Geotechnical Engineering Report

DPS Canine Training Facilities
Florence, Texas
September 30, 2021
Terracon Project No. AC215028

Prepared for:
Parkhill
Lubbock, Texas

Prepared by:
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Terracon GeoReport

September 30, 2021

Parkhill
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Attn: Mr. Jared Higgins
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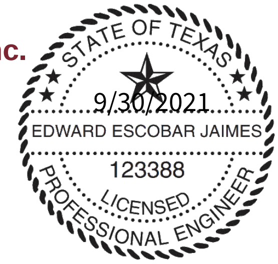
Re: Geotechnical Engineering Report
DPS Canine Training Facilities
810 County Road 240
Florence, Texas
Terracon Project No. AC215028

Dear Mr. Higgins:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PAC215028 dated April 28, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, subgrade preparation, and the design and construction of foundations, pavements, and site improvements for the proposed project.

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

Sincerely,
Terracon Consultants, Inc.



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

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

DPS Canine Training Facilities
810 County Road 240
Florence, Texas
Terracon Project No. AC215028
September 30, 2021

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed DPS Canine Training Facilities project to be located at 810 County Road 240 in Florence, Texas. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification

The geotechnical engineering Scope of Services for this project included the advancement of two (2) test borings designated B-1 and B-2 to depths of approximately 20 feet below existing site grades.

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

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 in the southeast portion of the existing Department of Public Safety (DPS) site located at 810 County Road 240 in Florence, Texas.
Existing Improvements	In the project area, none. The DPS facility currently consists of an administration building, parking and driveway areas, a driver training facility, and shooting ranges.
Current Ground Cover	Soils, grass, weeds, and scattered to dense trees

Item	Description
Existing Topography	Based on Google Earth imagery, existing grades range from about 1035 to 1039 feet within the proposed project area.
Geology	Based on our borings and geologic maps, the subsurface conditions consist of highly expansive fat clay soils overlying the Edwards Formation Limestone of Lower Cretaceous Age. The Edwards Formation Limestone is typically characterized by tan to gray fine-grained limestone and can exhibit karst features such as voids and clay-filled zones.

PROJECT DESCRIPTION

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

Item	Description
Proposed Structure	The project includes the construction of an approximately 3,000 square foot caning training facility.
Building Construction	Anticipated to be light-gage steel framing or concrete framing.
Finished Floor Elevation	Unknown at this time. Anticipated to be within 2 feet of existing grades.
Maximum Loads	Unknown at this time but anticipated to be typical light-frame loading.
Grading/Slopes	Minimal slopes anticipated.
Below-Grade Structures	None anticipated.
Free-Standing Retaining Walls	None anticipated.
Pavements	None planned for this scope of work.

GEOTECHNICAL CHARACTERIZATION

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	**Fat Clay**	Dark brown, stiff to very stiff
2	**Lean Clay**	Light brown, very stiff to hard
3	**Edwards Limestone**	Light brown to tan to light gray, unfractured to moderately fractured, weak, slightly vugular

Groundwater

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 as groundwater conditions can (and likely will) vary between the time of the geotechnical investigation and the timeframe of construction activities.

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, solution channels, and voids 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.

GEOTECHNICAL OVERVIEW

The near surface, stiff to hard high plasticity fat clay could become problematic with typical earthwork and construction traffic, especially after precipitation events. Effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. Additional site preparation recommendations including subgrade improvement and fill placement are provided in the **Earthwork** section.

The site exhibits some karst features located within the Stratum 3 limestone. These karst features can be problematic for construction, especially during earthwork and foundation construction. The contractor and owner should be aware of the risks associated with karst limestone. Some of these risks include, but are not limited to, schedule delay due to encountering karst features during earthwork, foundation construction, and associated mitigations techniques.

The **Shallow Foundations** section addresses the support of the structure on a monolithic slab-on-grade foundation / spread/strip footing foundation bearing into select fill. The **Building Subgrade Preparation** section addresses slab support of the structure.

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

EARTHWORK

Earthwork is anticipated to 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

Construction areas should be stripped of all vegetation, loose soils, top soils, 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. If any unusual items are unearthed during or after demolition, please contact us for further evaluation. 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 3 limestone subgrade areas. Weak areas detected during proof-rolling, zones containing debris or organics, and voids resulting from removal of tree roots, 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 inhibit 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-density testing is not required in cut areas that expose the Stratum 3 limestone subgrade, provided the Stratum 3 limestone is proof-rolled.

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 inches to allow for placement and compaction of an additional 6 inches of select fill. If this option is selected, the additional excavation should be made prior to proof-rolling.

Excavations

Excavation operations at this site may penetrate through the on-site soils and into the Stratum 3 limestone. While the on-site 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 3 limestone, along with the data obtained during our field and laboratory programs (average compressive strength of 2,000 psi), indicates that the Stratum 3 limestone may require sawcutting, jackhammering, hoe-ramming, milling, or similar techniques to excavate.

Please note that although Stratum 3 limestone was encountered at depths ranging from 5.5 to 6 feet below existing grades 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 can 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.

Temporary Groundwater Control

Although not encountered during our drilling operations, groundwater seepage might be encountered during construction, especially after periods of wet weather and in excavations which penetrate the Stratum 2 soils. Temporary groundwater control during construction would typically consist of perimeter gravel-packed drains sloping toward common sump areas for groundwater collection and removal. Placement of drain laterals within the excavation could be required to remediate isolated water pockets.

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 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]	CL, SC, and/or GC	■ TxDOT Item 247, Type A, Grade 3, OR ■ Percent Retained on No. 4 Sieve ≤ 40 percent with 7≤PI≤20 and rocks ≤ 4 inches in maximum dimensions, OR ■ Crushed concrete (TxDOT Item 247, Type D, Grade 3 or better)
General Fill [4]	CH, CL, SC and/or GC	■ On-Site Soils: Rocks ≤ 4 inches in maximum dimension ■ Imported Soils: PI ≤ 50; 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 on-site 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.

