

GEOTECHNICAL ENGINEERING REPORT

Steelwood Trail Subdivision Units 4, 6, & 7

Morningside Drive and Ron Road/County Road 376A
New Braunfels, Comal and Guadalupe Counties, Texas

Prepared for:
Lennar
San Antonio, Texas

Prepared by:
TTL, Inc.
San Antonio, Texas

Project No. 00220900622.00
June 7, 2022





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June 7, 2022

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RE: **Geotechnical Engineering Report**
Steelwood Trail Subdivision Units 4, 6, & 7
Morningside Drive and Ron Road/County Road 376A
Comal and Guadalupe Counties, Texas
TTL Project No.00220900622.00

Dear Mr. Mott:

TTL, Inc. (TTL) is pleased to submit this revised Geotechnical Engineering Report providing **final** pavement section designs and **preliminary** foundation designs for the above-referenced project. If you have any questions regarding our report or need additional services, please do not hesitate to contact us.

The preliminary geotechnical recommendations for foundations and the final pavement section design 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.

Alejandro Manzano Jr.
Project Professional
Geotechnical Services



Amit Bakane, P.E.
Senior Project Engineer
Geotechnical Services

06/07/2022

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GBA Informational Document

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Exploration Procedures
Laboratory Procedures

1.0 PROJECT INFORMATION

1.1 Project Description

Item	Description
Project Location	The project site is located in the northeastern quadrant of Morningside Drive and Ron Road/ County Road 376A in New Braunfels, Comal, and Guadalupe Counties, Texas.
Proposed Development	Based on the plan developed by Pape-Dawson Engineers, we understand there are 1030 residential lots within the Steelwood Trails Subdivision. Of the total number of lots, 501 lots will be located in UnitUnits6, and 7. Associated streets will be constructed as well.
Proposed Construction	The development will consist of one (1) and two (2) story single-family residences. The residences will be supported by a monolithic slab on grade foundations. We understand that Lennar requires preliminary foundation design parameters for the residential lots within this subdivision. Also, pavement design recommendations meeting the City of New Braunfels design guidelines are desired. <i>This report covers only preliminary foundation parameters and final pavement design sections for Units 4, 6, & 7.</i>
Maximum Loads	Loads were not provided to TTL as a part of this project.

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 on February 23, 2022, by Mr. Richard Mott with Lennar by acceptance of our Agreement for Services, TTL proposal No. P00220900622.00, dated February 23, 2022.

2.0 EXPLORATION FINDINGS

2.1 Site Conditions

Item	Description
Existing Site Conditions	The site appears to be relatively undeveloped based on Google Earth aerial imagery and was used for agricultural purposes. A newly developed subdivision can be found on the northwestern and northeastern sides of the project site.
Existing topography	Based on topographic information developed by Pape-Dawson Engineers, units 6 and 7 are generally flat at an El. of 704 feet. The topography of unit 4 ranges from about El. 710.00 feet on the western side to about El. 752.00 feet on the eastern side.

2.2 Site Geology

We reviewed the Geologic Atlas of Texas to determine the geologic setting of the project site and surrounding area. Our review indicated the Project site is located over either the Leona Formation (Qle) or the Fluvatile terrace deposits (Qt) of the Quaternary geologic age. These formations generally consist of gravel, sand, silt, and clay. The Leona and Fluvatile terrace formations typically range from a few feet to several tens of feet in thickness. The surficial Leona or Fluvatile terrace deposits may lay over the Pecan Gap Chalk (Kpg) of the Cretaceous geologic age. This formation generally consists of chalk and chalky marl that weathers into the moderately deep soil.

The thickness of this formation ranges typically from 100 to 400 feet. The Pecan Gap Chalk is known to contain expansive clay soils in the area of the project site.

2.3 Subsurface Stratigraphy

Subsurface conditions within the limits of the project were evaluated by drilling 11 exploratory borings at the approximate locations shown on the Boring Location Plan in Appendix A. Samples obtained during our field exploration were transported to our laboratory, where they were reviewed by geotechnical engineering personnel. Representative samples were selected and tested to determine pertinent engineering properties and characteristics for use in our evaluation of the project site. Based on the information developed during our field exploration and laboratory testing, we have determined the stratigraphy of the site is generally as shown on the logs of boring included in Appendix A.

The boring logs presented in Appendix A represent our interpretation of the subsurface conditions at each individual boring location. Our interpretation is based on tests and observations performed during drilling operations, visual examination of the soil samples by a geotechnical engineer, and laboratory tests conducted on the retrieved soil samples. The USCS classifications shown on the boring logs represent classifications based on either visual examination, laboratory testing, or both. The lines designating the interfaces between various strata on the boring logs represent the approximate strata boundary. 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 boring location as subsurface variations may occur between boring locations.

2.4 Subsurface Water Conditions

Subsurface water was not detected either during or upon completion of our exploratory borings. Upon completion of subsurface water observations, the boreholes were backfilled with the spoils generated during drilling operations.

Subsurface water is generally encountered as a ‘true’ or permanent continuous water source that is generally present year-round or as a discontinuous, isolated “perched” or temporary water source 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. The contractor should check for subsurface water before the commencement of excavation activities.

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 Soils

The expansive potential of a given soil profile may be characterized using the Potential Vertical Rise (PVR) methodology as described in the Texas Department of Transportation (TxDOT) Method TEX-124-E. This methodology is used to estimate how much a given point located on the ground surface may move due to volumetric changes in the soil resulting from fluctuations in soil moisture content. Based on our laboratory test results, the estimated PVR of this site ranges from about three (3) inches to about five (5) inches in its present condition. **These estimated PVR values indicate the soils at this site are highly expansive. Care should be taken to carefully evaluate the potential effects of these movements on the structural design of the residential foundations planned for this project.**

3.2 Corrosion Considerations

To evaluate the potential for sulfate exposure to the concrete used to construct foundations for this project, laboratory testing was conducted on soil samples recovered during the field exploration. Selected soil samples were submitted to an analytical laboratory to determine the sulfate content of each sample. The results of that laboratory testing are shown in the following table.

Summary of Laboratory Testing			
Boring No.	Sample Depth (ft.)	Sulfate (ppm)	ACI 318-14 Exposure Class
B-1	4½ - 6	62.7	S0
B-3	2½ - 4	63.5	S0
B-5	2½ - 4	84.6	S0
B-7	½ - 2	69.4	S0

According to the 2015 International Residential Code, concrete that will be 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, which infers that sulfate exposure to concrete is not an issue. Therefore, Type I/II cement may be used.

4.0 EARTHWORK RECOMMENDATIONS

4.1 Building Pad Preparation

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, along with subgrade preparation beneath the residential structures, pavements, and other areas to receive fill materials.

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 existing subsurface conditions we encountered during our drilling operations conducted at accessible locations within the project site. Further geotechnical field exploration consisting of additional test borings will need to be conducted after the mass grading is completed in order to characterize the actual bearing soils and their strength conditions. The final design foundation recommendations will be impacted by the modified site conditions.

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 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 otherwise unsuitable materials from planned construction areas.

- Stripping should extend at least three (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 and loose topsoil, should be removed from the site or disposed of at designated on-site areas located outside the limits of current or future development.

4.1.2 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 of 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 and

compacted to at least 95 percent of the maximum dry density determined in accordance with the Standard compaction effort (ASTM D 698). 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. 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. 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 4.2 of this report.

4.1.3 Proof-rolling

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

- Perform proof-rolling 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).
- Proof-rolling 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, or wet, or frozen.
- A TTL geotechnical engineer or their representative should observe the proof-rolling to identify, document, and mark areas of unstable subgrade response, such as pumping, rutting, or shoving, if any.

4.1.4 Underground Storage Tanks and Septic Tanks

Underground storage tanks, septic tanks, and any associated piping should be excavated and completely removed. On-site soils (i.e., general fill) or select fill meeting the specifications provided in Section 4.2 of this report should then be placed to match the desired final grade. It is likely that the excavation required to remove these tanks and piping will result in excavation depths greater than 5 feet. Even with proper compaction, it is likely that fill soils placed within this excavation will experience settlement over time. As a result, residential foundations, pavements, and/or utilities may be adversely affected by that settlement. Once final grades are determined, and the tanks and piping are removed, an evaluation should be undertaken to determine the most appropriate approach for backfilling the excavation to ensure that any structures or other facilities constructed over the area perform as intended.

4.1.5 Existing Foundations

Existing foundations and utilities at the project site should be completely removed prior to the commencement of the construction of the new foundations. Upon demolition of the existing foundations and the removal of all debris, the area should be restored to the desired grade by the backfilling the resulting holes/trenches with select fill materials. In lieu of the placement of a lean clay select fill, the grade may be restored with excavatable flowable fill meeting the specification of 2014 TxDOT Item 401. All old utilities should be removed and backfilled with flowable fill.

