

# S-23-94 (Hammett Bridge Road) Bridge Replacement over Suber Branch

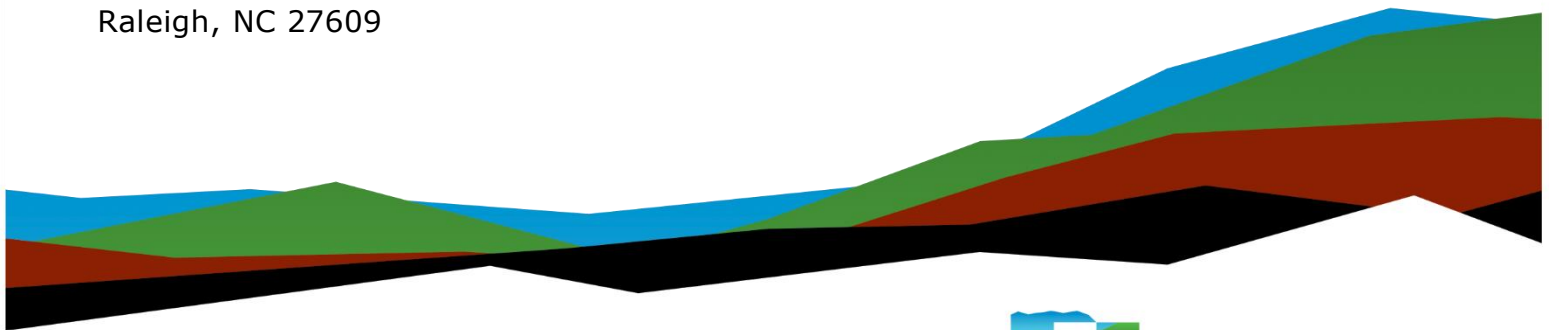
Greenville County, SC

## Geotechnical Baseline Report

October 30, 2024 | SCDOT Project ID: P041163  
Terracon Project No.: 8623P180 Revision 1

### Prepared for:

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





72 Pointe Circle  
Greenville, SC 29615  
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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-23-94 Bridge Replacement over Suber Branch  
Greenville County, South Carolina  
SCDOT Project ID.: P041163  
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 Task Order Number 001, dated May 25, 2023.

## Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, laboratory testing and limited preliminary engineering recommendations for the replacement of the S-23-94 bridge over Suber Branch in Greenville County, South Carolina. This will be a complete bridge replacement. 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-23-94 (Hammett Bridge Road) crossing over Suber Branch in Greenville County, South Carolina. Site location and exploration plans are presented in Appendix A of this report. Based on the conceptual plans by HNTB dated 8/30/2024, the

replacement bridge will be constructed on a new road alignment adjacent to and east of the current alignment. The current plan indicates the new bridge will be a 105-ft long single span bridge constructed with 54-inch prestressed concrete FIB girders.

## Geotechnical Testing

The geotechnical exploration for this project was performed between June 7 and August 19, 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-23-94-1 and S-23-94-2)
- One (1) offset boring near S-23-94-2 for bulk sample collection
- One (1) Downhole Shear Wave Velocity Test (DHT-1) located in Boring S-23-94-1
- Two (2) Cone Penetration Test soundings (S-23-94-1C and S-23-94-2C)

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.

### Laboratory Testing

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

- Twenty-three (23) Natural Moisture Content Tests
- Six (6) Atterberg Limits Tests
- Six (6) 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)
- Five (5) 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-23-94, in the city of Greer, in Greenville County, South Carolina. The site lies generally within the Piedmont Physiographic province. More specifically, the site is located within the Paris Mountain thrust sheet. According to regional geologic mapping and published geologic reports, the project area is mapped in an area mainly with sillimanite, biotite, muscovite, and smaller amounts of quartz. 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

Boring S-23-94-2 encountered a surface covering of 6 inches of asphalt followed by about 18 inches of gravel. After boring S-23-94-2 was drilled in June 2024, the road was re-paved with a layer of asphalt. Boring S-23-94-1 was drilled August 2024, after the re-paving of the roadway, and encountered a surface covering of 10 inches of asphalt. Beneath the surface layer, both borings encountered a fill layer consisting of loose to medium dense silty sand to a depth of around 4 feet below the existing ground surface. Under the fill soils a layer of alluvial soils consisting of very loose to loose clayey/silty sand or soft to very soft sandy silt to depths of approximately 10 to 20 feet below surface grades. Below the alluvium, residual soils consisting of loose to very dense silty sand or well graded sand with silt were encountered to depths of 63.5 to 76 feet below the existing ground surface, followed by bedrock.

Materials classified as IGM started at around 24 feet and continued intermittently at boring S-23-94-1 before remaining IGM below at a depth of 48 feet extending to bedrock at 76 feet below existing grade. Materials classified as IGM started at a depth of about 58 feet below existing ground at boring S-23-94-2 extending to bedrock at 76 feet below existing grade.

Bedrock was present to the maximum depth explored of 86 and 93.5 feet at borings S-23-94-1 and S-23-94-2, respectively. Ground water was not encountered at boring S-23-94-1 during drilling but was encountered at a depth of 7 feet after 24 hours at boring S-23-94-2.

Geology	Approximate Elevation of Layer Bottom (ft, NAVD88)	USCS Soil Type	Measured Field N Value	Plasticity Index	Fines Content	REC / RQD
Asphalt / Gravel	830 to 831	--	--	--	--	--
Fill	828	SM	10 to 20	NP <sup>2</sup>	30	--
Alluvium	812 to 822	SC, SM, ML	0 to 9	8 to 16	12 to 69	--
Residuum	756 to 768	SM, SW-SM	3 to 100+	NP <sup>2</sup>	11 to 27	--



Geology	Approximate Elevation of Layer Bottom (ft, NAVD88)	USCS Soil Type	Measured Field N Value	Plasticity Index	Fines Content	REC / RQD
Rock	PMDE <sup>1</sup>	--	--	--	--	55-100% / 27-95%

1. PMDE = Present to Maximum Depth Explored

2. NP = non-plastic

## Seismic Conditions

According to SCDOT Seismic Design Specifications for Highway Bridges version 2.0, the proposed bridge will be an Operational Classification II (OC II). Per SCDOT GDM 2022, the proposed bridge shall be designed to meet the performance limits for an OC II bridge.

### Acceleration Design Response Spectrum (ADRS)

The shear wave and compression wave velocity results, as measured at Boring S-23-94-1 using downhole seismic tests, were provided to SCDOT. SCDOT used these velocity measurements to develop Acceleration Design Response Spectrum (ADRS) curves by determining the seismic hazard and evaluating the local site effects on the response spectra.

SCDOT provided "3-Point Acceleration Design Response Spectrum" curves along with a table that included pseudo-spectral accelerations (PSA) for 5% critical damping and at selected frequencies, consistent with a Geologically Realistic (B-C Boundary) condition (shear wave velocity,  $V_s = 2,500$  feet per second). PSA values were provided for the:

- Functional Evaluation Earthquake (FEE): 15% probability of exceedance in 75 years
- Safety Evaluation Earthquake (SEE): 3% probability of exceedance in 75 years

The table below provides the maximum considered earthquake peak ground acceleration (PGA), the short period acceleration ( $S_{DS}$ ), and one-second period acceleration ( $S_{D1}$ ) for the FEE and SEE earthquakes at the ground surface. A copy of the "3-Point Acceleration Design Response Spectrum" provided by SCDOT is included in Appendix C.

Seismic Design Parameter	FEE	SEE
PGA	0.14	0.27
$S_{DS}$	0.25	0.57
$S_{D1}$	0.02	0.04

## 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 830 feet, within about 2 feet of the existing grades along the alignment. The depth to very dense residual soils/IGM is predicted to be between about 50 to 60 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 = $0.5 \cdot A_s \cdot F_y$		

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 (4,200 psi) times the cross-sectional area of the pile, 183 tons and 223 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 8/30/2024, about 5 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. 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 2 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 2, Boring S-23-94-2 Composite Sample from 2 to 15 feet	Indication of Corrosivity <sup>1</sup>
pH	5.65	Less than 5.5
Resistivity	2,231 ohm-cm	Less than 2,000 ohm-cm
Chloride	117 ppm	Greater than 500 ppm
Sulfate	24 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, about 6 to 7 feet of fill will be placed to support the bridge approach slabs and extend beyond the bridge with relatively short (less than 10 feet tall) 2H:1V rip rap lined fill slopes shown at the end abutment positions. Existing embankment will be excavated below the bridge to establish a shelf and an approximate 7 foot tall 2H:1V rip rap lined end slope. Bulk samples were obtained near End Bent 2 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.

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S-23-94 BRO Suber Branch | Greenville County, SC

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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-23-94-2 Offset	21+03	12 L	0 – 5	SC	13.0	115.7	c=3.0 psi ø=15°	c'=0 psi ø'=38°

1. Based on a maximum deviator stress failure criterion

## Seismic Induced Soil Shear Strength Loss (SSL)

A few feet of loose to very loose alluvial silty to clayey sands were noted below the existing fill at boring location and may likely be at or below the predicted ground water elevation of about 825 feet (coincident with approximate creek level). These low consistency/density soils are susceptible to soil shear strength loss (SSL) during design seismic events. Additional soil and ground water evaluation and SSL screening should be performed to assess potential for liquefaction related settlement and stability impacts on the planned bridge foundations and embankment slopes.

## Closure

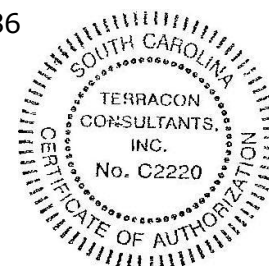
We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or we may be of further service, please contact us.

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 (3 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 (2 pages)
- Exhibit A-11 – Geophysical Testing Results
- Exhibit A-12 – CPT Sounding Logs (2 Pages)

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	9/19/2024


  
72 Pointe Cir  
Greenville, South Carolina 29615

SITE LOCATION
S-23-94 BRO Suber Branch Hammett Bridge Road Greenville County, SC

Exhibit
A-1





AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS  DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES	Project Manager: DJC	Project No. 8623P180	  72 Pointe Cir Greenville, SC 29615-3506	EXPLORATION PLAN		Exhibit
	Drawn by: MEM	Scale: AS SHOWN		S-23-94 BRO Suber Branch  Hammett Bridge Road Greenville County, SC		A-2
	Checked by: SG	File Name: -				
	Approved by: SG	Date: 9/20/24				



PRELIMINARY SITE PLAN PROVIDED BY HNTB

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

Project Manager:	DJC	Project No.	8623P180
Drawn by:	MEM	Scale:	AS SHOWN
Checked by:	SG	File Name:	
Approved by:	SG	Date:	9/20/24



72 Pointe Cir  
Greenville, SC 29615-3506

## EXPLORATION PLAN

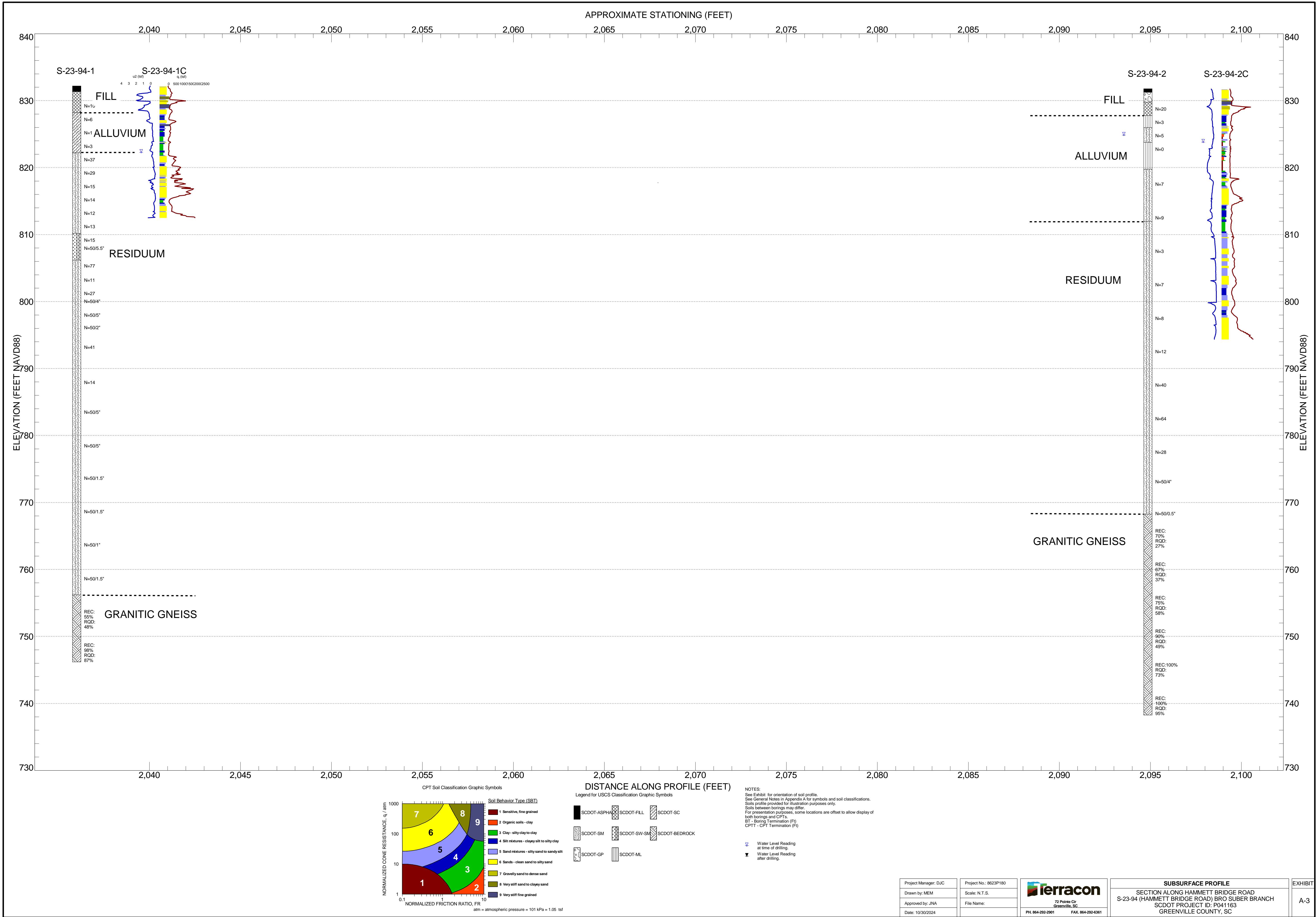
SCDOT S-23-94 BRO Suber Branch  
Hammitt Bridge Road  
Greenville County, SC

Exhibit

A-2



THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. INK FENCE CPT & STB FENCE AT 8623P180 SCDOT BRIDGE ROAD S-23-94 OVER SUBER TRIBUTARY-INTERNAL.GPJ TERRACON DATA TEMPLATE.GDT 10/30/24



## Summary of Boring Data – Exhibit A-4

S-23-94 Bridge Replacement over Suber Tributary | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041163



### 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-23-94-1	832.2	86	1119627.68	1624373.60	34.904204	-82.252710	20+36	13 L
S-23-94-2	831.8	93.5	1119666.90	1624417.50	34.904313	-82.252566	20+95	12 L
S-23-94-1C	832.2	19.7	1119630.82	1624377.33	34.904213	-82.252698	20+41	13 L
S-23-94-2C	831.7	37.3	1119670.19	1624420.40	34.904323	-82.252556	20+99	12 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 <sup>TM</sup>.
2. A bulk sample was collected about 7 feet and 9 feet northeast of S-23-94-2.
3. Station and offset are based on the plans provided at the time the tests were performed.

## GeoScoping Form

PROJECT INFORMATION			
Project ID:	P041163	Date of Trip:	6/7/2024
County:	Greenville	Location:	Greer
Rd/ Route:	S-23-94	Local Name:	Hammett Bridge Rd
Attendees:	M. McKenney		

EXISTING BRIDGE INFORMATION			
Bridge Length:	45 ft	Bridge Width:	27.5 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber and Steel H-Piles
Begin Bridge Sta <sup>1</sup> :	20+13	End Bridge Sta <sup>1</sup> :	21+18
Begin Bridge Embankment Sta <sup>1</sup> :	19+13	End Bridge Embankment Sta <sup>1</sup> :	22+18
Structure Number:	04129	Posted Weight Limit:	45 tons
Crossing:	Suber Branch	Skew:	N/A
Latitude:	34.904295°	Longitude:	-82.252594°
Existing Fill Height:	approx 4 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:	18+10	Begin Bridge Embankment Sta:	19+13
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and grassed shoulders		
Existing Fill Height:	4 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to creek		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	silty 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:	9 feet	Water Depth:	1 to 2 feet
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:	22+18	End Project Sta:	24+90
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and grassed shoulders		
Existing Fill Height:	4 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to creek		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	silty 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:	9 feet	Water Depth:	1 to 2 feet
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:	A waterline was observed attached to the northwest side of bridge.
Above Ground:	Overhead power was observed on both sides of the road.
Underground:	An underground fiber line was observed in the northwest shoulder. A gasline was observed in the southeast shoulder.

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 after testing and drilling was complete. The locations, as shown in the Exploration Plans, 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 sampling program is summarized in the following table:

Test ID	Total Depth	Interval of Continuous Sampling
S-23-94-1	86 feet w/ 10 feet rock coring	2 to 40 feet
S-23-94-2	93.5 feet w/ 30 feet rock coring	2 to 10 feet
S-23-94-2 Offset	5 feet	Bulk Sample <sup>1</sup>
S-23-94-1C	19.7 feet (refusal)	CPT - No sampling
S-23-94-2C	37.3 feet (refusal)	CPT - No sampling

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

## Exhibit A-6 – Field Exploration Description

S-23-94 Bridge Replacement over Suber Branch | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041163



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. 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.

### Cone Penetration Test (CPT) Soundings

Cone Penetration Test soundings were conducted in accordance with ASTM D5778 *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils*.

## **Downhole Shear Wave Velocity Test (DHT)**

One downhole seismic test was performed in a cased borehole drilled for this project. After the test boring was completed, the boring was filled with a fluid water/cement/bentonite grout and then a threaded PVC pipe casing (capped at the bottom end) was inserted into the borehole, providing a uniform bond between the soil and pipe exterior.

The downhole seismic test consisted of placing two downhole triaxial geophones at selected depth intervals in the borehole casing. The geophone was connected to a recording device (Seismic Source Daq Link 5 Seismograph) at the surface and clamped to the side of the casing at the selected test depth. The geophones are equipped with a spring-arm that is released at the bottom of the boring. The spring expands and forces the geophone against the casing wall. The interval between each geophone and each test depth was 3 feet for the entire depth of the cased borehole. An instrumented hammer was then used to strike a steel plate with cleats at the bottom (often called a shear wave golf shoe) that penetrated the ground and prevented sliding when struck. The steel plate was oriented to generate horizontal shear waves (SH) at the surface. An additional plate was also struck to better produce compression waves. The horizontal distance was measured and the plate was set exactly 10 feet from the borehole. The recorder was set to record the arrival times of the shear waves at the geophone locations. At least 15 blows (5 in each direction on the golf shoe, and 5 on the steel plate) were struck for each test depth to electronically stack and polarize the observed data, and to increase the signal-to-noise ratio. The data was stored on computer disks for processing and computation. The geophone was raised to the next depth interval and the process was repeated.

Shear Wave Velocity Test Results shows the downhole shear wave velocity and compressive wave velocity test results. The data was evaluated using the Fixed Interval method. S-wave arrival times using the Interval method were picked based on the onset of the signal (first break) as observed in the software package TomTime by GeoTom.