Fill Type [1]	USCS Classification	Acceptable Specifications

4. Excavated on-site soils, if free of organics, debris, and rocks larger than 4 inches may be considered for re-use as fill in 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 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 flatwork. If general 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	
	PI > 25	95	Optimum to +4	
Paving Fill, Paving Subgrade and General Fill	**PI ≤ 25**	95	-3 to +3	
	PI > 25	95	Optimum to +4	
Crushed Limestone Base (beneath pavements)		100 [4]	-3 to +3	

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.

Utility Trench Backfill

Leaking pipes underneath and/or near the foundations will increase the moisture content of the surrounding subgrade soils and will likely result in a PVR greater than discussed for these soils. For low permeability subgrades, 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. We recommend constructing an effective clay or flowable fill “trench plug” that extends at least 2 feet out from the face of the building exterior. The clay fill/flowable fill should be placed to completely surround the utility line and it should fill the utility trench completely in width and height, with the exception of topsoil at the surface. If clay plug is used, it should be fat clay with a minimum PI of 30 and should be compacted to comply with the water content and compaction recommendations for moisture conditioned building subgrade fill as specified in **Fill Compaction Requirements**. If flowable fill is used, it should be in accordance with TxDOT Item 401.

Grading and Drainage

The performance of the proposed structure will not only be dependent upon the quality of construction, but also upon the stability of the moisture content of the near surface soils. Therefore, we highly recommend that site drainage be developed so that ponding of surface runoff near the structure does not occur. Accumulation of water near the structure may cause significant moisture variations in soils adjacent to the structure, thus increasing the potential for structural distress.

Effective drainage away from the structure must be provided during construction and maintained through the life of the proposed project. Infiltration of water into excavations should be prevented during construction. It is important that foundation soils are not allowed to become wetted. All grades must provide effective drainage away from the structure during and after construction. Exposed (unpaved) ground should be sloped at a minimum of 5 percent away from the structure for at least 10 feet beyond the perimeter of the structure. Locally, flatter grades may be necessary to transition ADA access requirement for flatwork.

Roof runoff and surface drainage should be collected and discharged away from the structure to prevent wetting of the foundation soils. Roof gutters should be installed and connected to downspouts and pipes directing roof runoff at least 10 feet away from the structure or discharged on to positively sloped pavements.

Sprinkler mains and spray heads should preferably be located at least 5 feet away from the structure such that they cannot become a potential source of water directly adjacent to the structure. In addition, the owner and/or builder should be made aware that placing large bushes and trees adjacent to the structures may cause significant moisture variations in the soils underlying the structures. In general, tree roots can adversely influence the subsurface soil moisture content to a distance of 1 to 1½ times the mature height of the tree and beyond the tree canopy. Watering of vegetation should be performed in a timely and controlled manner and prolonged watering should be avoided. Landscaped irrigation adjacent to the foundation units should be minimized or eliminated. Special care should be taken such that underground utilities do not develop leaks with time.

After building construction and landscaping, final grades should be verified to document 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. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration. Water permitted to pond next to the structure can result in greater soil movements than those discussed in this report. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Earthwork Construction Considerations

Based on our test borings, very highly expansive soils that exhibit a potential for volumetric change 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 3 inches, as estimated by the TxDOT Method TEX-124-E, if present in a dry condition.

Excavations, for the proposed structure and utilities, are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided as much as possible. 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 desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction.

Groundwater could affect over-excavation efforts, especially during the construction of the building pad or replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps could be necessary to achieve the recommended depth of over-excavation. Sump pits should preferably be excavated just outside the building pad limits.

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.

Construction Observation and Testing

The earthwork efforts should be documented under the direction of the Geotechnical Engineer. This should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation and density/moisture testing of subgrade and fills. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should be contacted to evaluate the conditions.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Fill should be tested for density and water content at a frequency of at least one test for every 5,000 square feet per lift of compacted fill in the building areas (with a minimum of 3 tests per lift) and 10,000 square feet per lift in pavement areas. A minimum of one density and water content test should be conducted for every 100 linear feet of compacted utility trench backfill in paving areas.

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

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork** and **Building Subgrade Preparation**, the following design parameters are applicable for shallow foundations.

Design Parameters – Monolithic Slab-On-Grade

A monolithic slab-on-grade foundation system (either conventionally reinforced or post-tensioned) would be appropriate to support the proposed structure provided subgrade preparation as described in **Building Subgrade Preparation** is followed. The slab foundation design parameters presented in the tables below are based on the criteria published by the Building Research Advisory Board (BRAB), the Prestressed Concrete Institute (PCI), the Wire Reinforcement Institute (WRI), and the Post-Tensioning Institute (PTI) 3rd Edition. These are essentially empirical design methods and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the BRAB, PCI, WRI, and PTI design manuals.

Conventional Slab and Beam System Parameters	
Description	**Design Parameter**
Minimum Embedment of Grade Beams below Final Grade [1]	24 inches
Bearing Stratum	Select Fill
Bearing Pressures (allowable) [2]	Net Dead plus Sustained Live Load – 1,700 psf Net Total Load – 2,500 psf
Subgrade Modulus (k) [3]	125 pci

Conventional Slab and Beam System Parameters	
Description	**Design Parameter**
Approximate Potential Vertical Rise (PVR)	About 1-inch [4,5]

1. Embedment is to reduce surface water migration below the foundation elements and to develop proper end bearing and is not based on structural considerations. The grade beam width and depth should be properly evaluated by the structural engineer. Grade beams may be thickened and widened at interior column locations to serve as spread footings at these concentrated load areas.
2. Grade beams should bear on compacted select fill.
3. Several design methods use the modulus of subgrade reaction, k, to account for soil properties in design of flat, floor slabs. The modulus of subgrade reaction is a spring constant that depends on the kind of soil, the degree of compaction, and the moisture content. Based on our recommendations provided in **Building Subgrade Preparation**, the above indicated subgrade modulus can be used for design of a flat, grade-supported floor slab.
4. Differential movements may result from variances in subsurface conditions, loading conditions and construction procedures. We recommend that measures be taken whenever practical to increase the tolerance of the building to post-construction foundation movements. An example of such measures would be to provide frequent control joints for exterior masonry veneers and interior sheetrock walls (particularly near doors and windows) to control cracking across such walls and concentrate movement along the joints.
5. The building subgrade should be properly prepared as described in **Building Subgrade Preparation**.

