Geotechnical Engineering Report

Whirligig Station Parking Lot Improvements
Wilson, Wilson County, North Carolina
March 11, 2020
Terracon Project No. 72205015

Prepared for:
Bartlett Engineering & Surveying, PC
Wilson, North Carolina

Prepared by:
Terracon Consultants, Inc.
Winterville, North Carolina

March 11, 2020

Bartlett Engineering & Surveying, PC
1906 Nash Street North
Wilson, NC 27893

Attn: Mr. Robert S. Bartlett, PE
P: (252) 399-0704 x 224
E: robert@bartletteng.com

Re: Geotechnical Engineering Report
Whirligig Station Parking Lot Improvements
211 Tarboro St
Wilson, Wilson County, North Carolina
Terracon Project No. 72205015

Dear Mr. Bartlett:

We have completed Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P72205015 dated February 13, 2020. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs 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.

NORTH CAROLINA PROFESSIONAL SEAL 042183 ENGINEER ANDREW J. GLINIAK

Andrew J. Gliniak, PE
Geotechnical Project Engineer
Registered NC 042183

James (Jim) D. Hoskins, III, PE
Principal / Office Manager

REPORT TOPICS

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

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

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	The project includes the installation of an underground stormwater system, StormTrap, to handle stormwater beneath the parking lot in an approximately 100 by 200-foot area. Two culverts are proposed for conveyance. The stormwater system will bear approximately 11 feet below existing grades and the two culverts will be installed approximately 8.5 to 12 feet below existing grades.
Geotechnical Characterization	The borings encountered undocumented fill and concrete debris to depths of at least 5.5 feet underlain by very soft to stiff clay and loose sand. Groundwater is anticipated at a depth of 5 feet below the existing ground surface corresponding with the SHWT.
Geotechnical Overview	There is very soft clay near the bearing elevation of the proposed structures that should be removed and replaced for support of the system. We should be contacted if a bearing capacity in excess of the allowable 2000 psf is required. Groundwater controls will be required, and concrete debris should be anticipated in excavations. Due to the clay content of the soils, we anticipate a sump and perimeter ditches inside the excavation will be used to collect the groundwater to dewater the site at the beginning of construction.
Earthwork	The excavations should be overexcavated and dewatered. A 1-foot thick stone blanket should be installed in the bottom of the excavation to aid in construction and dewatering. Dewatering should continue until final grades are reached during construction.
Shallow Foundations	Allowable bearing pressure with recommended overexcavation = 2,000 psf Expected settlements: < 2-inch total, < 1 -inch differential
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report
Whirligig Station Parking Lot Improvements
211 Tarboro St
Wilson, Wilson County, North Carolina
Terracon Project No. 72205015
March 11, 2020

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed stormwater system to be located at 211 Tarboro St in Wilson, Wilson County, North Carolina. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Foundation design and construction
- Site preparation and earthwork

The geotechnical engineering Scope of Services for this project included the advancement of six cone penetration test soundings to depths of approximately 20 feet or refusal below existing site grades and soil conditions for the proposed stormwater system. Refusal on concrete debris was encountered in two of the sounding locations at depths less than 4 feet.

Maps showing the site and boring locations are shown in the **Site Location and Exploration Plans** 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 at 211 Tarboro St in Wilson, Wilson County, North Carolina. Wilson County Parcel Identification Number (PIN): 3722207111 See **Site Location and Exploration Plans**
Site Coordinates	Approximately 35.7242°N, 77.9129°W
Existing Improvements	Existing asphalt parking lot with landscaping and concrete sidewalks surrounded by existing buildings. The site has been previously developed.

Item	Description
Current Ground Cover	Asphalt with some sidewalks and landscaping.
Existing Topography	Relatively level.
Geology	The subject site is located in the Coastal Plain Physiographic Province. The Coastal Plain soils consist mainly of marine sediments that were deposited during successive periods of fluctuating sea level and moving shoreline. The soils include sands, silts, and clays with irregular deposits of shells, which are typical of those lain down in a shallow sloping sea bottom. Recent alluvial sands, silts, and clays are typically present near rivers and creeks. According to USGS Mineral Resources On-Line Spatial Data based on the 1998 digital equivalent of the 1985 Geologic Map of North Carolina updated in 1998, the site is mapped within the Yorktown Formation and Duplin Formation, Undivided (Tertiary).

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

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
Information Provided	Initial project details were obtained from the site plans and shared map locations in your email dated February 4, 2020.
Project Description	The project includes the installation of an underground stormwater system, StormTrap, to handle stormwater beneath the parking lot in an approximately 100 by 200-foot area. Two culverts are proposed for conveyance.
Proposed Structure	The StormTrap system includes generally 8.33 feet high pre-cast modules approximately 8.5 by 15.25 feet wide that can vary in width. An 18-inch and 36-inch RCP are proposed.
Invert Elevations	The stormwater system invert elevation is approximately 127 feet. The culvert invert elevations will range from approximately 126 to 129.5 feet from the ground surface elevation of approximately 138 to 139 feet.. The stormwater system will bear approximately 11 feet below existing grades and the two culverts will be installed approximately 8.5 to 12 feet below existing grades.

Item	Description
Maximum Loads	■ AASHTO HS-20 Highway loading ■ A bearing pressure of 2,000 to 3,000 psf
Grading/Slopes	Approximately 1 to 4 feet of fill including a pavement section is proposed over the stormwater structure. Approximately 8.5 to 12-foot deep trenches are anticipated for culvert construction.
Estimated Start of Construction	June 2020

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	**Existing Fill**	Sand, Bricks, Concrete Debris
2	**Clay and Sand I**	Very soft to stiff clay and loose to medium dense sand
3	**Very Soft Clay**	Very soft to soft clay near bearing elevation of system
4	**Clay and Sand II**	Soft to stiff clay and loose sand

The existing fill beneath the approximately 2-inch asphalt pavement consisted of sand, bricks, and concrete debris. The concrete debris could be associated with a slab-on-grade from previous developments. Boring B-5 in the southwest corner of the proposed stormwater system footprint and Boring B-6 in the proposed culvert alignment encountered refusal on the concrete debris at depths of 1.7 and 3.6 feet.

Groundwater

Groundwater was measured 6 feet below ground surface in the borings during our field exploration. Based on the CPT soundings, measured water levels in the borings, and moisture condition of the soil samples in the macrocores, groundwater is anticipated at a depth of 5 feet below the existing ground surface.

The groundwater level can change due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Seasonal High Water Table (SHWT) and Infiltration Testing

The seasonal high water table (SHWT) in the systems footprint was estimated at a depth of approximately 5 feet below existing grades. The SHWT was determined by examining the chroma value of the existing soils. Infiltration was not completed due to the high groundwater table and existing fill. See the attached **Soil Evaluation for Stormwater Treatment** report for more information.

GEOTECHNICAL OVERVIEW

The proposed invert elevation of the stormwater system will bear approximately 11.5 feet below existing grades. Groundwater at depths of 5 feet and undocumented fill to at least 5.5 feet will be encountered in excavations. There is also very soft clay near the bearing elevation of the proposed structures that should be removed and replaced for a maximum allowable bearing pressure of 2,000 psf. We recommend overexcavation and replacement of the very soft clay to depths of 13 feet such as the relatively softer layer of clay encountered in Boring B-3 near the center of the proposed system to reach the recommended bearing pressure. A contingency for up to 60 percent of overexcavation and replacement should be included for construction.

We understand 2,000 psf is a relatively low bearing pressure for this system and greater bearing capacities could be achieved prior to construction of the system by either surcharging the entire structure footprint or through ground improvement such as aggregate piers that consist of replacing portions of the soil with compacted aggregate. Aggregate piers would act as stiff elements within the soil matrix and create a stiffer bearing medium than the soil alone. We should be contacted if a bearing capacity in excess of the allowable 2000 psf is required.

Groundwater control, as required should continue until excavations are backfilled and construction completed to design grades. However, groundwater control could cease after excavations are backfilled above the groundwater table if the structures are designed to resist buoyancy during construction. Due to the clay content of the soils, we anticipate a sump and perimeter ditches inside the excavation will be used to collect the groundwater to dewater the site at the beginning of construction versus well points. We recommend the bottom of the excavation for the system be overexcavated 1 foot for a layer of 57 Stone to be placed, which is underlain by a geosynthetic separation fabric. The stone blanket that will aid in construction and dewatering the center of the excavation.

The existing fill contained concrete that will inhibit excavations or the installation of aggregate piers. The concrete appears to be floor slabs based on the nearby construction debris. We recommend the fill be removed entirely in its entirety in the footprints of the structures.

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

EARTHWORK

Earthwork is anticipated to include 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.

Site Preparation

The entire footprint of the system should be excavated and dewatered in accordance with the **Excavation and Groundwater** section of this report. Existing fill with concrete will likely inhibit the excavations on approximately half of the site. At least two of the six borings at the site refused on concrete.

Existing Fill

As noted in **Geotechnical Characterization**, the borings encountered existing fill to at least a depth of approximately 5.5 feet. We have no records to indicate the degree of control during fill placement. Excavation required to install the storm water system will likely remove the existing fill. Additional testing and observations of the existing fill could be required during construction.

Excavation and Groundwater

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Safety and Health Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will most likely be required during grading operations. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Groundwater is anticipated in excavations deeper than 5 feet. Groundwater in excavations should be pumped out with sumps or well points if applicable. A 1-foot thick washed No. 57 blanket underlain by a geosynthetic fabric should also be installed as required to protect the subgrade and provide a path for groundwater seepage in excavations. Pumping water, as required, should continue until excavations are completely backfilled and construction completed to final grades.

The dewatering system should be designed and installed by a specialty contractor experienced in this type of work.

