RBFCU – Potranco and Hwy 211

Geotechnical Engineering Report

August 2, 2024 | Terracon Project No. 90245209

Prepared for:

Randolph Brooks Federal Credit Union
1 Randolph Brooks Pkwy
Live Oak, Texas 78233-2416

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August 1, 2024

Randolph Brooks Federal Credit Union
1 Randolph Brooks Pkwy
Live Oak, Texas 78233-2416

Attn:Mr. Brian Kirkland

Re: Geotechnical Engineering Report
RBFCU – Potranco and Hwy 211
Potranco Road and Hwy 211
San Antonio, Texas.
Terracon Project No. 90245209

Dear Mr. Kirkland:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P90245209 dated July 9, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning the construction of a new bank building and associated parking areas for the proposed project.

We appreciate the opportunity to work with you on this project and look forward to contributing to the ongoing success of this project by providing Materials Testing services during construction. If you have any questions concerning this report, or if we may be of further service, please contact us

Sincerely,

Terracon
(Firm Registration No. F3272)

Carlos Cotilla
Senior Staff Engineer

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Table of Contents

Introduction **1**
Project Description **1**
Site Conditions **2**
Geotechnical Characterization **2**
Subsurface Conditions 2
Groundwater Conditions 3
Seismic Site Class **3**
Geotechnical Overview **4**
Expansion Potential 4
Sulfate Testing 4
Earthwork **4**
General Site Preparation 5
Pad Preparation 5
Fill Material Types 6
Fill Placement and Compaction Requirements 7
Grading and Drainage 7
Utility Trench Backfill 8
Earthwork Construction Considerations 9
Shallow Foundations **9**
Design Parameters – Slab on Grade 9
Design Parameters – Spread Foundation 10
Foundation Construction Considerations 11
Deep Foundations **12**
Drilled Pier Foundation 12
Drilled Pier Construction Considerations 13
Pavements **14**
Subgrade Preparation 14
Design Recommendations 15
Pavement Section Materials 17
Pavement Joints and Reinforcement 18
General Comments **20**
TABLE **22**

Figures
GeoModel

Attachments
Exploration and Testing Procedures
Site Location and Exploration Plans
Exploration and Laboratory Results
Supporting Information

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed bank building and associated parking areas to be located at Potranco Road and Hwy 211 in San Antonio, Texas.. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Pavement design and construction

The Geotechnical Engineering Scope of Services for this project included drilling, laboratory testing, engineering analysis, and preparation of this report. The field program for this project included the advancement of five (5) test borings drilled to depths ranging from about 6 to 30 feet below existing site grades.

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

Project Description

Our final understanding of the project conditions is as follows:

Item	Description
Information Provided	We have been provided the pertinent project details by Mr. Brian Kirkland via an email dated July 7, 2024.
Project Description	The project includes a single-story bank building with associated drive-thru, driveways and parking.
Proposed Construction	The project consists of construction of a single-story wood or metal frame building supported on shallow foundations. The drive-thru canopy can be supported on spread footings or drilled pier foundations.

Item	Description
Maximum Loads (Assumed)	Columns: 40 kips Wall: 3 kips per linear foot Floor Slab: 125 psf
Pavements	Both concrete and asphalt pavements will be considered.

Terracon should be notified if any of the above information is inconsistent with the planned construction, as modifications to our recommendations may be necessary.

Site Conditions

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

Item	Description
Parcel Information	The project is located at the southeast corner of the intersection of Potranco Road and Hwy 211 in San Antonio, Texas. See **Site Location**
Existing Improvements	Undeveloped.
Current Ground Cover	The site is partially wooded.
Existing Topography	Relatively level

Geotechnical Characterization

Subsurface Conditions

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

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

Model Layer	Layer Name	General Description
1	Lean Clay (CL)	Dark Brown to Tan; Very Stiff to Hard
2	Fat Clay (CH)	Grayish Tan; Stiff to Hard

The individual logs can be found in the **Exploration Results** section of this report. It should be emphasized the stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The borings were advanced to the required depths using dry drilling techniques to evaluate groundwater conditions at the time of our field program. The boreholes were observed for the presence of groundwater during and after completion of drilling. Groundwater was not observed in any of the borings.

Seasonal variations such as amount of rainfall and runoff, climatic conditions and other factors generally result in fluctuations of the groundwater level over time. A relatively long period may be necessary for groundwater level to develop and stabilize in a borehole. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The foundation contractor should check the groundwater conditions just before foundation excavation activities.

Seismic Site Class

Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with 1613.2.2 in the 2021 IBC and Table 20.3-1 in the 2016 ASCE-7. Based on the soil properties observed at the site and as described on the exploration logs and results, our professional opinion is for that a **Seismic Site Classification of D** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 30 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area.

Geotechnical Overview

Expansion Potential

Based on our findings, the subsurface soils at this site generally exhibit a high shrink/swell potential. Based on the information developed from our field and laboratory programs and on method TEX-124-E of the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, we estimate that the subgrade soils at this site exhibit a Potential Vertical Rise (PVR) of about 2 inches in their present condition. It should be emphasized that the actual movements could be greater than the values presented in this report because of inadequate drainage, ponded water and moisture infiltration beneath the structures after construction.

