Geotechnical Baseline Report

S-11-106 (Island Creek Rd.) Bridge Replacement over Suck 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 Baseline Report for the S-11-106 (Island Creek Rd.) Bridge Replacement over Suck 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

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

Nathan Yacobi

Nathan Yacobi, P.G.
Professional Geologist

SOUTH CAROLINA
LICENSED PROFESSIONAL ENGINEER
No. 24736
06-24-2022
EVANGELIA LEON

SOUTH CAROLINA
HDR ENGINEERING, INC. OF THE CAROLINAS
No. C0318
CERTIFICATE OF AUTHORIZATION

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

hdrinc.com

1201 Main Street, Suite 800 Columbia, SC 29201
T 803.509.6590

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1 Introduction

This Geotechnical Baseline Report (GBR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed S-11-106 Bridge Replacement over Suck Creek, in Cherokee County, South Carolina. The proposed bridge intends to replace the existing bridge over branch of Suck Creek on existing alignment.

This Geotechnical Baseline 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), bulk samples, rock cores, and a variety of laboratory tests are presented herein to provide geological features and site conditions for the design of the proposed bridge. Preliminary geotechnical considerations for design and construction are also included in this report.

1.1 Project Description

The project site is located northwest of Cowpens, approximately four miles south of the South Carolina/North Carolina State Line. It is bound to the west by Piedmont Road and to the east by Battleground Road. It is placed within an area experiencing a low volume of traffic. A Site Vicinity Map is included in Appendix A.

The existing bridge over branch of Suck Creek is approximately 35 feet in length and 25 feet wide and will be removed and replaced with a new bridge along the existing alignment. The proposed single span replacement bridge will be approximately 60 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, and bulk sample soil collection.

A test location plan showing all testing locations along with a subsurface profile are included in Appendix A. The boring logs and rock core photos 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-3 and B-4. Auger refusal was encountered in both borings at depths of 25.8 feet and 17.1 feet, respectively. Advancement of the bridge borings B-3 and B-4 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 40.8 feet and 32.1 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-2 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 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 8.4 feet and 8.1 feet, respectively. These depths correspond to elevations of 841.1 feet and 841.5 feet.

Stabilized groundwater levels recorded approximately 24 hours after completion of investigation operations indicated groundwater depths of 8.3 feet and 8.1 feet. These depths correspond to elevations of 841.2 feet and 841.5 feet.

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

2.3 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-3	31+80	4 RT	35.12295	-81.83403	849.5	SPT/RC	40.8
B-4	32+27	3 RT	35.12292	-81.83388	849.6	SPT/RC	32.1
BS-2	31+85	4 RT	35.12295	-81.83405	849.3	BULK	5.0

[a] Stations based on latest S-11-106 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	6
Atterberg Limits	4
Grain Size Analysis with Hydrometer	2
Grain Size Analysis with #200 Wash	4
CU Triaxial	1
Unconfined Compression of Rock	3
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-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty sand with gravel (SM) to clayey sand (SC). Tested samples yielded liquid limits ranging from 24 to 29 and plasticity indices ranging from 10 to 15.

Corrosion series test were performed on select split spoon samples. Standard proctor testing and remolded CU triaxial tests were performed on the collected bulk sample. Finally, three (3) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 10,490 psi to 26,420 psi. Results of laboratory testing are included in Appendix C.

4 Subsurface Conditions

4.1 Regional Geology

The bridge site is located on State Road S-11-106 just southeast of the Town of Chesnee in Cherokee County, South Carolina and crosses over Suck Creek which is part of the Broad River watershed (DHEC, 2016). It lies within the Piedmont Physiographic Province of South Carolina. The Piedmont Physiographic Province is bounded by the Blue Ridge Physiographic Province to the west and the Coastal Upper Coastal Plain Province to the east. With elevations ranging from 300 feet to 1,400 feet, the Piedmont Province is characterized by gently rolling topography, deeply weathered bedrock, few rock outcrops and complex geology with a multitude of rock types formed during the Paleozoic Era (250 to 570 MYA). The geology of this region is further complicated by the Alleghanian orogeny (325 to 260 MYA), the mountain building event which contributed to the formation of the present-day Appalachian Mountain chain, and subsequent deformation/metamorphism of the region (Butler, 1991). Soils overlying bedrock in the Piedmont are typically considered to be residual soils (soils weathered in place from bedrock). The contact between soil and bedrock is not strongly defined and is often marked by an intermediate transition zone. The materials of this zone can be soil, partially decomposed rock, and fragments of the underlying bedrock. Suck Creek provides a transport mechanism for soil eroded from higher elevations to be carried downstream and deposited along the banks of the creek including the proposed bridge site. The Piedmont Province lies far from the tectonic boundaries associated with seismic activity but does have a record of seismic events. Published geological maps of the region show the site is in proximity to the Kings Mountain terrane, Kings Mountain Shear Zone, and the Reedy River Fault Zone (Horton et al, 2001).

4.2 Soil and Rock Stratification

In general, the soil profile is dominated by very loose clayey sand, loose silty sand and dense sand with silt. These comprise the alluvial and residual soils overlying the partially weathered rock (PWR) layer of variable thickness developed upon the metamorphosed schist bedrock. Bedrock was intercepted within a depth of 17 to 26 feet from the existing ground.

Roadway fill consisting of medium dense, roadway aggregate and asphalt, and very loose clayey gravel, was interpreted to comprise the top 4 feet of the profile of boring B-3. The underlying alluvial soil is very loose clayey sand, with a varying thickness of 4 feet to 11 feet across borings B-3 and B-4. Residual soils consisting of dense sand with silt and loose silty sand are found below alluvium. The thickness of the residual soils zone ranged from 4 feet to 5 feet between borings B-3 and B-4. PWR is found underlying the residual soils as very dense silty sand with rock fragments and as saprolite with a thickness of approximately 0.5 feet to 13 feet and represents the transitional zone between soil and rock. Schist is the bedrock underlying the project site. Recovered rock core was in general highly to completely weathered and is heavily jointed and fractured with abundant clay infilling in discontinuities. Discontinuities were spaced very close with rough to slightly rough joint surfaces. A blue green secondary mineralization, possibly epidote or chlorite, is present in the core and infilling joints in the bottom half of core along with pyrite and

orange and red oxidation from pyrite is present as surface staining in discontinuities and across the core surface. Rock core recovery was typically above 63 percent, RQD ranged from 7 to 60 percent, and rock unconfined compression testing revealed strong to very strong rock with values ranging from 10,490 psi to 26,420 psi.

A summary of the main strata intercepted by the soil test borings is provided in Table 4-1 below. A subsurface profile developed based on the collected soil and rock information is included in Appendix A.

Table 4-1. Soil and Rock Stratification

Geology	Top of Layer Elev. (ft)	USCS Soil Type	SPT-N (1)	Plasticity Index(1)	Fines Content(1)	Recovery / RQD(1)	Unconfined Compressive Strength(2)
Roadway Fill	849	GC	3-6 (5)	-	-	-	-
Alluvium	849-845	SC	2-4 (3)	10-15 (13)	37-44 (42)	-	-
Residuum	841-838	SM, SP-SM	10-31 (21)	-	24	-	-
PWR	837-833	SM	100+	-	18	-	-
Rock	833-824	-	-	-	-	63-100% / 7-60% (82%) / (31%)	10,490 – 26,420 psi

(1) Values in parentheses indicate the average of the values in the range
(2) Testing performed on intact rock samples.

5 Design and Construction Considerations

5.1 Foundations

Driven steel H-piles are anticipated to be the most feasible foundation type for the proposed bridge abutments. Based on Table 9-3 in SCDOT GDM 2022, assuming redundant piles, a resistance factor of 0.5 will be used for design if wave equation is applied for verification and a resistance factor of 0.65 will be used assuming Dynamic Monitoring (PDA) with wave equation analysis. It is anticipated that foundation piles will be installed following the approach embankment construction. If for any reason foundation piles will already be in-place when the approach embankment construction begins, foundation pile design must account for any downdrag loads subjected to the piles.

Due to the variability in the rock surface or thickness of weathered rock underlying the site, tip elevations are also anticipated to exhibit variability across the site. For piles driven to practical refusal in PWR or rock their resistance will be limited by their structural resistance. Reinforced pile tips will be required to penetrate to PWR and rock. The wave equation analysis should be performed for predicting the drivability of piles along with estimating stresses during driving and in general, verifying the ability of the Contractor's selected hammer to drive the piles to the desired penetration while preventing overstressing.

Due to the potential of encountering shallow rock at the pile locations, pile pre-drilling may be required for the pile installation. The water table level may have an impact on the pre-drilled hole stability. If unstable soil conditions are encountered at these locations, temporary casing may be required to stabilize the pre-drilled holes. Pre-drilling is expected to encounter seams of hard rock within the PWR zone overlying bedrock as well as very hard rock conditions within the competent bedrock.

5.2 Corrosion and Deterioration

Corrosion testing of a representative split spoon sample was performed by F&ME Consultants and the results are included in Appendix C. The full corrosion and deterioration testing results included pH, resistivity, chlorides and sulfates content and are summarized in Table 5-1 below.

Table 5-1. Corrosion Series Laboratory Testing Summary

Test Hole No.	Alignment	Station	Offset	Sample Depth (ft)	Chloride (ppm)	Sulfate (ppm)	pH	Resistivity (ohm·cm)
B-4	S-11-106	32+27	3 RT	6.6-10.6	< 10	28	6.1	16,310

Based on the criteria set forth in section 7.18 in SCDOT GDM 2022, the environmental classification of the project site is non-aggressive. Interpretation of these data shall be communicated with the structural engineer for the project.

5.3 Embankment Construction

Some fill quantities may be required for construction of the embankments on this project. Assuming that the majority of embankment construction will utilize the available on-site materials, a bulk sample obtained from the top 5 ft of existing embankment material along the alignment was obtained to provide a better characterization of the material locally available. The bulk samples were tested for soil classification and was also remolded and compacted to 95% of the Standard Proctor prior to being tested under CU Triaxial Compression. Results are summarized in Table 5-2 below.

Table 5-2. Bulk Sample Testing Summary

Sample No.	Station	Offset (ft)	Sample Depth (ft)	USCS Soil Type	Compaction		Shear Strength			
					Optimum Moisture (%)	Max Dry Density (pcf)	c' (psf)	φ' (°)	c (psf)	φ (°)
BS-2	31+85	4 RT	0.0-5.0	CL	16.7	111.7	39	37.4	147	11.3

6 Limitations to Report

This report has been prepared in general accordance with procedures in SCDOT GDM Chapter 21 and generally accepted soil and foundation engineering practices for specific application to the proposed S-11-106 Bridge over Suck Creek in Cherokee County, South Carolina. No other warranty expressed or implied is made. The Geotechnical Engineer of Record for the project must review the data submitted in this report and develop their own interpretation of the testing results as they apply to design. 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.

7 References

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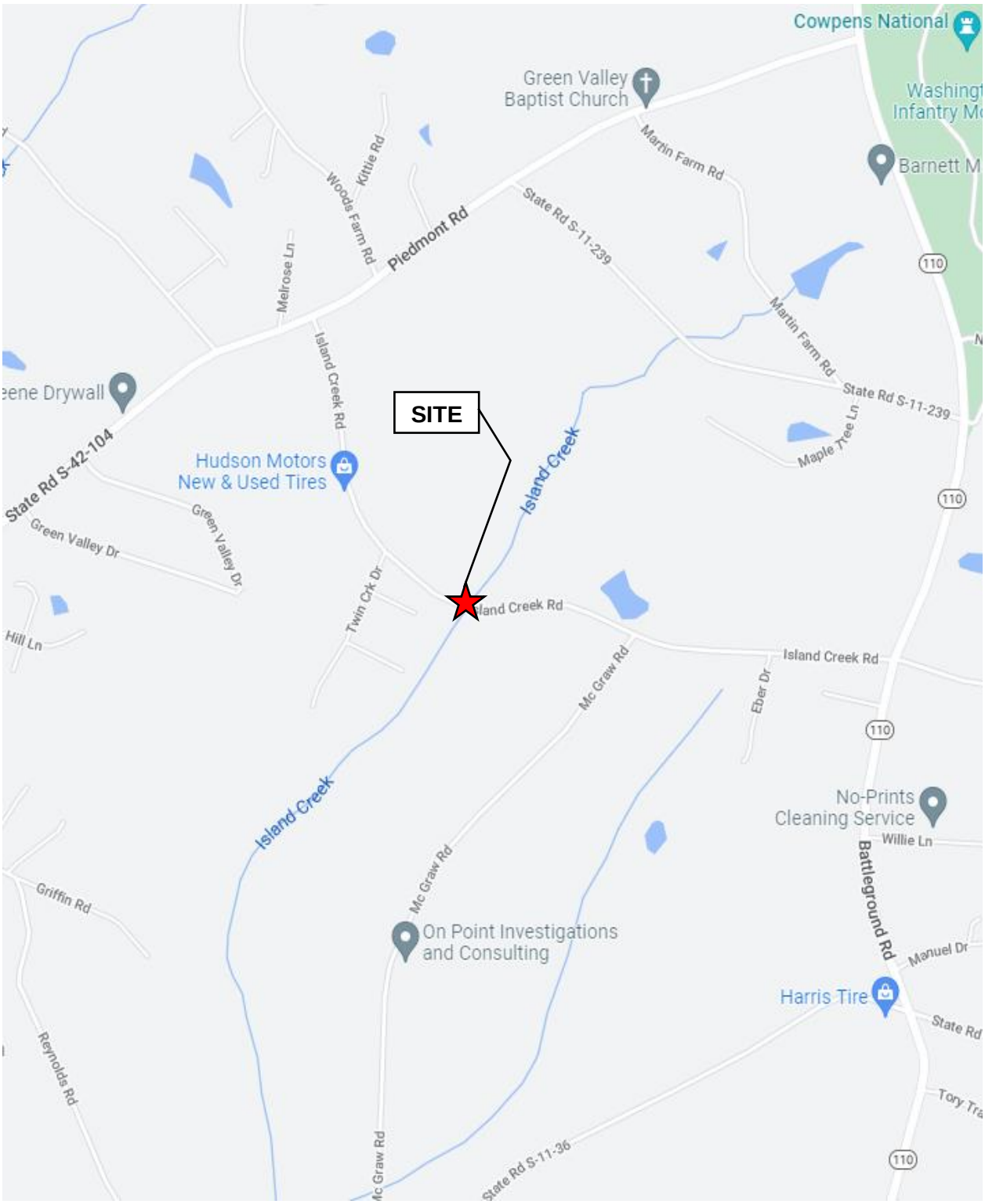
Appendix A. Site Vicinity Map, Test Location Plan, Subsurface Profile

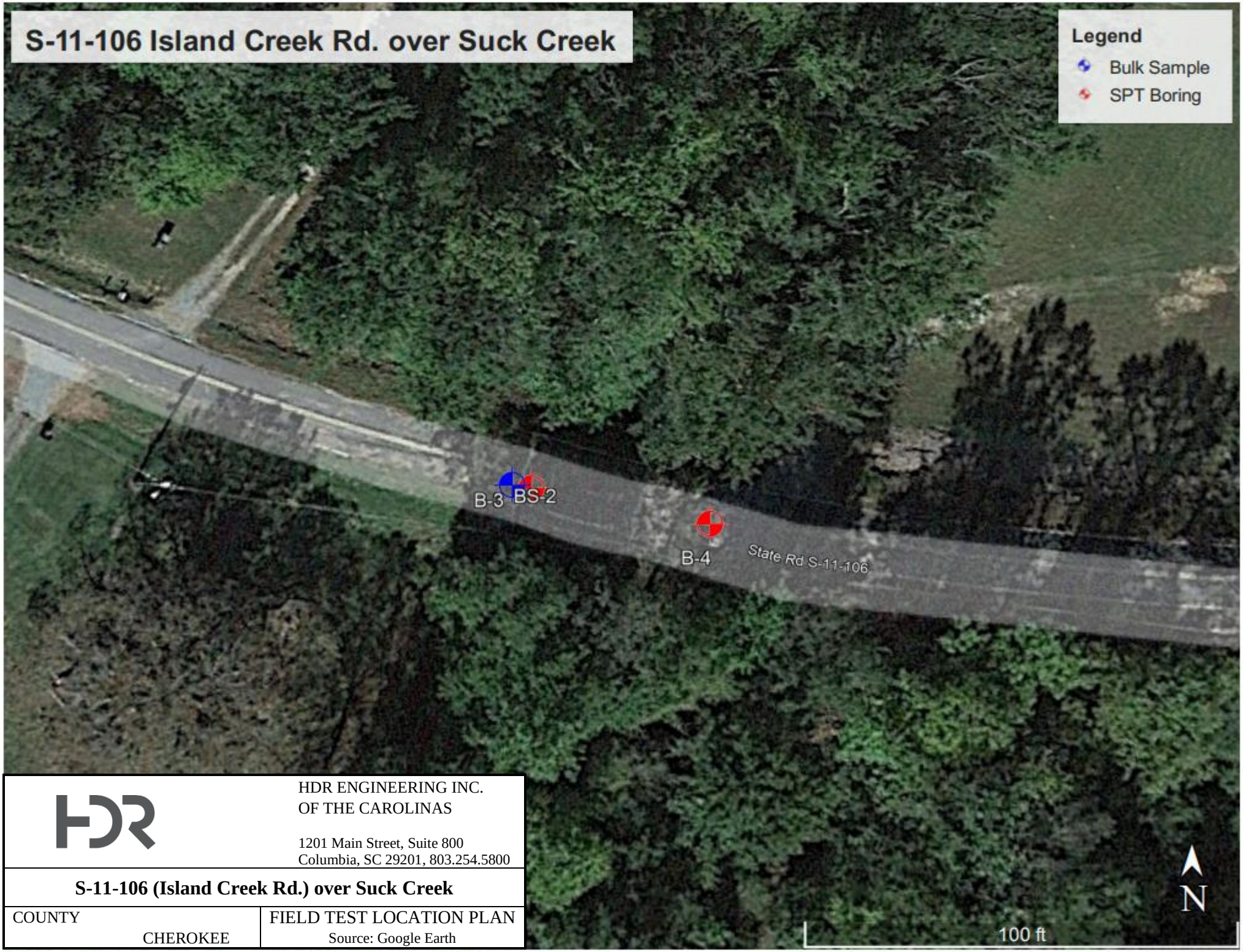


HDR ENGINEERING INC.
OF THE CAROLINAS

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

S-11-106 (Island Creek Rd.) over Suck Creek

COUNTY	SITE VICINITY MAP
CHEROKEE	Source: Google Maps



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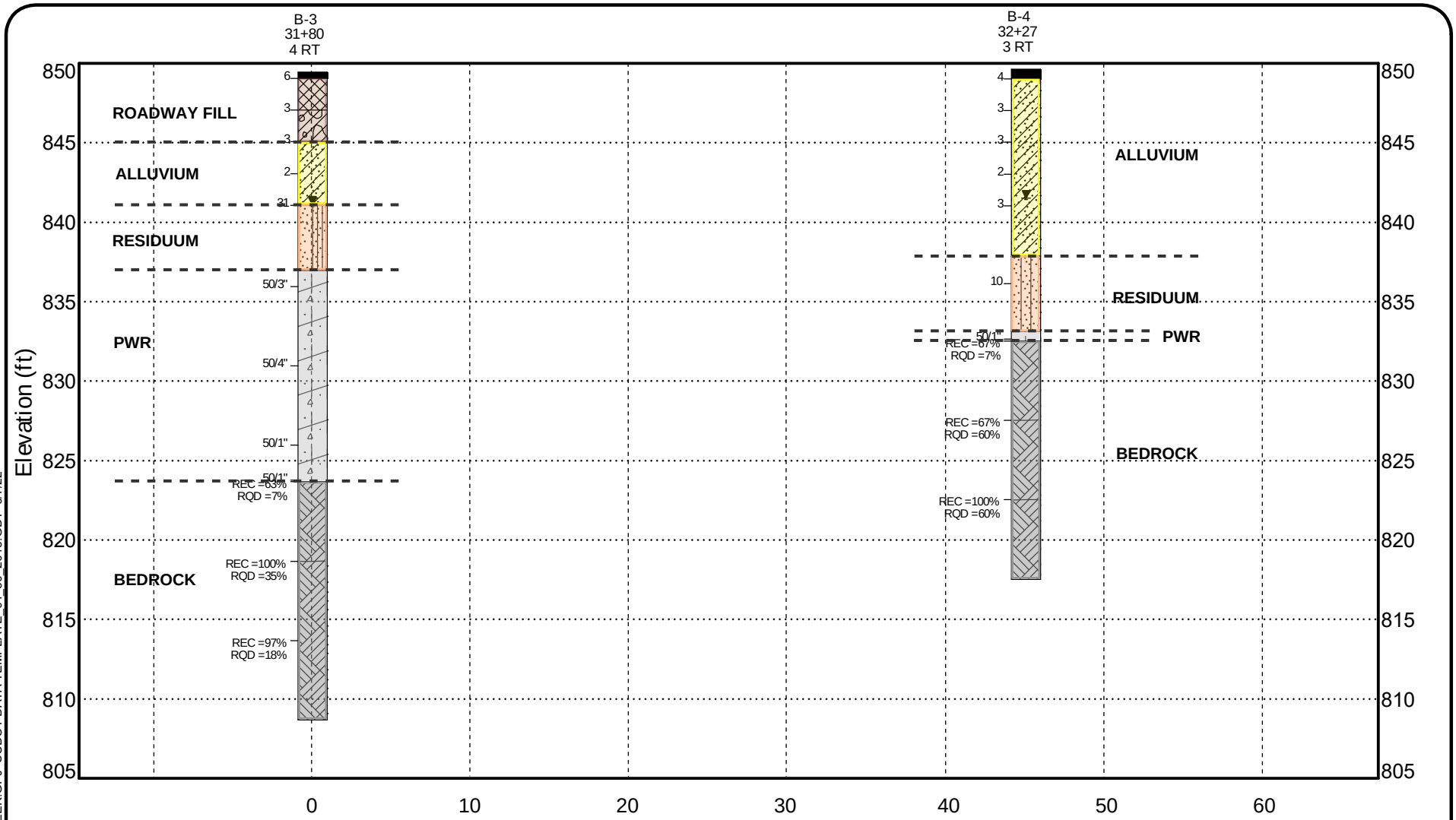
Columbia, SC 29201, 803.254.5800

S-11-106 (Island Creek Rd.) over Suck Creek

COUNTY	FIELD TEST LOCATION PLAN
CHEROKEE	Source: Google Earth



BORING	ELEVATION	STATION	OFFSET
B-3	849.5	31+80	4 RT
B-4	849.6	32+27	3 RT

Roadway Fill - Clayey Gravel (GC/A-1-b)

Aluvium - Clayey sands (SC/A-4, A-6)

Residuum - Sand with Silt, Silty Sand (SP-SM, SM/A-3, A-2-4)

PWR - Silty Sand with rock fragments (SM/A-2-4)

BEDROCK - Schist

HDR ENGINEERING INC.
OF THE CAROLINAS
1201 Main Street, Suite 800, Columbia, SC 29201
803.254.5800

SUBSURFACE PROFILE

S-11-106 (Island Creek Rd.) over Branch of Suck Creek

Cherokee, SC County, South Carolina

PROJECT ID.	DATE	PLATE
P041149	Jun 2022	1

HDR FENCE S-11-106 RBO BRANCH OF SUCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 6/7/22

Appendix B. Boring Logs; Rock Core Photos

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
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]

Descriptive Term	Relative Density	SPT Blow Count
Very Loose	0 to 15%	< 4
Loose	16 to 35%	5 to 10
Medium Dense	36 to 65%	11 to 30
Dense	66 to 85%	31 to 50
Very Dense	86to 100%	>51

Consistency[2]

Descriptive Term	Unconfined Compression Strength (q_u) (tsf)	SPT Blow Count
Very Soft	<0.25	<2
Soft	0.26 to 0.50	3 to 4
Firm	0.51 to 1.00	5 to 8
Stiff	1.01 to 2.00	9 to 15
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 **Angularity**[1]

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 Reaction**[3]

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 **Cementation**[3]

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 Range**[1]

Gravel

	mm	Sieve size
Fine	4.76 to 19.1	#4 to ¾ inch
Coarse	19.1 to 76.2	¾ inch to 3 inch

Sand

	mm	Sieve size
Fine	0.074 to 0.42	#200 to #40
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

[1]Applies to coarse-grained soils (major portion retained on No. 200 sieve)
[2]Appiles to fine-grained soils (major portion passing No. 200 sieve)
[3]Use 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

Descriptive Term	Criteria
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.

