Geotechnical Base Line Report (GBLR)

Route S-12-300 (2490) Bridge Replacement over Little Rocky Branch (South)

Chester County, South Carolina

SCDOT Project ID P038061

S&ME Project No. 1361-20-048

PREPARED FOR:

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

PREPARED BY:

S&ME, Inc.
134 Suber Road
Columbia, South Carolina 29210

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 Base Line Report (GBLR)
Route S-12-300 (2490) Bridge Replacement over Little Rocky Branch (South)
Chester County, South Carolina
SCDOT Project ID P038061
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.

SOUTH CAROLINA
S&ME, INC.
C00473
CERTIFICATE OF AUTHORIZATION

SOUTH CAROLINA
PROFESSIONAL ENGINEER
LICENSED
No. 37844
3/19/21
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Senior Project Manager

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1.0 Project Description

The proposed construction for this project includes replacement of the existing Rambo Road (S-12-300) bridge over Little Rocky Branch (South) located in Chester 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
P038061	S-12-300 (2490)	Rambo Road	Little Rocky Branch (South)	Chester	34.58117	-81.15942

From our review of the provided information, the existing bridge was built in 1957 and is 60 feet in length with two travel lanes. The proposed replacement bridge will be 70 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 on October 14, 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 Chester County to coordinate the field testing and traffic control along the SCDOT rights-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 on October 14, 2020 using an ATV-mounted CME 550X drill rig. Soil test borings with SPT sampling were performed using mud rotary drilling techniques. The borings were performed to drill bit refusal, , followed by wireline rock coring to termination depths. 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-12-300	1270030000200	B-1	19.5	25.5	Asphalt	Proposed South Abutment
		B-2	20.7	30.7	Asphalt	Proposed North 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	506.9	14.5	492.4	16.1	490.8
B-2	506.0	8.0	498.0	NE	-

NOTES: NE = not encountered

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 550X	290593	ATV	81.1

5.5 Wireline Rock Coring

Upon encountering refusal at the boring locations, wireline rock coring was performed to termination depths of 25.5 to 30.7 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 Results
- 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 Subsurface Conditions

Assessment of the geotechnical conditions included review of available topographic, geologic and soils maps for relevant information.

9.1 Area Geology

The site is located within the Charlotte Terrane of the Piedmont Physiographic Province of South Carolina. The Piedmont Province generally consists of well-rounded hills and ridges, which are dissected by a well-developed system of draws and streams. The Piedmont Province is predominantly underlain by metamorphic rock (formed by heat, pressure and/or chemical action) and igneous rock (formed directly from molten material), which were initially formed during the Precambrian and Paleozoic eras. The volcanic and sedimentary rocks deposited in the Piedmont Province during the Precambrian eras were the host for the metamorphism and were changed to gneiss and schist. The more recent Paleozoic era had periods of igneous emplacement, with at least several episodes of regional metamorphism resulting in the majority of the rock types seen today.

The topography and relief of the Piedmont Province have developed from differential weathering of the igneous and metamorphic rock. Because of the continued chemical and physical weathering, the rocks in the Piedmont Province are now generally covered with a mantle of soil that has weathered in place from the parent bedrock. These soils have variable thicknesses and are referred to as residuum or residual soils. The residuum is typically finer grained and has higher clay content near the surface because of the advanced weathering. Similarly, the soils typically become coarser grained with increasing depth because of decreased weathering. As the degree of weathering decreases, the residual soils generally retain the overall appearance, texture, gradation and foliations of the parent rock.

The boundary between soil and rock in the Piedmont is not sharply defined. A transitional zone termed "Partially Weathered Rock" is normally found overlying the parent bedrock. Partially Weathered Rock (PWR) is defined for engineering purposes as residual material with Standard Penetration Resistances (N-values) exceeding 100 blows per foot. The transition between hard/dense residual soils and PWR occurs at irregular depths due to variations in degree of weathering.

Water is typically present in the residual soils and within fractures in the PWR or underlying bedrock in the Piedmont. On upland ridges in the Piedmont, water may or may not be present in the residual soils above the PWR and bedrock. Alluvial soils, which have been transported and deposited by water, are typically found in floodplains and are generally saturated to within a few feet of the ground surface. Fluctuations in water levels are typical in residual soils and PWR in the Piedmont, depending on variations in precipitation, evaporation and surface water runoff. Seasonal high-water levels are expected to occur during or just after the typically wetter months of the year (November through April).

The existing roadway right-of-way includes areas of previously placed fill. It has been our experience that previously placed fill soils can change abruptly in composition or consistency over short horizontal distances. Previously placed fills often may contain hidden zones of detrimental materials and unsuitable soils or may contain voids.

9.2 Soil and Rock Stratification

The generalized subsurface conditions at the site are described below. An interpreted subsurface cross-sectional profile is attached as Figure 3 in Appendix I. The discussed subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring records included in

Appendix III should be reviewed for specific information at each boring location. The depth and thickness of the subsurface strata indicated on the boring records was estimated based on the drill cuttings and the samples recovered. The transition between materials may be more gradual than indicated on the boring records. Information on actual subsurface conditions exists only at the specific boring locations and is relevant to the time the exploration was performed. Variations may occur and should be expected at locations remote from the boring. The stratification lines were used for our analytical purposes and, unless specifically stated otherwise, should not be used as the basis for design or construction cost estimates.

Surface materials encountered at the existing ground surface in our borings consisted of 3 inches of asphalt pavement and 4 to 10 inches of graded aggregate base course. A summary of the stratification across the bridge alignment is provided in the table below.

Table 9-1 – Soil Stratification Table

Geotechnical Strata Designation	Depth Interval Range (ft.)	USCS Soil Class or Rock Type	Range of Raw SPT N-values (bpf)	Comments
Existing Roadway Embankment Fill	0 to 13	SC and CL	2 to 16	Very loose to medium dense, dry to wet, fine to coarse SAND with little to some low to medium plasticity fines, containing trace fine gravel. Firm, moist, low to medium plasticity CLAY with little fine to coarse sands.
Piedmont Residuum	8 to 18½	SC and CL	6 to 17	Loose, moist, fine to medium SAND with some low to medium plasticity fines. Very stiff, moist, medium plasticity CLAY with little fine to coarse sands.
Partially Weathered Rock (PWR)	13½ to 20½	SM	>100	Very dense, moist to wet, fine to coarse SAND with little to some low plasticity fines, containing trace rock fragments.
Metamorphic Bedrock	19½ to 31	Felsic Gneiss	N/A	Slightly to highly weathered, weak to very strong with poor to good quality.

The subsurface profile presented as Figure 3 in Appendix I illustrates interpolated conditions based on the boring data in the longitudinal direction. Interpolation of subsurface conditions between borings is an approximation based on reasonable engineering judgment and actual soil conditions beyond the test hole locations may vary substantially from those shown in the profiles.

10.0 Preliminary Design and Construction Considerations

Chapter 21 of the SCDOT GDM provides that the GBLR should provide limited (preliminary) geotechnical information on a D/B project, thus permitting the contractor to bid on the project with a certain degree of knowledge and acceptable risk. The preliminary design and construction considerations submitted herein are based, in part, upon data obtained from our preliminary field exploration and laboratory testing program. Subsurface conditions across the site will vary, as will grading and construction details. Additional geotechnical exploration and analysis will be required to provide detailed analysis and recommendations for the project.

10.1 Deep Foundations

Support for the bridge end bents appears possible with driven piles, drilled piles or drilled shafts. However, support of the bridge interior bents appears limited to drilled shafts.

10.1.1 Driven Piles

Driven steel H-pile foundations are anticipated to be driven to practical refusal to bear on very dense partially weathered rock or on material causing refusal to the borings. Driven steel H-piles are advantageous due primarily to their relative cost and ease for pile splicing and cutting. Piles are commonly paid for on an "in-place" basis and no charge is made for the length of steel cut off. The principal disadvantage associated with steel H-piles are their relatively small tip areas, which can result in very small end bearing resistance in residual soils since formation of a soil plug cannot be counted on in all cases to help with end bearing capacity development, hence piles will need to extend to sufficient depth to bear in PWR or rock. For piles driven to practical refusal in PWR or rock, factored pile resistance will be essentially the allowable stress of the steel pile cross sectional area.

10.1.2 Drilled Piles

Due to the depth to bedrock and required bent dimensions, drilled pile foundations may be required. Drilled piles are normally required where the depth to rock is less than 10 to 15 feet, and where lateral loading demands require the pile to be extended into rock to achieve lateral stability. The capacity of a drilled pile is determined based on whether the pile is driven or not after being placed in the borehole. Where not driven, these piles shall be designed as a drilled shaft. Drilled piles are typically steel H-piles of HP12x53 or HP14x73 sizing. The borehole diameter required for a drilled pile is equal to the diagonal dimension of the H-pile plus 6 inches to allow for placement of the pile and concrete.

10.1.3 Drilled Shafts

Drilled shaft foundations are anticipated to be socketed into the underlying bedrock to provide the required axial and lateral resistance. Drilled shafts are normally used when large loads are anticipated, where allowable deformation is small, where the losses due to scour are large, where slope instability cannot be maintained using conventional methods or where there is a limitation on water crossing work. Drilled shaft diameters should be a minimum 6 inches larger than the column above the shaft and the rock socket at the base of the shaft. Construction casing is required.

10.1.4 Driving Considerations

The following considerations are provided for the use of driven piles and drilled piles that are driven after placement within the borehole.

The contractor should take care not to overdrive or overstress the piles during driving. Prior to installing piles, a wave equation analysis should be performed to evaluate whether the Contractor's proposed driving system (i.e., hammer type and size) is capable of efficiently driving the piles to the desired depths without damaging the piles, and to establish driving criteria. Per the GDM, practical refusal is defined as 5 blows per quarter (¼) inch or 20 blows per inch. Steel pile compressive stresses during driving should not exceed 0.9 times the yield strength of the steel section during driving. Because the PWR and gneiss bedrock is anticipated to be very hard, we recommend that the piles be equipped with driving points or shoes to protect the pile from damage during driving.

Specifically, for drilled piles, a layer of apparent PWR with N-values exceeding 100 blows per foot was encountered just above the bedrock in Borings B-1 and B-2, while the initial core run in Borings B-1 and B-2 exhibited RQDs ranging from 40 to 50 percent. Piles can typically be driven into PWR materials with N-values of 100 blows per foot. Piles cannot typically be driven into rock with RQDs exceeding 10 percent. Therefore, drilled piles that are required to be installed below the refusal depths noted on the borings will likely need to be designed as drilled shaft.

10.1.5 Drilling Considerations

The bedrock elevation is slightly variable along the bridge alignment, varying up to roughly 2 feet in elevation from bent to bent. The bedrock encountered in the borings was slightly to moderately weathered medium strong to strong rock. A weathered zone was noted in the top approximate 1 foot of rock encountered in Boring B-2 and within the bottom 1 foot of core recovered from Boring B-1. RQD values ranged from 40 to 50 percent in the top of the rock profile and increased to 70 to 90 percent at depth. Therefore, difficult drilling and deeper penetration into the bedrock will likely be required to achieve proper bearing and lateral stability for the bridge foundations. Individual drilled piles/shafts may encounter ledges, boulders or seams of relatively hard rock within the partially weathered rock zone overlying competent bedrock, which may require special measures to permit advancement to the required bearing.

We anticipate drilled piles/shafts will be installed using the casing method of construction. Steel casing should be advanced and seated into the top of rock to provide an effective seal against overburden material falling into the shaft. Water may still enter the shaft through seams in the rock. If the wet method is used, either mineral slurry or potable water may be used during excavation and construction of the shaft. Depth to ground water along the bridge alignment was measured at roughly 8 to 14½ feet below the existing ground surface. Therefore, ground water control will be important during construction of drilled piles/shafts.

The overburden soil materials consisting of existing fill and Piedmont residual soils can typically be excavated with a conventional earth auger. PWR or low quality rock will necessitate use of a rock auger advanced by a large foundation drilling rig. Contractor should be required to provide augering equipment with adequate torque and power to install drilled piles/shafts through very dense PWR and low quality rock using augers with hardened tungsten carbide bits. The speed of excavation depends upon the type of material being penetrated, size of foundation element and size of the drilling rig. The explored soil profile shows zones of PWR, ranging from roughly 1 to 7 feet in thickness. The rate of penetration through these materials could be very slow and could require rotary percussion drills or core barrels to penetrate to relatively continuous bedrock encountered in the borings. Specialized drilling equipment may be required due to the observed rock strengths, depending on required penetration depths. This may include, but not be limited to, rock augers, core barrels, or rotary percussion drilling equipment.

Laboratory uniaxial strength test results performed on select cores from each end bent boring indicate compressive strengths as summarized in the table below:

Table 10-1 – Rock Core Compressive Strength Summary

Boring No.	Core Run	Core Interval (ft)	Sample No.	Sample Depth (ft)	Compressive Strength (psi)
B-1	RC-2	20.5-25.5	RS-1	22.05-22.45	12,715
B-2	RC-1	20.7-25.7	RS-1	21.0-21.4	29,205
B-2	RC-2	25.7-30.7	RS-2	28.0-28.4	25,595

Compressive strengths obtained in the laboratory represent strong to very strong, dense metamorphic rock which will pose substantial resistance to heavy duty drilling equipment. Diamond core barrels will be required to advance through hard rocks and contractor should be prepared to expend substantial time to advance the sockets in these materials.

10.1.6 Resistance Criteria

Axial resistance will likely govern the geotechnical foundation design and be developed in end bearing on the underlying PWR or bedrock. Development of lateral resistance of the pile/shaft foundations should be achievable in the Piedmont residuum and underlying PWR.

10.2 Corrosion Potential Results

Corrosion series testing was performed to determine the potential for material deterioration of the proposed foundations. One composite sample was taken from selected recovered samples of Boring B-2 to perform pH, resistivity, sulfate, and chloride geochemical tests. This boring is representative of the northern end bent. The sample was selected based on the proximity to the estimated soil/pile/ground water interface elevation.

Table 10-2 – Summary of Corrosion Series Testing

Sample	Depth (feet)	Minimum Resistivity (ohm-cm)	Sulfate Content (ppm)	Chloride Content (ppm)	pH
B-1 (SS-6)	13.5-15.0	8,040	36.1	21.0	6.7

The complete laboratory testing results of the corrosion series testing are provided in Appendix V and are summarized in Table 3 on Appendix II.

Section 7.19 of the GDM provides guidance on determining corrosion potential or aggressiveness. The following soil conditions from GDM Table 7-34 suggest aggressive conditions:

- pH less than 5.5;
- Sulfate concentrations greater than 1,000 ppm (mg/kg);
- Resistivity less than 2,000 ohm-cm;

Therefore, the site appears to be non-aggressive for foundations. However, interpretation of the data and corrosion protection of structural components shall be reviewed and provided by the structural engineer during the design phase of the project.

11.0 Closing

This base line 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.

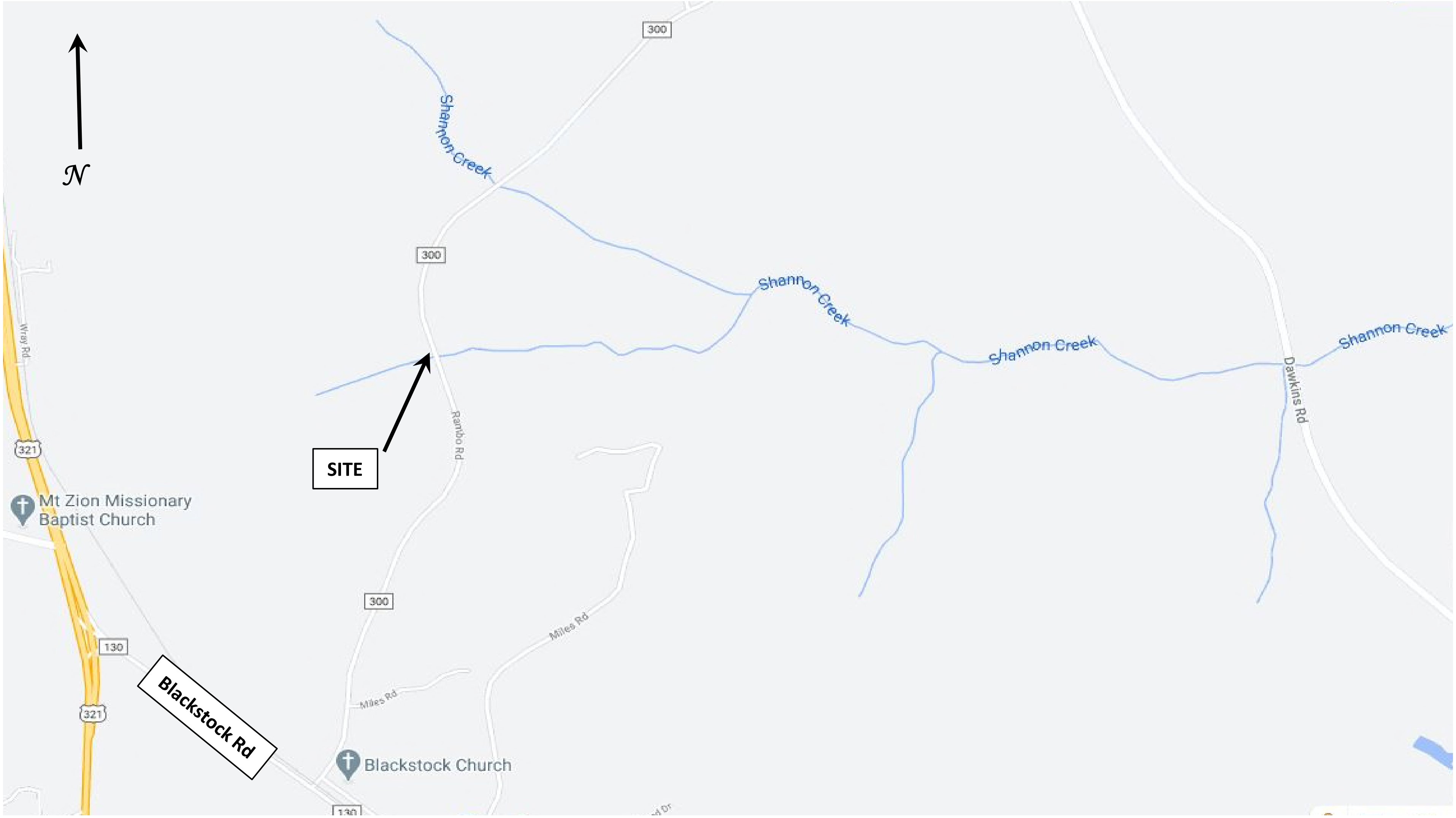
We relied on project information given to us to develop our exploration program. If project information described in this report is not accurate, or if it changes during project development, we should be notified of the changes.