Sulfate Testing

The sulfate test results indicate that the sulfate concentration of the subgrades soils at the project site is about 50 mg/Kg. The sulfate concentration values are below the threshold level for adverse reactions based on TxDOT (>3,000mg/Kg), the National Lime Association (>3,000mg/Kg) and AASHTO (>5,000mg/Kg).

Based on the test results, the severity of potential exposure of concrete to sulfate attack falls under Class 0.

Water Soluble Sulfate Content in Soil (mg/kg)	Severity of Potential Exposure
> 10,000	Class 3
1,500 – 10,000	Class 2
150 – 1,500	Class 1
0 – 150	Class 0

Earthwork

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

General Site Preparation

Prior to construction, any vegetation and any otherwise unsuitable materials should be removed from the construction area. After stripping and grubbing, the exposed subgrade should be proof rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a fully loaded dump truck or comparable pneumatic tired vehicle. Soils that are observed to rut or deflect excessively (typically greater than 1-inch) under the moving load should be overexcavated to provide a firm, uniform bearing layer. The proof rolling and overexcavation activities should be witnessed by a representative of the Geotechnical Engineer and should be performed during a period of dry weather. Subgrade stabilization may also be performed as described below if the exposed subgrade exhibits yielding or pumping under construction traffic.

- Removal and replacement with select fill.
- Chemical treatment of the soil to dry and increase the stability of the subgrade.
- Drying by natural means if the schedule allows.

Pad Preparation

The following building pad preparation recommendations should be performed for the proposed building prior to foundation construction. As previously mentioned, the existing PVR at this site is about 2 inches. Recommendations for at-grade pad preparation to reduce the PVR to about 1 inch and provide uniform support to the grade supported slabs and flatwork for this project site are provided in the following sections.

- As discussed in the Site Preparation section, remove any vegetation, loose topsoil and any otherwise unsuitable materials from the building pad area. Excavate and remove about 4 feet of onsite soil from the building pad area. The building pad area is defined as the area that extends at least 3 feet (horizontal) beyond the perimeter of the proposed building and to the outside edge of any movement sensitive flatwork. The limits of the building pad should be indicated on the drawings for the project.

- After excavating to the depth specified above, the exposed subgrade should be proof rolled with a fully loaded dump or water truck to evidence any weak yielding zones. A Terracon geotechnical engineer or their representative should be present to observe proof rolling operations.

- Over-excavate any confirmed weak yielding zones, both vertically and horizontally, to expose competent soil. The exposed subgrade should be moisture conditioned between 0 and +4 percentage points of the optimum moisture content and then compact to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

- Place and compact 4 feet of select fill in loose lifts of about 8 inches to achieve the Finished Pad Elevation (FPE). Each lift should be moisture conditioned between -2 and +3 percentage points of the optimum moisture content, and then compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. The upper 6 inches of the building pad may be constructed with granular select fill to provide an all-weathering surface course. If grades are to be raised further, select fill should be used.

This method should result in at least 4 feet of compacted select fill beneath the grade supported floor slab.

Details regarding select fill materials, placement and compaction are presented in the following sections Fill Material Types and Fill Compaction Requirements.

Fill Material Types

Fill required to achieve design grade should be classified as Select Fill and General Fill. Material property requirements for Select Fill and General Fill are noted in the table below:

Fill Type	USCS Classification	Comments
Select Fill	CL, GC, SC ➢ LL≤40 and 7<PI≤20 ➢ % passing #200 sieve ≥35% ➢ Maximum particle size 1½”	Note 1
Onsite Soils	CH, CL	Note 2
Granular Select Fill	TxDOT Item 247, Type A, Grade 1-2 crushed limestone base material	Upper 6 inches of the pad to act as an all-weathering layer

1/ Prior to any filling operations, samples of the proposed Select Fill and on-site materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to ensure that proper levels of compaction, including dry unit weight and moisture content are attained.

2/ Onsite soils should not be used as select fill

Fill Placement and Compaction Requirements

Select fill, on-site soil and general fill should meet the following compaction requirements.

Item	Requirements
Fill Lift Thickness	All fill should be placed in thin, loose lifts of about 8 inches, with compacted thickness not exceeding 6 inches.
Compaction of On-Site Soil and Select Fill	95 percent of the material's Standard Proctor maximum dry density (ASTM D 698)
Moisture Content of Select Fill	Between -2 and +3 percentage points of the optimum moisture content.
Moisture Content of On-Site Soil	Between 0 and +4 percentage points of the optimum moisture content.

Grading and Drainage

Effective drainage should be provided during construction and maintained throughout the life of the new improvements. After pad construction, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Proper site drainage should be maintained during the entire construction phase so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access, particularly in cut areas. During construction, it is possible that the surficial soils may become excessively wet because of inclement weather conditions. When the moisture content of these clay soils elevates above what is considered to be the optimum range of moisture for compaction operations, they can become difficult to handle and compact. If such conditions create a hindrance to compaction operations or site access, lime or cement may be mixed with these soils to improve their workability. The additive can be mixed as per 2014 TxDOT Item 260 (Lime). The subgrade should be tested for sulfates prior to the use of lime. The purpose of the additive is to dry out the subgrade and improve sire access. The strict requirements for curing and actual quantity of additive can be at the discretion of the contractor.