Size

Descriptor	mm	Sieve size
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

Shape

Descriptive Term	Criteria
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.

Description	Recognition
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**

F - Fault
J - Joint
Sh - Shear
Fo - Foliation
V - Vein
B - Bedding

s **Discontinuity Width (millimeters)**

W - Wide (12.5 – 50)
MW - Moderately Wide (2.5 – 12.5)
N - Narrow (1.25 – 2.5)
VN - Very Narrow (< 1.25)
T - Tight (0)

t **Amount of Infilling**

Su - Surface Stain
Sp - Spotty
Pa - Partially Filled
Fi - Filled
No - None

u **Type of Infilling**

Cl - Clay
Ca - Calcite
Ch - Chloride
Fe - Iron Oxide
Gy - Gypsum/Talc
H - Healed
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand

v **Surface Shape of Joint**

Wa - Wavy
Pl - Planar
St - Stepped
Ir - Irregular

w **Discontinuity Spacing (feet)**

EW Extremely Wide (> 65)
W Wide (22 – 65)
M Moderate (7.5 – 22)
C Close (2 – 7.5)
VC Very Close (< 2)

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

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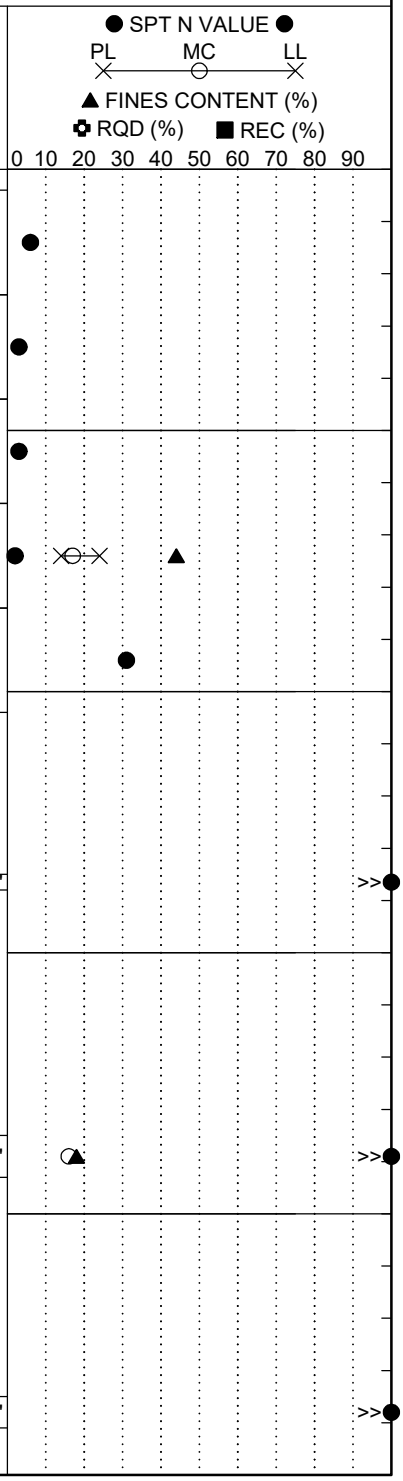
1201 Main Street, Suite 800 Columbia, SC 29201
T 803.254.5800

SCDOT Soil Test Log

Project ID:	P041149	**County:**	Cherokee, SC	**Boring No.:**	B-3		
Site Description:	S-11-106 (Island Creek Rd.) over Branch of Suck Creek			**Route:**	S-11-106		
Eng./Geo.:	N. Yacobi/ HDR	**Boring Location:**	31+80	**Offset:**	4 RT	**Alignment:**	S-11-106
Elev.:	849.5 ft	**Latitude:**	35.12295	**Longitude:**	-81.83403	**Date Started:**	5/4/2022
Total Depth:	40.8 ft	**Soil Depth:**	25.8 ft	**Core Depth:**	15 ft	**Date Completed:**	5/4/2022
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** 8.4 ft	**24HR**	8.3 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION
	0.0	
	0.4	0.4' ASPHALT
		ROADWAY FILL - Medium dense, dry, black and gray, roadway aggregate with asphalt. 2.5/N 5G5/1
	2.4	Very loose, wet, black and reddish brown, subangular, weakly cemented, fine to medium grained, Clayey GRAVEL (GC/A-1-b). 5YR2.5/1 5YR4/4
	4.4	**ALLUVIUM -** Very loose, wet, reddish brown, suabngular, weakly cemented, Clayey SAND (SC/A-4). 5YR4/4
844.5		LL=24, PL=14, PI=10, NMC=17.3, %200=43.6
	8.4	**RESIDUUM -** Dense, wet, brown and gray, subangular, weakly cemented, fine to coarse grained, SAND with Silt (SP-SM/A-3), micaceous. 7.5YR5/3 10GY6/1
839.5		
	12.5	**PARTIALLY WEATHERED ROCK (PWR)** Very dense, wet, black/gray/brown, angular, fine to coarse grained, Silty SAND with Gravel (SM/A-2-4) and Partially Weathered Rock. 2.5/N 10GY4/1 7.5YR3/3
834.5		
		NMC=15.9, %200=17.5
829.5		
		Auger and split-spoon refusal at 25.8'.

Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
0.4	SS-1	6	4	2	2	6
2.4	SS-2	2	2	1	2	3
4.4	SS-3	2	2	1	3	3
6.4	SS-4	1	1	1	1	2
8.4	SS-5	6	10	21	21	31
13.5	SS-6	50/3"				50/3"
18.5	SS-7	20	50/4"			50/4"
23.5	SS-8	50	50/1"			50/1"



LEGEND

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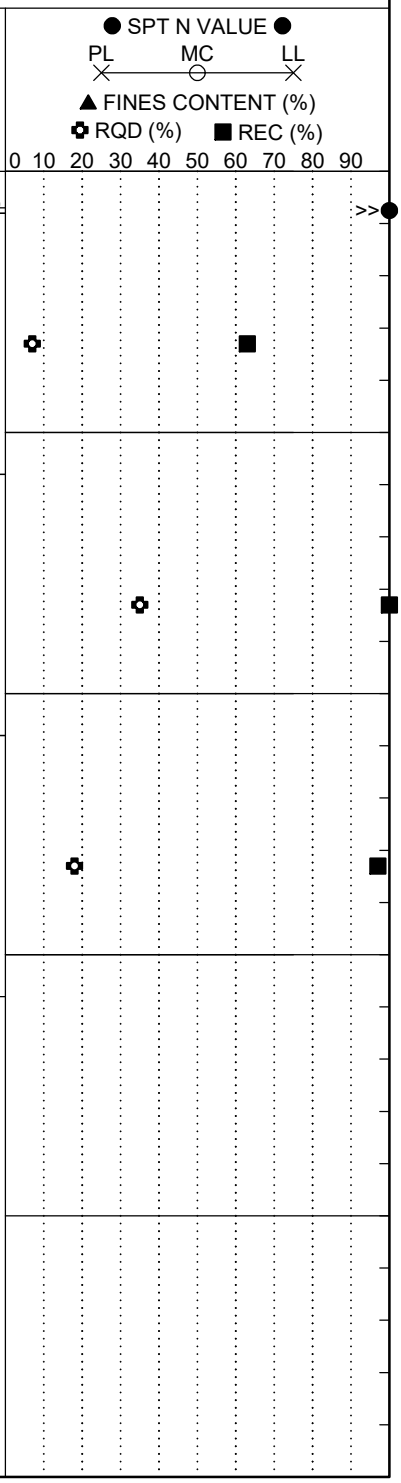
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041149			**County:**	Cherokee, SC	**Boring No.:**	B-3
Site Description:	S-11-106 (Island Creek Rd.) over Branch of Suck Creek					**Route:**	S-11-106
Eng./Geo.:	N. Yacobi/ HDR	**Boring Location:**	31+80	**Offset:**	4 RT	**Alignment:**	S-11-106
Elev.:	849.5 ft	**Latitude:**	35.12295	**Longitude:**	-81.83403	**Date Started:**	5/4/2022
Total Depth:	40.8 ft	**Soil Depth:**	25.8 ft	**Core Depth:**	15 ft	**Date Completed:**	5/4/2022
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** 8.4 ft	**24HR**	8.3 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	25.8	Begin coring.	25.7		50/1"				50/1"
		SCHIST: gray/black with reddish orange oxidation, very coarse to coarse grained, nonfoliated, highly to completely weathered, weak rock, low hardness, many rubble zones. Very close joint spacing, moderately wide to narrow, irregular joint surfaces, rough to smooth, filled with clay. 10Y7/1 5GY3/1 10R6/6	25.8	NQ-1					
819.5	30.8	NQ-1: %REC=63, RQD=7, 3.9 min/ft, GSI=30-35	30.8						
		Very coarse to medium grained, slightly to thinly foliated, slightly weathered, very strong rock, hard rock. Very close joint spacing, tight to open, very narrow to narrow, irregular joint surfaces, slightly rough to smooth, filled with blue/green secondary mineralization and pyrite.		NQ-2					
814.5		NQ-2: %REC=100, RQD=35, 3.3 min/ft, qu=13,470 psi, RMR=41, GSI=50-55	35.8						
		NQ-3: %REC=97, RQD=18, 3.5 min/ft, GSI=50-55		NQ-3					
809.5	40.8	Boring Terminated at 40.8' (Elev. 808.7')							
804.5									



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	

SC_DOT S-11-106 RBO BRANCH OF SUCK CREEK.GPJ SCDOT_DATATEMPLATE.GDT 6/6/22

Rock Core Photos

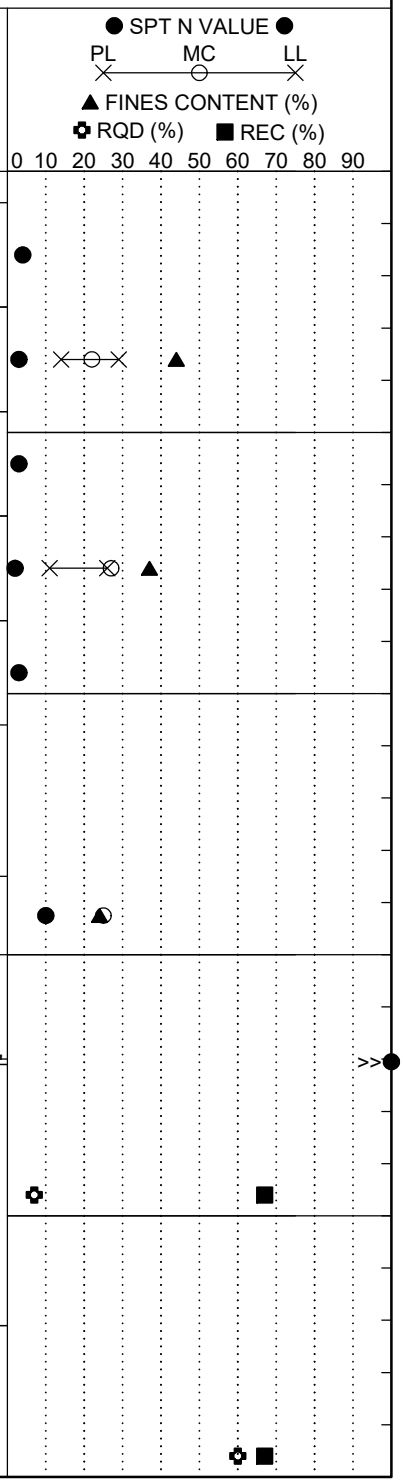
B-3
Box 1 of 2 (25.8’ to 35.8’)

B-3
Box 2 of 2 (35.8’ to 40.8’)

SCDOT Soil Test Log

Project ID:	P041149			**County:**	Cherokee, SC	**Boring No.:**	B-4
Site Description:	S-11-106 (Island Creek Rd.) over Branch of Suck Creek					**Route:**	S-11-106
Eng./Geo.:	N. Yacobi/ HDR	**Boring Location:**	32+27	**Offset:**	3 RT	**Alignment:**	S-11-106
Elev.:	849.6 ft	**Latitude:**	35.12292	**Longitude:**	-81.8339	**Date Started:**	5/4/2022
Total Depth:	32.1 ft	**Soil Depth:**	17.1 ft	**Core Depth:**	15 ft	**Date Completed:**	5/4/2022
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** 8.1 ft	**24HR**	8.1 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0								
	0.6	0.6' ASPHALT	0.6						
		ALLUVIUM - Very loose, wet, red and brown, subangular, weakly cemented, fine to coarse, Clayey SAND (SC/A-6). 7.5R4/6 5YR5/4 LL=29, PL=14, PI=15, NMC=22.4, %200=44.2	2.6	SS-1	2	1	3	2	4
			4.6	SS-2	2	1	2	2	3
844.6				SS-3	2	1	2	2	3
		LL=26, PL=11, PI=15, NMC=27.2, %200=37.3 (%Silt=18.7, %Clay=18.6)	6.6	SS-4	1	0	2	6	2
			8.6	SS-5	1	1	2	4	3
839.6									
	11.8	**RESIDUUM -** Loose, wet, brown and dark gray, subangular, weakly cemented, fine to coarse grained, silty SAND (SM/A-2-4), micaceous. 7.5YR4/4 10GY3/1 NMC=24.6, %200=24.2	13.5	SS-6	5	5	5		10
834.6									
	16.5								
	17.1	**PARTIALLY WEATHERED ROCK (PWR)** Very dense, SAPROLITE Auger and split-spoon refusal at 17.1' Begin coring.	17.0 / 17.1		50/1"				50/1"
829.6		**SCHIST**: gray and black with orange/red oxidation, coarse grained, slight and very thin foliation, highly weathered, weak rock, low hardness. Very close joint spacing, open to moderately open, irregular joint surfaces, rough to slightly rough, surface stain, oxidation and discoloration throughout. 10Y7/1 5GY3/1 10R6/6 NQ-1: %REC=67, RQD=7, 2.8 min/ft, GSI=25-30		NQ-1					
	22.1		22.1						
				NQ-2					



LEGEND

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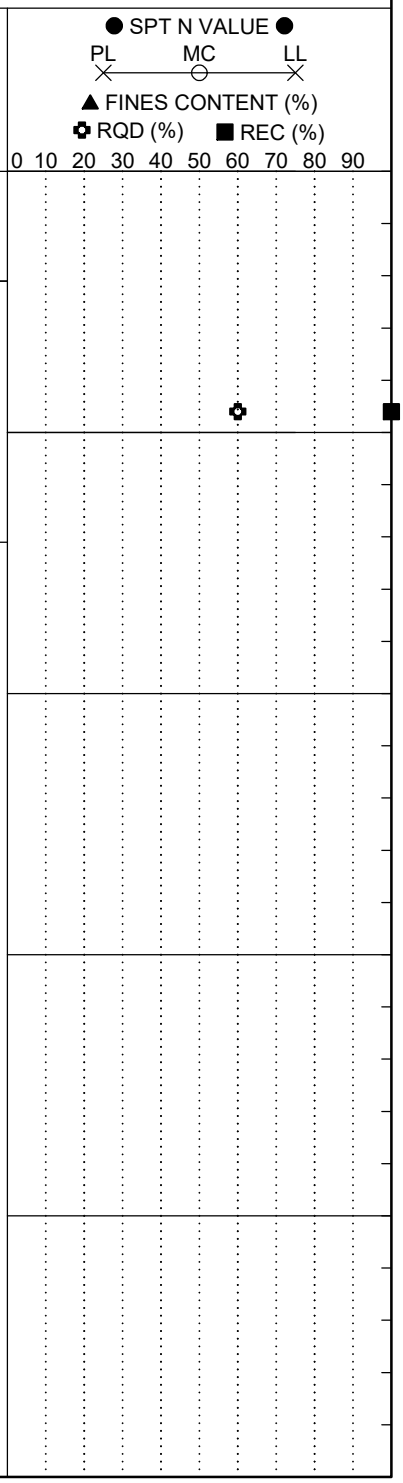
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041149			**County:**	Cherokee, SC	**Boring No.:**	B-4
Site Description:	S-11-106 (Island Creek Rd.) over Branch of Suck Creek					**Route:**	S-11-106
Eng./Geo.:	N. Yacobi/ HDR	**Boring Location:**	32+27	**Offset:**	3 RT	**Alignment:**	S-11-106
Elev.:	849.6 ft	**Latitude:**	35.12292	**Longitude:**	-81.8339	**Date Started:**	5/4/2022
Total Depth:	32.1 ft	**Soil Depth:**	17.1 ft	**Core Depth:**	15 ft	**Date Completed:**	5/4/2022
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** 8.1 ft	**24HR**	8.1 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
		Coarse to medium grained, slight and thin foliations, slightly weathered, stong to very strong rock, hard. Very close joint spacing, tight to open, irregular joint surfaces, rough to slightly rough, no filling.								
	27.1	NQ-2: %REC=67, RQD=60, 3.7 min/ft, qu=10,490 psi, RMR=46, GSI=65-70		27.1						
819.6		Appearence of blue/green secondary mineralization at end of run, partial pyrite infilling in joints, few garnets (10-15mm) on core surface.			NQ-3					
	32.1	NQ-3: %REC=100, RQD=60, 3.3 min/ft, qu=26,420 psi, RMR=51, GSI=60-65								
		Boring Terminated at 32.1' (Elev. 817.5')								
814.6										
809.6										
804.6										



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-11-106 RBO BRANCH OF SUCK CREEK.GPJ SCDOT_DATATEMPLATE.GDT 6/6/22

Rock Core Photos

B-4
Box 1 of 2 (17.1’ to 27.1’)

B-4
Box 2 of 2 (27.1’ to 32.1’)

Appendix C. Laboratory Testing

SUMMARY OF LABORATORY RESULTS

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck 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-3	6.4	24	14	10	0.075	44	SC	17.3			
B-4	2.6	29	14	15	0.075	44	SC	22.4			
B-4	6.6	26	11	15	0.075	37	SC	27.2			

Rock Coring Summary

PROJECT ID P041149

PROJECT NAME S-11-106 (Island Creek Rd.) over Branch of Suck 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-3	NQ-1	25.8	63	7						33
B-3	NQ-2	30.8	100	35	13470	0.18	2740	166	41	53
B-3	NQ-3	35.8	97	18						53
B-4	NQ-1	17.1	67	7						28
B-4	NQ-2	22.1	67	60	10490	0.09	1820	169	46	68
B-4	NQ-3	27.1	100	60	26420	0.20	5740	169	51	63

