Preliminary Geotechnical Engineering Report

McCoy School Tract
Georgetown, Texas

April 18, 2018
Terracon Project No. 96185088

Prepared for:
Georgetown ISD
Georgetown, Texas

Prepared by:
Terracon Consultants, Inc.
Austin, Texas

Terracon GeoReport

April 18, 2018

Georgetown ISD
603 Lakeway Drive
Georgetown, Texas 78628

Attn: Mr. David Biesheuvel
P: 512.943.5129
E: biesheuveld@georgetownisd.org

Re: Preliminary Geotechnical Engineering Report
McCoy School Tract
NEQ of Williams Drive and Park Lane
Georgetown, Texas
Terracon Project No. 96185088

Dear Mr. Biesheuvel:

We have completed the Preliminary Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P96185088 dated March 12, 2018. This report presents the findings of the subsurface exploration and provides comments with respect to earthwork, subgrade preparation, fill placement, and options for foundations and pavement systems for the future development. A final geotechnical report will be required once a site development plan is finalized and prior to final design/construction.

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

Sincerely,
Terracon Consultants, Inc.
(TBPE Firm Registration: TX-F3272)

STATE OF TEXAS
4/18/18
EDWARD ESCOBAR JAIMES
123388
LICENSED
PROFESSIONAL ENGINEER

Edward E. Jaimes, P.E.
Project Engineer

Bryan S. Moulin, P.E.
Principal, Geotechnical Department Manager

REPORT TOPICS

ATTACHMENTS

Preliminary Geotechnical Engineering Report

McCoy School Tract
NEQ of Williams Drive and Park Lane
Georgetown, Texas
Terracon Project No. 96185088
April 18, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed McCoy School Tract project to be located at the NEQ of Williams Drive and Park Lane in Georgetown, Texas. The purpose of these services is to analyze and evaluate the test data, and to provide preliminary comments with respect to

- Subsurface soil and rock conditions
- Groundwater conditions
- Building subgrade preparation
- Seismic site classification per IBC
- Foundation options
- Site preparation and earthwork
- Pavement systems

The geotechnical engineering scope of services for this project included the advancement of five (5) test borings, designated B-1 through B-5 to depths of approximately 20 feet below existing site grades to aid in developing preliminary geotechnical engineering recommendations for project planning purposes. Once project plans are more advanced, a more comprehensive geotechnical report based on a more extensive field exploration program should be performed prior to final design and construction.

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

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 on a 16.161-acre tract of land at the NEQ of Williams Drive and Park Lane in Georgetown, Texas. See **Site Location**.
Existing Improvements	Elementary school building located at the southern corner of the site.
Current Ground Cover	Soils, grass, weeds, scattered to dense trees, and asphaltic and concrete pavements in non-building areas.
Existing Topography	Elevations range from 760 to 755 feet based on Google Earth®.
Geology	Based on our borings, the subsurface consists of surficial high plasticity clay soils over Edwards Group limestone of Lower Cretaceous Age. The Edwards limestone is typically comprised of limestone and dolomitic limestone. Characteristics of the Edwards limestone which are of engineering importance include karst features such as sinkholes, solution cavities and channels, collapse breccia, and vugular zones. In addition, clay seams and layers are present in the Edwards limestone.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed in the project planning stage.

Item	Description
Proposed Structures	We understand that no development is currently planned at this site. Terracon will be performing borings and providing the data to the Client as well as preliminary recommendations for foundations, earthwork, and pavements.

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

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

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Density
1	2 – 10	Dark brown to brown to light brown fat clays (CH) to lean clays (CL)	Very stiff to hard

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Density
2	Undetermined: Borings terminated within this stratum at the planned depth of approximately 20 feet	Light brown to tan Edwards Group limestone	---

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

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, nor for the short duration the borings could remain open. However, this does not necessarily mean no groundwater may be present at the site.

Groundwater seepage is possible at this site, particularly in the form of seepage traveling along pervious seams/fissures in the soil, along the soil/limestone interface and or in fissures/fractures in the limestone. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Please contact us if this is desired. Groundwater conditions should be evaluated immediately prior to construction.

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

EARTHWORK

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

Site Preparation

After demolition of the existing structures, construction areas should be stripped of all vegetation, concrete, asphalt, loose soils, top soils, construction debris, and other unsuitable material currently present at the site. Roots of trees to be removed within construction areas, if any, should be grubbed to full depths, including the dry soil around the roots. All remnants of existing foundations should be completely excavated and removed to at least 2 feet below finished grades. If any unusual items are unearthed during or after demolition, please contact us for further evaluation. Utilities to be abandoned should be completely removed from all proposed construction areas. If this is not feasible, then the abandoned utility piping should be filled with flowable fill (TxDOT Item No. 401) and plugged such that it does not become a conduit for water flow. Site stripping/excavation operations in cut areas could loosen limestone rocks/boulders which should either be properly broken down or removed from the site. We recommend that Terracon be retained to assist in evaluating exposed subgrades during earthwork so that unsuitable materials, if any, are removed at the time of construction.

Proof-Rolling

Once initial subgrade elevations have been achieved (i.e., after cuts but prior to fills), the exposed subgrade in all construction areas (except landscaping) should be carefully and thoroughly proof-rolled with a 20-ton pneumatic roller, fully-loaded dump truck, or similar equipment to detect weak zones in the subgrade. Proof-rolling is not necessary in intact Stratum 2 limestone subgrade areas. Weak areas detected during proof-rolling, zones containing debris or organics, and voids resulting from removal of tree roots, existing foundation elements, utilities, fill, boulders, etc. should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils (or flowable fill). Proper site drainage should be maintained during construction so that ponding of surface runoff does not occur and cause construction delays and/or exhibit site access.

