



Geotechnical Subsurface Data Report

S-11-138 (Goucher School Rd.) Bridge
Replacement over Goucher Creek

Cherokee County, SC
June 24, 2022



June 24, 2022

Mr. Trapp Harris, PE, DBIA
Geotechnical Engineer
Alternative Delivery
South Carolina Department of Transportation
955 Park Street
Columbia, SC 29201

Dear Mr. Harris,

We have completed the Geotechnical Subsurface Data Report for the S-11-138 (Goucher School Rd.) Bridge Replacement over Goucher Creek in Cherokee County, SC. Please call at your convenience if you have questions or comments. HDR appreciates the opportunity to provide geotechnical engineering services to the South Carolina Department of Transportation.

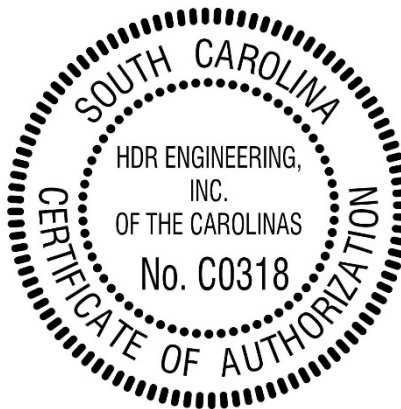
Sincerely,
HDR

Kiera Hughes, E.I.T.
Engineer-in-Training

Nathan Yacobi, P.G.
Professional Geologist



Lila Leon, P.E., Ph.D.
Senior Geotechnical Engineer



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1 Introduction

This Geotechnical Subsurface Data Report (GSDR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed S-11-138 Bridge Replacement over Goucher Creek, in Cherokee County, South Carolina. The proposed bridge intends to replace the existing bridge over Goucher Creek on existing alignment.

This Geotechnical Subsurface Data Report was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and PCDM-11 Supplemental Design Criteria for Low Volume Bridge Replacement Projects. Geotechnical data including standard penetration testing (SPT), cone penetration testing (CPT), bulk samples, rock cores, shear wave velocity measurements, and a variety of laboratory tests are presented herein to provide geological features and site conditions for the design of the proposed bridge. Geotechnical recommendations are not included in this report.

1.1 Project Description

The project site is located southwest of Gaffney, approximately half a mile south of the intersection of Goucher School Road with Pacolet Highway. It is bound to the north by Pacolet Hwy and to the south State Road S 11-72. Bridge is placed on a low-volume road based on the design criteria evolving after the initial scoping through the Design-Build Preparation process. A Site Vicinity Map is included in Appendix A.

The existing bridge over Goucher Creek is approximately 105 feet in length and 28 feet wide and will be removed and replaced with a new bridge along the existing alignment. The proposed multi span replacement bridge will be approximately 130 feet in length and will accommodate two 11-foot lanes with 6-foot shoulders. Construction is anticipated to be completed with a temporary detour of traffic.

2 Investigative Procedures

The geotechnical subsurface exploration at the project site was performed by F&ME Consultants in May 2022. The subsurface investigation consisted of standard penetration test (SPT) borings, rock core samples, bulk sample soil collection, CPTs, and shear wave velocity measurements with MASW testing. CPTs and shear wave velocity measurements were performed for this particular bridge per the initial scope of work and prior to the decision being made on its classification as a low-volume bridge based on the design criteria evolving through the Design-Build Preparation process.

A test location plan showing all testing locations is included in Appendix A. The boring logs, rock core photos, CPT logs, and MASW shear wave velocity profile from the subsurface investigation are included in Appendix B.

2.1 Drilling and Sampling

A total of two (2) SPT borings were performed during the subsurface investigation, B-7 and B-8. Auger refusal was encountered in both borings at depths of 20.3 feet and 21.7 feet, respectively. Advancement of the bridge borings B-9 and B-10 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 30.3 feet and 31.7 feet.

The boring logs from the subsurface investigations are included in Appendix B. The borings were advanced by a CME 45B using rotary wash and driven casing drilling techniques. Soil sampling and penetration testing was performed in general accordance with ASTM D-1586 and ASTM D-1587. SPT's were typically conducted continuously in the top 10 feet of each boring followed by 5-foot intervals thereafter until auger refusal was encountered. SPT's were carried out utilizing a standard 1.4-inch I.D., 2-inch O.D, split barrel, or split-spoon sampler. Blow counts recorded at these intervals were produced from SPT hammer with energy ratio of 81.4%. The hammer energy ratio is identified on each boring log. SPT hammer energy measurements on the CME 45B drill rig were performed with a pile driving analyzer (PDA) and the SPT Hammer Energy Calibration Report is included in Appendix D.

One (1) bulk sample was obtained at boring BS-3 collectively from 5 feet below the existing ground surface from auger cuttings. The collected rock core samples were evaluated in the field and the percentage of core recovery (REC) and Rock Quality Designation (RQD) were recorded.

Recovered SPT, bulk sample, and rock cores were sent to the F&ME laboratory for testing.

2.2 Cone Penetrometer Testing

Two (2) cone penetrometer tests (CPT-1 and CPT-2) were performed by F&ME Consultants, Inc., one near each end bent of the existing bridge. Upon encountering refusal, the CPTs were terminated at depths of 21.41 feet and 18.21 feet respectively. CPT sounding logs are included in Appendix B.

2.3 MASW Survey

Shear wave velocity measurements were obtained by F&ME Consultants from one (1) Multi-Channel Analysis of Surface Waves, MASW-1, performed near the southern approach of the existing bridge over Goucher Creek. Active survey data was obtained by a sledgehammer striking an aluminum block and polyethylene block and recording of the resulting vibrations. Passive survey data consisted of the collection of ambient background vibrations resulting from drilling equipment. The resulting shear-wave data from this investigation produced an average shear-wave velocity of 2323.4 ft/sec for the 0 to 100-foot interval. The MASW survey report is included in Appendix B.

2.4 Groundwater Conditions

Groundwater levels were recorded at the time of completion of soil drilling and/or rock coring at the boring locations at depths of 16.2 feet and 16.8 feet, respectively. These depths correspond to elevations of 525.3 feet and 525.9 feet.

Stabilized groundwater levels recorded approximately 24 hours after completion of investigation operations indicated a groundwater depth of 13.4 feet for boring B-8. This depth corresponds to an elevation of 529.3 feet.

These reported groundwater levels are interpreted to be dependent upon seasonal fluctuations, individual event intensity and/or level of the Goucher Creek.

2.5 Field Testing Summary

The field testing locations and other pertinent information are summarized in Table 2-1 below, and are also plotted on the test location plan included in Appendix A.

Table 2-1. Field Soil Testing Summary

Test Hole No.	Station ^a	Offset (ft)	Latitude	Longitude	Top of Boring Elevation (ft)	Test Type	Total Depth (ft)
B-7	88+38	4 RT	34.97481	-81.69421	541.5	SPT/RC	30.3
B-8	89+58	4 RT	34.97513	-81.69432	542.7	SPT/RC	31.7
BS-3	89+66	4 RT	34.97515	-81.69432	542.9	BULK	5.0
CPT-1	88+41	4 RT	34.97482	-81.69421	541.4	CPT	21.41
CPT-2	89+55	4 RT	34.97512	-81.69431	542.8	CPT	18.21
MASW-1						MASW	

^a Stations based on latest S-11-138 alignment.

3 Laboratory Test Program

Laboratory testing was performed by F&ME Consultants on representative samples collected from the geotechnical borings to obtain index and engineering properties. Geotechnical index property testing included natural moisture content, Atterberg limits, #200 wash, and sieve analysis. Engineering property tests included consolidated undrained (CU) triaxial compression, unconfined compression of rock, Standard Proctor, and corrosion series testing.

Laboratory testing was performed in general accordance with ASTM or AASHTO test procedures. Representative samples were classified in accordance with the AASHTO and Unified Soil Classification System (USCS). Table 3-1 summarizes the testing types and quantity of each test performed. For detailed laboratory information, refer to Appendix C.

Table 3-1. Laboratory Testing Summary

Test Type	Quantity
Natural Moisture Content	7
Atterberg Limits	4
Grain Size Analysis with Hydrometer	2
Grain Size Analysis with #200 Wash	5
CU Triaxial	1
Unconfined Compression of Rock	4
Standard Proctor	1
Corrosion Series	1

3.1 Soil and Rock Properties

Split spoon soil samples from the preliminary geotechnical subsurface site exploration for this bridge site were grouped and classified into AASHTO and USCS soil classifications. According to the AASHTO Soil Classification System, the classifications of these samples ranged from A-2-4 to A-7-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty sand (SM) to sandy fat clay (CH). Tested samples yielded liquid limits ranging from 26 to 58 and plasticity indices ranging from 3 to 33.

Corrosion series test were performed on select split spoon samples. Standard proctor testing and remolded CU triaxial tests were performed on each of the collected bulk samples. Finally, four (4) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 13,330 psi and 24,920 psi. Results of laboratory testing are included in Appendix C.

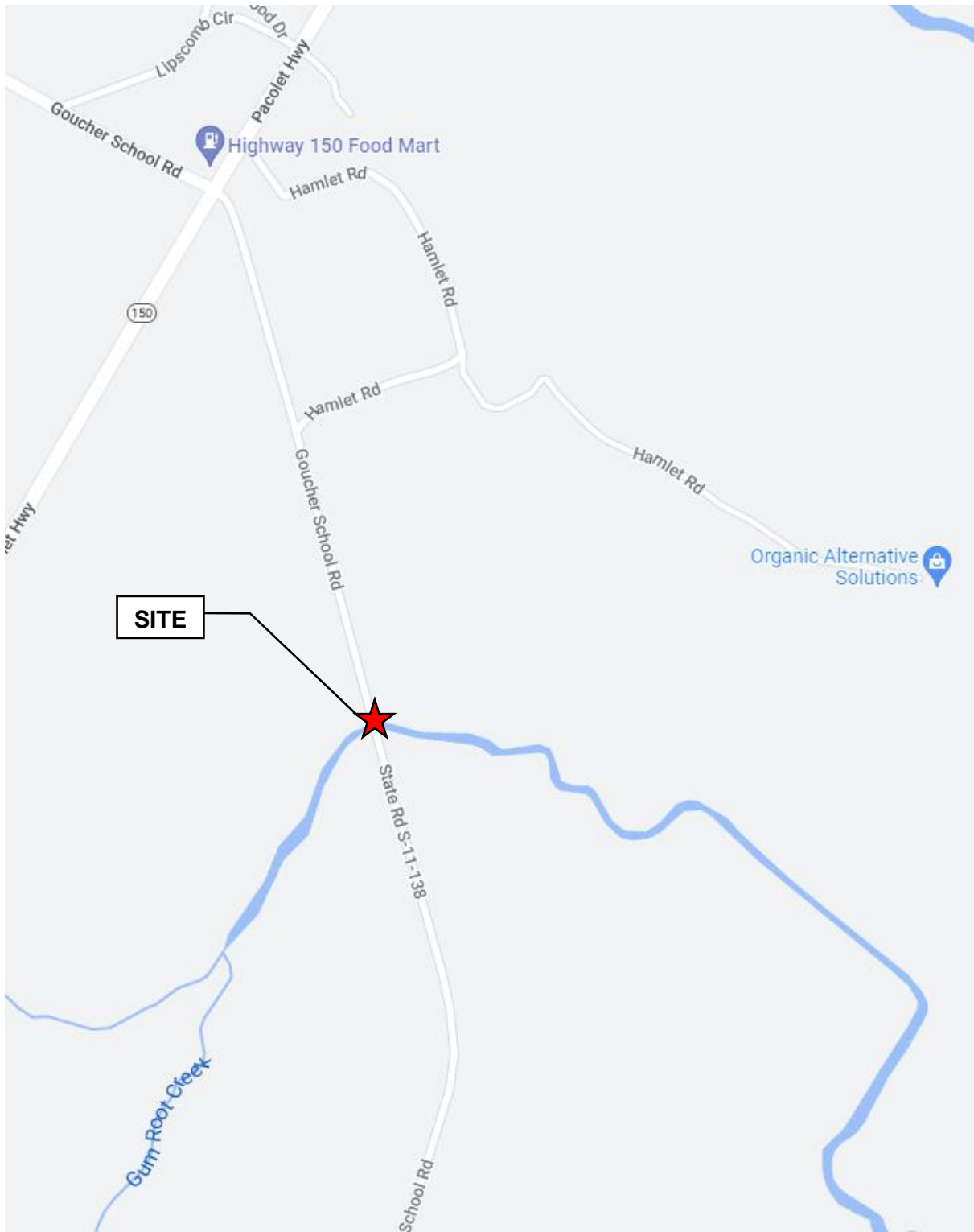
4 Limitations to Report


This report has been prepared for the exclusive use of the South Carolina Department of Transportation or their agent, for specific application to the proposed S-11-138 Bridge over Goucher Creek in Cherokee County, South Carolina in accordance with generally accepted soil and foundation engineering practices. No other warranty expressed or implied is made. The subsurface investigation logs included herein, do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to perform additional subsurface exploration based upon on-site observations of the conditions.

5 References

- Butler, J.R. (1991). "Metamorphism". In Horton, J.W., Jr., and Zullo, V.A., Eds., the Geology of the Carolinas: Knoxville, University of Tennessee Press: 127.
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Appendix A. Site Vicinity Map, Test Location Plan



		HDR ENGINEERING INC. OF THE CAROLINAS 1201 Main Street, Suite 800 Columbia, SC 29201, 803.254.5800
S-11-138 (Goucher School Rd.) over Goucher Creek		
COUNTY	CHEROKEE	SITE VICINITY MAP Source: Google Maps

S-11-138 Goucher School Rd. over Goucher Creek

Legend

-  Bulk Sample
-  CPT
-  MASW
-  SPT Boring

B-8
BS-3 CPT-2

B-7 CPT-1

MASW



HDR ENGINEERING INC.
OF THE CAROLINAS

1201 Main Street, Suite 800
Columbia, SC 29201, 803.254.5800

S-11-138 (Goucher School Rd.) over Goucher Creek

COUNTY

CHEROKEE

FIELD TEST LOCATION PLAN

Source: Google Earth



100 ft

Appendix B. Boring Logs; Rock Core Photos; CPT Sounding Logs; MASW Profile

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

SCDOT Soil Test Log Descriptors

a

-

Relative Density / Consistency Terms

Relative Density ¹			Consistency 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	Very Soft	<0.25	<2
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	Very Stiff	2.01 to 4.00	16 to 30
			Hard	>4.01	> 31

b

Moisture Condition

Descriptive Term	Criteria
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

c

Color

Describe the sample color while sample is still moist, using Munsell color chart.

d

Angularity¹

Descriptive Term	Criteria
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

e

HCl Reaction³

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

f

Cementation³

Descriptive Term	Criteria
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

g

Particle-Size Range¹

Gravel		Sand			
mm	Sieve size	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

h

Primary Soil Type^{1,2}

The primary soil type will be shown in all capital letters

i

USCS Soil Designation

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

j

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**Figure 6-15, SCDOT Soil Test Log Descriptors – Soil**

SCDOT Soil Test Log Descriptors

k **Rock Type**
Indicate type of rock encountered (i.e. granite, limestone, shale, slate, etc.)

l **Color**
Describe the sample color while sample is still moist, using Munsell color chart.

m **Texture**
Describe the nonfracture structural features. Stratification is the layering of sedimentary rock and foliation is the layering of metaphoric rock

<u>Descriptive Term</u>	<u>Criteria</u>
Very Thickly Bedded	> 1.0 m
Thickly Bedded	0.5 to 1.0 m
Thinly Bedded	50 to 500 mm
Very Thinly Bedded	10 to 50 mm
Laminated	2.5 to 10 mm
Thinly Laminated	< 2.5 mm

n **Grain Size and Shape**
Describe the size and shape of all visible grains, typically used on sedimentary rock.

<u>Size</u>		<u>Sieve size</u>
<u>Descriptor</u>	<u>mm</u>	
Very coarse grained	> 4.75	Grain sizes greater than popcorn kernels
Coarse grained	2.00 – 4.75	Individual grains easy to distinguish by eye
Medium grained	0.425 – 2.00	Individual grains distinguished by eye
Fine grained	0.075 – 0.425	Individual grains distinguished with difficulty
Very Fine grained	< 0.075	Individual grains cannot be distinguished by unaided eye
<u>Shape</u>		
<u>Descriptive Term</u>	<u>Criteria</u>	
Angular	Shows little wear; edges and corners are sharp	
Subangular	Shows definite effects of wear; edges and corners are slightly rounded off	
Subrounded	Shows considerable wear; edges and corners are rounded to smooth curves	
Rounded	Shows extreme wear; edges and corners are smoother to broad curves	
Well-rounded	Completely worn; edges and corners are not present	

o **Weathering / Alteration**
Weathering is the physical disintegration of the minerals by atmospheric processes. Alteration is disintegration of the minerals by geothermal processes.

<u>Description</u>	<u>Recognition</u>
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered / Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although the original fabric may be intact; material can be granulated by hand
Highly Weathered / Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 1-7/8 inch diameter sample can be easily broken readily by hand across rock fabric
Moderately Weathered / Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 1-7/8 inch diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered / Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh	Rock shows no discoloration, loss of strength, or other effect of weathering / alteration

Figure 6-16, SCDOT Soil Test Log Descriptors – Rock

SCDOT Soil Test Log Descriptors
p**Rock Strength**

Provide a qualitative assessment of the rock strength using either a geologic hammer or knife.

Description	Recognition	Approximately Uniaxial Compressive Strength (psi)
Extremely Weak Rock	Can be indented by thumbnail	35 – 150
Very Weak Rock	Can be peeled by pocket knife	150 – 700
Weak Rock	Can be peeled with difficulty by pocket knife	700 – 3,500
Medium Strong Rock	Can be indented 3/16 inch with sharp end of pick	3,500 – 7,200
Strong Rock	Requires one hammer blow to fracture	7,200 – 14,500
Very Strong Rock	Requires many hammer blows to fracture	14,500 – 35,000
Extremely Strong Rock	Can only be chipped with hammer blows	> 35,000

q**Strike and Dip**

Dip of fracture surface measured relative to horizontal with bearing and direction (i.e. N30°down, etc.)

r**Discontinuity Type****s****Discontinuity Width (millimeters)****t****Amount of Infilling**

F - Fault	W - Wide (12.5 – 50)	Su - Surface Stain
J - Joint	MW - Moderately Wide (2.5 – 12.5)	Sp - Spotty
Sh - Shear	N - Narrow (1.25 – 2.5)	Pa - Partially Filled
Fo - Foliation	VN - Very Narrow (< 1.25)	Fi - Filled
V - Vein	T - Tight (0)	No - None
B - Bedding		

u**Type of Infilling****v****Surface Shape of Joint****w****Discontinuity Spacing (feet)**

Cl - Clay	Wa - Wavy	EW - Extremely Wide (> 65)
Ca - Calcite	Pl - Planar	W - Wide (22 – 65)
Ch - Chloride	St - Stepped	M - Moderate (7.5 – 22)
Fe - Iron Oxide	Ir - Irregular	C - Close (2 – 7.5)
Gy - Gypsum/Talc		VC - Very Close (< 2)
H - Healed		
No - None		
Py - Pyrite		
Qz - Quartz		
Sd - Sand		

x**Roughness of Surface**

Slk - Slickensided (surface has smooth, glassy finish with visual evidence of striations)
S - Smooth (surface appears smooth and feels so to the touch)
SR - Slightly Rough (asperities on the discontinuity surfaces are distinguishable and can be felt)
R - Rough (some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive)
VR - Very Rough (near-vertical steps and ridges occur on the discontinuity surface)

Figure 6-17, SCDOT Soil Test Log Descriptors – Rock (con't)

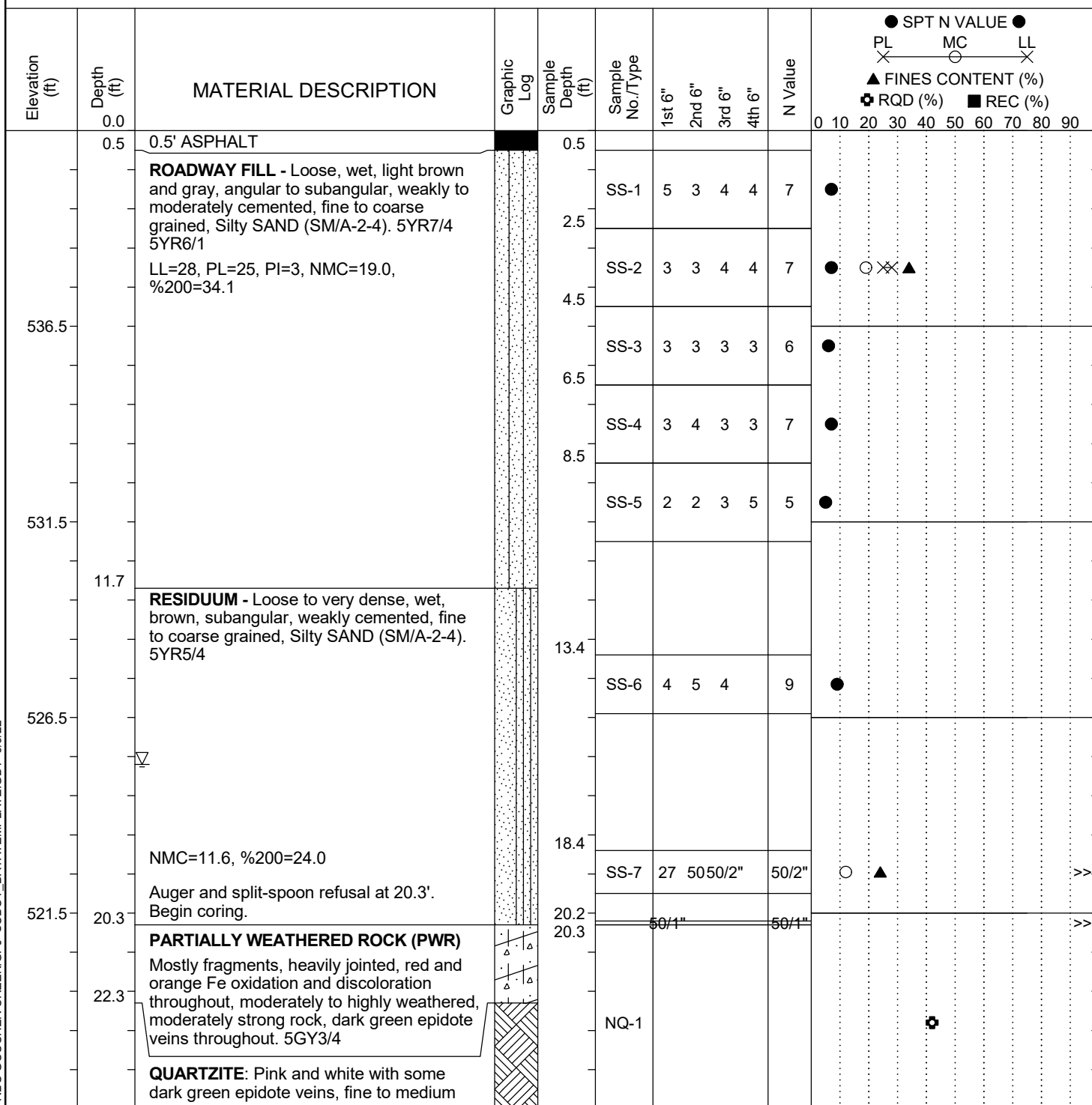


Appendix B. Subsurface Investigation

Boring Logs

SCDOT Soil Test Log

Project ID:	P041151	County:	Cherokee, SC	Boring No.:	B-7
Site Description:	S-11-138 (Goucher School Rd.) over Goucher Creek			Route:	S-11-138
Eng./Geo.:	N. Yacobi/ HDR	Boring Location:	88+38	Offset:	4 RT
Elev.:	541.5 ft	Latitude:	34.97481	Longitude:	-81.69421
Total Depth:	30.3 ft	Soil Depth:	20.3 ft	Core Depth:	10.0 ft
Date Started:	5/6/2022				
Date Completed:	5/6/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW & RC	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/ F&ME	Groundwater:	TOB 16.2 ft
24HR	N.M.				