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-12-300 (2490)

JOB NAME:	Rte. S-12-300 (2490) BRO Little Rocky Branch (South)	FIGURE NO.
LOCATION:	S-12-300 (Rambo Road)	1
CITY, STATE:	Blackstock, South Carolina	
JOB NO.:	1361-20-048	

SCALE:	NTS	CHECKED BY:	MFC
DATE:	3/19/2021	DRAWN BY:	AKS

Legend:

Approximate Boring Location

SOURCE: Google Earth

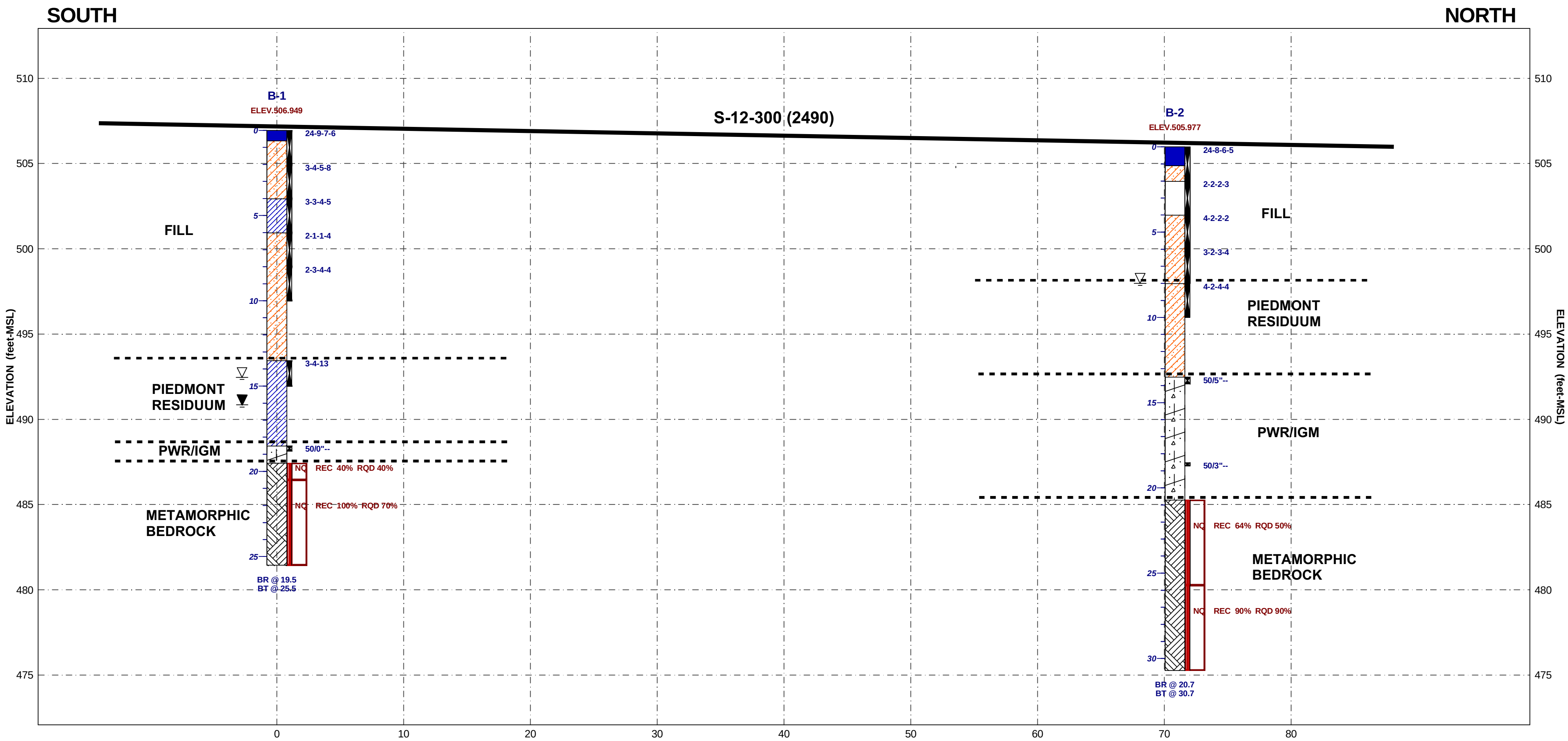
BORING LOCATION PLAN: S-12-300 (2490)

JOB NAME:	Rte. S-12-300 (2490) BRO Little Rocky Branch (South)
LOCATION:	S-12-300 (Rambo Road)
CITY, STATE:	Blackstock, South Carolina
JOB NO.:	1361-20-048

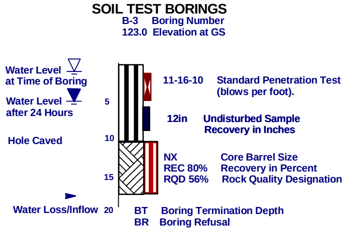
SCALE:	NTS	CHECKED BY:	MFC
DATE:	3/19/2021	DRAWN BY:	JPL

FIGURE NO.

2



SOIL TEST BORINGS



LEGEND OF MATERIAL GRAPHICS FOR SOIL TEST BORINGS

Asphalt | SC, Clayey Sand | CL, Low Plasticity Clay | SC DOT: Saprolite | Bedrock

The depicted stratigraphy is shown for illustrative purposes only and is not warranted. Separations between different strata may be gradual and likely vary considerably from those shown. Profiles between nearby borings have been estimated using reasonable engineering care and judgment. The actual subsurface conditions will vary between boring locations.

SUBSURFACE PROFILE

PROJECT: S-12-300 (2490) BRO Little Rocky Branch
SCDOT PROJECT ID: P038061
LOCATION: Chester County, SC

JOB NO: 1361-20-048

DATE: 2/26/21

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-12-300 (2490)	B-1	X						999530.4	1952117.9	34.58037	-81.15908	506.9	Existing
S-12-300 (2490)	B-2	X						999597.1	1952095.5	34.58056	-81.15915	506.0	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-12-300(2490)	B-1	SS-1/SS-2	0.0-4.0	11.4	26	17	9	80	58	33.0	-	A-2-4	SC	FILL
	B-1	SS-4	6.0-8.0	-	-	-	-	-	-	32.3	-	-	SC	FILL
	B-1	SS-5	8.0-10.0	17.2	34	17	17	-	-	45.3	-	-	SC	FILL
	B-2	SS-1	0.0-2.0	-	-	-	-	-		13.9	-	-	SC	FILL
	B-2	SS-3	4.0-6.0	8.0	-	-	-	-	-	16.1	-	-	SC	FILL
	B-2	SS-4	6.0-8.0	16.1	27	15	12	-	-	41.9	-	-	SC	FILL
	B-2	SS-5	8.0-10.0	13.9	28	15	13	89	73	41.0	-	A-6	SC	RESIDUUM

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)	Mininmum Resistivity (Ohm-cm)	Sulfates		Chlorides		pH
					(mg/kg)	(wt%)	(mg/kg)	(wt%)	
S-12-300 B-1 (2490)	13.5 - 15.0	SS-6	9,380	8,040	36.1	0.0036	21.0	0.0021	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-12-300 South B-1	RC-1	19.5	20.5	40	40	-	-	-	-	-	85
	RC-2	20.5	25.5	100	70	22.05	22.45	162	12,715	49	75
S-12-300 South B-2	RC-1	20.7	25.7	64	50	21.0	21.4	169.9	29,205	47	85
	RC-2	25.7	30.7	90	90	28.0	28.4	163.7	25,595	82	90

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	STD. PENETRATION RESISTANCE BLOWS/FOOT
Very Soft	0 to 2
Soft	3 to 4
Firm	5 to 8
Stiff	9 to 15
Very Stiff	16 to 30
Hard	31 to 50
Very Hard	Over 50

RELATIVE DENSITY OF COHESIONLESS SOILS

RELATIVE DENSITY	STD. PENETRATION RESISTANCE BLOWS/FOOT
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	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%.

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**

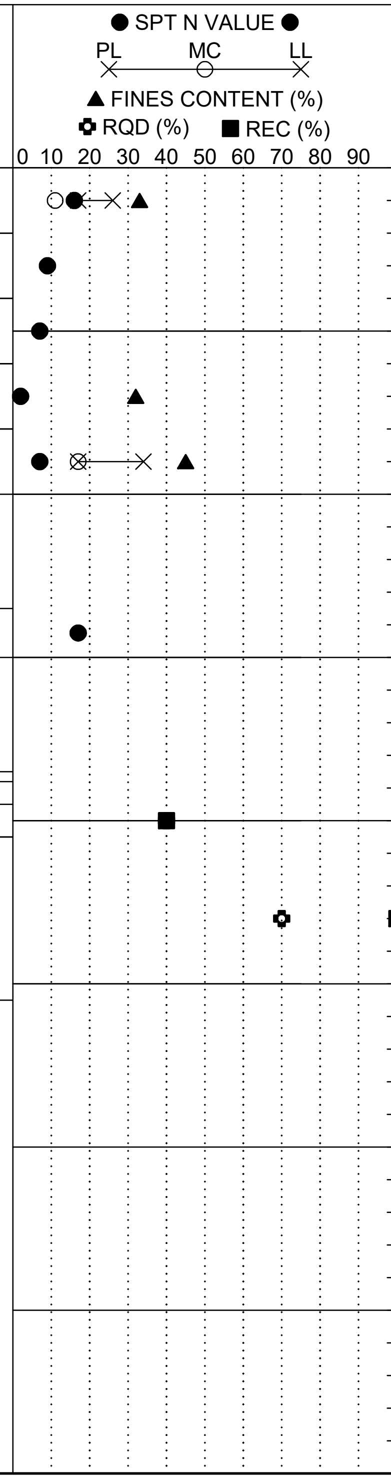
- Slk - Slickensided (surface has smooth, glassy finish with visual evidence of striations)
- S - Smooth (surface appears smooth and feels so to the touch)
- SR - Slightly Rough (asperities on the discontinuity surfaces are distinguishable and can be felt)
- R - Rough (some ridges and side-angle steps 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)

SCDOT Soil Test Log

Project ID:	P038061	**County:**	Chester	**Boring No.:**	B-1		
Site Description:	S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000200)	**Route:**	S-12-300 (S)				
Eng./Geo.:	AR	**Boring Location:**	7' S of SEB	**Offset:**	6' E of CL	**Alignment:**	Existing
Elev.:	506.9 ft	**Latitude:**	34.58037244	**Longitude:**	-81.15907576	**Date Started:**	10/14/2020
Total Depth:	25.5 ft	**Soil Depth:**	19.5 ft	**Core Depth:**	6.0 ft	**Date Completed:**	10/14/2020
Bore Hole Diameter (in):	3 7/8	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550X	**Drill Method:**	RW / DC / RC	**Hammer Type:**	Automatic	**Energy Ratio:**	81.1%
Core Size:	NQ	**Driller:**	J. Little	**Groundwater:**	TOB 14.5 ft	**24HR**	16.1 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	**SURFACE MATERIALS** - 3 inches of ASPHALT, 4 inches GABC.	0.0	SS-1	24	9	7	6	16
		FILL - medium dense to loose, dry, light brownish grey, Clayey fine to medium SAND (SC) (A-2-4), 2.5Y 6/2, some low plasticity fines, trace fine gravel. LL=26, PL=17, PI=9, NMC=11.4, %#200=33.0	2.0	SS-2	3	4	5	8	9
501.9	4.0		4.0	SS-3	3	3	4	5	7
	6.0	Firm, moist, reddish brown, lean CLAY with SAND (CL), [2.5YR 4/4], mostly medium to low plasticity fines, little fine to coarse sands.	6.0	SS-4	2	1	1	4	2
496.9			8.0	SS-5	2	3	4	4	7
	13.0	Very loose, wet, light gray and brown, Clayey fine to coarse SAND (SC) (A-2), 10YR 7/1, 7.5YR 4/3, some medium plasticity fines. %#200 =32.3 @ 8 feet - loose. LL=34, PL=17, PI=17, NMC=17.2, %#200=45.3	13.5	SS-6	3	4	13		17
491.9									
	18.5	**PIEDMONT RESIDUUM** - very stiff, moist, brown and light gray, Sandy Lean CLAY (CL), 7.5YR 4/3, 10YR 7/1, mostly medium plasticity fines, little fine to coarse sands.	18.5	~~SS-7~~	~~50/0"~~				
486.9	19.5	**PARTIALLY WEATHERED ROCK (PWR)** - very dense, moist, light gray and brown, Silty fine to coarse SAND (SM), 10YR 7/1, 7.5YR 4/3, little low plasticity fines. Auger Refusal at 19.5 feet. Install NW Casing to 19.5 feet for NQ wireline coring.	19.5	RC-1					
481.9			20.5	RC-2					
	25.5	**METAMORPHIC BEDROCK - FELSIC GNEISS** - pink [5YR 7/4] and black [2.5/N] and white [8/N], very coarse to medium grained, thinly foliated, slightly to moderately weathered, very strong to strong rock, VH-H, J (0-60° dip, VC, VN-N-MW-W, Pl, SR-S, Pa-Fi-No) RC-1: RQD = 40%, REC = 40%, GSI = 85, 1.75 min/ft RC-2: RQD = 70%, REC = 100%, GSI = 75, RMR = 49, 2.4 min/ft, qu=12,715 psi @ 24.5 feet - brown [7.5YR 4/3] and white [8/N] and black 2.5/N], highly weathered, weak rock, F-LH							
476.9									
471.9		Boring Terminated at 25.5 feet.							



LEGEND

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

Rock Core Discontinuity Worksheet

Project Name: S-12-300 (2490)
Project Number: 1361-20-048
Driller (Company/Name): S&ME/Jay Little
Logged By: AR
Date: 10/14/2020

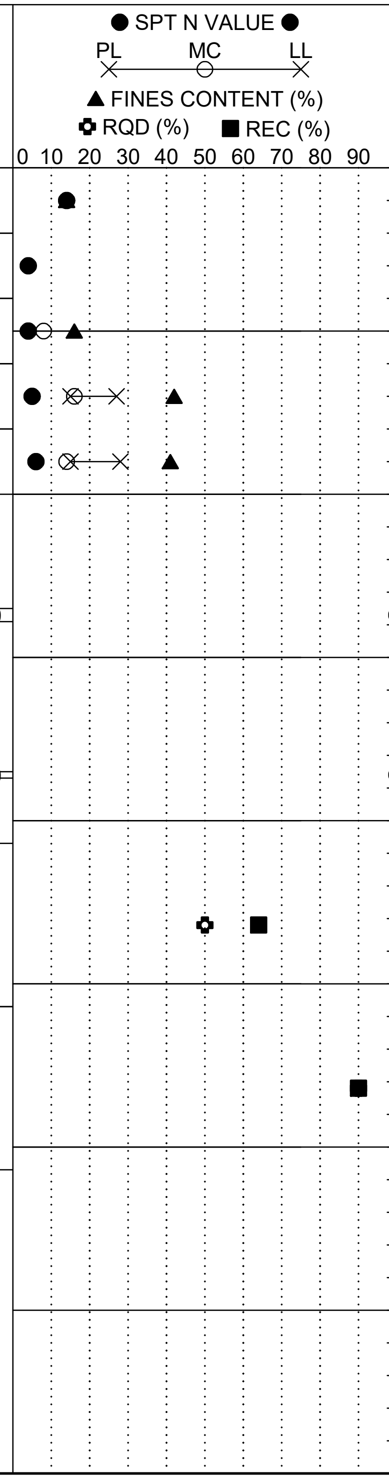
Boring Number: B-1
Core Barrel Type: NQ
Core Barrel Length: 5.0'
Coring Technique: wireline
Number of Core Boxes: 1

Depth (ft)	Disc. No.	Disc. Type	Dip Angle (deg)	Disc. Width (mm)	Infill Amount	Infill Type	Surface Shape	Surface Roughness	Notes
20.7	1	J	10	N	No	N/A	Pl	SR	
21	2	J	5	MW	No	N/A	Pl	SR	
21.1	3	J	5	MW	No	N/A	Pl	SR	
21.7	4	J	60	VN	No	N/A	Pl	SR	
21.9	5	J	5	N	No	N/A	Pl	SR	
22.7	6	J	60	VN	No	N/A	Pl	SR	
22.8	7	J	60	VN	No	N/A	Pl	SR	
23.6	8	J	60	N	No	N/A	Pl	SR	
24.5	9	J	60	MW	No	N/A	Pl	SR	
25.5	10	J	N/A	W	Fi-Pa-No	Sd-Cl	Pl	SR-S	highly fractured 24.5'-25.5'

SCDOT Soil Test Log

Project ID:	P038061	**County:**	Chester	**Boring No.:**	B-2		
Site Description:	S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000200)	**Route:**	S-12-300 (S)				
Eng./Geo.:	AR	**Boring Location:**	7' N of NEB	**Offset:**	6' E of CL	**Alignment:**	Existing
Elev.:	506.0 ft	**Latitude:**	34.580555572	**Longitude:**	-81.15915075	**Date Started:**	10/14/2020
Total Depth:	30.7 ft	**Soil Depth:**	20.7 ft	**Core Depth:**	10.0 ft	**Date Completed:**	10/14/2020
Bore Hole Diameter (in):	3 7/8	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550X	**Drill Method:**	RW / DC / RC	**Hammer Type:**	Automatic	**Energy Ratio:**	81.1%
Core Size:	NQ	**Driller:**	J. Little	**Groundwater:**	TOB 8.0 ft	**24HR**	N.E.

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0		0.0	SS-1	24	8	6	5	14
	1.1	**SURFACE MATERIALS** - 3 inches of ASPHALT, 10 inches GABC.	2.0	SS-2	2	2	2	3	4
	2.0	**FILL** - medium dense, moist, light grey, Clayey fine to coarse SAND (SC), 10YR 7/1, little medium plasticity fines, trace gravel. %#200=13.9	4.0	SS-3	4	2	2	2	4
501.0	4.0	NO RECOVERY	6.0	SS-4	3	2	3	4	5
496.0	8.0	Loose, moist to wet, light grey, Clayey fine to coarse SAND (SC), [10YR 7/1], little medium plasticity fines, trace gravel. NMC=8.0, %#200=16.1 @ 6 feet - some medium plasticity fines. LL=27, PL=15, PI=12, NMC=16.1, %#200=41.9	8.0	SS-5	4	2	4	4	6
491.0	13.5	**PIEDMONT RESIDUUM** - loose, moist, brown, Clayey fine to medium SAND (SC) (A-6), 7.5YR 4/3, some low to medium plasticity fines. LL=28, PL=15, PI=13, NMC=13.9, %#200=41.0	13.5	SS-6	50/5"				100
			18.5	SS-7	50/3"				100
486.0	20.7	**PARTIALLY WEATHERED ROCK (PWR)** - very dense, wet, pale brown, Silty coarse SAND (SM), 10YR 6/3, some low plasticity fines, trace rock fragments. Auger Refusal at 20.7 feet. Install NW Casing to 20.7 feet for NQ wireline coring.	20.7	RC-1					
481.0		**METAMORPHIC BEDROCK - FELSIC GNEISS** - white [8/N] and brown [7.5YR 4/3], fine to coarse grained, thinly to thickly foliated, slightly to moderately weathered, strong to medium strong rock, H-MH, J (0-10° dip, VC-C, VN-MW-W, Pl, SR-S, Su-Pa-No) RC-1: RQD = 50%, REC = 64%, GSI = 85, RMR = 47, 1.5 min/ft @ 23.3 feet - dark blueish gray [3/10B], very strong rock, qu = 29,205 psi RC-2: RQD = 90%, REC = 90%, GSI = 90, RMR = 82, 2.1 min/ft, qu = 25,595 psi @ 27.2 feet - pink [5YR 7/4] and black [2.5/N] and white [8/N]	25.7	RC-2					
476.0	30.7	Boring Terminated at 30.7 feet.							
471.0									



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

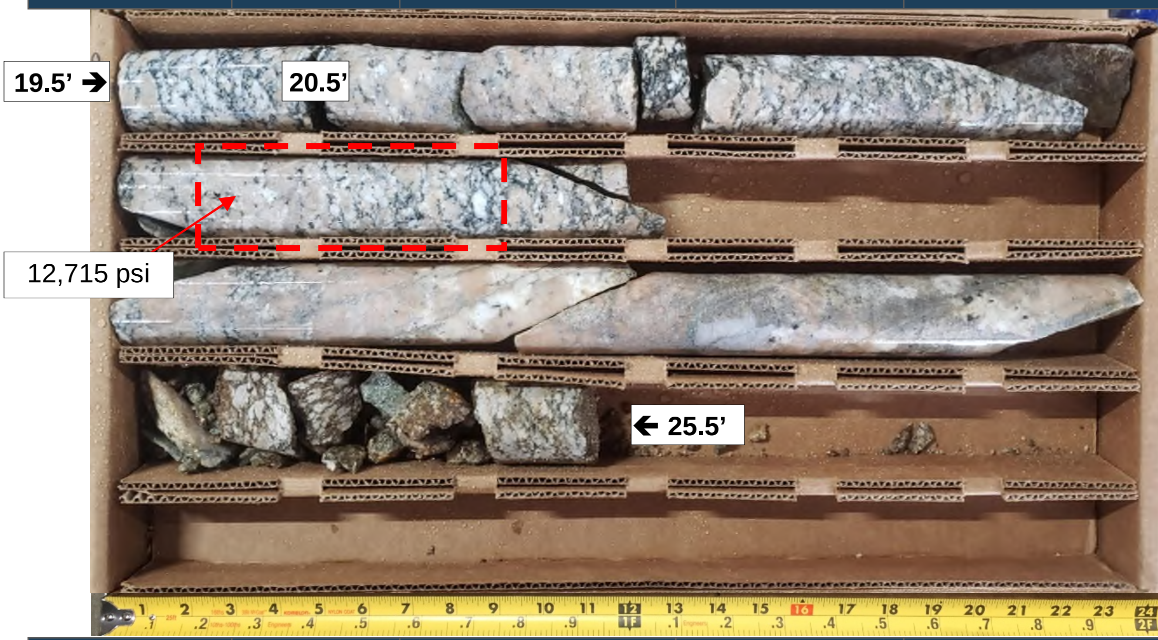
Project Name: S-12-300 (2490)
Project Number: 1361-20-048
Driller (Company/Name): S&ME/Jay Little
Logged By: AR
Date: 10/14/2020