BRAB/WRI/PCI Parameters			
Description	**Design Parameter**		
Design Plasticity Index (PI) [1]	BRAB/WRI/PCI	Prepared Subgrade [2]	20
Climatic Rating (C_w)			17
Unconfined Compressive Strength			1.0 tsf
Soil Support Index (C) for BRAB		Prepared Subgrade [2]	0.95

1. The BRAB effective PI is equal to the near surface PI if that PI is greater than all of the PI values in the upper 15 feet. If the near-surface PI is not highest (i.e., after the building pad is prepared), then the effective PI is the weighted average of the upper 15 feet. The WRI/PCI effective PI is always the weighted average of the PI values in the upper 15 feet.
2. The building subgrade should be properly prepared as described in **Building Subgrade Preparation**.

Post Tensioning Institute (PTI) Parameters [1]	
Description	**Design Parameter**
Depth of Seasonal Moisture Change [2]	Up to 6 feet (or top of limestone)
Plasticity Index [3]	Select Fill – 15 Stratum 1 Soils – 58 Stratum 2 Soils - 29

Post Tensioning Institute (PTI) Parameters [1]		
Description		**Design Parameter**
Percent Finer than 2 Microns [3]		Select Fill – 20 (estimated) Stratum 1 Soils – 60 (estimated) Stratum 2 Soils - 17
Soil Fabric Factor		1.0
Approximate Thornthwaite Moisture Index		-12
Estimated Constant Soil Suction		3.5 pF
Range of Soil Suction		3.0 to 4.5 pF
Edge Moisture Variation Distance, e_m [4,5]	**Center Lift**	9.0 feet [6]
	Edge Lift	5.0 feet [6]
Differential Soil Movement, y_m [5]	**Center Lift**	0.8 inches [6]
	Edge Lift	1.1 inches [6]

1. Based on our analysis of the field and laboratory data, design parameters were computed using the Addendum to the 2004 Post-Tensioning Institute (PTI) method[1] for slab-on-grade design and the subsequent Errata to the Addendum approved by the PTI Slab-on-Grade Committee on February 7, 2008.
2. The moisture beneath a shallow foundation will change in response to wetting and drying conditions around the foundation perimeter. The moisture condition has a significant effect on slab behavior and is highly variable with time, changing seasonally, with annual climate conditions, drainage patterns, ground cover, and vegetation (trees and shrubs).
3. The plasticity index and the clay mineral percentage are values of the soil that can be estimated by laboratory tests, and, although variable from location to location, remain relatively constant with time.
4. The maximum moisture variation distance is termed the edge moisture variation distance, e_m, and is an important factor governing the design of post-tensioned floor slabs. The e_m is related to percent fine clay and climatic conditions as well as other parameters, such as soil fabric factor and unsaturated diffusion coefficient.
5. The differential movements, y_m, and edge moisture variation distances, e_m, were calculated by modeling soil profiles using the commercial software program VOLFLO as recommended by the PTI manual.
6. Values may be used provided subgrade preparation is implemented as described in **Building Subgrade Preparation**.

1. Post-Tensioning Institute, "Addendum No. 1 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground", Post-Tensioning Institute, Phoenix, AZ, May 2007.

Design Parameters – Footings

Principal column and wall loads for the proposed structure may also be supported on isolated (spread) and/or continuous (strip) footings. Design parameters for spread/strip footing foundations are provided below.

Description	Design Parameter
Bearing Stratum [1]	Select Fill
Minimum Embedment Below Final Grade [2]	24 inches
Minimum Footing Dimensions	Spread – 3 feet by 3 feet square Strip – 18 inches wide
Allowable Bearing Pressures [3,4]	Net dead plus sustained live load – 1,700 psf Net allowable total load – 2,500 psf
Approximate Total Movement [5]	1-inch
Estimated Differential Movement [6]	½ to ¾ inch
Nominal (unfactored) Passive Resistance [7]	330 psf per foot of depth
Coefficient of Sliding Resistance [8]	0.35
Nominal (unfactored) Uplift Resistance [9]	Foundation Weight (150 pcf) & Soil Weight (120 pcf)