Moisture Conditioned Subgrade

After proof-rolling, and just prior to placement of fill, the exposed soil subgrade in all construction areas (except landscaping) should be evaluated for moisture and density through field density testing. If the moisture and/or density requirements do not meet the moisture and density requirements below, the subgrade should be scarified to a minimum depth of 6 inches, moisture conditioned and compacted as per the fill compaction requirements. Moisture conditioning is not required in intact Stratum 2 limestone subgrade areas.

As an alternative to evaluation of the existing soil subgrade through moisture-density testing in building areas, the subgrade may be over-excavated an additional 6 to 12 inches to allow for placement and compaction of an additional 6 to 12 inches of select fill. If this option is selected, the additional excavation should be made prior to proofrolling.

Excavations

Excavation operations at this site may penetrate through the Stratum 1 soils and into the Stratum 2 limestone. While the Stratum 1 soils should be relatively easy to excavate in comparison to the underlying limestone, there is a probability of encountering limestone cobbles, boulders, seams, and layers within these soils. Our past experience with the Stratum 2 limestone indicates that the Stratum 2 limestone may require sawcutting, jackhammering, hoe-ramming, milling, or similar techniques to excavate.

Please note that although Stratum 2 limestone was encountered at varying depths across the site, the weathering profile of limestone can be unpredictable. The Contractor should be prepared to encounter and properly excavate near-surface limestone anywhere on this site.

Our comments on excavation are based on our experience with the rock formation. Rock excavation depends on not only the rock hardness, weathering and fracture frequency, but also the contractor's equipment, capabilities, and experience. Therefore, it should be the contractor's responsibility to determine the most effective methods for excavation. The above comments are intended for information purposes for the design team only and may be used to review the contractor's proposed excavation methods.

Potential for Karst and Voids in Edwards limestone

As evidenced in our borings, the Edwards Formation limestone does exhibit voids, clay-filled zones, and/or solution activity which may impact construction. If voids or other significant solution features are encountered during site preparation/excavation operations, Terracon should be contacted to evaluate the feature from a geotechnical engineering standpoint. For most such features, filling or grouting the void with concrete would be appropriate to minimize the potential for water/material migration into the feature once construction has been completed. In some cases, for larger voids and in cases where groundwater is present, preparation of a void mitigation plan could be required by the Texas Commission of Environmental Quality (TCEQ), which could lead to significant construction delays of weeks to even a month or more, possibly for each occurrence.

Fill Material Types

Fill required to achieve design grade should be classified as select/structural fill and general fill. Select/structural fill is material used below, or within 5 feet of structures. General fill is material used to achieve grade in paving, non-reinforced earthen slopes, landscape, or other general areas (non-structural areas). Earthen materials used for select fill and general fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Specifications
Imported Select/Structural Fill [2,3,4]	CL, SC, and/or GC	■ TxDOT Item 247, Type A, Grade 3 ■ Percent Retained on No. 4 Sieve ≤ 40 percent with 7≤PI≤20 and rocks ≤ 4 inches in maximum dimensions ■ Crushed concrete (TxDOT Item 247, Type D, Grade 3 or better)
Paving Fill and General Fill [5]	CH, CL, SC and/or GC	PI ≤ 60; Rocks ≤ 4 inches in maximum dimension

1. Structural and general fill should consist of approved materials free of organic matter and debris. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. As an alternative to the Acceptable Specifications above, a low-plasticity granular material which does not meet these specifications may be used only if approved by Terracon.
3. Based on the laboratory testing performed during this exploration, the excavated Stratum 1 soils are <u>not</u> suitable for re-use as select fill. We do <u>not</u> recommend these soils be considered for re-use as select fill when planning budgets.
4. The excavated Stratum 2 limestone material may be acceptable for re-use as select fill provided that it is processed such that it meets one of the Acceptable Specifications above for Imported Select/Structural Fill. Please note that removal of higher plasticity soils/layers (typically dark brown to reddish-brown in color) may be necessary to maintain plasticity indices of the material within acceptable range. In some situations, the difference between more highly plastic clay, lower plasticity silty soils, and appropriate material may not be readily distinguishable without the performance of appropriate lab testing. After initial processing of the fill material, samples should be submitted to Terracon for evaluation of proper gradation, plasticity index, and maximum rock size prior to re-use as select fill. We recommend that periodic testing be performed throughout the material excavation phase to check for conformance with the select fill requirements given above.

   It has been our experience that proper processing of excavated limestone often involves such processes as breaking down of larger rock with equipment, screening, removal of more highly plastic clay layers, etc. The Contractor's proposed methods of processing these materials should be reviewed prior to initiation of construction to check that these methods will produce an acceptable select fill material. The relative ease of mining and segregating the materials is unknown at this time.
5. Excavated on-site soils, if free of organics, debris, and rocks larger than 4 inches may be considered for re-use as fill in pavement, landscape, or other general areas. Please note that the on-site soils exhibit high to very high shrink/swell potential. For economic reasons, expansive soils are often used in pavement and/or flatwork areas. The owner should be aware that the risk exists for future movements of the subgrade

soils which may result in movement and/or cracking of pavement and/or flatwork. If paving fill is imported, the PI should not exceed 50.