4.2 Compacted Fill Materials

Compacted fill materials may consist of general or select fill depending upon its intended use. The general fill material may consist of onsite soils or select fill materials. General fill material should possess good compaction characteristics that will provide uniform support for pavements or other facilities not extremely sensitive to moments. Select fill materials are typically selected for specific engineering characteristics and performance criteria. These characteristics and criteria are typically dependent on the requirements of the 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 three (3) 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
GENERAL FILL	<p>Shall consist of CH, CL, SC, GC, SW, or GW as defined by ASTM D 2487.</p> <p>Plasticity Index: Not more than 35.</p> <p>Maximum allowable organic content: 3 percent by weight.</p> <p>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.</p>	<p>Maximum loose lift thickness: 8 inches.</p> <p>Compaction requirement:</p> <p>Compaction should be at least 95 percent of the standard Proctor (ASTM D 698) maximum dry density for fill bodies less than 5 feet in thickness.</p> <p>Compaction should be at least 95 percent of the modified Proctor (ASTM D 1557) maximum dry density for fill bodies 5 feet or greater in thickness.</p> <p>Moisture content at time of compaction: within plus to minus 3 percent of the material's optimum moisture content.</p>	<p>General Fill Areas: One field test for every 10,000 square feet per lift, with a minimum of two tests per lift.</p> <p>Utility Trenches (in areas where Select Fill is not required): One field density test per every 100 linear feet, per lift.</p>
SELECT LEAN CLAY FILL (COMPACTED FILL)	<p>Maximum particle size: 3 inches.</p> <p>Maximum gravel and oversize particle content: 15 percent retained on a ¾-inch sieve.</p>	<p>Maximum loose lift thickness: 8 inches with a compacted thickness of about 6 inches.</p>	<p>Building Area: One field density test every 5,000 square feet per lift, with a minimum of two tests per lift.</p>

Material Type	Characteristics	Compaction Procedures	Compaction Control 1, 2
	<p>At least 70 percent of total material (by weight) passing the No. 200 sieve</p> <p>Maximum allowable organic content: 3 percent by weight, but large roots are not allowed.</p> <p>Liquid Limit: Not more than 40.</p> <p>Plasticity Index: Between 8 and 15.</p> <p>Designation as a CL in accordance with the Unified Soil Classification System (USCS).</p>	<p>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.</p> <p>Moisture content at time of compaction: within minus 2 to plus 3 percent of the material's optimum moisture content.</p>	<p>Pavement Areas and Slopes: One field density test every 10,000 square feet per lift, with a minimum of two tests per lift.</p> <p>Utility Trenches: One field density test per structure or one test per every 100 linear feet, per lift.</p>
SELECT GRANULAR FILL (COMPACTED FILL)	<p>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</p> <p>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.</p> <p>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.</p>	<p>Maximum loose lift thickness: 8 inches.</p> <p>Compaction requirement: Compaction should be to at least 98 percent of the TEX-113-E dry density.</p> <p>Moisture content at time of compaction: within minus 2 to plus 3 percent of the material's optimum moisture content.</p>	<p>Building Area: One field density test every 5,000 square feet per lift, with a minimum of two tests per lift.</p> <p>Pavement Areas and Slopes: One field density test every 10,000 square feet per lift, with a minimum of two tests per lift.</p> <p>Utility Trenches: One field density test per structure or one test per every 100 linear feet, per lift.</p>
<p>¹For preliminary planning only. Our technician/engineer should determine the actual test frequency.</p> <p>²In 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.</p>			

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 the consolidation of thick soil fills due to their own self-weight. For this project, we expect settlements of fills will occur over the course of several years after completion of fill placement due to the nature of the on-site soils. If thicker fills are constructed, settlements could continue for longer periods of time after completion of fill placement, which could adversely affect utilities, structures, or pavements supported by the fill.

4.3 Excavation Conditions

4.3.1 Temporary Slopes and OSHA Soil Types

The Occupational Safety and Health Administration (OSHA) Safety and Health Standards (29 CFR Part 1926) require that excavations be constructed in accordance with the current OSHA guidelines. The contractor is **solely** responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain the stability of both the excavation sides and bottom. To that end, the contractor's 'responsible person' as defined in 29 CFR Part 1926 should evaluate the required excavations and the soils exposed by those excavations and determine appropriate means as part of the contractor's safety procedures.

OSHA requires that excavations in excess of five (5) feet be shored or appropriately sloped. Currently, available and practiced methods for achieving excavation stability include sloping, benching, shoring, and the use of trench shields. In excavations that are less than 20 feet deep, OSHA addresses maximum allowable slopes on Table as reproduced below.

Soil or Rock Type	Maximum Allowable Slopes (H: V) ¹ for Excavations Less Than 20 Feet Deep ²	
Stable Rock	Vertical	90°
Type A ³	¾:1	53°
Type B	1:1	45°
Type C	1½:1	34°
<p>1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.</p> <p>2. Slopes or benching for excavations that exceed 20 feet shall be designed by a licensed professional engineer.</p> <p>3. For Type A soils, a short-term maximum allowable slope of ½:1 (63°) is allowed in excavations that are 12 feet deep or less. For excavations deeper than 12 feet, the short-term allowable slope shown above applies. OSHA defines short-term as a period of 24 hours or less.</p>		

Based on the results of our field and laboratory testing, it is our opinion that the FAT CLAY (CH) and LEAN CLAY (CL) soils encountered at the project site should be considered as Type B soils. If those soils become saturated or submerged, they should be downgraded to Type C soils.

We have provided this information solely as a service to our client. The actual OSHA regulations should be consulted prior to any excavations that would be subject to OSHA regulations. TTL does not assume responsibility for any construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

4.3.2 Anticipated Excavation Conditions

As is shown on the boring logs in Appendix A, Lean Clay and Fat Clay materials were encountered at this site. Typically, clayey soils penetrated by geotechnical drilling equipment such as those encountered at this site can be removed with conventional earthmoving equipment.

4.3.3 Drainage During Construction

Water should not be allowed to collect in foundation excavations, on foundation surfaces, or on prepared subgrades within the construction area during construction. Excavated areas should be sloped toward designated drainage points to facilitate removal of any collected rainwater, subsurface water, or surface runoff. Positive surface drainage at the site should be provided to reduce infiltration of surface water into subgrades and fill bodies during construction and promote prompt removal of water from the project site.

4.4 Long-Term Drainage Considerations

Long-term drainage conditions can have a significant impact on the performance of structures, pavements, utilities, and other ancillary facilities on a project site. We recommend that site drainage be developed such that long-term ponding does not occur except in areas specifically designed for such purposes. When establishing final grades, the design team should be reminded that in expansive clay environments, it is common for ground surface movements to occur that could potentially cause a reversal of site drainage patterns and unwanted ponding of surface water. We recommend the following be considered:

- Elevation of the ground surface adjacent to foundations should be at least 6 inches below the Finished Floor Elevation unless measures are taken to ensure long-term positive drainage away from the structure.
- The slope of the ground surface away from the structure (if not covered with pavement) should be a minimum of five (5) percent for a distance of at least 10 feet unless measures are taken to ensure long-term positive drainage away from the structure.
- Gutter downspouts should extend at least five (5) feet past the edge of the foundations.
- Sufficient slope of the ground surface should be maintained around pavements and other ancillary facilities to ensure long-term positive drainage.

5.0 INFRASTRUCTURE RECOMMENDATIONS

5.1 Utilities

Various utilities will be installed at these Sites. The utilities will likely include sanitary sewer lines, electrical lines, and possibly telecommunication lines. Installation of these utilities should conform to the applicable specifications of the appropriate utility entities. At a minimum, all utilities should meet the following installation guidelines.

- The bottoms of the utility trench excavations should be clean of loose soils and debris prior to placement of the utility pipe or cable.

- Utility trenches may be backfilled with general or select fill in accordance with Section 4.3 of this report.
- As an alternate, utility trenches may be backfilled with flowable fill materials that terminate at a depth sufficient to allow for the construction of structure foundations or any pavements constructed as a part of this project. Flowable fill should have a minimum 28-day compressive strength of 100 psi. The flowable fill should not have an unreasonably high compressive strength to ensure that it remains excavatable should the need arise in the future. Flowable fill is defined as materials complying with Item 401 of the 2014 TxDOT Standard Specifications.
- Where granular bedding is used for pipe bedding, consideration should be given to the placement of filter fabric around the bedding materials within the trench to reduce the potential for piping fines through the bedding material. Piping of fines within utility trenches often results in pronounced subsidence of the ground surface over time that could affect foundations and pavements constructed over the utility trenches.

5.2 Landscape Considerations

We realize landscaping is vital to the aesthetics of any project and is generally typical for residential construction. The owner and design team should be made aware that placing large bushes and trees adjacent to the structures and pavements may contribute to future distress. Vegetation placed in landscape beds adjacent to the structure should be limited to plants and shrubs that will not exceed a mature height of about three (3) to four (4) feet. Large bushes and trees that will generally exceed these heights should be planted at a reasonable distance away from structures and pavements so their canopy or “drip line” does not extend over the structure when the tree reaches maturity.

Watering of vegetation should be performed in a timely and controlled manner and in sufficient quantity to maintain healthy vegetative cover. Excessive watering should be avoided as excessive irrigation of landscaped areas adjacent to, near or up gradient from foundations and pavements can lead to water migration into building pads and base sections. This migration could cause moisture fluctuations in the underlying clay subgrade which could result in excessive soil movements and loss of subgrade strength.

6.0 PAVEMENT SECTION DESIGN

6.1 Pavement Design Considerations

Based on our experience and the City of New Braunfels guidelines, the following design parameters were used for design of the pavement section:

	One and Two Family Residential Local Parking on Both Sides	Residential Collector Parking Both Sides
Reliability, %	70	90
Initial Serviceability Index, p_o	4.2	4.2
Terminal Serviceability Index, p_t	2.0	2.0
Standard Deviation, S_o	0.45	0.45
Design Life, years	20	20
Minimum HMAC Thickness, inches	2	2
Minimum Base Thickness, inches	10	14.5
Design CBR Value	2.5	2.5
Minimum Required ESAL	80,000	175,000

Two (2) bulk soil samples were collected to determine the California Bearing Ratio (CBR) value to be used for our pavement design recommendations. The locations at which the CBR bulk samples were taken is indicated on the Boring Location Plan in Appendix A. Based on the laboratory test results, a CBR values of about 1.8 percent and about 4 percent were obtained for the existing untreated subgrade compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. Based on CBR testing results obtained by TTL in other units of the Subdivision, it is likely that the CBR value 4.0 is an outlier and is somewhat higher than CBR values obtained in other units. TTL recommends that a CBR value of 2.5 percent be used to represent the pavement subgrade conditions at this site. There are a number of published correlations relating CBR to the Resilient Modulus (MR). Our report used an $MR (psi) = 2555(CBR)^{0.64}$ to convert CBR to MR.

Although the City of New Braunfels does not require Lime-treated subgrades for the pavements, Lime series testing was performed on the bulk samples collected for this project to consider these as optional pavement sections. The result of a Lime Series test is provided in Appendix A. Based on the result of the test; we anticipate that six (6) percent lime (by weight) will be required for this project. TTL has also designed these pavement sections with a Tensar TX-5 Geogrid option.

