



Geotechnical Subsurface Data Report (GSDR)
Route S-11-97 Bridge Replacement over Goforth Creek
Cherokee County, South Carolina
SCDOT Project ID P038057
S&ME Project No. 1361-20-048

PREPARED FOR:

**South Carolina Department of Transportation
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Columbia, South Carolina 29201**

PREPARED BY:

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March 19, 2021



March 19, 2021

South Carolina Department of Transportation
955 Park Street
Columbia, South Carolina 29201

Attention: Mr. Trapp Harris, P.E.

Reference: **Closed and Load-Restricted Bridge Package 2021-1**
Geotechnical Subsurface Data Report (GSDR)
Route S-11-97 Bridge Replacement over Goforth Creek
Cherokee County, South Carolina
SCDOT Project ID P038057
S&ME Project No. 1361-20-048

Dear Mr. Harris:

The purpose of this report is to convey geotechnical information to the South Carolina Department of Transportation (SCDOT) for use by a contractor and is typically used with traditional design-build projects. Our services were performed in general accordance with the *Scope of Services* provided in the *On-Call Consultant Work Order Request* by SCDOT, dated September 10, 2020, and the SCDOT *Geotechnical Design Manual* (GDM), Version 2.0, dated January 2019.

S&ME appreciates this opportunity to work with you as your geotechnical engineering consultant on this project. Please contact us at (803) 561-9024 if you have any questions or need any additional information regarding this report.

Sincerely,

S&ME, Inc.

John P. Lewis, P.E.
Project Engineer

Robert C. Bruorton, P.E.
Senior Engineer



Matthew F. Cooke, P.G., P.E.
Senior Project Manager





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1.0 Project Description

The proposed construction for this project includes replacement of the existing Oak Ridge Road (S-11-97) bridge over Goforth Creek located in Cherokee County, South Carolina, as shown in the *Site Location Plan*, attached as Figure 1 in Appendix I.

Table 1-1 – Bridge Location Summary

Project ID	Route	Route Name	Crossing	County	Latitude	Longitude
P038057	S-11-97	Oak Ridge Road	Goforth Creek	Cherokee	35.15807	-81.66364

From our review of the provided information, the existing bridge was built in 1959 and is 105 feet in length with two travel lanes. The proposed replacement bridge will be 150 feet in length. Additional information regarding the proposed replacement bridge has not been provided at this time.

2.0 Objective

The objective of this project was to explore the subsurface conditions along the proposed alignment as they pertain to the proposed improvements, and in conjunction with field and laboratory testing, to provide geotechnical data to be utilized for project design.

3.0 Scope of Work

As requested, representatives of S&ME were present for on-site field activities between October 6 and 7, 2020, to conduct the following testing:

- Two (2) Standard Penetration Test (SPT) borings (B-1 and B-2), with one boring near each proposed abutment location.

Testing was conducted at or near the requested locations provided in the *Scope of Services*, provided by SCDOT, dated September 10, 2020. Testing locations were modified as necessary due to utilities, terrain, to minimize traffic control impacts, and to facilitate safe working conditions.

Additionally, laboratory testing was performed on disturbed split-spoon and rock core samples collected in the field. The laboratory testing program is described in more detail in the following sections.



4.0 Test Locations

Testing locations for the proposed new bridge abutments were determined by subtracting the existing bridge length from the proposed new bridge length, dividing that distance by two, and measuring that divided distance from the existing abutments. As-built survey of the testing locations was performed by Glenn Associates Surveying, Inc. The approximate testing locations are shown on the *Boring Location Plan*, included as Figure 2 in Appendix I. A summary of testing locations, including coordinates, elevation and alignment are presented in Table 1, *Test Location Summary*, in Appendix II. Surveyed coordinates are tabulated in decimal degree latitude and longitude as well as South Carolina State Plan northing and easting coordinates.

5.0 Exploration Procedures

The subsurface exploration for this project to date has included SPT borings. The following sections summarize the general outline of each test. The field testing data are organized into appendices of this report as follows:

- ◆ Appendix III – Soil Test Boring Records

5.1 Encroachment

S&ME contacted the Resident Maintenance Engineer for Cherokee County to coordinate the field testing and traffic control along the SCDOT right-of-way in lieu of applying for an encroachment permit.

5.2 Traffic Control

Traffic control for the project was provided by Area Wide Protective (AWP) under subcontract to S&ME. Traffic control was performed in accordance with SCDOT requirements for *Flagging Operations Two-Lane Two-Way Roadways without Intersections* – SCDOT Standard Drawing 610-005-10.

5.3 Standard Penetration Test (SPT) Borings

Two (2) soil test borings with SPT sampling were performed between the dates of October 6 and 7, 2020 using a truck-mounted CME 55 drill rig. Soil test borings with SPT sampling were performed using mud rotary drilling techniques. The borings were performed to drill bit refusal at depths followed by wireline rock coring to the termination depth. A summary of the SPT borings performed is provided in the table below:



Table 5-1 – Boring Summary

Route	Bridge ID	Boring No.	Refusal Depth (ft)	Total Boring Depth (ft)	Pavement	Purpose
S-11-97	1170009700100	B-1	23.6	33.8	Asphalt	Proposed Southwest Abutment
		B-2	32.6	37.6	Asphalt	Proposed Northeast Abutment

Soil sampling and penetration testing were performed in general accordance with ASTM D1586 *Standard Test Method for Penetration Test and Split Barrel Sampling of Soils*. SPT was performed in each boring continuously in the upper 10 feet, followed by approximate 5-foot centers, thereafter. The split-barrel sampler was opened at the drill site and sloughed material was identified and separated from the recovered sample. The recovered sample was visually described and classified by S&ME's rig engineer. A selected portion of the sample was placed in a glass jar with a moisture-proof lid. Where materials changed over the sample drive length, a sample of each material was retained. The sample jars were labeled, placed in cardboard boxes, and transported to the S&ME Columbia Office at the end of each workday.

5.3.1 Ground Water

Water level measurements were attempted immediately after completion of drilling and, where feasible, were repeated after a period of roughly 24 hours. We note that due to the use of drilling fluid additives in mud rotary borings, the water level readings recorded in the soil borings may not accurately reflect the ground water conditions at the site. Ground water readings were conducted in general accordance with ASTM D4750 *Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)*. A summary of the measured ground water depths and rough elevations are provided in the table below:

Table 5-2 – Ground Water Measurement Summary

Boring No.	Existing Grade (ft.)	GW Depth at TOB (ft)	GW Elevation at TOB (ft)	24-hr GW Depth (ft)	24-hr GW Elevation (ft)
B-1	723.9	16.2	707.7	16.5	707.4
B-2	724.7	19.1	705.6	19.0	705.7

After ground water measurements were complete, the borings were backfilled with bentonite chips, auger cuttings, or clean fill to within 20 feet of the existing ground surface then abandoned with Portland cement/bentonite grout. The surface pavements at each boring location were patched with commercially available bagged asphalt cold patch materials.



5.4 SPT Energy Measurements

SPT hammer energy measurements with a Pile Driving Analyzer (PDA) were performed by S&ME at an off-site location for the drill rig used on the project in general accordance with ASTM D4633 *Standard Test Method for Energy Measurement for Dynamic Penetrometers*. The SPT energy test results are summarized below and provided in Appendix VII. The N-values indicated on the soil test boring records are field values and were not corrected for overburden stress, rod length, borehole diameter or hammer efficiency.

Table 5-3 – S&ME Drilling Equipment Summary

Rig Make/Model	Serial No.	Carrier Type	Average SPT Energy Transfer Ratio (ETR), %
CME 55	328245	Truck	85.7

5.5 Wireline Rock Coring

Upon encountering refusal at the boring locations, wireline rock coring was performed to termination depths of 33.8 to 37.6 feet below the existing ground surface to explore the refusal materials in general accordance with ASTM D2113 *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*. Rock coring was performed using an NQ-size core barrel and wireline retrieval system. The recovered rock cores were visually logged by the S&ME rig geologist or engineer. The rock core samples were placed in cardboard core boxes and the boxes were labeled. Photographs were taken of each completed core box prior to any core being removed for laboratory testing. Completed core boxes were transported to the S&ME Columbia Office at the end of each workday. The rock cores were preserved, handled, and transported in general accordance with ASTM D5079.

6.0 Classification of Recovered Soil Samples

Recovered split-spoon samples were initially classified in general accordance with ASTM D2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Method)*. After laboratory testing was completed, provisional field classifications were revised as necessary to provide a soil description that generally follows the terminology given by ASTM D2487 *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)* and AASHTO M145 *Recommended Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes*.

Interpreted subsurface conditions encountered by the SPT borings are shown on the boring records in Appendix III. These records represent our interpretation of the subsurface conditions based on the test data. Stratification lines on the boring records represent approximate boundaries between soil types; however, the actual transition may be gradual, and the thicknesses of the strata will vary across the site. The soil samples will be retained at our laboratory for a period of seven years, or until completion of substructure installation, whichever is earlier.



7.0 Classification of Recovered Rock Samples

Recovered rock core samples were reviewed and classified in general accordance with the SCDOT GDM Chapter 6, Section 6.3. Upon return to our laboratory, the rock core samples were reviewed by a Professional Geologist (PG). Recovered cores examined in the laboratory were assigned descriptive terms using Tables 6-15 through 6-22 of the GDM where applicable to the rock type. Rock lithologic descriptions, and applicable descriptive information are included on the Soil Test Boring Records in Appendix III. Discontinuities in the recovered cores were evaluated using the terminology in GDM Tables 6-23 through 6-29. The results of the discontinuity examination are tabulated in the *Rock Core Discontinuity Worksheets* for each cored borehole, included in Appendix III. After logging, selected sections of rock core were removed and prepared for laboratory compressive strength testing.

After laboratory testing was completed, the Rock Mass Rating (RMR) and Geological Strength Index (GSI) were computed in general accordance with Sections 6.3.12 and 6.3.11, respectively, of the GDM. A summary of the rock core is provided in Table 4 *Rock Core – Laboratory Testing Summary*, in Appendix II.

Interpreted subsurface conditions encountered during rock coring activities are shown on the records in Appendix III. These records represent our interpretation of the subsurface conditions based on the test data. Stratification lines on the boring records represent approximate boundaries between rock types; however, the actual transition may be gradual, and the thicknesses of the strata will vary across the site. The rock samples will be retained at our laboratory for a period of seven years, or until completion of substructure installation, whichever is earlier.

8.0 Laboratory Physical Tests

Laboratory testing consisting of index property testing, and corrosion series testing was performed on selected split-spoon samples, while unconfined compressive strength testing was performed on selected rock core samples. The testing was performed in general accordance with ASTM, AASHTO, or SC state test procedures as follows:

- Atterberg limits – ASTM D4318 / AASHTO T89/90
- Particle-size distribution – ASTM D422 / ASTM D6913 / AASHTO T88
- Percent-finer 200 sieve – ASTM D1140 / AASHTO T11
- Natural moisture content – ASTM D2216 / AASHTO T265
- Corrosion Series:
 - pH – ASTM G51 / AASHTO T289
 - Chloride – AASHTO T291
 - Sulfate – ASTM C1580 / AASHTO T290
 - Resistivity – AASHTO T288
- Unconfined Compression – ASTM D7012

Tables summarizing the laboratory test results are provided in Appendix II as follows:

- Table 2: Split Spoon Samples – Laboratory Classification Testing Summary
- Table 3: Split Spoon Samples – Corrosion Series Testing Summary



- Table 4: Rock Core – Laboratory Testing Summary

The individual laboratory test data sheets are organized into appendices of this report as summarized below:

- Appendix IV: Laboratory Test Results – Split Spoon Samples
- Appendix V: Laboratory Test Data Sheets – Corrosion Series
- Appendix VI: Laboratory Test Data Sheets – Rock Cores

9.0 Closing

This data report has been prepared in general accordance with procedures in SCDOT GDM Chapter 21 and with generally applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express 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.

We relied on project information given to us to develop our exploration program. If project information described in this report is not accurate, or if it changes during project development, we should be notified of the changes.

This report presents data from a limited field exploration program. Subsurface conditions will vary widely between explored areas. Some variations may not become evident until further exploration or construction. If conditions are encountered which appear different than those described in our report, we should be notified. This report should not be construed to represent subsurface conditions for the entire site.

Unless specifically noted otherwise, our field exploration program did not include an assessment of regulatory compliance, environmental conditions or pollutants or presence of any biological materials (mold, fungi, bacteria). If there is a concern about these items, other studies should be performed.

Appendices

Appendix I – Figures



SOURCE: Google Maps



SITE LOCATION PLAN: S-11-97

JOB NAME: S-11-97 Bridge over Goforth Creek		FIGURE NO. 1
LOCATION: S-11-97 (Oak Ridge Road)		
CITY, STATE: Gaffney, South Carolina		
JOB NO.: 1361-20-048		
SCALE: NTS	CHECKED BY: MFC	
DATE: 3/19/2021	DRAWN BY: AKS	



Legend:

SOURCE: Google Earth



Approximate Boring Location



BORING LOCATION PLAN: S-11-97

JOB NAME: S-11-97 Bridge over Goforth Creek
LOCATION: S-11-97 (Oak Ridge Road)
CITY, STATE: Gaffney, South Carolina
JOB NO.: 1361-20-048

FIGURE NO.

2

SCALE: NTS

CHECKED BY: MFC

DATE: 3/19/2021

DRAWN BY: JPL

Appendix II – Tables



Table 1: Test Location Summary

Bridge ID	Boring No.	Test/SampleType(s)						SC State Plane Northing (ft.)	SC State Plane Easting (ft.)	Latitude (degrees)	Longitude (degrees)	Elevation (ft-msl)	Alignment
		SPT	CPT	DMT	Seismic	Bulk	UD						
S-11-97	B-1	X						1210339.1	1801574.0	35.15791	-81.66371	723.9	Existing
S-11-97	B-2	X						1210472.6	1801641.1	35.15827	-81.66349	724.7	Existing



Table 2: Split Spoon Samples – Laboratory Classification Testing Summary

Route ID	Boring Number	Sample Number	Sample Depth (ft)	Natural Moisture (%)	Atterberg Limits			Percent Finer #10 (%)	Percent Finer #40 (%)	Percent Finer #200 (%)	Organic Content (%)	Soil Classification		
					LL	PL	PI					AASHTO	USCS	Strata
S-11-97	B-1	SS-1	0.5-2.5	20.8	41	24	17	81.0	63.0	35.7	-	A-7-6	SC	FILL
	B-1	SS-6	13.5-15.0	34.8	30	20	10	100.0	97.0	68.0	-	A-4	CL	ALLUVIUM
	B-1	SS-7	18.5-20.0	52.5	56	31	25	-	-	80.7	-	-	CH	ALLUVIUM
	B-2	SS-1/SS-2	0.3-4.3	19.1	39	18	21	86.0	75.0	48.2	-	A-6	SC	FILL
	B-2	SS-4	6.3-8.3	25.6	-	-	-	-	-	53.2	-	-	ML	FILL
	B-2	SS-6	13.5-15.0	21.0	31	20	11	90.0	77.0	41.0	-	A-6	SC	ALLUVIUM

NT = Not Tested

NP = Non-plastic

Classification estimated based on test results and ASTM D2488 Visual Manual Procedure



Table 3: Split Spoon Samples - Corrosion Series Testing Summary

Route & Boring Number	Sample Depth (ft)	Sample Number	As-Rec'd Resistivity (Ohm-cm)	Minimum Resistivity (Ohm-cm)	Sulfates		Chlorides		pH
					(mg/kg)	(wt%)	(mg/kg)	(wt%)	
S-11-97 B-2	18.5 - 20.0	SS-7	31,490	26,800	34.8	0.0035	8.2	0.0008	6.7



Table 4: Rock Core - Laboratory Testing Summary

Route & Boring Number	Core Run No.	Core Run Top Depth	Core Run Bottom Depth	Recovery (%)	RQD	Sample Top Depth (ft)	Sample Bottom Depth (ft)	Unit Weight (pcf)	Unconfined Compressive Strength (psi)	RMR ⁽¹⁾	GSI ⁽²⁾ Range
S-11-97 B-1	RC-1	23.6	24.8	75	0	-	-	-	-	-	28
	RC-2	24.8	29.8	70	18	29.2	29.6	171	7,405	18	32
	RC-3	29.8	33.8	100	90	30.55	30.95	181	14,666	57	70-73
S-11-97 B-2	RC-1	32.6	34.9	100	100	32.7	33.1	176	10,385	72	85
	RC-2	34.9	37.6	98	98	34.95	35.35	170	18,522	77	80

Notes:

⁽¹⁾ RMR = Rock Mass Rating (Refer to SCDOT Geotechnical Design Manual, Chapter 6)

⁽²⁾ GSI = Geologic Strength Index (Refer to SCDOT Geotechnical Design Manual, Chapter 6)

Appendix III – Soil Test Boring Records

LEGEND TO SOIL CLASSIFICATION AND SYMBOLS

SOIL TYPES

(Shown in Graphic Log)



Fill



Asphalt



Concrete



Topsoil



Gravel



Sand



Silt



Clay



Organic



Silty Sand



Clayey Sand



Sandy Silt



Clayey Silt



Sandy Clay



Silty Clay



Partially Weathered Rock



Cored Rock

WATER LEVELS

(Shown in Water Level Column)

▽ = Water Level At Termination of Boring

▼ = Water Level Taken After 24 Hours

◀ = Loss of Drilling Water

HC = Hole Cave

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY

Very Soft
Soft
Firm
Stiff
Very Stiff
Hard
Very Hard

STD. PENETRATION RESISTANCE BLOWS/FOOT

0 to 2
3 to 4
5 to 8
9 to 15
16 to 30
31 to 50
Over 50

RELATIVE DENSITY OF COHESIONLESS SOILS

RELATIVE DENSITY

Very Loose
Loose
Medium Dense
Dense
Very Dense

STD. PENETRATION RESISTANCE BLOWS/FOOT

0 to 4
5 to 10
11 to 30
31 to 50
Over 50

TERMS

Standard Penetration Resistance - The Number of Blows of 140 lb. Hammer Falling 30 in. Required to Drive 1.4 in. I.D. Split Spoon Sampler 1 Foot. As Specified in ASTM D-1586.

