PERRYMAN
ENGINEERING
1088 Barfield Street • Charleston, South Carolina 29492 • 843-693-2227

April 28, 2014

Mr. Mitchell E. Farley
100 South Main Street, Suite B
Summerville, South Carolina 29483

Subject: Report of Geotechnical Exploration
1818 Rushland Grove Lane
Johns Island, South Carolina
PE Project No. 14-2580

Dear Mr. Farley:

Perryman Engineering, LLC is pleased to submit this report of geotechnical exploration for the subject project. The purpose of this exploration was to obtain information on the subsurface conditions at the site and provide recommendations for foundation support. This report presents our understanding of the project, a summary of the subsurface conditions, an evaluation of the data, and our geotechnical recommendations.

Project Description

The project site is located at 1818 Rushland Grove Lane on Johns Island, South Carolina. The 0.29 acre parcel is identified by Charleston County as TMS No. 311-00-00-298. The proposed construction is an elevated, two story, wood frame residence with elevated pool. The site appears to be located in FEMA Flood Zone VE, elevation 14, as indicated on FIRM Panel 45019C0493J. We estimate maximum foundation pier loads in the range of 20 to 30 kips per pier (1 kip = 1,000 pounds).

Exploration Procedures

Two cone penetration test soundings (S-1 & S-2) and two hand auger borings (HA-1 & HA-2) were performed at the approximate locations indicated on *Figure 1: Boring Location Plan*, attached. The cone penetration test soundings were hydraulically pushed to depths of 48 and 54 feet below the ground surface. The hand auger borings were excavated to depths of six feet below the ground surface. The sounding and boring locations were selected by our engineer based on the site plan provided.

Cone penetration test soundings were performed using a track mounted, direct push platform used to advance an instrumented cone penetrometer. The integrated, 10-ton, electronic, seismic, piezocone system was used to measure the subsurface soil strength parameters and determine the soil behavior type. Cone tip resistance, sleeve friction, and pore water pressure were recorded at depth intervals of approximately two inches. The cone penetration test soundings were performed in general accordance with ASTM D5778.

Hand auger borings were performed with a bucket type auger. Soil cuttings from the auger were visually classified in the field by the geotechnical engineer. The soil consistency at selected depths was measured with a static cone penetrometer. The penetrometer conical point was first seated two inches to penetrate loose cuttings and then pushed two additional two inch increments. The penetration resistance was recorded in tons per square foot. Groundwater measurements were recorded more than 24 hours after excavation.

Soil classification testing was performed to confirm the field classifications. The tests performed were natural moisture content and percent finer than No. 200 sieve. The test procedures were in general accordance with ASTM procedures.

Surface and Subsurface Conditions

The lot is located on a low lying island surrounded by marshes of the Stono River. The project site is clear of trees and the ground surface grass covered. The topography is level with ground elevations approximately seven feet above sea level. Standing water was noted on the ground surface due to recent precipitation; the surface soil was noted to be soft and unstable in these areas. Site conditions and test locations are indicated in the accompanying photograph.

The subsurface conditions encountered are indicated on the sounding and boring records attached to this report. The lines designating the interface between strata on the records represent approximate boundaries. The water levels indicated represent conditions prior to our departure from the site. The soil behavior types indicated on the cone penetration test sounding records are based on the Simplified Soil Classification Chart for Standard Electronic Friction Cone (Robertson et al, 1986). The hand auger boring records represent our interpretation of the subsurface conditions based on visual examination of the soil samples and laboratory testing.

The subsurface conditions encountered are summarized below:

- Approximately two feet of sandy fill was noted at the ground surface.
- Soft to firm clay and silt with varying amounts of sand were noted below the fill to a depth of approximately 20 feet.
- Loose sand with silt was noted from 20 to 30 feet below the ground surface.
- Firm sandy silt of the Ashley Formation, commonly referred to as Cooper Marl, was noted below a depths of 42 to 45 feet below the ground surface. The Ashley Formation is reportedly 30 million years old.
- Measurements indicate that groundwater is two to three feet below the ground surface. Some groundwater fluctuations will occur with seasons, tides, rainfall variations, construction operations, surface runoff, and other factors.

Laboratory test results are presented below:

Table 1: Laboratory Test Results

Boring	***Depth, feet***	***Moisture Content, %***	***Passing No. 200 Sieve, %***		***Boring***	***Depth, feet***	***Moisture Content, %***	***Passing No. 200 Sieve, %***
HA-2	1.5	21	30		HA-2	4.5	25	37
HA-2	3.0	30	37		HA-2	6.0	25	26

Notes: All percentages are by weight. Percent passing No. 200 sieve indicates silt and clay content.