Fill Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows.

Material Type		Minimum Compaction Requirement (%)[1]	Moisture Content Range (%)	Maximum Loose Lift Thickness (in)[2]
Select/Structural Fill		95[3]	-3 to +3	8 inches
Moisture Conditioned Building Subgrade	**PI ≤ 25**	95	-3 to +3	8 inches
	PI > 25	95	Optimum to +4	
Paving Fill, Paving Subgrade and General Fill	**PI ≤ 25**	95	-3 to +3	8 inches
	PI > 25	95	Optimum to +4	8 inches
Crushed Limestone Base (beneath pavements)		100[4]	-3 to +3	8 inches

1. Per the Standard Proctor Test (ASTM D 698).
2. Fill lift thickness must be reduced (typically 4 to 6 inches) if light compaction equipment is used, as is customary within a few feet of retaining walls and utility trenches.
3. **For fills greater than 5 feet in depth, if any, the compaction should be increased to at least 100 percent of the ASTM D 698 maximum dry unit weight.**
4. Per TEX-113-E (or 95% of Modified Proctor, ASTM D1557).

Earthwork Construction Considerations

Based on our test borings, highly to very highly expansive soils that exhibit a potential for volumetric chance during moisture variations are present at this site. These subgrade soils at the surface may experience expansion and contraction due to changes in moisture content. Based on existing grades, the soils at this site could exhibit a Potential Vertical Rise (PVR) of up to about 2½ inches, as estimated by the TxDOT Method TEX-124-E, if present in a dry condition.

PRELIMINARY COMMENTS ON BUILDING SUBGRADE PREPARATION

The Stratum 1 soils exhibit high to very high shrink/swell potential. The in-situ soils at this site generally exhibit a PVR of up to 2½ inches, if present in a dry condition. The expansive clay soils at this site could induce movement upon grade-supported floor slabs due to their potential to undergo volumetric change during variations in in-situ moisture conditions. This movement potential is influenced primarily by the properties of the subgrade soils as well as the moisture content of the subgrade at the time of construction, overburden pressures, and the stability of moisture contents after construction is complete.

For preliminary planning/budgeting purposes, we anticipate that the dark brown Stratum 1 clays encountered within building areas below existing grades should be excavated to depths of 4 to 7 feet below existing grades, or until the underlying Stratum 2 limestone is encountered, whichever occurs first, in order to reduce/limit potential for shrink/swell of expansive soils. The removed soils should be replaced with properly compacted select fill within all building areas up to final grades. If Stratum 2 limestone is exposed while excavating, it should be overexcavated as necessary in order to attain a minimum of 12 inches of select fill.

We recommend the use of crushed limestone base as the select fill material within the upper 6 inches of final subgrades, from a standpoint of construction access during wet weather, as well as from a standpoint of more uniform floor slab support. Prior to placement and compaction of select fill or base course material, the soil subgrade should be thoroughly proof-rolled with a 20-ton roller to detect weak zones as discussed in **Earthwork** section.

All fill material placed within the building footprint should meet the requirements of Select Fill described in **Earthwork**. Material and placement requirements for select fill, as well as other subgrade preparation recommendations, are presented in **Earthwork**.

The above preliminary estimates are based on planned FFE's being approximately at existing grade and must be reviewed and finalized based on planned finished floor elevation and subsurface conditions during the final geotechnical study.

PRELIMINARY COMMENTS ON FOUNDATION SYSTEMS

Based upon the subsurface conditions observed during this exploration, shallow footing or slab-on-grade foundation systems would be appropriate for lightly loaded structures, such as apartment buildings and/or retail buildings. Drilled piers into the Stratum 2 limestone would likely be more appropriate for heavier loaded structures such as tilt-wall warehouses, parking garages, and multi-storied concrete buildings.

The following foundation design parameters are for preliminary purposes only. Final design and construction recommendations will be presented in a Final Geotechnical Report once development plans are more advanced and a more comprehensive subsurface exploration is completed.

Monolithic Slab-On-Grade/Footing Foundations

Many lightly loaded structures in the Central Texas area are supported on monolithic slab-on-grade foundation systems (either conventionally reinforced or post-tensioned) or shallow spread/continuous footings. Design bearing capacities will depend on the subsurface conditions at specific locations, finished grades, and loading conditions. Based on the data obtained during this exploration, we anticipate maximum allowable bearing capacities for the grade beams/footings in the range of 2,000 psf to 3,000 psf for beams/footings bearing in properly compacted select fills prepared as per **Preliminary Comments on Building Subgrade Preparation**.

Drilled Piers

More heavily loaded structures are typically supported on drilled pier foundation systems. Based on our borings, drilled straight-sided piers may be an option, however the quality of the rock is very poor to poor. With such poor rock quality, the following options may be considered for planning purposes:

- Side friction only piers bearing into Edwards limestone: With this option, a reduced side friction would be considered for the rock and clay layers, however no side friction can be considered in voids and no end bearing component should be used (side friction of about 1,000 to 2,000 psf may be considered)
- Side friction and end bearing piers bearing into Edwards limestone: With this option, end bearing may only be considered if pilot holes are performed to confirm that intact limestone is present to a depth of 1 to 2 times the pier diameter below the bottom of the pier. (side friction of about 1,000 to 2,000 psf with an end bearing component of 15,000 to 40,000 psf may be considered)
- Side friction and end bearing piers bearing into the deeper more competent regional dense member of the Edwards limestone: With this option the piers would need to be advanced until the more intact regional dense member is encountered. The regional dense member is distinct from the upper leached and collapsed member, which exhibit excessive voids and karst feature (side friction of about 3,000 to 5,000 psf with an end bearing component of 30,000 to 70,000 psf may be considered). Please note that the regional dense member was not encountered in the preliminary borings and much deeper borings will be needed during the final investigation in order to more fully consider this design option.