Dewatering systems should be in-place and operating before excavations extend below the groundwater level. The groundwater should be lowered at least 3 feet below the foundation bearing elevation. We recommend that it be confirmed that the groundwater has been adequately lowered by the installation of temporary piezometers prior to beginning excavation. Existing structures appear to be far enough away that the excavations will not impact them. However, the geotechnical engineer should be contacted if this is not the case.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 5 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Imported Soil	SC, SM, SP	All location and elevations.
On-Site Soils	SC, SM	On site soils that meet these soil classifications are generally suitable for fill if properly moisture conditioned.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

On-site near surface clays are not recommended for use as structural fill due to their high fines content and moisture sensitivity relative to sandy soils available. Near surface clay could be considered for use as general fill.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as Structural fill
Minimum Compaction Requirements [1, 2]	95% of max. above and below foundations	92% of max.
Water Content Range [1]	-2% to +2% of optimum	As required to achieve min. compaction requirements

1. Fill should be tested for moisture content and compaction during placement. If in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the tests should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. It is not necessary to achieve 95% compaction on the existing ground prior to placing fill or beginning construction. However, the subgrade should be evaluated by a representative of the geotechnical engineer prior to placing fill or beginning construction.

It is important to note that the use of rubber-tired traffic, such as lulls, may impact the prepared subgrade soils leading to re-grading. We recommend that the use of rubber-tired traffic be limited on the prepared subgrades or that the stabilized area be prepared for their travel.

Utility Abandonment

Special precautions should be made to remove all underground utilities and their associated backfill as the structure's foundations may overlay these materials. Terracon considers removing the utilities and underground structures and backfilling the resulting trenches to be the preferred method of abandonment. In-place abandonment by filling piping with grout should only be considered in the building footprint after checking the location of the piping in both plan and elevation space for potential conflict with the proposed foundations and new utilities. Care should be given to locating and addressing these items during the site preparation phase of the project. If overlooked, they could be detrimental to the long-term performance of the structure.

Earthwork Construction Considerations

Rock hammers could be required to break up the concrete beneath the existing fill. The remainder of the excavations for the proposed structures are anticipated to be accomplished with conventional construction equipment. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to construction.

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 monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

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. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas. One density and water content test should be performed for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

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**, the following design parameters are applicable for shallow foundations.

Design Parameters

Item	Description
Maximum allowable bearing pressure	2,000 psf
Anticipated embedment depth	11 feet
Approximate total settlement [1]	Up to 2 inches
Estimated differential settlement [1]	Less than 1 inch
Ultimate coefficient of sliding friction [2]	0.35

1. The actual magnitude of settlement that will occur beneath the foundations will depend upon the variations within the subsurface soil profile, the structural loading conditions and the quality of the foundation excavation. The estimated total and differential settlements listed assume that the foundation-related earthwork and the foundation design are completed in accordance with our recommendations.
2. For uplift resistance, use the weight of the foundation concrete plus the weight of the soil over the plan area of the footings. 110 pounds per cubic foot above the groundwater level and 48 pcf below the groundwater level should be used for the density of the soil.

The structures should be designed to resist the buoyancy effects of being submerged/excessive hydrostatic uplift. If adequate dead load is not available to resist the maximum buoyant condition (an empty structure), it should be protected from excessive uplift loading with additional overburden or heavier overburden. Soil anchors may also be used to resist excessive uplift loads.

Foundation Construction Considerations

The foundation bearing materials should be evaluated at the time of the foundation excavation. This is an essential part of the construction process. A representative of the geotechnical engineer should use a combination of hand auger borings and dynamic cone penetrometer (DCP) testing to determine the suitability of the bearing materials for the design bearing pressure. DCP testing should be performed to a depth of 3 to 5 feet below the bottom of foundation excavation. Excessively soft, loose, or wet bearing soils should be over excavated to a depth recommended by the geotechnical engineer. The excavated soils should be replaced with structural fill or washed, crushed stone (NCDOT No. 57) wrapped in a geotextile fabric (Mirafi 140 N or equivalent).

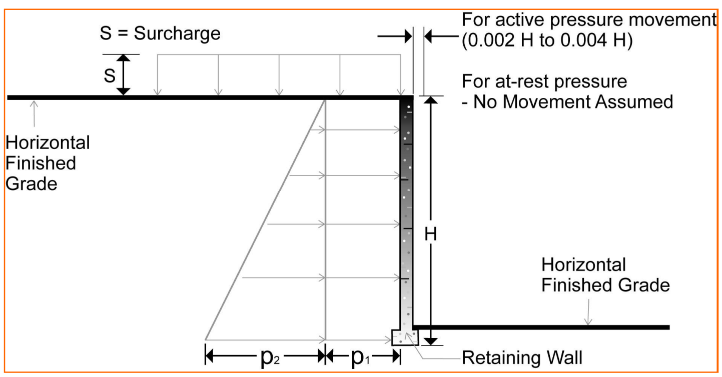
The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance.

Should the soils at bearing level become excessively disturbed or saturated, the affected soil should be removed prior to placing concrete.

LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3, 4, 5] p_1 (psf)	Effective Fluid Pressures (psf) [2, 4, 5]	
			Unsaturated [6]	Submerged [6]
Active (Ka)	Granular - 0.33 Cohesive/Existing – 0.53	(0.33)S (0.53)S	(40)H (63)H	(80)H (93)H
At-Rest (Ko)	Granular - 0.50 Cohesive/Existing – 0.69	(0.50)S (0.69)S	(60)H (83)H	(90)H (102)H
Passive (Kp)	Granular - 3.0 Cohesive/Existing – 1.9	---	(360)H (225)H	(240)H (170)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted between 95 and 98 percent of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

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.

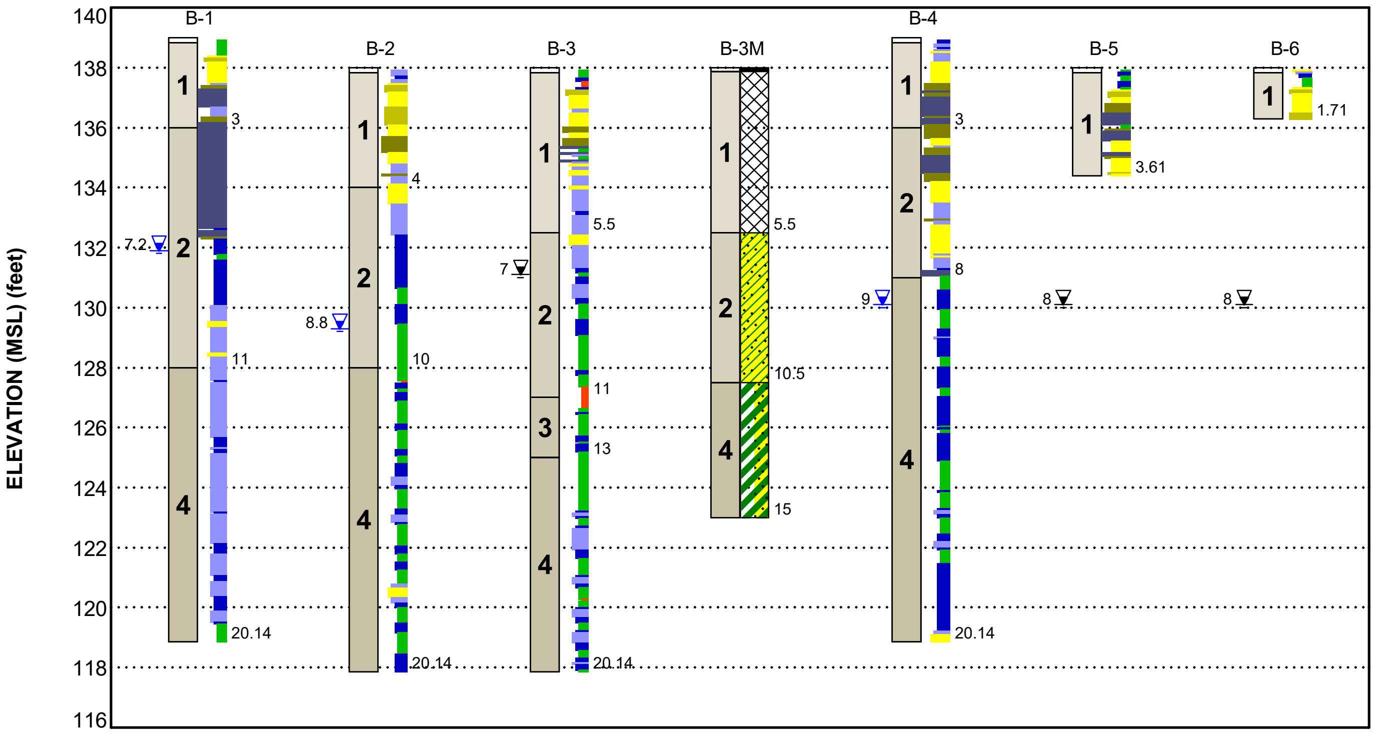
FIGURES

Contents:

GEOMODEL

Whirligig Station Parking Lot Improvements ■ Wilson, NC
Terracon Project No. 72205015

Terracon GeoReport



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	Existing Fill	Sand, Bricks, Concrete Debris
2	Clay and Sand I	Very soft to stiff clay and loose to medium dense sand
3	Very Soft Clay	Very soft to soft clay near bearing elevation of system
4	Clay and Sand II	Soft to stiff clay and loose sand

LEGEND

- Asphalt
- Fill
- Sandy Lean Clay
- Fat Clay with Sand

Soil Behavior Type (SBT)

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

CPT Water Depth

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

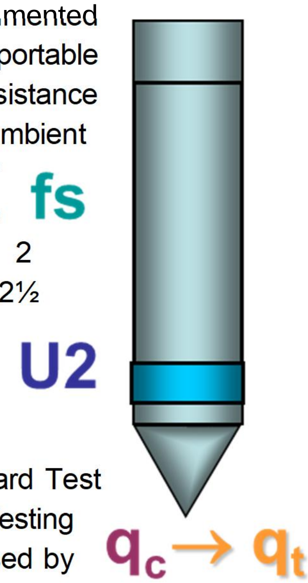
Field Exploration

Soundings/Borings	Boring Depth (feet)	Location
B-1, B-2, B-3, B-4	20	Planned Stormwater System
B-5	3.6	Planned Stormwater System
B-6	1.7	Culvert Alignment

Boring Layout and Elevations: Coordinates of the soundings were determined by overlaying the plans provided on aerial photography by referencing common features. The soil sounding/boring locations were marked in the field by Terracon by referencing existing site features and a handheld GPS. The elevations were determined by spotting the boring locations on the provided site plans. The locations and elevations of the soundings/borings should be considered accurate only to the degree implied by the means and methods used to define them.