Recommendations for Foundation Design and Construction

Our recommendations for foundation support of the residence are provided in the following sections. Recommendations for both shallow spread foundations and driven pile foundations are provided. A brief discussion of the alternatives is presented below:

- Although typically less expensive, shallow spread foundations will be difficult to construct due to shallow groundwater conditions and the requirement for scour protection. Shallow spread foundations are also more susceptible to settlement and ground movement that may occur during an earthquake event.
- Driven timber piles mitigate the issues associated with localized scour and potential earthquake soil liquefaction. In general, the driven pile foundation would be considered a more reliable foundation system for the site and project conditions, but at an increased cost. In addition to cost, one of the drawbacks to be considered is construction vibrations affecting neighboring residences during installation.

Site Preparation: Site preparation will consist of stripping surface organic soils and roots. We estimate that stripping depths will be approximately six inches. This material should be removed from the construction area and can be re-used as topsoil in areas to be landscaped. Excavations resulting from the removal of tree root systems or other buried subsurface features that might be encountered should be properly backfilled with structural fill. During stripping and rough grading, positive surface drainage should be maintained to prevent the accumulation of water on the subgrade surface.

Soil fill that will be required to backfill the elevated pool and deck should be placed during site preparation activities, prior to foundation construction. We recommend that the pool area be temporarily surcharged with a minimum of eight feet of fill, above the finished grade elevation, to reduce long term settlement. The fill and surcharge weight will cause consolidation settlement of the underlying soils.

The primary consolidation should be complete within a few weeks after fill placement. The geotechnical engineer can develop a surcharge plan and monitor consolidation settlement as requested.

Excavation: Dry sand will not maintain vertical excavation sidewalls and will revert to a slope or angle of repose of approximately 25 degrees from horizontal. Moist sand will maintain a vertical slope for a short period, but upon drying and extended periods of exposure and/or precipitation will also revert to an angle of repose of approximately 25 degrees.

Excavations more than a few feet below the ground surface should be properly sloped and/or shored. Excavations for footings and grade beams may require shoring, dewatering, and/or formwork depending on depth.

Groundwater Control: Groundwater will be encountered in excavations made more than two feet below the existing ground surface. Groundwater encountered during construction can be maintained with sump pits, well points, or horizontal drains. Well points, pumped horizontal drains, or other active dewatering methods will be required for excavations made below the groundwater table, most notably foundation excavations. Site grading plans should allow for sloping grades and surface drainage away from the residence and paved areas.

Structural Fill Placement and Compaction: Imported soil used for structural fill supporting foundations, concrete slabs on grade, or other structural elements should be relatively clean sand having ten to twenty percent non-plastic or low plasticity fines. The fill moisture content at the time of placement and compaction should be within four percent of the optimum moisture content. Fill significantly wet of the optimum moisture content should not be placed as adequate compaction will not be achieved and shallow groundwater conditions will not permit soil drying in place. Compacted fill should be constructed by spreading acceptable soils in loose layers generally not more than 12 inches thick and compacted immediately after placement. Vibratory compaction should be used to compact the sandy structural fill. Structural fill should be compacted in thin lifts to at least 95 percent maximum dry density, as determined by the Modified Proctor method (ASTM D1557).

Shallow Spread Foundations: The proposed residence can be supported on shallow spread foundations sized for a net allowable bearing pressure of up to 1,500 pounds per square foot. Individual pier footings and wall footings should have minimum widths of 24 inches. Total settlement of foundations under the static loading conditions considered should be less than one inch, with differential settlements less than approximately half of the total settlement.

Foundation excavation side wall stability will be an issue during construction. Dewatering, shoring, forms, or other methods will need to be employed to minimize sand caving into the foundation excavations and allow concrete and reinforcing steel placement. As noted, groundwater will be encountered more than two feet below the ground surface.

Due to the potential for localized scour around the foundation elements during a storm event, foundations will need to bear significantly below the existing ground surface elevation. Due to the clay content of deeper soils, localized scour should be limited to a depth of approximately 30 inches. Shallow spread foundations will need to bear below the estimated scour depth. Groundwater will be encountered at this foundation depth which will require an active dewatering system such as sump pits, well points, or other similar measures to permit construction.

Since the pool is elevated above grade, it will impart a larger area load on the subsurface soils, subsequently affecting soft soils deeper in the profile. Our calculations indicate that an elevated pool with coping approximately eight feet above existing grade, could experience settlement in the range of two to three inches. Surcharging the pool area, as described in the *Site Preparation* section above, will reduce the expected settlement to less than one inch; or the pool can be supported on driven timber piles.