REC - Total Length of Rock Recovered in the Core Barrel Divided by the Total Length of the Core Run Times 100%.

RQD - Total Length of Sound Rock Segments Recovered that are Longer Than or Equal to 4" (mechanical breaks excluded) Divided by the Total Length of the Core Run Times 100%.



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		Sieve size
Descriptor	mm	
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

6-38

January 2019

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)

SCDOT Soil Test Log

Project ID:	P038057				County:	Cherokee		Boring No.:	B-1		
Site Description:	S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)							Route:	S-11-97		
Eng./Geo.:	NB		Boring Location:		22.5' S of SEB		Offset:	6' E of CL		Alignment:	Existing
Elev.:	723.9 ft		Latitude:	35.157906361		Longitude:	-81.663714653		Date Started:	10/6/2020	
Total Depth:	33.8 ft		Soil Depth:	23.6 ft		Core Depth:	10.2 ft		Date Completed:	10/7/2020	
Bore Hole Diameter (in):			3 7/8		Sampler Configuration		Liner Required:	Y (N)		Liner Used:	Y (N)
Drill Machine:	CME 55		Drill Method:	RW / DC / RC		Hammer Type:	Automatic		Energy Ratio:	85.7%	
Core Size:	NQ		Driller:	T. Miller		Groundwater:	TOB	16.2 ft		24HR	16.5 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL MC LL X X X ▲ FINES CONTENT (%) ✕ RQD (%) ■ REC (%)
	0.0										0 10 20 30 40 50 60 70 80 90
	0.5	SURFACE MATERIALS - 6 inches of ASPHALT.		0.5	SS-1	4	4	4	4	8	● ✕ ▲ ✕
	2.5	FILL - medium dense, slightly moist, reddish-brown, Clayey fine to medium SAND (SC) (A-7-6), 5YR 4/3, some medium plasticity fines, trace fine rock fragments.		2.5	SS-2	3	4	6	6	10	●
718.9	4.5	LL=41, PL= 24, PI=17, NMC=20.8, %200=35.7		4.5	SS-3	6	6	5	5	11	●
	6.5	ALLUVIUM - firm, slightly moist to moist, light brown, Sandy LEAN CLAY (CL) (A-4), 7.5YR 6/4, mostly medium plasticity fines, some fine to medium sands, trace organics, trace fine rock fragments.		6.5	SS-4	4	4	3	4	7	●
713.9	8.0			8.0	SS-5	3	3	2	3	5	●
	13.5	@ 13.5 feet - very soft, trace roots.		13.5	SS-6	WOHWOH 1				1	● ✕ ✕ ○ ▲
708.9	17.0	LL=30 , PL= 20, PI=10, NMC=34.8, %200=68.0		17.0							
	18.5	Soft, moist, dark gray, FAT CLAY with Sand (CH), 5Y 4/1, mostly high plasticity fines, little fine sands, trace organics.		18.5	SS-7	WOH	1	2		3	● ✕ ✕ ○ ▲
703.9	23.6	LL=56 , PL= 31, PI=25, NMC=52.5, %200=80.7		23.6							
	24.8	METAMORPHIC BEDROCK - BIOTITE-GARNET AUGEN GNEISS - reddish brown (5YR 4/4), brownish yellow (10YR 6/6), gray (N5), fine to coarse grained, thickly foliated, biotite garnet quartz feldspar, moderately to highly weathered, medium strong rock, MH, J (0-40° dip, VC, very wide, Wa-Pl-Ir-St, SR-R, No)		24.8	RC-1						✕ ■
698.9	29.8	RC-1: REC=75, RQD=0, GSI=28, 2.3 min/ft		29.8	RC-2						✕ ■
693.9	33.8	RC-2: REC=70, RQD=18, GSI=32*, RMR=18, 6.7 min/ft		33.8	RC-3						✕ ■
		*Excludes portion of RC-2 below 28.2 ft									
688.9		@ 28.2 feet - gray (N5), white (N8), fine to coarse grained, thickly foliated with some schistosity, biotite garnet quartz feldspar, slightly weathered, strong rock, MH-H, J (0-45° dip, VC, partly open to wide, Pl-Ir, SR-R, No)									

LEGEND

Continued Next Page

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

SC.DOT 1361-20-048 S-11-97 BORING LOGS.GPJ SCDOT_DATATEMPLATE.GDT 3/19/21

SCDOT Soil Test Log

Project ID:	P038057				County:	Cherokee		Boring No.:	B-1		
Site Description:	S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)							Route:	S-11-97		
Eng./Geo.:	NB		Boring Location:		22.5' S of SEB		Offset:	6' E of CL		Alignment:	Existing
Elev.:	723.9 ft		Latitude:	35.157906361		Longitude:	-81.663714653		Date Started:	10/6/2020	
Total Depth:	33.8 ft		Soil Depth:	23.6 ft		Core Depth:	10.2 ft		Date Completed:	10/7/2020	
Bore Hole Diameter (in):			3 7/8		Sampler Configuration		Liner Required:	Y (N)		Liner Used:	Y (N)
Drill Machine:	CME 55		Drill Method:	RW / DC / RC		Hammer Type:	Automatic		Energy Ratio:	85.7%	
Core Size:	NQ		Driller:	T. Miller		Groundwater:	TOB	16.2 ft		24HR	16.5 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL — MC — LL X — X — X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
678.9		@ 29.2 feet - qu=7,405 psi RC-3: REC=100, RQD=90, GSI=70-73*, RMR=57*, 4.8 min/ft, very strong rock *Includes portion of RC-2 below 28.2 ft @ 30.5 feet - qu=14,666 psi Boring Terminated at 33.8 feet.									0 10 20 30 40 50 60 70 80 90
673.9											
668.9											
663.9											
658.9											
653.9											
648.9											

LEGEND

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



Rock Core Discontinuity Worksheet

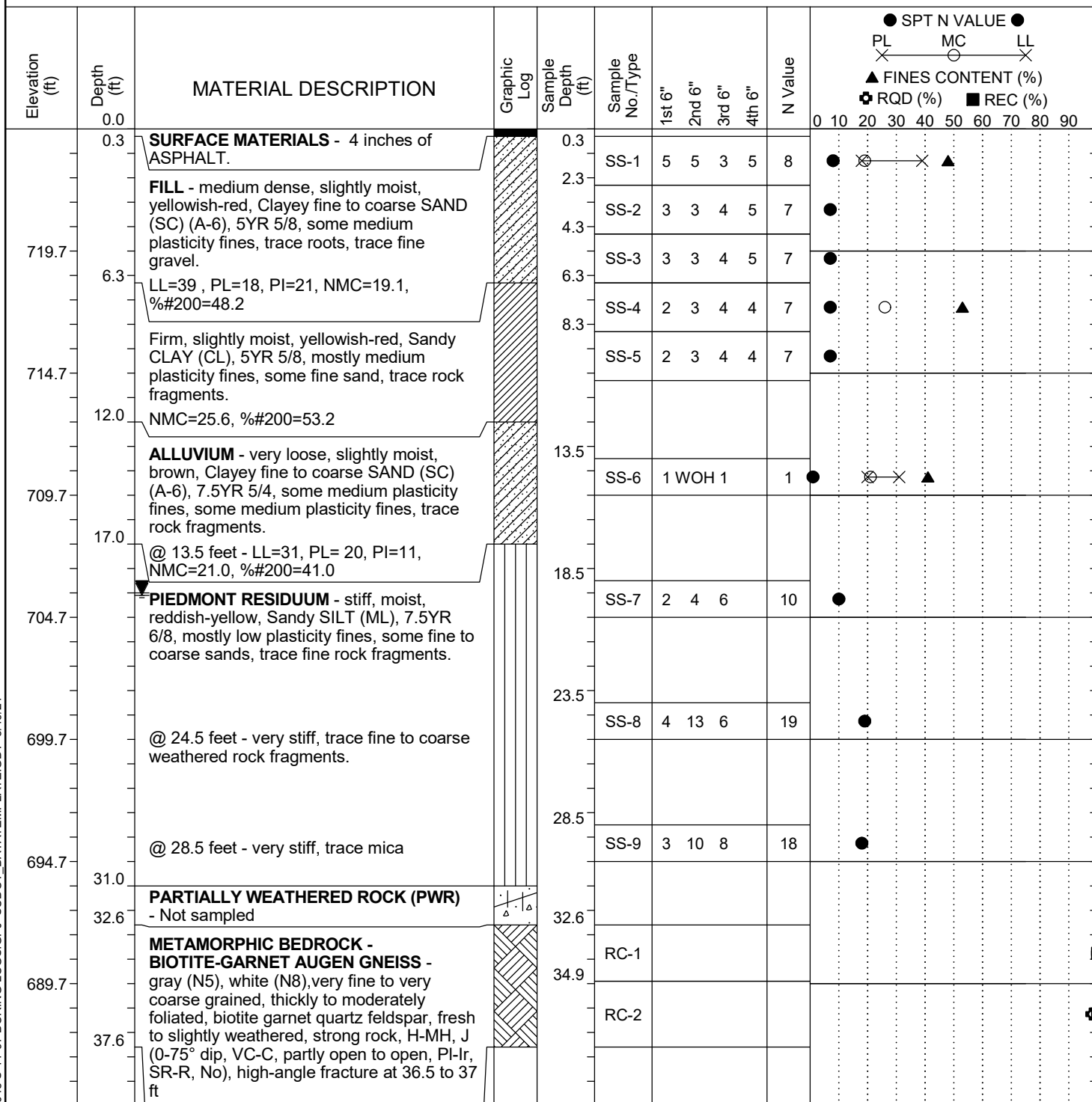
Project Name: S-11-97 over Goforth Creek
 Project Number: 1361-20-048
 Driller (Company/Name): S&ME/Ted Miller
 Logged By: NB
 Date: 10/6/2020

Boring Number: B-1
 Core Barrel Type: NQ
 Core Barrel Length: 5.0'
 Coring Technique: wireline
 Number of Core Boxes: 1

Depth (ft)	Disc. No.	Disc. Type	Dip Angle (deg)	Disc. Width (mm)	Infill Amount	Infill Type	Surface Shape	Surface Roughness	Notes
23.6	1	J	N/A	V	No	N/A	PI	SR	highly fractured 26.9' to 25.9'
25.9	2	J	32	VN	No	N/A	PI	SR	
26.1	3	J	27	VN	No	N/A	PI	SR	
26.2	4	J	30	VN	No	N/A	PI	SR	
26.3	5	J	41	VN	No	N/A	PI	SR	
30.5	6	J	36	VN	No	N/A	PI	SR	
31.8	7	J	29	VN	No	N/A	PI	SR	
32.5	8	J	48	VN	No	N/A	PI	SR	
33.4	9	J	33	VN	No	N/A	PI	SR	

SCDOT Soil Test Log

Project ID:	P038057				County:	Cherokee		Boring No.:	B-2		
Site Description:	S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)							Route:	S-11-97		
Eng./Geo.:	NB		Boring Location:	22.5' N of NEB		Offset:	6' E of CL		Alignment:	Existing	
Elev.:	724.7 ft		Latitude:	35.158274241		Longitude:	-81.663493192		Date Started:	10/6/2020	
Total Depth:	37.6 ft		Soil Depth:	32.6 ft		Core Depth:	5 ft		Date Completed:	10/6/2020	
Bore Hole Diameter (in):	3 7/8		Sampler Configuration			Liner Required:	Y (N)		Liner Used:	Y (N)	
Drill Machine:	CME 55		Drill Method:	RW / DC / RC		Hammer Type:	Automatic		Energy Ratio:	85.7%	
Core Size:	NQ		Driller:	T. Miller		Groundwater:	TOB	19.1 ft		24HR	19 ft



LEGEND

Continued Next Page

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

SCDOT Soil Test Log

Project ID:	P038057			County:	Cherokee		Boring No.:	B-2		
Site Description:	S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)						Route:	S-11-97		
Eng./Geo.:	NB		Boring Location:	22.5' N of NEB		Offset:	6' E of CL		Alignment:	Existing
Elev.:	724.7 ft		Latitude:	35.158274241		Longitude:	-81.663493192		Date Started:	10/6/2020
Total Depth:	37.6 ft		Soil Depth:	32.6 ft		Core Depth:	5 ft		Date Completed:	10/6/2020
Bore Hole Diameter (in):	3 7/8		Sampler Configuration			Liner Required:	Y (N)		Liner Used:	Y (N)
Drill Machine:	CME 55		Drill Method:	RW / DC / RC		Hammer Type:	Automatic		Energy Ratio:	85.7%
Core Size:	NQ		Driller:	T. Miller		Groundwater:	TOB	19.1 ft	24HR	19 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL — MC — LL X — X — X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
679.7		RC-1: REC=100, RQD=100, GSI=85, RMR=72, 5.5 min/ft, qu=10,385 psi RC-2: very strong rock, REC=98, RQD=98, GSI=80, RMR=77, 4.7 min/ft, qu=18,522 psi Boring Terminated at 37.6 feet.									0 10 20 30 40 50 60 70 80 90
674.7											
669.7											
664.7											
659.7											
654.7											
649.7											

LEGEND

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

SC.DOT 1361-20-048 S-11-97 BORING LOGS.GPJ SCDOT_DATATEMPLATE.GDT 3/19/21



Rock Core Discontinuity Worksheet

Project Name: S-11-97 over Goforth Creek
Project Number: 1361-20-048
Driller (Company/Name): S&ME/Ted Miller
Logged By: NB
Date: 10/6/2020

Boring Number: B-2
Core Barrel Type: NQ
Core Barrel Length: 5.0'
Coring Technique: wireline
Number of Core Boxes: 1

Depth (ft)	Disc. No.	Disc. Type	Dip Angle (deg)	Disc. Width (mm)	Infill Amount	Infill Type	Surface Shape	Surface Roughness	Notes
33.1	1	J	17	VN	No	N/A	PI	SR	
35.5	2	J	14	VN	No	N/A	PI	SR	
36.1	3	J	25	VN	No	N/A	PI	SR	

Rock Core Photo Log

Boring: B-1	Box: 1 of 1	Date: 10/7/2020	Driller: T. Miller	Geologist: J. Gathro
Run: RC-1	Length: 1.2	Depth Int: 23.6-24.8	Recovery: 75%	RQD: 0%
Run: RC-2	Length: 5.0	Depth Int: 24.8-29.8	Recovery: 70%	RQD: 18%
Run: RC-3	Length: 4.0	Depth Int: 29.8-33.8	Recovery: 100%	RQD: 90%



Boring: B-2	Box: 1 of 1	Date: 10/6/2020	Driller: T. Miller	Geologist: J. Gathro
Run: RC-1	Length: 2.3	Depth Int: 32.6-34.9	Recovery: 100%	RQD: 100%
Run: RC-2	Length: 2.7	Depth Int: 34.9-37.6	Recovery: 98%	RQD: 98%