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

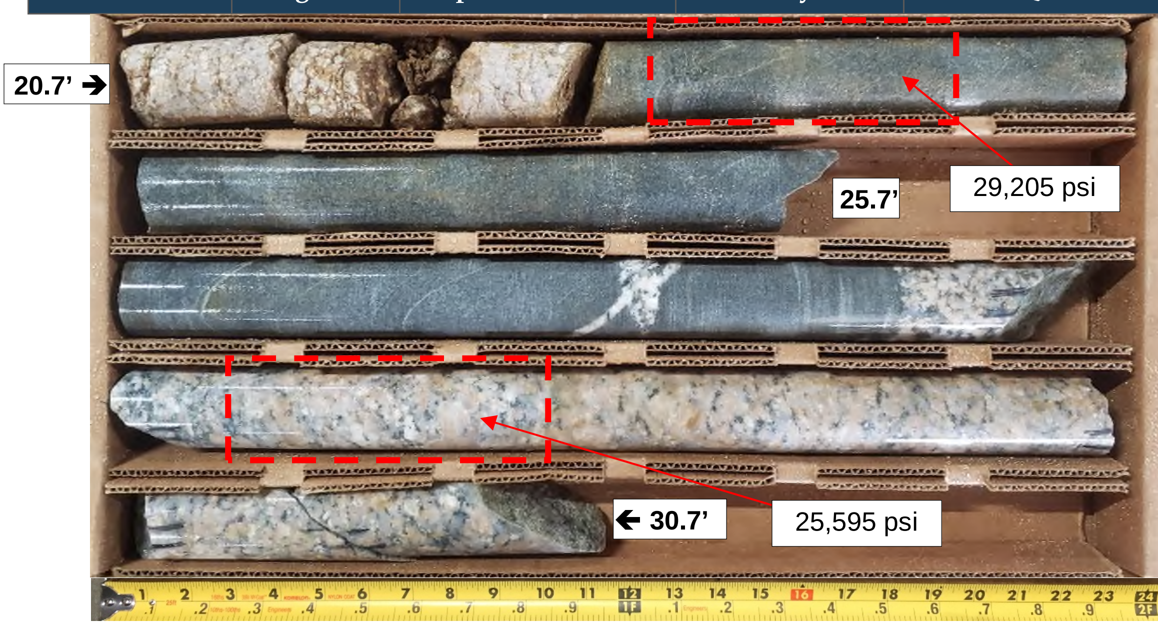
Depth (ft)	Disc. No.	Disc. Type	Dip Angle (deg)	Disc. Width (mm)	Infill Amount	Infill Type	Surface Shape	Surface Roughness	Notes
21	1	J	5	W	Pa	Sd	Pl	SR	
21.2	2	J	5	W	No	N/A	Pl	SR	
23	3	J	5	W	No	N/A	Pl	SR	
23.3	4	J	10	MW	Su	Sd	Pl	SR-S	
24.3	5	J	5	VN	No	N/A	Pl	SR	

Rock Core Photo Log

Boring: B-1	Box: 1 of 1	Date: 10/14/2020	Driller: J. Little	Geologist: A. Rodriguez
Run: RC-1	Length: 1.0	Depth Int: 19.5-20.5	Recovery: 40%	RQD: 40%
Run: RC-2	Length: 5.0	Depth Int: 20.5-25.5	Recovery: 100%	RQD: 70%



Boring: B-2	Box: 1 of 1	Date: 10/14/2020	Driller: J. Little	Geologist: A. Rodriguez
Run: RC-1	Length: 5.0	Depth Int: 20.7-25.7	Recovery: 64%	RQD: 50%
Run: RC-2	Length: 5.0	Depth Int: 25.7-30.7	Recovery: 90%	RQD: 90%



Appendix IV – Laboratory Test Results – Split-Spoon Samples

INDEX PROPERTIES VERSUS DEPTH

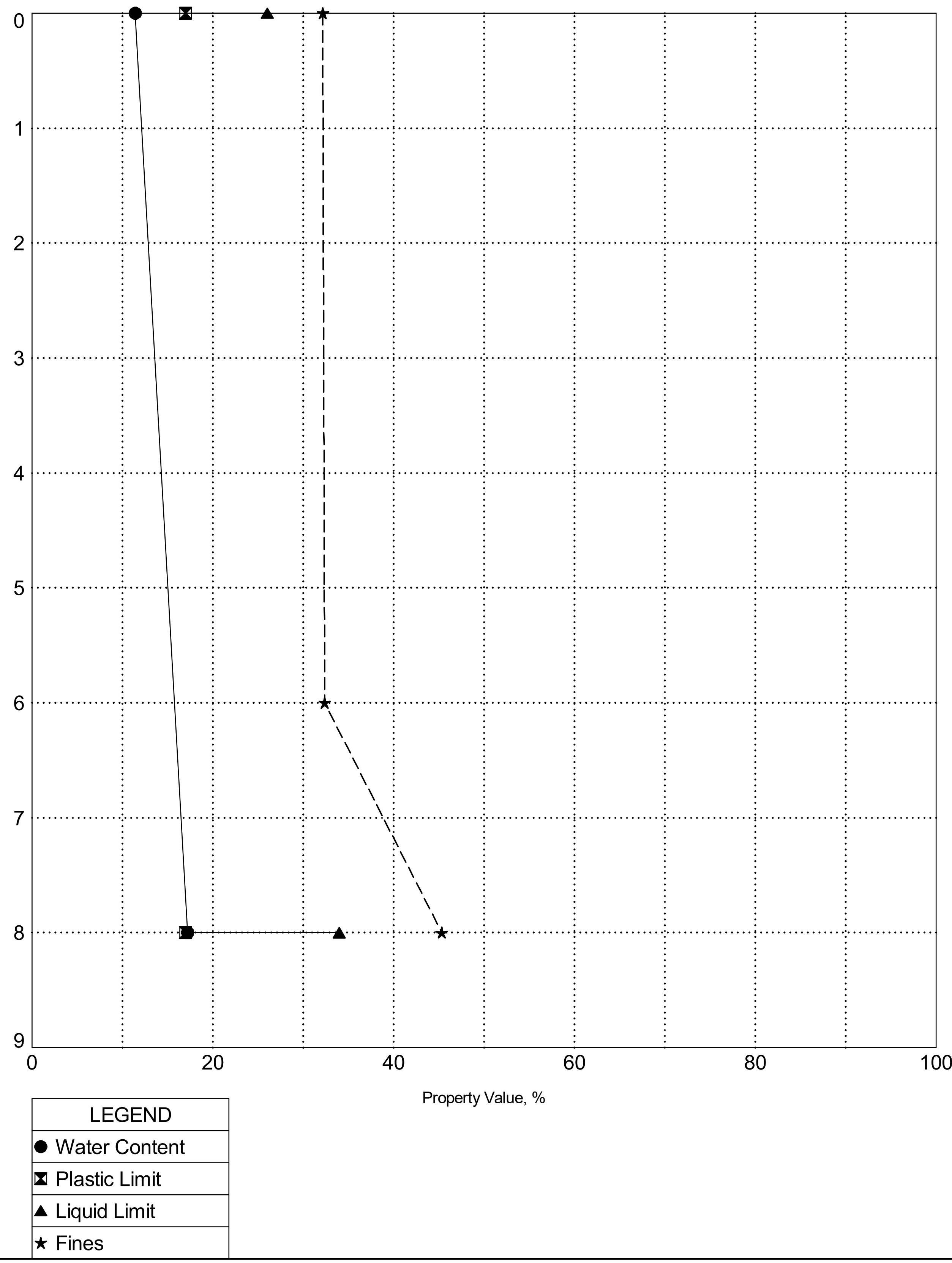
PROJECT ID P038061

PROJECT NAME S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000

PROJECT COUNTY Chester

BORING B-1

SURFACE ELEVATION: 506.9



INDEX PROPS 1361-20-048 S-12-300 (2490) BORING LOGS.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 2/8/21

INDEX PROPERTIES VERSUS DEPTH

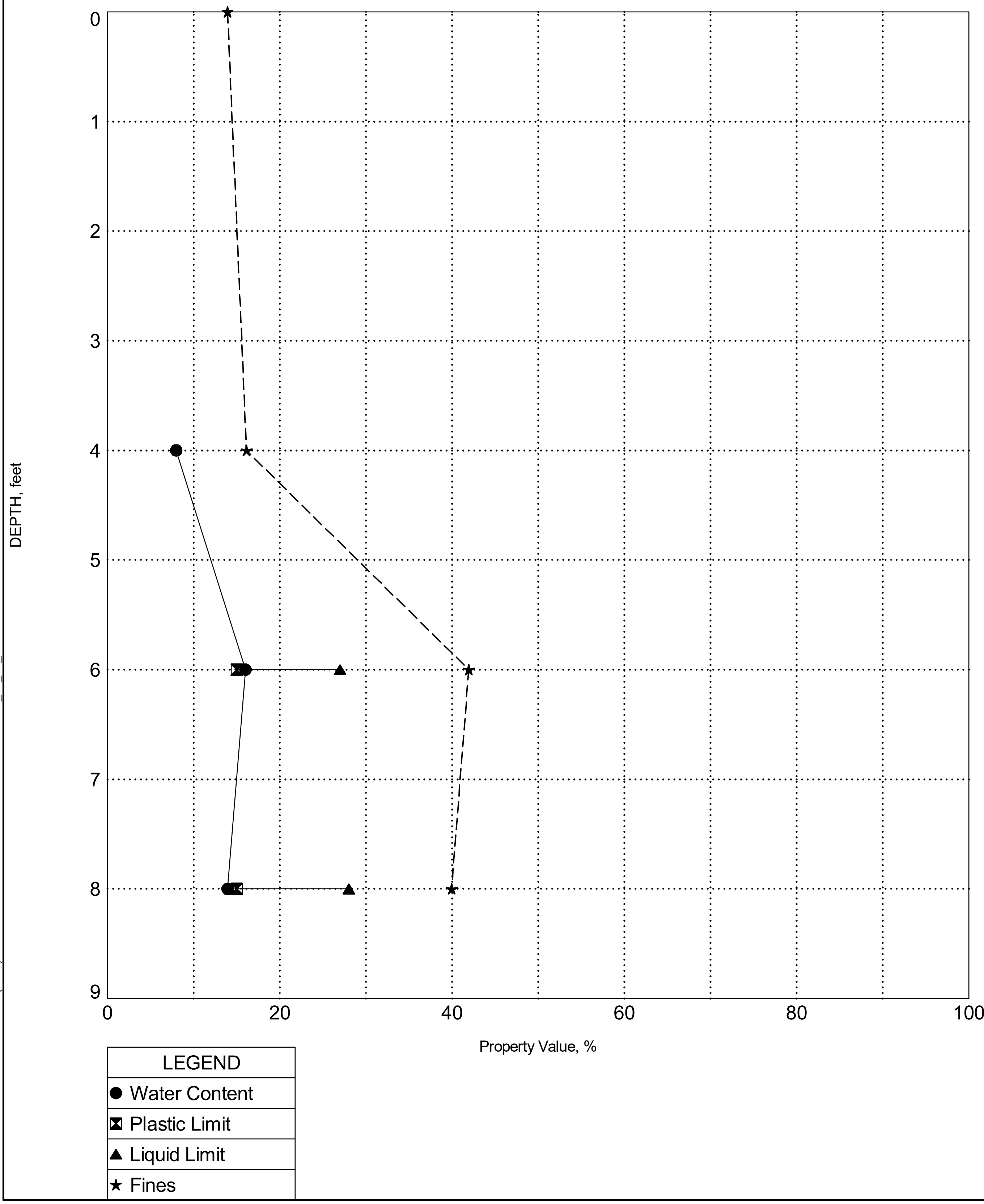
PROJECT ID P038061

PROJECT NAME S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000

PROJECT COUNTY Chester

BORING B-2

SURFACE ELEVATION: 506.0



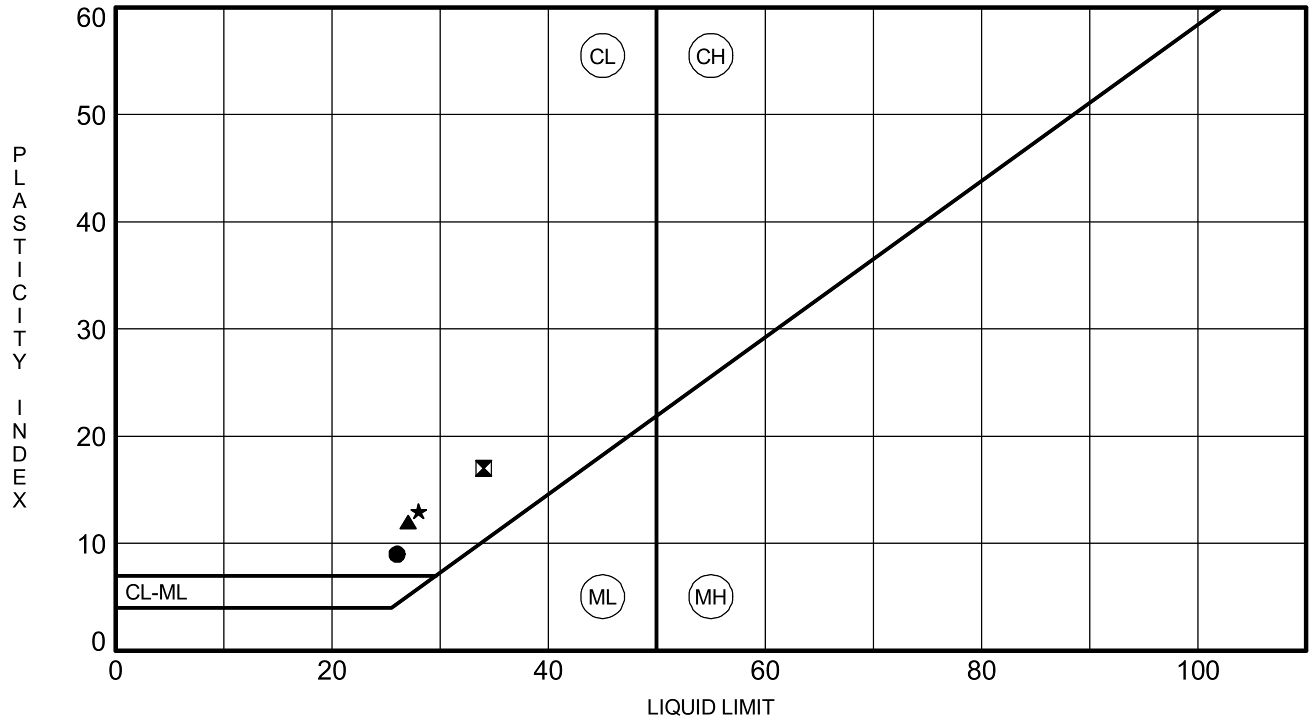
INDEX PROPS 1361-20-048 S-12-300 (2490) BORING LOGS.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 2/8/21

ATTERBERG LIMITS' RESULTS

PROJECT ID P038061

PROJECT NAME S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000

PROJECT COUNTY Chester



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**0.0**	**26**	**17**	**9**	**32**	**CLAYEY SAND (SC)**
⊠	**B-1**	**8.0**	**34**	**17**	**17**	**45**	**CLAYEY SAND (SC)**
▲	**B-2**	**6.0**	**27**	**15**	**12**	**42**	**CLAYEY SAND (SC)**
★	**B-2**	**8.0**	**28**	**15**	**13**	**40**	**CLAYEY SAND (SC)**

ATTERBERG LIMITS 1361-20-048 S-12-300 (2490) BORING LOGS.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 2/8/21

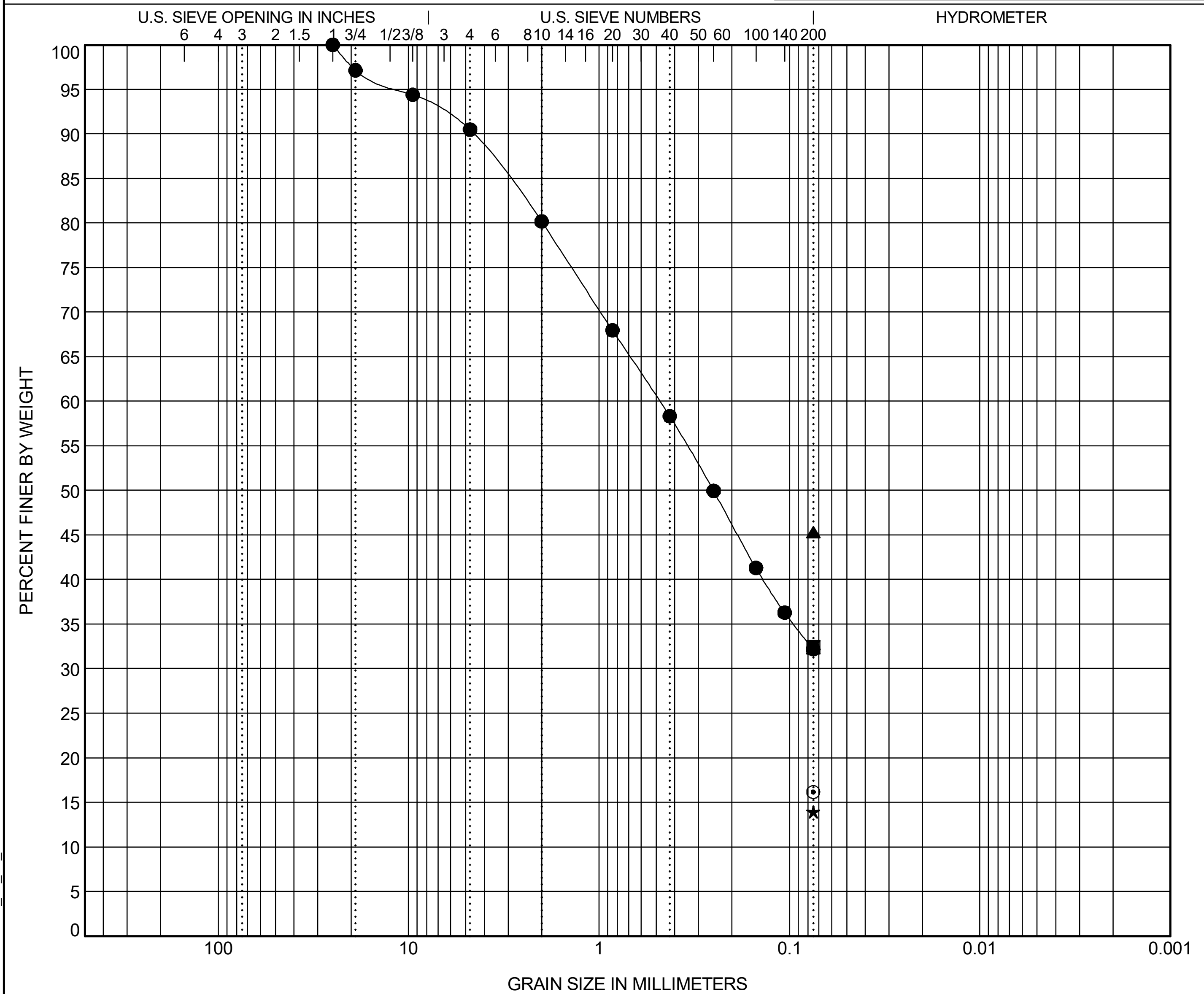
GRAIN SIZE DISTRIBUTION

SCDOT

PROJECT ID P038061

PROJECT NAME S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000

PROJECT COUNTY Chester



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**0.0**	**CLAYEY SAND (SC)**	**26**	**17**	**9**		
⊠	**B-1**	**6.0**	**CLAYEY SAND (SC)**					
▲	**B-1**	**8.0**	**CLAYEY SAND (SC)**	**34**	**17**	**17**		
★	**B-2**	**0.0**	**CLAYEY SAND (SC)**					
⊙	**B-2**	**4.0**	**CLAYEY SAND (SC)**					