LEGEND

Continued Next Page

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

SCDOT Soil Test Log

Project ID:	P041151	County:	Cherokee, SC	Boring No.:	B-7
Site Description:	S-11-138 (Goucher School Rd.) over Goucher Creek			Route:	S-11-138
Eng./Geo.:	N. Yacobi/ HDR	Boring Location:	88+38	Offset:	4 RT
Elev.:	541.5 ft	Latitude:	34.97481	Longitude:	-81.69421
Date Started:	5/6/2022				
Total Depth:	30.3 ft	Soil Depth:	20.3 ft	Core Depth:	10.0 ft
Date Completed:	5/6/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW & RC	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/ F&ME	Groundwater:	TOB 16.2 ft
24HR	N.M.				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL X — MC — LL X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
541.5	25.9	grained, nonfoliated, fresh to slightly weathered, very strong rock, very hard. Very close joint spacing, tight to open, irregular joint surfaces, slightly rough to smooth, no filling. 7.5YR8/2 NQ-1: %REC=85, RQD=20, 4.7 min/ft, GSI=45-50		25.3	NQ-2						0 10 20 30 40 50 60 70 80 90 + RQD (%) ■ REC (%)
511.5	30.3	SCHIST: White/gray/black, medium to coarse grained, slightly weathered, low grade metamorphism, thin foliations, strong rock, hard, no oxidation or discoloration. Very close joints spacing, tight to open, irregular joint surfaces, rough to slightly rough, no filling. No epidote at this depth. 7.5YR9.5/1 10GY6/1 10Y2.5/1 NQ-2: %REC=100, RQD=42, 4.0 min/ft, GSI=55-60 25.5'-25.8': qu=24,920 psi, RMR=54 29.3'-29.6': qu=13,330 psi, RMR=49									
506.5		Boring Terminated at 30.3' (Elev. 511.2')									
501.5											
496.5											

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	

Rock Core Photos

B-7

Box 1 of 1 (20.3' to 30.3')

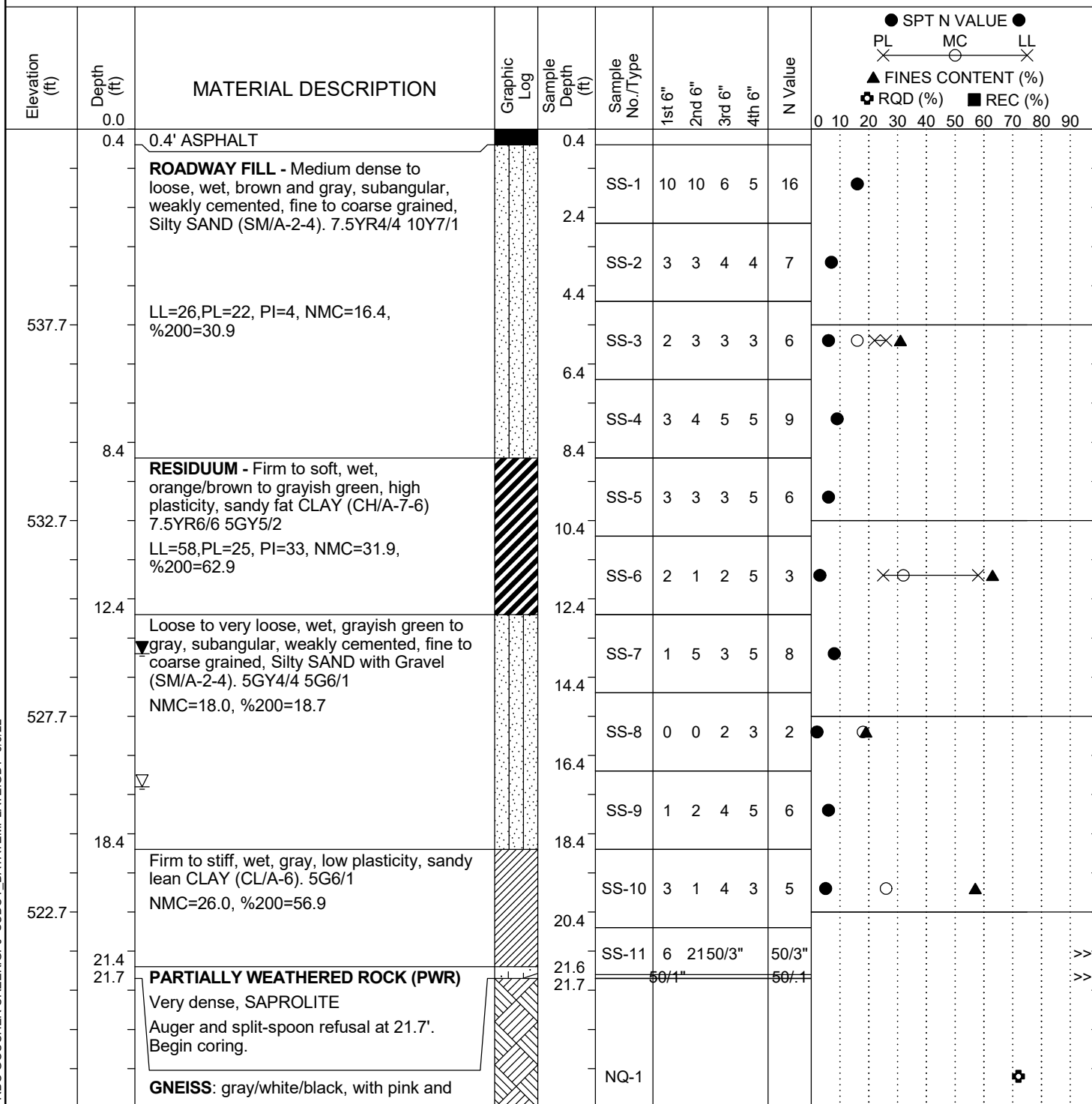


13,330 psi

24,920 psi

SCDOT Soil Test Log

Project ID:	P041151	County:	Cherokee, SC	Boring No.:	B-8
Site Description:	S-11-138 (Goucher School Rd.) over Goucher Creek			Route:	S-11-138
Eng./Geo.:	N. Yacobi/ HDR	Boring Location:	89+58	Offset:	4 RT
Elev.:	542.7 ft	Latitude:	34.97513	Longitude:	-81.69432
Total Depth:	31.7 ft	Soil Depth:	21.7 ft	Date Started:	5/5/2022
Core Depth:	10.0 ft	Date Completed:	5/5/2022		
Bore Hole Diameter (in):	2.97"	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 45B	Drill Method:	RW & RC	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/ F&ME	Groundwater:	TOB 16.8 ft
24HR	13.4 ft				



LEGEND

Continued Next Page

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

SC.DOT S-11-138 RBO GOUCHER CREEK.GPJ SCDOT_DATATEMPLATE.GDT 6/6/22

SCDOT Soil Test Log

Project ID:	P041151	County:	Cherokee, SC	Boring No.:	B-8
Site Description:	S-11-138 (Goucher School Rd.) over Goucher Creek			Route:	S-11-138
Eng./Geo.:	N. Yacobi/ HDR	Boring Location:	89+58	Offset:	4 RT
Elev.:	542.7 ft	Latitude:	34.97513	Longitude:	-81.69432
Total Depth:	31.7 ft	Soil Depth:	21.7 ft	Core Depth:	10.0 ft
Date Started:	5/5/2022				
Date Completed:	5/5/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW & RC	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/ F&ME	Groundwater:	TOB 16.8 ft
24HR	13.4 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	● SPT N VALUE ● PL X — MC — LL X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
512.7	26.9	white quartz banding, fine to medium grained, thinly foliated, slightly weathered (first 1.5' of NQ-1 moderately weathered), strong rock, moderately hard to hard, dark green epidote veins across core surface. Very close to close joint spacing, tight to open, narrow to very narrow, irregular joint surfaces, slightly rough to smooth, partially filled to filled with epidote in some joints. 7.5YR9.5/1 10GY6/1 10Y2.5/1 5GY3/4 NQ-1: %REC=100, RQD=72, 3.1 min/ft, qu=20,870 psi, RMR=59, GSI=75-80		26.7							
507.7	31.7	QUARTZITE: white and pink, fine to coarse grained, fresh to slightly weathered, very strong rock, hard. Very close to close joints, irregular joint surfaces, rough, no filling. 7.5YR8/2 NQ-2: %REC=92, RQD=80, 4.1 min/ft, qu=22,080 psi, RMR=78, GSI=75-80 Boring Terminated at 31.7' (Elev. 511.0')			NQ-2						
502.7											
497.7											

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 S-11-138 RBO GOUCHER CREEK.GPJ SCDOT_DATATEMPLATE.GDT 6/6/22

Rock Core Photos

B-8

Box 1 of 1 (21.7' to 31.7')



20,870 psi

22,080 psi



Appendix B. Subsurface Investigation

CPT Logs

CPT: CPT-1

Total depth: 21.41 ft, Date: 6/1/2022

Surface Elevation: 541.40 ft

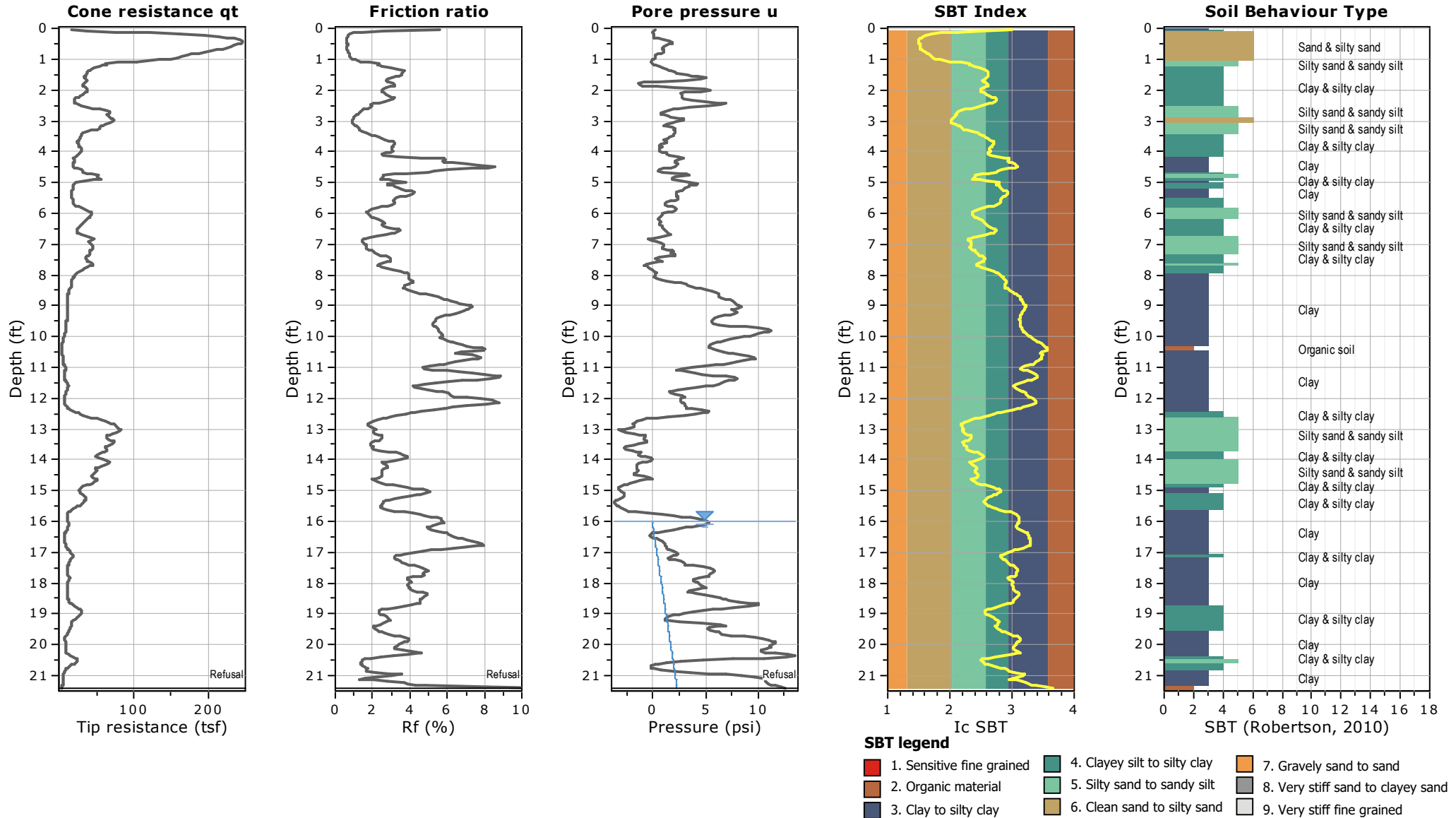
Coords: X:1792004.92, Y:1143750.70

Cone Type: DDG1329

Cone Operator: F&ME Consultants

Project: S-11-138 (Goucher School Rd.) over Goucher Creek

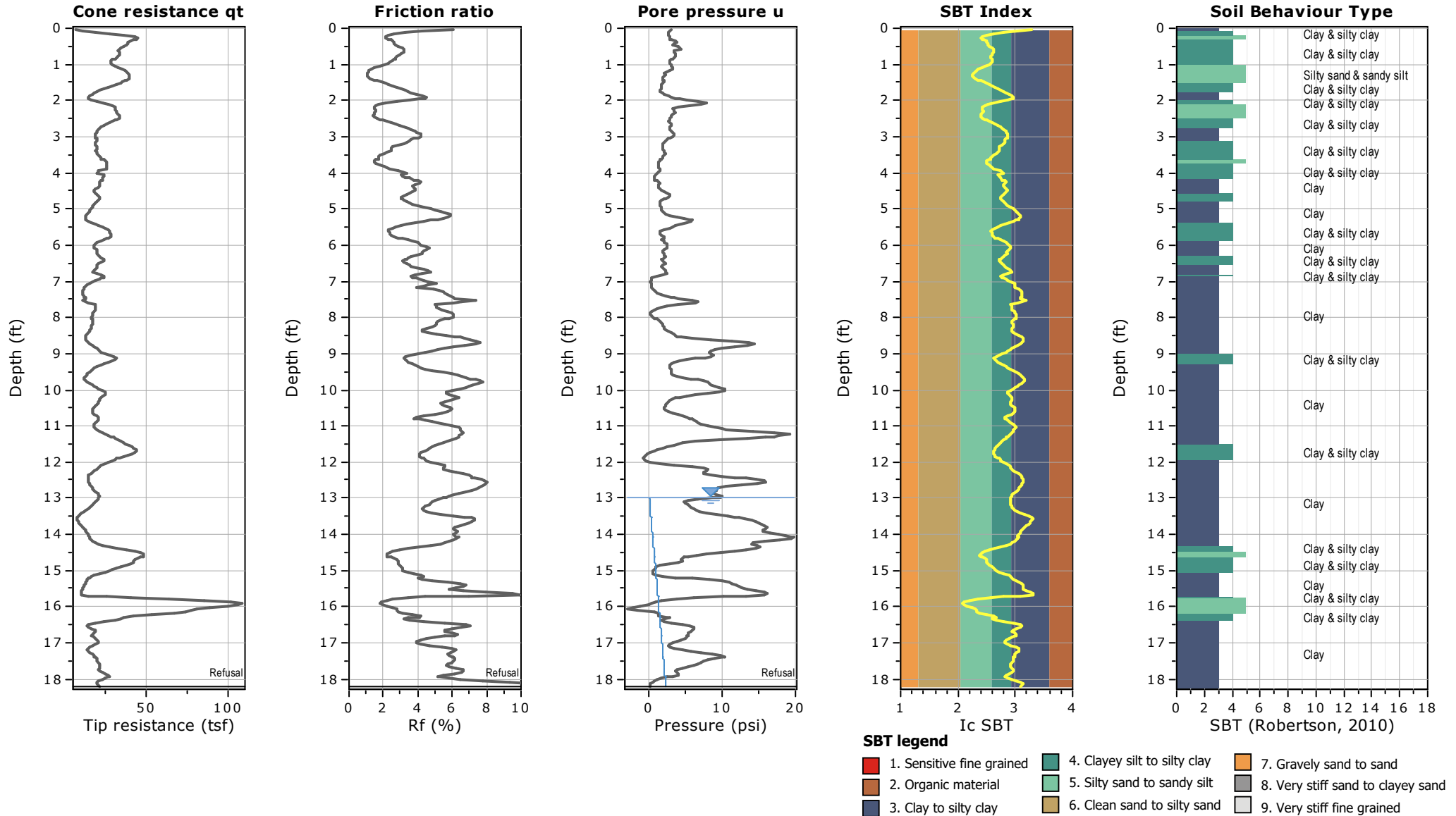
Location: Cherokee County, SC



CPT: CPT-2

Total depth: 18.21 ft, Date: 6/1/2022
 Surface Elevation: 542.80 ft
 Coords: X:1791975.36, Y:1143860.68
 Cone Type: DDG1329
 Cone Operator: F&ME Consultants

Project: S-11-138 (Goucher School Rd.) over Goucher Creek
 Location: Cherokee County, SC





Appendix B. Subsurface Investigation

Multichannel Analysis of Surface Waves (MASW)

June 2, 2022

Ms. Lila Leon, P.E., PhD
South Carolina Geotechnical Lead
HDR
1201 Main Street Suite 800
Columbia, South Carolina 29201

Re: Report of Multi-Channel Analysis of Surface Waves
S-138 Replacement Bridge over Goucher Creek
Gaffney, South Carolina
F&ME Project No.: G6655.004

Dear Ms. Leon:

On May 12, 2022, F&ME Consultants performed one (1) Multi-Channel Analysis of Surface Waves (MASW) test near the S 138 bridge over Goucher Creek to determine the average shear wave velocity to a depth of 100 feet at the location. A 16-channel Geometrics ES-3000 seismograph with 4.5 Hz geophones was used for data collection. Active and Passive survey data was obtained using a 225-foot linear array with 16 geophones spaced at 15 feet.

A 16-pound sledge hammer striking an aluminum block and a polyethylene block were used as the energy source for the active survey. Sixteen (16) active shots were performed at various distances (25, 50 and 100 feet) off the array ends. Resultant vibrations were recorded with a sample rate of 0.5 milliseconds and a recording length of 2 seconds after each hammer blow. The data was stacked five times at each location to minimize the effect of unknown ambient vibrations commonly referred to as noise. The stacking process increases the signal to noise ratio.

The passive survey consisted of the collection of ambient background vibrations, which consisted of drilling equipment. Eighty-nine (89) recordings with a record length of 32 seconds and a sample rate of 2 milliseconds were made during this phase of data acquisition.

Prior to departing the site, the data collected from both the passive and active surveys were reviewed and checked for variations from what would be typically expected from the prevailing area geology.

After completion of passive and active survey the data was processed and analyzed using Geometric's SeisImager software suite (Pickwin and WaveEq). This resulted in a one-dimensional subsurface shear wave velocity curve that is developed utilizing both the passive and active survey data. The data from the active survey defines the near surface shear wave velocities, while the passive survey data defines deeper shear wave velocities due to the lower frequencies. The resulting curve represents the average shear wave velocities below the surface arrays to a depth of 100 feet.



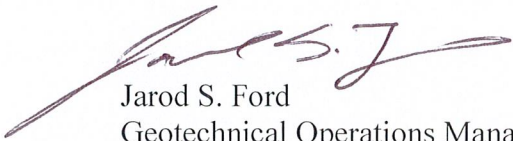
The resulting Shear Wave Velocity Curve, Vs100, for the location defined on Figure 1 of this report. The following table summarizes the average shear wave velocity (Vs100) at the aforementioned location.

Boring No.	Average Shear Wave Velocity (Vs100)
MASW-1	2323.4 ft/sec

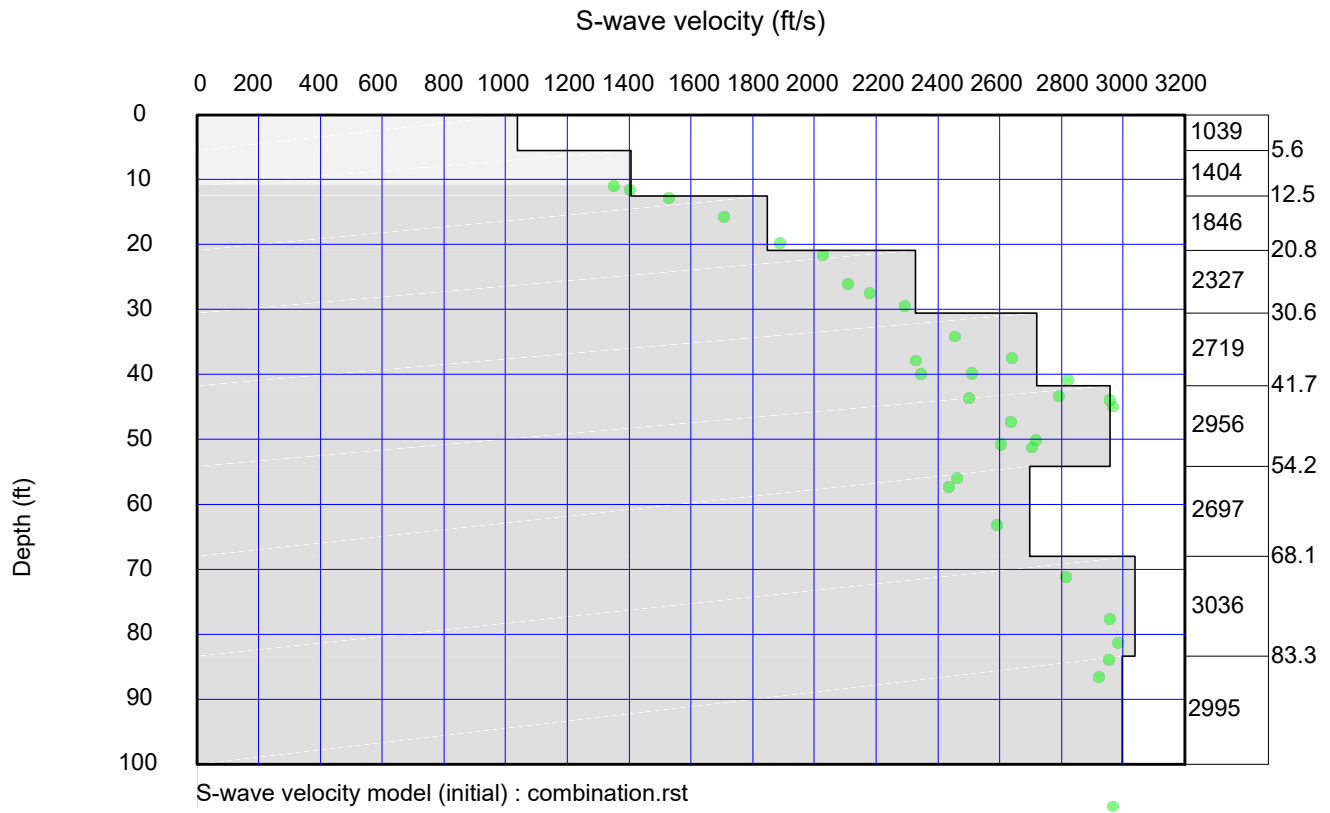
It has been a pleasure working for you on this project and we appreciate the opportunity to be of service. Please contact us if you have any questions or concerns.

Sincerely,

F&ME CONSULTANTS



Jarod S. Ford
Geotechnical Operations Manager



F&ME CONSULTANTS, INC.
COLUMBIA, SC

4			
3			
2			
1			
REV.	BY	DATE	DESCRIPTION OF REVISION
TOPO.		DATE	
DWG.	CTC	DATE 6.1.22	GROUP - -
R/W		DATE	

**S-138 REPLACEMENT BRIDGE OVER GOUCHER CREEK
GAFFNEY, SOUTH CAROLINA**

MASW DATA RESULTS

F&ME JOB NO. G6655.004

SCALE: NTS

FIGURE 1



F&ME CONSULTANTS, INC.
COLUMBIA, SC

4			
3			
2			
1			
REV.	BY	DATE	DESCRIPTION OF REVISION
TOPO.		DATE	
DWG.	CTC	DATE 6.1.22	GROUP - -
R/W		DATE	

S-138 REPLACEMENT BRIDGE OVER GOUCHER CREEK
GAFFNEY, SOUTH CAROLINA

MASW LOCATION PLAN

F&ME JOB NO. G6655.004

SCALE: NTS

FIGURE 2

Appendix C. Laboratory Testing



SUMMARY OF LABORATORY RESULTS

PAGE 1 OF 1

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-7	2.5	28	25	3	0.075	34	SM	19.0			
B-8	4.4	26	22	4	0.075	31	SM	16.4			
B-8	8.4	58	25	33	0.075	63	CH	31.9			

Rock Coring Summary

PAGE 1 OF 1



PROJECT ID P041151

PROJECT NAME S-11-138 (Goucher School Rd.) over Goucher Creek

PROJECT COUNTY Cherokee, SC

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q _u (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
B-7	NQ-1	20.3	85	20						48
B-7	NQ-2.1	25.3	100	42	24920	0.08	3740	161	54	58
B-7	NQ-2.2	25.3	100	42	13330	0.21	4980	169	49	58
B-8	NQ-1	21.7	100	72	20870	0.19	5630	166	59	78
B-8	NQ-2	26.7	92	80	22080	0.04	4740	162	78	78



INDEX PROPERTIES VERSUS DEPTH

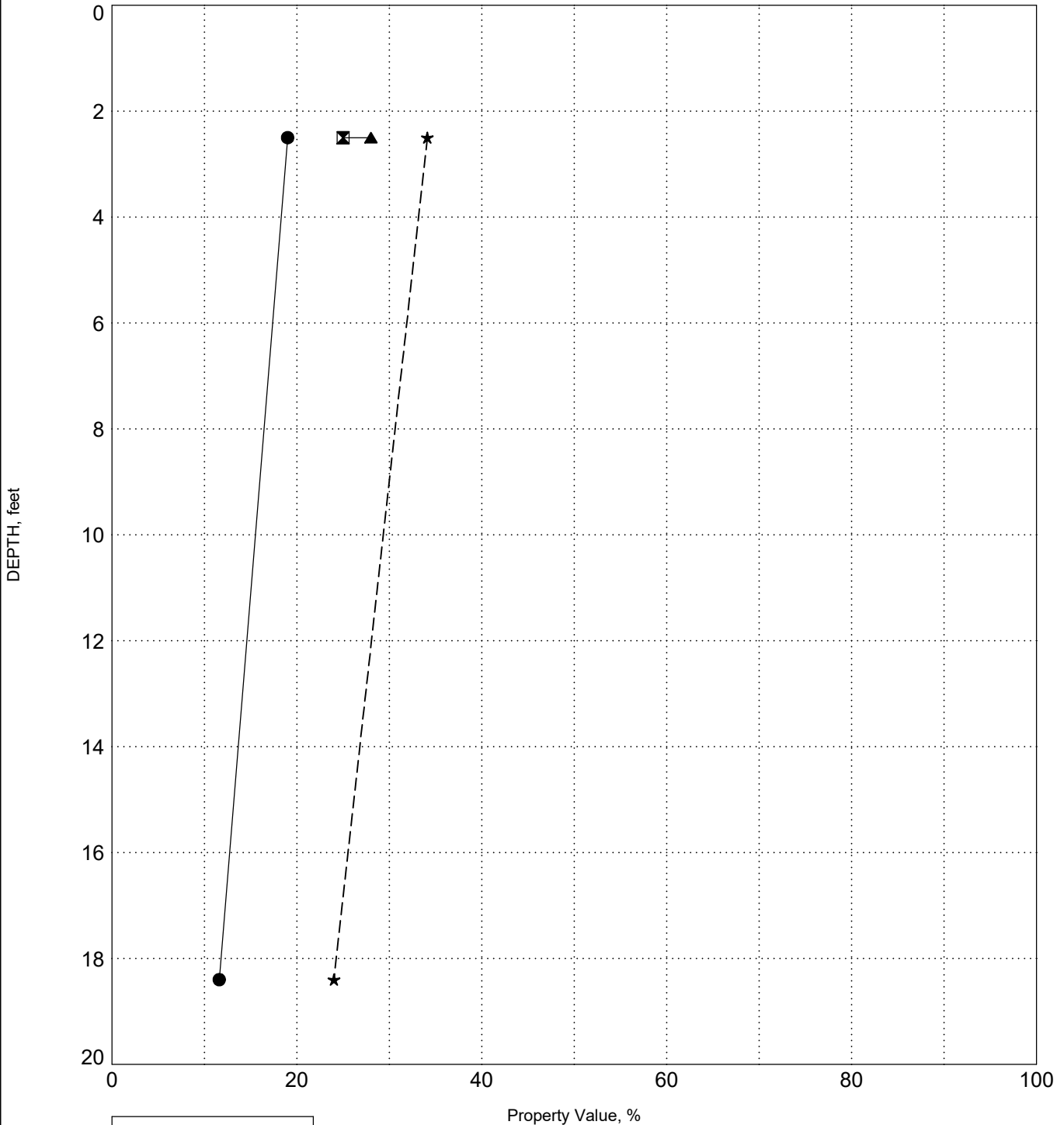
PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