Seismic Considerations: Based on the soundings performed and seismic shear wave velocity testing performed in the area, we have identified the site as Site Class D in accordance with the International Building Code 2012 (IBC 2012). The short period, mapped spectral acceleration is S_S = 123% of gravity. The 1-second period, mapped spectral acceleration is S_1 = 40% of gravity. The maximum considered earthquake spectral response accelerations adjusted for site class effects are S_{MS} = 124% of gravity and S_{M1} = 64% of gravity. These values were determined using the software at the geohazards.usgs.gov website.

Our analysis indicates that soil liquefaction at this site is unlikely due the generally high clay content of surface soils and soil age. In general, loose sands located below the water table are subject to liquefaction in the event of a significant earthquake. Soil liquefaction can be defined as a sudden reduction in soil shear strength of sufficiently saturated cohesionless soils caused by external loading (i.e. earthquake), which induces excess inter-granular pore water pressure. The loss in soil shear strength can cause shallow foundation bearing failure, sand boils, settlement, and lateral spread or lateral structure movements.

Employing the soil sample data obtained in our exploration of the subject site along with shear wave velocity data collected, our analyses indicate that liquefaction at this site is unlikely. However, calculations indicate that post earthquake settlements on the order of two to four inches could result in the event of a significant earthquake. The soils most susceptible to liquefaction are generally at depths of 15 to 30 feet below the ground surface. Differential settlements and lateral movements caused by soil liquefaction may be evident after a significant earthquake. Isolated shallow spread foundations should not be used. Pier foundations should be tied together with continuous foundations and/or grade beams.

Driven Timber Piles: Considering the potential for soil liquefaction settlement after an earthquake and the difficulties that may be encountered during site clearing and grading, driven timber piles may be a cost effective alternative to shallow spread foundations. Driven timber piles would develop their resistance primarily through skin friction in the Cooper Marl formation at depths greater than 46 feet below the existing ground surface. An allowable pile capacity of approximately 30 kips would be available for an eight inch tip diameter timber pile driven to a depth of approximately 52 feet below the existing ground surface. Detailed pile recommendations including lateral loading and settlement estimates can be provided upon request.

Construction Observations and Testing: Additional observations and testing can be performed as requested during construction. These services are described below:

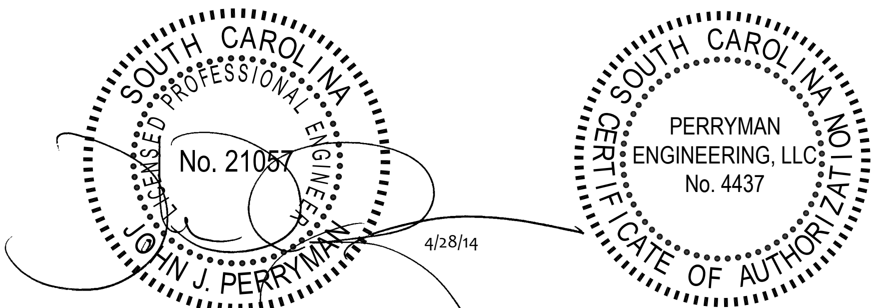
- If required by the proposed grade changes, the geotechnical engineer should perform field density testing on imported structural fill supporting foundations, concrete slabs, or other structural elements.
- Observe shallow spread foundation excavations prior to concrete placement to confirm the allowable bearing capacity.
- Observe deep foundation installation to confirm conformance with the design requirements and geotechnical recommendations.

Basis of Recommendations

The recommendations provided herein are based on the results of the soundings and borings performed and on project information provided to us. Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between test locations will differ from those encountered. This geotechnical exploration was performed using that degree of skill and care ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality at the time of performance. No other warranty, express or implied, is made or intended and the same are specifically disclaimed.