Flatwork and pavements will be subjected to post-construction movement. Maximum grades that are feasible should be used for paving and flatwork to prevent water from ponding. Allowances in final grades should also consider post-construction movement of flatwork, particularly if such movements are deemed critical. Where paving or flatwork abuts the structure, joints should be effectively sealed and maintained to prevent surface water infiltration. In areas where sidewalks or paving do not immediately adjoin the structure, we recommend that protective slopes be provided with a grade of at least five percent for at least 10 feet from perimeter walls (except in areas where ADA ramps are required; these should comply with state and local regulations). Backfill against grade beams, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of construction debris to reduce the possibility of moisture infiltration.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation and expansion index requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended. Utility trench backfill compaction should be 95 percent of Standard Proctor compaction for paved and structure areas and 90 percent of Standard Proctor compaction for unpaved and non-structure areas.

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

Earthwork Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable. However, the stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If conditions develop, workability may be improved by scarifying and drying.

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

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

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

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in the Pad Preparation section in **Earthwork**, the following design parameters are applicable.

Design Parameters – Slab on Grade

Conventional Method Parameters	Prepared Subgrade
Net Allowable Bearing Pressures [1]	2,000 psf
Subgrade Modulus (k)	100 pci
Potential Vertical Rise (PVR)	1 inch
WRI Method Parameters	
Design Plasticity Index (PI)	26
Climatic Rating (C_w)	17

Conventional Method Parameters	Prepared Subgrade
Soil – Climate Support Index (1-C)	0.12

1. The net allowable bearing pressure includes a factor of safety of 3. The allowable bearing pressure may be increased by up to one-third for wind or seismic loads

We recommend that exterior grade beams be at least 30 inches below the finished exterior grade. Interior grade beams should be designed by the Structural Engineer. These recommendations are for a proper development of bearing capacity for the continuous beam sections of the foundation system and to reduce the potential for water to migrate beneath the slab foundation. These recommendations are not based on structural considerations. Grade beam depths may need to be greater than recommended herein for structural considerations and should be properly evaluated and designed by the Structural Engineer. The grade beams or slab portions may be thickened and widened to serve as spread footings at concentrated load areas.

For a slab foundation system designed and constructed as recommended in this report, post construction settlements should be about 1 inch. Settlement response of a select fill supported slab is influenced more by the quality of construction than by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the pad and foundation.

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

Design Parameters – Spread Foundation

Design recommendations for spread foundations for the proposed canopy are presented in the table below. The spread footings can provide some uplift resistance for those structures subjected to wind or other induced structural loading. The uplift resistance of a spread footing may be computed using the effective weight of the soil above the spread footing along with the weight of the spread footing and structure. A soil unit weight of 120 pcf may be assumed for the soils placed above the footing, provided the fill is properly compacted.

Description	Parameters
Net allowable bearing pressure [1]	2,000 psf
Minimum dimensions	30 inches

Description	Parameters
Minimum embedment below finished grade for bearing	36 inches
Approximate heave or total settlement from foundation loads	<1 inch
Allowable Net passive pressure [2]	200 pcf, equivalent fluid density
Allowable coefficient of sliding friction	0.25

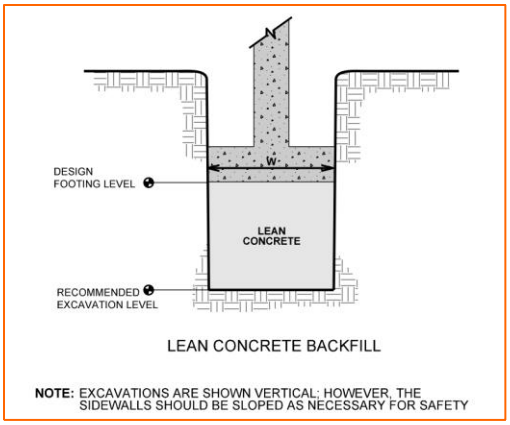
[1] The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes any soft soils, if encountered, will be undercut and replaced with compacted select fill or footing bears in competent native soils. Based upon a minimum Factor of Safety of 3.

[2] The spread footing foundation excavation sides must be nearly vertical and the concrete should be placed neat against these vertical faces for the passive earth pressure values to be valid. If the loaded side is sloped or benched, and then backfilled, the allowable passive pressure will be significantly reduced. Passive resistance in the upper 12 inches of the soil profile should be neglected.

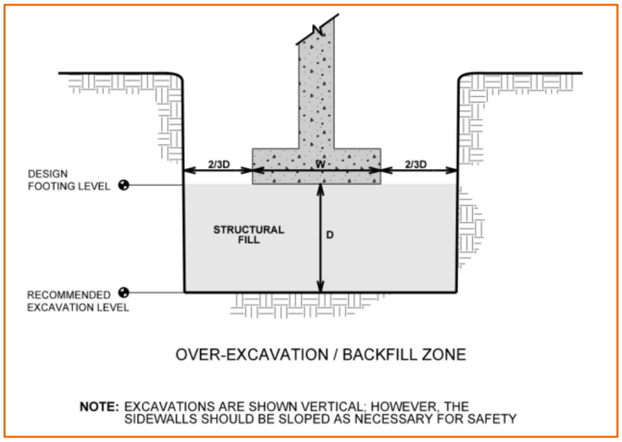
Foundation Construction Considerations

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

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



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



Deep Foundations

Drilled Pier Foundation

The canopy may be supported on straight-sided drilled piers bearing at a depth no shallower than 15 feet below existing grade.