INDEX PROPERTIES VERSUS DEPTH

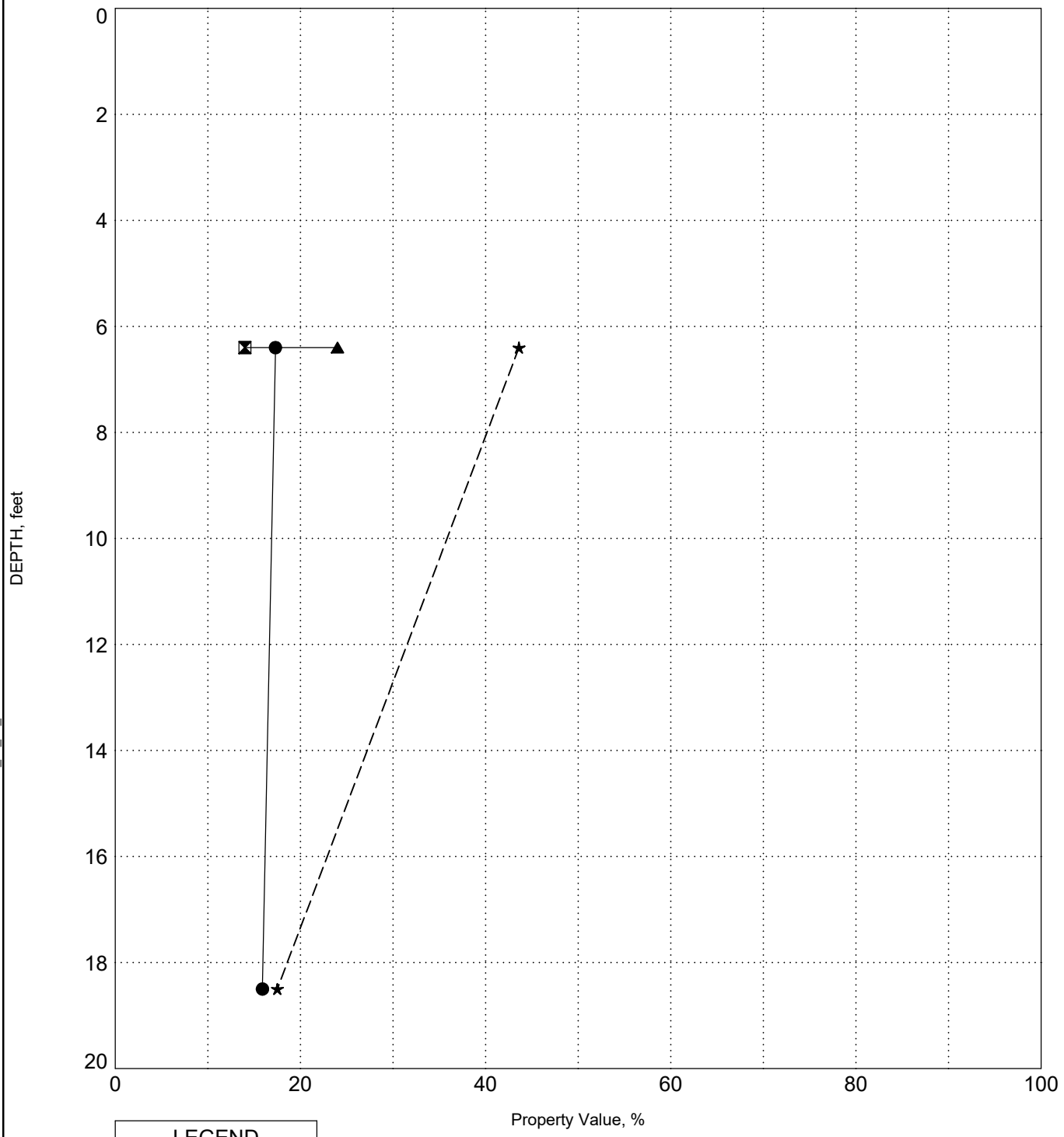
PROJECT ID P041149

PROJECT NAME S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC

BORING B-3

SURFACE ELEVATION: 849.5



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

INDEX PROPERTIES VERSUS DEPTH

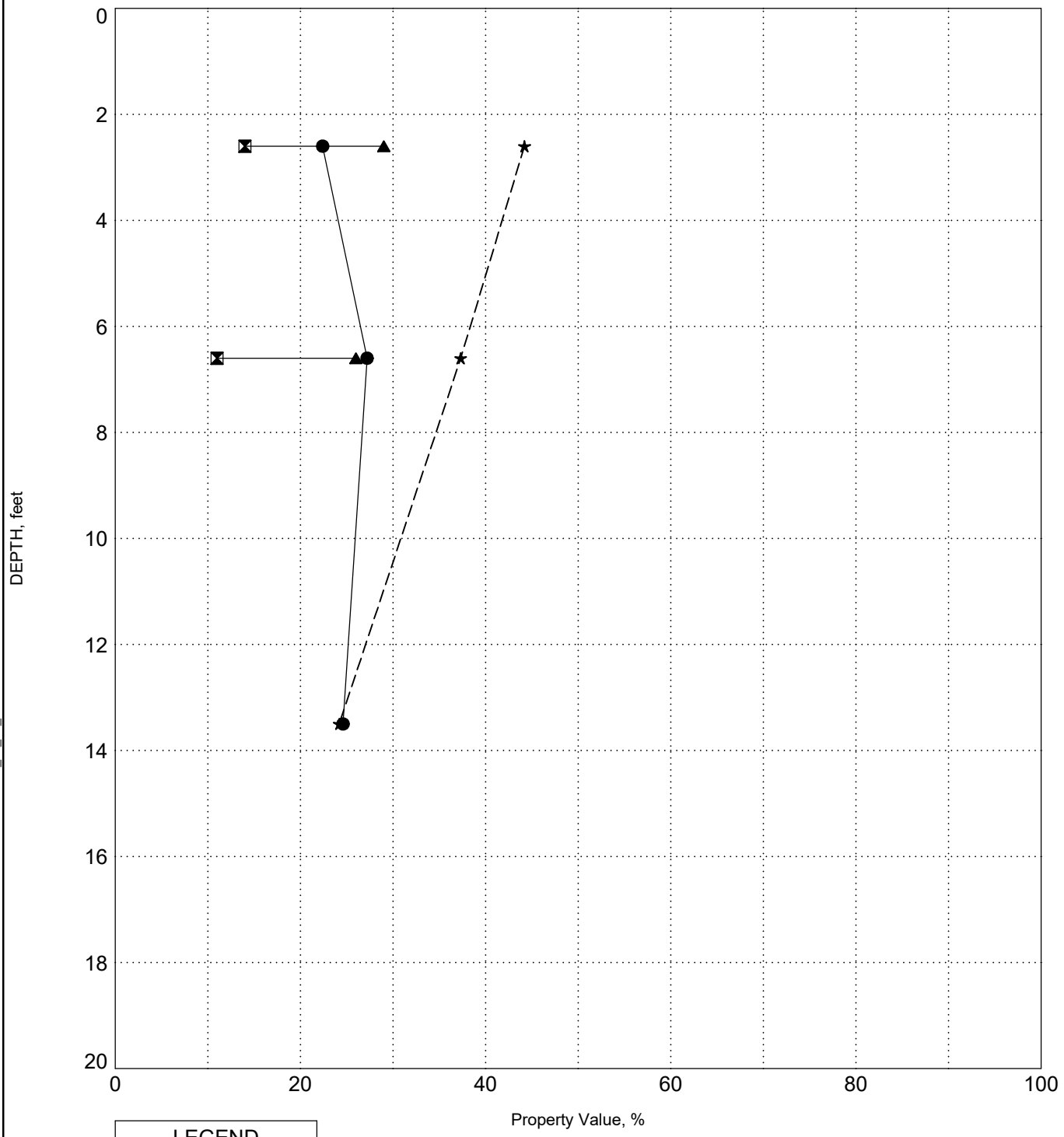
PROJECT ID P041149

PROJECT NAME S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC

BORING B-4

SURFACE ELEVATION: 849.6



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 that 75-µm (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/ft 3 (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 is 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

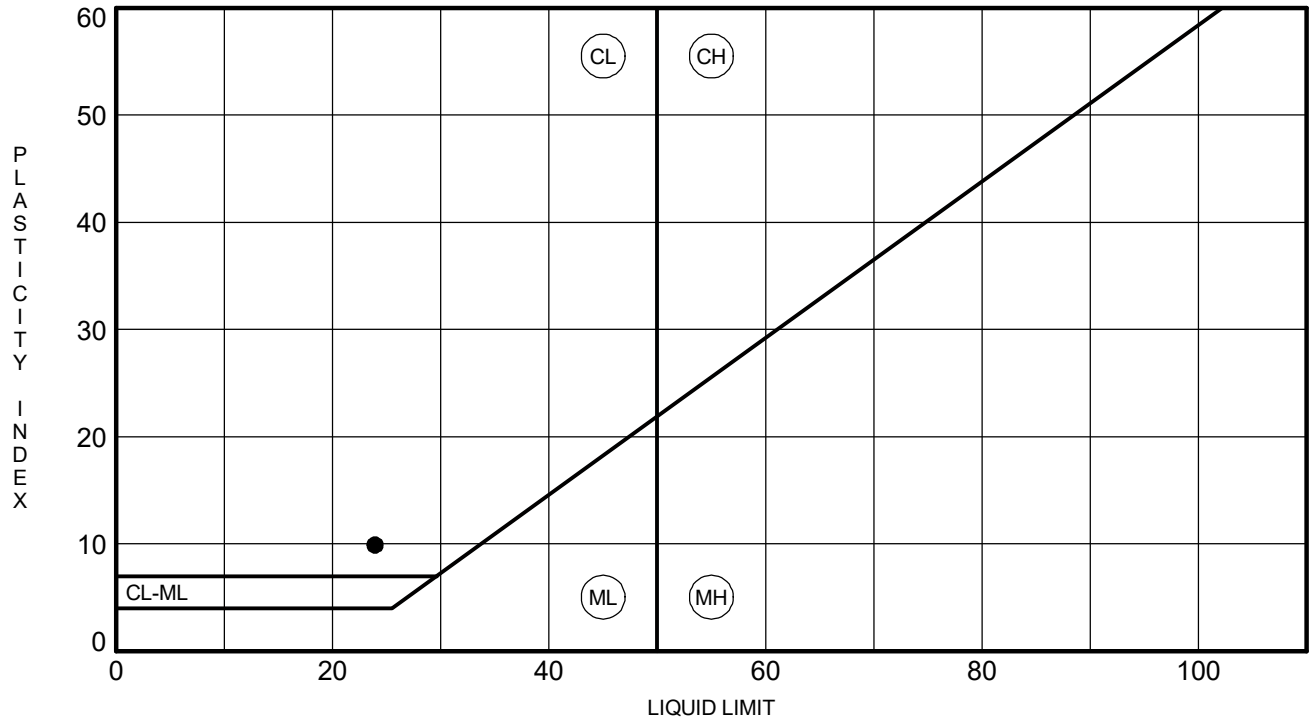
hdrinc.com

1122 Lady Street, Suite 1100 Columbia, SC 29201
T 803.509.6590 **T** 803.929.0334

ATTERBERG LIMITS' RESULTS

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



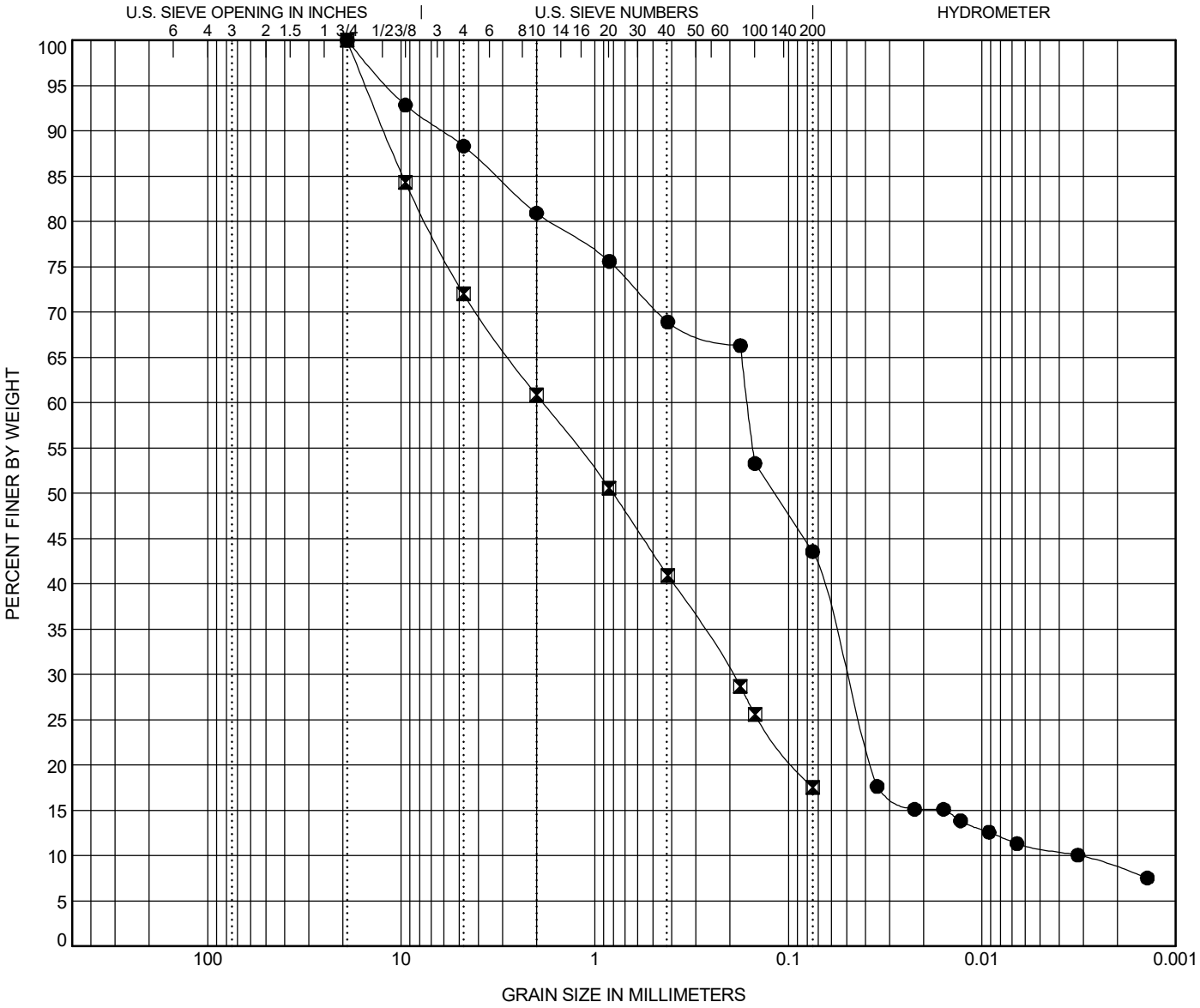
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-3**	**8.4**	**24**	**14**	**10**	**44**	**Clayey SAND (SC/A-4)**

ATTERBERG LIMITS G6655.002 - S-106 RBO SUCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 5/27/22

GRAIN SIZE DISTRIBUTION

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-3**	**8.4**	**Clayey SAND (SC/A-4)**	**24**	**14**	**10**	**4.94**	**52.09**
⊠	**B-3**	**20.0**	**Silty SAND (SM/A-2-4) with Gravel**					

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-3**	**8.4**	**19**	**0.163**	**0.05**	**0.003**	**11.7**	**44.7**	**32.7**	**10.9**
⊠	**B-3**	**20.0**	**19**	**1.862**	**0.194**		**28.0**	**54.5**	**17.5**	

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION
(AASHTO T265)

PROJECT:	S-11-106 RBO Branch of Suck Creek	**SCDOT PROJECT ID:**	P041149
SAMPLE NUMBER:	22-1398	**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-3	B-3			
SAMPLE NO.	SS-3	SS-7			
SAMPLE DEPTH (FT.)	6.4 - 8.4	18.5 - 20.0			
WATER CONTENT, W%	17.3	15.9			

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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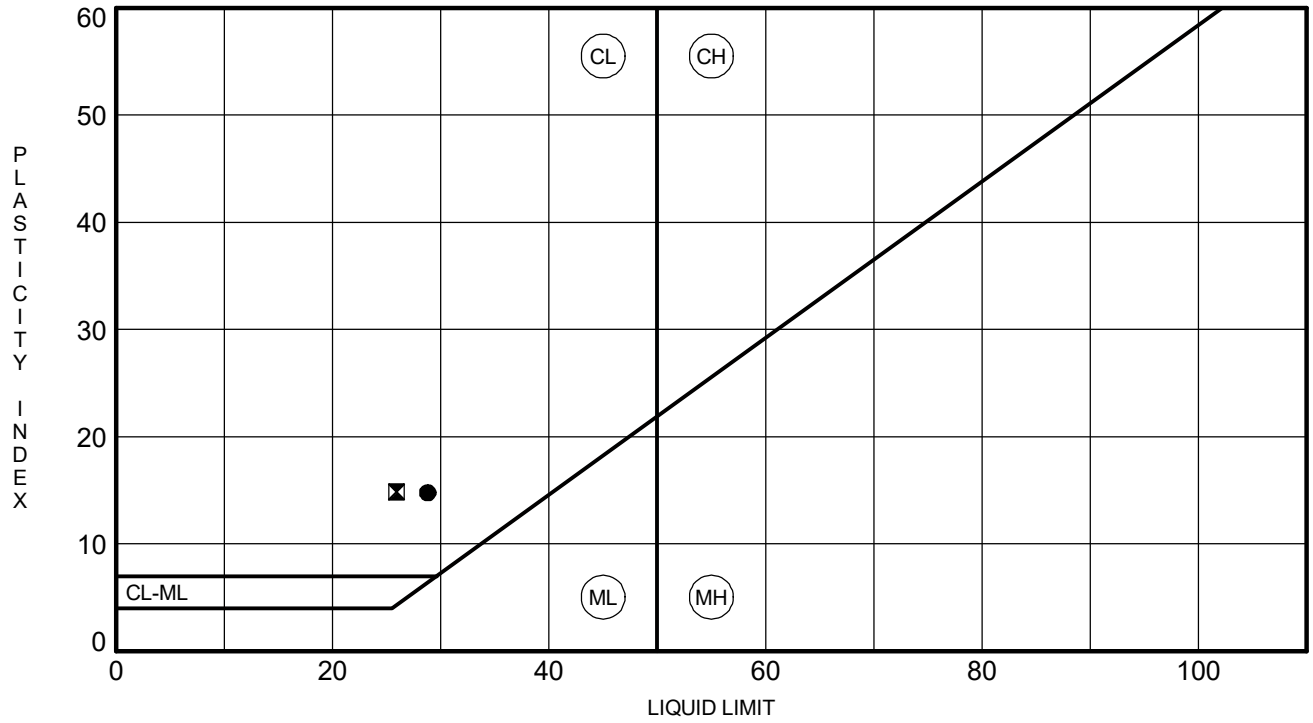
3112 Devine St., Columbia, SC 29205

ATTERBERG LIMITS' RESULTS

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



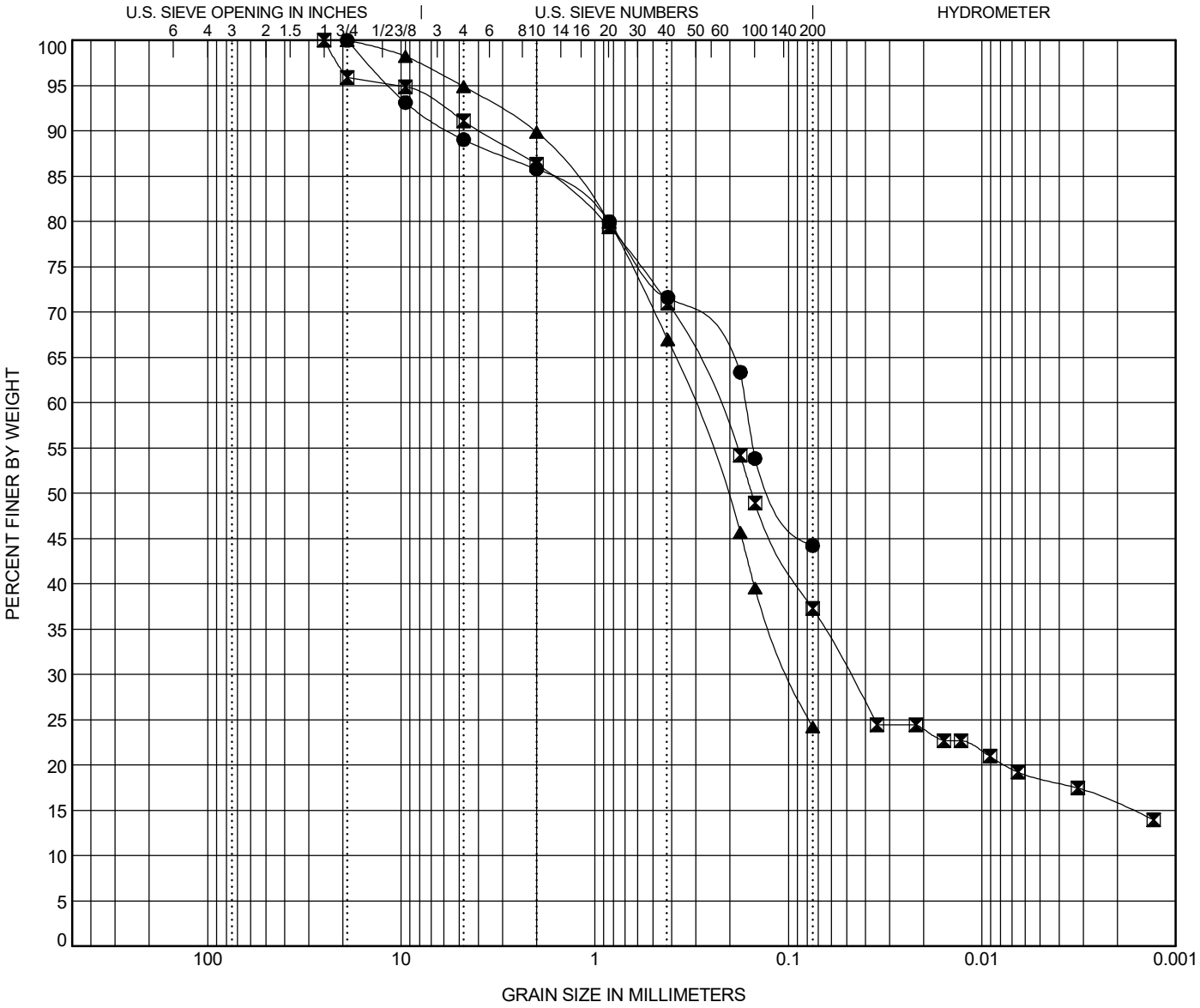
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-4**	**4.6**	**29**	**14**	**15**	**44**	**Clayey SAND (SC/A-6)**
⧗	**B-4**	**10.6**	**26**	**11**	**15**	**37**	**Clayey SAND (SC/A-6)**

ATTERBERG LIMITS G6655.002 - S-106 RBO SUCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 5/27/22

GRAIN SIZE DISTRIBUTION

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-4**	**4.6**	**Clayey SAND (SC/A-6)**	**29**	**14**	**15**		
⊠	**B-4**	**10.6**	**Clayey SAND (SC/A-6)**	**26**	**11**	**15**		
▲	**B-4**	**15.0**	**Silty SAND (SM/A-2-4)**					

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-4**	**4.6**	**19**	**0.167**			**11.0**	**44.8**	**44.2**	
⊠	**B-4**	**10.6**	**25**	**0.239**	**0.048**		**8.9**	**53.8**	**18.7**	**18.6**
▲	**B-4**	**15.0**	**19**	**0.317**	**0.097**		**5.1**	**70.7**	**24.2**	

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION
(AASHTO T265)

PROJECT:	S-11-106 RBO Branch of Suck Creek	**SCDOT PROJECT ID:**	P041149
SAMPLE NUMBER:	22-1399	**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-4	B-4	B-4		
SAMPLE NO.	SS-2	SS-4	SS-6		
SAMPLE DEPTH (FT.)	2.6 - 4.6	6.6 - 10.6	13.5 - 15.0		
WATER CONTENT, W%	22.4	27.2	24.6		