## 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
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>

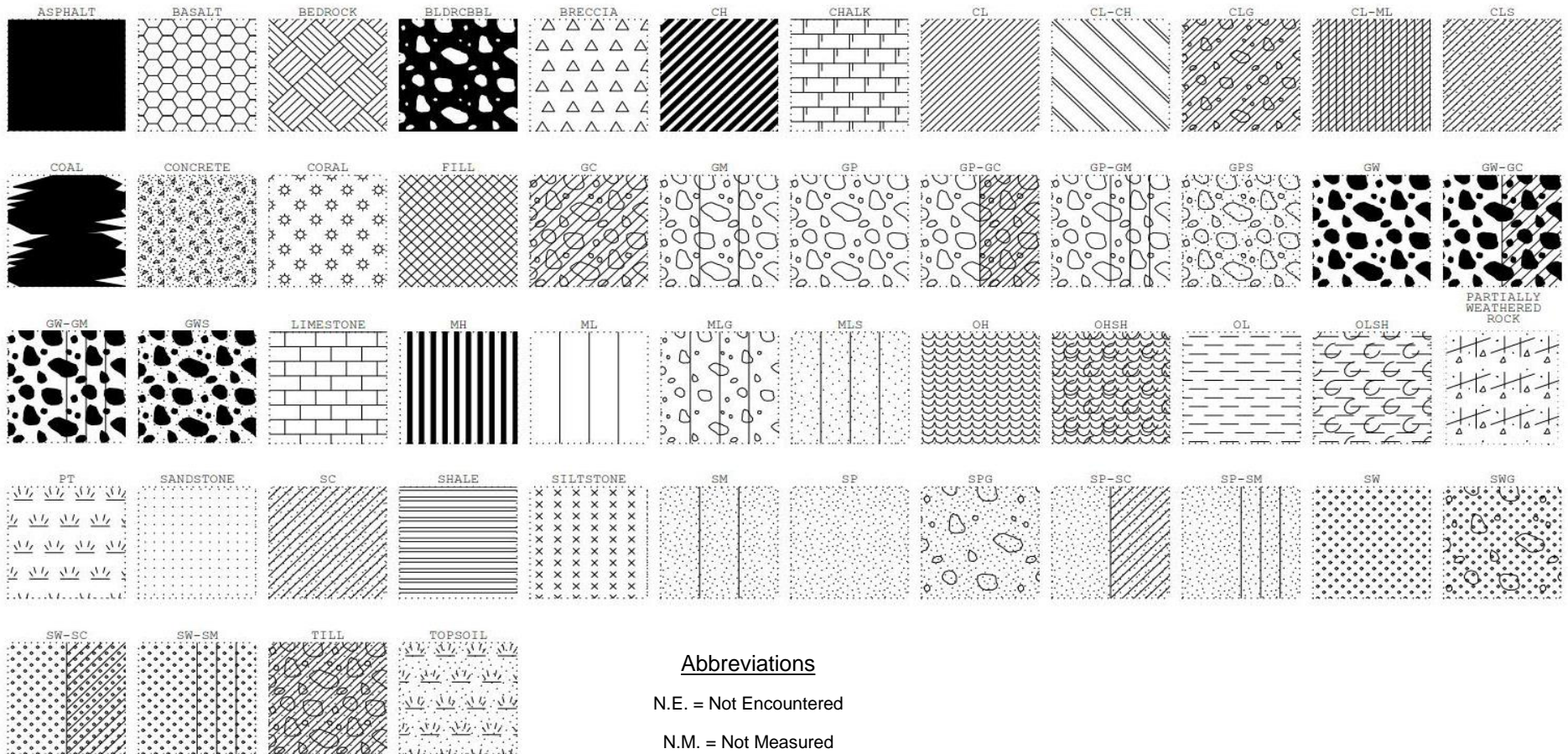
RQD, as a percentage	Diagnostic Description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

<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.



Project Manager:	MEM
Drawn by:	KJZ
Checked by:	SG
Approved by:	DJC

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



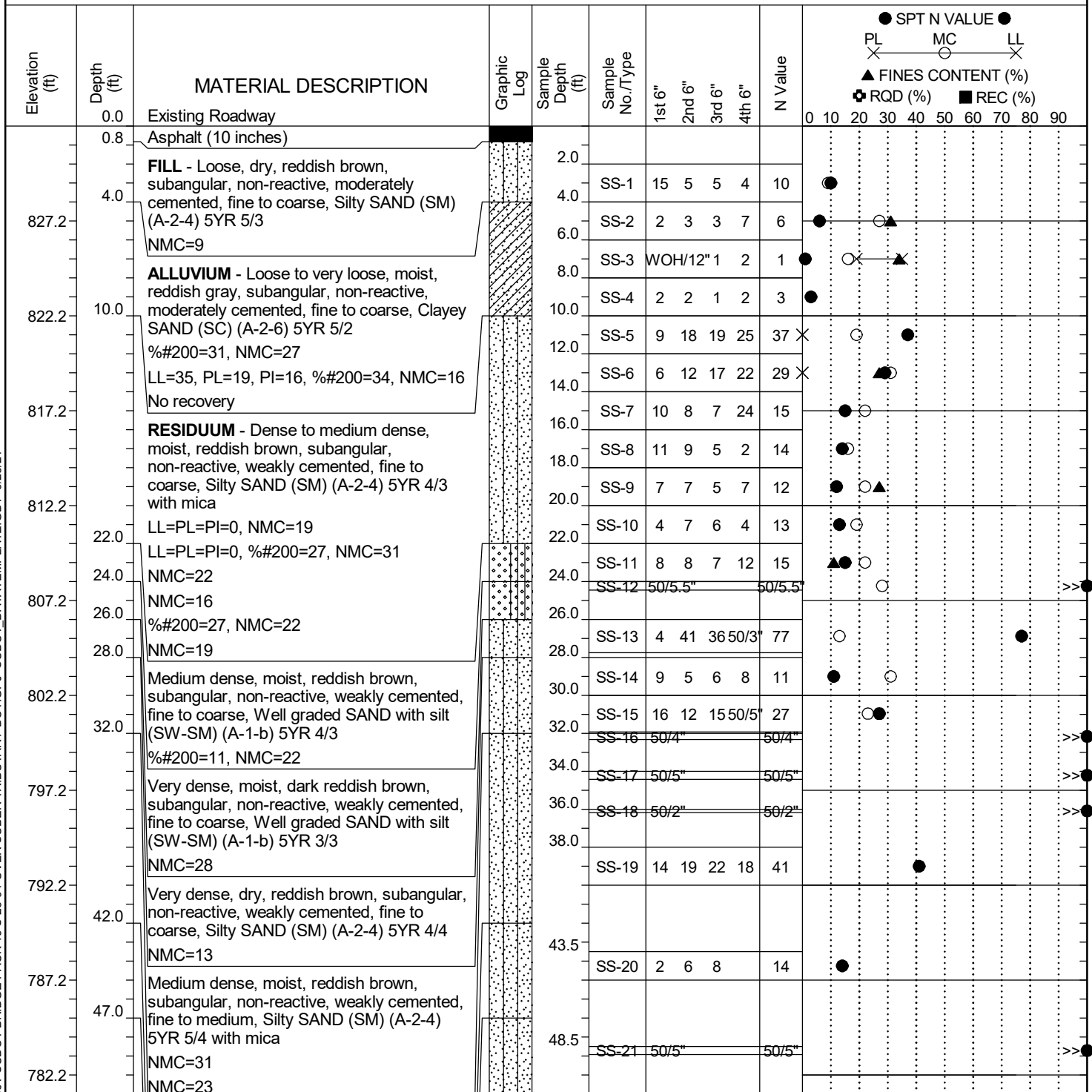
72 Pointe Circle  
PH. (864) 292-2901  
Greenville, SC 29615  
FAX. (864) 292-6361

## SOIL AND ROCK SYMBOLS

Exhibit A-8

# SCDOT Soil Test Log

<b>Project ID:</b>	P041163				<b>County:</b>	Greenville		<b>Boring No.:</b>	S-23-94-1	
<b>Site Description:</b>	S-23-94 BRO Suber Branch							<b>Route:</b>	S-23-94	
<b>Eng./Geo.:</b>	S. Greaber		<b>Boring Location:</b>	20+36		<b>Offset:</b>	13 L		<b>Alignment:</b>	Proposed
<b>Elev.:</b>	832.2 ft		<b>Latitude:</b>	34.9042042		<b>Longitude:</b>	-82.2527104		<b>Date Started:</b>	8/17/24
<b>Total Depth:</b>	86 ft		<b>Soil Depth:</b>	76 ft		<b>Core Depth:</b>	10 ft		<b>Date Completed:</b>	8/19/2024
<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.		24HR N.M.



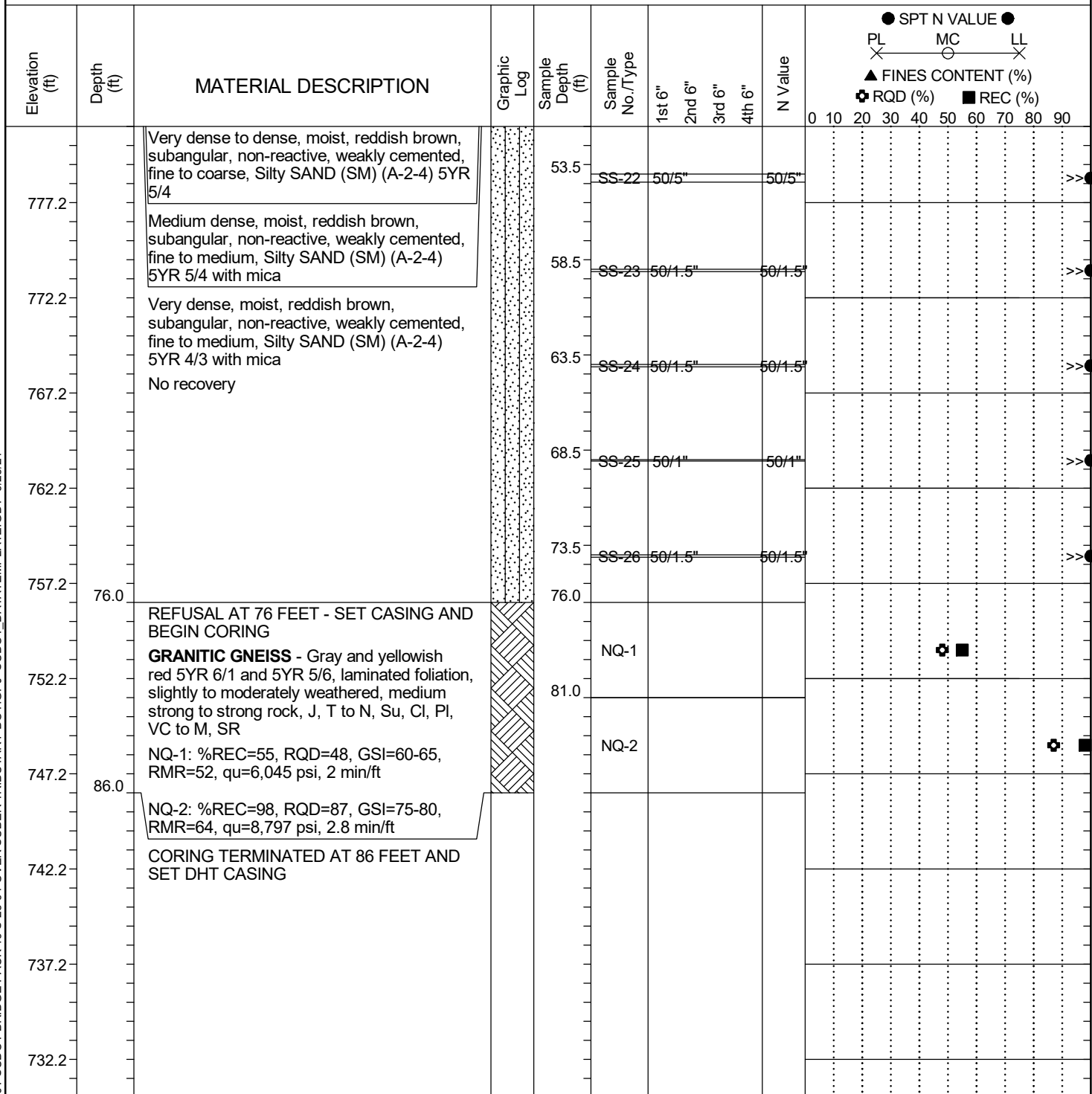
## LEGEND

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	

# SCDOT Soil Test Log

Project ID:		P041163			County:		Greenville		Boring No.:		S-23-94-1				
Site Description:		S-23-94 BRO Suber Branch								Route:		S-23-94			
Eng./Geo.:		S. Greaber		Boring Location:		20+36		Offset:		13 L		Alignment:		Proposed	
Elev.:		832.2 ft		Latitude:		34.9042042		Longitude:		-82.2527104		Date Started:		8/17/24	
Total Depth:		86 ft		Soil Depth:		76 ft		Core Depth:		10 ft		Date Completed:		8/19/2024	
Bore Hole Diameter (in):			4		Sampler Configuration			Liner Required:		Y (N)		Liner Used:		Y (N)	
Drill Machine:		DR#1327		Drill Method:		RW/RC		Hammer Type:		Automatic		Energy Ratio:		92.6%	
Core Size:		NQ2		Driller:		B. Burnette		Groundwater:		TOB N.M.		24HR		N.M.	



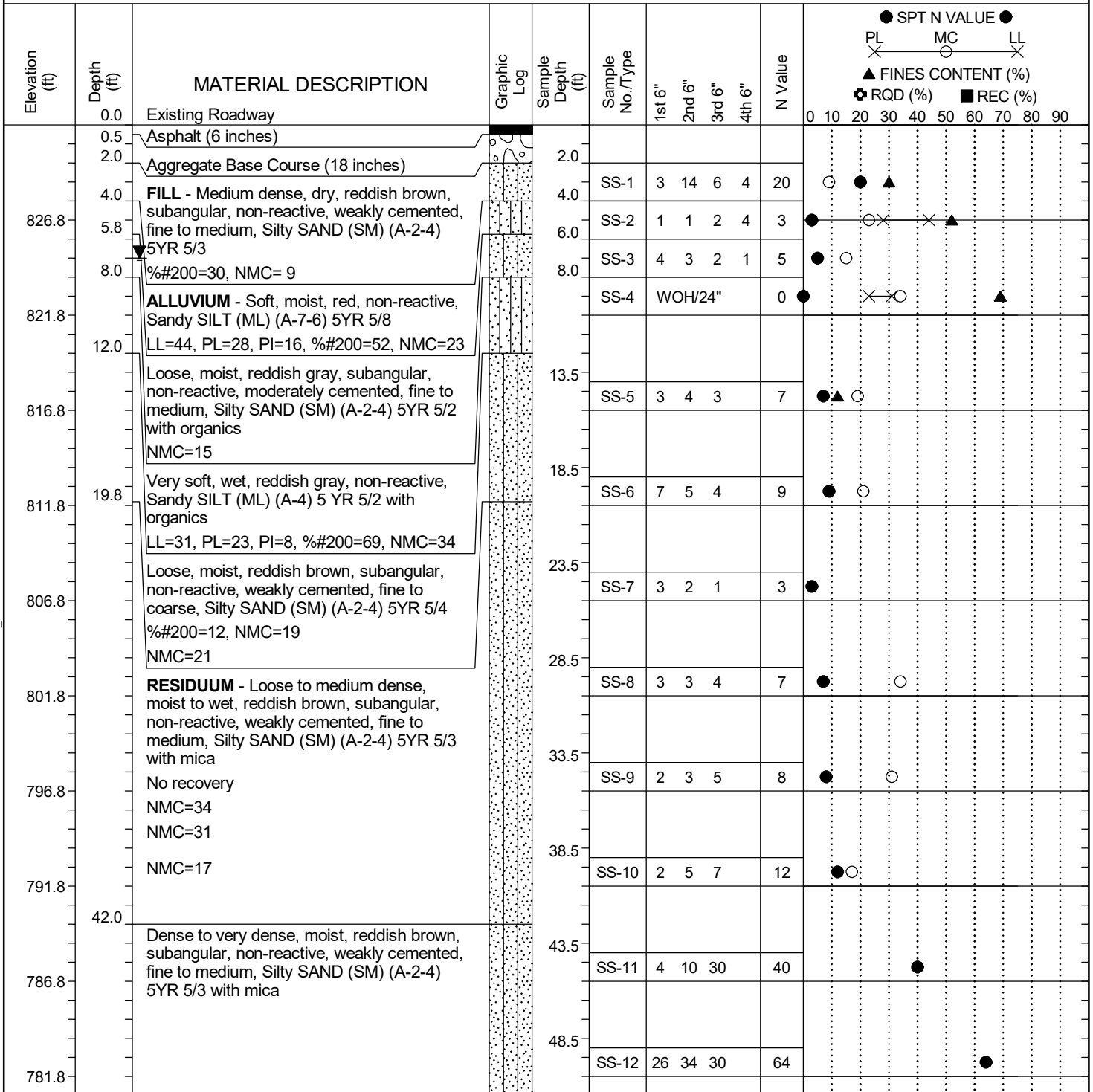
## LEGEND

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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-94 OVER SUBER TRIBUTARY.DOT.GPJ SCDOT\_DATATEMPLATE.GDT 9/23/24

# SCDOT Soil Test Log

Project ID: P041163				County: Greenville		Boring No.: S-23-94-2		
Site Description:		S-23-94 BRO Suber Branch					Route: S-23-94	
Eng./Geo.: S. Greaber		Boring Location: 20+95		Offset: 12 L		Alignment: Proposed		
Elev.: 831.8 ft		Latitude: 34.9043134		Longitude: -82.2525656		Date Started: 6/7/24		
Total Depth: 93.5 ft		Soil Depth: 63.5 ft		Core Depth: 30 ft		Date Completed: 6/14/2024		
Bore Hole Diameter (in): 4		Sampler Configuration		Liner Required: Y (N)		Liner Used: Y (N)		
Drill Machine: DR#554		Drill Method: RW/RC		Hammer Type: Automatic		Energy Ratio: 88.5%		
Core Size: NQ2		Driller: B. Burnette		Groundwater: TOB N.M.		24HR: 7 ft		



## LEGEND

Continued Next Page

<b>SAMPLER TYPE</b>		<b>DRILLING METHOD</b>	
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	

# SCDOT Soil Test Log

Project ID:		P041163			County:		Greenville		Boring No.:		S-23-94-2				
Site Description:			S-23-94 BRO Suber Branch							Route:		S-23-94			
Eng./Geo.:		S. Greaber		Boring Location:		20+95		Offset:		12 L		Alignment:		Proposed	
Elev.:		831.8 ft		Latitude:		34.9043134		Longitude:		-82.2525656		Date Started:		6/7/24	
Total Depth:		93.5 ft		Soil Depth:		63.5 ft		Core Depth:		30 ft		Date Completed:		6/14/2024	
Bore Hole Diameter (in):			4		Sampler Configuration			Liner Required:		Y (N)		Liner Used:		Y (N)	
Drill Machine:		DR#554		Drill Method:		RW/RC		Hammer Type:		Automatic		Energy Ratio:		88.5%	
Core Size:		NQ2		Driller:		B. Burnette		Groundwater:		TOB N.M.		24HR		7 ft	

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	<div> ● SPT N VALUE ●  PL X MC X LL X  ▲ FINES CONTENT (%)  ⊕ RQD (%) ■ REC (%) </div>
776.8	52.0	Medium dense, moist, reddish yellow, subangular, non-reactive, weakly cemented, fine to medium, Silty SAND (SM) (A-2-4) 5YR 7/6		53.5	SS-13	21	18	10		28	●
771.8	57.0	Very dense, moist, yellowish red, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4) 5YR 5/8		58.5	SS-14	50/4"			50/4"		●
766.8	63.5	REFUSAL AT 63.5 FEET - SET CASING AND BEGIN CORING		63.4	SS-15	50/0.5"			50/0.5"		●
761.8		<b>GRANITIC GNEISS</b> - Yellowish red and gray 5YR 5/6 and 5YR 6/1, laminated foliation, slightly to highly weathered, medium strong to strong rock, J, T to N, No, No, Pl, C to W, SR		63.5							
756.8		NQ-1: %REC=70, RQD=27, GSI=60-65, 1.23 min/ft			NQ-1						⊕
751.8		NQ-2: %REC=67, RQD=37, GSI=60-65, RMR=55, qu=9,104 psi, 1.0 min/ft		68.5	NQ-2						⊕
746.8		NQ-3: %REC=75, RQD=58, GSI=65-70, 1.0 min/ft		73.5	NQ-3						⊕
741.8		NQ-4: %REC=90, RQD=49, GSI=60-65, RMR=52, qu=4,264 psi, 1.1 min/ft		78.5	NQ-4						⊕
736.8		NQ-5: %REC=100, RQD=73, GSI=75-80, 1.5 min/ft		83.5	NQ-5						⊕
731.8		NQ-6: %REC=100, RQD=95, GSI=85-90, RMR=77, qu=10,191 psi, 2.1 min/ft		88.5	NQ-6						⊕
	93.5	CORING TERMINATED AT 93.5 FEET									⊕

## LEGEND

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

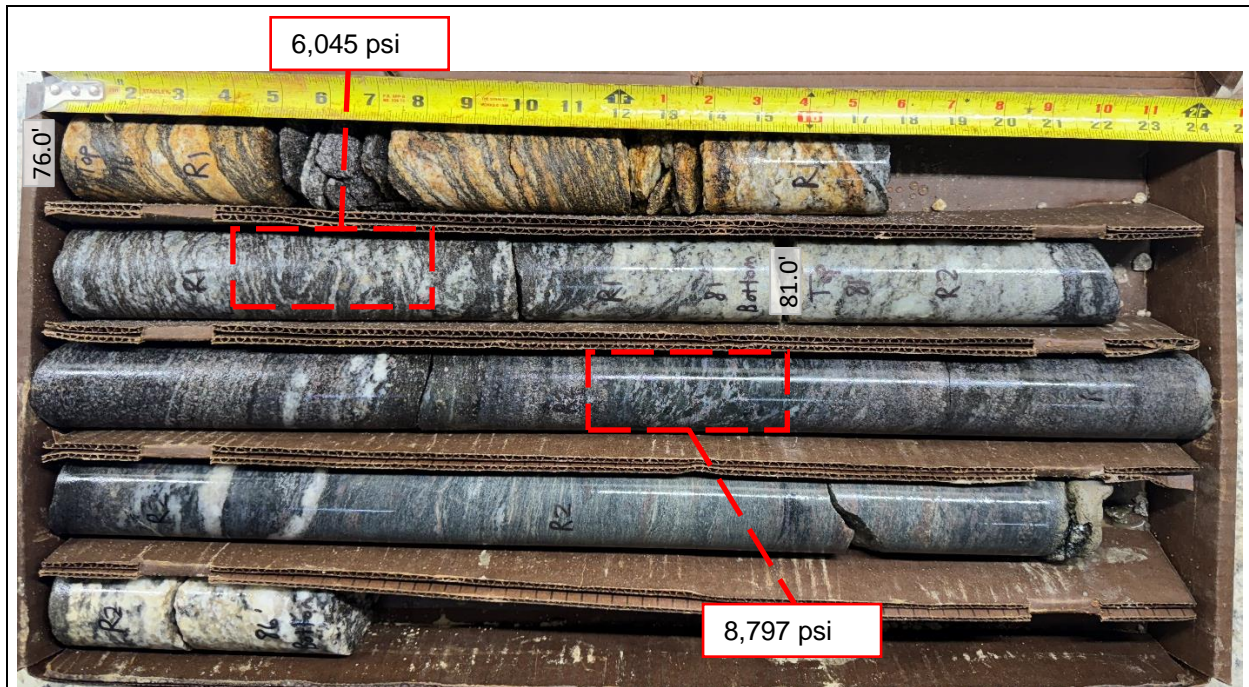
SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-94 OVER SUBER TRIBUTARY.DOT.GPJ SCDOT\_DATATEMPLATE.GDT 9/23/24



**Rock Core Photograph Logs – Exhibit A-10**

S-23-94 BRO Suber Branch | Greenville County, SC

Terracon Project No. 8623P180 | SCDOT Project ID: P041163



S-23-94-1, NQ-1 and NQ-2 (76 to 86 feet)



S-23-94-2, NQ-1 and NQ-2 (63.5 to 73.5 feet)



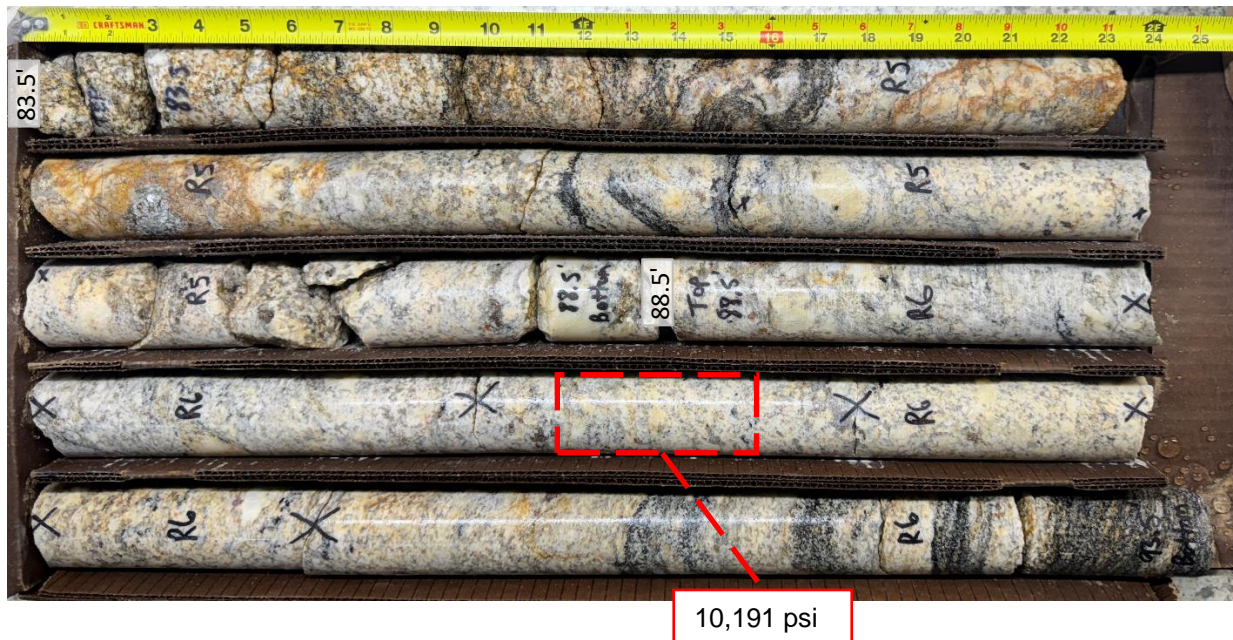
**Rock Core Photograph Logs – Exhibit A-10**

S-23-94 BRO Suber Branch | Greenville County, SC

Terracon Project No. 8623P180 | SCDOT Project ID: P041163



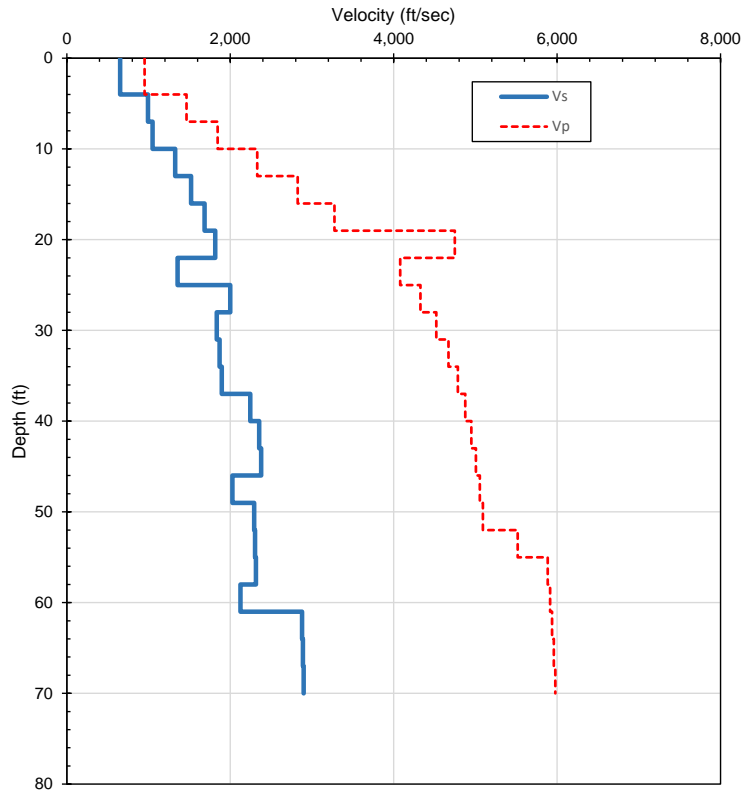
S-23-94-2, NQ-3 and NQ-4 (73.5 to 83.5 feet)



S-23-94-2, NQ-5 and NQ-6 (83.5 to 93.5 feet)




# Downhole Seismic Velocity Fixed Interval Method



Depth (ft)	Vp (ft/sec)	Vs (ft/sec)	$\Delta i$ (ft)	$\Delta t$ (sec)	Est. In-Situ Unit Wt (pcf)
4	951	652	4	0.00613	100
7	1463	992	3	0.00302	
10	1846	1049	3	0.00286	
13	2329	1325	3	0.00226	
16	2825	1520	3	0.00197	125
19	3276	1685	3	0.00178	
22	4748	1817	3	0.00165	
25	4080	1356	3	0.00221	
28	4328	1998	3	0.00150	130
31	4520	1834	3	0.00164	
34	4669	1869	3	0.00161	125
37	4786	1896	3	0.00158	
40	4877	2244	3	0.00134	130
43	4949	2353	3	0.00127	
46	5007	2376	3	0.00126	
49	5054	2027	3	0.00148	130
52	5092	2293	3	0.00131	
55	5518	2304	3	0.00130	
58	5884	2314	3	0.00130	
61	5913	2125	3	0.00141	
64	5938	2879	3	0.00104	
67	5960	2889	3	0.00104	
70	5978	2898	3	0.00104	
100					

1. Assuming shear wave of 2,890 ft/s for rock below 70 feet.

Project Mgr: MM	Project No. 8623P180	 <p>Consulting Engineers and Scientists</p> <p>72 Pointe Circle Ph: (864) 292-2901</p> <p>Greenville, South Carolina Fax: (864) 292-6361</p>	<h2>GEOPHYSICAL TESTING RESULTS</h2> <h3>DOWNHOLE SEISMIC TEST</h3> <p><b>S-23-94 (Hammett Bridge Road) Bridge Replacement over Suber Branch</b></p> <p><b>GREENVILLE COUNTY, SOUTH CAROLINA</b></p> <p><b>P041163</b></p>	<p>TEST NO. S-23-94-1</p> <p>EXHIBIT A-11</p>
Prepared by: MM	Scale: NA			
Checked by: SG	Date: 9/12/2024			
Approved by:				

# CPT Sounding ID S-23-94-1C

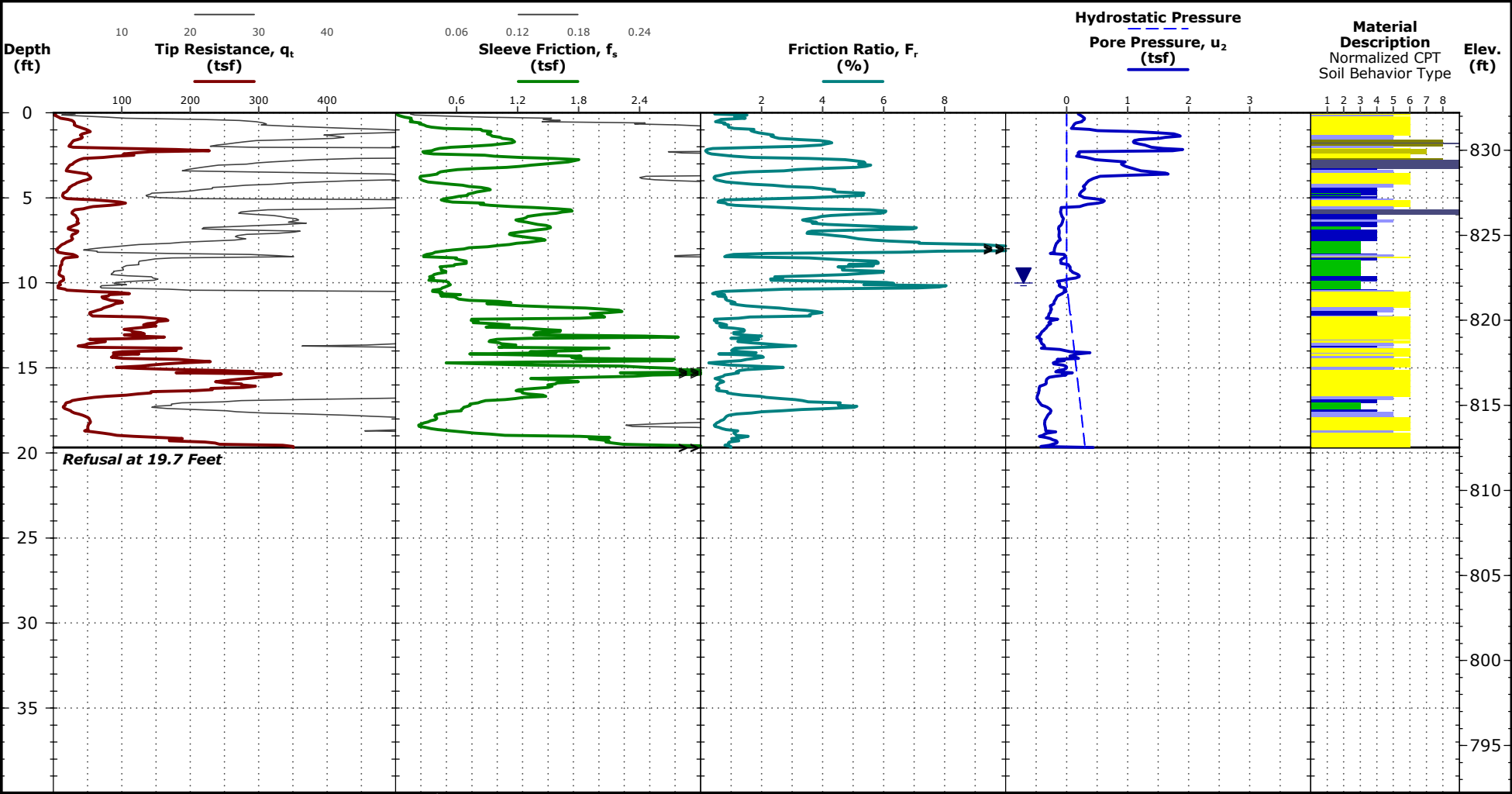


72 Pointe Cir  
Greenville, SC

Elevation: 832.2 (ft)  
Elevation Reference: Elevations were provided by others.

Latitude: 34.904213° Longitude: -82.252698°  
Station: 20+41 Offset: 13 L

CPT Started: 8/21/2024  
CPT Completed: 8/21/2024



See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data, if any.  
See [Supporting Information](#) for explanation of symbols and abbreviations.

## Notes

Test Location: See [Exploration Plan](#)

## CPT Equipment

CPT Rig: CR#CPT03  
Operator: AM/BR  
CPT sensor calibration reports available upon request  
Probe No. 6025 with net area ratio of .84  
Manufactured by Geoprobe Systems- Calibrated 4/17/2024  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>

## Water Level Observation

▼ 10 ft estimated water depth  
(used in normalizations and correlations)

## Normalized Soil Behavior Type (Robertson 1990)

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

# CPT Sounding ID S-23-94-2C

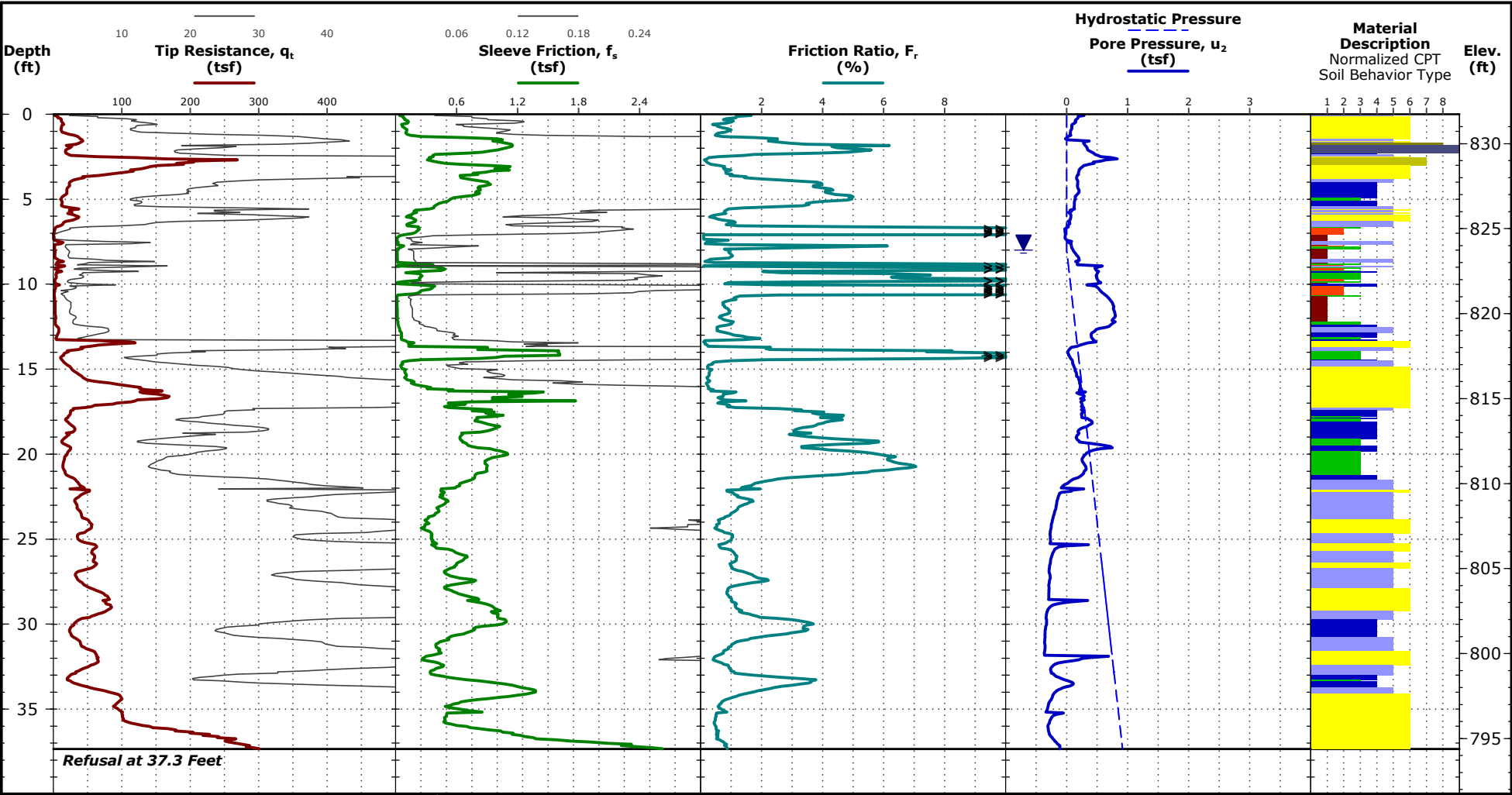


72 Pointe Cir  
Greenville, SC

Elevation: 831.73 (ft)  
Elevation Reference: Elevations were provided by others.

Latitude: 34.904323° Longitude: -82.252556°  
Station: 20+99 Offset: 12 L

CPT Started: 8/21/2024  
CPT Completed: 8/21/2024



See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data, if any.  
See [Supporting Information](#) for explanation of symbols and abbreviations.

**Notes**  
Test Location: See [Exploration Plan](#)

**CPT Equipment**  
CPT Rig: CR#CPT03  
Operator: AM/BR  
CPT sensor calibration reports available upon request  
Probe No. 6025 with net area ratio of .84  
Manufactured by Geoprobe Systems- Calibrated 4/17/2024  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>

**Water Level Observation**  
8 ft estimated water depth  
(used in normalizations and correlations)

**Normalized Soil Behavior Type (Robertson 1990)**

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

## **Appendix B – Laboratory Testing**

S-23-94 Bridge Replacement over Suber Branch | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041163



# **Appendix B**

## **Laboratory Testing**

Exhibit B-1 – Laboratory Testing Description  
Summary of Laboratory Data (2 Pages)  
Laboratory Data Sheets (21 Pages)

Note: All exhibits are one page unless noted above.

## Exhibit B-1 – Laboratory Testing Description

S-23-94 Bridge Replacement over Suber Branch | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041163



### Laboratory Testing Description

The samples collected during the field exploration were taken to our laboratory for additional testing. The laboratory testing scope was developed by the SCDOT and laboratory assignment was performed by Terracon. The laboratory tests were conducted on selected soil samples from the borings and the bulk sample locations. The test results are presented in this appendix.

The laboratory test results were used to confirm the soil descriptions presented on the boring logs in Appendix A. Laboratory tests were performed in general accordance with the applicable ASTM, AASHTO, SCDOT or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

■ Rock Compressive Strength	ASTM D7012
■ Moisture Content	AASHTO T265/(ASTM D2216)
■ Atterberg Limits	AASHTO T89/T90(ASTM D4318)
■ Wash 200	AASHTO T11/(ASTM D1140)
■ Proctor (Standard effort)	AASHTO T99/ (ASTM D698)
■ Triaxial Shear CU w/ PP	AASHTO T297/(ASTM D4767)
■ Grain Size Distribution	ASTM D6913
■ Hydrometer	ASTM D7928
■ Corrosion Series	AASHTO D422
	AASHTO T289/ASTM G51
	AASHTO T290/ASTM C1580
	AASHTO T291

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-23-94-1	2-4	SILTY SAND(SM) / A-2-4									9.0	
S-23-94-1	4-6	CLAYEY SAND(SC) / A-2-6				3.7	65.8	30.5			27.3	
S-23-94-1	6-8	CLAYEY SAND(SC) / A-2-6 (1)	35	19	16	0.0	65.8	34.1	14.7	19.4	16.2	
S-23-94-1	10-12	SILTY SAND(SM) / A-2-4	NP	NP	NP						18.8	
S-23-94-1	12-14	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	0.0	72.9	27.1	20.6	6.5	30.8	
S-23-94-1	14-16	SILTY SAND(SM) / A-2-4									21.6	
S-23-94-1	16-18	SILTY SAND(SM) / A-2-4									15.9	
S-23-94-1	18-20	SILTY SAND(SM) / A-2-4				1.1	72.3	26.6			21.5	
S-23-94-1	20-22	SILTY SAND(SM) / A-2-4									18.5	
S-23-94-1	22-24	WELL-GRADED SAND with SILT / A-1-B				1.4	87.3	11.3			22.4	
S-23-94-1	24-24.46	WELL-GRADED SAND with SILT / A-1-B									27.5	
S-23-94-1	26-27.75	SILTY SAND(SM) / A-2-4									12.7	
S-23-94-1	28-30	SILTY SAND(SM) / A-2-4									30.6	
S-23-94-1	30-32	SILTY SAND(SM) / A-2-4									23.2	
S-23-94-2	2-4	SILTY SAND(SM) / A-2-4				0.3	69.5	30.3			8.7	
S-23-94-2	4-6	SANDY SILT(ML) / A-7-6 (6)	44	28	16	0.0	47.6	52.4	15.9	36.6	22.9	
S-23-94-2	6-8	SILTY SAND(SM) / A-2-4									14.7	
S-23-94-2	8-10	SANDY SILT(ML) / A-4 (4)	31	23	8	0.0	31.2	68.8	35.8	33.1	33.7	
S-23-94-2	13.5-15	SILTY SAND(SM) / A-2-4				3.1	84.8	12.1			18.9	

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-23-94-2	18.5-20	SILTY SAND(SM) / A-2-4									21.0	
S-23-94-2	28.5-30	SILTY SAND(SM) / A-2-4									34.2	
S-23-94-2	33.5-35	SILTY SAND(SM) / A-2-4									31.4	
S-23-94-2	38.5-40	SILTY SAND(SM) / A-2-4									16.9	
S-23-94-2 Offset	0-5	CLAYEY SAND(SC) / A-2-4 (0)	33	23	10	2.2	68.4	29.4				115.7 / 13.0



# INDEX PROPERTIES VERSUS DEPTH

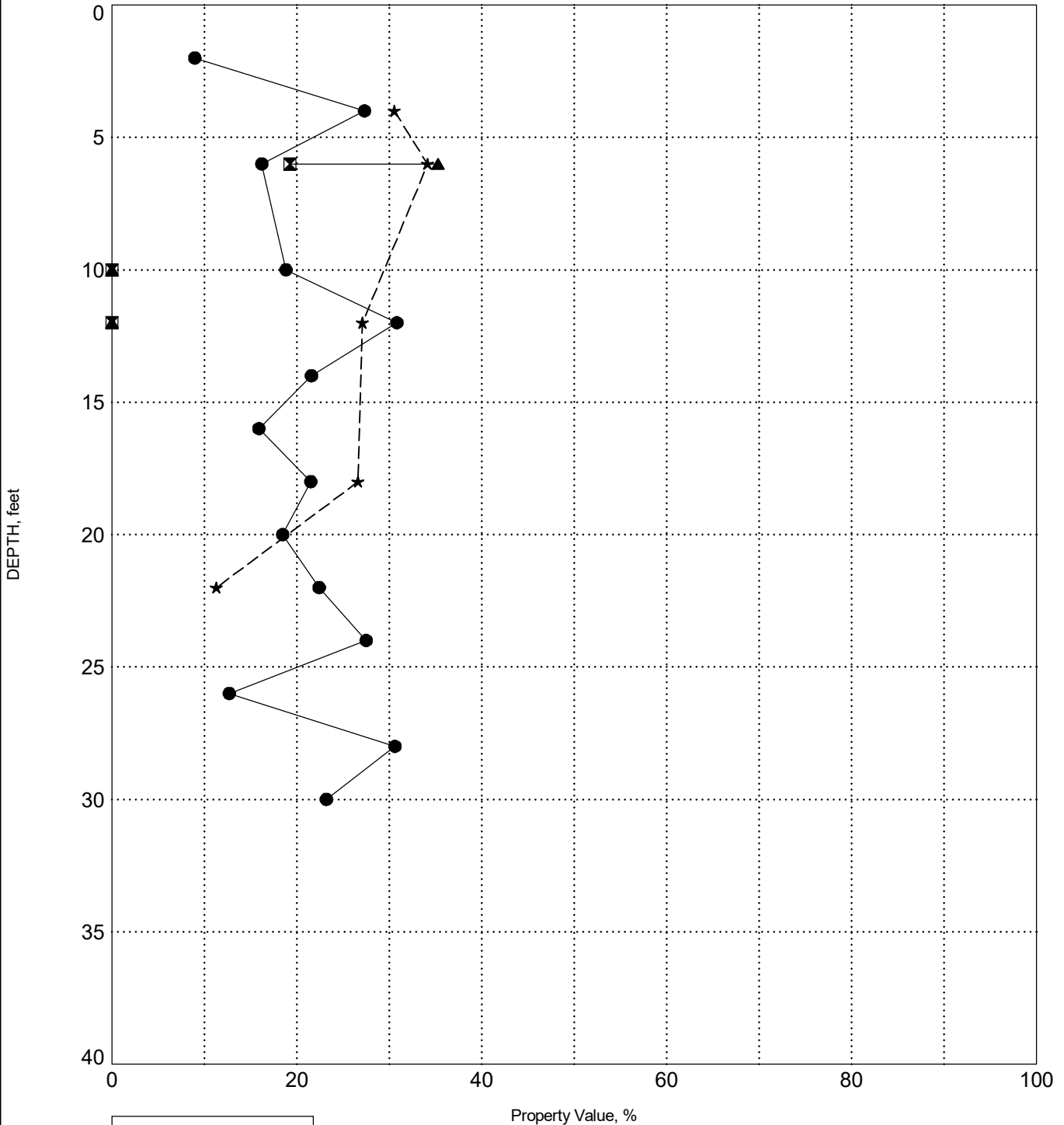
PROJECT ID P041163

PROJECT NAME S-23-94 BRO Suber Branch

PROJECT COUNTY Greenville

SURFACE ELEVATION: 832.2

## BORING S-23-94-1



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





# INDEX PROPERTIES VERSUS DEPTH

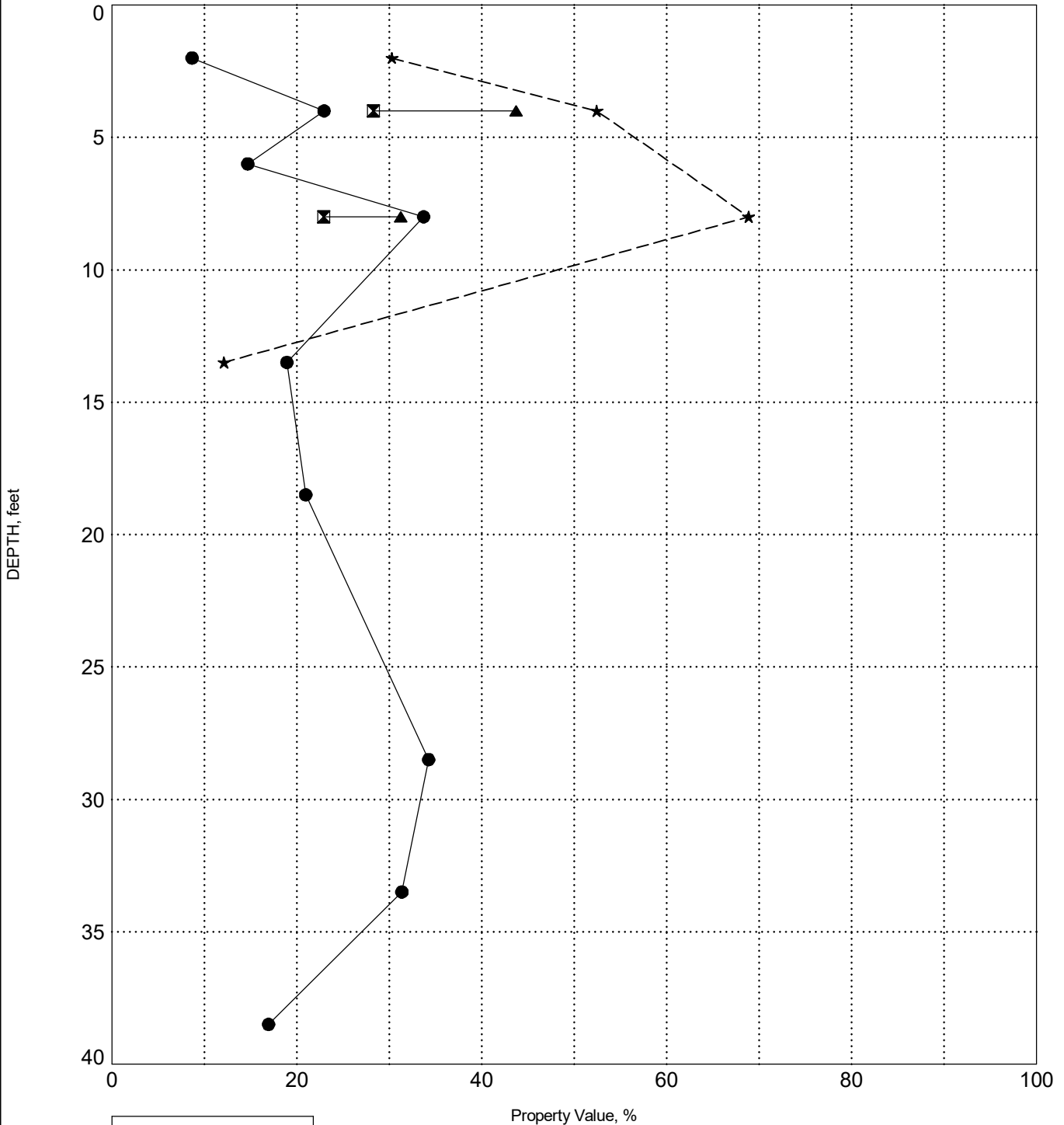
PROJECT ID P041163

PROJECT NAME S-23-94 BRO Suber Branch

PROJECT COUNTY Greenville

SURFACE ELEVATION: 831.8

## BORING S-23-94-2



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



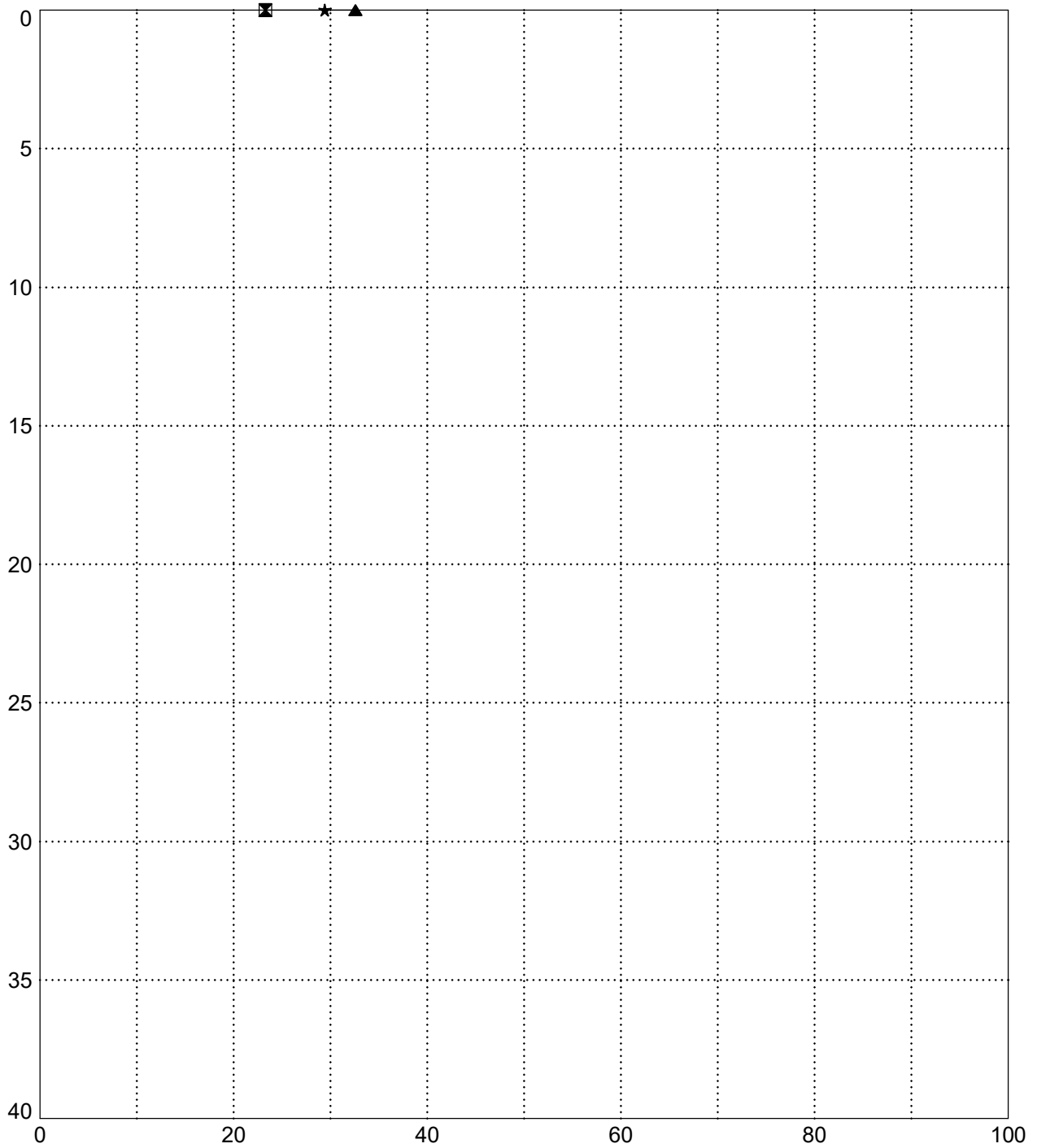
# INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041163

PROJECT NAME S-23-94 BRO Suber Branch

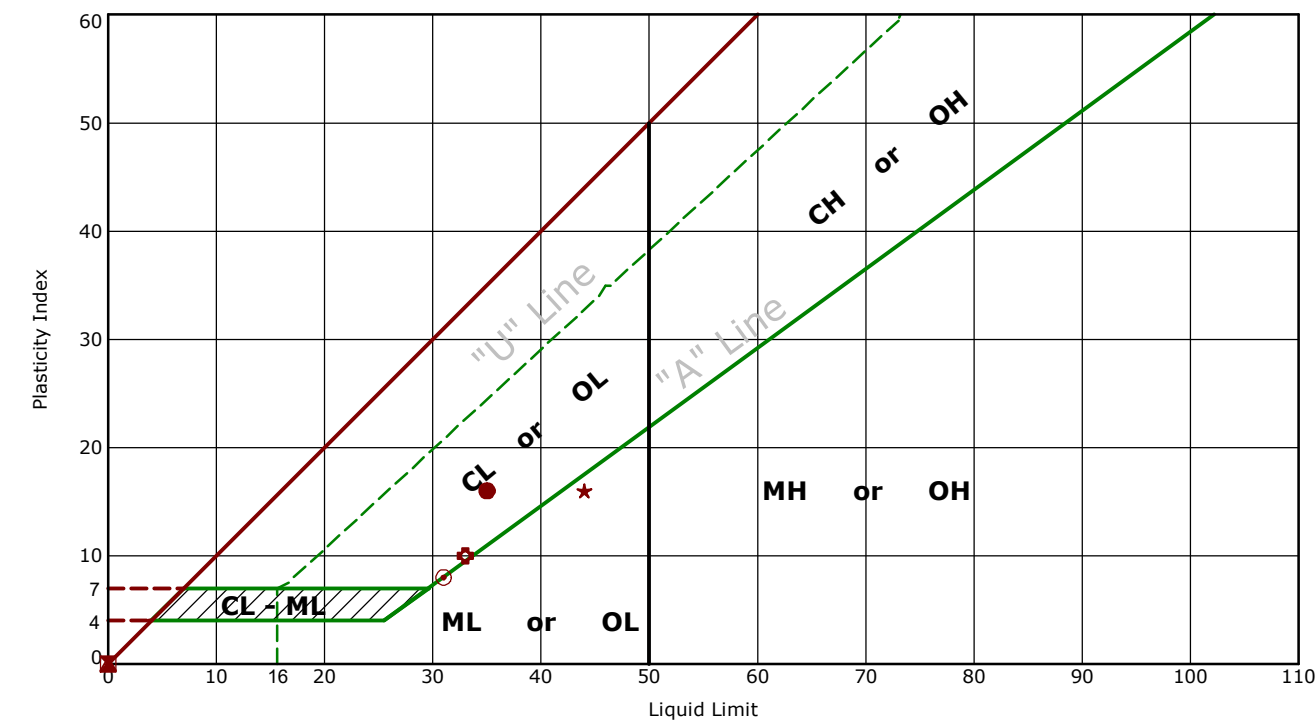
PROJECT COUNTY Greenville

## BORING S-23-94-2 Offset



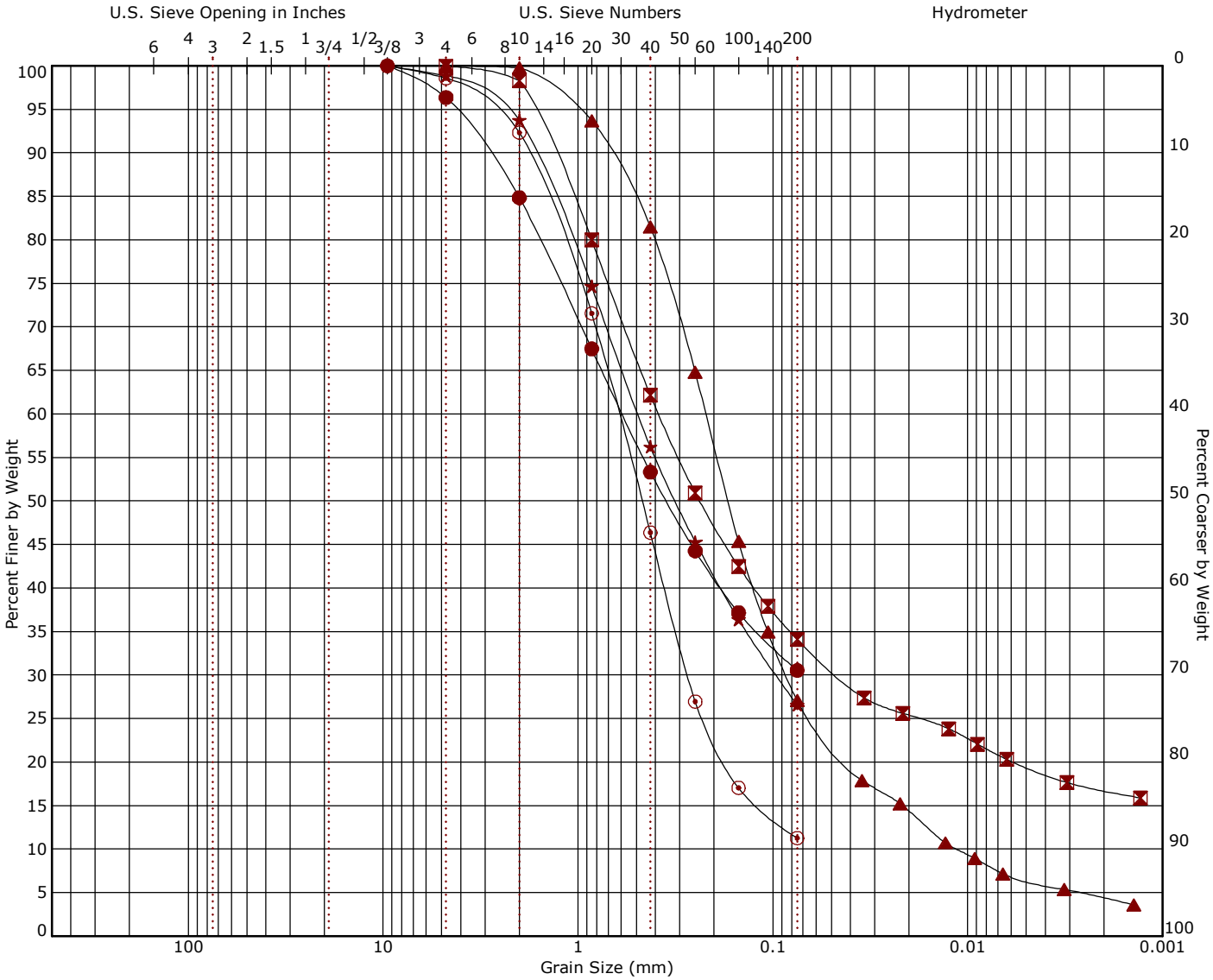
LEGEND	
●	Water Content
⊠	Plastic Limit
▲	Liquid Limit
★	Fines

Atterberg Limit Results  
ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	AASHTO	Description
●	S-23-94-1	6 - 8	35	19	16	34.1	A-2-6 (1)	CLAYEY SAND
⊠	S-23-94-1	10 - 12	NP	NP	NP		A-2-4	SILTY SAND
▲	S-23-94-1	12 - 14	NP	NP	NP	27.1	A-2-4 (0)	SILTY SAND
★	S-23-94-2	4 - 6	44	28	16	52.4	A-7-6 (6)	SANDY SILT
⊙	S-23-94-2	8 - 10	31	23	8	68.8	A-4 (4)	SANDY SILT
⊕	S-23-94-2 Offset	0 - 5	33	23	10	29.4	A-2-4 (0)	CLAYEY SAND

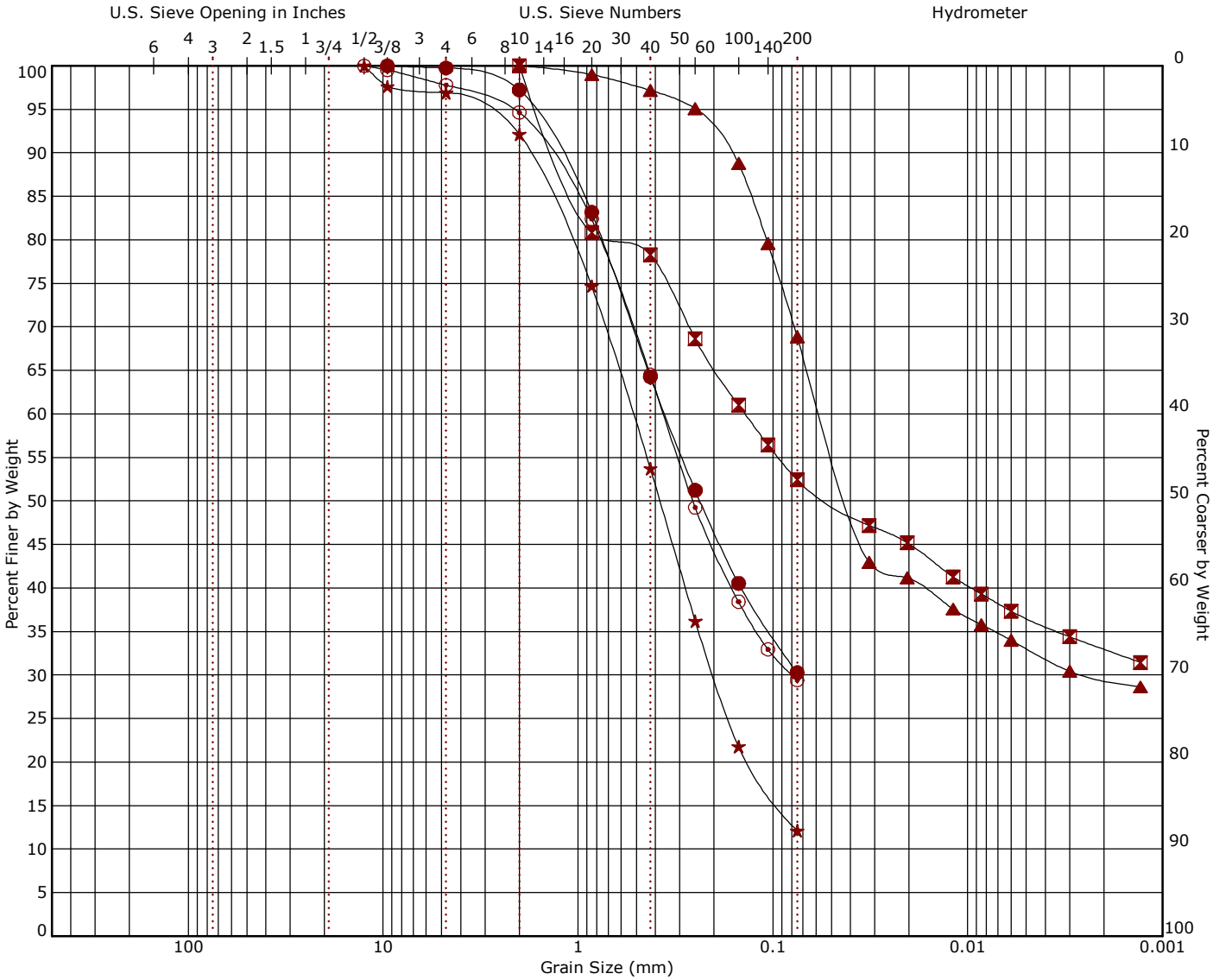
Grain Size Distribution  
ASTM D422 / ASTM C136



	Cobbles	Gravel		Sand			Silt or Clay				
		coarse	fine	coarse	medium	fine					
Boring ID	Depth (Ft)	USCS Classification			USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-94-1	4 - 6	CLAYEY SAND			SC	A-2-6					
☒ S-23-94-1	6 - 8	CLAYEY SAND			SC	A-2-6 (1)	35	19	16		
▲ S-23-94-1	12 - 14	SILTY SAND			SM	A-2-4 (0)	NP	NP	NP	2.93	19.53
★ S-23-94-1	18 - 20	SILTY SAND			SM	A-2-4					
⊙ S-23-94-1	22 - 24	WELL-GRADED SAND with SILT			SW-SM	A-1-b				1.85	9.60
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-23-94-1	4 - 6	9.5	0.589			0.0	3.7	65.8	30.5		
☒ S-23-94-1	6 - 8	4.75	0.384	0.046				65.8		14.7	19.4
▲ S-23-94-1	12 - 14	4.75	0.22	0.085	0.011	0.0	0.0	72.9		20.6	6.5
★ S-23-94-1	18 - 20	9.5	0.49	0.095		0.0	1.1	72.3	26.6		
⊙ S-23-94-1	22 - 24	9.5	0.618	0.272		0.0	1.4	87.3	11.3		



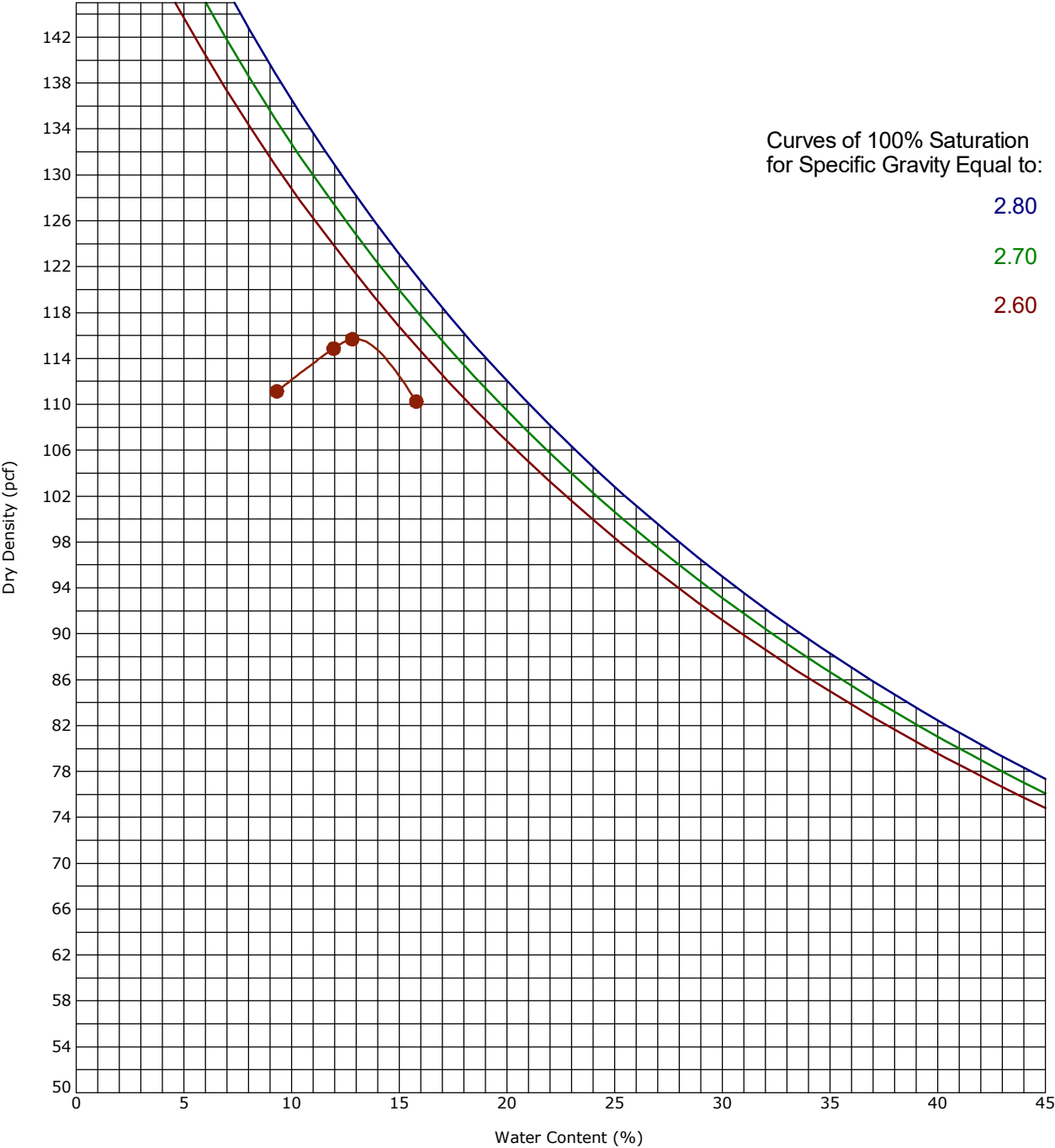
Grain Size Distribution  
ASTM D422 / ASTM C136



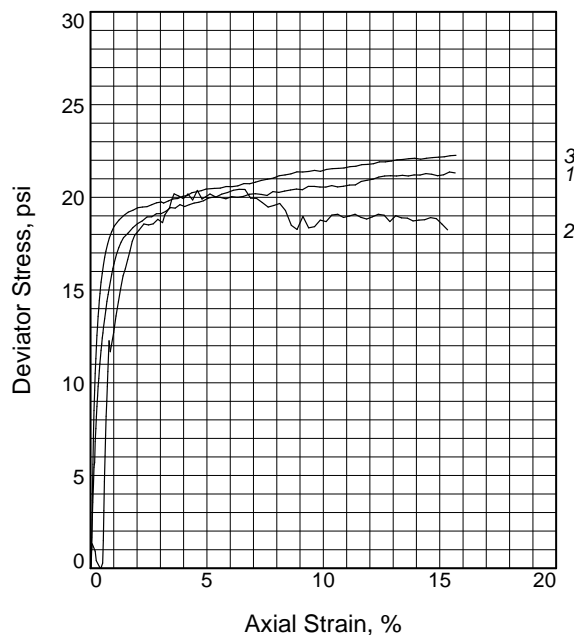
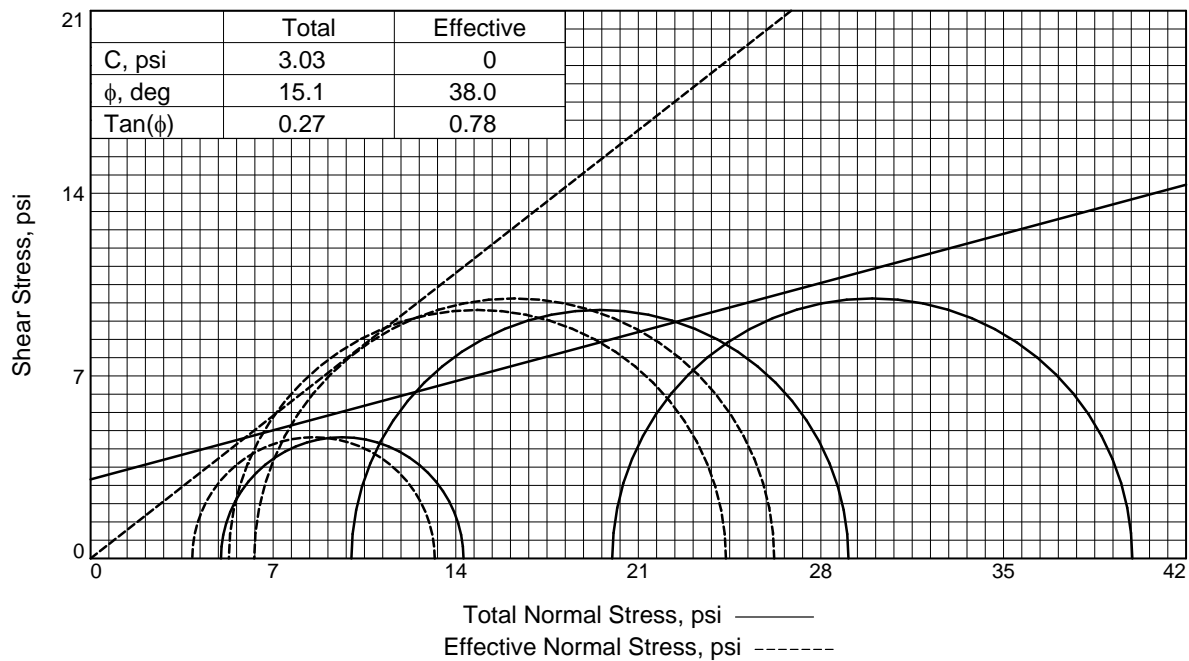
	Cobbles	Gravel		Sand			Silt or Clay				
		coarse	fine	coarse	medium	fine					
Boring ID	Depth (Ft)	USCS Classification			USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-94-2	2 - 4	SILTY SAND			SM	A-2-4					
▣ S-23-94-2	4 - 6	SANDY SILT			ML	A-7-6 (6)	44	28	16		
▲ S-23-94-2	8 - 10	SANDY SILT			ML	A-4 (4)	31	23	8		
★ S-23-94-2	13.5 - 15	SILTY SAND			SM	A-2-4				1.20	8.12
⊗ S-23-94-2 Offset	0 - 5	CLAYEY SAND			SC	A-2-4 (0)	33	23	10		
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-23-94-2	2 - 4	9.5	0.357			0.0	0.3	69.5	30.3		
▣ S-23-94-2	4 - 6	2	0.139			0.0	0.0	47.6		15.9	36.6
▲ S-23-94-2	8 - 10	2	0.056	0.002		0.0	0.0	31.2		35.8	33.1
★ S-23-94-2	13.5 - 15	12.5	0.523	0.201		0.0	3.1	84.8	12.1		
⊗ S-23-94-2 Offset	0 - 5	12.5	0.363	0.079		0.0	2.2	68.4	29.4		

# Moisture-Density Relationship

ASTM D698-Method B



Boring ID		Depth (Ft)		Description of Materials			
S-23-94-2 Offset		0 - 5		CLAYEY SAND(SC)			
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)
29	0.0	33	23	10	ASTM D698-Method B	115.7	13.0



Sample No.		1	2	3
Initial	Water Content, %	12.9	12.8	13.0
	Dry Density, pcf	110.2	110.3	110.2
	Saturation, %	65.6	65.5	66.1
	Void Ratio	0.5290	0.5278	0.5291
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.62	5.62	5.62
At Test	Water Content, %	16.9	17.1	16.8
	Dry Density, pcf	115.7	115.3	115.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4574	0.4624	0.4540
	Diameter, in.	2.74	2.73	2.74
	Height, in.	5.56	5.64	5.55
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		9.3	19.1	19.9
Excess Pore Pr., psi		1.1	4.7	13.7
Ult. Stress, psi		21.2	18.6	22.2
Excess Pore Pr., psi		-2.4	3.8	12.9
$\bar{\sigma}_1$ Failure, psi		13.2	24.4	26.2
$\bar{\sigma}_3$ Failure, psi		3.9	5.3	6.3

#### Type of Test:

CU with Pore Pressures

**Sample Type:** Shelby Tube

**Description:** Clayey Sand (SC)

**LL=** 26

**PL=** 17

**PI=** 9

**Specific Gravity=** 2.7

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

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

**Client:** HNTB North Carolina PC

**Project:** S-23-94 (Hammett Bridge Road) BRO Suber Branch

**Source of Sample:** S-23-94-2 Offset **Depth:** 1-5'

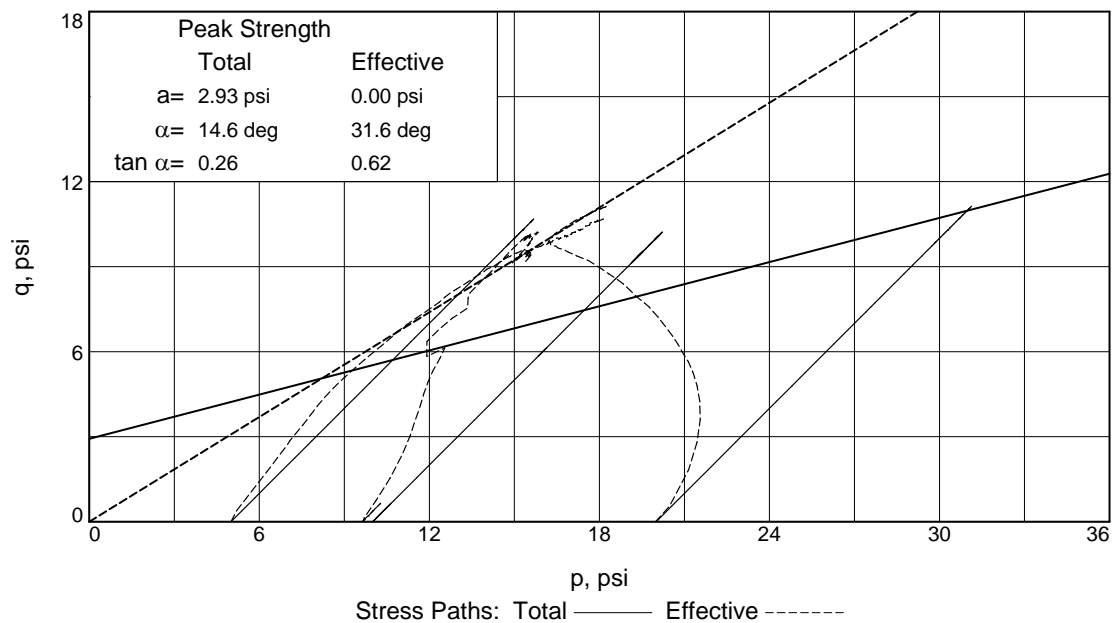
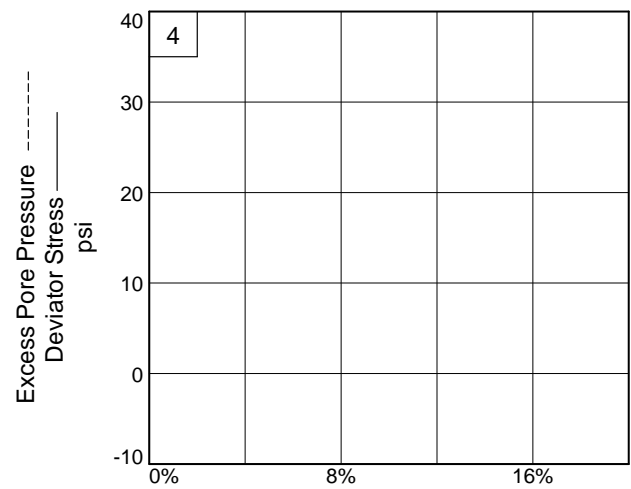
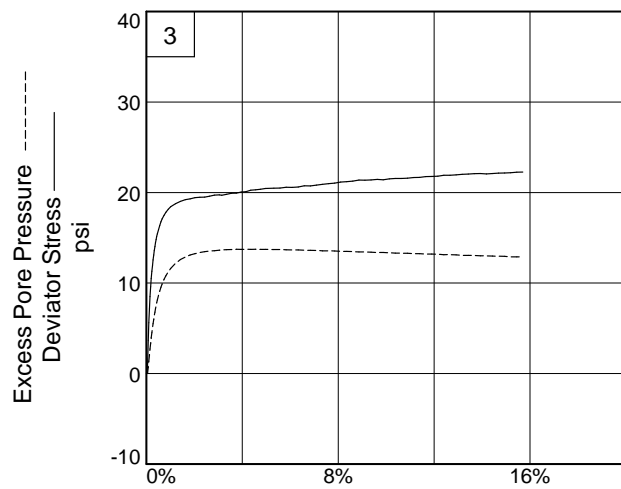
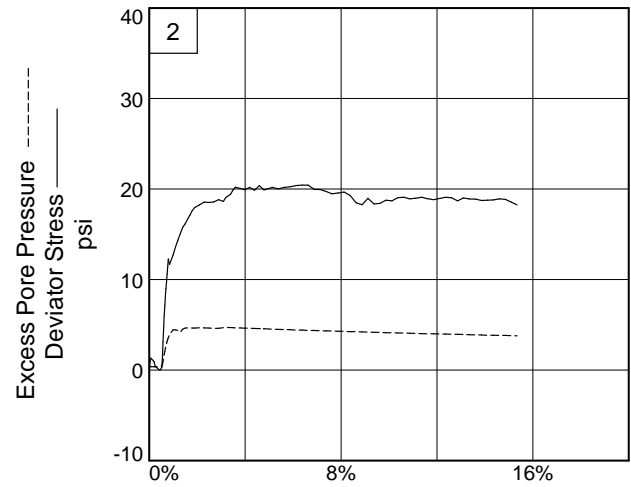
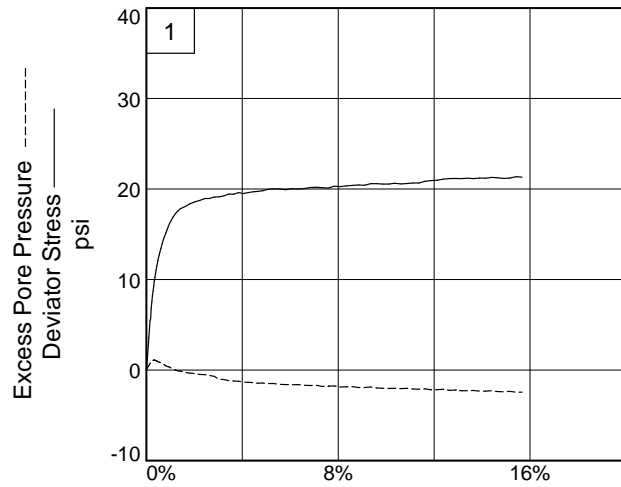
**Proj. No.:** 8623P180

**Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.

Chattanooga, TN



**Client:** HNTB North Carolina PC

**Project:** S-23-94 (Hammett Bridge Road) BRO Suber Branch

**Source of Sample:** S-23-94-2 Offset **Depth:** 1-5'

**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-23-94 (Hammett Bridge Road) BRO Suber Branch

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

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

**Lab No.:** 24-0279

**Results of Corrosion Analysis**

<b>Sample Number</b>	S-23-94-2
<b>Sample Location</b>	--
<b>Sample Depth (ft.)</b>	2.0-15.0
pH Analysis, AASHTO T289	5.65
Water Soluble Sulfate (SO4), AASHTO T290 (mg/kg)	24
Chlorides, AASHTO T291, (mg/kg)	117
Saturated Minimum Resistivity, AASHTO T288, (ohm-cm)	2231

**Analyzed By**

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

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.



PROJECT ID P041163 PROJECT NAME S-23-94 BRO Suber Branch  
PROJECT COUNTY Greenville

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-23-94-1	NQ-1	76.0	55	48	6045	0.00	565	169	52	60
S-23-94-1	NQ-2	81.0	98	87	8797	0.00	1312	194	64	75
S-23-94-2	NQ-1	63.5	70	27						60
S-23-94-2	NQ-2	68.5	67	37	9104	0.06	1191	171	55	60
S-23-94-2	NQ-3	73.5	75	58						65
S-23-94-2	NQ-4	78.5	90	49	4264	0.10	598	164	52	60
S-23-94-2	NQ-5	83.5	100	73						75
S-23-94-2	NQ-6	88.5	100	95	10191	0.09	1063	163	77	85

## Client

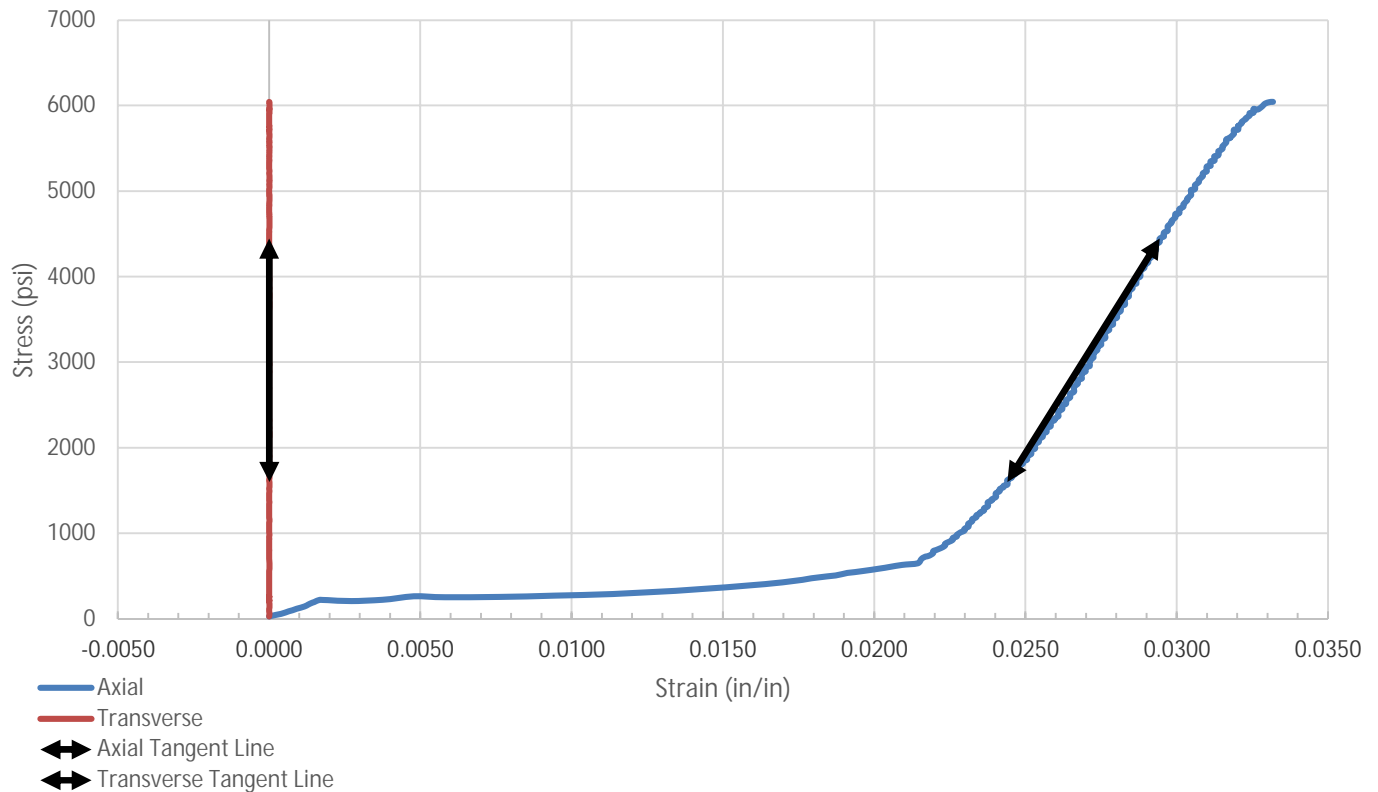
HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

## Project

S-23-94 (Hammett Bridge Road) BRO Suber Branch

Project No. 8623P180

### ASTM D7012 Stress/ Strain Curve



## SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Gneiss		
Boring:	S-23-94-1	Depth (feet):	77.5-78.3

## SPECIMEN INFORMATION

Sample No.:	R1	Mass (g):	534.62
Length (in.):	3.88	Diameter (in.):	1.99
L/D Ratio:	1.9	Density (pcf):	168.77

## TEST RESULTS

Failure Load (lbs):	18800
Failure Strain (%):	3.55
Unconfined Compressive Strength (psi):	6,045
Elastic Modulus, E, (ksi):	565
Poisson's Ratio, $\nu$ :	0.0009
Time of Failure (min):	00:55
Rate of Loading (psi/sec):	110.303
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°.

Per ASTM D4543 and ASTM D7012, the desired specimen length to diameter are between 2.0:1 and 2.5:1.  
Specimen lengths other than specified may differ from results obtained from a test specimen that meets the requirements.

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

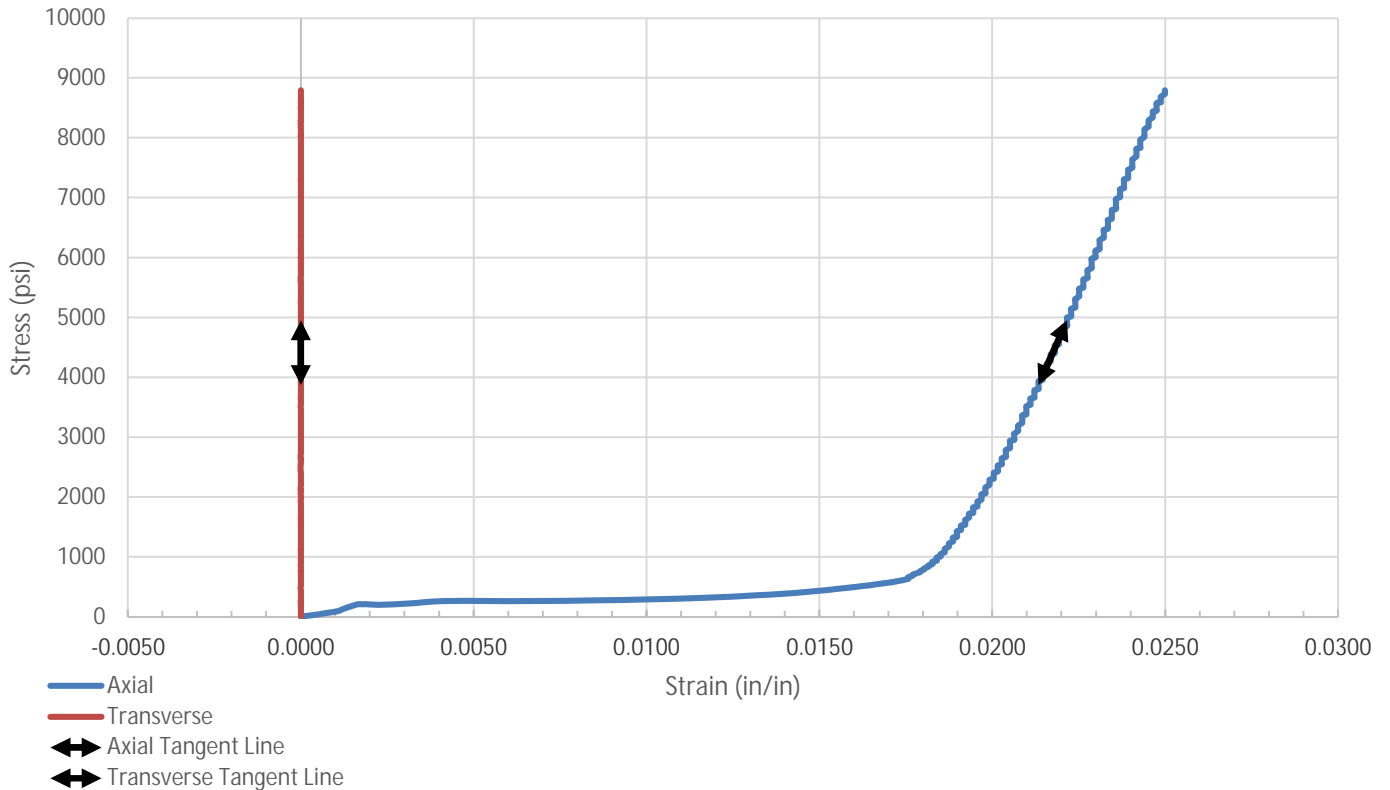
HNTB North Carolina PC  
Attn: Spencer Franklin  
343 E Six Forks Rd Ste 200  
Raleigh, NC 27609

## Project

S-23-94 (Hammett Bridge Road) BRO Suber Branch

Project No. 8623P180

### ASTM D7012 Stress/ Strain Curve



## SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Schist		
Boring:	S-23-94-1	Depth (feet):	82.2-83.1

## SPECIMEN INFORMATION

Sample No.:	R2	Mass (g):	671.43
Length (in.):	4.25	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	193.51

## TEST RESULTS

Failure Load (lbs):	27362
Failure Strain (%):	2.78
Unconfined Compressive Strength (psi):	8,797
Elastic Modulus, E, (ksi):	1312
Poisson's Ratio, u:	0.001
Time of Failure (min):	01:20
Rate of Loading (psi/sec):	109.693
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°.

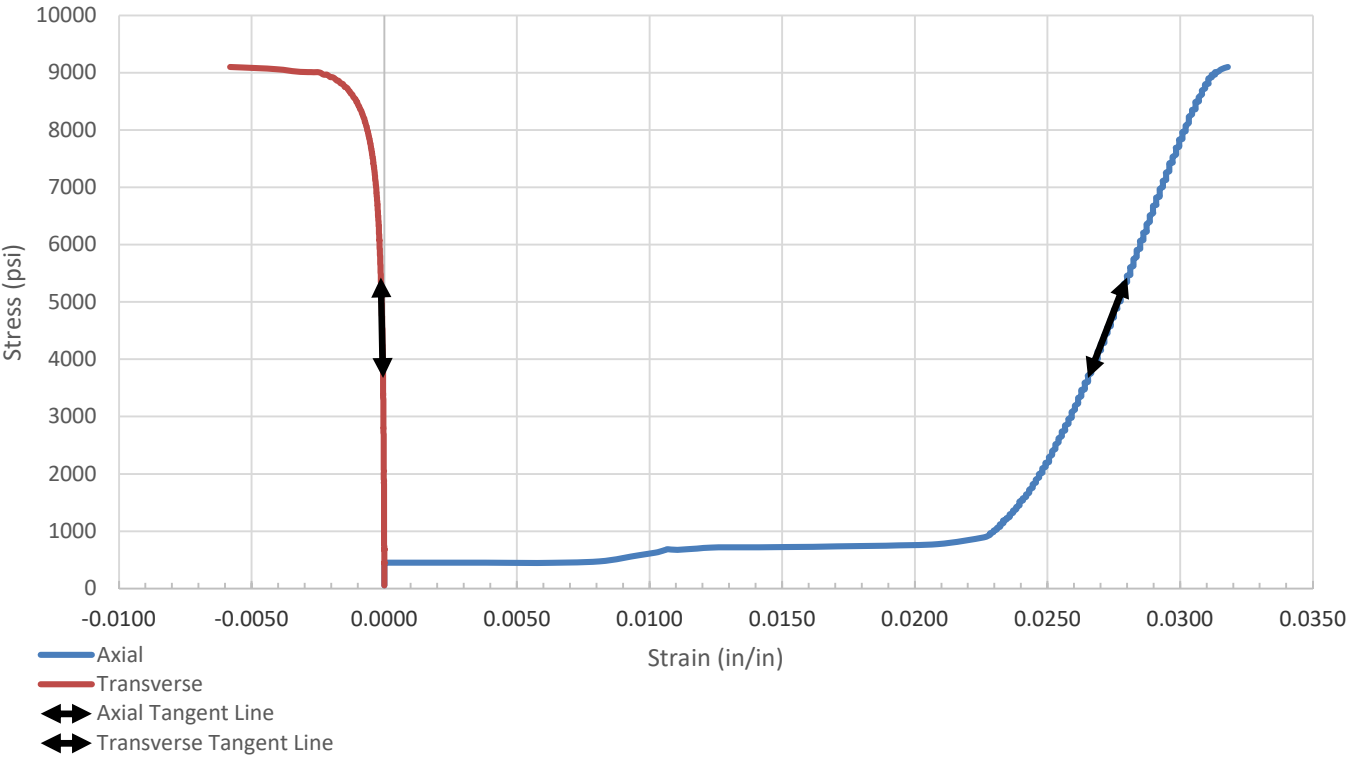
Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

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	Project
HNTB North Carolina PC Attn: Spencer Franklin 343 E Six Forks Rd Ste 200 Raleigh, NC 27609	S-23-94 (Hammett Bridge Road) BRO Suber Branch    Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION			
Site:	SCDOT Bridge Package 19		
Description:	Gneiss		
Boring:	S-23-94-2	Depth (feet):	70.2-71.0
SPECIMEN INFORMATION			
Sample No.:	R2	Mass (g):	545.74
Length (in.):	4.08	Diameter (in.):	1.95
L/D Ratio:	2.09	Density (pcf):	170.63
TEST RESULTS			
Failure Load (lbs):	27188		
Failure Strain (%):	3.46		
Unconfined Compressive Strength (psi):	9,104		
Elastic Modulus, E, (ksi):	1191		
Poisson's Ratio, u:	0.056		
Time of Failure (min):	01:23		
Rate of Loading (psi/sec):	0.041		
Moisture Content Post-break:	0.0012		



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

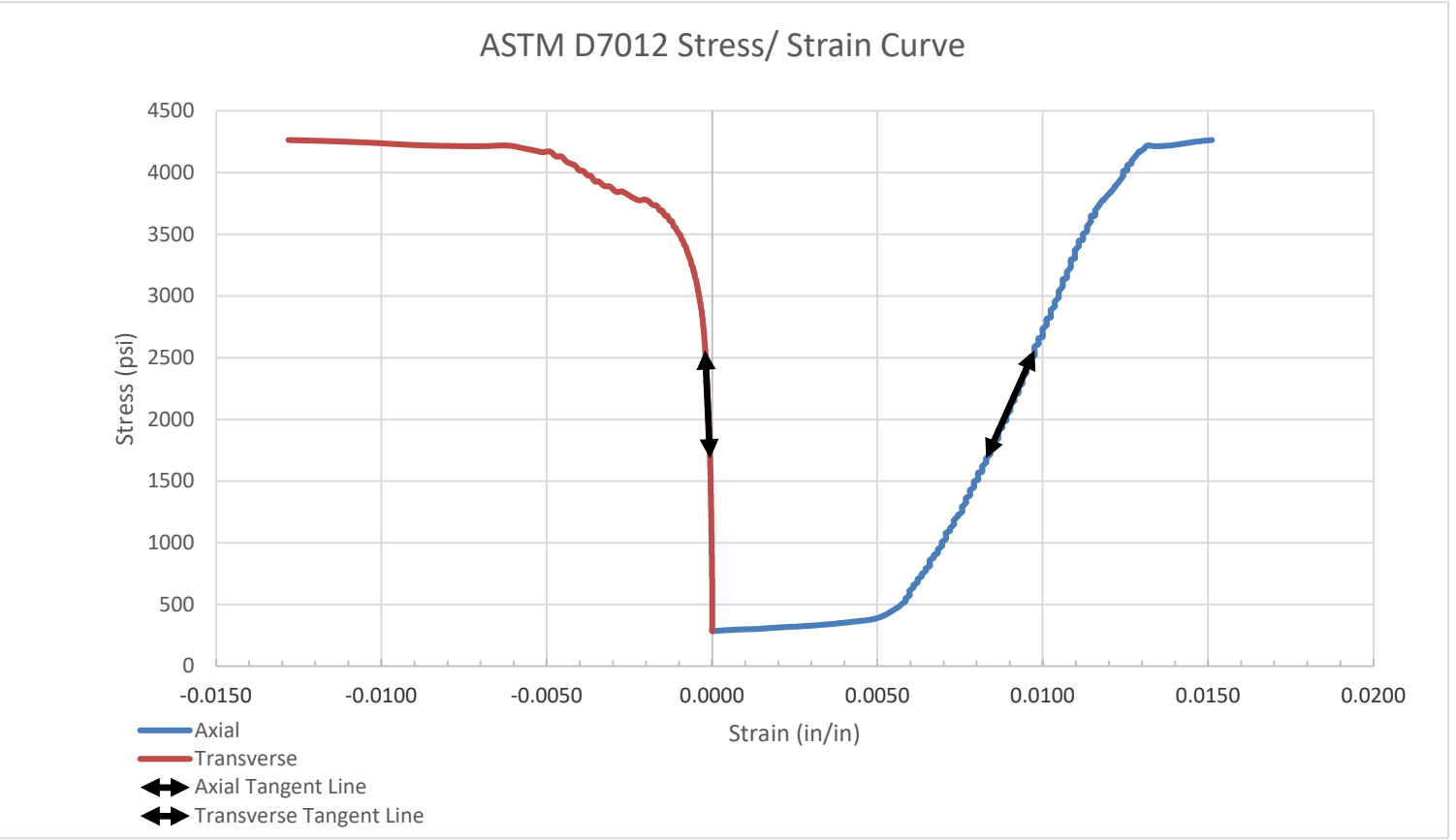
Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.

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	Project
HNTB North Carolina PC Attn: Spencer Franklin 343 E Six Forks Rd Ste 200 Raleigh, NC 27609	S-23-94 (Hammett Bridge Road) BRO Suber Branch  



SAMPLE LOCATION			
Site:	SCDOT Bridge Package 19		
Description:	Gneiss		
Boring:	S-23-94-2	Depth (feet):	79.8-80.7
SPECIMEN INFORMATION			
Sample No.:	R4	Mass (g):	533.92
Length (in.):	4.11	Diameter (in.):	1.96
L/D Ratio:	2.10	Density (pcf):	164.02
TEST RESULTS			
Failure Load (lbs):		12864	
Failure Strain (%):		1.51	
Unconfined Compressive Strength (psi):		4,264	
Elastic Modulus, E, (ksi):		598	
Poisson's Ratio, u:		0.098	
Time of Failure (min):		00:37	
Rate of Loading (psi/sec):		0.041	
Moisture Content Post-break:		0.0019	





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

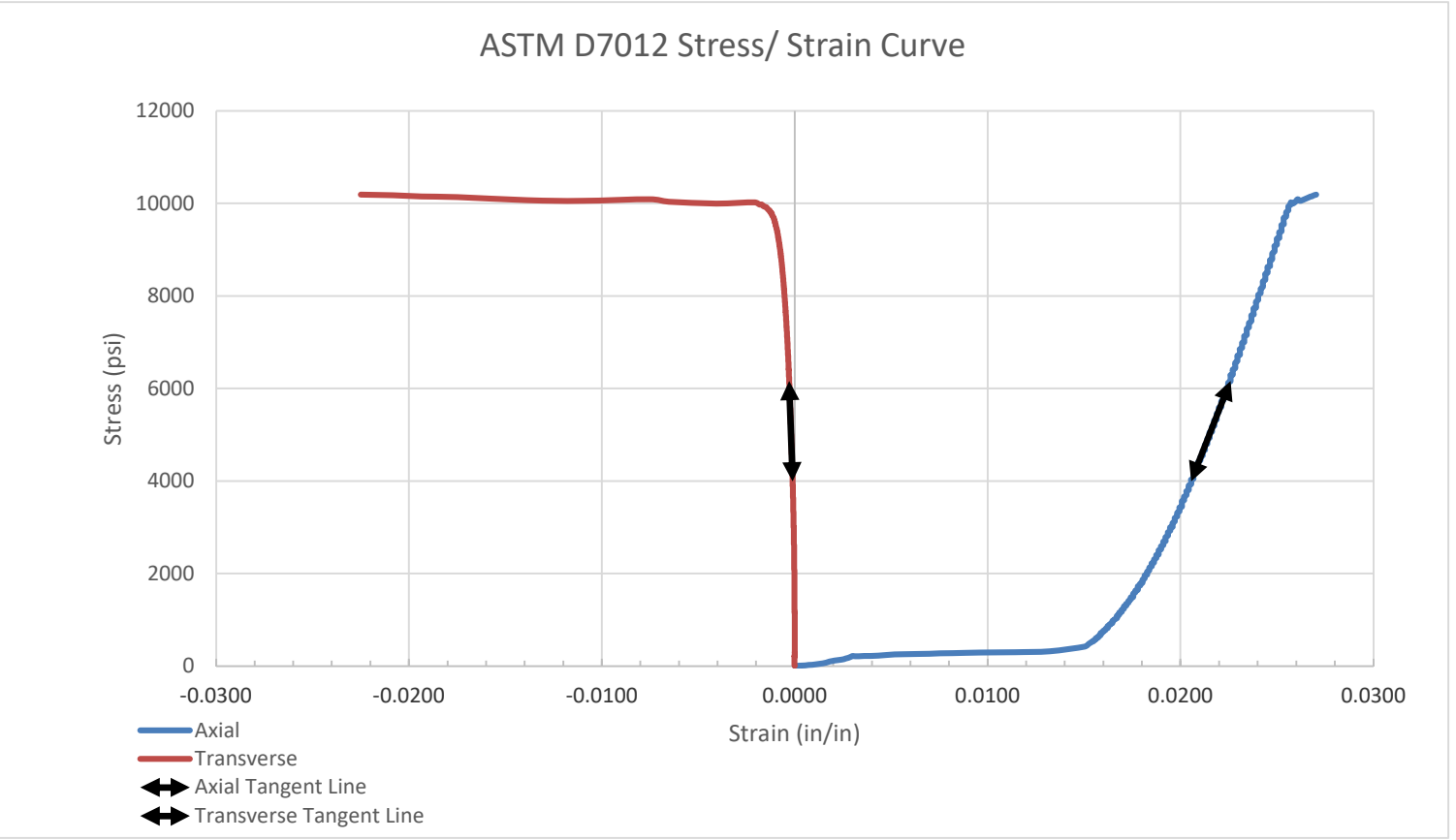
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Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

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	Project
HNTB North Carolina PC	S-23-94 (Hammett Bridge Road) BRO Suber Branch
Attn: Spencer Franklin	
343 E Six Forks Rd Ste 200	
Raleigh, NC 27609	Project No. 8623P180



SAMPLE LOCATION			
Site:	SCDOT Bridge Package 19		
Description:	Granite		
Boring:	S-23-94-2	Depth (feet):	90.2-90.8
SPECIMEN INFORMATION			
Sample No.:	R6	Mass (g):	533.65
Length (in.):	4.17	Diameter (in.):	1.95
L/D Ratio:	2.14	Density (pcf):	163.24
TEST RESULTS			
Failure Load (lbs):		30435	
Failure Strain (%):		2.70	
Unconfined Compressive Strength (psi):		10,191	
Elastic Modulus, E, (ksi):		1063	
Poisson's Ratio, u:		0.087	
Time of Failure (min):		01:33	
Rate of Loading (psi/sec):		0.042	
Moisture Content Post-break:		0.0016	



Client	Project
HNTB North Carolina PC Attn: Spencer Franklin 343 E Six Forks Rd Ste 200 Raleigh, NC 27609	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-23-94 Bridge Replacement over Suber Branch | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041163



# **Appendix C**

## **Supporting Documents**

3-Point Acceleration Design Response Spectrum By SCDOT  
Rig Calibration Report – DR#1327 (8 Pages)  
Rig Calibration Report – DR#554 (5 Pages)

Note: All exhibits are one page unless noted above.

### 3-Point Acceleration Design Response Spectrum

SCDOT v3.2 - 06/01/2023

Project ID:	P041163	Latitude:	34.9042
Route:	S-23-94	County:	23 - Greenville
Project:	BRO Suber Branch		
		Longitude:	82.2527

Designer:	D. Sapkota - Support
Date:	10/15/2024

Design EQ	PGA	S <sub>DS</sub>	S <sub>D1</sub>	M <sub>W</sub>	R	PGV	D <sub>5-95</sub>	T' <sub>o</sub>
	g	g	g	-	km	inches/sec	sec	sec
FEE	0.14	0.25	0.02	7.29	265.90	0.76	58.34	0.17
SEE	0.27	0.57	0.04	5.63	98.17	1.68	19.83	0.13

Fundamental Period of Structure, T <sub>0</sub>	Range of Interest		V <sub>s,H</sub> *	H	T <sub>NH</sub>	
	sec				sec	
sec	0.5*T <sub>0</sub>	2.0*T <sub>0</sub>	ft/sec	ft	(4*H)/V <sub>s,H</sub> *	(6*H)/V <sub>s,H</sub> *
0.00	0.00	0.00	1602.38	64.00	0.10	0.24
0.00	0.00	0.00	H = B-C Boundary			

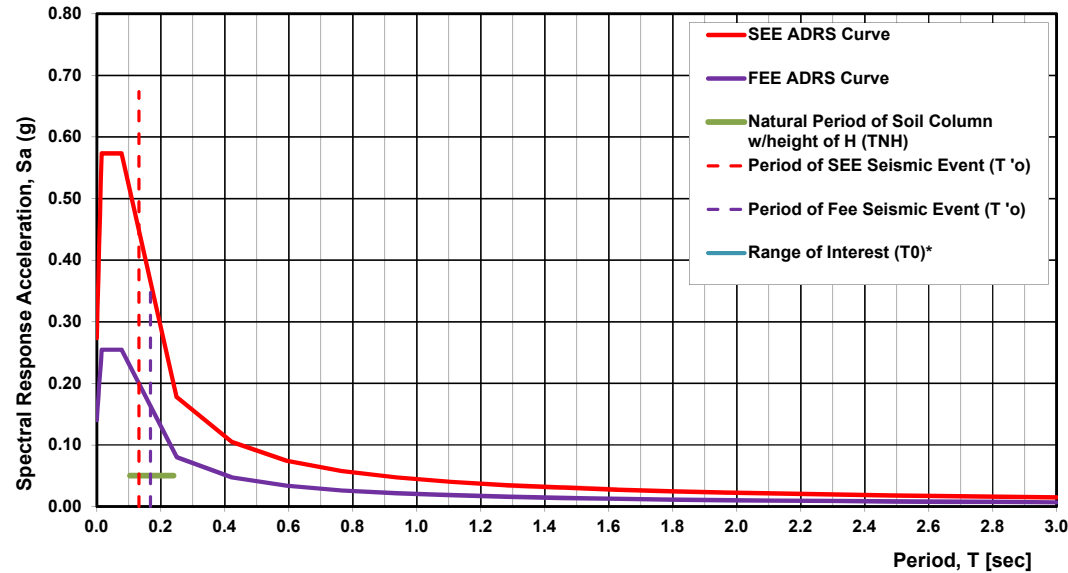
H = B-C Boundary

Damping:	5%
Geologic Condition:	Geologically Realistic (Q = 100)*
ADRS Location within Soil Column:	SCP
	At Ground Surface

South Carolina Piedmont

\*Same Geologic Condition as used in SCENARIO\_PC (2006)

### SC Seismic ADRS Curve



#### FEE Data

T	S <sub>a</sub>
0.00	0.140
0.00	0.159
0.01	0.178
0.01	0.197
0.01	0.216
0.01	0.235
0.02	0.254
0.02	0.254
0.03	0.254
0.03	0.254
0.04	0.254
0.04	0.254
0.05	0.254
0.05	0.254
0.06	0.254
0.06	0.254
0.07	0.254
0.07	0.254
0.08	0.254
0.25	0.080
0.42	0.047
0.59	0.034
0.77	0.026
0.94	0.021
1.11	0.018
1.28	0.016
1.45	0.014
1.63	0.012
1.80	0.011
1.97	0.010
2.14	0.009
2.31	0.009
2.48	0.008
2.66	0.008
2.83	0.007
3.00	0.007

#### SEE Data

T	S <sub>a</sub>
0.00	0.273
0.00	0.323
0.01	0.373
0.01	0.423
0.01	0.473
0.01	0.523
0.02	0.573
0.02	0.573
0.03	0.573
0.03	0.573
0.04	0.573
0.04	0.573
0.05	0.573
0.05	0.573
0.06	0.573
0.06	0.573
0.07	0.573
0.07	0.573
0.08	0.573
0.25	0.177
0.42	0.105
0.59	0.075
0.76	0.058
0.94	0.047
1.11	0.040
1.28	0.035
1.45	0.030
1.62	0.027
1.80	0.025
1.97	0.022
2.14	0.021
2.31	0.019
2.48	0.018
2.66	0.017
2.83	0.016
3.00	0.015

## For Boring S-23-94-1

## 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 29615Attn: Nitin Dudani  
E: nitin.dudani@terracon.comRe: 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

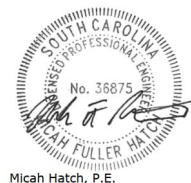
Drill Rig Make/Model	Drill Rig Serial Number	Drill Rig Year	Asset Number	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (C <sub>e</sub> )
Geoprobe	3126S5V224106	2024	DR#1327	92.6% ± 1.75%	1.54

\*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

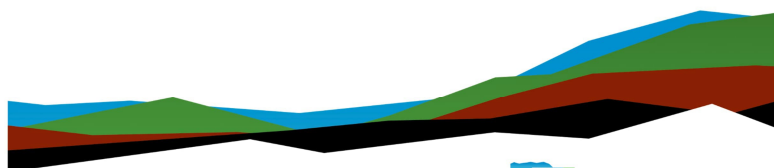
Susheel R. Kolwalkar

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

Facilities | Environmental | Geotechnical | Materials |



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>mean</sub>  (bpf)	Soil Type <sup>4</sup>	
					2 ft	5 ft	10 ft	1 <sup>st</sup> Inc.			2 <sup>nd</sup> 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

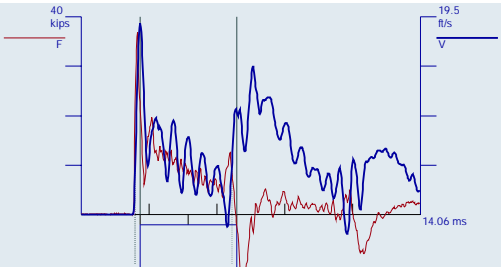
1. Boring ID and depth from existing ground surface to start of SPT.  
2. Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.  
3. 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



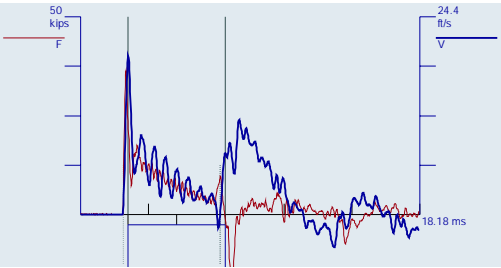
BN 13  
05Sep2024 10:07:23 AM

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<sup>3</sup>  
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 mm/6.4v/5000g (1) VF1  
A4 (PR): [K14006] 375.226 mm/6.4v/5000g (1) VF1

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

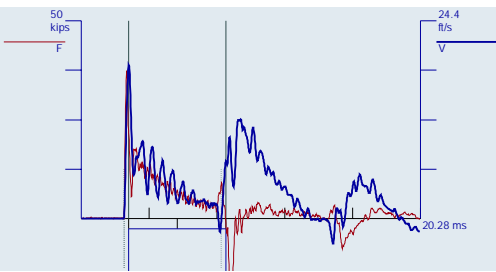
Pile Driving Analyzer ® (PDA)  
Version: 2022.35.2



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<sup>3</sup>  
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 mm/6.4v/5000g (1) VF1  
A4 (PR): [K14006] 375.226 mm/6.4v/5000g (1) VF1

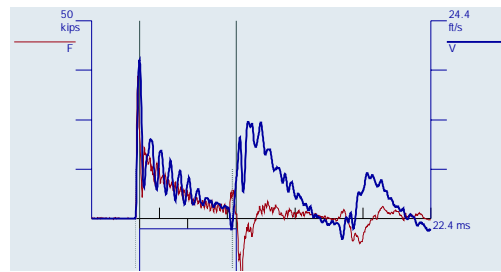


BN 14  
 05Sep2024 10:32:57 AM

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 in<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 in<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



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?

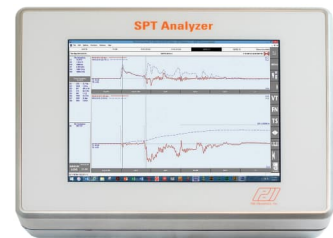
The Standard Penetration Test (SPT) is a widely-employed soil exploration tool that involves using an SPT hammer to drive a split sampler at the bottom of a drill string to obtain soil samples. The number of blows required to penetrate the last 300mm (1ft) is the "N value" which is related to soil strength.

### 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



Exhibit B

SPT Analyzer Literature and Equipment Calibrations

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).

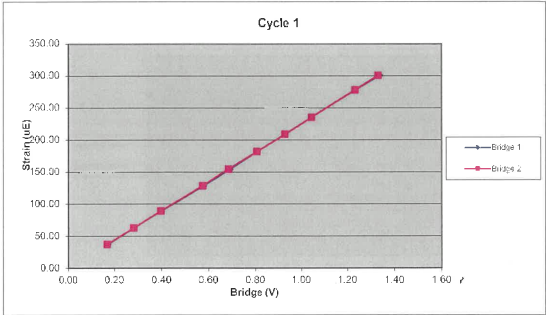
[www.pile.com](http://www.pile.com) | +1 (216) 831-6131 | [info@pile.com](mailto:info@pile.com)



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	7067.05	208.93	0.93	0.93
9	7958.18	235.42	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	-0.83
Correlation	0.999989	Correlation	0.999992

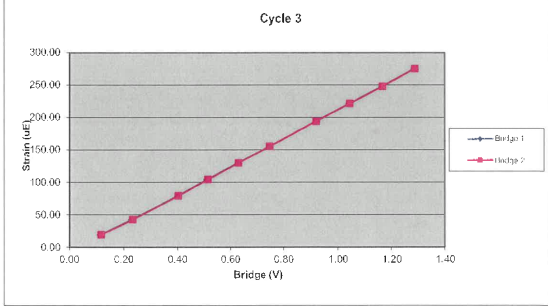
Force Strain Calibration	
EA (Kips)	33651.50
Offset	33.98
Correlation	0.999994



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	1.06
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

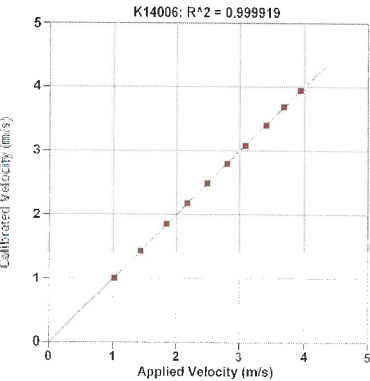
PDA CALIBRATION FACTOR  
375.2 mv/5000g  
(75.0  $\mu$ v/g)  
R<sup>2</sup>: 0.999919 [Chip programmed]

Operator: 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 2020 09 11 16 42 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

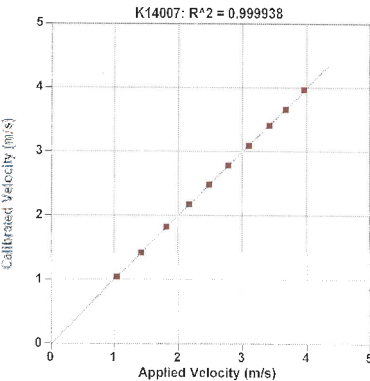
PDA CALIBRATION FACTOR  
407.2 mv/5000g  
(81.4  $\mu$ v/g)  
R<sup>2</sup>: 0.999938 [Chip programmed]

Operator: 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

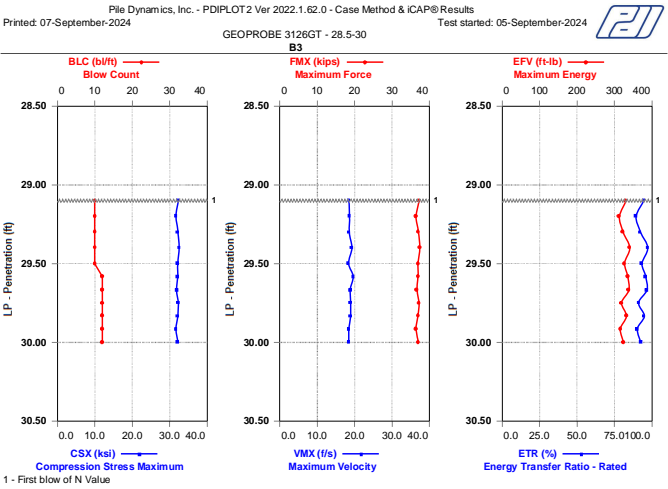
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Version 2020 06 16 16 42 04



Exhibit C  
SPT Analyzer Results





Case Method & iCAP® Results

GEOPROBE 3126GT - 28.5-30

B3

OP: RW  
AR: 1.15 in²  
LE: 33.70 ft  
WS: 16.807 g f/s  
SP: 0.492 klf/ft  
EM: 30,000 ksi  
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

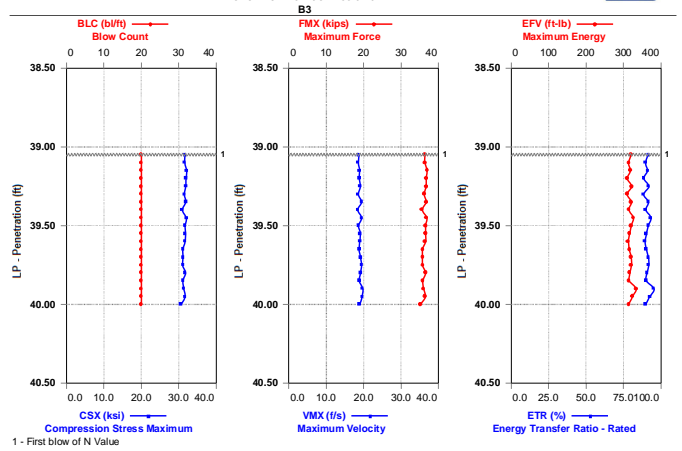
5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);  
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 38.5-40

B3

OP: RW  
AR: 1.15 in²  
LE: 43.70 ft  
WS: 16.807 g f/s  
SP: 0.492 klf/ft  
EM: 30,000 ksi  
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

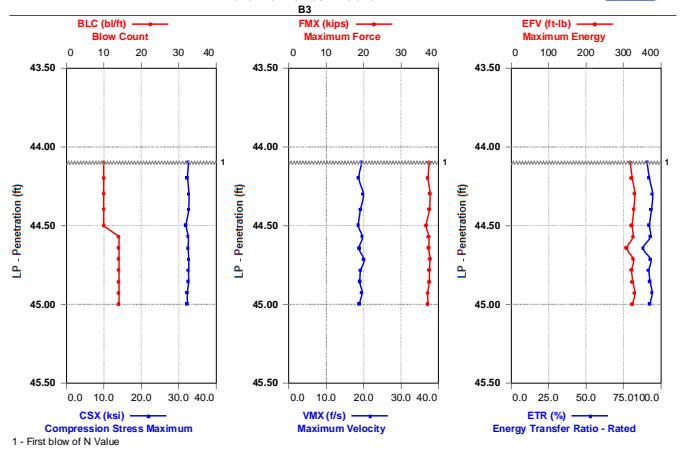
7-26 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);  
A4: [K14006] 375.2 (1.00)

BL# Comments

7 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 43.5-45

B3

Date: 05-September-2024

OP: RW  
AR: 1.15 in²  
LE: 48.70 ft  
WS: 16,807.9 f/s

SP: 0.492 k/ft³  
EM: 30,000 ksi  
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	0.92	32.5
Std. Dev.		0	0.5	5.5	5.5	1.6	0.1	0.15	0.17	0.2	0.2
Maximum		38	20.1	330.1	330.1	94.3	53.6	1.30	1.20	0.86	32.8
Minimum		37	18.6	309.1	309.1	88.3	53.2	0.89	0.85	0.86	32.0

