

# S-39-26 (Pace Bridge Road) Bridge Replacement over Tributary to South Saluda River

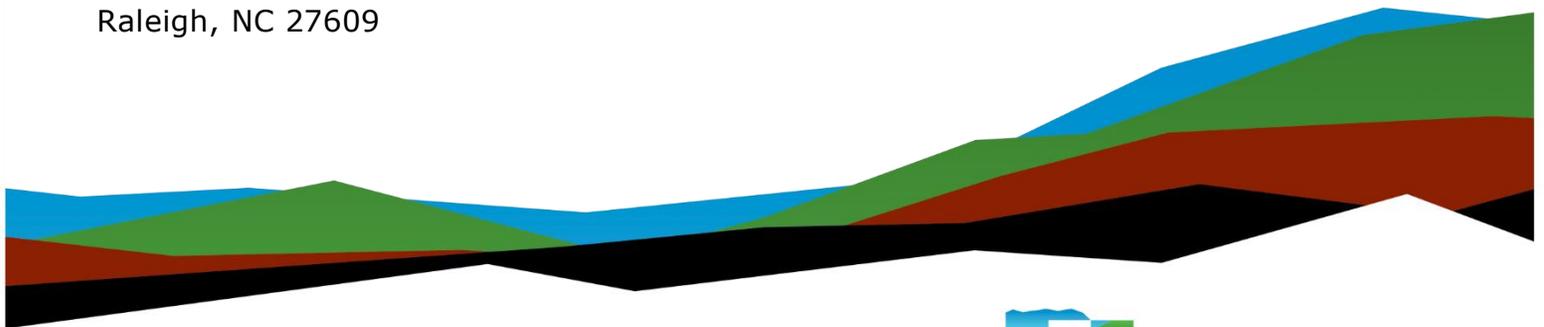
Pickens County, SC

## Geotechnical Baseline Report

October 30, 2024 | SCDOT Project ID: P043138  
Terracon Project No.: 8623P180 Revision 1

### Prepared for:

HNTB Corporation  
343 E. Six Forks Road, Suite 200  
Raleigh, NC 27609



Nationwide  
[Terracon.com](https://www.terracon.com)

- Facilities
- Environmental
- Geotechnical
- Materials



72 Pointe Circle  
Greenville, SC 29615  
P (864) 292-2901  
[Terracon.com](https://www.terracon.com)

October 30, 2024

HNTB Corporation  
343 E. Forks Road, Suite 200  
Raleigh, NC 27609

Attn: Mr. Spencer Franklin, PE, Senior Vice President  
P: 919-546-8997

Re: Geotechnical Baseline Report  
S-39-26 Bridge Replacement over Tributary to South Saluda River  
Pickens County, South Carolina  
SCDOT Project ID.: P043138  
Terracon Project No.: 8623P180 Revision 1

Dear Mr. Franklin:

Terracon Consultants Inc. (Terracon) has completed the exploration, testing and limited engineering analysis services for the above referenced project. The services were conducted in general accordance with our Supplement Number 004 to Task Order Number 001, dated July 19, 2024.

## Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, laboratory testing and limited preliminary engineering recommendations for the replacement of the S-39-26 bridge over Tributary to South Saluda River in Pickens County, South Carolina. This will be a complete bridge replacement within the project existing alignment. The results of subsurface exploration and laboratory testing have been separately presented in a Geotechnical Subsurface Data Report (GSDR). For convenience, those data are also provided here in this Geotechnical Baseline Report (GBR) along with a characterization of the subsurface conditions for the project. Limited preliminary geotechnical design and construction considerations associated with the requested scope of work are included in this GBR. This GBR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM).

## Project Description

The project site is located at the S-39-26 (Pace Bridge Road) crossing over Tributary to South Saluda River in Pickens County, South Carolina. Site location and exploration plans are presented in Appendix A of this report. Based on the conceptual plans by HNTB dated 9/3/2024, the replacement bridge will be constructed on the same alignment as the current bridge. The current plan indicates the new bridge will be a 70-ft long single span bridge constructed with a prestressed concrete cored slab.

## Geotechnical Testing

The geotechnical exploration for this project was performed between August 14 and August 20, 2024. The results of our fieldwork and our associated laboratory testing are included in Appendices A and B.

### Field Exploration

Our field exploration consisted of the following:

- Two (2) Standard Penetration Test (SPT) Borings (S-39-26-1 and S-39-26-2)
- Two (2) offset borings near S-39-26-1 and S-39-26-2 for bulk sample collection

The tests were performed at the approximate locations as approved by SCDOT. A description of our testing methods and graphical logs outlining the soil conditions at each test location are presented in Appendix A. The test locations were established in the field by Terracon and surveyed by Thomas & Hutton after completion. Station and offset are based on the plans provided at the time the tests were performed.

### Laboratory Testing

The following laboratory tests were performed on the soil samples collected at the site.

- Twenty-two (22) Natural Moisture Content Tests
- Six (6) Atterberg Limits Tests
- Seven (7) Fines Content Tests
- Four (4) Grain Size Tests with Hydrometer
- One (1) Remolded, Consolidated-Undrained (CU) Triaxial Compression Test with Pore Pressure Readings
- One (1) Standard Proctor Test
- One (1) Corrosivity Suite (pH, chloride content, sulfate content, and resistivity tests)
- Four (4) Compressive Strength of Rock Cores

The general scope of the laboratory testing frequency was determined by the SCDOT. The laboratory testing assignment was performed by our engineers. The laboratory procedures and results of the laboratory tests are presented in Appendix B.

## Subsurface Conditions

### Regional Geology

The bridge site is located on route S-39-26, on the outskirts of the town of Marietta in Pickens County, South Carolina. The site lies generally within the Piedmont Physiographic Complex. More specifically, the site is located within the Sixmile Thrust sheet. According to regional geologic mapping and published geologic reports, the project area is mapped in an area with migmatitic granitoid gneiss. Migmatitic granitoid gneiss is mainly composed of quartz, feldspar, and mica. The bridge end bents and approach embankments contain existing fill above alluvial and/or residual soils, very dense residual soils classified as Intermediate Geomaterials (IGM) and bedrock.

### Soil and Rock Stratification

Both borings encountered 4 to 6 inches of asphalt followed by 4 to 6 inches of gravel at the surface of the borings. Underlying the surface layer, fill soils consisting of very loose to loose silty/clayey sand or firm sandy silt were encountered to around 8 feet below the existing ground surface. Beneath the fill soils, a layer of alluvial soils consisting of very soft to soft sandy silt/elastic silt and/or loose to medium dense silty sand/poorly graded sand with silt and gravel was encountered to around 22 to 32 feet below the existing ground surface. Under the alluvial soil, residual soils were encountered consisting of firm sandy silt or medium dense to very dense silty sand to depths of 59 to 60 feet below the existing ground level, followed by bedrock. Bedrock was present to the maximum depth explored of 69.5 and 70.5 feet at borings S-39-26-1 and S-39-26-2, respectively. Groundwater was encountered at a depth of 13.5 feet after 24 hours at both borings.

Geology	Approximate Elevation of Layer Bottom (ft, NAVD88)	USCS Soil Type	Measured Field N Value	Plasticity Index	Fines Content	REC / RQD
Asphalt / Gravel	916	--	--	--	--	--
Fill	909	SM, SC, ML	2 to 10	18	17 to 50	--
Alluvium	884 to 894	SM, SP-SM, ML, MH	0 to 25	10 to 19	13 to 76	--

Geology	Approximate Elevation of Layer Bottom (ft, NAVD88)	USCS Soil Type	Measured Field N Value	Plasticity Index	Fines Content	REC / RQD
Residuum	856 to 857	SM, SP-SM, ML	6 to 100+	--	--	--
Rock	PMDE <sup>1</sup>	--	--	--	--	93-100% / 91-100%

1. PMDE = Present to Maximum Depth Explored

## Design and Construction Considerations

### Foundations

Driven steel H-piles driven to practical refusal on rock or within IGM materials (i.e., >20 blows per inch [bpi] with appropriately sized hammer) are expected to be feasible for the proposed bridge end abutments. Per the preliminary plans, the estimated bottom of pile cap is at about Elevation 915 feet, within about 1 to 2 feet below existing grades along the alignment. The depth to rock is predicted to be about 58 feet below the estimated bottom of abutment pile cap. Reinforced pile tips will be needed to minimize potential pile damage while penetrating through IGM to the top of rock. Pile drivability using the wave equation should be performed as part of subsequent detailed geotechnical evaluations.

Piles driven to practical refusal within the IGM or to top of rock can be designed to the factored structural capacity of the pile. The table below provides the maximum factored pile structural capacity assuming an AASHTO permitted factored pile capacity of  $0.5A_sF_y$ , using 50 ksi steel piles. An efficiency factor ( $\eta$ ) of 1.0 can be used if the pile spacing divided by the pile dimension is greater than 2.5 (Per Section 16.3.3 of the GDM).

Pile Size	Area of Steel ( $A_s$ ) in <sup>2</sup>	Maximum Factored Pile Load (tons) <sup>1</sup>
HP14x73 (21.4 in <sup>2</sup> )	21.4	267
HP14x89 (26.1 in <sup>2</sup> )	26.1	326

1. Max Load =  $0.5 * A_s * F_y$

The nominal geotechnical resistance of the piles considering refusal upon competent rock is typically set at 4 times the minimum compressive strength measured in the rock at the end bents (9,200 psi) times the cross-sectional area of the pile, 400 tons and 480 tons for HP 14x73 and HP14x89 piles, respectively. Piles driven to practical refusal in IGM will have lower nominal resistance; however, as indicated above for piles driven to practical refusal, the pile design will

be governed by the maximum factored structural capacity of the pile rather than geotechnical capacity.

According to the conceptual bridge plans by HNTB dated 9/3/2024, about 3 to 4 feet of fill is expected at the end bent embankments to support the approach slab, with excavation of the existing soil profile below the new bridge to establish a bench shelf and a relatively short (10 -ft tall maximum) rip rap lined end slope. Foundations should typically be installed after the approach embankment construction to reduce potential downdrag settlement issues. However, it is noted that piles driven to practical refusal are not considered sensitive to down drag settlement. The pile design should account for drag loads from the settling alluvium at the site; however, this additional drag load is not expected to control the pile design.

We have observed variability in the top of rock and thickness of IGM, as seen in **Soil and Rock Stratification**. Therefore, we expect variability in tip elevations at each bent location. Resistance of piles driven to practical refusal in IGM or rock will be limited by their structural resistance. Therefore, likely reinforced pile tips will be required to penetrate to IGM and rock. Pile drivability using the wave equation should be performed along with estimating stresses during driving and, in general, verifying the ability of the Contractor’s selected hammer to drive the piles to the desired penetration while preventing overstressing.

### Corrosion and Deterioration

Corrosion testing was performed on a composite sample obtained from split spoons in the upper 0.5 to 15 feet. Corrosion testing included pH, resistivity, chlorides, and sulfates content as summarized in Table below. Corrosion test results are included in Appendix B.

Corrosion Test	Results Bent 1, Boring S-39-26-1 Composite Sample from 0.5 to 15 feet	Indication of Corrosivity <sup>1</sup>
pH	5.71	Less than 5.5
Resistivity	2,376 ohm-cm	Less than 2,000 ohm-cm
Chloride	110 ppm	Greater than 500 ppm
Sulfate	55 ppm	Greater than 1,000 ppm

1. AASHTO LRFD bridge design specifications, Ninth Edition 2020, Section 10.7.5.

Based on the criteria for electro-chemical properties in the GDM Section 7.18, the electro-chemical classification of the project site is non-aggressive. Interpretation of these data should be communicated with the project’s structural engineer.

### Embankment Construction

Based on the conceptual plans by HNTB, 3 to 4 feet of will be placed to support the bridge approach slabs with some cut excavation below the bridge to establish a bench and relatively

## Geotechnical Baseline Report

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
October 30, 2024 | Terracon Project No. 8623P180 R1 | SCDOT Project ID: P043138



short (less than 10 feet tall) 2H:1V rip rap lined fill slopes shown at the end abutment positions. Bulk samples were obtained from near Interior Bent 1 and 2 (composite) from the top 5 feet of existing embankment material. Per our scope, a bulk sample was tested for soil classification and was also remolded to about 95% of the Standard-effort Proctor prior to being tested for shear strength envelopes under CU Triaxial Compression with pore pressure readings. Test results are presented in Appendix B and summarized in the table below.

Sample No.	Station	Offset (ft)	Sample Depth (ft)	USCS Soil Type	Compaction		Shear Strength <sup>1</sup>	
					Optimum Moisture (%)	Max Dry Density (pcf)	Total	Effective
S-39-26-1/2 Offset	27+69 and 28+26	4 L and 6 R	0 - 5	SM	15.2	111.4	c=4.6 psi $\phi=15^\circ$	c'=1.4 psi $\phi'=33^\circ$

1. Based on a maximum deviator stress failure criterion

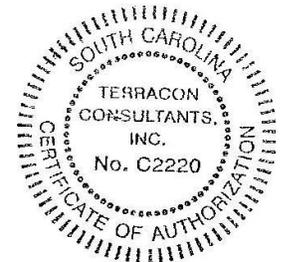
## Closure

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

Sincerely,  
**Terracon Consultants, Inc.**

Maggie McKenney, EIT  
Senior Staff Engineer

Jonathan ARd, PE  
Manager Regional Services  
SC Registration No. 30886



## **Appendix A**

### **Field Exploration**

- Exhibit A-1 – Site Location Map
- Exhibit A-2 – Exploration Plans (2 Pages)
- Exhibit A-3 – Subsurface Profile
- Exhibit A-4 – Summary of Boring Data
- Exhibit A-5 – GeoScoping Form (2 Pages)
- Exhibit A-6 – Field Exploration Description (2 Pages)
- Exhibit A-7 – Soil/Rock Description Terms (2 Pages)
- Exhibit A-8 – Soil/Rock Symbols
- Exhibit A-9 – Boring Logs (4 Pages)
- Exhibit A-10 – Rock Core Photograph Logs

Note: All exhibits are one page unless noted above

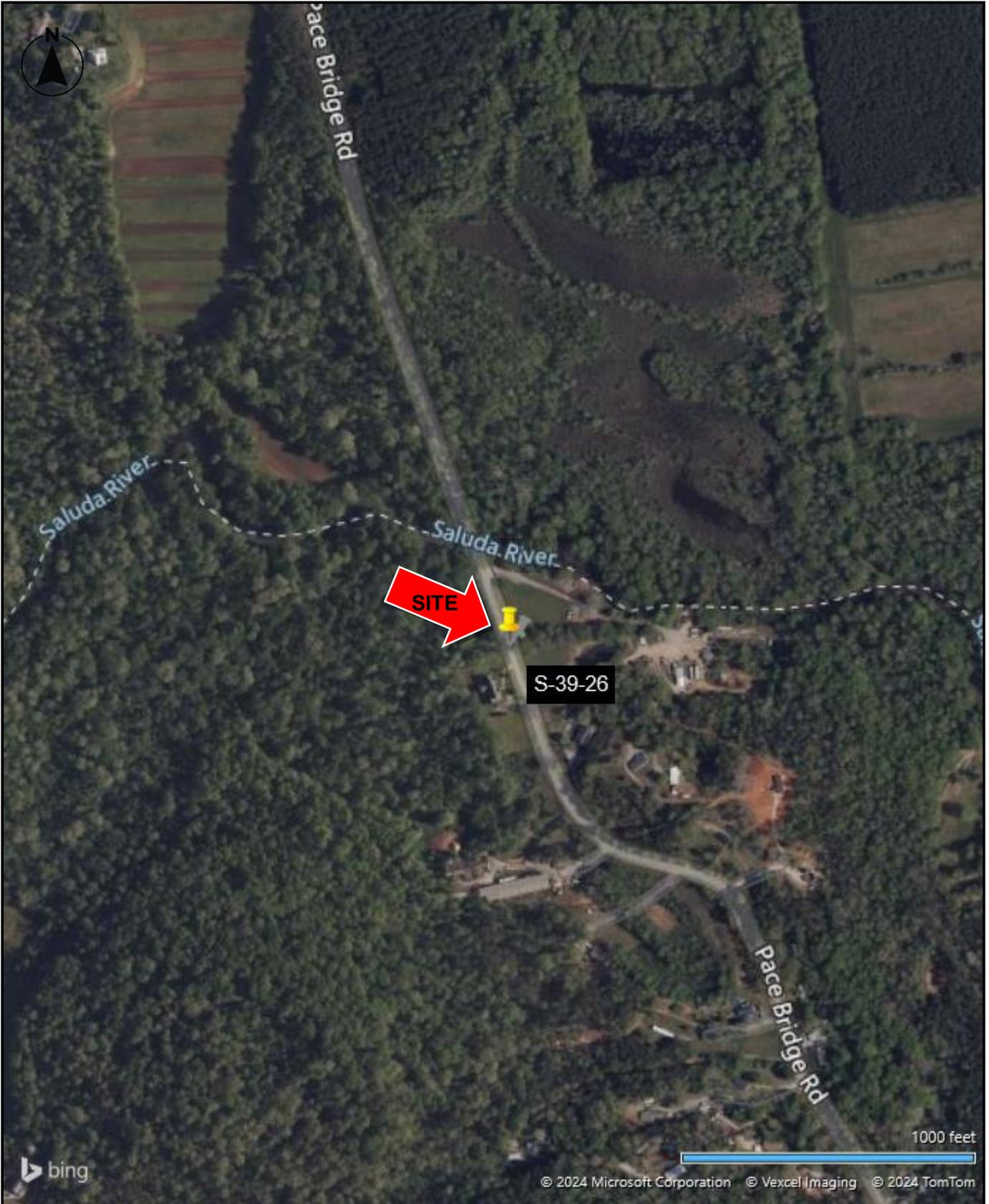


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Number	8623P180
Scale	AS SHOWN
Client	HNTB
Date	9/20/2024



72 Pointe Cir  
Greenville, South Carolina 29615

SITE LOCATION	
S-39-26 BRO Tributary to South Saluda River Pace Bridge Road Pickens County, SC	

Exhibit
A-1

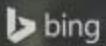


SPT Boring Location

S-39-26-2

S-39-26-1

50 feet



© 2024 Microsoft Corporation © Vexcel Imaging © 2024 TomTom

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Number	8623P180
Scale	AS SHOWN
Client	HNTB
Date	9/20/2024



72 Pointe Cir  
Greenville, South Carolina 29615

**EXPLORATION PLAN**

S-39-26 BRO Tributary to South Saluda River  
Pace Bridge Road  
Pickens County, SC

Exhibit

**A-2**



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

PRELIMINARY SITE PLAN PROVIDED BY HNTB

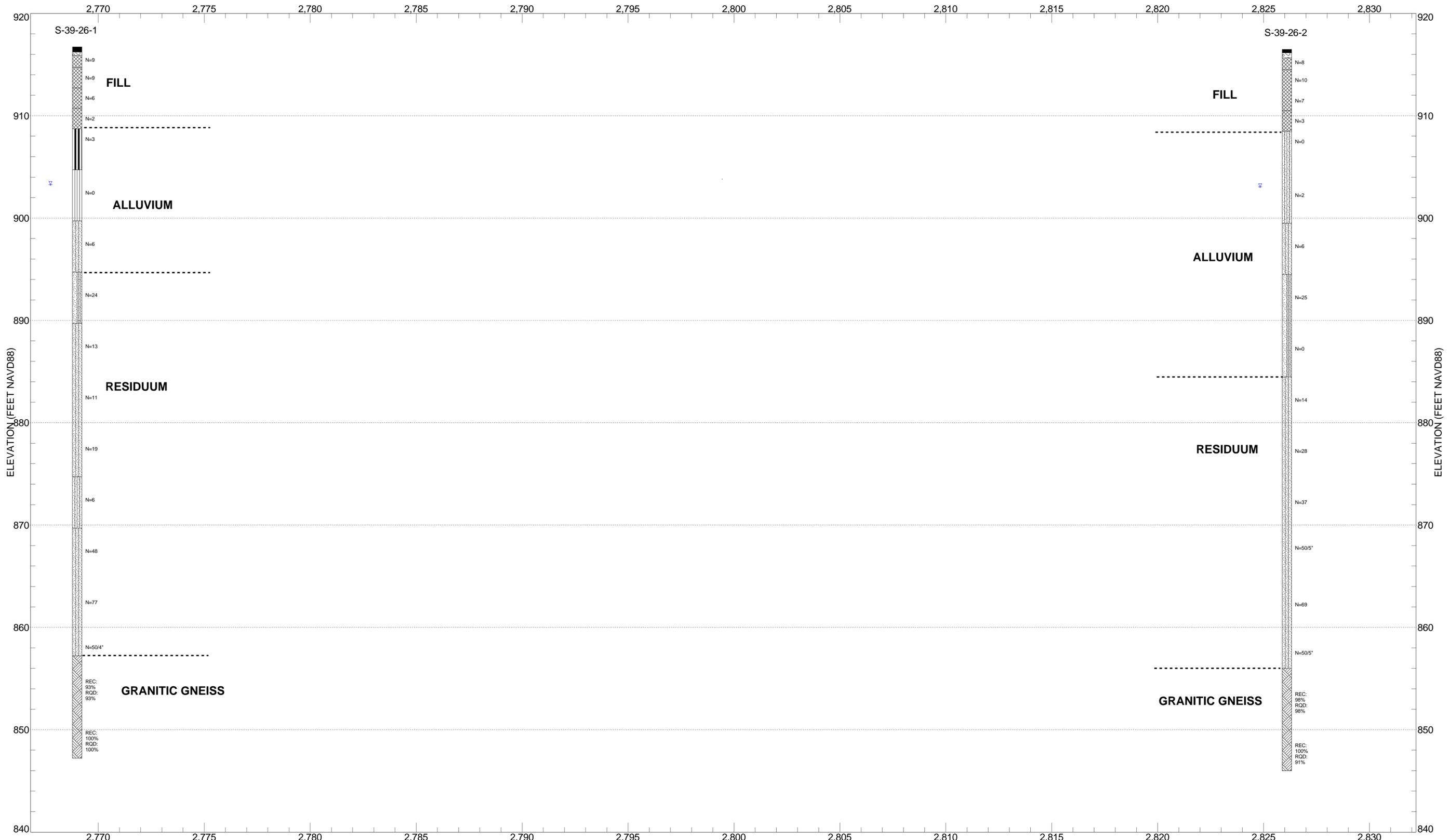
Project Number	8623P180
Scale	AS SHOWN
Client	HNTB
Date	9/20/2024

**Terracon**  
 72 Pointe Cir  
 Greenville, South Carolina 29615

**EXPLORATION PLAN**  
 S-39-26 BRO Tributary to South Saluda River  
 Pace Bridge Road  
 Pickens County, SC

Exhibit  
**A-2**

APPROXIMATE STATIONING (FEET)



DISTANCE ALONG PROFILE (FEET)

- Legend for USCS Classification Graphic Symbols
- SCDOT-ASPHALT
  - SCDOT-GP
  - SCDOT-FILL
  - SCDOT-MH
  - SCDOT-ML
  - SCDOT-SM
  - SCDOT-SP-SM
  - SCDOT-MLS
  - SCDOT-BEDROCK

NOTES:  
 See Exhibit for orientation of soil profile.  
 See General Notes in Appendix A for symbols and soil classifications.  
 Soils profile provided for illustration purposes only.  
 Soils between borings may differ.  
 For presentation purposes, some locations are offset to allow display of both borings and CPTs.  
 BT - Boring Termination (ft)

Water Level Reading at time of drilling.  
 Water Level Reading after drilling.