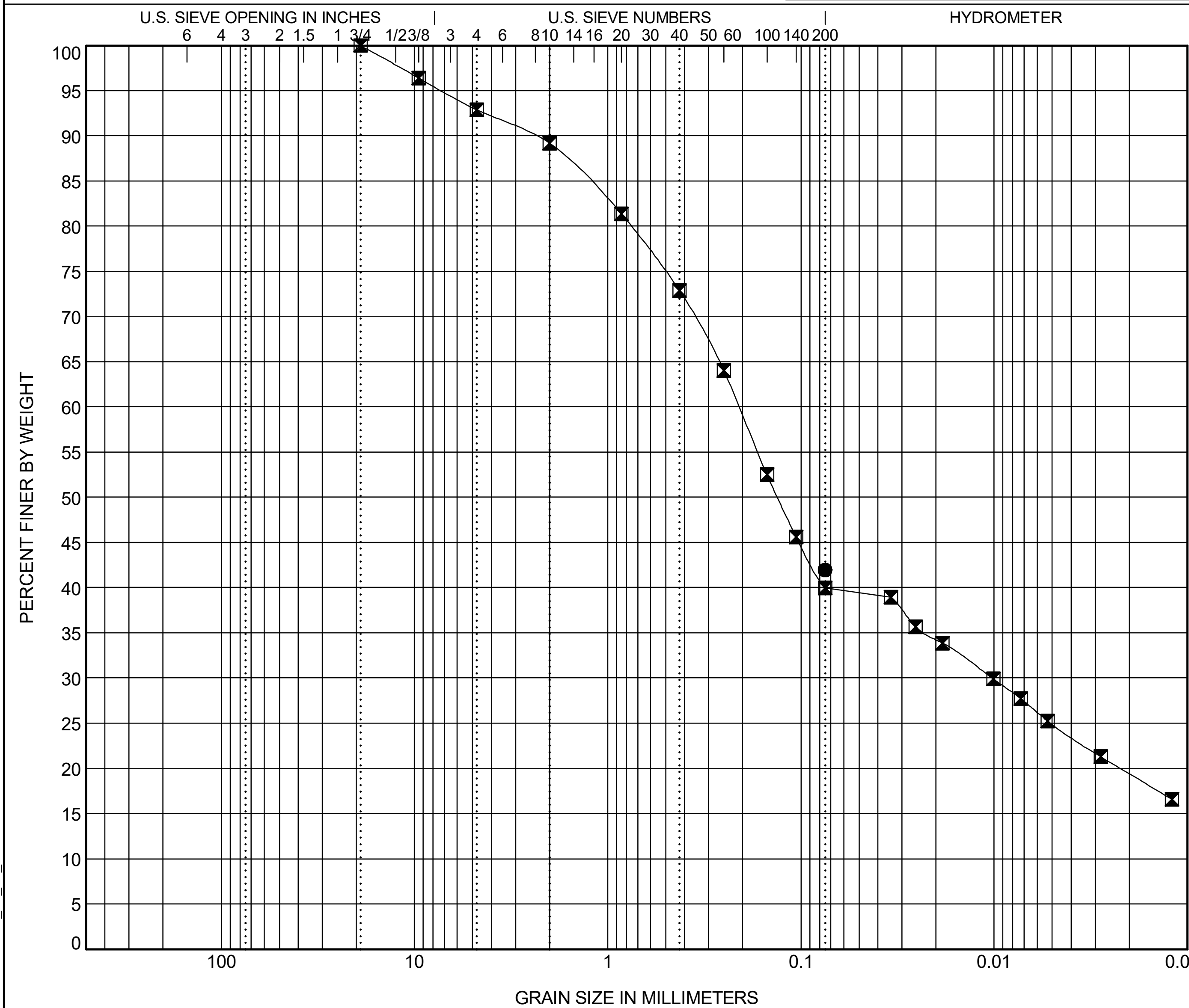
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**0.0**	**25**	**0.479**			**9.5**	**58.3**	**32.2**	
⊠	**B-1**	**6.0**	**0.075**						**32.4**	
▲	**B-1**	**8.0**	**0.075**						**45.3**	
★	**B-2**	**0.0**	**0.075**						**13.9**	
⊙	**B-2**	**4.0**	**0.075**						**16.1**	

GRAIN SIZE DISTRIBUTION

PROJECT ID P038061

PROJECT NAME S-12-300 (2490) BRO Little Rocky Branch (BRIDGE ID 1270030000

PROJECT COUNTY Chester



BOREHOLE		DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-2**	**6.0**	**CLAYEY SAND (SC)**	**27**	**15**	**12**		
⧗	**B-2**	**8.0**	**CLAYEY SAND (SC)**	**28**	**15**	**13**		

BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-2**	**6.0**	**0.075**						**41.9**	
⧗	**B-2**	**8.0**	**19**	**0.209**	**0.01**		**7.1**	**52.9**	**15.1**	**24.9**

GRAIN SIZE 1361-20-048 S-12-300 (2490) BORING LOGS.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 2/8/21

Appendix V – Laboratory Test Data Sheets – Corrosion Series Testing

Results Only Soil Testing for SCDOTBridge 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

REGISTERED PROFESSIONAL ENGINEER
EDUARDO HERNANDEZ
No. M37102
MECHANICAL
STATE OF CALIFORNIA

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

Project X Corrosion Engineering
Corrosion Control - Soil, Water, and Metallurgy Lab

Lab Request Sheet Chain of Custody
Phone: (213) 928-7213 · Fax (951) 226-1720 · www.projectxcorrosion.com

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

Project X Job Number

IMPORTANT: Please complete Project and Sample Identification Data as you would like it to appear in report & include this form with samples.

Company Name:	S&ME, Inc.	**Contact Name:**	Matt Cooke	**Phone No:**	803-561-9024
Mailing Address:	134 Suber Road, Columbia, SC 29210	**Contact Email:**	mcooke@smeinc.com		
Accounting Contact:	Kathryn Friedrichs	**Invoice Email:**	AP@smeinc.com		
Client Project No:	1361-20-48	**Project Name:**	SCDOT Bridge Package 2021-01 DB Prep		

P.O. #:	1361-20-48	**3-5 Day Standard**	**3 Day Guarantee** 50% mark-up	**24 Hr RUSH** 100% mark-up
(Business Days) Turn Around Time:		✔		

Results By: ☐ Phone ☐ Fax ☑ Email

Date & Received by :

Special Instructions:
Use AASHTO Methods for resistivity, pH, sulfate, and chloride

ANALYSIS REQUESTED (Please circle)

			Default Method
Soil Resistivity (Geo Quad)	Caltrans CTM643	AASHTO T2888	ASTM G187
pH (Geo Quad)	Caltrans CTM643	AASHTO T 289	ASTM G 51
Sulfate (Geo Quad)	Caltrans CTM417	AASHTO T 290	ASTM D4327
Chloride (Geo Quad)	Caltrans CTM422	AASHTO T 291	ASTM D4327
Redox Potential		SM 2580B	ASTM G200
Sulfide			SM 4500-S2
Ammonia		SM 4500-NH3	ASTM D6919
Nitrate		SM 4500-NO3	ASTM D4327
Flouride			ASTM D4327
Phosphate			ASTM D4327
Lithium			ASTM D6919
Sodium			ASTM D6919
Potassium			ASTM D6919
Magnesium			ASTM D6919
Calcium			ASTM D6919
BiCarbonate			SM 2320B
Full Corrosion Series			
Soil Corrosivity Evaluation Report (Reports)	*Req: Min. 3 Samples, site map, and groundwater info		
Water Corrosivity Mini Report (Reports)	*Req: Min. 3 Samples, site map, and groundwater info		
Moisture Content			ASTM D2216
Total Alkalinity			SM 2520B
Thermal Resistivity			
Metallurgical Analysis			
Langelier Index			
Puckorius Index			
XRF Elemental Analysis			
Water Hardness			

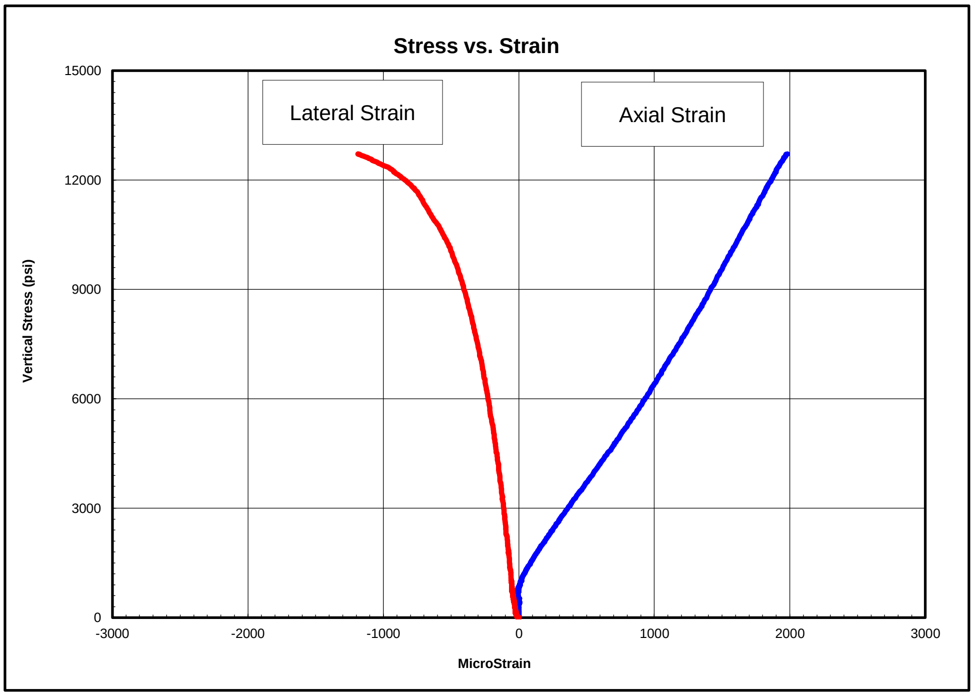
Full Corrosion Series: Soil Resistivity through BiCarbonate.

	SAMPLE ID - BORE #	DESCRIPTION	DEPTH (ft)	DATE COLLECTED	Soil Resistivity	pH	Sulfate	Chloride	Redox Potential	Sulfide	Ammonia	Nitrate	Flouride	Phosphate	Lithium	Sodium	Potassium	Magnesium	Calcium	BiCarbonate	Full Corrosion Series	Soil Corrosivity Evaluation Report	Water Corrosivity Mini Report	Moisture Content	Total Alkalinity	Thermal Resistivity	Metallurgical Analysis	Langelier Index	Puckorius Index	XRF Elemental Analysis	Water Hardness
1	SS-7 - B-2	S-11-97 Bridge	18.5-20.0	10/6/20	X	X	X	X																							
2	SS-6/SS-7 - B-2	S-11-119 Bridge	8.2 - 14.4	10/22/20	X	X	X	X																							
3	SS-5 - B-2	S-11-265 Bridge	8.5 - 10.0	10/7/20	X	X	X	X																							
4	SS-4 - B-1	S-12-58 Bridge	6.0-8.0	10/8/20	X	X	X	X																							
5	SS-4/SS-4 - B-2	S-12-300 (2310) Bridge	6.0-10.0	10/16/20	X	X	X	X																							
6	SS-6 - B-1	S-12-300 (2490) Bridge	13.5-15.0	10/14/20	X	X	X	X																							
7	SS-7/SS-8 - B-2	S-20-214 Bridge	18.5-25.0	10/23/20	X	X	X	X																							
8	SS-6 - B-1	S-29-97 Bridge	13.4-14.9	10/6/20	X	X	X	X																							
9	SS-4/SS-5 - B-2	S-44-87 Bridge	7.0-11.0	10/19/20	X	X	X	X																							
10																															
11																															
12																															
13																															
14																															
15																															

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-11-300(2490), B1
Sample ID:	RS-1
Depth, ft:	22.05-22.45
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: 12,715 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
1300-4700	5,260,000	0.17
4700-8100	5,840,000	0.29
8100-11400	6,720,000	---

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.

GeoTesting EXPRESS

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-11-300(2490),B1			
Sample ID:	RS-1			
Depth:	22.05-22.45	ft		
Visual Description:	See photographs			

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

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.69	4.69	4.69		
Specimen Diameter, in:	1.99	1.99	1.99		
Specimen Mass, g:	621.49				
Bulk Density, lb/ft^3	162			**Minimum Diameter Tolerence Met?**	**YES**
Length to Diameter Ratio:	2.4			**Length to Diameter Ratio Tolerance Met?**	**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **YES**

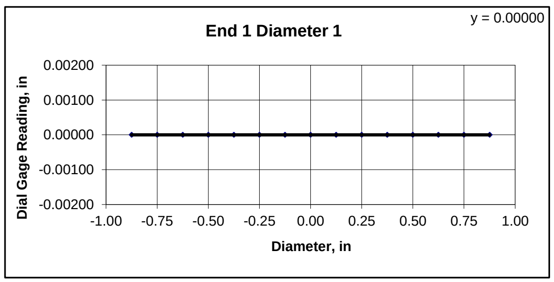
END FLATNESS AND PARALLELISM (Procedure FP1)

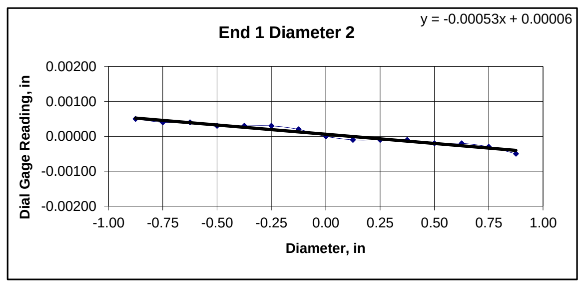
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	0.00050	0.00040	0.00040	0.00030	0.00030	0.00030	0.00020	0.00000	-0.00010	-0.00010	-0.00010	-0.00020	-0.00020	-0.00030	-0.00050

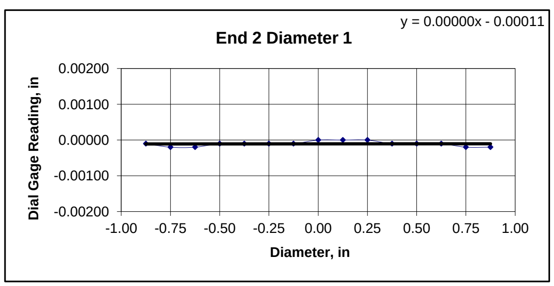
Difference between max and min readings, in:
0° = 0.00000 90° = 0.00100

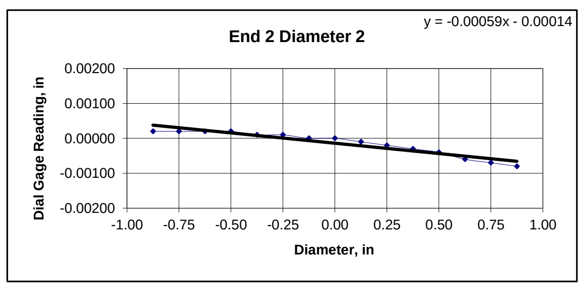
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00010	-0.00020	-0.00020	-0.00010	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00010	-0.00020	-0.00020
Diameter 2, in (rotated 90°)	0.00020	0.00020	0.00020	0.00020	0.00010	0.00010	0.00000	0.00000	-0.00010	-0.00020	-0.00030	-0.00040	-0.00060	-0.00070	-0.00080

Difference between max and min readings, in:
0° = 0.0002 90° = 0.001
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00050
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	0.00000
	Angle of Best Fit Line:	0.00016
Maximum Angular Difference:		0.00016

Parallelism Tolerance Met? **YES**
Spherically Seated

DIAMETER 2

End 1:		
	Slope of Best Fit Line	0.00053
	Angle of Best Fit Line:	0.03028
End 2:		
	Slope of Best Fit Line	0.00059
	Angle of Best Fit Line:	0.03389
Maximum Angular Difference:		0.00360

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

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
Diameter 2, in (rotated 90°)	0.00100	1.990	0.00050	0.029	YES
END 2					
Diameter 1, in	0.00020	1.990	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00100	1.990	0.00050	0.029	YES

Maximum angle of departure must be $\leq$ 0.25°
Perpendicularity Tolerance Met? **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-11-300(2490),B1
Sample ID:	RS-1
Depth, ft:	22.05-22.45

After cutting and grinding

After break

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project Name: SCDOT Bridge Package 2021-1
Project Number: 1361-20-048

Report Date: February 25, 2021
Reviewed By: N. Randy Rainwater

Boring No.	Sample No.	Depth (ft)	Dimensions, in.		Shape (See Key)	Area (in^2)	Unit Weight (lbs/ft^3)	Loading Rate (psi/sec)	Maximum Load (lbs)	Strength (psi)	Moisture (%)
			Length	Diameter							
S-12-300, B-2	RS-1	21.0 - 21.4	4.32	1.99	A	3.11	169.9	82	90,827	29,205	0.0
S-12-300, B-2	RS-2	28.0 - 28.4	4.52	1.99	A	3.11	163.7	84	79,601	25,595	0.1

NOTES: Effective (as received) unit weight as determined by RTH 109-93.
Loading rates were selected to target reaching failure between 2 and 15 minutes.
Test results for specimens not meeting the requirements of ASTM D4543-19 may differ from a test specimen that meets the requirements of ASTM D4543.

SHAPE KEY

ASTM D4543-19 Standard Practice for Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional and Shape Tolerance Section 1.2 - "Rock is a complex engineering material that can vary greatly as a function of lithology, stress history, weathering, moisture content and chemistry, and other natural geologic processes. As such, it is not always possible to obtain or prepare rock core specimens that satisfy the desirable tolerances given in this practice. Most commonly, this situation presents itself with weaker, more porous, and poorly cemented rock types and rock types containing significant or weak (or both) structural features. For rock types which are difficult to prepare, all reasonable efforts shall be made to prepare a specimen in accordance with this practice and for the intended test procedure. However, when it has been determined by trial and error that this is not possible, prepare the rock specimen to the closest tolerances practicable and consider this to be the best effort and report it as such and if allowable or necessary for the intended test, capping the ends of the specimen as discussed in this practice is permitted."

A Test specimen measurements met the desired shape tolerances of ASTM D4543-19 (side straightness, end flatness & parallelism, and end perpendicularity to axis)

B Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness & parallelism, and end perpendicularity to axis. Specimen did not meet the desired tolerance for side straightness. Specimen prepared to closest tolerances practicable.

C Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness & parallelism. Specimen did not meet the desired tolerances for side straightness and end perpendicularity to axis. Specimen prepared to closest tolerances practicable.

D Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness. Specimen did not meet the desired tolerances for side straightness, parallelism and end perpendicularity to axis. Specimen prepared to closest tolerances practicable.

E Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness and end perpendicularity to axis. Specimen did not meet the desired tolerance for side straightness and parallelism. Specimen prepared to closest tolerances practicable.