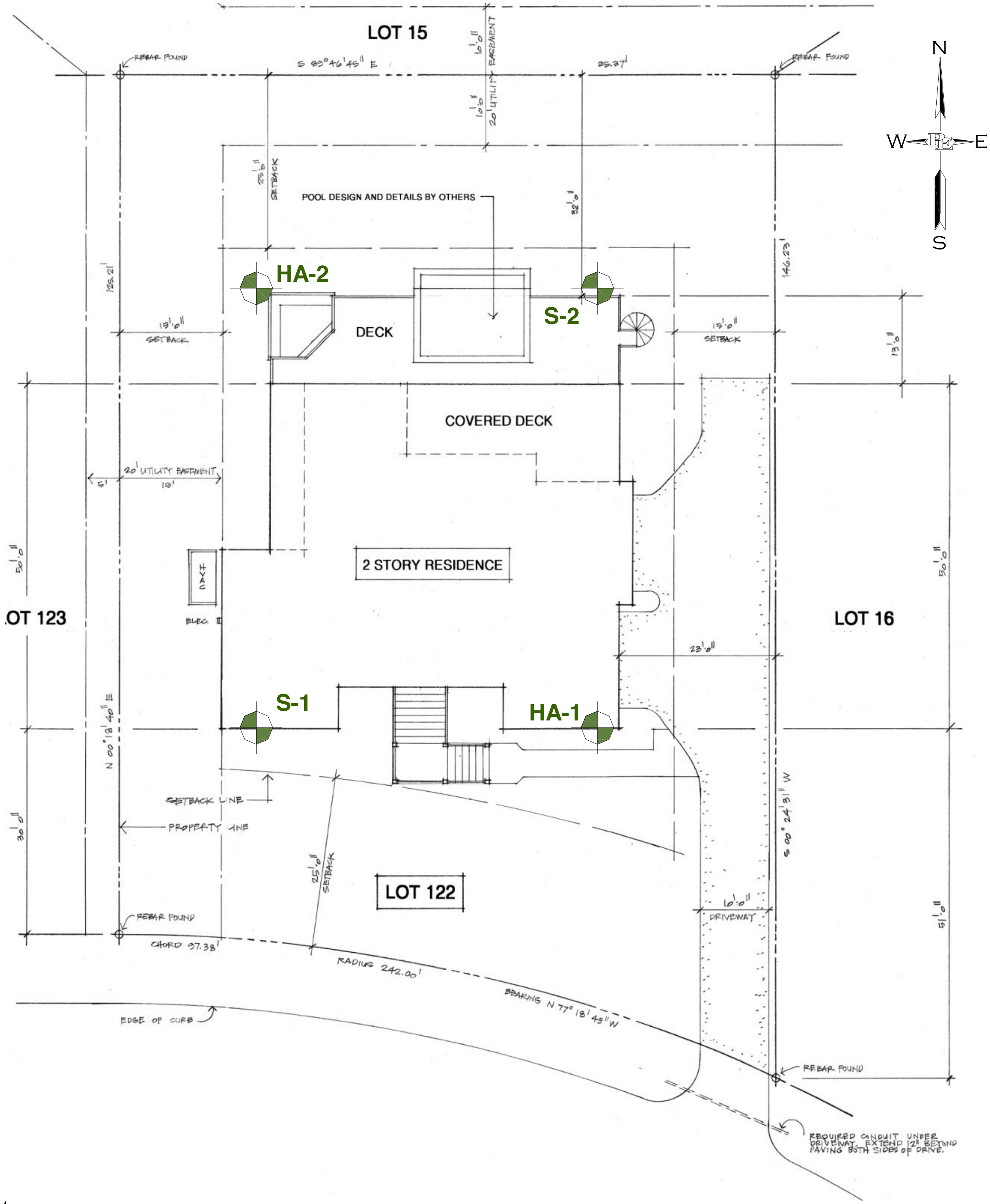
We appreciate the opportunity to provide geotechnical services to you on this project. If you have any questions about this report or if we may be of further service, please contact us at (843) 693-2227.

Sincerely,
PERRYMAN ENGINEERING, LLC



John J. Perryman, PE
Principal Engineer

Attachment: *Figure 1: Boring Location Plan*
Cone Penetration Test Sounding Records S-1 & S-2
Hand Auger Boring Records HA-1 & HA-2