6.2 Pavement Section Recommendations

Following are the recommended pavement sections for One and Two Family Residential Local Parking on Both Side and Residential Collector Parking Both Side.

Flexible Pavement System			
Component	One and Two Family Residential Local		
	Pavement Material Thickness, inches		
Hot Mixed Asphaltic Concrete	2 inches	2 inches	2 inches
Prime Coat	Yes	Yes	Yes
Granular Base Course (Type A, Grade 1 or 2)	11 inches	8 inches	6 inches
Tensar TX-5 Geogrid	---	---	Yes

Flexible Pavement System			
Component	One and Two Family Residential Local		
	Pavement Material Thickness, inches		
Lime Treated Subgrade	---	6 inches	---
Required Structural Number	2.29	2.29	2.29
Calculated Structural Number	2.42	2.42	2.48
Calculated Traffic (ESALs)	87,000	87,000	101,000

Flexible Pavement System			
Component	Residential Collector		
	Pavement Material Thickness, inches		
Hot Mixed Asphaltic Concrete	2½ inches	2½ inches	2½ inches
Prime Coat	Yes	Yes	Yes
Granular Base Course (Type A, Grade 1 or 2)	14½ inches	11 inches	8½ inches
Tensar TX-5 Geogrid	---	---	Yes
Lime Treated Subgrade	---	6 inches	---
Required Structural Number	3.04	3.04	3.04
Calculated Structural Number	3.13	3.06	3.11
Calculated Traffic (ESALs)	210,800	181,500	200,800

6.2.1 General Guidelines for Pavements

All pavement design and construction shall conform to the latest edition of City of New Braunfels guidelines. Proper perimeter drainage is very important and should be provided so infiltration of surface water from unpaved areas surrounding the pavements is minimized.

Curbs shall be designed in accordance with City of New Braunfels guidelines. It is important that proper perimeter drainage be provided so that infiltration of surface water from unpaved areas surrounding the pavement is reduced, or if this is not possible, curbs should extend through the base and into the clay subgrade for a depth of at least three (3) inches. A crack sealant compatible to both asphalt and concrete should be provided at all concrete-asphalt interfaces. Base must extend one (1) foot beyond back of curb.

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 saturate 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 proofrolling 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 six (6) inches into lime-treated subgrade soils.

Preventive maintenance should be planned and provided for through an ongoing 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.

6.2.2 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 two (2) 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, lime stabilized layer and at least three (3) inches into the pavement subgrade.

6.2.3 Pavement Section Materials

All pavement materials shall conform to the latest edition of City of New Braunfels design and construction 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.

Asphalt Cement Grades			
Street Classifications	Minimum PG Asphalt Cement Grade		
	Surface Courses	Binder and Level up courses	Base Courses
Arterials	PG 76-22	PG 70-22	PG 64-22
Residential Collector Streets	PG 70-22		
Residential Local Streets	PG 64-22	PG 64-22	

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.

Geogrid – Tensar TX-5 triaxial geogrid may be used to provide additional structural support to flexible base materials. The geogrid should be placed as per the manufacturer's recommendations at the interface between the flexible base and subgrade.

Lime Treatment - The subgrade shall be treated with hydrated lime in accordance with TxDOT Item 260. We anticipate that approximately six (6) percent hydrated lime will be required (approximately 32 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 below.

6.2.4 Pavement Earthwork

The intended performance of street 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, subgrade preparation beneath the streets.

The clay soils across the site have a high 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 a 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. If additional earthwork preparation methods will be used or evaluated, please contact us. The following earthwork recommendations must be performed prior to pavement construction.

- Strip vegetation, loose topsoil, existing pavements, vegetation and any otherwise unsuitable materials from the pavement area. The pavement area is defined as the area that extends at least three (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). On-site soils can be used for grade adjustments in fill areas. Refer to the Section 4.2 of this report for requirements for the placement of on-site 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 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 and compacted as described in the Section 4.2.
- ***If lime treatment option is considered:*** After proof-rolling and replacing any weak yielding zones, the clay subgrade should be lime treated in accordance with TxDOT Item 260. The lime shall be in slurry form. It is anticipated that approximately six (6) percent hydrated lime will be required (approximately 35 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 the lime treatment option, the earth work described here should result in approximately 6 inches of lime treated soil below the design pavement subgrade elevation.

7.0 STRUCTURAL RECOMMENDATIONS

7.1 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		29.651040°
Site Longitude		-98.162450°
Maximum Considered Earthquake 0.2 second Design Spectral Response Acceleration (S _{DS})		0.080 g
Maximum Considered Earthquake 1.0 second Design Spectral Response Acceleration (S _{D1})		0.050 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 boring 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.	

7.2 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. The recommendations and construction guidelines shall not be used for the final foundation design.

7.2.1 Preliminary Monolithic Slab and Beam Foundation Recommendations

Slab foundations should be designed such that if the subsoils expand or contract, the entire slab foundation would move as one unit. **Please note that such a foundation system does not eliminate potential foundation movement due to the expansion or contraction of the subsoils. As stated previously, the subsoils may yield a PVR ranging from three (3) inches to about five (5) inches, thus foundation movement of approximately three (3) inches to about five (5) 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 **preliminary** foundation parameters are provided for the observed soil conditions and are presented in the following table.

EXISTING CONDITIONS – Preliminary Parameters			
PTI Method; 3rd Edition ^{1,3,4,5}			
Vertical Moisture Barrier Depth (ft) ^{6,7} :	<2½	2½	3
Edge Moisture Variation Distance (e _m):			
Center Lift (ft):	5.0	4.3	4.0

EXISTING CONDITIONS – Preliminary Parameters			
PTI Method; 3rd Edition ^{1,3,4,5}			
Edge Lift (ft):	3.1	2.1	2.1
Maximum Unrestrained Differential Soil Movement or Swell (y_m):*			
Center Lift (in):	2.8	1.9	1.8
Edge Lift (in):	4.8*	2.9	2.6
Coefficient of Slab-Subgrade Friction (μ):	0.75	0.75	0.75
Net Allowable Bearing Pressures ² :			
Total Load Conditions (psf):	3000	3000	3000
Dead Load Plus Gravity Live Load Conditions (psf):	2000	2000	2000
Maximum Allowable Deflection Ratio of Foundation Beam:	1/360	1/360	1/360

Notes Applicable to the PTI Slab Foundation Design:

*	<i>Y_m exceeds 4 inches. Please refer to Design of Post-Tensioned Slabs-on-Ground, Third Edition publication for slab foundation design recommendations. A vertical moisture barrier shall be considered for this design group; special design considerations may also be required.</i>
1	Design parameters based on preparing the subgrade and constructing a residential pad as recommended in EARTHWORK RECOMMENDATIONS SECTION 4.0 of this report.
2	Includes a factor of safety (FS) of at least two (2) for total load conditions and at least three (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 beams should not be less than 12 inches. The minimum bearing depth below the adjacent ground surface (also referred to as “ <u>final grade</u> ”) should not be less than 30 inches for perimeter and interior foundation beams. These foundation dimension recommendations are for the 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 3 rd 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 the adjacent ground surface (“ <u>final grade</u> ”) are not considered a vertical moisture barrier.
7	According to the PTI 3 rd 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, the site had not been cleared of vegetation and mass grading had not been conducted. Therefore, our recommendations for PTI design are based on the subsoil conditions that we encountered during our drilling operations at the Site and at the existing grade.

7.2.2 Shallow Foundation Construction Considerations

Excavations for shallow foundations and grade beams shall be neat excavated with a smooth-mouthed bucket. If a toothed bucket is used, excavation with this bucket should be stopped six (6) inches above the final foundation bearing surface and the excavation completed with a smooth-mouthed bucket or by hand labor. Debris in the bottom of the excavations should be removed prior to steel placement. If neat excavation is not possible, the foundation should be overexcavated and formed. All loose materials should be removed from the overexcavated areas and filled with lean concrete or flowable fill as described in ACI 229R.

Reinforcing steel should be placed and the foundation constructed as quickly as possible to avoid exposure of the foundation bottoms to wetting and drying. The excavations should be sloped sufficiently to create internal sumps for runoff collection and removal of water. If surface runoff or subsurface water seepage in excess of one (1) inch accumulates at the bottom of the excavation, it should be collected and removed so that ponding water does not adversely affect the quality of the bearing surfaces. Special care should be taken to protect exposed bearing surfaces from disturbance or drying out prior to the placement of concrete.

7.3 **Settlement of Grade Supported Foundations**

Total settlement of grade supported foundations designed and constructed as recommended in this report is expected to be about one (1) inch or less. The settlement of the foundations is expected to be elastic in nature with most of the observed settlement occurring during construction. Differential settlement approaching $\frac{1}{2}$ to $\frac{3}{4}$ of the total foundation settlement should be expected to occur between load bearing foundation elements. The settlement response of grade supported foundations is impacted more by the quality of construction than by soil-structure interaction. The improper installation of foundation elements can result in differential settlements that are greater than we have estimated.

8.0 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 preliminary design 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. The information provided in this report is intended for planning purposes only and should not be used for final design considerations.

This geotechnical engineering report is based upon the information provided to us by the Client and various other individuals and entities associated with the Project, along with the field exploration, laboratory testing, and engineering analyses and evaluations performed by TTL as described in this report. The Client and readers of this geotechnical engineering report should realize that subsurface variations and anomalies may exist across the site which may not be revealed by our field exploration. Furthermore, the Client and readers should realize that site conditions can change due to the modifying effects of seasonal and climatic conditions and conditions at times after our 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 properly evaluated and, if necessary, addressed with provide applicable recommendations.

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. In addition, TTL is not responsible for permitting, site safety, excavation support, and dewatering requirements.