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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3112 Devine St., Columbia, SC 29205

Client:	F&ME Consultants
Project Name:	S-106 RBO Branch of Suck Creek
Project Location:	Cherokee County, South Carolina
GTX #:	315484
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-4	---	6.6-10.6	Clayey SAND (SC/A-6)	6.1

Notes:

Client:	F&ME Consultants
Project:	S-106 RBO Branch of Suck Creek
Location:	Cherokee County, South Carolina
GTX#:	315484
Test Date:	05/23/22
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-4	---	6.6-10.6	Clayey SAND (SC/A-6)	16,310

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-A2210295
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-106 Bridge Replacement over Suck Creek; Site Location: Cherokee County, SC; Job Number: GTX-315484

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-4		< 10.	< 0.0010	10.
- – -	6.6 – 10.6'			

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

AASHTO T 290 – Sulfates (Soluble)

Sample		Results		Detection Limit
		ppm (mg/kg)	%[1]	
B-4		28.	0.0028	10.
- – -	6.6 – 10.6'			

NOTE: [1]Percent 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

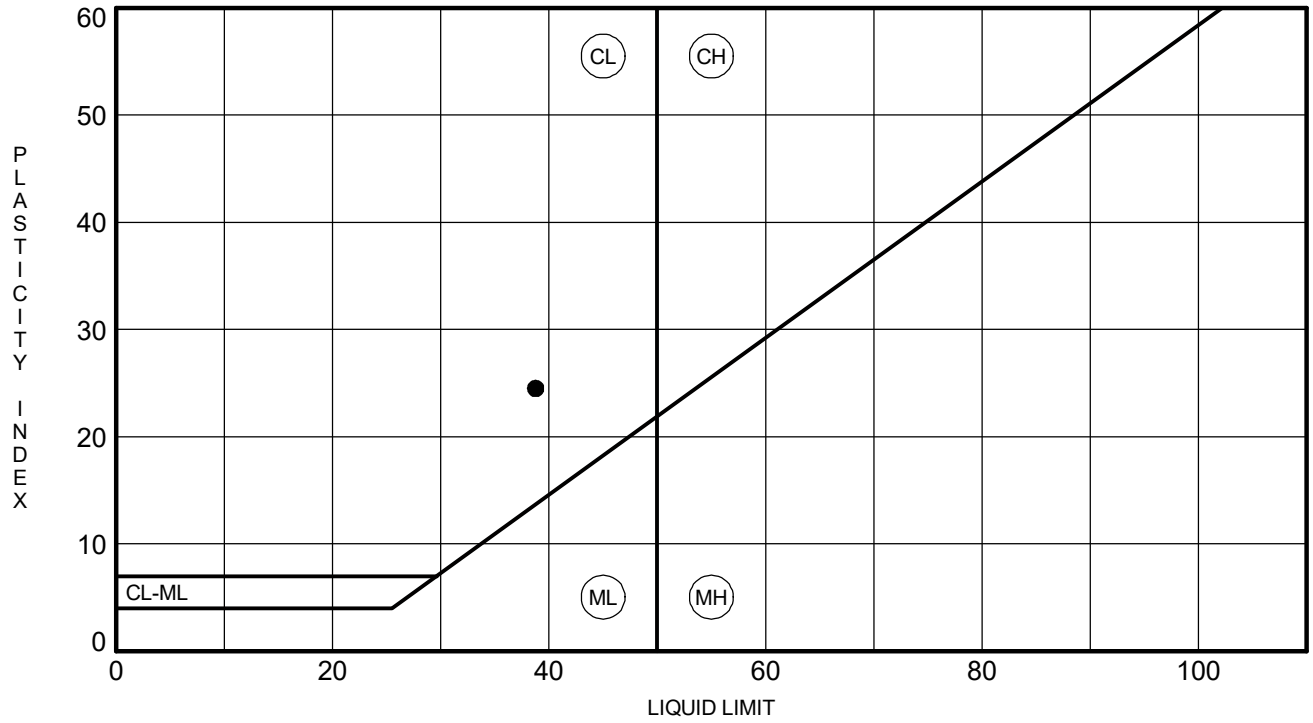
hdrinc.com

1122 Lady Street, Suite 1100 Columbia, SC 29201
T 803.509.6590 **T** 803.929.0334

ATTERBERG LIMITS' RESULTS

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



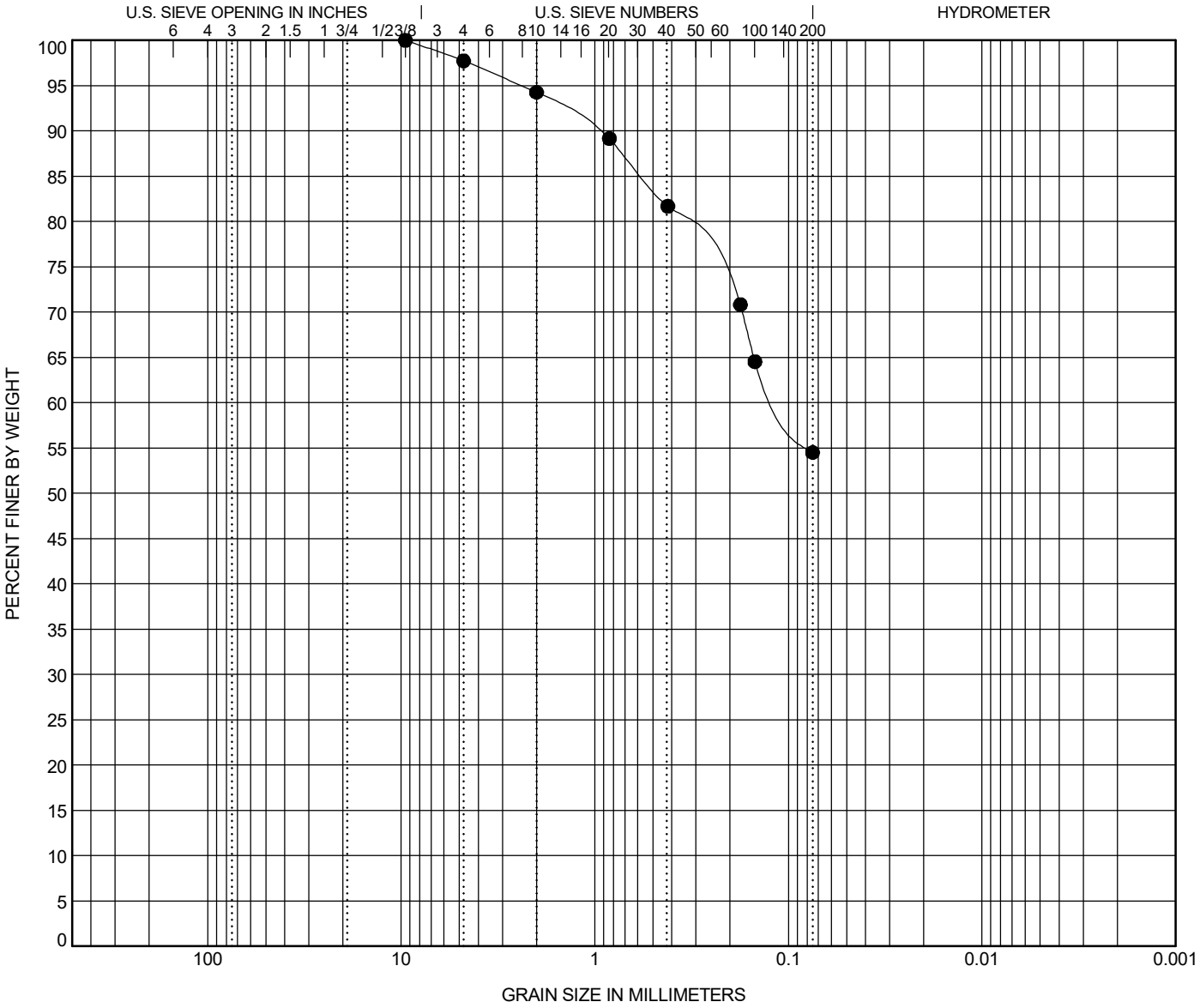
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**BS-2**	**5.0**	**39**	**14**	**25**	**55**	**Sandy Lean CLAY (CL/A-6)**

ATTERBERG LIMITS G6655.002 - S-106 RBO SUCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 5/27/22

GRAIN SIZE DISTRIBUTION

PROJECT ID P041149 **PROJECT NAME** S-11-106 RBO Branch of Suck 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-2**	**5.0**	**Sandy Lean CLAY (CL/A-6)**	**39**	**14**	**25**		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BS-2**	**5.0**	**9.51**	**0.109**			**2.3**	**43.2**	**54.5**	

GRAIN SIZE G6655.002 - S-106 RBO SUCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 5/27/22

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION
(AASHTO T265)

PROJECT:	S-11-106 RBO Branch of Suck Creek	**SCDOT PROJECT ID:**	P041149
SAMPLE NUMBER:	22-1400	**DATE SAMPLE RECEIVED:**	5/9/2022
DESCRIPTION OF SOIL:	Sandy Lean CLAY (CL/A-6)		
TESTED BY:	C. Meyers	**DATE SETUP:**	5/9/2022
WEIGHED BY:	T. Peterson	**DATE OF WEIGHING:**	5/10/2022

BORING NO.	BS-2				
SAMPLE NO.	--				
SAMPLE DEPTH (FT.)	0.0 - 5.0				
WATER CONTENT, W%	19.4				

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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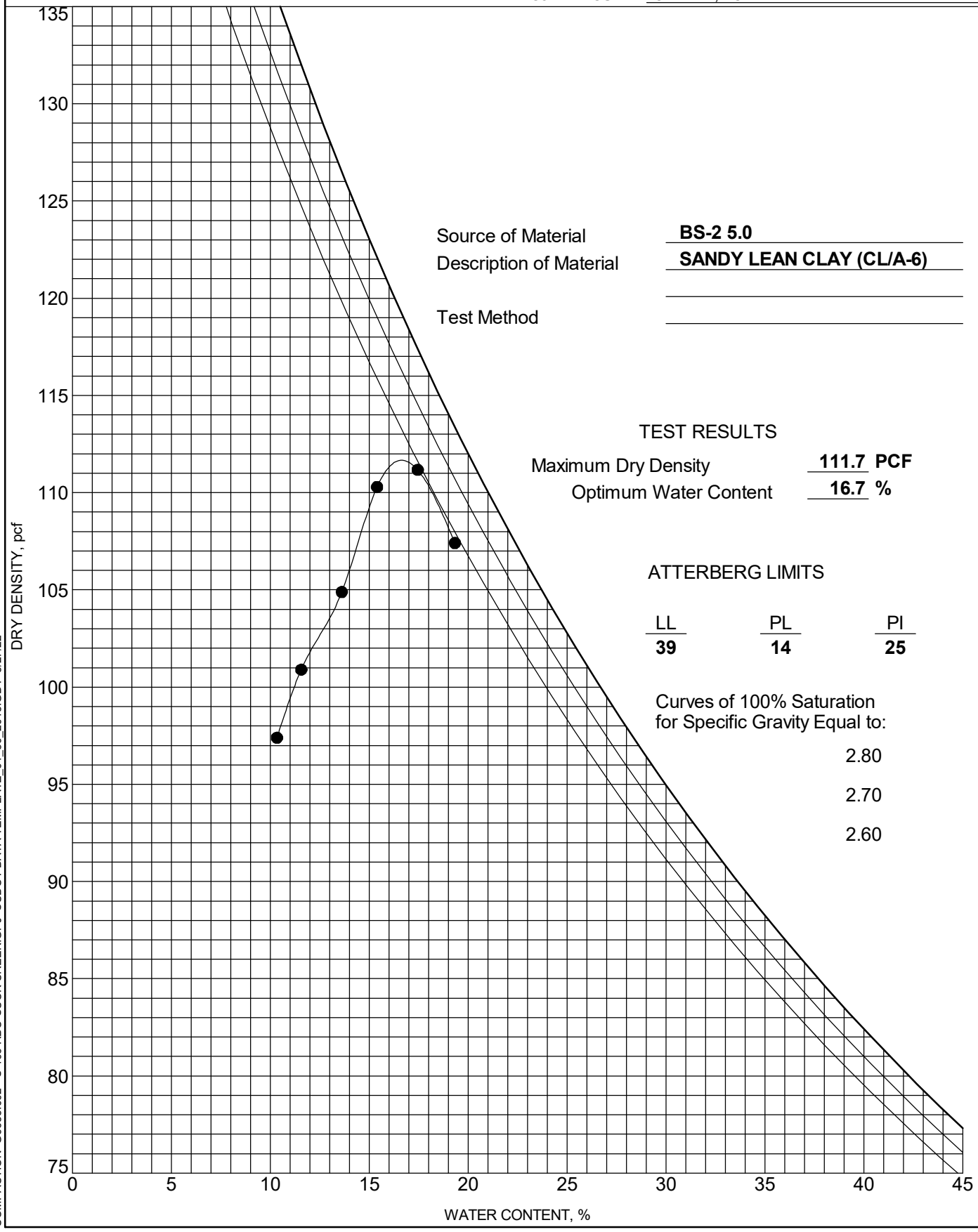
MOISTURE-DENSITY RELATIONSHIP

PROJECT ID P041149

PROJECT NAME S-11-106 RBO Branch of Suck Creek

PROJECT COUNTY Cherokee, SC



Source of Material **BS-2 5.0**

Description of Material **SANDY LEAN CLAY (CL/A-6)**

Test Method

TEST RESULTS

Maximum Dry Density **111.7** **PCF**

Optimum Water Content **16.7** **%**

ATTERBERG LIMITS

LL	PL	PI
39	**14**	**25**

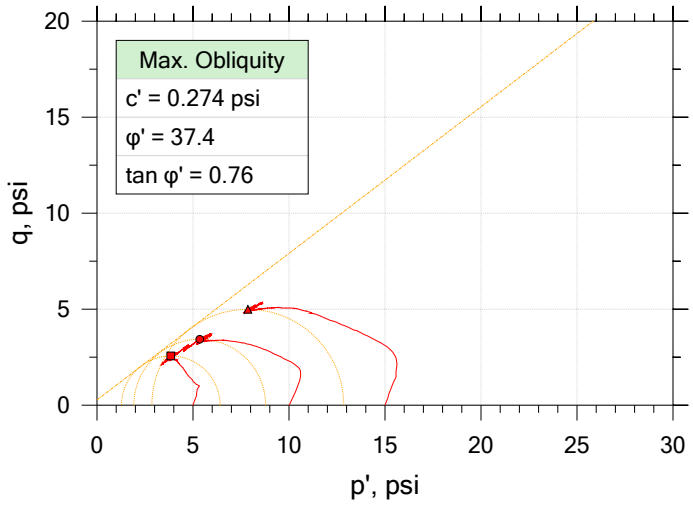
Curves of 100% Saturation for Specific Gravity Equal to:

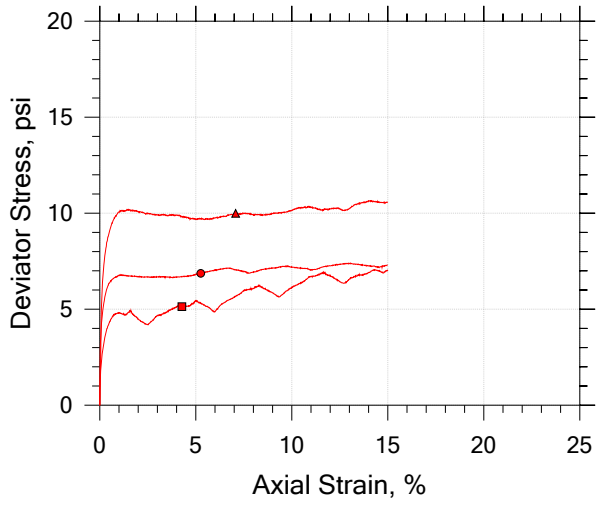
2.80

2.70

2.60

Consolidated Undrained by AASHTO T297



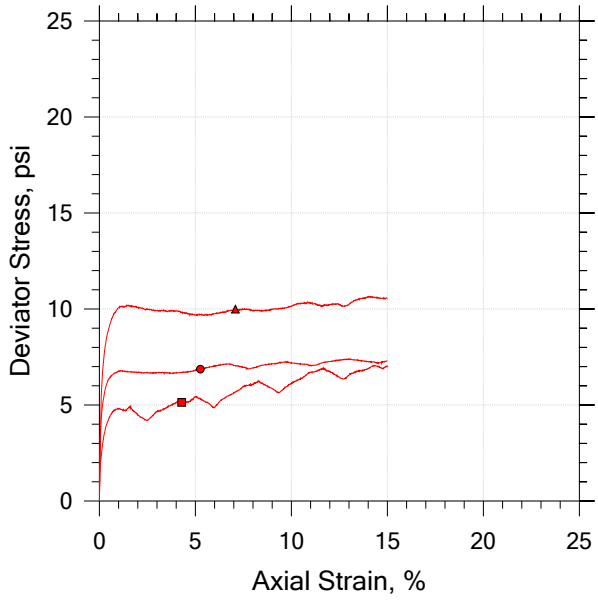


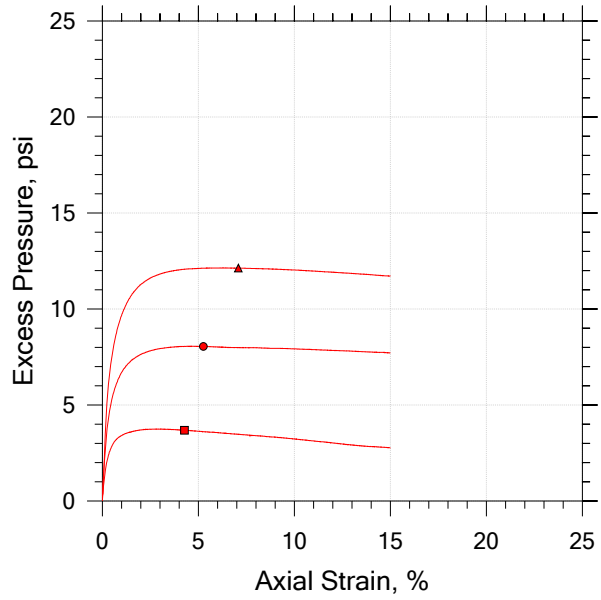
Symbol		■	●	▲	
Sample ID		22-1400	22-1400	22-1400	
Depth		0.0' - 5.0'	0.0 - 5.0	0.0' - 5.0'	
Test Number		A	B	C	
Initial	Height, in	6.000	6.000	6.000	
	Diameter, in	2.800	2.800	2.800	
	Moisture Content (from Cuttings), %	16.4	16.0	16.0	
	Dry Density, pcf	106.	107.	107.	
	Saturation (Wet Method), %	76.5	75.6	75.6	
	Void Ratio	0.573	0.567	0.567	
Final	Moisture Content, %	19.8	18.2	17.6	
	Dry Density, pcf	109.	112.	114.	
	Cross-Sectional Area (Method A), in²	6.037	5.933	5.874	
	Saturation, %	100.0	100.0	100.0	
	Void Ratio	0.530	0.487	0.473	
	Back Pressure, psi	79.99	91.99	74.00	
Vertical Effective Consolidation Stress, psi		4.948	9.937	14.93	
Horizontal Effective Consolidation Stress, psi		4.999	10.01	15.00	
Vertical Strain after Consolidation, %		0.4278	1.093	1.148	
Volumetric Strain after Consolidation, %		1.669	3.927	5.032	
Time to 50% Consolidation, min		0.7000	0.6000	0.6000	
Shear Strength, psi		2.566	3.434	4.995	
Strain at Failure, %		4.28	5.26	7.08	
Strain Rate, %/min		0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi		5.132	6.869	9.991	
Effective Minor Principal Stress at Failure, psi		1.273	1.916	2.859	
Effective Major Principal Stress at Failure, psi		6.405	8.785	12.85	
B-Value		0.95	0.95	0.96	

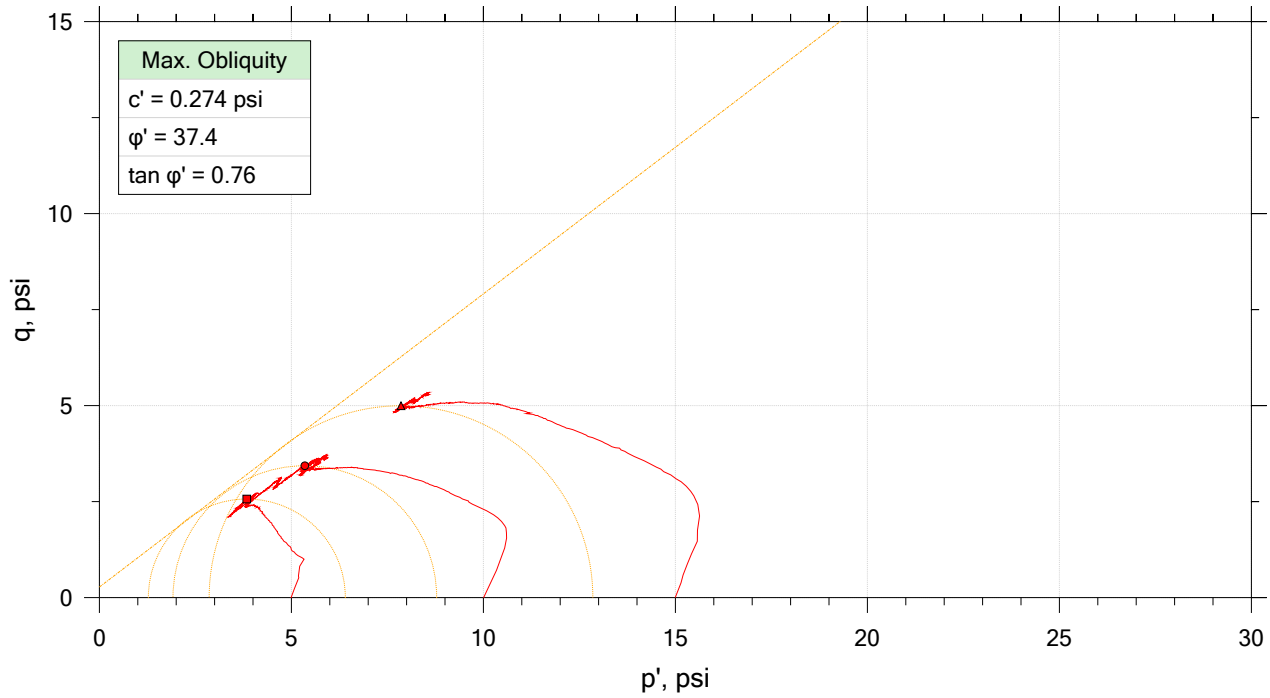
Notes:
- Before Shear Saturation set to 100% for phase calculation.
- Moisture Content determined by ASTM D2216.
- Atterberg Limits determined by ASTM D4318.
- Deviator Stress includes membrane correction.
- Values for c and φ determined from best-fit straight line for the specific test conditions. Actual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