Legend

Boring/Sounding Location

Source: Digital Copy of Client Provided Site Plan, No Scale

1818 Rushland Grove Lane, Johns Island, South Carolina

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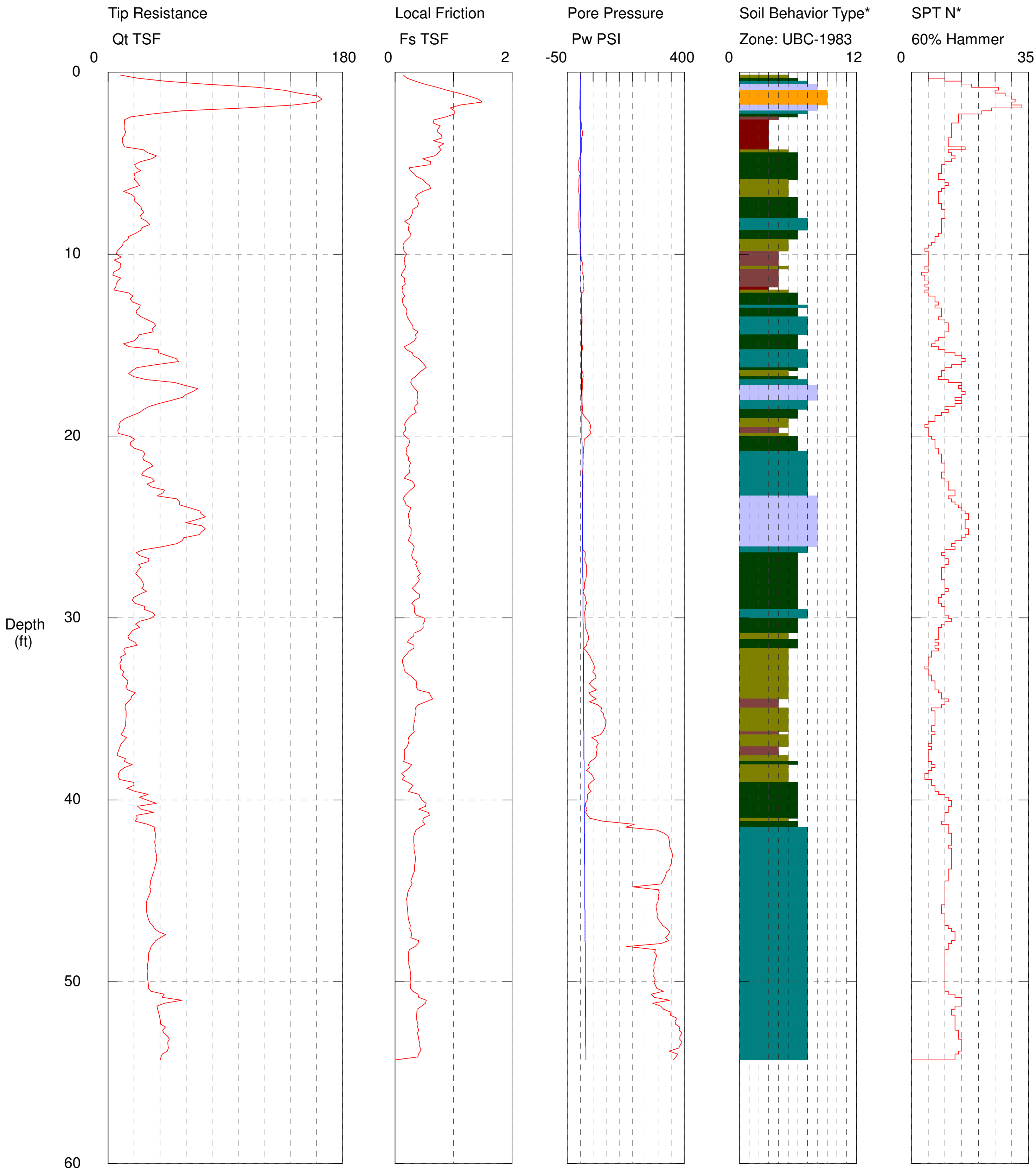
Figure 1
Boring Location Plan

Prepared By : JJP | Date: 4/28/14 | PE Project No. 14-2580

Perryman Engineering

Operator: John J. Perryman, PE
Sounding: S-1: 1818 Rushland Grove Lane
Cone Used: DDG1291

CPT Date/Time: 4/22/2014 8:19:48 AM
Location: Johns Island, SC
Job Number: 14-2580