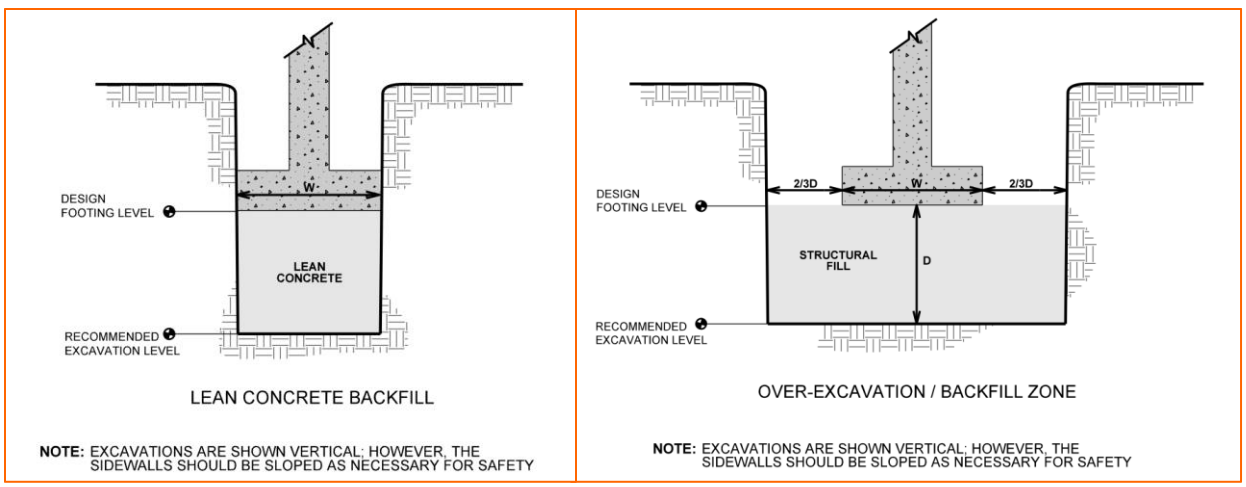
1. Unsuitable or soft soils must be over-excavated and replaced per the recommendations presented in **Earthwork** and the building area should be prepared as per **Building Subgrade Preparation**.
2. To bear within select fill soils.
3. Whichever condition yields a larger bearing area.
4. Values provided are for maximum loads noted in **Project Description**.
5. The estimated post-construction settlement of the shallow footings is assuming proper construction practices are followed.
6. Differential settlements may result from variances in subsurface conditions, loading conditions and construction procedures. The settlement response of the footings will be more dependent upon the quality of construction than upon the response of the subgrade to the foundation loads.
7. Passive resistance should be neglected in the first 12 inches below finished grades. Care should be taken to avoid disturbance of the footing bearing area since loose material could increase settlement and decrease resistance to lateral loading. If the footing is formed during construction, the open space between the footings and the in-situ soils should be backfilled with concrete.
8. Lateral loads transmitted to the footings will be resisted by a combination of soil-concrete friction on the base of the footings and passive pressure on the side of the footings. We recommend that the allowable frictional resistance be limited to 500 psf.
9. The nominal values should be reduced by an appropriate factor of safety to compute allowable values.

Foundation Construction Considerations

Footings/Grade beams should be neat excavated, if possible. If neat excavation is not possible, the foundation should be properly formed. If a toothed bucket is used, excavation with this bucket should be stopped approximately 6 inches above final grade of the footings and the footing excavation be completed with a smooth-mouthed bucket or by hand labor. Debris in the bottom of the excavation should be removed prior to steel reinforcement placement. The foundation excavation should be sloped sufficiently to create internal sumps for runoff collection and removal. If surface runoff water or groundwater seepage in excess of ½-inch accumulates at the bottom of the foundation excavation, it should be collected, removed, and not allowed to adversely affect the quality of the bearing surface.

If utilized, the post-tensioned slab-on-grade construction technique should be carefully observed by qualified personnel. The sophistication of this construction procedure requires careful attention to details such as concrete integrity and anchorages, along with tendon spacing, support, covering, and stressing. Poor construction could result in a non-functional slab foundation system.

If unsuitable bearing soils are encountered at the base of the planned footing excavation (such as low strength or disturbed soils), the footing excavations should be deepened to expose suitable bearing materials. The footings could then bear directly on these soils at the lower level, on lean concrete backfill placed in the excavations, or on compacted structural fill backfilled in the excavations and compacted as in **Earthwork**. This is illustrated in the figure below.



Concrete should be placed as soon as possible after excavation to reduce bearing soil disturbance. Soils at bearing level that become disturbed or saturated should be removed prior to placing reinforcing steel and concrete. Adequate water control/dewatering system will aid in minimizing the need for over-excavation and backfill of any soils disturbed by prolonged exposure. It is important that the foundation subgrade not be disturbed by construction activities (e.g., setting forms and placing reinforcing steel). If disturbance occurs, we recommend that the disturbed soils be removed and that the foundation subgrade be protected with the placement of a lean concrete "mud mat".

Foundation Construction Observation

The performance of the foundation system for the proposed structure will be highly dependent upon the quality of construction. Thus, we recommend that the foundation construction be monitored by Terracon to identify the proper bearing strata and depths and to help evaluate foundation construction. We would be pleased to develop a plan for foundation observation to be incorporated in the overall quality assurance program.

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 and the International Building Code (IBC). Based on the soil/bedrock properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is C**. Subsurface explorations 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.

BUILDING SUBGRADE PREPARATION

The subgrade soils are comprised of high plasticity clays exhibiting the potential to shrink/swell with changes in water content. Construction of the floor slab and revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and damage the floor slab. Therefore, we recommend the following recommendations be implemented in order to reduce the risk of damaged floor slabs due to swelling clays.

Due to the potential for significant moisture fluctuations of subgrade material beneath the select fill pad, the exposed final subgrade should be prepared as discussed in the first three sub-sections of **Earthwork**.

The post-construction performance of the foundation will likely be influenced more by post-construction volumetric changes of the subgrade due to in-situ moisture variations than upon settlement due to foundation loads. Settlement response of select fill supported slabs will be influenced as much by the quality of construction and fill placements as by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the building pad and foundation.

Building Subgrade Preparation

Information about existing grades, proposed grades, and FFE for the proposed building has not been provided to Terracon at this time, However, we assume that the planned FFE is within two feet of existing grades. If these assumptions are incorrect, Terracon should be notified to review and modify or verify recommendations in writing.

In order to reduce PVR to 1-inch, we recommend that the on-site Stratum 1 dark brown fat clay soils be excavated to a depth of about 4 feet below existing grades, or until the Stratum 2 light brown lean clay soils are encountered, whichever occurs first. The removed soils must then be replaced with properly compacted select fill up to finished grades. The excavated soils must then be replaced with properly compacted select fill, up to finished grades. All fill within building areas must be select fill. A modulus of subgrade reaction of 125 pci may be used if these recommendations are followed.

General Comments for Pad Preparation

The above building subgrade preparation recommendations should be applied to an area extending a minimum of 5 feet outside of building areas including attached walkways and any other architectural members. We suggest the use of crushed limestone base in the upper 6 inches of the select fill pad from a standpoint of construction access during wet weather, as well as from a standpoint of floor slab support.