SURFACE ELEVATION: 541.5

BORING B-7



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



INDEX PROPERTIES VERSUS DEPTH

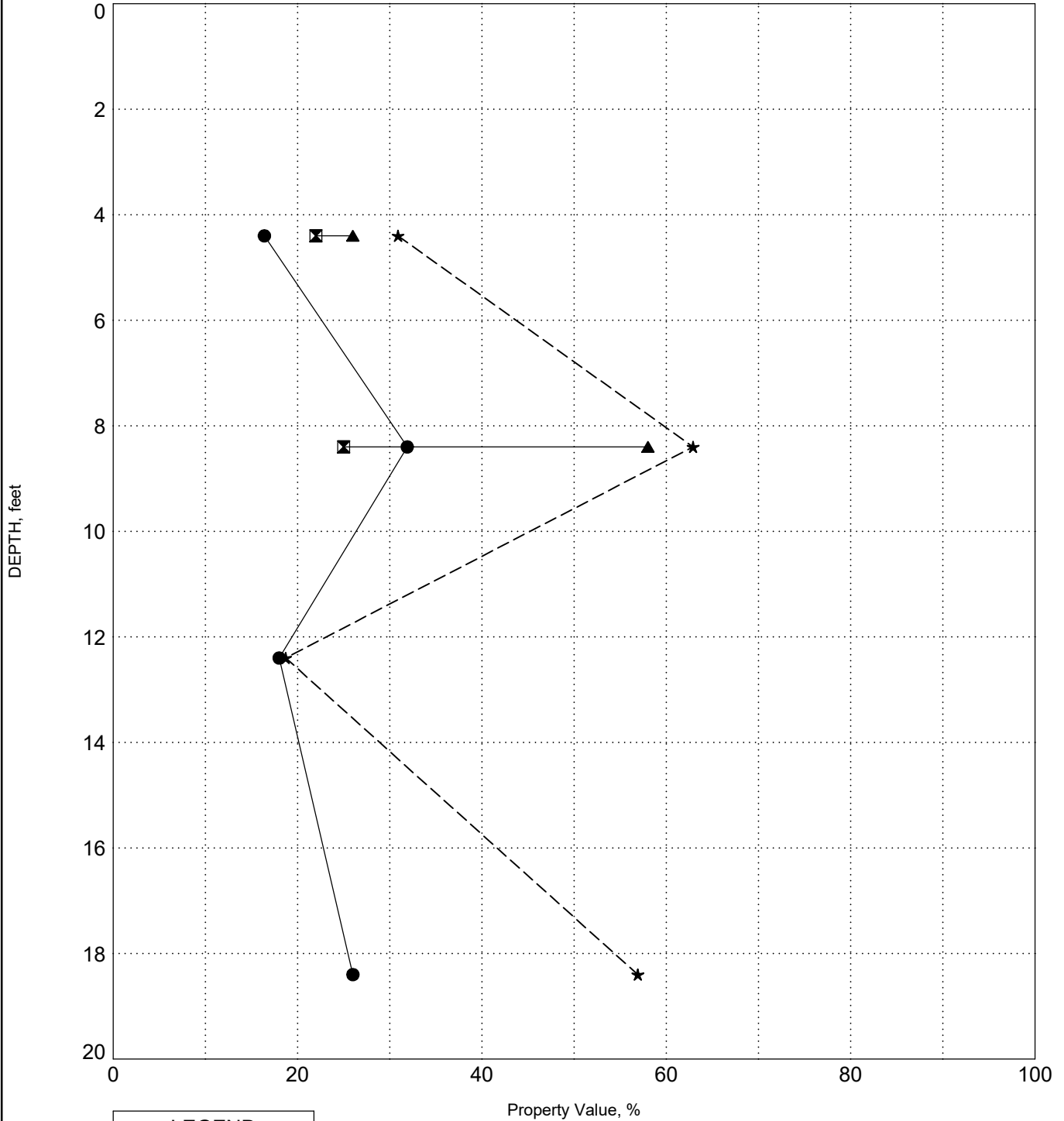
PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

SURFACE ELEVATION: 542.7

BORING B-8



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



Laboratory Testing Procedures

Grain Size Distribution

Wash #200 Testing has been conducted following ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than 75- μ m (No. 200) Sieve in Soils by Washing. Full grain size analysis was conducted on select samples following ASTM D6913 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

Hydrometer

Hydrometer grain size analysis for soils was conducted following ASTM D7928 Standard Test Method for Particle Size Analysis of Soils.

Atterberg Limits

Atterberg limits testing have been conducted following ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

Moisture Content

Moisture content testing has been conducted following ASTM D2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

Standard Proctor

Standard Proctor testing has been conducted following ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600kN-m/m³)).

Consolidated-Undrained Triaxial Test

CU testing allows the soil specimen to be consolidated under a confining pressure prior to shear and has been conducted following ASTM D4767 Standard Test Method for Consolidated-Undrained Triaxial Compression Test for Cohesive Soils. The soil specimens in this case were bulk samples that were remolded and compacted to 95% of the Standard Proctor.

Corrosion Series

Corrosion series testing has been conducted including pH, chloride content, sulfate content, and resistivity. PH testing was conducted AASHTO T289 Standard Method of Test for Determining pH of Soil for Use in Corrosion Testing. Chloride content testing was conducted following AASHTO T291 Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil. Sulfate content testing was conducted following AASHTO T290 Standard Method of Test for Determining Water-Soluble Sulfate Content in Soil. Resistivity testing was conducted following AASHTO T288 Standard Method of Test for Determining Minimum Laboratory Soil Resistivity.

Compressive Strength of Rock Cores

Compressive strength of rock cores has been conducted following ASTM D7012 Standard Test for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.



Appendix C. Laboratory Testing

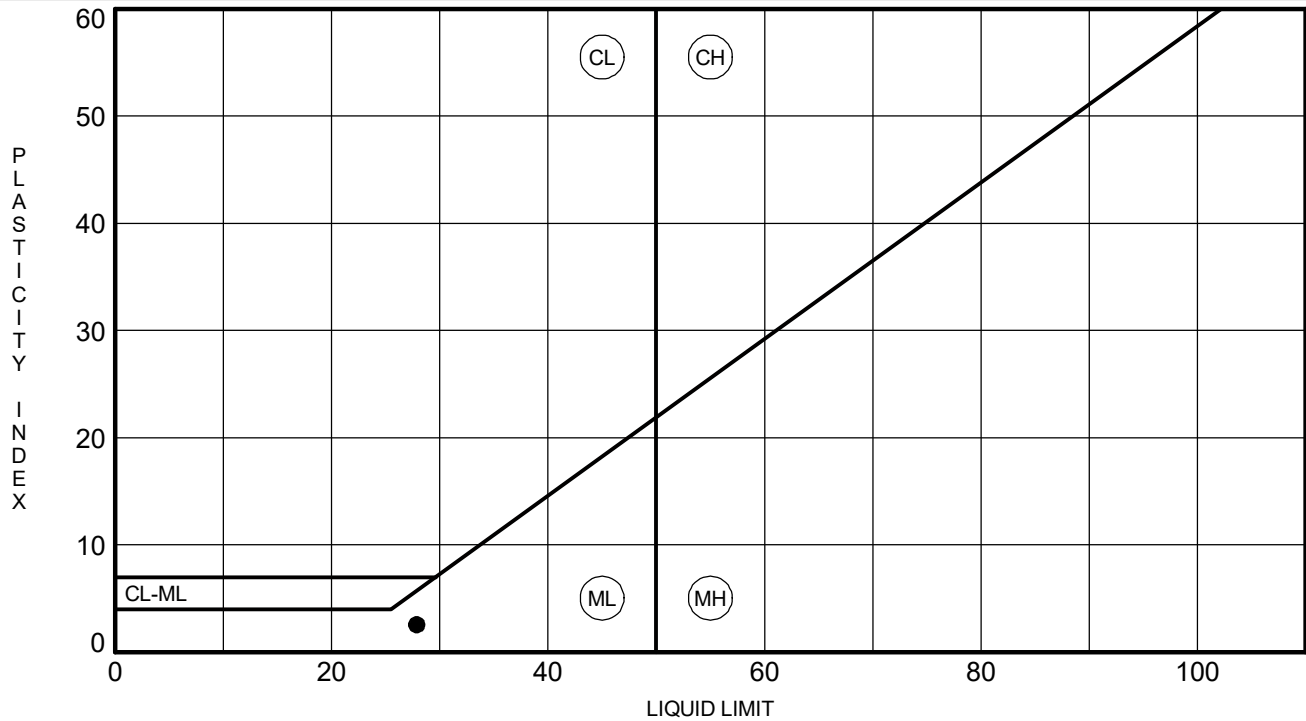
Split Spoon Samples

ATTERBERG LIMITS' RESULTS

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

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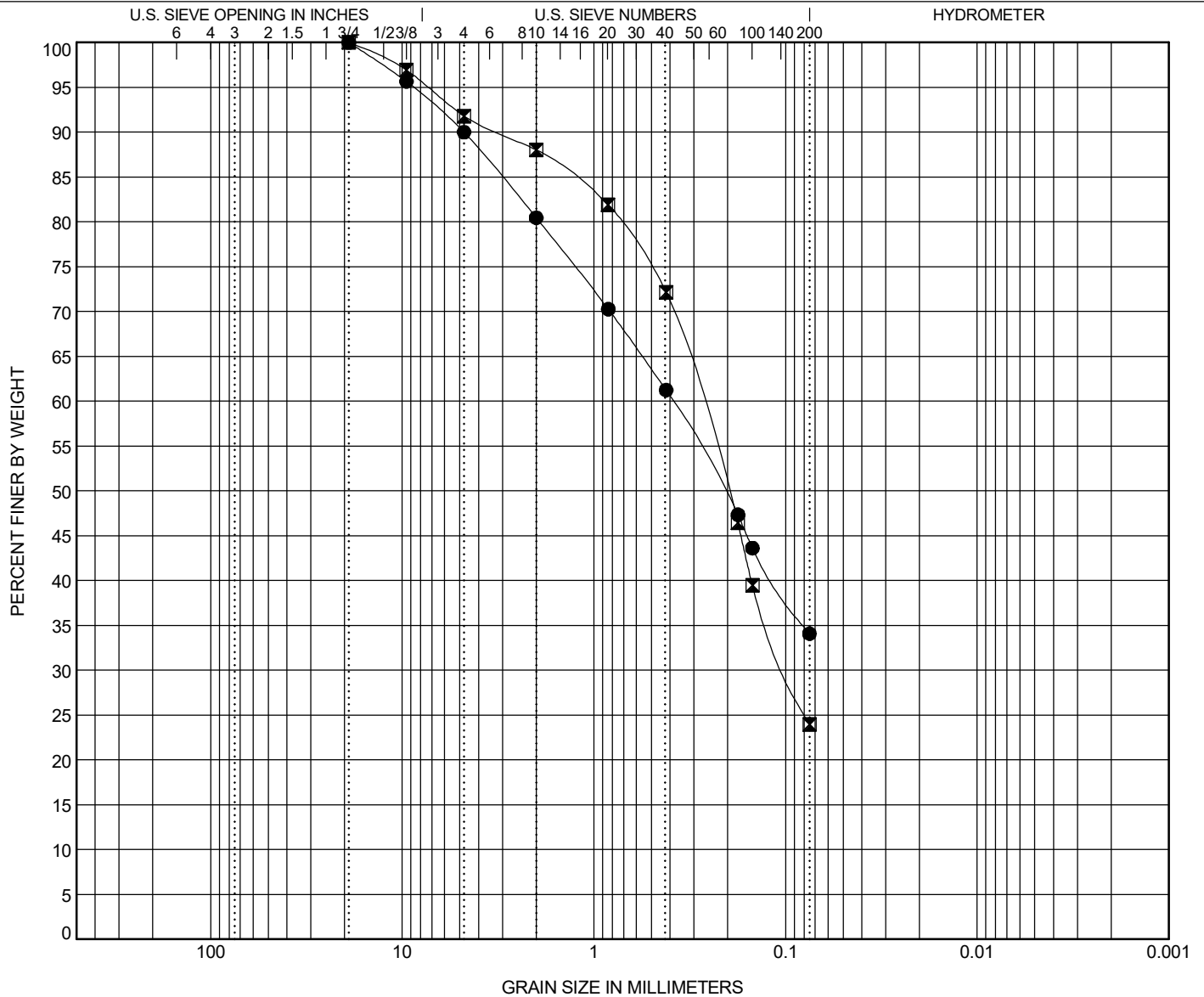


GRAIN SIZE DISTRIBUTION

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC



F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: S-11-138 RBO Goucher Creek **SCDOT PROJECT ID:** P041151
SAMPLE NUMBER: 22-1401 **DATE SAMPLE RECEIVED:** 5/9/2022
DESCRIPTION OF SOIL: Various
TESTED BY: C. Meyers **DATE SETUP:** 5/9/2022
WEIGHED BY: T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	B-7	B-7			
SAMPLE NO.	SS-2	SS-7			
SAMPLE DEPTH (FT.)	2.5 - 4.5	18.4 - 19.9			
WATER CONTENT, W%	19.0	11.6			

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



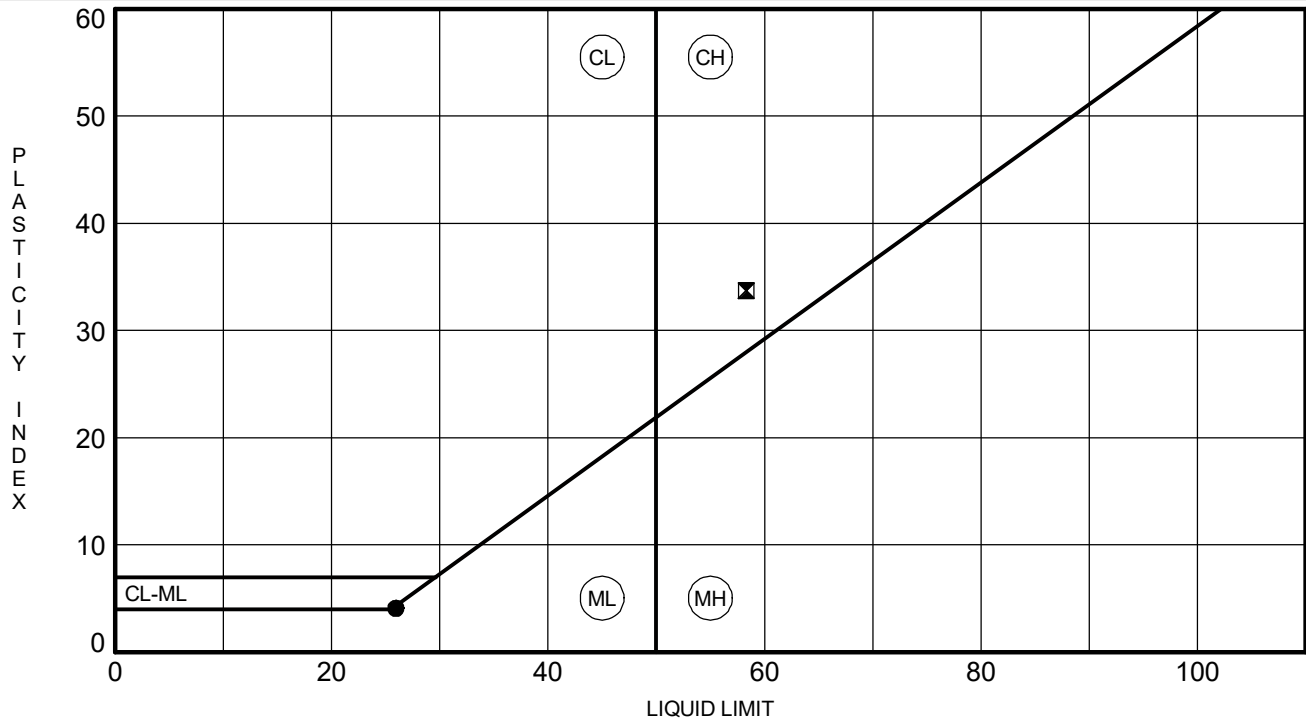
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ATTERBERG LIMITS' RESULTS

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

[illegible]

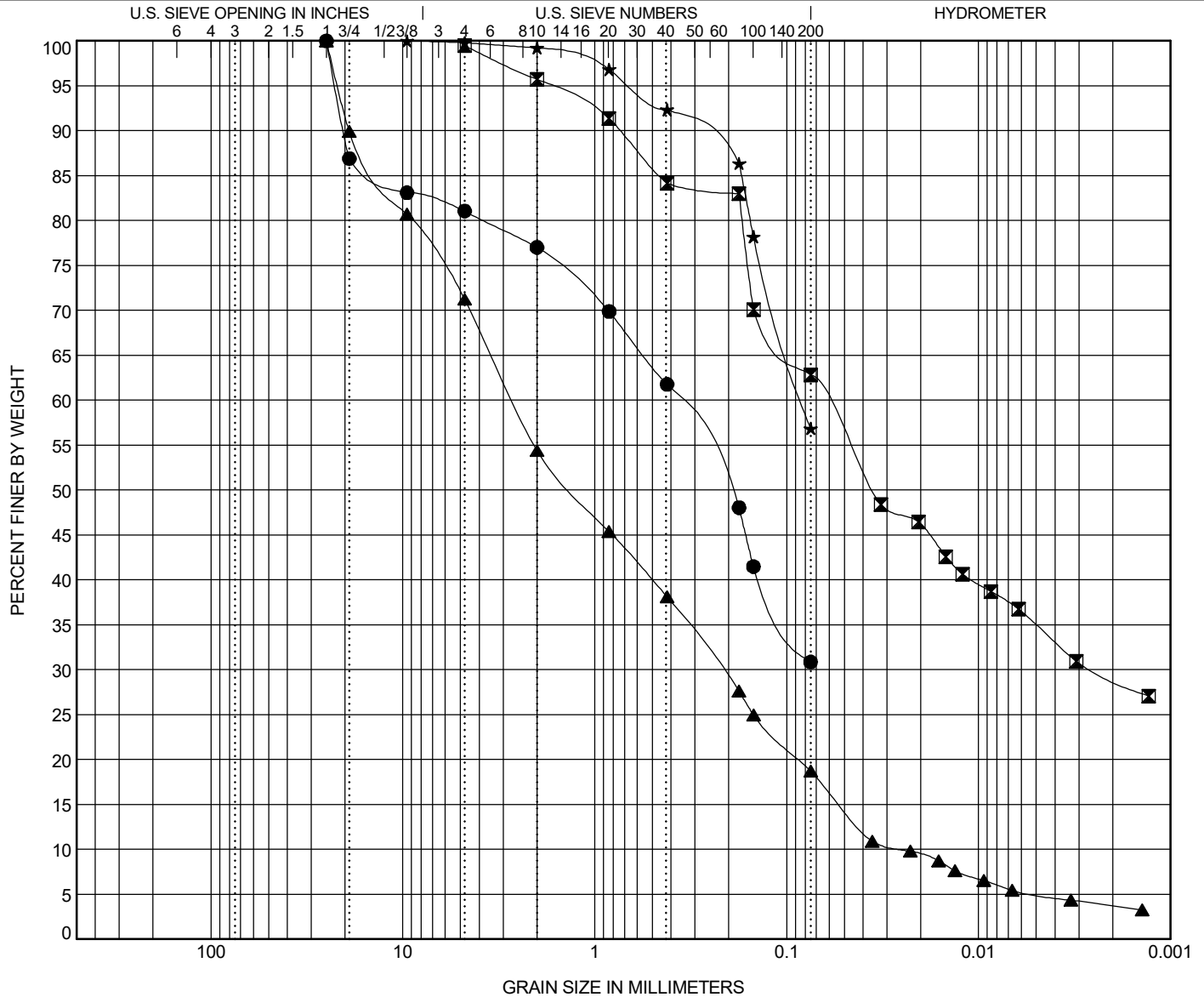


GRAIN SIZE DISTRIBUTION

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC



F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: S-11-138 RBO Goucher Creek **SCDOT PROJECT ID:** P041151
SAMPLE NUMBER: 22-1402 **DATE SAMPLE RECEIVED:** 5/9/2022
DESCRIPTION OF SOIL: Various
TESTED BY: C. Meyers **DATE SETUP:** 5/9/2022
WEIGHED BY: T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	B-8	B-8	B-8	B-8	
SAMPLE NO.	SS-3	SS-5	SS-7	SS-10	
SAMPLE DEPTH (FT.)	4.4 - 6.4	8.4 - 12.4	12.4 - 14.4	18.4 - 20.4	
WATER CONTENT, W%	16.4	31.9	18.0	26.0	

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



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Client:	F&ME Consultants
Project Name:	S-138 Bridge Replacement over Goucher Creek
Project Location:	Cherokee County, South Carolina
GTX #:	315485
Test Date:	5/18/2022
Tested By:	mgh
Checked By:	jm

pH by AASHTO T 289

Boring ID	Sample ID	Depth, ft	Description	pH
B-8	---	8.4-12.4	Sandy Fat <u>CLAY (CH/A-7-6)</u>	4.5

Notes:



Client:	F&ME Consultants
Project:	S-138 Bridge Replacement over Goucher Creek
Location:	Cherokee County, South Carolina
GTX#:	315485
Test Date:	05/20/22
Tested By:	mgh
Checked By:	jm

Minimum Laboratory Soil Resistivity by AASHTO T 288

Boring ID	Sample ID	Depth, ft.	Sample Description	Minimum Soil Resistivity, ohm-cm
B-8	---	8.4-12.4	Sandy Fat CLAY (CH/A-7-6)	2,039

Notes: Test Equipment: Nilsson Model 400 Soil Resistance Meter, MC Miller Soil Box
Test conducted in standard laboratory atmosphere: 68-73 F



PO Box 572455 / Salt Lake City UT 84157-2455 / USA
TEL +1 801 262 2448 · FAX +1 801 262 9870 · www.TEi-TS.com

|||||
GEOTESTING EXPRESS INCORPORATED
2358 PERIMETER PARK DRIVE
SUITE 320
ATLANTA GA 30341-1315
USA

Analysis No. TS-A2210297
Report Date 18 May 2022
Date Sampled 16 May 2022
Date Received 17 May 2022
Where Sampled Atlanta, GA USA
Sampled By Client

This is to attest that we have examined: Soil: Project: S-138 Bridge Replacement over Goucher Creek; Site Location: Cherokee County, SC; Job Number: GTX-315485

When examined to the applicable requirements of:

AASHTO T-291-18 "Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil" Method B

AASHTO T 290-20 "Standard Method of Test for Determining Water-Soluble Sulfate Ion Content in Soil"

Results:

AASHTO T 291 - Chloride Method B

Sample		Results		Detection Limit
		ppm (mg/kg)	% ¹	
B-8		20.	0.0020	10.
---	8.4 – 12.4'			

NOTE: ¹Percent by weight after drying and prepared as per the Standard.