Project Manager: DJC	Project No.: 6623P180	<p>72 Pointe Cir Greenville, SC PH: 864-292-2901 FAX: 864-292-6361</p>	<b>SUBSURFACE PROFILE</b>		EXHIBIT A-3
Drawn by: MEM	Scale: N.T.S.		SECTION ALONG PACE BRIDGE ROAD S-39-26 BRO TRIBUTARY TO SOUTH SALUDA RIVER SCDOT PROJECT ID: P043138 PICKENS COUNTY, SC		
Approved by: JNA	File Name:				
Date: 10/30/2024					

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT, BENCH MARK, OR SITE FENCE. AT 8623P180 SCDOT BRIDGE PACK 19 S-39-26 OVER TRIBUTARY TO SOUTH SALUDA RIVER INTERNAL GP, TERRACON DATA TEMPLATE GDT, 10/30/24

### Summary of Boring Data – Exhibit A-4

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P043138



#### Summary of Boring Data

Boring No.	Ground Elevation (ft)	Test Depth (ft)	Northing (ft)	Easting (ft)	Latitude (°)	Longitude (°)	Station (ft) <sup>1</sup>	Offset (ft) <sup>1</sup>
S-39-26-1	916.72	69.5	1159885.36	1529783.68	35.011245°	-82.570163°	27+69	4 R
S-39-26-2	916.49	70.5	1159935.94	1529757.18	35.011383°	-82.570254°	28+26	5 L

1. Plans were provided by HNTB after the field exploration and survey. Station and offset values are estimated based on overlay in Google Earth™.
2. A composite bulk sample was collected about 7.5 feet west of S-39-26-1 and about 11 feet east of S-39-26-2.
3. Station and offset are based on the plans provided at the time the tests were performed.

## GeoScoping Form

PROJECT INFORMATION			
Project ID:	P043138	Date of Trip:	8/14/2024
County:	Pickens	Location:	Marietta
Rd/ Route:	S-39-26	Local Name:	Pace Bridge Road
Attendees:	M. McKenney		

EXISTING BRIDGE INFORMATION			
Bridge Length:	45 ft	Bridge Width:	28 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber and Steel H-Piles
Begin Bridge Sta <sup>1</sup> :	27+64	End Bridge Sta <sup>1</sup> :	28+34
Begin Bridge Embankment Sta <sup>1</sup> :	26+64	End Bridge Embankment Sta <sup>1</sup> :	29+34
Structure Number:	05605	Posted Weight Limit:	11 tons
Crossing:	Tributary to Saluda River	Skew:	N/A
Latitude:	35.011314°	Longitude:	-82.570205°
Existing Fill Height:	approximately 8 ft	Approx Existing Slope Angle:	2H:1V
1. Begin & End Bridge Embankment 100 ft down Sta. or up Sta., respectively. Sta. estimated from overlay of bridge plan provided by HNTB.			

EXISTING ROADWAY EMBANKMENT INFORMATION			
Begin Project Sta:	27+10	Begin Bridge Embankment Sta:	26+64
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and grass shoulder		
Existing Fill Height:	8 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to tributary		
Traffic Control Necessary:	No		
Surface Soils:	clayey sand	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	10 feet	Water Depth:	0.5 to 1 ft
Depth to Existing Ground:	approximately 11 feet at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical
End Bridge Embankment Sta:	29+34	End Project Sta:	29+60
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and grass shoulder		
Existing Fill Height:	8 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to tributary		
Traffic Control Necessary:	No		
Surface Soils:	sandy silt	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	10 feet	Water Depth:	0.5 to 1 ft
Depth to Existing Ground:	approximately 11 feet at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical

### GeoScoping Form

UTILITIES INFORMATION	
Attached:	N/A
Above Ground:	Overhead power was observed on the west side of the road
Underground:	N/A

Comments:

## Field Exploration Description

### Overview

The testing locations were proposed to and approved by SCDOT and located in the field by Terracon using measurements from existing structures shown on the provided drawings. The borings were surveyed by Thomas and Hutton, LLC after testing and drilling was complete. The locations as shown in the Exploration Plan are shown to the scale indicated.

A field log of each test location was prepared by our engineer. The final boring logs included with this report represent the engineer's description of the encountered conditions modified as necessary based on laboratory test results of the individual samples.

### Soil Test Borings (STB)

All boring and sampling operations were conducted in general accordance with the following procedures:

- SCDOT Geotechnical Design Manual 2022
- Preconstruction Design Memorandum (PCDM) 11 - Supplemental Design Criteria for Low Volume Bridge Replacement Projects
- ASTM D5783, "Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geo-environmental Exploration"
- ASTM D6151, "Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling"
- ASTM D1586 "Test Method for Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D4220 "Standard Practices for Preserving and Transporting Soil"
- ASTM D2113 "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration"
- ASTM D5079 "Standard Practices for Preserving and Transporting Rock Core Samples"

Each soil test boring was advanced using rotary wash drilling techniques. The initial sampling program is summarized in the following table:

Test ID	Total Depth	Interval of Continuous Sampling
S-39-26-1	69.5 feet with 10 feet rock coring	0 to 10 feet
S-39-26-2	70.5 feet with 10 feet rock coring	0 to 10 feet
S-39-26-1/2 Offset	5 feet	Bulk Sample

1. Bulk sample was obtained with 2 ¼-inch Hollow Stem Auger (HSA).

Soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel sampler, also known as a standard split-spoon. The sampler is advanced into the soil a total of 18 to 24 inches by striking the drill rod using a 140-pound automatic hammer falling 30 inches.

## Exhibit A-6 – Field Exploration Description

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P043138



The number of blows required to advance the sampler for each of three to four, 6-inch increments is recorded. The sum of the number of blows for the second and third increments is called the "Standard Penetration Value", or N-value ( $N_{meas}$ , blows per foot). The N-value, when properly evaluated, is an index to the soil strength.

Soil classification provides a general guide to the engineering properties of various soil types and enables the engineer to apply his experience to current situations. In our exploration, samples obtained during drilling operations are examined and visually classified by a geotechnical engineer using the procedures outlined in ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System). Laboratory testing was also performed on select split-spoon samples to evaluate index properties for further classification. The soils are described according to color, texture, and relative density or consistency (based on standard penetration resistance). The designations shown on the logs are described in the 2022 SCDOT Geotechnical Design Manual, Chapter 6.

The borings were advanced either to the planned drilling depth at which they were terminated, or to refusal of the drilling equipment. Select borings were continued below this depth using diamond bit rock coring techniques. NQ2 sized cores were recovered from the borehole. The rock recovery ratios (REC, percentage of the total core run), Rock Quality Designation (RQD, percentage of the total core run of pieces greater than 4 inches) were recorded along with a description of the rock. An explanation of the rock descriptions shown on the logs is provided in the SCDOT GDM Chapter 6. Photos of the recovered rock core specimens are provided in the Rock Core Photograph Log.

As practical, groundwater readings were collected from each of the soil test borings after 24 hours. These water levels are indicated on the boring logs. The borings were advanced using mud rotary drilling techniques. As the drilling method introduces water into the borehole, time-of-drilling water levels may not be reliable.

At the conclusion of the work, the boreholes and sounding holes were backfilled with the drill cuttings and clean sand. The upper 20 feet of those in the embankments were grouted with a cement bentonite grout and capped with cold-patch asphalt.

## SOIL DESCRIPTION TERMS

### Relative Density/Consistency Terms

<u>Relative Density</u> <sup>1</sup>			<u>Consistency</u> <sup>2</sup>		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q <sub>u</sub> ) (tsf)	SPT Blow Count
Very Loose	0 to 15%	4 and less	Very Soft	0.25 and less	2 and less
Loose	16 to 35%	5 to 10	Soft	0.26 to 0.50	3 to 4
Medium Dense	36 to 65%	11 to 30	Firm	0.51 to 1.00	5 to 8
Dense	66 to 85%	31 to 50	Stiff	1.01 to 2.00	9 to 15
Very Dense	86 to 100%	51 and more	Very Stiff	2.01 to 4.00	16 to 30
			Hard	4.01 and more	31 and more

### Moisture Condition

<u>Descriptive Term</u>	<u>Criteria</u>
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually in coarse-grained soils below the water table

### Color

Describe the sample color while sample is still moist.

### Angularity<sup>1</sup>

<u>Descriptive Term</u>	<u>Criteria</u>
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

### HCl Reaction<sup>3</sup>

<u>Descriptive Term</u>	<u>Criteria</u>
None Reactive	No visible reaction
Weakly Reactive	Some reaction, with bubbles forming slowly
Strongly Reactive	Violent reaction, with bubbles forming immediately

### Cementation<sup>3</sup>

<u>Descriptive Term</u>	<u>Criteria</u>
Weakly Cemented	Crumbles or breaks with handling or little finger pressure Moderately
Cemented	Crumbles or breaks with considerable finger pressure
Strongly Cemented	Will not crumble or break with finger pressure

### Particle-Size Range<sup>1</sup>

<u>Gravel</u>	Diameter, mm	Sieve Size	<u>Sand</u>	Diameter, mm	Sieve Size
Fine	4.76 to 19.1	#4 to ¾ inch	Fine	0.074 to 0.42	#200 to #40
Coarse	19.1 to 76.2	¾ inch to 3 inch	Medium	0.42 to 2.00	#40 to #10
			Coarse	4.00 to 4.76	#10 to #4

### Primary Soil Type<sup>1, 2</sup>

The primary soil type will be shown in all capital letters.

### USCS Soil Designation

Indicate USCS soil designation as defined in ASTM D-2487 and D-2488

### AASHTO Soil Designation

Indicate AASHTO soil designation as defined in AASHTO M-145 and ASTM D-3282

<sup>1</sup>Applies to coarse-grained soils (major portion retained on No. 200 sieve)

<sup>2</sup>Applies to fine-grained soils (major portion passing No. 200 sieve)

<sup>3</sup>Use as required

## DESCRIPTION OF ROCK PROPERTIES

### WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

### HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

### Joint, Bedding, and Foliation Spacing in Rock<sup>a</sup>

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

<sup>a</sup>Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

### Rock Quality Designation (RQD)<sup>a</sup>

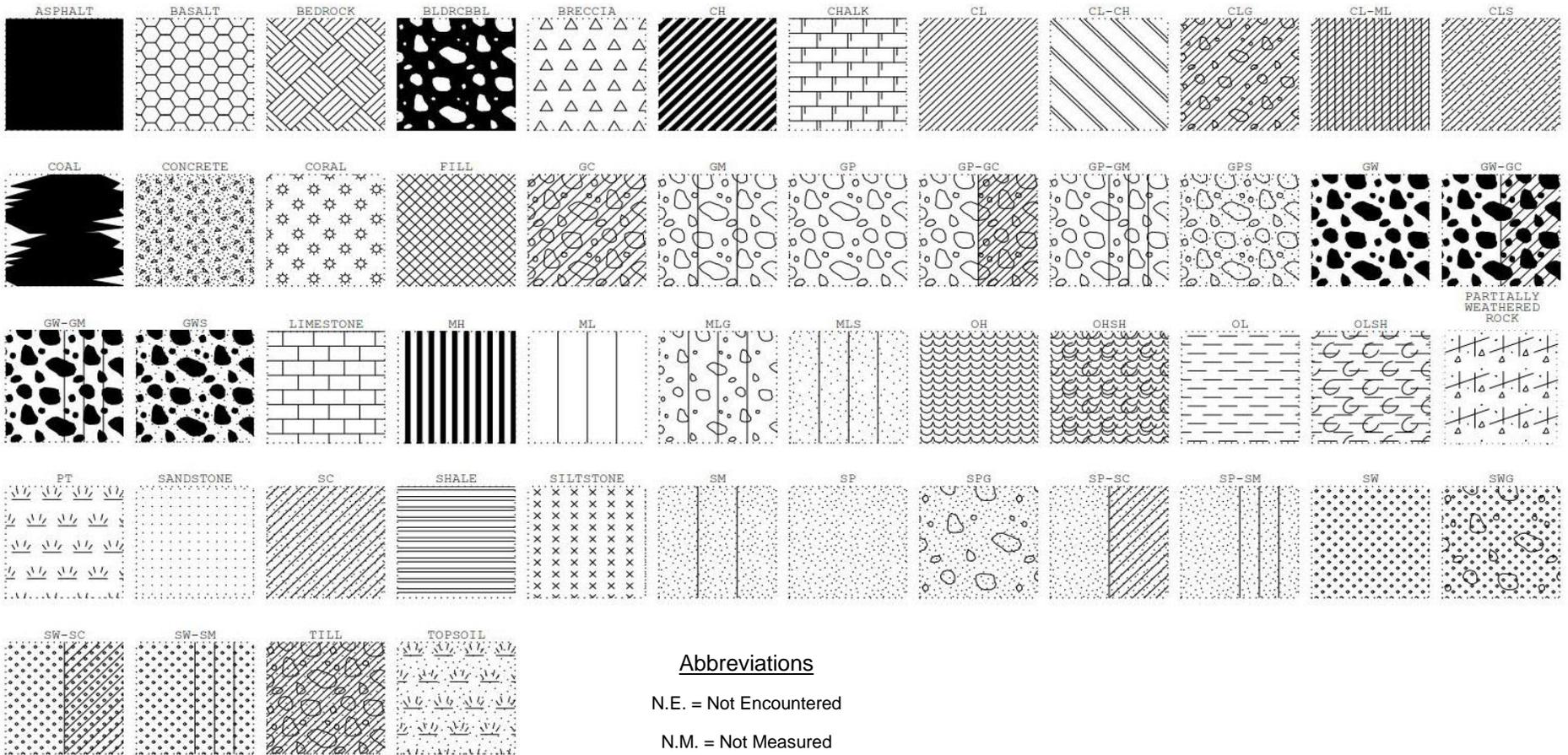
RQD, as a percentage	Diagnostic Description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

<sup>a</sup>RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

### Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly open
1/32 to 3/8 in.	Moderately open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

Project Manager:  
MEM  
Drawn by:  
K.JZ  
Checked by:  
SG  
Approved by:  
DJC

Project No.  
8623P180  
Scale:  
N.T.S.  
File Name:  
Soil - Rock - Log  
Date:  
Jul 2023

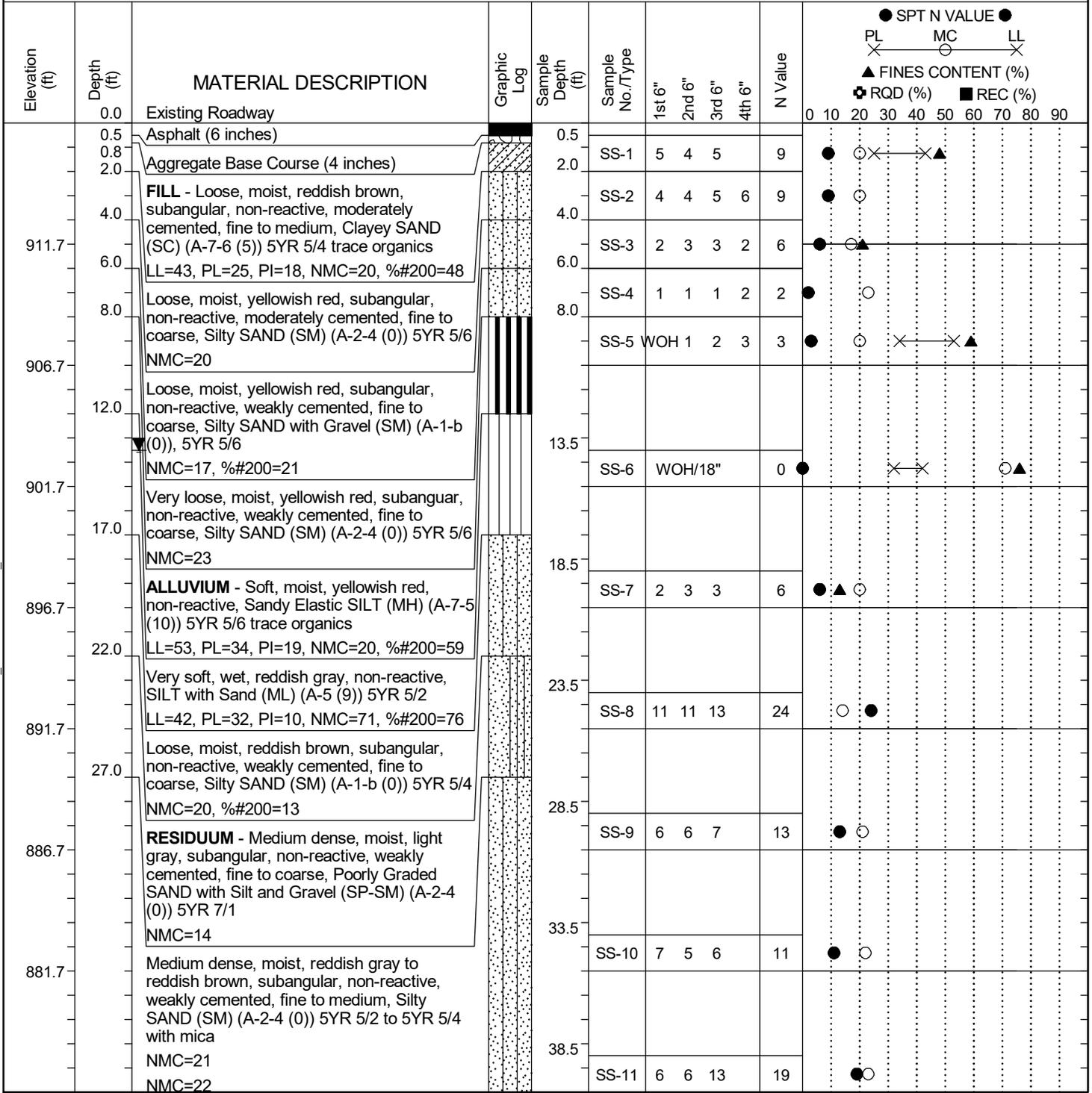


72 Pointe Circle  
Greenville, SC 29615  
PH. (864) 292-2901  
FAX. (864) 292-6361

SOIL AND ROCK SYMBOLS

# SCDOT Soil Test Log

<b>Project ID:</b> P043138	<b>County:</b> Pickens	<b>Boring No.:</b> S-39-26-1
<b>Site Description:</b> S-39-26 BRO Tributary to South Saluda River		<b>Route:</b> S-39-26
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 27+69	<b>Offset:</b> 4 R
<b>Alignment:</b> Existing	<b>Elev.:</b> 916.7 ft	<b>Latitude:</b> 35.01125
<b>Longitude:</b> -82.57016	<b>Date Started:</b> 8/14/2024	<b>Total Depth:</b> 69.5 ft
<b>Soil Depth:</b> 59.5 ft	<b>Core Depth:</b> 10 ft	<b>Date Completed:</b> 8/14/2024
<b>Bore Hole Diameter (in):</b> 4	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Liner Used:</b> Y (N)	<b>Drill Machine:</b> DR#1327	<b>Drill Method:</b> RW/RC
<b>Hammer Type:</b> Automatic	<b>Energy Ratio:</b> 92.6%	<b>Core Size:</b> NQ2
<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB N.M.	<b>24HR:</b> 13.5 ft