Appendix IV – Laboratory Test Results – Split-Spoon Samples



INDEX PROPERTIES VERSUS DEPTH

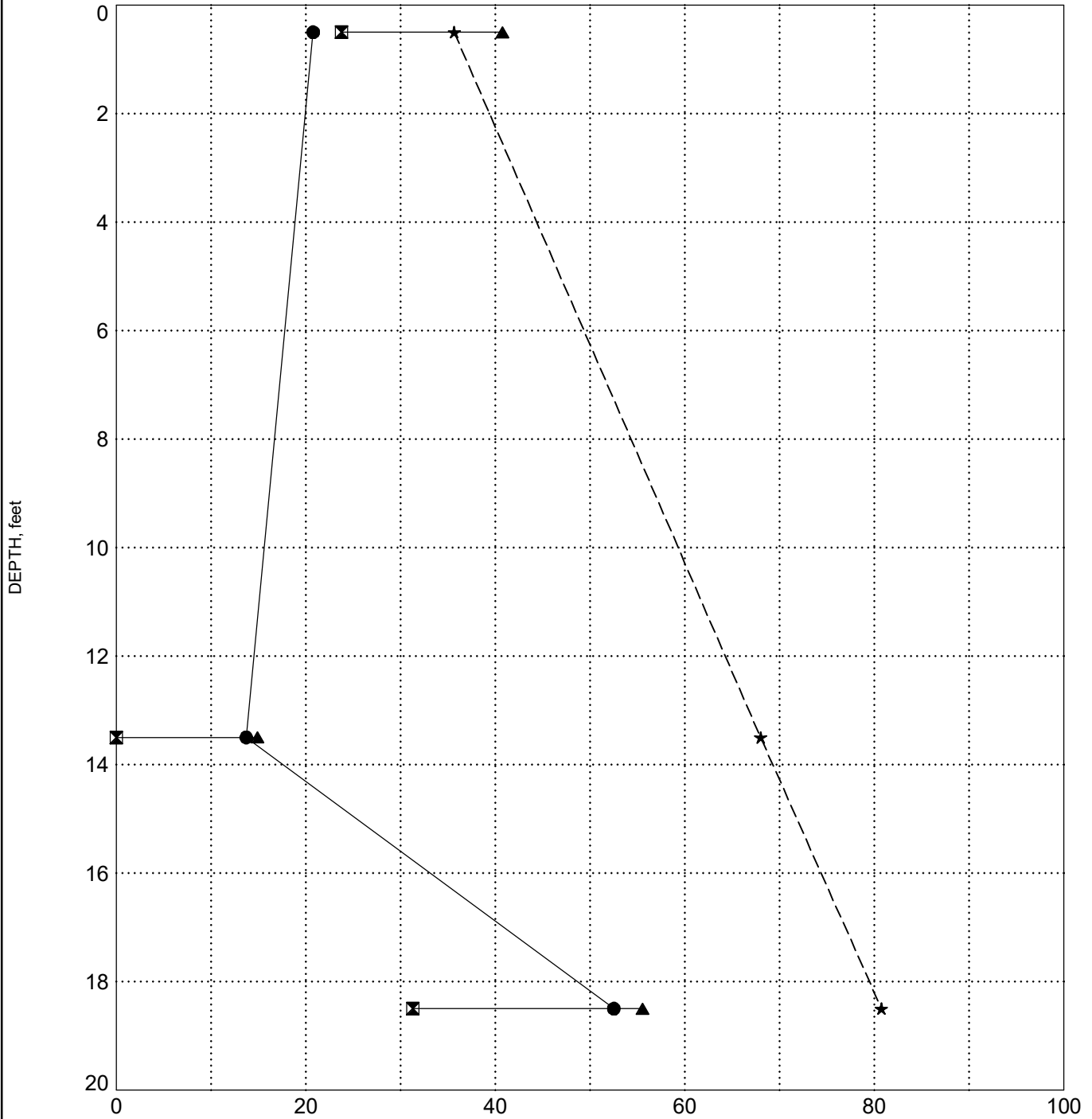
PROJECT ID P038057

PROJECT NAME S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)

PROJECT COUNTY Cherokee

SURFACE ELEVATION: 524.9

BORING B-1



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



INDEX PROPERTIES VERSUS DEPTH

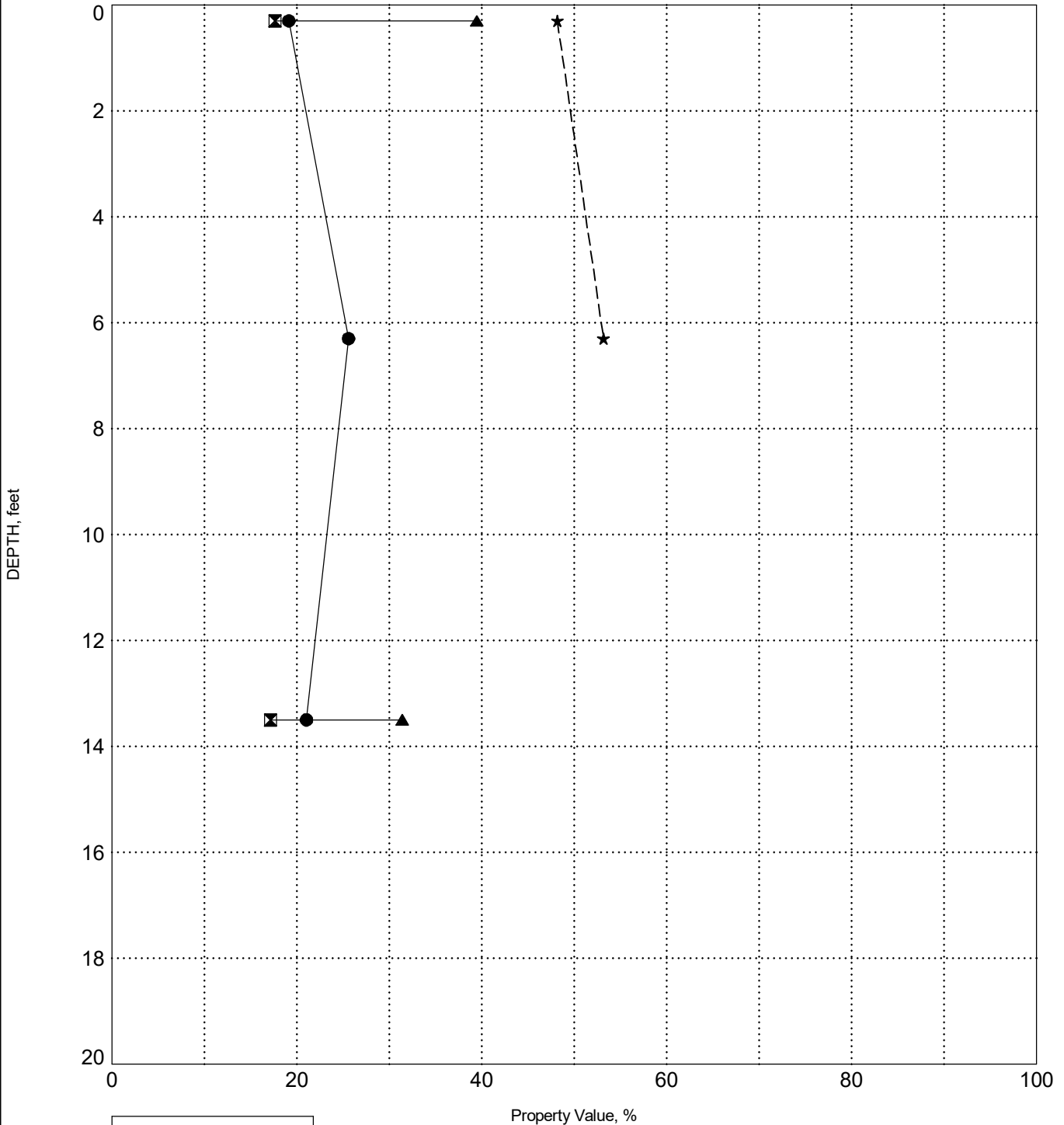
PROJECT ID P038057

PROJECT NAME S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)

PROJECT COUNTY Cherokee

SURFACE ELEVATION: 524.7

BORING B-2



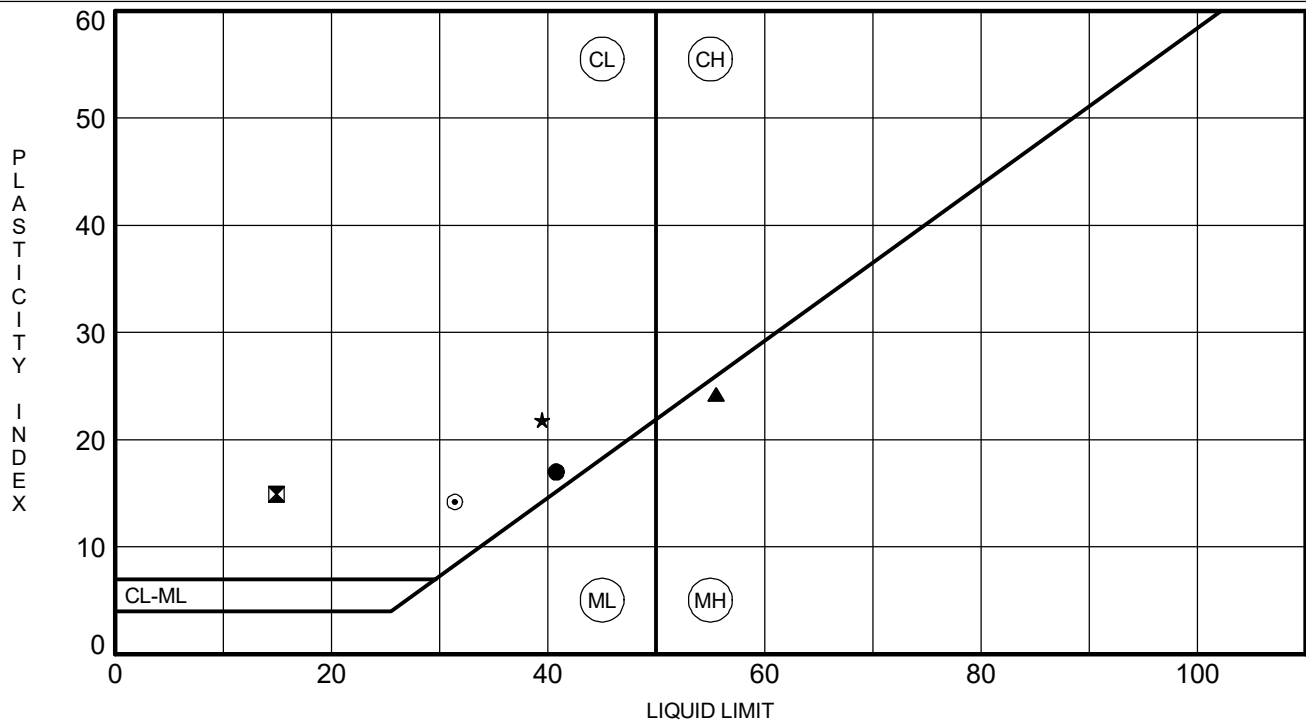
LEGEND	
●	Water Content
⊠	Plastic Limit
▲	Liquid Limit
★	Fines

ATTERBERG LIMITS' RESULTS

PROJECT ID P038057

PROJECT NAME S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)

PROJECT COUNTY Cherokee

[illegible]

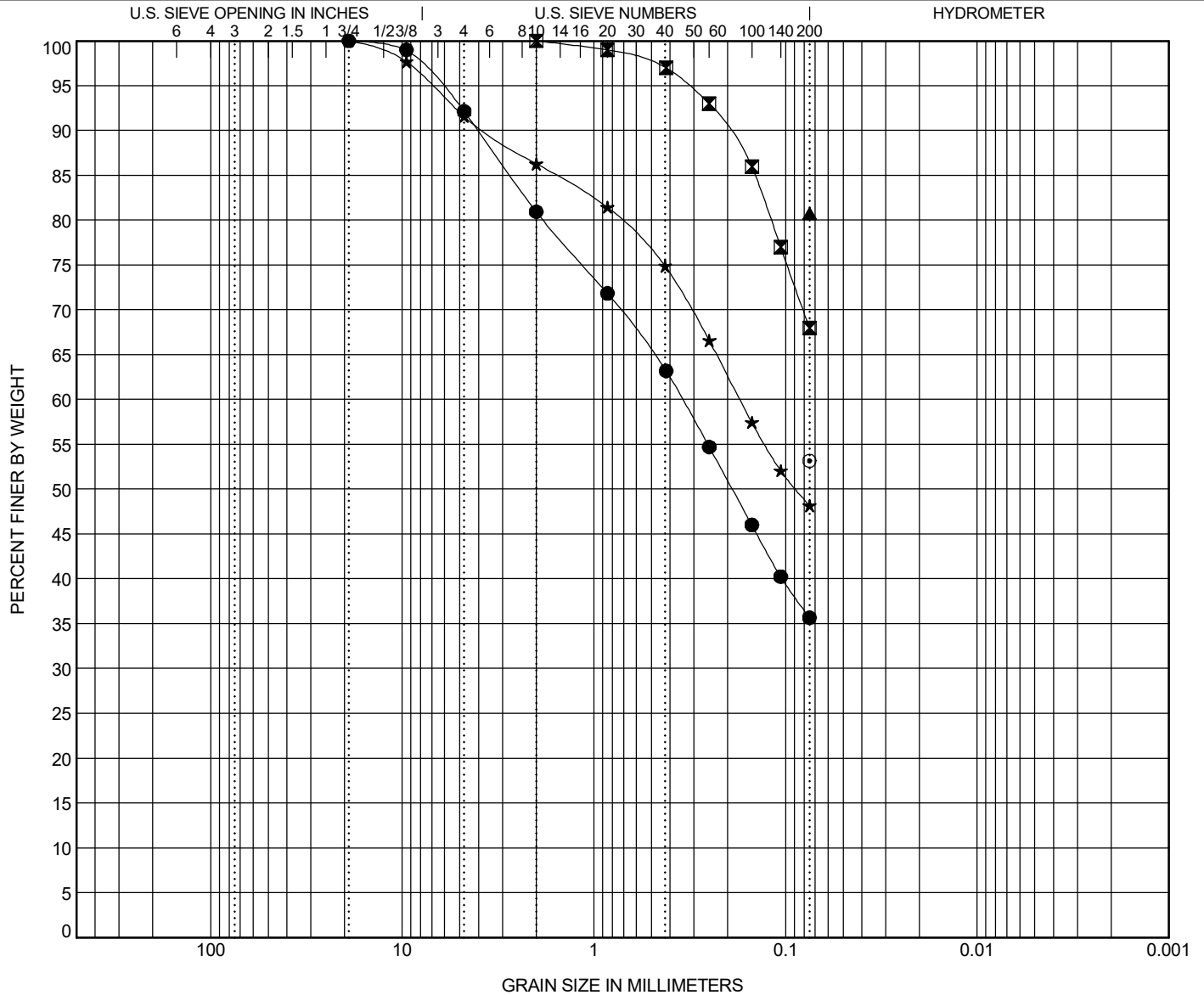


GRAIN SIZE DISTRIBUTION

PROJECT ID P038057

PROJECT NAME S-11-97 BRO Goforth Creek (S&ME Project 1361-20-048)

PROJECT COUNTY Cherokee



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-1	0.5	clayey SAND (SC)					41	24	17		
■ B-1	13.5	sandy lean CLAY (CL)					15	NP	NP		
▲ B-1	18.5	fat CLAY with sand (CH)					56	31	25		
★ B-2	0.3	clayey SAND (SC)					39	18	21		
⊙ B-2	6.3	sandy SILT (ML)									
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-1	0.5	19	0.346			7.8	56.5	35.7			
■ B-1	13.5	2				0.0	32.0	68.0			
▲ B-1	18.5	0.075						80.7			
★ B-2	0.3	19	0.173			8.4	43.4	48.2			
⊙ B-2	6.3	0.075						53.2			

Appendix V – Laboratory Test Data Sheets – Corrosion Series Testing



Results Only Soil Testing for SCDOT Bridge Package 2021-01 DB Prep

December 8, 2020

**Prepared for:
Matthew F. Cooke
S&ME, Inc.
134 Suber Road
Columbia, SC 29210
mcooke@smeinc.com**

**Project X Job#: S201125D
Client Job or PO#: 1361-20-48**

Respectfully Submitted,

Eduardo Hernandez, M.Sc., P.E.
Sr. Corrosion Consultant
NACE Corrosion Technologist #16592
Professional Engineer
California No. M37102
ehernandez@projectxcorrosion.com





Soil Analysis Lab Results

Client: S&ME, Inc.
Job Name: SCDOTBridge Package 2021-01 DB Prep
Client Job Number: 1361-20-48
Project X Job Number: S201125D
December 8, 2020