For any flatwork (sidewalk, ramps, etc.) outside of the building area which will be sensitive to movement, subgrade preparation as discussed above should be considered to reduce differential movements between the flatwork and the adjacent building. If subgrade preparation as given above for building areas is not implemented in the exterior flatwork areas, those areas may be susceptible to post-construction movements in excess of that given above.

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

The potential movement values indicated are based upon moisture variations in the subgrade due to circumstances such as moisture increases due to rainfall and loss of evapotranspiration. In circumstances where significant water infiltration beneath the floor slab occurs (such as a leaking utility line or water seepage from outside the buildings resulting from poor drainage), movements in isolated floor slab areas could potentially be in excess of those indicated in this report.

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

Floor Slab Construction Considerations

Design recommendations for floor slabs assume the requirements in **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the subgrade and select fill pad beneath the floor slab.

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

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. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in 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 or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

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

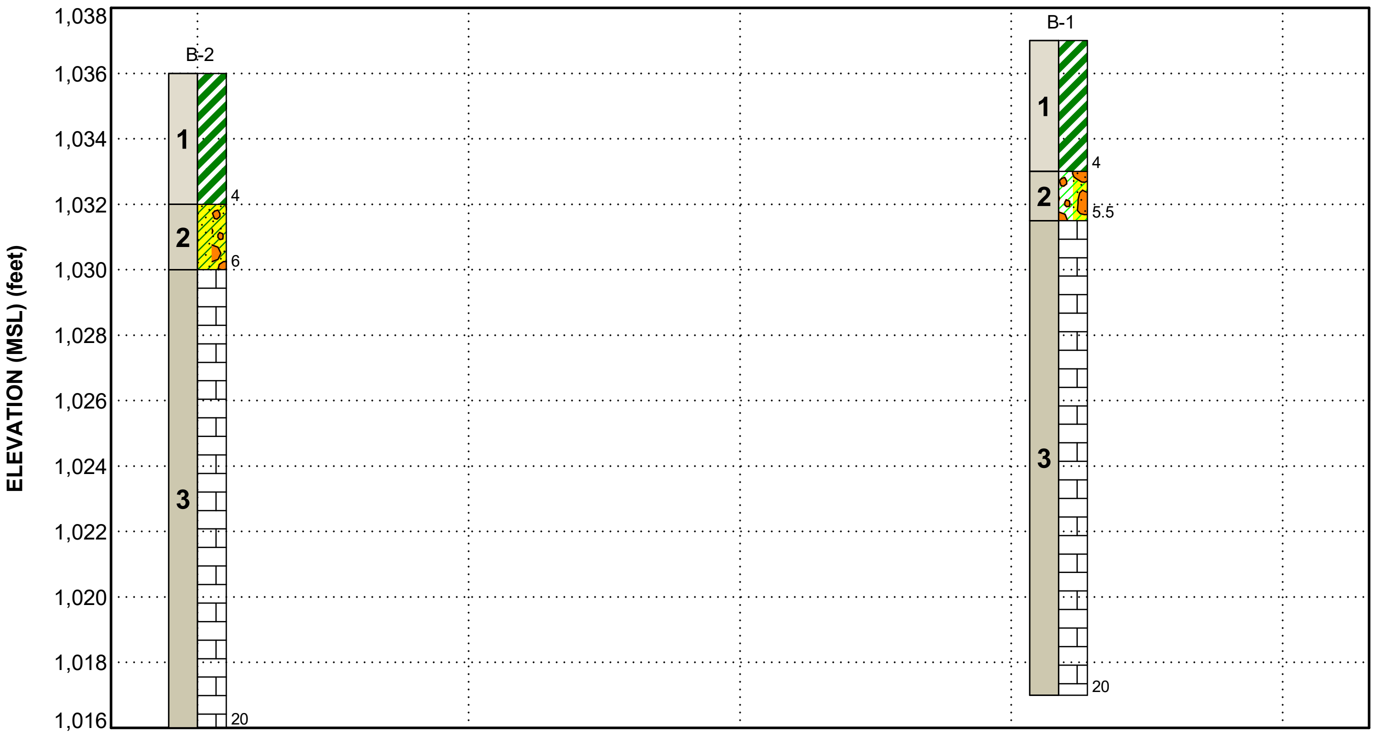
FIGURES

Contents:

GeoModel

GEOMODEL

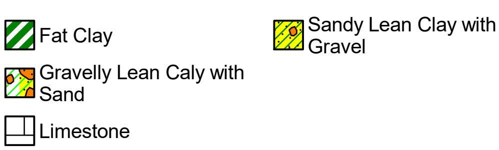
DPS Canine Training Facility - Florence ■ Florence, TX
Terracon Project No. AC215028



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	FAT CLAYS	DARK BROWN FAT CLAYS
2	LEAN CLAYS	LIGHT BROWN LEAN CLAYS
3	LIMESTONE	LIGHT BROWN TO TAN TO LIGHT GRAY LIMESTONE

LEGEND



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

Location	Number of Borings	Boring Depth (feet)
Building Area	2	20

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and approximate elevations were obtained by interpolation from Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using continuous flight augers. Soil sampling was performed using thin-wall tube (shelby tubes) and/or split-barrel sampling procedures. The split-barrel samplers were driven in accordance with the standard test method for standard penetration test (SPT) and split-barrel sampling of soils (ASTM D1586/D1886M–18). Bedrock was sampled with either split-barrel-sampling spoons or continuously cored using NX rock coring equipment. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were 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 reviewed the field data and assigned laboratory tests to 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 were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
- ASTM D7012, Method C Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

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

Rock classification was 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 was determined using the Description of Rock Properties.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

DPS Canine Training Facilities ■ Florence, Texas
September 30, 2021 ■ Terracon Project No. AC215028