### LEGEND

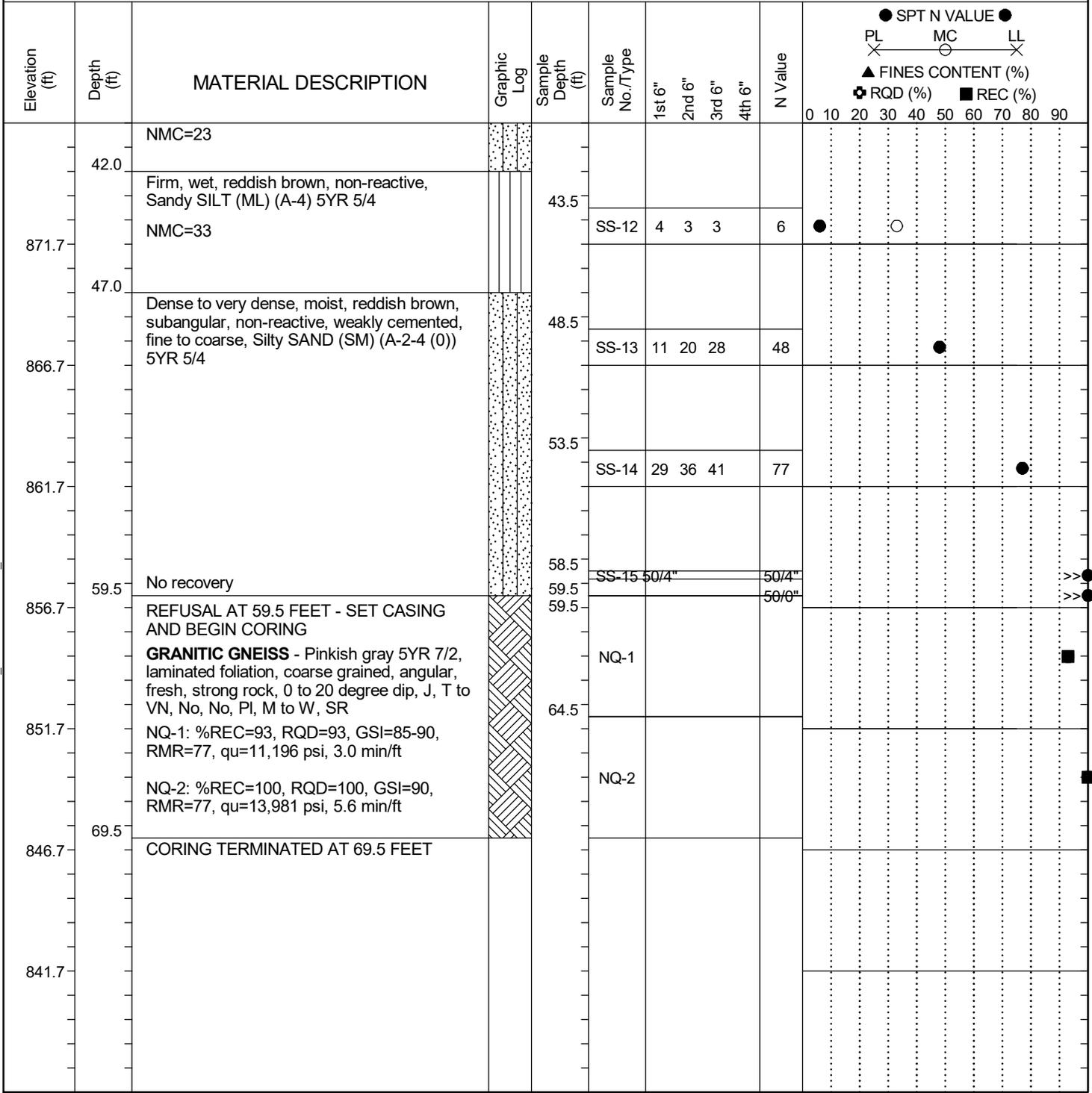
Continued Next Page

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER.DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/26/24

# SCDOT Soil Test Log

<b>Project ID:</b> P043138	<b>County:</b> Pickens	<b>Boring No.:</b> S-39-26-1
<b>Site Description:</b> S-39-26 BRO Tributary to South Saluda River		<b>Route:</b> S-39-26
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 27+69	<b>Offset:</b> 4 R
<b>Alignment:</b> Existing		
<b>Elev.:</b> 916.7 ft	<b>Latitude:</b> 35.01125	<b>Longitude:</b> -82.57016
<b>Date Started:</b> 8/14/2024		
<b>Total Depth:</b> 69.5 ft	<b>Soil Depth:</b> 59.5 ft	<b>Core Depth:</b> 10 ft
<b>Date Completed:</b> 8/14/2024		
<b>Bore Hole Diameter (in):</b> 4	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Liner Used:</b> Y (N)		
<b>Drill Machine:</b> DR#1327	<b>Drill Method:</b> RW/RC	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 92.6%		
<b>Core Size:</b> NQ2	<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB N.M.
<b>24HR:</b> 13.5 ft		



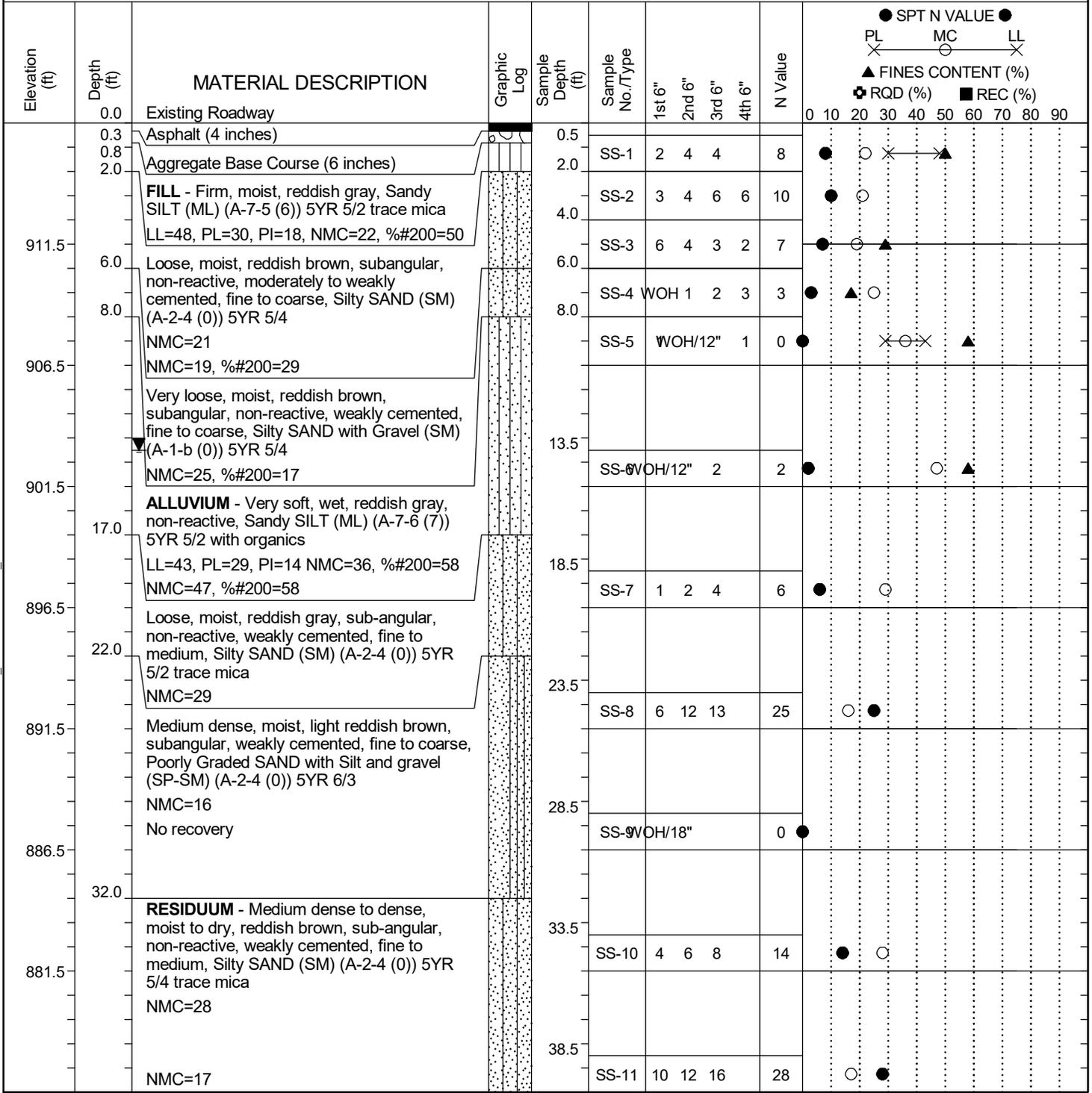
### LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATATEMPLATE.GDT 9/26/24

# SCDOT Soil Test Log

<b>Project ID:</b> P043138	<b>County:</b> Pickens	<b>Boring No.:</b> S-39-26-2
<b>Site Description:</b> S-39-26 BRO Tributary to South Saluda River	<b>Route:</b> S-39-26	
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 28+26	<b>Offset:</b> 5 L
<b>Alignment:</b> Existing		
<b>Elev.:</b> 916.5 ft	<b>Latitude:</b> 35.01138	<b>Longitude:</b> -82.57025
<b>Date Started:</b> 8/20/2024		
<b>Total Depth:</b> 70.5 ft	<b>Soil Depth:</b> 60.5 ft	<b>Core Depth:</b> 10 ft
<b>Date Completed:</b> 8/20/2024		
<b>Bore Hole Diameter (in):</b> 4	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Liner Used:</b> Y (N)		
<b>Drill Machine:</b> DR#1327	<b>Drill Method:</b> RW/RC	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 92.6%		
<b>Core Size:</b> NQ2	<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB N.M.
<b>24HR:</b> 13.5 ft		



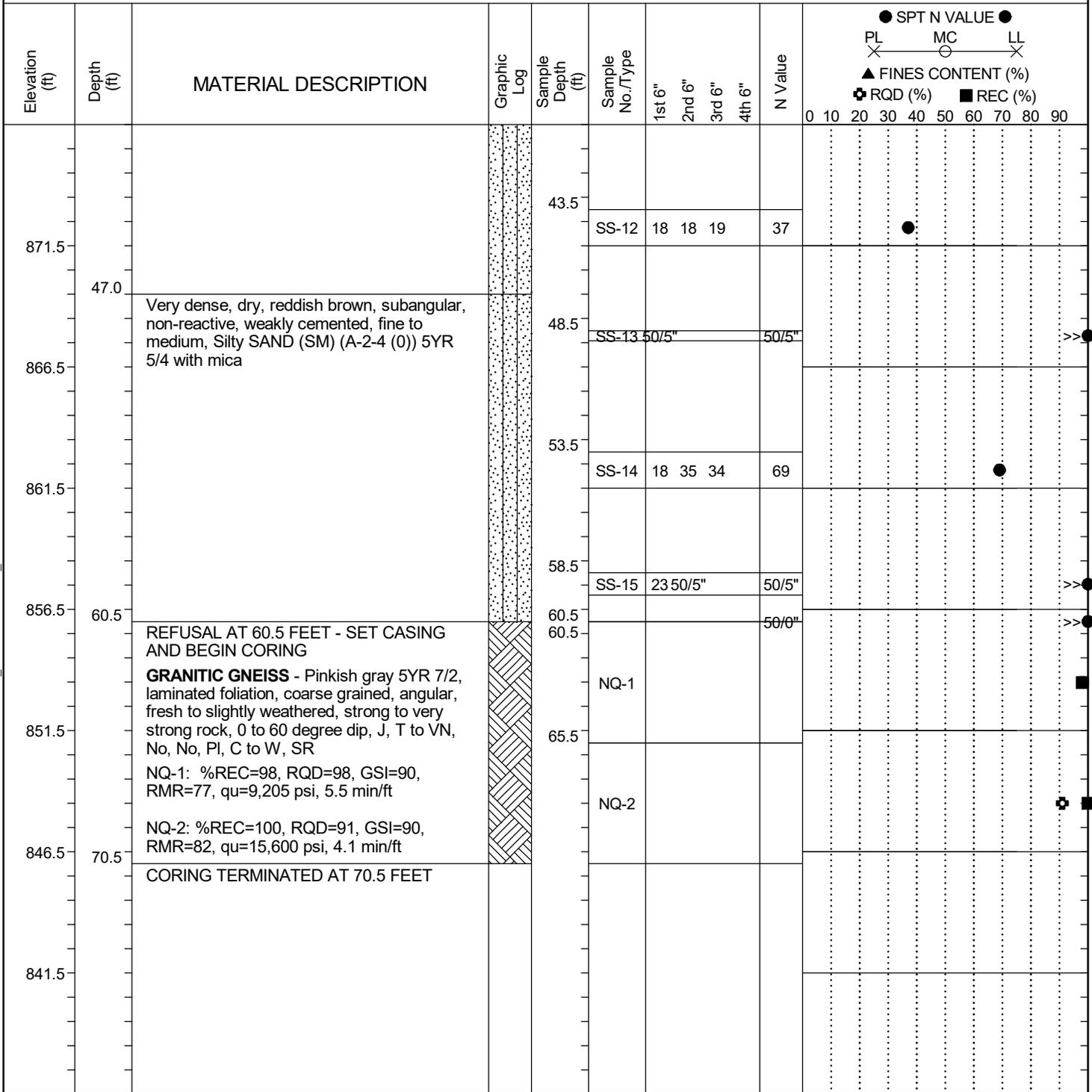
LEGEND Continued Next Page

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER.DOT\_JNA.GPJ SCDOT DATATEMPLATE.GDT 9/26/24

# SCDOT Soil Test Log

<b>Project ID:</b> P043138	<b>County:</b> Pickens	<b>Boring No.:</b> S-39-26-2
<b>Site Description:</b> S-39-26 BRO Tributary to South Saluda River		<b>Route:</b> S-39-26
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 28+26	<b>Offset:</b> 5 L
<b>Alignment:</b> Existing		
<b>Elev.:</b> 916.5 ft	<b>Latitude:</b> 35.01138	<b>Longitude:</b> -82.57025
<b>Date Started:</b> 8/20/2024		
<b>Total Depth:</b> 70.5 ft	<b>Soil Depth:</b> 60.5 ft	<b>Core Depth:</b> 10 ft
<b>Date Completed:</b> 8/20/2024		
<b>Bore Hole Diameter (in):</b> 4	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Liner Used:</b> Y (N)		
<b>Drill Machine:</b> DR#1327	<b>Drill Method:</b> RW/RC	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 92.6%		
<b>Core Size:</b> NQ2	<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB N.M.
<b>24HR:</b> 13.5 ft		



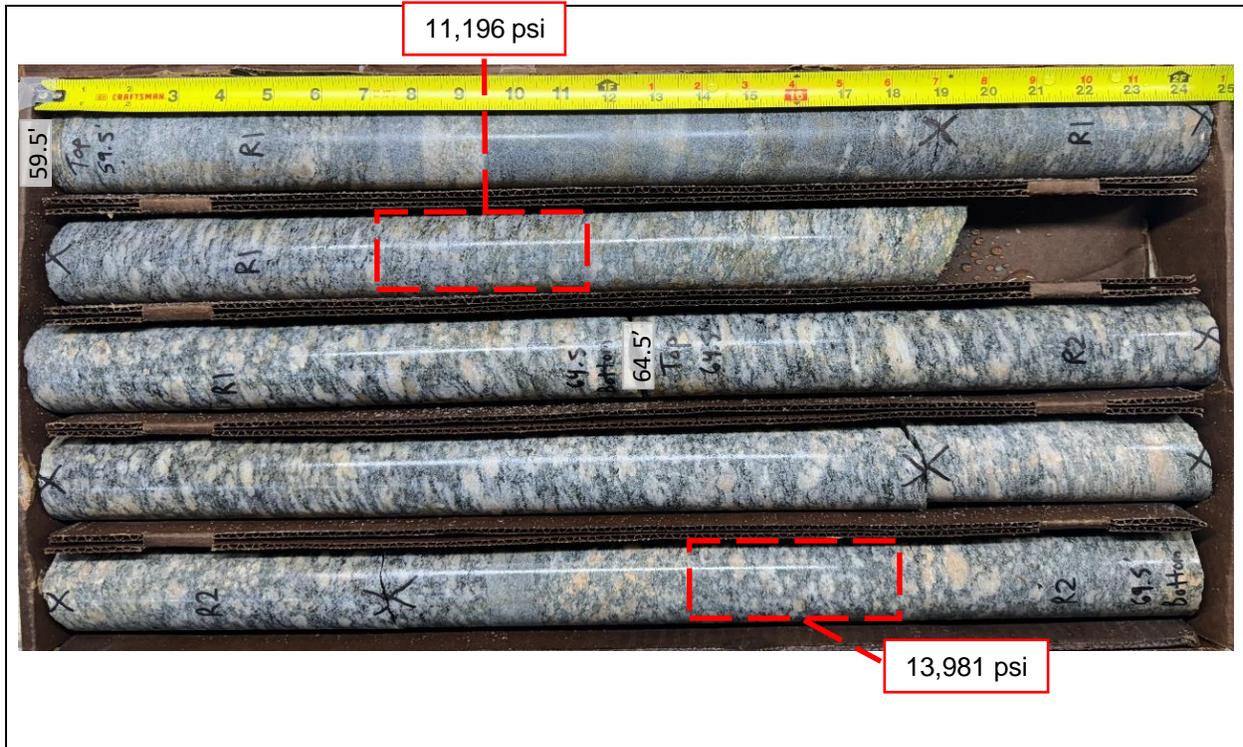
## LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

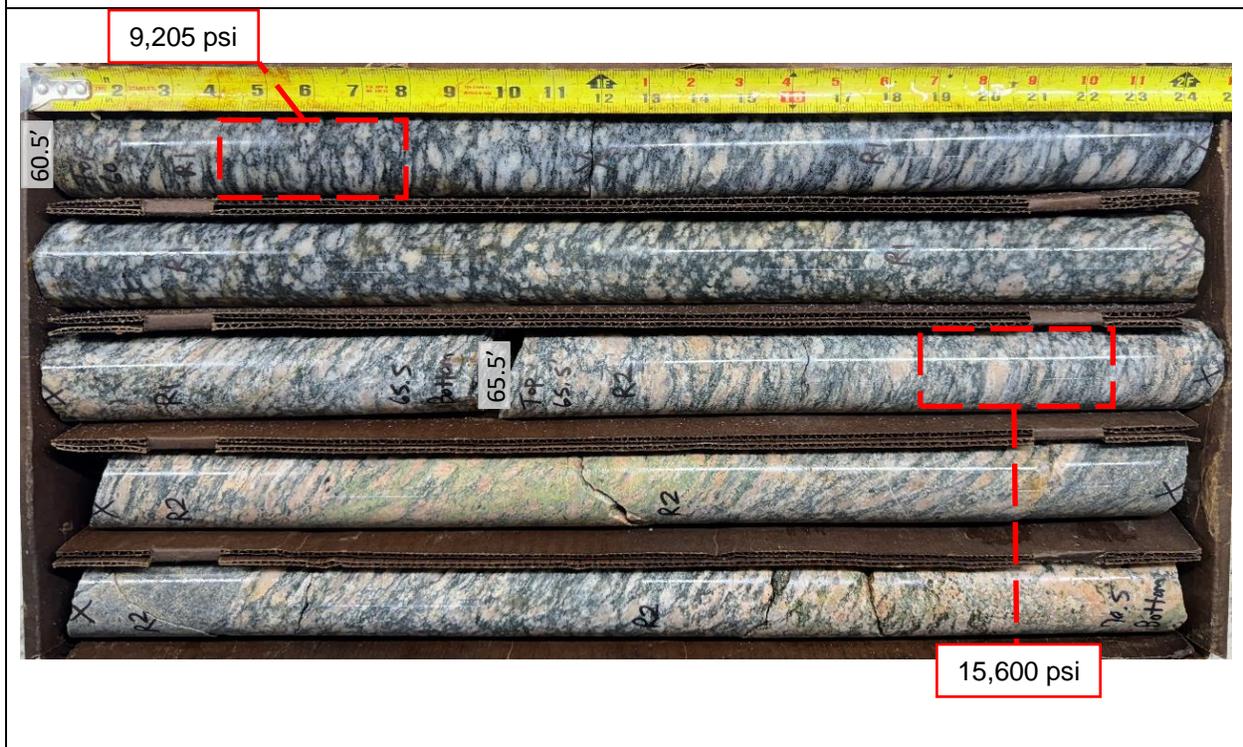
SC.DOT 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER.DOT\_JNA.GPJ SCDOT DATATEMPLATE.GDT 9/26/24

Rock Core Photograph Logs – Exhibit A-10

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P043138



S-39-26-1, NQ-1 and NQ-2 (59.5 to 69.5 feet)



S-39-26-2, NQ-1 and NQ-2 (60.5 to 70.5 feet)

**Appendix B – Laboratory Testing**

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P043138



## **Appendix B**

### **Laboratory Testing**

Exhibit B-1 – Laboratory Testing Description  
Summary of Laboratory Data (2 Pages)  
Laboratory Data Sheets (20 Pages)

Note: All exhibits are one page unless noted above.