AASHTO T 290 – Sulfates (Soluble)

Sample		Results		Detection Limit
		ppm (mg/kg)	% ¹	
B-8		34.	0.0034	10.
---	8.4 – 12.4'			

NOTE: ¹Percent by weight after drying and prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee P.E. – Engineer in Charge

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Appendix C. Laboratory Testing

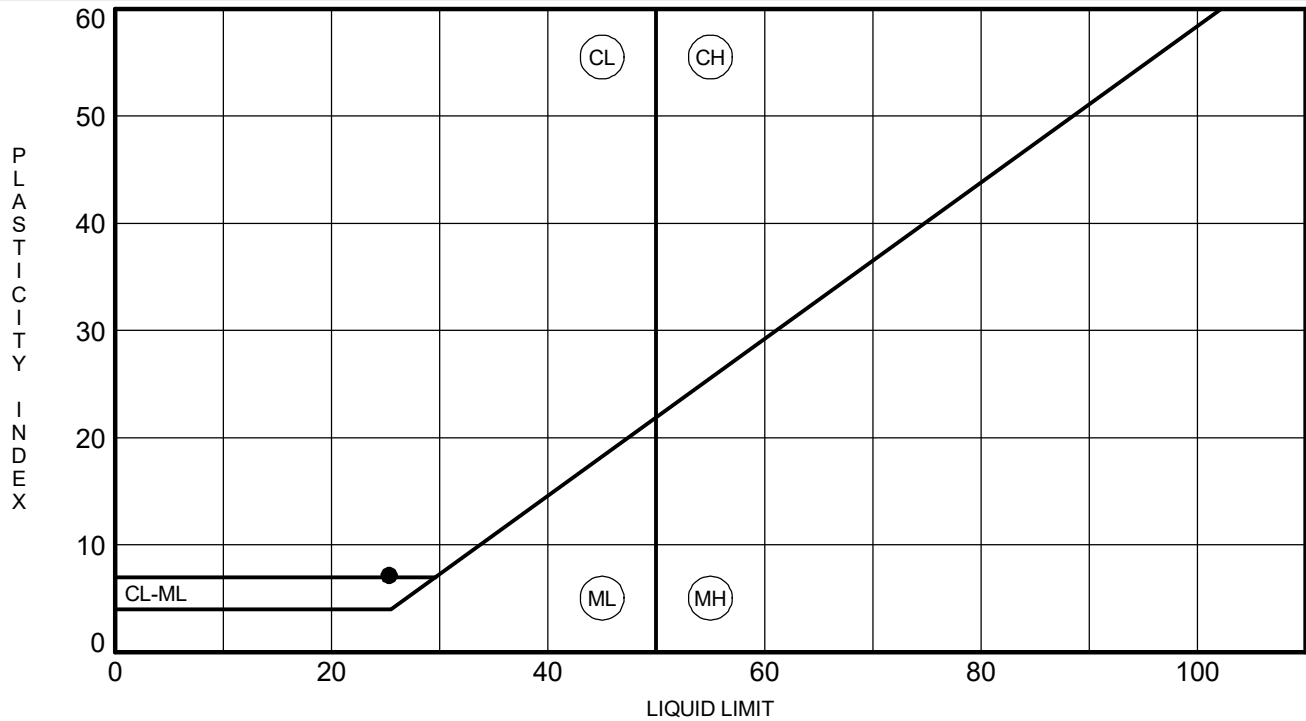
Bulk Samples

ATTERBERG LIMITS' RESULTS

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC

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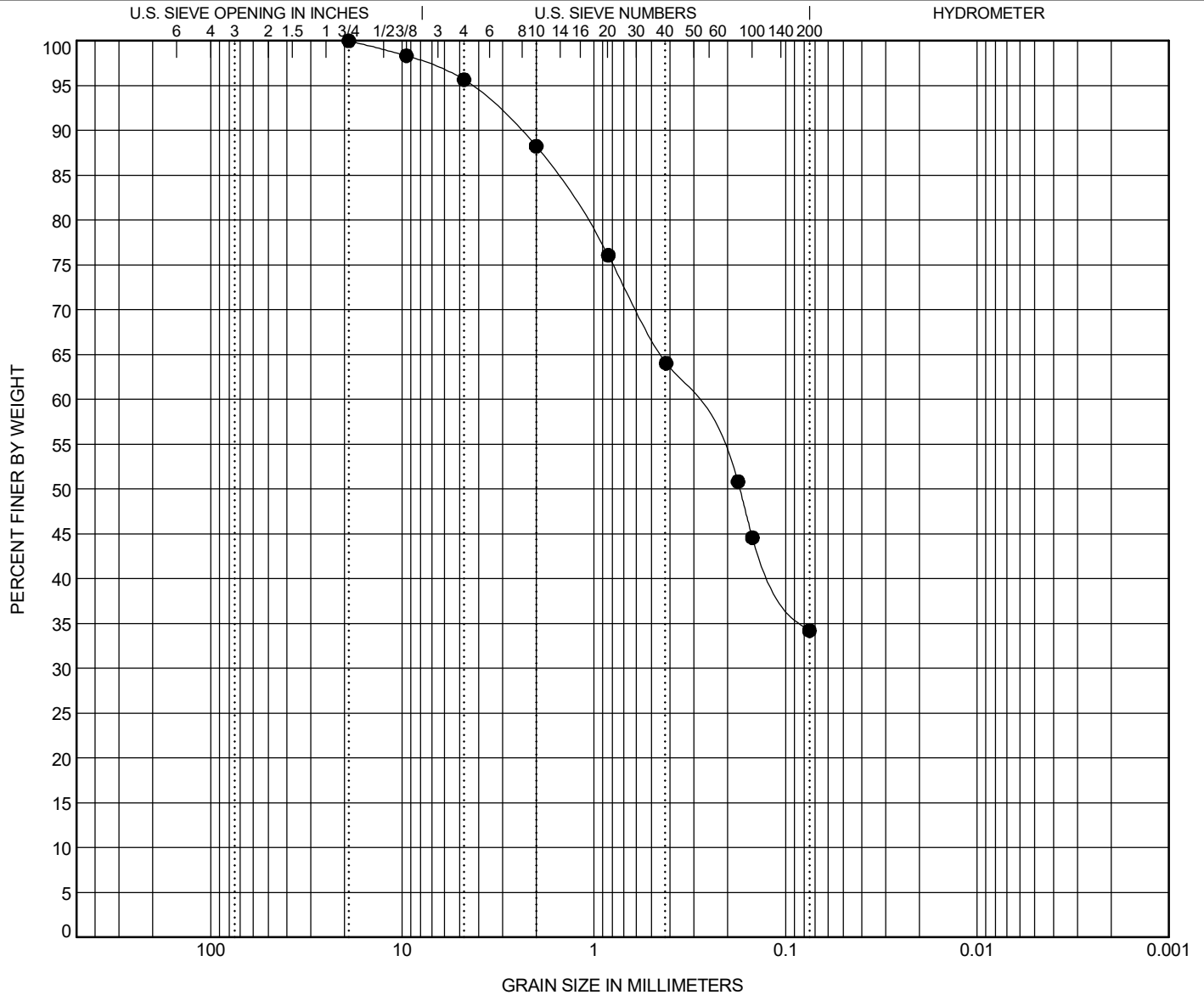


GRAIN SIZE DISTRIBUTION

PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● BS-3	5.0	Silty, Clayey SAND (SC-SM/A-2-4)					25	18	7		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BS-3	5.0	19	0.322			4.3	61.4	34.2			

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: S-11-138 RBO Goucher Creek **SCDOT PROJECT ID:** P041151
SAMPLE NUMBER: 22-1403 **DATE SAMPLE RECEIVED:** 5/9/2022
DESCRIPTION OF SOIL: Silty, Clayey SAND (SC-SM/A-2-4)
TESTED BY: C. Meyers **DATE SETUP:** 5/9/2022
WEIGHED BY: T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	BS-3				
SAMPLE NO.	--				
SAMPLE DEPTH (FT.)	0.0 - 5.0				
WATER CONTENT, W%	12.0				

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



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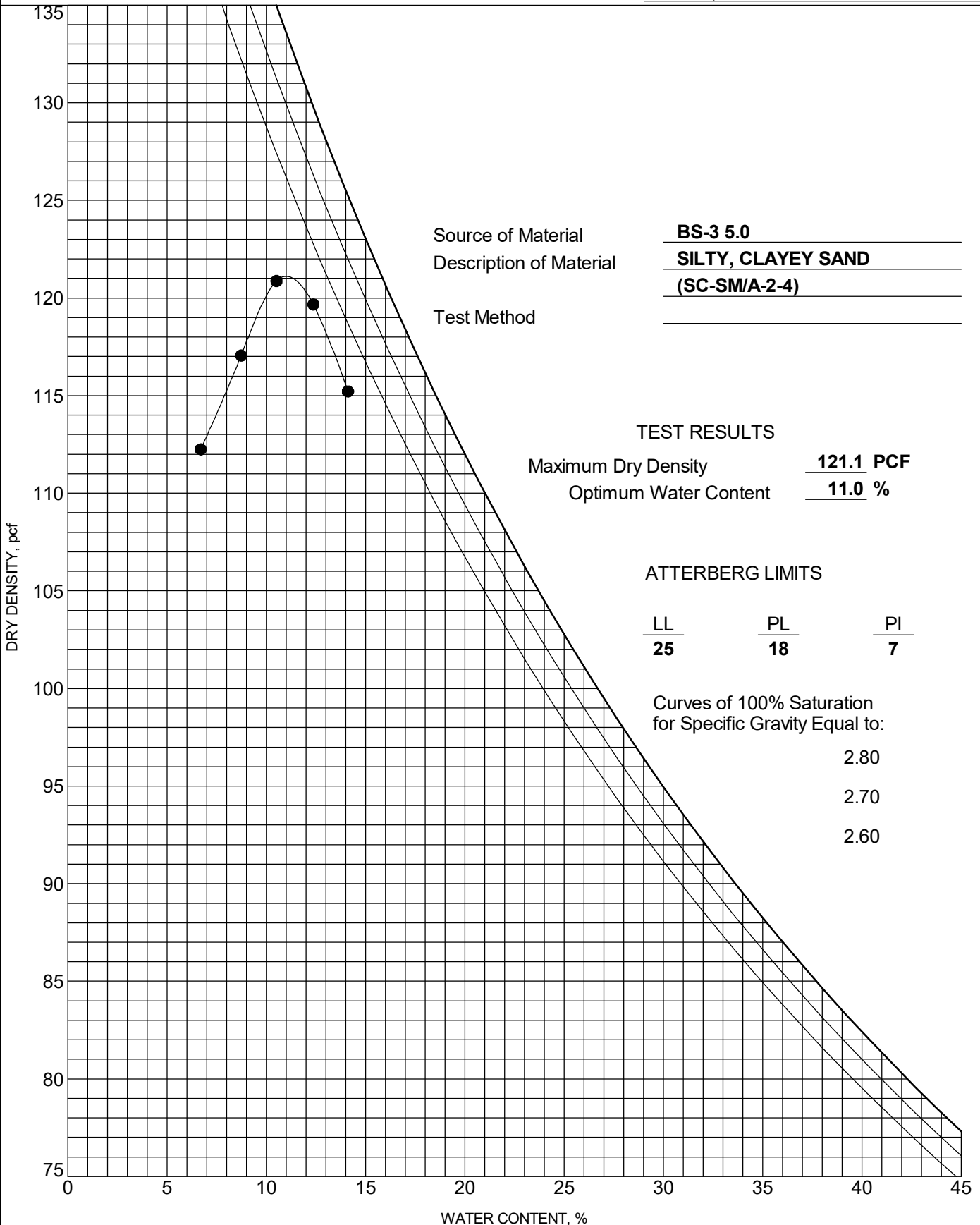


MOISTURE-DENSITY RELATIONSHIP

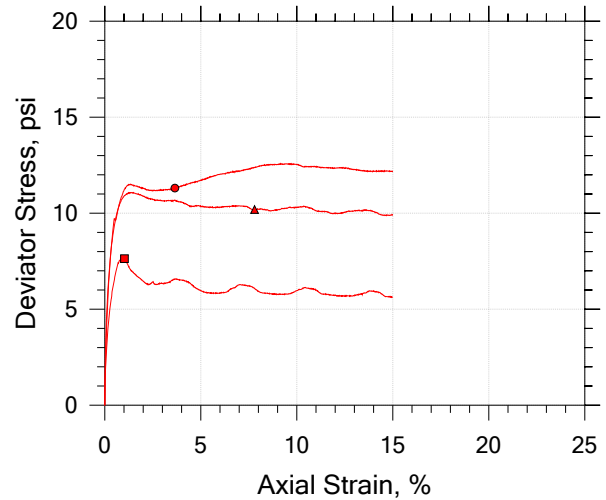
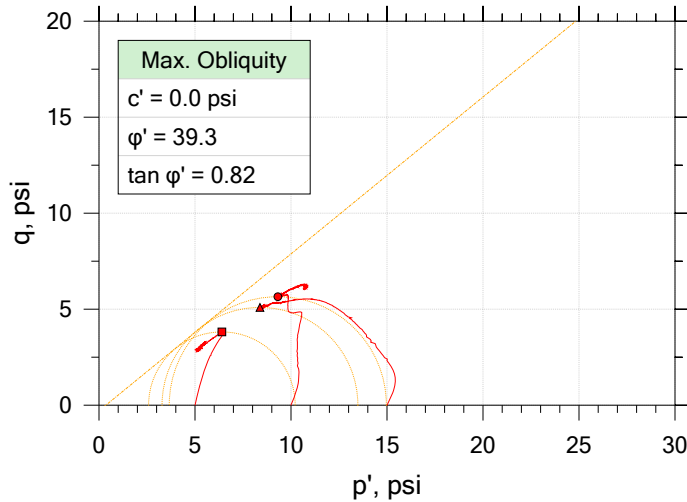
PROJECT ID P041151

PROJECT NAME S-11-138 RBO Goucher Creek

PROJECT COUNTY Cherokee, SC



Consolidated Undrained by AASHTO T297

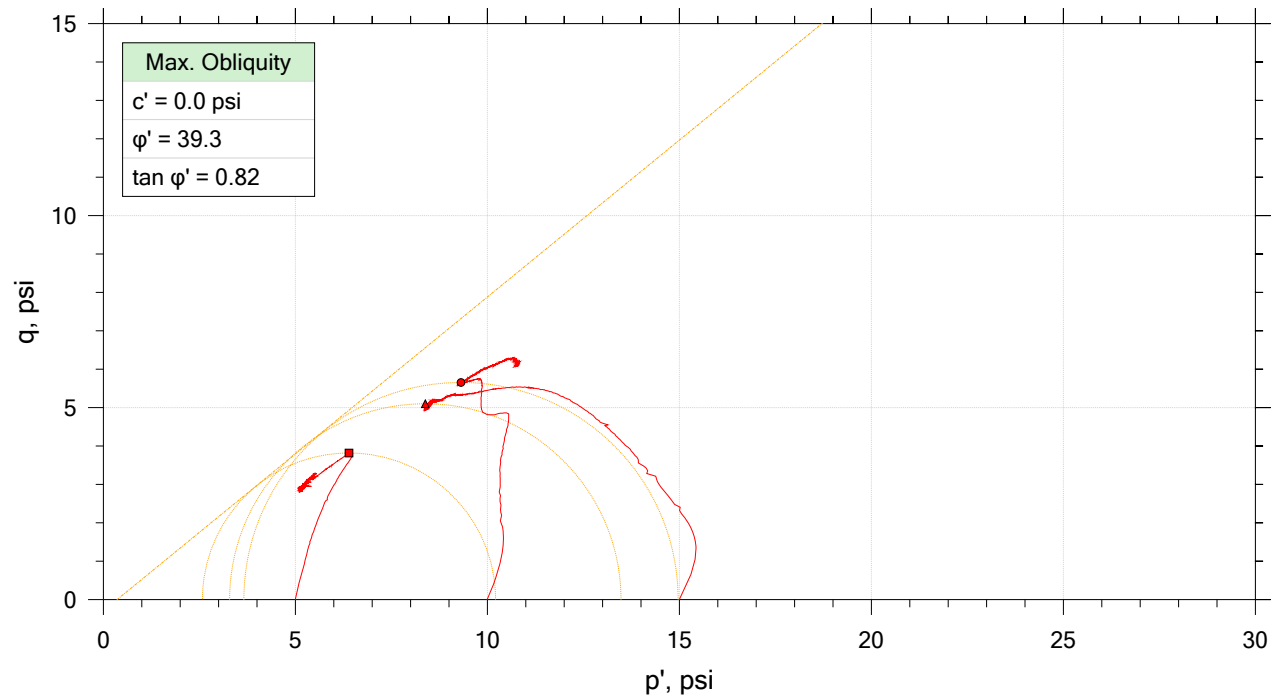
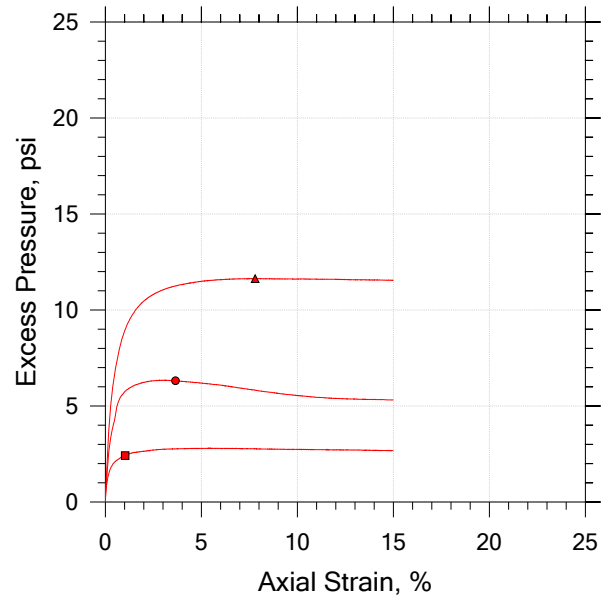
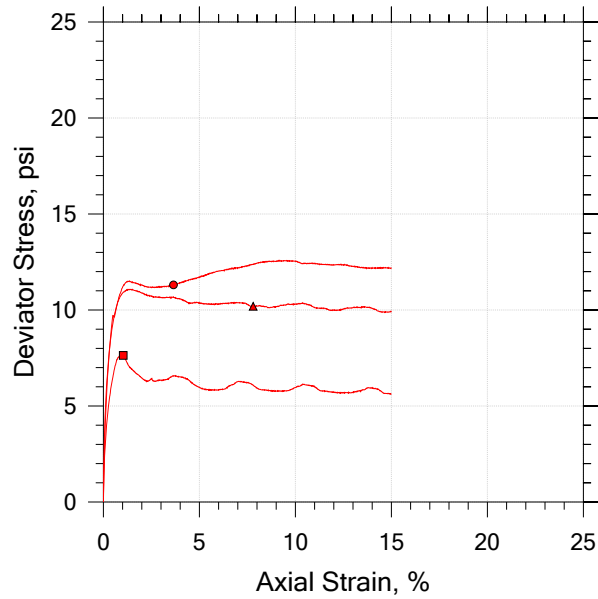


Symbol	■	●	▲	
Sample ID	22-1403	22-1403	22-1403	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0' - 5.0'	
Test Number	A	B	C	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	10.9	11.2	11.2	
Dry Density, pcf	115.	117.	115.	
Saturation (Wet Method), %	64.5	70.2	65.5	
Void Ratio	0.454	0.426	0.457	
Final				
Moisture Content, %	16.4	14.6	14.8	
Dry Density, pcf	116.	120.	120.	
Cross-Sectional Area (Method A), in ²	6.102	6.043	5.962	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.440	0.392	0.397	
Back Pressure, psi	91.99	86.00	101.0	
Vertical Effective Consolidation Stress, psi	4.984	9.960	14.95	
Horizontal Effective Consolidation Stress, psi	4.999	9.998	15.00	
Vertical Strain after Consolidation, %	0.09513	0.4292	0.7588	
Volumetric Strain after Consolidation, %	1.131	2.131	3.582	
Time to 50% Consolidation, min	0.5000	0.3500	0.4600	
Shear Strength, psi	3.816	5.654	5.098	
Strain at Failure, %	1.03	3.65	7.80	
Strain Rate, %/min	0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi	7.632	11.31	10.20	
Effective Minor Principal Stress at Failure, psi	2.580	3.657	3.285	
Effective Major Principal Stress at Failure, psi	10.21	14.97	13.48	
B-Value	0.95	0.95	0.94	


Notes:
 - Before Shear Saturation set to 100% for phase calculation.
 - Moisture Content determined by ASTM D2216.
 - Atterberg Limits determined by ASTM D4318.
 - Deviator Stress includes membrane correction.
 - Values for c and ϕ determined from best-fit straight line for the specific test conditions.
 Actual strength parameters may vary and should be determined by an engineer for site conditions.

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		

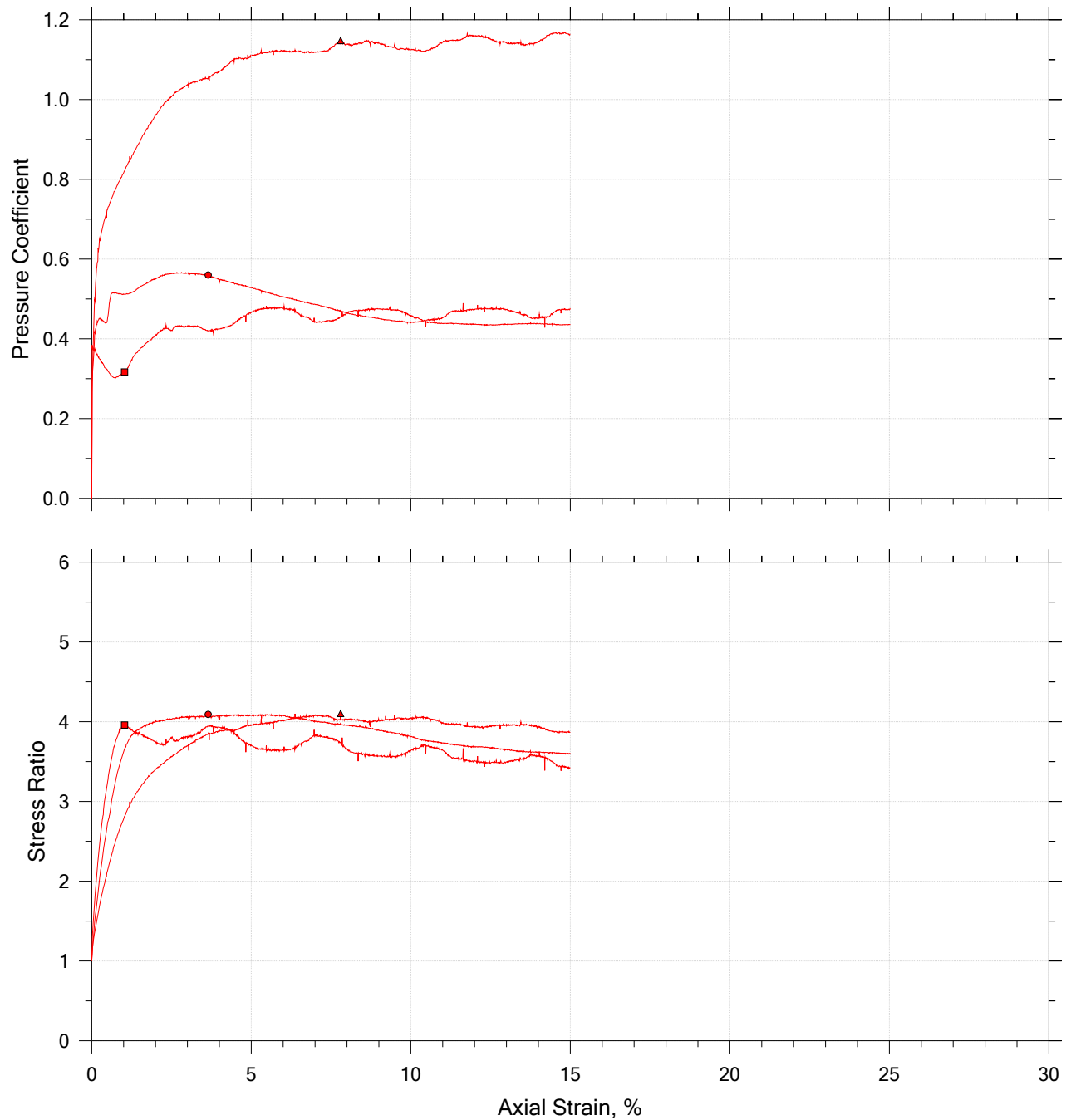
Consolidated Undrained by AASHTO T297




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1403	A	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.A.dat
●	22-1403	B	0.0 - 5.0	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.B.dat
▲	22-1403	C	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.C.dat

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		

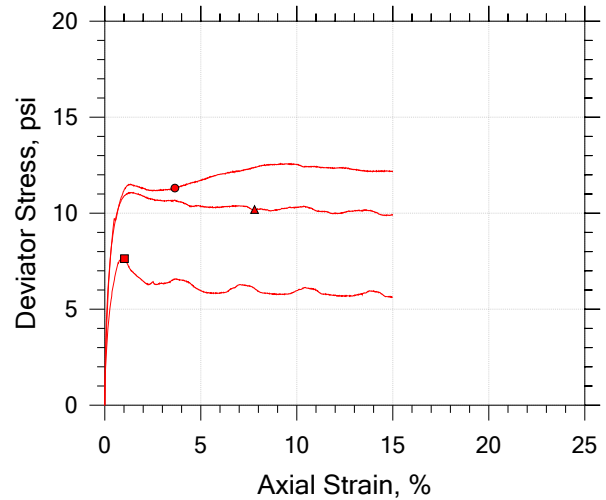
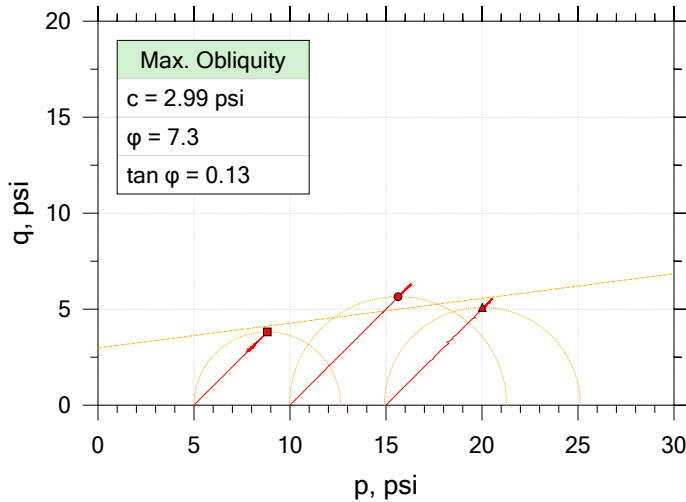
Consolidated Undrained by AASHTO T297



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1403	A	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.A.dat
●	22-1403	B	0.0 - 5.0	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.B.dat
▲	22-1403	C	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.C.dat