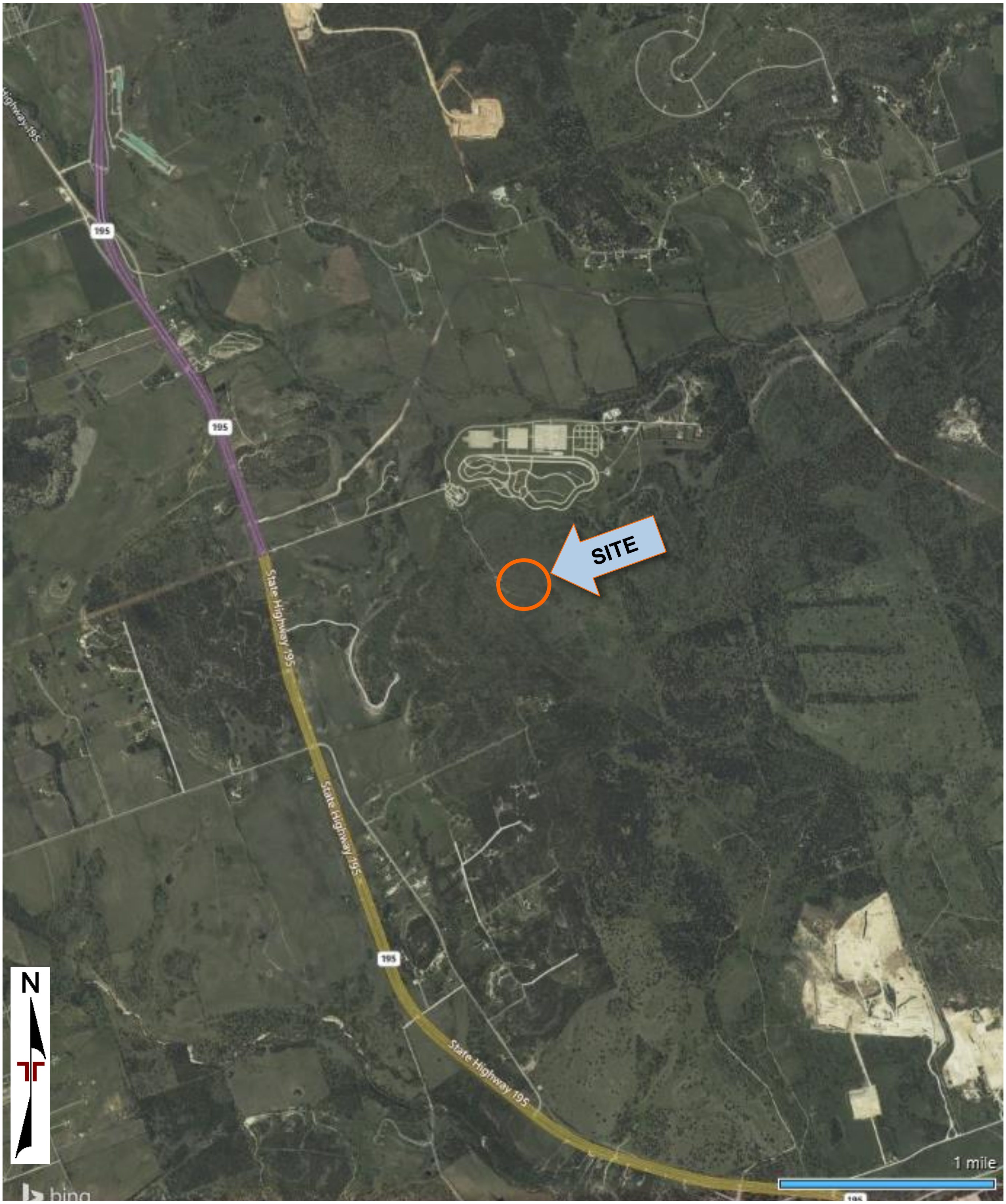
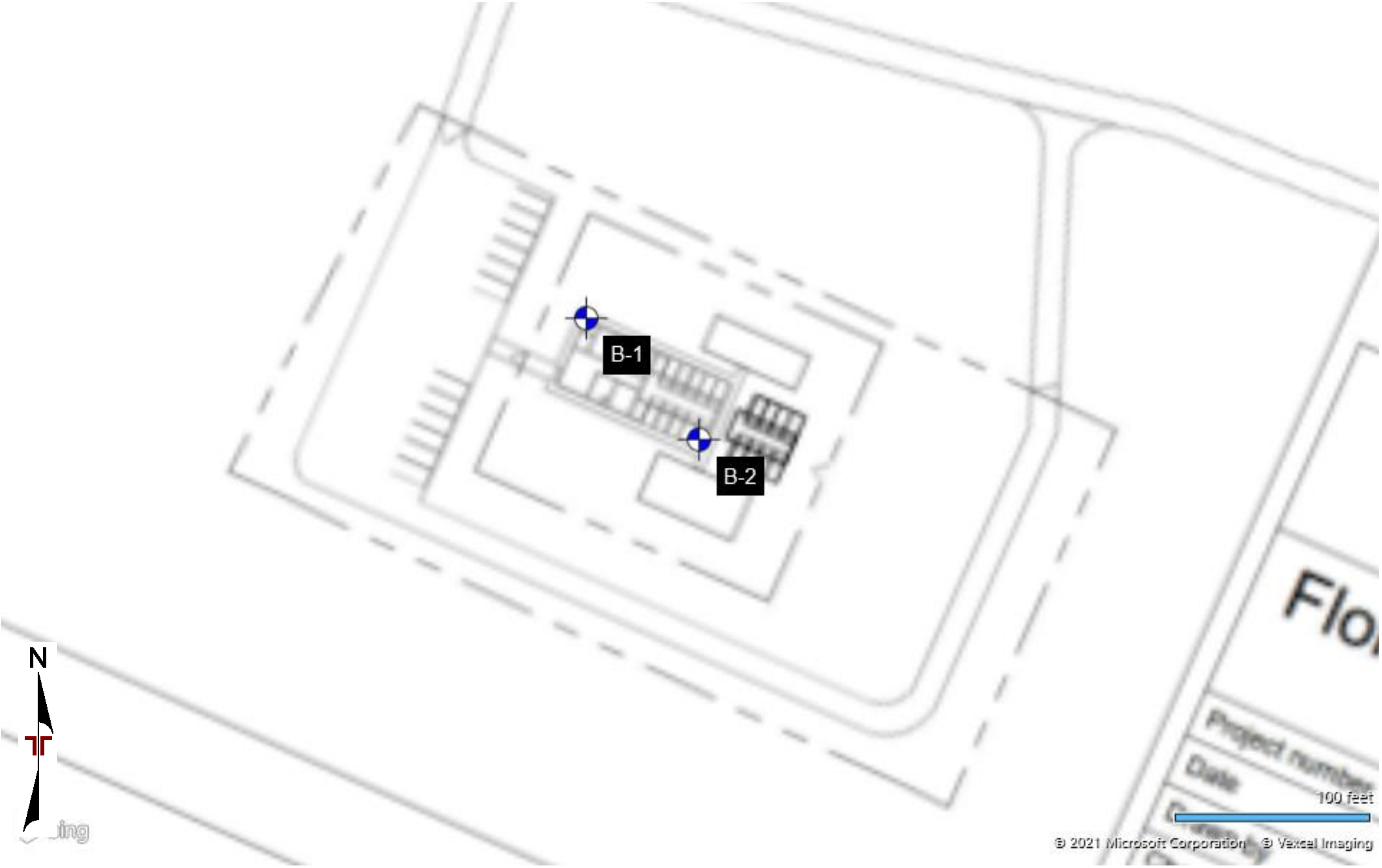