## Summary of Laboratory Results

Boring ID	Depth (Ft.)	Soil Classification USCS & AASHTO	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Fines	% Silt	% Clay	Water Content (%)	Proctor Dry Density (pcf)/Opt. Moisture (%)
S-39-26-1	0.5-2	CLAYEY SAND(SC) / A-7-6 (5)	43	25	18	2.6	49.9	47.5			19.5	
S-39-26-1	2-4	SILTY SAND(SM) / A-2-4 (0)									20.1	
S-39-26-1	4-6	SILTY SAND with GRAVEL(SM) / A-1-b (0)				18.9	60.2	20.9			16.6	
S-39-26-1	6-8	SILTY SAND(SM) / A-2-4 (0)									23.4	
S-39-26-1	8-10	SANDY ELASTIC SILT(MH) / A-7-5 (10)	53	34	19	1.1	40.3	58.7	24.0	34.6	19.5	
S-39-26-1	13.5-15	SILT WITH SAND(ML) / A-5 (9)	42	32	10	0.0	24.3	75.7	38.4	37.3	70.6	
S-39-26-1	18.5-20	SILTY SAND(SM) / A-1-b (0)				5.0	82.5	12.5			20.1	
S-39-26-1	23.5-25	POORLY GRADED SAND with SILT and GRAVEL(SP-SM) / A-2-4 (0)									14.0	
S-39-26-1	28.5-30	SILTY SAND(SM) / A-2-4 (0)									20.9	
S-39-26-1	33.5-35	SILTY SAND(SM) / A-2-4 (0)									22.4	
S-39-26-1	38.5-40	SILTY SAND(SM) / A-2-4 (0)									22.6	
S-39-26-1	43.5-45	SANDY SILT(ML) / A-4									33.1	
S-39-26-2	0.5-2	SANDY SILT(ML) / A-7-5 (6)	48	30	18	0.0	49.6	50.4			22.3	
S-39-26-2	2-4	SILTY SAND(SM) / A-2-4 (0)									21.3	
S-39-26-2	4-6	SILTY SAND(SM) / A-2-4 (0)				8.0	62.6	29.4			19.3	
S-39-26-2	6-8	SILTY SAND with GRAVEL(SM) / A-1-b (0)				26.5	56.5	17.0	8.4	8.6	24.8	
S-39-26-2	8-10	SANDY SILT(ML) / A-7-6 (7)	43	29	14	0.0	42.4	57.6	28.7	28.9	35.5	
S-39-26-2	13.5-15	SANDY SILT(ML) / A-7-6 (7)				0.0	41.9	58.1			47.4	
S-39-26-2	18.5-20	SILTY SAND(SM) / A-2-4 (0)									28.5	





# INDEX PROPERTIES VERSUS DEPTH

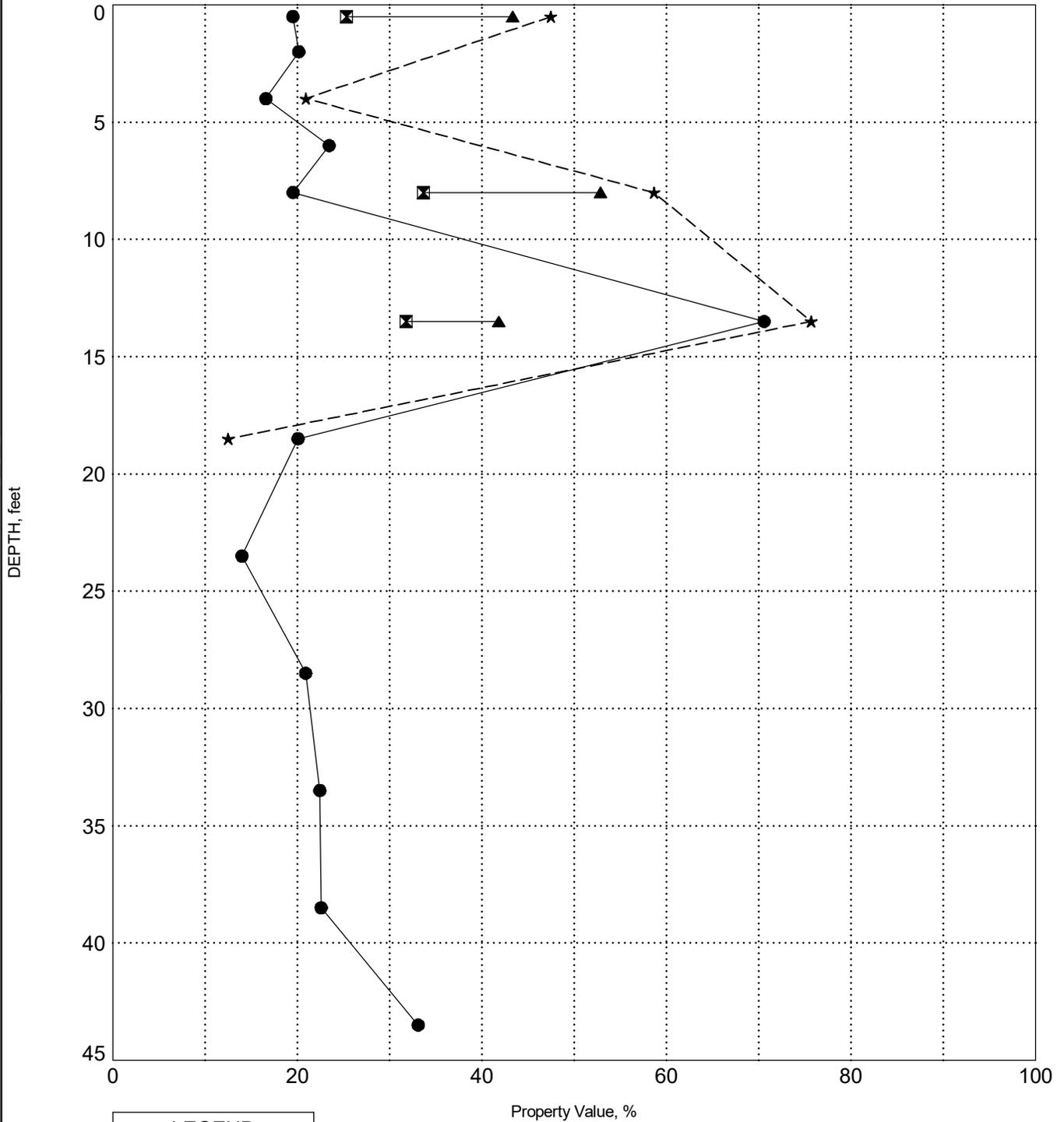
PROJECT ID P043138

PROJECT NAME S-39-26 BRO Tributary to South Saluda River

PROJECT COUNTY Pickens

## BORING S-39-26-1

SURFACE ELEVATION: 916.7



LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE 01\_30\_2015.GDT 9/26/24



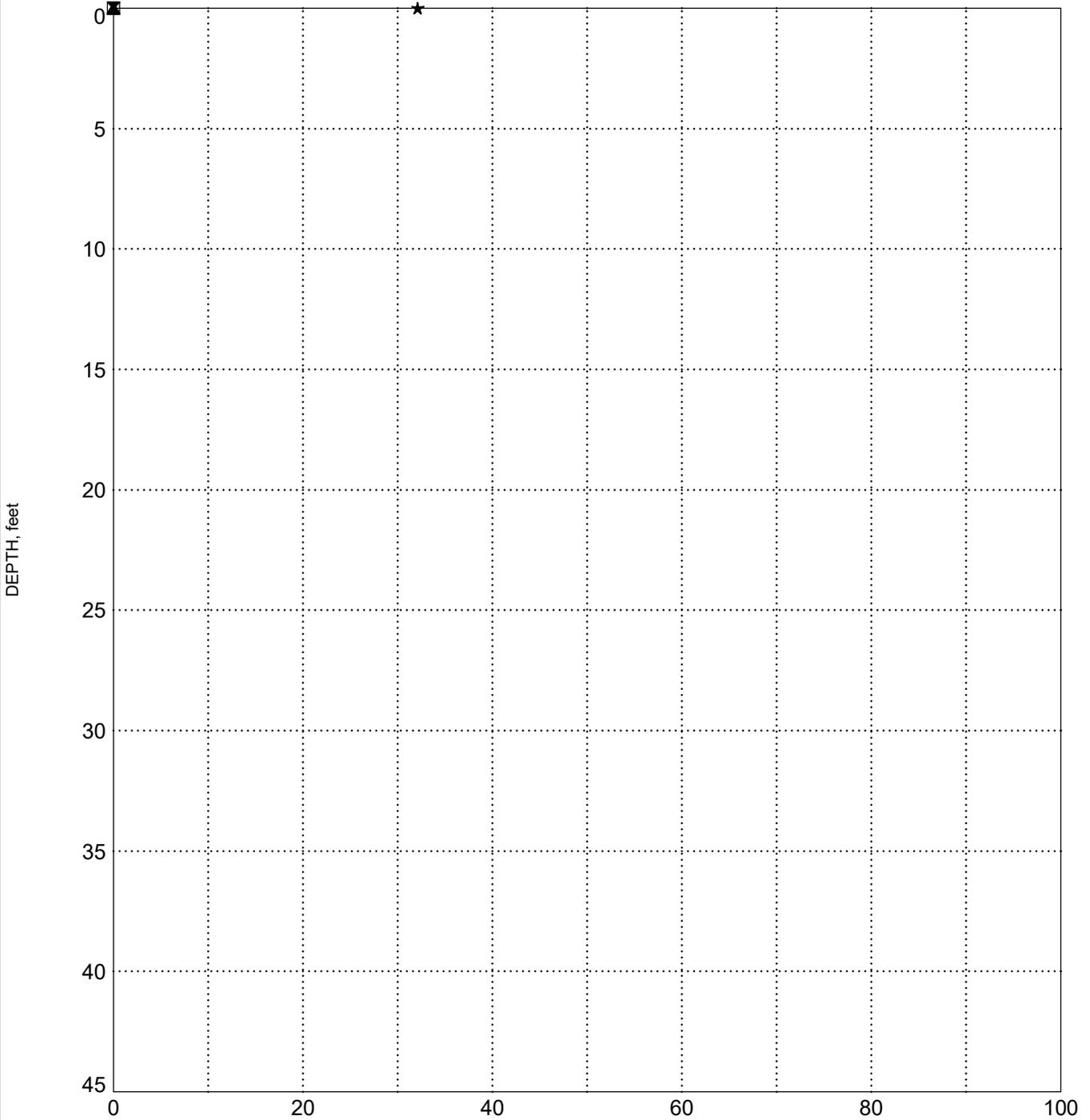
# INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P043138

PROJECT NAME S-39-26 BRO Tributary to South Saluda River

PROJECT COUNTY Pickens

## BORING S-39-26-1/2 Offset



INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE 01\_30\_2015.GDT 9/26/24

LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines



# INDEX PROPERTIES VERSUS DEPTH

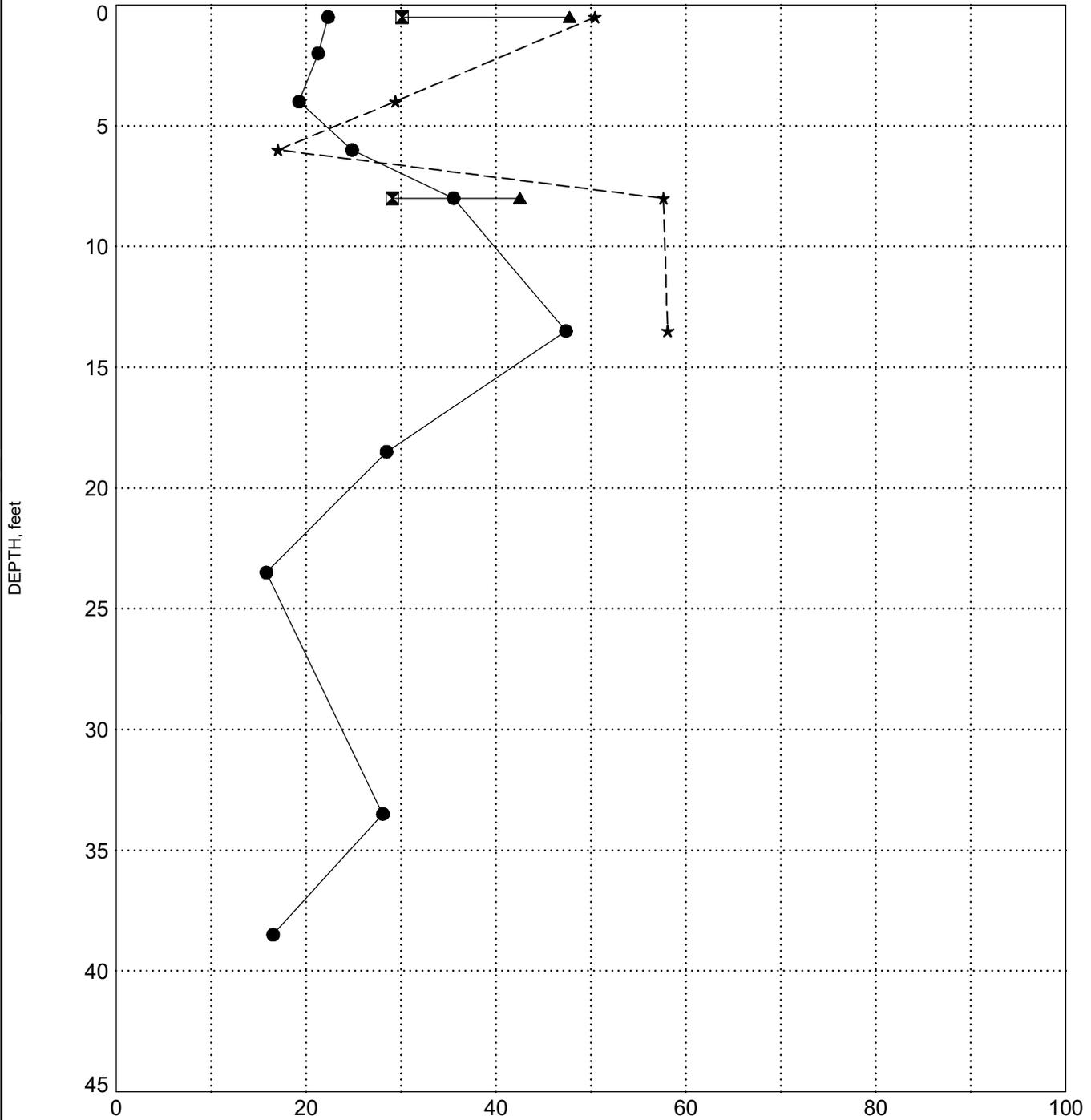
PROJECT ID P043138

PROJECT NAME S-39-26 BRO Tributary to South Saluda River

PROJECT COUNTY Pickens

SURFACE ELEVATION: 916.5

## BORING S-39-26-2



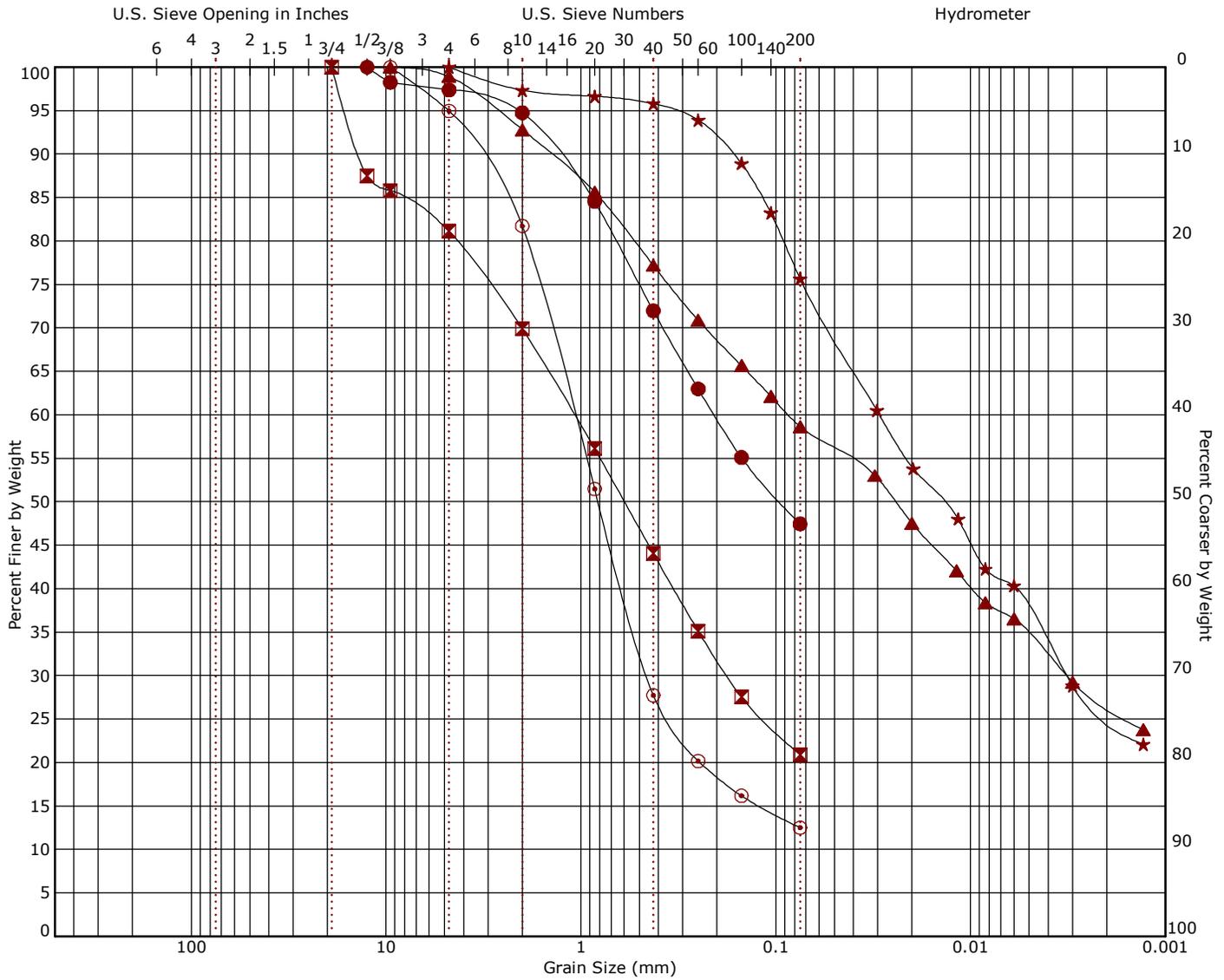
LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 OVER TRIB TO SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE 01\_30\_2015.GDT 9/26/24