UNCONFINED COMPRESSION WITH YOUNG'S MODULUS AND POISSON'S RATIO
(ASTM D7012 Method C and D)

1413 Topside Road, Louisville, TN 37777

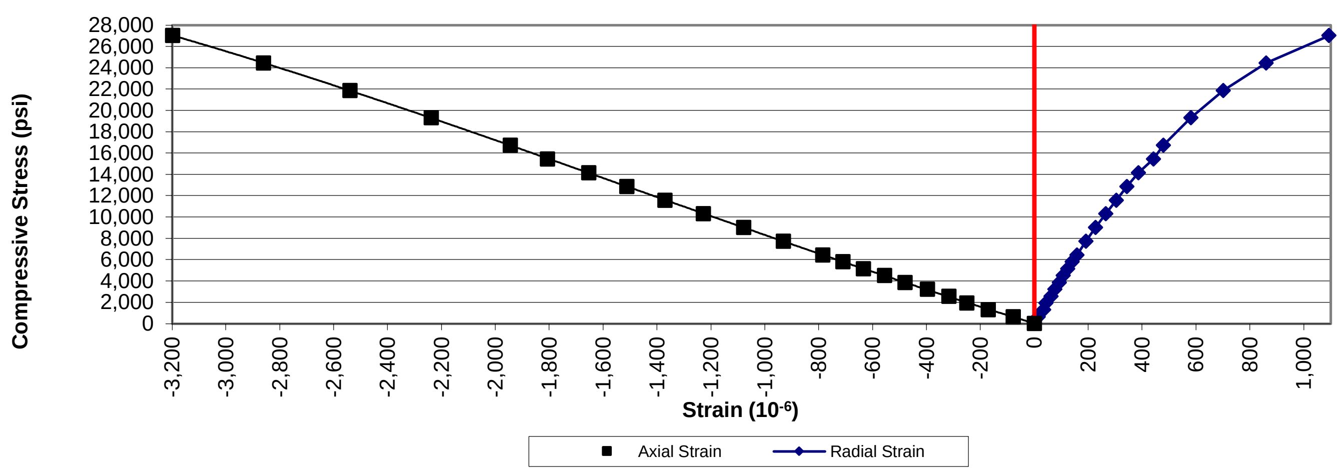
Project:	SCDOT Bridge Package 2021-1	**Diameter, in.:**	1.99	**Date:**	1/23/2021
Project No.:	1361-20-048	**Length, in.:**	4.32	**Tested by:**	Tori Igoe
Boring Id:	S-12-300 (2490), B-2	**Unit Weight, pcf:**	169.9	**Reviewed by:**	N. Randy Rainwater
Sample No:	RS-1	**Moisture Content, %:**	0.0		
Depth (ft):	21.0 - 21.4	**Load Rate, psi/sec:**	82		

Data Point	Strain (10^{-6}) axial	Strain (10^{-6}) radial	Load (lb)	Compressive Stress (psi)	Secant Modulus x 10^6 (psi)	Poisson's Ratio	Remarks Failure
1	0	0	0	0	0.00	0.00	
2	-78	15	2,000	643	8.24	0.19	
3	-170	35	4,000	1,286	7.56	0.21	
4	-250	43	6,000	1,929	7.72	0.17	
5	-317	62	8,000	2,572	8.11	0.20	
6	-396	77	10,000	3,215	8.12	0.19	
7	-479	93	12,000	3,859	8.06	0.19	
8	-556	108	14,000	4,502	8.10	0.19	
9	-634	124	16,000	5,145	8.12	0.20	
10	-710	141	18,000	5,788	8.15	0.20	
11	-785	158	20,000	6,431	8.19	0.20	
12	-931	192	24,000	7,717	8.29	0.21	
13	-1,078	228	28,000	9,003	8.35	0.21	
14	-1,228	266	32,000	10,289	8.38	0.22	
15	-1,371	305	36,000	11,576	8.44	0.22	
16	-1,512	344	40,000	12,862	8.51	0.23	
17	-1,653	387	44,000	14,148	8.56	0.23	
18	-1,806	443	48,000	15,434	8.55	0.25	
19	-1,944	479	52,000	16,720	8.60	0.25	
20	-2,238	582	60,000	19,293	8.62	0.26	
21	-2,539	701	68,000	21,865	8.61	0.28	
22	-2,860	861	76,000	24,437	8.54	0.30	
23	-3,198	1,093	84,000	27,010	8.45	0.34	
			90,872	29,219			Failure

TNR - Test Not Requested

Comments: Loading rate was selected to target reaching failure between 2 and 15 minutes.
Test specimen measurements met the desired shape tolerances of ASTM D4543-19 (side straightness, end flatness & parallelism, and end perpendicularity to axis)

Stress vs. Strain



UNCONFINED COMPRESSION WITH YOUNG'S MODULUS AND POISSON'S RATIO
(ASTM D7012 Method C and D)

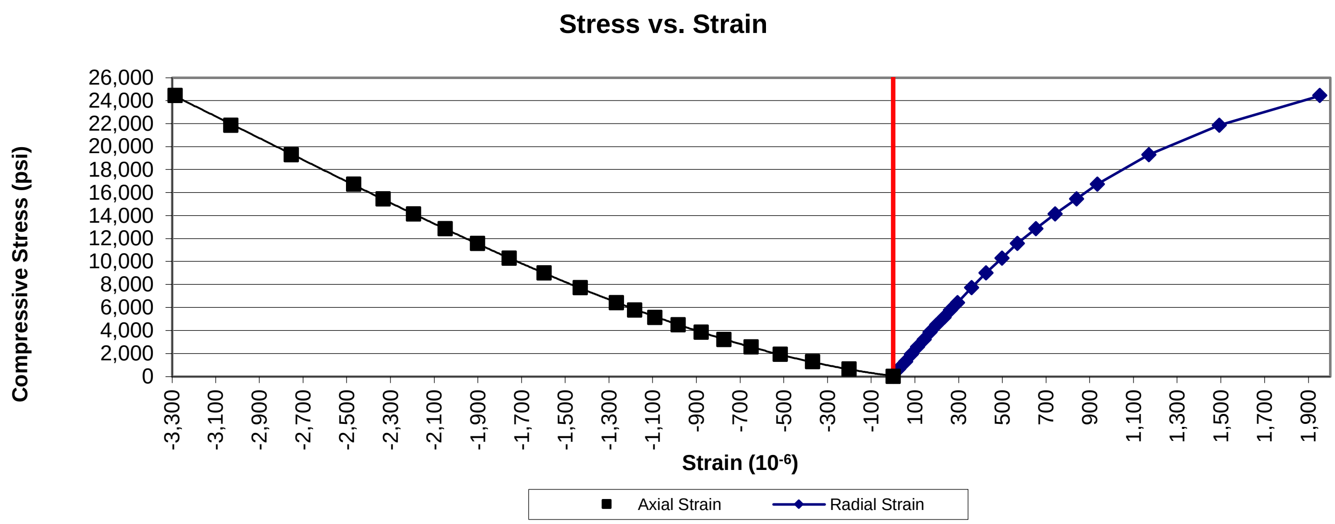
1413 Topside Road, Louisville, TN 37777

Project:	SCDOT Bridge Package 2021-1	**Diameter, in.:**	1.99	**Date:**	1/23/2021
Project No.:	1361-20-048	**Length, in.:**	4.52	**Tested by:**	Tori Igoe
Boring Id:	S-12-300 (2490), B-2	**Unit Weight, pcf:**	163.7	**Reviewed by:**	N. Randy Rainwater
Sample No:	RS-2	**Moisture Content, %:**	0.1		
Depth (ft):	28.0 - 28.4	**Load Rate, psi/sec:**	84		

Data Point	Strain (10^{-6}) axial	Strain (10^{-6}) radial	Load (lb)	Compressive Stress (psi)	Secant Modulus x 10^6 (psi)	Poisson's Ratio	Remarks Failure
1	0	0	0	0	0.00	0.00	
2	-202	25	2,000	643	3.18	0.12	
3	-369	58	4,000	1,286	3.49	0.16	
4	-517	84	6,000	1,929	3.73	0.16	
5	-650	112	8,000	2,572	3.96	0.17	
6	-774	142	10,000	3,215	4.15	0.18	
7	-878	169	12,000	3,859	4.40	0.19	
8	-984	200	14,000	4,502	4.58	0.20	
9	-1,091	233	16,000	5,145	4.72	0.21	
10	-1,182	263	18,000	5,788	4.90	0.22	
11	-1,266	295	20,000	6,431	5.08	0.23	
12	-1,432	360	24,000	7,717	5.39	0.25	
13	-1,597	425	28,000	9,003	5.64	0.27	
14	-1,757	498	32,000	10,289	5.86	0.28	
15	-1,901	569	36,000	11,576	6.09	0.30	
16	-2,050	653	40,000	12,862	6.27	0.32	
17	-2,195	741	44,000	14,148	6.45	0.34	
18	-2,334	839	48,000	15,434	6.61	0.36	
19	-2,468	935	52,000	16,720	6.77	0.38	
20	-2,754	1,171	60,000	19,293	7.01	0.43	
21	-3,030	1,492	68,000	21,865	7.22	0.49	
22	-3,285	1,953	76,000	24,437	7.44	0.59	
			79,601	25,595			Failure

TNR - Test Not Requested

Comments: Loading rate was selected to target reaching failure between 2 and 15 minutes.
Test specimen measurements met the desired shape tolerances of ASTM D4543-19 (side straightness, end flatness & parallelism, and end perpendicularity to axis)



PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

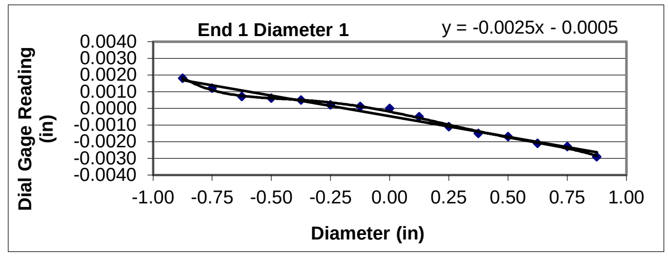
Project:	SCDOT Bridge Package 2021-1	**Diameter (in):**	1.99	**Date:**	2/9/2021
Project No.:	1361-20-048	**Length (in):**	4.32	**Tested by:**	Tori Igoe
Boring Id:	S-12-300 (2490), B-2	**Unit Weight (pcf):**	169.9	**Reviewed by:**	N. Randy Rainwater
Sample No.:	RS-1	**Moisture Content (%):**	0.0		
Depth (ft):	21.0 - 21.4				

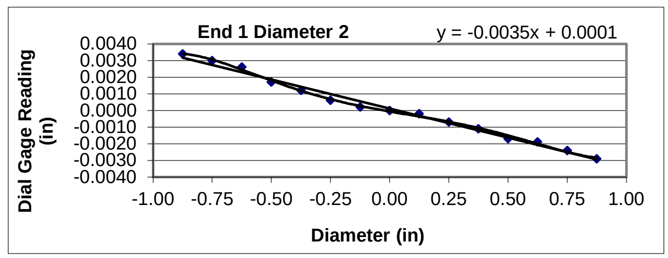
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES**   Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

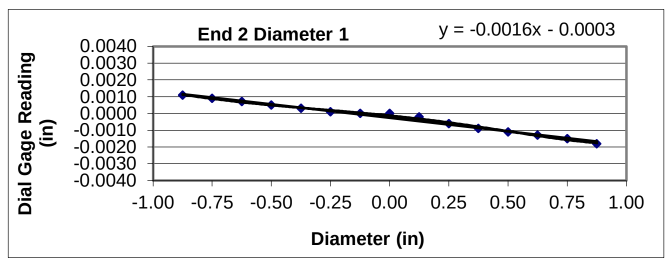
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	0.0018	0.0034	0.0011	0.0018
- 6/8	0.0012	0.0030	0.0009	0.0015
- 5/8	0.0007	0.0026	0.0007	0.0013
- 4/8	0.0006	0.0017	0.0005	0.0009
- 3/8	0.0005	0.0012	0.0003	0.0005
- 2/8	0.0002	0.0006	0.0001	0.0002
- 1/8	0.0001	0.0002	0.0000	0.0001
0	0.0000	0.0000	0.0000	0.0000
1/8	-0.0005	-0.0002	-0.0002	-0.0004
2/8	-0.0011	-0.0007	-0.0006	-0.0006
3/8	-0.0015	-0.0011	-0.0009	-0.0008
4/8	-0.0017	-0.0017	-0.0011	-0.0009
5/8	-0.0021	-0.0019	-0.0013	-0.0012
6/8	-0.0023	-0.0024	-0.0015	-0.0015
7/8	-0.0029	-0.0029	-0.0018	-0.0016

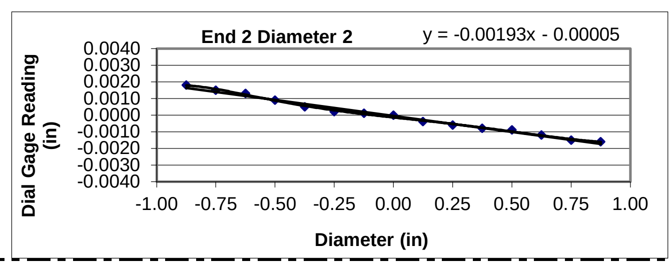




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	-0.00247
	Angle of Best Fit Line:	-0.14128
End 2:	Slope of Best Fit Line:	-0.00161
	Angle of Best Fit Line:	-0.09216
	Max Angular Difference:	**-0.05**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	-0.00350
	Angle of Best Fit Line:	-0.20054
End 2:	Slope of Best Fit Line:	-0.00193
	Angle of Best Fit Line:	-0.11050
	Max Angular Difference:	**-0.09**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0047	0.0024	**YES**
End 1 Diam 2	0.0063	0.0032	**YES**
End 2 Diam 1	0.0029	0.0015	**YES**
End 2 Diam 2	0.0034	0.0017	**YES**

Perpendicularity Tolerance Met? **YES**

PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

Project:	SCDOT Bridge Package 2021-1	**Diameter (in):**	1.99	**Date:**	2/9/2021
Project No.:	1361-20-048	**Length (in):**	4.52	**Tested by:**	Tori Igoe
Boring Id:	S-12-300 (2490), B-2	**Unit Weight (pcf):**	163.7	**Reviewed by:**	N. Randy Rainwater
Sample No.:	RS-2	**Moisture Content (%):**	0.1		
Depth (ft):	28.0 - 28.4				

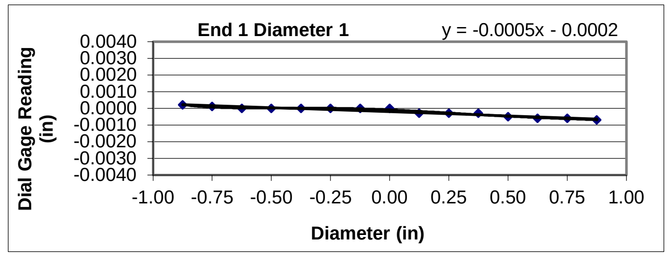
Deviation From Straightness (Procedure S1)

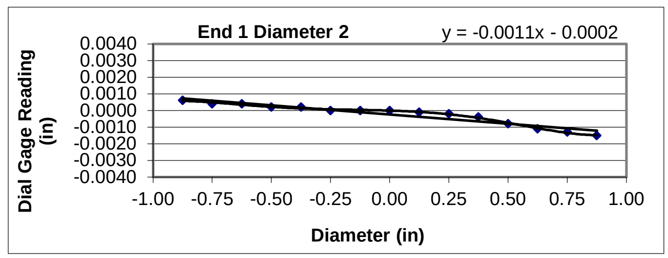
Is the maximum gap ≤ 0.02 in.? **YES**

Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

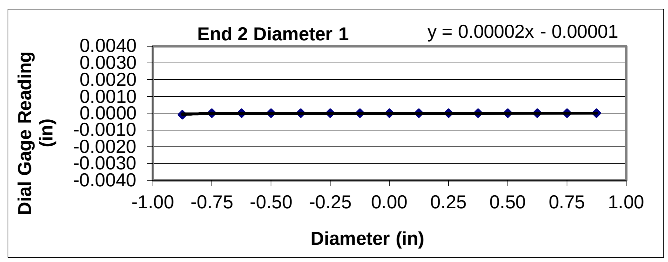
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	0.0002	0.0006	-0.0001	0.0007
- 6/8	0.0001	0.0004	0.0000	0.0006
- 5/8	0.0000	0.0004	0.0000	0.0004
- 4/8	0.0000	0.0002	0.0000	0.0002
- 3/8	0.0000	0.0002	0.0000	0.0002
- 2/8	0.0000	0.0000	0.0000	0.0000
- 1/8	0.0000	0.0000	0.0000	0.0000
0	0.0000	0.0000	0.0000	0.0000
1/8	-0.0003	-0.0001	0.0000	-0.0002
2/8	-0.0003	-0.0002	0.0000	-0.0003
3/8	-0.0003	-0.0004	0.0000	-0.0004
4/8	-0.0005	-0.0008	0.0000	-0.0005
5/8	-0.0006	-0.0011	0.0000	-0.0009
6/8	-0.0006	-0.0013	0.0000	-0.0010
7/8	-0.0007	-0.0015	0.0000	-0.0011

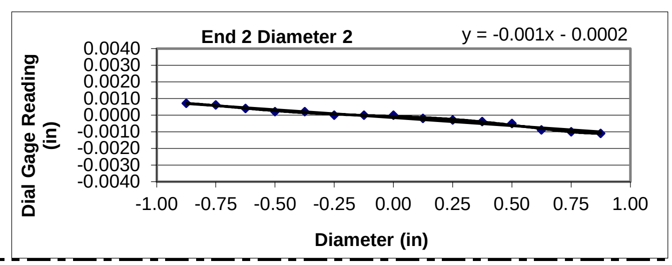




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	-0.00049
	Angle of Best Fit Line:	-0.02832
End 2:	Slope of Best Fit Line:	0.00002
	Angle of Best Fit Line:	0.00115
	Max Angular Difference:	**-0.03**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	-0.00111
	Angle of Best Fit Line:	-0.06335
End 2:	Slope of Best Fit Line:	-0.00097
	Angle of Best Fit Line:	-0.05582
	Max Angular Difference:	**-0.01**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0009	0.0005	**YES**
End 1 Diam 2	0.0021	0.0011	**YES**
End 2 Diam 1	0.0001	0.0001	**YES**
End 2 Diam 2	0.0018	0.0009	**YES**

Perpendicularity Tolerance Met? **YES**

Date: 2/12/2021-2/23/2021

Photographer: Tori Igoe

1	**Location / Orientation**	S-12-300 (2490), B-2, RS-1 (21.0' – 21.4')
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method D)

Date: 2/12/2021-2/23/2021

Photographer: Tori Igoe

2	**Location / Orientation**	S-12-300 (2490), B-2, RS-2 (28.0' – 28.4')
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method D)

Appendix VII – SPT Hammer Energy Measurements

Report of SPT Energy Measurements
S&ME CME-550X ATV (Serial No. 290593)
Rutherfordton, North 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 4, 2020

June 4, 2020

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

Attention: Dr. 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-550X ATV (Serial No. 290593)
Rutherfordton, North 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 our CME-550X ATV-mounted drill rig (Serial No. 290593). This service was performed by Mr. Joseph Williamson, P.E. of our firm on May 5, 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. Williamson and Mr. Canivan are included in 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. 3733L) Pile Driving Analyzer^{TM} (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K5641 and K10181) bolted to a 2.0-foot long AWJ drill rod (Serial No. 203) internally instrumented with two strain transducers. Calibration sheets for the accelerometers and the instrumented rod are included in Appendix II. The instrumented AWJ drill rod has a cross-sectional area of 1.19 square inches and an outside diameter of approximately 1.75 inches. Therefore, we calculate the inside diameter to be approximately 1.25 inches at the gauge location. The accelerometers and strain gauges, 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 5, 2020, to observe and perform high-strain dynamic testing during SPT sampling on the CME-550X ATV-mounted drill rig operated by Fred Johnson of S&ME. The measurements were taken during drilling and sampling of a soil test boring for an NCDOT project (R-2233BA boring L3_121) in Rutherfordton, North Carolina. SPT energy measurements were recorded during six sampling intervals at depths of approximately 28.5, 33.5, 38.5, 43.5, 48.5 and 53.5 ft below the ground surface. The 48.5 and 53.5 ft sample intervals did not meet the NCDOT blow count requirements and were not included in the data analysis. The information presented in the tables below summarizes the equipment and tooling used during the SPT energy measurements. The SPT Energy Evaluation Form and Boring L3_121 Soil Boring Log are included in Appendix III.