Maximum Depth = 54.30 feet

Depth Increment = 0.164 feet

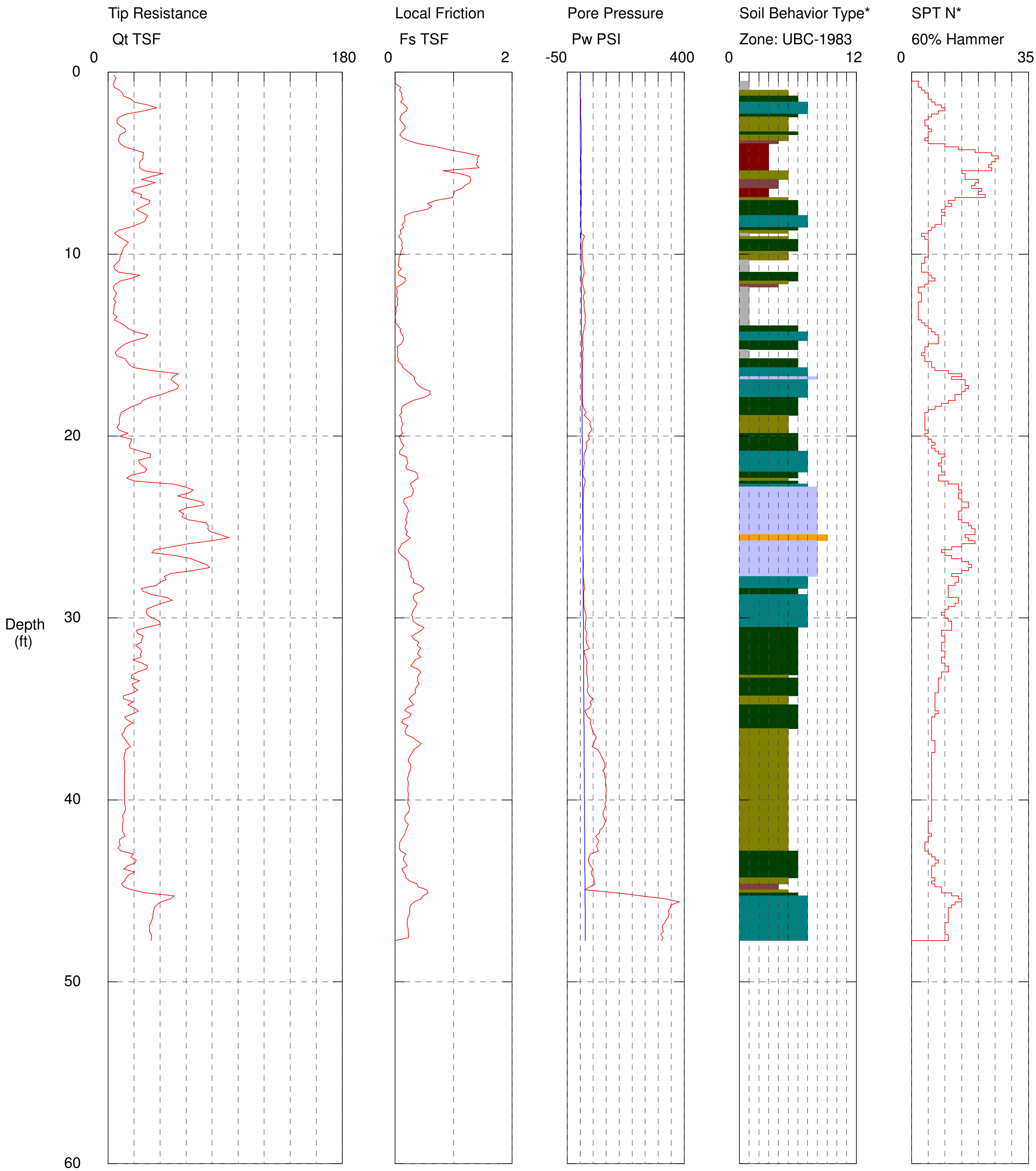
1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

Perryman Engineering

Operator: John J. Perryman, PE
Sounding: S-2: 1818 Rushland Grove Lane
Cone Used: DDG1291

CPT Date/Time: 4/22/2014 10:04:53 AM
Location: Johns Island, SC
Job Number: 14-2580