Subsurface Exploration Procedures: The soil test locations, were performed by a track mounted power direct push rig utilizing cone penetration testing (CPT) to advance the soundings. Samples taken during the testing process were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification.

Cone Penetration Testing (CPT): The CPT hydraulically pushes an instrumented cone through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 10 cm^2. Digital data representing the tip resistance, friction resistance, pore water pressure, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1½ and 2½ centimeters per second. These measurements are correlated to various soil properties used for geotechnical design. No soil samples are gathered through this subsurface investigation technique.



CPT testing is conducted in general accordance with ASTM D5778 "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils." Upon completion, the data collected was downloaded and processed by the project engineer.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil 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 D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- ASTM D2488 Standard Practice of Description and Identification of Soils (Visual Manual Method)
- 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 D1140 Standard Test Methods for Determining the Amount of Material Finer than No. 200 Sieve in Soils by Washing

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.

PHOTOGRAPHY LOG

Photos taken February 18, 2020 and March 2, 2020.

Site photo 1: Northeast of site facing southwest

Site photo 2: Northwest of site facing southeast

Site photo 3: West of site facing northeast

Site photo 4: South of site facing north

Site photo 5: Goldsboro St facing northwest at site and driveway

Site photo 6: Nearby construction west of driveway with concrete slab

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Whirligig Station Parking Lot Improvements ■ Wilson, NC
March 11, 2020 ■ Terracon Project No. 72205015

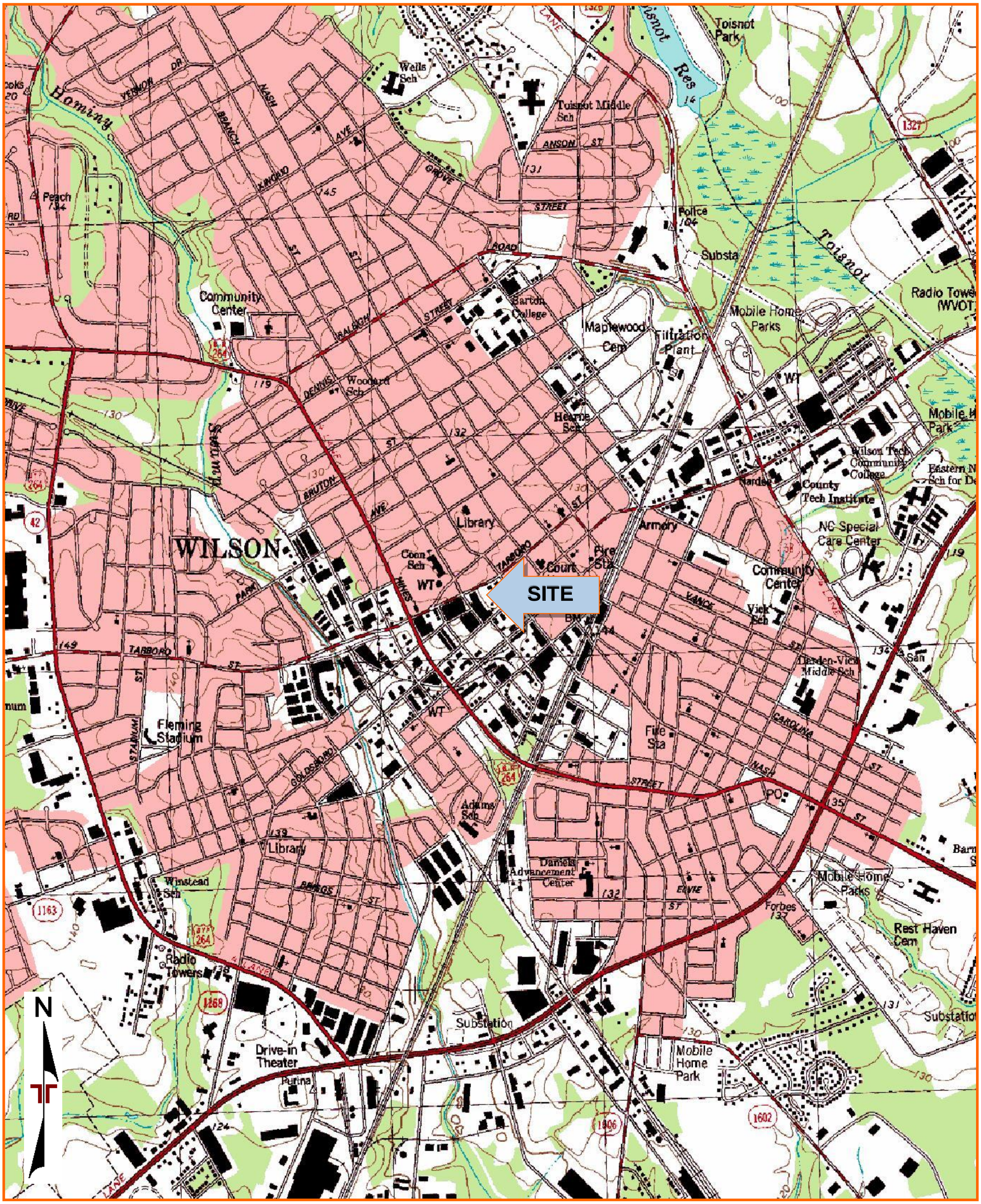


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: WILSON, NC (1/1/1998).

EXPLORATION PLAN

Whirligig Station Parking Lot Improvements ■ Wilson, NC
March 11, 2020 ■ Terracon Project No. 72205015