## Grain Size Distribution

### ASTM D422 / ASTM C136



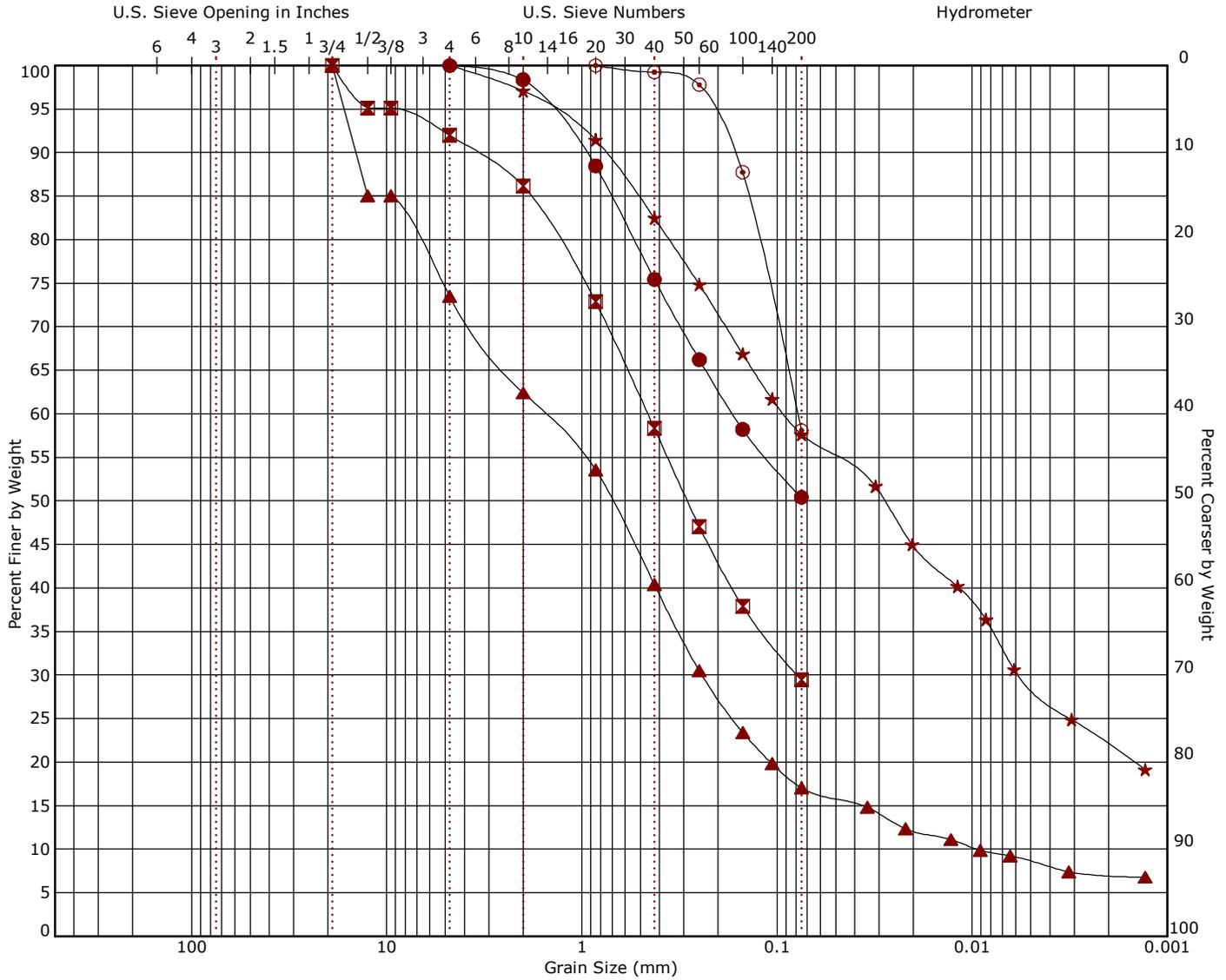
Boring ID	Depth (Ft)	USCS Classification					USCS	AASHTO	LL	PL	PI	Cc	Cu
		Cobbles	Gravel (coarse, fine)	Sand (coarse, medium, fine)	Silt or Clay								
● S-39-26-1	0.5 - 2	CLAYEY SAND					SC	A-7-6 (5)	43	25	18		
⊠ S-39-26-1	4 - 6	SILTY SAND with GRAVEL					SM	A-1-b (0)					
▲ S-39-26-1	8 - 10	SANDY ELASTIC SILT					MH	A-7-5 (10)	53	34	19		
★ S-39-26-1	13.5 - 15	SILT with SAND					ML	A-5 (9)	42	32	10		
⊙ S-39-26-1	18.5 - 20	SILTY SAND					SM	A-1-b (0)					

Boring ID	Depth (Ft)	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-39-26-1	0.5 - 2	12.5	0.206			0.0	2.6	49.9	47.5		
⊠ S-39-26-1	4 - 6	19	1.081	0.177		0.0	18.9	60.2	20.9		
▲ S-39-26-1	8 - 10	9.5	0.086	0.003		0.0	1.1	40.3		24.0	34.6
★ S-39-26-1	13.5 - 15	4.75	0.029	0.003		0.0	0.0	24.3		38.4	37.3
⊙ S-39-26-1	18.5 - 20	9.5	1.082	0.454		0.0	5.0	82.5	12.5		

## Grain Size Distribution

### ASTM D422 / ASTM C136



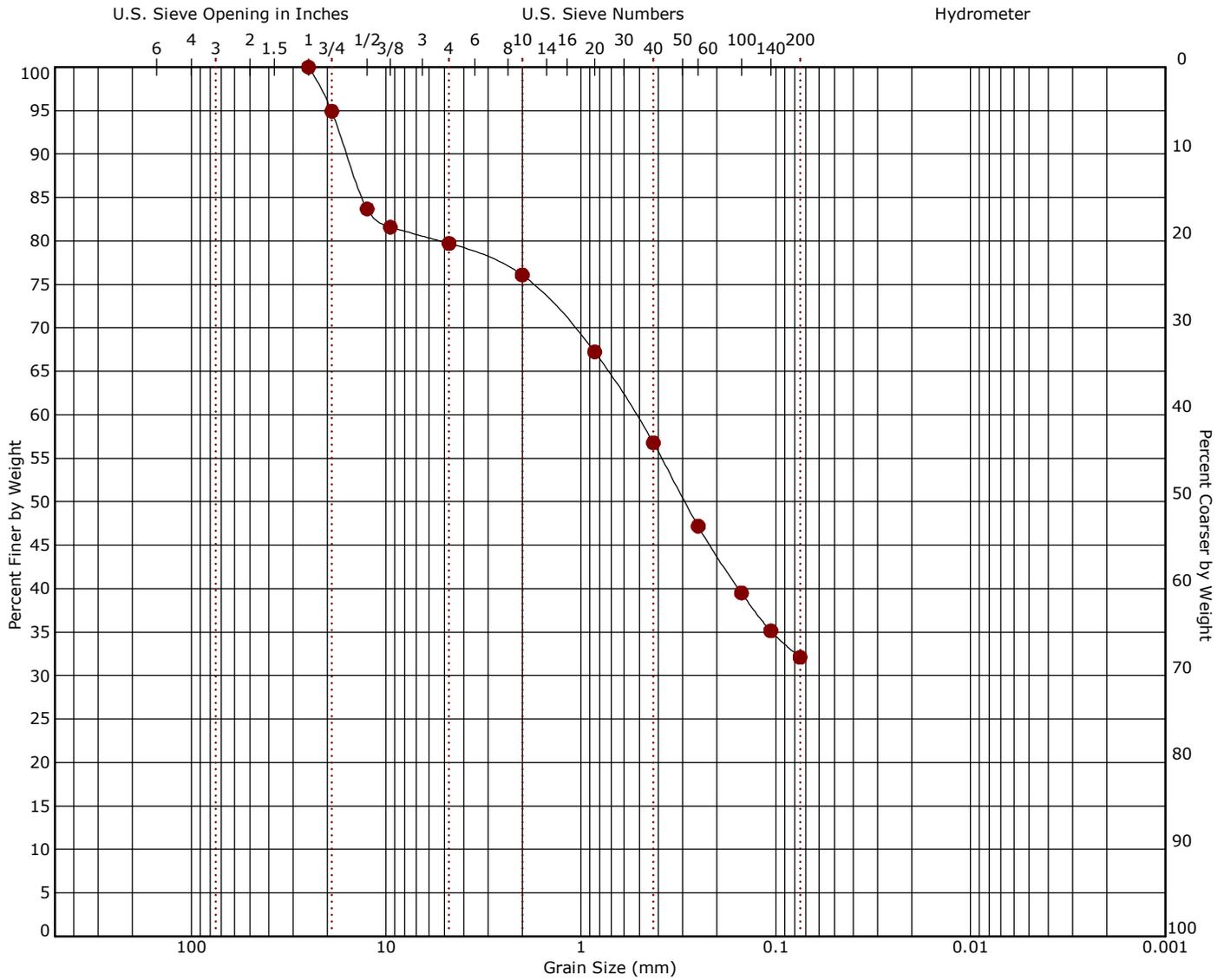
Boring ID	Depth (Ft)	USCS Classification					USCS	AASHTO	LL	PL	PI	Cc	Cu
		Cobbles	Gravel (coarse, fine)	Sand (coarse, medium, fine)	Silt or Clay								
● S-39-26-2	0.5 - 2	SANDY SILT					ML	A-7-5 (6)	48	30	18		
⊠ S-39-26-2	4 - 6	SILTY SAND					SM	A-2-4 (0)					
▲ S-39-26-2	6 - 8	SILTY SAND with GRAVEL					SM	A-1-b (0)				3.90	167.98
★ S-39-26-2	8 - 10	SANDY SILT					ML	A-7-6 (7)	43	29	14		
⊙ S-39-26-2	13.5 - 15	SANDY SILT					ML	A-7-6 (7)					

Boring ID	Depth (Ft)	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-39-26-2	0.5 - 2	4.75	0.168			0.0	0.0	49.6	50.4		
⊠ S-39-26-2	4 - 6	19	0.46	0.079		0.0	8.0	62.6	29.4		
▲ S-39-26-2	6 - 8	19	1.584	0.241	0.009	0.0	26.5	56.5		8.4	8.6
★ S-39-26-2	8 - 10	4.75	0.092	0.006		0.0	0.0	42.4		28.7	28.9
⊙ S-39-26-2	13.5 - 15	0.85	0.078			0.0	0.0	41.9	58.1		

## Grain Size Distribution

### ASTM D422 / ASTM C136

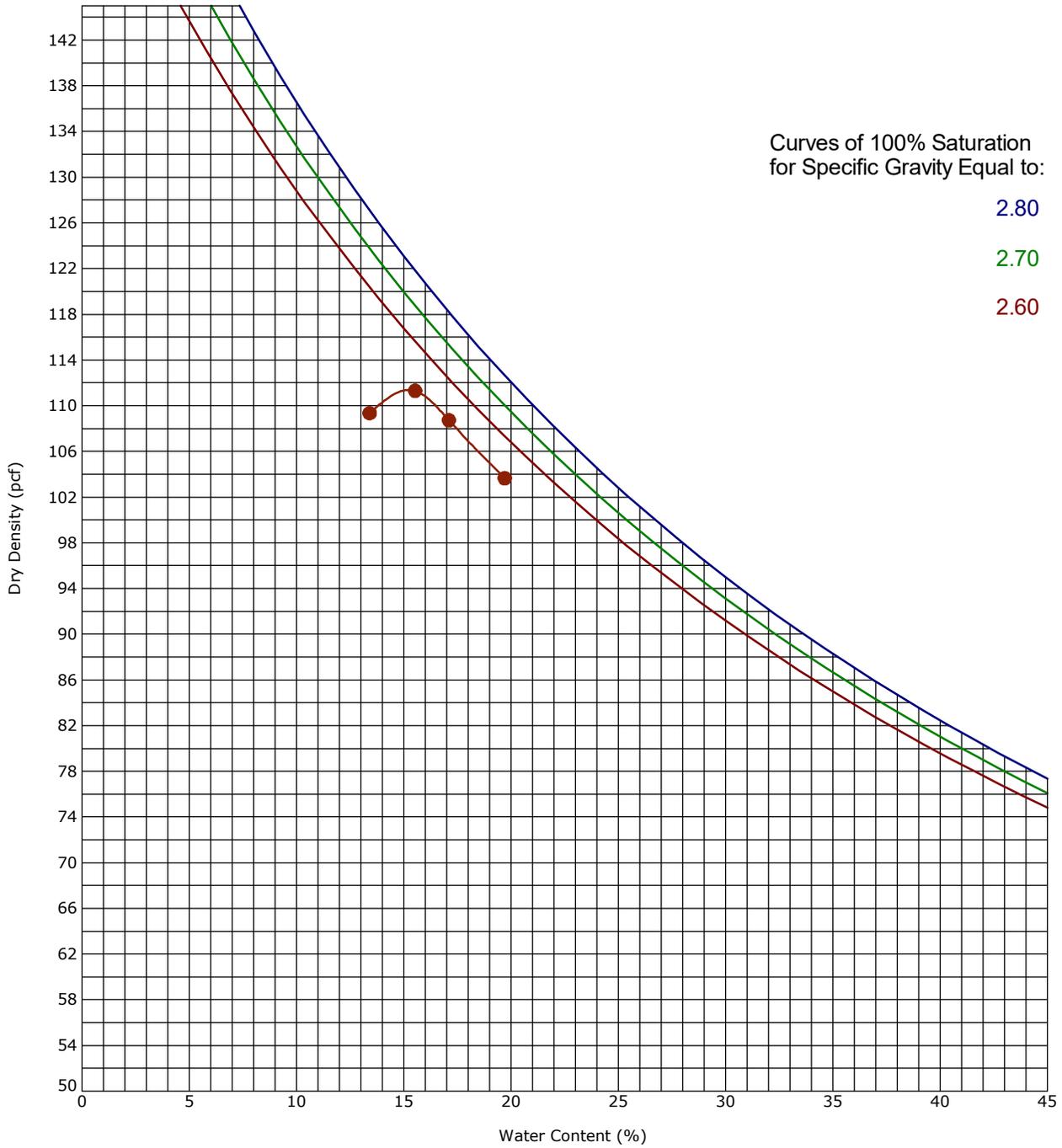


Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
S-39-26-1/2 Offset	0 - 5	SILTY SAND with GRAVEL	SM	A-2-4 (0)	NP	NP	NP		

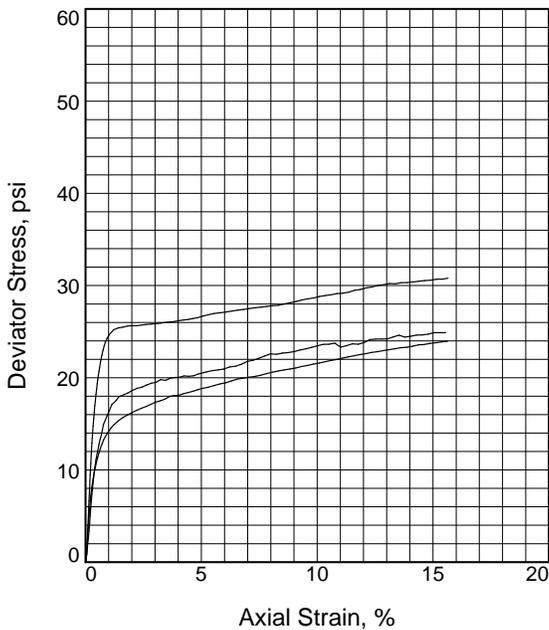
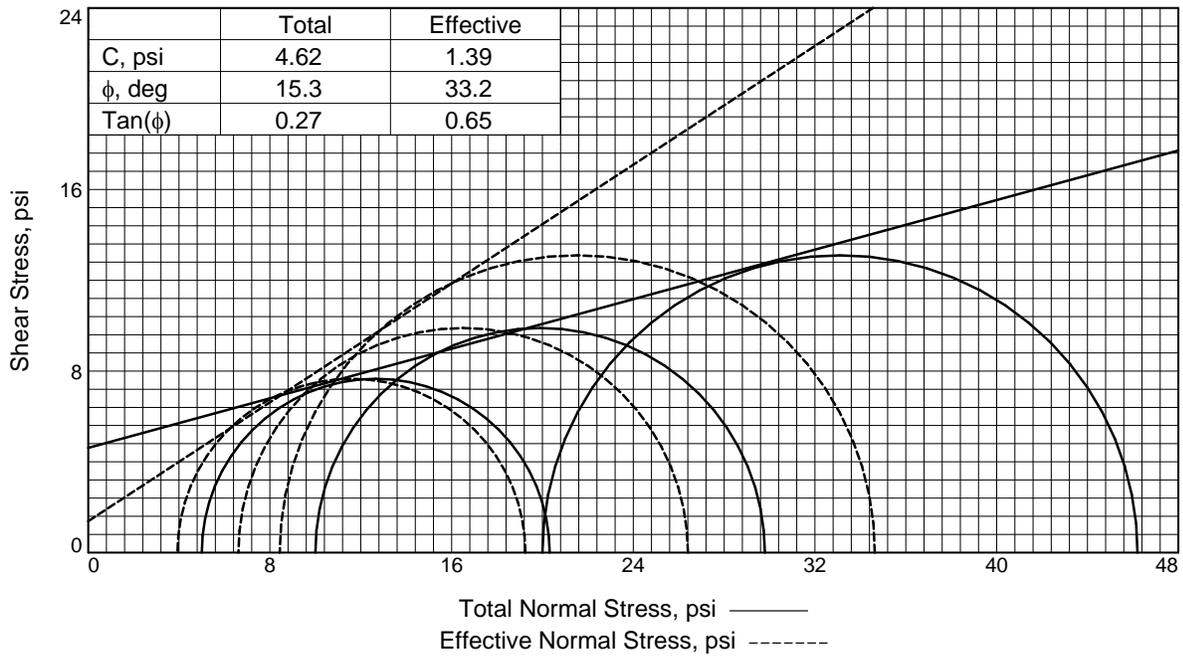
Boring ID	Depth (Ft)	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
S-39-26-1/2 Offset	0 - 5	25	0.526			0.0	20.3	47.6	32.1		

## Moisture-Density Relationship

### ASTM D698-Method B



Boring ID		Depth (Ft)		Description of Materials				
S-39-26-1/2 Offset		0 - 5		SILTY SAND with GRAVEL(SM)				
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)	
32	0.0	NP	NP	NP	ASTM D698-Method B	111.4	15.2	



Sample No.	1	2	3	
Initial	Water Content, %	15.0	14.9	15.3
	Dry Density, pcf	106.2	106.4	106.0
	Saturation, %	69.1	68.6	70.2
	Void Ratio	0.5868	0.5848	0.5896
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.62	5.62	5.62
At Test	Water Content, %	20.0	20.0	19.9
	Dry Density, pcf	109.4	109.4	109.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5409	0.5412	0.5369
	Diameter, in.	2.77	2.77	2.76
	Height, in.	5.58	5.58	5.57
Strain rate, in./min.	0.001	0.001	0.001	
Back Pressure, psi	50.0	50.0	50.0	
Cell Pressure, psi	55.0	60.0	70.0	
Fail. Stress, psi	15.3	19.8	26.2	
Excess Pore Pr., psi	1.1	3.4	11.6	
Ult. Stress, psi	23.8	24.9	30.7	
Excess Pore Pr., psi	-2.4	1.4	9.6	
$\bar{\sigma}_1$ Failure, psi	19.2	26.4	34.6	
$\bar{\sigma}_3$ Failure, psi	3.9	6.6	8.4	