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297

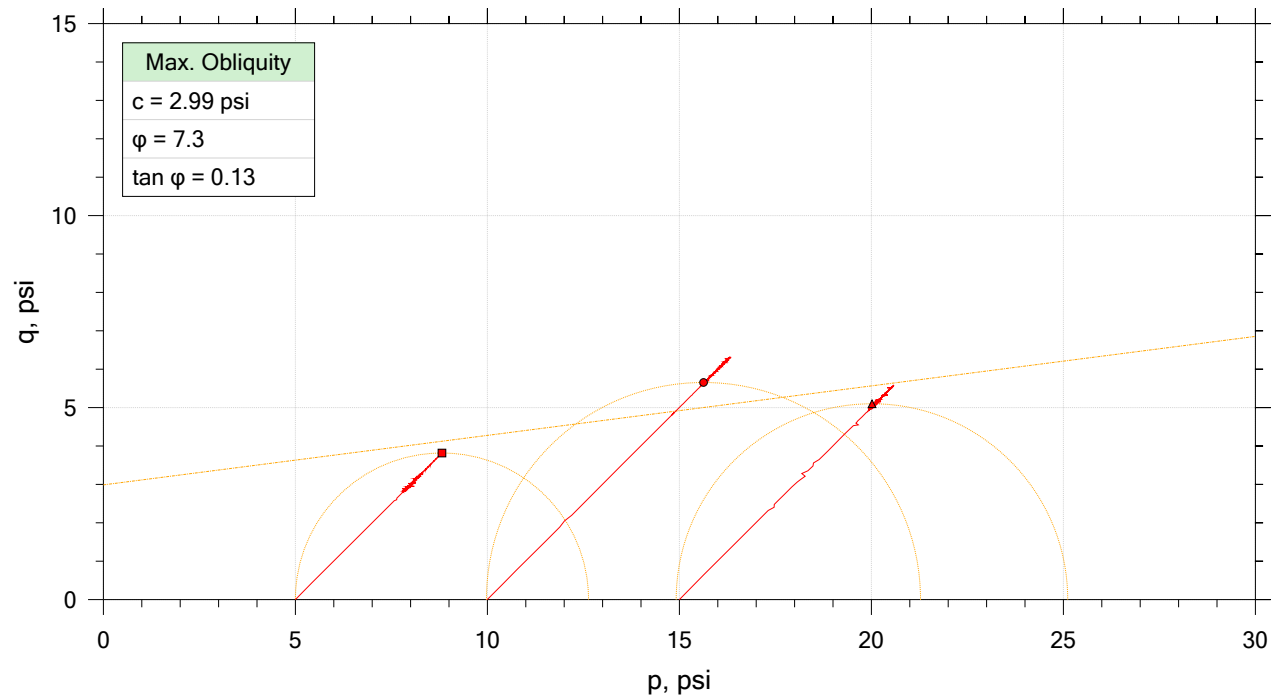
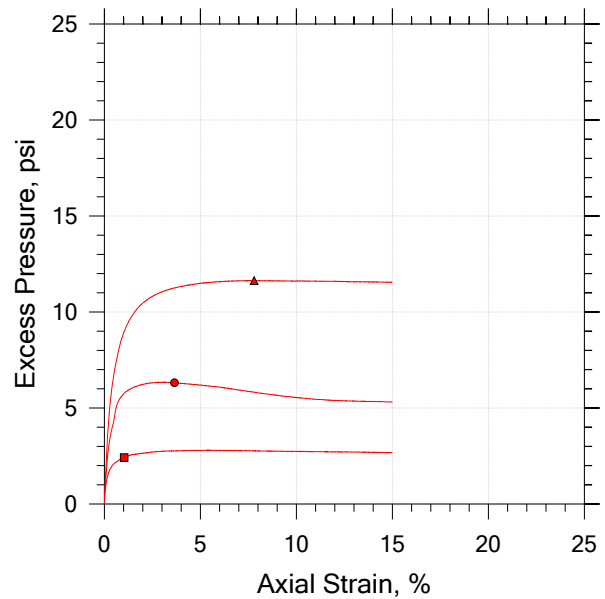
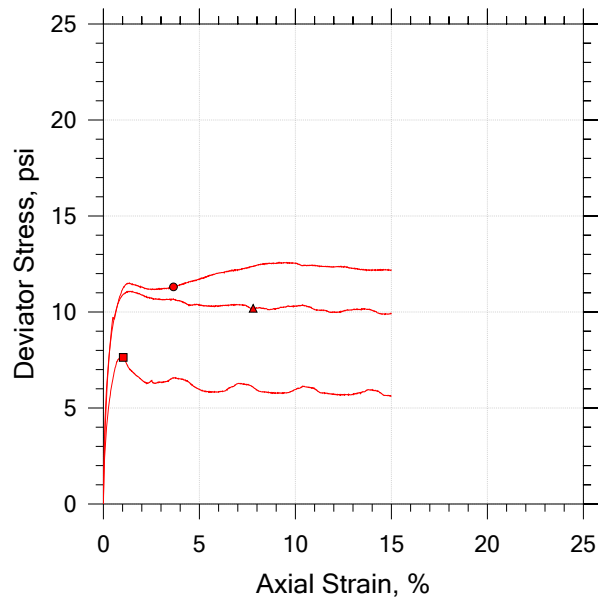


Symbol	■	●	▲	
Sample ID	22-1403	22-1403	22-1403	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0' - 5.0'	
Test Number	A	B	C	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	10.9	11.2	11.2	
Dry Density, pcf	115.	117.	115.	
Saturation (Wet Method), %	64.5	70.2	65.5	
Void Ratio	0.454	0.426	0.457	
Final				
Moisture Content, %	16.4	14.6	14.8	
Dry Density, pcf	116.	120.	120.	
Cross-Sectional Area (Method A), in ²	6.102	6.043	5.962	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.440	0.392	0.397	
Back Pressure, psi	91.99	86.00	101.0	
Vertical Effective Consolidation Stress, psi	4.984	9.960	14.95	
Horizontal Effective Consolidation Stress, psi	4.999	9.998	15.00	
Vertical Strain after Consolidation, %	0.09513	0.4292	0.7588	
Volumetric Strain after Consolidation, %	1.131	2.131	3.582	
Time to 50% Consolidation, min	0.5000	0.3500	0.4600	
Shear Strength, psi	3.816	5.654	5.098	
Strain at Failure, %	1.03	3.65	7.80	
Strain Rate, %/min	0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi	7.632	11.31	10.20	
Effective Minor Principal Stress at Failure, psi	2.580	3.657	3.285	
Effective Major Principal Stress at Failure, psi	10.21	14.97	13.48	
B-Value	0.95	0.95	0.94	


Notes:
 - Before Shear Saturation set to 100% for phase calculation.
 - Moisture Content determined by ASTM D2216.
 - Atterberg Limits determined by ASTM D4318.
 - Deviator Stress includes membrane correction.
 - Values for c and ϕ determined from best-fit straight line for the specific test conditions.
 - Actual strength parameters may vary and should be determined by an engineer for site conditions.

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		

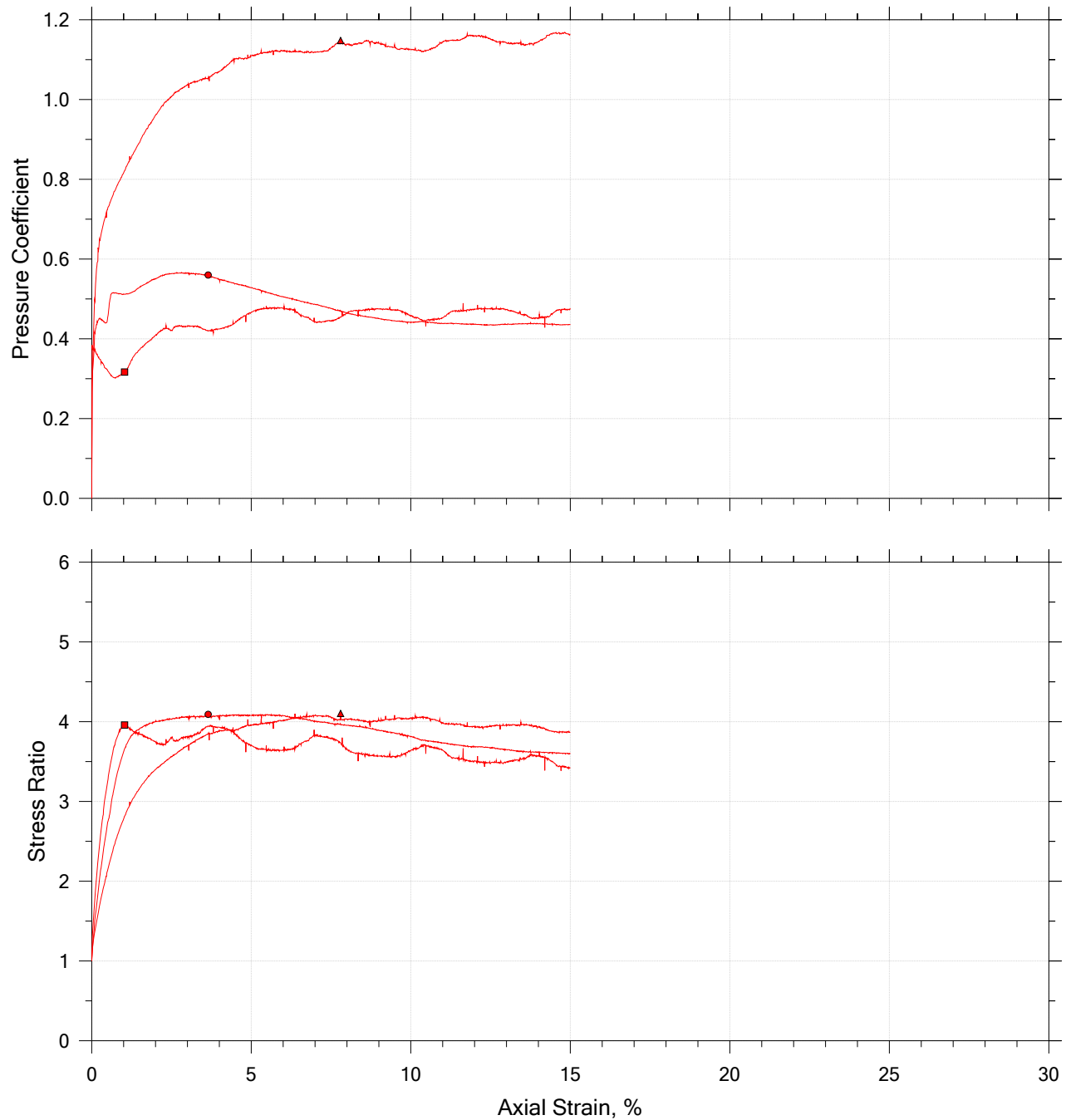
Consolidated Undrained by AASHTO T297




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1403	A	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.A.dat
●	22-1403	B	0.0 - 5.0	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.B.dat
▲	22-1403	C	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.C.dat

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1403	A	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.A.dat
●	22-1403	B	0.0 - 5.0	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.B.dat
▲	22-1403	C	0.0' - 5.0'	WAP/RMC	5/17/2022	WAP/ WJG	5/25/2022	BS-3.C.dat

	Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-138 RBO Goucher Creek	Project Number: G6655.004
	Boring Number: BS-3	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1403	Test Date: 5/17/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty Clayey SAND (SC-SM/A-2-4) LL=25, PL=18, PI=7, %200=34.2		
	Remarks: Max Dry Density=121.1 pcf, OMC=11.0%, Samples Molded at 95% of Max Dry Density		



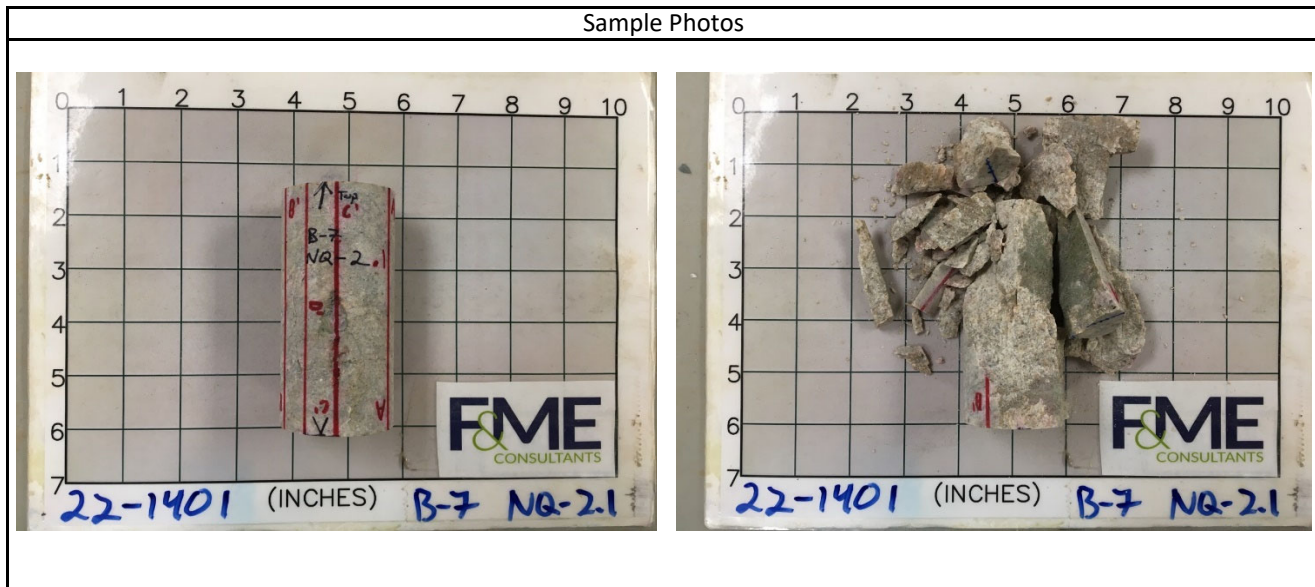
Appendix C. Laboratory Testing

Rock Cores

Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.964	Reviewed By	WJG
Boring	B-7	Unit Weight (pcf)	161.3	Core Size	NQ
Sample No.	NQ-2.1 / 22-1401A	L/D Ratio	2.12	Recovery	100%
Depth	25.5' - 25.8'	Load Rate (psi/sec)	30	RQD	42%
Description	White/Gray/Black Schist				

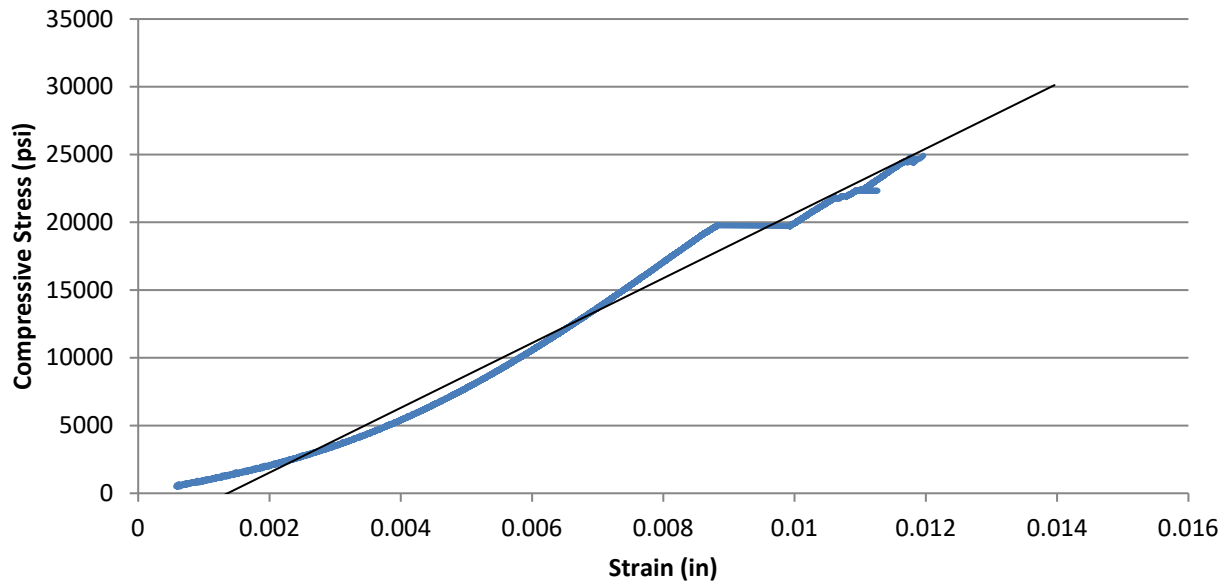
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-2336	146	6,877	2,501	2.14	0.06
20%	-3800	291	13,772	5,009	2.64	0.08
30%	-4896	389	20,555	7,476	3.05	0.08
40%	-5794	451	27,413	9,971	3.44	0.08
50%	-6616	505	34,226	12,449	3.76	0.08
60%	-7380	561	41,104	14,950	4.05	0.08
70%	-8108	636	47,932	17,434	4.30	0.08
80%	-10009	2091	54,845	19,948	3.99	0.21
90%	-11012	2658	61,635	22,418	4.07	0.24
100%	-11961	2846	68,503	24,916		



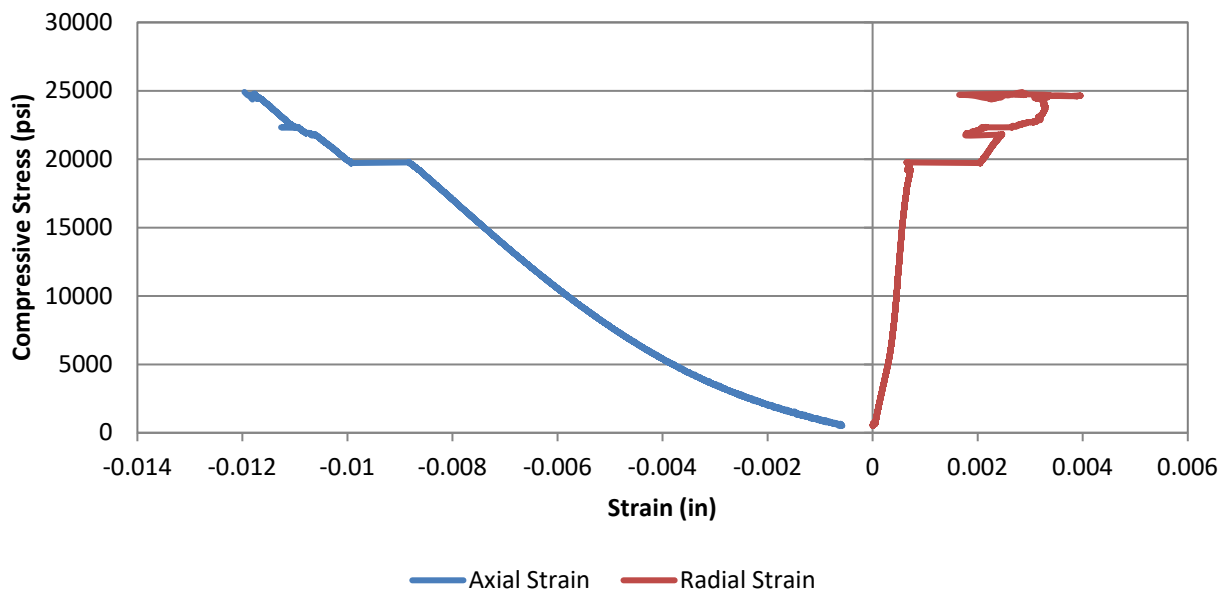
Test Results			
Unconfined Compressive Strength (psi)	24,920	Elastic Modulus (psi)	3.74E+06
		Poisson's Ratio in Elastic Range	0.08
Comments	Elastic range was taken as between 0.005 and 0.008 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.964	Reviewed By	WJG
Boring	B-7	Unit Weight (pcf)	161.3	Core Size	NQ
Sample No.	NQ-2.1 / 22-1401A	L/D Ratio	2.12	Recovery	100%
Depth	25.5' - 25.8'	Load Rate (psi/sec)	30	RQD	42%
Description	White/Gray/Black Schist				

Axial Stress vs. Strain



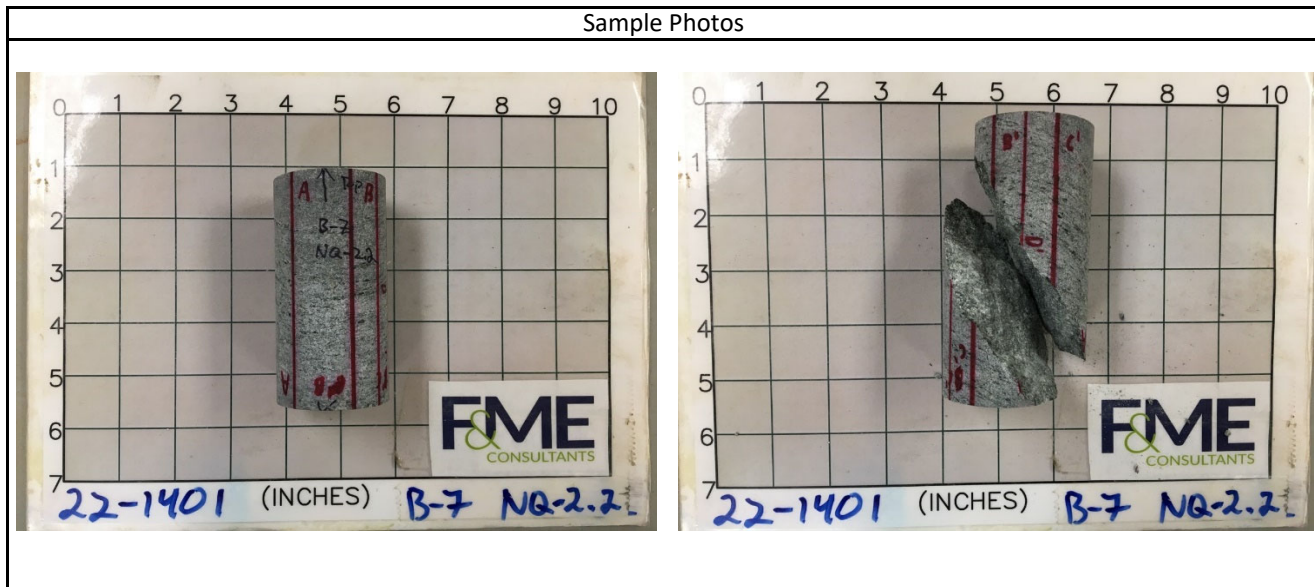
Stress vs. Strain



Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.875	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.827	Reviewed By	WJG
Boring	B-7	Unit Weight (pcf)	168.5	Core Size	NQ
Sample No.	NQ-2.2 / 22-1401B	L/D Ratio	2.04	Recovery	100%
Depth	29.3' - 29.6'	Load Rate (psi/sec)	30	RQD	42%
Description	White/Grey/Black Schist				

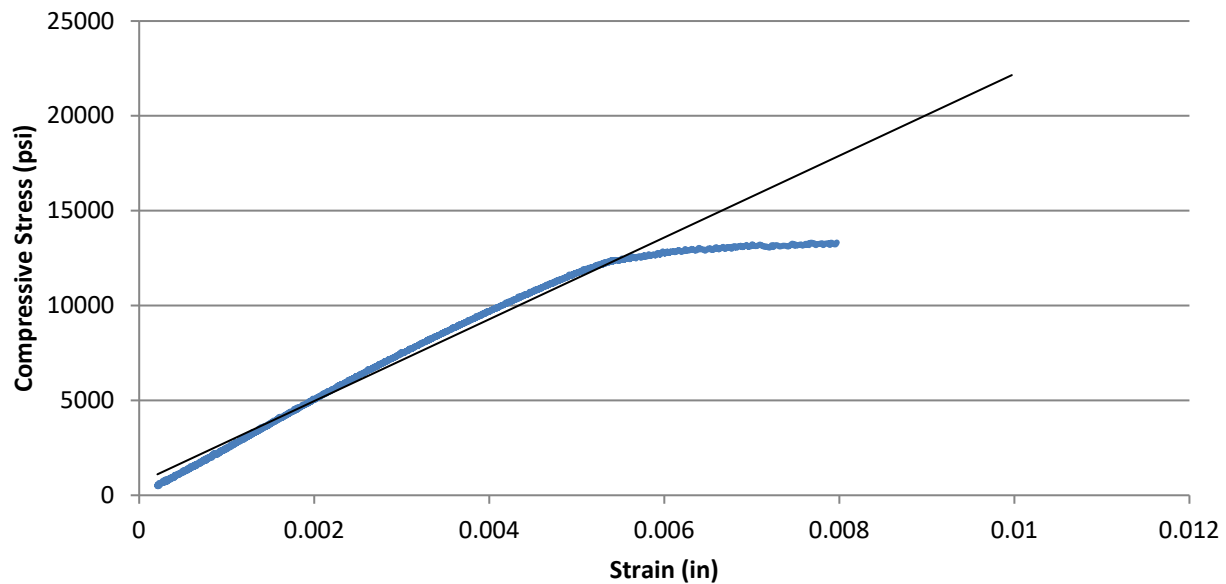
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-540	69	3,675	1,331	4.93	0.13
20%	-1075	162	7,380	2,673	4.97	0.15
30%	-1585	266	11,005	3,986	5.03	0.17
40%	-2113	385	14,718	5,330	5.05	0.18
50%	-2641	521	18,314	6,633	5.02	0.20
60%	-3213	687	22,038	7,981	4.97	0.21
70%	-3822	893	25,731	9,319	4.88	0.23
80%	-4469	1142	29,471	10,673	4.78	0.26
90%	-5178	1446	33,200	12,024	4.64	0.28
100%	-7971	2972	36,795	13,326		



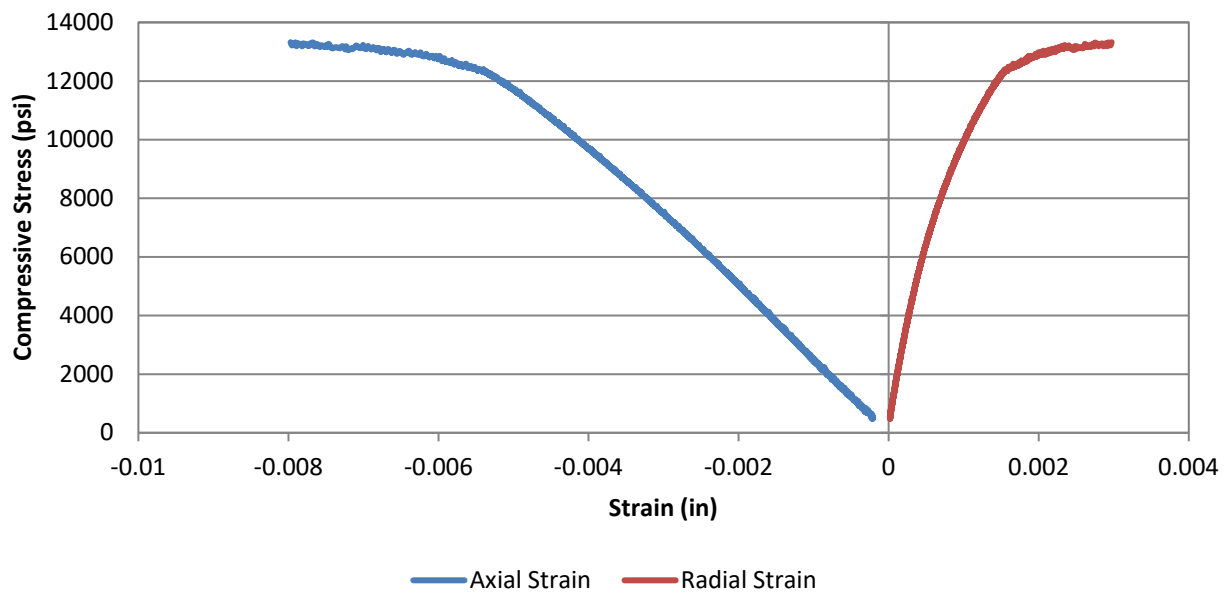
Test Results			
Unconfined Compressive Strength (psi)	13,330	Elastic Modulus (psi)	4.98E+06
		Poisson's Ratio in Elastic Range	0.21
Comments	Elastic range was taken as between 0.002 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.875	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.827	Reviewed By	WJG
Boring	B-7	Unit Weight (pcf)	168.5	Core Size	NQ
Sample No.	NQ-2.2 / 22-1401B	L/D Ratio	2.04	Recovery	100%
Depth	29.3' - 29.6'	Load Rate (psi/sec)	30	RQD	42%
Description	White/Grey/Black Schist				

Axial Stress vs. Strain

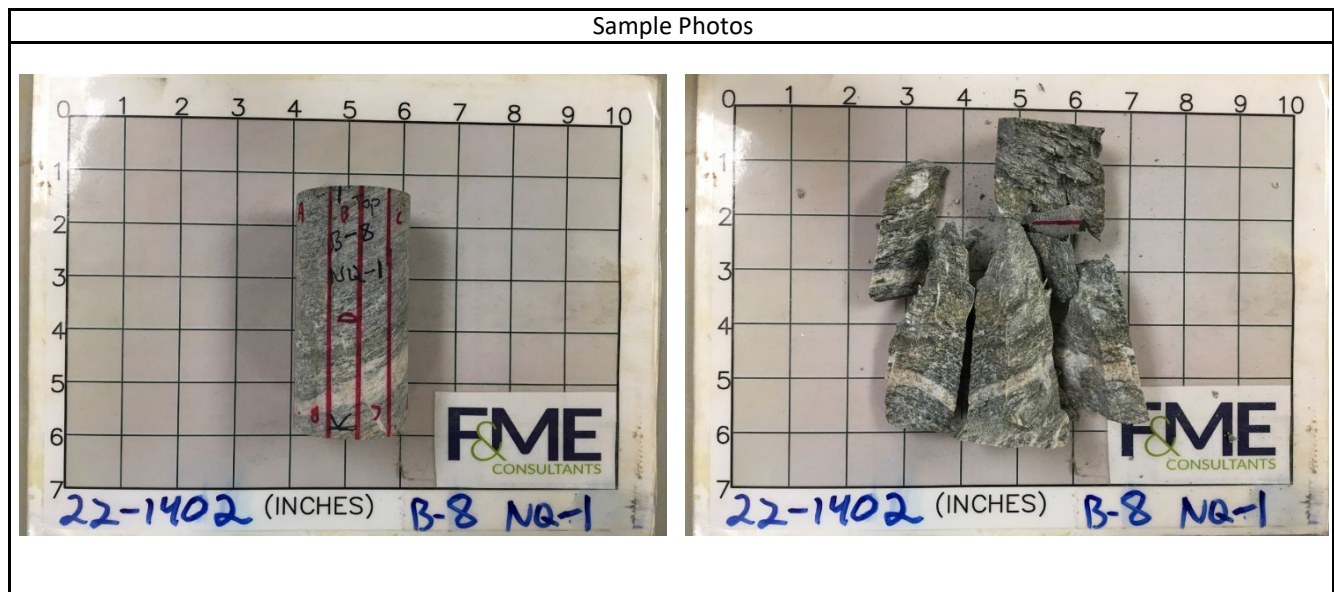


Stress vs. Strain



Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.966	Reviewed By	WJG
Boring	B-8	Unit Weight (pcf)	166.3	Core Size	NQ
Sample No.	NQ-1 / 22-1402A	L/D Ratio	2.12	Recovery	100%
Depth	23.1' - 23.4'	Load Rate (psi/sec)	30	RQD	72%
Description	White/Gray/Black Gneiss				

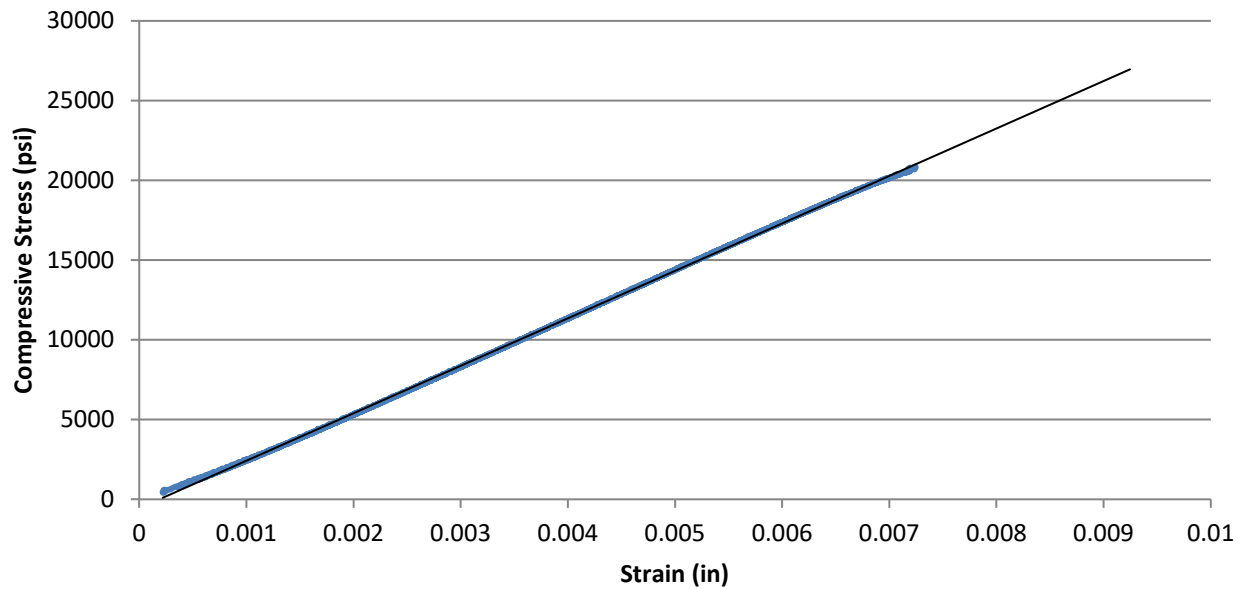
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-880	109	5,795	2,108	4.79	0.12
20%	-1609	236	11,420	4,154	5.16	0.15
30%	-2332	379	17,304	6,294	5.40	0.16
40%	-3008	527	22,907	8,332	5.54	0.18
50%	-3705	696	28,699	10,438	5.64	0.19
60%	-4383	879	34,447	12,529	5.72	0.20
70%	-5084	1087	40,186	14,616	5.75	0.21
80%	-5773	1326	45,969	16,720	5.79	0.23
90%	-6478	1627	51,630	18,779	5.80	0.25
100%	-7239	2213	57,383	20,871		



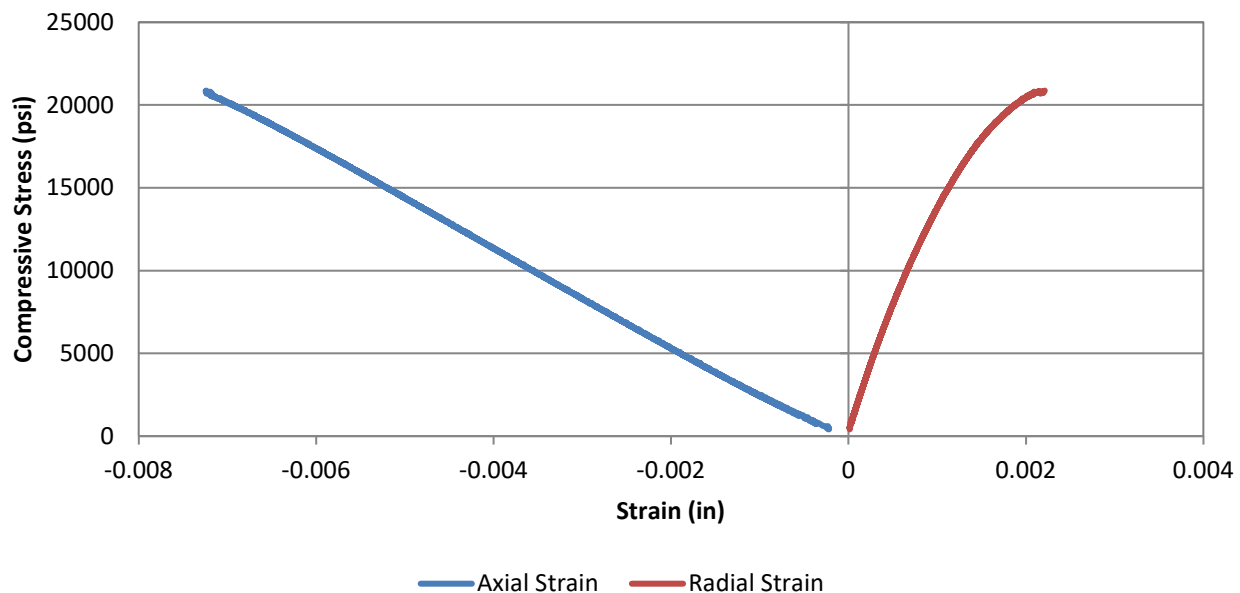
Test Results			
Unconfined Compressive Strength (psi)		20,870	Elastic Modulus (psi)
			5.63E+06
			Poisson's Ratio in Elastic Range
			0.19
Comments	Elastic range was taken as between 0.002 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.966	Reviewed By	WJG
Boring	B-8	Unit Weight (pcf)	166.3	Core Size	NQ
Sample No.	NQ-1 / 22-1402A	L/D Ratio	2.12	Recovery	100%
Depth	23.1' - 23.4'	Load Rate (psi/sec)	30	RQD	72%
Description	White/Gray/Black Gneiss				

Axial Stress vs. Strain

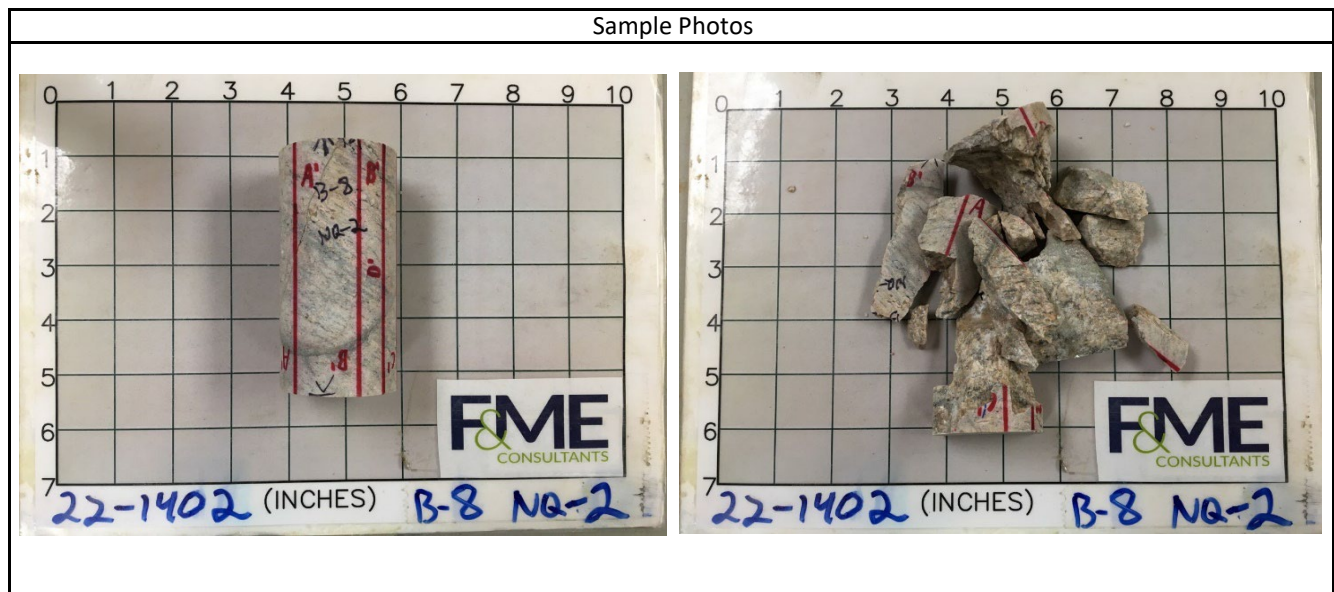


Stress vs. Strain



Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.905	Reviewed By	WJG
Boring	B-8	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-2 / 22-1402B	L/D Ratio	2.09	Recovery	92%
Depth	27.7' - 28.0'	Load Rate (psi/sec)	30	RQD	80%
Description	White/Pink Quartzite				

Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-1220	41	6,073	2,211	3.62	0.03
20%	-2220	89	12,174	4,433	3.99	0.04
30%	-3061	124	18,189	6,623	4.33	0.04
40%	-3796	158	24,236	8,825	4.65	0.04
50%	-4498	193	30,375	11,060	4.92	0.04
60%	-5139	224	36,390	13,250	5.16	0.04
70%	-5786	273	42,486	15,469	5.35	0.05
80%	-6475	444	48,517	17,665	5.46	0.07
90%	-7234	2459	54,597	19,879	5.50	0.34
100%	-9452	7126	60,645	22,081		



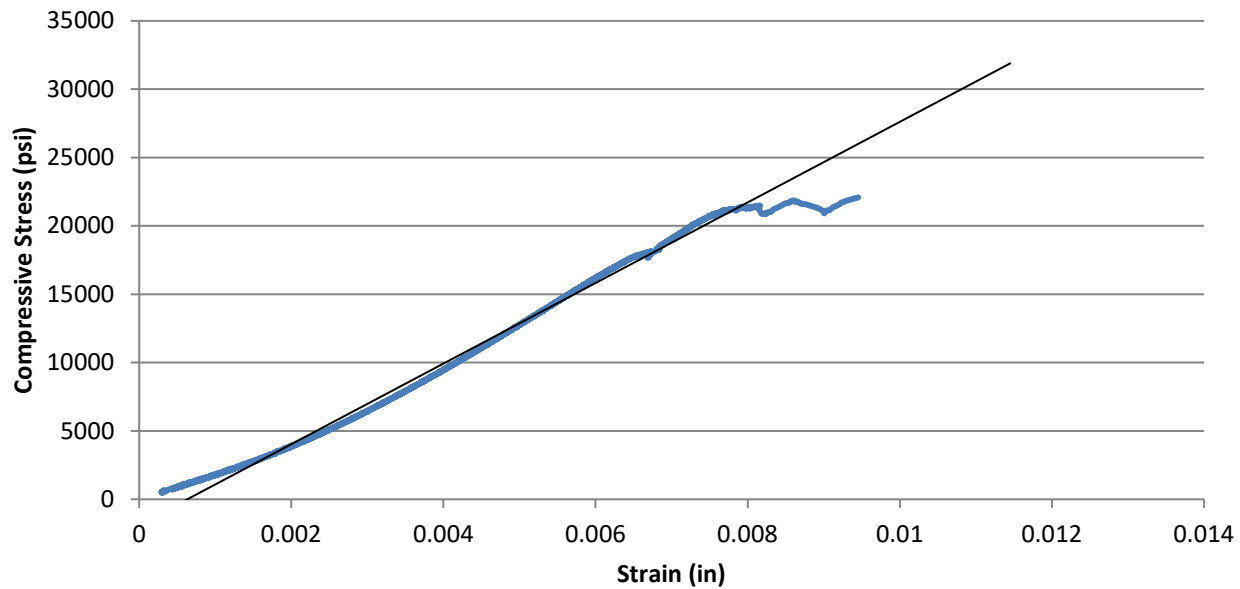
Test Results			
Unconfined Compressive Strength (psi)		22,080	Elastic Modulus (psi)
			4.74E+06
			Poisson's Ratio in Elastic Range
			0.04
Comments	Elastic range was taken as between 0.002 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		



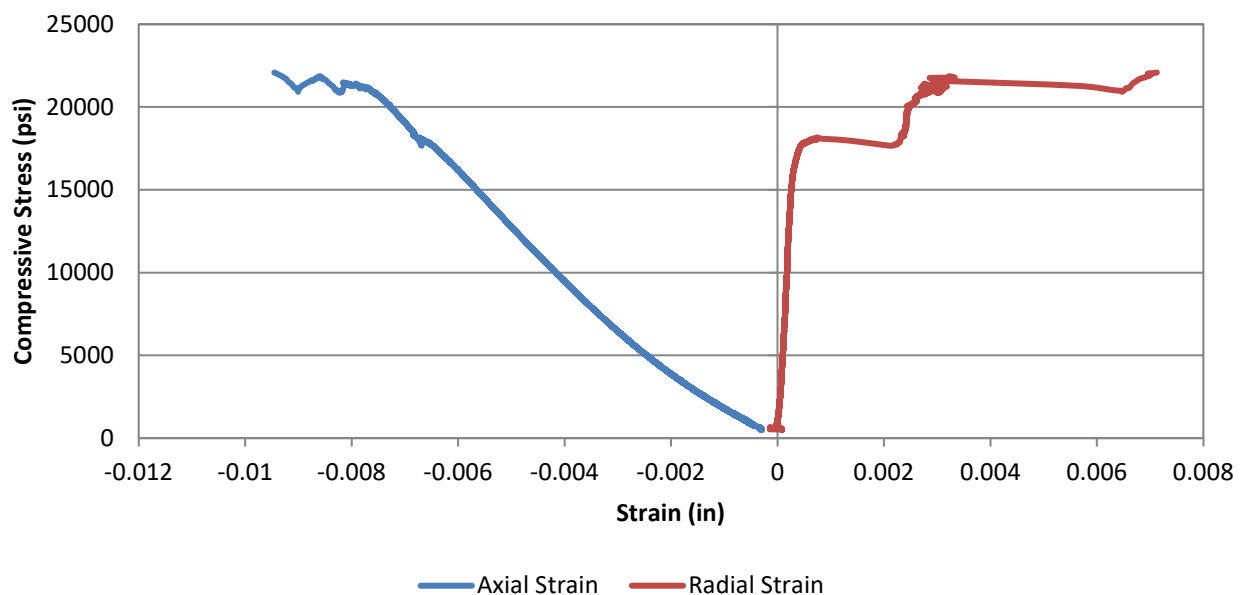
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

Project	S-11-138 RBO Goucher Creek			Date	5/26/2022
Project No.	G6655.004	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P041151	Sample Length (in.)	3.905	Reviewed By	WJG
Boring	B-8	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-2 / 22-1402B	L/D Ratio	2.09	Recovery	92%
Depth	27.7' - 28.0'	Load Rate (psi/sec)	30	RQD	80%
Description	White/Pink Quartzite				

Axial Stress vs. Strain



Stress vs. Strain



Appendix D. SPT Hammer Energy Calibration Report

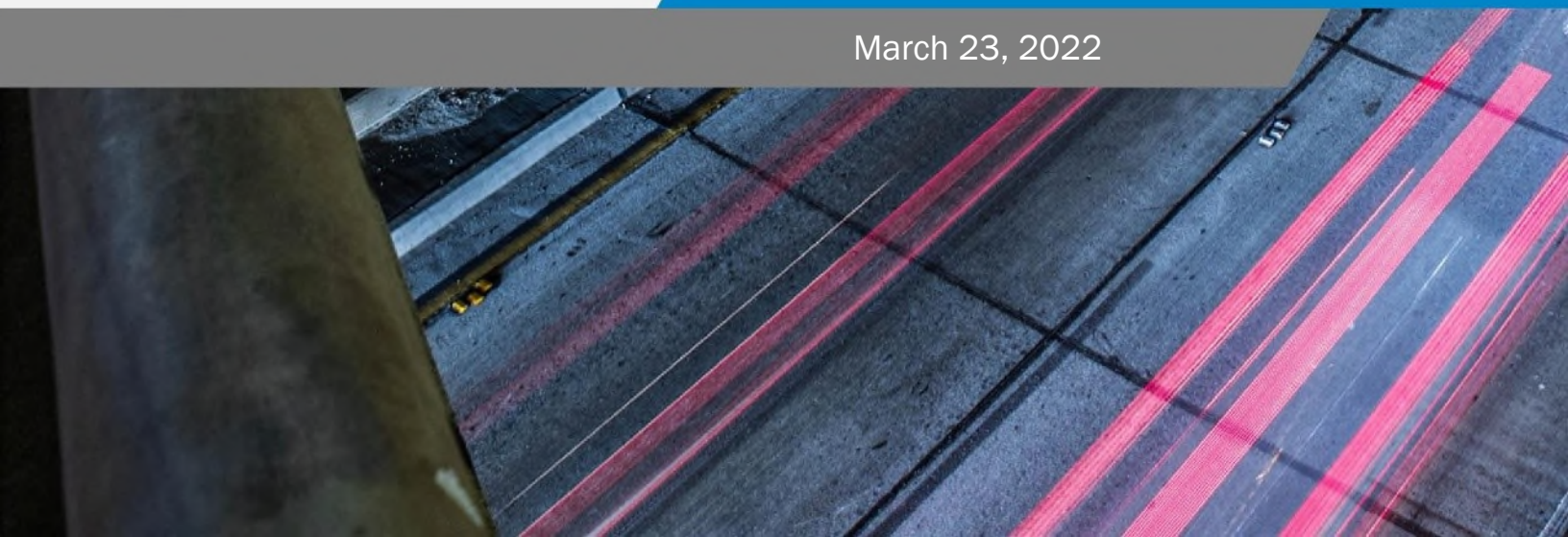


**CAROLINAS
GEOTECHNICAL
GROUP**

Report of SPT Hammer Energy

Prepared for:
Breccia Construction, LLC
620-B Industrial Way
Chester, South Carolina 29706

March 23, 2022





2400 Crownpoint Executive Drive
Suite 800
Charlotte, NC 28227



(980) 339-8684



contact@carolinasgeotech.com



www.carolinasgeotech.com

March 23, 2022

Mr. Jarod S. Ford
Breccia Construction, LLC
620-B Industrial Way
Chester, South Carolina 29706

SUBJECT: **Report of SPT Hammer Energy**
Breccia Construction, LLC CME 45B Trailer Rig (SN 303304)
Chester, South Carolina
CG2 Project No.: 240021095

Dear Mr. Ford:

Carolinas Geotechnical Group, PLLC (CG2) has completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer mounted on a Breccia Construction, LLC (Breccia) CME 45B trailer-mounted drill rig with a serial number of 303304, see attached Drill Rig Photo Log. This service was performed by Mr. Robert E. Kral, PE on March 11, 2022. SPT energy testing was performed in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation (NCDOT), Geotechnical Engineering Unit's requirements. The testing procedures, equipment used during testing, and detailed results are presented in this report.

CG2 recommends Breccia submit this Report of SPT Hammer Energy to the NCDOT Geotechnical Engineering Unit for review and approval no later than April 8, 2022.

DYNAMIC TESTING METHODOLOGY

Testing was performed using a model SPT (Serial No. 4549 TB) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K11957 and K10959) bolted to a 2-foot long AWJ drill rod (SN 528AWJ) internally instrumented with two strain transducers. The instrumented AWJ drill rod has a cross-sectional area of 1.19 square inches, an outside diameter of approximately 1.75 inches, and an inside diameter of 1.25 inches at the gauge location. The accelerometers and strain gauges, which are mounted on opposing axis near the middle of the instrumented rod, monitor acceleration and strain for each hammer blow. The analyzer converts the data to velocities and forces and computes the maximum transferred hammer energies with the "EFV" method described in ASTM D4633. Preliminary results are recorded and displayed in real-time for each blow. Calibration sheets for the PDA, accelerometers, and the instrumented rod are included in the Appendix III.

Report of SPT Hammer Energy
Chester, South Carolina
CG2 Project No.: 240021095

TESTING AND OBSERVATIONS

CG2 personnel was on site March 11, 2022 to observe and perform high-strain dynamic testing during SPT sampling on the CME 45B trailer-mounted drill rig operated by D. Harris of Breccia. The measurements were taken during drilling operations at 1817 Lowrys Highway in Chester, South Carolina (Chester County). The approximate coordinates (not professionally surveyed) for the test location are 34.770585, -81.245517. No Soil Test Boring Log was maintained. SPT energy measurements were recorded during three intervals at depths of approximately 28½, 33½, and 38½ feet below the existing ground surface. The information presented in the table below summarizes the equipment tested and tooling used during the SPT energy measurements.

Table 1: SPT Field Data

Drill Rig Information	
Manufacturer	CME
Model	45B
Serial Number	303304
Operator	D. Harris
Carrier	Trailer
Hammer Information	
Model / Type	CME / Auto
Serial Number	N/A
Anvil Height (inches)	11.5
Anvil Diameter (inches)	2.5
Drop Height (inches)	30
Ram Weight (pounds)	140
Ram Serial Number	N/A
Drilling and Instrumented Rod Information	
Drill Rod Type	AWJ
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in ²)	1.19
Typical Lengths (feet)	5
Instrumented Rod Type	AWJ (SN 528)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in ²)	1.19
Total Instrumented Rod Length (feet)	2.00
Length Below Gages (feet)	0.70
Split-Spoon Length (feet)	2.85

Report of SPT Hammer Energy
Chester, South Carolina
CG2 Project No.: 240021095

DYNAMIC TESTING RESULTS

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.6 feet to the required drill rod length at each sample depth. Based on the test data, the automatic hammer on the CME 45B Trailer-mounted drill rig operated at a rate of about 53.2 to 61.4 blows per minute (BPM) during dynamic testing. The measured transferred hammer energy (EFV) ranged from 273.5 to 298.0 foot-pounds, which corresponds to Energy Transfer Ratio (ETR) values of 78.2 to 85.1%, respectively.

The SPT Energy Measurement Data Summary tables in the Appendix present the test data from every hammer blow at each sampling interval along with representative force and velocity traces for each test interval. The reported blow counts, obtained by the drill rig personnel, and a summary of the test data and average computed hammer energy and transfer ratio values are provided in Table 2. Plots and tables of the following are also included in the Appendix and present the test data with depth for each test interval:

- Penetration vs. BLC
- Penetration vs. CSX
- Average ETR vs. Rod Length
- Penetration vs. FMX
- Penetration vs. VMX
- ETR vs. Rod Length
- Penetration vs. EFV
- Penetration vs. ETR

Table 2: Summary of Dynamic Testing Results

Data Set ID	Sample Depth (ft)	Drill Rod Length (ft)	Instrumentation to Sampler Tip Length (ft)	Blows per 6" Increment / N-value	Soil Sample Description (Piedmont Residual)	Avg. BPM	Avg. EFV (ft-lbs)	Avg. ETR (%)
1	28½ - 30	30	33.6	4-6-7 / 13	SA SILT	53.4	277.5	79.3
2	33½ - 35	35	38.6	3-5-6 / 11	SA SILT	58.3	291.4	83.3
3	38½ - 40	40	43.6	4-6-9 / 15	SA SILT	55.5	286.8	81.9
Overall Average						55.6	285.0	81.4

The average hammer rate, transferred energy, and transfer ratio were calculated for each depth interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e., the blows that determine the N-value) were included when computing the average values shown in Table 2. The overall average transferred hammer energy for the automatic hammer on the CME 45B trailer-mounted drill rig (for all the depth intervals tested) was 285.0 foot-pounds, with an average ETR of 81.4%.

Report of SPT Hammer Energy
Chester, South Carolina
CG2 Project No.: 240021095

LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The information contained in this report were based on the applicable standards of our profession in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

CLOSING

CG2 is pleased to have the opportunity to provide these services to you. If you have questions concerning the content of this report, or if CG2 can be of further service, please contact CG2 at (980) 339-8684.

Sincerely,
Carolinas Geotechnical Group, PLLC

DocuSigned by:

386129C0A4C1462...
D. Matthew Brewer, PE
Senior Project Engineer

DocuSigned by:

8AD703B2A8484F4...
Robert E. Kral, PE
Senior Project Engineer
NC Registration No. 042642



Appendices:

- Appendix I - CME 45B Trailer Rig (SN 303304) SPT Energy Measurements Summary Plots and Tables
- Appendix II - SPT Hammer Energy Field Form (Field Log) and Drill Rig Photo Log
- Appendix III - Instrumented Rod and Accelerometer Calibration Sheets
- Appendix IV - Certificate of Proficiency



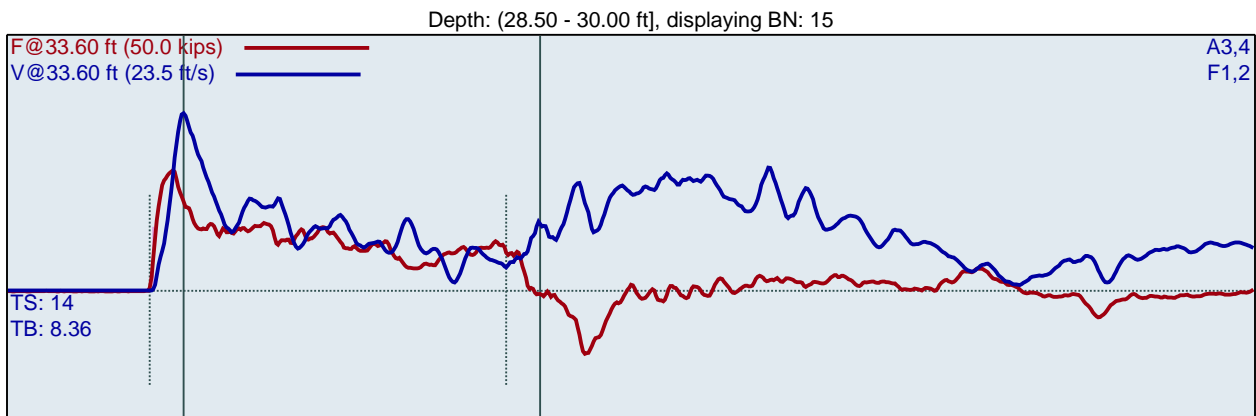
APPENDIX I

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 33.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

BPM: Blows/Minute

FMX: Maximum Force

VMX: Maximum Velocity

DMX: Maximum Displacement

CSX: Compression Stress Maximum

DFN: Final Displacement

EFV: Maximum Energy

ETR: Energy Transfer Ratio - Rated

LP	BL#	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
ft		/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
28.63	1	4	1.9	23.8	15.1	2.0	20.0	1.5	258.9	74.0
28.75	2	4	52.7	25.1	15.4	1.6	21.1	1.5	269.5	77.0
28.88	3	4	53.1	25.1	15.7	1.6	21.1	1.5	272.5	77.8
29.00	4	4	53.5	24.6	15.4	1.5	20.7	1.5	269.5	77.0
29.08	5	6	53.4	25.0	15.6	1.2	21.0	1.0	273.5	78.2
29.17	6	6	53.3	24.8	15.7	1.1	20.8	1.0	274.5	78.4
29.25	7	6	53.4	24.6	15.7	1.1	20.7	1.0	277.2	79.2
29.33	8	6	53.3	24.7	16.0	1.1	20.8	1.0	274.8	78.5
29.42	9	6	53.4	24.6	16.0	1.1	20.6	1.0	275.4	78.7
29.50	10	6	53.7	24.3	15.9	1.1	20.4	1.0	276.7	79.1
29.57	11	7	53.3	24.6	16.3	1.0	20.7	0.9	281.6	80.4
29.64	12	7	53.3	24.1	16.2	1.1	20.2	0.9	279.6	79.9
29.71	13	7	53.5	23.8	16.1	1.1	20.0	0.9	280.2	80.0
29.79	14	7	53.7	23.7	16.5	1.0	19.9	0.9	278.2	79.5
29.86	15	7	53.2	23.6	16.3	1.0	19.8	0.9	277.1	79.2
29.93	16	7	53.4	23.3	15.7	0.9	19.6	0.9	278.7	79.6
30.00	17	7	53.5	23.2	17.1	0.9	19.5	0.9	280.6	80.2
Average			53.4	24.2	16.1	1.1	20.3	0.9	277.5	79.3
Std Dev			0.1	0.6	0.4	0.1	0.5	0.1	2.4	0.7
Maximum			53.7	25.0	17.1	1.2	21.0	1.0	281.6	80.4
Minimum			53.2	23.2	15.6	0.9	19.5	0.9	273.5	78.2

N-value: 13

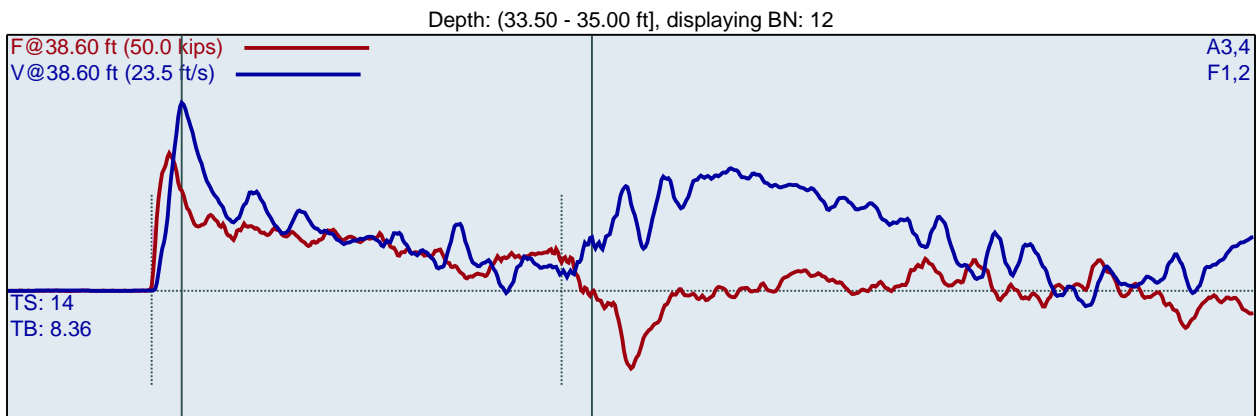
Sample Interval Time: 17.92 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 38.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

LP ft	BL#	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
33.67	1	3	1.9	27.2	16.3	2.3	22.8	2.0	290.7	83.0
33.83	2	3	60.1	27.7	17.1	2.0	23.2	2.0	300.3	85.8
34.00	3	3	60.9	27.7	17.1	2.0	23.3	2.0	302.3	86.4
34.10	4	5	61.4	27.6	16.8	1.3	23.2	1.2	293.7	83.9
34.20	5	5	58.8	27.3	16.7	1.3	22.9	1.2	286.9	82.0
34.30	6	5	57.9	27.1	16.9	1.2	22.8	1.2	288.5	82.4
34.40	7	5	57.7	27.5	17.0	1.2	23.2	1.2	288.2	82.3
34.50	8	5	57.9	26.7	16.8	1.2	22.5	1.2	292.5	83.6
34.58	9	6	57.8	26.6	17.0	1.1	22.4	1.0	290.0	82.9
34.67	10	6	58.1	26.9	17.0	1.0	22.6	1.0	287.6	82.2
34.75	11	6	58.1	26.6	17.1	1.0	22.4	1.0	288.5	82.4
34.83	12	6	57.8	26.9	17.3	1.0	22.6	1.0	298.0	85.1
34.92	13	6	58.1	26.5	17.2	1.0	22.3	1.0	295.9	84.6
35.00	14	6	58.2	26.2	17.0	1.0	22.0	1.0	295.4	84.4
Average			58.3	26.9	17.0	1.1	22.6	1.1	291.4	83.3
Std Dev			1.0	0.4	0.2	0.1	0.4	0.1	3.7	1.1
Maximum			61.4	27.6	17.3	1.3	23.2	1.2	298.0	85.1
Minimum			57.7	26.2	16.7	1.0	22.0	1.0	286.9	82.0

N-value: 11

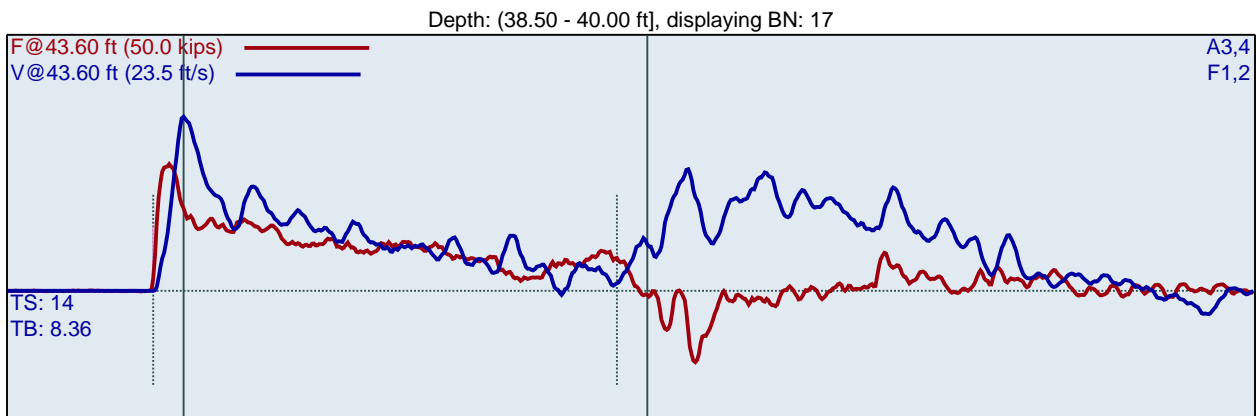
Sample Interval Time: 13.30 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 43.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

LP ft	BL#	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
38.63	1	4	1.9	26.6	16.9	2.2	22.3	1.5	303.5	86.7
38.75	2	4	59.6	25.2	16.8	1.8	21.2	1.5	301.7	86.2
38.88	3	4	59.9	25.2	16.3	1.5	21.2	1.5	295.2	84.3
39.00	4	4	56.8	24.6	16.3	1.5	20.7	1.5	291.6	83.3
39.08	5	6	55.7	24.9	16.0	1.2	20.9	1.0	290.3	82.9
39.17	6	6	55.5	24.9	16.0	1.2	21.0	1.0	290.4	83.0
39.25	7	6	56.0	24.7	16.2	1.2	20.8	1.0	288.0	82.3
39.33	8	6	55.4	25.2	16.2	1.1	21.2	1.0	287.7	82.2
39.42	9	6	55.7	25.1	15.8	1.0	21.1	1.0	283.1	80.9
39.50	10	6	55.3	24.9	15.8	1.0	21.0	1.0	288.5	82.4
39.56	11	9	55.5	24.5	16.0	0.8	20.6	0.7	286.8	82.0
39.61	12	9	55.7	24.6	16.0	0.8	20.7	0.7	284.4	81.3
39.67	13	9	55.4	24.4	16.2	0.8	20.5	0.7	289.2	82.6
39.72	14	9	55.4	24.4	15.9	0.8	20.5	0.7	283.6	81.0
39.78	15	9	55.3	24.7	15.9	0.8	20.7	0.7	287.0	82.0
39.83	16	9	55.5	24.0	15.6	0.8	20.2	0.7	284.1	81.2
39.89	17	9	55.6	24.8	16.0	0.7	20.8	0.7	283.9	81.1
39.94	18	9	55.6	24.4	15.7	0.7	20.5	0.7	284.9	81.4
40.00	19	9	55.4	24.2	16.2	0.8	20.3	0.7	289.6	82.7
Average			55.5	24.7	16.0	0.9	20.7	0.8	286.8	81.9
Std Dev			0.2	0.3	0.2	0.2	0.3	0.2	2.5	0.7
Maximum			56.0	25.2	16.2	1.2	21.2	1.0	290.4	83.0
Minimum			55.3	24.0	15.6	0.7	20.2	0.7	283.1	80.9

N-value: 15

Sample Interval Time: 19.28 seconds.

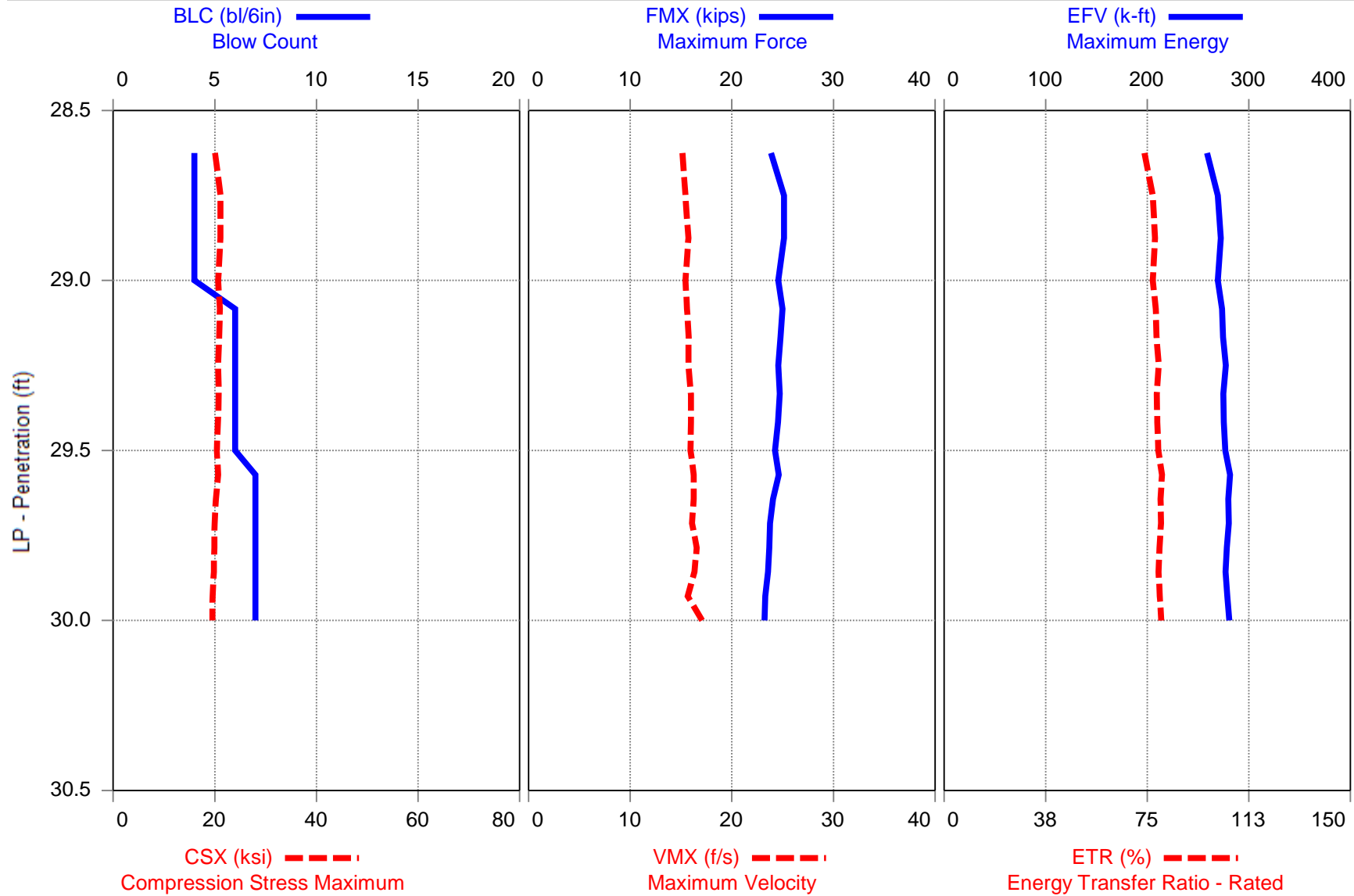
Summary of SPT Test Results

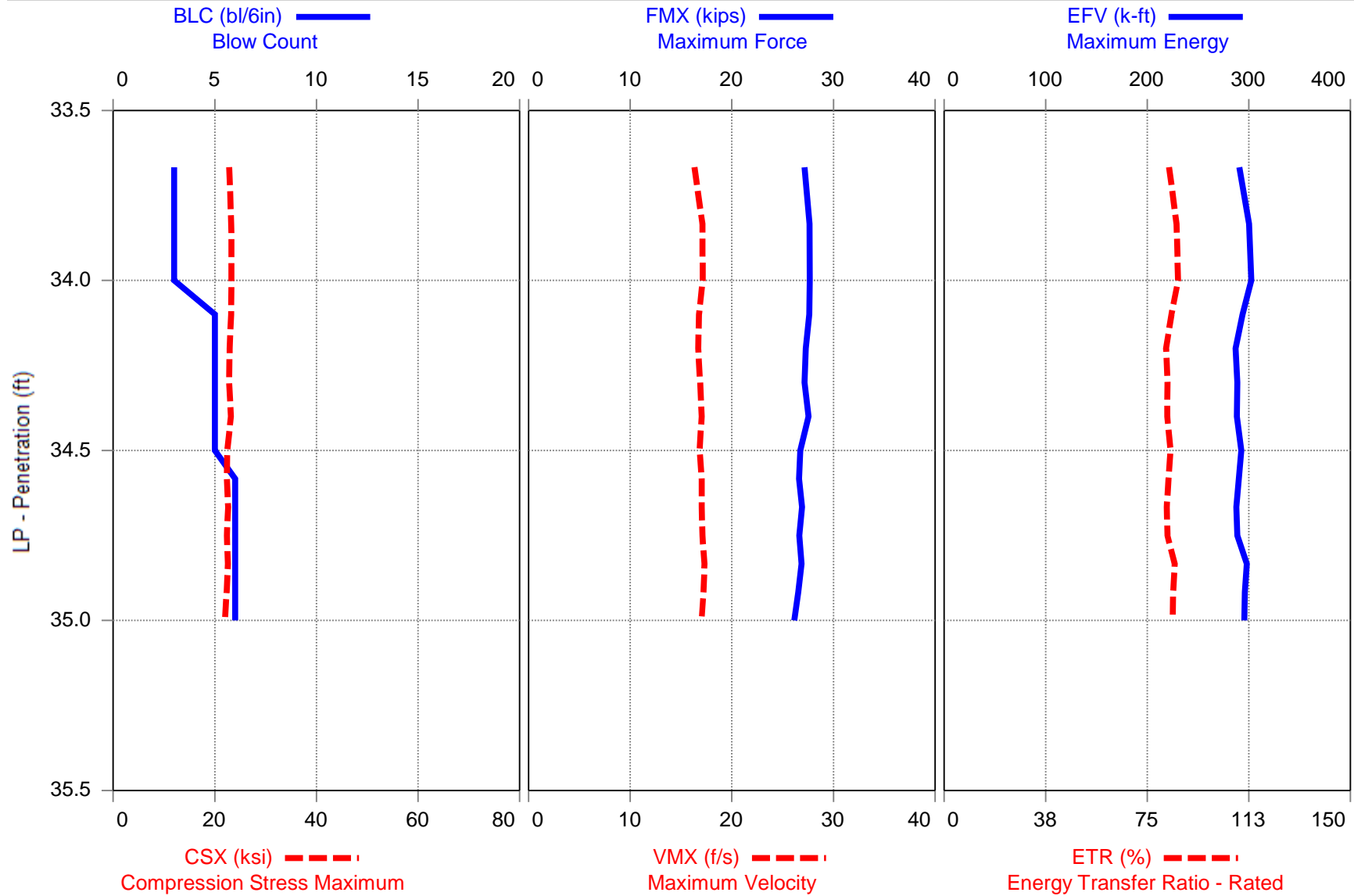
Project: CME 45B (SN 303304), Test Date: 3/11/2022

BPM: Blows/Minute						CSX: Compression Stress Maximum							
FMX: Maximum Force						DFN: Final Displacement							
VMX: Maximum Velocity						EFV: Maximum Energy							
DMX: Maximum Displacement						ETR: Energy Transfer Ratio - Rated							
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	N Value	N60 Value	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR %
33.60	28.50	30.00	4-6-7	13	17	53.4	24.2	16.1	1.1	20.3	0.9	277.5	79.3
38.60	33.50	35.00	3-5-6	11	14	58.3	26.9	17.0	1.1	22.6	1.1	291.4	83.3
43.60	38.50	40.00	4-6-9	15	20	55.5	24.7	16.0	0.9	20.7	0.8	286.8	81.9
Overall Average Values:						55.6	25.1	16.3	1.0	21.1	0.9	285.0	81.4
Standard Deviation:						2.0	1.2	0.5	0.2	1.0	0.2	6.3	1.8
Overall Maximum Value:						61.4	27.6	17.3	1.3	23.2	1.2	298.0	85.1
Overall Minimum Value:						53.2	23.2	15.6	0.7	19.5	0.7	273.5	78.2