For all options, the piers must bear at least 2 to 5 feet into the Edwards limestone. In addition, a minimum shaft steel percentage of ½ to 1 percent of the gross shaft area should be considered for planning purposes.

As previously mentioned, groundwater was not encountered during our field program, however groundwater influx and/or sloughing of pier sidewalls are a possibility during excavation of drilled piers. It is possible that the use of temporary casing to control groundwater and/or sidewall sloughing during pier construction may be needed from a planning standpoint.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10.

Code Used	Seismic Design Category	Site Soil Classification
2015 International Building Code (IBC) [1]	A [2,3]	C [4]

1. Seismic site classification in general accordance with the *2015 International Building Code*, which refers to ASCE 7-10.
2. Per IBC 2015 Section 1613.3.1. Latitude: 30.6499°N Longitude 97.6862°W
   S_S=0.063; S_1=0.035; S_{MS}=0.075; S_{M1}=0.060, S_{DS}=0.050; S_{D1}=0.040
3. This seismic design category was obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).
4. The 2015 International Building Code (IBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 20 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. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth. If you desire parameters for different versions of IBC, please contact us.

PRELIMINARY COMMENTS ON PAVEMENTS

For the subgrade conditions observed, it is our opinion that the site would be suited for either conventional flexible pavement systems (asphaltic concrete underlain by crushed limestone base) or rigid pavement systems (reinforced concrete). These two types of pavement are not considered equal. Over the life of the pavement, concrete pavements would be expected to exhibit better performance and require less maintenance.

For planning purposes, we anticipate that flexible pavement systems would be comprised of about 2 inches of asphalt underlain by 9 to 12 inches of base material over moisture conditioned subgrade in parking areas and light duty drive lanes, along with 2.5 to 3 inches of asphalt over 10 to 13 inches of base material over moisture conditioned subgrade in main access drives, medium to heavy duty drive lanes, and loading areas, depending on final subgrade conditions. If lime-treatment to depths of about 6 to 8 inches is used on the Stratum 1 soils, the base thickness could possibly decrease by about 2 to 3 inches. For rigid pavement systems, reinforced concrete pavement thicknesses would likely be on the order of 5 to 6 inches in parking areas and light duty drive lanes, along with 6 to 7 inches in heavier traffic areas, such as loading areas, dumpster pads, and main access drive lanes.

GENERAL COMMENTS

The comments contained in this preliminary report are intended for use only for planning purposes, are preliminary in nature, and are based on widely spaced borings. We do not anticipate subsurface conditions to differ significantly from those encountered on site during this preliminary exploration. However, variations should be expected which may not have been detected in this widely spaced and limited boring program due to the geologic and topographic conditions at this site.

Additional geotechnical studies will be required prior to final design and construction of the project. Additional borings and/or test pits will be required at specific building and pavement locations to confirm or modify the preliminary recommendations presented herein. Terracon will not be responsible for any final design and/or construction which are based on the information present in this report.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and 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.

For any excavation construction activities at this site, all Occupational Safety and Health Administration (OSHA) guidelines and directives should be followed by the Contractor during construction such that a safe working environment is provided. In regards to worker safety, OSHA Safety and Health Standards require the protection of workers from excavation instability in trench situations.

This preliminary report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location, of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Planned Location	Number of Borings	Planned Boring Depth (feet)
Site	5	20

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provide the boring layout. Coordinates are obtained with a handheld GPS unit (estimated horizontal accuracy of about ±5 feet) and approximate elevations are obtained by interpolation from Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advance the borings with a truck-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem as necessary depending on soil conditions). Four to five samples are obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. Bedrock is sampled with either split-barrel sampling spoons or continuously cored using NX rock coring equipment. We observe and record groundwater levels during drilling and sampling. For safety purposes, all borings are backfilled with auger cuttings after their completion.

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

Laboratory Testing

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

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil

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

Rock classification is conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification is determined using the Description of Rock Properties.