	Method	AASHTO T290		AASHTO T291		AASHTO T288		AASHTO T289
Bore# / Description	Depth	Sulfates SO ₄ ²⁻		Chlorides Cl ⁻		Resistivity As Rec'd Minimum		pH
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)	
SS-7 B-2; S-11-97 Bridge	18.5-20.0	34.8	0.0035	8.2	0.0008	31,490	26,800	6.7
SS-6/SS-7 B-2; S-11-119 Bridge	8.2-14.4	8.7	0.0009	21.4	0.0021	13,400	8,710	6.7
SS-5 B-2; S-11-265 Bridge	8.5-10.0	35.6	0.0036	109.9	0.0110	2,881	2,345	6.4
SS-4 B-1; S-12-58 Bridge	6.0-8.0	31.1	0.0031	23.9	0.0024	25,460	18,760	6.4
SS-4/SS-5 B-2; S-12-300 (2310) Bridge	6.0-10.0	19.3	0.0019	103.7	0.0104	3,283	2,479	6.5
SS-6 B-1; S-12-300 (2490) Bridge	13.5-15.0	36.1	0.0036	21.0	0.0021	9,380	8,040	6.7
SS-7/SS-8 B-2; S-20-214 Bridge	18.5-25.0	9.9	0.0010	7.4	0.0007	49,580	23,450	7.1
SS-6 B-1; S-29-97 Bridge	13.4-14.90	4.6	0.0005	1.9	0.0002	10,050	6,700	7.1
SS-4/SS-5 B-2; S-44-87 Bridge	7.0-11.0	45.9	0.0046	15.3	0.0015	16,080	15,410	6.2

Cations and Anions, except Sulfide and Bicarbonate, tested with Ion Chromatography
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
ND = 0 = Not Detected | NT = Not Tested | Unk = Unknown
Chemical Analysis performed on 1:3 Soil-To-Water extract



Ship Samples To: 29990 Technology Dr, Suite 13, Murrieta, CA 92563

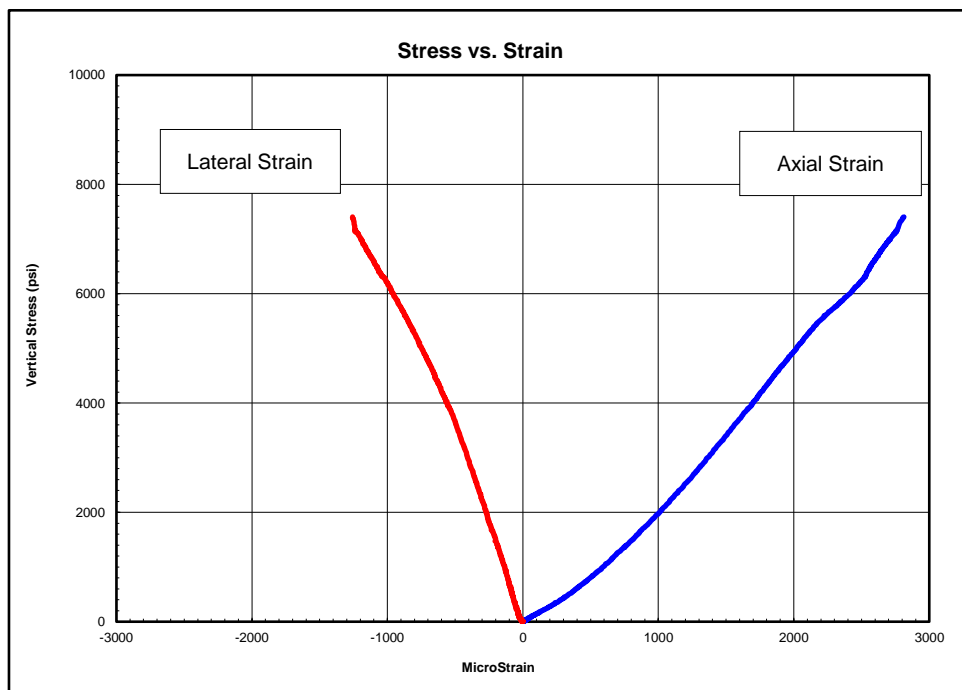
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Appendix VI – Laboratory Test Data Sheets – Rock Cores



Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	jsc
Boring ID:	S-11-97, B-1
Sample ID:	RS-1
Depth, ft:	29.2-29.6
Sample Type:	rock core
Sample Description:	See photographs Intact material failure

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 7,405 psi

The strain values recorded within the second and third stress ranges for this test produce values of Poisson's Ratio that exceed maximum values found in rocks.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
700-2700	2,440,000	0.33
2700-4600	3,050,000	0.49
4600-6700	2,680,000	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

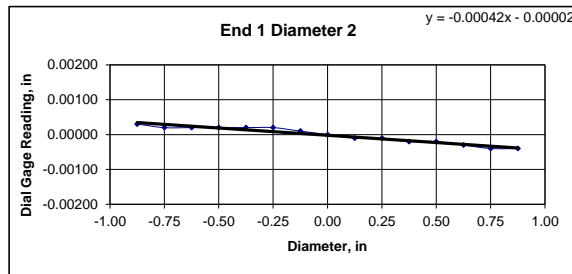
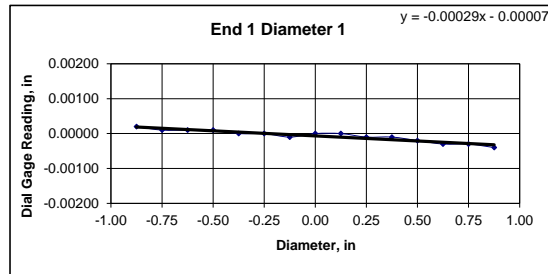


Client:	S&ME, Inc.	Test Date:	1/13/2021
Project Name:	SCDOT Bridge Package 2021-1	Tested By:	cmh
Project Location:	South Carolina	Checked By:	smd
GTX #:	313047		
Boring ID:	S-11-97, B-1		
Sample ID:	RS-1		
Depth:	29.2-29.6 ft		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY				DEVIATION FROM STRAIGHTNESS (Procedure S1)	
	1	2	Average	Maximum gap between side of core and reference surface plate: Is the maximum gap \leq 0.02 in.? YES	
Specimen Length, in:	4.78	4.78	4.78	Maximum difference must be $<$ 0.020 in. Straightness Tolerance Met? YES	
Specimen Diameter, in:	1.99	1.99	1.99		
Specimen Mass, g:	666.83				
Bulk Density, lb/ft ³ :	171				
Length to Diameter Ratio:	2.4	Minimum Diameter Tolerance Met? YES	Length to Diameter Ratio Tolerance Met? YES		

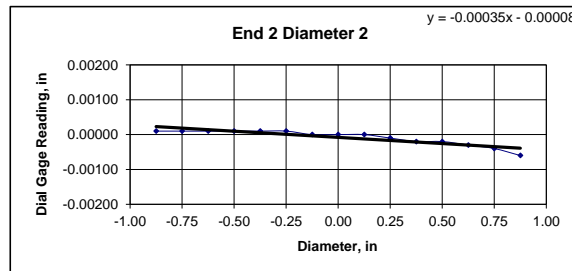
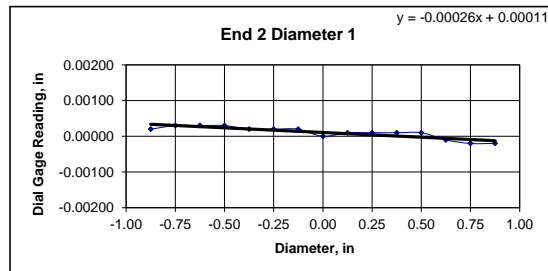
END FLATNESS AND PARALLELISM (Procedure FP1)															
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00020	0.00010	0.00010	0.00010	0.00000	0.00000	-0.00010	0.00000	0.00000	-0.00010	-0.00010	-0.00020	-0.00030	-0.00030	-0.00040
Diameter 2, in (rotated 90°)	0.00030	0.00020	0.00020	0.00020	0.00020	0.00020	0.00010	0.00000	-0.00010	-0.00010					
Difference between max and min readings, in: 0° = 0.00060 90° = 0.00070															
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00020	0.00030	0.00030	0.00030	0.00020	0.00020	0.00020	0.00000	0.00010	0.00010	0.00010	0.00010	-0.00010	-0.00020	-0.00020
Diameter 2, in (rotated 90°)	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00000	0.00000	0.00000	-0.00010	-0.00020	-0.00020	-0.00030	-0.00040	-0.00060
Difference between max and min readings, in: 0° = 0.0005 90° = 0.0007 Maximum difference must be < 0.0020 in. Difference = ± 0.00035 Flatness Tolerance Met? YES															



DIAMETER 1

End 1:	Slope of Best Fit Line	0.00029
	Angle of Best Fit Line:	0.01670
End 2:	Slope of Best Fit Line	0.00026
	Angle of Best Fit Line:	0.01506
Maximum Angular Difference:		0.00164

Parallelism Tolerance Met? YES
Spherically Seated



DIAMETER 2

End 1:	Slope of Best Fit Line	0.00042
	Angle of Best Fit Line:	0.02390
End 2:	Slope of Best Fit Line	0.00035
	Angle of Best Fit Line:	0.02030
Maximum Angular Difference:		0.00360

Parallelism Tolerance Met? YES
Spherically Seated

PERPENDICULARITY (Procedure P1)						Maximum angle of departure must be \leq 0.25°	
END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?	Perpendicularity Tolerance Met? YES	
Diameter 1, in	0.00060	1.990	0.00030	0.017	YES		
Diameter 2, in (rotated 90°)	0.00070	1.990	0.00035	0.020	YES		
END 2							
Diameter 1, in	0.00050	1.990	0.00025	0.014	YES		
Diameter 2, in (rotated 90°)	0.00070	1.990	0.00035	0.020	YES		

Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	smd
Boring ID:	S-11-97, B-1
Sample ID:	RS-1
Depth, ft:	29.2-29.6



After cutting and grinding

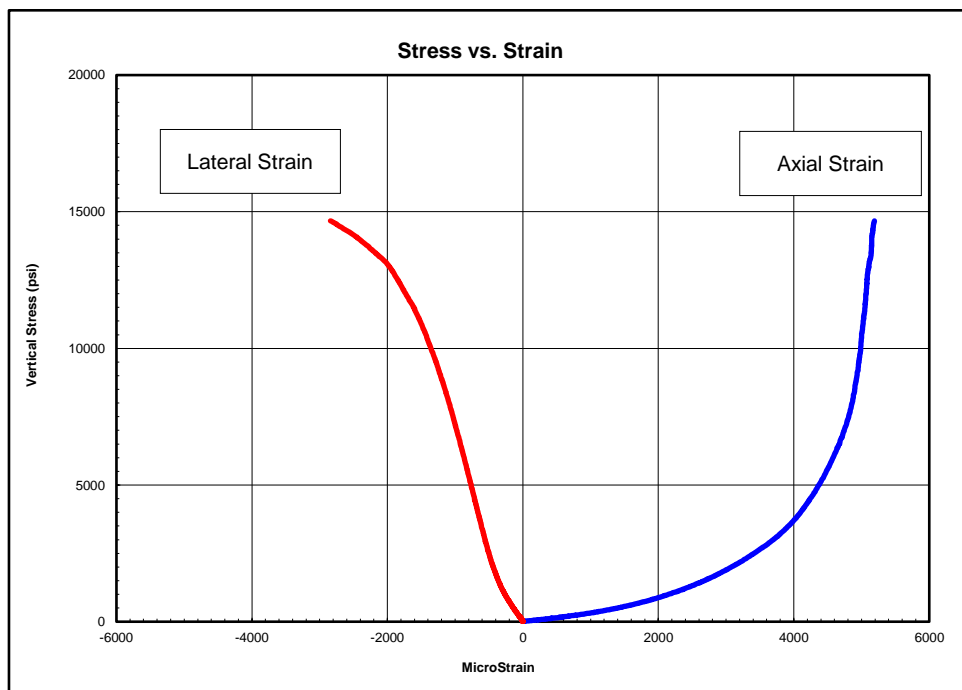


After break



Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	jsc
Boring ID:	S-11-97, B-1
Sample ID:	RS-2
Depth, ft:	30.55-30.95
Sample Type:	rock core
Sample Description:	See photographs Intact material failure

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 14,666 psi

The strain values recorded within the second and third stress ranges for this test produce values of Poisson's Ratio that exceed maximum values found in rocks.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
1500-5400	2,100,000	0.23
5400-9300	7,700,000	---
9300-13200	24,700,000	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

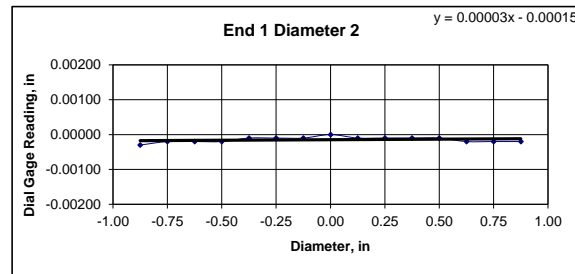
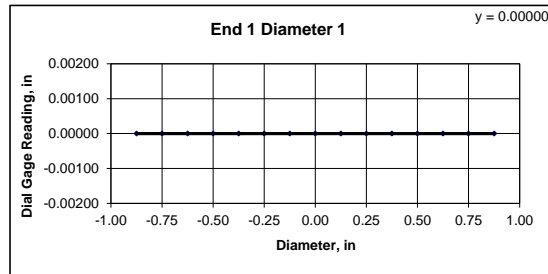


Client:	S&ME, Inc.	Test Date:	1/14/2021
Project Name:	SCDOT Bridge Package 2021-1	Tested By:	cmh
Project Location:	South Carolina	Checked By:	smd
GTX #:	313047		
Boring ID:	S-11-97, B-1		
Sample ID:	RS-2		
Depth:	30.55-30.95 ft		
Visual Description:	See photographs		

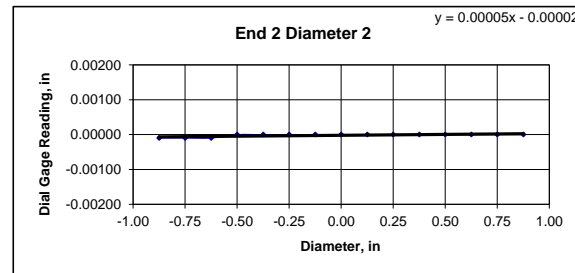
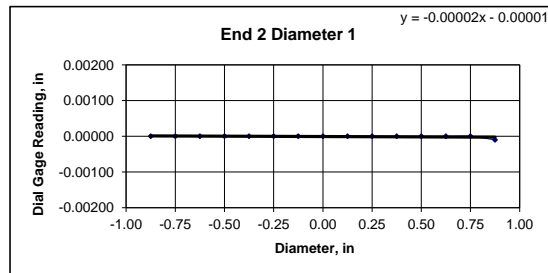
UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY				DEVIATION FROM STRAIGHTNESS (Procedure S1)	
	1	2	Average	Maximum gap between side of core and reference surface plate: Is the maximum gap \leq 0.02 in.? YES	
Specimen Length, in:	4.51	4.51	4.51	Maximum difference must be < 0.020 in. Straightness Tolerance Met? YES	
Specimen Diameter, in:	1.99	1.99	1.99		
Specimen Mass, g:	666.39				
Bulk Density, lb/ft ³ :	181				
Length to Diameter Ratio:	2.3	Minimum Diameter Tolerance Met? YES	Length to Diameter Ratio Tolerance Met? YES		

END FLATNESS AND PARALLELISM (Procedure FP1)															
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	-0.00030	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	-0.00010	0.00000	-0.00010	-0.00010	-0.00010	-0.00010	-0.00020	-0.00020	-0.00020
Difference between max and min readings, in: 0° = 0.00000 90° = 0.00030															
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010
Diameter 2, in (rotated 90°)	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Difference between max and min readings, in: 0° = 0.0001 90° = 0.0001 Maximum difference must be < 0.0020 in. Difference = ± 0.00015 Flatness Tolerance Met? YES															