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297



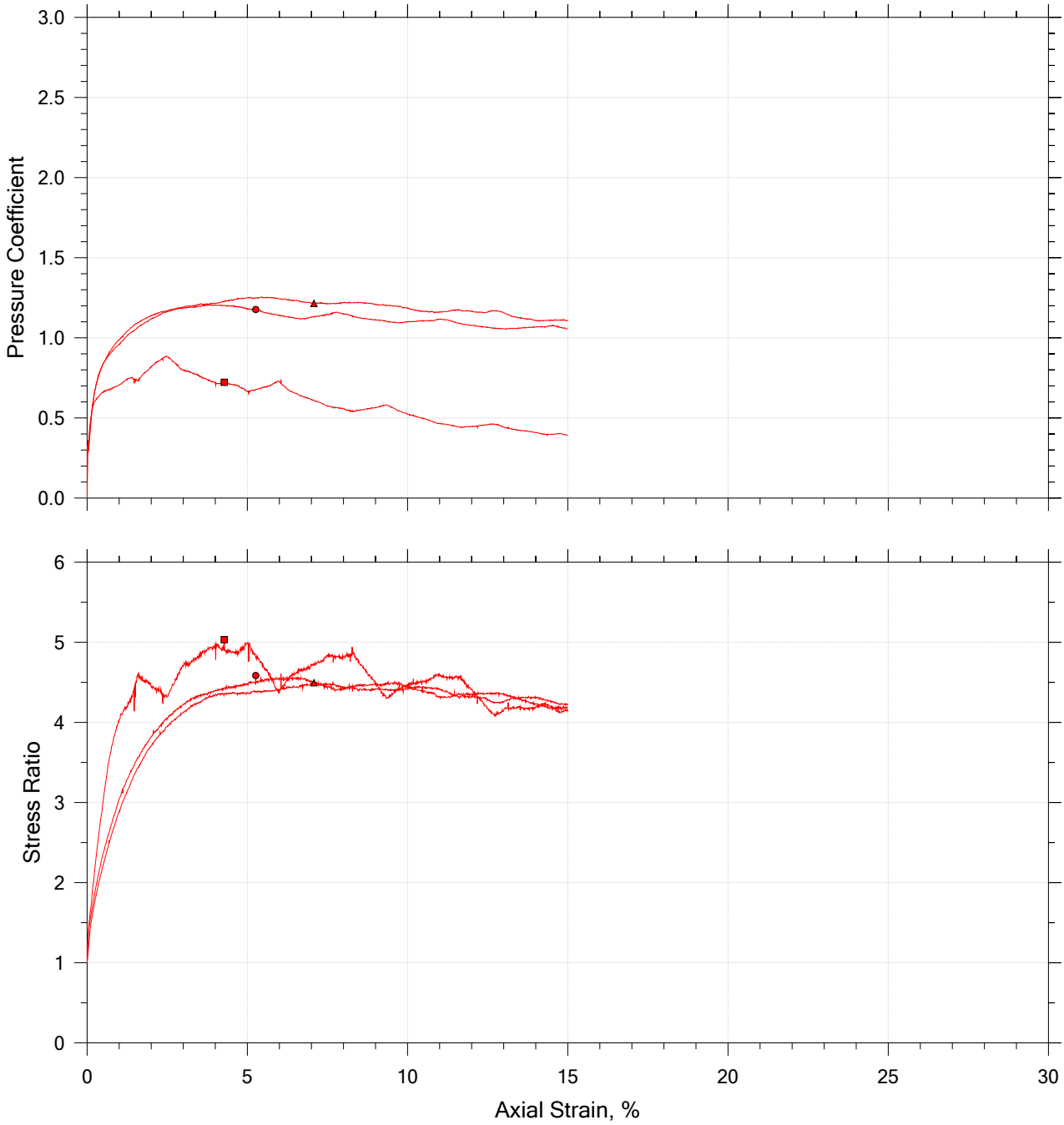




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1400	A	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.A.dat
●	22-1400	B	0.0 - 5.0	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.B.dat
▲	22-1400	C	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.C.dat

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, Samples Molded at 95% of Max Dry Density		

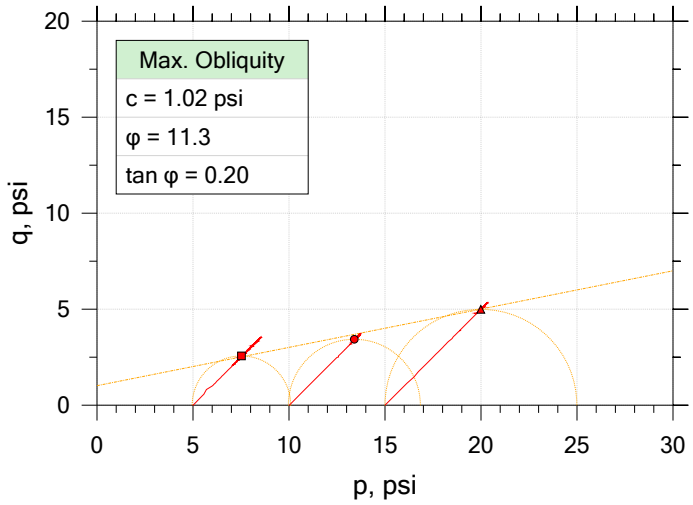
Consolidated Undrained by AASHTO T297

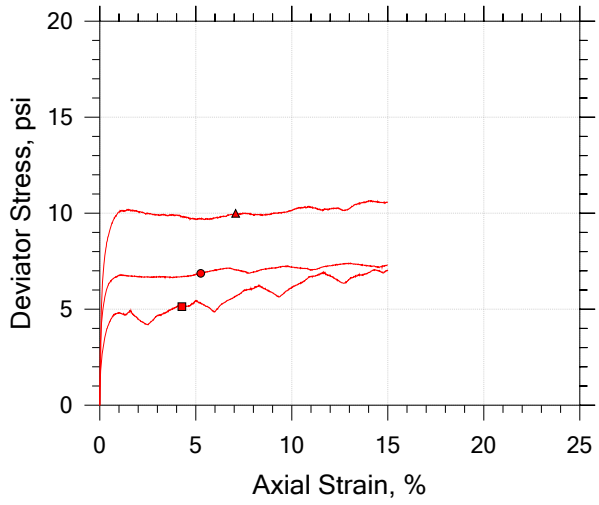


	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1400	A	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.A.dat
●	22-1400	B	0.0 - 5.0	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.B.dat
▲	22-1400	C	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.C.dat

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297



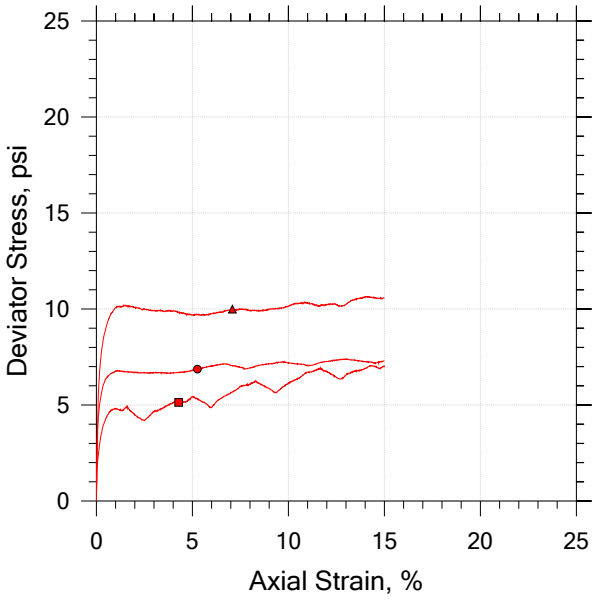


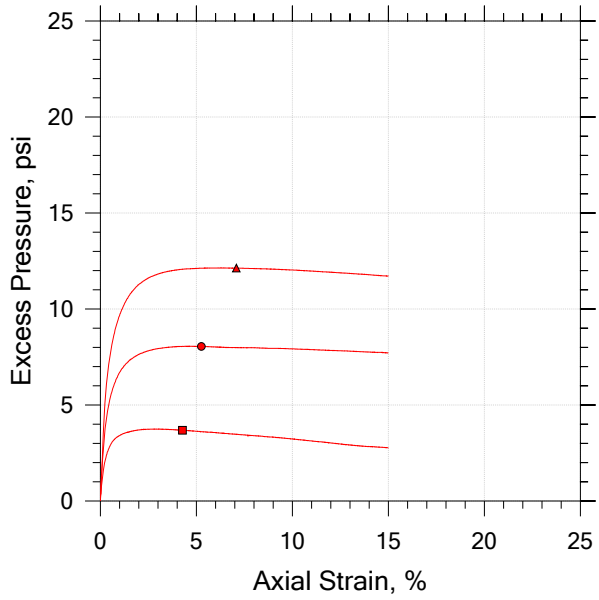
Symbol		■	●	▲	
Sample ID		22-1400	22-1400	22-1400	
Depth		0.0' - 5.0'	0.0 - 5.0	0.0' - 5.0'	
Test Number		A	B	C	
Initial	Height, in	6.000	6.000	6.000	
	Diameter, in	2.800	2.800	2.800	
	Moisture Content (from Cuttings), %	16.4	16.0	16.0	
	Dry Density, pcf	106.	107.	107.	
	Saturation (Wet Method), %	76.5	75.6	75.6	
	Void Ratio	0.573	0.567	0.567	
Final	Moisture Content, %	19.8	18.2	17.6	
	Dry Density, pcf	109.	112.	114.	
	Cross-Sectional Area (Method A), in²	6.037	5.933	5.874	
	Saturation, %	100.0	100.0	100.0	
	Void Ratio	0.530	0.487	0.473	
	Back Pressure, psi	79.99	91.99	74.00	
Vertical Effective Consolidation Stress, psi		4.948	9.937	14.93	
Horizontal Effective Consolidation Stress, psi		4.999	10.01	15.00	
Vertical Strain after Consolidation, %		0.4278	1.093	1.148	
Volumetric Strain after Consolidation, %		1.669	3.927	5.032	
Time to 50% Consolidation, min		0.7000	0.6000	0.6000	
Shear Strength, psi		2.566	3.434	4.995	
Strain at Failure, %		4.28	5.26	7.08	
Strain Rate, %/min		0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi		5.132	6.869	9.991	
Effective Minor Principal Stress at Failure, psi		1.273	1.916	2.859	
Effective Major Principal Stress at Failure, psi		6.405	8.785	12.85	
B-Value		0.95	0.95	0.96	

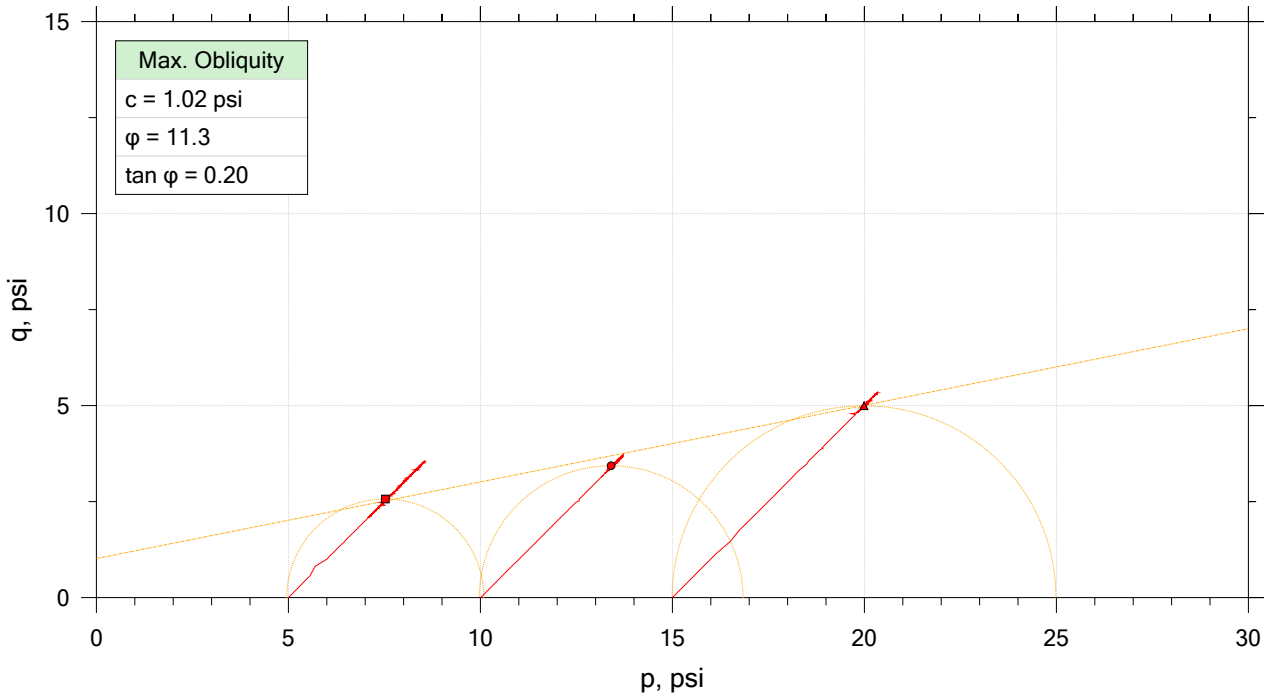
Notes:
- Before Shear Saturation set to 100% for phase calculation.
- Moisture Content determined by ASTM D2216.
- Atterberg Limits determined by ASTM D4318.
- Deviator Stress includes membrane correction.
- Values for c and φ determined from best-fit straight line for the specific test conditions. Actual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

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297



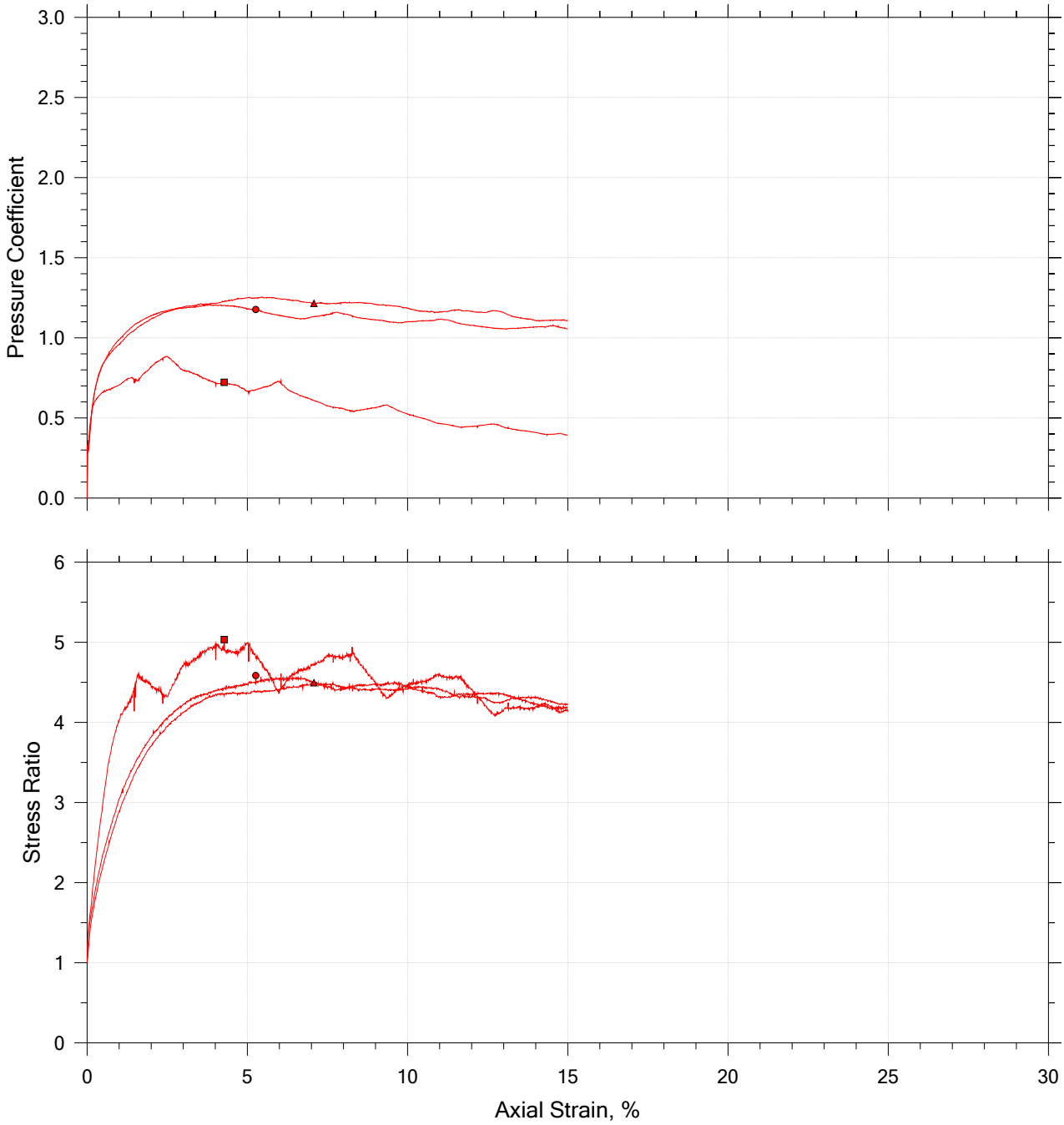




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1400	A	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.A.dat
●	22-1400	B	0.0 - 5.0	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.B.dat
▲	22-1400	C	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.C.dat

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, 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
■	22-1400	A	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.A.dat
●	22-1400	B	0.0 - 5.0	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.B.dat
▲	22-1400	C	0.0' - 5.0'	WAP/RMC	5/21/2022	WAP/ WJG	5/25/2022	BS-2.C.dat

Project Name: CLRB Replacements 2022 - Pkg 14	Location: S-106 RBO Branch of Suck Creek	Project Number: G6655.002
Boring Number: BS-2	Tester: WAP/RMC	Checker: WAP/ WJG
Sample Number: 22-1400	Test Date: 5/21/2022	Depth: 0.0' - 5.0'
Test Number: ABC	Preparation: Remolded	Elevation:
Description: Sandy Lean CLAY (CL/A-6) LL=39, PL=14, PI=25, %200=54.5		
Remarks: Max Dry Density=111.7 pcf, OMC=16.7%, Samples Molded at 95% of Max Dry Density		

Appendix C. Laboratory Testing

Rock Cores

hdrinc.com

1122 Lady Street, Suite 1100 Columbia, SC 29201
T 803.509.6590 **T** 803.929.0334

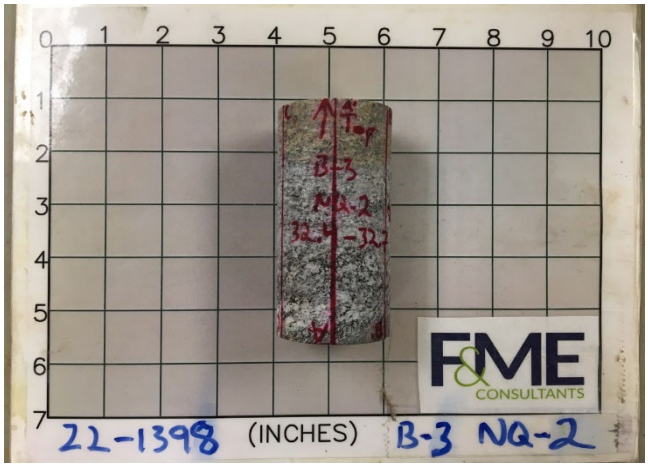
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

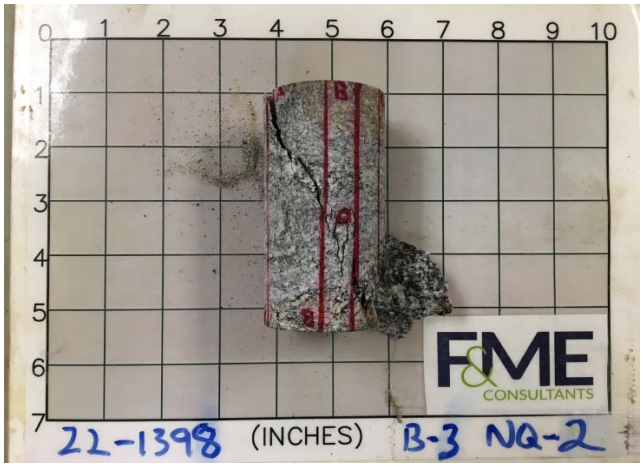
Project	S-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.828	Reviewed By	WJG
Boring	B-3	Unit Weight (pcf)	165.7	Core Size	NQ
Sample No.	NQ-2 / 22-1398	L/D Ratio	2.05	Recovery	100%
Depth	32.4' - 32.7'	Load Rate (psi/sec)	20	RQD	35%
Description	White/Gray/Black Schist				

Test Data

Percent of Failure Load	Strain (10^{-6}) Axial	Strain (10^{-6}) Radial	Load (lbs)	Compressive Stress (psi)	Secant Modulus $x10^6$ (psi)	Poisson's Ratio
10%	-1407	149	3,709	1,349	1.92	0.11
20%	-2426	321	7,410	2,695	2.22	0.13
30%	-3252	502	11,172	4,064	2.50	0.15
40%	-3982	700	14,809	5,386	2.71	0.18
50%	-4660	919	18,531	6,740	2.89	0.20
60%	-5282	1161	22,224	8,083	3.06	0.22
70%	-5908	1471	25,931	9,431	3.19	0.25
80%	-6554	1882	29,690	10,799	3.30	0.29
90%	-7209	2205	33,472	12,174	3.38	0.31
100%	-7473	3517	37,044	13,474		

Sample Photos



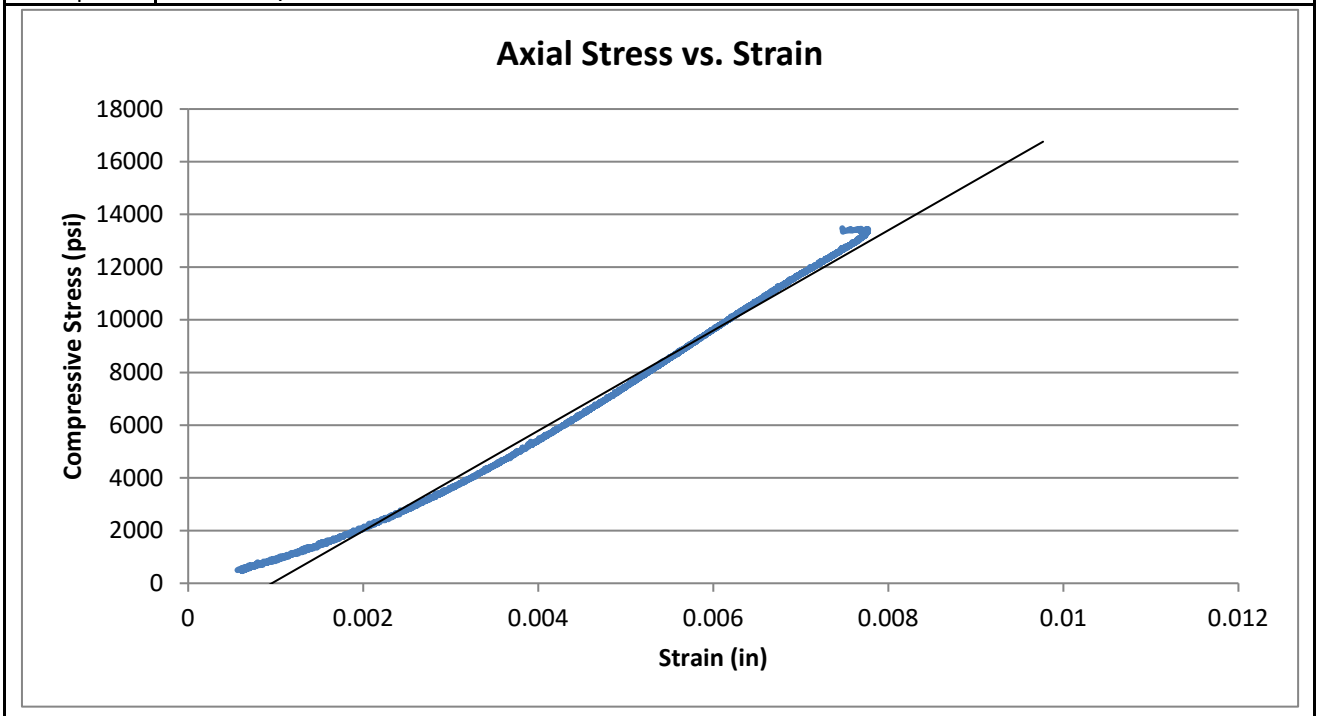


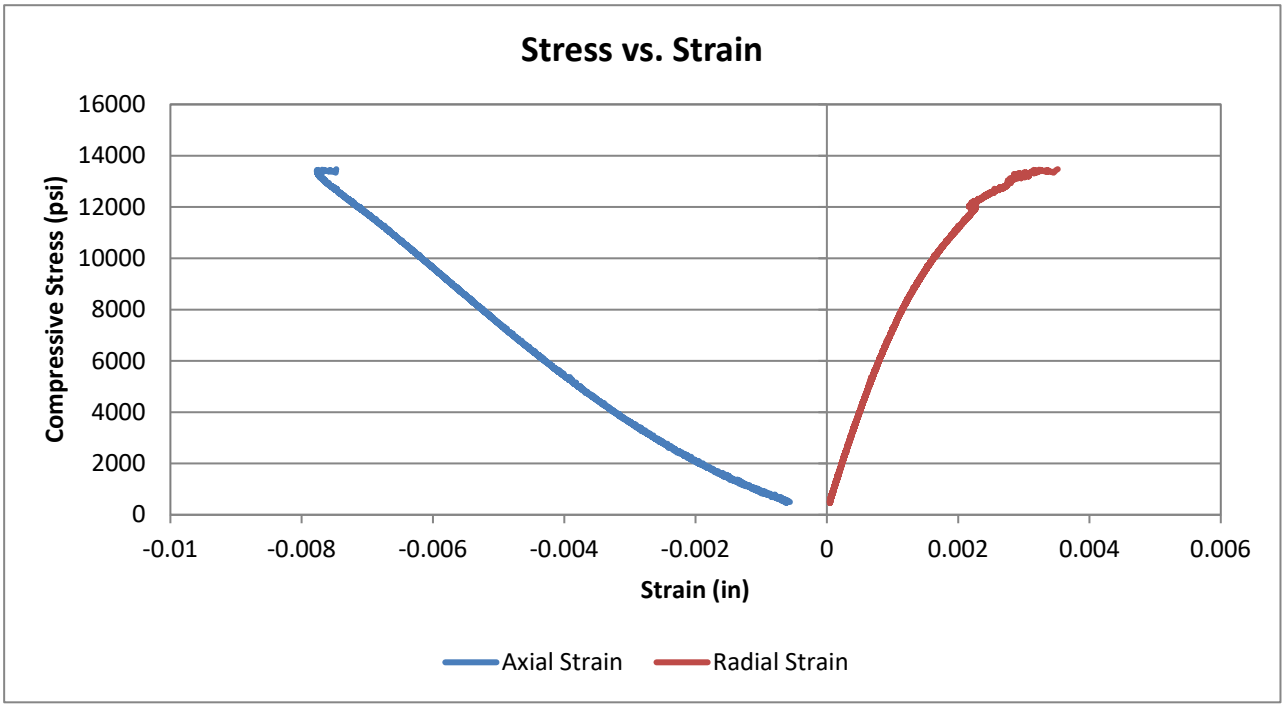
Test Results

Unconfined Compressive Strength (psi)	**13,470**	Elastic Modulus (psi)	2.74E+06
		Poisson's Ratio in Elastic Range	0.18
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-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.828	Reviewed By	WJG
Boring	B-3	Unit Weight (pcf)	165.7	Core Size	NQ
Sample No.	NQ-2 / 22-1398	L/D Ratio	2.05	Recovery	100%
Depth	32.4' - 32.7'	Load Rate (psi/sec)	20	RQD	35%
Description	White/Gray/Black Schist				





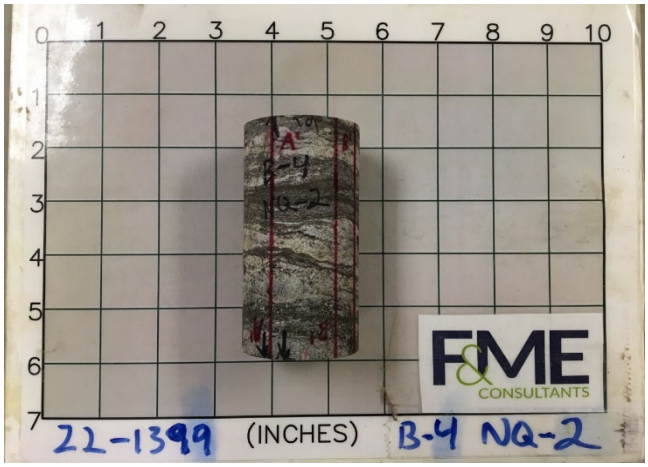
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

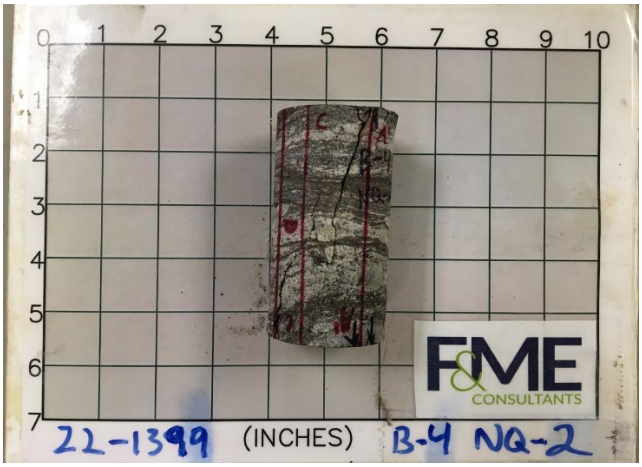
Project	S-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.741	Reviewed By	WJG
Boring	B-4	Unit Weight (pcf)	169.0	Core Size	NQ
Sample No.	NQ-2 / 22-1399A	L/D Ratio	2.00	Recovery	67%
Depth	23.6' - 23.9'	Load Rate (psi/sec)	20	RQD	60%
Description	White/Gray/Black Biotite Micaceous Schist				

Test Data

Percent of Failure Load	Strain (10^{-6}) Axial	Strain (10^{-6}) Radial	Load (lbs)	Compressive Stress (psi)	Secant Modulus $x10^6$ (psi)	Poisson's Ratio
10%	-1633	33	2,882	1,049	1.28	0.02
20%	-2952	113	5,707	2,078	1.41	0.04
30%	-4069	219	8,667	3,156	1.55	0.05
40%	-4974	335	11,511	4,191	1.69	0.07
50%	-5843	477	14,491	5,276	1.81	0.08
60%	-6610	632	17,292	6,296	1.90	0.10
70%	-7378	834	20,131	7,330	1.99	0.11
80%	-8187	1115	23,032	8,386	2.05	0.14
90%	-9052	1576	25,975	9,458	2.09	0.17
100%	-10132	3087	28,806	10,488		

Sample Photos



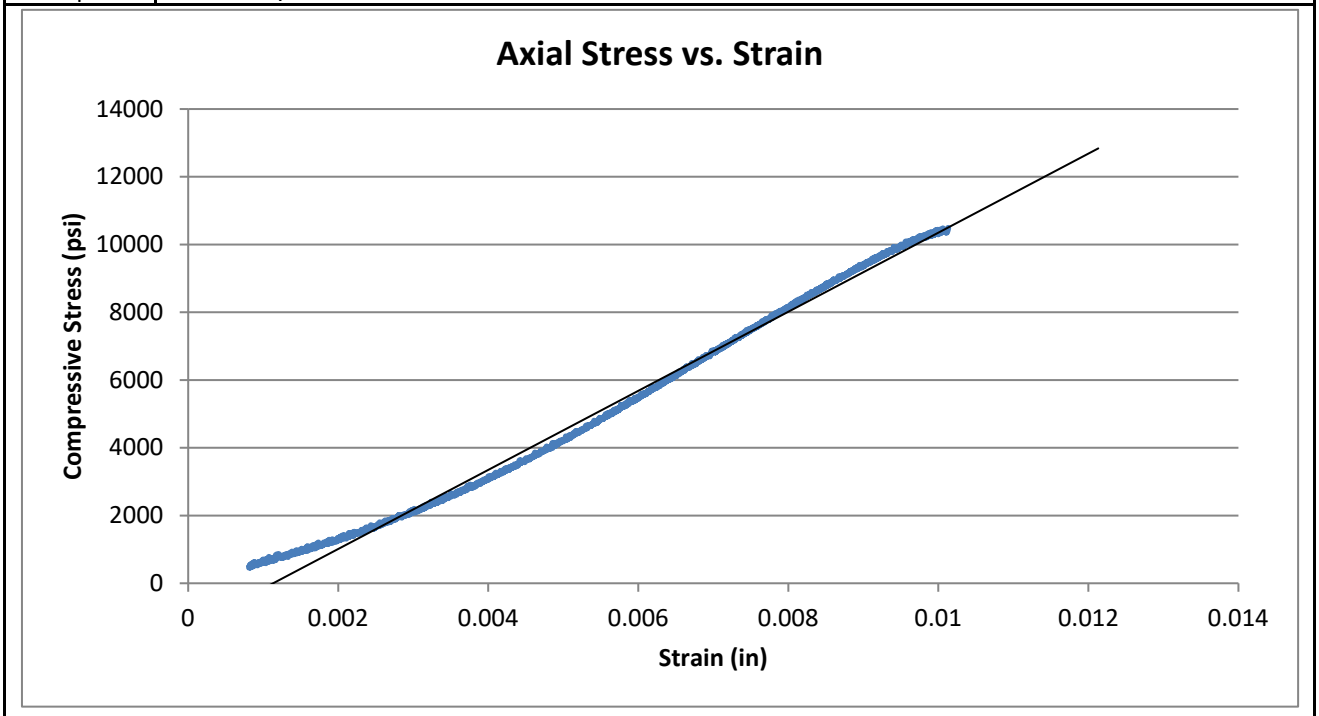


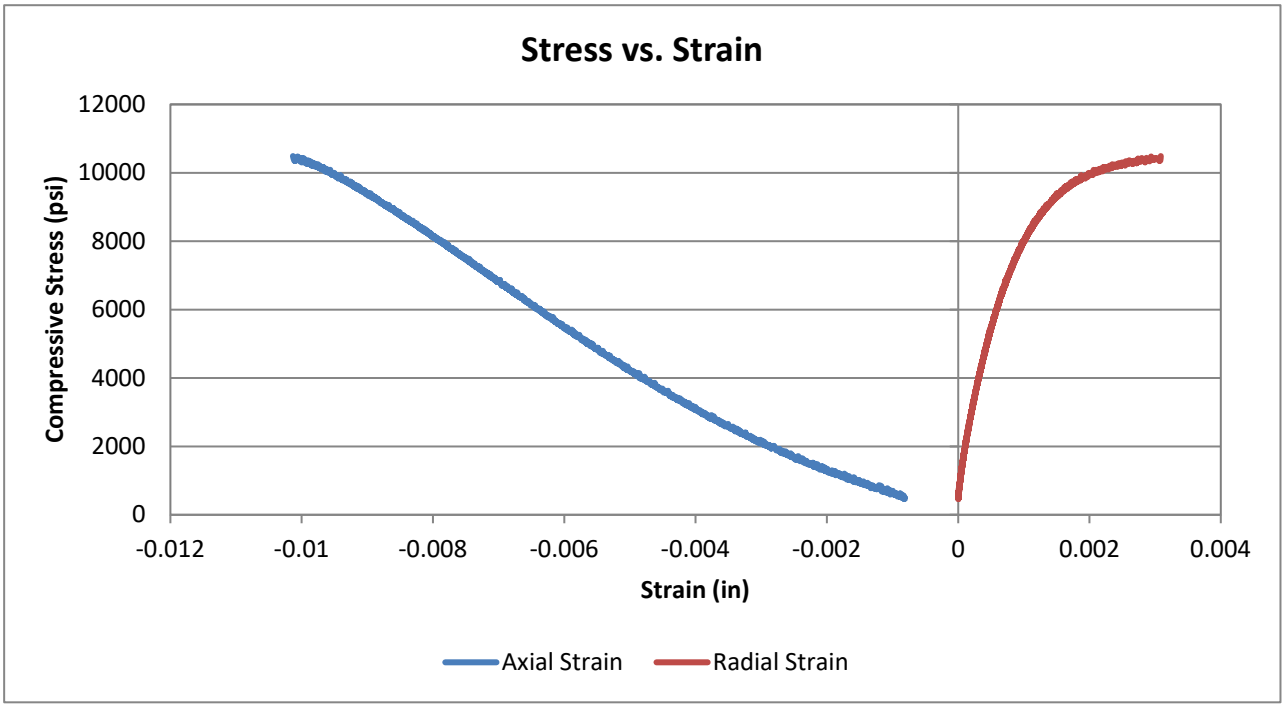
Test Results

Unconfined Compressive Strength (psi)	**10,490**	Elastic Modulus (psi)	1.82E+06
		Poisson's Ratio in Elastic Range	0.09
Comments	Elastic range was taken as between 0.004 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.		

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

Project	S-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.741	Reviewed By	WJG
Boring	B-4	Unit Weight (pcf)	169.0	Core Size	NQ
Sample No.	NQ-2 / 22-1399A	L/D Ratio	2.00	Recovery	67%
Depth	23.6' - 23.9'	Load Rate (psi/sec)	20	RQD	60%
Description	White/Gray/Black Biotite Micaceous Schist				





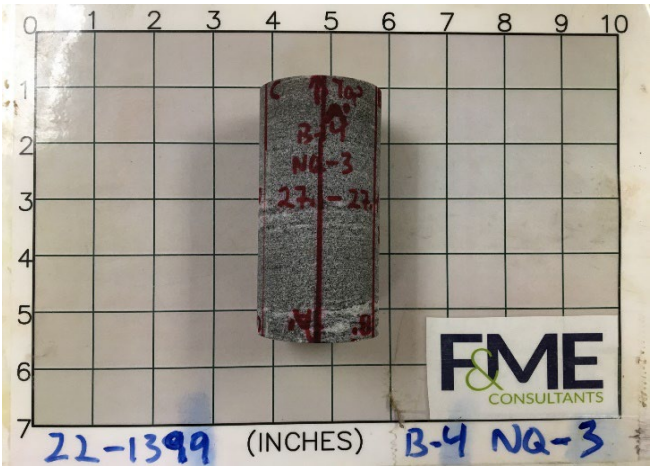
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

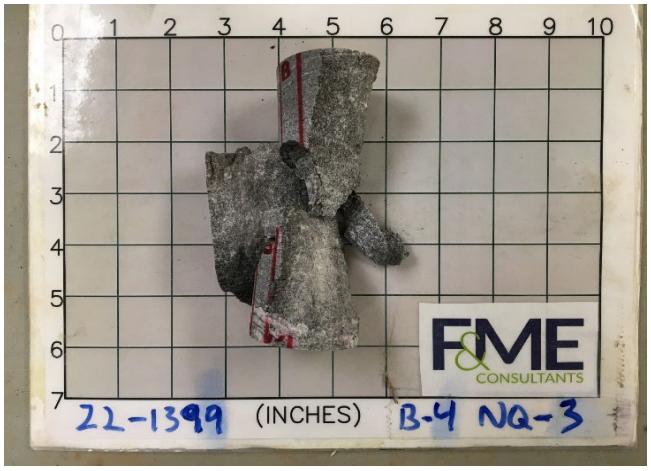
Project	S-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.877	Reviewed By	WJG
Boring	B-4	Unit Weight (pcf)	169.0	Core Size	NQ
Sample No.	NQ-3 / 22-1399B	L/D Ratio	2.07	Recovery	100%
Depth	29.1 - 29.4	Load Rate (psi/sec)	20	RQD	60%
Description	White/Gray/Black Biotite Micaceous Schist				

Test Data

Percent of Failure Load	Strain (10^{-6}) Axial	Strain (10^{-6}) Radial	Load (lbs)	Compressive Stress (psi)	Secant Modulus $x10^6$ (psi)	Poisson's Ratio
10%	-1014	143	7,276	2,646	5.22	0.14
20%	-1991	310	14,541	5,289	5.31	0.16
30%	-2884	479	21,772	7,919	5.49	0.17
40%	-3753	660	29,026	10,557	5.63	0.18
50%	-4608	858	36,384	13,233	5.74	0.19
60%	-5429	1075	43,593	15,856	5.84	0.20
70%	-6251	1336	50,779	18,469	5.91	0.21
80%	-7106	1675	58,116	21,138	5.95	0.24
90%	-8005	2071	65,391	23,784	5.94	0.26
100%	-8778	2520	72,626	26,415		

Sample Photos



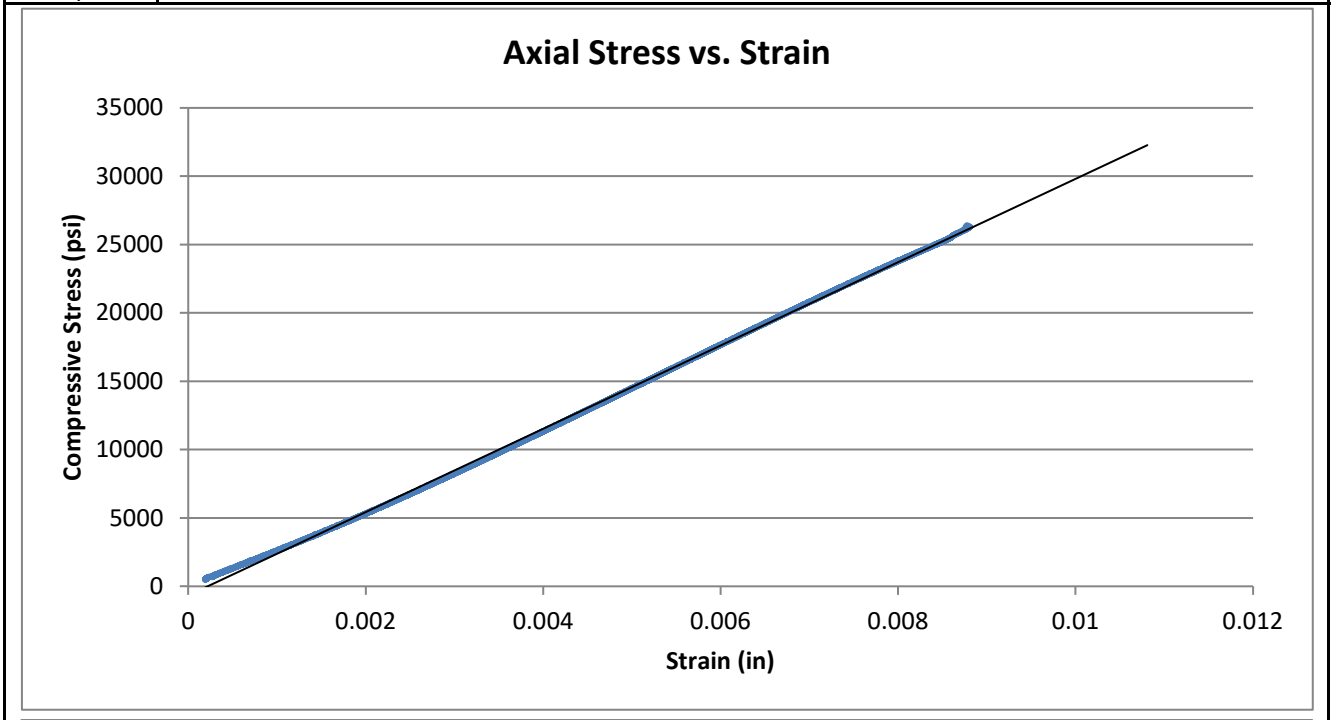


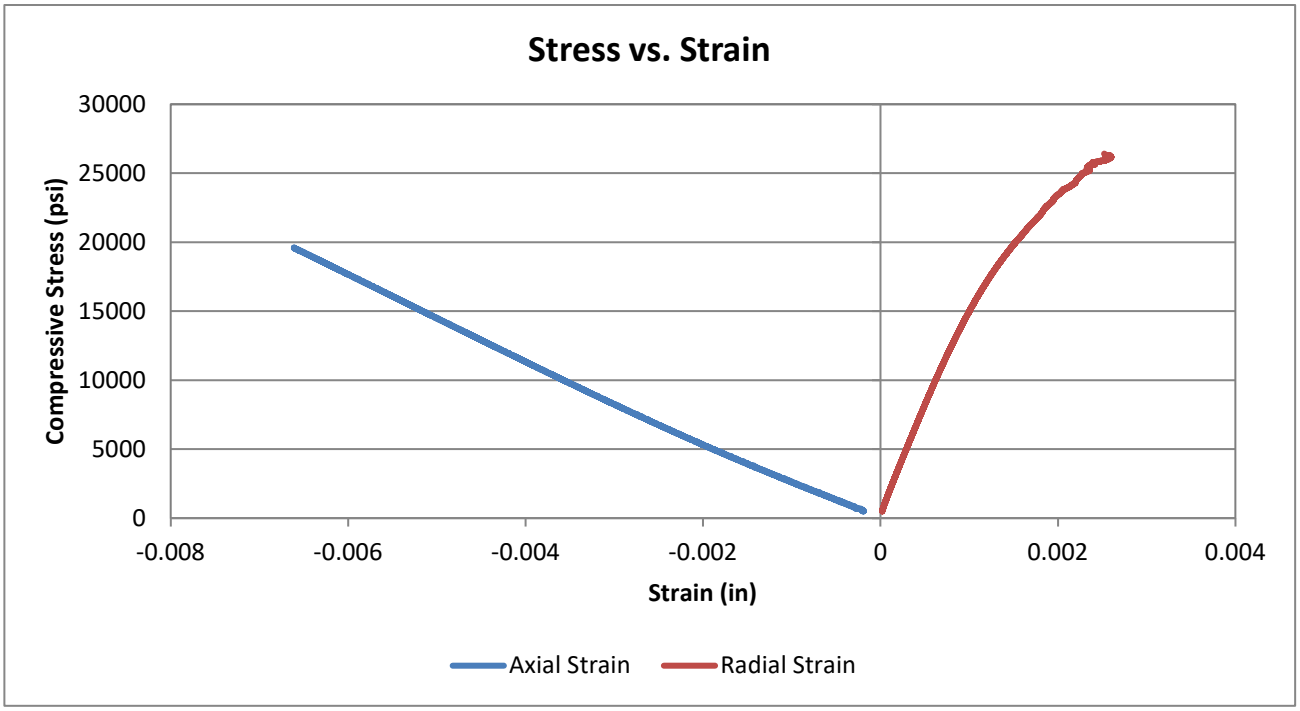
Test Results

Unconfined Compressive Strength (psi)	**26,420**	Elastic Modulus (psi)	5.74E+06
		Poisson's Ratio in Elastic Range	0.20
Comments	Elastic range was taken as between 0.002 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.		