Should the nature, design, or location of the Project, as outlined in 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 review 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 Geoprofessional 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 site-wide 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 not 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 Not 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 not 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 not building-envelope or mold specialists.*

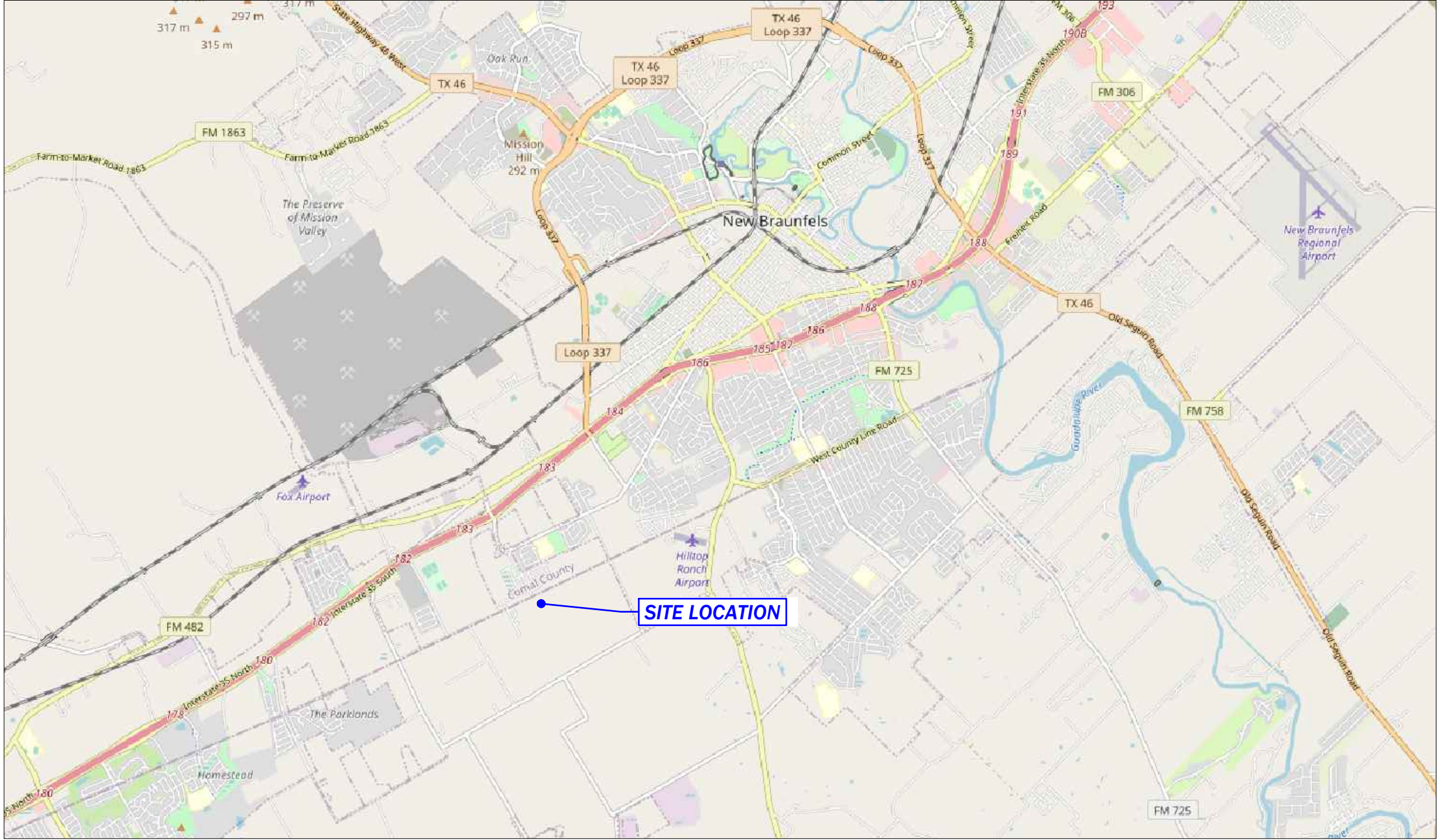


GEOPROFESSIONAL
BUSINESS
ASSOCIATION

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APPENDIX A ILLUSTRATIONS



Legend

SITE LOCATION MAP

STEELWOOD TRAIL SUBDIVISION,
UNITS 4, 6, AND 7

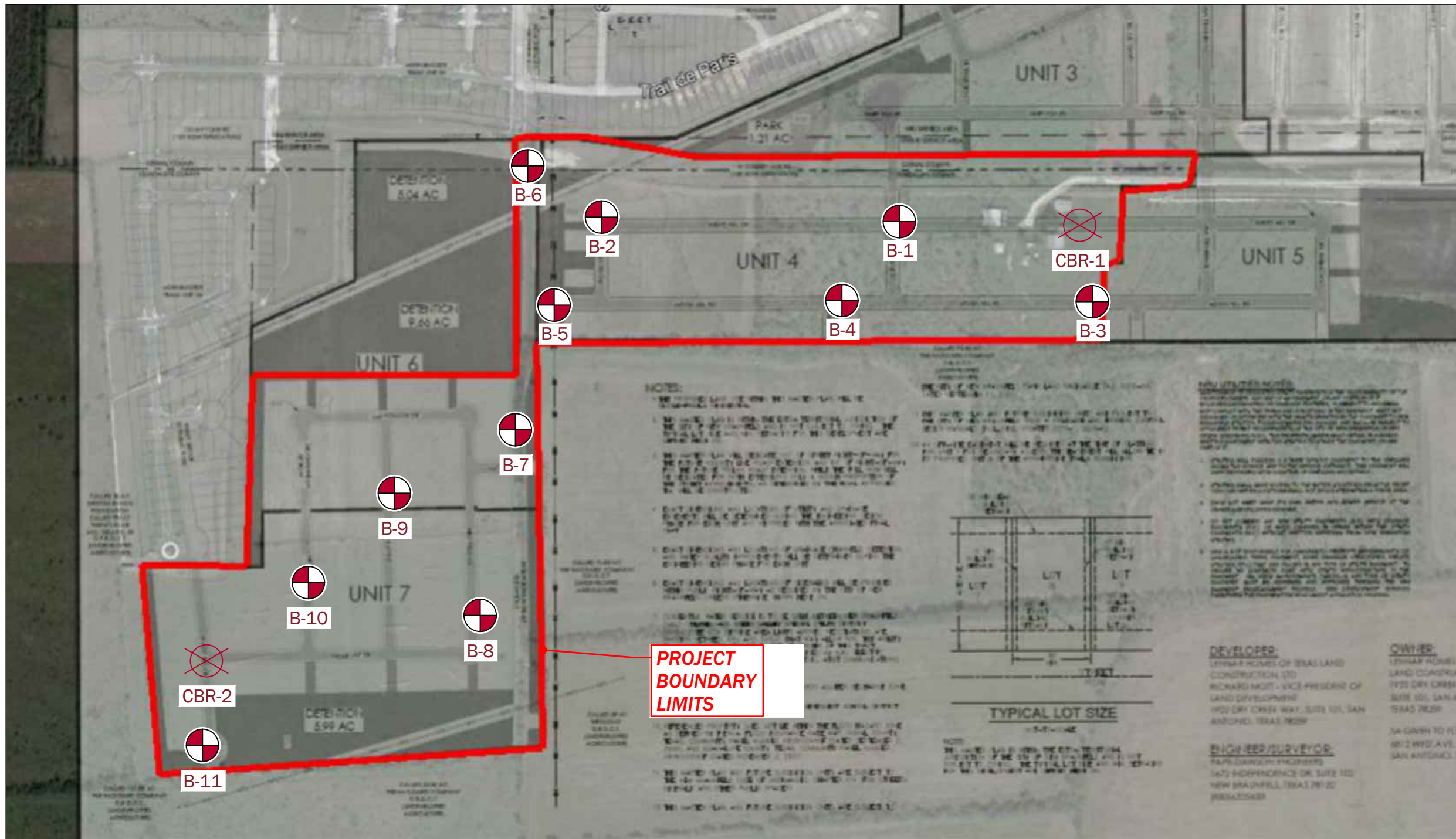
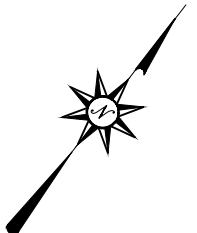
MORNINGSIDE DRIVE AND RON ROAD/COUNTY ROAD 376A
NEW BRAUNFELS, COMAL AND GUADALUPE COUNTIES, TEXAS






Date:	04/29/2022
Drawn By:	AM
Checked By:	AB
Approved By:	AB
Project No.:	00220900622.00

Exhibit 1



17215 Jones Maltsberger Rd., Suite 101
San Antonio, TX 78247 210.888.6100
TBPE Registration: F-12622
TBPB Registration: 50456



<div>Legend</div> <div><div> Boring Location and Identifier</div><div> B-X</div><div> CBR-X</div><div> CBR Location and Identifier</div></div>	BORING LOCATIONS		Date:	04/29/2022	Exhibit 2	
	STEELWOOD TRAIL SUBDIVISION, UNITS 4, 6, AND 7		Drawn By:	AM	 <div>17215 Jones Maltsberger Rd., Suite 101 San Antonio, TX 78247 210.888.6100 TBPE Registration: F-12622 TBPB Registration: 50456</div>	
	MORNINGSIDE DRIVE AND RON ROAD/COUNTY ROAD 376A NEW BRAUNFELS, COMAL AND GUADALUPE COUNTIES, TEXAS		Checked By:	AB		
			Approved By:	AB		
			Project No.:	00220900622.00		