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION

McCoy School Tract ■ Georgetown, Texas

April 18, 2018 ■ Terracon Project No. 96185088

Terracon GeoReport

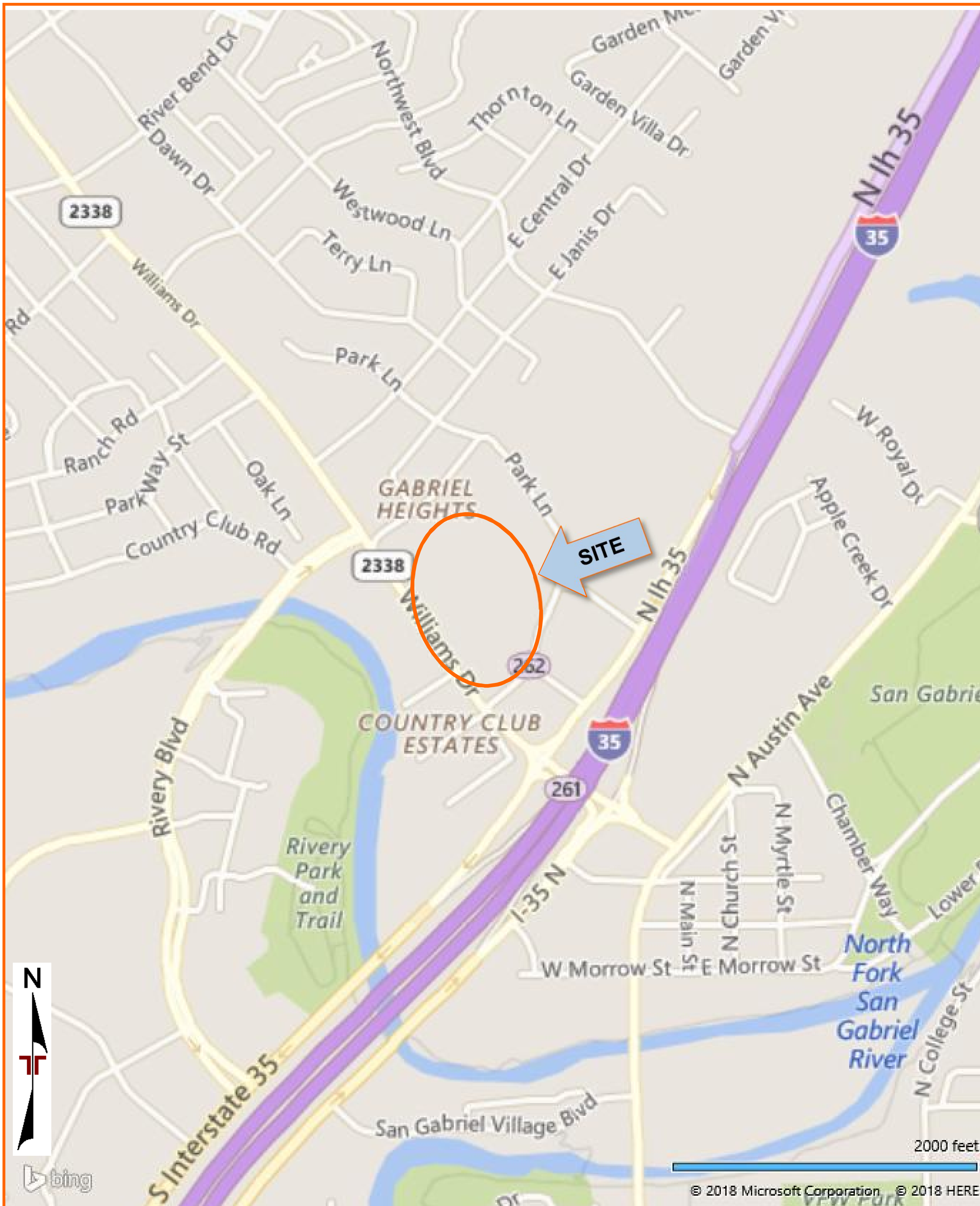


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

McCoy School Tract ■ Georgetown, Texas
April 18, 2018 ■ Terracon Project No. 96185088