Drilled piers may be designed for net allowable bearing pressure of 7,500 psf. This bearing pressure include factor of safety against a bearing capacity failure of approximately 3. An allowable side shear value of 600 psf, with an assumed factor of safety of at least 2, may be used to aid in resisting axial compressive loads on the piers. The side shear should be neglected for the upper 4 feet of soil in contact with the pier shaft. Piers should not extend deeper than 25 feet below the existing grades at the time of our geotechnical field activities without contacting our office. Piers should be designed with a shaft diameter at least 18 inches to facilitate inspection.

The allowable end bearing and skin friction values presented in this report are based on center-to-center spacing of the pier foundations no closer than a horizontal distance of three shaft diameters (using the larger bearing diameter). A closer spacing may be considered but may effect (reduce) the axial capacity of the foundation depending on the spacing pattern of the foundations. Terracon can assist in evaluating the possibility of a closer spacing once a foundation layout has been determined.

Total settlements, based on the indicated bearing pressures, should be about 1 inch for properly designed and constructed drilled piers. Settlement beneath individual piers will be primarily elastic with most of the settlement occurring during construction. Differential settlement may also occur between adjacent piers. The amount of differential settlement could approach 50 to 75 percent of the total pier settlement. For properly designed and constructed piers, differential settlement between adjacent piers is estimated to be less than ¾ of an inch. Settlement response of drilled piers is impacted more by the quality of construction than by soil-structure interaction.

Improper pier installation could result in differential settlements significantly greater than we have estimated. In addition, larger magnitudes of settlement should be expected if the soil is subjected to bearing pressures higher than the allowable values presented in this report.

Lateral Loading - The piers supporting the canopies may be subjected to lateral loading. The criteria for lateral load analysis is presented in Table 1 are for use with the computer program LPILE.

Drilled Pier Construction Considerations

The pier excavations should be augered and constructed in a continuous manner. Steel and concrete should be placed in the pier excavation immediately following drilling and evaluation for proper bearing stratum, embedment, and cleanliness. In no circumstances should the pier excavation remain open overnight.

During the time of our drilling operations, groundwater was not observed. Groundwater levels are influenced by seasonal and climatic conditions which result in fluctuations in subsurface water elevations. Therefore, the foundation contractor should be prepared to use temporary casing should water be encountered and/or sloughing of the excavation sidewalls occur. The casing method is discussed in the following paragraphs.

> **Casing Method -** Casing will provide stability of the excavation walls but will reduce water influx. However, casing may not completely eliminate subsurface water influx potential. In order for the casing to be effective, a "water tight" seal must be achieved between the casing and surrounding soils. The drilling subcontractor should determine casing depths and casing procedures. Water that accumulates in excess of six (6) inches in the bottom of the pier excavation

should be pumped out prior to steel and concrete placement. If the water is not pumped out, a long closed-end tremie should be used to place the concrete completely to the bottom of the pier excavation in a controlled manner to effectively displace the water during concrete placement. If this operation is not successful or to the satisfaction of the foundation contractor and engineer, the pier excavation should be flooded with fresh water to offset the differential water pressure caused by the unbalanced water levels inside and outside of the casing. If water is not a factor, concrete should be placed with a short tremie so that the concrete is directed to the bottom of the pier excavation. The concrete should not be allowed to ricochet off the walls of the pier excavation nor off reinforcing steel. When the pier excavation depth is achieved and the bearing area has been cleaned, steel and concrete should then be placed immediately in the excavation.

Removal of casing should be performed with extreme care and under proper supervision to reduce mixing of the surrounding soil and water with the fresh concrete. Rapid withdrawal of casing or the auger may develop suction that could cause the soil to intrude into the excavation. An insufficient head of concrete in the casing during its withdrawal could also allow the soils to intrude into the wet concrete. Both of these conditions may induce "necking", a section of reduced diameter, in the pier.

The concrete should be placed completely to the bottom of the excavation with a closed-end tremie in the pier excavation if more than six (6) inches of water is ponded on the bearing surface or the water should be pumped from the excavation. A short tremie may be used if the excavation has less than 6 inches of ponded water. The fluid concrete should not be allowed to strike the pier reinforcement, temporary casing (if required) or excavation sidewalls during concrete placement. All aspects of concrete design and placement should comply with the American Concrete Institute (ACI) 318 Code Building Code Requirements for Structural Concrete, ACI 336.1 Standard Specification for the Construction of Drilled Piers, and ACI 336.3R entitled Suggested Design and Construction Procedures for Pier Foundations.

Pavements

Both flexible and rigid pavement systems may be considered for the project. Based on our knowledge of the project, we anticipate that traffic loads will be produced primarily by automobile traffic, delivery and trash removal trucks.

Subgrade Preparation

Prior to construction, any pavements, vegetation, and any otherwise unsuitable materials should be removed from the new pavement areas. After stripping, the subgrade should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a fully loaded dump truck. Wet, soft, low-density or dry material should either be removed or moisture conditioned and recompacted to the moisture contents and densities described in section Fill Compaction Requirements prior to placing fill.