SOIL LEGEND

FINE- AND COARSE-GRAINED SOIL INFORMATION
















FINE-GRAINED SOILS (SILTS AND CLAYS)			COARSE-GRAINED SOILS (SANDS AND GRAVELS)		PARTICLE SIZE	
SPT N-Value	Consistency	Estimated Q_u (TSF)	SPT N-Value	Relative Density	Name	Size (US Std. Sieve)
0 - 1	Very Soft	0 - 0.25	0 - 4	Very Loose	Boulders	>300 mm (>12 in.)
2 - 4	Soft	0.25 - 0.5	5 - 10	Loose	Cobbles	75 mm to 300 mm (3 - 12 in.)
5 - 8	Firm	0.5 - 1.0	11 - 30	Medium Dense	Coarse Gravel	19 mm to 75 mm (3/4 - 3 in.)
9 - 15	Stiff	1.0 - 2.0	31 - 50	Dense	Fine Gravel	4.75 mm to 19 mm (#4 - 3/4 in.)
16 - 30	Very Stiff	2.0 - 4.0	51+	Very Dense	Coarse Sand	2 mm to 4.75 mm (#10 - #4)
31+	Hard	4.0+			Medium Sand	0.425 mm to 2 mm (#40 - #10)
Q_u = Unconfined Compression Strength					Fine Sand	0.075 mm to 0.425 mm (#200 - #40)
					Silts and Clays	< 0.075 mm (< #200)

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF CLAYS AND SILTS	
Descriptive Terms	Percent of Dry Weight	Descriptive Terms	Percent of Dry Weight
"Trace"	< 15	"Trace"	< 5
"With"	15 - 30	"With"	5 - 12
Modifier	> 30	Modifier	> 12




























CRITERIA FOR DESCRIBING MOISTURE CONDITION		CRITERIA FOR DESCRIBING CEMENTATION	
Description	Criteria	Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch	Weak	Crumbles or breaks with handling or little finger pressure
Moist	Damp, but no visible water	Moderate	Crumbles or breaks with considerable finger pressure
Wet	Visible free water, usually soil is below water table	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

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

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

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UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)							
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
		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	Inorganic 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

UNIFORMITY COEFFICIENT

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

COEFFICIENT OF CURVATURE

$$C_c = (D_{30})^2/(D_{60} \times D_{10})$$

Where:

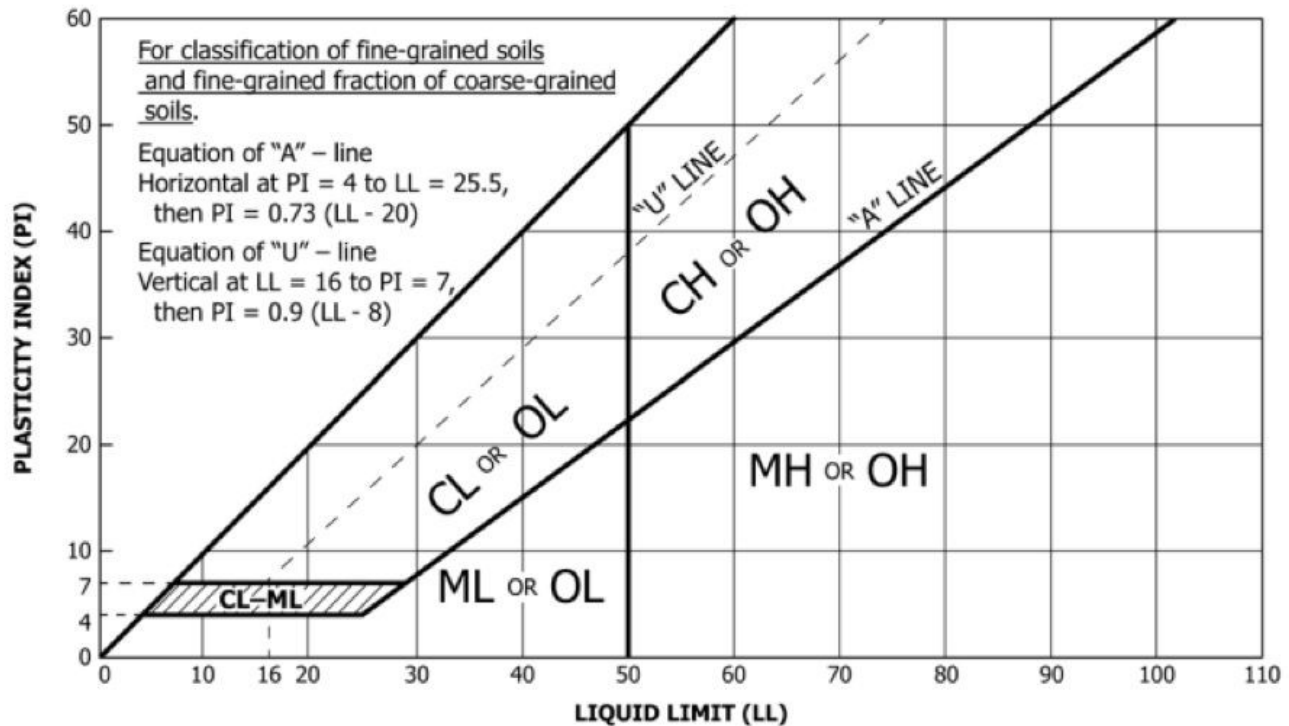
D_{60} = grain diameter at 60% passing

D_{30} = grain diameter at 30% passing

D_{10} = grain diameter at 10% passing

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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 $N = 75/8"$



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**Log of
B-01**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/11/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.15924 Latitude: 29.62334</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOWS/FT	2nd 6" P: TONS/SQFT	3rd 6" RQD % REC		LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI					
			FAT CLAY; stiff, dark gray to light brown, calcareous (CH)			3 - 5 - 6 N = 11	25	56	26	30						
			- interbedded CALICHE layer, POWDERED CLAY between 3 and 6 feet			4 - 5 - 4 N = 9	22									
	5					4 - 4 - 6 N = 10	16									95.3
			LEAN CLAY; very stiff, brown to mottled brown and gray (CL)			4 - 7 - 10 N = 17	16	49	21	28						
			- interbedded CALICHE layer between 6½ and 8½ feet			6 - 7 - 10 N = 17	15									
	10		- calcareous between 8½ feet													
			FAT CLAY; hard, mottled brown and gray (CH)			7 - 14 - 20 N = 34	14	52	18	34						
	15		Boring terminated at 15 feet.													




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**Log of
B-02**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16245 Latitude: 29.652</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA														
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE		
					1st 6" N-VALUE BLOWS/FT	2nd 6" P: TONS/SQFT	3rd 6" RQD % REC		LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI							
			FAT CLAY; firm to very stiff, very dark brown (CH)															
							2 - 3 - 4 N = 7	31										
							2 - 3 - 4 N = 7	30	78	26	52							
	5						4 - 5 - 8 N = 13	27										
			- calcareous between 6½ and 10 feet				3 - 5 - 6 N = 11	27										
							4 - 11 - 9 N = 20	21	66	23	43							
	10																	
			- becomes yellowish-brown below 12 feet															
							5 - 7 - 10 N = 17	22										97.3
	15		Boring terminated at 15 feet.															
														</				




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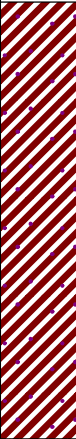









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**Log of
B-03**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/11/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.1568 Latitude: 29.65346</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (psf)	SHEAR STRENGTH (psf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOWS/FT	2nd 6" 3rd 6"	RQD % REC		LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX					
			SANDY FAT CLAY; stiff to very stiff, light brown (CH)		3 - 4 - 5 N = 9	23									68.5	
			- interbedded CALICHE layer, POWDERED CLAY between 2½ and 6½ feet		5 - 6 - 8 N = 14	21										
	5				7 - 9 - 11 N = 20	15										98.7
			LEAN CLAY; very stiff to hard, mottled yellowish-brown and gray to yellowish-brown, trace sand (CL)		7 - 11 - 17 N = 28	15	47	19	28							
					10 - 16 - 20 N = 36	14										
	10															
					8 - 17 - 21 N = 38	14	49	16	33							
	15		Boring terminated at 15 feet.													




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**Log of
B-05**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16245 Latitude: 29.65104</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA													
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE	
					1st 6" N-VALUE BLOWS/FT	2nd 6" 3rd 6"	P: TONS/SQFT		RQD % REC	LIQUID LIMIT	PLASTIC LIMIT						PLASTICITY INDEX
			FAT CLAY; firm to very stiff, very dark brown to mottled brown and gray (CH)														
			- WITH GARVEL between 0 and 2½ feet				2 - 3 - 5 N = 8		12								
							2 - 3 - 4 N = 7		32	79	27	52					
	5						3 - 5 - 6 N = 11		23								
			- WITH SAND, grayish-brown between 6½ and 8½ feet				4 - 7 - 12 N = 19		28								84.3
			- calcareous between 6½ and 8½ feet														
							4 - 7 - 8 N = 15		26	67	22	45					
	10																
							6 - 6 - 9 N = 15		19								
	15		Boring terminated at 15 feet.														




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**Log of
B-07**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16228 Latitude: 29.64972</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOWS/FT	2nd 6" P: TONS/SQFT	3rd 6" RQD % REC		LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX					
			FAT CLAY; firm to very stiff, very dark brown to gray (CH)			2 - 3 - 4 N = 7	32									96.2
						3 - 5 - 7 N = 12	24	83	27	56						
	5					5 - 6 - 7 N = 13	24	92	26	66						
						4 - 5 - 6 N = 11	28									
			- calcareous between 8½ and 10 feet			4 - 7 - 8 N = 15	24	73	28	45						
	10															
			- becomes light brown and gray below 12 feet													
						5 - 8 - 10 N = 18	20									
	15		Boring terminated at 15 feet.													




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Steelwood Trail Subdivision, Units 4, 6, & 7
Morningside Drive and Ron Road/County Road 376A
New Braunfels, Comal and Guadalupe Counties, Texas

**Log of
B-08**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16173 Latitude: 29.64773</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOWS/FT	2nd 6" P: TONS/FT	3rd 6" RQD % REC		LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI					
			FAT CLAY; firm to very stiff, very dark brown to grey (CH)		1 - 2 - 2 N = 4		34	101	27	74						
					2 - 4 - 6 N = 10		31									
	5				2 - 4 - 6 N = 10		28									
			- becomes light gray between 6½ and 12 feet - calcareous below 6½ feet		4 - 5 - 7 N = 12		30	77	29	48						94.5
					5 - 7 - 8 N = 15		29									
	10															
			- WITH GRAVEL, yellowish-brown below 12 feet													
					6 - 8 - 9 N = 17		15	50	18	32						
	15		Boring terminated at 15 feet.													