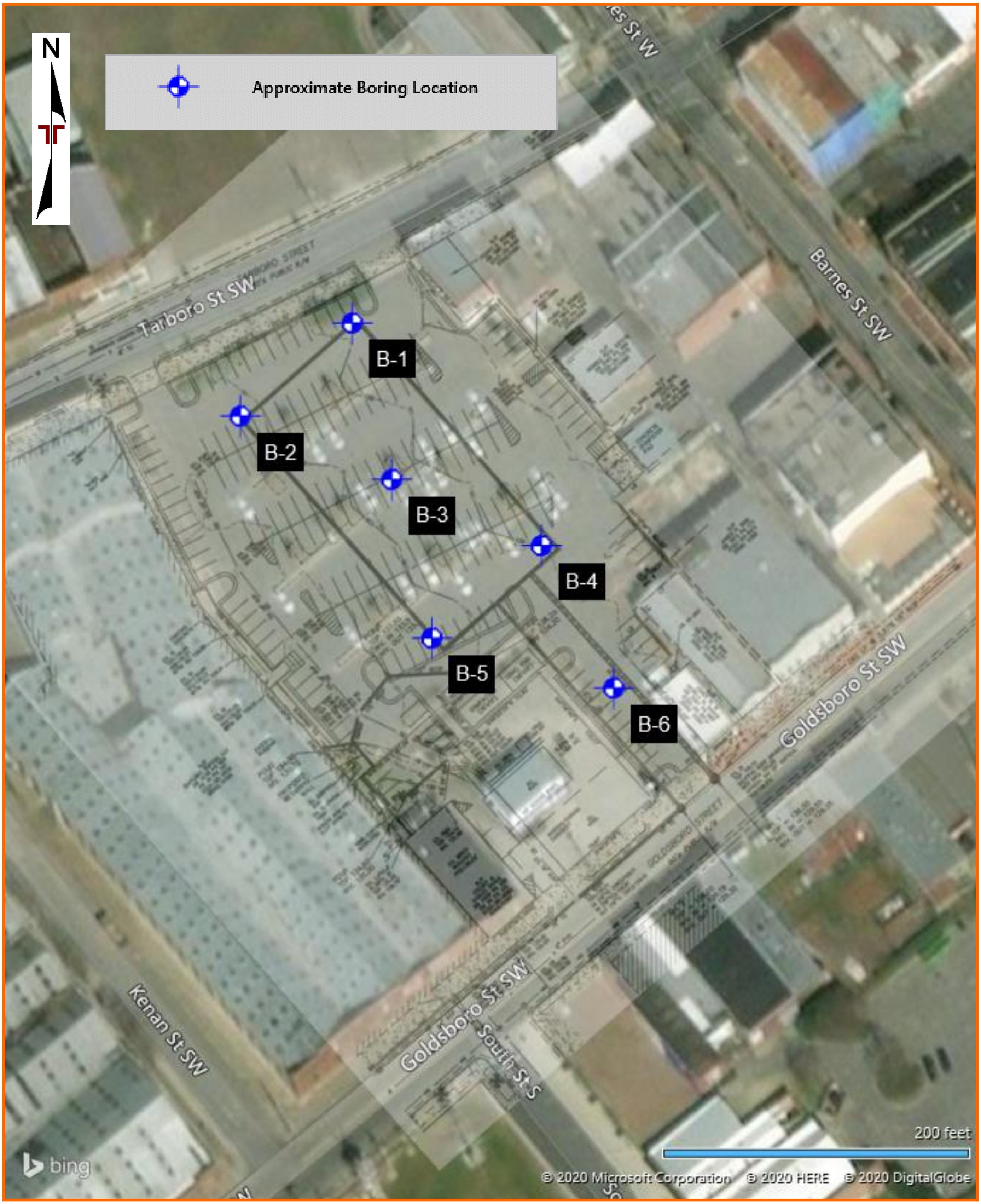


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

CPT LOG NO. B-1

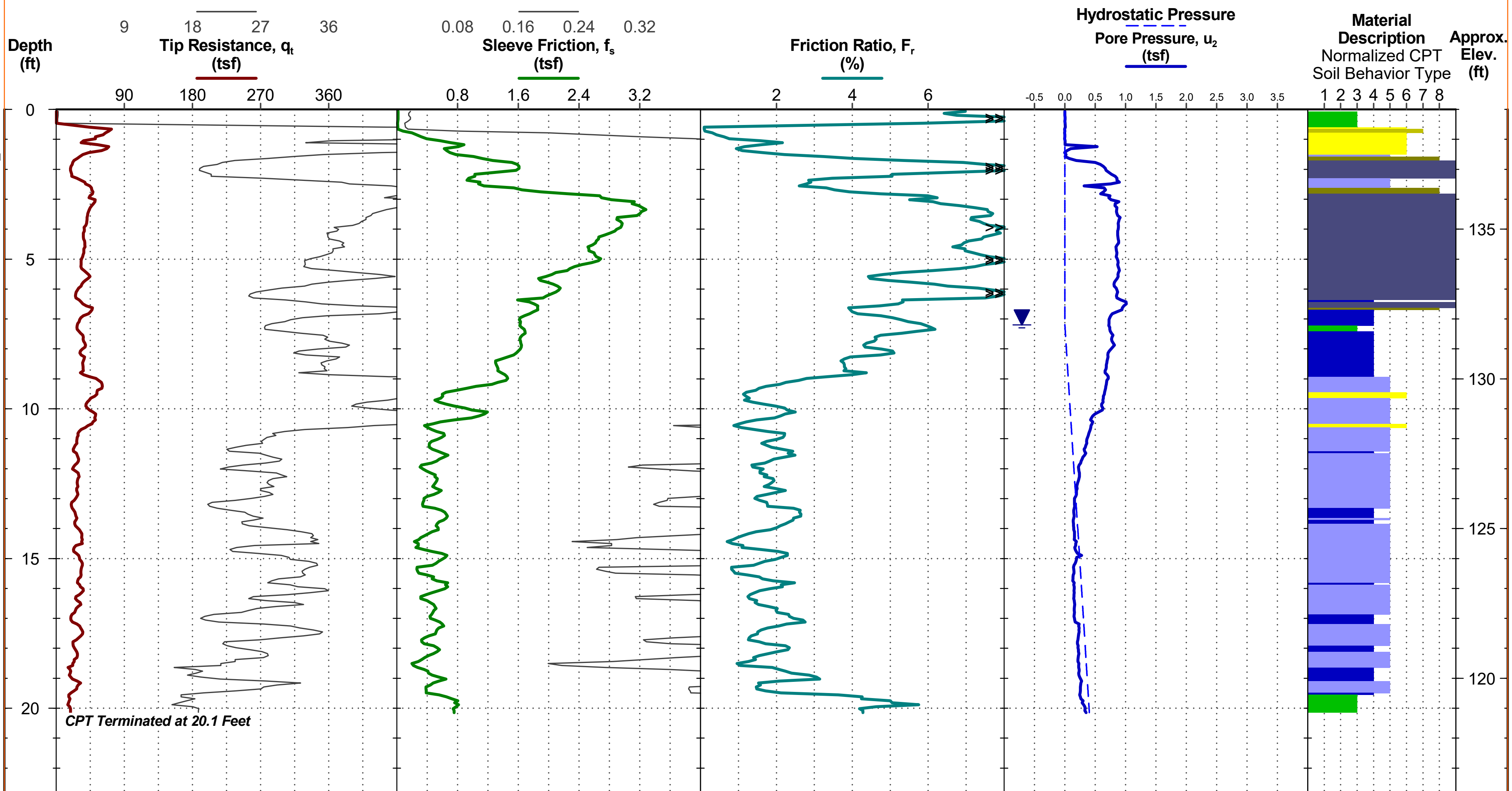
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

SITE: 211 Tarboro Street Wilson, NC

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 139 ft +/-
Latitude: 35.724514°
Longitude: -77.913067°



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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

7.2 ft measured water depth (used in normalizations and correlations; See Supporting Information)

Probe no. 4287 with net area ratio of 0.84

Calibrated 3/9/2017

Terracon
314 Beacon Dr
Winterville, NC

CPT Started: 3/2/2020	CPT Completed: 3/2/2020
Rig: Geoprobe	Operator: BJM
Project No.: 72205015	

CPT LOG NO. B-2

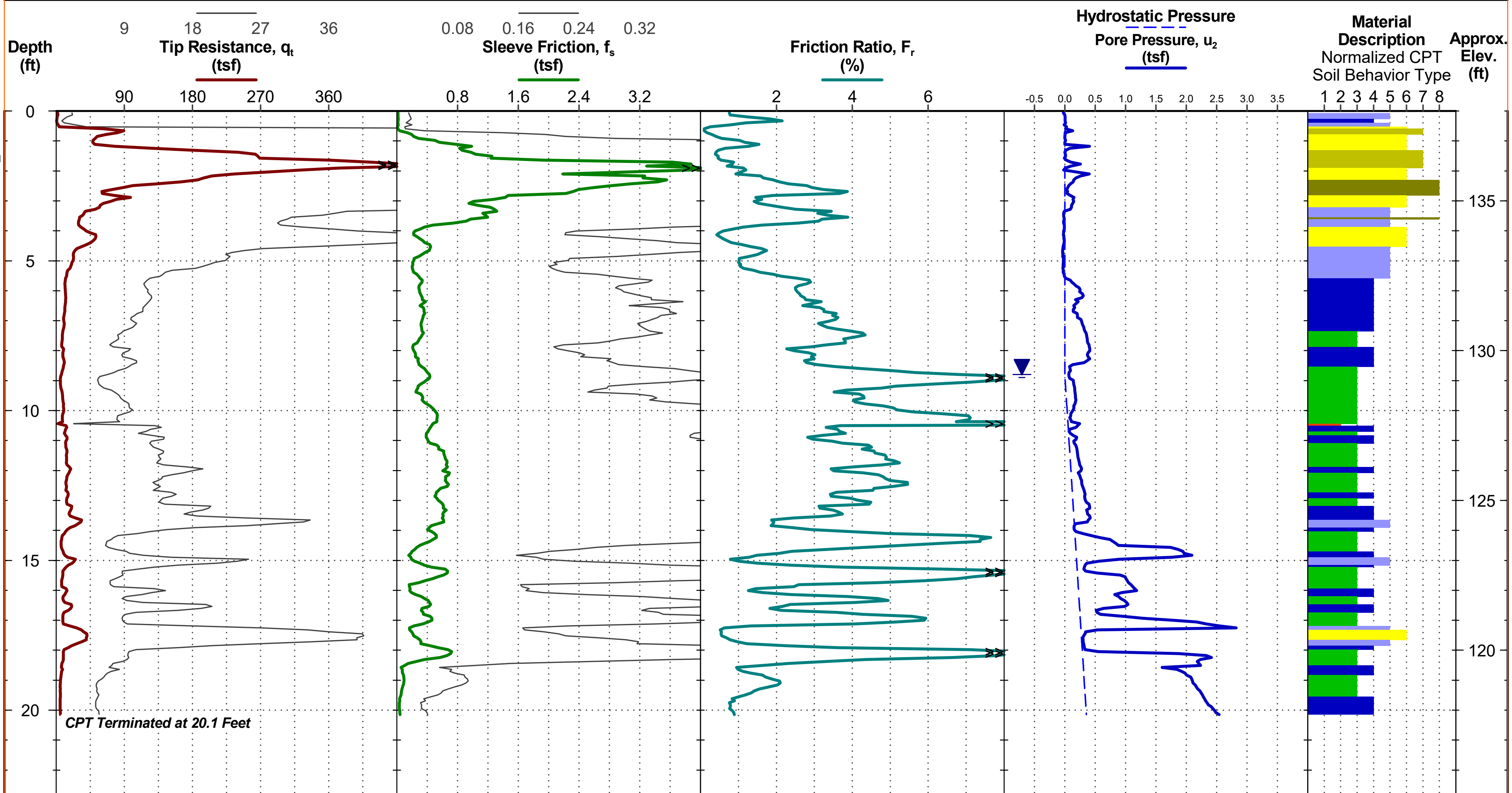
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

SITE: 211 Tarboro Street Wilson, NC

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 138 ft +/-
Latitude: 35.724348°
Longitude: -77.913313°



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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
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8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

8.8 ft measured water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. 4287 with net area ratio of 0.84

Calibrated 3/9/2017

Terracon
314 Beacon Dr
Winterville, NC

CPT Started: 3/2/2020	CPT Completed: 3/2/2020
Rig: Geoprobe	Operator: BJM
Project No.: 72205015	