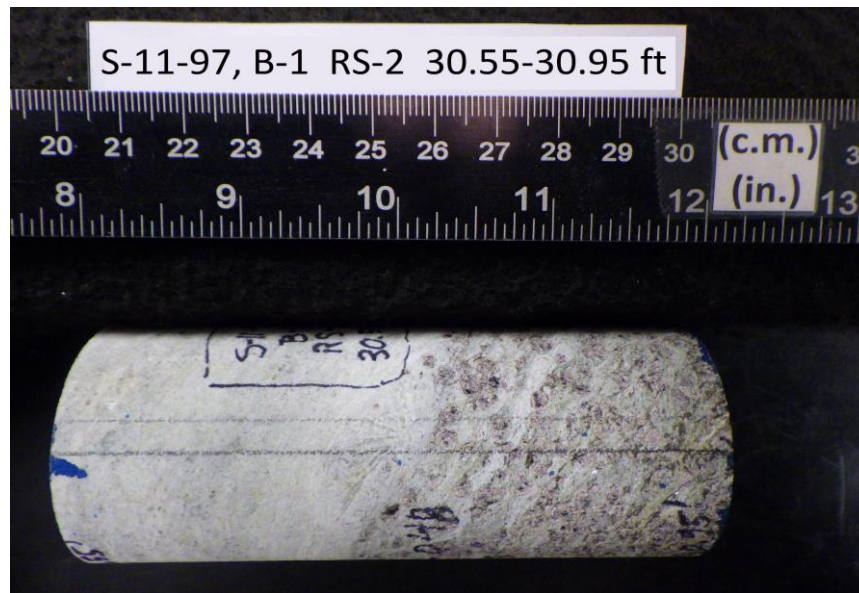
DIAMETER 1	
End 1:	
Slope of Best Fit Line	0.00000
Angle of Best Fit Line:	0.00000
End 2:	
Slope of Best Fit Line	0.00002
Angle of Best Fit Line:	0.00115
Maximum Angular Difference:	0.00115
Parallelism Tolerance Met? Spherically Seated	YES



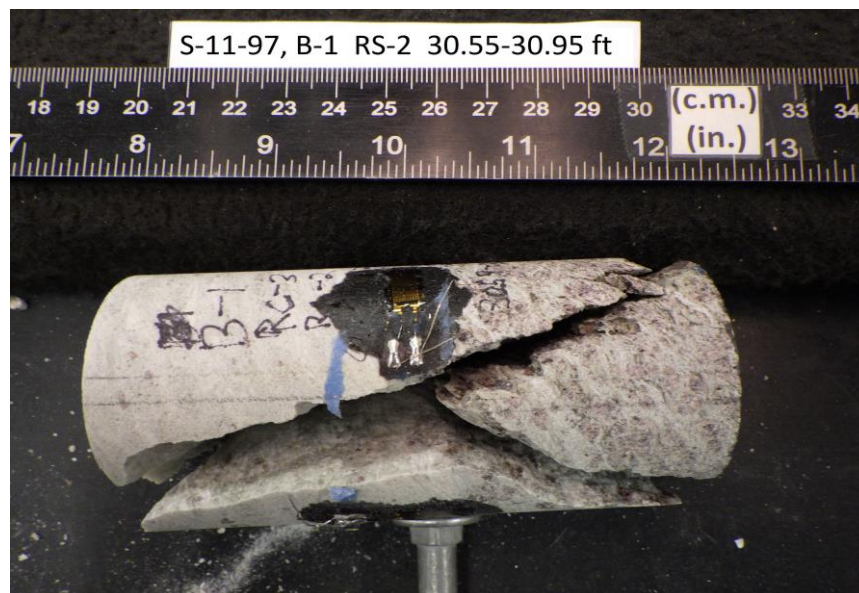
DIAMETER 2	
End 1:	
Slope of Best Fit Line	0.00003
Angle of Best Fit Line:	0.00180
End 2:	
Slope of Best Fit Line	0.00005
Angle of Best Fit Line:	0.00295
Maximum Angular Difference:	0.00115
Parallelism Tolerance Met? Spherically Seated	YES

PERPENDICULARITY (Procedure P1)						Maximum angle of departure must be $\leq 0.25^\circ$	
END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?		
Diameter 1, in	0.00000	1.990	0.00000	0.000	YES	Perpendicularity Tolerance Met? YES	
Diameter 2, in (rotated 90°)	0.00030	1.990	0.00015	0.009	YES		
END 2							
Diameter 1, in	0.00010	1.990	0.00005	0.003	YES		
Diameter 2, in (rotated 90°)	0.00010	1.990	0.00005	0.003	YES		

Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	smd
Boring ID:	S-11-97, B-1
Sample ID:	RS-2
Depth, ft:	30.55-30.95



After cutting and grinding

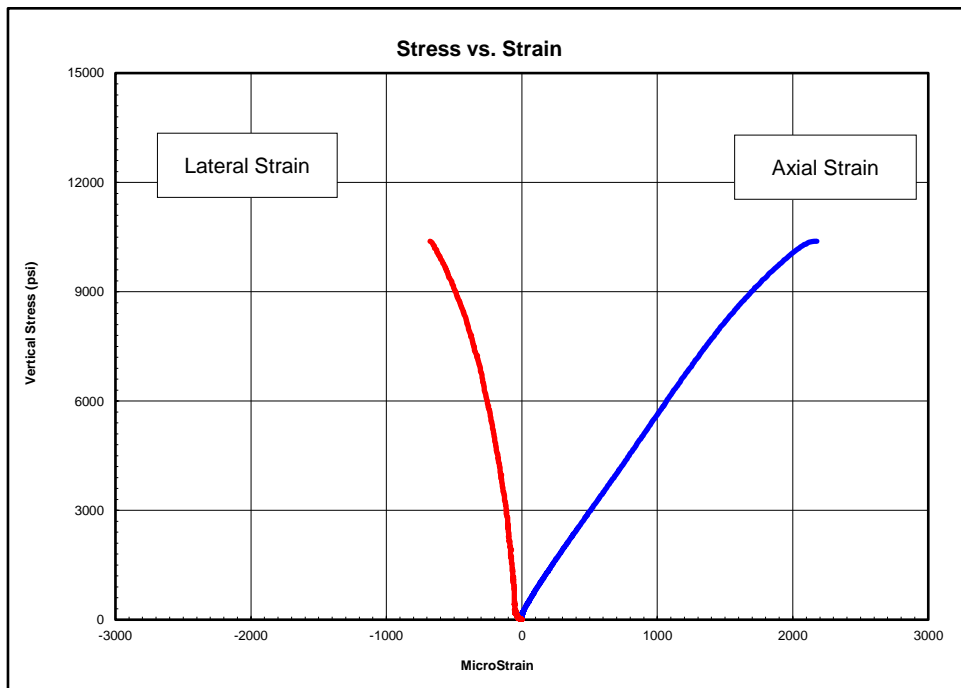


After break



Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	jsc
Boring ID:	S-11-97, B-2
Sample ID:	RS-1
Depth, ft:	32.7-33.1
Sample Type:	rock core
Sample Description:	See photographs Intact material failure

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 10,385 psi

The strain values recorded within the second and third stress ranges for this test produce values of Poisson's Ratio that exceed maximum values found in rocks.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
1000-3800	5,310,000	0.16
3800-6600	5,390,000	0.28
6600-9300	4,600,000	0.40

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

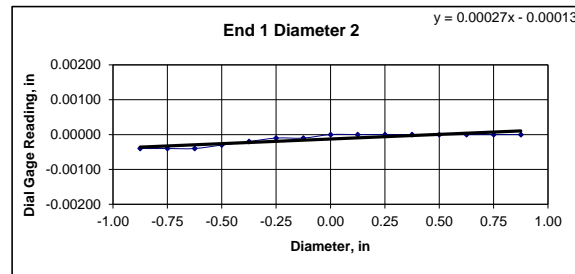
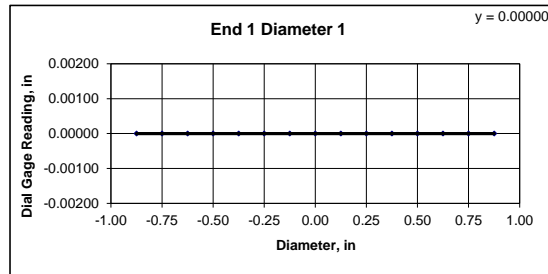


Client:	S&ME, Inc.	Test Date:	1/14/2021
Project Name:	SCDOT Bridge Package 2021-1	Tested By:	cmh
Project Location:	South Carolina	Checked By:	smd
GTX #:	313047		
Boring ID:	S-11-97. B-2		
Sample ID:	RS-1		
Depth:	32.7-33.1 ft		
Visual Description:	See photographs		

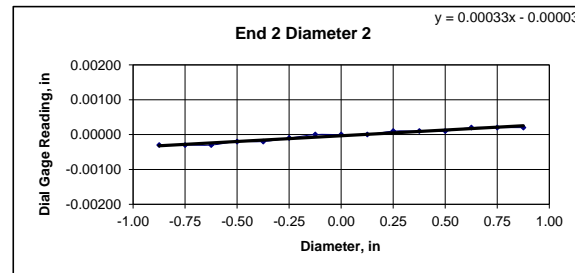
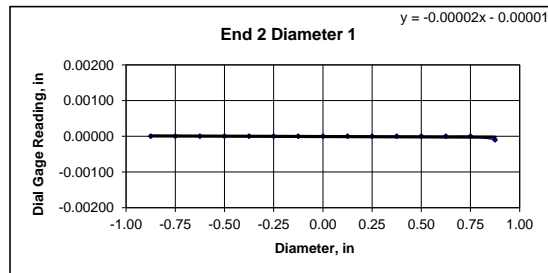
UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY				DEVIATION FROM STRAIGHTNESS (Procedure S1)	
	1	2	Average	Maximum gap between side of core and reference surface plate: Is the maximum gap \leq 0.02 in.? YES	
Specimen Length, in:	4.59	4.60	4.60	Maximum difference must be $<$ 0.020 in. Straightness Tolerance Met? YES	
Specimen Diameter, in:	1.99	1.99	1.99		
Specimen Mass, g:	660.96				
Bulk Density, lb/ft ³	176				
Length to Diameter Ratio:	2.3				
		Minimum Diameter Tolerance Met?	YES		
		Length to Diameter Ratio Tolerance Met?	YES		

END FLATNESS AND PARALLELISM (Procedure FP1)															
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	-0.00040	-0.00040	-0.00040	-0.00030	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Difference between max and min readings, in: 0° = 0.00000 90° = 0.00040															
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010
Diameter 2, in (rotated 90°)	-0.00030	-0.00030	-0.00030	-0.00020	-0.00020	-0.00010	0.00000	0.00000	0.00000	0.00010	0.00010	0.00010	0.00020	0.00020	0.00020
Difference between max and min readings, in: 0° = 0.0001 90° = 0.0005 Maximum difference must be < 0.0020 in. Difference = ± 0.00025 Flatness Tolerance Met? YES															



DIAMETER 1	
End 1:	
Slope of Best Fit Line	0.00000
Angle of Best Fit Line:	0.00000
End 2:	
Slope of Best Fit Line	0.00002
Angle of Best Fit Line:	0.00115
Maximum Angular Difference:	0.00115
Parallelism Tolerance Met?	YES
Spherically Seated	



DIAMETER 2	
End 1:	
Slope of Best Fit Line	0.00027
Angle of Best Fit Line:	0.01522
End 2:	
Slope of Best Fit Line	0.00033
Angle of Best Fit Line:	0.01883
Maximum Angular Difference:	0.00360
Parallelism Tolerance Met?	YES
Spherically Seated	

PERPENDICULARITY (Procedure P1)						Maximum angle of departure must be \leq 0.25°	
END 1	(Calculated from End Flatness and Parallelism measurements above)						
	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?		
Diameter 1, in	0.00000	1.990	0.00000	0.000	YES		
Diameter 2, in (rotated 90°)	0.00040	1.990	0.00020	0.012	YES		
Perpendicularity Tolerance Met? YES							
END 2							
Diameter 1, in	0.00010	1.990	0.00005	0.003	YES		
Diameter 2, in (rotated 90°)	0.00050	1.990	0.00025	0.014	YES		

Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	smd
Boring ID:	S-11-97, B-2
Sample ID:	RS-1
Depth, ft:	32.7-33.1



After cutting and grinding

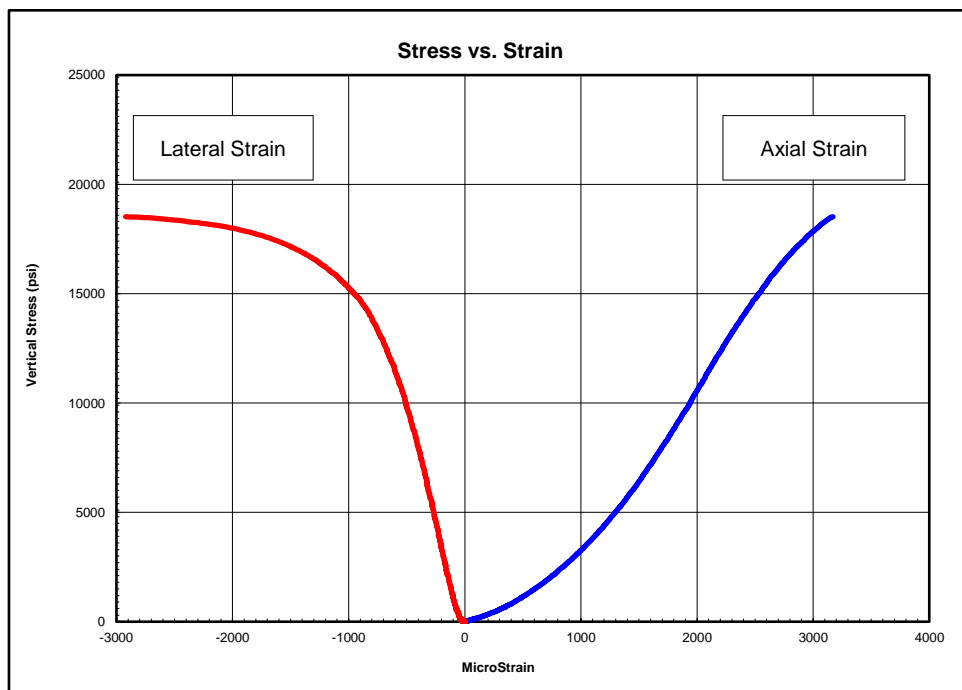


After break



Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	jsc
Boring ID:	S-11-97, B-2
Sample ID:	RS-2
Depth, ft:	34.95-35.35
Sample Type:	rock core
Sample Description:	See photographs Intact material failure

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 18,522 psi

The strain values recorded within the third stress range for this test produce values of Poisson's Ratio that exceed maximum values found in rocks.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
1900-6800	5,790,000	0.24
6800-11700	8,550,000	0.47
11700-16700	7,630,000	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

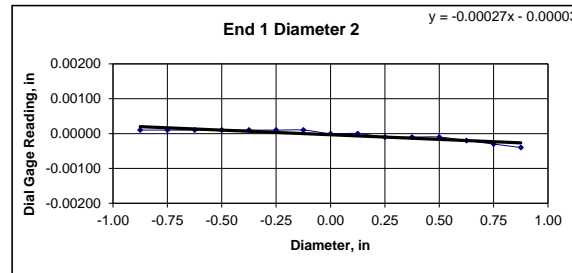
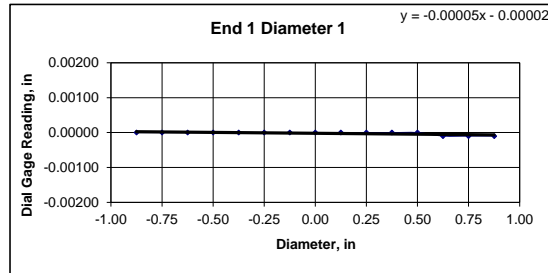


Client:	S&ME, Inc.	Test Date:	1/14/2021
Project Name:	SCDOT Bridge Package 2021-1	Tested By:	cmh
Project Location:	South Carolina	Checked By:	smd
GTX #:	313047		
Boring ID:	S-11-97, B-2		
Sample ID:	RS-2		
Depth:	34.95-35.35 ft		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY				DEVIATION FROM STRAIGHTNESS (Procedure S1)	
	1	2	Average	Maximum gap between side of core and reference surface plate: Is the maximum gap \leq 0.02 in.? YES	
Specimen Length, in:	4.47	4.47	4.47	Maximum difference must be $<$ 0.020 in. Straightness Tolerance Met? YES	
Specimen Diameter, in:	1.99	1.99	1.99		
Specimen Mass, g:	621.21				
Bulk Density, lb/ft ³	170				
Length to Diameter Ratio:	2.2	Minimum Diameter Tolerance Met? YES	Length to Diameter Ratio Tolerance Met? YES		