Maximum Depth = 47.74 feet

Depth Increment = 0.164 feet

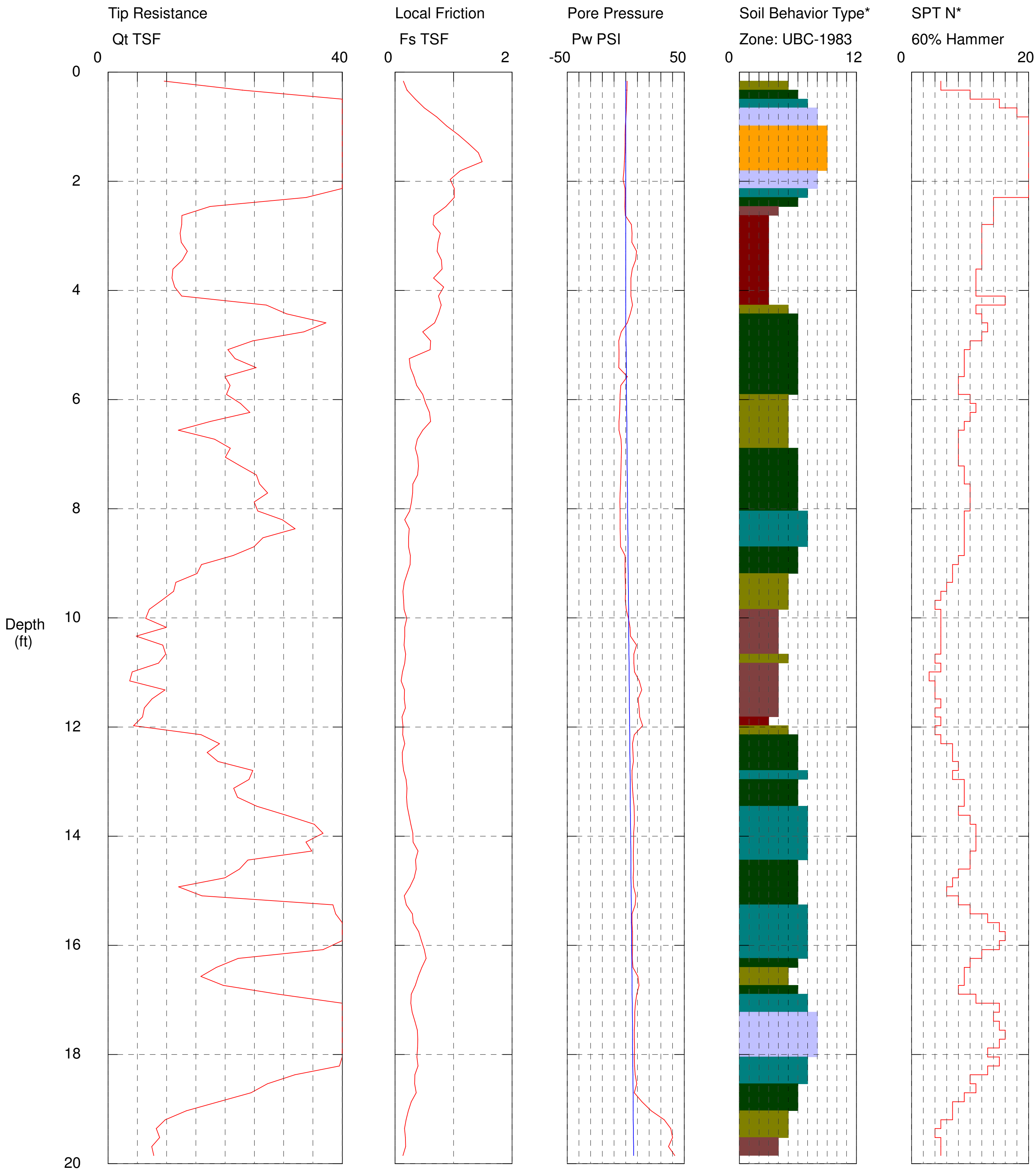
1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

Perryman Engineering

Operator: John J. Perryman, PE
Sounding: S-1: 1818 Rushland Grove Lane
Cone Used: DDG1291

CPT Date/Time: 4/22/2014 8:19:48 AM
Location: Johns Island, SC
Job Number: 14-2580



Maximum Depth = 54.30 feet

Depth Increment = 0.164 feet

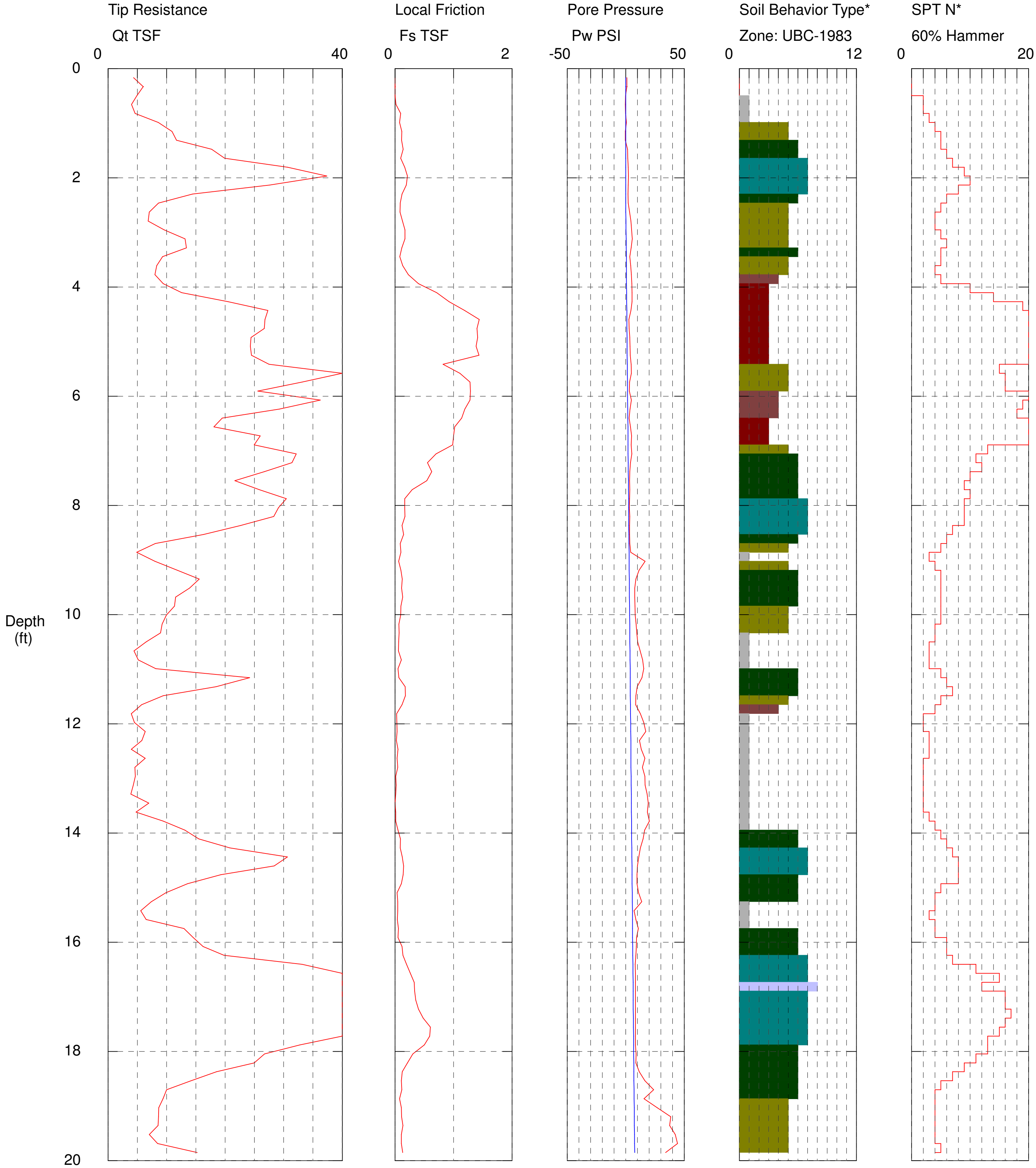
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