CPT LOG NO. B-3

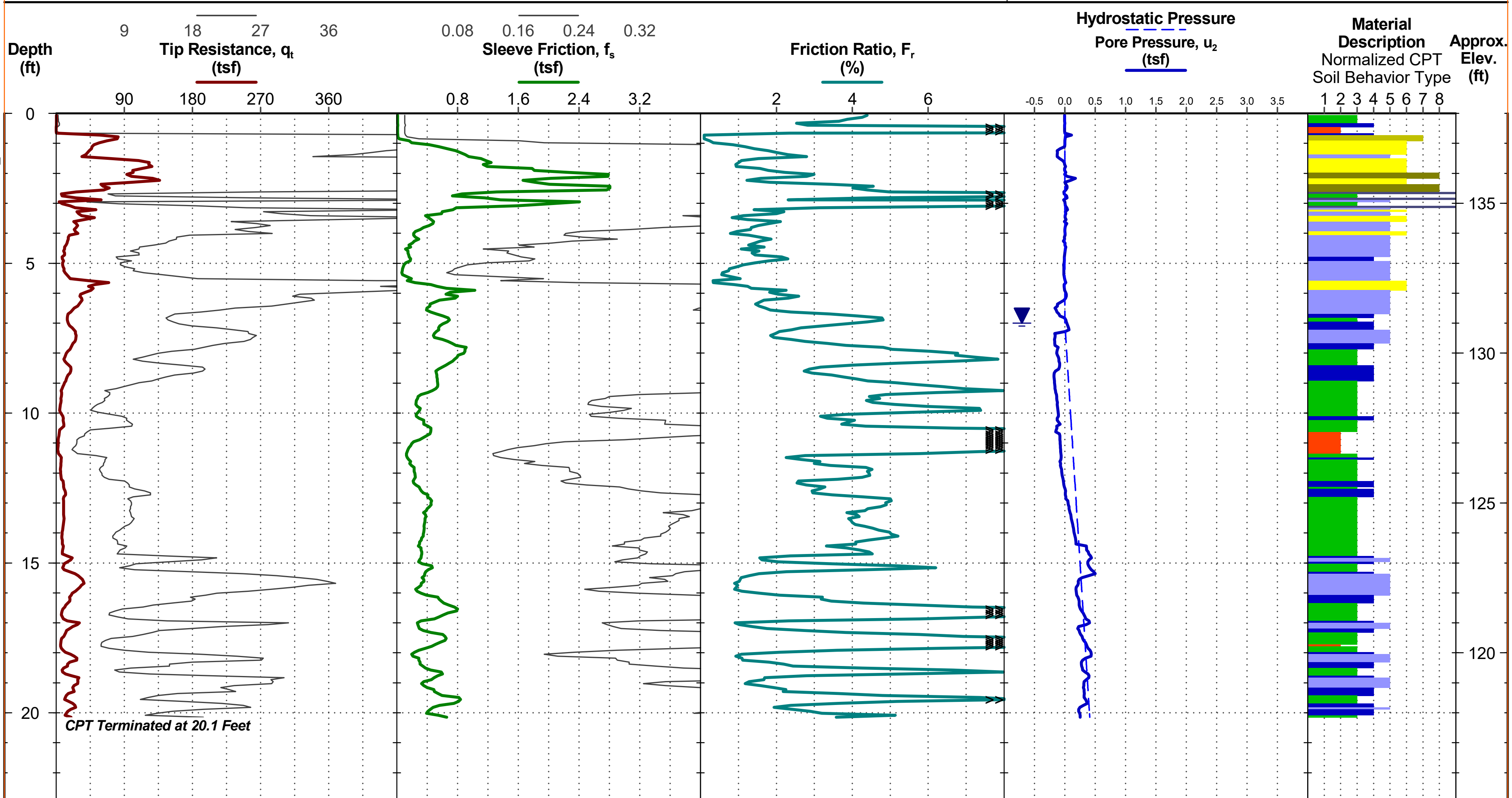
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 138 ft +/-
Latitude: 35.724235°
Longitude: -77.91298°

SITE: 211 Tarboro Street Wilson, NC



Cave in at 6.3 ft

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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION				
7 ft estimated water depth (used in normalizations and correlations; See Supporting Information)	Probe no. 4287 with net area ratio of 0.84 Calibrated 3/9/2017	Terracon 314 Beacon Dr Winterville, NC	CPT Started: 3/2/2020 Rig: Geoprobe Project No.: 72205015	CPT Completed: 3/2/2020 Operator: BJM

BORING LOG NO. B-3M

PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

SITE: 211 Tarboro Street Wilson, NC

LOCATION See Exploration Plan

Latitude: 35.7242° Longitude: -77.913°

Approximate Surface Elev.: 138 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.1	**ASPHALT**, 1.5 Inches	138+/-						
			FILL - CLAYEY SAND, SILTY SAND, AND BRICKS, trace gravel, gray and red					11		
								14		
		5.5		132.5+/-	5					
2			**SANDY LEAN CLAY (CL)**, gray and brown					23	35-14-21	53
		10.5		127.5+/-	10					
4			**FAT CLAY WITH SAND (CH)**, light brown with red					33		
								41	55-19-36	85
		15.0		123+/-	15					
			Boring Terminated at 15 Feet							

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

Advancement Method:
Direct Push

Abandonment Method:
Boring backfilled with Soil Cuttings
Surface capped with asphalt

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

Terracon
314 Beacon Dr
Winterville, NC

Boring Started: 03-02-2020	Boring Completed: 03-02-2020
Drill Rig: Geoprobe	Driller: BJM
Project No.: 72205015	

CPT LOG NO. B-4

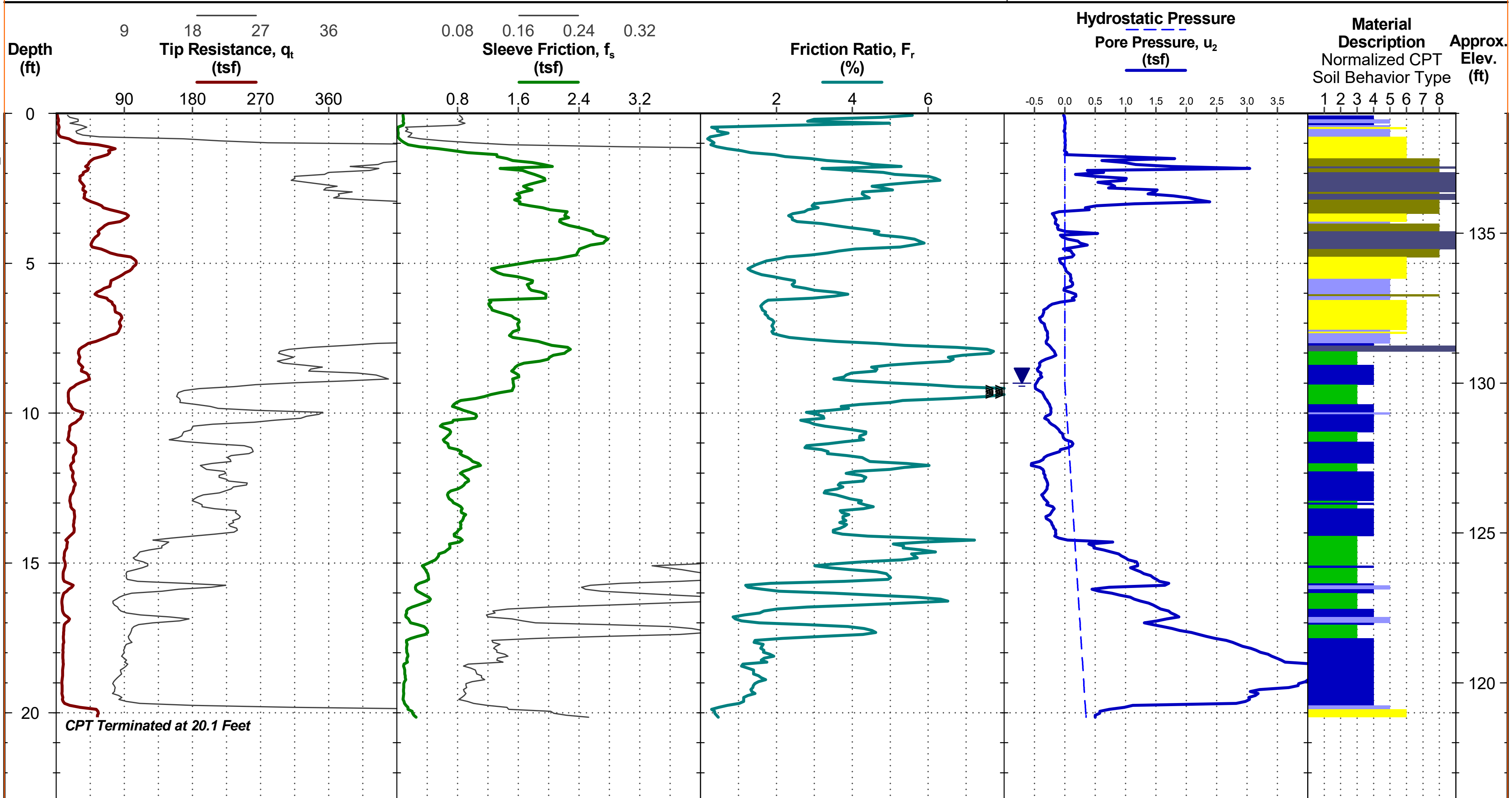
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

TEST LOCATION: See Exploration Plan

SITE: 211 Tarboro Street Wilson, NC

Approx. Surface Elev: 139 ft +/-
Latitude: 35.724117°
Longitude: -77.912651°



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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
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6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

9 ft measured water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. 4287 with net area ratio of 0.84

Calibrated 3/9/2017

Terracon
314 Beacon Dr
Winterville, NC

CPT Started: 3/2/2020	CPT Completed: 3/2/2020
Rig: Geoprobe	Operator: BJM
Project No.: 72205015	