Terracon GeoReport

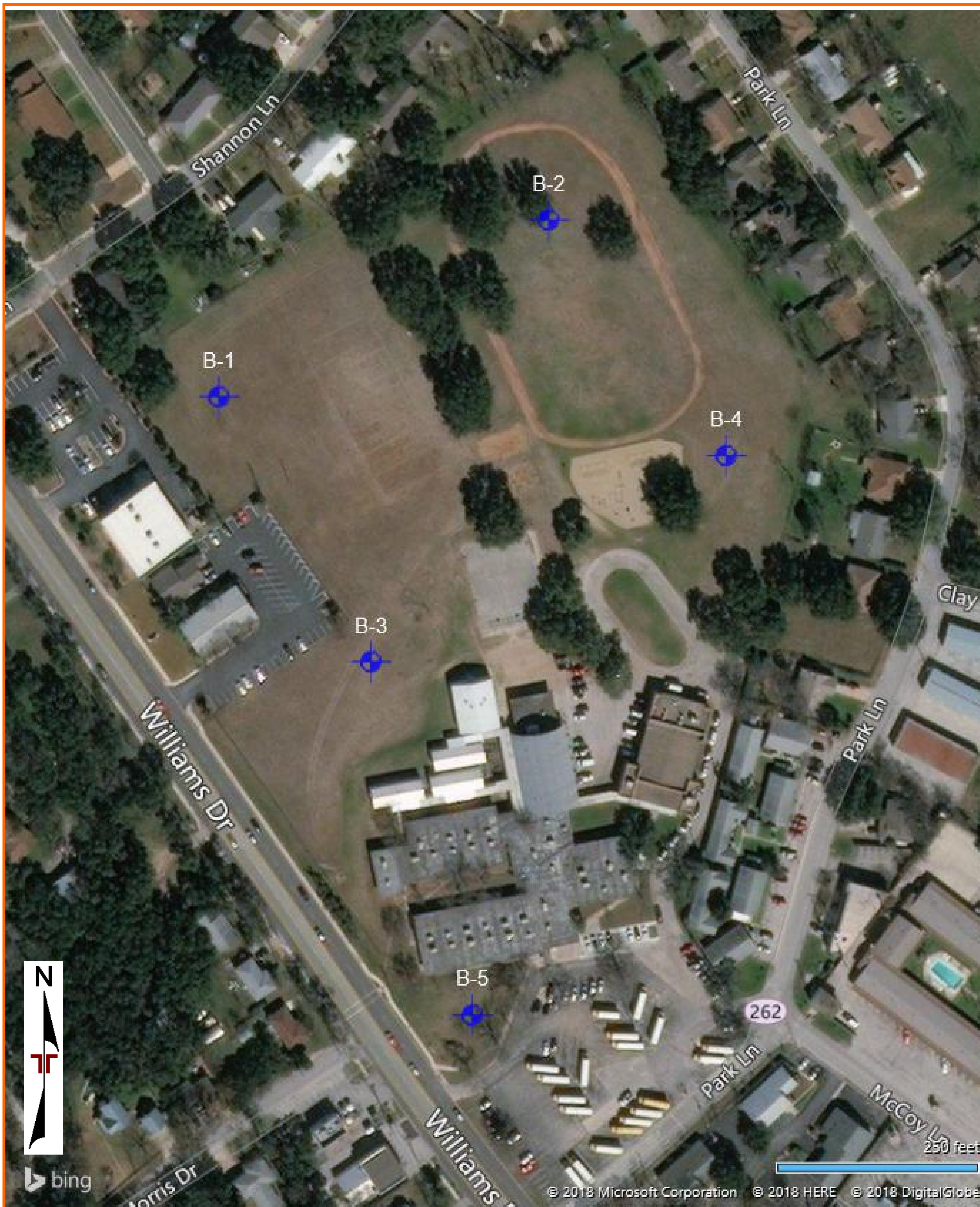


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

BORING LOG NO. B-1

PROJECT: McCoy School Tract

**CLIENT: GISD - Facilities & Construction
Georgetown, TX**

**SITE: NEQ of Williams Drive and Park Lane
Georgetown, TX**

LOCATION See Exploration Plan

Latitude: 30.6541° Longitude: -97.6826°

Approximate Surface Elev: 763 (Ft.) +/-

DEPTH	MODEL LAYER	DESCRIPTION	ELEVATION (Ft.)
0.0 – 8.0	1	**FAT CLAY WITH GRAVEL (CH)**, dark brown to brown, very stiff to hard	755+/-
8.0 – 10.0	1	**LEAN CLAY WITH GRAVEL (CL)**, brown to light brown, hard	753+/-
10.0 – 20.0	2	**LIMESTONE**, light brown to tan, intensely to completely fractured, with abundant clay seams and layers	743+/-
		Boring Terminated at 20 Feet	

DEPTH (Ft.) (approx.)	WATER LEVEL OBSERVATIONS	FIELD TEST RESULTS	RECOVERY (%) / RQD (%)	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0–2		3.5 tsf (HP)		UC	1.64	7.1	26	89		
2–4		4.5 tsf (HP)					22			
4–6		4.0 tsf (HP)					20		52-17-35	79
6–8		4.5+ tsf (HP)					15			
8.5–10		7-18-28 N=46					17		47-16-31	80
10–15			15 / 0							
15		50/1"								
15–19.5			23 / 0							
19.5–20		50/6"								

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 10 feet; Air Rotary 10 to 20 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 03-23-2018	Boring Completed: 03-23-2018
Drill Rig: GD - 1000	Driller: Texas Geo Bore
Project No.: 96185088	

BORING LOG NO. B-2

PROJECT: McCoy School Tract

CLIENT: GISD - Facilities & Construction Georgetown, TX

SITE: NEQ of Williams Drive and Park Lane Georgetown, TX

LOCATION See Exploration Plan

Latitude: 30.6547° Longitude: -97.6813°

Approximate Surface Elev: 760 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	RECOVERY (%) RQD (%)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.0 tsf (HP)					20		81-25-56	
		2.0 — 758+/-												
	2	**LIMESTONE**, light brown to tan, intensely to completely fractured, with abundant clay seams and layers				50/1"					5			
			5			50/2"								
							28 / 13							
			10			50/2"								
			15			50/0"								
		20.0 — 740+/-	20			50/0"								
		Boring Terminated at 20 Feet												

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet; Air Rotary 5 to 10 feet; Dry Augered 10 to 20 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 03-23-2018	Boring Completed: 03-23-2018
Drill Rig: GD - 1000	Driller: Texas Geo Bore
Project No.: 96185088	

BORING LOG NO. B-3

PROJECT: McCoy School Tract

CLIENT: GISD - Facilities & Construction Georgetown, TX

SITE: NEQ of Williams Drive and Park Lane Georgetown, TX

LOCATION See Exploration Plan

Latitude: 30.6532° Longitude: -97.682°

Approximate Surface Elev: 760 (Ft.) +/-

Model Layer	Depth / Description	Elevation (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Recovery (%) RQD (%)	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	**FAT CLAY (CH)**, dark brown to brown, hard					4.0 tsf (HP)					27		70-21-49	90
						4.5 tsf (HP)					29			
	4.0	756+/-												
2	**LIMESTONE**, light brown to tan, with abundant clay seams and layers		5			19-50/2"					11			
						17-50/4"								
			10			20-25-36 N=61								
						50/2"								
			15											
						50/2"								
	20.0	740+/-	20											
	Boring Terminated at 20 Feet													

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 20 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 03-23-2018	Boring Completed: 03-23-2018
Drill Rig: GD - 1000	Driller: Texas Geo Bore
Project No.: 96185088	