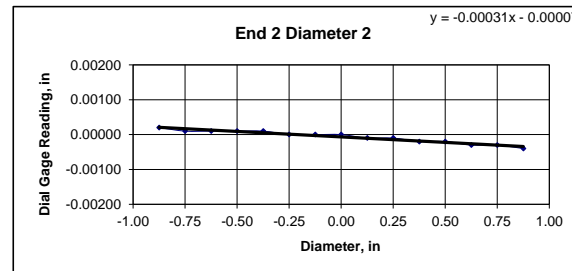
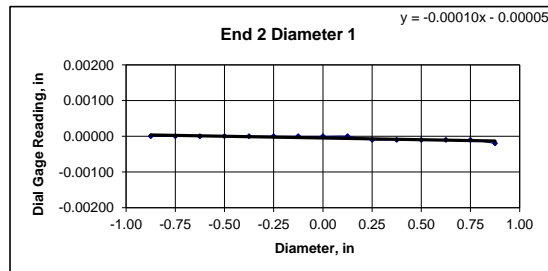
END FLATNESS AND PARALLELISM (Procedure FP1)															
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00010
Diameter 2, in (rotated 90°)	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00000	0.00000	-0.00010	-0.00010	-0.00010	-0.00020	-0.00030	-0.00040
Difference between max and min readings, in: 0° = 0.00010 90° = 0.00050															
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00010	-0.00010	-0.00010	-0.00020
Diameter 2, in (rotated 90°)	0.00020	0.00010	0.00010	0.00010	0.00010	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00020	-0.00020	-0.00030	-0.00030	-0.00040
Difference between max and min readings, in: 0° = 0.0002 90° = 0.0006 Maximum difference must be < 0.0020 in. Difference = ± 0.00030 Flatness Tolerance Met? YES															



DIAMETER 1

End 1:	Slope of Best Fit Line	0.00005
	Angle of Best Fit Line:	0.00295
End 2:	Slope of Best Fit Line	0.00010
	Angle of Best Fit Line:	0.00557
Maximum Angular Difference:		0.00262

Parallelism Tolerance Met? YES
Spherically Seated



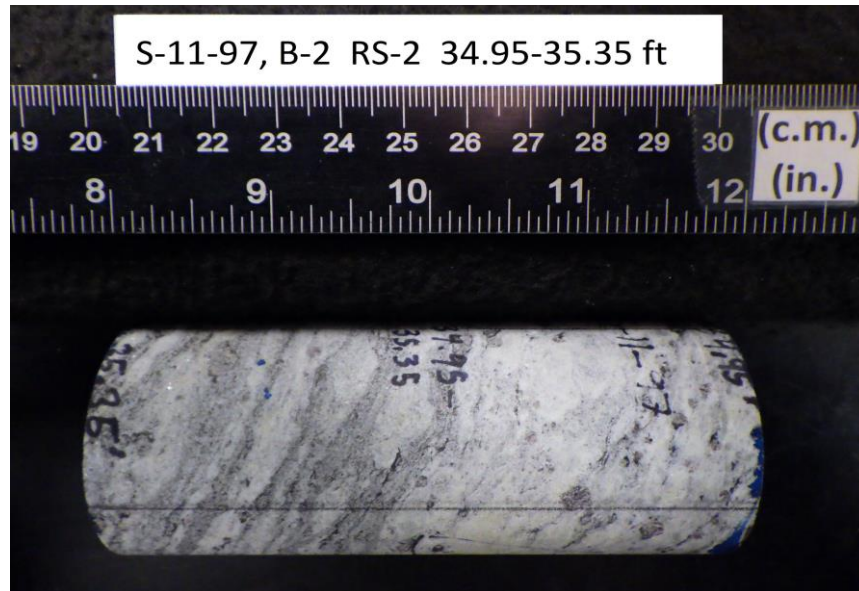
DIAMETER 2

End 1:	Slope of Best Fit Line	0.00027
	Angle of Best Fit Line:	0.01522
End 2:	Slope of Best Fit Line	0.00031
	Angle of Best Fit Line:	0.01801
Maximum Angular Difference:		0.00278

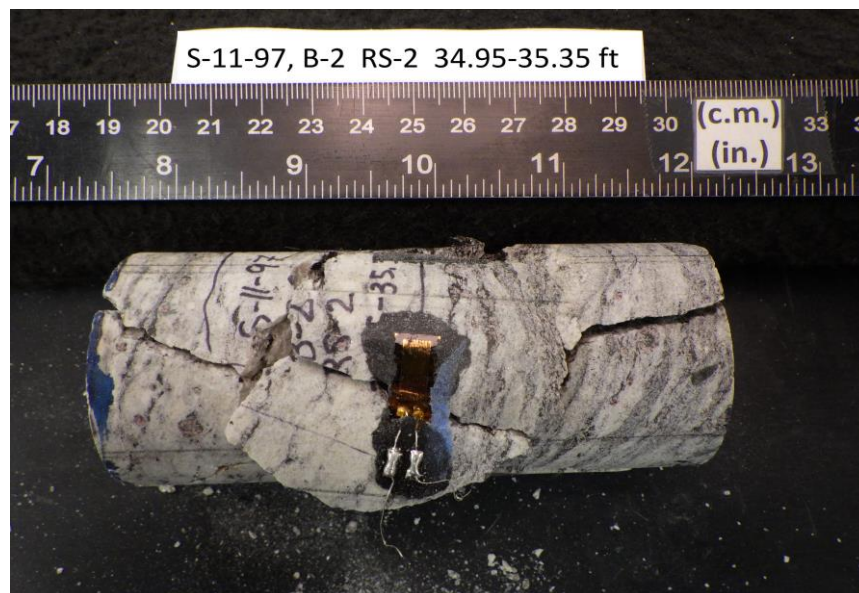
Parallelism Tolerance Met? YES
Spherically Seated

PERPENDICULARITY (Procedure P1)						Maximum angle of departure must be \leq 0.25°	
END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?		
Diameter 1, in	0.00010	1.990	0.00005	0.003	YES	Perpendicularity Tolerance Met? YES	
Diameter 2, in (rotated 90°)	0.00050	1.990	0.00025	0.014	YES		
END 2							
Diameter 1, in	0.00020	1.990	0.00010	0.006	YES		
Diameter 2, in (rotated 90°)	0.00060	1.990	0.00030	0.017	YES		

Client:	S&ME, Inc.
Project Name:	SCDOT Bridge Package 2021-1
Project Location:	South Carolina
GTX #:	313047
Test Date:	1/18/2021
Tested By:	cmh
Checked By:	smd
Boring ID:	S-11-97, B-2
Sample ID:	RS-2
Depth, ft:	34.95-35.35



After cutting and grinding



After break

Appendix VII – SPT Hammer Energy Measurements



Report of SPT Energy Measurements
S&ME CME 55 Truck (Serial No. 328245)
Spartanburg, South Carolina
S&ME Project No. 1535-20-200

PREPARED FOR:

**North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699**

PREPARED BY:

**S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, North Carolina 28273**

June 1, 2020



June 1, 2020

North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699

Attention: Shunyi (Chris) Chen, Ph.D., P.E.

Cc: Ms. Cheryl A. Youngblood, L.G.
Ms. Christina M. Bruinsma, L.G.

Reference: **Report of SPT Energy Measurements**
S&ME CME 55 Truck (Serial No. 328245)
Edgefield County, South Carolina
S&ME Project No. 1535-20-200
NC PE Firm License No. F-0176

Dear Dr. Chen:

We have completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer used with S&ME's CME 55 truck-mounted drill rig (Serial No. 328245). This service was performed by Mr. Heath Forbes, P.E. of our firm on May 7, 2020, in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation (NCDOT) Geotechnical Engineering Unit's requirements. Review of the data quality and analyses was performed by Mr. Gregory Canivan, P.E. of our firm. Copies of the Certificates of Proficiency issued by Pile Dynamics based on the Dynamic Measurement and Analysis Proficiency Test for Mr. Forbes and Mr. Canivan are included in the Appendix I. The testing procedures, equipment used during testing, and detailed results are presented in this report.

1.0 Dynamic Testing Methodology

Testing was performed using a model PAX (Serial No. 3726L) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K10673 and K10674) bolted to a 2-foot long AW drill rod (Serial No. 203) internally instrumented with two strain transducers. Calibration sheets for the accelerometers and the instrumented rod are included in the Appendix II. The instrumented AW drill rod has a cross-sectional area of 1.19 square inches at the gage locations. The accelerometers and strain gages, which are diametrically opposed 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.



2.0 Testing and Observations

S&ME personnel were on site May 7, 2020, to observe and perform high-strain dynamic testing during SPT sampling on the CME 55 truck-mounted drill rig operated by Ted Miller of S&ME. The measurements were taken during drilling and sampling of a test hole at a power transmission line project site in Edgefield County, South Carolina. SPT energy measurements were recorded during four sampling intervals at depths of approximately 28.5, 33.5, 38.5, and 43.5 ft below the ground surface. Due to an error that occurred during testing, the data from the 28.5-ft interval has been omitted from this report and the calculations of average transferred hammer energy. The information presented in the tables below summarizes the equipment and tooling used during the SPT energy measurements.

Table 2-1: Drill Rig Information

Manufacturer	CME
Model	55
Serial Number	328245
Operator	T. Miller
Carrier	Truck

Table 2-2: Hammer Information

Model / Type	CME / Auto
Serial Number	328245
Anvil Height (inches)	N/A – Anvil Built into Casing of Auto Hammer
Anvil Diameter (inches)	N/A – Anvil Built into Casing of Auto Hammer
Typical Drop Height (inches)	30
Typical Ram Weight (pounds)	140
Ram Serial Number	N/A

Table 2-3: Drilling and Instrumented Rod Information

Drill Rod Type	AW
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in²)	1.19
Typical Lengths (feet)	2 ft, 5 ft, and 10 ft
Instrumented Rod Type	AW (Serial No. 203)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in²)	1.19
Total Instrumented Rod Length (feet)	2.0
Length Below Gages (feet)	0.75
Split-Spoon Length (feet)	2.8



3.0 Dynamic Testing Results

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.55 ft to the drill rod length at each sample depth. The SPT Energy Measurement Data Summary tables in the Appendix III present the test data from every hammer blow at each sampling interval, along with representative force and velocity traces for each test interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e. the blows that determine the N-value) are considered when computing the average measurement values of each test interval.

The reported blow counts obtained by the drill rig personnel, a summary of the test data, and average computed hammer energy and transfer ratio values are provided in Table 3-1. Based on the test data, the automatic hammer on the CME 55 operated at an average rate of about 51 blows per minute (bpm) during dynamic testing. The measured average transferred hammer energy (EFV) of the three sample intervals ranged from 297 to 302 ft-lbs, which corresponds to Energy Transfer Ratio (ETR) values of 84.7 to 86.3%, respectively. 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. BLC¹
- Penetration vs. FMX²
- Penetration vs. EFV³
- Penetration vs. CSX⁴
- Penetration vs. VMX⁵
- Penetration vs. ETR⁶
- ETR vs. Rod Length
- Average ETR vs. Rod Length

Table 3-1: 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	33.5 – 35	35	38.55	8-13-7 / 20	CLAY	52.1	297	84.7
2	38.5 – 40	40	43.55	4-8-9 / 17	SANDY SILT	49.8	300	85.8
3	43.5 – 45	45	48.55	8-16-21 / 37	SILTY SAND	51.9	302	86.3
Overall Average						51.4	300	85.7

The overall average transferred hammer energy for the automatic hammer on the CME 55 truck-mounted drill rig was 300 foot-pounds, with an average ETR of 85.7%.

¹ BLC - Blow Count per 6-in. increment

² FMX - Maximum Compressive Force

³ EFV - Maximum Transferred Energy

⁴ CSX - Maximum Compressive Stress

⁵ VMX - Maximum Velocity

⁶ ETR - Energy Transfer Ratio - Ratio of Calculated Energy to Theoretical Energy of 140 lb hammer falling 30 inches



4.0 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions 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.

5.0 Closing

S&ME appreciates the opportunity to provide this report to the North Carolina Department of Transportation, Geotechnical Engineering Unit. Please let us know if you have any questions concerning this report.

Sincerely,

S&ME, Inc.

A handwritten signature in black ink, appearing to read 'R. Heath Forbes'.

R. Heath Forbes, P.E.
Project Engineer
S.C. Registration No. 29560



Gregory J. Canivan, P.E.
Technical Principal
N.C. Registration No. 028593

Appendices:

- Appendix I - Certificates of Proficiency
- Appendix II - Instrumented Rod and Accelerometer Calibration Sheets
- Appendix III – CME 55 Truck (SN 328245) SPT Energy Measurements Summary Plots and Tables

Appendix I - Certificates of Proficiency



This documents that

**Greg Canivan
S&ME Inc.**

has on October 8, 2014 achieved the rank of

MASTER


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 Master level seek to attain Expert level through additional study within five years of the date of this document***

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


Steven A. Hall, Executive Director
Pile Driving Contractors Association




Garland Likins, President
Pile Dynamics, Inc

No. 721



This documents that
Heath Forbes, P.E.
S&ME, Inc.

has on October 31, 2017 achieved the rank of

ADVANCED

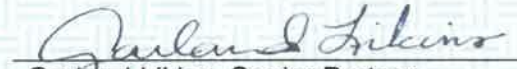
on the **Dynamic Measurement and Analysis Proficiency Test.**

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.

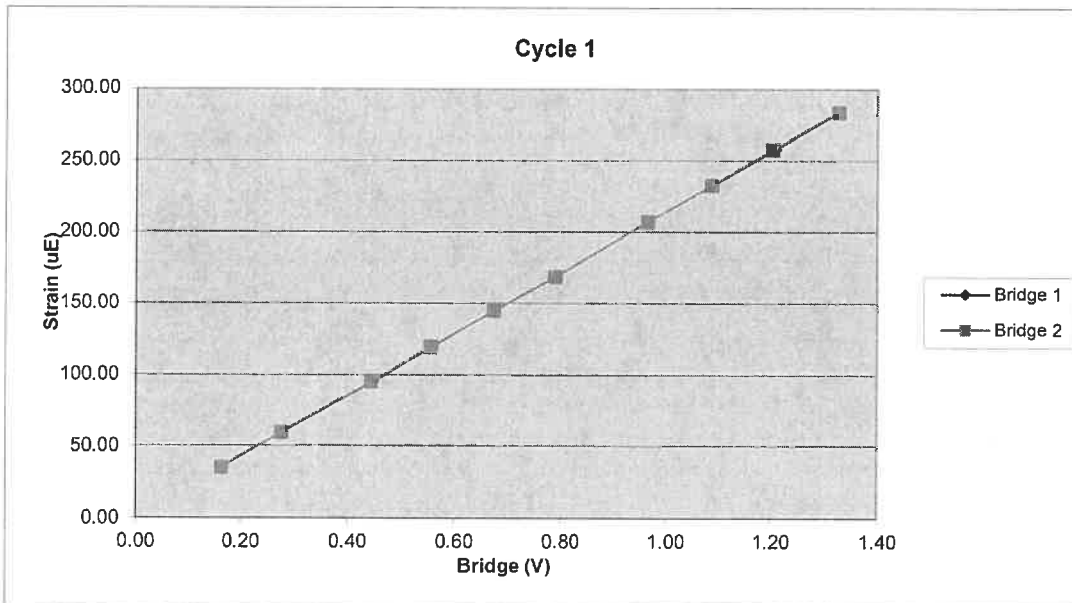
No. 2425

Appendix II - Calibration Sheets

203AWJ		Cycle 1		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1238.45	35.09	0.16	0.16
3	2101.82	59.39	0.28	0.28
4	3386.54	94.77	0.44	0.44
5	4235.08	119.35	0.56	0.56
6	5136.73	144.58	0.67	0.67
7	6021.00	168.91	0.79	0.79
8	7359.61	207.34	0.97	0.97
9	8298.94	232.84	1.09	1.09
10	9187.31	257.76	1.21	1.20
11	10120.00	284.12	1.33	1.33

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7630.77	Force Calibration (lb/V)	7630.97
Offset	-7.83	Offset	-3.17
Correlation	1.000000	Correlation	0.999999
Strain Calibration (μ E/V)	213.97	Strain Calibration (μ E/V)	213.98
Offset	0.12	Offset	0.25
Correlation	0.999992	Correlation	0.999995

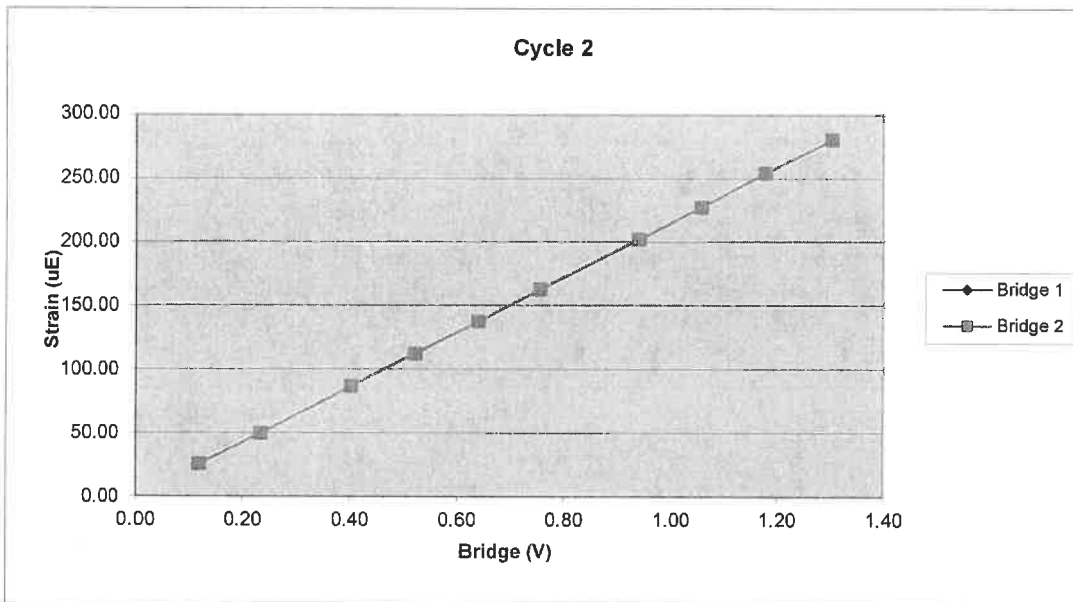
Force Strain Calibration	
EA (Kips)	35662.28
Offset	-12.17
Correlation	0.999993



203AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	883.29	25.21	0.12	0.12
3	1765.61	49.65	0.23	0.23
4	3049.75	86.59	0.40	0.40
5	3958.42	112.20	0.52	0.52
6	4857.33	137.43	0.64	0.64
7	5743.75	162.78	0.76	0.76
8	7145.42	202.15	0.94	0.94
9	8044.14	227.44	1.06	1.06
10	8969.22	253.99	1.18	1.18
11	9924.95	280.34	1.30	1.30

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7617.86	Force Calibration (lb/V)	7627.07
Offset	-11.91	Offset	-18.36
Correlation	0.999998	Correlation	1.000000
Strain Calibration ($\mu\text{E}/\text{V}$)	215.30	Strain Calibration ($\mu\text{E}/\text{V}$)	215.56
Offset	-0.14	Offset	-0.33
Correlation	0.999995	Correlation	0.999996

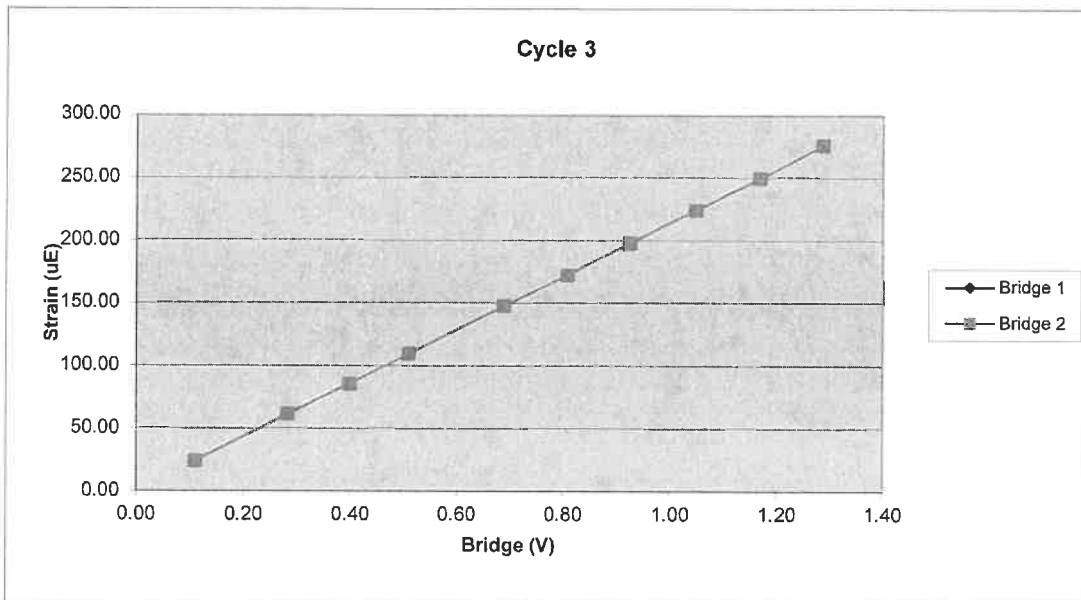
Force Strain Calibration	
EA (Kips)	35381.61
Offset	-6.76
Correlation	0.999996



203AWJ		Cycle 3		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	843.85	23.93	0.11	0.11
3	2145.36	61.00	0.28	0.28
4	3029.63	85.25	0.40	0.40
5	3880.71	109.47	0.51	0.51
6	5241.19	147.71	0.69	0.69
7	6147.33	172.47	0.81	0.81
8	7034.72	198.06	0.92	0.92
9	7979.71	224.33	1.05	1.05
10	8906.15	249.58	1.17	1.17
11	9817.56	275.86	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7623.93	Force Calibration (lb/V)	7629.88
Offset	-3.49	Offset	-9.59
Correlation	0.999999	Correlation	0.999999
Strain Calibration (μ E/V)	213.65	Strain Calibration (μ E/V)	213.81
Offset	0.47	Offset	0.30
Correlation	0.999992	Correlation	0.999991

Force Strain Calibration	
EA (Kips)	35684.19
Offset	-20.08
Correlation	0.999992




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

Calibration Factors	203AWJ		
Bridge 1 ($\mu\text{E/V}$)	214.31	Bridge 2 ($\mu\text{E/V}$)	214.45
EA Factor (Kips)	35576.02	Area (in^2)	1.19

Calibrated by:

Calibrated Date:


2/26/2019

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

File Dynamics, Inc.				TG F2	DPF
File Dynamics 2018-07-26 10:47		FS — 10	BN 6241 SL 970/ 3440/ 99	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 17.0 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 7312 ft/s JC 0.40 FM 1.00 UM 1.00 EA/C 30.3 Ks/ft UN KIPS*0.1 FR 20000 MB 90 DL -41 UT -1 IP 0.00 PK 1 TM-PEAK F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 340					
TS 12 TB 8.0		E B PD: K10673 T1 9.4 2L/C 4.7		VA 1000 UE 1024 LP 0.00 ft LI 1.0	
ACCEPT SQ-OFF FL-OFF PR-OFF		VMX= 4.4 FMX= 68 AMX= 149 EMX= 0.3 MEX= 133 FVP= 1.00			
ACCEPT 		ACCELEROMETER CALIBRATION N.I.S.T. Traceable SERIAL NUMBER: K10673 CALIBRATION FACTOR: .068 mV/g PAK (*5000): 340 DATE: 26 July 18 PDA OPERATOR: [Signature]			
<-AT:PIEZORESISTIVE		OP: laine lver:5.011		AT:PIEZOELECTRIC->	

Smart Sensor

Smart Chip Programmed By A.W. on 26 July 18 CRC Value BA96

Pile Dynamics, Inc.		TG F2	DPF
File Dynamics 2018-07-26 10:43	FS — BN 6235 10 SL 964/ 3440/ 2	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 17.0 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 7312 ft/s			
JC 0.40 FM 1.00 UM 1.00			
EA/C 30.3 Ks/ft UN KIPS*0.1 FR 20000 MB 90			
DL -40 UT -1 IP 0.00 PK 1 TM-PEAK			
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 370	TS 12 TB 8.0	E B PD: K10674 T1 9.5 2L/C 4.7 UA 1000	LP 0.00 ft LI 1.0
ACCEPT SQ-OFF FL-OFF PR-OFF		VMX= 4.4 FMX= 67 AMX= 149 EMX= 0.3 MEX= 131 FVP= 1.00	
ACCEPT 		ACCELEROMETER CALIBRATION N.I.S.T. Traceable SERIAL NUMBER: K10674 CALIBRATION FACTOR: .074 mV/g PAK (*5000): 370 DATE: 26 July 18 PDA OPERATOR:	
←-AT:PIEZORESISTIVE		AT:PIEZOELECTRIC→	

Smart Sensor

Smart Chip Programmed By A.W. on 26 July 18 CRC Value 3E56

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model PAX

Serial Number: 3726 L

was calibrated on 30 Aug. 2018
using a PDA Calibration Box whose output was calibrated with test equipment
traceable to NIST.

This certificate is valid for 2 years from above date.



Tested by:



A handwritten signature in black ink, appearing to be 'L. ...', written over a horizontal line.

Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

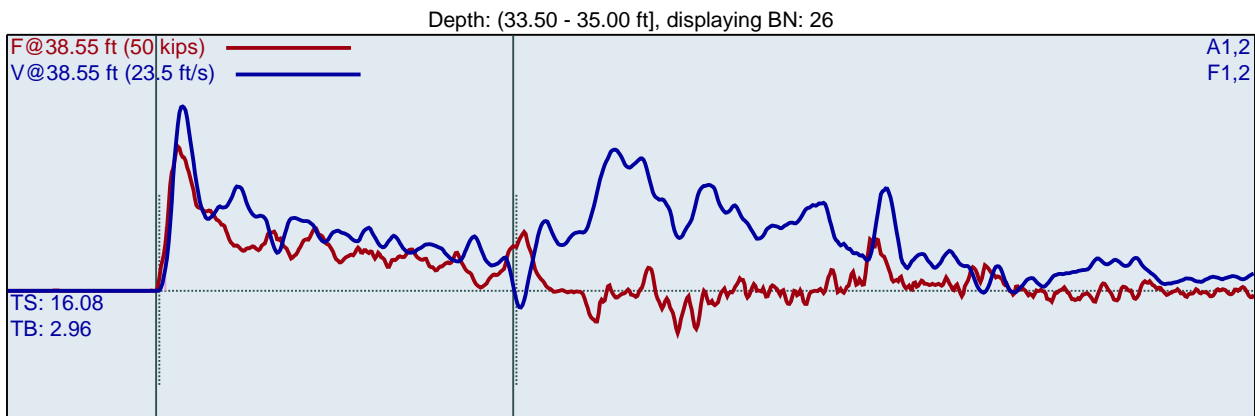
Appendix III - SPT Energy Measurements Plots and Tables

CME 55 (SN 328245)
H. Forbes
B-14B

Annual Calibration
Test date: 5/7/2020

AR: 1.19 in²
LE: 38.55 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [203-AWJ] 214 PDICAL (1) FF1
F2 : [203-AWJ] 214 PDICAL (1) FF1

A1 (PR): [K10674] 370 mv/6.4v/5000g (1) VF1
A2 (PR): [K10673] 340 mv/6.4v/5000g (1) VF1

BPM: Blows/Minute

FMX: Maximum Force

VMX: Maximum Velocity

DMX: Maximum Displacement

DFN: Final Displacement

CSX: Compression Stress Maximum

EFV: Maximum Energy

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	DFN in	CSX ksi	EFV ft-lb	ETR %
1	33.56	8	1.9	29	17.8	1.05	0.75	24.1	280	79.9
2	33.63	8	58.3	29	17.6	0.93	0.75	24.2	299	85.3
3	33.69	8	52.5	29	17.5	0.90	0.75	24.0	297	84.7
4	33.75	8	52.0	29	17.6	0.88	0.75	24.3	302	86.2
5	33.81	8	52.2	29	17.8	0.82	0.75	24.4	300	85.6
6	33.88	8	51.9	29	17.6	0.79	0.75	24.2	301	86.0
7	33.94	8	52.4	29	17.4	0.76	0.75	24.6	302	86.3
8	34.00	8	52.2	29	17.2	0.75	0.75	24.1	296	84.5
9	34.04	13	52.1	29	17.1	0.66	0.46	24.4	301	86.0
10	34.08	13	52.1	29	16.9	0.60	0.46	24.0	296	84.7
11	34.12	13	52.3	29	17.3	0.57	0.46	24.1	299	85.6
12	34.15	13	51.9	29	17.4	0.54	0.46	24.3	298	85.1
13	34.19	13	52.2	29	17.4	0.55	0.46	24.5	300	85.9
14	34.23	13	51.9	29	16.9	0.54	0.46	24.0	290	82.9
15	34.27	13	52.0	29	17.2	0.55	0.46	24.2	297	84.9
16	34.31	13	52.1	29	17.0	0.55	0.46	24.0	291	83.2
17	34.35	13	52.0	29	17.4	0.59	0.46	24.4	294	83.9
18	34.38	13	52.2	29	17.1	0.66	0.46	24.4	292	83.5
19	34.42	13	52.2	30	17.3	0.87	0.46	25.0	297	84.9
20	34.46	13	52.1	29	16.6	0.97	0.46	24.1	294	84.1
21	34.50	13	52.1	29	16.8	1.04	0.46	24.2	295	84.4
22	34.57	7	52.1	29	17.0	1.00	0.86	24.2	291	83.2
23	34.64	7	52.2	29	18.0	0.93	0.86	24.3	300	85.8
24	34.71	7	52.0	29	17.9	0.98	0.86	24.3	309	88.3
25	34.79	7	52.1	29	17.2	0.89	0.86	24.2	296	84.5
26	34.86	7	52.0	28	16.9	0.89	0.86	23.7	296	84.6
27	34.93	7	52.1	29	16.9	0.87	0.86	24.2	297	84.8

28	35.00	7	51.9	30	16.7	0.86	0.86	25.3	296	84.5
		Average	52.1	29	17.2	0.76	0.60	24.3	297	84.7
		Std Dev	0.1	0	0.3	0.18	0.19	0.3	4	1.2
		Maximum	52.3	30	18.0	1.04	0.86	25.3	309	88.3
		Minimum	51.9	28	16.6	0.54	0.46	23.7	290	82.9
N-value: 20										

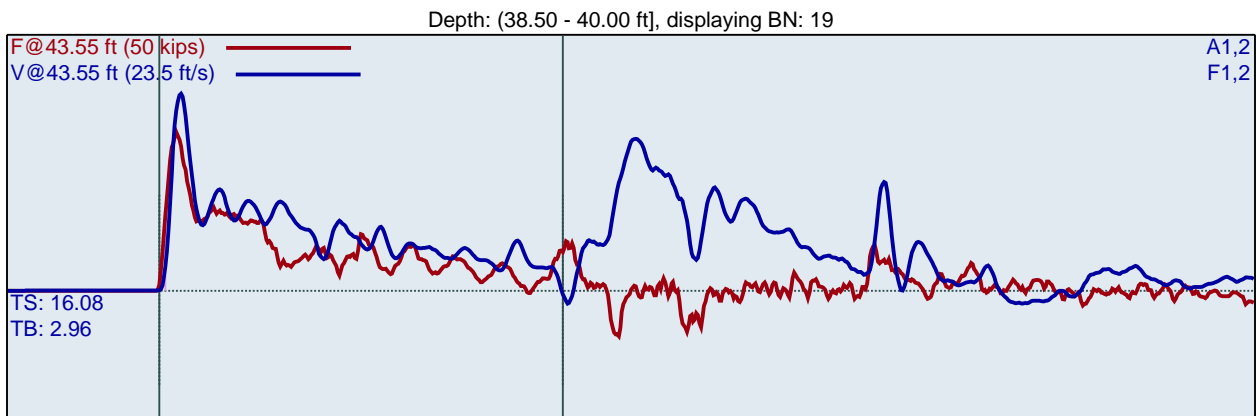
Sample Interval Time: 53.08 seconds.