Due to the presence of the expansive clay soil at the site, movement of pavement up to 2 inches should be expected. If the movement of the pavement is not acceptable, then the pavement subgrade should be prepared similar to the structure pad provided in the **Pad Preparation** section of this report.

Design Recommendations

For this project Light and Heavy pavement section alternatives have been provided. Light is for areas expected to receive only car traffic. Heavy assumes areas with heavy traffic, such as trash pickup areas, delivery areas and main access drive areas.

The flexible pavement section was designed in general accordance with the National Asphalt Pavement Association (NAPA) Information Series (IS-109) method (Class 1 for Light and Class 2 for Heavy). The rigid pavement section was designed using the American Concrete Institute (ACI 330R-01) method (Traffic Category A (ADTT=1) for Light and A-1 (ADTT=10) for Heavy). If heavier traffic loading is expected, Terracon should be provided with the information and allowed to review these pavement sections.

	FLEXIBLE PAVEMENT SYSTEM (inches)			
	Raw Subgrade		Modified Subgrade	
	Light Duty	Heavy Duty	Light Duty	Heavy Duty
Hot Mix Asphaltic Concrete	2.0	2.5	2.0	2.5
Granular Base Material	10.0	14.0	6.0	10.0
Lime Treated Subgrade	---	---	6.0	6.0
Moisture Conditioned Raw Subgrade	6.0	6.0	---	---

	RIGID PAVEMENT SYSTEM (inches)			
	Raw Subgrade		Modified Subgrade	
	Light Duty	Heavy Duty	Light Duty	Heavy Duty
Reinforced Concrete	5.5	6.5	5.0	6.0
Lime Treated Subgrade	---	---	6.0	6.0
Moisture Conditioned Raw Subgrade	6.0	6.0	---	---

1/ Dumpster pad should be constructed as heavy-duty rigid section.

Pavement areas that will be subjected to heavy wheel and traffic volumes, such as waste bin or "dumpster" areas, entrance/exit ramps, and delivery areas, should be a heavy-duty rigid pavement section constructed of reinforced concrete. The concrete pavement areas should be large enough to properly accommodate the vehicular traffic and loads. For example:

- The dumpster pad should be large enough so that the wheels of the collection truck are entirely supported on the concrete pavement during lifting of the waste bin; and
- The concrete pavement should extend beyond any areas that require extensive turning, stopping, and maneuvering.
- The pavement design engineer should consider these and other similar situations when planning and designing pavement areas. Waste bin and other areas that are not designed to accommodate these situations often result in localized pavement failures.

The pavement section has been designed using generally recognized structural coefficients for the pavement materials. These structural coefficients reflect the relative strength of the pavement materials and their contribution to the structural integrity of the pavement. If the pavement does not drain properly, it is likely that ponded water will infiltrate the pavement materials resulting in a weakening of the materials. As a result, the structural coefficients of the pavement materials will be reduced and the life and performance of the pavement will be shortened. The Asphalt Institute recommends a minimum of 2 percent slope for asphalt pavements. The importance of proper drainage cannot be overemphasized and should be thoroughly considered by the project team.

Pavement Section Materials

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 the Geotechnical Engineer and appropriate members of the design team and should provide test information necessary to verify full compliance with the recommended or specified material properties.

- **Hot Mix Asphaltic Concrete Surface Course** - The asphaltic surface material should meet the specification requirements of 2014 TxDOT Standard Specification Item 341 or SS3076/3077, Type D.

- **Concrete** - Concrete should have a minimum 28-day design compressive strength of 4,000 psi.

- **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 1-2; including triaxial strength. The material should be compacted to at least 95 percent of the maximum dry density as determined in accordance with ASTM D 1557 at moisture contents ranging from -2 and +3 percentage points of the optimum moisture content.

- **Lime Treated Subgrade** - Due to the presence of clay at this site, the subgrade may be modified with hydrated lime in accordance with TxDOT Item 260 in order to improve its strength and improve its load carrying capacity. We anticipate that approximately 6 percent hydrated lime will be required. This is equivalent to about 30 pounds of hydrated lime per square yard for a 6-inch treatment depth. However, the actual percentage should be determined by laboratory tests on samples of the clayey subgrade prior to construction. The optimum 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 and should reduce the Plasticity Index to 20 or less.

  The lime should initially be blended with a mixing device such as a Pulvermixer, sufficient water added, and be allowed to cure for at least 48 hours. After curing, the lime-soil should be remixed to meet the in-place gradation requirements of Item 260 and compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698 at moisture contents ranging from optimum and 4 percentage points above the optimum moisture content.

- **Moisture Conditioned Subgrade** - The subgrade should be scarified to a depth of 6 inches and then moisture conditioned and compacted as recommended in the Compaction Requirements section of this report.

Details regarding subgrade preparation, fill materials, placement and compaction are presented in Earthwork section under subsections Fill Material Types and Fill Compaction Requirements.

Pavement Joints and Reinforcement

The following is recommended for all concrete pavement sections in this report. Refer to ACI 330 "Guide for Design and Construction of Concrete Parking Lots" for additional information.