Table 2-1: Drill Rig Information

Manufacturer	CME
Model	550X
Serial Number	290593
Operator	F. Johnson
Carrier	ATV

Table 2-2: Hammer Information

Model / Type	CME / Auto
Serial Number	290593
Anvil Height (inches)	12
Anvil Diameter (inches)	2.5
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	AWJ
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in^2)	1.19
Typical Lengths (feet)	5
Instrumented Rod Type	AWJ (Serial No. 203)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in^2)	1.19
Total Instrumented Rod Length (feet)	2.0
Length Below Gages (feet)	0.8
Split-Spoon Length (feet)	2.85

3.0 Dynamic Testing Results

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.65 ft to the drill rod length at each sample depth. The SPT Energy Measurement Data Summary tables in Appendix IV 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-550X operated at an average rate of about 51 blows per minute (bpm) during dynamic testing. The measured average transferred hammer energy (EFV) of the four sample intervals tested ranged from 263 to 292 ft-lbs, which corresponds to Energy Transfer Ratio (ETR) values of 75.2 to 83.4%, 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. BLC[1]
- Penetration vs. FMX[2]
- Penetration vs. EFV[3]
- Penetration vs. CSX[4]
- Penetration vs. VMX[5]
- Penetration vs. ETR[6]
- 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	28.5 – 30.0	30.0	33.65	7-9-11 / 20	SILTY SAND	43.3	263	75.2
2	33.5 – 35.0	35.0	38.65	7-11-14 / 25	SILTY SAND	53.2	289	82.6
3	38.5 – 40.0	40.0	43.65	9-10-12 / 22	SILTY SAND	53.2	289	82.6
4	43.5 – 45.0	45.0	48.65	10-10-11 / 21	SILTY SAND	53.3	292	83.4
					Overall Average	**51.0**	**284**	**81.1**

The overall average transferred hammer energy for the automatic hammer on the CME-550X ATV-mounted drill rig was 284 foot-pounds, with an average ETR of 81.1%.

[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.

NORTH CAROLINA
PROFESSIONAL
SEAL
028593
ENGINEER
GREGORY J. CANIVAN

Joseph R. Williamson, P.E.
Geotechnical Group Leader

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 - SPT Energy Evaluation Form (Field Log) & Boring L3_121 Soil Boring Log
- Appendix IV - CME-550X ATV (SN 290593) SPT Energy Measurements Summary Plots and Tables

Appendices

Appendices

Appendix I

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Joseph Williamson
S&ME

has on October 31, 2017 achieved the rank of

INTERMEDIATE

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 Intermediate level seek Advanced, Master or Expert levels through additional study within four 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
Steven A. Hall, Executive Director
Pile Driving Contractors Association

Garland Likins
Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2426

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

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

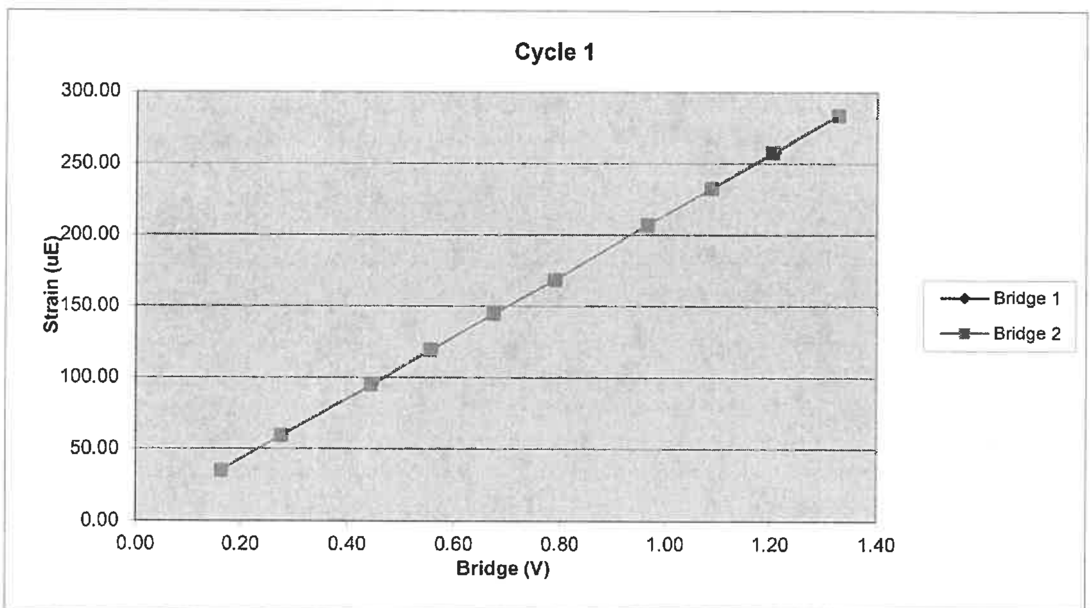
No. 721

Appendix II

203AWJ		Cycle 1		
Sample	**Force (lb)**	**Strain (µE)**	**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 (µE/V)	**213.97**	**Strain Calibration (µE/V)**	**213.98**
Offset	0.12	Offset	0.25
Correlation	0.999992	Correlation	0.999995

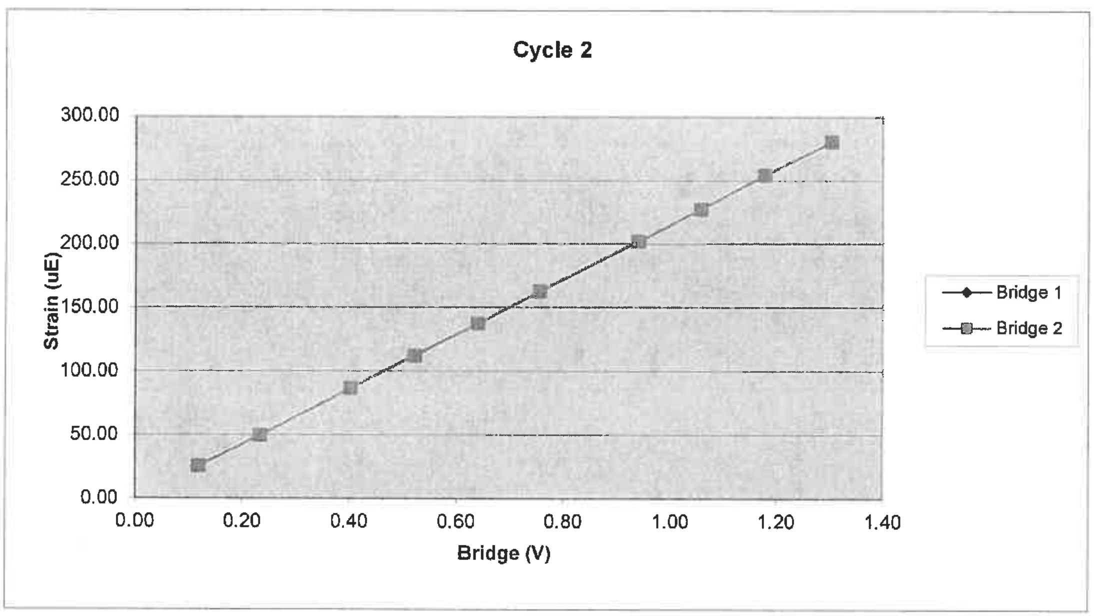
Force Strain Calibration	
EA (Kips)	**35662.28**
Offset	-12.17
Correlation	0.999993



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 (µE/V)	**215.30**	**Strain Calibration (µE/V)**	**215.56**
Offset	**-0.14**	Offset	**-0.33**
Correlation	**0.999995**	Correlation	**0.999996**

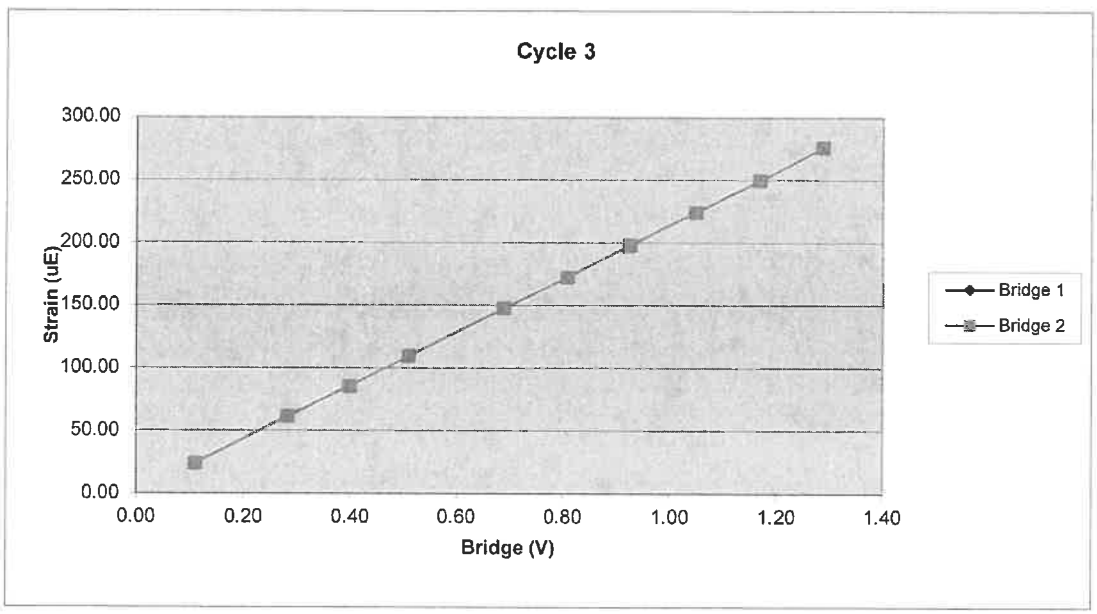
Force Strain Calibration	
EA (Kips)	**35381.61**
Offset	**-6.76**
Correlation	**0.999996**



203AWJ		Cycle 3		
Sample	**Force (lb)**	**Strain (µE)**	**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 (µE/V)	**213.65**	**Strain Calibration (µE/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 Resitor (ohm) 60.4k

Calibration Factors	203AWJ		
Bridge 1 (µE/V)	214.31	Bridge 2 (µE/V)	214.45
EA Factor (Kips)	35576.02	Area (in^2)	1.19

Calibrated by: David [signature]
Calibrated Date: 2/26/2019

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. TG F2 DPF

Pile Dynamics
2019-05-21 10:07

FS — 10

BN 3743
SL 1513/ 3440/ 2

PJ:
PN: HOPBAR

A 4
F 2

-- VS 3.3

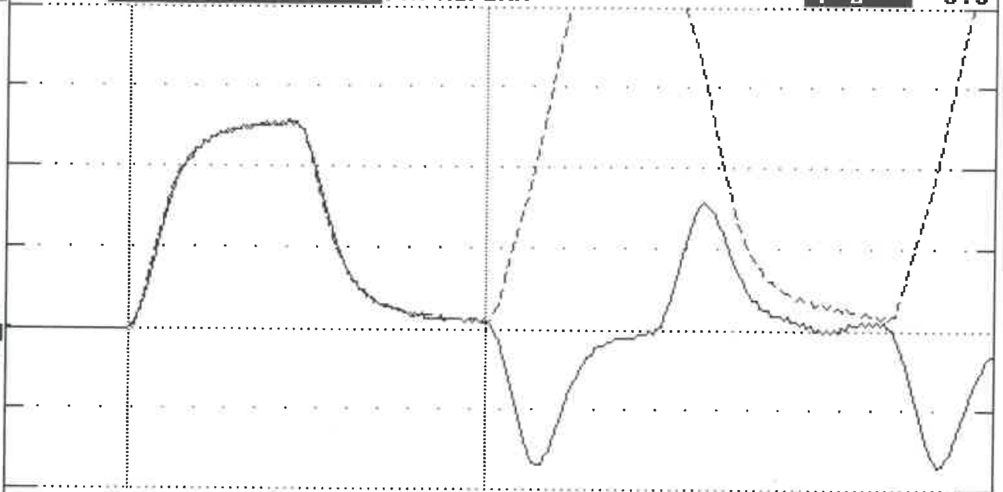
LE 17.0 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16815 ft/s
WC 7312 ft/s

JC 0.40
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -42
VT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 378



TS 12
TB 8.0

E B
T1 9.6

PD: K5641
2L/C 4.7

VA 1000 VE 1024

LP 0.00 ft
LI 1.0

ACCEPT SQ-OFF FL-OFF PR-OFF

VMX= 4.1 FMX= 65 AMX= 139
EMX= 0.2 MEX= 127 FVP= 1.00

ACCEPT

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: K5641

CALIBRATION FACTOR: .0756 mV/G

PAK (*5000): 378 DATE: 21 MAY 19

PDA OPERATOR: [signature]

<-AT:PIEZORESISTIVE OP: LAINE [ver:5.01] AT:PIEZOELECTRIC->

Smart Sensor

Programmed By: R.W.

CRC Value F648

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. TG F2 DPF

Pile Dynamics
2020-02-28 11:23

FS — 10

BN 5034/15033
SL 1255/ 3440/ 99

PJ:
PN: HOPBAR

A 4
F 2

-- VS
3.3

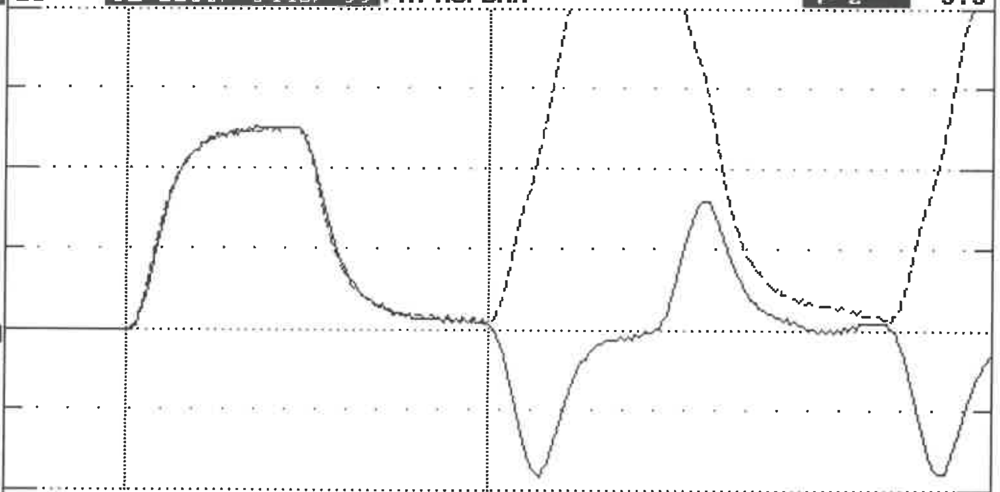
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16815 ft/s
WC 16851 ft/s

JC 0.40
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -27
VT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 385



TS 12
TB 8.0

E B
T1 9.6

PD: K10181
2L/C 4.7

VA 1000 VE 1024

LP 0.00 ft
LI 1.0

VMX= 4.1 FMX= 64 AMX= 149
EMX= 0.2 MEX= 125 FVP= 0.99

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCEPT

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: K10181

CALIBRATION FACTOR: .077 mV/G

PAK (*5000): 385 DATE: 28Feb20

PDA OPERATOR: Jas

<-AT:PIEZORESISTIVE OP: LAINE [ver:5.01] AT:PIEZOELECTRIC->

Smart Sensor

Programmed By: X.W.

CRC Value 1108

Appendix III

SPT Energy Evaluation Form

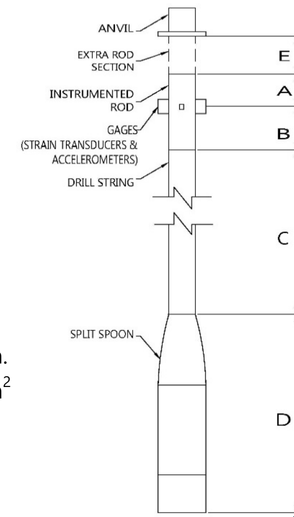
Project: RUTHERFORDTON / US-221 RELOCATION
Project No.: 6235-20-004 / R-2233BA
Boring No.: L3_121
Date: 5/5/2020
Weather: CLEAR / 70s
Drill Rod Type: 5' LONG AWJ

On-site Personnel

Drilling Company: S&ME, INC.
Rig Operator: F. JOHNSON
Engr/Geologist: B. KEBEA
Client Rep.: N/A
Analyzer Oper.: J. WILLIAMSON

Rod Info

(A + E) Impact Surface to Gages Length: 1.2 ft
(B) Instr. Rod Length below Gages: 0.8 ft
(A) + (B) Instr. Rod Length: 2.0 ft
(D) Spoon Length: 2.85 ft
(E) Rod Length Above Instr. Rod (if applicable): N/A ft
Instr. Rod S/N: 203AWJ
Instr. Rod Outside Dia.: 1.75 in.
Instr. Rod Area: 1.19 in^2
PDA Make/Model: PDI/PAX
PDA Serial No.: 3733L
Calib. Pulse Test (y/n): Y



Rig/Hammer Info

Drill Rig Make/Model: CME-550X
Carrier Type: ATV
Rig Serial No.: 290593
Hammer Type/Model: CME-550X
Hammer Serial No.: N/A - BUILT IN
Hammer Drop System: AUTOMATIC
Lubrication Condition: PER MANUFACTURER
Manufacturer Recommended Operation Rate (bpm): 50
Typical Drop Height (in.): 30
Typical Hammer Weight (lbs): 140
Anvil Dimension (in.): 12
Drilling Method: MUD ROTARY - 2-15/16" TRICONE

Gage Info

Gage		Serial No.	Calibration No.
Accel.	A3	K5641	378.0
	A4	K10181	385.0
Strain	F3	203AWJ-1	214.31
	F4	203AWJ-2	214.45

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)	
5/5/2020	28.5 - 30.0	9:52	30	33.65	43	7	9	11	20	Y	A-2-4
	33.5 - 35.0	10:02	35	38.65	53	7	11	14	25	Y	A-2-4
	38.5 - 40.0	10:14	40	43.65	53	9	10	12	22	Y	A-2-4
	43.5 - 45.0	10:23	45	48.65	53	10	10	11	21	Y	A-2-4
	48.5 - 50.0	10:36	50	53.65	53	12	18	35	53	Y	A-2-4
	53.5 - 55.0	10:48	55	58.65	53	25	58	42/0.2'	100/0.7'	Y	WR

Notes:

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.