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

Project	S-11-106 RBO Branch of Suck Creek			Date	5/25/2022
Project No.	G6655.002	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P0411149	Sample Length (in.)	3.877	Reviewed By	WJG
Boring	B-4	Unit Weight (pcf)	169.0	Core Size	NQ
Sample No.	NQ-3 / 22-1399B	L/D Ratio	2.07	Recovery	100%
Depth	29.1 - 29.4	Load Rate (psi/sec)	20	RQD	60%
Description	White/Gray/Black Biotite Micaceous Schist				





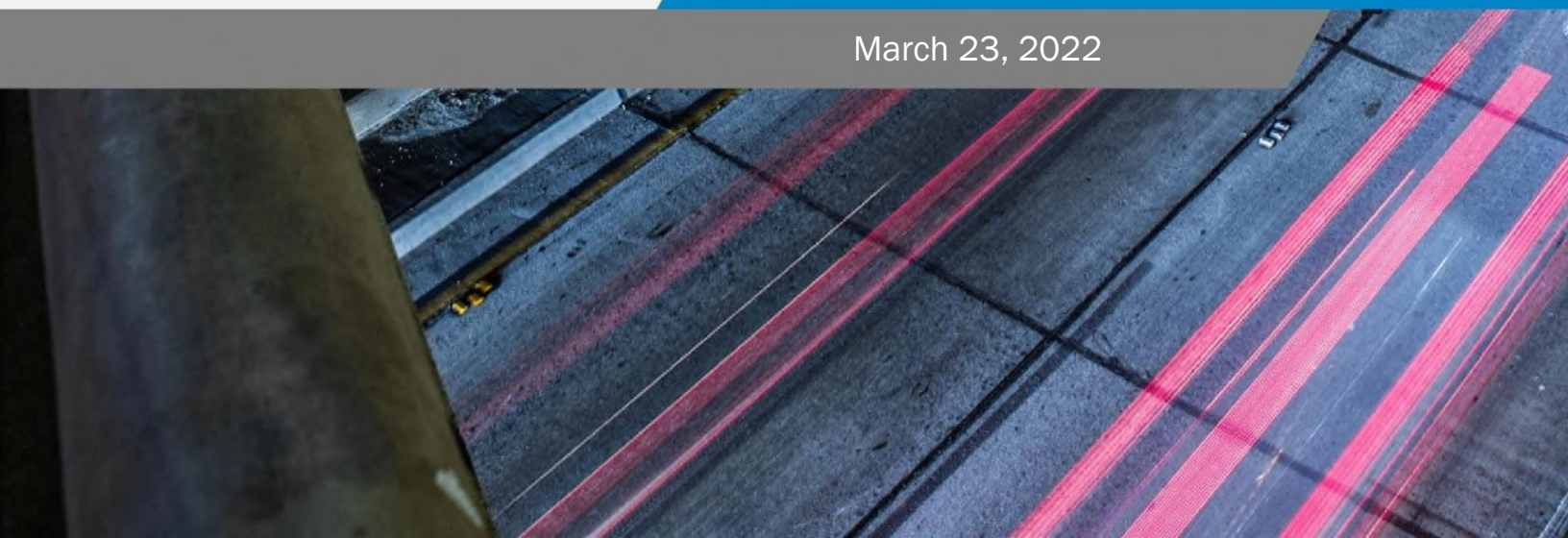
Appendix D. SPT Hammer Energy Calibration Report

CAROLINAS GEOTECHNICAL GROUP

Report of SPT Hammer Energy

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

March 23, 2022



CAROLINAS GEOTECHNICAL GROUP

N.C. Firm License: P-1904

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.

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

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

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%.

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

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

NORTH CAROLINA PROFESSIONAL SEAL 042642 ENGINEER ROBERT E. KRAL

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

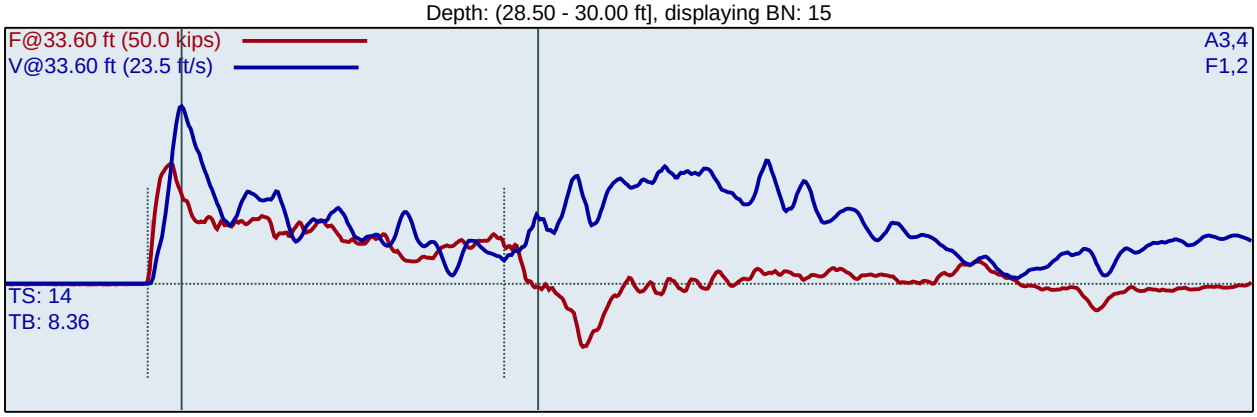
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 33.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (28.50 - 30.00 ft], displaying BN: 15



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.

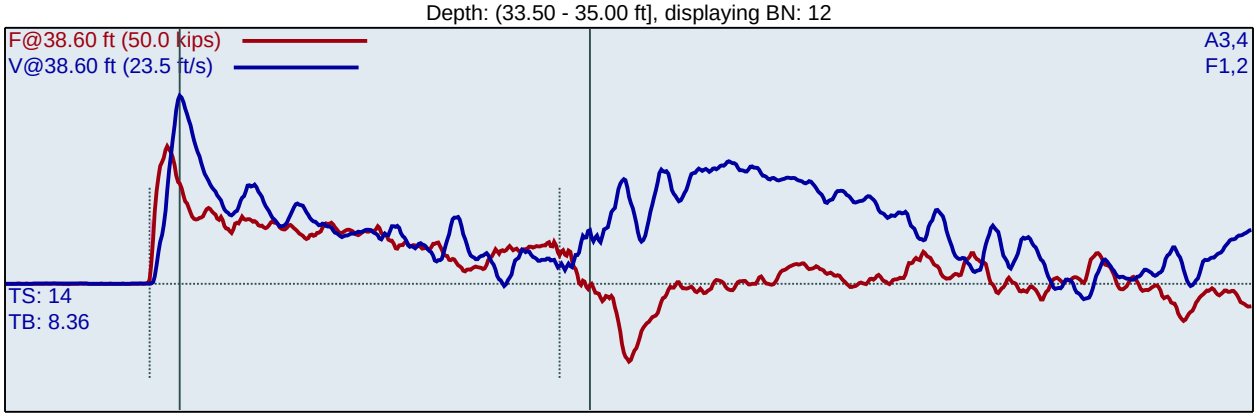
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 38.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (33.50 - 35.00 ft], displaying BN: 12



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.

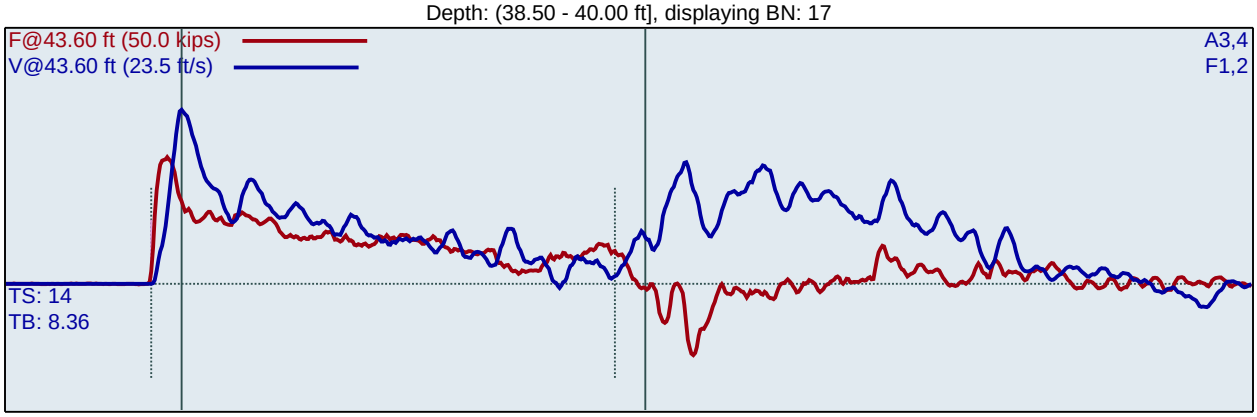
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 43.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (38.50 - 40.00 ft], displaying BN: 17



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
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement
CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

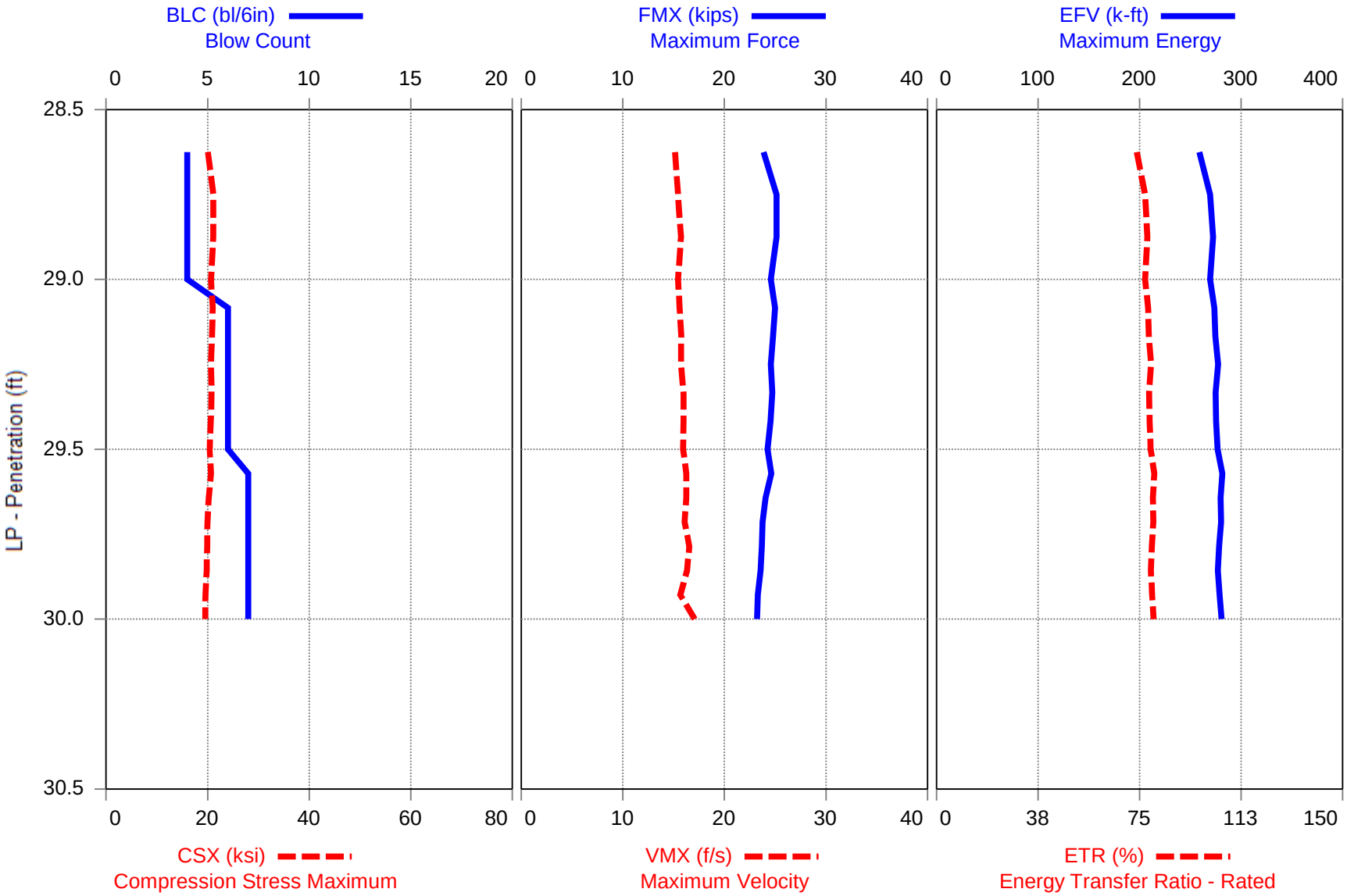
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	**N Value**	**N60 Value**	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR %
33.60	28.50	30.00	**4-6-7**	**13**	**17**	53.4	24.2	16.1	1.1	20.3	0.9	277.5	79.3
38.60	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

Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 28.5 TO 30.0

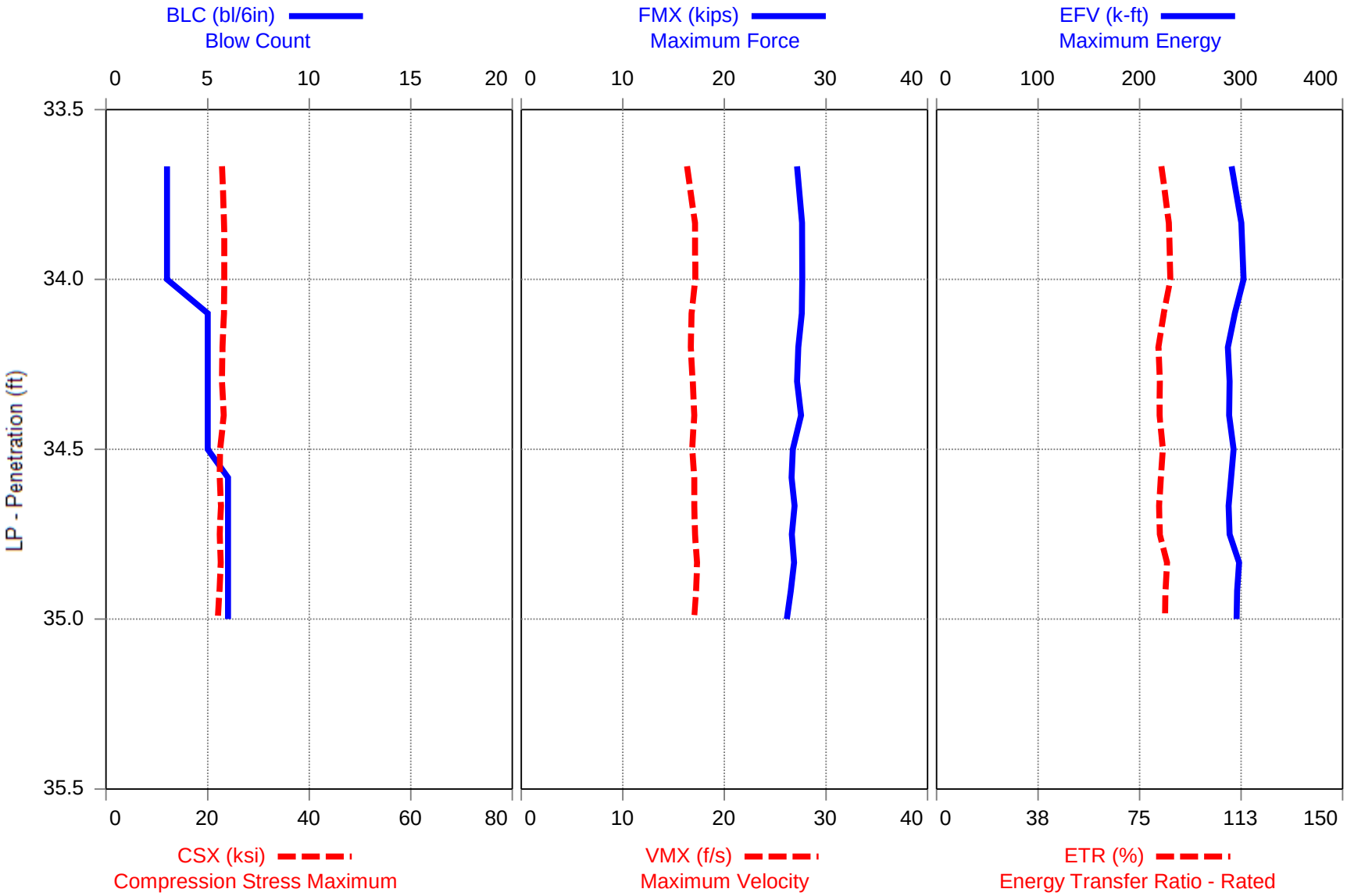


Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 33.5 TO 35.0

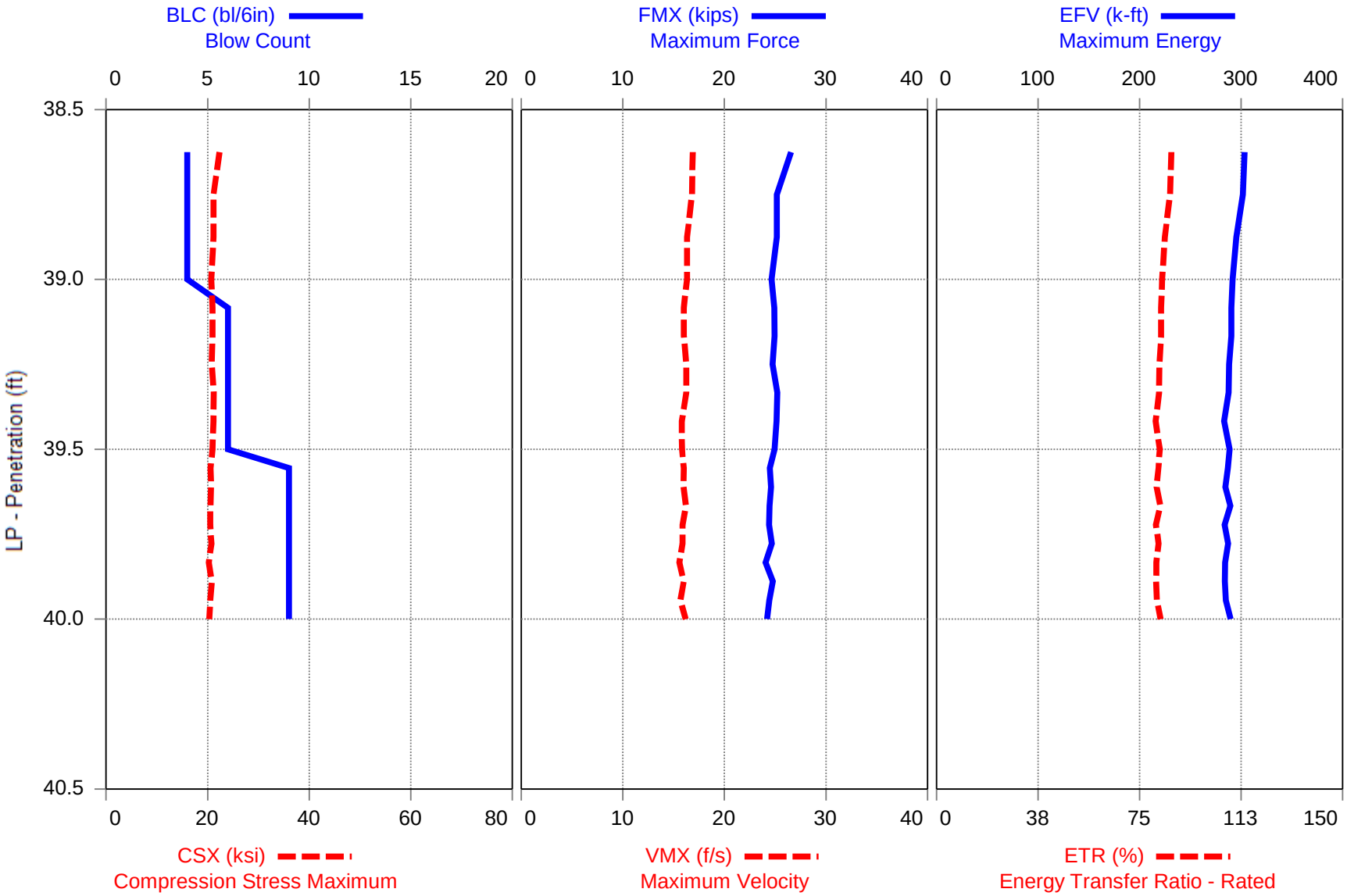


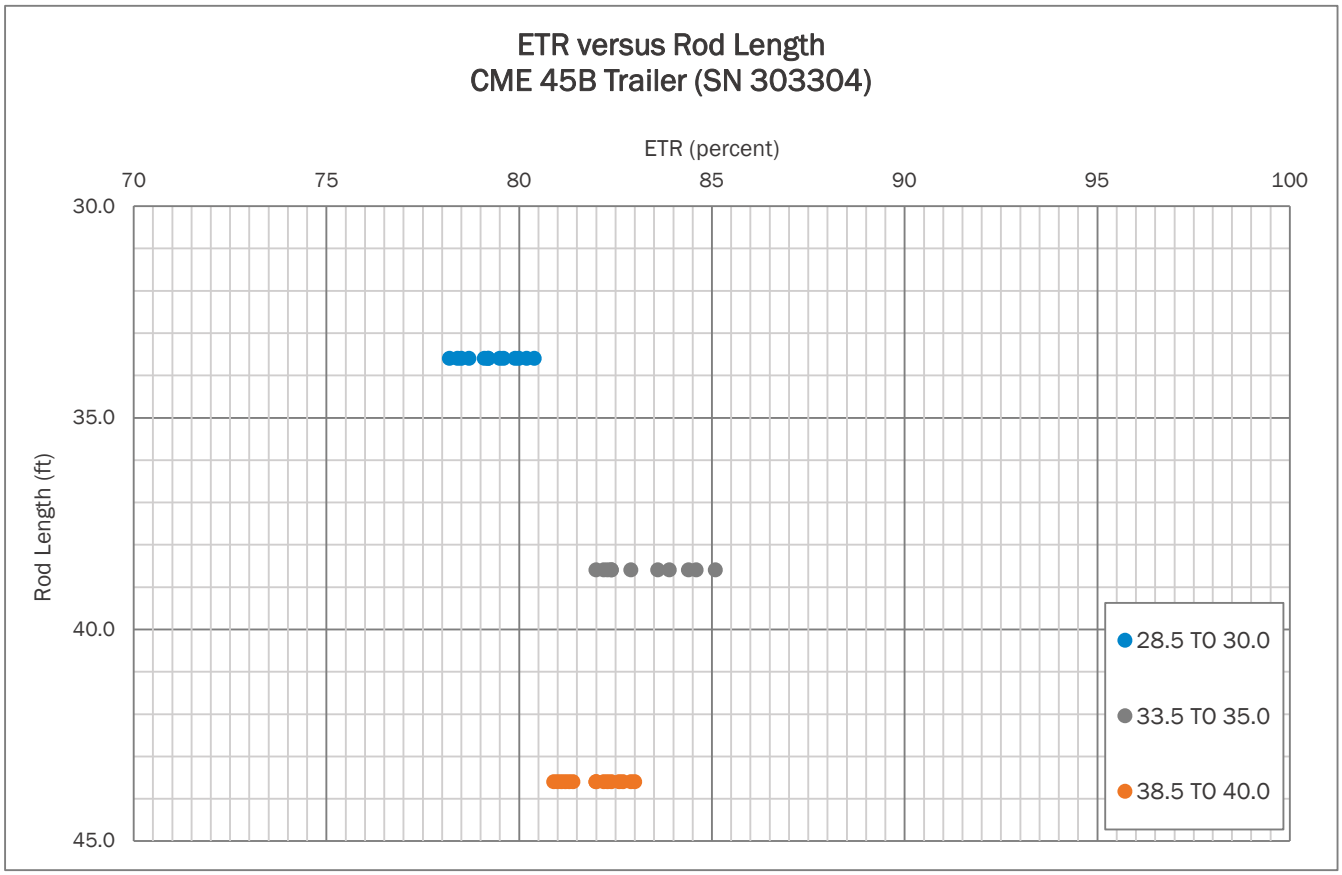
Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

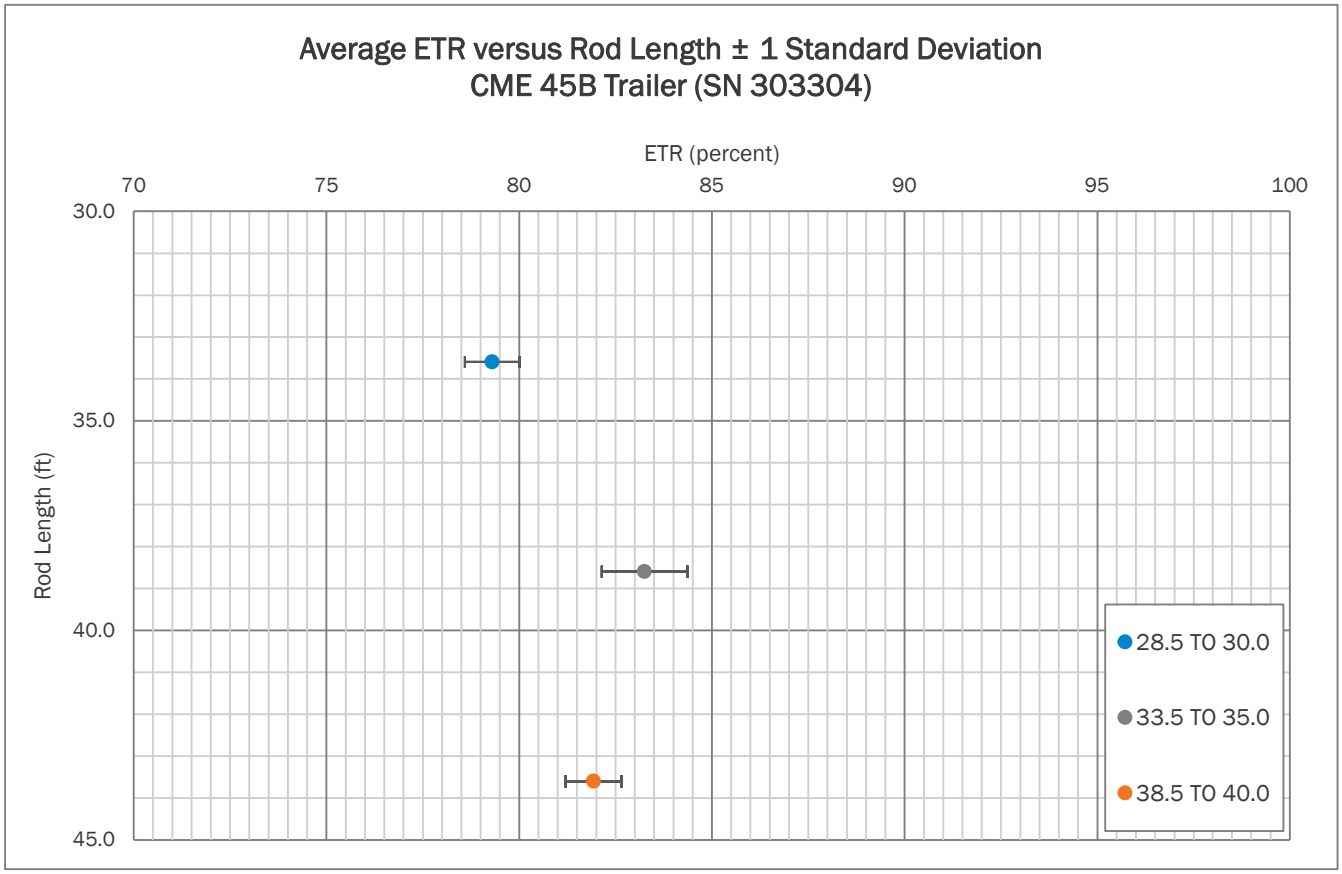
Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 38.5 TO 40.0




ETR versus Rod Length
CME 45B Trailer (SN 303304)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30.0
35.0
40.0
45.0
28.5 TO 30.0
33.5 TO 35.0
38.5 TO 40.0


Average ETR versus Rod Length ± 1 Standard Deviation
CME 45B Trailer (SN 303304)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30.0
35.0
40.0
45.0
28.5 TO 30.0
33.5 TO 35.0
38.5 TO 40.0

APPENDIX II

SPT Hammer Energy Field Form

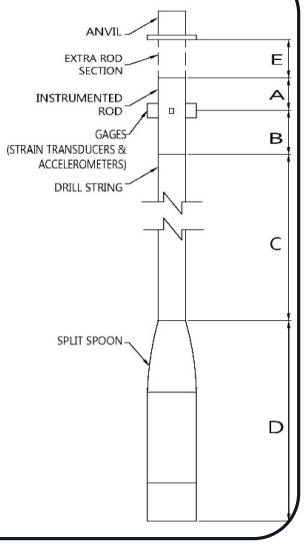
Project:	SPT HAMMER ENERGY	**Date:**	3/11/2022
Project No.:	240021095	**Weather:**	50's CLOUDY
Boring No.:	B-1	**Drill Rod Type:**	AWJ

On-site Personnel

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

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	in^2
PDA Make/Model:	SPT	
PDA Serial No.:	4549 TB	
Calib. Pulse Test (y/n):	Y	



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

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 6"	12"	18"	N-Value	Drop Height in Tolerance (y/n)	Soil Class.
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. veritcality, 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) — Date: 3/11/2022

Figure No. 1: Rear View of Drill Rig

Figure No. 2: Side View of Drill Rig

Figure No. 3: Serial Number Plate

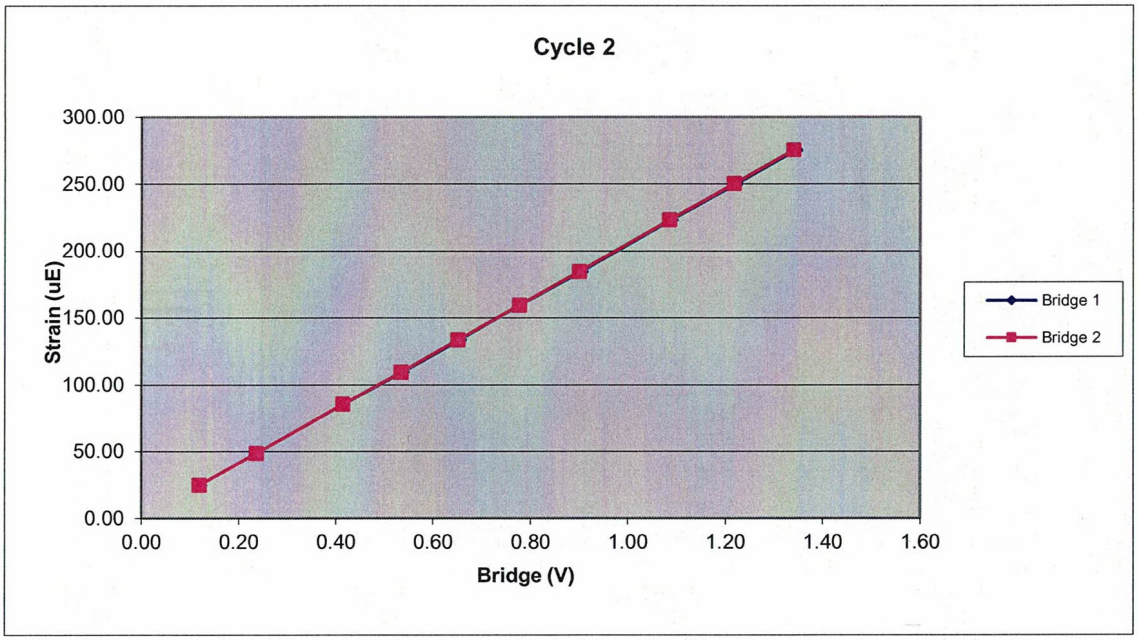
Figure No. 4: Automatic Hammer

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 (µE/V)	**204.74**	**Strain Calibration (µE/V)**	**205.35**
Offset	**-0.39**	Offset	**-0.39**
Correlation	**0.999993**	Correlation	**0.999995**

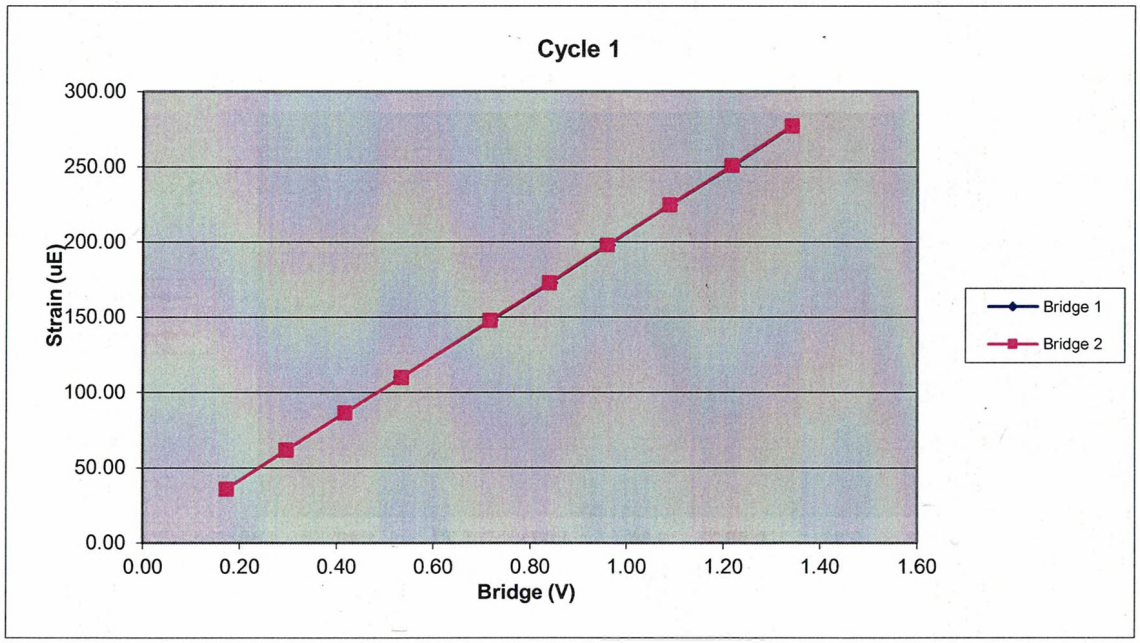
Force Strain Calibration	
EA (Kips)	**35851.72**
Offset	**27.08**
Correlation	**0.999996**



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 (μE/V)	**205.65**	**Strain Calibration (μE/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 Resitor (ohm) 60.4k

Calibration Factors	528AWJ		
Bridge 1 (µE/V)	205.26	Bridge 2 (µE/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		

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

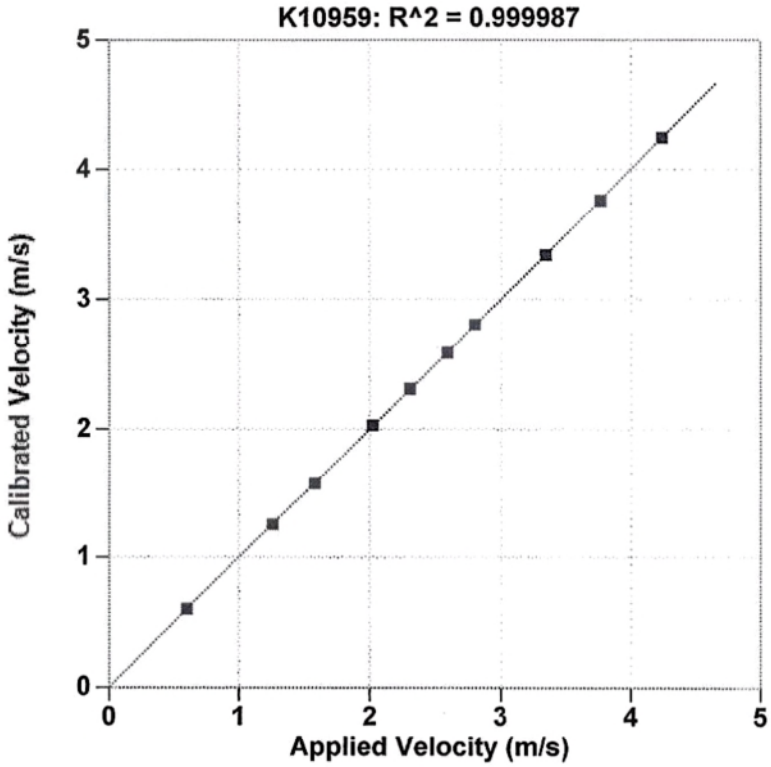
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

417.3 mv/5000g
(83.5 µv/g)
R^2: 0.999987 [Chip programmed]

Operator: William Johnson

Signed



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		

Ref Acc 1:	63479! 1080 g's/volt	**Cal on:**	09Sep2020
Ref Acc 2:	65538! 1040 g's/volt	**Cal on:**	27Jan2020

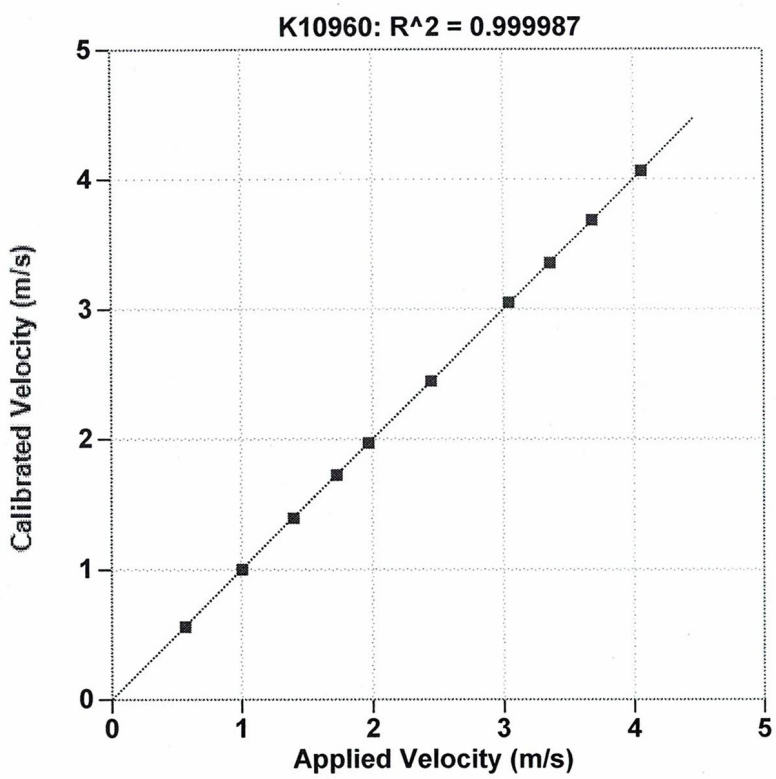
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

425.7 mv/5000g
(85.1 μv/g)
R^2: 0.999987 [Chip programmed]

Operator: William Johnson

Signed



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		

Ref Acc 1:	63479! 1079 g's/volt	**Cal on:**	22Jan2021
Ref Acc 2:	65538! 1043 g's/volt	**Cal on:**	22Jan2021

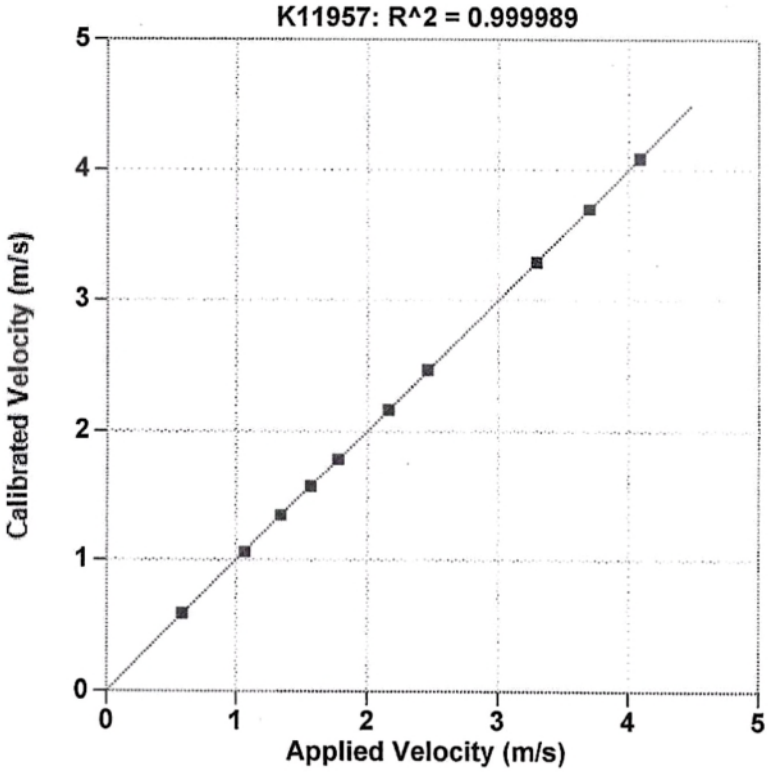
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

407.0 mv/5000g
(81.4 µv/g)
R^2: 0.999989 [Chip programmed]

Operator: William Johnson

Signed



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

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

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