Item	Description
Distributed Reinforcing Steel	No. 3 reinforcing steel bars at 18 inches on-center-each-way, Grade 60. It is imperative that the distributed steel be positioned accurately in the pavement cross section, namely 2 inches from the top of the pavement.
Contraction Joint Spacing	12.5 feet each way for pavement thickness of 5 to 5.5 inches. 15 feet each way for pavement thickness of 6 inches or greater. Saw cut control joints should be cut within 6 to 12 hours of concrete placement.
Contraction Joint Depth	At least ¼ of pavement thickness.
Contraction Joint Width	One-fourth inch or as required by joint sealant manufacturer.
Construction Joint Spacing	To attempt to limit the quantity of joints in the pavement, consideration can be given to installing construction joints at contraction joint locations, where it is applicable.
Construction Joint Depth/Width	Full depth of pavement thickness. Construct sealant reservoir along one edge of the joint. Width of reservoir to be ¼ inch or as required by joint sealant manufacturer. Depth of reservoir to be at least ¼ of pavement thickness.
Isolation Joint Spacing	As required to isolate pavement from structures, etc.

Item	Description
Isolation Joint Depth	Full depth of pavement thickness.
Isolation Joint Width	½ to 1 inch or as required by the joint sealant manufacturer.
Expansion Joint	In this locale, drying shrinkage of concrete typically significantly exceeds anticipated expansion due to thermal affects. As a result, the need for expansion joints is eliminated provided all joints (including saw cuts) are sealed. Construction of an unnecessary joint may be also become a maintenance problem. All joints should be sealed. If all joints, including sawcuts, are not sealed then expansion joints should be installed.

All construction joints have dowels. Dowel information varies with pavement thickness as presented as follows:

Parameter	5 to 5½ inches	6 to 6½ inches
Dowels	⅝ inch diameter	¾ inch diameter
Dowel Spacing	12 inches on center	12 inches on center
Dowel Length	12 inches long	14 inches long
Dowel Embedment	5 inches	6 inches

Pavement Drainage and Maintenance

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance. The following recommendations should be implemented to help promote long-term pavement performance:

- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2 percent.
- Install joint sealant and seal cracks immediately.
- Extend curbs into the subgrade for a depth of at least 4 inches to help reduce moisture migration into the subgrade soils beneath the pavement section.
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter.
- Slope subgrade in landscape islands to low points should drain to an appropriate outlet.
- Edge drains are recommended along pavement/ landscape borders.

General Comments

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

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

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

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

TABLE

TABLE 1
LPILE PARAMETERS

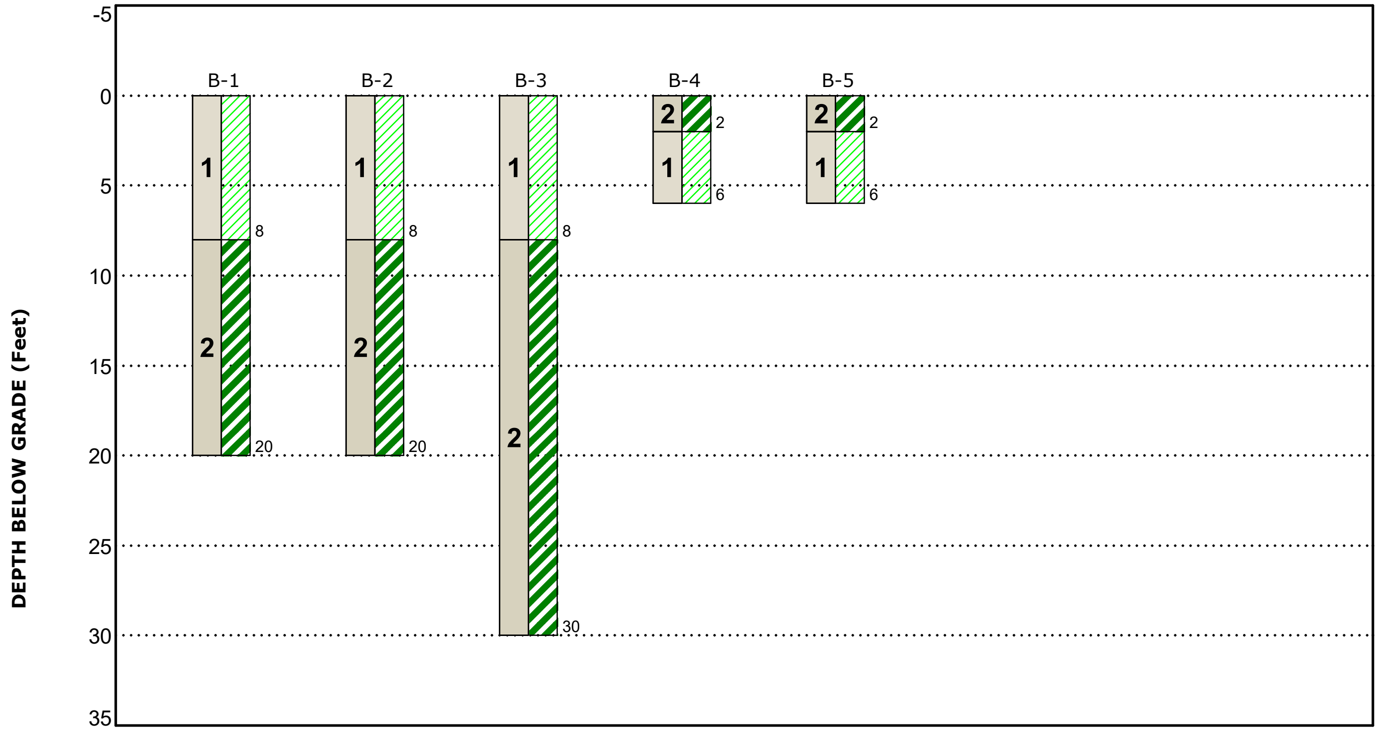
Layer	Depth to Bottom of Layer (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength (psf)	Soil Strain Factor (ε_{50})	LPILE Soil Types	Soil /Rock Modulus, k or E_r (pci or psi)	Bearing Capacity Factors		
							N_c [5]	N_q	N_γ
1	4	120	1,000	0.010	Stiff Clay without Free Water	428	6	1	0
2	10	120	2,000	0.007	Stiff Clay without Free Water	622	6	1	0
3	20	120	3,000	0.006	Stiff Clay without Free Water	815	6	1	0
4	30	120	4,500	0.005	Stiff Clay without Free Water	1,105	9	1	0