CPT LOG NO. B-5

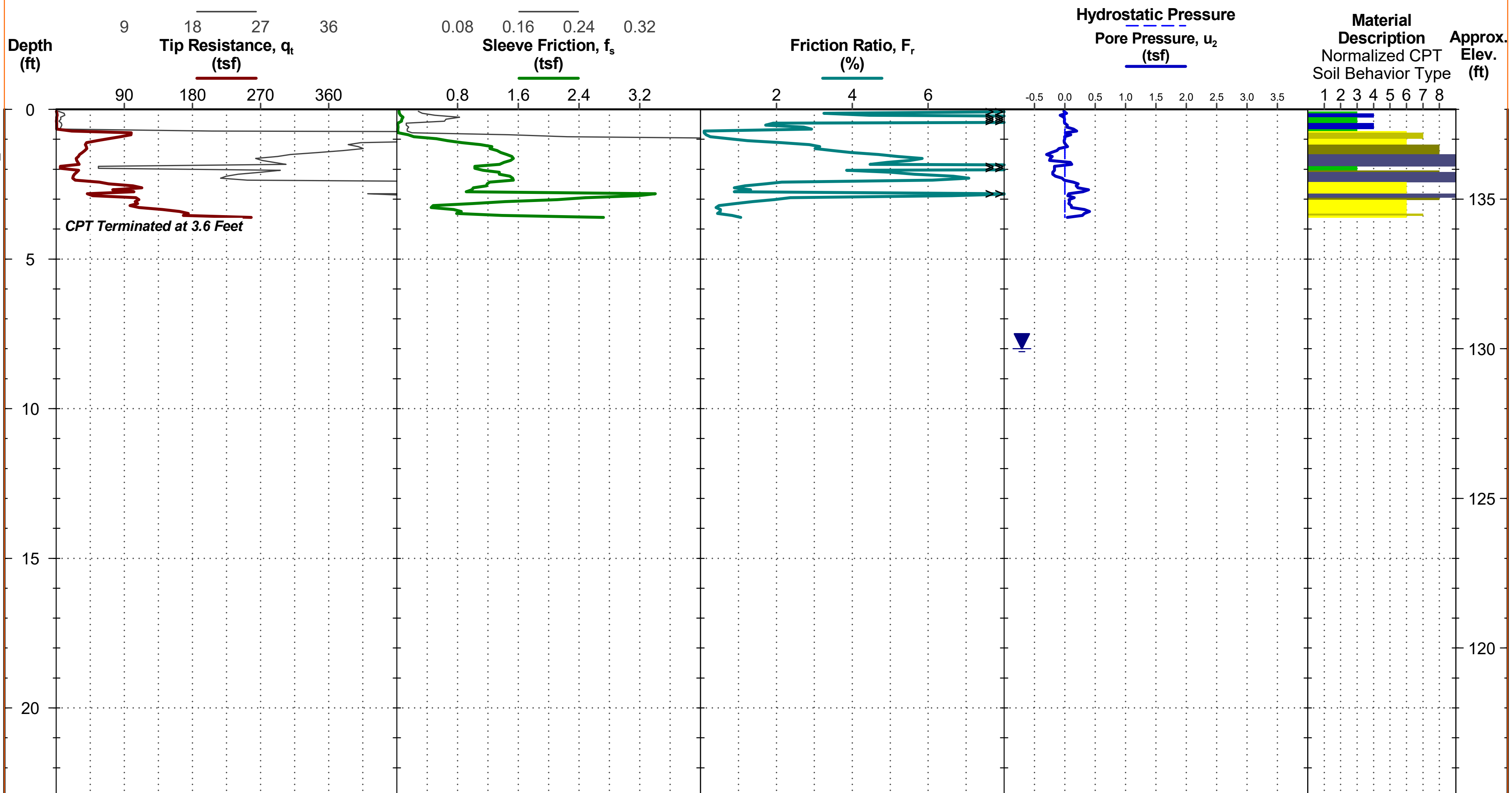
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 138 ft +/-
Latitude: 35.723952°
Longitude: -77.912892°

SITE: 211 Tarboro Street Wilson, NC



Refusal on concrete slab at 3.5 ft

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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
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4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

8 ft estimated water depth (used in normalizations and correlations; See Supporting Information)

Probe no. 4287 with net area ratio of 0.84

Calibrated 3/9/2017

Terracon
314 Beacon Dr
Winterville, NC

CPT Started: 3/2/2020	CPT Completed: 3/2/2020
Rig: Geoprobe	Operator: BJM
Project No.: 72205015	

CPT LOG NO. B-6

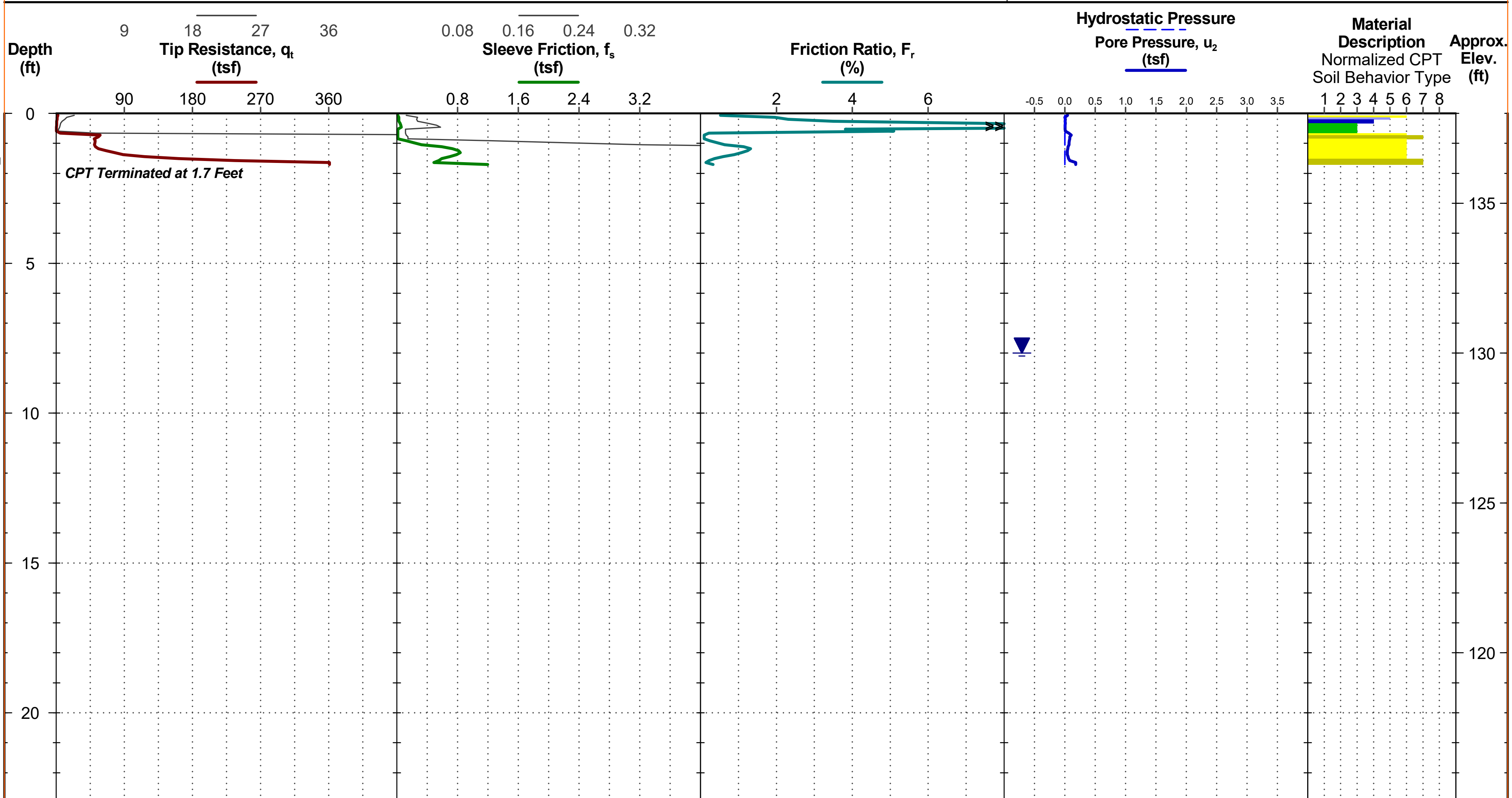
PROJECT: Whirligig Station Parking Lot Improvements

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 138 ft +/-
Latitude: 35.723863°
Longitude: -77.912492°