Perryman Engineering

Operator: John J. Perryman, PE
Sounding: S-2: 1818 Rushland Grove Lane
Cone Used: DDG1291

CPT Date/Time: 4/22/2014 10:04:53 AM
Location: Johns Island, SC
Job Number: 14-2580



Maximum Depth = 47.74 feet

Depth Increment = 0.164 feet

1	sensitive fine grained
2	organic material
3	clay
4	silty clay to clay
5	clayey silt to silty clay
6	sandy silt to clayey silt
7	silty sand to sandy silt
8	sand to silty sand
9	sand
10	gravelly sand to sand
11	very stiff fine grained (*)
12	sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

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Hand Auger Boring Records

Project	1818 Rushland Grove Lane
Location	Charleston, South Carolina
Performed By	J. Perryman 4/22/14
Project No.	14-2580

HA-1: Front Right Residence Corner

Strata Depth (feet)		Soil Description	Test Depth[1] (feet)	Static Cone Penetration Resistance[2] (tsf)		
0.0	2.1	Moist, brown fine SAND with silt (SP-SM) - FILL	1.5	18+	18+	18+
2.1	2.3	Wet, brown grey orange clayey SAND (SC) - FILL	2.2	18+	18+	18+
2.3	3.0	Moist to wet, dark brown to brown silty SAND with roots (SM)	3.0	11.0	10.6	10.1
3.0	6.0	Wet, grey with brown sandy CLAY (CL) to clayey SAND (SC). Softer soils appear to be associated with previous tree root system.	4.5	5.9	6.0	7.5
			5.0	4.4	4.2	6.9
Groundwater measured at 2.7 feet below the ground surface.			6.0	18+		

HA-2: Back Left Residence Corner

Strata Depth (feet)		Soil Description	Test Depth[1] (feet)	Static Cone Penetration Resistance[2] (tsf)		
0.0	0.9	Wet, brown silty SAND (SM) - FILL	1.5	18+	18+	18+
0.9	2.5	Wet, dark brown to brown silty SAND with roots and brick fragments (SM) - FILL	2.2	18+	18+	18+
2.5	6.0	Wet, grey orange brown sandy CLAY (CL) to clayey SAND (SC)	3.0	18+	17.1	13.2
			4.0	7.3	8.2	11.2
			5.0	9.7	12.2	18+
Groundwater measured at 2.5 feet below the ground surface.			6.0	13.8	18+	18+

Notes:
1. *The strata and test depth were referenced from the ground surface.*
2. *The penetration resistance is expressed in tons per square foot and is limited to a maximum reading of 18 tons per square foot.*
3. *Equipment: 3.25" Hand Auger and one square inch, static cone penetrometer.*
4. *Soil description in accordance with USCS, Unified Soil Classification System.*