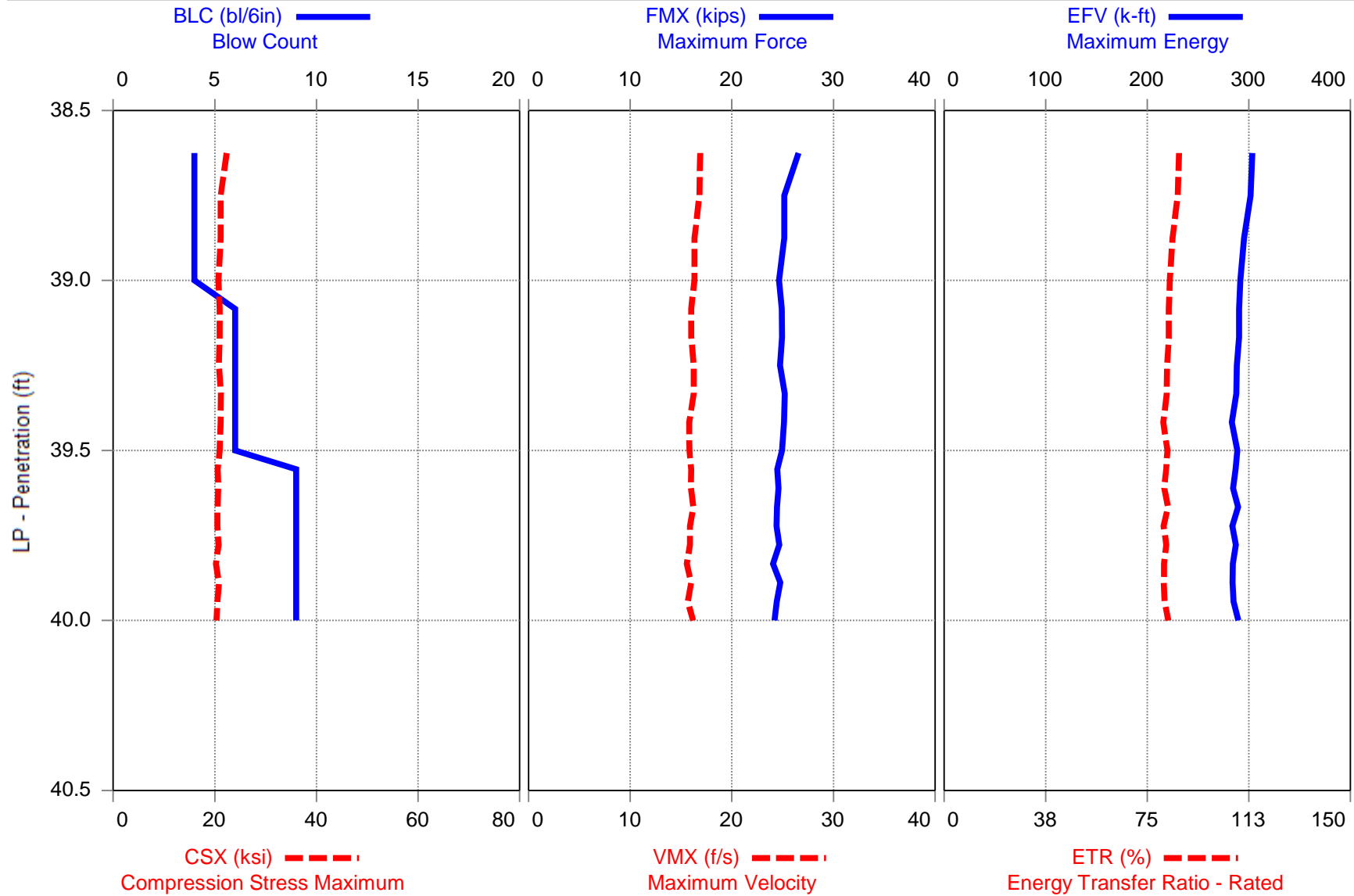
CME 45B (SN 303304) - 28.5 TO 30.0

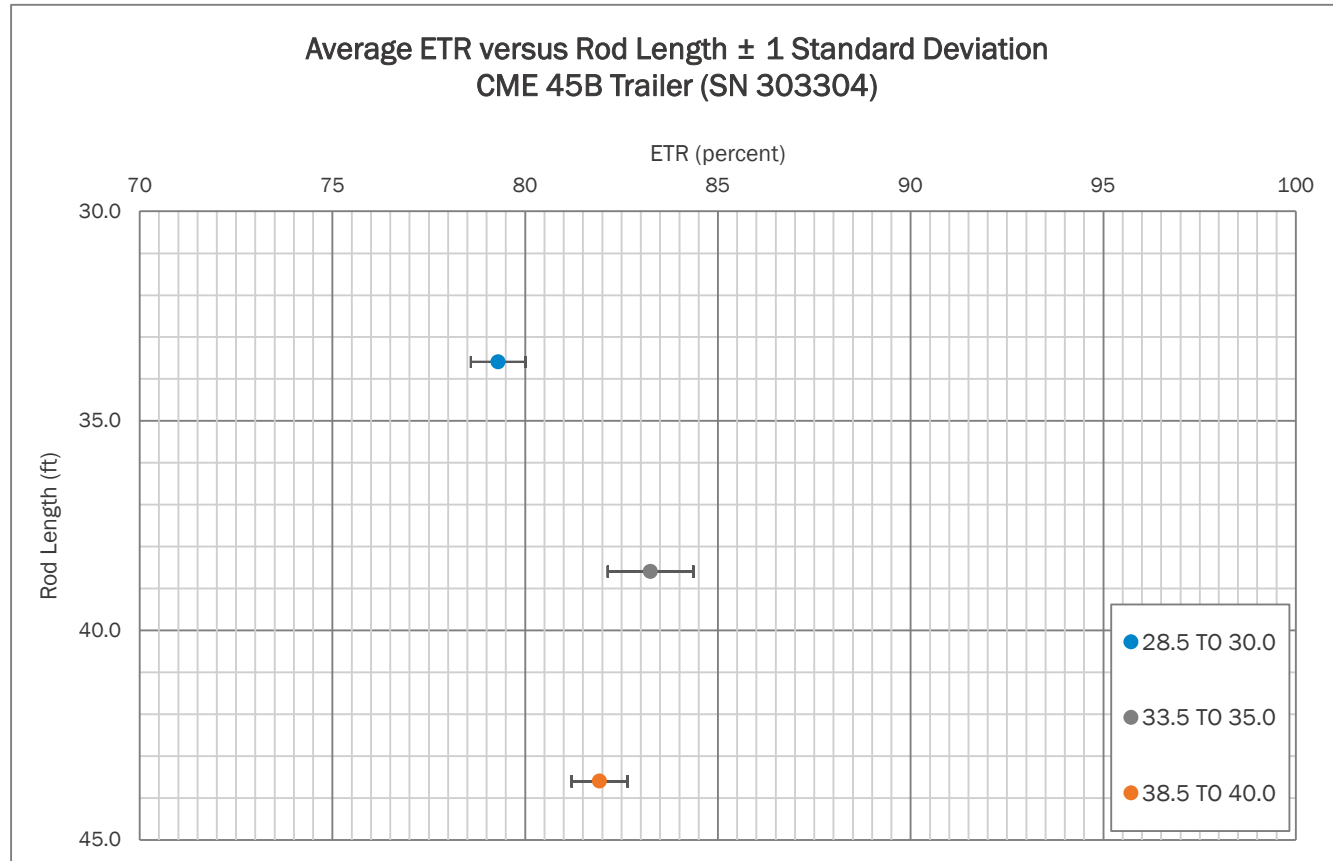
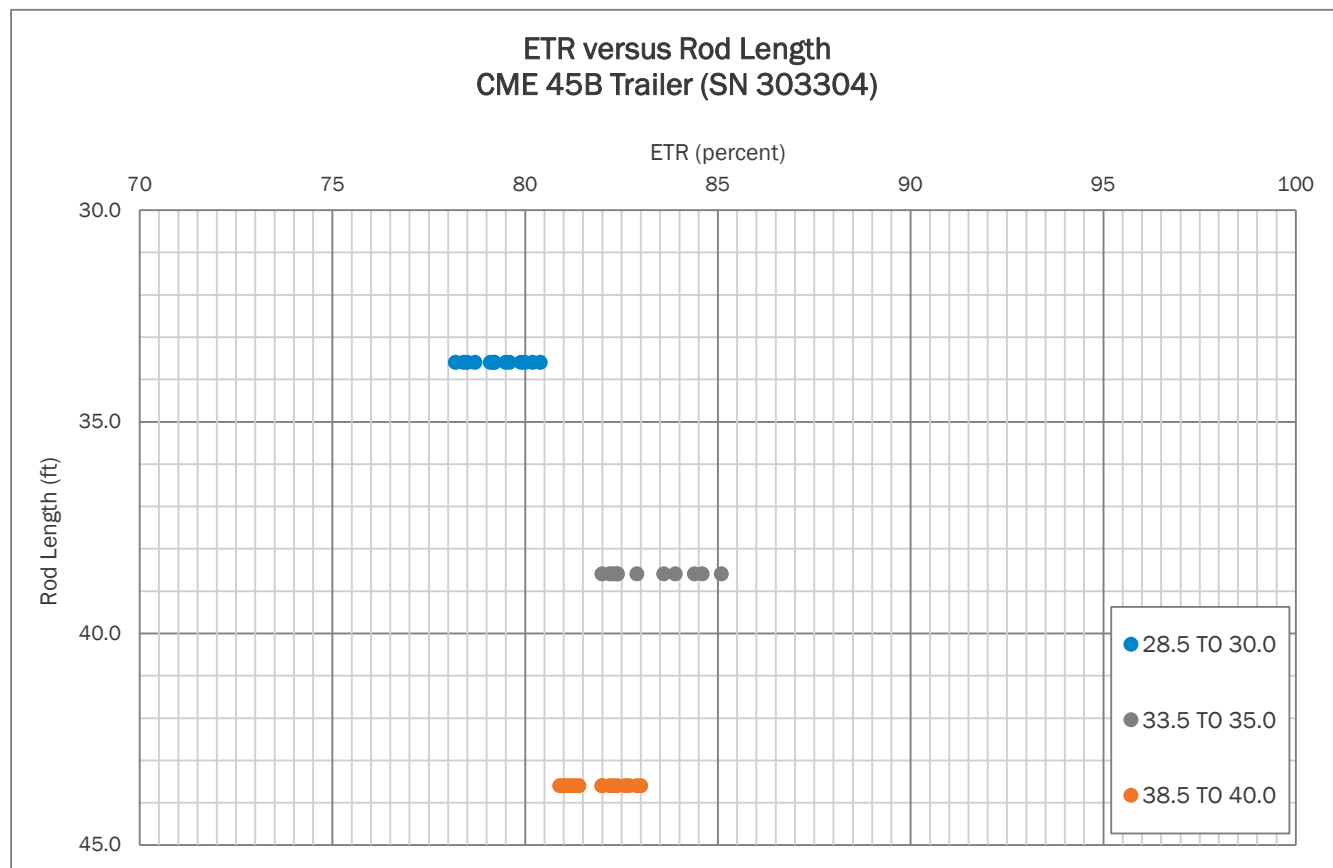






CME 45B (SN 303304) - 38.5 TO 40.0







APPENDIX II

SPT Hammer Energy Field Form

Project: SPT HAMMER ENERGY
Project No.: 240021095
Boring No.: B-1

Date: 3/11/2022
Weather: 50's CLOUDY
Drill Rod Type: AWJ

On-site Personnel

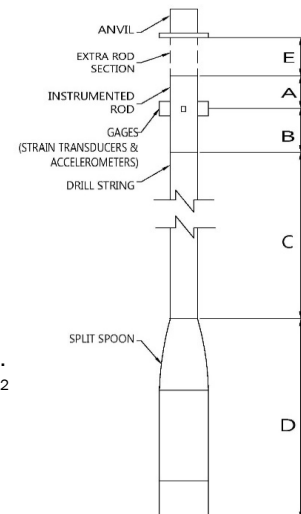
Drilling Company: BRECCIA CONSTRUCTION, LLC
 Rig Operator: D. HARRIS
 Engr/Geologist: N/A
 Client Rep.: N/A
 Analyzer Oper.: R. KRAL

Rig/Hammer Info

Drill Rig Make/Model: CME 45B
 Carrier Type: TRAILER
 Rig Serial No.: 303304 (DR-1)
 Hammer Type/Model: CME
 Hammer Serial No.: N/A
 Hammer Drop System: AUTO
 Lubrication Condition: PER MANUFACTURER
 Manufacturer Recommended
 Operation Rate (bpm): 55
 Drop Height (in.): 30
 Hammer Weight (lbs): 140
 Anvil Dimension (in.): 11.5
 Drilling Method: 2.25 HSA

Rod Info

(A + E) Impact Surface to Gages Length: 1.36 ft
(B) Instr. Rod Length below Gages: 0.70 ft
(A) + (B) Instr. Rod Length: 2.00 ft
(D) Spoon Length: 2.85 ft
(E) Rod Length Above Instr. Rod (if applicable): 0.06 ft
 Instr. Rod S/N: 528AWJ
 Instr. Rod Outside Dia.: 1.75 in.
 Instr. Rod Area: 1.19 in²
 PDA Make/Model: SPT
 PDA Serial No.: 4549 TB
 Calib. Pulse Test (y/n): Y



Gage Info

Gage		Serial No.	Calibration No.
Accel.	A3	K11957	407.00
	A4	K10959	417.30
Strain	F3	528AWJ-1	205.26
	F4	528AWJ-2	205.86

Date of Test	Test Depth Increment (ft to ft)	Test Time Start / Stop (military)	Length of Drill String (ft) (C)	(LE) Length below Gages (ft) (B) + (C) + (D)	Avg. Meas. Hammer Rate (BPM)	SPT Blow Counts				Drop Height in Tolerance (y/n)	Soil Class.
						6"	12"	18"	N-Value		
11-Mar	28.5 TO 30.0	0830/0830	30	33.6	53	4	6	7	13	Y	SA SI
11-Mar	33.5 TO 35.0	0837/0837	35	38.6	57	3	5	6	11	Y	SA SI
11-Mar	38.5 TO 40.0	0842/0843	40	43.6	56	4	6	9	15	Y	SA SI

Notes:

TESTING PERFORMED AT 1817 LOWRYS HIGHWAY IN CHESTER, SOUTH CAROLINA (CHESTER COUNTY). THE APPROXIMATE COORDINATES ARE 34.770585, - 81.245517.

NOTE: (1) Note any unusual hammer operating conditions that affect the hammer performance, or changes in operating conditions (e.g. verticality, weather, or lubrication between trials). (2) Note any changes in rod diameter along drill string and record locations of short rod sections.



Prepared By (print/signature)

3/11/2022
Date



Figure No. 1: Rear View of Drill Rig



Figure No. 2: Side View of Drill Rig



Figure No. 3: Serial Number Plate



Figure No. 4: Automatic Hammer

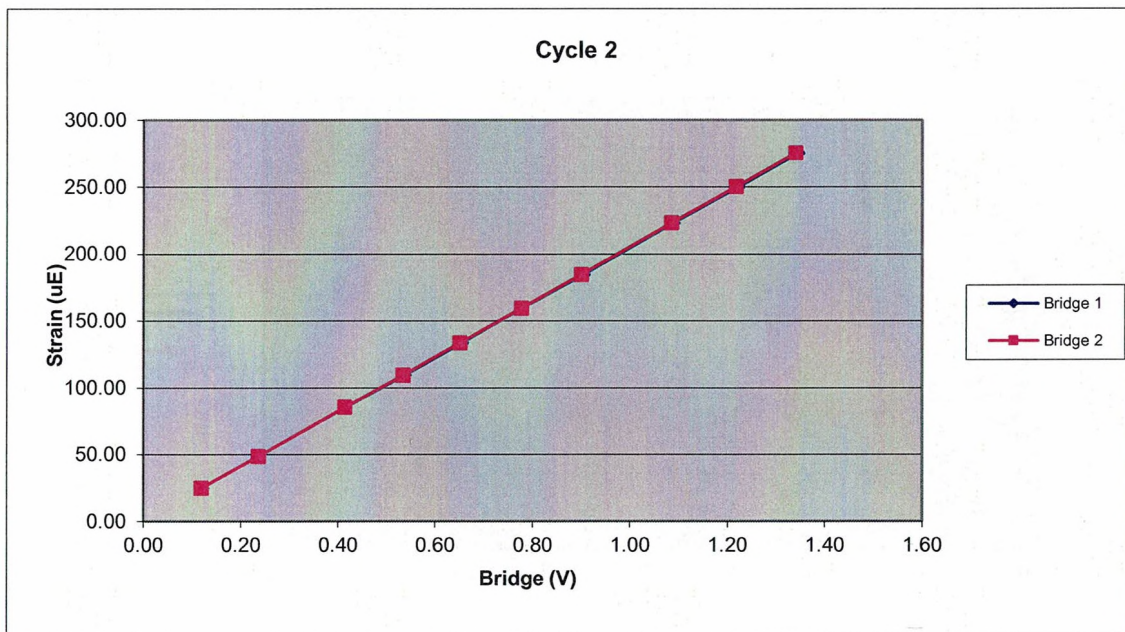


APPENDIX III

528AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	905.16	24.61	0.12	0.12
3	1753.20	48.18	0.24	0.24
4	3064.74	84.99	0.42	0.41
5	3947.87	108.99	0.54	0.53
6	4813.36	133.40	0.65	0.65
7	5727.49	159.02	0.78	0.78
8	6643.67	184.17	0.90	0.90
9	8004.82	222.89	1.09	1.09
10	8980.07	249.70	1.22	1.22
11	9885.91	275.04	1.35	1.34

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7340.27	Force Calibration (lb/V)	7362.32
Offset	12.98	Offset	13.21
Correlation	1.000000	Correlation	0.999999
Strain Calibration ($\mu\text{E}/\text{V}$)	204.74	Strain Calibration ($\mu\text{E}/\text{V}$)	205.35
Offset	-0.39	Offset	-0.39
Correlation	0.999993	Correlation	0.999995

Force Strain Calibration	
EA (Kips)	35851.72
Offset	27.08
Correlation	0.999996



528AWJ		Cycle 1		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1278.49	35.63	0.17	0.17
3	2188.92	61.59	0.30	0.30
4	3085.11	86.16	0.42	0.42
5	3944.56	110.01	0.53	0.54
6	5284.17	147.69	0.72	0.72
7	6199.57	172.59	0.84	0.84
8	7071.20	197.80	0.96	0.96
9	8023.54	224.47	1.09	1.09
10	8958.62	250.45	1.22	1.22
11	9876.55	276.81	1.34	1.34

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7346.16	Force Calibration (lb/V)	7359.87
Offset	9.71	Offset	6.72
Correlation	0.999998	Correlation	0.999999
Strain Calibration ($\mu\text{E/V}$)	205.65	Strain Calibration ($\mu\text{E/V}$)	206.03
Offset	0.08	Offset	-0.01
Correlation	0.999990	Correlation	0.999993

Force Strain Calibration	
EA (Kips)	35721.25
Offset	7.11
Correlation	0.999990



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

Calibration Factors	528AWJ		
Bridge 1 ($\mu\text{E/V}$)	205.26	Bridge 2 ($\mu\text{E/V}$)	205.86
EA Factor (Kips)	35777.05	Area (in^2)	1.19

Calibrated by: 

Calibrated Date: 1/28/2021

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 19Apr2021

Serial No: K10959 Temperature: 21.0 °C

Model: PR Humidity: 38%

Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR

417.3 mv/5000g
(83.5 μ v/g)
R²: 0.999987 [Chip programmed]

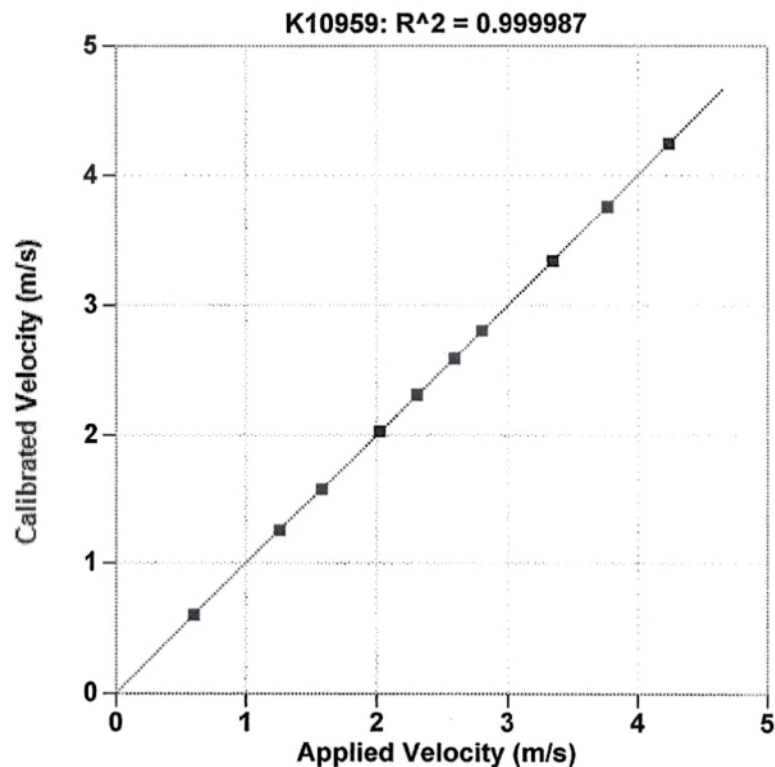
Operator: William Johnson

Ref Acc 1: 69096! Cal on: 27Jan2021
978 g's/volt

Ref Acc 2: 69132! Cal on: 09Feb2021
960 g's/volt


Signed

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



Reference Velocity	S/N K10959 Velocity
m/s	m/s
0.600	0.600
1.260	1.255
1.578	1.577
2.021	2.028
2.306	2.311
2.590	2.590
2.801	2.806
3.346	3.344
3.767	3.762
4.241	4.241
Maximum Acceleration: 938 g's	

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on 22Jan2021

Serial No: K10960 Temperature: 20.0 °C

Model: PR Humidity: 28%

Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR

425.7 mv/5000g

(85.1 μ v/g)

R²: 0.999987 [Chip programmed]

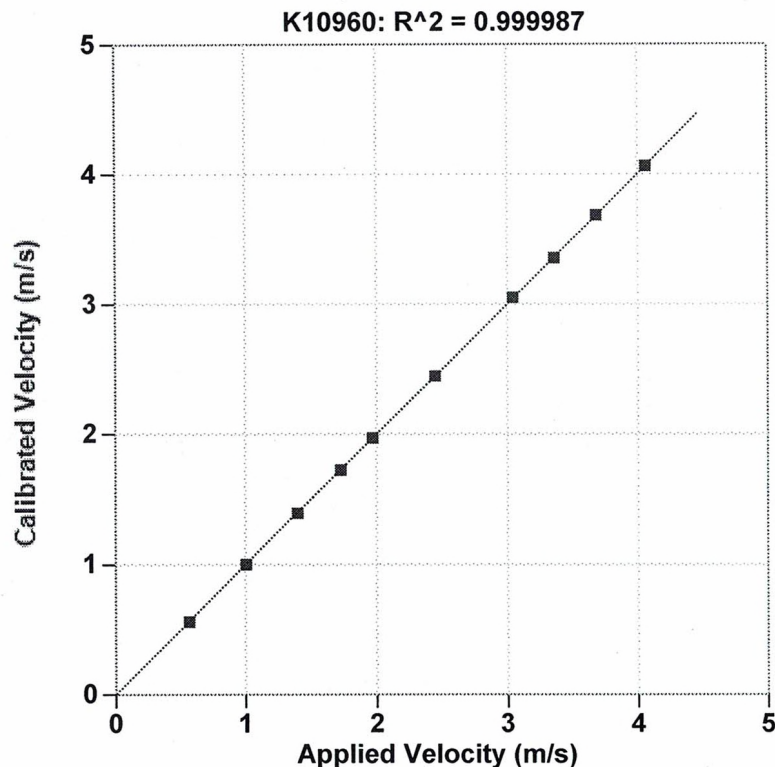
Operator: William Johnson

Ref Acc 1: 63479! Cal on: 09Sep2020
1080 g's/volt

Ref Acc 2: 65538! Cal on: 27Jan2020
1040 g's/volt


Signed

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



Reference Velocity	S/N K10960 Velocity
m/s	m/s
0.568	0.564
1.006	1.001
1.400	1.393
1.728	1.726
1.969	1.970
2.447	2.448
3.043	3.051
3.359	3.356
3.683	3.684
4.063	4.062

Maximum Acceleration: 889 g's

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on

MAR 2 2021

Serial No: K11957 Temperature: 20.0 °C

Model: PR Humidity: 27%

Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR

407.0 mv/5000g

(81.4 μ v/g)

R²: 0.999989 [Chip programmed]

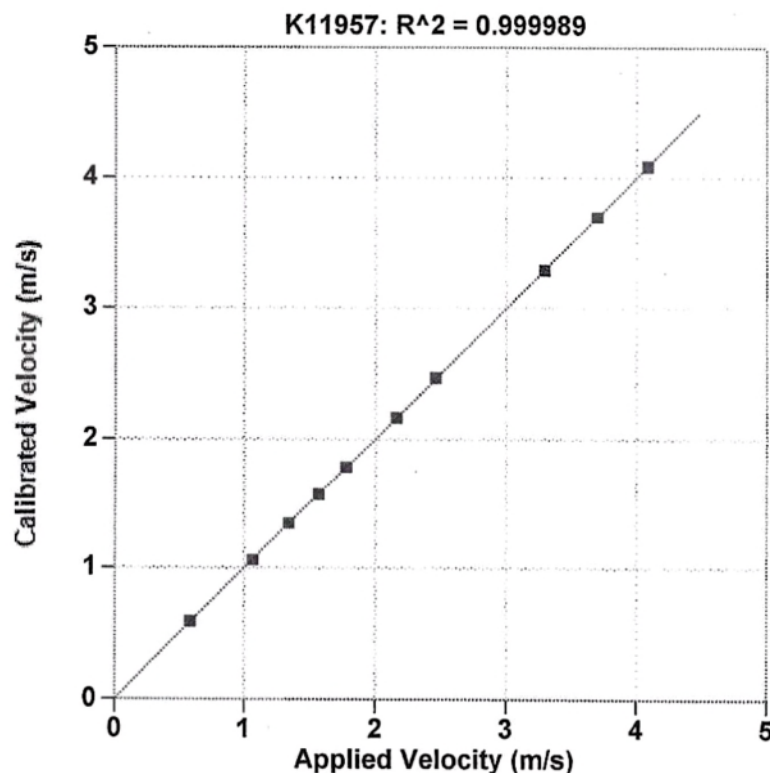
Operator: William Johnson

Ref Acc 1: 63479! Cal on: 22Jan2021
1079 g's/volt

Ref Acc 2: 65538! Cal on: 22Jan2021
1043 g's/volt


Signed

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



Reference Velocity	S/N K11957 Velocity
m/s	m/s
0.588	0.589
1.066	1.061
1.344	1.345
1.571	1.570
1.779	1.783
2.161	2.164
2.458	2.465
3.294	3.291
3.701	3.700
4.089	4.086
Maximum Acceleration: 894 g's	



APPENDIX IV



This documents that
Robert E. Kral
Carolinas Geotechnical Group
has on May 20, 2016 achieved the rank of
ADVANCED


on the Dynamic Measurement and Analysis Proficiency Test.

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

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** 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.


Steven A. Hall, Executive Director
Pile Driving Contractors Association




Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2072