SITE: 211 Tarboro Street Wilson, NC



Refusal on concrete slab at 2.0 ft

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

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
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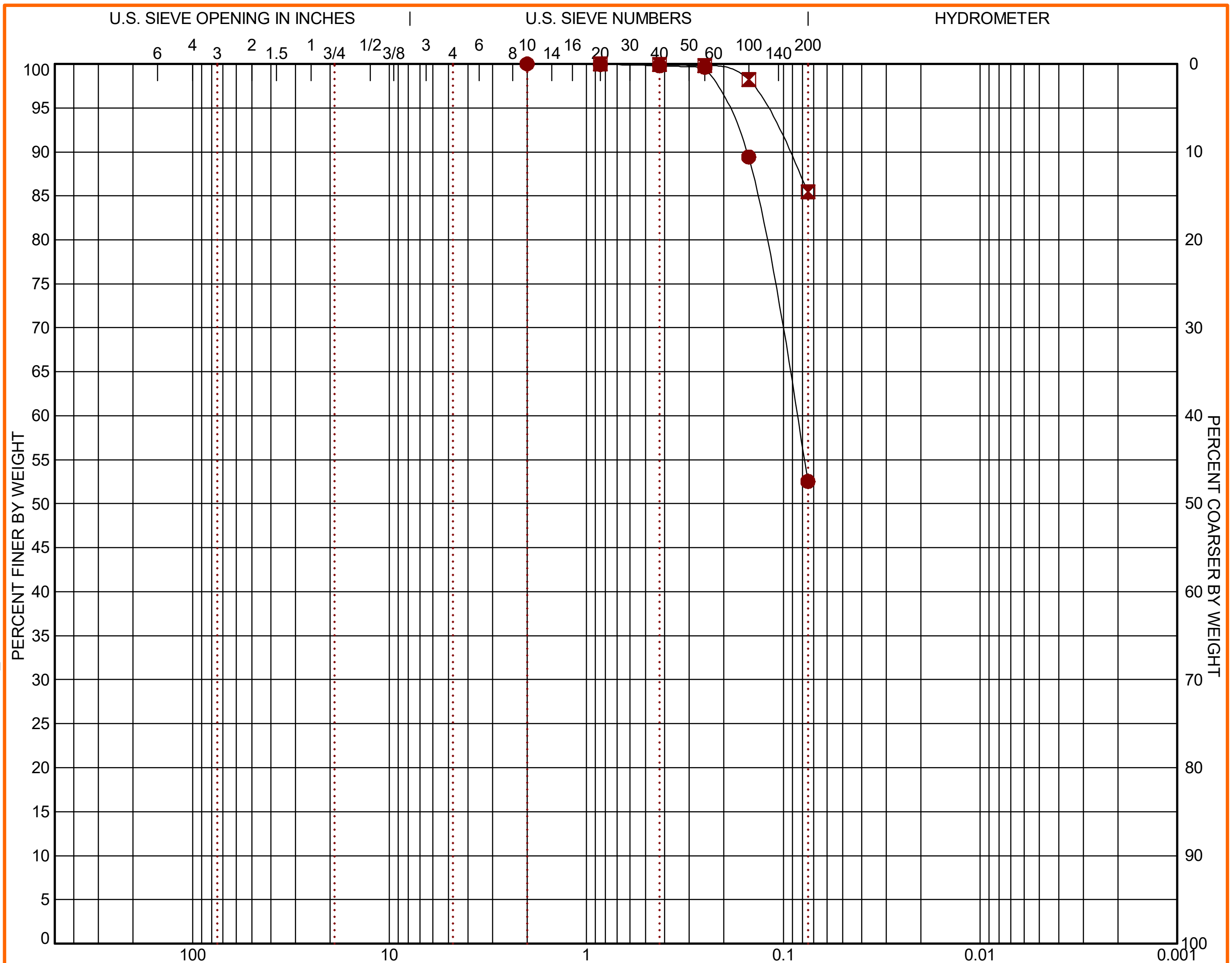
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION				
8 ft estimated water depth (used in normalizations and correlations; See Supporting Information)	Probe no. 4287 with net area ratio of 0.84 Calibrated 3/9/2017	Terracon 314 Beacon Dr Winterville, NC	CPT Started: 3/2/2020 Rig: Geoprobe Project No.: 72205015	CPT Completed: 3/2/2020 Operator: BJM

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-3M	8.5	0.0	0.0	47.5		52.5		CL
☒	B-3M	13.5	0.0	0.0	14.5		85.5		CH

GRAIN SIZE

	●	☒	
D_{60}	0.086		
D_{30}			
D_{10}			

COEFFICIENTS

	●	☒	
C_C			
C_U			

● Sieve	● % Finer	☒ Sieve	☒ % Finer	Sieve	% Finer
#10	100.0	#20	100.0		
#20	99.94	#40	99.92		
#40	99.79	#60	99.81		
#60	99.61	#100	98.23		
#100	89.43	#200	85.47		
#200	52.54				

SOIL DESCRIPTION

● SANDY LEAN CLAY (CL)

☒ FAT CLAY (CH)

REMARKS

●

☒

PROJECT: Whirligig Station Parking Lot Improvements

PROJECT NUMBER: 72205015

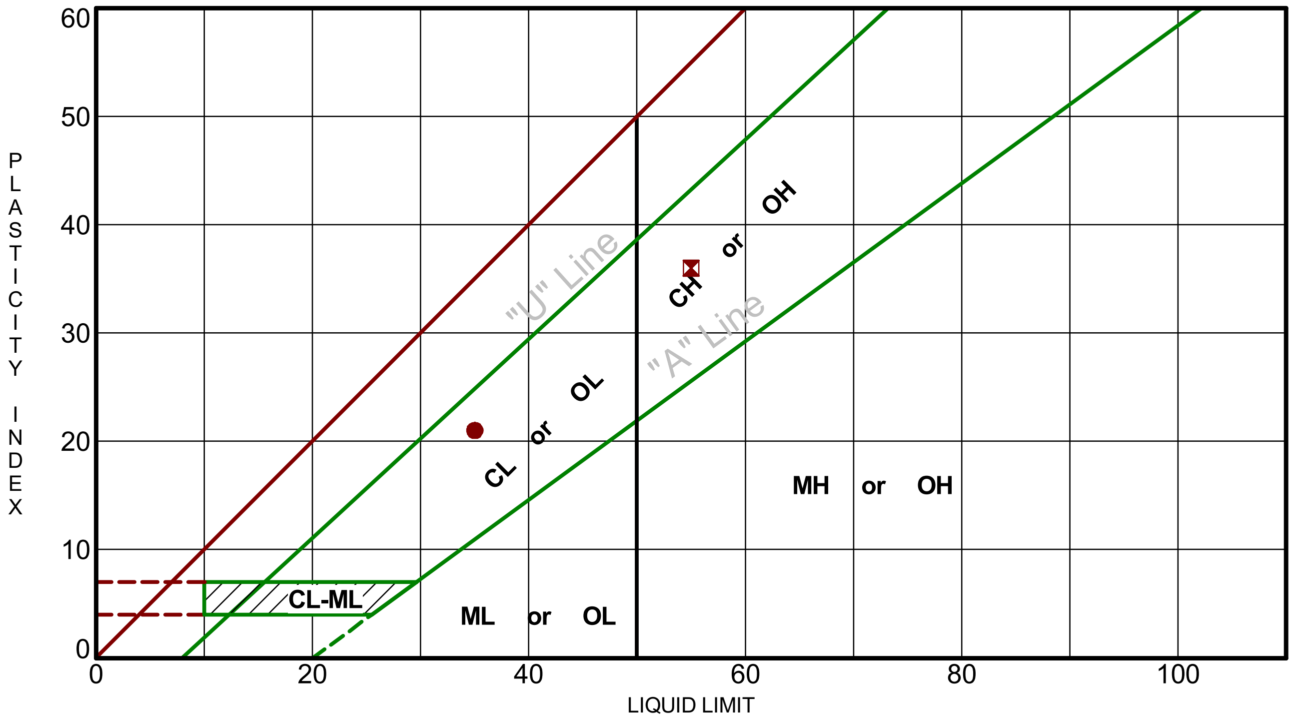
SITE: 211 Tarboro Street
Wilson, NC

Terracon
314 Beacon Dr
Winterville, NC

CLIENT: Bartlett Engineering & Surveying, P.C.
Wilson, NC

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-3M	8.5	35	14	21	52.5	CL	SANDY LEAN CLAY
⊠	B-3M	13.5	55	19	36	85.5	CH	FAT CLAY

PROJECT: Whirligig Station Parking Lot Improvements

SITE: 211 Tarboro Street Wilson, NC

Terracon
314 Beacon Dr
Winterville, NC

PROJECT NUMBER: 72205015

CLIENT: Bartlett Engineering & Surveying, P.C. Wilson, NC

SOIL EVALUATION FOR STORMWATER TREATMENT

Fred D. Smith Soil Scientist

March 7, 2020

Mr. Drew Gliniak
Terracon Consulting Engineers and Scientists
314 Beacon Dr
Winterville, NC 28590

Subject: Report of a Soil Evaluation for Stormwater Treatment
Whirligig Station Parking Lot
211 Tarboro St
Wilson, NC

Dear Mr. Gliniak,

This letter concerns the soil evaluation at the above-mentioned site. You authorized me to determine the depth to the 'seasonal high-water table' (SHWT) at two specific locations on the site and to perform permeability testing at two locations.

You provided me with a drawing that shows the location of the Terracon borings. The drawing is attached.

The lot is almost completely covered by asphalt except for some planters for trees and shrubs. You planned to have the drill rig open holes through the asphalt for me to access the soils beneath with a hand auger and to perform the permeability testing.

Seasonal High-Water Table (SHWT)

The SHWT has become more frequently used as an indicator of the highest level of water table fluctuations due to agricultural considerations, regulations for septic system designs and, more recently, stormwater design. The SHWT is routinely estimated by Soil Scientists from soil morphology (soil forming factors) and landscape position. Soil colors are evaluated because gray colors are associated with saturated and chemically reducing soil environments- the presence or absence of iron. Red, reddish yellow, brown, and brownish yellow colors are associated with aerobic and chemically oxidizing conditions.

During weathering of soil minerals, over a period of time, soluble constituents are removed from the soil profile and more stable compounds will precipitate. Iron is released from minerals and coats soil particles with thin oxide coatings that give soils their red to yellow colors. The natural color of soil particles is gray until they are coated with iron.

Soils also contain microorganisms that generate energy from the oxidation of soil organic matter. When the soil becomes saturated from flooding or slowly percolating water, oxygen is removed from the soil layer and anaerobic conditions prevail. Under anaerobic conditions, other types of soil microbes can derive energy the chemical reduction of oxidized iron and change its state from ferric to ferrous iron (loss of an electron). The requirements for this chemical-microbiological process are the absence of oxygen for several weeks, a temperature of at least 41 degrees (F), and the presence of organic matter (roots, etc).

During periods of alternative wetting and drying cycles, or SHWT cycles, ferrous iron may move short distances and precipitate during the drying (reoxidation) process. These mottling patterns are called redoximorphic colors.