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**Log of
B-09**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16328 Latitude: 29.64855</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	 Water Level at Time of Drilling: <i>Not Encount.</i>	 Delayed Water Level: <i>N/A</i>
	 Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA													
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE	
					1st 6" N-VALUE BLOWS/FT	2nd 6" 3rd 6"	P-TONS/SQFT		RQD % REC	LIQUID LIMIT LL	PLASTIC LIMIT PL						PLASTICITY INDEX PI
			FAT CLAY; firm to very stiff, very dark brown to dark brown (CH)			2 - 3 - 4 N = 7	38	91	27	64							
						3 - 4 - 6 N = 10	31									94.8	
	5					4 - 5 - 5 N = 10	32	86	28	58							
			- becomes dark gray between 6½ and 8½ feet			2 - 4 - 5 N = 9	32										
			- calcareous below 8½ feet														
			- becomes light gray between 8½ and 12 feet			2 - 5 - 6 N = 11	29										
	10																
			- becomes yellowish-brown below 12 feet														
						6 - 7 - 10 N = 17	20										
	15		Boring terminated at 15 feet.														

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**Log of
B-10**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.1637 Latitude: 29.64735</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	▽ Water Level at Time of Drilling: <i>Not Encount.</i>	▼ Delayed Water Level: <i>N/A</i>
	☒ Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOW/FT	2nd 6" P: TONS/FT	3rd 6" RQD % REC		LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI					
			FAT CLAY; firm to stiff, very dark brown (C) - trace roots between ½ and 2½ feet		2 - 2 - 3 N = 5	32										
					2 - 4 - 6 N = 10	28	83	26	57							
5			FAT CLAY WITH SAND AND GRAVEL; stiff to hard, dark gray to grayish-brown, calcareous (CH)		2 - 5 - 6 N = 11	28										
					3 - 5 - 5 N = 10	30										
			- LESS SAND AND GRAVEL between 8½ and 12 feet		4 - 5 - 7 N = 12	29										
10																
			- becomes yellowish-brown below 12 feet													
					24 - 29 - 33 N = 62	25										
15			Boring terminated at 15 feet.													

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**Log of
B-11**

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Drilling Co.: <i>Eagle Drilling</i>	TTL Project No.: <i>00220900622.00</i>	Remarks: Subsurface water was not encountered during drilling. The borehole was backfilled with soil cuttings after drilling activities were completed.
Driller: <i>C. Kuntscher</i>	Date Drilled: <i>4/12/2022</i>	
Logged by: <i>T. Burford</i>	Boring Depth: <i>15 feet</i>	
Equipment: <i>Mobile B-47</i>	Boring Elevation: <i>Ground Surface</i>	
Hammer Type: <i>Automatic</i>	Coordinates: <i>Longitude: -98.16393 Latitude: 29.64534</i>	
Drilling Method: <i>Solid Flight Auger w/SPT Sampling</i>	▽ Water Level at Time of Drilling: <i>Not Encount.</i>	▼ Delayed Water Level: <i>N/A</i>
	⚠ Cave-In at Time of Drilling: <i>N/A</i>	Delayed Water Observation Date: <i>N/A</i>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIALS DESCRIPTION	SAMPLE DATA												
				TYPE	BORE/CORE DATA			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			DRY DENSITY (pcf)	SHEAR STRENGTH (pcf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	% PASSING #200 SIEVE
					1st 6" N-VALUE BLOWS/FT	2nd 6" P: TONS/SQFT	3rd 6" RQD % REC		LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI					
			FAT CLAY; firm to stiff, very dark brown to gray and dark gray (CH)			1 - 2 - 3 N = 5	32									
						3 - 4 - 6 N = 10	25	64	27	37						
	5		- calcareous below 4½ feet			3 - 6 - 5 N = 11	24									
			- WITH SAND, mottled brown and gray between 6½ and 12 feet			3 - 5 - 7 N = 12	21	61	11	50						
	10					5 - 7 - 8 N = 15	19									97.3
			- becomes yellowish-brown below 12 feet													
	15		Boring terminated at 15 feet.			5 - 7 - 8 N = 15	21									

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Boring	Depth	USCS	AASHTO	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	Maximum Size (mm)	% Passing #200 (If hydrometer data available)		D50 (mm)
B-01	0.5 - 2	---	---	25	56	26	30	---	---	---	---	---	---
B-01	2.5 - 4	---	---	22	---	---	---	---	---	---	---	---	---
B-01	4.5 - 6	---	---	16	---	---	---	0.0	0.0	0.075	95.3	---	---
B-01	6.5 - 8	---	---	16	49	21	28	---	---	---	---	---	---
B-01	8.5 - 10	---	---	15	---	---	---	---	---	---	---	---	---
B-01	13.5 - 15	---	---	14	52	18	34	---	---	---	---	---	---
B-02	0.5 - 2	---	---	31	---	---	---	---	---	---	---	---	---
B-02	2.5 - 4	---	---	30	78	26	52	---	---	---	---	---	---
B-02	4.5 - 6	---	---	27	---	---	---	---	---	---	---	---	---
B-02	6.5 - 8	---	---	27	---	---	---	---	---	---	---	---	---
B-02	8.5 - 10	---	---	21	66	23	43	---	---	---	---	---	---
B-02	13.5 - 15	---	---	22	---	---	---	0.0	0.0	0.075	97.3	---	---
B-03	0.5 - 2	---	---	23	---	---	---	0.0	0.0	0.075	68.5	---	---
B-03	2.5 - 4	---	---	21	---	---	---	---	---	---	---	---	---
B-03	4.5 - 6	---	---	15	---	---	---	0.0	0.0	0.075	98.7	---	---
B-03	6.5 - 8	---	---	15	47	19	28	---	---	---	---	---	---
B-03	8.5 - 10	---	---	14	---	---	---	---	---	---	---	---	---
B-03	13.5 - 15	---	---	14	49	16	33	---	---	---	---	---	---
B-04	0.5 - 2	---	---	10	86	33	53	---	---	---	---	---	---
B-04	2.5 - 4	---	---	13	---	---	---	---	---	---	---	---	---
B-04	4.5 - 6	---	---	19	---	---	---	---	---	---	---	---	---
B-04	6.5 - 8	---	---	14	---	---	---	0.0	0.0	0.075	78.1	---	---
B-04	8.5 - 10	---	---	11	---	---	---	---	---	---	---	---	---
B-04	13.5 - 15	---	---	13	48	17	31	---	---	---	---	---	---
B-05	0.5 - 2	---	---	12	---	---	---	---	---	---	---	---	---
B-05	2.5 - 4	---	---	32	79	27	52	---	---	---	---	---	---
B-05	4.5 - 6	---	---	23	---	---	---	---	---	---	---	---	---
B-05	6.5 - 8	---	---	28	---	---	---	0.0	0.0	0.075	84.3	---	---
B-05	8.5 - 10	---	---	26	67	22	45	---	---	---	---	---	---
B-05	13.5 - 15	---	---	19	---	---	---	---	---	---	---	---	---
B-06	0.5 - 2	---	---	28	81	26	55	---	---	---	---	---	---
B-06	2.5 - 4	---	---	25	---	---	---	0.0	0.0	0.075	96.5	---	---
B-06	4.5 - 6	---	---	24	---	---	---	---	---	---	---	---	---
B-06	6.5 - 8	---	---	24	85	28	57	---	---	---	---	---	---
B-06	8.5 - 10	---	---	21	---	---	---	---	---	---	---	---	---
B-06	13.5 - 15	---	---	19	45	18	27	---	---	---	---	---	---
B-07	0.5 - 2	---	---	32	---	---	---	0.0	0.0	0.075	96.2	---	---
B-07	2.5 - 4	---	---	24	83	27	56	---	---	---	---	---	---
B-07	4.5 - 6	---	---	24	92	26	66	---	---	---	---	---	---
B-07	6.5 - 8	---	---	28	---	---	---	---	---	---	---	---	---
B-07	8.5 - 10	---	---	24	73	28	45	---	---	---	---	---	---
B-07	13.5 - 15	---	---	20	---	---	---	---	---	---	---	---	---