Total number of blows analyzed: 12

BL# Sensors

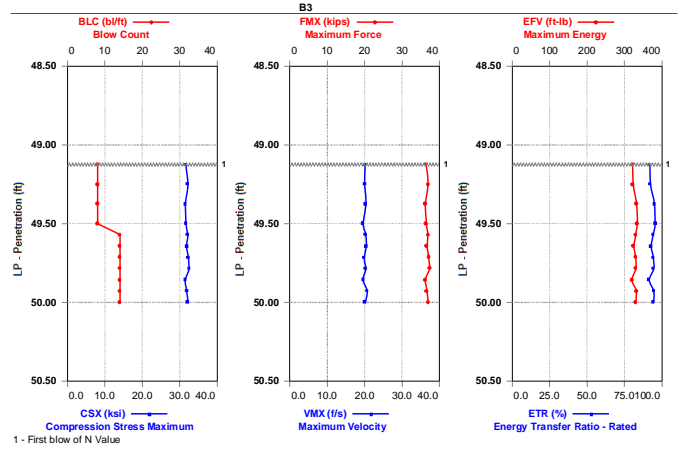
5-16 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);  
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 48.5-50

B3

Date: 05-September-2024

OP: RW  
AR: 1.15 in²  
LE: 53.70 ft  
WS: 16,807.9 f/s

SP: 0.492 k/ft³  
EM: 30,000 ksi  
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	0.91	31.9
Std. Dev.		0	0.3	4.5	4.5	1.3	0.2	0.36	0.31	0.3	0.3
Maximum		37	20.7	334.0	334.0	95.4	53.8	1.81	1.50	0.86	32.4
Minimum		36	19.6	319.8	319.8	91.4	53.1	0.87	0.86	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: (Signature)  
PDA MODEL/SN: SPT 4621 TR  
TERRACON RIG #: 1327

### DRILL RIG DATA

Type/Transport: Truck  
Manufacturer: Geopac  
Model No.: 3126 GS  
Serial No.: 7126554224106  
Year Built: 2024  
Modifications: N/A  
Maint. Schedule: 50 hrs

### SPT HAMMER DATA

Type: A40  
Manufacturer: Geopac  
Lifting Mechanism: Chain  
Model No.: A40H31  
Serial No.: 10001  
Hammer Weight: 140  
Hammer Operator(s): B. R. Hest

### PDA INPUT DATA

Operator: OP (Signature)  
Project No./Location: 7324515/  
Rig Mode & SN: PN 60000/3126 GS  
Hammer Type, LM, Rods: PD A40/AWJ  
Drill Rod Area (in<sup>2</sup>): AR 1.15

Elastic Modulus (ksi): EM 3000  
Specific Weight (kip/ft<sup>3</sup>): SP 0.492  
Wave Speed (ft/sec): WS 16808  
Increment Length (ft): LI 0.5  
Sampling Freq. (kHz): FR 50

### TRANSDUCER INFORMATION

Gage SN Calibration  
F1/F3: 746 AWJ1 222.05  
F2/F4: 746 AWJ2 222.19  
A1/A3: K14002 407.23  
A2/A4: K14006 375.83

NOTES: 286.25 + 1.875  
34.36 + 25 + 10.5 = 28.78  
SPLIT SPOON SAMPLER LENGTH 38' + 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	5'x5	1	30	5	10	14	24
10:05	SP		28.5	30	53.7	5'x6	3	18	4	5	6	11
10:10	CL		33.5	35	58.7	5'x7	1	1	0	0	0	0
10:15	SP		38.5	40	63.7	5'x8	3	30	7	10	10	20
10:25	SP		43.5	45	68.7	5'x9	1	18	4	5	7	12
10:35	SP		48.5	50	73.7	5'x10	1	17	4	4	7	11
10:50	SC		53.5	55	78.7	5'x11	1	6	2	1	2	3
11:10	CL		58.5	60	83.7	5'x12	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

Terracon SPT Rig Calibration Worksheet.xlsx

Exhibit E

Copy of Certificate of Proficiency



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

*Gordon Likins*  
Gordon 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

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

No. 2898

## For Boring S-23-94-2

## SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: GeoProbe 3126

Drill Rig Serial Number: 3126TTS52010006

Asset Number: DR#554

August 21, 2023



## Prepared for:

Terracon  
Greenville-Spartanburg, South Carolina

Nationwide  
Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials



July 19, 2023

Terracon  
72 Pointe Circle  
Greenville, South Carolina 29607Attn: Maggie McKenney  
E: m.mckenney@terracon.com

**Re:** SPT Automatic Hammer Energy Measurement Report  
Rig Serial Number: 3126TTS52010006  
Terracon Project Number: DYXX0500

Dear Ms. McKenney:

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 (Ce)
GeoProbe 3126	3126TTS52010006	2021	GP#554	88.5% ± 4.2%	1.48

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

James P. Smith  
National Manager of Equipment & Training

Rob Kramer  
Group Manager Geophysics

## Attachments:

Exhibit A: PDA SPT Analyzer Results  
Exhibit B: PDA Equipment Calibration

Facilities | Environmental | **Geotechnical** | Materials |

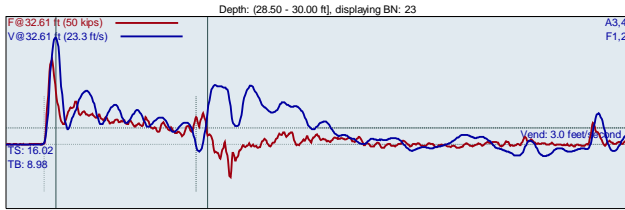
## MEASUREMENT SUMMARY

ITEM	DESCRIPTION
Drill Rig Owner	Terracon Greenville-Spartanburg - Greenville, SC
Drill Rig Operator	Brett Burnett; Terracon Exploration Services
Testing Date	08/21/2023
Testing Location	Spartanburg, SC
Boring Identification	B-1
Hammer Type	140 pounds (automatic)
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> <li>■ AWJ</li> <li>■ 1-3/4" outside diameter</li> <li>■ 3/16" 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</li> <li>■ Model SPT Analyzer™ (PDA)</li> </ul>
ASTM Methods Used	<p><b>ASTM D1586</b>, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils</p> <p><b>ASTM D4633-16</b>, Standard Method for Energy Measurement for Dynamic Penetrometers</p>
SPT Calibration Personnel	Jim Smith, National Manager of Equipment and Training

## Exhibit A

## PDA SPT Analyzer Results

GP554-3126 28.5/30  
JIM SMITH Interval start: 8/21/2023  
TB-1  
AR: 1.20 in/2 SP: 0.492 k/ft3  
LE: 32.61 ft EM: 30000 ksi  
WS: 16807.9 fts



F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4v/5000g (1) VF1  
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4v/5000g (1) VF1

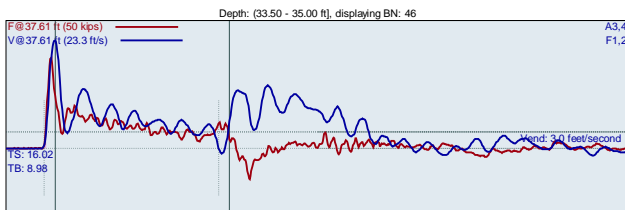
FMX: Maximum Force EFV: Maximum Energy  
VMX: Maximum Velocity ETR: Energy Transfer Ratio - Rated  
BPM: Blows/Minute

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
1	6	40	19.4	1.9	294	84.1
2	6	39	19.2	51.9	292	83.4
3	6	25	16.9	52.7	274	78.2
4	6	28	17.9	52.4	273	77.9
5	6	32	19.6	52.6	294	83.9
6	6	27	17.3	53.1	268	76.5
7	8	38	19.0	52.7	289	82.5
8	8	39	19.6	52.4	305	87.2
9	8	36	19.2	52.7	290	82.8
10	8	28	18.2	52.5	292	83.4
11	8	38	19.0	53.0	293	83.8
12	8	35	19.4	52.6	282	80.4
13	8	36	19.1	52.9	299	85.3
14	8	34	19.8	52.8	307	87.7
15	11	34	19.5	52.7	307	87.6
16	11	33	19.5	52.9	299	85.6
17	11	36	19.4	52.7	308	88.1
18	11	37	18.5	52.8	320	91.4
19	11	32	19.6	52.9	301	86.1
20	11	39	18.7	52.9	301	85.9
21	11	26	17.5	52.8	277	79.1
22	11	30	19.1	52.6	306	87.4
23	11	33	19.5	52.7	298	85.1
24	11	35	19.9	52.4	303	86.5
25	11	36	19.4	53.1	313	89.6

Average	34	19.2	52.8	299	85.6
Std Dev	3	0.6	0.2	10	3.0
Maximum	39	19.9	53.1	320	91.4
Minimum	26	17.5	52.4	277	79.1
N-value: 19					

Sample Interval Time: 27.36 seconds.

GP554-3126 28.5/30  
JIM SMITH Interval start: 8/21/2023  
TB-1  
AR: 1.20 in/2 SP: 0.492 k/ft3  
LE: 37.61 ft EM: 30000 ksi  
WS: 16807.9 fts

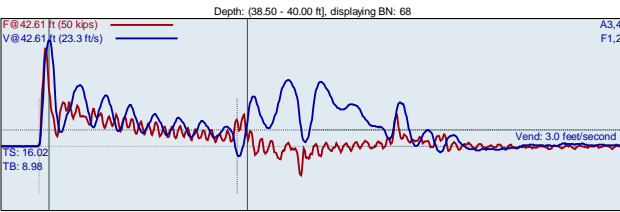


F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4v/5000g (1) VF1  
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
26	5	38	19.1	1.9	302	86.4
27	5	35	18.9	52.0	301	86.1
28	5	29	18.8	52.0	299	85.5
29	5	35	19.2	52.7	299	85.5
30	5	37	19.4	52.5	297	84.8
31	8	37	19.5	52.4	307	87.7
32	8	26	16.4	52.7	282	80.5
33	8	34	19.5	52.4	307	87.6
34	8	40	19.1	52.2	307	87.6
35	8	37	19.4	52.6	299	85.5
36	8	40	20.6	52.4	321	91.7
37	8	41	19.6	52.8	308	87.9
38	8	40	19.8	52.7	313	89.5
39	10	34	20.2	52.2	323	92.2
40	10	32	19.4	52.8	297	84.9
41	10	36	19.8	52.6	311	88.8
42	10	37	19.7	52.5	317	90.7
43	10	35	20.0	52.6	324	92.6
44	10	38	19.5	52.7	308	88.1
45	10	34	20.1	52.4	322	92.0
46	10	35	19.7	52.4	322	92.0
47	10	37	19.9	52.6	314	89.7
48	10	37	19.8	52.7	332	94.8
Average		36	19.6	52.6	312	89.1
Std Dev		3	0.8	0.2	12	3.3
Maximum		41	20.6	52.8	332	94.8
Minimum		26	16.4	52.2	282	80.5
N-value: 18						

Sample Interval Time: 25.16 seconds.

GP554-3126  
JIM SMITH  
TB-1  
AR: 1.20 in/2  
LE: 42.61 ft  
WS: 16807.9 ft/s  
28.5-30  
Interval start: 8/21/2023  
SP: 0.492 kft/s  
EM: 30000 ksi



F1 : [648AWJ1] 226.21 PDICAL (1) FF1		A3 (PR): [K4483] 410.187 mm/6.4v/5000g (1) VF1				
F2 : [648AWJ2] 225.58 PDICAL (1) FF1		A4 (PR): [K10491] 421.907 mm/6.4v/5000g (1) VF1				
BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
49	5	34	19.6	1.9	307	87.6
50	5	34	19.3	52.0	301	86.1
51	5	27	16.5	52.7	278	79.4
52	5	33	19.9	52.5	310	88.6
53	5	29	17.7	52.7	288	82.2
54	8	29	18.6	52.5	295	84.2
55	8	23	15.6	52.9	287	82.0
56	8	34	20.1	52.6	323	92.2
57	8	28	18.1	52.8	295	84.3
58	8	38	18.8	53.1	312	89.1
59	8	35	19.2	52.6	329	94.0
60	8	36	19.3	52.9	327	93.3
61	8	40	19.7	52.8	323	92.4
62	9	35	18.8	53.0	320	91.3
63	9	37	19.1	52.7	320	91.3
64	9	35	19.9	52.9	327	93.4
65	9	29	18.8	52.7	314	89.7
66	9	35	19.7	53.0	342	97.8
67	9	36	19.9	52.8	331	94.5
68	9	38	19.3	52.8	335	95.8
69	9	36	19.9	52.5	325	92.9
70	9	39	19.5	52.9	329	94.0
Average		34	19.1	52.8	320	91.3
Std Dev		4	1.0	0.2	15	4.1
Maximum		40	20.1	53.1	342	97.8
Minimum		23	15.6	52.5	287	82.0
N-value: 17						

Sample Interval Time: 23.91 seconds.

Summary of SPT Test Results

Project: GP554-3126, Test Date: 8/21/2023		EFV: Maximum Energy ETR: Energy Transfer Ratio - Rated					
FMX: Maximum Force							
VMX: Maximum Velocity							
BPM: Blows/Minute							
Length	Blows	N	N60	Average	Average	Average	Average
ft	Applied	Value	Value	FMX	VMX	BPM	EFV
	/6"			kips	ft/s	bpm	ft-lb
32.61	6-8-11	19	28	34	19.2	52.8	299
37.61	5-8-10	18	26	36	19.6	52.6	312
42.61	5-8-9	17	25	34	19.1	52.8	320
Overall Average Values:				35	19.3	52.7	310
Standard Deviation:				4	0.8	0.2	15
Overall Maximum Value:				41	20.6	53.1	342
Overall Minimum Value:				23	15.6	52.2	277



Exhibit B

PDA Equipment Calibration

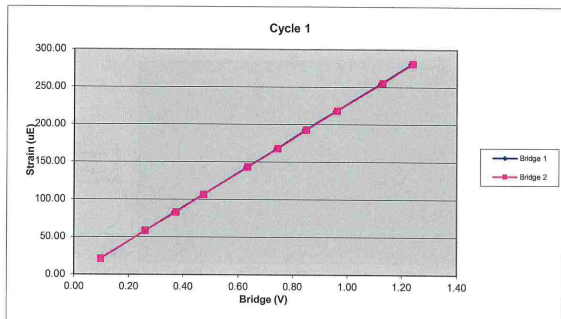




648AWJ		Cycle 1		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	799.99	21.12	0.10	0.10
3	2111.63	58.22	0.26	0.26
4	2997.39	82.70	0.37	0.37
5	3848.07	106.26	0.47	0.47
6	5131.83	143.07	0.63	0.63
7	6017.79	167.81	0.74	0.75
8	6872.07	192.74	0.85	0.85
9	7783.57	218.15	0.96	0.96
10	9136.93	255.02	1.12	1.13
11	10026.70	280.73	1.24	1.24

Bridge 1		Bridge 2	
Force Calibration (lb/V)	8120.30	Force Calibration (lb/V)	8089.75
Offset	-4.24	Offset	-2.24
Correlation	0.999998	Correlation	0.999995
Strain Calibration (µE/V)	228.56	Strain Calibration (µE/V)	227.70
Offset	-1.57	Offset	-1.51
Correlation	0.999991	Correlation	0.999983

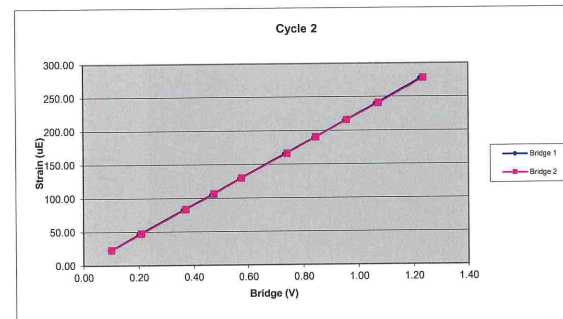
Force Strain Calibration	
EA (Kips)	35527.98
Offset	51.69
Correlation	0.999986



648AWJ		Cycle 2		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	805.54	22.23	0.10	0.10
3	1679.81	47.04	0.20	0.21
4	2989.11	83.03	0.37	0.37
5	3830.62	105.81	0.47	0.47
6	4658.00	129.50	0.57	0.58
7	5984.74	165.81	0.74	0.74
8	6848.87	189.76	0.84	0.84
9	7747.90	215.15	0.95	0.96
10	8674.21	240.08	1.07	1.07
11	9994.82	277.48	1.23	1.24

Bridge 1		Bridge 2	
Force Calibration (lb/V)	8127.14	Force Calibration (lb/V)	8103.79
Offset	10.37	Offset	-14.59
Correlation	0.999997	Correlation	0.999997
Strain Calibration (µE/V)	225.29	Strain Calibration (µE/V)	224.64
Offset	0.36	Offset	-0.33
Correlation	0.999990	Correlation	0.999992

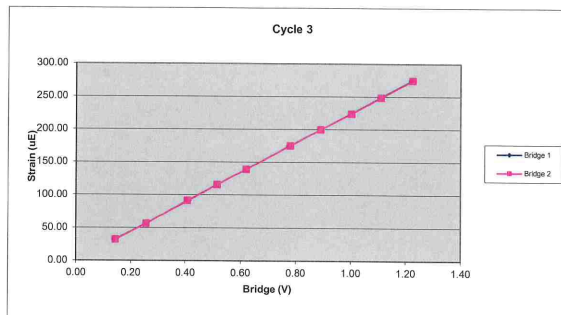
Force Strain Calibration	
EA (Kips)	36073.41
Offset	-2.66
Correlation	0.999993



648AWJ		Cycle 3		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1153.24	31.90	0.14	0.14
3	2056.55	56.28	0.26	0.26
4	3310.19	91.18	0.41	0.41
5	4155.51	115.51	0.51	0.51
6	5035.81	139.16	0.62	0.62
7	6303.78	175.10	0.78	0.78
8	7221.91	199.87	0.89	0.89
9	8120.94	223.92	1.00	1.00
10	9001.15	248.68	1.11	1.11
11	9931.66	274.33	1.22	1.23

Bridge 1		Bridge 2	
Force Calibration (lb/V)	8132.32	Force Calibration (lb/V)	8118.57
Offset	-20.37	Offset	-15.36
Correlation	0.999998	Correlation	0.999997
Strain Calibration (µE/V)	224.79	Strain Calibration (µE/V)	224.41
Offset	-0.57	Offset	-0.43
Correlation	0.999984	Correlation	0.999985

Force Strain Calibration	
EA (Kips)	36175.62
Offset	0.42
Correlation	0.999984



Bridge Excitation (V) 5  
Shunt Resistor (ohm) 60.4k

Calibration Factors		648AWJ	
Bridge 1 (µE/V)	226.21	Bridge 2 (µE/V)	225.58
EA Factor (Kips)	35925.67	Area (in <sup>2</sup> )	1.20

Calibrated by: *Aht*  
Calibrated Date: 3/3/2022

Pile Dynamics Inc  
30725 Aurora Rd  
Solon, OH 44139

Traceable to N.I.S.T.

Accelerometer Calibration Certificate  
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on 26Oct2021

Serial No: K4483 Temperature: 22.1 °C  
Model: PR Humidity: 45%  
Calibrated on: Channel 3 on 8G 5161 LE

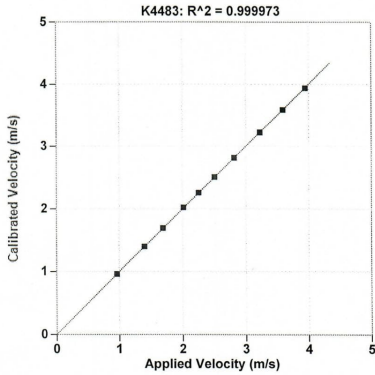
PDA CALIBRATION FACTOR  
410.2 mv/5000g  
(62.0  $\mu$ v/g)  
R<sup>2</sup>: 0.999973 [Chip programmed]

Operator: William Johnson

*William Johnson*  
Signed

Ref Acc 1: 690961 Cal on: 27Jan2021  
978 g's/volt  
Ref Acc 2: 691321 Cal on: 09Feb2021  
960 g's/volt

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



Date printed: 26Oct2021, version: 2020.30.170 0.57

Accelerometer Calibration Certificate  
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on 25Jan2022

Serial No: K10491 Temperature: 19.3 °C  
Model: PR Humidity: 30%  
Calibrated on: Channel 3 on 8G 5161 LE

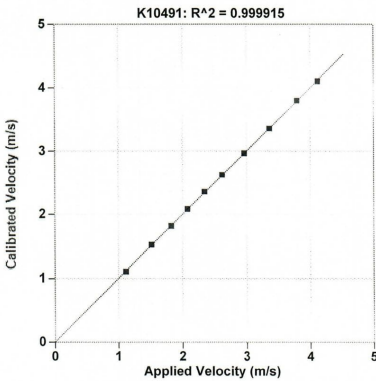
PDA CALIBRATION FACTOR  
421.9 mv/5000g  
(84.4  $\mu$ v/g)  
R<sup>2</sup>: 0.999915 [Chip programmed]

Operator: William Johnson

*William Johnson*  
Signed

Ref Acc 1: 691321 Cal on: 09Feb2021  
960 g's/volt  
Ref Acc 2: 690961 Cal on: 27Jan2021  
978 g's/volt

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



Date printed: 25Jan2022, version: 2020.30.170 0.05