[1] Design depth to subsurface water is greater than 30 feet.
[2] For uplift conditions, the computed skin friction should be multiplied by 0.9 for clay.
[3] Stratigraphy shown above is based on our interpretation of soil strength and may not correspond with the descriptive classifications shown on the boring log.
[4] The lateral load criteria shown above are for use in the computer programs LPILE.
[5] The depth to diameter ratio must exceed 4 to use N_c = 9. Otherwise, use N_c = 6.

Figures

6000 Northwest Pkwy Ste 100
San Antonio, TX

GeoModel



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

Model Layer	Layer Name	General Description
1	Lean Clay (CL)	Dark Brown to Tan; Very Stiff to Hard
2	Fat Clay (CH)	Grayish Tan; Stiff to Hard

Legend

Lean Clay
Fat Clay

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
2 (B-1 and B-2)	20	Building
1 (B-3)	30	Drive-Thru Canopy
2 (B-4 and B-5)	6	Pavement

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features.

Subsurface Exploration Procedures: We advanced the soil borings with a truck-mounted drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Soils were sampled by means of split barrel sampling procedure. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration was recorded as the Standard Penetration Test (SPT) resistance value. The samples were removed from the samplers in the field, visually classified, and appropriately sealed in sample containers to preserve in-situ moisture contents. We observed and recorded groundwater levels during drilling, coring and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

Our exploration team prepared field boring logs as part of the drilling operations. The sampling depths, visual classification of the materials encountered, SPT values, pocket penetrometer readings, other pertinent sampling information were recorded on the field boring logs.

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in this Appendix. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented in this appendix. The laboratory test results were used for the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards. Selected soil samples obtained from the site were tested for the following engineering properties:

- Moisture Content
- Atterberg Limits
- Percent Passing No.200 Sieve
- Sulfate Tests

Final boring logs that were prepared represented the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Site Location and Exploration Plans