Summary of Laboratory Test Results

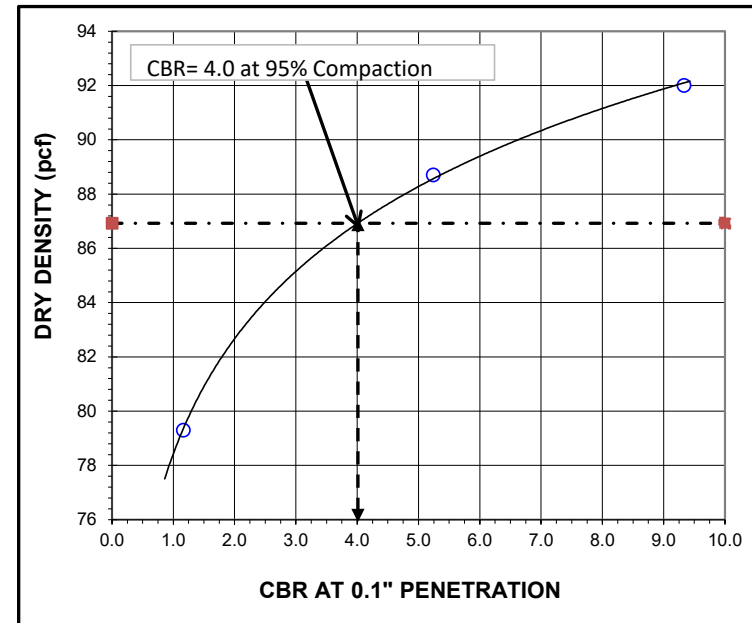
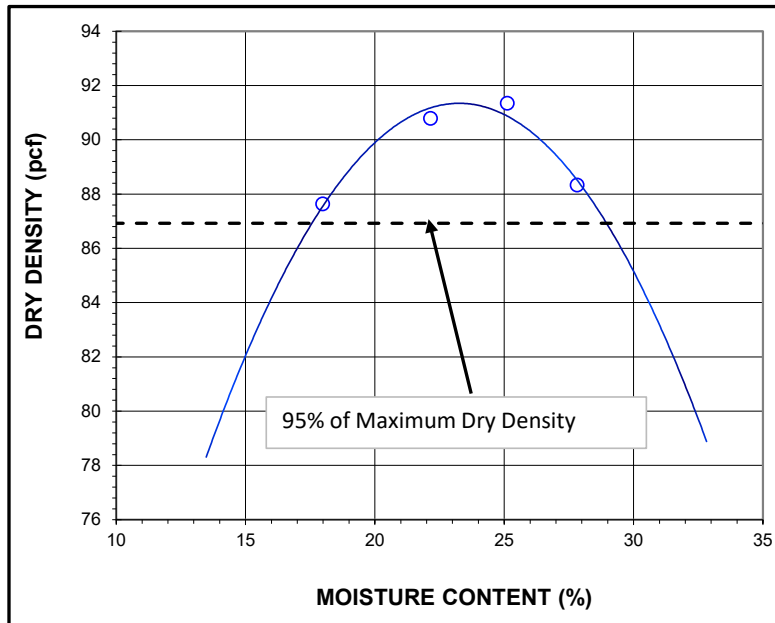
Client: Lennar
 Project: Steelwood Trail Subdivision, Units 4, 6, & 7
 Location: New Braunfels, Comal and Guadalupe Counties, Texas
 Project Number: 00220900622.00

Boring	Depth	USCS	AASHTO	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	Maximum Size (mm)	% Passing #200 <small>(If hydrometer data available)</small>		D50 (mm)
B-08	0.5 - 2	---	---	34	101	27	74	---	---	---	---	---	---
B-08	2.5 - 4	---	---	31	---	---	---	---	---	---	---	---	---
B-08	4.5 - 6	---	---	28	---	---	---	---	---	---	---	---	---
B-08	6.5 - 8	CH	A-7-6 (54)	30	77	29	48	0.0	0.0	0.075	94.5	---	---
B-08	8.5 - 10	---	---	29	---	---	---	---	---	---	---	---	---
B-08	13.5 - 15	---	---	15	50	18	32	---	---	---	---	---	---
B-09	0.5 - 2	---	---	38	91	27	64	---	---	---	---	---	---
B-09	2.5 - 4	---	---	31	---	---	---	0.0	0.0	0.075	94.8	---	---
B-09	4.5 - 6	---	---	32	86	28	58	---	---	---	---	---	---
B-09	6.5 - 8	---	---	32	---	---	---	---	---	---	---	---	---
B-09	8.5 - 10	---	---	29	---	---	---	---	---	---	---	---	---
B-09	13.5 - 15	---	---	20	---	---	---	---	---	---	---	---	---
B-10	0.5 - 2	---	---	32	---	---	---	---	---	---	---	---	---
B-10	2.5 - 4	---	---	28	83	26	57	---	---	---	---	---	---
B-10	4.5 - 6	---	---	28	---	---	---	0.0	0.0	4.75	81.5	---	---
B-10	6.5 - 8	---	---	30	---	---	---	---	---	---	---	---	---
B-10	8.5 - 10	---	---	29	---	---	---	---	---	---	---	---	---
B-10	13.5 - 15	---	---	25	---	---	---	---	---	---	---	---	---
B-11	0.5 - 2	---	---	32	---	---	---	---	---	---	---	---	---
B-11	2.5 - 4	---	---	25	64	27	37	---	---	---	---	---	---
B-11	4.5 - 6	---	---	24	---	---	---	---	---	---	---	---	---
B-11	6.5 - 8	---	---	21	61	11	50	---	---	---	---	---	---
B-11	8.5 - 10	---	---	19	---	---	---	0.0	0.0	0.075	97.3	---	---
B-11	13.5 - 15	---	---	21	---	---	---	---	---	---	---	---	---
CBR-1		CH	A-7-6 (32)	---	54	25	29	0.0	0.0	0.075	95.6	---	---
CBR-2		CH	A-7-6 (41)	---	66	27	39	0.0	0.0	0.075	91.9	---	---

Summary of Laboratory Test Results



Client: Lennar
 Project: Steelwood Trail Subdivision, Units 4, 6, & 7
 Location: New Braunfels, Comal and Guadalupe Counties, Texas
 Project Number: 00220900622.00



Sample: **CBR Sample No. 1**
 Proctor Test Method: Standard Proctor (ASTM D-698)
 CBR Test Method: California Bearing Ration (ASTM D-1883)
 Material: FAT CLAY (CH), dark gray

CBR Sample Location: 27.83946°, -97.62809°
 Sample Depth: Between 0 and 5 feet below existing ground surface
 Optimum Moisture Content: 24.2 %
 Maximum Dry Unit Weight: 91.5 pcf
 % Passing # 200 Sieve: 95.6 %
 Atterberg Limits: LL = 54 , PL = 24 , PI = 30



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STEELWOOD TRAIL SUBDIVISION, UNITS 4, 6, AND 7
MORNINGSIDE DRIVE AND RON ROAD/COUNTY ROAD 376A

NEW BRAUNFELS, COMAL AND GUADALUPE COUNTIES, TEXAS

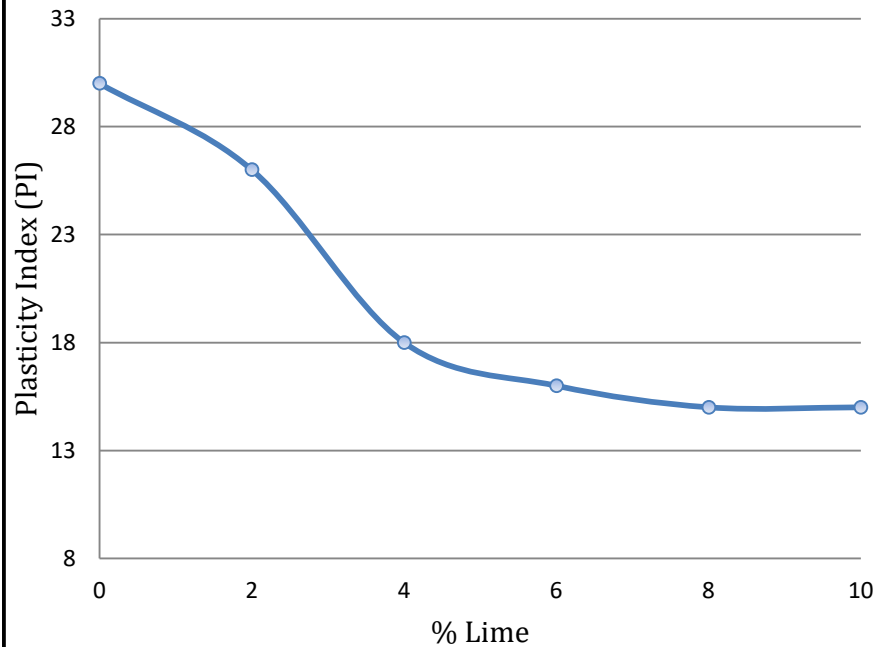
Drawn By: NKA

Checked By: AB

Proj No:00220900622.00

File Name

CBR PLOT



% Lime	Plasticity	pH	LL	PL
0	30	8.76	54	24
2	26	12.21	54	28
4	18	12.38	57	39
6	16	12.41	56	40
8	15	12.42	56	41
10	15	12.49	56	41

Test Location: **CBR Sample No. 1**
 Material: FAT CLAY (CH), dark gray
 Test Method: TxDOT Item 260, Lime Treatment
 Test Method: ASTM C 977, Appendix XI; pH:Lime Saturation Content
 CBR Sample Location: 27.83946°, -97.62809°



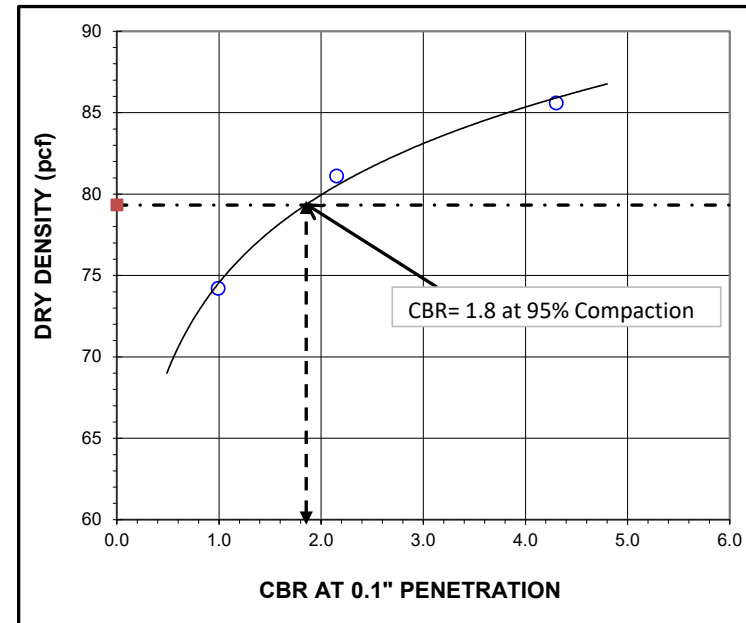
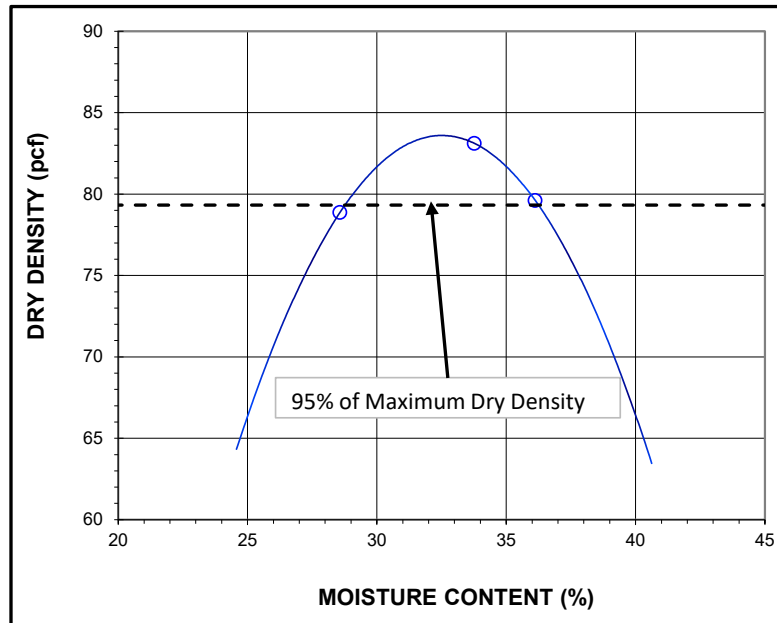
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MORNINGSIDE DRIVE AND RON ROAD/COUNTY ROAD 376A