**Type of Test:**

CU with Pore Pressures

**Sample Type:** Remolded

**Description:** Silty Sand with Gravel (SM)

LL= NV

PI= NP

**Specific Gravity=** 2.7

**Remarks:** Specimens were remolded to approximately 95% MDD at optimum water content.

**Figure** \_\_\_\_\_

**Client:** HNTB North Carolina PC

**Project:** S-39-26 BRO Tributary to South Saluda River

**Source of Sample:** S-39-26-1/2 Offset **Depth:** 0-5'

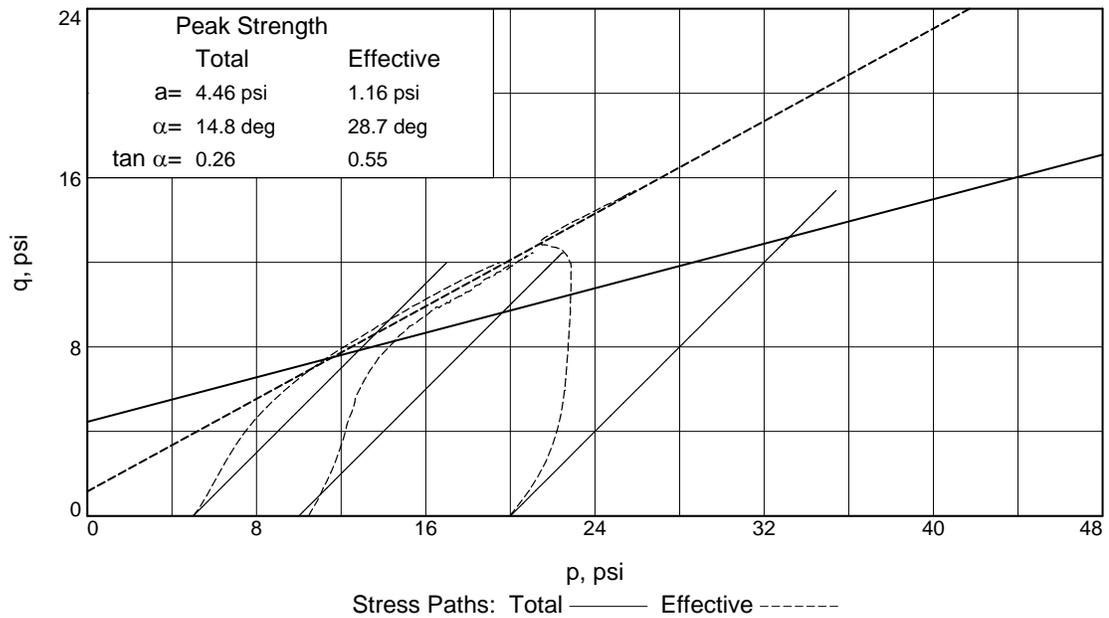
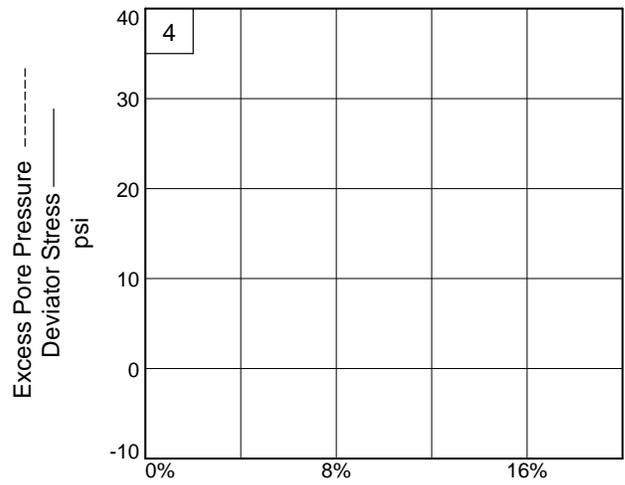
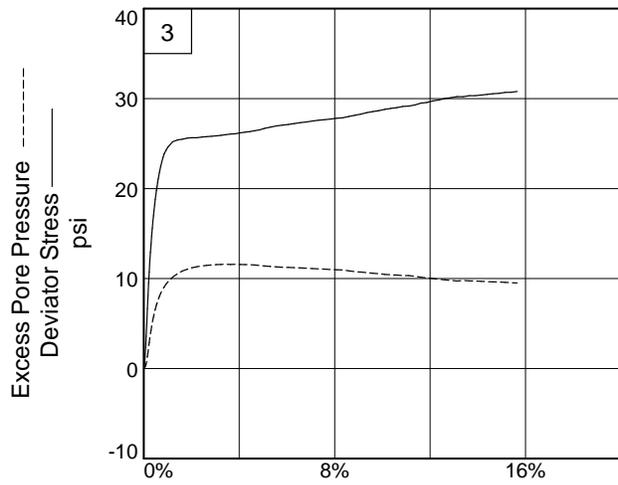
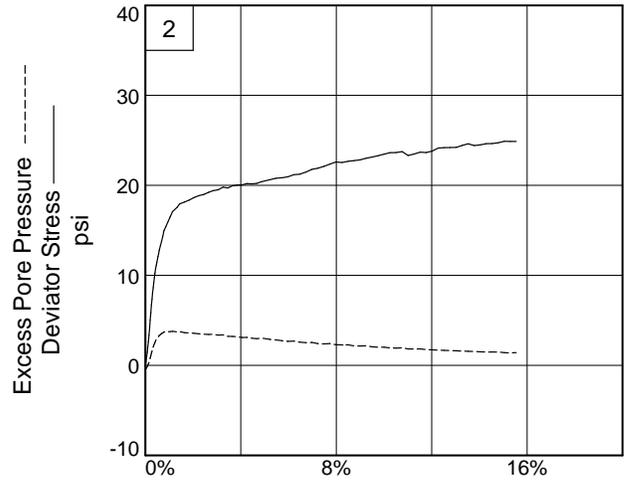
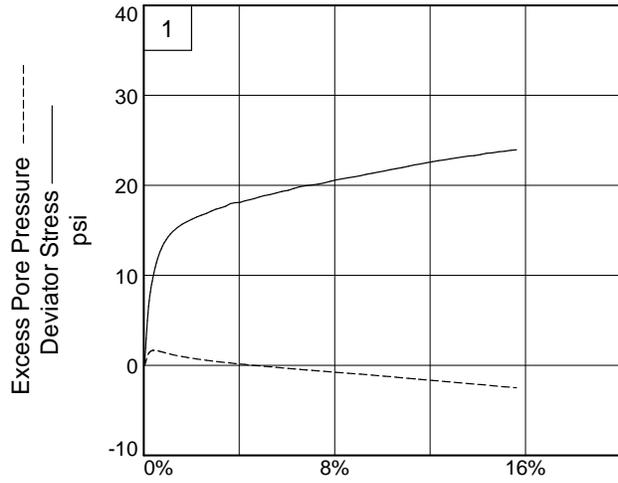
**Proj. No.:** 8623P180

**Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.

Chattanooga, TN



**Client:** HNTB North Carolina PC

**Project:** S-39-26 BRO Tributary to South Saluda River

**Source of Sample:** S-39-26-1/2 Offset **Depth:** 0-5'

**Project No.:** 8623P180

**Figure** \_\_\_\_\_

**Terracon Consultants, Inc.**

750 Pilot Road, Suite F  
Las Vegas, Nevada 89119  
(702) 597-9393



**Client**

HNTB North Carolina PC

**Project**

S-39-26 BRO Tributary to South Saluda River

**Sample Submitted By:** Terracon (86)

**Date Received:** 8/16/2024

**Lab No.:** 24-0279

**Results of Corrosion Analysis**

<b>Sample Number</b>	S-39-26-1
<b>Sample Location</b>	--
<b>Sample Depth (ft.)</b>	0.5-15.0
pH Analysis, AASHTO T289	5.71
Water Soluble Sulfate (SO4), AASHTO T290 (mg/kg)	55
Chlorides, AASHTO T291, (mg/kg)	110
Saturated Minimum Resistivity, AASHTO T288, (ohm-cm)	2376

A handwritten signature in black ink, appearing to read "N. Campo".

**Analyzed By** \_\_\_\_\_

Nathan Campo  
Laboratory Coordinator

The tests were performed in general accordance with applicable ASTM and AWWA test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.



# Rock Coring Summary

PROJECT ID P043138

PROJECT NAME S-39-26 BRO Tributary to South Saluda River

PROJECT COUNTY Pickens

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q <sub>u</sub> (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
S-39-26-1	NQ-1	59.5	93	93	11196	0.065	1167	163	77	85
S-39-26-1	NQ-2	64.5	100	100	13981	0.044	1394	166	77	90
S-39-26-2	NQ-1	60.5	98	98	9205	0.001	1095	167	77	90
S-39-26-2	NQ-2	65.5	100	91	15600	0.001	1366	165	82	90

**Client**

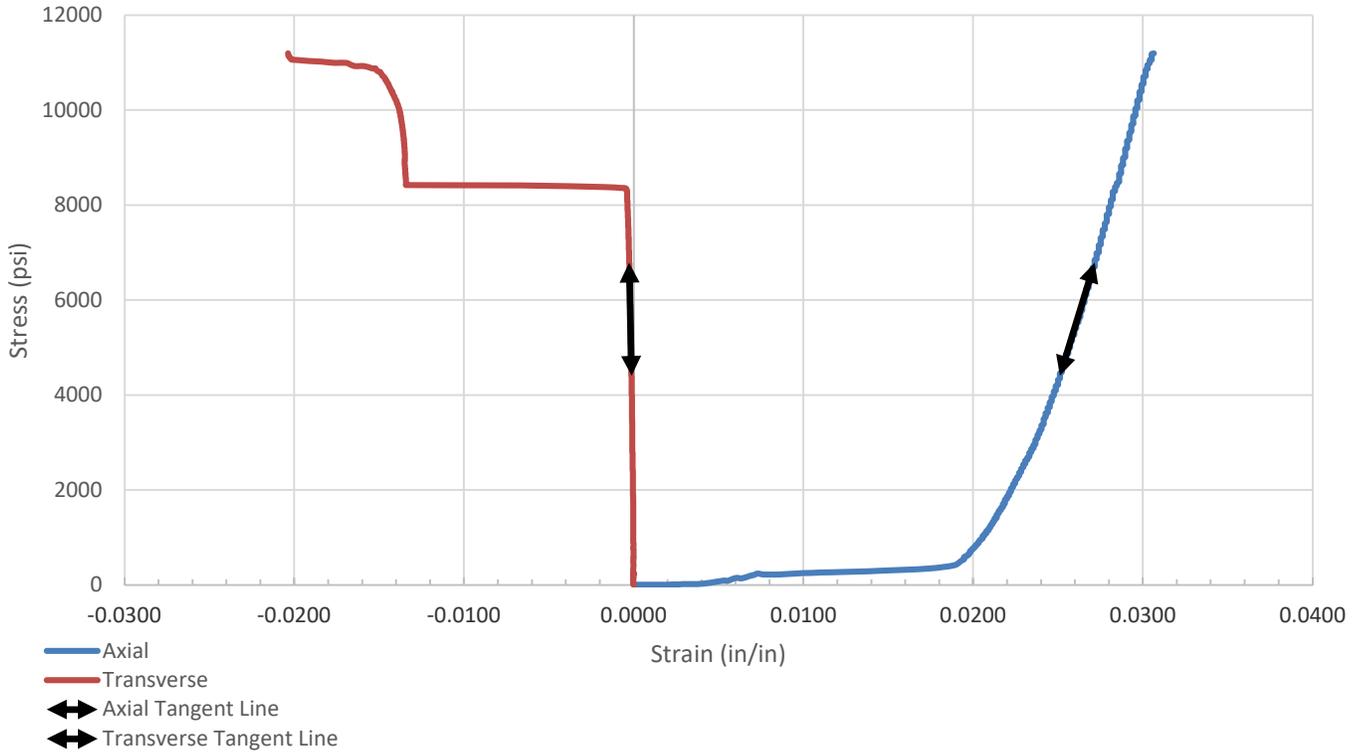
HNTB North Carolina PC  
 Attn: Spencer Franklin  
 343 E Six Forks Rd Ste 200  
 Raleigh, NC 27609

**Project**

S-39-26 BRO Tributary to South Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



**SAMPLE LOCATION**

Site:	SCDOT Bridge Package 19		
Description:	Gneiss		
Boring:	S-39-26-1	Depth (feet):	61.6-62.8

**SPECIMEN INFORMATION**

Sample No.:	NQ 1	Mass (g):	539.68
Length (in.):	4.17	Diameter (in.):	1.96
L/D Ratio:	2.13	Density (pcf):	163.41

**TEST RESULTS**

Failure Load (lbs):	33782
Failure Strain (%):	3.06
Unconfined Compressive Strength (psi):	11,196
Elastic Modulus, E, (ksi):	1167
Poisson's Ratio, u:	0.065
Time of Failure (min):	01:45
Rate of Loading (psi/sec):	0.042
Moisture Content Post-break:	0.0014

---

---

**Client**

HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

**Project**

SCDOT Bridge Package 19

Project No. 8623P180

---

**Equipment:**

	Calipers	TICCS ID: W-54522
	Scale	B-71466
	Dial Indicator	C-70608
	Compression (spherically seated)	C-48999

---

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:

**Notes:**

Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.

Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

**Client**

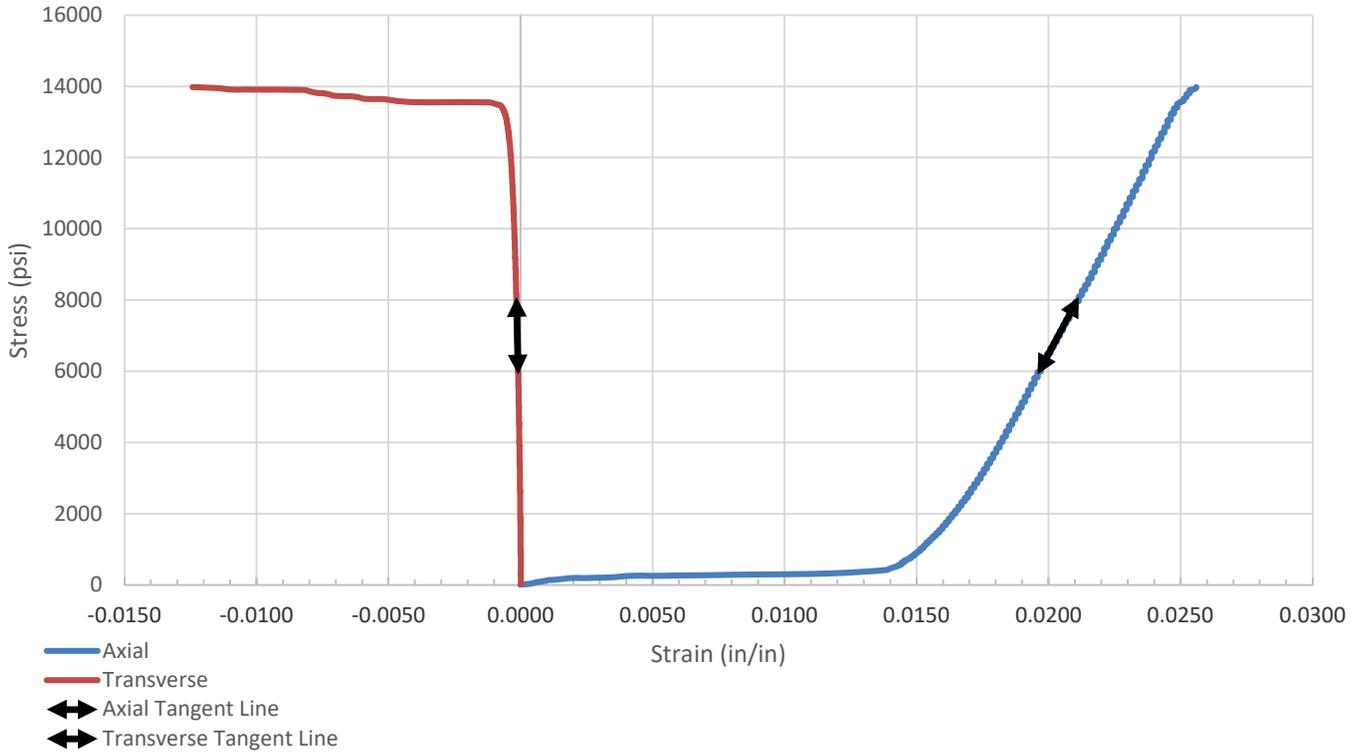
HNTB North Carolina PC  
 Attn: Spencer Franklin  
 343 E Six Forks Rd Ste 200  
 Raleigh, NC 27609

**Project**

S-39-26 BRO Tributary to South Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



**SAMPLE LOCATION**

Site:	SCDOT Bridge Package 19		
Description:	Gneiss		
Boring:	S-39-26-1	Depth (feet):	68.2-69.5

**SPECIMEN INFORMATION**

Sample No.:	NQ 2	Mass (g):	548.01
Length (in.):	4.17	Diameter (in.):	1.96
L/D Ratio:	2.13	Density (pcf):	165.93

**TEST RESULTS**

Failure Load (lbs):	42184
Failure Strain (%):	2.94
Unconfined Compressive Strength (psi):	13,981
Elastic Modulus, E, (ksi):	1394
Poisson's Ratio, u:	0.044
Time of Failure (min):	02:08
Rate of Loading (psi/sec):	0.042
Moisture Content Post-break:	0.0012

---

---

**Client**

HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

**Project**

SCDOT Bridge Package 19

Project No. 8623P180

---

**Equipment:**

	Calipers	TICCS ID:	W-54522
	Scale		B-71466
	Dial Indicator		C-70608
	Compression (spherically seated)		C-48999

---

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:

**Notes:**

- Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.
  - Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.
  - Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.
- According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

**Client**

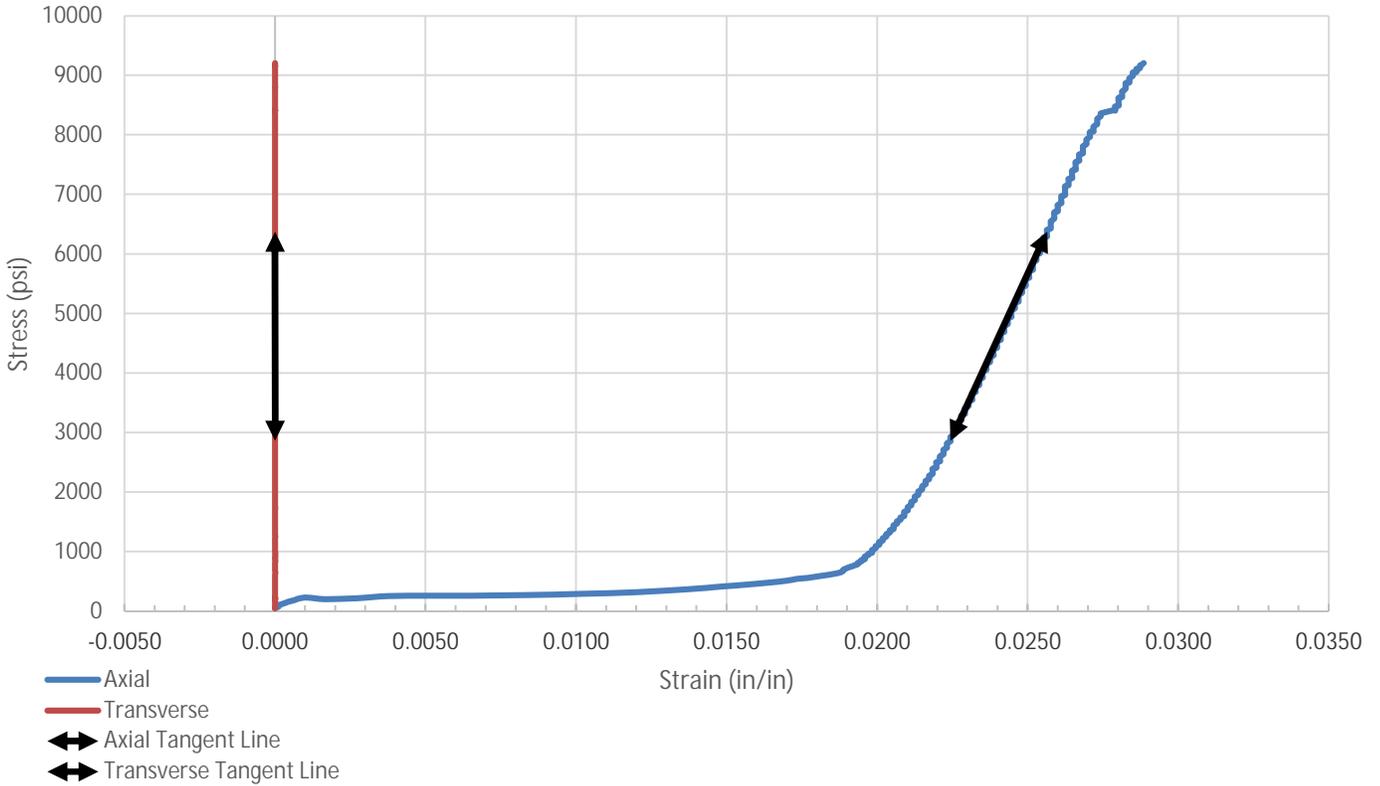
HNTB North Carolina PC  
 Attn: Spencer Franklin  
 343 E Six Forks Rd Ste 200  
 Raleigh, NC 27609

**Project**

S-39-26 BRO Tributary to South Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



**SAMPLE LOCATION**

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-39-26-2	Depth (feet):	60.5-61.5

**SPECIMEN INFORMATION**

Sample No.:	NQ1	Mass (g):	575.14
Length (in.):	4.22	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	166.93

**TEST RESULTS**

Failure Load (lbs):	28630
Failure Strain (%):	3.26
Unconfined Compressive Strength (psi):	9,205
Elastic Modulus, E, (ksi):	1095
Poisson's Ratio, u:	0.001
Time of Failure (min):	01:24
Rate of Loading (psi/sec):	109.845
Moisture Content Post-break:	0.01%



---

**Client**

HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

**Project**

SCDOT Bridge Package 19

Project No. 8623P180

---

**Equipment:**

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

---

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:  
Notes:

Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.

Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

**Client**

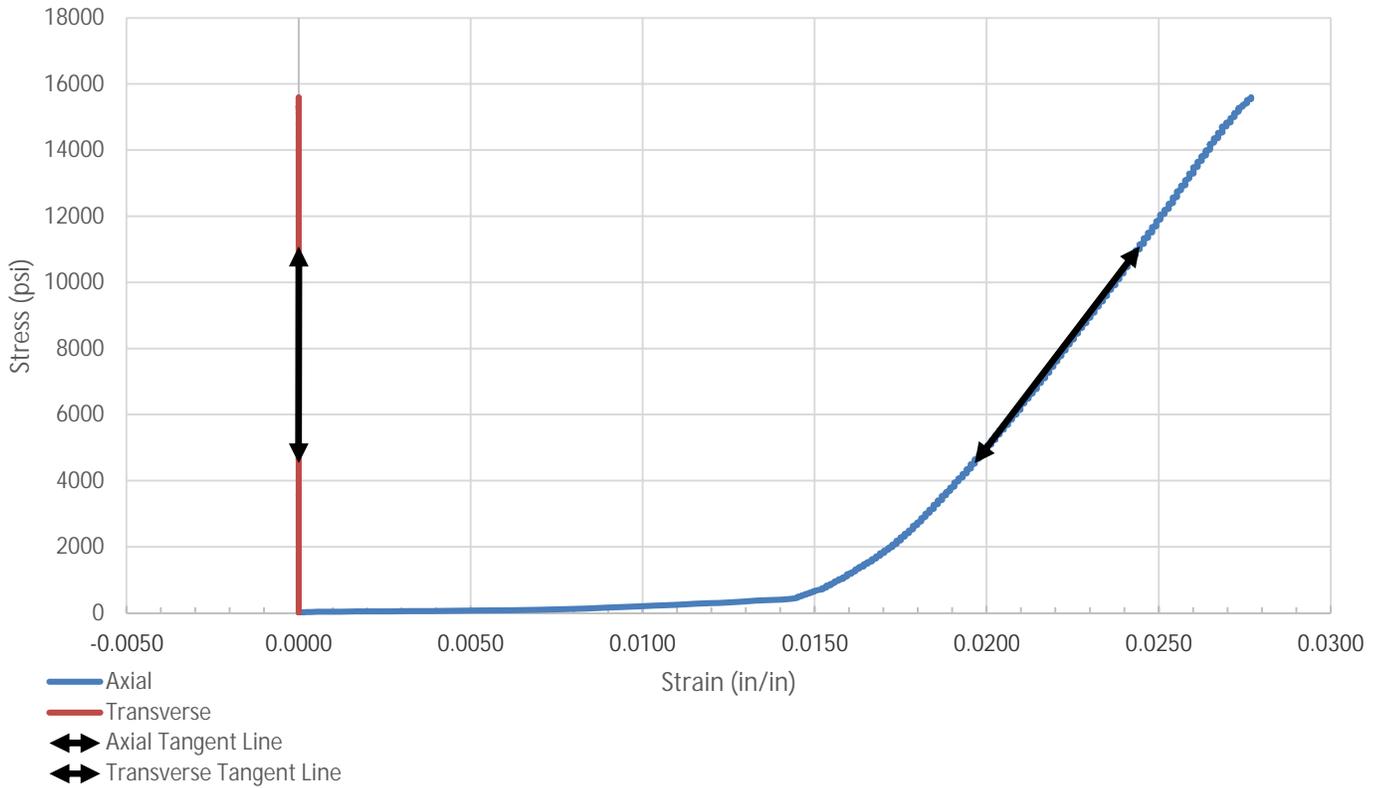
HNTB North Carolina PC  
 Attn: Spencer Franklin  
 343 E Six Forks Rd Ste 200  
 Raleigh, NC 27609

**Project**

S-39-26 BRO Tributary to South Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



**SAMPLE LOCATION**

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-39-26-2	Depth (feet):	66-66.8

**SPECIMEN INFORMATION**

Sample No.:	NQ2	Mass (g):	561.51
Length (in.):	4.18	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	164.54

**TEST RESULTS**

Failure Load (lbs):	48519
Failure Strain (%):	3.43
Unconfined Compressive Strength (psi):	15,600
Elastic Modulus, E, (ksi):	1366
Poisson's Ratio, u:	0.001
Time of Failure (min):	02:23
Rate of Loading (psi/sec):	109.089
Moisture Content Post-break:	0.01%

---

**Client**

HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

**Project**

SCDOT Bridge Package 19

Project No. 8623P180

---

**Equipment:**

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

---

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:  
Notes:

Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.

Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

**Appendix C – Supporting Documents**

S-39-26 BRO Tributary to South Saluda River | Pickens County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P043138



## **Appendix C**

### **Supporting Documents**

Rig Calibration Report – DR#1327 (8 Pages)

Note: All exhibits are one page unless noted above.

# SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: Geoprobe 3126GT  
 Drill Rig Serial Number: 3126S5V224106  
 Asset Number: DR#1327

September 13, 2024

September 13, 2024

Terracon Consultants Inc.  
 72 Pointe Circle  
 Greenville, SC 29615

Attn: Nitin Dudani  
 E: nitin.dudani@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report  
 Rig No: 1327  
 Terracon Project Number: 73245115

Dear Mr. Dudani:

This report provides the Energy Transfer Ratio (ETR) for the Standard Penetration Testing (SPT) automatic hammer as summarized below:

Table 1: Hammer Efficiency Summary

Drill Rig Make/Model	Drill Rig Serial Number	Drill Rig Year	Asset Number	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (C <sub>e</sub> )
Geoprobe	3126S5V224106	2024	DR#1327	92.6% ± 1.75%	1.54

\*Please Note: according to ASTM standard, a minimum of three recordings should be collected at five-foot intervals no shallower than twenty feet below current ground surface (bgs). The sample intervals were obtained between 30 and 50 feet bgs.

If you have any questions concerning this summary, or if we may be of further service, please contact us.

Ryan C. Wakeford, P.E.  
 Geotechnical Engineer

Susheel R. Kolwalkar, Ph.D., P.E.  
 Regional Services Manager

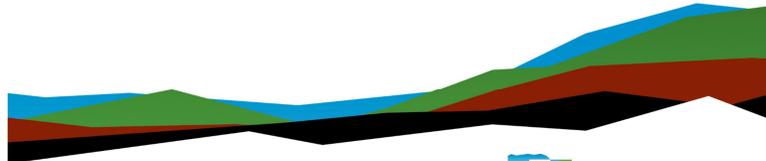


Micah Hatch, P.E.  
 Geotechnical Department Manager



Attachments:

- Exhibit A: SPT Representative Blow
- Exhibit B: SPT Analyzer Literature and Equipment Calibrations
- Exhibit C: SPT Analyzer Results
- Exhibit D: Field Log
- Exhibit E: Copy of Certificate of Proficiency



Prepared for:  
 Terracon Consultants, Inc.  
 Greenville, South Carolina



## 1.0 MEASUREMENT SUMMARY

ITEM	DESCRIPTION
Drill Rig Owner	Terracon Consultant, Inc. – Greenville, SC
Drill Rig Operator	Brett Burnett: Terracon Exploration
Testing Date	9/5/2024
Testing Location	Sumter County, SC
Boring Identification	B-3
Energy Measurement Depths	30 ft, 40 ft, 45 ft, 50 ft
Subsurface Soils	Poorly graded sands (SP) to clayey sands (SC)
Hammer Type/Height	140 pounds (automatic) with 2.5-foot drop height
Boring Method	Mud rotary
Drill Rods	<ul style="list-style-type: none"> <li>AWJ</li> <li>1-3/4" outside diameter</li> <li>1-1/4" inside diameter</li> <li>1.15 in<sup>2</sup> cross sectional area</li> <li>1/4" wall thickness</li> </ul>
Calibration Testing Equipment	<ul style="list-style-type: none"> <li>2-foot AWJ rod instrumented w/ two strain gauges and two accelerometers manufactured by Pile Dynamics Inc. (PDI)</li> <li>SN: 746AWJ</li> <li>Model SPT Analyzer™ (PDA) SN: 4621 TB</li> </ul>
ASTM Methods Used	ASTM D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils  ASTM D4633-16, Standard Method for Energy Measurement for Dynamic Penetrometers
SPT Calibration Personnel	Ryan Wakeford – Intermediate PDA Proficiency, Terracon Consultants, Inc.

## 2.0 PURPOSE AND SCOPE OF WORK

The North Charleston office of Terracon Consultants, Inc. conducted SPT energy measurements in accordance with ASTM D4633-16 at a site off Panola Road in Sumter County, South Carolina. Energy measurements on the rig were taken during eight samples events.

## 3.0 TEST RESULTS

Table 2: SPT Hammer Energy Calibration Testing Summary

Boring	Start Depth <sup>1</sup> (ft)	Rod Length <sup>2</sup> (ft)	Rod Sections <sup>3</sup>					Measured Blow Counts (blows/6 inches)				SPT N <sub>meas</sub> (bpf)	Soil Type <sup>4</sup>
			2 ft	5 ft	10 ft	1 <sup>st</sup> 1 inc.	2 <sup>nd</sup> 1 inc.	3 <sup>rd</sup> 1 inc.	4 <sup>th</sup> 1 inc.				
B-3	28.5	33.7	0	6	0	4	5	6	-	11	SP		
	38.5	43.7	0	8	0	7	10	10	-	20	SP		
	43.5	48.7	0	9	0	4	5	7	-	12	SP		
	48.5	53.7	0	10	0	4	4	7	-	11	SP		

- Depth from existing ground surface to start of SPT
- Total rod length from instrumentation to bottom of sampler
- Two-foot section is instrumented and is located at top of drill rods
- Soil type visually classified by Terracon

Table 3: Energy Measurement and Analysis Summary

Boring	Start Depth <sup>1</sup> (ft)	SPT N <sub>m</sub> (bpf)	No. of Blows <sup>2</sup>	EMX <sup>3</sup> (ft-lbs)			ETR <sup>3</sup> (%)		
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
B-3	28.5	11	11	340	313	327	8.8	93.4	2.5
	38.5	20	20	334	309	318	5.6	90.9	1.6
	43.5	12	12	330	309	323	5.5	92.4	1.6
	48.5	11	11	334	320	328	4.5	93.7	1.3
Average:				335	313	334	6.1	92.6	1.75

- Boring ID and depth from existing ground surface to start of SPT
- Number of blows used in energy calibration analysis; limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the first increment if refusal were encountered
- EMX = Maximum Transferred Energy, ETR = Energy Transfer Ratio.

Table 4: Hammer Blow Rate Summary

Boring	Start Depth <sup>1</sup> (ft)	SPT N <sub>meas</sub> (bpf)	No. of Blows <sup>2</sup>	BPM <sup>3</sup>			
				Max.	Min.	Ave.	Std. Dev.
B-3	28.5	11	11	53.8	53.1	53.5	0.2
	38.5	20	20	53.7	53.0	53.4	0.1
	43.5	12	12	53.6	53.2	53.4	0.1
	48.5	11	11	53.8	53.1	53.4	0.2
Average:				53.7	53.1	53.4	0.2

- Boring ID and depth from existing ground surface to start of SPT.
- Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
- BPM = Blows per minute

Exhibit A

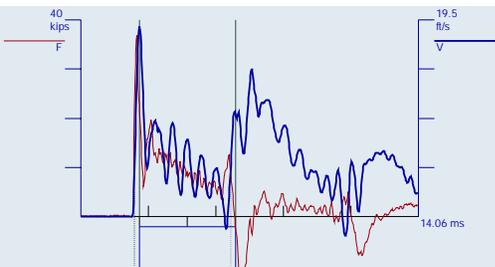
SPT Representative Blow

GRL Engineers, Inc.  
 GEOPROBE 3126GT  
 28.5-30  
 B3  
 PDA Operator: RW

Pile Driving Analyzer ® (PDA)  
 Version: 2022.35.2

GRL Engineers, Inc.  
 GEOPROBE 3126GT  
 38.5-40  
 B3  
 PDA Operator: RW

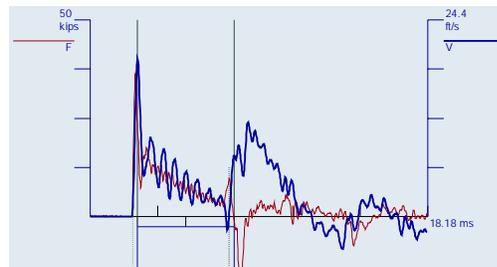
Pile Driving Analyzer ® (PDA)  
 Version: 2022.35.2



BN 13  
 05Sep2024 10:07:23 AM

CSX	32.1 ksi
DMX	1.11 in
EFV	331 ft-lb
ETR	94.7 %
BPM	53.8 bpm
RAT	1.0
VMX	18.9 ft/s
FMX	37 kips
DFN	1.00 in
MEX	1070 µE
AMX	3001 g/s
FVP	0.6
LE	33.70 ft
AR	1.15 in <sup>2</sup>
EM	30000 ksi
SP	0.492 k-ft/3
WS	16807.9 ft/s
WC	16766.2 ft/s
JC	0.90
JF	1.00

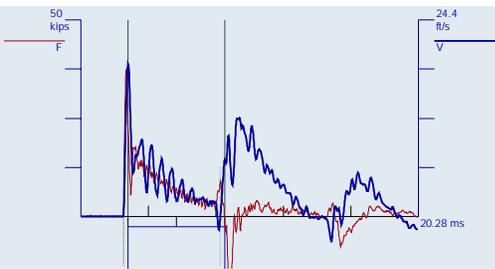
F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 25  
 05Sep2024 10:24:35 AM

CSX	31.7 ksi
DMX	0.66 in
EFV	324 ft-lb
ETR	92.6 %
BPM	53.4 bpm
RAT	1.1
VMX	19.6 ft/s
FMX	36 kips
DFN	0.60 in
MEX	1056 µE
AMX	3358 g/s
LE	43.70 ft
AR	1.15 in <sup>2</sup>
EM	30000 ksi
SP	0.492 k-ft/3
WS	16807.9 ft/s
WC	16807.7 ft/s
JC	0.90
JF	1.00

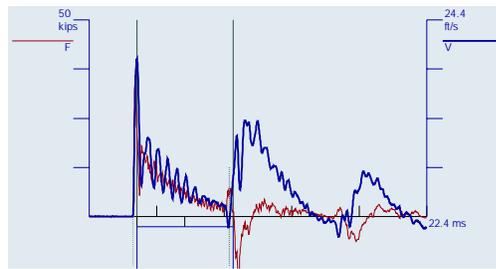
F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 14  
05Sep2024 10:32:57 AM

CSX	32.6 ksi
DMX	0.91 in
EFV	325 ft-lb
ETR	92.8 %
BPM	53.4 bpm
RAT	1.0
VMX	19.0 ft/s
FMX	37 kips
DFN	0.86 in
MEX	1086 µE
AMX	3426 g's
LE	48.70 ft
AR	1.15 m <sup>2</sup>
EM	30000 ksi
SP	0.492 k-ft <sup>3</sup>
WS	16807.9 ft/s
WC	16793.1 ft/s
JC	0.90
JF	1.00

F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 13  
05Sep2024 10:42:13 AM

CSX	31.5 ksi
DMX	1.01 in
EFV	320 ft-lb
ETR	91.4 %
BPM	53.7 bpm
RAT	1.1
VMX	19.6 ft/s
FMX	36 kips
DFN	0.86 in
MEX	1049 µE
AMX	4077 g's
LE	53.70 ft
AR	1.15 m <sup>2</sup>
EM	30000 ksi
SP	0.492 k-ft <sup>3</sup>
WS	16807.9 ft/s
WC	16781.3 ft/s
JC	0.90
JF	1.00

F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1

Exhibit B

SPT Analyzer Literature and Equipment Calibrations



# PI SPT Analyzer

## SPT Analyzer

Measures the energy transferred into an instrumented SPT rod during a Standard Penetration Test (SPT)

### Reliable. Simplified. Rugged.

The SPT Analyzer determines the energy transferred by SPT hammers using force and velocity measurements, for improved reliability of SPT N-values.

### What is SPT?

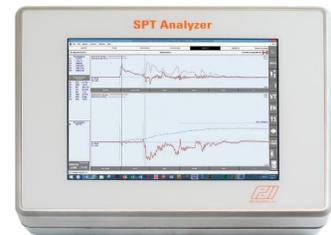
The Standard Penetration Test (SPT) is a widely-employed soil exploration tool that involves using an SPT hammer to drive a split sampler at the bottom of a drill string to obtain soil samples. The number of blows required to penetrate the last 300mm (1ft) is the "N value" which is related to soil strength.

### Why measure the energy transferred by the SPT hammer?

Several different types of SPT hammers are used to conduct Standard Penetration Tests. Their varying efficiencies influence the N value. The measured N value is normalized by multiplying it by the ratio of the measured energy transferred to the rod to 60% of the theoretical potential energy. The normalization compensates for the variability of the efficiencies of different SPT hammer types, and improves the reliability of soil strength estimates used in geotechnical applications.

The SPT Analyzer is furnished with a 0.6m sub assembly (or section) of an SPT rod (AW, NW or other type) instrumented with two strain gage bridges, and calibrated by Pile Dynamics. Once in the field, two accelerometers are bolted to the rod section. The instrumented section is inserted at the top of the drill string between the hammer and the existing sampling rod. The sensors on the rod are connected to the SPT Analyzer.

Smart Sensor technology allows the SPT Analyzer to read the rod instrumentation, obtaining the sensor calibration and rod cross sectional area.



- Calculates energy transferred by SPT hammers using force and velocity measurements
- Determines N value to help improve reliability of soil strength estimates
- Offers simplified reporting and analysis option to speed testing results
- Operates in English, SI, or Metric units



**EN ISO 22486-3:2005/ASTM Compliant**

The SPT Analyzer is compliant with EN ISO 22476-3:2005. ASTM D1586 recommends normalizing results from any SPT test using energy measurements. When these tests are performed to determine the liquefaction potential of sands, ASTM D6066 not only recommends but mandates the normalization. ASTM D4633 states that the only acceptable method of determining energy for normalization of N values is by force and velocity measurements.

These quantities are input to the SPT Analyzer automatically. This significantly simplifies the initial test setup.

The strain gages and accelerometers obtain the force and velocity signals necessary for the calculation of transferred energy to the drill string for each hammer blow. The energy is displayed in real time on the SPT Analyzer screen.

**Output**

SPT Analyzer data is stored and transferred to a computer via USB memory stick. The software furnished with the SPT Analyzer has a Report Creation Option that makes it quick and easy to summarize results and create output graphs of Force, Velocity, Energy and Displacement versus Time, as well as numerical, statistical, and graphical results for each data set. The software is fully customizable.



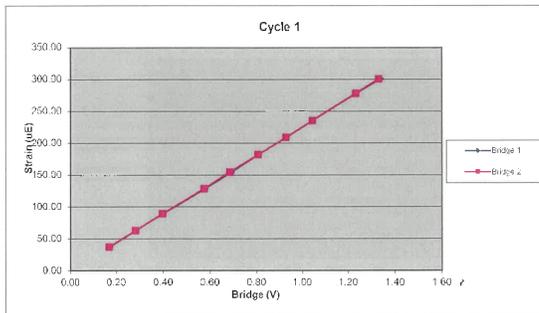
**Pile Dynamics, Inc. (PDI)** is the world leader in developing, manufacturing and supplying state of the art QA/QC products and systems for the deep foundations industry. The company is headquartered in Cleveland, Ohio, USA, with offices and representatives worldwide. For additional information visit us at [www.pile.com](http://www.pile.com) or contact [info@pile.com](mailto:info@pile.com).