BORING LOG NO. B-4

PROJECT: McCoy School Tract

CLIENT: GISD - Facilities & Construction
Georgetown, TX

SITE: NEQ of Williams Drive and Park Lane
Georgetown, TX

LOCATION See Exploration Plan

Latitude: 30.6539° Longitude: -97.6806°

Approximate Surface Elev: 757 (Ft.) +/-

MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	RECOVERY (%) RQD (%)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	**FAT CLAY WITH GRAVEL (CH)**, dark brown to brown, hard				4.0 tsf (HP)					29		83-24-59	79
					4.5+ tsf (HP)					15			
		5			26-28-37 N=65					10		50-15-35	51
	6.0 — 751+/-												
2	**LIMESTONE**, light brown to tan, intensely to completely fractured, with abundant clay seams and layers				50/4"								
					50/5"								
		10				15 / 0							
		15				28 / 0							
	20.0 — 737+/-	20											
	Boring Terminated at 20 Feet												

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 10 feet; Air Rotary 10 to 20 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 03-23-2018	Boring Completed: 03-23-2018
Drill Rig: GD - 1000	Driller: Texas Geo Bore
Project No.: 96185088	

BORING LOG NO. B-5

PROJECT: McCoy School Tract

CLIENT: GISD - Facilities & Construction Georgetown, TX

SITE: NEQ of Williams Drive and Park Lane Georgetown, TX

LOCATION See Exploration Plan

Latitude: 30.652° Longitude: -97.6816°

Approximate Surface Elev: 758 (Ft.) +/-

Model Layer	Depth	Material Description	Elevation (Ft.)	Sample Depth (Ft.)	Water Level Observations	Field Test Results	Recovery (%) RQD (%)	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**FAT CLAY (CH)**, dark brown to brown, hard		0-2		4.0 tsf (HP)					15			
				2-4		4.5+ tsf (HP)					34			
	4.0		754+/-											
2		**LIMESTONE**, light brown to tan, with abundant clay seams and layers		4.5		50/2"								
				9.5		50/1"								
				14.5		50/0"								
				19.5		50/0"								
	20.0		738+/-											
		Boring Terminated at 20 Feet												

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 20 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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.

Notes:

WATER LEVEL OBSERVATIONS

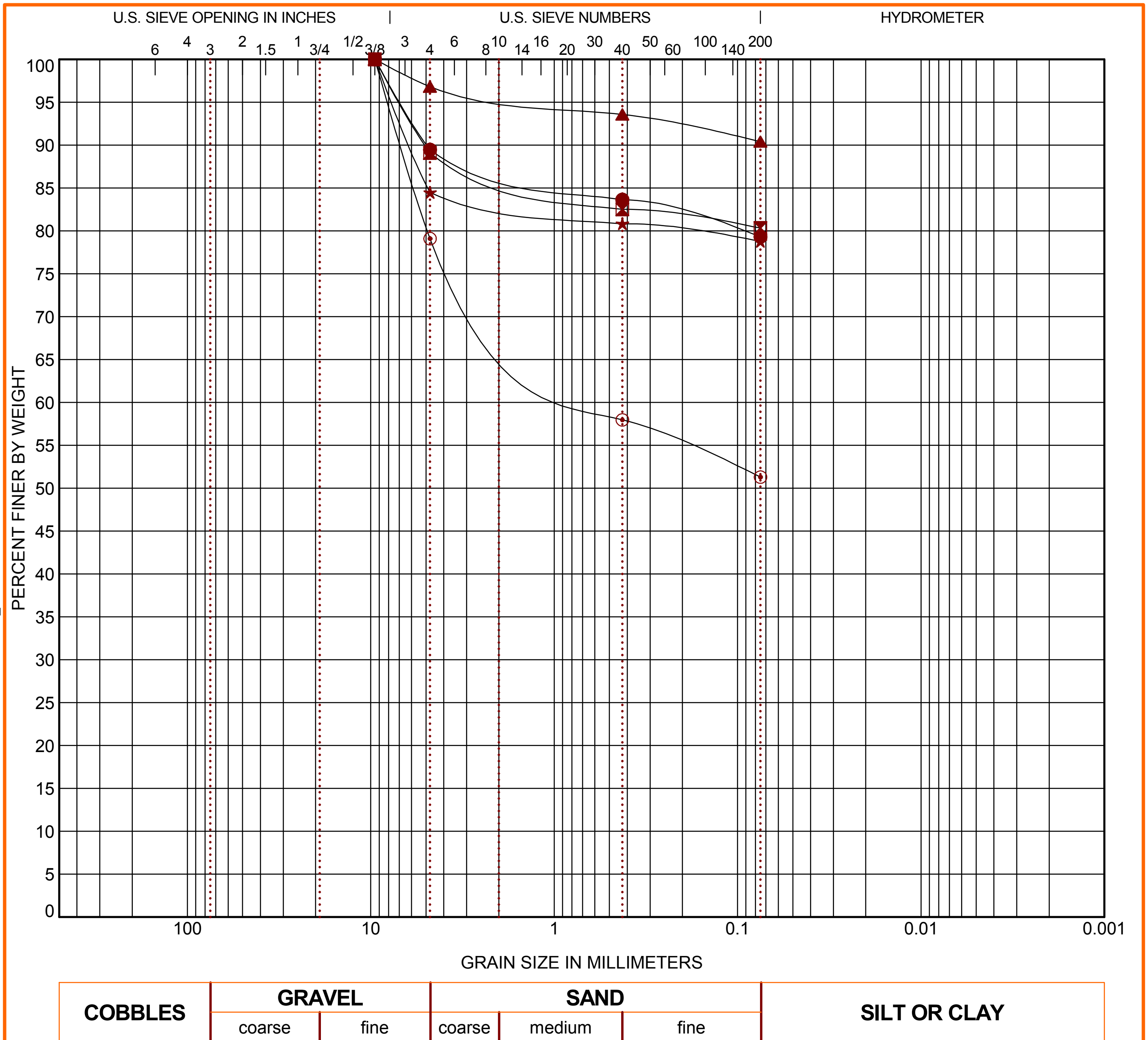
No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 03-23-2018	Boring Completed: 03-23-2018
Drill Rig: GD - 1000	Driller: Texas Geo Bore
Project No.: 96185088	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	4 - 6	FAT CLAY with GRAVEL (CH)	20	52	17	35		
⊠	B-1	8.5 - 10	LEAN CLAY with GRAVEL (CL)	17	47	16	31		
▲	B-3	0 - 2	FAT CLAY (CH)	27	70	21	49		
★	B-4	0 - 2	FAT CLAY with GRAVEL (CH)	29	83	24	59		
⊙	B-4	4.5 - 6	SANDY FAT CLAY with GRAVEL (CH)	10	50	15	35		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	4 - 6	9.5				10.5	10.2		79.3	
⊠	B-1	8.5 - 10	9.5				10.9	8.8		80.3	
▲	B-3	0 - 2	9.5				3.2	6.4		90.4	
★	B-4	0 - 2	9.5				15.5	5.7		78.8	
⊙	B-4	4.5 - 6	9.5	0.536			20.9	27.8		51.3	