Joseph Williamson

Prepared By (print/signature)

5/5/2020

Date

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 34400.1.4	**TIP** R-2233BA	**COUNTY** RUTHERFORD	**GEOLOGIST** B. Kebea

SITE DESCRIPTION Rutherfordton Bypass

BORING NO. L3_121	**STATION** 5915+47	**OFFSET** 90 ft RT	**ALIGNMENT** -L3-	**GROUND WTR (ft)** **0 HR.** N/A
COLLAR ELEV. N/A	**TOTAL DEPTH** 83.5 ft	**NORTHING** 591,547	**EASTING** 1,122,032	**24 HR.** 49.0

DRILL RIG/HAMMER EFF./DATE SME0593 CME-550X 86% 05/01/2019	**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic

DRILLER F. Johnson	**START DATE** 05/05/20	**COMP. DATE** 05/05/20	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI	SOIL AND ROCK DESCRIPTION
									GROUND SURFACE 0.0
		0.0	3	5	5	10		M	TOPSOIL 0.3
									RESIDUAL LOOSE TO VERY DENSE RED BROWN BLACK SILTY FINE TO COARSE SAND (A-2-4), TRACE MICA, TRACE ANGULAR MANGANESE OXIDE
		3.5	6	5	7	12		D	
		8.5	4	4	5	9		M	
		13.5	7	5	11	16		M	
		18.5	5	7	7	14		M	
		23.5	11	12	13	25		M	
		28.5	7	9	11	20		M	
		33.5	7	11	14	25		M	
		38.5	9	10	12	22		M	
		43.5	10	10	11	21		M	
		48.5	12	18	35	53		M	52.0
									WEATHERED ROCK MIGMATITIC GRANITIC GNEISS
		53.5	25	58	42/0.2	100/0.7			57.0
									RESIDUAL DENSE TO MEDIUM DENSE GRAY BROWN BLACK SILTY FINE TO COARSE SAND (A-2-4), TRACE MICA, TRACE GRAVEL, TRACE ANGULAR MANGANESE OXIDE
		58.5	12	13	26	39		M	
		63.5	12	18	29	47		M	
		68.5	8	10	14	24		M	
		73.5	5	6	8	14		M	
		78.5	8	13	19	32		M	

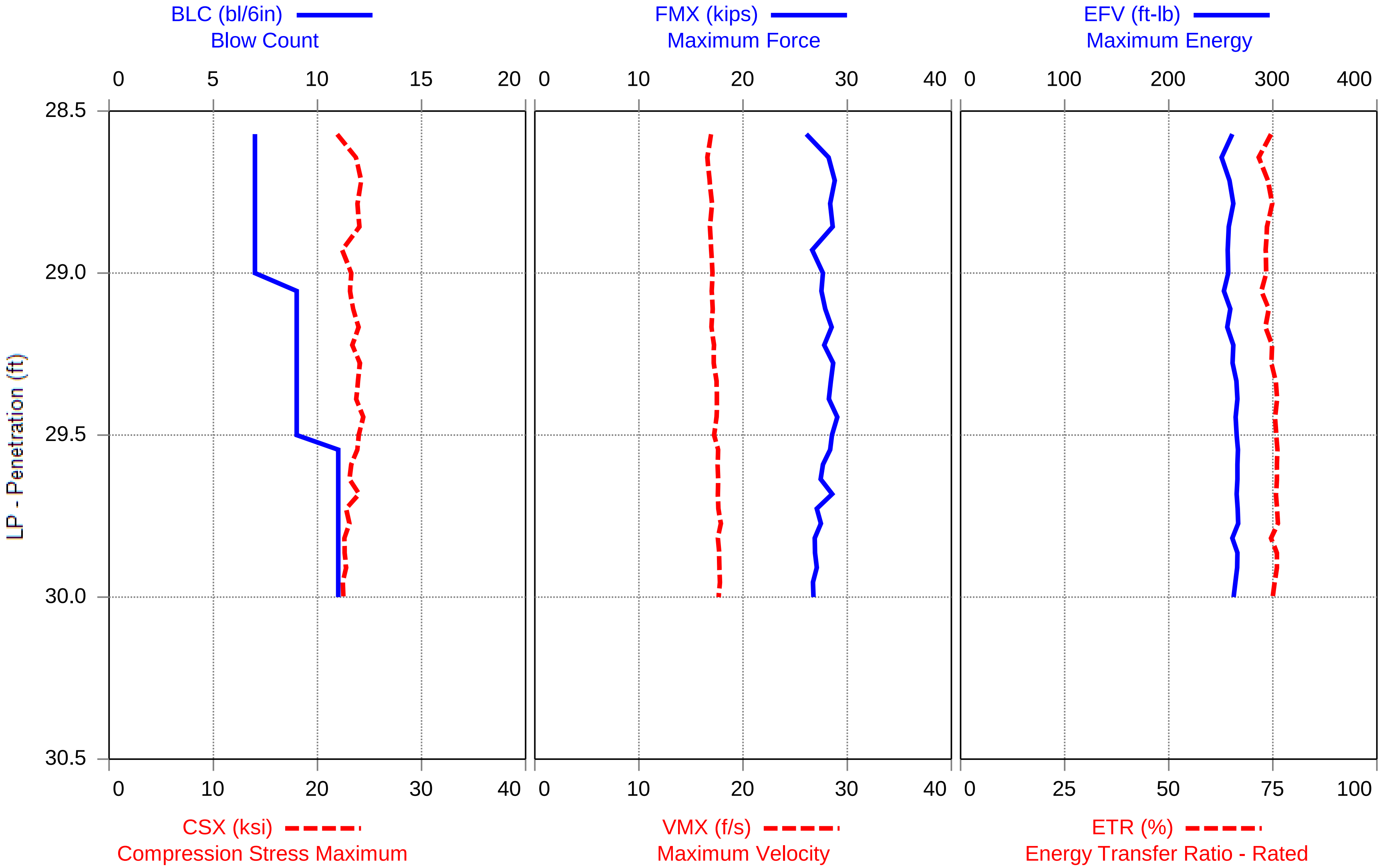
Appendix IV

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 06-May-2020 Test started: 05-May-2020

CME-550X (SN 290593) - 28.5-30.0 FEET

L3_121



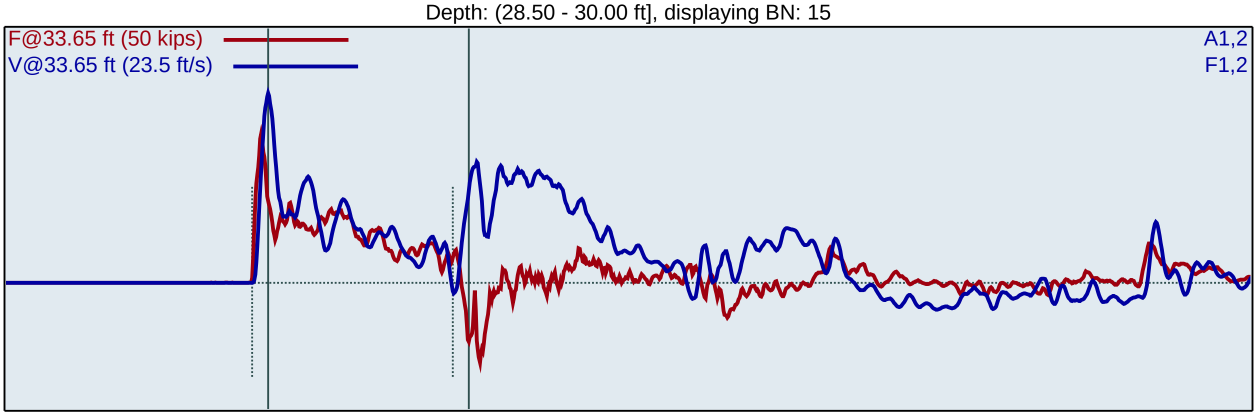
CME-550X (SN 290593)
JRW
L3_121

Annual Calibration
Test date: 5/5/2020

AR: 1.19 in^2
LE: 33.65 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

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



F1 : [203 AWJ-1] 214.31 PDICAL (1) FF1
F2 : [203 AWJ-2] 214.45 PDICAL (1) FF1

A1 (PR): [K5641] 378 mv/6.4v/5000g (1) VF1
A2 (PR): [K10181] 385 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

BL#	LP	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
	ft	/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
1	28.57	7	1.9	26	16.9	1.29	21.9	0.86	261	74.6
2	28.64	7	31.6	28	16.6	1.10	23.7	0.86	251	71.6
3	28.71	7	41.8	29	16.8	1.03	24.2	0.86	258	73.8
4	28.79	7	43.3	28	17.0	0.96	23.8	0.86	262	74.9
5	28.86	7	43.0	29	16.8	0.91	24.0	0.86	257	73.6
6	28.93	7	43.2	27	16.9	0.91	22.4	0.86	257	73.3
7	29.00	7	43.4	28	17.0	0.90	23.2	0.86	257	73.4
8	29.06	9	43.0	28	17.0	0.84	23.1	0.67	253	72.2
9	29.11	9	43.1	28	17.1	0.86	23.4	0.67	259	74.0
10	29.17	9	43.2	28	17.0	0.81	23.9	0.67	256	73.2
11	29.22	9	43.3	28	17.2	0.80	23.4	0.67	262	74.8
12	29.28	9	43.3	29	17.2	0.76	24.1	0.67	261	74.6
13	29.33	9	43.2	28	17.5	0.72	23.9	0.67	265	75.7
14	29.39	9	43.2	28	17.5	0.71	23.7	0.67	266	76.0
15	29.44	9	43.2	29	17.5	0.70	24.4	0.67	264	75.5
16	29.50	9	43.3	29	17.2	0.69	24.0	0.67	265	75.8
17	29.55	11	43.3	28	17.6	0.66	23.8	0.55	266	76.1
18	29.59	11	43.2	28	17.6	0.66	23.2	0.55	266	76.0
19	29.64	11	43.3	27	17.6	0.65	23.1	0.55	266	76.0
20	29.68	11	43.4	29	17.6	0.64	24.0	0.55	265	75.7
21	29.73	11	43.3	27	17.6	0.62	22.8	0.55	266	76.0
22	29.77	11	43.3	27	17.9	0.61	23.1	0.55	267	76.2
23	29.82	11	43.2	27	17.6	0.60	22.6	0.55	261	74.6
24	29.86	11	43.4	27	17.7	0.60	22.6	0.55	266	76.0
25	29.91	11	43.4	27	17.7	0.58	22.7	0.55	266	75.9
26	29.95	11	43.4	27	17.8	0.55	22.4	0.55	264	75.4
27	30.00	11	43.5	27	17.6	0.55	22.5	0.55	262	75.0

Average	43.3	28	17.5	0.68	23.3	0.60	263	75.2
Std Dev	0.1	1	0.3	0.09	0.6	0.06	4	1.0
Maximum	43.5	29	17.9	0.86	24.4	0.67	267	76.2
Minimum	43.0	27	17.0	0.55	22.4	0.55	253	72.2

N-value: 20

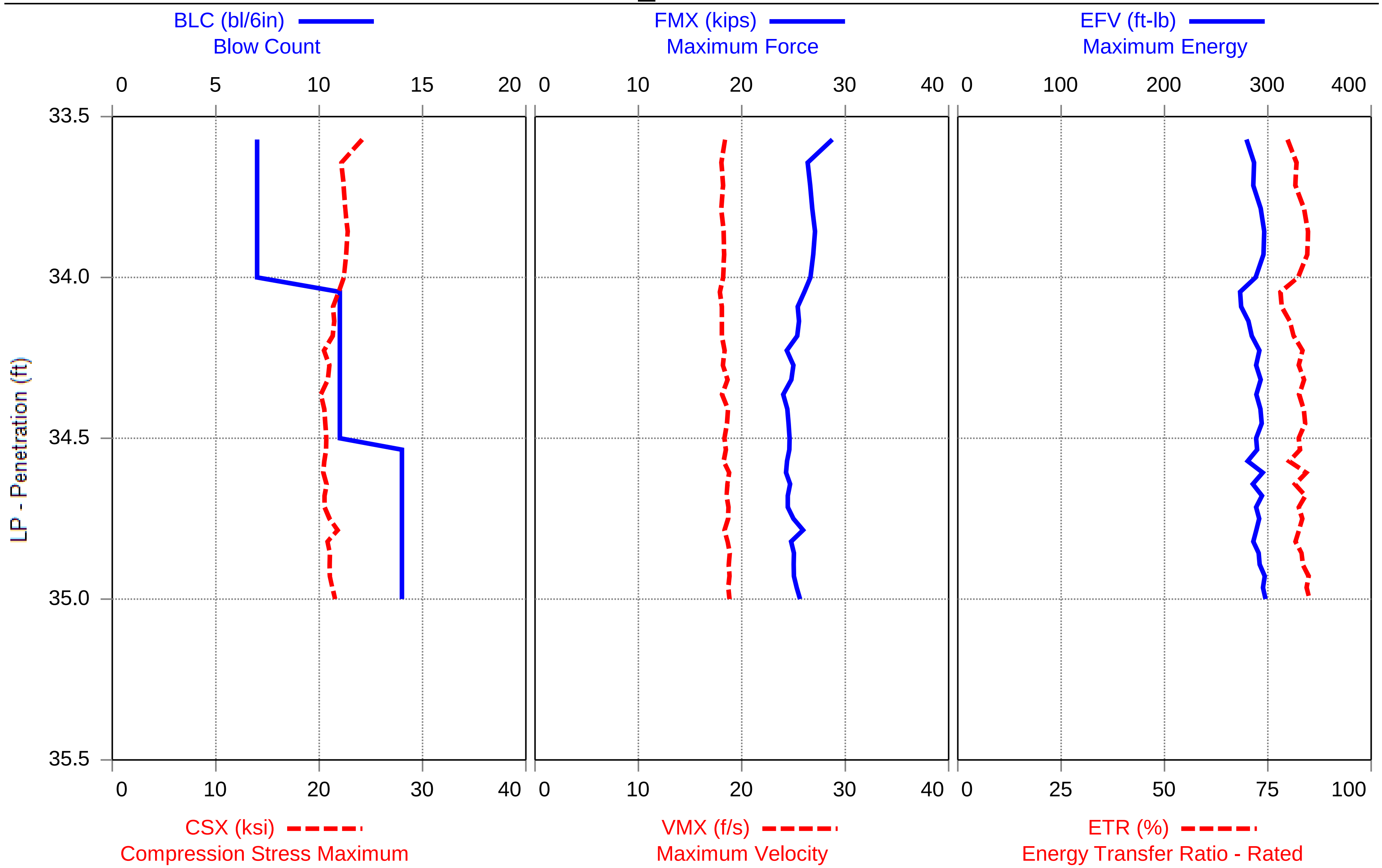
Sample Interval Time: 36.56 seconds.

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 06-May-2020

Test started: 05-May-2020

CME-550X (SN 290593) - 33.5-35.0 FEET
L3_121



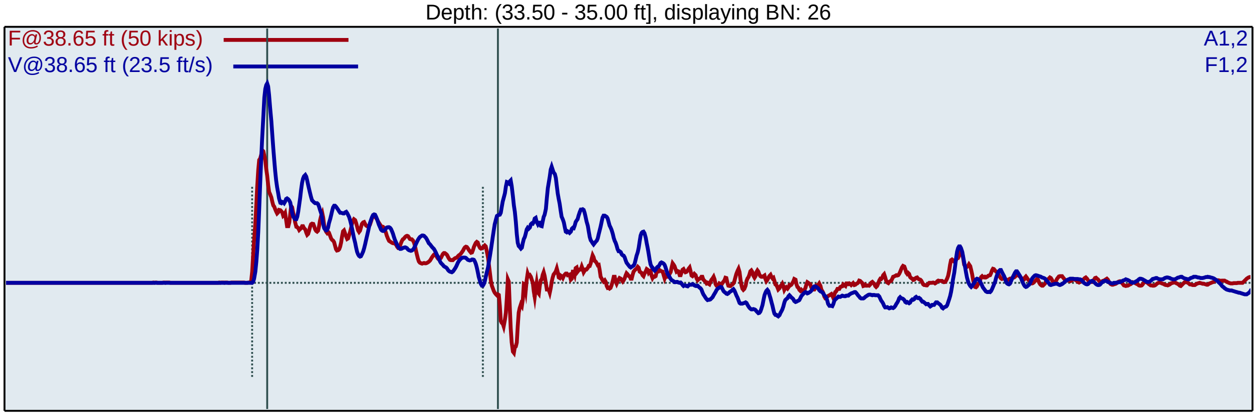
CME-550X (SN 290593)
JRW
L3_121

Annual Calibration
Test date: 5/5/2020

AR: 1.19 in^2
LE: 38.65 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (33.50 - 35.00 ft], displaying BN: 26



F1 : [203 AWJ-1] 214.31 PDICAL (1) FF1
F2 : [203 AWJ-2] 214.45 PDICAL (1) FF1

A1 (PR): [K5641] 378 mv/6.4v/5000g (1) VF1
A2 (PR): [K10181] 385 mv/6.4v/5000g (1) VF1

BL#	LP	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
	ft	/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
1	33.57	7	1.9	29	18.4	1.07	24.2	0.86	279	79.8
2	33.64	7	52.6	26	18.0	1.00	22.1	0.86	287	81.9
3	33.71	7	52.9	27	18.2	0.91	22.4	0.86	286	81.7
4	33.79	7	53.4	27	18.0	0.90	22.5	0.86	293	83.8
5	33.86	7	53.4	27	18.2	0.92	22.8	0.86	296	84.7
6	33.93	7	53.2	27	18.3	0.91	22.6	0.86	296	84.5
7	34.00	7	53.3	27	18.2	0.86	22.4	0.86	288	82.3
8	34.05	11	53.3	26	17.9	0.74	21.9	0.54	273	78.0
9	34.09	11	53.1	25	18.1	0.70	21.3	0.54	274	78.3
10	34.14	11	53.1	26	18.1	0.69	21.4	0.54	281	80.3
11	34.18	11	53.4	25	18.1	0.69	21.3	0.54	284	81.2
12	34.23	11	53.0	24	18.3	0.68	20.5	0.54	292	83.4
13	34.27	11	53.4	25	18.2	0.59	21.0	0.54	289	82.5
14	34.32	11	53.4	25	18.6	0.55	20.8	0.54	293	83.8
15	34.36	11	53.3	24	18.1	0.54	20.2	0.54	289	82.5
16	34.41	11	53.0	24	18.7	0.54	20.5	0.54	293	83.7
17	34.45	11	53.4	25	18.6	0.54	20.6	0.54	294	84.0
18	34.50	11	53.2	25	18.3	0.54	20.7	0.54	289	82.4
19	34.54	14	53.4	25	18.5	0.52	20.7	0.43	290	82.8
20	34.57	14	53.1	24	18.2	0.51	20.5	0.43	281	80.1
21	34.61	14	53.1	24	18.8	0.53	20.4	0.43	295	84.3
22	34.64	14	53.2	25	18.6	0.51	20.7	0.43	285	81.5
23	34.68	14	53.3	24	18.5	0.55	20.5	0.43	294	84.1
24	34.71	14	53.1	24	18.7	0.51	20.5	0.43	289	82.5
25	34.75	14	53.1	25	18.7	0.51	21.0	0.42	292	83.3
26	34.79	14	53.3	26	18.3	0.50	21.8	0.43	289	82.6
27	34.82	14	53.1	25	18.6	0.50	20.8	0.43	286	81.7
28	34.86	14	53.1	25	18.8	0.50	21.0	0.43	291	83.1
29	34.89	14	53.5	25	18.7	0.50	21.0	0.43	292	83.4
30	34.93	14	52.8	25	18.8	0.51	21.0	0.43	297	84.8
31	34.96	14	53.3	25	18.7	0.50	21.3	0.43	295	84.3

32	35.00	14	52.7	26	18.8	0.50	21.5	0.43	298	85.1
		Average	53.2	25	18.5	0.56	20.9	0.48	289	82.6
		Std Dev	0.2	1	0.3	0.07	0.4	0.06	6	1.8
		Maximum	53.5	26	18.8	0.74	21.9	0.54	298	85.1
		Minimum	52.7	24	17.9	0.50	20.2	0.42	273	78.0

N-value: 25

Sample Interval Time: 34.93 seconds.