Site Location

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

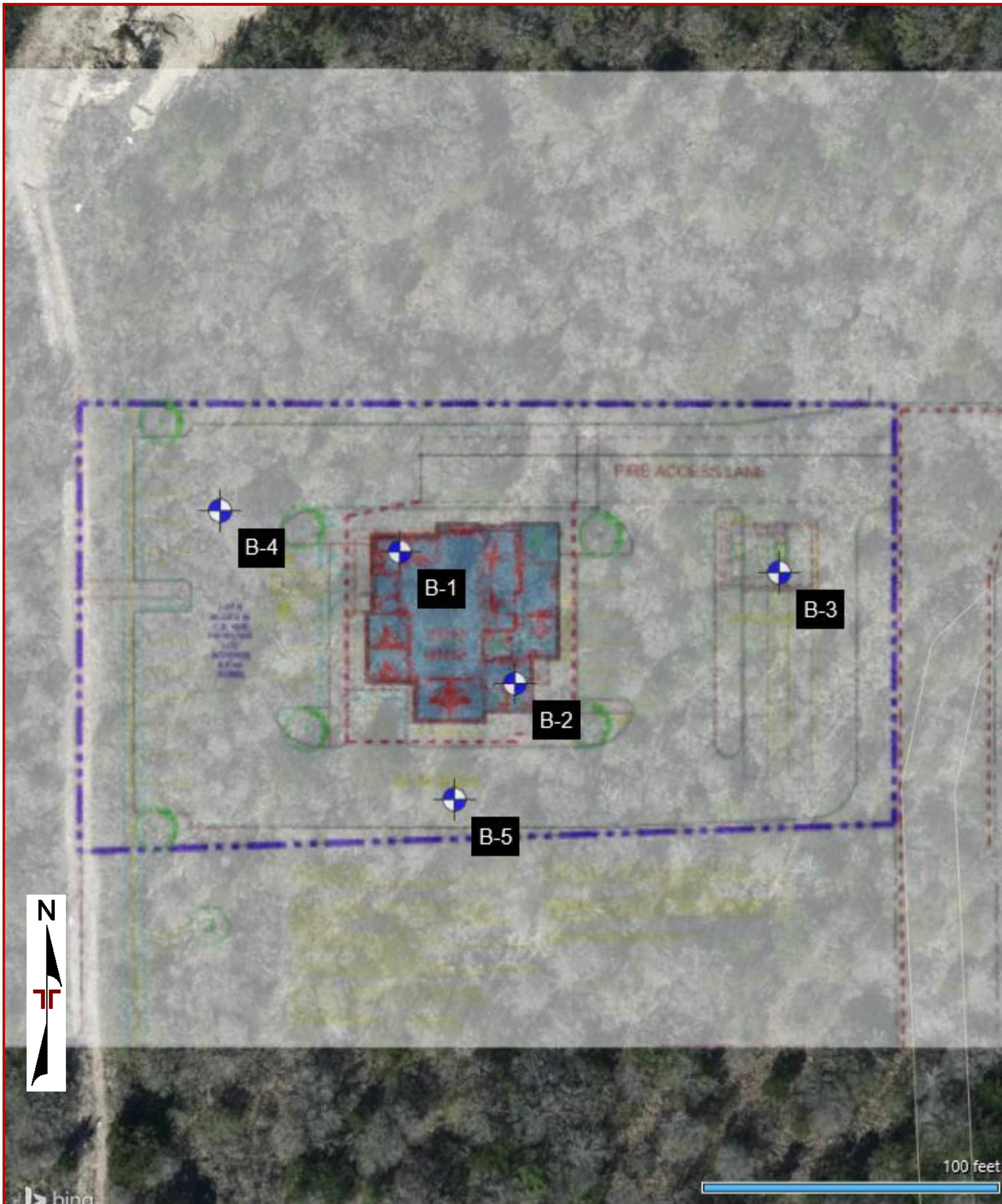


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 29.4205° Longitude: -98.7809°

Graphic Log	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		LEAN CLAY (CL), calcareous nodules, dark brown to tan, very stiff to hard				3-7-8 N=15	11.3	48-24-24	
						9-12-16 N=28	6.6		94
			5			18-24-29 N=53	9.3	43-17-26	
	8.0					33-40-50/3"	8.1		94
		FAT CLAY (CH), grayish tan, hard				7-16-18 N=34	16.5	57-19-38	
			10						
						6-20-50/4"			
			15						
	20.0		20			4-24-40 N=64			
		Boring Terminated at 20 Feet							

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

Water Level Observations
No free water observed

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Terracon

Notes

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
07-17-2024

Boring Completed
07-17-2024

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 29.4203° Longitude: -98.7808°

Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	LEAN CLAY (CL), calcareous nodules, dark brown to tan, medium stiff to very stiff			X	2-3-4 N=7	9.9		88
				X	5-8-9 N=17	7.1	44-24-20	
		5		X	9-12-17 N=29	7.0		
8.0				X	12-13-13 N=26	10.9	48-18-30	
	FAT CLAY (CH), tan, very stiff to hard			X	8-13-13 N=26			
		10						
		15		X	3-34-50/3"			
20.0		20		X	11-18-21 N=39			
	Boring Terminated at 20 Feet							

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

Water Level Observations
No free water observed

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Terracon

Notes

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
07-17-2024

Boring Completed
07-17-2024

6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 29.4204° Longitude: -98.7805°

Graphic Log	Depth (Ft.) / Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	LEAN CLAY (CL), calcareous nodules, dark brown to tan, very stiff to hard				5-6-7 N=13	16.6	49-22-27	
					7-9-9 N=18	8.5		90
		5			5-8-12 N=20	9.6	44-18-26	
	8.0				11-16-19 N=35			
	FAT CLAY (CH), grayish tan, stiff to hard				4-8-9 N=17	21.2		
		10						
	- cemented seams between 13 to 15 feet				10-50/2"			
		15						
					13-24-34 N=58	13.7	50-16-34	
		20						
					27-37-50/2"			
		25						
	30.0	30			3-5-7 N=12			
	Boring Terminated at 30 Feet							

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

Water Level Observations
No free water observed

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Terracon

Notes

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
07-17-2024

Boring Completed
07-17-2024

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 29.4205° Longitude: -98.7811°

Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		FAT CLAY (CH), calcareous nodules, dark brown, very stiff			X	5-8-8 N=16	13.1	52-20-32	
	2.0	**LEAN CLAY (CL)**, calcareous nodules, tan, very stiff to hard			X	7-9-12 N=21	8.1		
	6.0		5		X	9-15-20 N=35	8.6		
		Boring Terminated at 6 Feet							

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

Water Level Observations
No free water observed

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Terracon

Notes

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
07-17-2024

Boring Completed
07-17-2024

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 29.4202° Longitude: -98.7808°

Graphic Log Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	FAT CLAY (CH), calcareous nodules, dark brown, stiff				4-7-5 N=12	11.9		
2.0	**LEAN CLAY (CL)**, calcareous nodules, tan, very stiff to hard				5-8-15 N=23	6.8	39-25-14	
6.0		5			13-18-15 N=33	6.5		
	Boring Terminated at 6 Feet							

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

Water Level Observations
No free water observed

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Terracon

Notes

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
07-17-2024

Boring Completed
07-17-2024

Supporting Information

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

General Notes

Sampling

Split Spoon

Water Level

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Cave In Encountered

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

Field Tests

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

Descriptive Soil Classification

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

Location And Elevation Notes

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

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		Consistency of Fine-Grained Soils (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

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

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.