NEW BRAUNFELS, COMAL AND GUADALUPE COUNTIES, TEXAS

Drawn By: NKA
 Checked By: AB
 Proj No:00220900622.00
 File Name

LIME SERIES



Sample: **CBR Sample No. 2**
 Proctor Test Method: Standard Proctor (ASTM D-698)
 CBR Test Method: California Bearing Ratio (ASTM D-1883)
 Material: **FAT CLAY (CH), dark brown**

CBR Sample Location: 27.83855°, -97.62245°
 Sample Depth: Between 0 and 5 feet below existing ground surface
 Optimum Moisture Content: 32.9 %
 Maximum Dry Unit Weight: 83.5 pcf
 % Passing # 200 Sieve: 91.9 %
 Atterberg Limits: LL= 62; PL = 24, PI = 38



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NEW BRAUNFELS, COMAL AND GUADALUPE COUNTIES, TEXAS

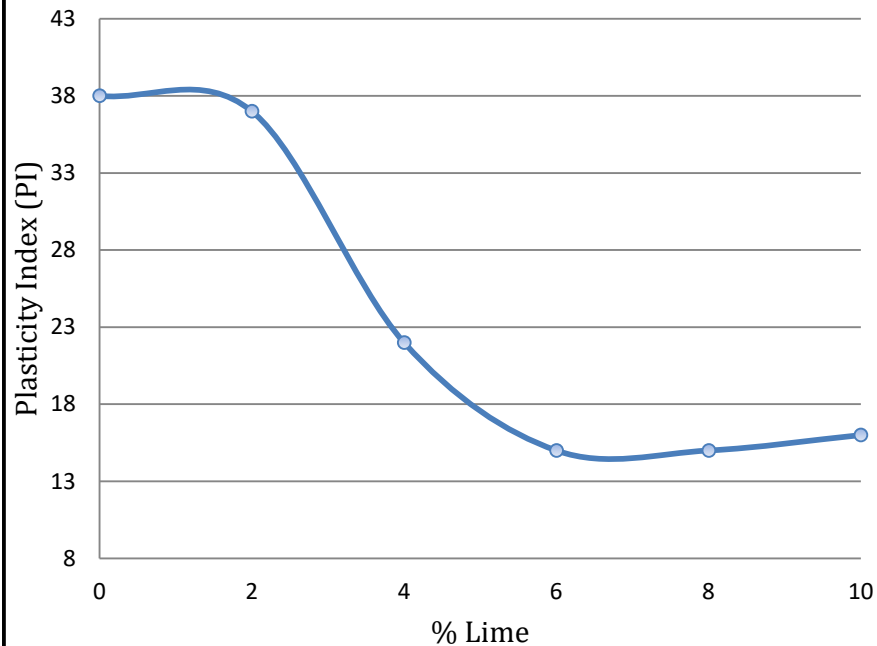
Drawn By: NKA

Checked By: AB

Proj No:00220900622.00

File Name

CBR PLOT



% Lime	Plasticity	pH	LL	PL
0	38	8.72	62	24
2	37	11.98	62	25
4	22	12.21	60	38
6	15	12.31	57	42
8	15	12.40	60	45
10	16	12.49	59	43

Test Location: **CBR Sample No. 2**
 Material: FAT CLAY (CH), dark brown
 Test Method: TxDOT Item 260, Lime Treatment
 Test Method: ASTM C 977, Appendix XI; pH:Lime Saturation Content
 CBR Sample Location: 27.83855°, -97.62245°



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 File Name

LIME SERIES

APPENDIX B

REFERENCE MATERIALS

EXPLORATION PROCEDURES

General

Various drill equipment and procedures are used to obtain soil or rock specimens during geotechnical engineering exploration activities. The drill equipment typically consists of fuel powered machinery that is mounted on a flat-bed truck or an all-terrain vehicle. The ground surface conditions at the site generally determine the type of vehicle to use.

Borings can be drilled either dry or wet. The drilling technique depends on the type of subsurface materials (clays, sands, silts, gravels, rock) encountered and whether or not subsurface water is present during the drilling operations. Sometimes a combination of both techniques is implemented.

The dry method can generally be employed when subsurface water or granular soils are not present. The dry method generally consists of advancing the augers without the use of water or drilling fluids. Air can be employed as necessary to remove cuttings from the borehole or cool the drilling bits during some drilling applications. The wet rotary process is generally used when subsurface water, rock or granular soils are present. The wet rotary process utilizes water or drilling fluids to advance the augers, remove cuttings from the borehole, and cool the drilling bits during drilling.

Sampling

Various sampling devices are available to recover soil or rock specimens during the geotechnical exploration program. The type of sampling apparatus to employ depends on the subsurface materials (clays, sands, silts, gravels, rock) encountered and on their consistency or strength. Most commonly used samplers are Shelby tubes, split-spoons or split-barrels, and NX core barrels. Depending on the subsurface conditions, sampling apparatus such as the Pitcher barrel, Osterberg sampler, Dennison barrel, or California sampler are sometimes used. The procedures for using and sampling subsurface materials with most of these samplers are described in detail by the American Society for Testing and Materials (ASTM). Sampling is generally performed on a two (2) foot continuous interval to a depth of about ten (10) feet, followed by five (5) foot intervals between the depths of about ten (10) to 50 feet, and on ten (10) foot intervals thereafter to the termination depth of the borings. However, sampling intervals may change depending on the project scope and actual subsurface conditions encountered.

If cohesive soils (clays and some silts) are present during drilling, samples are retrieved by using the Shelby tube sampler (ASTM D 1587) or the split-barrel sampler (ASTM D 1586). The Shelby tube is used to recover “virtually” undisturbed soil specimens that can be returned to the laboratory for strength and compressibility testing. The Shelby tube is a three (3) inch nominal diameter, thin-walled tube that is advanced hydraulically into the soil by a single stroke of the drill equipment.

The split-barrel sampler is used when performing the Standard Penetration Test (SPT). The recovered sample is considered to be a “disturbed” specimen due to the SPT procedure. The split-barrel is advanced into the soil by driving the sampler with blows from a 140-pound hammer free falling 30 inches. The SPT procedure is performed to evaluate the strength or competency of the material being sampled. This evaluation is based on the material sampled, depth of the sample, and the number of blows required to obtain full penetration of the split-barrel sampler. This blow count or penetration resistance is referred to as the “N” value.

The split-barrel is typically used when cohesionless soils (sands, silts, gravels) are encountered or when good quality cohesive soils cannot be recovered with the Shelby tube sampler. The SPT procedure can be employed when rock or cemented zones are encountered. However, the split-barrel may not penetrate the rock or cemented zone if the layer is extremely hard, thus resulting in no sample recovery.

When rock or cemented zones are present and depending on the type of project and engineering testing required, rock coring may be implemented to recover specimens of the particular layer. Typically, an NX double tube core barrel (ASTM D 2113) is used.

Logging

During the drilling activities, one of our geologists or engineering technicians is present to make sure that the appropriate sampling techniques are employed and to extrude or remove all materials from the samplers. The samples are then visually classified by our field representative who records the information on a field boring log. Our field representative may perform pocket penetrometer, hand torvane, or field vane tests on the subsurface materials recovered from the Shelby tube samplers. If the SPT procedure is employed, our field representative will record the N values or blow counts that are germane to that particular field test. If rock coring is utilized, our field representative will calculate the percent recovery and Rock Quality Designation (RQD). The test data for all the field tests will be noted on the appropriate field boring log. Upon completion of the logging activities and field testing of the recovered soil or rock samples, representative portions of the specimens were placed in appropriately wrapped and sealed containers to preserve their natural moisture condition and to minimize disturbance during handling and transporting to our laboratory for additional testing.

When subsurface water is observed during the drilling and sampling operations, drilling will be temporarily delayed so the subsurface water level can be monitored for a period of at least 15 to 30 minutes. Depending on the rise of the subsurface water in the borehole and project requirements, subsurface water measurements may be monitored for periods of 24 hours or more. Generally, observation wells or piezometers are installed in the completed boreholes to monitor subsurface water levels for periods longer than 24 hours.

Following completion of drilling, sampling, and subsurface water monitoring, all boreholes are backfilled with soil cuttings from the completed borings unless the client requests or local

ordinance requires special backfilling requirements. If there are not enough soil cuttings available, clean sand will be used to backfill the completed boreholes.

Details concerning the subsurface conditions are provided on each individual boring log presented in this Appendix. The terms and symbols used on each boring log are defined in the Legend Sheet which is also presented in this Appendix.

LABORATORY TESTING PROCEDURES

Classification and Index Testing

The recovered soil 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),
- Grain Size Analysis (ASTM D6913 or D1140),
- California Bearing Ratio test (ASTM D1883). With lime series (Tex-121-E) and pH
- Soluble Sulfates (M4500-SO₄ E).

Results of tests 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.