CME 55 (SN 328245)
H. Forbes
B-14B

Annual Calibration
Test date: 5/7/2020

AR: 1.19 in²
LE: 43.55 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [203-AWJ] 214 PDICAL (1) FF1
F2 : [203-AWJ] 214 PDICAL (1) FF1

A1 (PR): [K10674] 370 mv/6.4v/5000g (1) VF1
A2 (PR): [K10673] 340 mv/6.4v/5000g (1) VF1

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	DFN in	CSX ksi	EFV ft-lb	ETR %
1	38.63	4	56.8	29	16.7	2.59	1.50	24.0	282	80.5
2	38.75	4	1.9	27	17.0	1.83	1.50	22.4	291	83.1
3	38.88	4	49.8	28	17.2	1.58	1.50	23.1	293	83.8
4	39.00	4	50.1	28	16.9	1.50	1.50	23.7	294	84.0
5	39.06	8	49.8	28	16.9	1.17	0.75	23.7	295	84.3
6	39.13	8	50.0	28	16.4	1.00	0.75	23.8	297	84.8
7	39.19	8	49.7	29	17.0	0.98	0.75	24.0	298	85.0
8	39.25	8	49.8	29	17.0	1.05	0.75	24.2	299	85.5
9	39.31	8	50.1	29	17.6	0.99	0.75	24.7	295	84.3
10	39.38	8	49.8	30	17.6	1.06	0.75	25.1	300	85.8
11	39.44	8	49.8	30	17.6	0.97	0.75	24.9	301	85.9
12	39.50	8	49.9	29	17.8	0.91	0.75	24.7	302	86.4
13	39.56	9	49.9	30	17.4	0.92	0.67	24.8	301	86.0
14	39.61	9	49.6	30	17.6	0.88	0.67	25.0	296	84.5
15	39.67	9	49.9	30	17.8	0.79	0.67	25.0	301	86.0
16	39.72	9	49.7	30	17.8	0.79	0.67	25.1	304	86.8
17	39.78	9	50.0	30	17.6	0.75	0.67	25.1	301	86.0
18	39.83	9	49.7	31	18.1	0.77	0.67	25.8	303	86.6
19	39.89	9	49.9	31	18.1	0.74	0.67	26.1	311	88.8
20	39.94	9	49.7	30	17.9	0.70	0.67	24.8	306	87.4
21	40.00	9	49.6	29	18.0	0.67	0.67	24.0	296	84.6
Average			49.8	29	17.5	0.89	0.71	24.8	300	85.8
Std Dev			0.1	1	0.5	0.14	0.04	0.6	4	1.2
Maximum			50.1	31	18.1	1.17	0.75	26.1	311	88.8
Minimum			49.6	28	16.4	0.67	0.67	23.7	295	84.3

N-value: 17

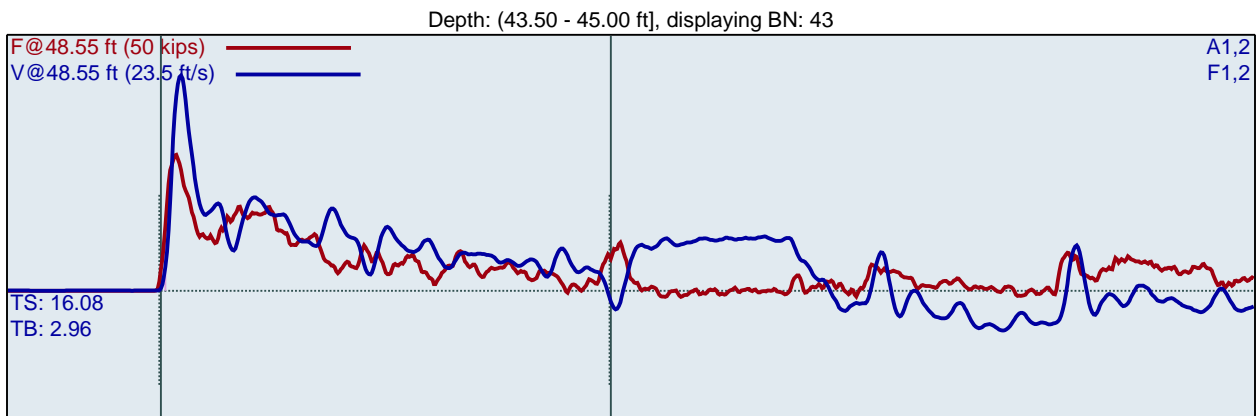
Sample Interval Time: 55.15 seconds.

CME 55 (SN 328245)
H. Forbes
B-14B

Annual Calibration
Test date: 5/7/2020

AR: 1.19 in²
LE: 48.55 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [203-AWJ] 214 PDICAL (1) FF1
F2 : [203-AWJ] 214 PDICAL (1) FF1

A1 (PR): [K10674] 370 mv/6.4v/5000g (1) VF1
A2 (PR): [K10673] 340 mv/6.4v/5000g (1) VF1

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	DFN in	CSX ksi	EFV ft-lb	ETR %
1	43.56	8	1.9	26	18.2	1.58	0.75	21.9	284	81.0
2	43.63	8	57.1	26	18.2	1.32	0.75	22.3	288	82.3
3	43.69	8	48.4	26	18.2	1.05	0.75	21.7	286	81.7
4	43.75	8	48.6	27	18.7	1.06	0.75	22.8	296	84.6
5	43.81	8	48.1	26	18.6	0.98	0.75	21.5	288	82.2
6	43.88	8	1.9	27	19.3	0.93	0.75	22.6	301	86.0
7	43.94	8	51.8	26	18.6	0.90	0.75	21.9	294	83.9
8	44.00	8	52.2	27	18.7	0.84	0.75	22.3	293	83.7
9	44.03	16	52.1	27	17.9	0.71	0.37	22.7	297	84.8
10	44.06	16	51.7	27	18.7	0.64	0.37	22.5	307	87.6
11	44.09	16	52.5	26	17.7	0.57	0.37	22.0	287	82.1
12	44.13	16	51.6	27	18.7	0.56	0.38	22.7	305	87.0
13	44.16	16	51.8	26	18.4	0.51	0.37	21.8	294	84.0
14	44.19	16	52.3	27	18.6	0.51	0.37	22.5	303	86.7
15	44.22	16	51.5	26	18.1	0.50	0.37	22.0	288	82.3
16	44.25	16	52.0	27	18.5	0.49	0.37	22.4	302	86.2
17	44.28	16	52.0	27	18.8	0.49	0.37	22.5	303	86.5
18	44.31	16	52.1	26	18.1	0.48	0.37	22.0	294	83.9
19	44.34	16	51.8	26	18.1	0.47	0.38	22.2	297	84.8
20	44.38	16	51.8	25	18.0	0.50	0.37	21.3	300	85.7
21	44.41	16	51.8	26	18.1	0.44	0.38	21.7	298	85.0
22	44.44	16	51.9	26	18.2	0.45	0.38	21.7	298	85.0
23	44.47	16	51.9	25	18.1	0.45	0.38	21.4	302	86.4
24	44.50	16	51.7	26	17.5	0.44	0.38	21.5	302	86.4
25	44.52	21	51.9	27	17.9	0.44	0.29	22.3	303	86.5
26	44.55	21	51.7	27	18.0	0.46	0.29	22.6	301	86.0
27	44.57	21	51.9	26	17.9	0.47	0.29	22.0	302	86.4
28	44.60	21	51.6	27	18.6	0.47	0.29	22.6	306	87.5
29	44.62	21	51.8	27	19.0	0.49	0.29	22.7	310	88.7
30	44.64	21	51.6	28	18.9	0.48	0.29	23.1	305	87.1
31	44.67	21	51.9	27	18.7	0.49	0.29	22.7	308	88.0

32	44.69	21	51.7	26	18.7	0.49	0.29	22.2	304	86.9
33	44.71	21	52.1	27	18.7	0.49	0.29	22.3	304	86.7
34	44.74	21	51.8	27	19.1	0.49	0.29	22.9	308	88.0
35	44.76	21	51.9	28	19.3	0.50	0.29	23.4	310	88.6
36	44.79	21	51.9	27	18.8	0.47	0.29	23.0	299	85.5
37	44.81	21	51.6	28	19.2	0.47	0.29	23.4	303	86.6
38	44.83	21	52.1	29	19.6	0.48	0.29	24.0	310	88.6
39	44.86	21	51.7	28	19.5	0.48	0.29	23.6	306	87.4
40	44.88	21	51.7	27	19.5	0.48	0.29	22.8	309	88.2
41	44.90	21	51.9	27	18.9	0.47	0.29	22.4	300	85.7
42	44.93	21	52.1	28	19.3	0.48	0.29	23.4	306	87.5
43	44.95	21	51.6	27	19.8	0.47	0.29	22.3	301	86.1
44	44.98	21	51.6	27	19.0	0.46	0.29	22.7	298	85.2
45	45.00	21	51.9	27	19.2	0.46	0.29	22.8	301	86.1
Average			51.9	27	18.6	0.49	0.32	22.5	302	86.3
Std Dev			0.2	1	0.6	0.05	0.04	0.6	5	1.6
Maximum			52.5	29	19.8	0.71	0.38	24.0	310	88.7
Minimum			51.5	25	17.5	0.44	0.29	21.3	287	82.1
N-value: 37										

Sample Interval Time: 136.91 seconds.

Summary of SPT Test Results

Project: CME 55 (SN 328245), Test Date: 5/7/2020

BPM: Blows/Minute

FMX: Maximum Force

VMX: Maximum Velocity

DMX: Maximum Displacement

DFN: Final Displacement

CSX: Compression Stress Maximum

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 DFN in	Average CSX ksi	Average EFV ft-lb	Average ETR %
38.55	33.50	35.00	8-13-7	20	28	52.1	29	17.2	0.76	0.60	24.3	297	84.7
43.55	38.50	40.00	4-8-9	17	24	49.8	29	17.5	0.89	0.71	24.8	300	85.8
48.55	43.50	45.00	8-16-21	37	52	51.9	27	18.6	0.49	0.32	22.5	302	86.3
Overall Average Values:						51.4	28	18.0	0.65	0.49	23.5	300	85.7
Standard Deviation:						0.9	1	0.8	0.21	0.20	1.2	5	1.5
Overall Maximum Value:						52.5	31	19.8	1.17	0.86	26.1	311	88.8
Overall Minimum Value:						49.6	25	16.4	0.44	0.29	21.3	287	82.1



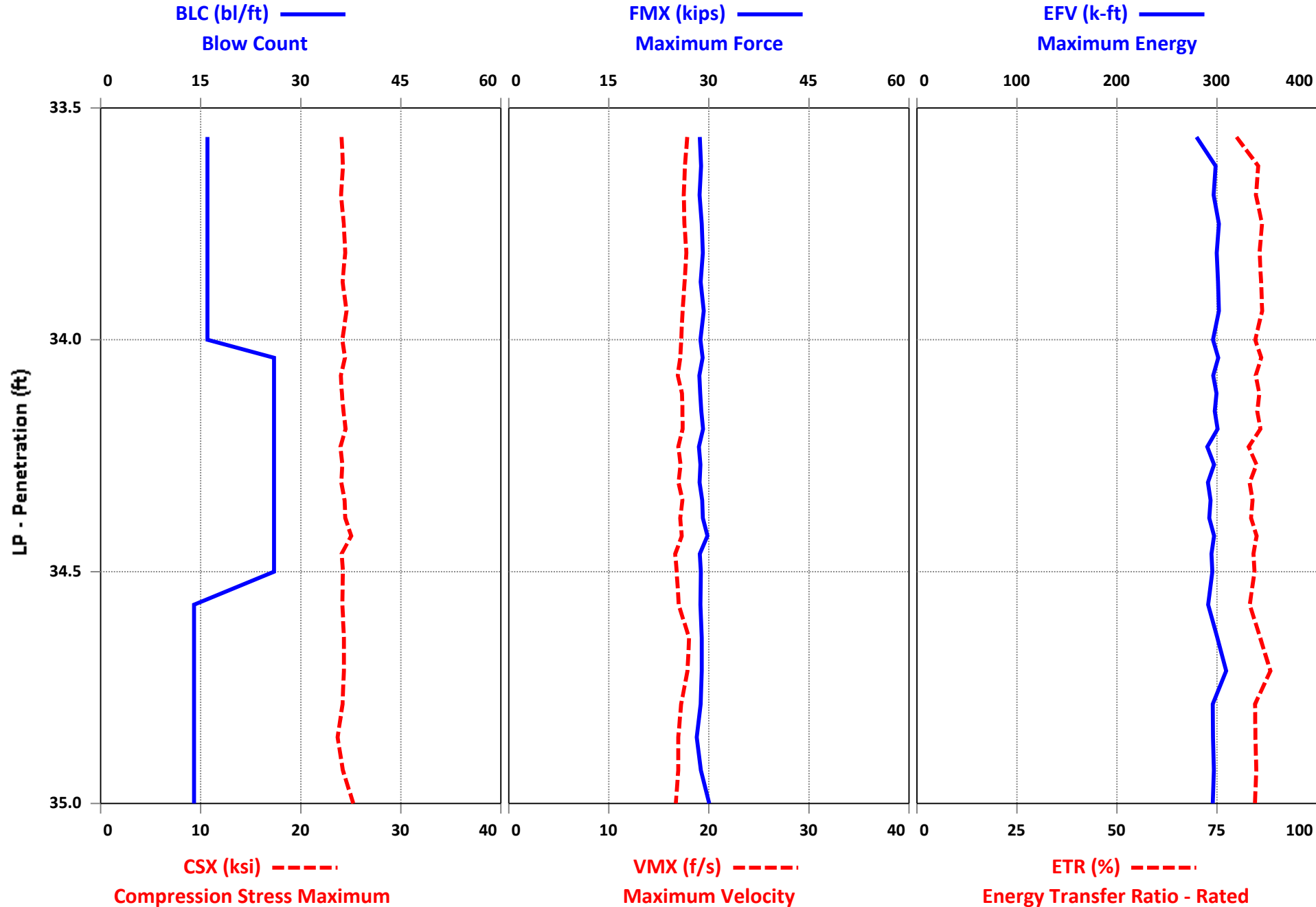
Printed: 22-May-2020

Pile Dynamics, Inc. - PDILOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Test started: 07-May-2020



CME 55 (SN 328245) - 33.5 to 35 ft





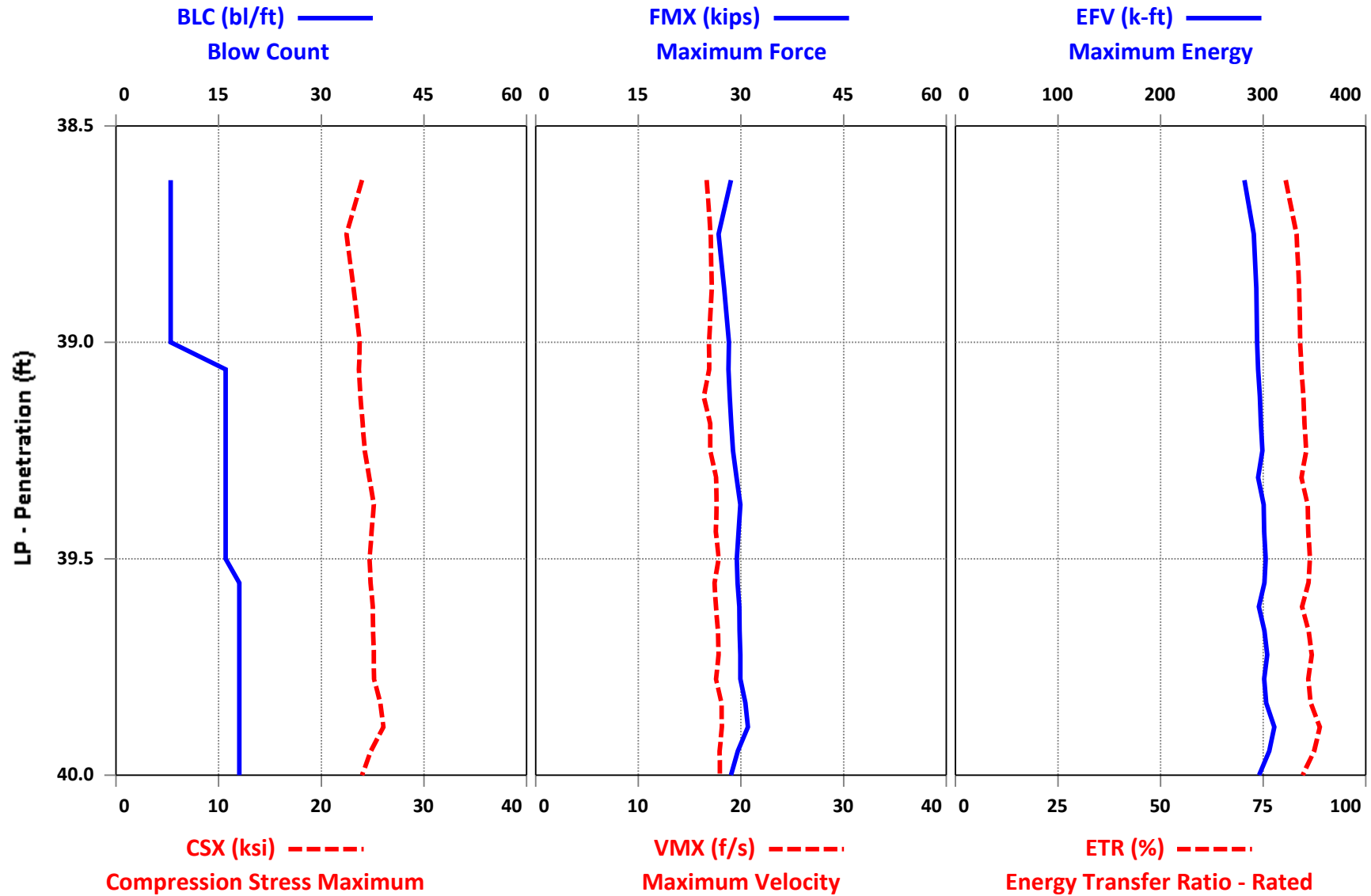
Printed: 22-May-2020

Pile Dynamics, Inc. - PDILOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Test started: 07-May-2020



CME 55 (SN 328245) - 38.5 to 40 ft





CME 55 (SN 328245) - 43.5 to 45 ft