[www.pile.com](http://www.pile.com) | +1 (216) 831-6131 | [info@pile.com](mailto:info@pile.com)

746AWJ		Cycle 1		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1296.93	37.22	0.17	0.17
3	2135.32	62.74	0.28	0.28
4	3028.79	89.39	0.40	0.40
5	4377.09	128.61	0.58	0.57
6	5243.07	154.57	0.69	0.68
7	6143.17	181.90	0.81	0.81
8	7067.95	208.93	0.93	0.93
9	7958.18	238.42	1.04	1.05
10	9380.66	278.02	1.23	1.23
11	10161.74	300.76	1.34	1.33

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7605.07	Force Calibration (lb/V)	7606.74
Offset	-0.16	Offset	12.66
Correlation	0.999997	Correlation	0.999999
Strain Calibration (µE/V)	225.99	Strain Calibration (µE/V)	226.04
Offset	-1.01	Offset	-8.33
Correlation	0.999989	Correlation	0.999992

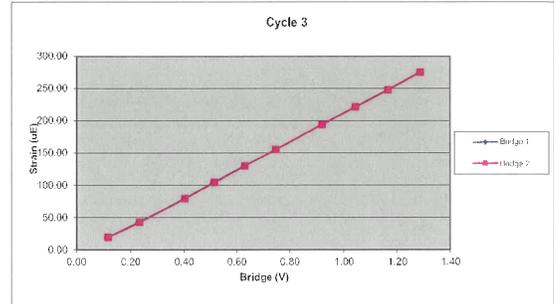
Force Strain Calibration	
EA (Kips)	33651.50
Offset	33.98
Correlation	0.999994



746AWJ		Cycle 3		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	838.16	19.27	0.11	0.12
3	1786.75	42.28	0.23	0.23
4	3083.67	79.12	0.40	0.40
5	3943.80	104.13	0.51	0.51
6	4839.52	129.87	0.63	0.63
7	5750.14	155.24	0.75	0.75
8	7079.92	194.22	0.92	0.92
9	8007.70	221.43	1.04	1.05
10	8943.28	247.95	1.17	1.17
11	9871.55	275.44	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7659.96	Force Calibration (lb/V)	7667.39
Offset	13.76	Offset	-1.59
Correlation	0.999999	Correlation	0.999998
Strain Calibration (µE/V)	219.43	Strain Calibration (µE/V)	219.64
Offset	-7.95	Offset	-8.39
Correlation	0.999934	Correlation	0.999939

Force Strain Calibration	
EA (Kips)	34904.41
Offset	291.93
Correlation	0.999935



**Accelerometer Calibration Certificate**  
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on **MAY 16 2024**

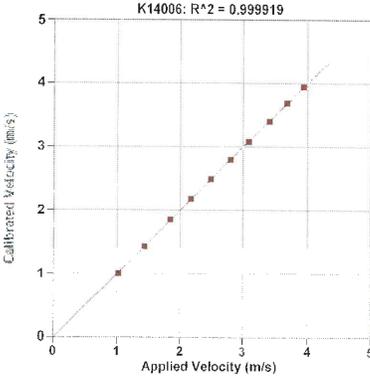
Serial No: K14006 Temperature: 24.0 °C  
Model: PR Humidity: 42%  
Calibrated on: Channel 3 on 8G 5161 LE

**PDA CALIBRATION FACTOR**  
375.2 mv/5000g  
(75.0 μv/g)  
R<sup>2</sup>: 0.999919 [Chip programmed]

Operator: William Johnson  
*William Johnson*  
Signed

Ref Acc 1: 78268! Cal on: 11Jan2024  
986 g/s/volt  
Ref Acc 2: 78270! Cal on: 11Jan2024  
971 g/s/volt

Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Version: 2023-09-17 4: 17

**Accelerometer Calibration Certificate**  
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on **MAY 16 2024**

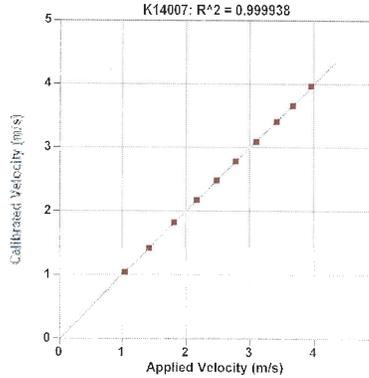
Serial No: K14007 Temperature: 23.8 °C  
Model: PR Humidity: 42%  
Calibrated on: Channel 4 on 8G 5161 LE

**PDA CALIBRATION FACTOR**  
407.2 mv/5000g  
(81.4 μv/g)  
R<sup>2</sup>: 0.999938 [Chip programmed]

Operator: William Johnson  
*William Johnson*  
Signed

Ref Acc 1: 78268! Cal on: 11Jan2024  
986 g/s/volt  
Ref Acc 2: 78270! Cal on: 11Jan2024  
971 g/s/volt

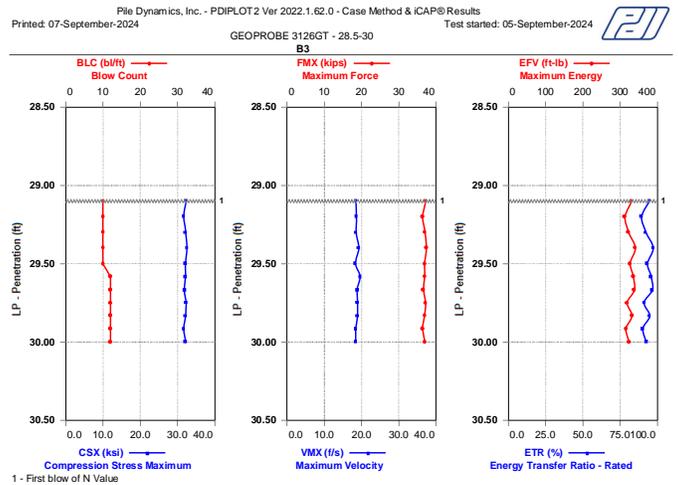
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Version: 2023-09-17 4: 24



Exhibit C  
SPT Analyzer Results





GEOPROBE 3126GT - 28.5-30

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf<sup>2</sup>  
LE: 33.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force  
VMX: Maximum Velocity  
EMX: Maximum Energy  
EFV: Maximum Energy  
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute  
DMX: Maximum Displacement  
DFN: Final Displacement  
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	29.10	10	37	18.4	331.0	331.0	94.6	53.1	1.58	1.20	32.3
6	29.20	10	36	18.7	312.7	312.7	89.3	53.4	1.47	1.20	31.7
7	29.30	10	37	18.5	323.0	323.0	92.3	53.6	1.54	1.20	32.2
8	29.40	10	37	19.2	340.4	340.4	97.3	53.4	1.57	1.20	32.5
9	29.50	10	37	18.4	326.6	326.6	93.3	53.5	1.48	1.20	32.1
10	29.58	12	37	19.6	335.5	335.5	95.9	53.3	1.41	1.00	32.1
11	29.67	12	37	18.8	338.0	338.0	96.6	53.7	1.58	1.00	31.8
12	29.75	12	37	18.9	318.3	318.3	90.9	53.5	1.37	1.00	32.3
13	29.83	12	37	18.9	331.4	331.4	94.7	53.8	1.11	1.00	32.1
14	29.92	12	36	18.5	315.2	315.2	90.1	53.8	1.09	1.00	31.7
15	30.00	12	37	18.4	324.1	324.1	92.6	53.6	1.07	1.00	32.1
Average			37	18.8	326.9	326.9	93.4	53.5	1.39	1.09	32.1
Std. Dev.			0	0.4	8.8	8.8	2.5	0.2	0.19	0.10	0.3
Maximum			37	19.6	340.4	340.4	97.3	53.8	1.58	1.20	32.5
Minimum			36	18.4	312.7	312.7	89.3	53.1	1.07	1.00	31.7

Total number of blows analyzed: 11

BL# Sensors

5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 15 seconds 10:07 AM - 10:07 AM BN 1 - 15



GEOPROBE 3126GT - 38.5-40

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf<sup>2</sup>  
LE: 43.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force  
VMX: Maximum Velocity  
EMX: Maximum Energy  
EFV: Maximum Energy  
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute  
DMX: Maximum Displacement  
DFN: Final Displacement  
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
7	39.05	20	36	18.7	320.4	320.4	91.5	53.3	0.91	0.60	31.6
8	39.10	20	36	18.5	313.6	313.6	89.6	53.2	0.65	0.60	31.6
9	39.15	20	37	18.9	318.4	318.4	91.0	53.4	0.66	0.60	32.1
10	39.20	20	37	18.9	309.8	309.8	88.5	53.5	0.64	0.60	31.9
11	39.25	20	37	19.1	321.4	321.4	91.8	53.2	0.93	0.60	31.9
12	39.30	20	36	18.5	309.3	309.3	88.4	53.5	0.64	0.60	31.5
13	39.35	20	37	19.5	320.6	320.6	91.6	53.0	0.69	0.60	31.9
14	39.40	20	36	18.4	314.3	314.3	89.8	53.3	0.80	0.60	30.9
15	39.45	20	37	19.5	326.5	326.5	93.3	53.5	0.92	0.60	32.0
16	39.50	20	36	18.6	320.6	320.6	91.6	53.5	1.02	0.60	31.7
17	39.55	20	37	19.1	316.4	316.4	90.4	53.7	0.68	0.60	31.8
18	39.60	20	36	19.0	312.4	312.4	89.2	53.3	0.66	0.60	31.7
19	39.65	20	36	18.8	315.8	315.8	90.2	53.5	0.70	0.60	31.1
20	39.70	20	36	19.2	320.1	320.1	91.5	53.4	0.78	0.60	31.1
21	39.75	20	36	19.5	320.9	320.9	91.7	53.3	0.63	0.60	31.0
22	39.80	20	37	19.2	317.1	317.1	90.6	53.5	0.74	0.60	31.7
23	39.85	20	36	18.8	315.1	315.1	90.0	53.5	0.61	0.60	31.1
24	39.90	20	36	19.7	333.6	333.6	95.3	53.5	0.83	0.60	31.3
25	39.95	20	36	19.6	323.9	323.9	92.6	53.4	0.66	0.60	31.7
26	40.00	20	35	18.9	313.5	313.5	89.6	53.5	0.60	0.60	30.6
Average			36	19.0	318.2	318.2	90.9	53.4	0.74	0.60	31.5
Std. Dev.			0	0.4	5.6	5.6	1.6	0.1	0.12	0.00	0.4
Maximum			37	19.7	333.6	333.6	95.3	53.7	1.02	0.60	32.1
Minimum			35	18.4	309.3	309.3	88.4	53.0	0.60	0.60	30.6

Total number of blows analyzed: 20

BL# Sensors

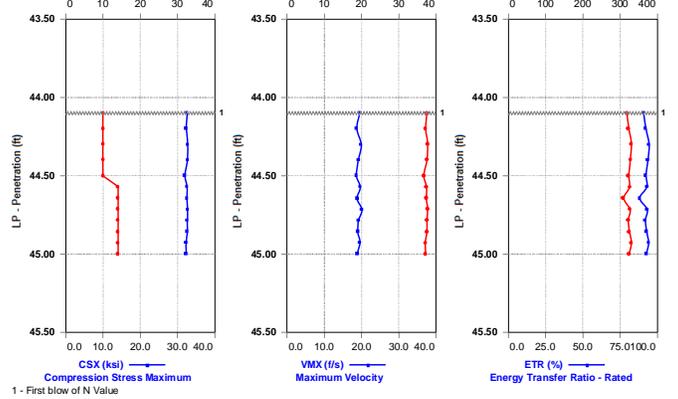
7-26 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

7 First blow of N Value

Time Summary

Drive 28 seconds 10:24 AM - 10:24 AM BN 1 - 26





GEOPROBE 3126GT - 43.5-45

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf/ft  
LE: 48.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force  
VMX: Maximum Velocity  
EMX: Maximum Energy  
EFV: Maximum Energy  
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute  
DMX: Maximum Displacement  
DFN: Final Displacement  
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	44.10	10	37	19.5	317.4	317.4	90.7	53.2	1.23	1.19	32.6
6	44.20	10	37	18.7	322.7	322.7	92.2	53.3	1.22	1.20	32.4
7	44.30	10	38	19.9	330.1	330.1	94.3	53.4	1.30	1.20	32.8
8	44.40	10	38	19.2	327.2	327.2	93.5	53.5	1.22	1.20	32.6
9	44.50	10	37	18.6	323.0	323.0	92.3	53.5	1.21	1.20	32.0
10	44.57	14	37	19.7	325.2	325.2	92.9	53.4	0.95	0.85	32.6
11	44.64	14	37	18.8	309.1	309.1	88.3	53.6	0.90	0.85	32.5
12	44.71	14	38	20.1	326.0	326.0	93.2	53.5	1.06	0.86	32.8
13	44.79	14	37	19.2	321.1	321.1	91.8	53.4	1.05	0.86	32.6
14	44.86	14	37	19.0	324.7	324.7	92.8	53.4	0.91	0.86	32.6
15	44.93	14	37	19.5	329.6	329.6	94.2	53.5	0.99	0.86	32.3
16	45.00	14	37	18.8	323.5	323.5	92.4	53.4	0.89	0.86	32.3
Average			37	19.3	323.3	323.3	92.4	53.4	1.08	1.00	32.5
Std. Dev.			0	0.5	5.5	5.5	1.6	0.1	0.15	0.17	0.2
Maximum			38	20.1	330.1	330.1	94.3	53.6	1.30	1.20	32.8
Minimum			37	18.6	309.1	309.1	88.3	53.2	0.89	0.85	32.0

Total number of blows analyzed: 12

BL# Sensors

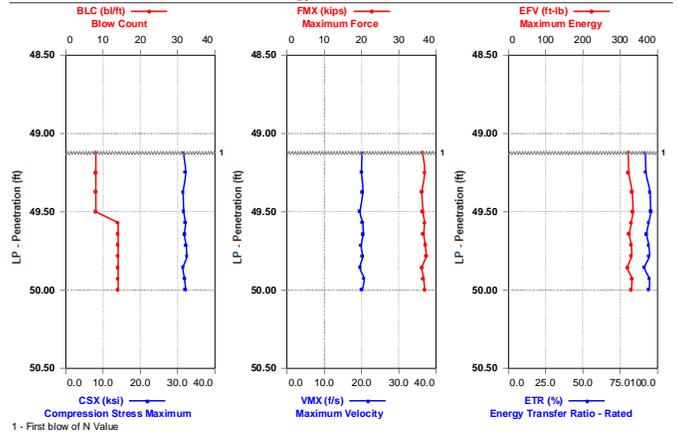
5-16 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 16 seconds 10:32 AM - 10:33 AM BN 1 - 16



1 - First blow of N Value

GEOPROBE 3126GT - 48.5-50

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf/ft  
LE: 53.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force  
VMX: Maximum Velocity  
EMX: Maximum Energy  
EFV: Maximum Energy  
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute  
DMX: Maximum Displacement  
DFN: Final Displacement  
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	49.13	8	36	20.1	321.6	321.6	91.9	53.3	1.81	1.50	31.6
6	49.25	8	37	20.1	323.0	323.0	92.3	53.4	1.81	1.50	32.1
7	49.38	8	36	20.3	332.2	332.2	94.9	53.5	1.50	1.50	31.5
8	49.50	8	36	19.6	334.0	334.0	95.4	53.3	1.50	1.50	31.7
9	49.57	14	37	20.3	329.3	329.3	94.1	53.8	0.87	0.86	32.1
10	49.64	14	37	20.4	324.8	324.8	92.8	53.4	1.00	0.86	31.9
11	49.71	14	37	19.9	329.7	329.7	94.2	53.2	0.89	0.86	32.2
12	49.79	14	37	20.2	330.1	330.1	94.3	53.7	0.89	0.86	32.4
13	49.86	14	36	19.6	319.8	319.8	91.4	53.7	1.01	0.86	31.5
14	49.93	14	37	20.7	331.0	331.0	94.6	53.1	0.91	0.86	31.9
15	50.00	14	37	20.1	330.2	330.2	94.4	53.2	1.03	0.86	32.1
Average			37	20.1	327.8	327.8	93.7	53.4	1.20	1.09	31.9
Std. Dev.			0	0.3	4.5	4.5	1.3	0.2	0.36	0.31	0.3
Maximum			37	20.7	334.0	334.0	95.4	53.8	1.81	1.50	32.4
Minimum			36	19.6	319.8	319.8	91.4	53.1	0.87	0.86	31.5

Total number of blows analyzed: 11

BL# Sensors

5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 15 seconds 10:42 AM - 10:42 AM BN 1 - 15

Exhibit D  
Field Log





### SPT HAMMER CALIBRATION FIELD WORKSHEET

PROJECT NAME: 7324515  
 PROJECT NO.: Terracon Associates, Inc.  
 BORING NO.: 8-3  
 CLIENT:

ARRIVAL TIME:  
 DEPART TIME:  
 TOTAL TRAVEL:  
 TOTAL TIME:  
 CLIENT REP:  
 MILEAGE:  
 DATE: 9/5/24  
 TERRACON REP: (N/A)  
 PDA MODEL/SN: SPT 4621 TR  
 TERRACON RIG #: 1307

**DRILL RIG DATA**  
 Type/Transport: Fork  
 Manufacturer: Geopole  
 Model No.: 3026GS  
 Serial No.: 7126550224106  
 Year Built: 2024  
 Modifications: N/A  
 Maint. Schedule: 50 hrs

**SPT HAMMER DATA**  
 Type: ATO  
 Manufacturer: Geopole  
 Lifting Mechanism: Chain  
 Model No.: AD1131  
 Serial No.: 10201  
 Hammer Weight: 140  
 Hammer Operator(s): B. R. MEHTA

**PDA INPUT DATA**  
 Operator: OP (N/A)  
 Project No./Location: PJ 7324515/  
 Rig Mode & SN: PN 60000/3026GS  
 Hammer Type, LM, Rods: PD ATO/ANJ  
 Drill Rod Area (in<sup>2</sup>): AR 115  
 Elastic Modulus (ksi): EM 3000  
 Specific Weight (kips/ft<sup>3</sup>): SP 0.492  
 Wave Speed (ft/sect): WS 16808  
 Increment Length (ft): LI 0.5  
 Sampling Freq. (kHz): FR 50

**TRANSDUCER INFORMATION**  
 Gage SN Calibration  
 F1/F3: 746 ANJ1 222.05  
 F2/F4: 746 ANJ2 222.09  
 A1/A3: K14002 402.23  
 A2/A4: K14006 375.83  
 NOTES: 286.25 + 1.875 = 288.125  
 288.125 + 10.55 = 298.675  
 SPLIT SPOON SAMPLER LENGTH: 38K + 0.88 = 38.88  
 \*LE is Measured from the Center of the Strain Gauges to the bottom of Split Spoon Sampler

#### SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		LE (ft)	Rods & Lengths	PDA Blows		SPT Blows			
			Start	End			Start	End	1st 6"	2nd 6"	3rd 6"	4th 6"
9:55	CL		27.5	25	48.7	5x5	1	30	5	10	14	24
10:05	SP		28.5	30	53.7	5x6	3	18	4	5	6	11
10:10	CL		33.5	35	58.7	5x7	1	1	0	0	0	0
10:15	SP		38.5	40	63.7	5x8	3	30	7	10	10	20
10:25	SP		43.5	45	68.7	5x9	1	18	4	5	7	12
10:35	SP		48.5	50	73.7	5x10	1	17	4	4	7	11
10:50	SC		53.5	55	78.7	5x11	1	6	2	1	2	3
11:10	CL		58.5	60	83.7	5x12	1	2	0	0	0	1

Individual pairs of F or V signals versus time shall be very similar for good quality data.  
 If you see Force goes negative before 2L/C after impact, drill rod joints should be carefully tightened for good quality data

#### PICTURE NUMBERS AND INFO:

Take Photo of Each Rigs, Boring Locations at the Site

Exhibit E

Copy of Certificate of Proficiency

Terracon SPT Rig Calibration Worksheet.xlsx



This documents that  
**Susheel R. Kolwalker**  
**Terracon Consultants**  
 has on March 11, 2016 achieved the rank of  
**EXPERT**

on the Dynamic Measurement and Analysis Proficiency Test.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations.

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate. This certificate can be verified at [www.PDAproficiencytest.com](http://www.PDAproficiencytest.com).

*Steven A. Hall*  
 Steven A. Hall, Executive Director  
 Pile Driving Contractors Association

*Garland Likins*  
 Garland Likins, Senior Partner  
 Pile Dynamics, Inc.

No. 2005



This documents that  
**Ryan Wakeford**  
**Terracon Consultants, Inc.**  
 has on March 15, 2019 achieved the rank of  
**INTERMEDIATE**

on the Dynamic Measurement and Analysis Proficiency Test.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. It is recommended that individuals at the Intermediate level seek Advanced, Master or Expert levels through additional study within four years of the date of this document.

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate. This certificate can be verified at [www.PDAproficiencytest.com](http://www.PDAproficiencytest.com).

*Frank T. Peters*  
 Frank T. Peters, Executive Director  
 Pile Driving Contractors Association



*Garland Likins*  
 Garland Likins, Senior Partner  
 Pile Dynamics, Inc.

No. 2898