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS


B-1
B-2
N
100 feet
© 2021 Microsoft Corporation © Vexcel Imaging

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 and B-2)
Grain Size Distribution

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: DPS Canine Training Facility - Florence

CLIENT: Parkhill
Lubbock, TX

SITE: 810 County Road 240
Florence, TX

LOCATION See Exploration Plan

Latitude: 30.7986° Longitude: -97.749°

Approximate Surface Elev.: 1037 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / MATERIAL 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, stiff				2.0 tsf (HP)					32.5		81-23-58	95
						4.0 tsf (HP)		UC	1.92	7.4	28.4	99		
		4.0 — 1033+/-												
2		**GRAVELLY LEAN CLAY WITH SAND (CL)**, light brown, hard	5			11-15-50/4"					10.7		45-16-29	52
		5.5 — 1031.5+/-												
3		**LIMESTONE**, light brown to light gray, unfractured to moderately fractured, weak					67 / 31	UC	222.94		3.7	137		
			10				100 / 88							
		-becomes light brown at about 15 feet	15				82 / 23							
		20.0 — 1017+/-	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 6 feet; Air Rotary 6 to 20 feet

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations based on Google Earth

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
800 Paloma Dr Ste 150
Round Rock, TX

Boring Started: 08-25-2021	Boring Completed: 08-25-2021
Drill Rig: Mobile B-59	Driller: Core Tech Drilling, Inc.
Project No.: AC215028	

BORING LOG NO. B-2

PROJECT: DPS Canine Training Facility - Florence

CLIENT: Parkhill
Lubbock, TX

SITE: 810 County Road 240
Florence, TX

LOCATION See Exploration Plan

Latitude: 30.7954° Longitude: -97.7488°

Approximate Surface Elev.: 1036 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	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, very stiff				2.5 tsf (HP)					24.0		77-22-55	
						3-27-12 N=39					26.6			90
		4.0 — 1032+/-												
2		**SANDY LEAN CLAY WITH GRAVEL (CL)**, light brown, very stiff	5			23-10-10 N=20					13.7			70
		6.0 — 1030+/-												
3		**LIMESTONE**, light brown to tan, unfractured to moderately fractured, slightly vugular, weak					92/33							
			10				100/58	UC	132.55		2.9	132		
			15				88/25							
		20.0 — 1016+/-	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 6 feet; Air Rotary 6 to 20 feet

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations based on Google Earth

Notes:

WATER LEVEL OBSERVATIONS

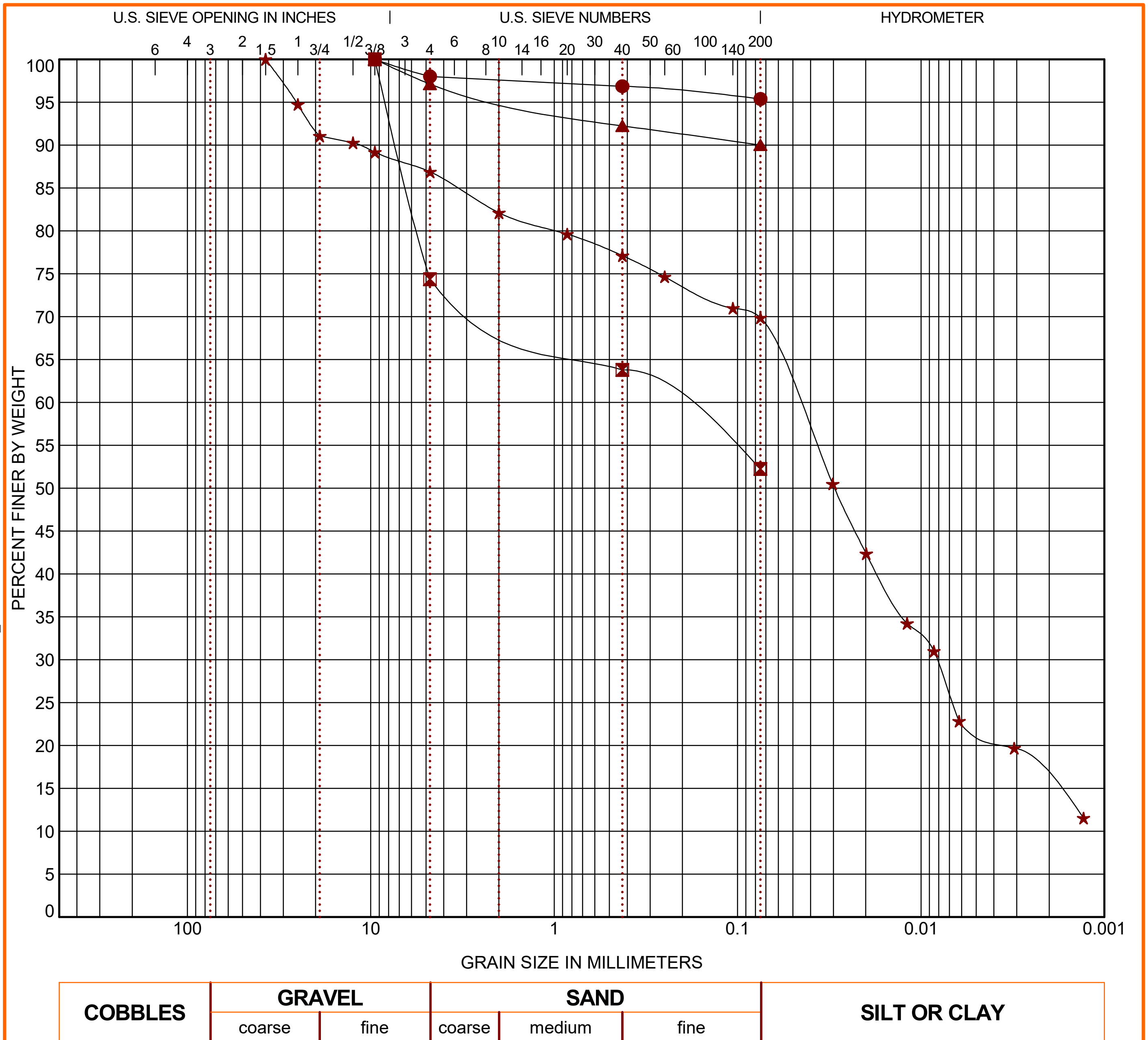
Groundwater not encountered

Terracon
800 Paloma Dr Ste 150
Round Rock, TX

Boring Started: 08-25-2021	Boring Completed: 08-25-2021
Drill Rig: Mobile B-59	Driller: Core Tech Drilling, Inc.
Project No.: AC215028	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Symbol	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	0 - 2	FAT CLAY (CH)	32.5	81	23	58		
⊠	B-1	4.5 - 5.8	GRAVELLY LEAN CLAY with SAND (CL)	10.7	45	16	29		
▲	B-2	2.5 - 4		26.6					
★	B-2	4.5 - 6		13.7					

Symbol	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	0 - 2	9.5				0.0	2.0	2.6		95.4	
⊠	B-1	4.5 - 5.8	9.5	0.241			0.0	25.6	22.1		52.2	
▲	B-2	2.5 - 4	9.5				0.0	2.9	7.1		90.0	
★	B-2	4.5 - 6	37.5	0.047	0.008		0.0	13.1	17.0	48.0		21.9

PROJECT: DPS Canine Training Facility - Florence

SITE: 810 County Road 240
Florence, TX

Terracon
800 Paloma Dr Ste 150
Round Rock, TX

PROJECT NUMBER: AC215028

CLIENT: Parkhill
Lubbock, TX

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

DPS Canine Training Facility - Florence ■ Florence, TX

Terracon Project No. AC215028

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core Shelby Tube Split Spoon	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.	**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			**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		

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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 on or above “A” line		CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

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

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

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

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

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

[F] If soil contains ≥ 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.

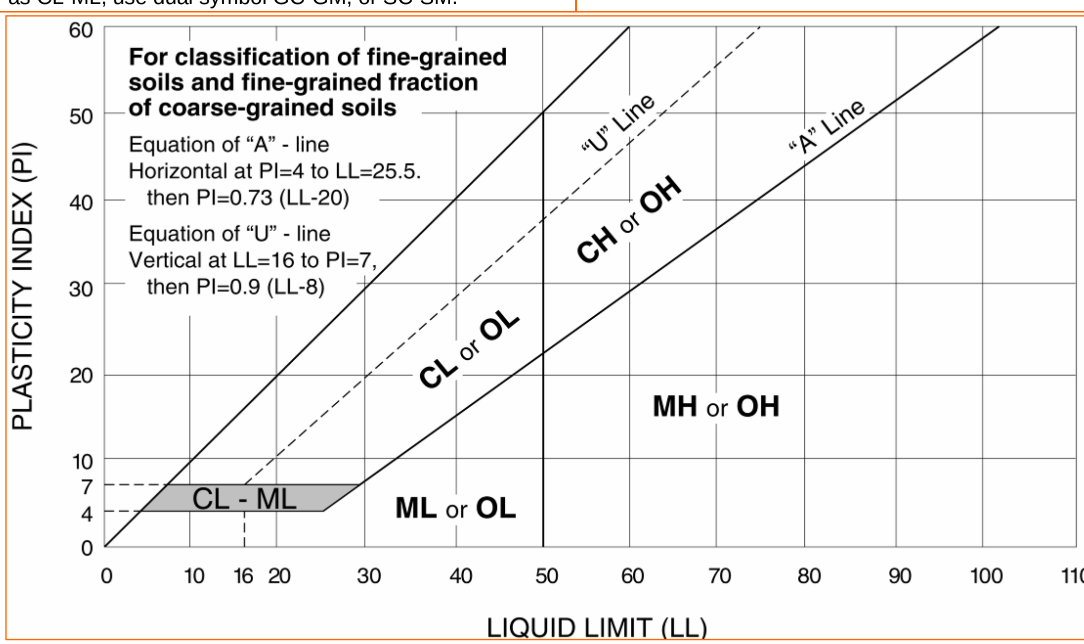
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[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.



DESCRIPTION OF ROCK PROPERTIES

Terracon GeoReport

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 (tsf)**
Extremely weak	Indented by thumbnail	40-150 (3.9-10.8)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (10.8-50.4)
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 (50.4-288)
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 (288-504)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (504-1,080)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (1,080-2,592)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>2,592)

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