PROJECT: McCoy School Tract

SITE: NEQ of Williams Drive and Park Lane
Georgetown, TX

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

PROJECT NUMBER: 96185088

CLIENT: GISD - Facilities & Construction
Georgetown, TX

SUPPORTING INFORMATION

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

McCoy School Tract ■ Georgetown, TX

4/17/2018 ■ Terracon Project No. 96185088

Terracon GeoReport

SAMPLING

Rock Core

Shelby Tube

Split Spoon

WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

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 is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. 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			**BEDROCK**	
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1	< 20	Weathered
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4	20 - 29	Firm
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8	30 - 49	Medium Hard
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15	50 - 79	Hard
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30	>79	Very Hard
		Hard	> 4.00	> 30		

RELATIVE PROPORTIONS OF SAND AND GRAVEL		**RELATIVE PROPORTIONS OF FINES**	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		**PLASTICITY DESCRIPTION**	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

McCoy School Tract ■ Georgetown, Texas

April 18, 2018 ■ Terracon Project No. 96185088

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 ³ 4 and 1 £ Cc £ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - 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:	Liquid limit - oven dried / Liquid limit - 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 ³ 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 ³ 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 ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

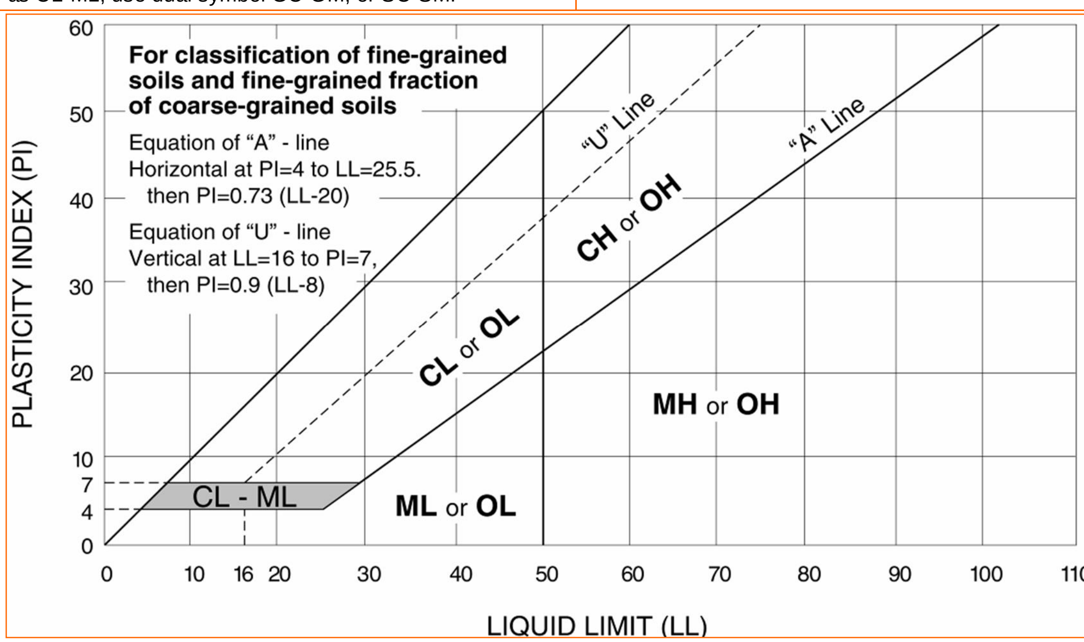
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 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.



DESCRIPTION OF ROCK PROPERTIES

McCoy School Tract ■ Georgetown, Texas

April 18, 2018 ■ Terracon Project No. 96185088

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements