

S-13-531 (Henry Funderburk Road) Bridge Replacement over Mangum Branch

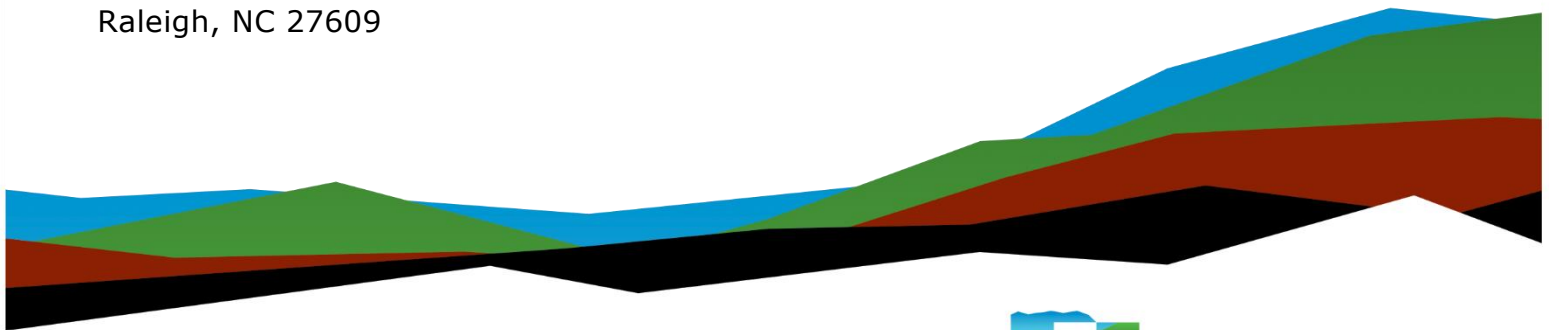
Chesterfield County, SC

Geotechnical Subsurface Data Report

August 18, 2023 | SCDOT Project ID: P041959
Terracon Project No.: 7323P100

Prepared for:

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





521 Clemson Road
Columbia, SC 29229
P (803) 741-9000
[Terracon.com](https://www.terracon.com)

August 18, 2023

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-13-531 Bridge Replacement over Mangum Branch
Chesterfield County, South Carolina
SCDOT Project ID.: P041959
Terracon Project No.: 7323P100

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, and laboratory testing for the replacement of the S-13-531 bridge over Mangum Branch in Chesterfield County, South Carolina. The proposed bridge intends to replace the existing one. 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-13-531 (Henry Funderburk Road) crossing over Mangum Branch in Chesterfield County, South Carolina. Site location and exploration plans are presented in Appendix A of this report. Based on the conceptual plans by HNTB dated 6/13/2023, the replacement bridge will be constructed on essentially the same alignment as the current bridge. The existing bridge is a multi-span structure supported by deep

foundations. The conceptual plans show that the replacement bridge will be a single-span structure supported by deep foundations.

Geotechnical Testing

The geotechnical exploration for this project was performed between June 1 and June 7, 2023. The results of our field work 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-13-531-1 and S-13-531-2)
- One (1) offset boring near S-13-531-1 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 Construction Support Services, LLC after completion.

Laboratory Testing

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

- Nine (9) Natural Moisture Content Tests
- Five (5) 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 Tests (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.

Geotechnical Subsurface Data Report

S-13-531 BRO Mangum Branch | Chesterfield County, SC

August 18, 2023 | Terracon Project No. 7323P100 | SCDOT Project ID: P041959



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.

Phillip A. Morrison, P.E.
Senior Engineer
SC Registration No. 17275

Abdul Q. Fekrat, PhD, P.E.
Project Engineer
SC Registration No. 38531

Reviewed by Terracon's Authorized Project Reviewer: David J. Corley, P.E.

Appendix A

Field Exploration

- Exhibit A-1 – Site Location Map
- Exhibit A-2 – Exploration Plan
- 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/Rock Description Terms (2 Pages)
- Exhibit A-7 – Soil/Rock Symbols
- Exhibit A-8 – Boring Logs (4 Pages)
- Exhibit A-9 – Grout Logs (3 Pages)
- Exhibit A-10 – Rock Core Photograph Log

Note: All exhibits are one page unless noted above.

Site Location Map – Exhibit A-1

S-13-531 BRO Mangum Branch | Chesterfield County, SC
Terracon Project No. 7323P100 | SCDOT Project ID: P041959

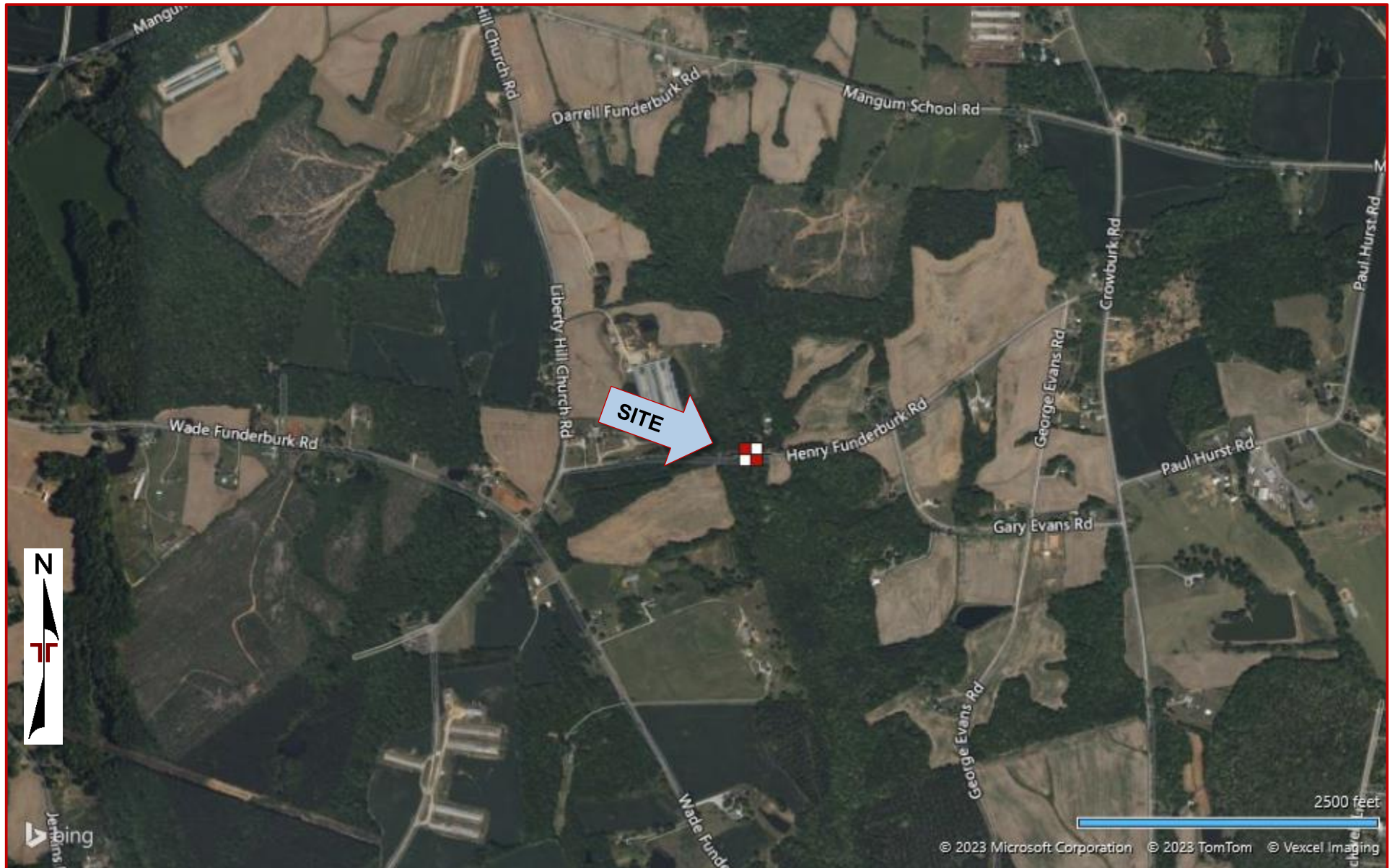


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT
INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: HORNSBORO, SC (1/1/1983) and MT CROGHAN, NC
(1/1/1983).



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

AERIAL PHOTOGRAPHY PROVIDED BY
MICROSOFT BING MAPS

Summary of Boring Data – Exhibit A-3

S-13-531 BRO Mangum Branch | Chesterfield County, SC
Terracon Project No. 7323P100 | SCDOT Project ID: P041959



Summary of Boring Data

Boring No.	Ground Elevation ft.	Test Depth ft.	Northing	Easting	Latitude	Longitude	Station	Offset
S-13-531-1	515.1	65.0	1079596.50	2162769.69	34.799302	-80.457843	21+11.59	2.14 L
S-13-531-2	517.8	65.0	1079598.50	2162847.49	34.799306	-80.457584	21+89.41	2.13 L

Note: A bulk sample was collected near S-13-531-1.

GeoScoping Form

PROJECT INFORMATION	
Project ID:	Date of Trip:
County:	Location:
Rd/Route:	Local Name:
Attendees:	

EXISTING BRIDGE INFORMATION	
Bridge Length:	Bridge Width:
Superstructure Type:	Substructure Type:
Begin Bridge Sta.:	End Bridge Sta.:
Begin Bridge Embankment Sta. ¹ 20+31	End Bridge Embankment Sta. ¹ :
Structure Number:	Posted Weight Limit:
Crossing:	Skew:
Latitude:	Longitude:
Existing Fill Height:	Approximate Existing Slope Angle:

¹Begin and End Bridge Embankment 100 feet down station or up station from bridge, respectively

EXISTING ROADWAY EMBANKMENT INFORMATION	
Begin Project Sta.:	Begin Bridge Embankment Sta. ¹ :
Accessibility Issues:	
Ground Cover:	
Existing Fill Height:	Approximate Existing Slope Angle: 2H:1V
Local Development (undeveloped, developed residential, developed commercial, developed industrial, etc.): Rural, Residential	
Topography (level, flat, rolling, steep, hillside, valley, swamp, gully, etc.):	
Traffic Control Necessary (Y/N):	
Surface Soil:	Muck (Y/N):
Exposed Rock (Y/N):	In Stream Bed (Y/N):
Wetlands On-Site (Y/N):	Wetlands Adjacent (Y/N):
Depth FG to Water:	Water Depth:
Depth to Existing Ground:	
Scour Condition at EB:	Scour Condition at IB:
End Bridge Embankment Sta. ¹ : 22+66	End Project Sta.: 33+50
Accessibility Issues:	
Ground Cover:	
Existing Fill Height:	Approximate Existing Slope Angle: 2H:1V
Local Development (undeveloped, developed residential, developed commercial, developed industrial, etc.): Rural Residential	
Topography (level, flat, rolling, steep, hillside, valley, swamp, gully, etc.):	
Traffic Control Necessary (Y/N):	
Surface Soil:	Muck (Y/N):
Exposed Rock (Y/N):	In Stream Bed (Y/N):
Wetlands On-Site (Y/N):	Wetlands Adjacent (Y/N):
Depth FG to Water:	Water Depth:
Depth to Existing Ground:	
Scour Condition at EB:	Scour Condition at IB:

GeoScoping Form

UTILITIES INFORMATION	
Attached:	
Above Ground/ Overhead:	
Underground:	

COMMENTS	

Instructions:

1. Attach boring location plan for bridge and roadway.
2. Attach all photographs taken, photographs to be labeled as to direction looking in and what is being depicted.
3. Fill out GeoScoping Form as completely as possible, using additional sheets as necessary to describe site conditions.
4. If representative of GEC on site during GeoScoping, include GEC representative's name and contact number in Attendees block.

Exhibit A-5

S-13-531 BRO Mangum Branch | Chesterfield County, SC

August 18, 2023 | Terracon Project No. 7323P100 | SCDOT Project ID: P041959



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 Construction Support Services, LLC after testing and drilling was complete. The locations as shown in the Exploration Plan are shown to the scale indicated.

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

Soil Test Borings (STB)

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

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

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

Test ID	Total Depth	Interval of Continuous Sampling
S-13-531-1	100 feet or 10 feet rock coring	0 to 10 feet
S-13-531-2	100 feet or 10 feet rock coring	0 to 10 feet
S-13-531-1 Bulk	5 feet	Bulk Sample

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

S-13-531 BRO Mangum Branch | Chesterfield County, SC

August 18, 2023 | Terracon Project No. 7323P100 | SCDOT Project ID: P041959



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 terminated after deep penetration into high consistency soils. At Boring S-13-531-1, shallow refusal of the drilling equipment was encountered, requiring rock coring to continue the boring. 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. After penetration of the rock layer, the boring was continued by drilling procedures.

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 the boreholes were grouted with a cement bentonite grout and capped with cold-patch asphalt.

SOIL DESCRIPTION TERMS

Relative Density/Consistency Terms

<u>Relative Density</u> ¹			<u>Consistency</u> ²		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q _u) (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.

Angularity¹

<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 Reaction³

<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

Cementation³

<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 Range¹

<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^{1, 2}

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

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

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

³Use 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^a

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

^aSpacing 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)^a

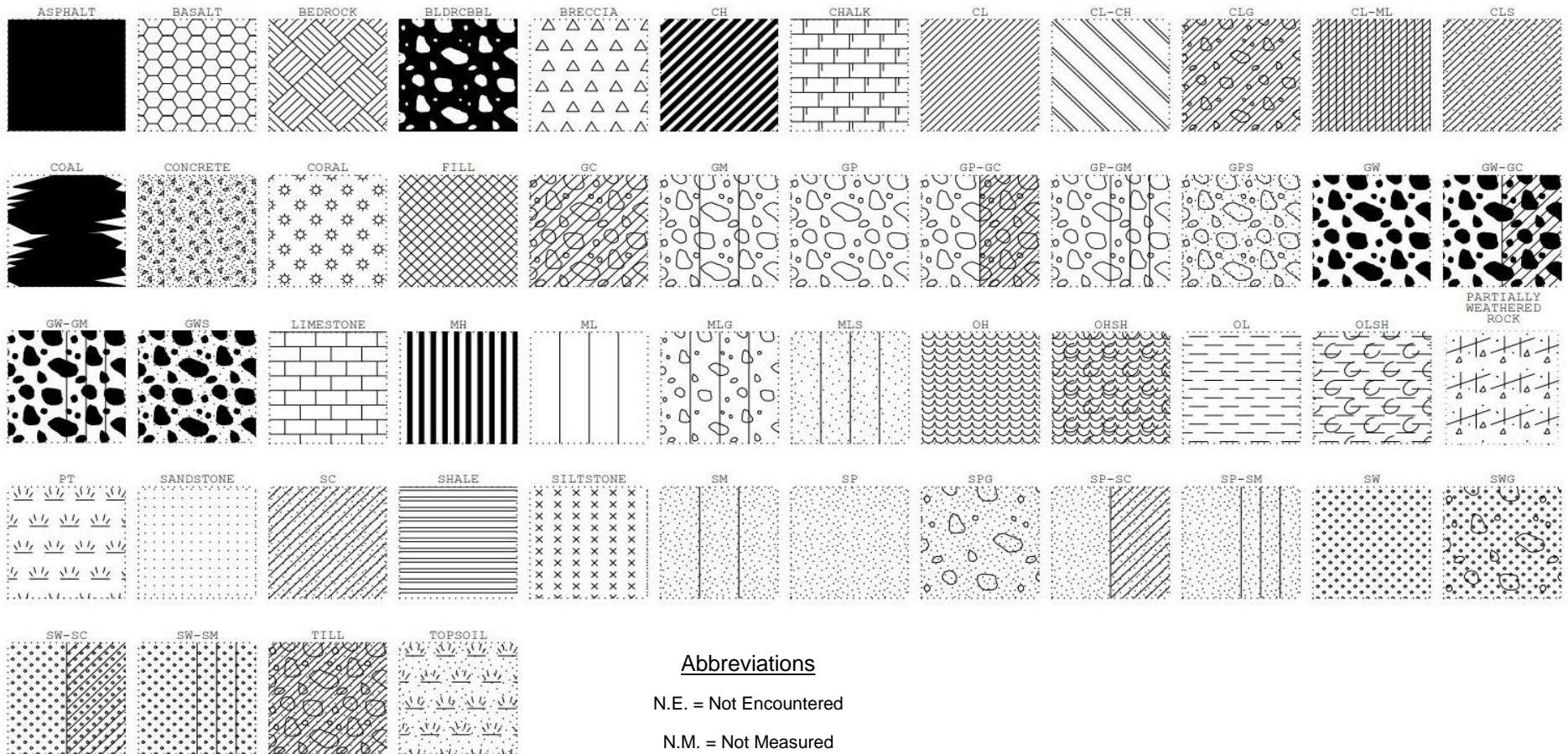
RQD, as a percentage	Diagnostic Description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

^aRQD (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:	PAM
Drawn by:	KJZ
Checked by:	PAM
Approved by:	DJC

Project No.	7323P100
Scale:	N.T.S.
File Name:	Soil – Rock – Log
Date:	Jul 2023



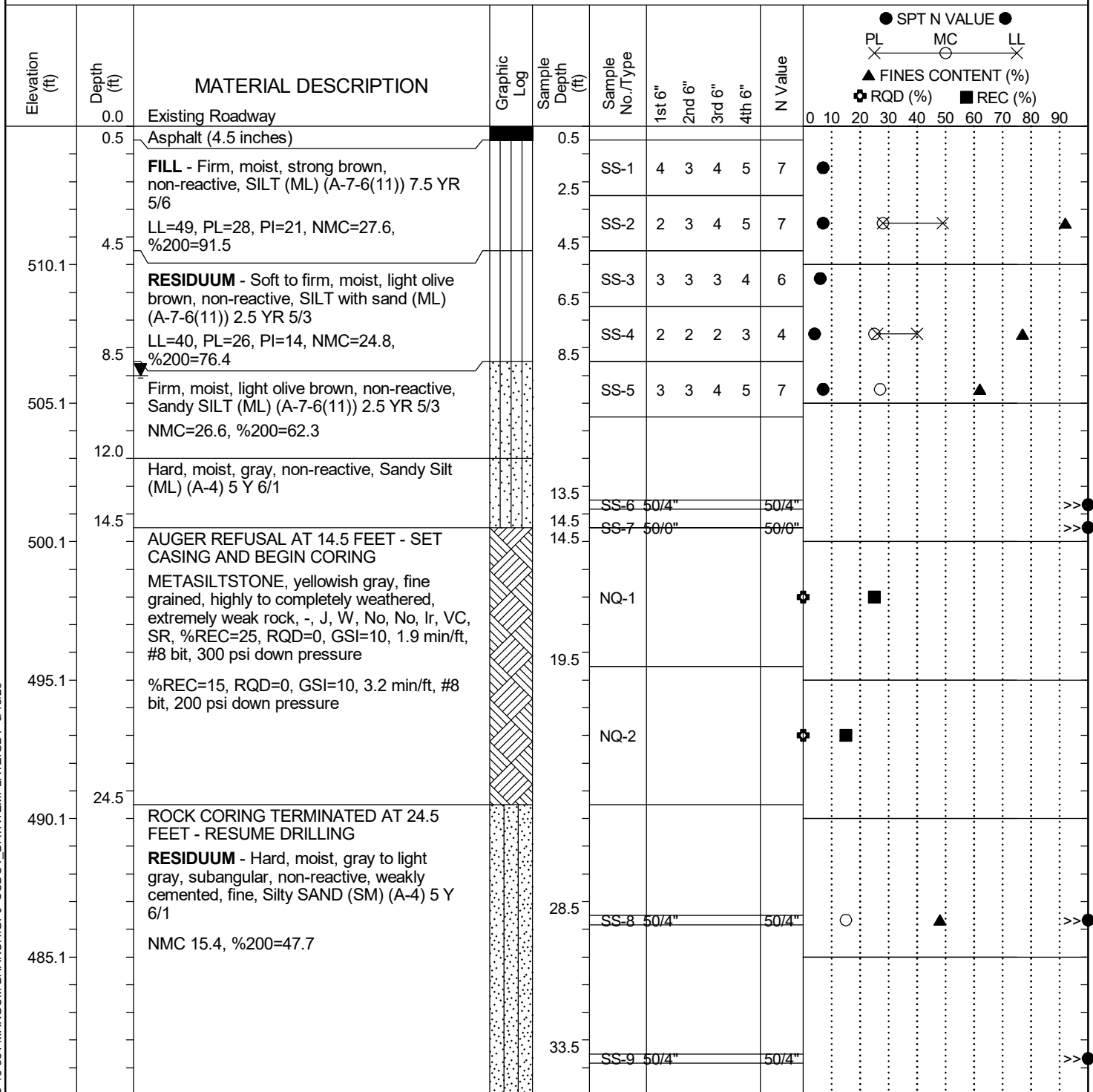
521 Clemson Road
PH. (803) 741-9000
Columbia, SC 29229
FAX. (803) 741-9900

SOIL AND ROCK SYMBOLS

Exhibit A-7

SCDOT Soil Test Log

Project ID: P041959				County: Chesterfield		Boring No.: S-13-531-1		
Site Description:		S-13-531 RBO Mangum Branch					Route: S-13-531	
Eng./Geo.: S.Pardy		Boring Location: 21+11.59		Offset: 2.14 L		Alignment: Existing		
Elev.:	515.1 ft	Latitude: 34.799302	Longitude: -80.457843		Date Started: 6/1/2023			
Total Depth: 65 ft		Soil Depth: 55 ft		Core Depth: 10 ft		Date Completed: 6/2/2023		
Bore Hole Diameter (in): 4		Sampler Configuration		Liner Required: Y (N)		Liner Used: Y (N)		
Drill Machine: DR 543		Drill Method: RW/RC		Hammer Type: Automatic		Energy Ratio: 93.5%		
Core Size: NQ2		Driller: C. Costner		Groundwater: TOB N.M.		24HR 9 ft		



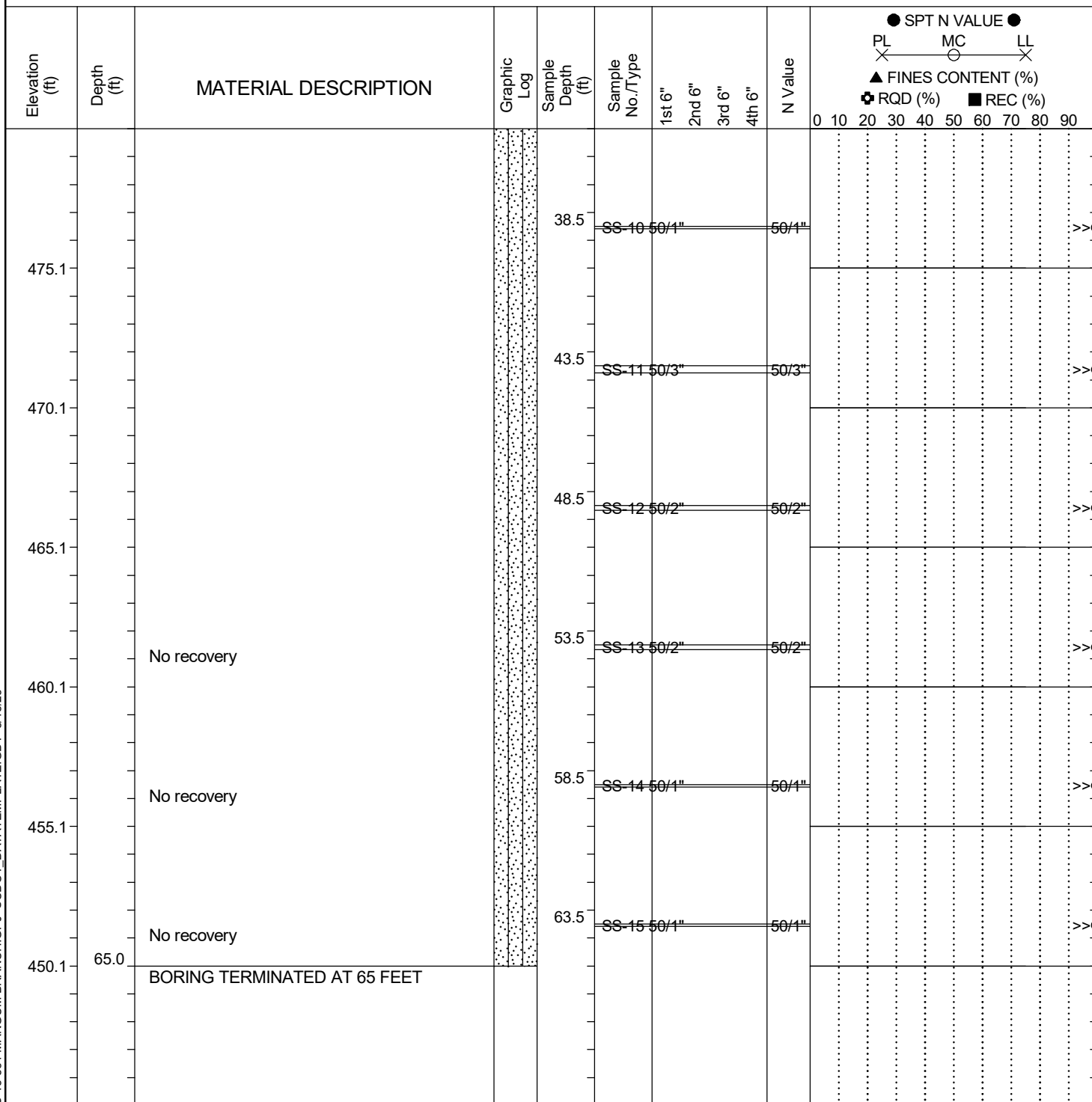
LEGEND

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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	

SCDOT Soil Test Log

Project ID:	P041959	County:	Chesterfield	Boring No.:	S-13-531-1
Site Description:	S-13-531 RBO Mangum Branch			Route:	S-13-531
Eng./Geo.:	S.Pardy	Boring Location:	21+11.59	Offset:	2.14 L
Elev.:	515.1 ft	Latitude:	34.799302	Longitude:	-80.457843
Date Started:	6/1/2023				
Total Depth:	65 ft	Soil Depth:	55 ft	Core Depth:	10 ft
Date Completed:	6/2/2023				
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR 543	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	93.5%				
Core Size:	NQ2	Driller:	C. Costner	Groundwater:	TOB N.M.
24HR	9 ft				



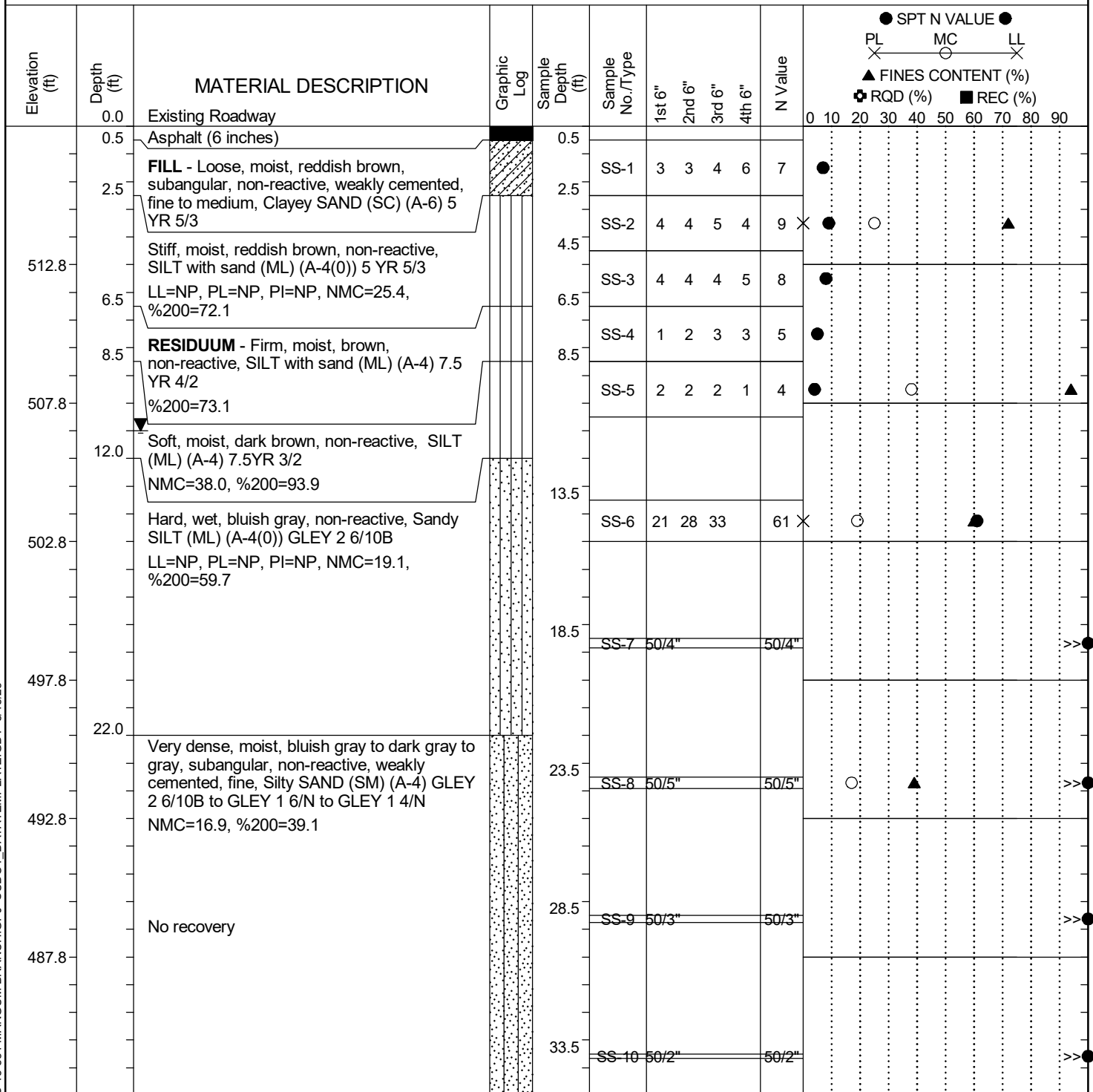
LEGEND

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

SC.DOT SCDOT S-13-531 MANGUM BRANCH.GPJ SCDOT_DATATEMPLATE.GDT 8/18/23

SCDOT Soil Test Log

Project ID:	P041959	County:	Chesterfield	Boring No.:	S-13-531-2
Site Description:	S-13-531 RBO Mangum Branch			Route:	S-13-531
Eng./Geo.:	W. Botts	Boring Location:	21+89.41	Offset:	2.13 L
Elev.:	517.8 ft	Latitude:	34.799306	Longitude:	-80.457584
Total Depth:	65 ft	Soil Depth:	65 ft	Date Started:	6/6/2023
Core Depth:	0 ft	Date Completed:	6/7/2023		
Bore Hole Diameter (in):	3	Sampler Configuration		Liner Required:	Y (N)
Drill Machine:	DR 543	Drill Method:	RW	Hammer Type:	Automatic
Core Size:		Driller:	C. Costner	Energy Ratio:	93.5%
		Groundwater:	TOB	N.M.	24HR
					11 ft



LEGEND

Continued Next Page

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

SCDOT Soil Test Log

Project ID:	P041959	County:	Chesterfield	Boring No.:	S-13-531-2
Site Description:	S-13-531 RBO Mangum Branch			Route:	S-13-531
Eng./Geo.:	W. Botts	Boring Location:	21+89.41	Offset:	2.13 L
Elev.:	517.8 ft	Latitude:	34.799306	Longitude:	-80.457584
Date Started:	6/6/2023				
Total Depth:	65 ft	Soil Depth:	65 ft	Core Depth:	0 ft
Date Completed:	6/7/2023				
Bore Hole Diameter (in):	3	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR 543	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	93.5%				
Core Size:		Driller:	C. Costner	Groundwater:	TOB N.M.
24HR	11 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> <div> ● SPT N VALUE ● </div> <div> PL X MC X LL X </div> <div> ▲ FINES CONTENT (%) </div> <div> ⊕ RQD (%) ■ REC (%) </div> </div>
477.8				38.5	SS-11 50/3"	50/3"					>>●
472.8				43.5	SS-12 50/1"	50/1"					>>●
467.8		No recovery		48.5	SS-13 50/0"	50/0"					>>●
462.8		No recovery		53.5	SS-14 50/3"	50/3"					>>●
457.8		No recovery		58.5	SS-15 50/3"	50/3"					>>●
452.8	65.0	No recovery		63.5	SS-16 50/1"	50/1"					>>●
		BORING TERMINATED AT 65 FEET									

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	

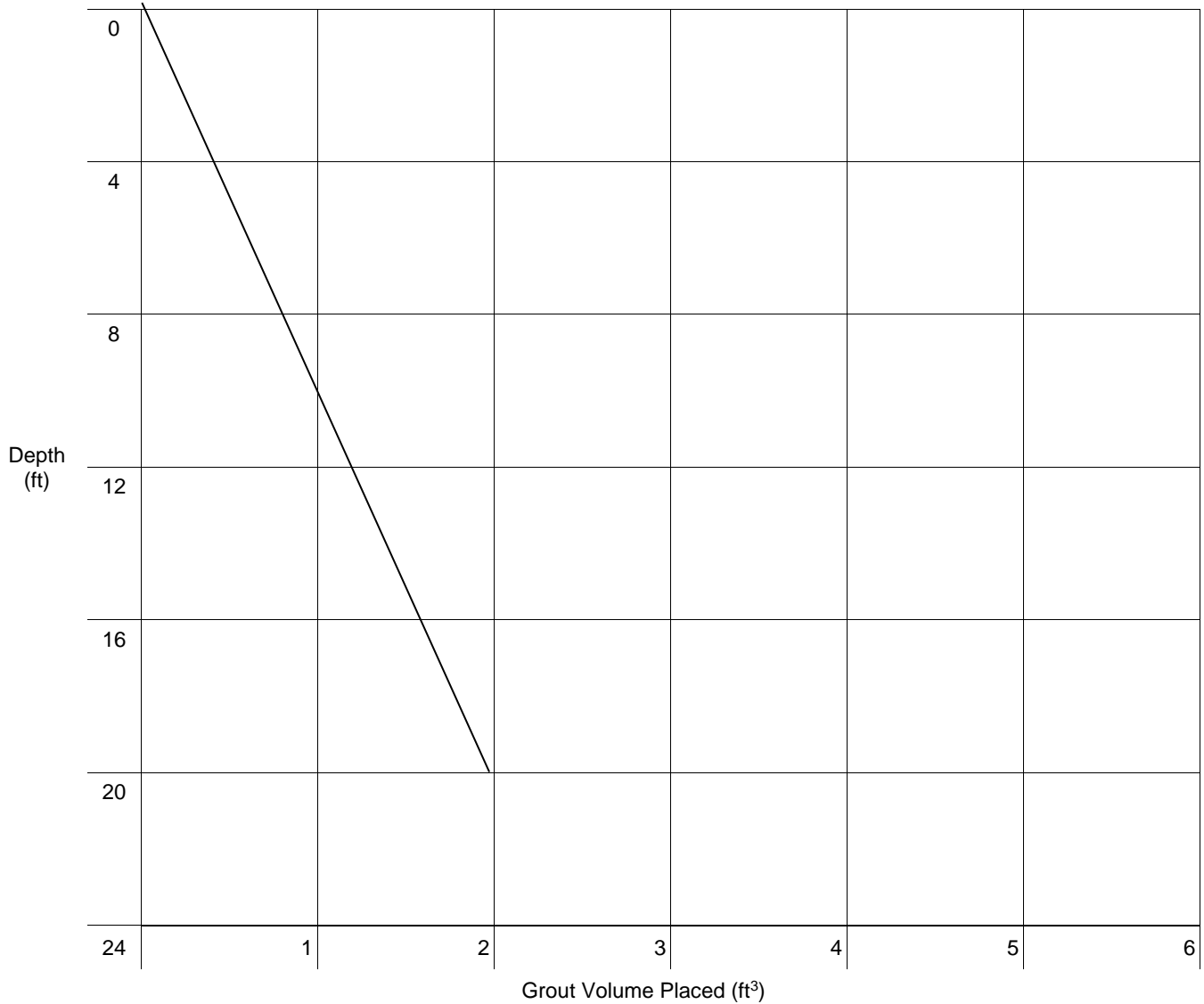
SC.DOT SCDOT S-13-531 MANGUM BRANCH.GPJ SCDOT_DATATEMPLATE.GDT 8/18/23



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name:	S-13-531 RBO Mangum Branch		Test Hole No.:	S-13-531-1
Project ID:	P041959		Station:	21+11.59
Consultant Firm:	Terracon Consultants, Inc.		Offset:	2.14 L
Grouted By (Driller's Name):	Costner	Date	6/2/23	
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water			

Grout Curve

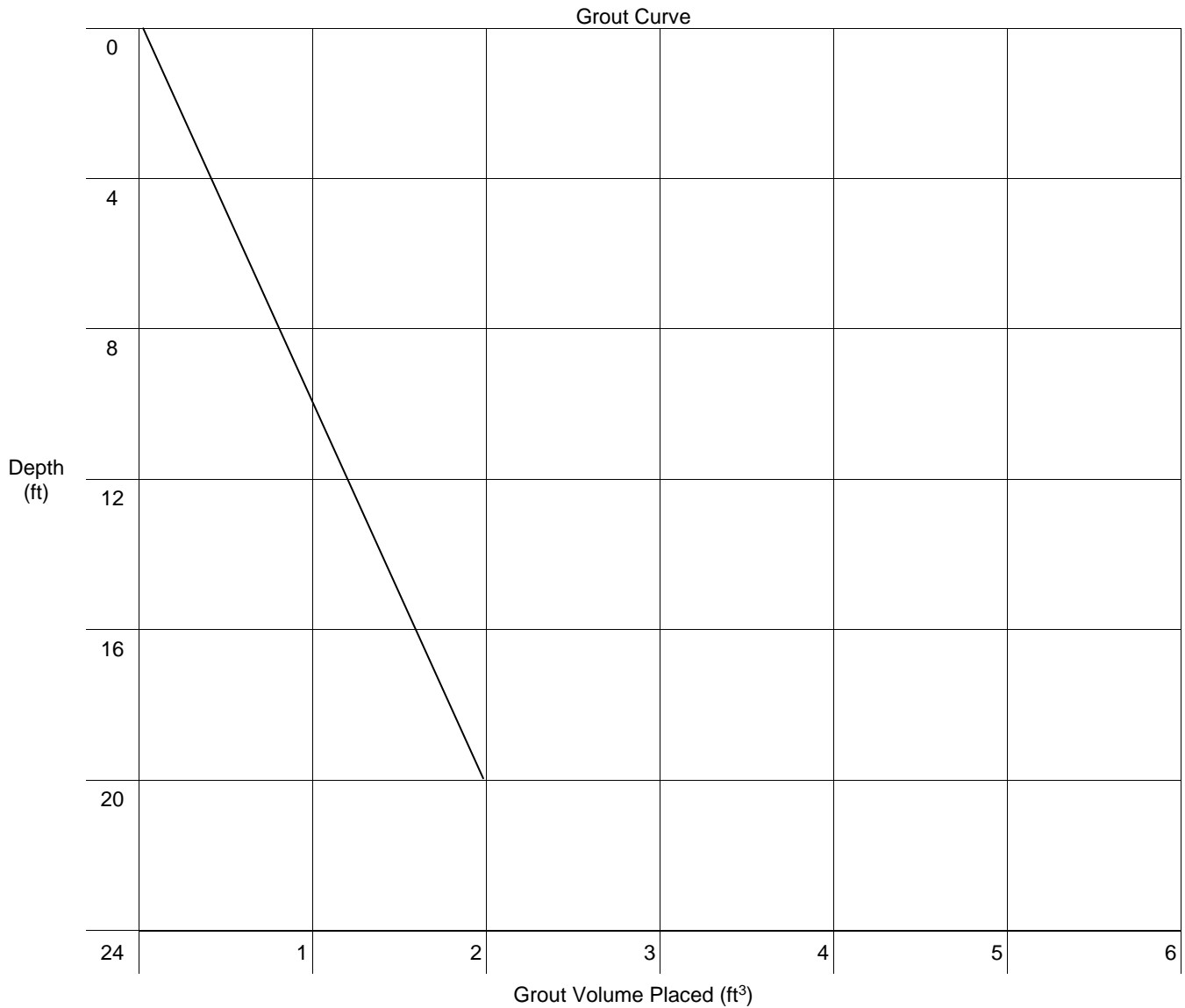


Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	20	ft.
Diameter of Test Hole	0.33	ft.
Area of Test Hole	0.09	ft²
Volume of Test Hole	1.74	ft³
Volume of Casing (If applicable)	-	ft³
Theoretical Volume of Test Hole	1.74	ft³
Number of Bags Used	2.5	ea.
Volume Placed	2	ft³



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name:	S-13-531 RBO Mangum Branch		Test Hole No.:	S-13-531-2
Project ID:	P041959		Station:	21+89.41
Consultant Firm:	Terracon Consultants, Inc.		Offset:	2.13 L
Grouted By (Driller's Name):	Costner	Date	6/7/23	
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water			

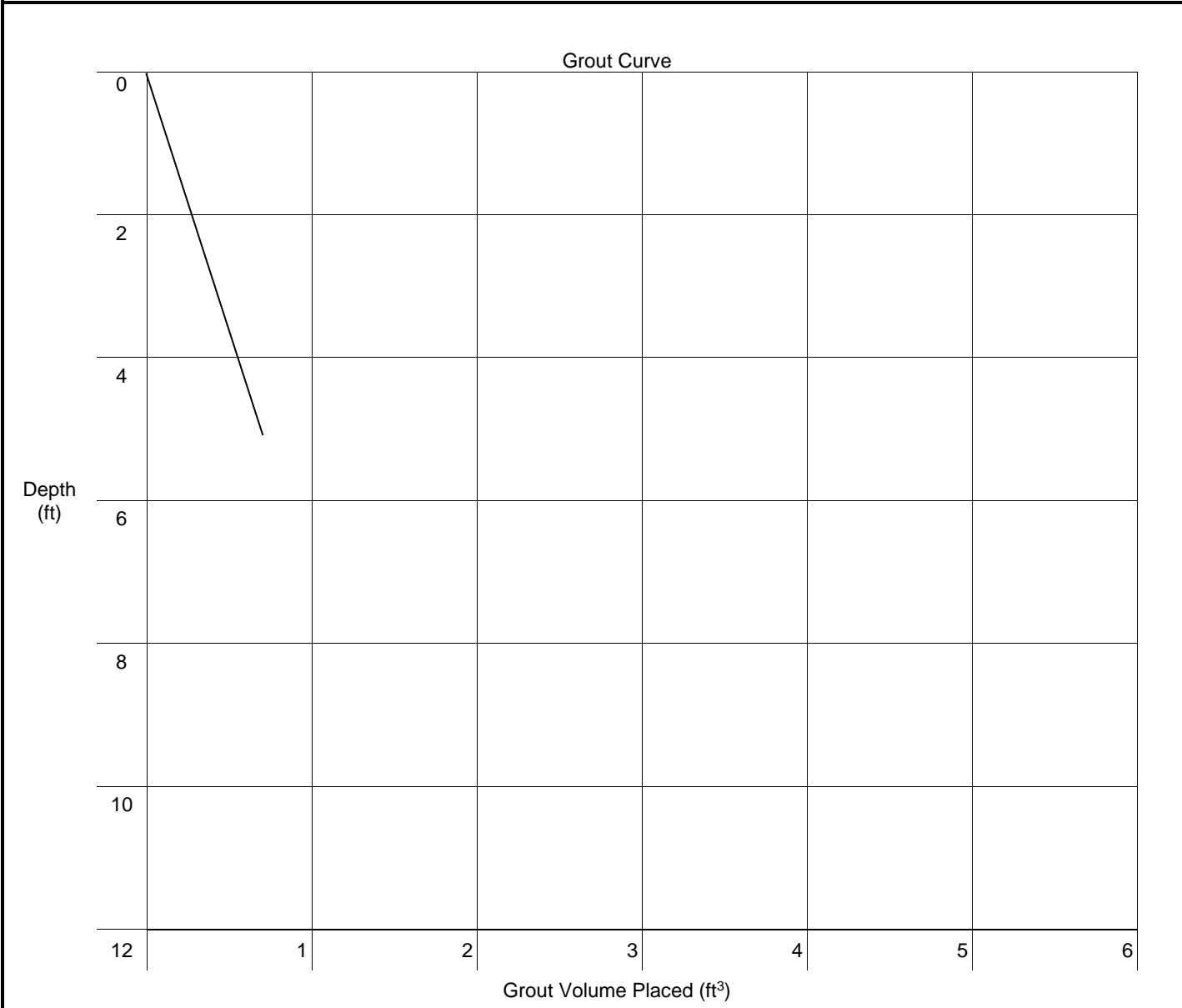


Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	20	ft.
Diameter of Test Hole	0.33	ft.
Area of Test Hole	0.09	ft²
Volume of Test Hole	1.74	ft³
Volume of Casing (If applicable)	-	ft³
Theoretical Volume of Test Hole	1.74	ft³
Number of Bags Used	2.5	ea.
Volume Placed	2	ft³



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name:	S-13-531 RBO Mangum Branch	Test Hole No.:	S-13-531-1
Project ID:	P041959	Station:	21+11.59
Consultant Firm:	Terracon Consultants, Inc.	Offset:	2.14 L
Grouted By (Driller's Name):	Truesdale	Date	6/7/23
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water		



Number of Bags On-Site	20	ea.	
Depth of Test Hole Grouted	5	ft.	
Diameter of Test Hole	0.5	ft.	
Area of Test Hole	0.2	ft ²	
Volume of Test Hole	1.0	ft ³	
Volume of Casing (If applicable)	-	ft ³	
Theoretical Volume of Test Hole	1.0	ft ³	
Number of Bags Used	1.5	ea.	
Volume Placed	0.7	ft ³	

Geotechnical Data Report – Exhibit A-10

S-13-531 BRO Mangum Branch | Chesterfield County, SC

Terracon Project No. 7323P100 | SCDOT Project ID: P041959



S-13-531-1 NQ-1 and NQ-2

Appendix B

Laboratory Testing

Exhibit B-1 – Laboratory Testing Description
Summary of Laboratory Data
Laboratory Data Sheets (16 Pages)

Note: All exhibits are one page unless noted above.

Exhibit B-1

S-13-531 BRO Mangum Branch | Chesterfield County, SC

August 18, 2023 | Terracon Project No. 7323P100 | SCDOT Project ID: P041959



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)
■ 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	% Fines	% Gravel	% Sand	% Silt	% Clay	Water Content (%)
S-13-531-1 Bulk	0-5	LEAN CLAY with SAND(CL) / A-6 (11)	38	21	17	73.0					18.6
S-13-531-1	2.5-4.5	SILT(ML) / A-7-6 (22)	49	28	21	91.5					27.6
S-13-531-1	6.5-8.5	SILT with SAND(ML) / A-6 (11)	40	26	14	76.4	6.9	16.6	41.2	35.2	24.8
S-13-531-1	8.5-10.5					62.3	17.9	19.7	34.5	27.8	26.6
S-13-531-1	28.5-28.8					47.7					15.2
S-13-531-2	2.5-4.5	SILT with SAND(ML) / A-4 (0)	NP	NP	NP	72.1					25.4
S-13-531-2	4.5-6.5					73.1	5.5	21.4	36.7	36.4	
S-13-531-2	8.5-10.5					93.9	2.3	3.9	54.1	39.8	38.0
S-13-531-2	13.5-15	SANDY SILT(ML) / A-4 (0)	NP	NP	NP	59.7					19.1
S-13-531-2	23.5-24					39.1					16.9
PROJECT: S-13-531 BRO Mangum Branch			<div>Terracon</div> <div>521 Clemson Rd Columbia, SC</div> <div>PH. 803-741-9000 FAX. 803-741-9900</div>					PROJECT NUMBER: 7323P100			
SITE: Chesterfield County, SC								CLIENT: NHTB			



INDEX PROPERTIES VERSUS DEPTH

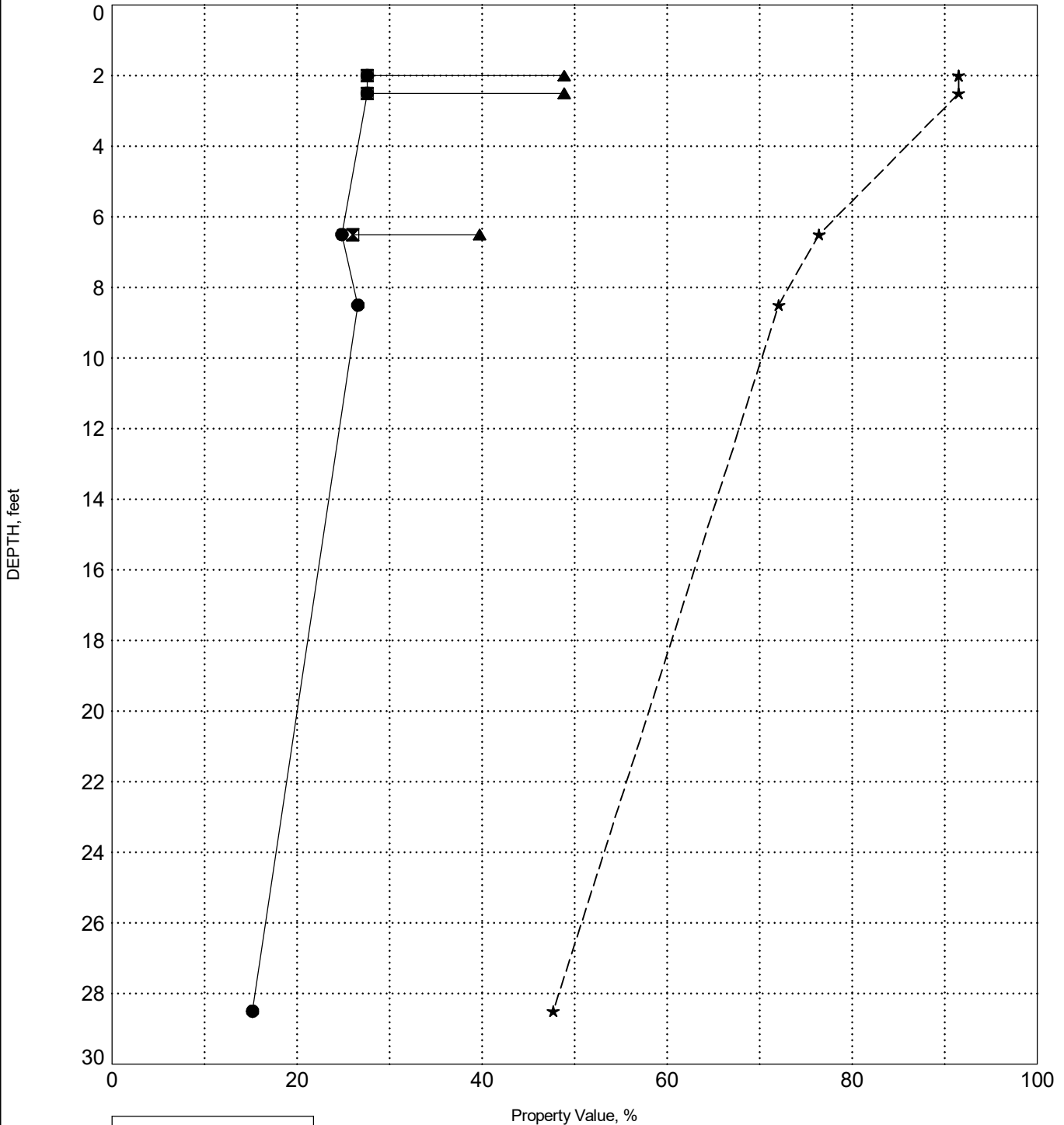
PROJECT ID P041959

PROJECT NAME S-13-531 RBO Mangum Branch

PROJECT COUNTY Chesterfield

SURFACE ELEVATION: 515.1

BORING S-13-531-1



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



INDEX PROPERTIES VERSUS DEPTH

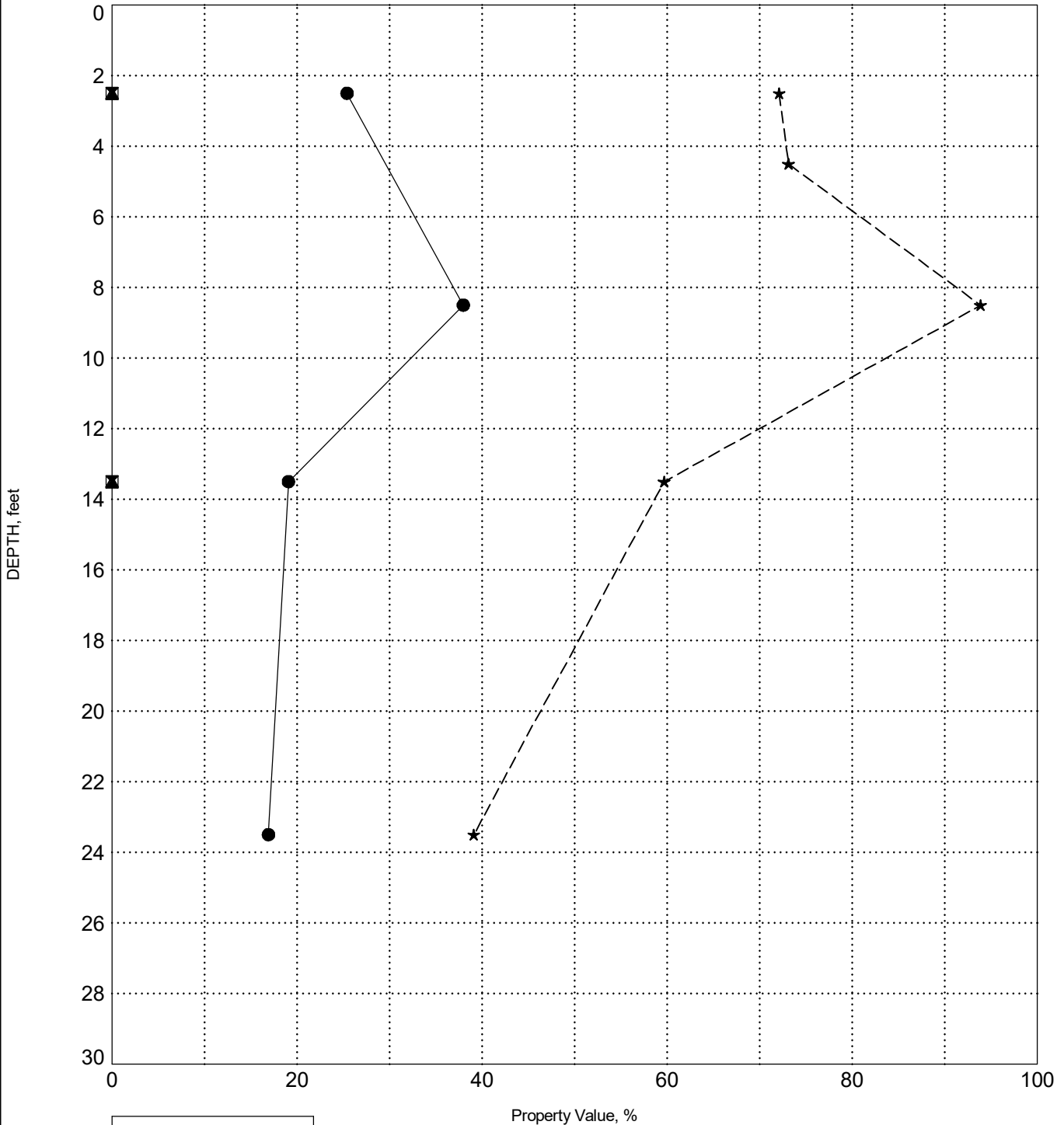
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PROJECT NAME S-13-531 RBO Mangum Branch

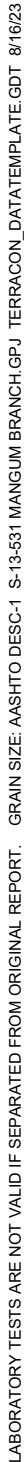
PROJECT COUNTY Chesterfield

SURFACE ELEVATION: 517.8

BORING S-13-531-2



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

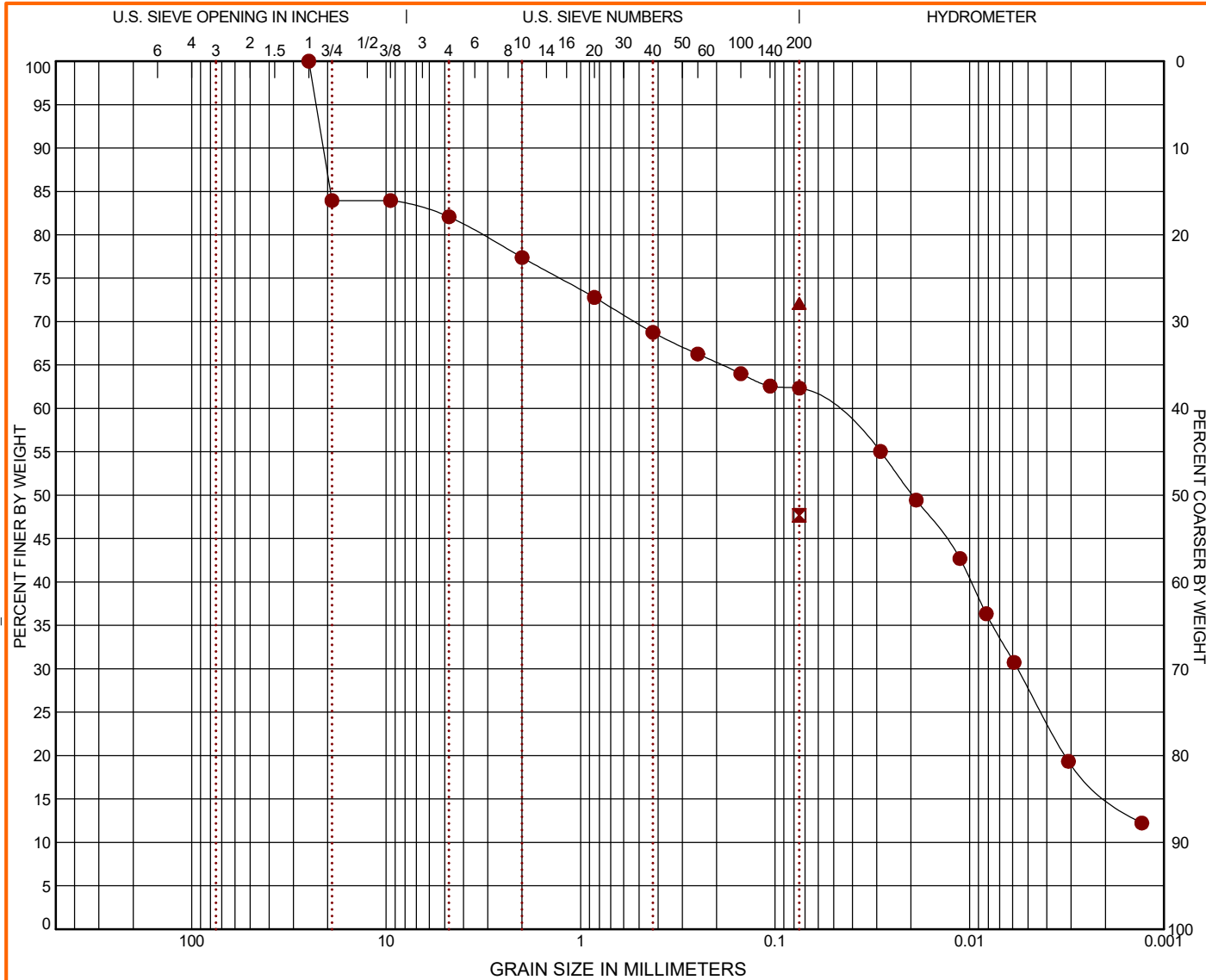
ASTM D422 / ASTM C136

PROJECT: S-13-531 BRO Mangum Branch	 521 Clemson Rd Columbia, SC	PROJECT NUMBER: 7323P100
SITE: Chesterfield County, SC		CLIENT: NHTB

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: AASHTO DESC-1 S-13-531 MANGUM BRANCH.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● S-13-531-1	8.5 - 10.5	0.0	17.9	19.7	34.5		27.8	
✕ S-13-531-1	28.5 - 28.8					47.7		
▲ S-13-531-2	2.5 - 4.5					72.1		ML

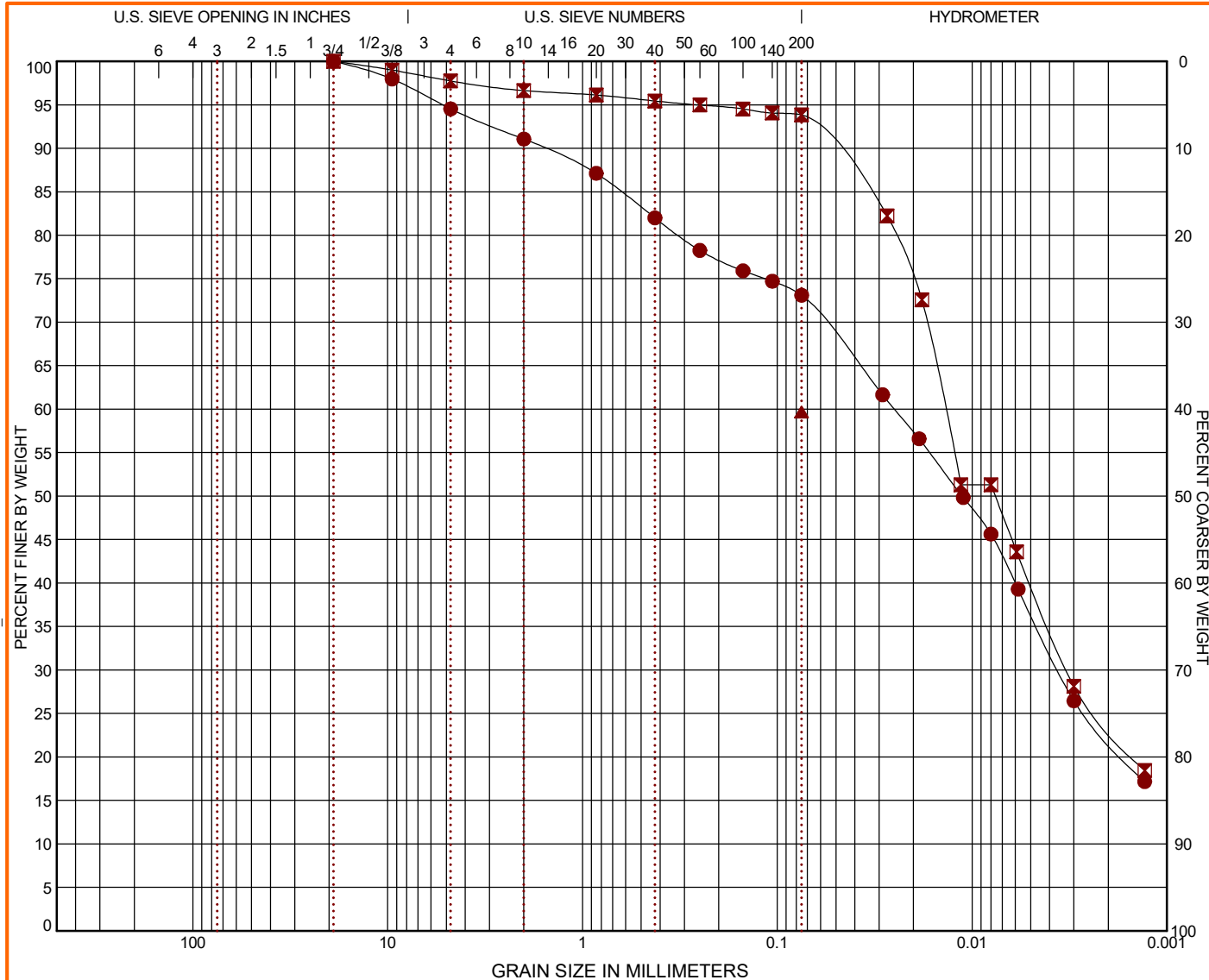
GRAIN SIZE				SOIL DESCRIPTION			
	●	✕	▲	Sieve	% Finer	Sieve	% Finer
D ₆₀	0.055			1"	100.0	#200	72.1
D ₃₀	0.006			3/4"	83.95		
D ₁₀				3/8"	83.95		
				#4	82.07		
				#10	77.38		
				#20	72.79		
				#40	68.76		
				#60	66.27		
				#100	64.0		
				#140	62.57		
				#200	62.34		
COEFFICIENTS				REMARKS			
	●	✕	▲				
C _c							
C _u							

PROJECT: S-13-531 BRO Mangum Branch	<p>521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7323P100
SITE: Chesterfield County, SC		CLIENT: NHTB

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: AASHTO DESC-1 S-13-531 MANGUM BRANCH.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● S-13-531-2	4.5 - 6.5	0.0	5.5	21.4	36.7		36.4	
☒ S-13-531-2	8.5 - 10.5	0.0	2.3	3.9	54.1		39.8	
▲ S-13-531-2	13.5 - 15					59.7		ML

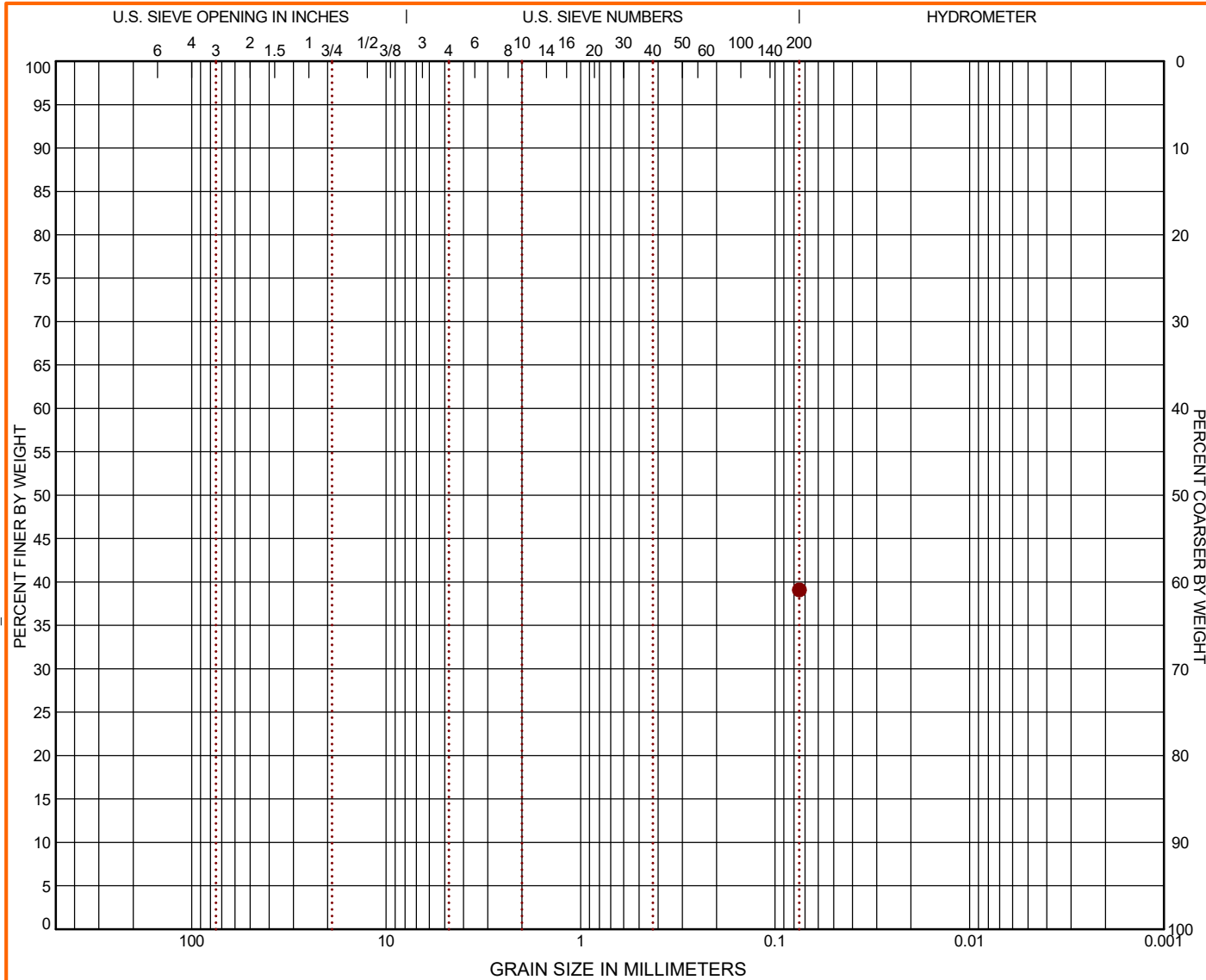
GRAIN SIZE				SOIL DESCRIPTION			
	●	☒	▲	Sieve	% Finer	Sieve	% Finer
D ₆₀	0.025	0.014		3/4"	100.0	3/4"	100.0
D ₃₀	0.004	0.003		3/8"	97.97	3/8"	99.0
D ₁₀				#4	94.53	#4	97.74
				#10	91.06	#10	96.63
				#20	87.12	#20	96.12
				#40	82.0	#40	95.44
				#60	78.25	#60	94.97
				#100	75.91	#100	94.52
				#140	74.7	#140	94.05
				#200	73.1	#200	93.85
COEFFICIENTS				REMARKS			
C _c	●	☒	▲	●			
C _u				☒			
				▲			

PROJECT: S-13-531 BRO Mangum Branch	<p>521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7323P100
SITE: Chesterfield County, SC		CLIENT: NHTB

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: AASHTO DESC-1 S-13-531 MANGUM BRANCH.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23



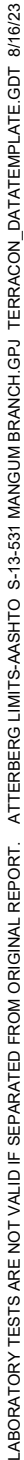
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● S-13-531-2	23.5 - 24					39.1		

GRAIN SIZE				SOIL DESCRIPTION			
	●			Sieve	% Finer	Sieve	% Finer
D ₆₀				#200	39.09		
D ₃₀							
D ₁₀							
COEFFICIENTS				REMARKS			
	●			●			
C _c							
C _u							

PROJECT: S-13-531 BRO Mangum Branch	<p>521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7323P100
SITE: Chesterfield County, SC		CLIENT: NHTB

ASTM D4318

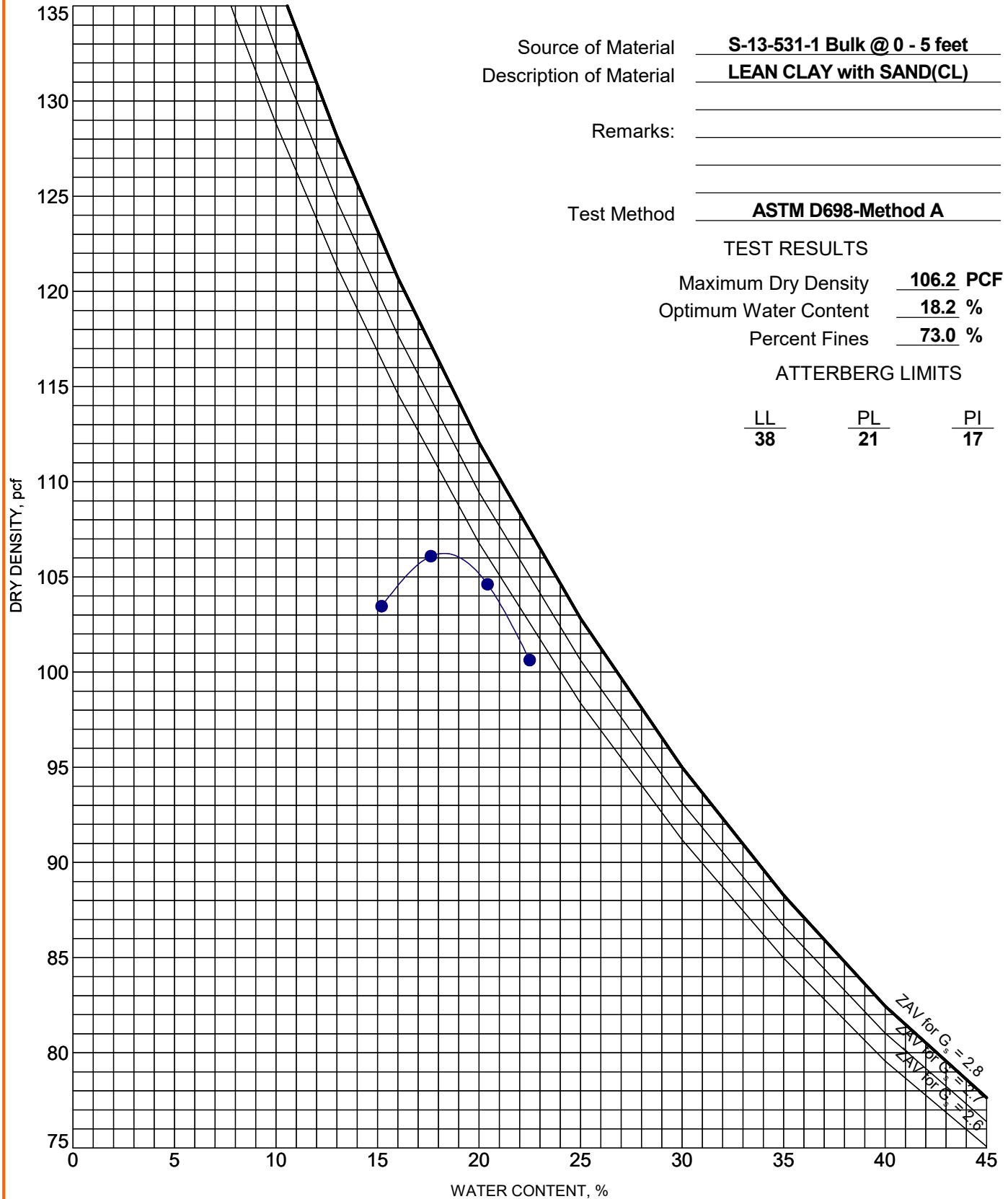


CLIENT: NHTB

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 S-13-531 MANGUM BRANCH.GPJ TERRACON DATATEMPLATE.GDT 8/16/23



PROJECT: S-13-531 BRO Mangum Branch

SITE: Chesterfield County, SC

Terracon
521 Clemson Rd
Columbia, SC

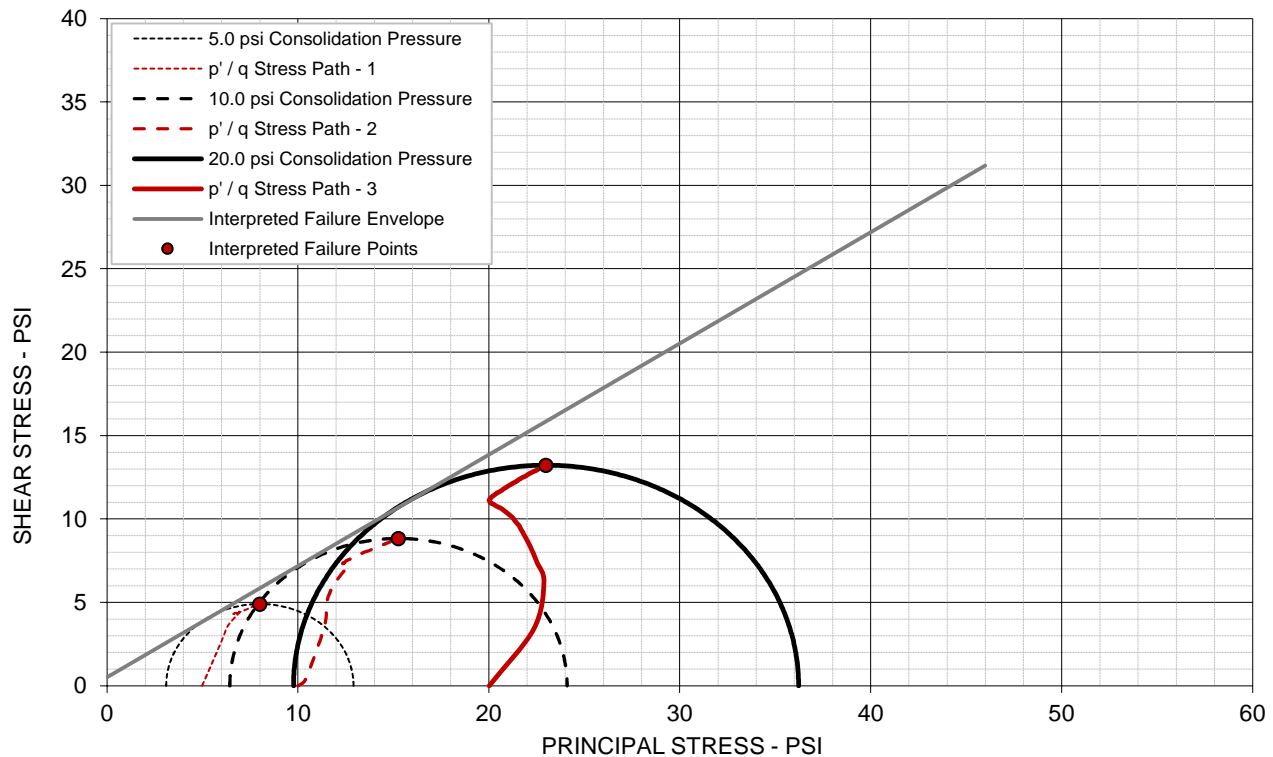
PROJECT NUMBER: 7323P100

CLIENT: NHTB

ICU TRIAXIAL COMPRESSION TEST

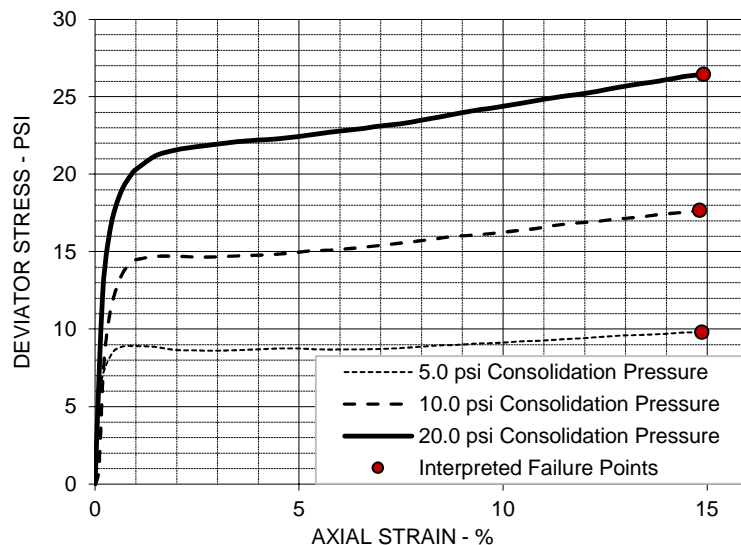
ASTM D4767 / AASHTO T297

Failure Criteria: Max Deviator Stress



EFFECTIVE STRESS PARAMETERS

$\phi' = 33.7$ deg $c' = 0.5$ psi



SPECIMEN NO.

1 2 3

INITIAL

Moisture Content - %	17.8	17.8	18.3
Dry Density - pcf	100.2	100.6	100.8
Diameter - inches	2.86	2.86	2.86
Height - inches	6.05	6.03	6.00

AT TEST

Final Moisture - %	24.8	23.4	23.1
Dry Density - pcf	100.3	101.2	103.4
Calculated Diameter (in.)	2.85	2.84	2.83
Height - inches	6.04	5.99	5.93
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	9.81	17.67	26.45
Total Pore Pressure - psi	81.9	83.6	90.3
Strain Rate - %/min.	0.0330	0.0335	0.0331
Failure Strain - %	14.9	14.8	14.9
σ_1' Failure - psi	12.91	24.09	36.22
σ_3' Failure - psi	3.09	6.43	9.77

TEST DESCRIPTION

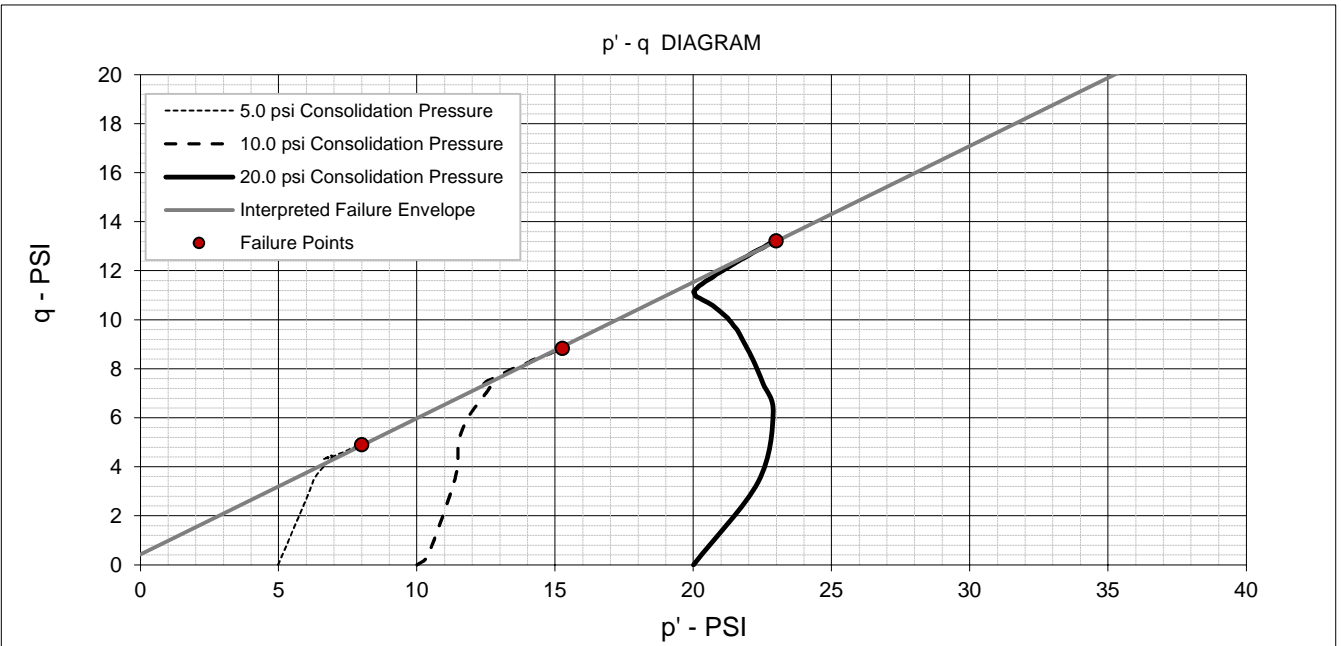
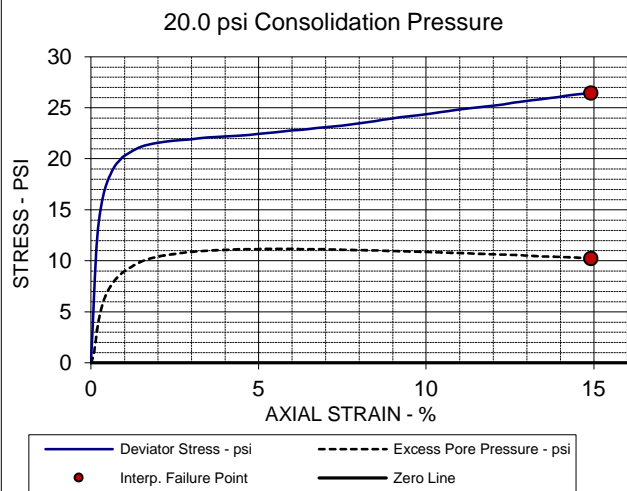
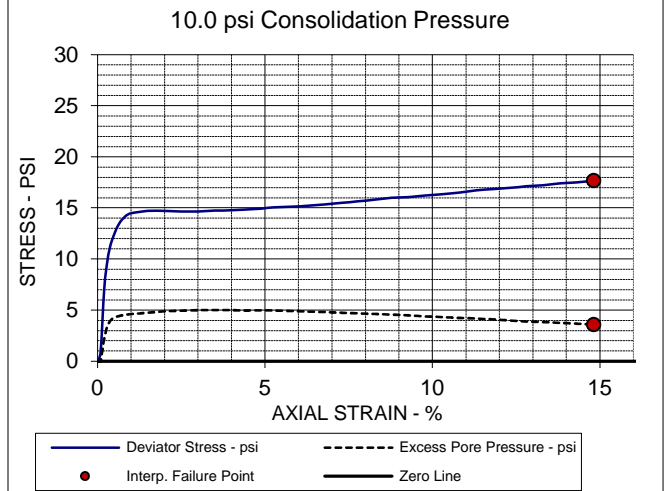
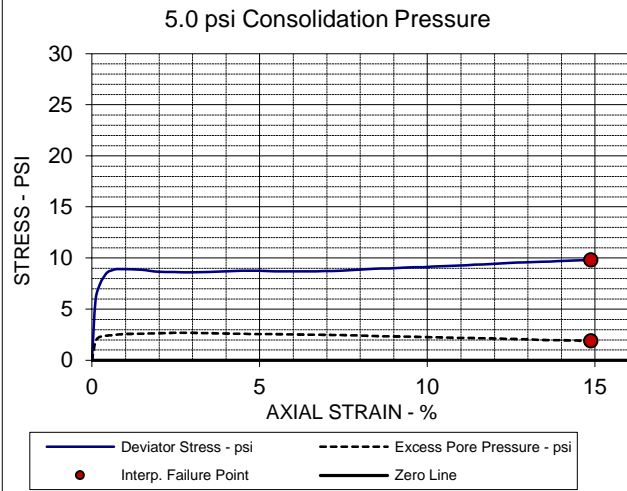
ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION
 SAMPLE TYPE: Remolded
 DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)
 SAMPLE ID: S-13-531-1 Bulk 0-5'
 SPECIFIC GRAVITY: 2.65
 LL: 38 PL: 21 PI: 17 Percent -200: 73.0%
 Remarks: Remolded to 95% of the Standard Proctor


PROJECT INFORMATION

PROJECT: S-13-531 Mangum Branch
 LOCATION: Chesterfield County, SC
 PROJECT #: 7323P100
 CLIENT: HNTB
 DATE: 07/05/23

521 Clemson Road
 Columbia, SC



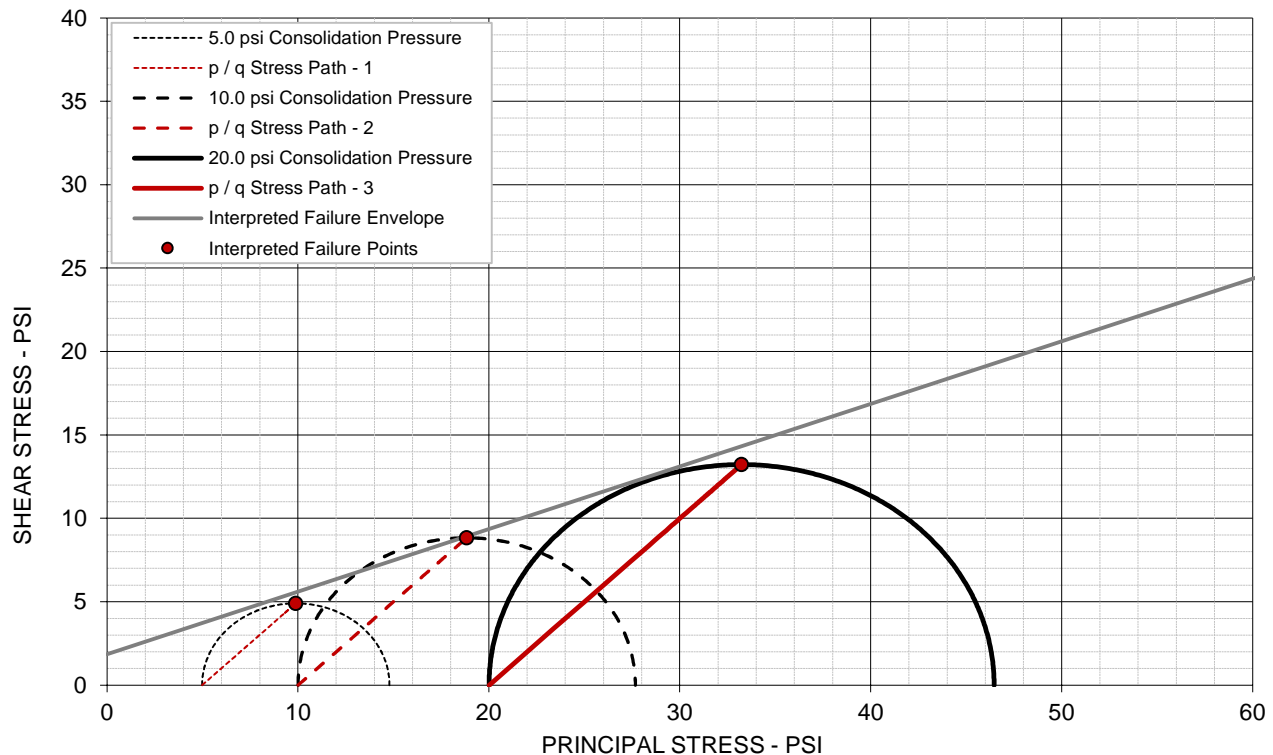


EFFECTIVE STRESS PARAMETERS		R ² = 1.00	α = 29.1 deg	a = 0.4 psi
PROJECT: S-13-531 Mangum Branch			ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST	
LOCATION: Chesterfield County, SC			CLIENT: HNTB	
SAMPLE ID: S-13-531-1 Bulk 0-5'			<div>521 Clemson Road Columbia, SC</div> <div></div>	
DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)				

ICU TRIAXIAL COMPRESSION TEST

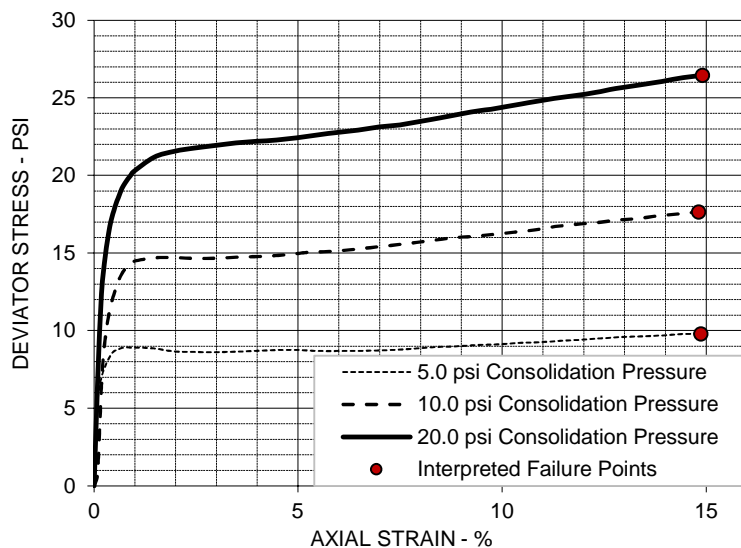
ASTM D4767 / AASHTO T297

Failure Criteria: Max Deviator Stress



TOTAL STRESS PARAMETERS

$\phi = 20.6 \text{ deg}$ $c = 1.8 \text{ psi}$



SPECIMEN NO.

1 2 3

INITIAL

Moisture Content - %	17.8	17.8	18.3
Dry Density - pcf	100.2	100.6	100.8
Diameter - inches	2.86	2.86	2.86
Height - inches	6.05	6.03	6.00

AT TEST

Final Moisture - %	24.8	23.4	23.1
Dry Density - pcf	100.3	101.2	103.4
Calculated Diameter (in.)	2.85	2.84	2.83
Height - inches	6.04	5.99	5.93
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	9.81	17.67	26.45
Total Pore Pressure - psi	81.9	83.6	90.3
Strain Rate - %/min.	0.0330	0.0335	0.0331
Failure Strain - %	14.9	14.8	14.9
σ_1 Failure - psi	14.79	27.67	46.46
σ_3 Failure - psi	4.98	10.00	20.01

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)

SAMPLE ID: S-13-531-1 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 38 PL: 21 PI: 17 Percent -200: 73.0%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-13-531 Mangum Branch

LOCATION: Chesterfield County, SC

PROJECT #: 7323P100

CLIENT: HNTB

DATE: 07/05/23

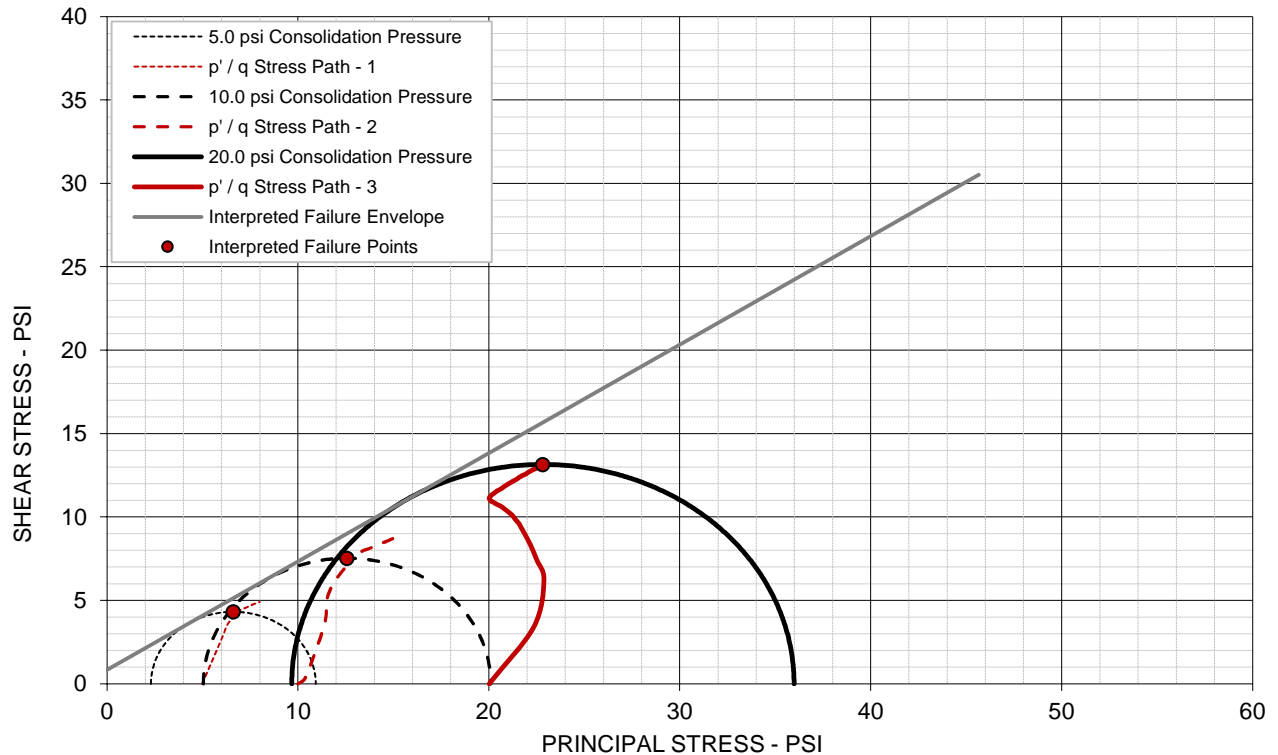
521 Clemson Road
Columbia, SC



ICU TRIAXIAL COMPRESSION TEST

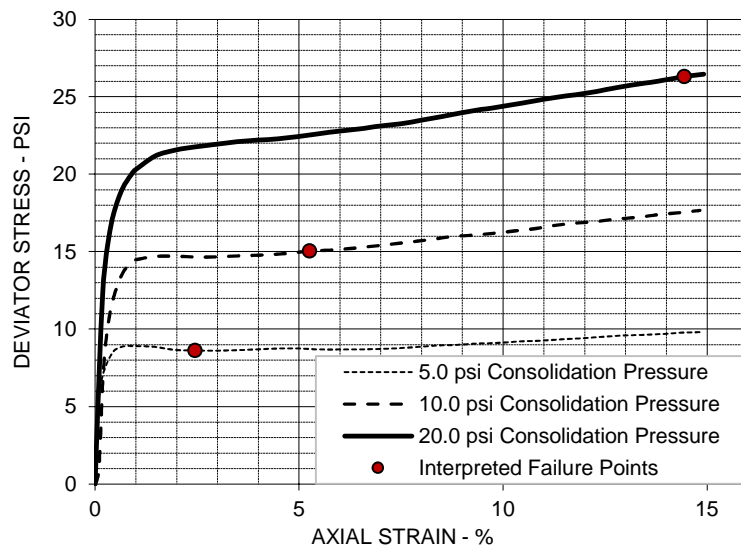
ASTM D4767 / AASHTO T297

Failure Criteria: Max Obliquity (s1': s3')



EFFECTIVE STRESS PARAMETERS

$\phi' = 33.1$ deg $c' = 0.8$ psi



SPECIMEN NO.

1 2 3

INITIAL

Moisture Content - %	17.8	17.8	18.3
Dry Density - pcf	100.2	100.6	100.8
Diameter - inches	2.86	2.86	2.86
Height - inches	6.05	6.03	6.00

AT TEST

Final Moisture - %	24.8	23.4	23.1
Dry Density - pcf	100.3	101.2	103.4
Calculated Diameter (in.)	2.85	2.84	2.83
Height - inches	6.04	5.99	5.93
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	8.63	15.05	26.30
Total Pore Pressure - psi	82.7	85.0	90.3
Strain Rate - %/min.	0.0330	0.0335	0.0331
Failure Strain - %	2.4	5.3	14.4
σ_1' Failure - psi	10.93	20.10	35.98
σ_3' Failure - psi	2.30	5.04	9.68

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)

SAMPLE ID: S-13-531-1 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 38 PL: 21 PI: 17 Percent -200: 73.0%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-13-531 Mangum Branch

LOCATION: Chesterfield County, SC

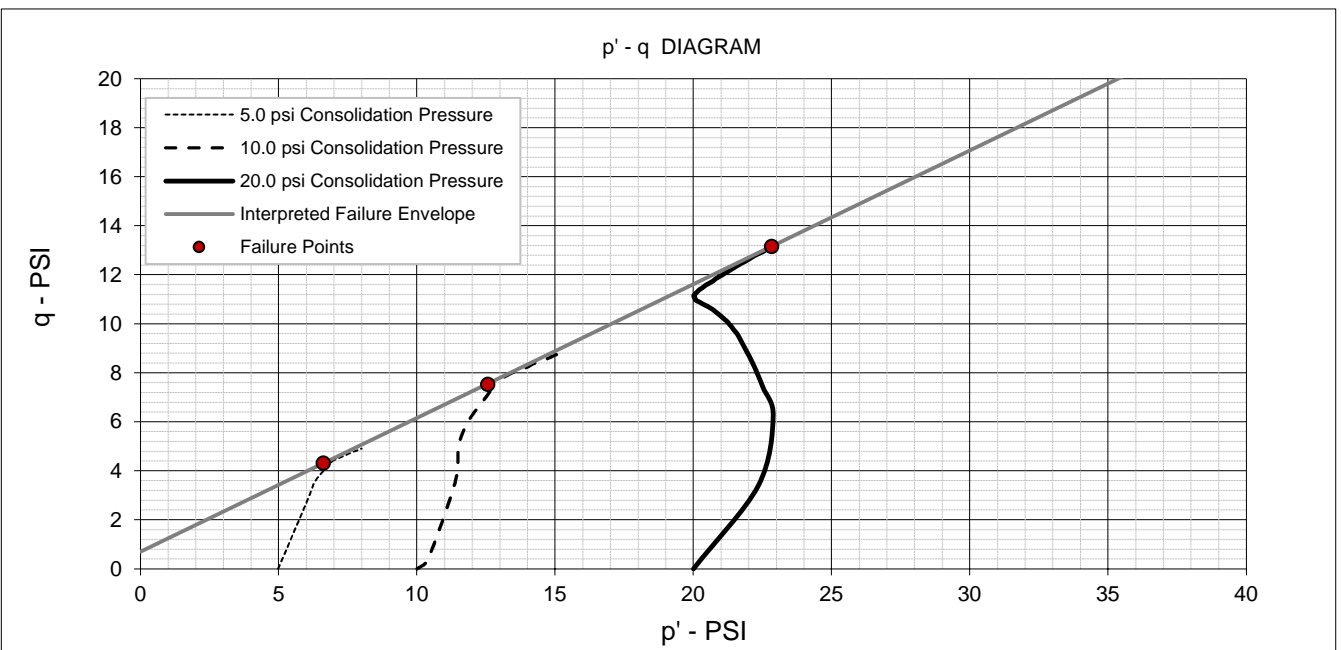
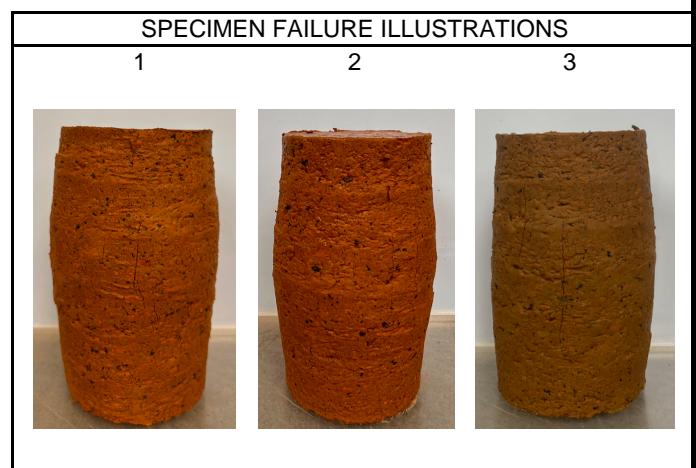
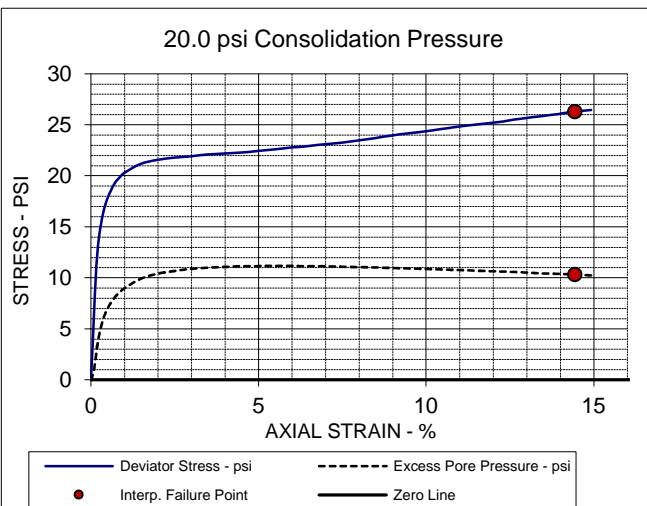
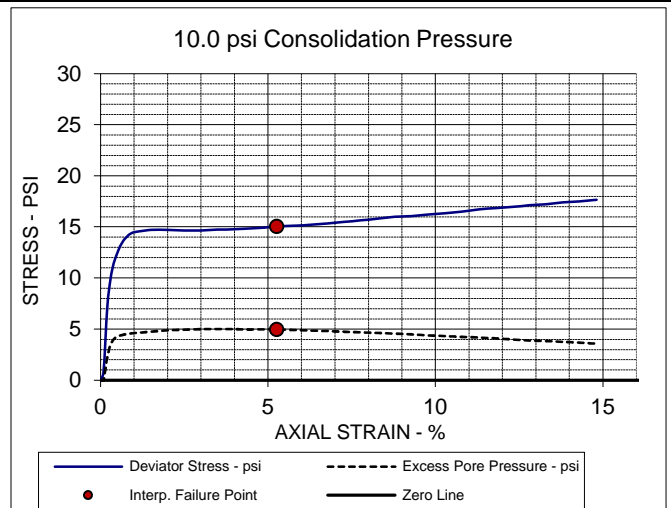
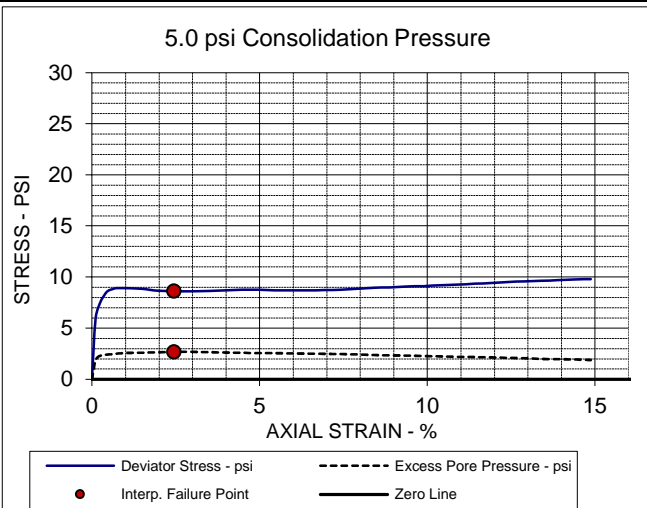
PROJECT #: 7323P100


CLIENT: HNTB

DATE: 07/05/23

521 Clemson Road
Columbia, SC



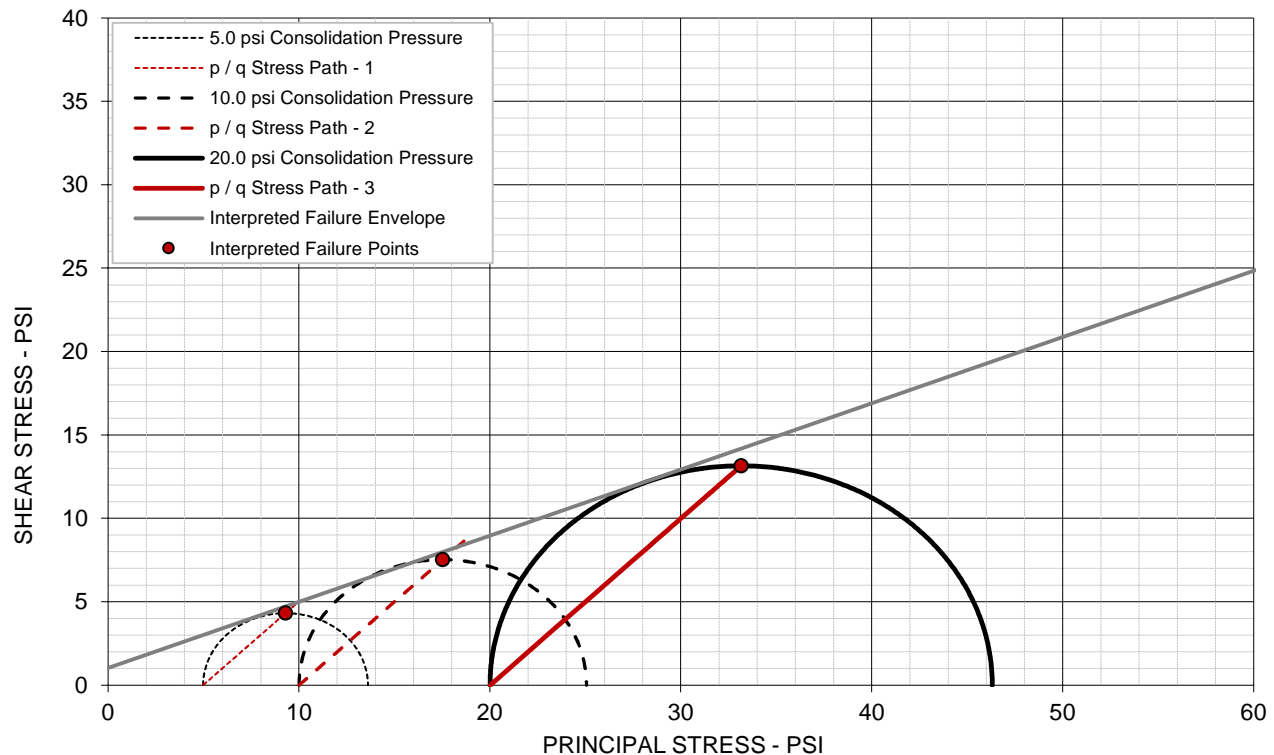


EFFECTIVE STRESS PARAMETERS		R ² = 1.00	α = 28.6 deg	a = 0.7 psi
PROJECT: S-13-531 Mangum Branch			ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST	
LOCATION: Chesterfield County, SC			CLIENT: HNTB	
SAMPLE ID: S-13-531-1 Bulk 0-5'			<div>521 Clemson Road Columbia, SC</div> <div></div>	
DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)				

ICU TRIAXIAL COMPRESSION TEST

ASTM D4767 / AASHTO T297

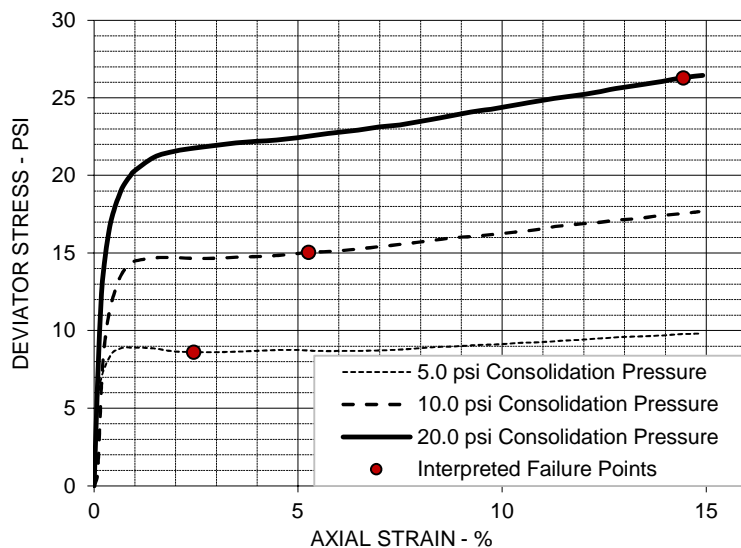
Failure Criteria: Max Obliquity (s1': s3')



TOTAL STRESS PARAMETERS

$\phi = 21.7$ deg

$c = 1.0$ psi



SPECIMEN NO.

1 2 3

INITIAL

Moisture Content - %	17.8	17.8	18.3
Dry Density - pcf	100.2	100.6	100.8
Diameter - inches	2.86	2.86	2.86
Height - inches	6.05	6.03	6.00

AT TEST

Final Moisture - %	24.8	23.4	23.1
Dry Density - pcf	100.3	101.2	103.4
Calculated Diameter (in.)	2.85	2.84	2.83
Height - inches	6.04	5.99	5.93
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	8.63	15.05	26.30
Total Pore Pressure - psi	82.7	85.0	90.3
Strain Rate - %/min.	0.0330	0.0335	0.0331
Failure Strain - %	2.4	5.3	14.4
σ_1 Failure - psi	13.61	25.06	46.31
σ_3 Failure - psi	4.98	10.00	20.01

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION
 SAMPLE TYPE: Remolded
 DESCRIPTION: Lean Clay with Sand (CL) / A-6 (11)
 SAMPLE ID: S-13-531-1 Bulk 0-5'
 SPECIFIC GRAVITY: 2.65
 LL: 38 PL: 21 PI: 17 Percent -200: 73.0%
 Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-13-531 Mangum Branch
 LOCATION: Chesterfield County, SC
 PROJECT #: 7323P100
 CLIENT: HNTB
 DATE: 07/05/23

521 Clemson Road
 Columbia, SC



Client

HNTB North Carolina PC
Raleigh, NC

Project

S-13-531 BRO Mangum Branch
7323P100

Date Received: 6/27/2023

Results from Corrosion Testing

Sample Location	S-13-531-2
Sample Depth (ft.)	0'-10'

pH Analysis, ASTM G 51	5.76
------------------------	------

Water Soluble Sulfate (SO ₄), ASTM D516-07 (mg/kg)	9
---	---

Chlorides, APHA 4500-Cl ⁻ E, (mg/kg)	8
---	---

Resistivity (Saturated), ASTM G 57, (ohm-cm)	19000
--	-------

Analyzed By: Kyle Lemcke
Laboratory Manager

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 P041959 PROJECT NAME S-13-531 RBO Mangum Branch
PROJECT COUNTY Chesterfield

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q _u (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
S-13-531-1	NQ-1	14.5	25	0						10
S-13-531-1	NQ-2	19.5	15	0						10

Appendix C

Supporting Documents

Rig Calibration Report (5 Pages)

Note: All exhibits are one page unless noted above.

SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: CME 45C
Serial Number: 406484
Terracon Drill Rig Asset Number: DR#543
July 29, 2022



Prepared for:
Terracon Consultants, Inc.
Columbia Exploration Services

Prepared by:
Terracon Consultants, Inc.
Exploration Services Group



July 29, 2022

Terracon Consultants, Inc.
521 Clemson Rd,
Columbia, SC 29229

Attn: Mr. Phillip Morris
E: phillip.morrison@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report
Terracon Drill Rig DR#543; CME 45C
Terracon Project Number: DUXX0500

Dear Mr. Phillip Morrison:

This report provides the Energy Transfer Ratio (ETR) for the SPT automatic hammer found on drill rig model CME 45C; Terracon Drill Rig Asset Number DR#543 (Serial Number: 406484).

Table 1: Hammer Measurement Summary

Drill Rig Model	Serial No.	Drill Rig Year	Drill Rig No.	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (Ce)
CME 45C	406484	2018	DR#543	93.5% ± 4.5%	1.56

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

Sincerely,
Terracon Consultants, Inc.

Smith,
James P.
James Smith
National Exploration Manager

Digitally signed by Smith, James P.
DN: cn=Smith, James P., o=Terracon
Consultants, Inc., email=j.smith@terracon.com
Reason: I have signed this document and
I agree with its contents.
Date: 2022.08.10 17:46:58 -0400

Jerry Salsgiver, P.E.
Assistant National Manager

Attachments:
Exhibit A: Measurement Information
Exhibit B: PDA SPT Analyzer Results

Terracon Consultants, Inc. 10841 S. Ridgeview Road Olathe, KS 66061
P (407) 446 2527 terracon.com

terracon.com

Terracon

Environmental Facilities Geotechnical Materials

Environmental Facilities Geotechnical Materials

Exhibit A Measurement Information

MEASUREMENT INFORMATION

ITEM	DESCRIPTION
Drill Rig Identification	Drill Rig Model: CME 45C Drill Rig Year: 2018 Terracon Drill Rig Asset No.: DR#543; Serial No. 406484
Drill Rig Owner	Terracon Consultants, Inc. – Columbia, SC
Drill Rig Operator	Aaron Bowen; Columbia Exploration
Testing Date	07/28/2022
Testing Location	Columbia, SC
Boring Identification	B-1
Hammer Type	140 pounds (automatic)
Boring Method	Rotary Wash
Drill Rods	■ AWJ ■ 1 3/4" outside diameter ■ 3/16" wall thickness
Testing Equipment	■ 2-foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers ■ Model SPT Analyzer™ (PDA)
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
Personnel	Jim Smith – National Exploration Manager - Terracon Consultants, Inc.

Exhibit B

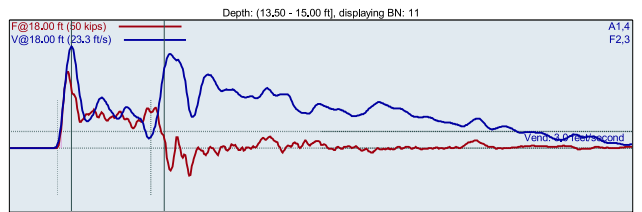
PDA SPT ANALYZER RESULTS

Pile Dynamics, Inc.
SPT Analyzer Results

Page 1 of 5
PDA-S Ver. 2018.24 - Printed: 7/29/2022

DU-543-406484
Jim Smith
AR: 1.20 in²
LE: 18.00 ft
WS: 16807.9 f/s

13.5-15.1
Test date: 7/28/2022
SP: 0.492 k/ft³
EM: 30000 ksi



F2 : [648AWJ1] 226,21 PDICAL (1) FF1
F3 : [648AWJ2] 225,58 PDICAL (1) FF1

A1 (PR): [K4484] 353,907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410,187 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	2	28	18.4	1.9	279	79.8
2	2	30	18.4	51.6	276	78.9
3	2	31	18.9	51.6	305	87.1
4	2	30	18.3	51.6	309	88.2
5	9	30	18.4	51.7	319	91.2
6	9	29	19.0	51.5	318	91.0
7	9	29	18.5	51.3	305	87.0
8	9	29	18.4	51.2	313	89.3
9	9	30	18.0	51.0	317	90.5
10	9	29	18.6	51.1	317	90.5
11	9	30	18.5	51.0	302	86.1
12	9	30	19.3	51.0	312	89.1
13	9	30	18.8	51.0	321	91.6
Average		30	18.6	51.3	312	89.2
Std Dev		1	0.3	0.3	6	1.8
Maximum		31	19.3	51.7	321	91.6
Minimum		29	18.0	51.0	302	86.1
N-value: 11						

Sample Interval Time: 14.02 seconds.

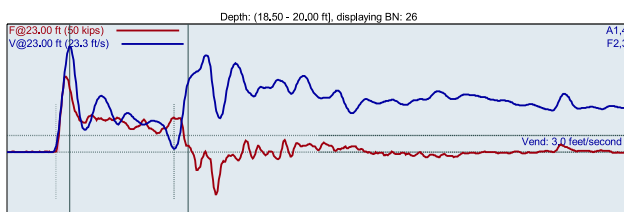
Responsive ■ Resourceful ■ Reliable

Pile Dynamics, Inc.
SPT Analyzer Results

Page 2 of 5
PDA-S Ver. 2018.24 - Printed: 7/29/2022

DU-543-406484
Jim Smith
AR: 1.20 in²
LE: 23.00 ft
WS: 16807.9 f/s

13.5-15.1
Test date: 7/28/2022
SP: 0.492 k/ft³
EM: 30000 ksi



F2 : [648AWJ1] 226,21 PDICAL (1) FF1
F3 : [648AWJ2] 225,58 PDICAL (1) FF1

A1 (PR): [K4484] 353,907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410,187 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
14	5	29	18.1	1.9	322	91.9
15	5	29	19.0	55.9	320	91.3
16	5	30	18.7	55.3	315	90.3
17	5	30	19.2	55.4	334	95.6
18	5	29	19.5	55.7	317	90.5
19	5	29	19.0	55.8	316	90.3
20	5	29	19.4	55.1	320	91.3
21	5	29	18.8	55.9	320	91.5
22	5	30	19.3	55.2	324	92.5
23	5	29	19.2	55.5	320	91.6
24	5	29	19.0	55.6	314	89.7
25	5	30	18.7	55.4	330	94.2
26	5	29	19.2	55.0	310	88.5
27	5	29	18.5	55.2	301	86.0
28	5	30	18.4	54.6	311	88.8
Average		29	19.0	55.3	317	90.4
Std Dev		0	0.3	0.4	8	2.2
Maximum		30	19.4	55.9	330	94.2
Minimum		29	18.4	54.6	301	86.0
N-value: 10						

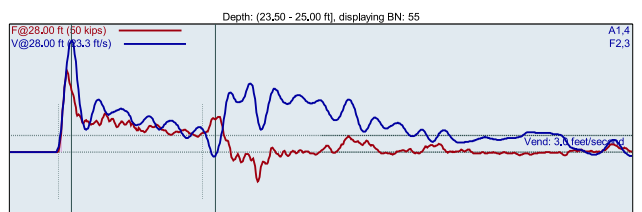
Sample Interval Time: 15.13 seconds.

Pile Dynamics, Inc.
SPT Analyzer Results

Page 3 of 5
PDA-S Ver. 2018.24 - Printed: 7/29/2022

DU-543-406484
Jim Smith
AR: 1.20 in²
LE: 28.00 ft
WS: 16807.9 f/s

13.5-15.1
Test date: 7/28/2022
SP: 0.492 k/ft³
EM: 30000 ksi



F2 : [648AWJ1] 226,21 PDICAL (1) FF1
F3 : [648AWJ2] 225,58 PDICAL (1) FF1

A1 (PR): [K4484] 353,907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410,187 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
29	12	1	0.4	1.9	3	0.9
30	12	30	19.1	63.1	340	97.2
31	12	29	20.1	55.5	357	101.9
32	12	29	20.1	55.2	364	104.0
33	12	10	7.3	78.6	55	15.7
34	12	31	20.4	41.0	361	103.2
35	12	31	19.8	57.1	346	98.8
36	12	31	20.0	55.3	342	97.6
37	12	30	19.6	55.6	342	97.8
38	12	31	19.9	55.6	332	94.8
39	12	31	19.8	55.5	337	96.3
40	12	31	19.9	55.5	336	95.9
41	9	31	19.6	55.6	345	98.4
42	9	31	20.1	55.2	335	95.6
43	9	31	19.6	55.6	341	97.4
44	9	31	20.2	55.4	341	97.3
45	9	32	19.5	55.4	341	97.5
46	9	31	19.9	55.5	349	99.7
47	9	31	19.8	55.3	344	98.1
48	9	31	19.9	55.5	346	98.9
49	9	31	19.9	55.6	341	97.6
50	8	31	19.9	55.2	347	99.2
51	8	31	20.0	55.6	338	96.6
52	8	31	20.1	55.2	341	97.4
53	8	32	20.1	55.4	352	100.7
54	8	32	19.8	55.8	348	99.3
55	8	32	20.3	55.1	345	98.5
56	8	32	20.0	55.6	347	99.2
57	8	31	20.0	55.5	340	97.1

Average	31	19.9	55.4	344	98.1
Std Dev	0	0.2	0.2	4	1.2
Maximum	32	20.3	55.8	352	100.7
Minimum	31	19.5	55.1	335	95.6

N-value: 17

Sample Interval Time: 30.24 seconds.

Summary of SPT Test Results

Project: DU-543-406484, Test Date: 7/28/2022

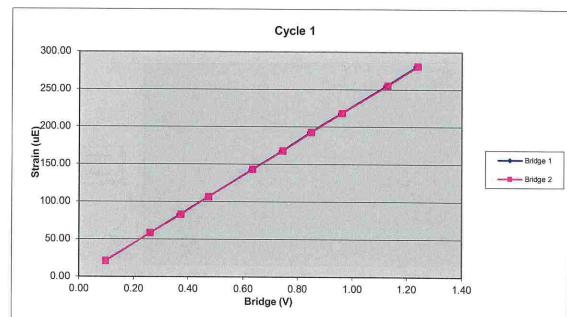
FMX: Maximum Force					EFV: Maximum Energy				
VMX: Maximum Velocity					ETR: Energy Transfer Ratio - Rated				
BPM: Blows/Minute									
Blow Length ft	Blows Applied /ft	N Value	N50 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %	
18.00	20.0	11	17	30	18.6	51.3	312	89.2	
23.00	15.0	10	15	29	19.0	55.3	317	90.4	
28.00	12.0	17	26	31	19.9	55.4	344	98.1	
Overall Average Values:				30	19.3	54.2	327	93.3	
Standard Deviation:				1	0.7	1.9	16	4.5	
Overall Maximum Value:				32	20.3	55.9	352	100.7	
Overall Minimum Value:				29	18.0	51.0	301	89.0	



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

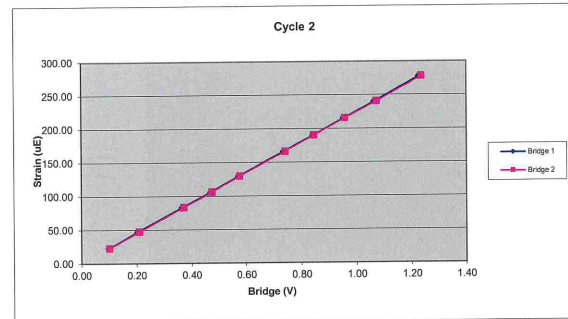
Force Strain Calibration	
EA (Kips)	35527.98
Offset	51.69
Correlation	0.999986



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

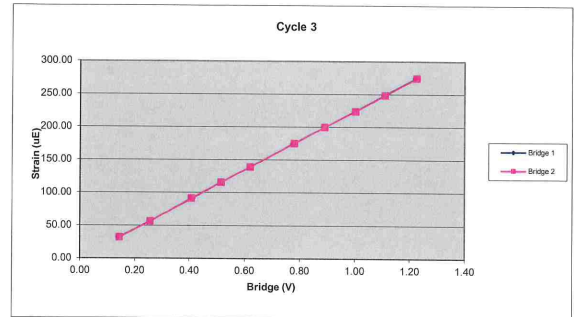
Force Strain Calibration	
EA (Kips)	36073.41
Offset	-2.66
Correlation	0.999993



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 ²)	1.20

Calibrated by: *Robt. Lee*
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

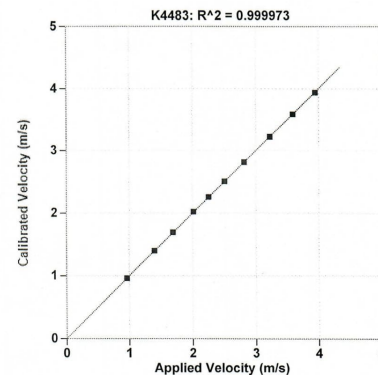
PDA CALIBRATION FACTOR
410.2 mv/5000g
(82.0 µV/g)
R²: 0.999973 [Chip programmed]

Operator: William Johnson

Ref Acc 1: 69096I Cal on: 27Jan2021
978 g's/volt
Ref Acc 2: 69132I Cal on: 09Feb2021
960 g's/volt

William Johnson
Signed

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	

Accelerometer Calibration Certificate
Pile Dynamics, Inc.



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

Serial No: K4484 Temperature: 19.3 °C
Model: PR Humidity: 30%
Calibrated on: Channel 4 on 8G 5161 LE

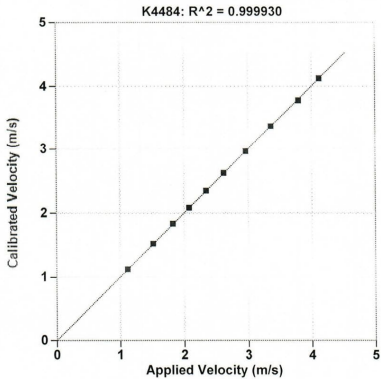
PDA CALIBRATION FACTOR
353.9 mv/5000g
(70.8 μv/g)
R^2: 0.999930 [Chip programmed]

Ref Acc 1: 69132! Cal on: 09Feb2021
960 g's/volt
Ref Acc 2: 69096! Cal on: 27Jan2021
978 g's/volt

Operator: William Johnson

Signed

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



Reference Velocity m/s	S/N K4484 Velocity m/s
1.117	1.124
1.518	1.523
1.823	1.835
2.078	2.080
2.344	2.349
2.616	2.624
2.963	2.962
3.360	3.357
3.794	3.778
4.121	4.122

Maximum Acceleration: 916 g's