	2,000,000

A soil bulk sample was collected to determine the California Bearing Ratio (CBR) value to be used for our pavement design recommendations. Based on laboratory test results the soil sample is classified as a non-plastic Clayey Sand (SC) and a CBR value of about 10 percent was obtained (see attached *CBR and Moisture Density Plot*). However, based on our experience with sites composed of Lean Clays (CL) and Clayey Sands (SC), and supported by literature correlation of soil types and CBR values, TTL recommends the pavement design utilize a CBR of 5 percent for the existing subgrade compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. In accordance with the Bexar County design guidelines, we used a Resilient Modulus (MR) = 1,500 times the CBR in psi, to convert CBR to MR.

As stated previously, the near-surface soils at the boring locations are primarily classified as non-plastic Clayey Sands (SC). Lime treatment of these soils is not required. However, underlying these soils are Lean Clays (CL) with Plasticity Indexes (PIs) of 20 to 25. The Bexar County pavement guidelines require lime treatment of clay subgrades with a PI greater than 20. Therefore, upon completion of the grading operations at the site, the index properties of the subgrade soils should be checked to determine whether or not lime treatment is required.

For lime treated subgrade, we anticipate that approximately four (4) percent of hydrated lime will be required (about 22 pounds per square yard). We understand the lime treated subgrade will not be treated to meet the Bexar County requirement for lime stabilization.

However, it should be noted that, upon completion of the grading operations at the site, the index properties of the subgrade soils should be checked to determine whether or not lime treatment is required. This is because mass grading operations may have removed lower PI material to expose higher PI material or higher PI fill may have been placed over lower PI materials.

Even after subgrade lime treatment, eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if other measures are used during construction.

5.3.1 Pavement Section Recommendations

Presented below are the recommended pavement sections. The mass grading within the pavement area should include the removal of the surficial gravel stratum and the replacement of this material, as needed, with fill soils.

Fill and Cut Conditions: For On-site Soils Subgrade

FLEXIBLE PAVEMENT SYSTEM		
Component	**Pavement Material Thickness, inches**	
	Local Type A	
	Pavement Sections	
	Clayey Sand/Fill Subgrade	**Fat Clay Subgrade**
	CBR of 5%	**CBR of 5%**
Hot Mixed Asphaltic Concrete	2 inches	2 inches
Prime Coat	Yes	Yes
Granular Base Course (Type A, Grade 1 or 2)	9 inches	9 inches
Moisture Conditioned Subgrade	6	----
Lime Treated Subgrade	----	6 inches
Calculated Structural Number	2.14	2.14
Required Structural Number	2.10	2.10

[1]Structural Number for Lime Treated Subgrade was not used in the Pavement Section Calculations.

FLEXIBLE PAVEMENT SYSTEM		
Component	**Pavement Material Thickness, inches**	
	Local Type B	
	Pavement Sections	
	Clayey Sand/Select Fill Subgrade	**Fat Clay Subgrade**
	CBR of 5%	**CBR of 5%**
Hot Mixed Asphaltic Concrete	3 inches	3 inches
Prime Coat	Yes	Yes
Granular Base Course (Type A, Grade 1 or 2)	18 inches	18 inches

FLEXIBLE PAVEMENT SYSTEM		
Component	Pavement Material Thickness, inches	
	Local Type B	
	Pavement Sections	
	Clayey Sand/Select Fill Subgrade	Fat Clay Subgrade
	CBR of 5%	CBR of 5%
Moisture Conditioned Subgrade	6	----
Lime Treated Subgrade	----	6 inches
Calculated Structural Number	3.84	3.84
Required Structural Number	3.80	3.80

[1]Structural Number for Lime Treated Subgrade was not used in the Pavement Section Calculations.

5.3.2 General Guidelines for Pavements

All pavement design and construction shall conform to the latest edition of Bexar County/City of San Antonio Design and Construction guidelines. Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. **The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clayey subgrade. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. It is, therefore, important to minimize moisture changes in the subgrade to reduce shrink/swell movements.**

On most projects, rough site grading is accomplished relatively early in the construction phase. However, as construction proceeds, excavations are made into these areas; dry weather may desiccate some areas; rainfall and surface water saturates some areas; heavy traffic from concrete and other delivery vehicles disturbs the subgrade; and many surface irregularities are filled in with loose soils to improve trafficability temporarily. As a result, the pavement subgrade should be carefully evaluated as the time for pavement construction approaches. This is particularly important in and around utility trench cuts.

Thorough proof-rolling of pavement areas using appropriate construction equipment weighing at least 20 tons should be performed no more than 24 hours prior to surface paving. Any problematic areas should be reworked and compacted at that time.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventive maintenance. The following recommendations should be considered at a minimum:

- Maintain and promote proper surface drainage away from pavement edges;
- Consider appropriate edge drainage systems;
- Install drainage in areas anticipated for frequent wetting (e.g., landscape beds, discharge area, collection areas, etc.).
- Place joint sealant and seal cracks immediately;

- Seal all landscaped areas in, or adjacent to pavements, to minimize or prevent moisture migration to subgrade soils;
- Placing compacted, low permeability backfill against the exterior side of curb and gutter; and,
- Extending the base of the curb and gutter system through the pavement base material and at least 6 inches into lime treated subgrade soils.

Preventive maintenance should be planned and provided for through an on-going pavement management program. These activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. This 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 first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance.

5.3.3 Pavement Section Materials

All pavement materials shall conform to the latest edition of Bexar County guidelines. Presented below are selection and preparation guidelines for various materials that may be used to construct the pavement sections. Submittals should be made for each pavement material. The submittals should be reviewed by TTL and any appropriate members of the Project Team. The submittals should provide test information necessary to verify full compliance with the recommended or specified material properties.

Hot Mix Asphaltic Concrete Surface -, The paving mixture and construction methods shall conform to Item 340, "Hot Mix Asphaltic Concrete, Type D" of the Standard Specifications by TxDOT. The mix should be compacted between 91 and 95 percent of the maximum theoretical density as measured by TEX-227-F. The asphalt cement content by percent of total mixture weight should fall within a tolerance of ±0.3 percent asphalt cement from the specific mix. In addition, the mix should be designed so 75 to 85 percent of the voids in the mineral aggregate (VMA) are filled with asphalt cement. The asphalt cement grades should conform to the table shown below.

<table>
<tr><th colspan="4">Asphalt Cement Grades</th></tr>
<tr><th rowspan="2">Street Classifications</th><th colspan="3">Minimum PG Asphalt Cement Grade</th></tr>
<tr><th>Surface Courses</th><th>Binder and Level up courses</th><th>Base Courses</th></tr>
<tr><td>Arterials</td><td>PG 76-22</td><td>PG 70-22</td><td rowspan="3">PG 64-22</td></tr>
<tr><td>Local Type B Streets</td><td>PG 70-22</td><td rowspan="2">PG 64-22</td></tr>
<tr><td>Local Type A Streets</td><td>PG 64-22</td></tr>
</table>

Aggregates known to be prone to stripping should not be used in the hot mix. If such aggregates are used measures should be taken to mitigate this concern. The mix should have at least 70 percent strength retention when tested in accordance with TEX-531-C.

Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method TEX-207-F. The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from Project pavement specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required pavement specimens at their expense and in a manner and at locations selected by the Engineer.

Prime Coat - The prime coat should consist of sealing the base with an oil such as MC-30 or AE-P asphalt cement. The prime coat should be applied at a rate not to exceed 0.35 gallons per square yard with materials which meet TxDOT Item 300. The prime coat will help to minimize penetration of rainfall and other moisture that penetrates the base.

Granular Base Material - Base material may be composed of crushed limestone base meeting all of the requirements of 2014 TxDOT Item 247, Type A, Grade 1 or 2; and should have no more than 15 percent of the material passing the No. 200 sieve. The base should be compacted to at least 95 percent of the maximum dry density determined in accordance with test method TEX-113-E at moisture contents ranging between -2 and +3 percentage points of the optimum moisture content.

Lime Treatment - Lime treatment shall be performed only on the dark brown clay subgrade. The subgrade shall be treated with hydrated lime in accordance with TxDOT Item 260. We anticipate that approximately four (4) percent hydrated lime will be required (approximately 22 pounds per square yard). The optimum hydrated lime content should result in a soil-lime mixture with a pH of at least 12.4 when tested in accordance with ASTM C 977, Appendix XI.

The hydrated lime should initially be blended with a mixing device such as a pulvermixer. After sufficient moisture conditioning, the treated soil mixture shall be compacted to at least 95 percent of the maximum dry density as determined in accordance with the Standard effort (ASTM D 698) at moisture contents from optimum to +4 percentage points of the optimum moisture content. If the in-place gradation requirements can be achieved during initial mixing, the remixing after the curing period can be eliminated.

Details regarding subgrade preparation are presented in Pavement Earthwork Section 4.3.1

6.0 STRUCTURAL RECOMMENDATIONS

6.1 Seismic Design Parameters

Presented below are the seismic design criteria for the Project site and immediate area.

Description	Value
2015 International Building Code Site Classification (IBC)[1]	D[2]
Site Latitude	29.21546°
Site Longitude	-98.44546°
Maximum Considered Earthquake 0.2 second Design Spectral Response Acceleration (S_{DS})	0.099 g
Maximum Considered Earthquake 1.0 second Design Spectral Response Acceleration (S_{D1})	0.043 g

1 As per the requirements of Section R301.2.2.1.1 in the 2015 IRC and Section 1613.3.2 in the 2015 IBC, the site class definition was determined using SPT N-values in conjunction with Table 20.3-1 of the ASCE 7. The Spectral Acceleration values were determined using publicly available information provided on the United States Geological Survey (USGS) website. The above criteria can be used to determine the Seismic Design Category using Table R301.2.2.1.1 in the 2015 IRC.

2 Note: Chapter 20 of ASCE 7 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. The borings extended to a maximum depth of ***15 feet***, and this seismic site class definition considers that similar soils continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration.

6.2 Shallow Foundations

Please note that the foundation design recommendations and construction guidelines provided in this section are ***preliminary*** and shall _only_ be used for planning and budgeting purposes; not for final foundation design.

The subsurface soils exhibit a high potential to undergo expansion and contraction with fluctuations in their moisture contents. Based on our calculations, the subsoils at this site may yield a Potential Vertical Rise (PVR) ranging from less than 1 inch to approximately 1½ inches. The actual movements could be greater if inadequate drainage or other sources of water are allowed to infiltrate beneath the structures after construction. TTL understands that slab foundation systems are being planned to support the residential structures. Recommendations for this foundation type are presented below.

6.2.1 Preliminary Monolithic Slab and Beam Foundation Recommendations

The slab foundation shall be designed as a rigid unit such that if the subsoils expand or contract, the entire slab foundation would move as one unit. ***Please note that a rigid foundation system does not eliminate potential foundation movement due to expansion or contraction of the subsoils. As stated previously, the subsoils may yield a PVR ranging from less than 1 inch to approximately 1½ inches, thus foundation movement of approximately less than 1 inch to 1½ inches should be expected.*** Should this range of potential foundation movement exceed the desired performance, earthwork operations may be required to reduce the PVR of subsoils. TTL can provide these recommendations once a desired PVR is provided to us.

The foundation system would consist of perimeter and interior concrete foundation beams poured monolithic with the slab. Based on subsurface conditions encountered at the Site, without accounting for any cuts or fills, ***preliminary*** design parameters for this foundation type are provided below. The foundation parameters are provided for the observed soil conditions and are presented in the following table.

EXISTING CONDITIIONS			
PTI Method: 3rd Edition [1,3,4,5]			
Vertical Moisture Barrier Depth (ft) [6]:	<2½	2½	3
Edge Moisture Variation Distance (e_m):			
Center Lift (ft):	9.0	8.6	8.5
Edge Lift (ft):	4.5	3.7	3.2
Maximum Unrestrained Differential Soil Movement or Swell (y_m):			
Center Lift (in):	1.2	0.9	0.9
Edge Lift (in):	1.6	1.1	1.0
Coefficient of Slab-Subgrade Friction (μ):	0.75	0.75	0.75
Net Allowable Bearing Pressures [2]:			
Total Load Conditions (psf):	2,600	2,600	2,600
Dead Load Plus Gravity Live Load Conditions (psf):	1,700	1,700	1,700
Maximum Allowable Deflection Ratio of Foundation Beam:	1/360	1/360	1/360

Notes Applicable to the PTI Slab Foundation Design:	
1	Design parameters based on preparing the subgrade and constructing a residential pad as recommended in this report in the section entitled **Compacted Fill**.
2	Includes a factor of safety (FS) of at least 2 for total load conditions and at least 3 for dead load plus gravity live load conditions.
3	If the floor slab of the foundation is to be covered with wood, vinyl tile, carpet, or other moisture sensitive or impervious coverings, a vapor barrier should be placed beneath concrete slab foundations or concrete floor slabs if they are bearing directly on the ground. The designer should be familiar with the American Concrete Institute (ACI) 302 for procedures and cautions about the use and placement of a vapor barrier.
4	The width of foundation grade beams should not be less than 10 inches. The minimum bearing depth below adjacent ground surface (also referred to as “final grade”) should not be less than 18 inches for exterior (i.e., perimeter) foundation grade beams. Interior foundation grade beams should not be less than 12 inches below the bottom of the slab. These foundation dimension recommendations are for proper development of bearing capacity for the foundations and to reduce the potential for water to migrate beneath the foundation. These recommendations are not based on structural considerations of the applicable design method. Actual foundation depths and widths may need to be greater than the minimum recommended herein for structural considerations, which should be properly evaluated and designed by the Structural or Foundation Engineer.
5	This is essentially an empirical design method and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the PTI design manual.
6	According to the PTI 3rd Edition, a vertical barrier must extend at least 30 inches below the adjacent ground surface to be considered as having any significant effect. Foundation beams bearing less than 30 inches below adjacent ground surface (“final grade”) are not considered a vertical moisture barrier.
7	According to the PTI 3rd Edition, once the foundation plan has been determined, the Shape Factor (SF) shall be calculated. If the SF exceeds 24, the designer should contact us to discuss additional geotechnical engineering recommendations to reduce the y_m and e_m values to recommended values.

At the time of the field exploration mass grading of the site had not been conducted. Our recommendations for PTI design are based on the subsoil conditions that we encountered during our drilling operations on the existing grading and our assumptions that the FFE will be within 6 *inches of the existing grades. If this information changes, please contact us so that we can revise our recommendations.*

The minimum bearing depth below the adjacent ground surface (also referred to as “final grade”) should not be less than ***18 inches*** for exterior (i.e., perimeter) foundation grade beams. Interior foundation grade beams should not be less than ***12 inches*** below the bottom of the slab. The foundation beams may be sized for a net allowable total load-bearing pressure of 2,600 psf (pounds per square foot) or a net allowable dead plus gravity live load-bearing pressure of 1,700 psf if bearing below 2½ feet below existing grade or if bearing on a minimum of 1 foot of properly compacted select fill soils. For the foundation beams bearing in the upper 2½ feet of the natural soils, the foundation beams may be sized for a net allowable total load-bearing pressure of 1,300 psf or a net allowable dead plus gravity live load-bearing pressure of 800 psf.

6.2.2 Foundation Construction Considerations

Excavations for the foundation beams shall be neat excavated with a smooth-mouthed bucket. If a toothed bucket is used, excavation with this bucket should be stopped 6 inches above the final foundation beam bearing elevation and the foundation beam excavation completed with a smooth-mouthed bucket or by hand labor. Debris in the bottom of the foundation beam excavation should be removed prior to steel placement. All loose materials should be removed from the over-excavated areas and filled with lean concrete or compacted cement stabilized sand (two sacks cement to one cubic yard of sand).

The foundation beam excavations should be sloped sufficiently to create internal sumps for runoff collection and removal of water. If surface runoff water or subsurface water seepage in excess of 1 inch accumulates at the bottom of the foundation beam excavation, it should be collected and removed so that the ponding water does not adversely affect the quality of the foundation beam bearing surface. Special care should also be taken to protect the exposed foundation beam bearing soils from being disturbed or drying out prior to placement of the concrete.

7.0 LIMITATIONS

This geotechnical engineering report has been prepared for the exclusive use of our Client for specific application to this Project. This geotechnical engineering report has been prepared in accordance with generally accepted geotechnical engineering practices using that level of care and skill ordinarily exercised by licensed members of the engineering profession currently practicing under similar conditions in the same locale. No warranties, express or implied, are intended or made.

TTL understands that this geotechnical engineering report will be used by the Client and various individuals and firms’ designers and contractors involved with the design and construction of the Project. TTL should be invited to attend Project meetings (in person or teleconferencing) or be contacted in writing to address applicable issues relating to the geotechnical engineering aspects of the Project. TTL should also be retained to review the final construction plans and specifications to evaluate if the information and recommendations in this geotechnical engineering report has have been properly interpreted and implemented in the design and specifications. This report has not been prepared as, and should not be used as, a design or specification document to be directly implemented by the contractor. The contractor and applicable subcontractors should familiarize themselves with this report prior to the start of their construction activities, contact TTL for any interpretation or clarification of the report, and retain the services of their own consultants to interpret this report, or perform additional geotechnical testing prior to bidding and construction.

This geotechnical engineering report is based upon the information provided to us by the Client and various other individuals and entities professionals associated with the Project, exploratory borings/test pits drilled within the Project limits, laboratory testing of randomly selected soil or rock samples recovered during drilling of the exploratory borings, and our engineering analyses and evaluation. The Client and readers of this geotechnical engineering report, should realize that subsurface variations and anomalies can and will may exist across the site and between the exploratory boring locations. The Client and readers should realize that site conditions will can change due to the modifying effects of seasonal and climatic conditions and conditions at times after the exploration may be different than reported herein.

The nature and extent of such site or subsurface variations may not become evident until construction commences or is in progress. If site and subsurface anomalies or variations exist or develop, TTL should be contacted immediately so that the situation can be and authorized to evaluate such conditions and, if necessary, addressed with provide applicable recommendations. The contractor and applicable subcontractors should familiarize themselves with this report prior to the start of their construction activities, contact TTL for any interpretation or clarification of the report, and retain the services of their own consultants to interpret this report, or perform additional geotechnical testing prior to bidding and construction.

Unless stated otherwise in this report or in the contract documents between TTL and Client, our scope of services for this Project did not include, either specifically or by implication, any environmental or biological assessment of the site or buildings, or any identification or prevention of pollutants, hazardous materials or conditions at the site or within buildings. If the Client is concerned about the potential for such contamination or pollution, TTL should be contacted to provide a scope of additional services to address the environmental concerns. Also, permitting, site safety, excavation support, and dewatering requirements are the responsibility of others.

Should the nature, design, or location of the Project, as outlined in addressed by this geotechnical engineering report, be modified, the geotechnical engineering recommendations and guidelines provided in this document will not be considered valid unless TTL is authorized to reviews the changes and either verifies or modifies the applicable Project changes in writing.

Additional information about the use and limitations of a geotechnical report is provided within the Geo-professional Business Association document included at the end of this report.

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:
- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:
- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are <u>not</u> final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are <u>Not</u> Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will <u>not</u> of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are <u>not</u> building-envelope or mold specialists.***

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

Telephone: 301/565-2733
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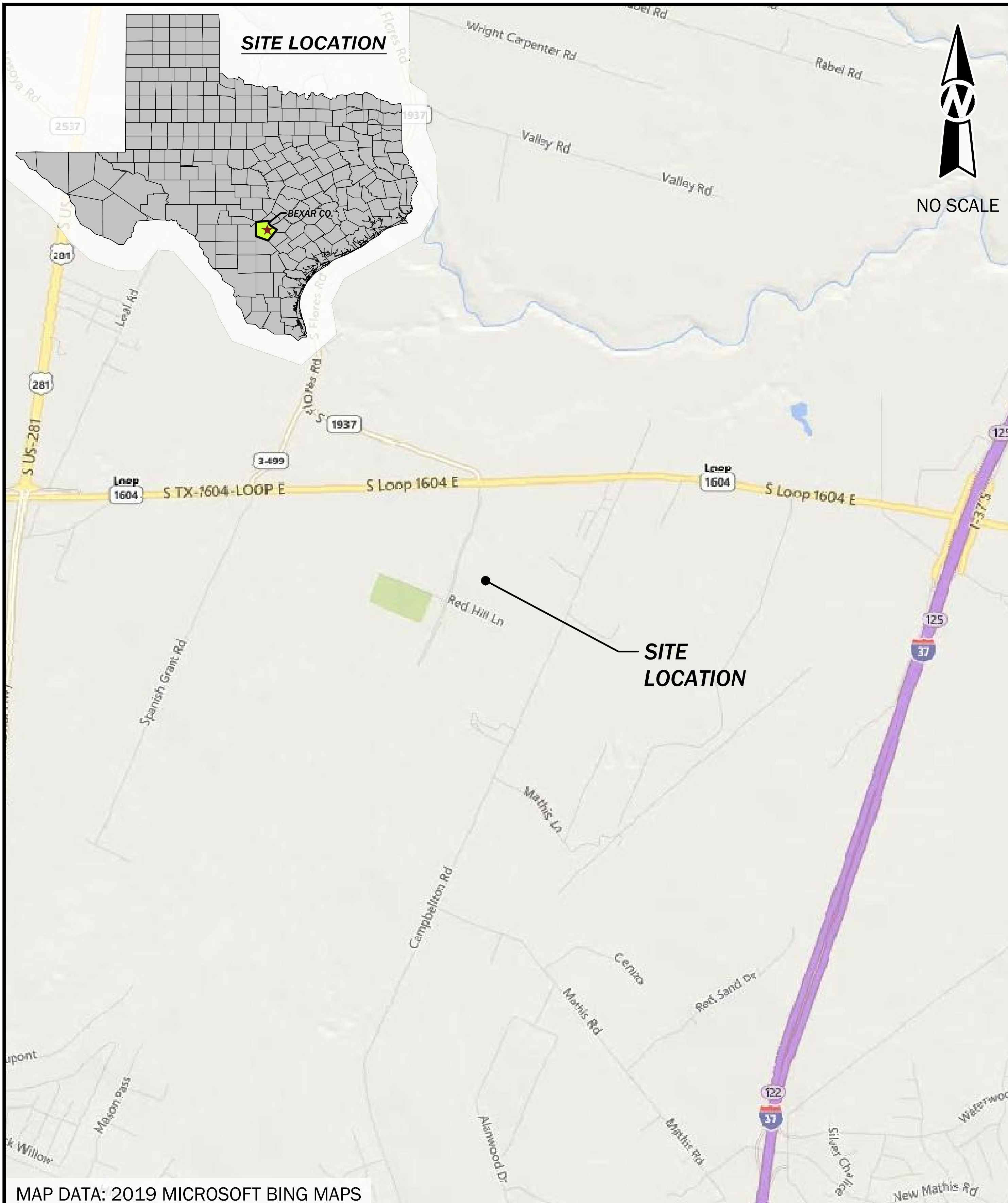
APPENDIX A
ILLUSTRATIONS



MAP DATA: 2019 MICROSOFT BING MAPS

TTL

1045 Central Parkway North, Suite 103 | San Antonio, TX 78232
210.888.6100 | www.ttlusa.com
TBPE Registration: F-12622 | TBPG Registration: 50456

COPPER RIDGE (RUBY CROSSING)
LENNAR

NORTHEAST QUADRANT FORMED BY THE RED HILL LANE AND RED FOREST LANE
SAN ANTONIO, BEXAR COUNTY, TEXAS

Drawn By: S M
Checked By: B B
Date: 05/08/19
Proj. No.: 000190901138.02
File Name: 191138.SLM.dwg

EXHIBIT 1
SITE LOCATION MAP

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17215 Jones Maltsberger Rd., Suite 101 | San Antonio, TX 78247
210.888.6100 | www.ttlusa.com
TBPE Registration: F-12622 | TBPG Registration: 50456

COPPER RIDGE (RUBY CROSSING)
LENNAR

NORTHEAST QUADRANT FORMED BY THE RED HILL LANE AND RED FOREST LANE
SAN ANTONIO, BEXAR COUNTY, TEXAS

Drawn By: JMP
Checked By: AB
Date: 05/23/23
Proj. No.: 000190901138.02
File Name: 191138.BLP2.dwg

EXHIBIT 2
BORING LOCATION PLAN

SOIL LEGEND

FINE- AND COARSE-GRAINED SOIL INFORMATION

FINE-GRAINED SOILS (SILTS AND CLAYS)

SPT N-Value	Consistency	Estimated Q_u (TSF)
0 - 1	Very Soft	0 - 0.25
2 - 4	Soft	0.25 - 0.5
5 - 8	Firm	0.5 - 1.0
9 - 15	Stiff	1.0 - 2.0
16 - 30	Very Stiff	2.0 - 4.0
31+	Hard	4.0+

Q_u = Unconfined Compression Strength

COARSE-GRAINED SOILS (SANDS AND GRAVELS)

SPT N-Value	Relative Density
0 - 4	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
51+	Very Dense

PARTICLE SIZE

Name	Size (US Std. Sieve)
Boulders	>300 mm (>12 in.)
Cobbles	75 mm to 300 mm (3 - 12 in.)
Coarse Gravel	19 mm to 75 mm (3/4 - 3 in.)
Fine Gravel	4.75 mm to 19 mm (#4 - 3/4 in.)
Coarse Sand	2 mm to 4.75 mm (#10 - #4)
Medium Sand	0.425 mm to 2 mm (#40 - #10)
Fine Sand	0.075 mm to 0.425 mm (#200 - #40)
Silts and Clays	< 0.075 mm (< #200)

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Terms	Percent of Dry Weight
"Trace"	< 15
"With"	15 - 30
Modifier	> 30

RELATIVE PROPORTIONS OF CLAYS AND SILTS

Descriptive Terms	Percent of Dry Weight
"Trace"	< 5
"With"	5 - 12
Modifier	> 12

CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

CRITERIA FOR DESCRIBING CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

CRITERIA FOR DESCRIBING STRUCTURE

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note the thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

SAMPLERS AND DRILLING METHODS

- AUGER CUTTINGS
- BAG/BULK SAMPLE
- GRAB SAMPLE
- CONTINUOUS SAMPLES
- SHELBY TUBE SAMPLE
- PITCHER SAMPLE
- STANDARD PENETRATION SPLIT-SPOON SAMPLE
- SPLIT-SPOON SAMPLE WITH NO RECOVERY
- DYNAMIC CONE PENETROMETER
- ROCK CORE

WATER LEVEL SYMBOLS

- WATER LEVEL AT TIME OF DRILLING
- PERCHED WATER OBSERVED AT DRILLING
- DELAYED WATER LEVEL OBSERVATION
- CAVE-IN DEPTH
- OBSERVED SEEPAGE

ABBREVIATIONS AND ACRONYMS

WOH	Weight of Hammer
WOR	Weight of Rod
Ref.	Refusal
ATD	At Time of Drilling
DCP	Dynamic Cone Penetrometer
Elev.	Elevation
ft.	feet
HSA	Hollow Stem Auger
ID	Inside Diameter
in.	inches
lbs	pounds
N-Value	Sum of the blows for last two 6-in increments of SPT
NA	Not Applicable or Not Available
OD	Outside Diameter
PPV	Pocket Penetrometer Value
SFA	Solid Flight Auger
SH	Shelby Tube Sampler
SS	Split-Spoon Sampler
SPT	Standard Penetration Test
USCS	Unified Soil Classification System

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UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

Major Division				Symbol	Description
COARSE GRAINED SOILS (>50% of the material is larger than the #200 sieve)	GRAVELS (>50% of coarse fraction is larger than the #4 sieve)	CLEAN GRAVEL WITH <5% FINES	Cu > 4 Cc = 1-3	GW	Well-graded gravels, gravel-sand mixtures with trace or no fines
			Cu ≤ 4 and/or Cc < 1 Cc > 3	GP	Poorly-graded gravels, gravel-sand mixtures with trace or no fines
		GRAVEL WITH 5% TO 12% FINES	Cu > 4 Cc = 1-3	GW-GM	Well-graded gravels, gravel-sand mixtures with silt fines
				GW-GC	Well-graded gravels, gravel-sand mixtures with clay fines
			Cu ≤ 4 and/or Cc < 1 Cc > 3	GP-GM	Poorly-graded gravels, gravel-sand mixtures with silt fines
				GP-GC	Poorly-graded gravels, gravel-sand mixtures with clay fines
		GRAVEL WITH MORE THAN 12% FINES		GM	Silty gravels, gravel-silt-sand mixtures
				GC	Clayey gravels, gravel-sand-clay mixtures
				GC-GM	Clayey gravels, gravel-sand-clay-silt mixtures
	SANDS (>50% of coarse fraction is smaller than the #4 sieve)	CLEAN SAND WITH <5% FINES	Cu > 6 Cc = 1-3	SW	Well-graded sands, sand-gravel mixtures with trace or no fines
			Cu ≤ 6 and/or Cc < 1 Cc > 3	SP	Poorly-graded sands, sand-gravel mixtures with trace or no fines
		SAND WITH 5% TO 12% FINES	Cu > 6 Cc = 1-3	SW-SM	Well-graded sands, sand-gravel mixtures with silt fines
				SW-SC	Well-graded sands, sand-gravel mixtures with clay fines
			Cu ≤ 6 and/or Cc < 1 Cc > 3	SP-SM	Poorly-graded sands, sand-gravel mixtures with silt fines
				SP-SC	Poorly-graded sands, sand-gravel mixtures with clay fines
		SAND WITH MORE THAN 12% FINES		SM	Silty sands, sand-gravel-silt mixtures
				SC	Clayey sands, sand-gravel-clay mixtures
				SC-SM	Clayey sands, sand-gravel-clay-silt mixtures
FINE GRAINED SOILS (>50% of material is smaller than the #200 sieve)		SILTS & CLAYS (Liquid Limit less than 50)		ML	Inorganic silts with low plasticity
				CL	Inorganic clays of low plasticity, gravelly or sandy clays, silty clays, lean clays
				CL-ML	Inorganic clay-silts of low plasticity, gravelly clays, sandy clays, silty clays, lean clays
				OL	Organic silts and organic silty clays of low plasticity
		SILTS & CLAYS (Liquid Limit more than 50)		MH	Inorgatinc silts of high plasticity, elastic silts
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic clays and organic silts of high plasticity

USCS - HIGHLY ORGANIC SOILS

Primarily organic matter, dark in color, organic odor	
PT	Peat, humus, swamp soils with high organic contents

OTHER MATERIALS

BITUMINOUS CONCRETE (ASPHALT)
CONCRETE
CRUSHED STONE/AGGREGATE BASE
TOPSOIL
FILL
UNDIFFERENTIATED ALLUVIUM
UNDIFFERENTIATED OVERBURDEN
BOULDERS AND COBBLES

<u>UNIFORMITY COEFFICIENT</u>

$$C_u = D_{60}/D_{10}$$

<u>COEFFICIENT OF CURVATURE</u>

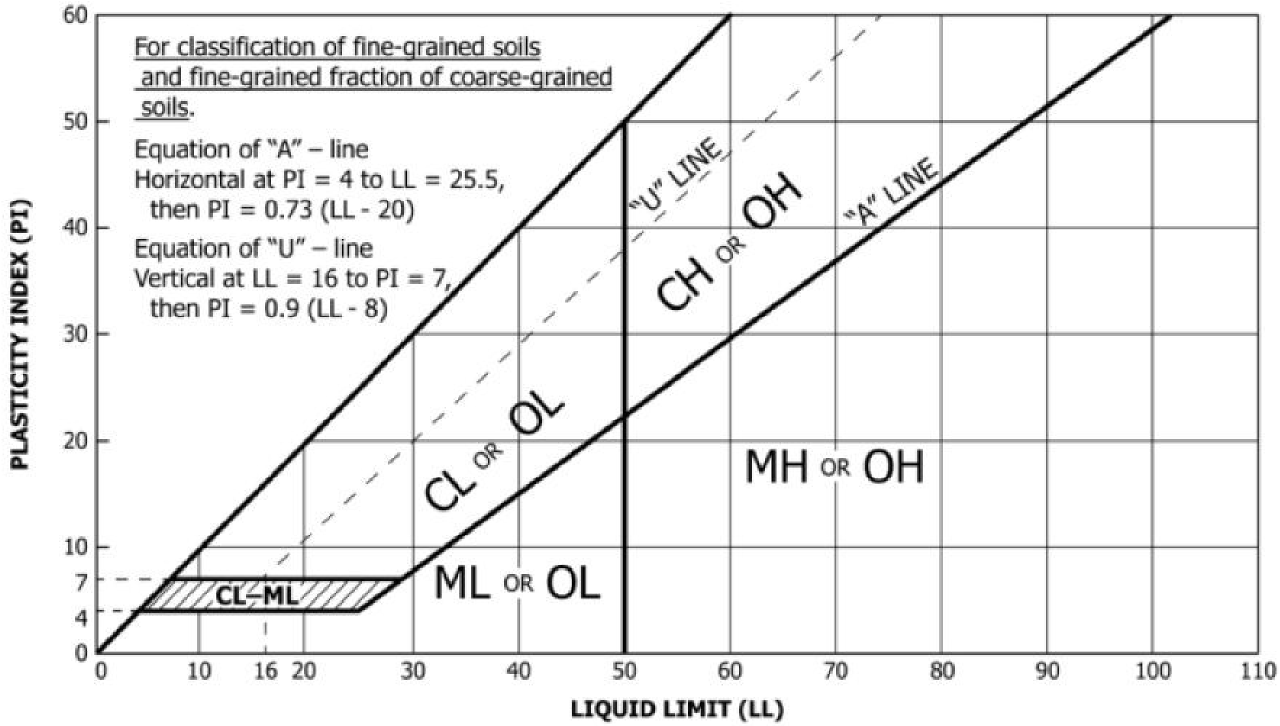
$$C_C = (D_{30})^2/(D_{60} x D_{10})$$

Where:

D_{60} = grain diameter at 60% passing
D_{30} = grain diameter at 30% passing
D_{10} = grain diameter at 10% passing

TTL

PLASTICITY CHART FOR USCS CLASSIFICATION OF FINE-GRAINED SOILS



IMPORTANT NOTES ON TEST BORING RECORDS

1) The report and graphics key are an integral part of these logs. All data and interpretations in this log are subject to the explanations and limitations stated in the report.

2) Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual or differ from those shown. Solid lines are used to indicate a change in the material type, particularly a change in the USCS classification. Dashed lines are used to separate two materials that have the same material type, but that differ with respect to two or more other characteristics (e.g. color, consistency).

3) No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.

4) Logs represent general soil and rock conditions observed at the point of exploration on the date indicated.

5) In general, Unified Soil Classification System (USCS) designations presented on the logs were based on visual classification in the field and were modified where appropriate based on gradation and index property testing.

6) Fine-grained soils that plot within the hatched area on the Plasticity Chart, and coarse-grained soils with between 5% and 12% passing the #200 sieve require dual USCS symbols as presented on the previous page.

7) If the sampler is not able to be driven at least 6 inches, then 50/X" indicates that the sampler advanced X inches when struck 50 times with a 140-pound hammer falling 30 inches.

8) If the sampler is driven at least 6 inches, but cannot be driven either of the subsequent two 6-inch increments, then either 50/X" or the sum of the second 6-inch increment plus 50/X" for the third 6-inch increment will be indicated.

Example 1: Recorded SPT blow counts are 16 - 50/4", the SPT N-value will be shown as N = 50/4"

Example 2: Recorded SPT blow counts are 18 - 25 - 50/2", the SPT N-value will be shown as N = 75/8"

TTL

LENNAR
Copper Ridge (Ruby Crossing)
Red Hill Lane and Red Forest Lane
Bexar County, Texas

Log of B-03

Drilling Co.:	*Eagle Drilling*	**TTL** Project No.:	*00190901138.02*
Driller:	*WD*	Date Drilled:	*5/16/2019*
Logged by:	*EG*	Boring Depth:	*15 feet*
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*
Hammer Type:	*Automatic*	Coordinates:	*Not Available*
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*
		Cave-In at Time of Drilling:	*N/A*

Remarks:
Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.
.

Delayed Water Level: *N/A*

Delayed Water Observation Date: *N/A*

SAMPLE DATA

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	TYPE	BORE/CORE DATA: N-VALUE BLOWS/FT (1st 6" 2nd 6" 3rd 6")	P: TONS/SOFT	RQD / % REC	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
			CLAYEY SAND (SC), loose, dark brown - with organics		4 - 4 - 2 N = 6			13	15	11	4					
			LEAN CLAY with Sand (CL), hard, dark brown		3 - 14 - 17 N = 31			23								
	5		SANDY LEAN CLAY (CL), firm, yellowish-brown		4 - 4 - 4 N = 8			13	34	14	20					59.9
			- stiff, light brown below 6 foot depth		4 - 4 - 5 N = 9			13								
			- light brown with dark reddish-brown and calcareous deposits below 8 foot depth		5 - 5 - 6 N = 11			12	31	14	17					52.0
	10		CLAYEY SAND (SC), dense, reddish-gray brown		12 - 16 - 17 N = 33			9								
	15		Boring terminated at 15 feet.													

LENNAR
Copper Ridge (Ruby Crossing)
Red Hill Lane and Red Forest Lane
Bexar County, Texas

Drilling Co.:	*Eagle Drilling*	**TTL** Project No.:	*00190901138.02*
Driller:	*WD*	Date Drilled:	*5/16/2019*
Logged by:	*EG*	Boring Depth:	*15 feet*
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*
Hammer Type:	*Automatic*	Coordinates:	*Not Available*
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*
		Cave-In at Time of Drilling:	*N/A*

Remarks:
Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.
.

Delayed Water Level: *N/A*

Delayed Water Observation Date: *N/A*

SAMPLE DATA

ELEVATION (ft)	DEPTH (ft)	MATERIALS DESCRIPTION	N-VALUE BLOWS/FT (1st 6" - 2nd 6" - 3rd 6") / P: TONS/SQFT	MOISTURE CONTENT (%)	LL	PL	PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
	0	CLAYEY SAND (SC), loose, dark brown										
			2 - 2 - 3 N = 5	13								40.0
	2	SANDY LEAN CLAY (CL), stiff, dark brown with reddish-brown	4 - 4 - 5 N = 9	11	37	12	25					
	4	SANDY FAT CLAY (CH), hard, yellowish-brown										
	5		P = 4.5									
		- with calcareous deposits below 6 foot depth										
			10 - 14 - 23 N = 37	9	52	17	35					70.4
		- mottled brown and gray below 8 foot depth										
			12 - 15 - 18 N = 33	7								
	10	SANDY LEAN CLAY (CL), hard, light yellowish-brown with light redidsh-brown										
			13 - 21 - 34 N = 55	15	39	16	23					64.9
	15	Boring terminated at 15 feet.										

LENNAR
Copper Ridge (Ruby Crossing)
Red Hill Lane and Red Forest Lane
Bexar County, Texas

Drilling Co.:	*Eagle Drilling*	**TTL** Project No.:	*00190901138.02*
Driller:	*WD*	Date Drilled:	*5/16/2019*
Logged by:	*EG*	Boring Depth:	*15 feet*
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*
Hammer Type:	*Automatic*	Coordinates:	*Not Available*
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*
		Cave-In at Time of Drilling:	*N/A*

Remarks:
Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.
.

Delayed Water Level: *N/A*
Delayed Water Observation Date: *N/A*

SAMPLE DATA

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	TYPE	BORE/CORE DATA: 1st 6" - 2nd 6" - 3rd 6", N-VALUE BLOWS/FT	P: TONS/SQFT	RQD / % REC	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%): LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
	0–2		CLAYEY SAND (SC), medium dense, light brown with reddish-brown	X	10 - 9 - 10 N = 19			15								
	2–4		SANDY LEAN CLAY (CL), very stiff, dark brown with reddish-brown	X	11 - 9 - 11 N = 20			12	42	15	27					
	4–10		SANDY FAT CLAY (CH), very stiff to hard, dark brown with light brown	X	9 - 10 - 11 N = 21			12								
			- hard below 6 foot depth	X	10 - 16 - 20 N = 36			14								66.3
			- mottled brown and gray below 8 foot depth	X	8 - 14 - 16 N = 30			15	51	17	34					
	10–15		SANDY LEAN CLAY (CL), hard, mottled yellowish brown and gray	X	12 - 19 - 18 N = 37			10								
	15		Boring terminated at 15 feet.													

R:\GINT\TTL\PROJECTS\2019\00190901138.02 -- COPPER RIDGE-LENNAR.GPJ 5/24/23 Report:1-GEOTECH LOG - LAT LONG

LENNAR Copper Ridge (Ruby Crossing) Red Hill Lane and Red Forest Lane Bexar County, Texas	Log of B-07 Page 1 of 1

Drilling Co.:	*Eagle Drilling*	TTL Project No.:	*00190901138.02*	Remarks: Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location. .
Driller:	*WD*	Date Drilled:	*5/16/2019*	
Logged by:	*EG*	Boring Depth:	*15 feet*	
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*	
Hammer Type:	*Automatic*	Coordinates:	*Not Available*	
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling: *Not Encount.* Cave-In at Time of Drilling: *N/A*		Delayed Water Level: *N/A* Delayed Water Observation Date: *N/A*

ELEVATION (ft)	DEPTH (ft)	MATERIALS DESCRIPTION	TYPE	BORE/CORE DATA: 1st 6" - 2nd 6" - 3rd 6" N-VALUE BLOWS/FT	P: TONS/SQFT	RQD / % REC	MOISTURE CONTENT (%)	LL	PL	PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
	0–2	CLAYEY SAND (SC), loose, brown - organics	SPT	2 - 2 - 5 N = 7			11								28.5
	2–6	LEAN CLAY (CL), stiff, reddish brown and gray - calcareous deposits	SPT	3 - 4 - 6 N = 10			19								
			Shelby												
	6–15	CLAYEY SAND (SC), light brown	SPT	4 - 5 - 7 N = 12			16								
			SPT	4 - 5 - 7 N = 12			17								42.5
		- light gray below 13 foot depth	SPT	13 - 21 - 41 N = 62			16								
	15	Boring terminated at 15 feet.													

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TTL	LENNAR Copper Ridge (Ruby Crossing) Red Hill Lane and Red Forest Lane Bexar County, Texas	Log of B-08 Page 1 of 1

Drilling Co.:	*Eagle Drilling*	TTL Project No.:	*00190901138.02*	Remarks: Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.	
Driller:	*WD*	Date Drilled:	*5/16/2019*		
Logged by:	*EG*	Boring Depth:	*15 feet*		
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*		
Hammer Type:	*Automatic*	Coordinates:	*Not Available*		
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*	Delayed Water Level:	*N/A*
		Cave-In at Time of Drilling:	*N/A*	Delayed Water Observation Date:	*N/A*

SAMPLE DATA

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	TYPE	BORE/CORE DATA: N-VALUE BLOWS/FT (1st 6" - 2nd 6" - 3rd 6") / P: TONS/SQFT / RQD / % REC	MOISTURE CONTENT (%)	ATTERBERG LIMITS (%): LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
			CLAYEY SAND (SC), loose, brown											
				X	1 - 2 - 3 N = 5	10								
			LEAN CLAY with Sand (CL), stiff, mottled brown and gray											
				X	2 - 4 - 6 N = 10	14								
			CLAYEY SAND (SC), dense, reddish-brown mottled with gray											
	5			X	10 - 16 - 17 N = 33	8	32	13	19					
			- medium dense between 6 to 8 foot depths											
				X	13 - 14 - 15 N = 29	8								
			- dense below 8 foot depth											
				X	14 - 17 - 21 N = 38	11	43	16	27					40.8
	10													
				X	11 - 13 - 20 N = 33	14								
	15		Boring terminated at 15 feet.											

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LENNAR
Copper Ridge (Ruby Crossing)
Red Hill Lane and Red Forest Lane
Bexar County, Texas

Drilling Co.:	*Eagle Drilling*	TTL Project No.:	*00190901138.02*
Driller:	*WD*	Date Drilled:	*5/16/2019*
Logged by:	*EG*	Boring Depth:	*15 feet*
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*
Hammer Type:	*Automatic*	Coordinates:	*Not Available*
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*
		Cave-In at Time of Drilling:	*N/A*

Remarks: Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.
.

Delayed Water Level: *N/A*

Delayed Water Observation Date: *N/A*

SAMPLE DATA

DEPTH (ft)	MATERIALS DESCRIPTION	TYPE	BORE/CORE DATA: 1st 6" - 2nd 6" - 3rd 6" / N-VALUE BLOWS/FT	MOISTURE CONTENT (%)	LL	PL	PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
0–2	CLAYEY SAND (SC), medium dense, brown	SPT	4 - 6 - 6 N = 12	9	13	10	3					
2–4	LEAN CLAY with Sand (CL), firm, light brown	SPT	3 - 3 - 5 N = 8	15								
4–15	CLAYEY SAND (SC), medium dense, mottled gray and reddish brown	Core		10								
		SPT	12 - 12 - 13 N = 25	9								43.5
		SPT	9 - 12 - 14 N = 26	10								
	- medium dense below 13 foot depth	SPT	5 - 5 - 7 N = 12	20								

Boring terminated at 15 feet.

LENNAR
Copper Ridge (Ruby Crossing)
Red Hill Lane and Red Forest Lane
Bexar County, Texas

Drilling Co.:	*Eagle Drilling*	**TTL** Project No.:	*00190901138.02*
Driller:	*WD*	Date Drilled:	*5/16/2019*
Logged by:	*EG*	Boring Depth:	*15 feet*
Equipment:	*Mobile B-47*	Boring Elevation:	*Existing grade. feet*
Hammer Type:	*Automatic*	Coordinates:	*Not Available*
Drilling Method:	*Solid Stem Auger w/SPT Sampling*	Water Level at Time of Drilling:	*Not Encount.*
		Cave-In at Time of Drilling:	*N/A*

Remarks:
Subsurface water was not encountered during drilling. Boring was backfilled with cuttings prior to leaving location.
.

Delayed Water Level: *N/A*

Delayed Water Observation Date: *N/A*

ELEVATION (ft)	DEPTH (ft)	MATERIALS DESCRIPTION	TYPE	N-VALUE BLOWS/FT (1st 6" - 2nd 6" - 3rd 6") / P: TONS/SQFT	RQD / % REC	MOISTURE CONTENT (%)	LL	PL	PI	DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
	0–2	CLAYEY SAND (SC), very loose, brown - some calcareous deposits	SPT	1 - 2 - 7 N = 9		15								
	2–4	LEAN CLAY with Sand (CL), stiff, brown with reddish-brown	SPT	2 - 4 - 5 N = 9		14								
	4–15	CLAYEY SAND (SC), dense, reddish-brown - pocket of gray sand observed in 4 to 6 foot soil sample	Shelby Tube	P = 4.5		12	32	14	18					38.4
			SPT	11 - 16 - 20 N = 36		8								
		- medium dense below 8 foot depth	SPT	11 - 13 - 14 N = 27		9								
		- light brown below 13 foot depth	SPT	16 - 22 - 19 N = 41		12								
	15	Boring terminated at 15 feet.												

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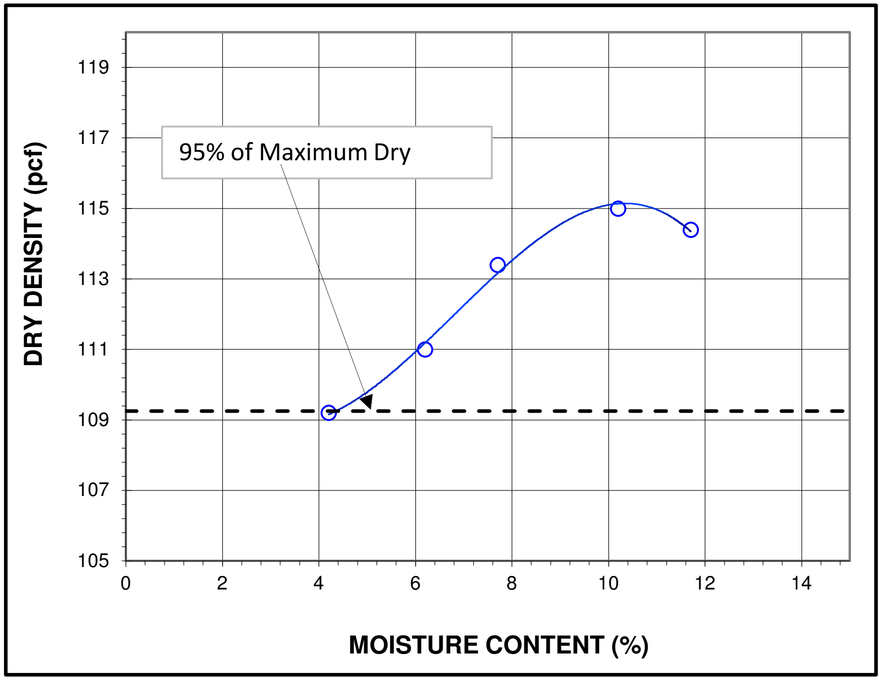

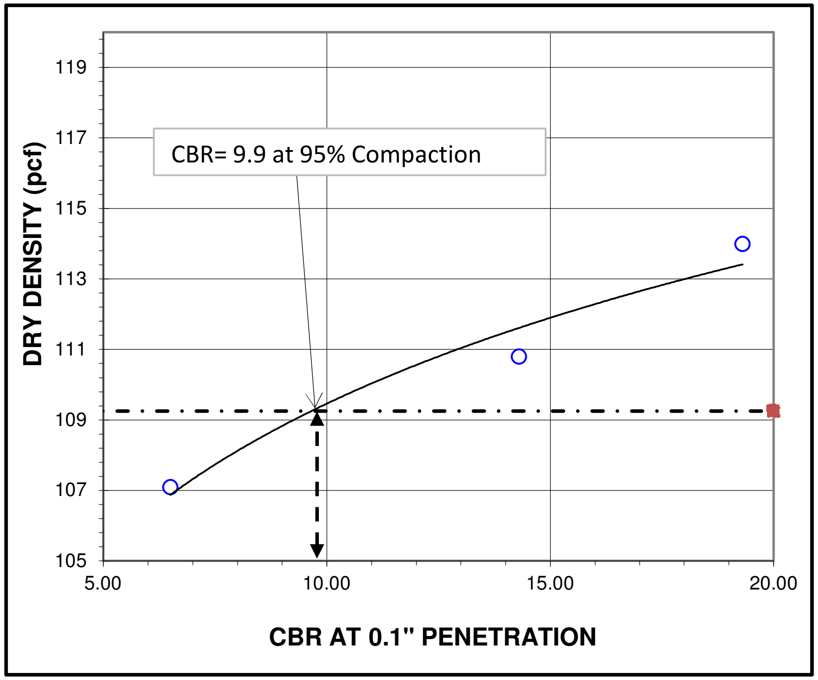

CBR Sample Location: Copper Ridge 29.21479°, -98.44507°
Sample Depth: Between 0 and 5 feet below existing ground surface
Optimum Moisture Content: 10.1 %
Maximum Dry Unit Weight: 115 pcf
Atterberg Limit (PI) non-plastic
Fines (-200 Sieve) % passing 20.1

Sample: CBR # 1
Proctor Test Method: Standard Proctor (ASTM D-698)
CBR Test Method: California Bearing Ration (ASTM D-1883)
Material: CLAYEY SAND (SC), brown

TTL
17215 Jones Maltsberger Rd, Suite 101
San Antonio, Texas 78232
T: 210-340-5004 / F: 210-340-5009
WWW.TTLUSA.COM

Copper Ridge - Lennar

BEXAR COUNTY, TEXAS

Drawn By: BB	
Checked By: AB	
Proj No: 000190901138.02	
File Name	
CBR PLOT	

APPENDIX B
REFERENCE MATERIALS

EXPLORATION PROCEDURES

Field Locating of Explorations

Exploratory borings were located in the field with a hand-held Global Positioning (GPS) device and confirmed with GoogleEarth imagery of the area where project features were superimposed on the imagery. The range of accuracy of the device and the mapping software used to identify locations is not precise; and therefore, the locations of the boreholes should not be considered more accurate than implied by the methods used. Elevations of the ground surface were not indicated on the logs of boring. Surveying the test locations for vertical and horizontal control was beyond the scope of this exploration.

Soil Borings

The borings were drilled using conventional hollow-stem auger drilling methods by a truck-mounted drill rig and an all-terrain-vehicle drill rig. Soil samples were obtained at selected depths in general accordance with the Standard Penetration Test (SPT) described in ASTM D1586. For this test, a split-barrel sampler is driven into the soil through three increments of 6 inches with blows from a 140-pound hammer falling 30 inches. The number of hammer blows required to advance the split barrel sampler through each increment is recorded, and the sum of the final two blow counts is called the "N-value," with units of blows per foot (bpf). Where it was not possible to advance the sampler through a full 6-inch increment with 50 hammer blows, driving the sampler was terminated and the sampler penetration was measured. N-values for this condition are reported as “50/x,” where x is the sampler penetration in inches. The N values recorded during the sampling process provide an index to the strength and compressibility of the soil.

Groundwater Measurements

Each borehole was checked for the presence of groundwater during the drilling operation. Had subsurface water been encountered, the depth would have been obtained after removing the drill tools and lowering a measuring tape down the open borehole. With the presence of subsurface water, the depth to groundwater or the depth at which the borehole caved-in would also have been recorded.

Backfilling Boreholes

Each borehole was backfilled to the ground surface with auger cuttings after making final groundwater measurements. Auger cuttings sometimes consolidate after backfilling causing the top of the backfill column to settle and leaving an open hole at the ground surface. Return trips to the site to top-off backfill that has settled were not part of our scope of services.

LABORATORY TESTING PROCEDURES

Classification, and Index Testing

The recovered soil and rock samples were classified in the laboratory by a geoprofessional using the USCS as a guide. Samples were tested for the following properties in general accordance with the applicable ASTM standards:

- Moisture content (ASTM D2216),
- Atterberg Limits (ASTM D4318),
- Percent material passing the No. 200 sieve (ASTM D1140).

Results of test for moisture content, Atterberg Limits, and percent material passing the No. 200 sieve are presented on individual boring logs in Appendix A. The results are also tabulated on the Summary of Laboratory Results sheet in Appendix A. Results of particle size distributions by sieve analyses and/or hydrometer are presented on separate sheets in Appendix A.