

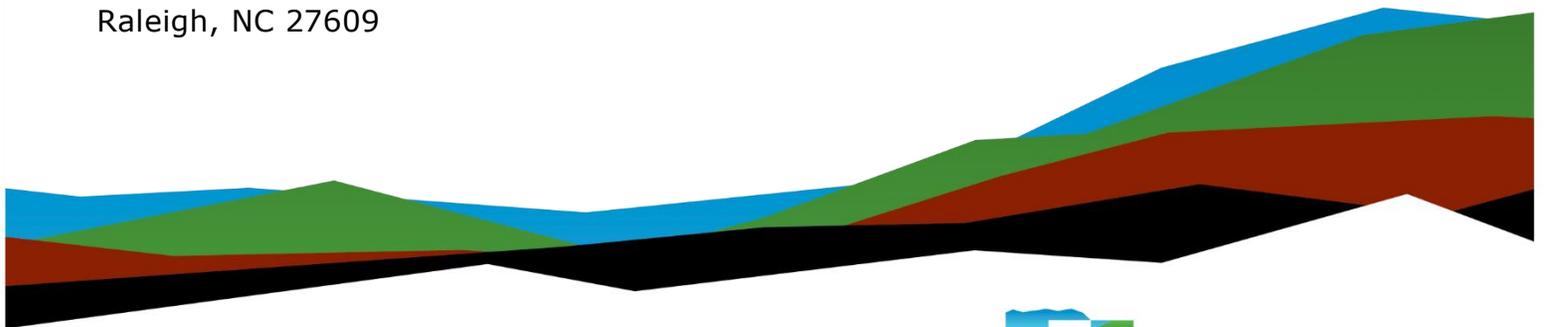
# S-23-40 (Pace Bridge Road) Bridge Replacement over South Saluda River Greenville County, SC

## Geotechnical Subsurface Data Report

October 30, 2024 | SCDOT Project ID: P041160  
Terracon Project No.: 8623P180 Revision 1

### Prepared for:

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



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

- Facilities
- Environmental
- Geotechnical
- Materials



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

October 30, 2024

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

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

Re: Geotechnical Subsurface Data Report  
S-23-40 Bridge Replacement over South Saluda River  
Greenville County, South Carolina  
SCDOT Project ID.: P041160  
Terracon Project No.: 8623P180 Revision 1

Dear Mr. Franklin:

Terracon Consultants Inc. (Terracon) has completed the exploration, testing and limited engineering analysis services (contained in the geotechnical baseline report) 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-23-40 bridge over South Saluda River in Greenville County, South Carolina. This will be a complete bridge replacement within the project existing alignment. This GSDR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and Preconstruction Design Memorandum (PCDM) 11 - Supplemental Design Criteria for Low Volume Bridge Replacement Projects.

## Project Description

The project site is located at the S-23-40 (Pace Bridge Road) crossing over South Saluda River 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 in the same general alignment as the current bridge. The current plan indicates the new bridge will be a 150-ft long two-span bridge constructed

with AASHTO Type BIII-36 Box Beams for span A and a prestressed concrete cored slab for span B.

## **Geotechnical Testing**

The geotechnical exploration for this project was performed between August 20 and August 21, 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:

- Three (3) Standard Penetration Test (SPT) Borings (S-23-40-1, S-23-40-2, and S-23-40-3)
- Two (2) offset borings near S-23-40-1 and S-23-40-3 for bulk sample collection

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

### **Laboratory Testing**

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

- Twenty-four (24) Natural Moisture Content Tests
- Six (6) Atterberg Limits Tests
- Eight (8) 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)

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.

## 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.

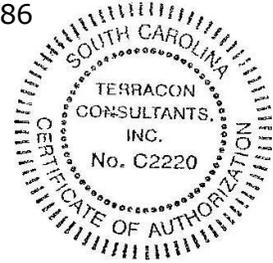
Sincerely,

**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 – Summary of Boring Data

Exhibit A-4 – GeoScoping Form (2 Pages)

Exhibit A-5 – Field Exploration Description (2 Pages)

Exhibit A-6 – Soil Description Terms

Exhibit A-7 – Soil/Rock Symbols

Exhibit A-8 – Boring Logs (6 Pages)

Note: All exhibits are one page unless noted above

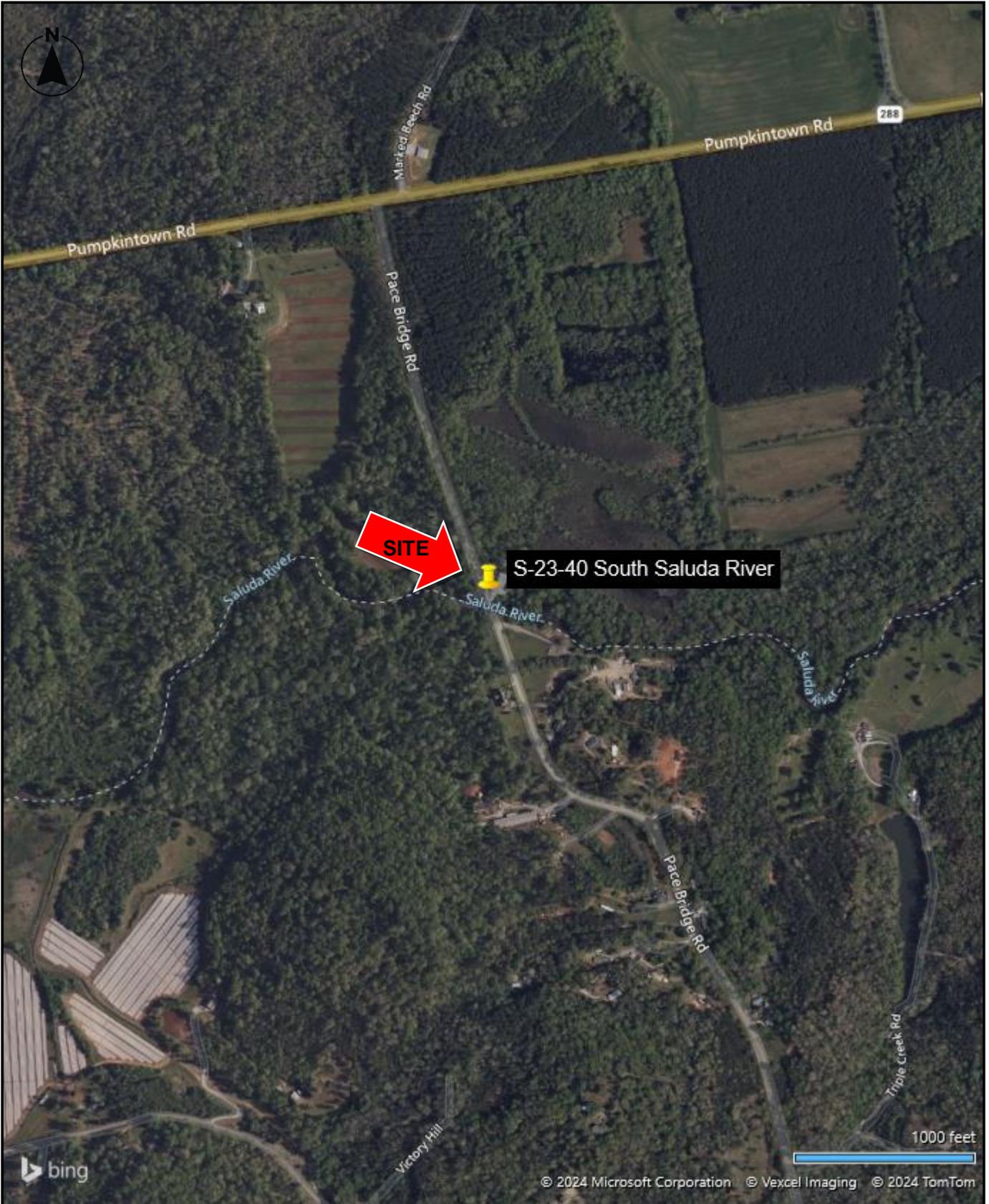


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

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

SITE LOCATION	
S-23-40 BRO South Saluda River Pace Bridge Road Greenville County, SC	

Exhibit
A-1



SPT Boring Location

S-23-40-3

Pace Bridge Rd

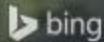
S-23-40-2

Saluda River

Pace Bridge Rd

S-23-40-1

50 feet



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AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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



72 Pointe Cir  
Greenville, South Carolina 29615

EXPLORATION PLAN
S-23-40 BRO South Saluda River Pace Bridge Road Greenville County, SC

Exhibit
A-2

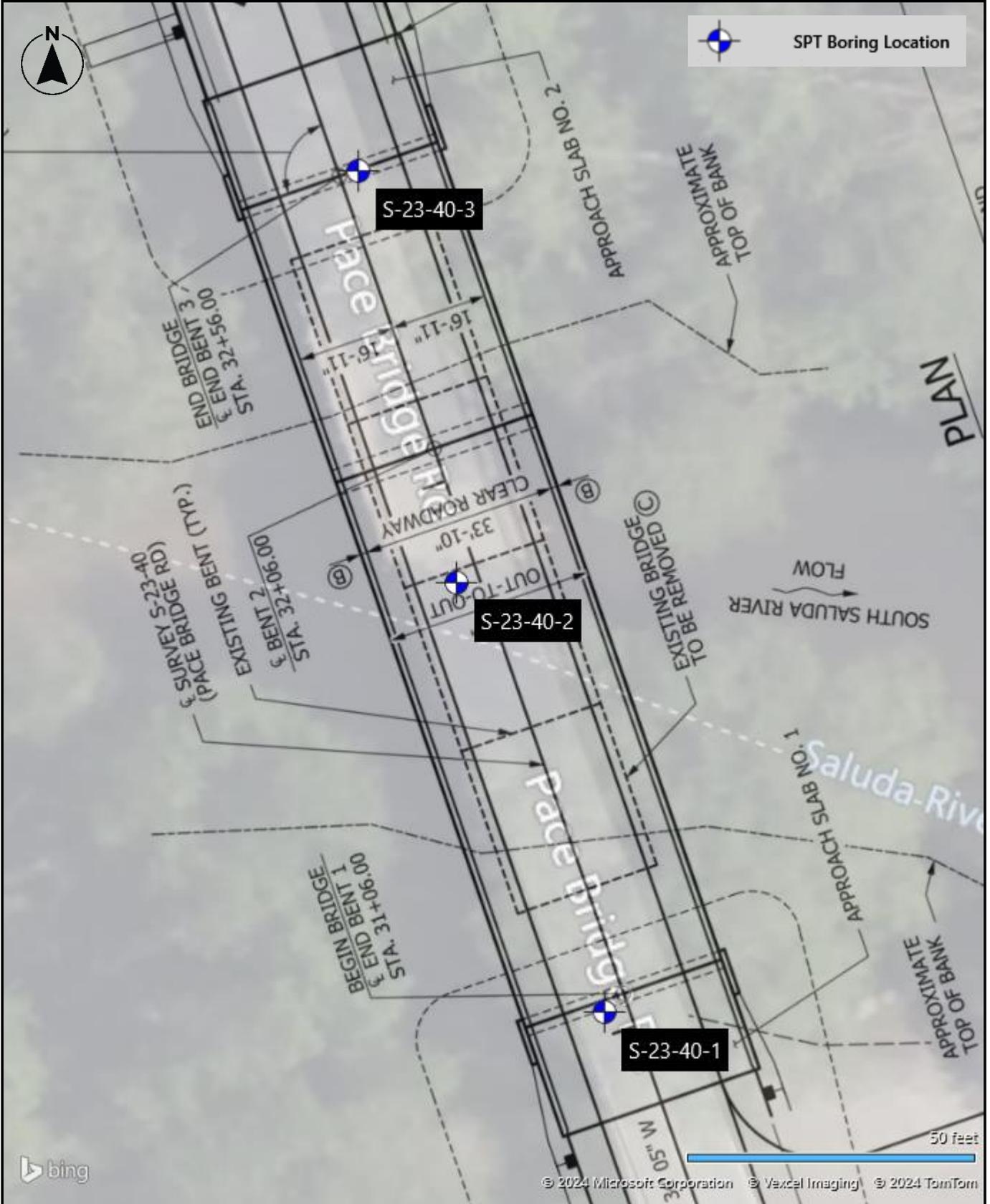


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

PRELIMINARY SITE PLAN PROVIDED BY HNTB

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



72 Pointe Cir  
Greenville, South Carolina 29615

**EXPLORATION PLAN**

S-23-40 BRO South Saluda River  
Pace Bridge Road  
Greenville County, SC

Exhibit

**A-2**

**Summary of Boring Data – Exhibit A-3**

S-23-40 Bridge Replacement over South Saluda River | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041160



**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-23-40-1 <sup>2,3</sup>	917	100	1160199.42	1529669.78	35.012103	-82.570559	31+04	4 L
S-23-40-2	917.5	100	1160273.90	1529645.30	35.012307	-82.570645	31+83	4 L
S-23-40-3 <sup>2</sup>	917.2	100	1160345.21	1529629.35	35.012502	-82.570702	32+56	4 R

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 composite bulk sample was collected about 14 feet south of S-23-40-1 and 8.5 feet west of S-23-40-3.
3. Boring S-23-40-1 was not surveyed due to a dirt mound being placed at the boring location after testing was completed. Testing location values are based on field measurements taken at the time of drilling.
4. Station and offset are based on the plans provided at the time the tests were performed.

## GeoScoping Form

PROJECT INFORMATION			
Project ID:	P041160	Date of Trip:	8/21/2024
County:	Greenville	Location:	Marietta
Rd/ Route:	S-23-40	Local Name:	Pace Bridge Road
Attendees:	M. McKenney		

EXISTING BRIDGE INFORMATION			
Bridge Length:	120 ft	Bridge Width:	26 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber and Steel H-Piles
Begin Bridge Sta <sup>1</sup> :	31+06	End Bridge Sta <sup>1</sup> :	32+56
Begin Bridge Embankment Sta <sup>1</sup> :	30+06	End Bridge Embankment Sta <sup>1</sup> :	33+56
Structure Number:	02540	Posted Weight Limit:	11 tons
Crossing:	South Saluda River	Skew:	N/A
Latitude:	35.01233°	Longitude:	-82.57065°
Existing Fill Height:	approx. 8 ft	Approx Existing Slope Angle:	2H:1V

1. Begin & End Bridge Embankment 100 ft down Sta. or up Sta., respectively. Sta. estimated from overlay of bridge plan provided by HNTB.

EXISTING ROADWAY EMBANKMENT INFORMATION			
Begin Project Sta:	29+60	Begin Bridge Embankment Sta:	30+06
Accessibility Issues:	Dirt mounds		
Ground Cover:	Asphalt pavement and vegetation along shoulders		
Existing Fill Height:	8 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	slope to river		
Traffic Control Necessary:	No		
Surface Soils:	silty sand / clayey sand	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	14 ft	Water Depth:	2 ft
Depth to Existing Ground:	approx. 16 ft at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical

End Bridge Embankment Sta:	33+56	End Project Sta:	33+56
Accessibility Issues:	Dirt mounds		
Ground Cover:	Asphalt pavement and vegetation along shoulders		
Existing Fill Height:	8 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	slope to river		
Traffic Control Necessary:	No		
Surface Soils:	silty sand / clayey sand	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	14 ft	Water Depth:	2 ft
Depth to Existing Ground:	approx. 16 ft at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical

### GeoScoping Form

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

Comments:

## Field Exploration Description

### Overview

The testing locations were proposed to and approved by SCDOT and located in the field by Terracon using measurements from existing structures shown on the provided drawings. The borings were surveyed by Thomas and Hutton, LLC after testing and drilling was complete. Boring S-23-40-1 was not surveyed due to a dirt mound being placed at the boring location prior to the survey being completed. The locations as shown in the Exploration Plan are shown to the scale indicated.

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

### Soil Test Borings (STB)

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

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

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

Test ID	Total Depth	Interval of Continuous Sampling
S-23-40-1	100 feet	2 to 10 feet
S-23-40-2	100 feet	16 to 26 feet
S-23-40-3	100 feet	2 to 10 feet
S-23-40-1/3 Offset	5 feet	Bulk Sample <sup>1</sup>

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

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

#### Exhibit A-5 – Field Exploration Description

S-23-40 BRO South Saluda River | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041160



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 to the planned drilling depth at which they were terminated. 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 were backfilled with the drill cuttings and clean sand. The upper 20 feet of those in the embankments were grouted with a cement bentonite grout and capped with cold-patch asphalt.

## SOIL DESCRIPTION TERMS

### Relative Density/Consistency Terms

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

### Moisture Condition

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

### Color

Describe the sample color while sample is still moist.

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

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

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

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

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

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

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

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

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

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

### USCS Soil Designation

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

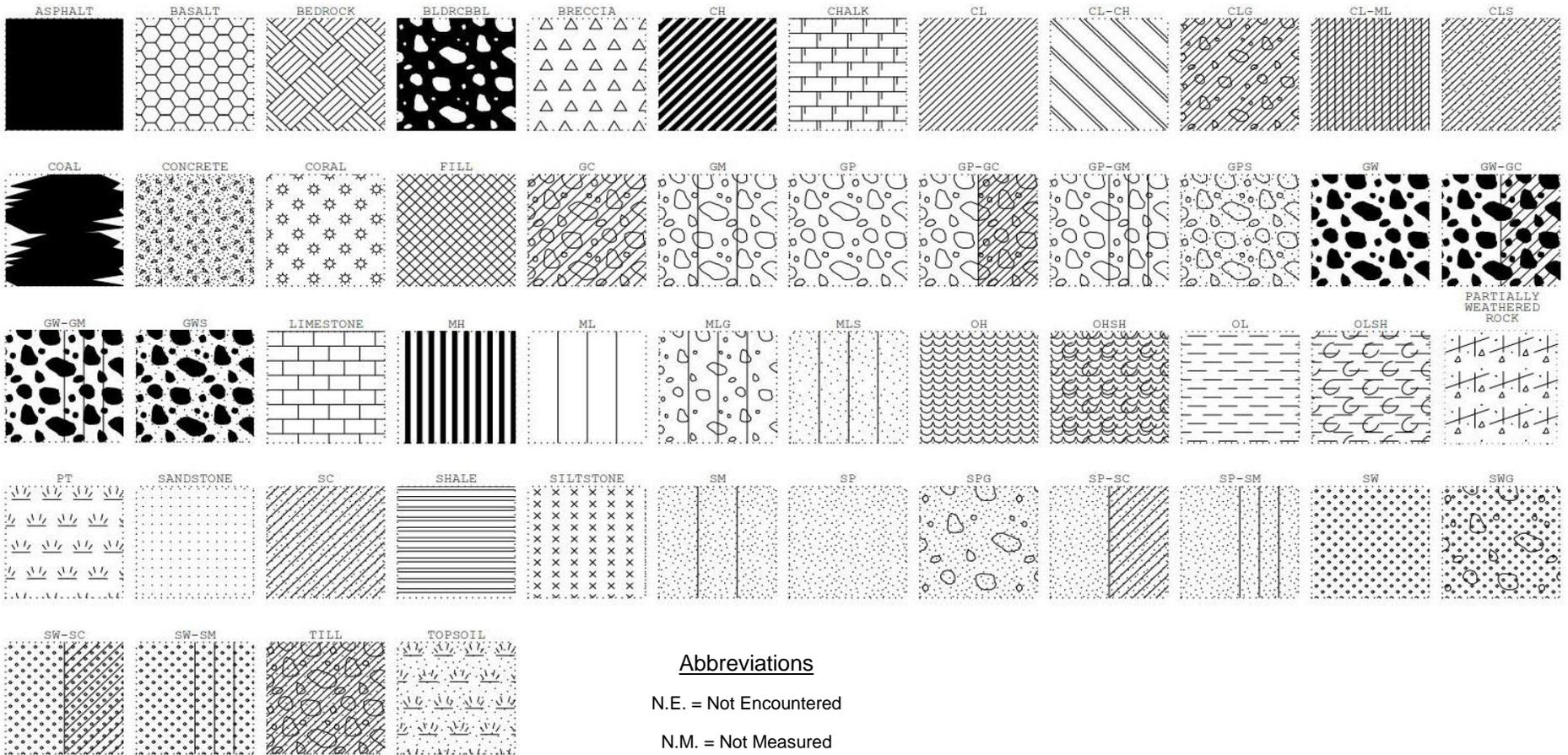
### AASHTO Soil Designation

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

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

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

<sup>3</sup>Use as required



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

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

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

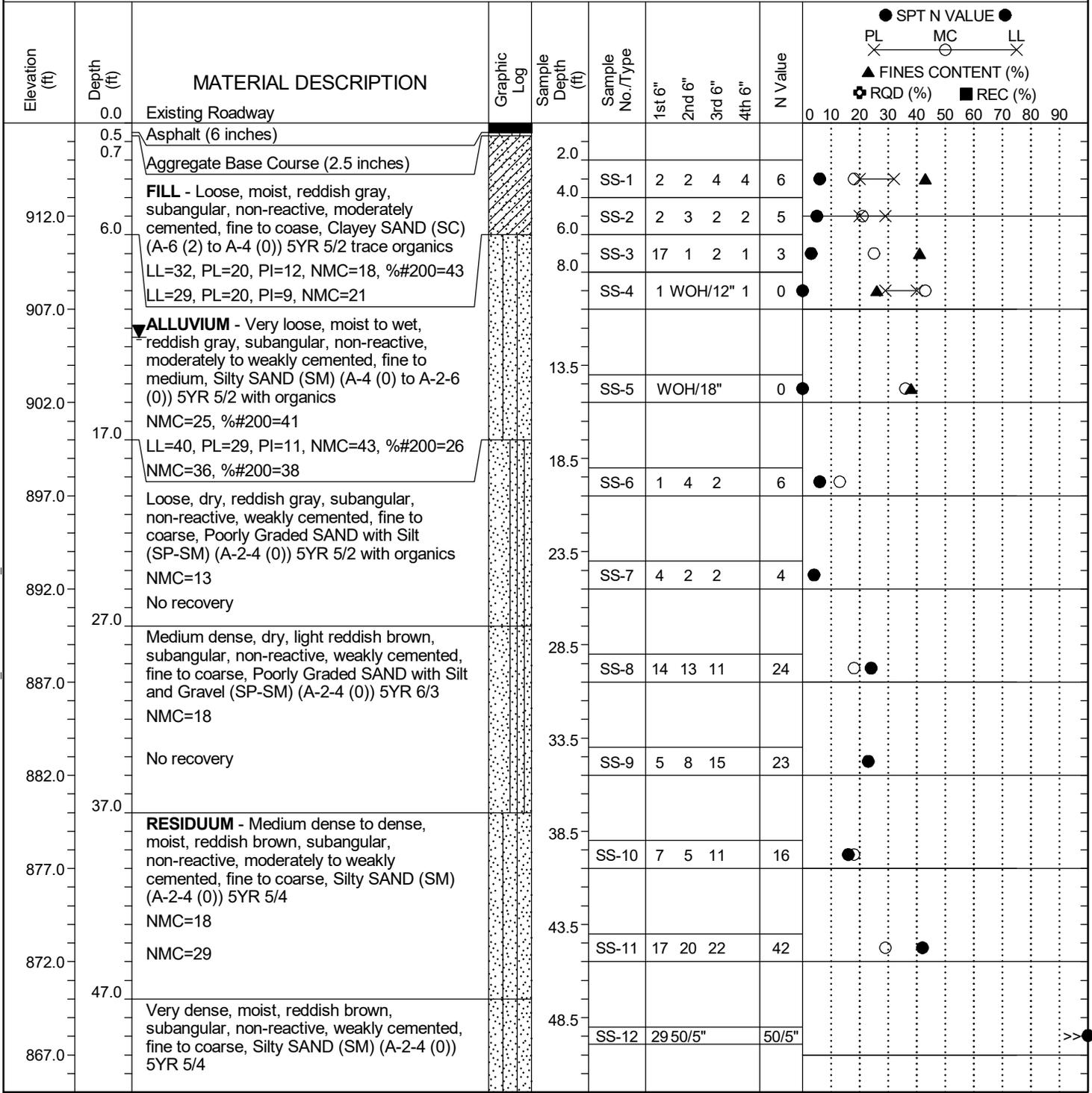


72 Pointe Circle  
Greenville, SC 29615  
PH. (864) 292-2901 FAX. (864) 292-6361

SOIL AND ROCK SYMBOLS

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-1
<b>Site Description:</b> S-23-40 BRO South Saluda River		<b>Route:</b> S-23-40
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 31+04	<b>Offset:</b> 4 L
<b>Alignment:</b> Existing	<b>Date Started:</b> 8/20/2024	<b>Date Completed:</b> 8/20/2024
<b>Elev.:</b> 917.0 ft	<b>Latitude:</b> 35.0121	<b>Longitude:</b> -82.57056
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<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#554	<b>Drill Method:</b> RW
<b>Hammer Type:</b> Automatic	<b>Energy Ratio:</b> 88.5%	<b>Groundwater:</b> TOB N.M.
<b>Core Size:</b> N/A	<b>Driller:</b> G. Robinson	<b>24HR:</b> 11.5 ft



## LEGEND

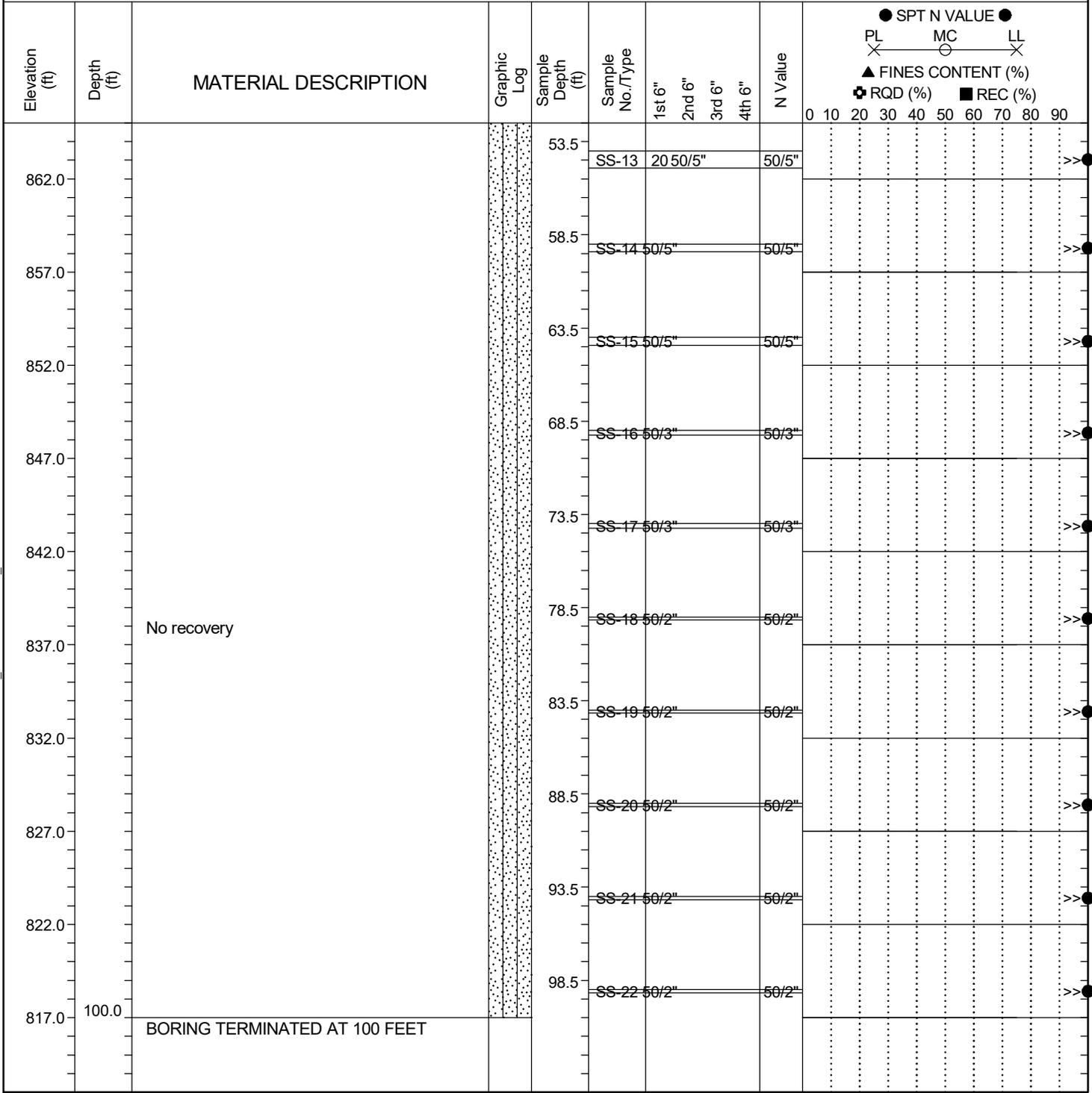
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-1
<b>Site Description:</b> S-23-40 BRO South Saluda River	<b>Route:</b> S-23-40	
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 31+04	<b>Offset:</b> 4 L
<b>Alignment:</b> Existing		
<b>Elev.:</b> 917.0 ft	<b>Latitude:</b> 35.0121	<b>Longitude:</b> -82.57056
<b>Date Started:</b> 8/20/2024		
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<b>Date Completed:</b> 8/20/2024		
<b>Bore Hole Diameter (in):</b> 4	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Liner Used:</b> Y (N)		
<b>Drill Machine:</b> DR#554	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 88.5%		
<b>Core Size:</b> N/A	<b>Driller:</b> G. Robinson	<b>Groundwater:</b> TOB N.M.
<b>24HR:</b> 11.5 ft		



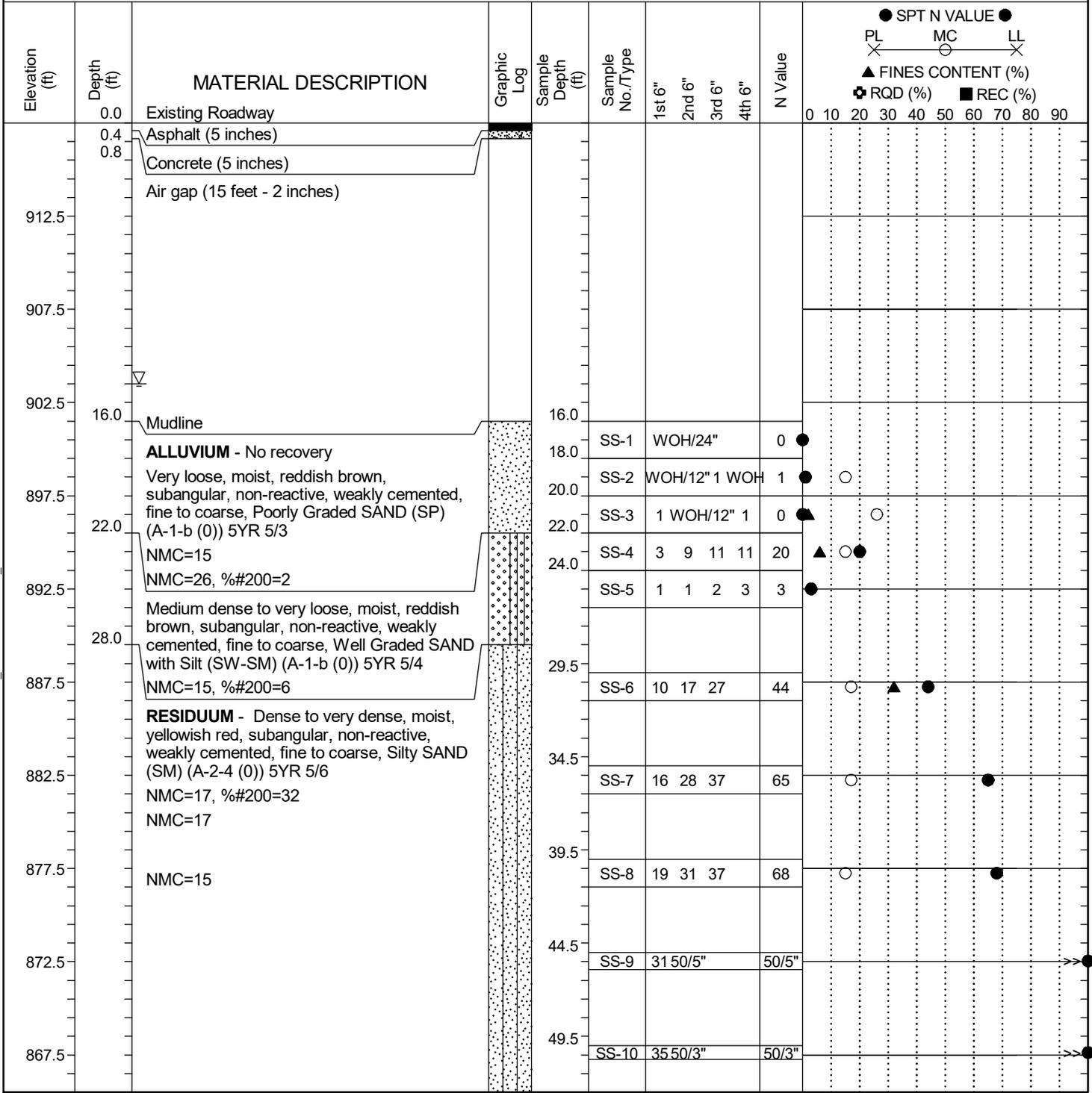
## LEGEND

SAMPLER TYPE		DRILLING METHOD	
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UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
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SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-2
<b>Site Description:</b> S-23-40 BRO South Saluda River		<b>Route:</b> S-23-40
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 31+83	<b>Offset:</b> 4 L
<b>Alignment:</b> Existing	<b>Date Started:</b> 8/20/2024	<b>Date Completed:</b> 8/21/2024
<b>Elev.:</b> 917.5 ft	<b>Latitude:</b> 35.01231	<b>Longitude:</b> -82.57065
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<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
<b>Hammer Type:</b> Automatic	<b>Energy Ratio:</b> 92.6%	<b>Core Size:</b> N/A
<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB	<b>24HR:</b> N.M.



LEGEND

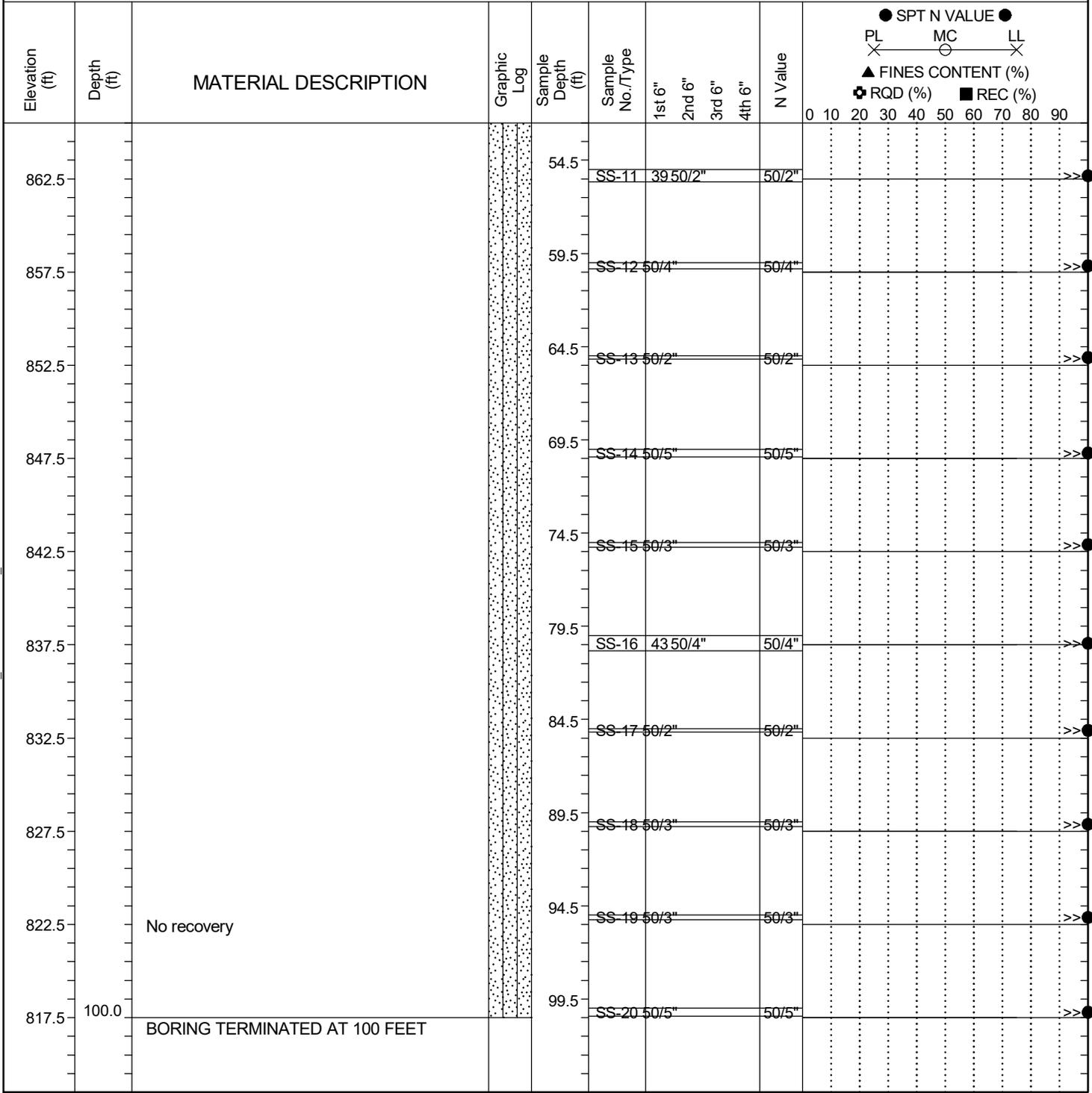
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER.DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-2
<b>Site Description:</b> S-23-40 BRO South Saluda River		<b>Route:</b> S-23-40
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 31+83	<b>Offset:</b> 4 L
<b>Alignment:</b> Existing		
<b>Elev.:</b> 917.5 ft	<b>Latitude:</b> 35.01231	<b>Longitude:</b> -82.57065
<b>Date Started:</b> 8/20/2024		
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<b>Date Completed:</b> 8/21/2024		
<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	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 92.6%		
<b>Core Size:</b> N/A	<b>Driller:</b> B. Burnette	<b>Groundwater:</b> TOB 14 ft
		<b>24HR:</b> N.M.



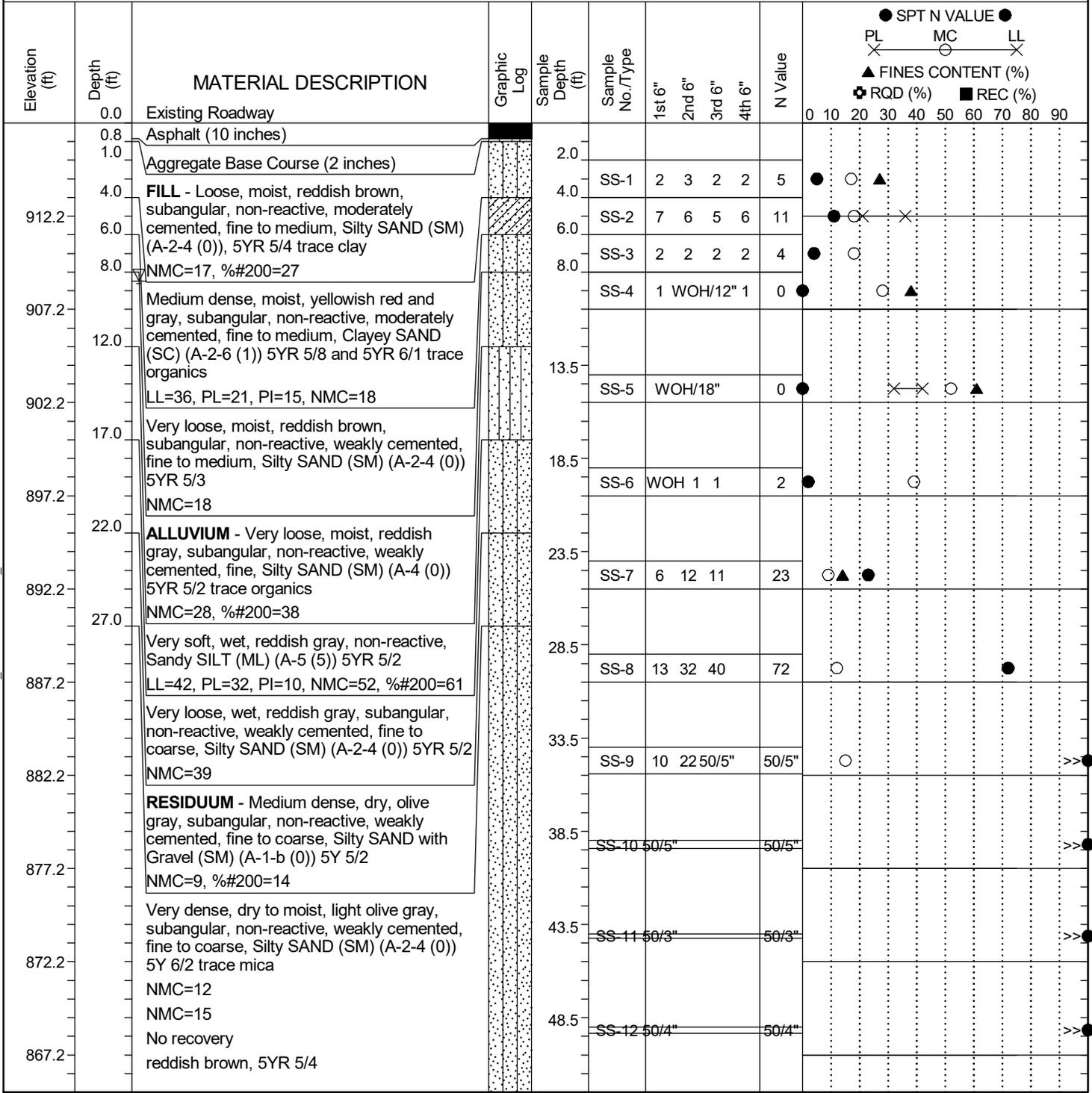
### LEGEND

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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-3
<b>Site Description:</b> S-23-40 BRO South Saluda River		<b>Route:</b> S-23-40
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 32+56	<b>Offset:</b> 4 R
<b>Alignment:</b> Existing		
<b>Elev.:</b> 917.2 ft	<b>Latitude:</b> 35.0125	<b>Longitude:</b> -82.5707
<b>Date Started:</b> 8/21/2024		
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<b>Date Completed:</b> 8/21/2024		
<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#554	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 88.5%		
<b>Core Size:</b> N/A	<b>Driller:</b> G. Robinson	<b>Groundwater:</b> TOB 8.5 (After 1hr) 24HR N.M.



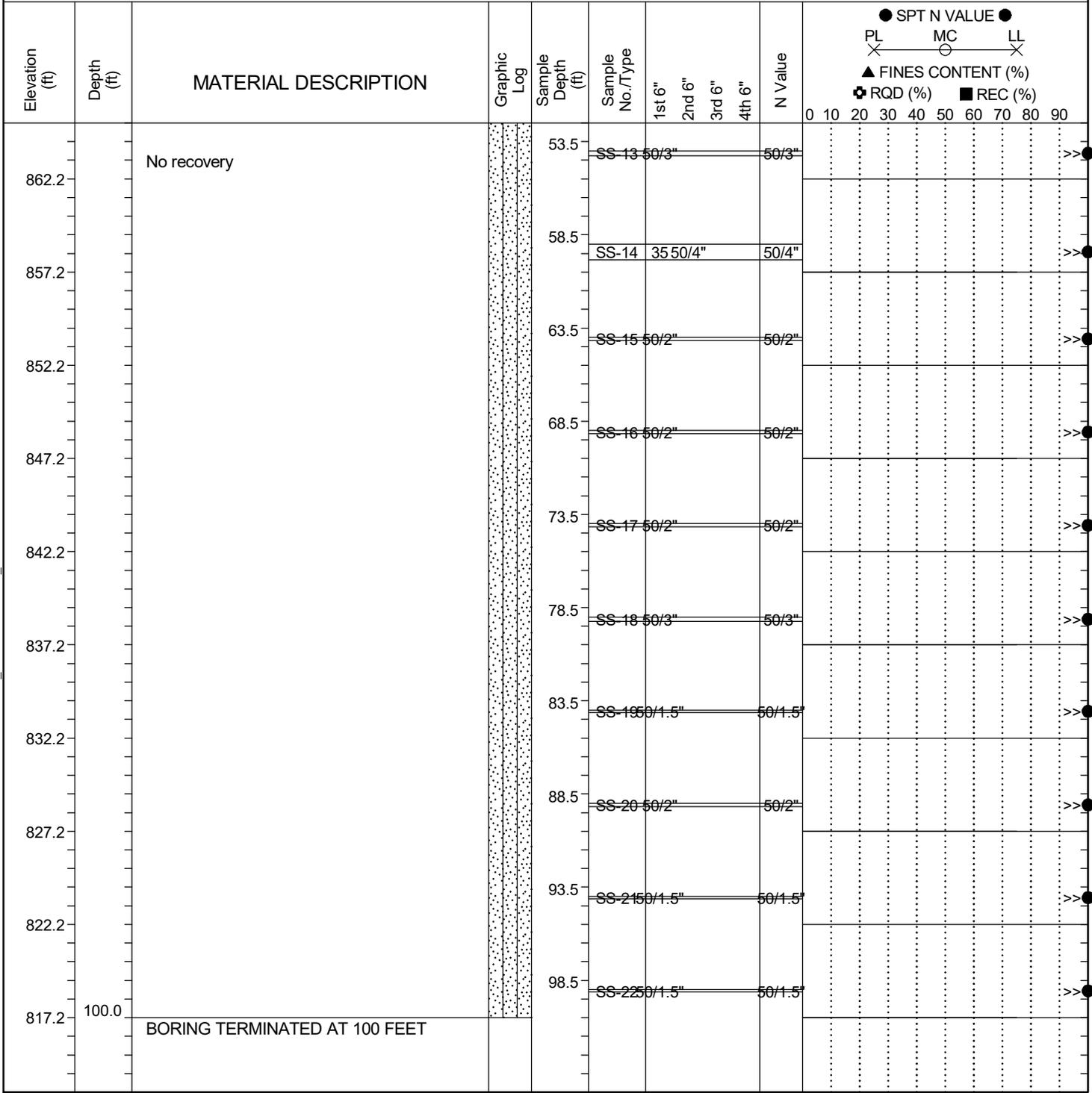
LEGEND Continued Next Page

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	

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

# SCDOT Soil Test Log

<b>Project ID:</b> P041160	<b>County:</b> Greenville	<b>Boring No.:</b> S-23-40-3
<b>Site Description:</b> S-23-40 BRO South Saluda River	<b>Route:</b> S-23-40	
<b>Eng./Geo.:</b> S. Greaber	<b>Boring Location:</b> 32+56	<b>Offset:</b> 4 R
<b>Alignment:</b> Existing		
<b>Elev.:</b> 917.2 ft	<b>Latitude:</b> 35.0125	<b>Longitude:</b> -82.5707
<b>Date Started:</b> 8/21/2024		
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> 0 ft
<b>Date Completed:</b> 8/21/2024		
<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#554	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Energy Ratio:</b> 88.5%		
<b>Core Size:</b> N/A	<b>Driller:</b> G. Robinson	<b>Groundwater:</b> TOB 8.5 (After 1hr) 24HR N.M.



### LEGEND

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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT\_DATATEMPLATE.GDT 9/30/24

**Appendix B – Laboratory Testing**

S-23-40 BRO South Saluda River | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041160



## **Appendix B**

### **Laboratory Testing**

Exhibit B-1 – Laboratory Testing Description  
Summary of Laboratory Data (2 Pages)  
Laboratory Data Sheets (12 Pages)

Note: All exhibits are one page unless noted above.

**Exhibit B-1 – Laboratory Testing Description**

S-23-40 BRO South Saluda River | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041160



**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:

- 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-23-40-1	2-4	CLAYEY SAND(SC) / A-6 (2)	32	20	12	3.1	54.3	42.6			18.3	
S-23-40-1	4-6	CLAYEY SAND(SC) / A-4 (0)	29	20	9						20.9	
S-23-40-1	6-8	SILTY SAND(SM) / A-4 (0)				0.6	58.9	40.5			25.2	
S-23-40-1	8-10	SILTY SAND(SM) / A-2-6 (0)	40	29	11	1.1	72.9	26.0	20.5	5.5	42.9	
S-23-40-1	13.5-15	SILTY SAND(SM) / A-4 (0)				0.1	62.2	37.7	26.7	11.0	35.9	
S-23-40-1	18.5-20	POORLY GRADED SAND with SILT(SP-SM) / A-2-4 (0)									12.8	
S-23-40-1	28.5-30	POORLY GRADED SAND with SILT(SP-SM) / A-2-4 (0)									17.6	
S-23-40-1	38.5-40	SILTY SAND(SM) / A-2-4 (0)									18.1	
S-23-40-1	43.5-45	SILTY SAND(SM) / A-2-4 (0)									28.5	
S-23-40-2	18-20	POORLY GRADED SAND(SP) / A-1-b (0)									14.6	
S-23-40-2	20-22	POORLY GRADED SAND(SP) / A-1-b (0)				0.8	97.4	1.7	0.9	0.9	26.1	
S-23-40-2	22-24	WELL GRADED SAND with SILT(SW-SM) / A-1-b (0)				5.0	88.6	6.4			14.6	
S-23-40-2	29.5-31	SILTY SAND(SM) / A-2-4 (0)				0.5	68.0	31.5			17.1	
S-23-40-2	34.5-36	SILTY SAND(SM) / A-2-4 (0)									16.6	
S-23-40-2	39.5-41	SILTY SAND(SM) / A-2-4 (0)									14.6	
S-23-40-3	2-4	SILTY SAND(SM) / A-2-4 (0)				3.1	70.0	26.8			16.6	
S-23-40-3	4-6	CLAYEY SAND(SC) / A-2-6 (1)	36	21	15						18.1	
S-23-40-3	6-8	SILTY SAND(SM) / A-2-4 (0)									17.8	
S-23-40-3	8-10	SILTY SAND(SM) / A-4 (0)				0.5	61.3	38.2			28.4	

## 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-23-40-3	13.5-15	SANDY SILT(ML) / A-5 (5)	42	32	10	0.0	39.1	60.9	44.2	16.7	51.6	
S-23-40-3	18.5-20	SILTY SAND(SM) / A-2-4 (0)									38.9	
S-23-40-3	23.5-25	SILTY SAND with GRAVEL(SM) / A-1-b (0)				34.5	51.7	13.9			9.4	
S-23-40-3	28.5-30	SILTY SAND(SM) / A-2-4 (0)									12.0	
S-23-40-3	33.5-34.96	SILTY SAND(SM) / A-2-4 (0)									15.3	
S-23-40-1/3 Offset	0-5	SILTY SAND(SM) / A-4 (0)	NP	NP	NP	4.4	52.3	43.3				111.0 / 15.4



# INDEX PROPERTIES VERSUS DEPTH

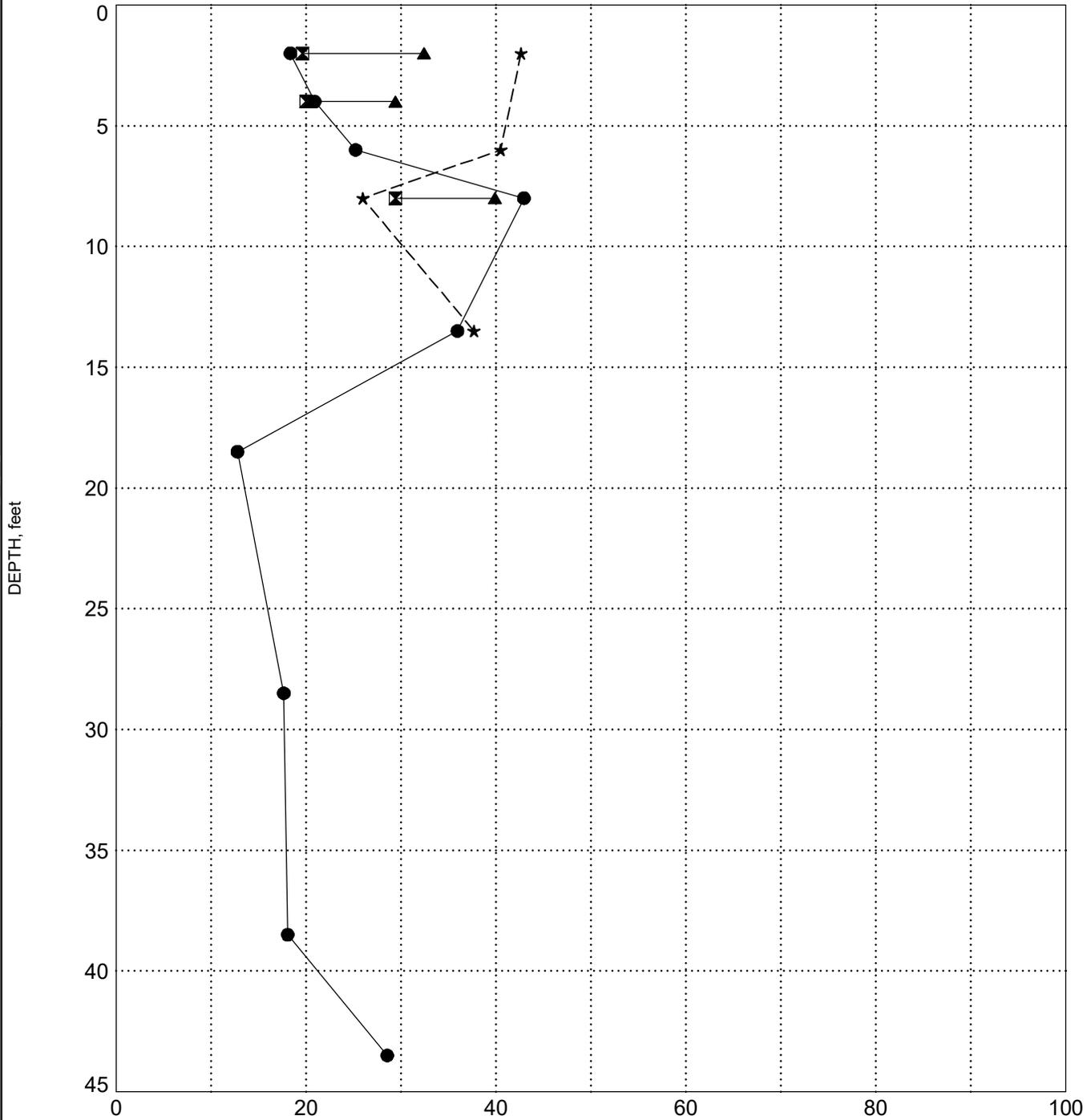
PROJECT ID P041160

PROJECT NAME S-23-40 BRO South Saluda River

PROJECT COUNTY Greenville

## BORING S-23-40-1

SURFACE ELEVATION: 917.0



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

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 9/30/24



# INDEX PROPERTIES VERSUS DEPTH

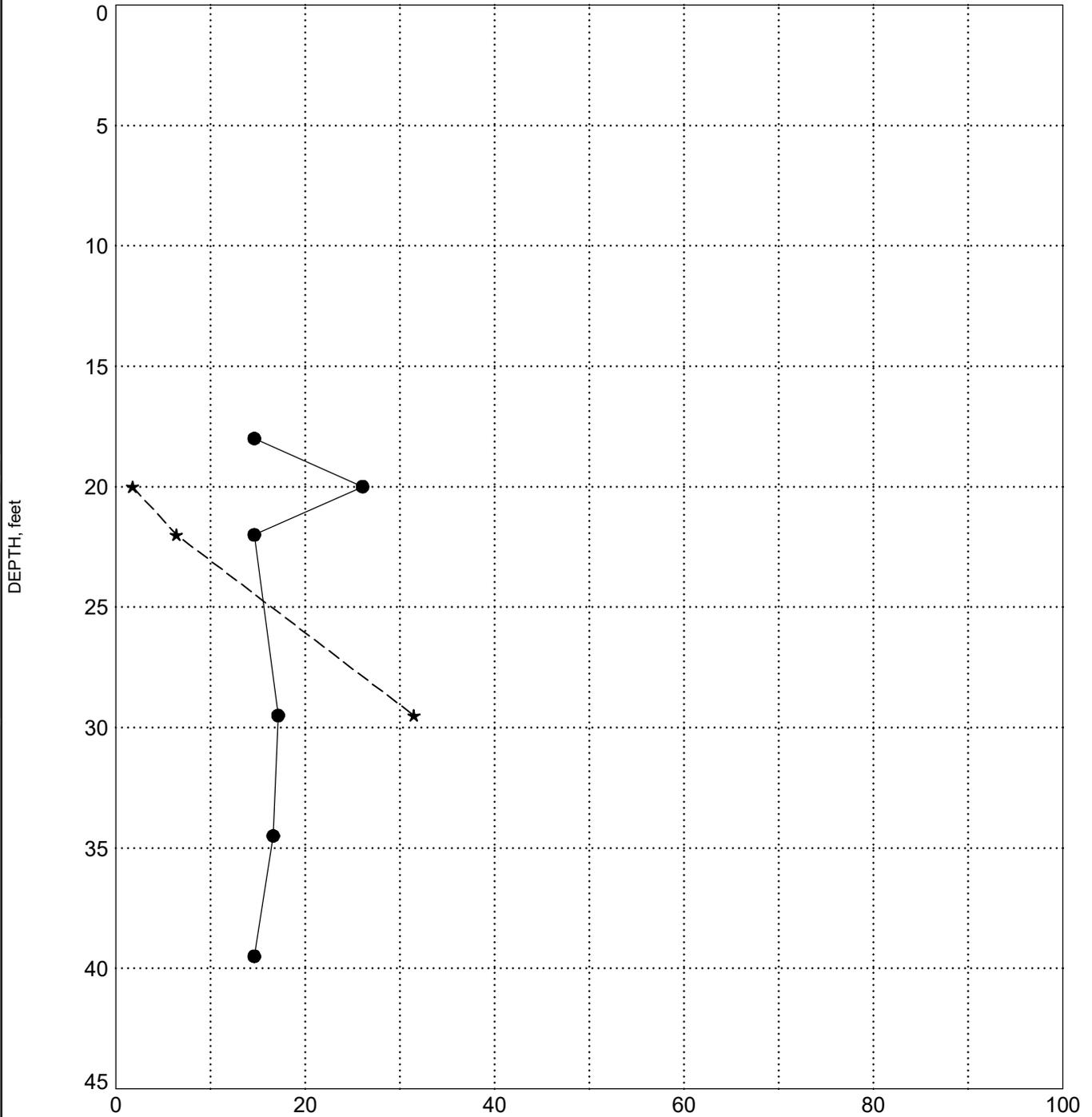
PROJECT ID P041160

PROJECT NAME S-23-40 BRO South Saluda River

PROJECT COUNTY Greenville

SURFACE ELEVATION: 917.5

## BORING S-23-40-2



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

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 9/30/24



# INDEX PROPERTIES VERSUS DEPTH

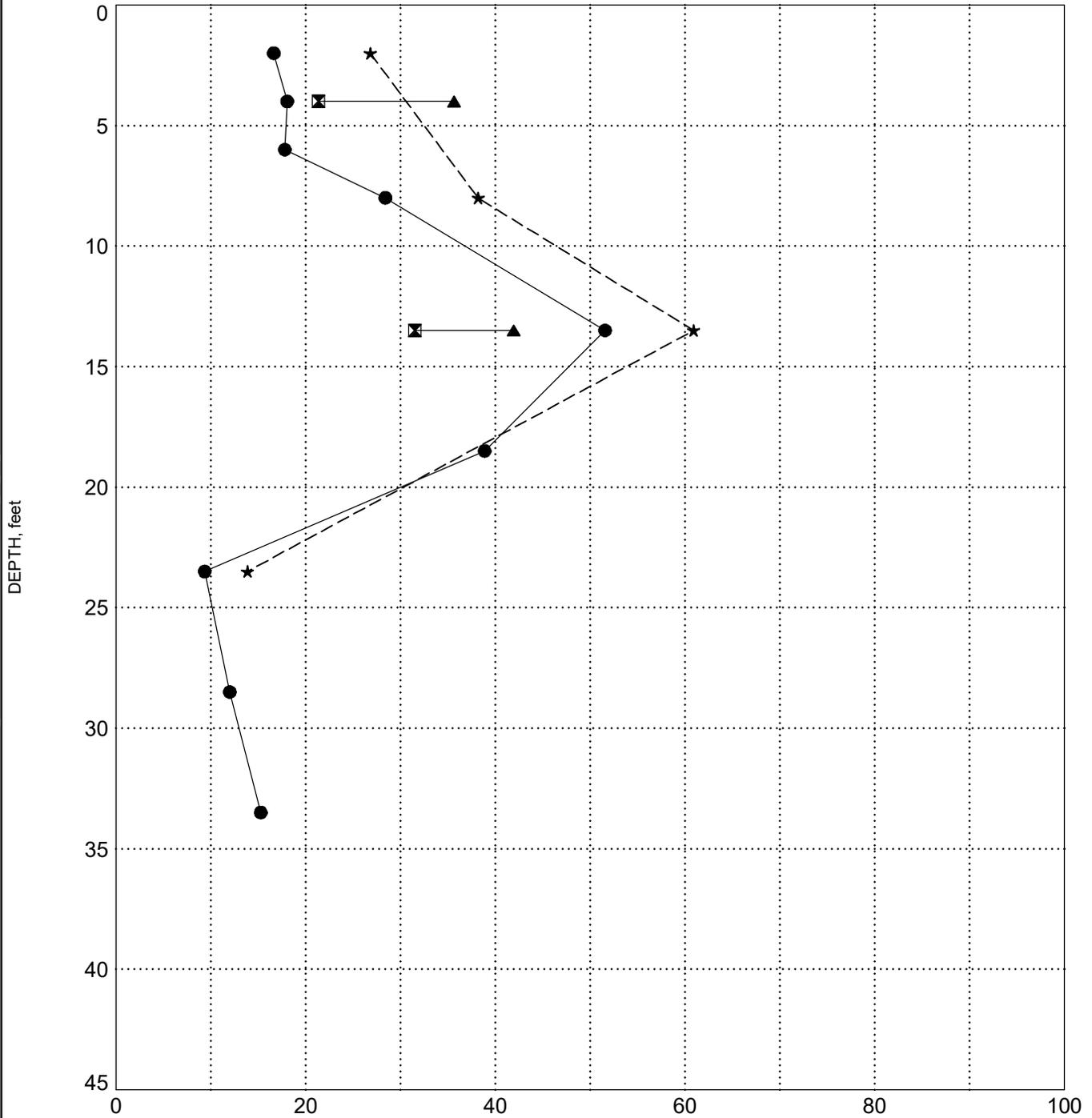
PROJECT ID P041160

PROJECT NAME S-23-40 BRO South Saluda River

PROJECT COUNTY Greenville

SURFACE ELEVATION: 917.2

## BORING S-23-40-3



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

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 9/30/24



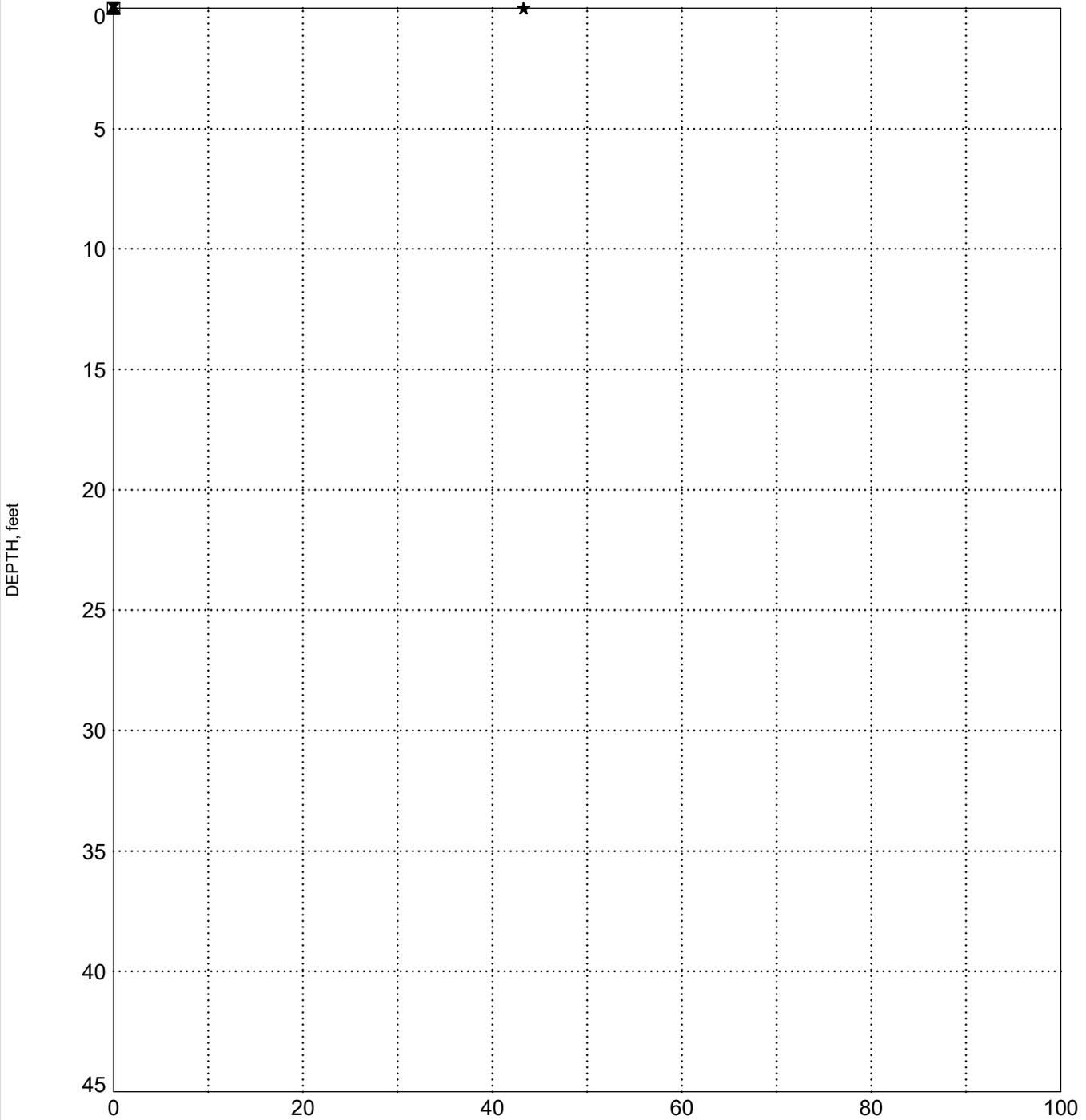
# INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041160

PROJECT NAME S-23-40 BRO South Saluda River

PROJECT COUNTY Greenville

## BORING S-23-40-1/3 Offset



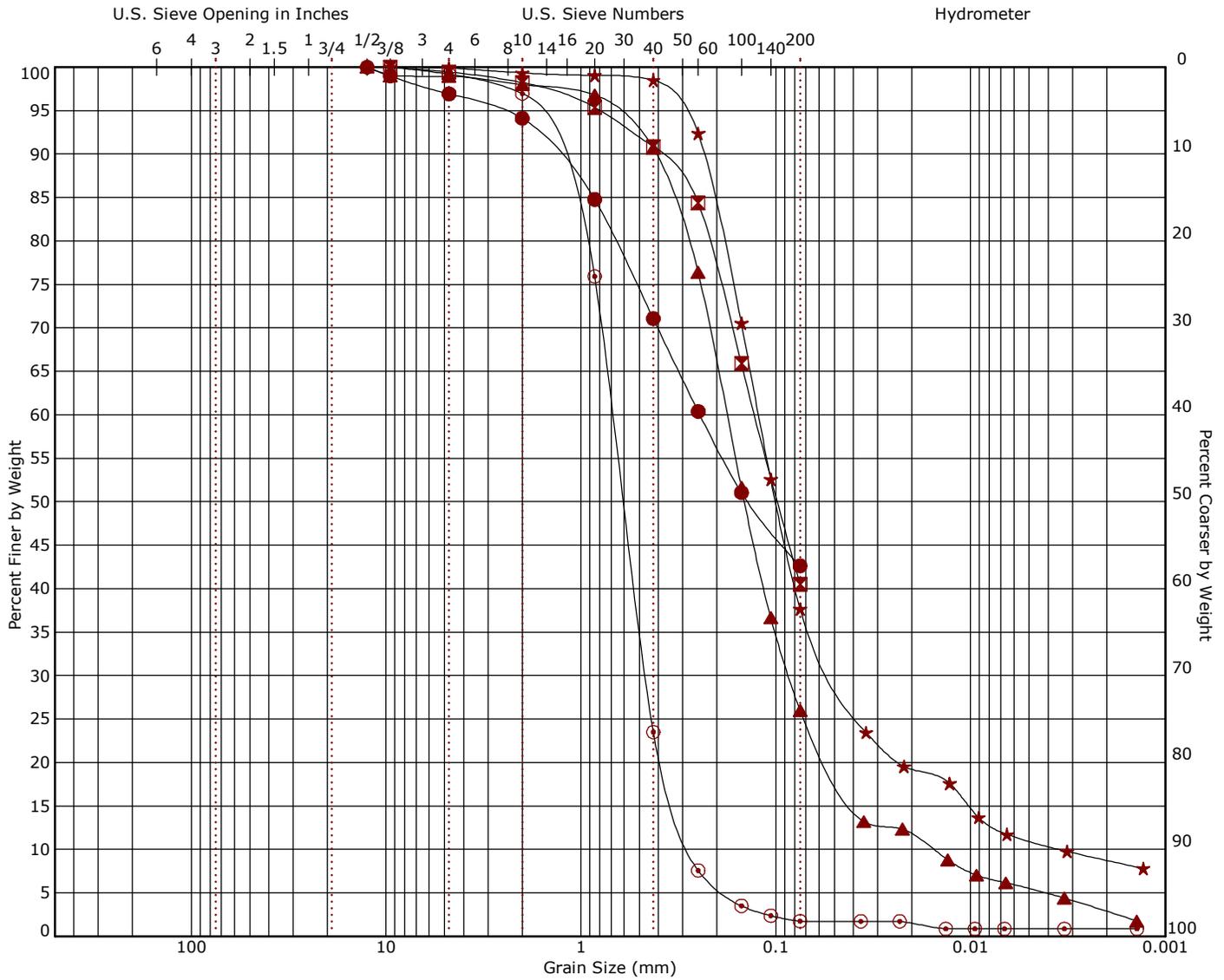
LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-40 OVER SOUTH SALUDA RIVER-DOT\_JNA.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 9/30/24



## Grain Size Distribution

### ASTM D422 / ASTM C136



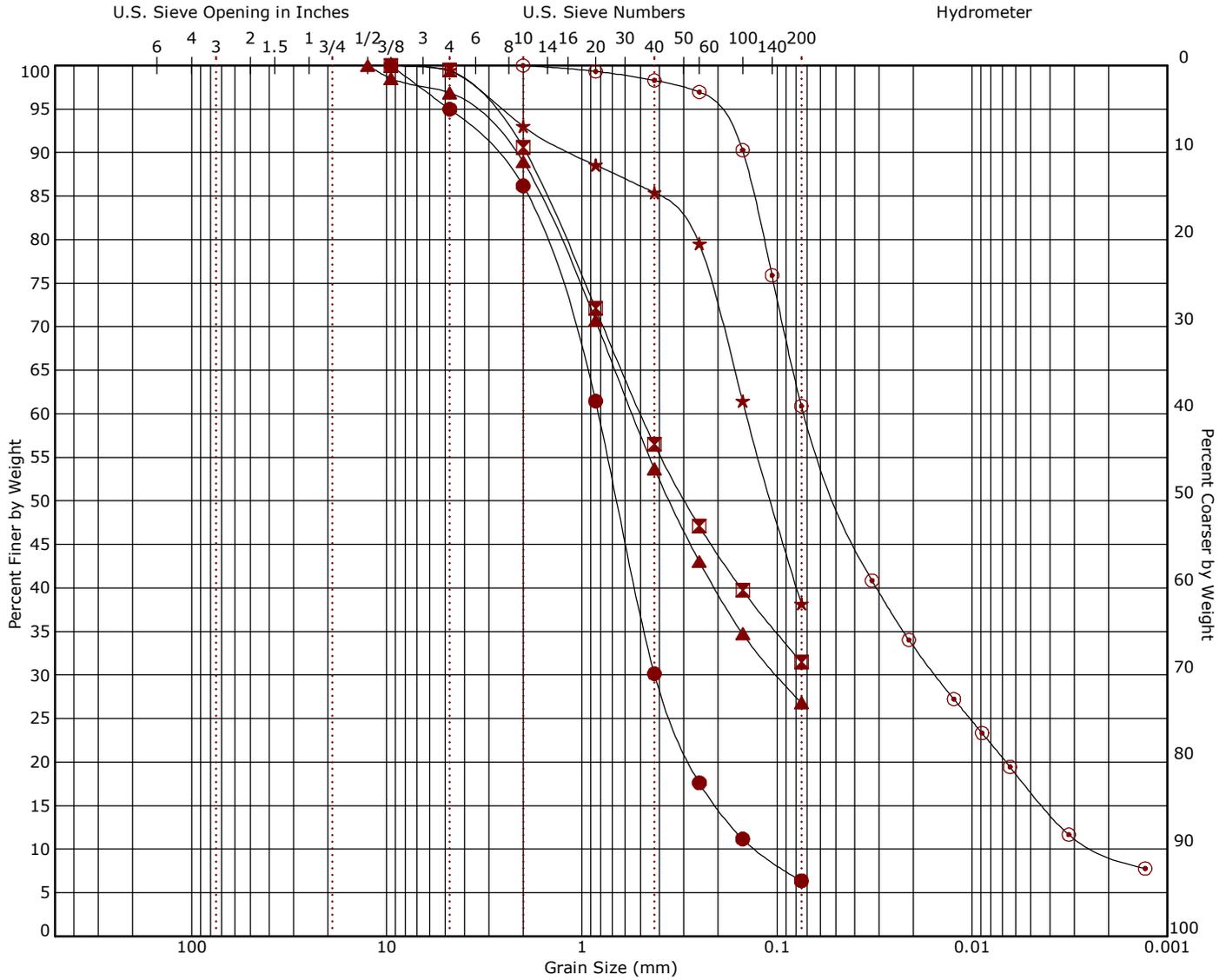
Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-40-1	2 - 4	CLAYEY SAND	SC	A-6 (2)	32	20	12		
☒ S-23-40-1	6 - 8	SILTY SAND	SM	A-4 (0)					
▲ S-23-40-1	8 - 10	SILTY SAND	SM	A-2-6 (0)	40	29	11	2.60	11.34
★ S-23-40-1	13.5 - 15	SILTY SAND	SM	A-4 (0)				5.70	35.21
⊙ S-23-40-2	20 - 22	POORLY GRADED SAND	SP	A-1-b (0)				1.15	2.54

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-23-40-1	2 - 4	12.5	0.245			0.0	3.1	54.3	42.6		
☒ S-23-40-1	6 - 8	9.5	0.128			0.0	0.6	58.9	40.5		
▲ S-23-40-1	8 - 10	12.5	0.178	0.085	0.016	0.0	1.1	72.9		20.5	5.5
★ S-23-40-1	13.5 - 15	9.5	0.122	0.049	0.003	0.0	0.1	62.2		26.7	11.0
⊙ S-23-40-2	20 - 22	9.5	0.689	0.463	0.271	0.0	0.8	97.4		0.9	0.9

## Grain Size Distribution

### ASTM D422 / ASTM C136



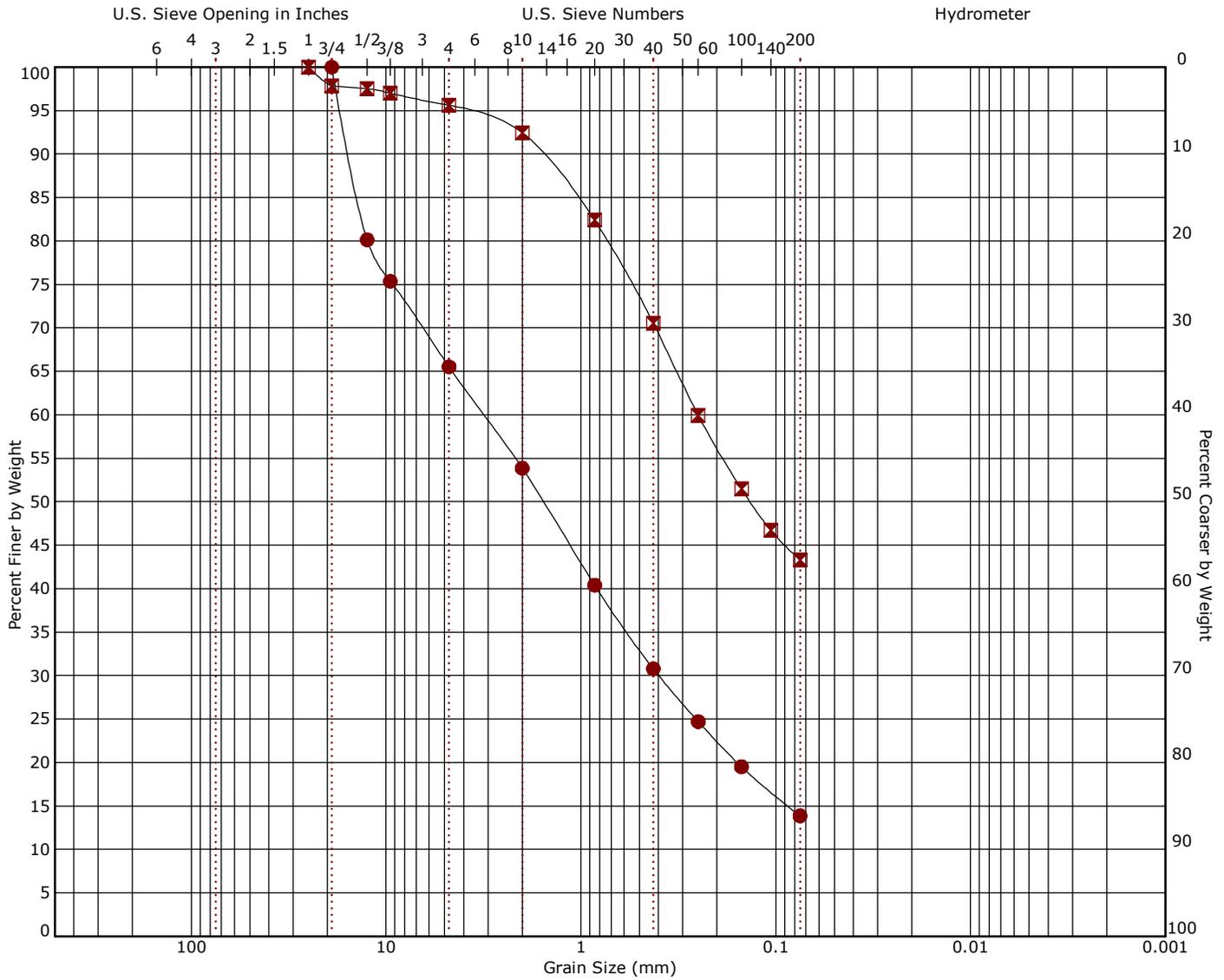
Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-40-2	22 - 24	WELL GRADED SAND with SILT	SW-SM	A-1-b (0)				1.71	6.50
⊠ S-23-40-2	29.5 - 31	SILTY SAND	SM	A-2-4 (0)					
▲ S-23-40-3	2 - 4	SILTY SAND	SM	A-2-4 (0)					
★ S-23-40-3	8 - 10	SILTY SAND	SM	A-4 (0)					
⊙ S-23-40-3	13.5 - 15	SANDY SILT	ML	A-5 (5)	42	32	10	1.51	33.26

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-23-40-2	22 - 24	9.5	0.823	0.422	0.127	0.0	5.0	88.6	6.4		
⊠ S-23-40-2	29.5 - 31	9.5	0.497			0.0	0.5	68.0	31.5		
▲ S-23-40-3	2 - 4	12.5	0.549	0.099		0.0	3.1	70.0	26.8		
★ S-23-40-3	8 - 10	9.5	0.144			0.0	0.5	61.3	38.2		
⊙ S-23-40-3	13.5 - 15	2	0.072	0.015	0.002	0.0	0.0	39.1		44.2	16.7

## Grain Size Distribution

### ASTM D422 / ASTM C136



Cobbles | 
 Gravel | 
 Sand | 
 Silt or Clay

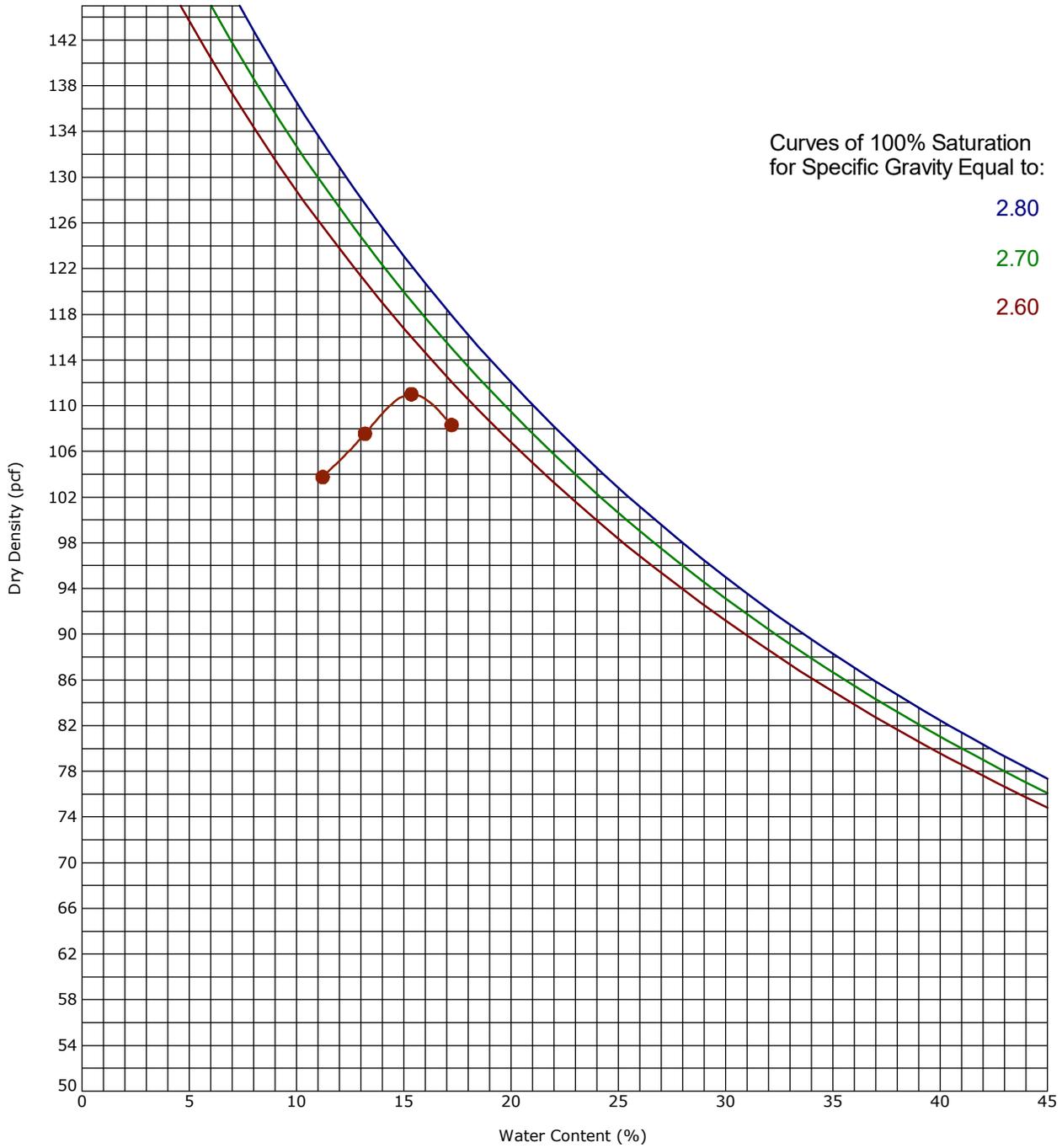
coarse | fine | coarse | medium | fine

Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-40-3	23.5 - 25	SILTY SAND with GRAVEL	SM	A-1-b (0)					
☒ S-23-40-1/3 Offset	0 - 5	SILTY SAND	SM	A-4 (0)	NP	NP	NP		

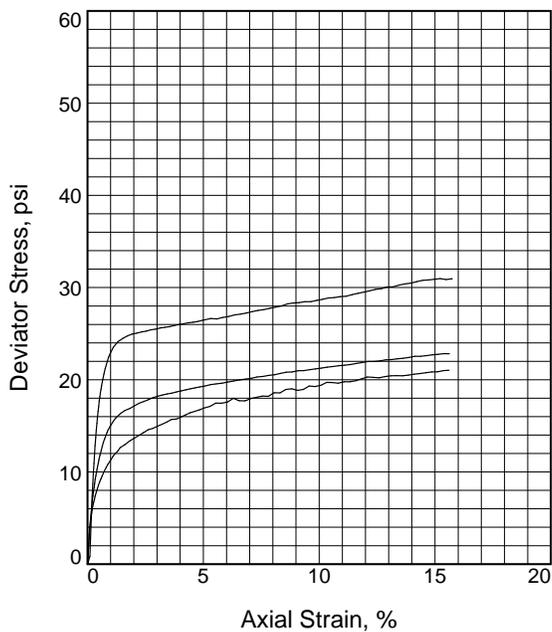
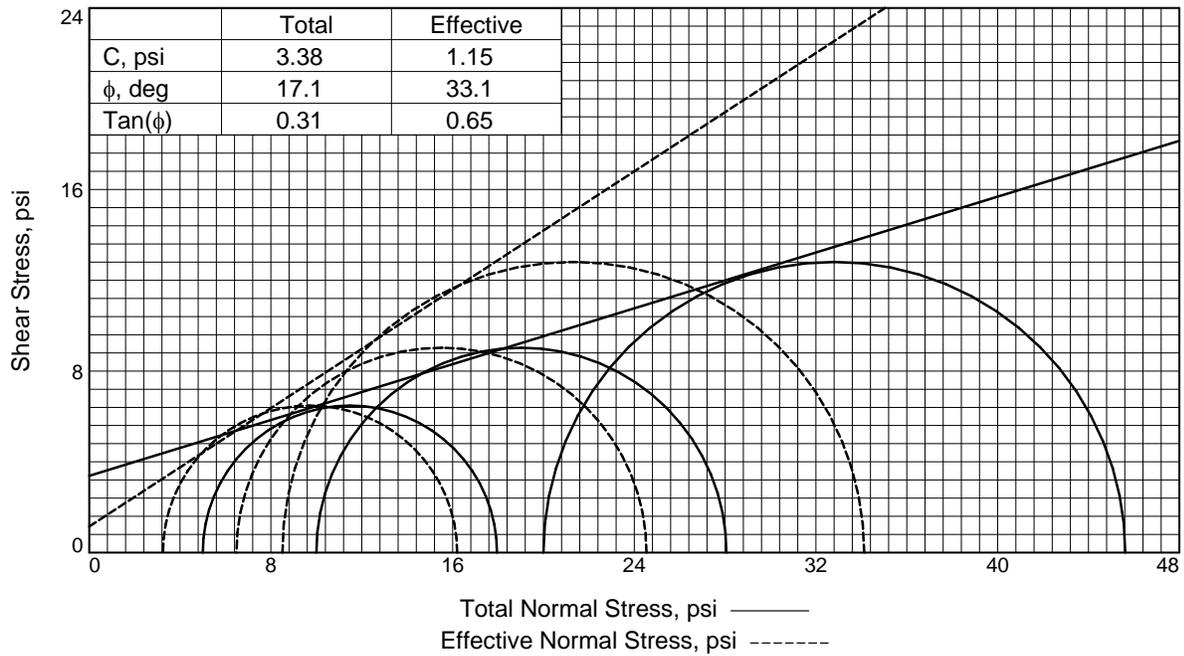
Boring ID	Depth (Ft)	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-23-40-3	23.5 - 25	19	3.153	0.397		0.0	34.5	51.7	13.9		
☒ S-23-40-1/3 Offset	0 - 5	25	0.251			0.0	4.4	52.3	43.3		

## Moisture-Density Relationship

### ASTM D698-Method B



Boring ID		Depth (Ft)		Description of Materials				
S-23-40-1/3 Offset		0 - 5		SILTY SAND(SM)				
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)	
43	0.0	NP	NP	NP	ASTM D698-Method B	111.0	15.4	



Sample No.	1	2	3	
Initial	Water Content, %	15.4	15.7	15.5
	Dry Density, pcf	105.5	105.6	105.6
	Saturation, %	69.4	71.0	70.1
	Void Ratio	0.5971	0.5964	0.5955
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.62	5.62	5.62
At Test	Water Content, %	20.2	20.8	19.4
	Dry Density, pcf	109.0	108.0	110.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5467	0.5604	0.5227
	Diameter, in.	2.76	2.77	2.75
	Height, in.	5.58	5.58	5.54
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	13.0	18.1	25.6	
Excess Pore Pr., psi	1.8	3.5	11.5	
Ult. Stress, psi	20.9	22.8	30.9	
Excess Pore Pr., psi	-2.2	1.2	9.4	
$\bar{\sigma}_1$ Failure, psi	16.2	24.5	34.1	
$\bar{\sigma}_3$ Failure, psi	3.2	6.5	8.5	

**Type of Test:**

CU with Pore Pressures

**Sample Type:** Remolded

**Description:** Silty Sand (SM)

LL= NV

PI= NP

**Specific Gravity=** 2.7

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

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

**Client:** HNTB North Carolina PC

**Project:** S-23-40 BRO South Saluda River

**Source of Sample:** S-23-40-1/3 Offset **Depth:** 0-5'

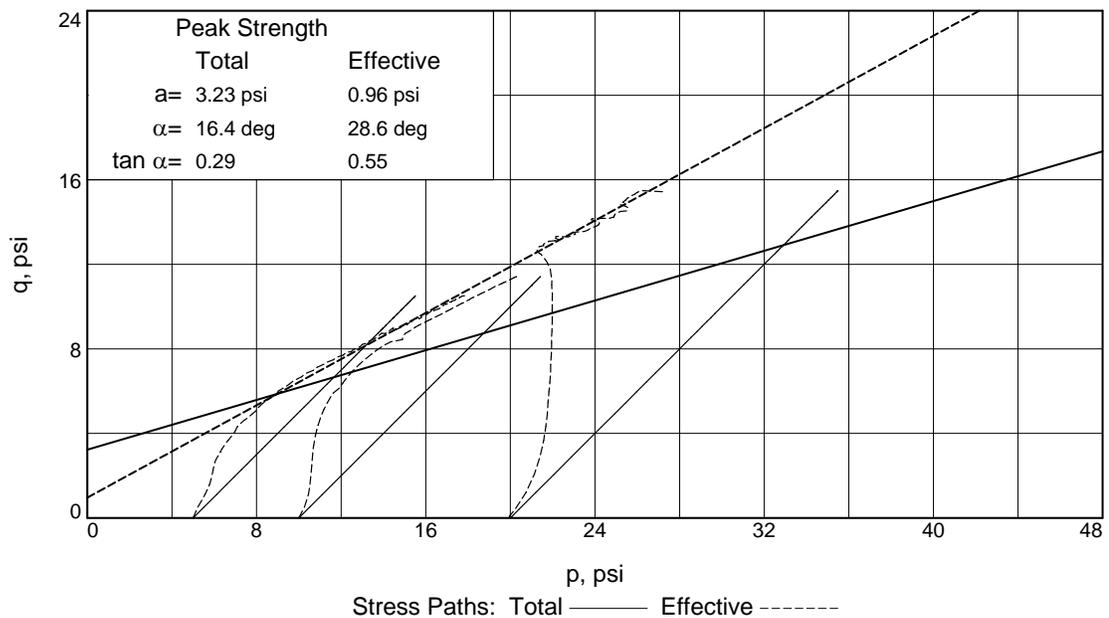
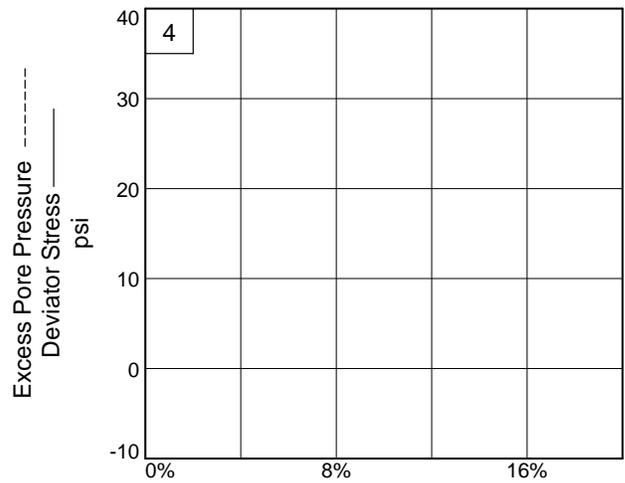
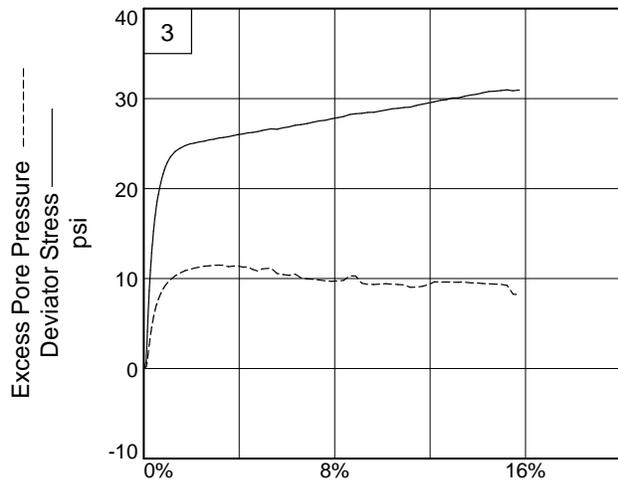
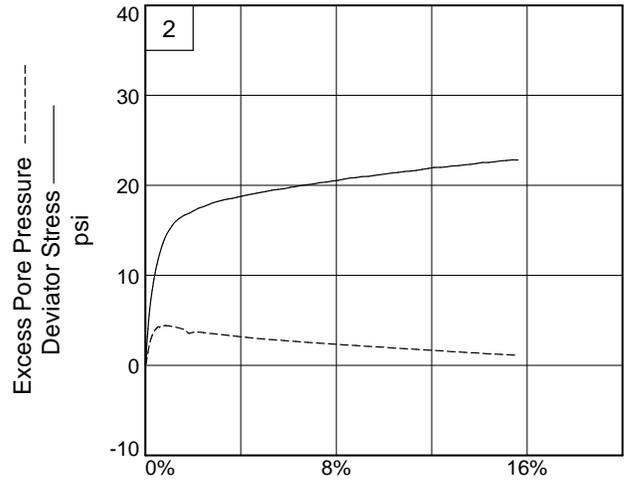
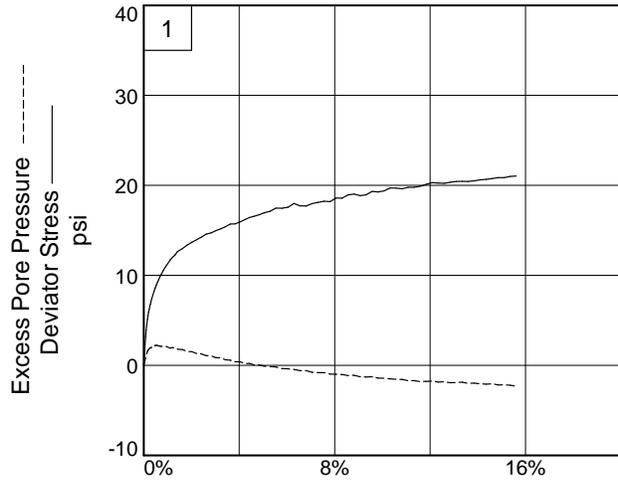
**Proj. No.:** 8623P180

**Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.

Chattanooga, TN



**Client:** HNTB North Carolina PC

**Project:** S-23-40 BRO South Saluda River

**Source of Sample:** S-23-40-1/3 Offset **Depth:** 0-5'

**Project No.:** 8623P180

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

**Terracon Consultants, Inc.**

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



**Client**

HNTB North Carolina PC

**Project**

S-23-40 BRO South Saluda River

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

**Date Received:** 8/29/2024

**Lab No.:** 24-0289

**Results of Corrosion Analysis**

<b>Sample Number</b>	S-23-40-1
<b>Sample Location</b>	--
<b>Sample Depth (ft.)</b>	2.0-20.0
pH Analysis, AASHTO T289	5.94
Water Soluble Sulfate (SO4), AASHTO T290 (mg/kg)	47
Chlorides, AASHTO T291, (mg/kg)	133
Saturated Minimum Resistivity, AASHTO T288, (ohm-cm)	7370

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

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

Nathan Campo  
Laboratory Coordinator

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

**Appendix C – Supporting Documents**

S-23-40 BRO South Saluda River | Greenville County, SC  
Terracon Project No. 8623P180 | SCDOT Project ID: P041160



## **Appendix C**

### **Supporting Documents**

Rig Calibration Report – DR#554 (5 Pages)

Rig Calibration Report – DR#1327 (8 Pages)

Note: All exhibits are one page unless noted above.

# For Borings S-23-40-1 and S-23-40-3

## SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: GeoProbe 3126

Drill Rig Serial Number: 3126TTS52010006

Asset Number: DR#554

August 21, 2023



July 19, 2023

Terracon  
72 Pointe Circle  
Greenville, South Carolina 29607

Attn: 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.

*Jim Smith*

James P. Smith  
National Manager of Equipment & Training

*Rob Kramer*

Rob Kramer  
Group Manager Geophysics

Attachments:

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

Prepared for:

Terracon  
Greenville-Spartanburg, South Carolina



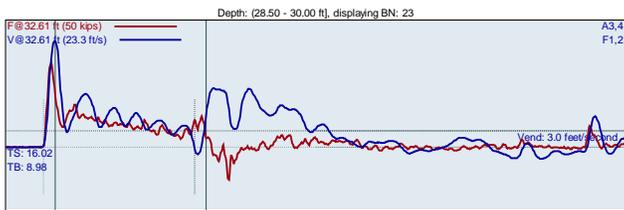
### MEASUREMENT SUMMARY

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 28.530  
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/6.4w5000g (1) VF1  
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w5000g (1) VF1

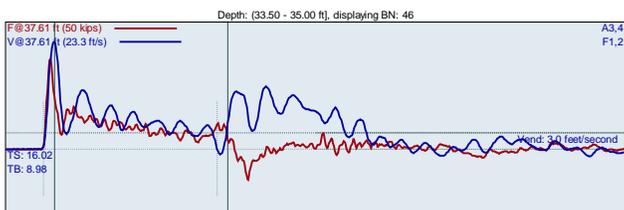
FMX: Maximum Force EFV: Maximum Energy  
VMX: Maximum Velocity ETR: Energy Transfer Ratio - Rated  
BPM: Blows/Minute

BL#	BC /6"	FMX kips	VMX fts	BPM bpm	EFV ft-lb	ETR %
1	6	40	19.4	1.9	234	84.1
2	6	39	19.2	51.9	232	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	269	79.5
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 28.530  
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



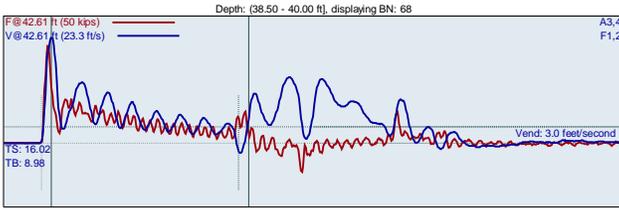
F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4w5000g (1) VF1  
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w5000g (1) VF1

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

BL#	BC /6"	FMX kips	VMX fts	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 28.5-30  
JIM SMITH Interval start: 8/21/2023  
TB-1 SP: 0.492 k/ft  
AR: 1.20 in/2 EM: 30000 ksi  
LE: 42.61 ft  
WS: 16807.9 ft/s



F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4w/5000g (1) VF1  
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w/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	279	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.

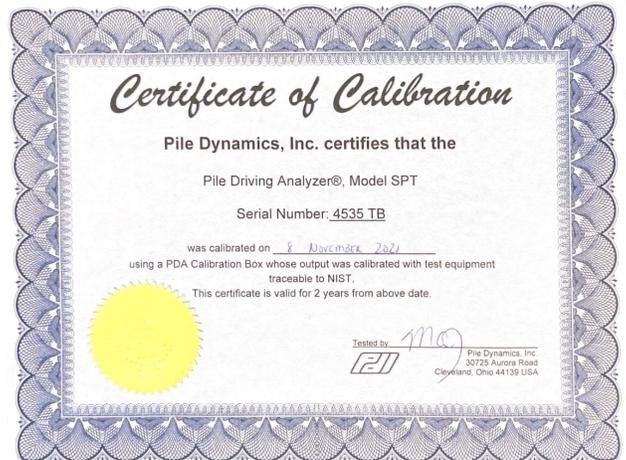
Summary of SPT Test Results

Project: GP554-3126, Test Date: 8/21/2023

Blow/Minute	Blows Applied /6"	N Value	N60 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
32.61	6-8-11	19	28	34	19.2	52.8	299	85.6
37.61	5-8-10	18	26	36	19.6	52.6	312	89.1
42.61	5-9-9	17	25	34	19.1	52.8	320	91.3
Overall Average Values:				35	19.3	52.7	310	88.5
Standard Deviation:				4	0.8	0.2	15	4.2
Overall Maximum Value:				41	20.6	53.1	342	97.8
Overall Minimum Value:				23	15.6	52.2	277	79.1



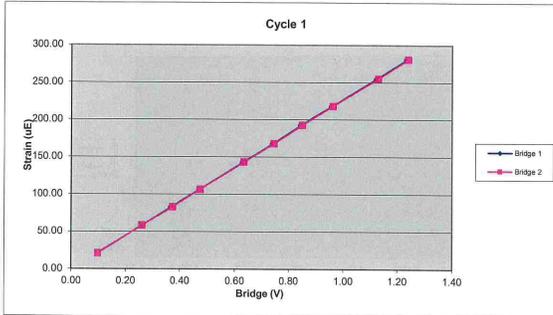
**Exhibit B**  
**PDA Equipment Calibration**



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

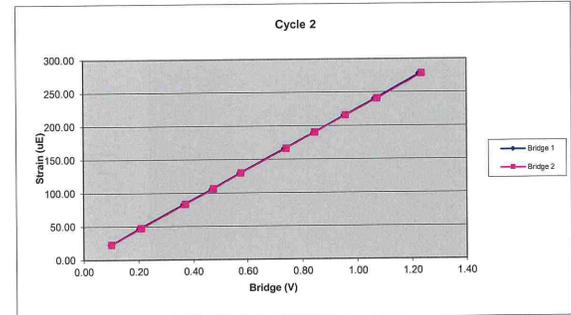
Force Strain Calibration	
EA (Kips)	35527.98
Offset	51.69
Correlation	0.999986



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

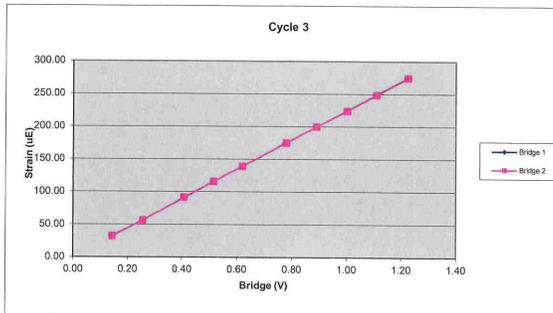
Force Strain Calibration	
EA (Kips)	36073.41
Offset	-2.66
Correlation	0.999993



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

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]

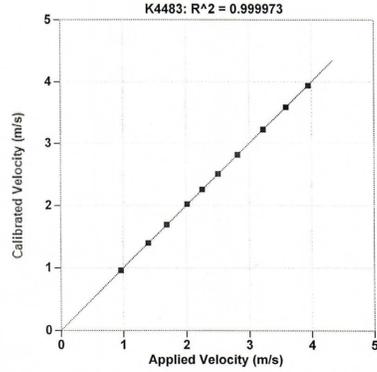
Operator: William Johnson

*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).



Reference Velocity m/s	S/N K4483 Velocity m/s
0.964	0.962
1.399	1.401
1.691	1.700
2.014	2.022
2.254	2.257
2.507	2.508
2.815	2.814
3.226	3.220
3.590	3.591
3.947	3.941

Maximum Acceleration: 874 g's

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]

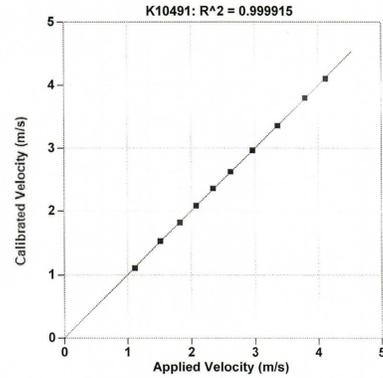
Operator: William Johnson

*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).



Reference Velocity m/s	S/N K10491 Velocity m/s
1.117	1.106
1.518	1.521
1.823	1.818
2.078	2.084
2.344	2.355
2.616	2.623
2.963	2.969
3.360	3.357
3.794	3.801
4.121	4.104

Maximum Acceleration: 916 g's

Date printed: 25Jan2022, version: 2020.30.170 0.05

# For Boring S-23-40-2

## SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: Geoprobe 3126GT

Drill Rig Serial Number: 3126S5V224106

Asset Number: DR#1327

September 13, 2024

September 13, 2024

Terracon Consultants Inc.  
72 Pointe Circle  
Greenville, SC 29615

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

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

Dear Mr. Dudani:

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

Table 1: Hammer Efficiency Summary

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

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

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

Ryan C. Wakeford, P.E.  
Geotechnical Engineer

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

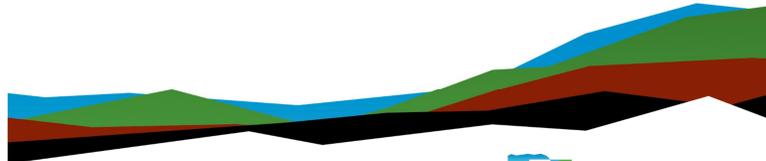


Micah Hatch, P.E.  
Geotechnical Department Manager



Attachments:

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



Prepared for:

Terracon Consultants, Inc.  
Greenville, South Carolina



### 1.0 MEASUREMENT SUMMARY

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

### 2.0 PURPOSE AND SCOPE OF WORK

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

### 3.0 TEST RESULTS

Table 2: SPT Hammer Energy Calibration Testing Summary

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

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

Table 3: Energy Measurement and Analysis Summary

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

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

Table 4: Hammer Blow Rate Summary

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

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

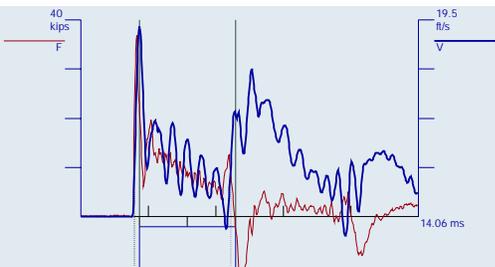
Exhibit A  
SPT Representative Blow

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

Pile Driving Analyzer ® (PDA)  
Version: 2022.35.2

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

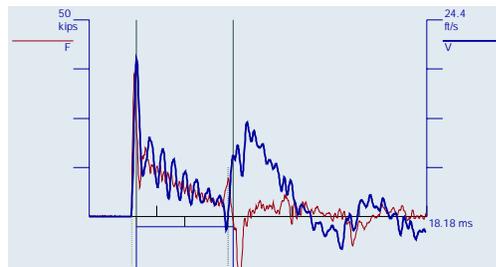
Pile Driving Analyzer ® (PDA)  
Version: 2022.35.2



BN 13  
05Sep2024 10:07:23 AM

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

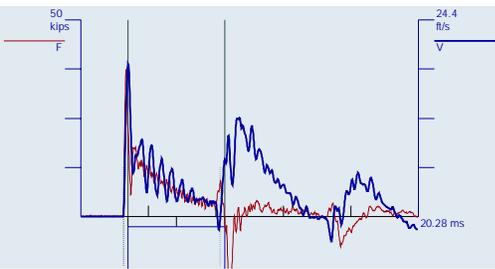
F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 25  
05Sep2024 10:24:35 AM

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

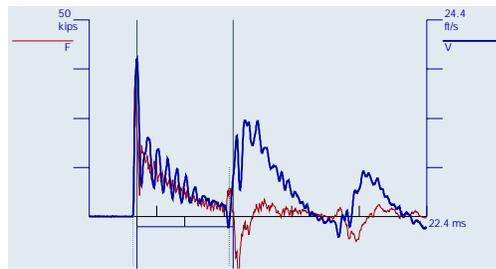
F1: [746AWJ1] 222.05 PDICAL (1) FF1  
 F2: [746AWJ2] 222.19 PDICAL (1) FF1  
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1  
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 14  
05Sep2024 10:32:57 AM

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

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



BN 13  
05Sep2024 10:42:13 AM

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

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

Exhibit B

SPT Analyzer Literature and Equipment Calibrations



# SPT Analyzer

## SPT Analyzer

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

### Reliable. Simplified. Rugged.

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

### What is SPT?

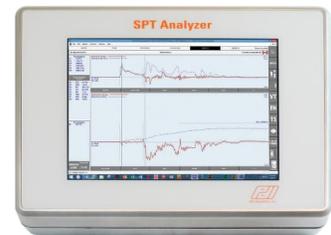
The Standard Penetration Test (SPT) is a widely-employed soil exploration tool that involves using an SPT hammer to drive a split sampler at the bottom of a drill string to obtain soil samples. The number of blows required to penetrate the last 300mm (1ft) is the "N value" which is related to soil strength.

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

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

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

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



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



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

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

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

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

**Output**

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



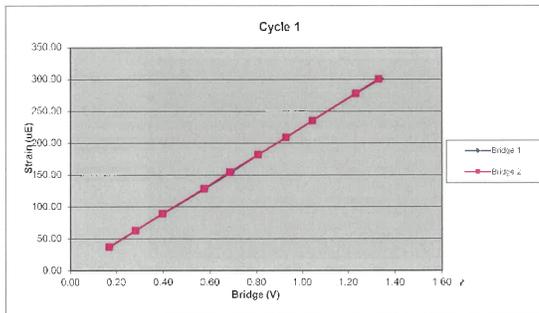
**Pile Dynamics, Inc. (PDI)** is the world leader in developing, manufacturing and supplying state of the art QA/QC products and systems for the deep foundations industry. The company is headquartered in Cleveland, Ohio, USA, with offices and representatives worldwide. For additional information visit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

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

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

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

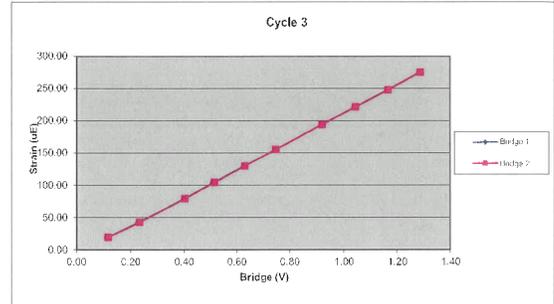
Force Strain Calibration	
EA (Kips)	33651.50
Offset	33.98
Correlation	0.999994



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

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

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



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



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

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

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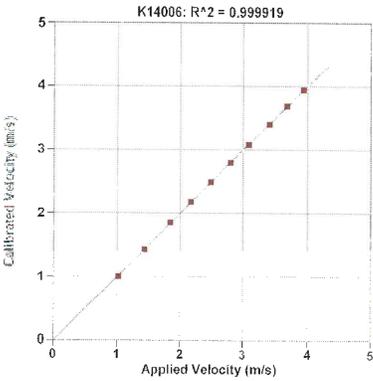
Ref Acc 1: 78268! Cal on: 11Jan2024  
 986 g/s/volt

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

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

Operator: William Johnson  
  
 Signed

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



Version: 2023-09-17 4: 17

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



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

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

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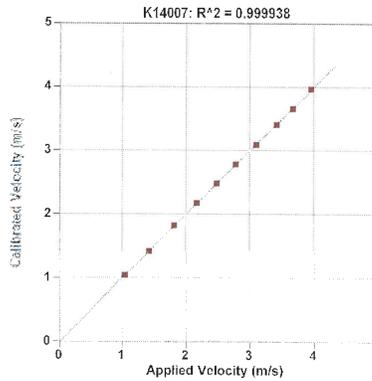
Ref Acc 1: 78268! Cal on: 11Jan2024  
 986 g/s/volt

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

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

Operator: William Johnson  
  
 Signed

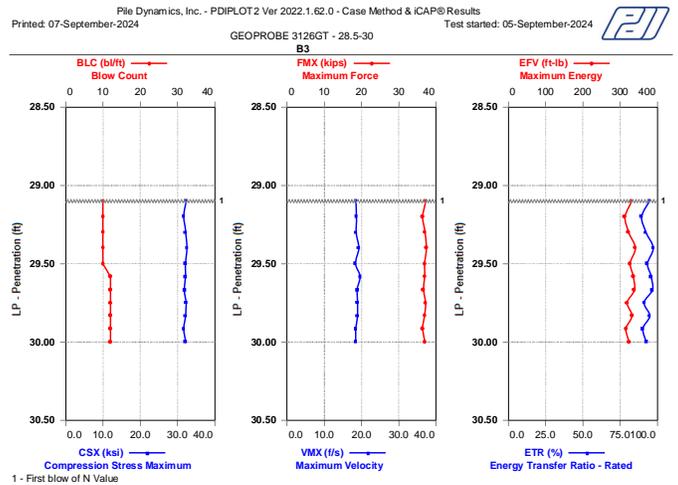
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Version: 2023-09-17 4: 24



Exhibit C  
SPT Analyzer Results





GEOPROBE 3126GT - 28.5-30

Case Method & iCAP® Results

B3

OP: RW Date: 05-September-2024  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf<sup>2</sup>  
LE: 33.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

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

Total number of blows analyzed: 11

BL# Sensors

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

BL# Comments

5 First blow of N Value

Time Summary

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



GEOPROBE 3126GT - 38.5-40

Case Method & iCAP® Results

B3

OP: RW Date: 05-September-2024  
AR: 1.15 in<sup>2</sup> SP: 0.492 klf<sup>2</sup>  
LE: 43.70 ft EM: 30,000 ksi  
WS: 16,807.9 f/s JC: 0.00

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

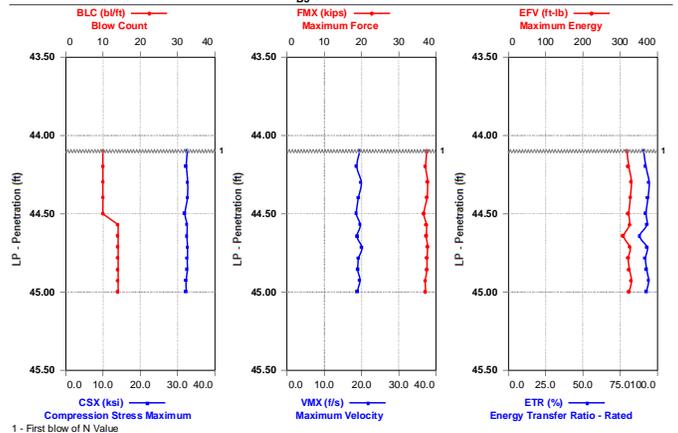
7-26 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

7 First blow of N Value

Time Summary

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



CSX (ksi) Compression Stress Maximum  
VMX (f/s) Maximum Velocity  
ETR (%) Energy Transfer Ratio - Rated  
1 - First blow of N Value



Case Method & iCAP® Results

GEOPROBE 3126GT - 43.5-45  
OP: RW  
Date: 05-September-2024  
B3

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

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

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

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

Total number of blows analyzed: 12

BL# Sensors

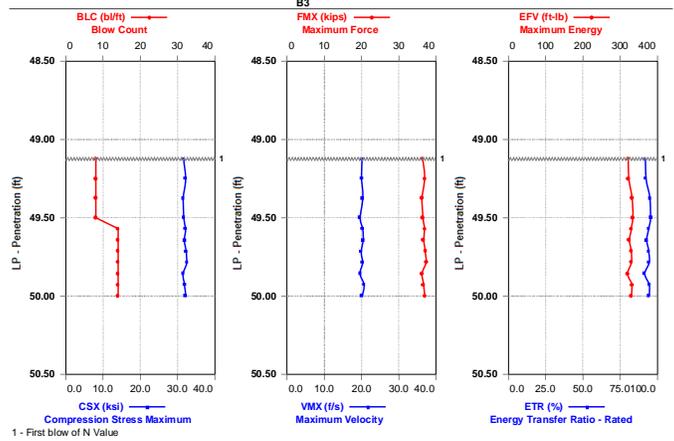
5-16 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

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



1 - First blow of N Value

Case Method & iCAP® Results

GEOPROBE 3126GT - 48.5-50  
OP: RW  
Date: 05-September-2024  
B3

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

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

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

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

Total number of blows analyzed: 11

BL# Sensors

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

BL# Comments

5 First blow of N Value

Time Summary

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

Exhibit D  
Field Log





SPT HAMMER CALIBRATION FIELD WORKSHEET

PROJECT NAME: 7324515
PROJECT NO.: Terracon Assets Site
BORING NO.: 8-3
CLIENT:

ARRIVAL TIME:
DEPART TIME:
TOTAL TRAVEL:
TOTAL TIME:
CLIENT REP:
MILEAGE:
DATE: 9/5/24
TERRACON REP: (u)
PDA MODEL/SN: SPT 4021 TR
TERRACON RIG #: 1307

DRILL RIG DATA
Type/Transport: Fork
Manufacturer: Geopole
Model No.: 3126 GS
Serial No.: 7126550224106
Year Built: 2024
Modifications: N/A
Maint. Schedule: 50 hrs

SPT HAMMER DATA
Type: A10
Manufacturer: Geopole
Lifting Mechanism: Claw
Model No.: AD1131
Serial No.: 10001
Hammer Weight: 140
Hammer Operator(s): B. R. HEAT

PDA INPUT DATA
Operator: OP (u)
Project No./Location: PJ 7324515/
Rig Mode & SN: PN 60000/3126 GS
Hammer Type, LM, Rods: PD A10/AWJ
Drill Rod Area (in^2): AR 115
Elastic Modulus (ksi): EM 3000
Specific Weight (kips/ft^3): SP 0.492
Wave Speed (ft/sect): WS 16808
Increment Length (ft): LI 0.5
Sampling Freq (kHz): FR 50

TRANSDUCER INFORMATION
Gage SN Calibration
F1/F3: 746 AWJ1 222.05
F2/F4: 746 AWJ2 222.19
A1/A3: K14002 402.23
A2/A4: K14006 375.83
NOTES: 286.25 + 1.875 = 288.125
34.38 + 25 + 10.25 = 69.63
SPLIT SPOON SAMPLER LENGTH: 38K + 0.88 = 38.88
LE is measured from the center of the strain gauges to the bottom of split spoon sampler

SPT TESTING INFORMATION table with columns: Start Time, Soil, Stick Up Length (ft), Depth (ft), LE (ft), Rods & Lengths, PDA Blows, SPT Blows.

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

PICTURE NUMBERS AND INFO:
Take Photo of Each Rigs, Boring Locations at the Site

Exhibit E
Copy of Certificate of Proficiency

Terracon SPT Rig Calibration Worksheet.xlsx



This documents that
Susheel R. Kolwalker
Terracon Consultants
has on March 11, 2016 achieved the rank of
EXPERT
on the Dynamic Measurement and Analysis Proficiency Test.

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

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

Steven A. Hall, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2005

Certificate of Proficiency for Ryan Wakeford, Terracon Consultants, Inc. on the Dynamic Measurement and Analysis Proficiency Test. Includes PDCA and PDI logos, signatures of Frank T. Peters and Garland Likins, and a gold seal.