Soil Scientists use the Munsell Color System to evaluate the degree of color changes visible in the soil. Low chroma colors are considered to be gray or black in the Munsell System (chroma less than 2). We normally

PHONE 252-908-4369 –1004 ROUNDTABLE CT-KNIGHTDALE, NC 27545---EMAIL FDS4444@REAGAN.COM

consider that once a soil layer has about 5% gray colors and redoximorphic patterns (red-yellow colored mottles), then that soil is saturated at least 21 days and qualifies as a SHWT.

Soils and Groundwater

The drill rig did open several holes through the pavement, but I was unable to advance a hand auger more than about 20-22 inches below the surface. I also tried to hand auger in the planter areas to obtain the necessary soil information and testing. At every location, I encountered auger refusal at about 20 inches below the surface.

Therefore, I could not perform the permeability testing. If these tests are mandatory, then we will need to excavate shallow pits in two locations in the parking area to a depth of about 5 feet.

I did evaluate the drilling samples from the rig. I found that the top about 5 feet consists of fill materials. Below about 5 feet, the soils show redoximorphic colors and become wetter with depth.

At about 5.5 feet below the surface I found sandy clay loam soils that have gray and red mottling colors with a matrix soil color of brown or yellowish brown. At about 7 feet below the surface the samples were wet or saturated. The samples became wetter as depth increased to 10 feet. The soils also became more clayey (sandy clay) with depth.

These soil colors and properties indicate that a SHWT exists at 5 feet or 5.5 feet below the surface or along the natural soil and fill material interface.

The SHWT may be shallower within the fill material too. But I can not determine that because the fill colors (gray and dark gray and brown) may be caused by their parent colors that were evident before they were transported to this site and placed as fill for the parking lot.

Based on the soil colors I found, a SHWT exists uniformly on this site at about 5 feet below the surface.

I appreciate the opportunity to work with you on this project. Please contact me if you have questions or need additional information.

Sincerely,

Fred D. Smith
Licensed Soil Scientist

LICENSED SOIL SCIENTIST
FRED D. SMITH
1059
STATE OF NORTH CAROLINA

PHONE 252-908-4369 –1004 ROUNDTABLE CT-KNIGHTDALE, NC 27545---EMAIL FDS4444@REAGAN.COM

Project Number: 72205015 ▲ HAND AUGER LOCATIONS

Project Name: Whirligig Station Parking Lot Improvements

Site Location: 211 Tarboro St SW (Tarboro St W), Wilson, NC

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES
DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING	WATER LEVEL	FIELD TESTS
GeoProbe Macro Core or Large Bore	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.	**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		
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.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

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)		

CPT GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Terracon GeoReport

DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

Uncorrected Tip Resistance, q_c
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance, q_t
Cone resistance corrected for porewater and net area ratio effects
$q_t = q_c + u_2(1 - a)$
Where a is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

Pore Pressure, u
Pore pressure measured during penetration
u_1 - sensor on the face of the cone
u_2 - sensor on the shoulder (more common)

Sleeve Friction, f_s
Frictional force acting on the sleeve divided by its surface area

Normalized Friction Ratio, F_r
The ratio as a percentage of f_s to q_t, accounting for overburden pressure

To be reported per ASTM D7400, if collected:

Shear Wave Velocity, V_s
Measured in a Seismic CPT and provides direct measure of soil stiffness

DESCRIPTION OF GEOTECHNICAL CORRELATIONS

Normalized Tip Resistance, Q_{tn}
$Q_{tn} = ((q_t - \sigma_{V0})/P_a)(P_a/\sigma'_{V0})^n$
$n = 0.381(I_c) + 0.05(\sigma'_{V0}/P_a) - 0.15$

Over Consolidation Ratio, OCR
$OCR\ (1) = 0.25(Q_{tn})^{1.25}$
$OCR\ (2) = 0.33(Q_{tn})$

Undrained Shear Strength, S_u
$S_u = Q_{tn} \times \sigma'_{V0}/N_{kt}$
N_{kt} is a soil-specific factor (shown on S_u plot)

Sensitivity, S_t
$S_t = (q_t - \sigma_{V0}/N_{kt}) \times (1/f_s)$

Effective Friction Angle, ϕ'
$\phi'\ (1) = \tan^{-1}(0.373[\log(q_t/\sigma'_{V0}) + 0.29])$
$\phi'\ (2) = 17.6 + 11[\log(Q_{tn})]$

Unit Weight, γ
$\gamma = (0.27[\log(F_r)]+0.36[\log(q_t/atm)]+1.236) \times \gamma_{water}$
σ_{V0} is taken as the incremental sum of the unit weights

Small Strain Shear Modulus, G_0
$G_0\ (1) = \rho V_s^2$
$G_0\ (2) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$

Soil Behavior Type Index, I_c
$I_c = [(3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2]^{0.5}$

SPT N_{60}
$N_{60} = (q_t/atm) / 10^{(1.1268 - 0.2817Ic)}$

Elastic Modulus, E_s (assumes $q/q_{ultimate} \sim 0.3$, i.e. FS = 3)
$E_s\ (1) = 2.6\Psi G_0$ where $\Psi = 0.56 - 0.33\log Q_{tn,clean\ sand}$
$E_s\ (2) = G_0$
$E_s\ (3) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$
$E_s\ (4) = 2.5q_t$

Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{V0})$
For $I_c > 2.2$ (fine-grained soils)
$\alpha_M = Q_{tn}$ with maximum of 14
For $I_c < 2.2$ (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

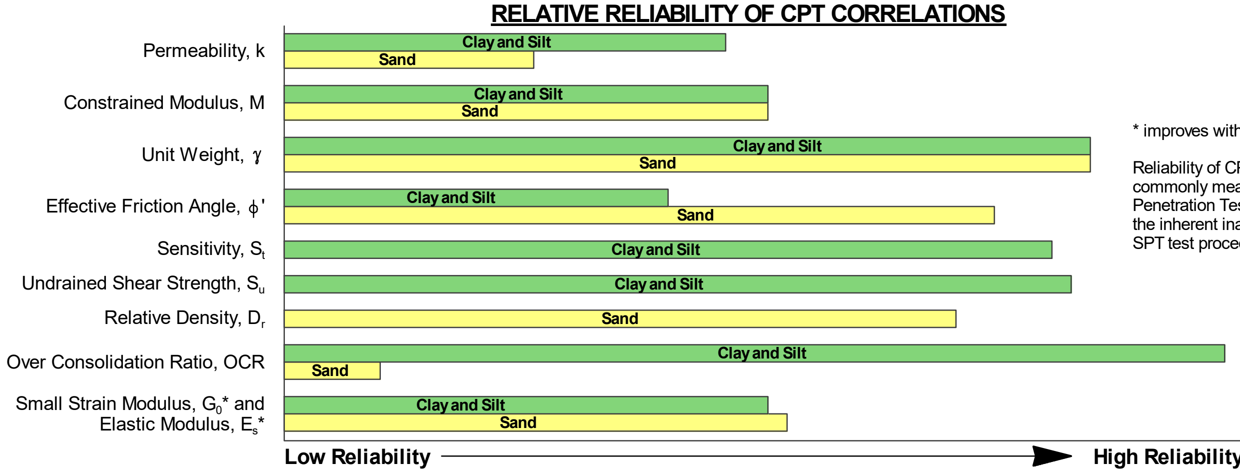
Hydraulic Conductivity, k
For $1.0 < I_c < 3.27$ $k = 10^{(0.952 - 3.04Ic)}$
For $3.27 < I_c < 4.0$ $k = 10^{(-4.52 - 1.37Ic)}$

Relative Density, D_r
$D_r = (Q_{tn} / 350)^{0.5} \times 100$

REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include q_t, f_s, and u. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. To this end, more than one correlation to a given parameter may be provided. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

RELATIVE RELIABILITY OF CPT CORRELATIONS



* improves with seismic V_s measurements

Reliability of CPT-predicted N_{60} values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

Measured - Depth to water directly measured in the field

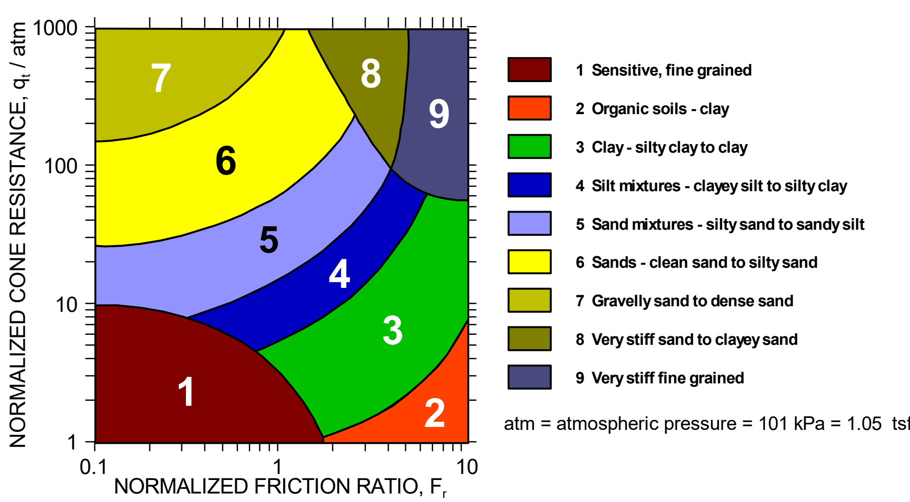
Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance (q_t), friction resistance (f_s), and porewater pressure (u_2). The normalized friction ratio (F_r) is used to classify the soil behavior type.

Typically, silts and clays have high F_r values and generate large excess penetration porewater pressures; sands have lower F_r's and do not generate excess penetration porewater pressures. The adjacent graph (Robertson *et al.*) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.



atm = atmospheric pressure = 101 kPa = 1.05 tsf

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UNIFIED SOIL CLASSIFICATION SYSTEM

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: 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 [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 ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A” line [J]		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 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.