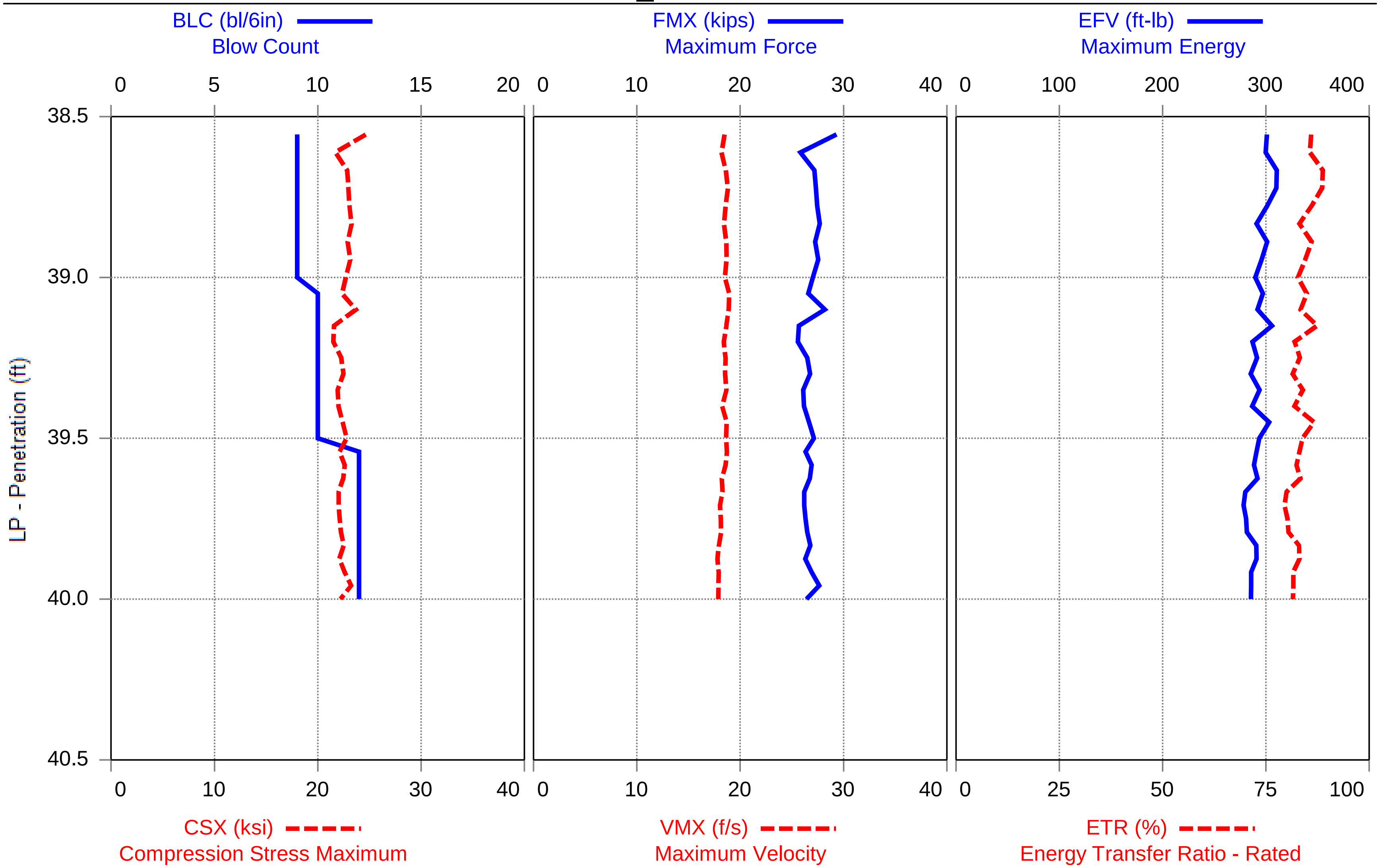
Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 06-May-2020

Test started: 05-May-2020

CME-550X (SN 290593) - 38.5-40.0 FEET

L3_121



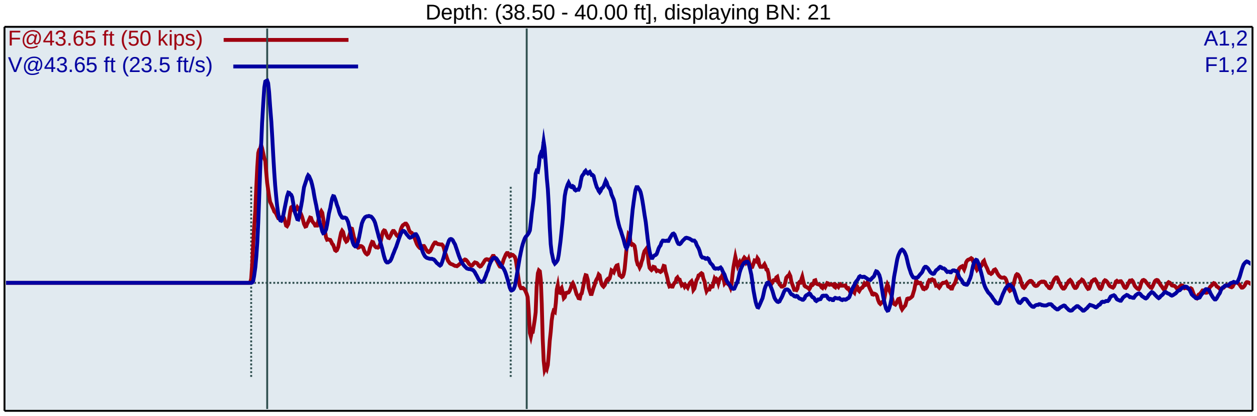
CME-550X (SN 290593)
JRW
L3_121

Annual Calibration
Test date: 5/5/2020

AR: 1.19 in^2
LE: 43.65 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (38.50 - 40.00 ft], displaying BN: 21



F1 : [203 AWJ-1] 214.31 PDICAL (1) FF1
F2 : [203 AWJ-2] 214.45 PDICAL (1) FF1

A1 (PR): [K5641] 378 mv/6.4v/5000g (1) VF1
A2 (PR): [K10181] 385 mv/6.4v/5000g (1) VF1

BL#	LP	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
	ft	/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
1	38.56	9	1.9	29	18.5	1.03	24.6	0.67	301	85.9
2	38.61	9	52.8	26	18.2	0.78	21.7	0.67	300	85.6
3	38.67	9	52.7	27	18.6	0.72	22.8	0.67	311	88.8
4	38.72	9	53.2	27	18.8	0.74	23.0	0.67	310	88.6
5	38.78	9	53.1	27	18.6	0.72	23.1	0.67	301	86.0
6	38.83	9	53.2	28	18.4	0.70	23.3	0.67	291	83.1
7	38.89	9	53.2	27	18.6	0.78	22.9	0.67	301	86.1
8	38.94	9	53.5	28	18.7	0.75	23.1	0.67	296	84.5
9	39.00	9	53.0	27	18.5	0.75	22.7	0.66	290	82.7
10	39.05	10	53.5	27	18.9	0.74	22.3	0.60	297	84.9
11	39.10	10	53.2	28	18.9	0.72	23.7	0.60	292	83.4
12	39.15	10	53.2	26	18.7	0.85	21.6	0.60	306	87.4
13	39.20	10	53.4	26	18.4	0.74	21.5	0.60	287	81.9
14	39.25	10	53.0	26	18.6	0.71	22.3	0.60	291	83.2
15	39.30	10	53.2	27	18.5	0.63	22.5	0.60	285	81.5
16	39.35	10	53.1	26	18.7	0.62	21.9	0.60	294	83.9
17	39.40	10	53.0	26	18.3	0.61	22.0	0.60	287	81.9
18	39.45	10	53.4	27	18.7	0.64	22.4	0.60	303	86.6
19	39.50	10	53.2	27	18.6	0.60	22.8	0.60	294	83.9
20	39.54	12	53.3	26	18.7	0.58	22.1	0.50	291	83.1
21	39.58	12	53.2	27	18.6	0.58	22.6	0.50	288	82.4
22	39.63	12	52.9	27	18.2	0.69	22.5	0.50	292	83.4
23	39.67	12	53.3	26	18.3	0.57	22.0	0.50	280	80.0
24	39.71	12	53.2	26	18.1	0.57	22.0	0.50	278	79.5
25	39.75	12	53.1	26	18.1	0.56	22.1	0.50	281	80.2
26	39.79	12	53.1	26	18.2	0.56	22.3	0.50	281	80.4
27	39.83	12	53.1	27	17.9	0.58	22.5	0.50	291	83.0
28	39.88	12	53.1	26	17.8	0.64	22.1	0.50	291	83.1
29	39.92	12	53.5	27	17.9	0.56	22.6	0.50	286	81.6
30	39.96	12	53.0	28	17.9	0.56	23.2	0.50	286	81.6
31	40.00	12	52.9	26	17.9	0.58	22.2	0.50	285	81.5

Average	53.2	27	18.4	0.63	22.3	0.54	289	82.6
Std Dev	0.2	1	0.3	0.08	0.5	0.05	7	1.9
Maximum	53.5	28	18.9	0.85	23.7	0.60	306	87.4
Minimum	52.9	26	17.8	0.56	21.5	0.50	278	79.5

N-value: 22

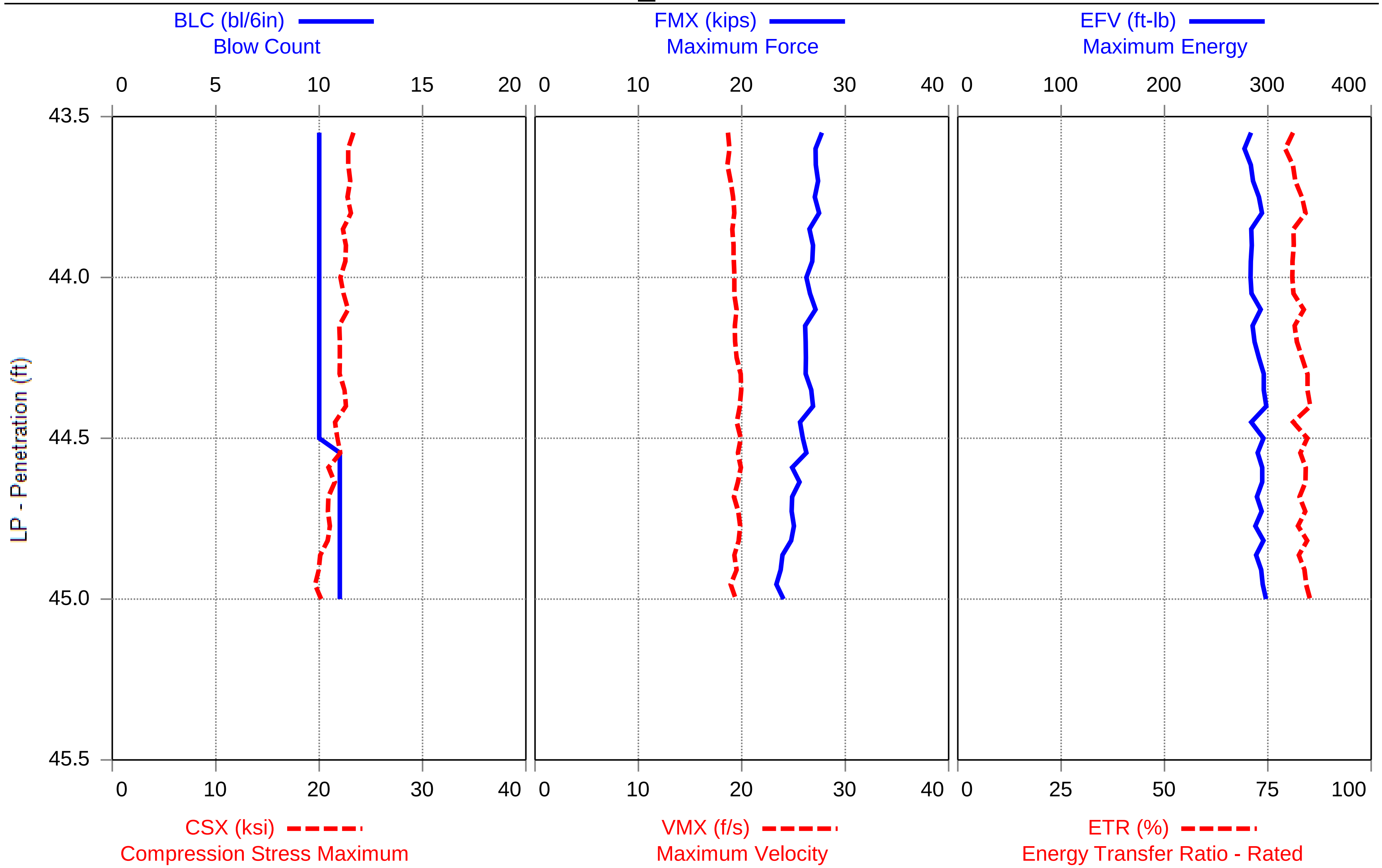
Sample Interval Time: 33.81 seconds.

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 06-May-2020

Test started: 05-May-2020

CME-550X (SN 290593) - 43.5-45.0 FEET
L3_121



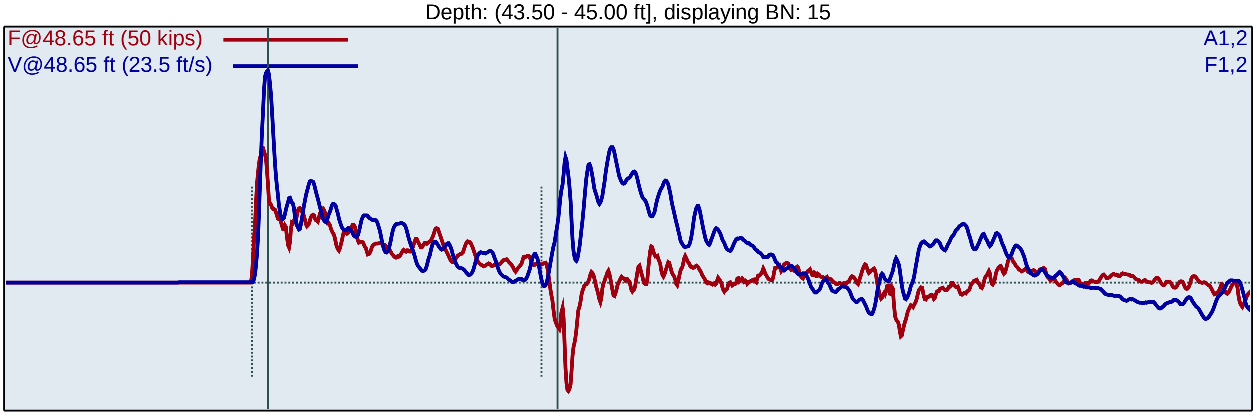
CME-550X (SN 290593)
JRW
L3_121

Annual Calibration
Test date: 5/5/2020

AR: 1.19 in^2
LE: 48.65 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (43.50 - 45.00 ft], displaying BN: 15



F1 : [203 AWJ-1] 214.31 PDICAL (1) FF1
F2 : [203 AWJ-2] 214.45 PDICAL (1) FF1

A1 (PR): [K5641] 378 mv/6.4v/5000g (1) VF1
A2 (PR): [K10181] 385 mv/6.4v/5000g (1) VF1

BL#	LP	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
	ft	/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
1	43.55	10	1.9	28	18.7	0.78	23.3	0.60	284	81.1
2	43.60	10	52.3	27	18.8	0.63	22.8	0.60	277	79.2
3	43.65	10	54.0	27	18.6	0.63	22.8	0.60	284	81.0
4	43.70	10	52.9	27	18.9	0.64	23.0	0.60	286	81.6
5	43.75	10	53.5	27	19.2	0.64	22.7	0.60	291	83.2
6	43.80	10	53.5	27	19.3	0.66	23.1	0.60	294	84.1
7	43.85	10	53.2	27	19.1	0.68	22.3	0.60	284	81.2
8	43.90	10	53.4	27	19.2	0.69	22.6	0.60	284	81.2
9	43.95	10	53.3	27	19.2	0.70	22.5	0.60	283	81.0
10	44.00	10	53.5	26	19.3	0.70	22.1	0.60	283	80.9
11	44.05	10	53.1	27	19.3	0.70	22.4	0.60	284	81.2
12	44.10	10	53.3	27	19.5	0.71	22.8	0.60	293	83.7
13	44.15	10	53.5	26	19.3	0.72	21.9	0.60	285	81.4
14	44.20	10	53.5	26	19.3	0.74	22.0	0.60	287	82.0
15	44.25	10	53.3	26	19.5	0.75	22.0	0.60	291	83.2
16	44.30	10	53.3	26	19.9	0.74	22.0	0.60	296	84.6
17	44.35	10	53.3	27	19.9	0.70	22.5	0.60	296	84.6
18	44.40	10	53.2	27	19.8	0.69	22.6	0.60	298	85.3
19	44.45	10	53.5	26	19.5	0.68	21.5	0.60	284	81.1
20	44.50	10	53.0	26	19.9	0.68	21.8	0.60	296	84.5
21	44.55	11	53.2	26	19.6	0.64	22.0	0.54	290	82.9
22	44.59	11	53.1	25	19.9	0.64	20.9	0.54	295	84.1
23	44.64	11	53.2	26	19.6	0.61	21.5	0.54	294	84.1
24	44.68	11	53.1	25	19.2	0.61	20.9	0.54	289	82.6
25	44.73	11	53.5	25	19.7	0.61	20.8	0.54	294	84.0
26	44.77	11	53.3	25	19.8	0.57	21.0	0.54	288	82.3
27	44.82	11	53.2	25	19.7	0.59	20.8	0.54	296	84.5
28	44.86	11	53.2	24	19.3	0.58	20.1	0.54	289	82.5
29	44.91	11	53.2	24	19.5	0.56	20.0	0.54	293	83.8
30	44.95	11	53.4	23	18.9	0.58	19.6	0.54	295	84.3
31	45.00	11	53.2	24	19.4	0.58	20.2	0.54	298	85.2

Average	53.3	25	19.6	0.65	21.4	0.57	292	83.4
Std Dev	0.1	1	0.3	0.06	0.9	0.03	4	1.3
Maximum	53.5	27	19.9	0.75	22.8	0.60	298	85.3
Minimum	53.0	23	18.9	0.56	19.6	0.54	284	81.1

N-value: 21

Sample Interval Time: 33.74 seconds.

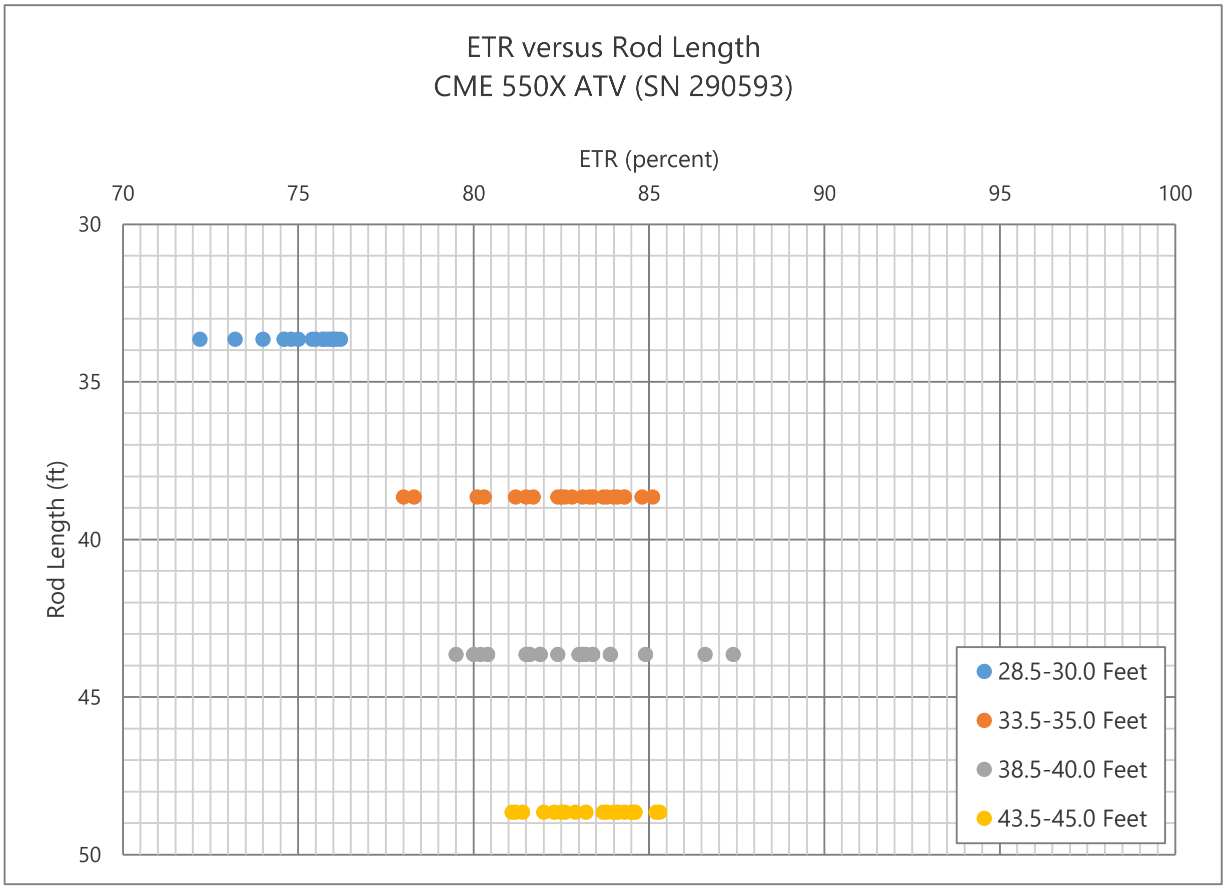
Summary of SPT Test Results

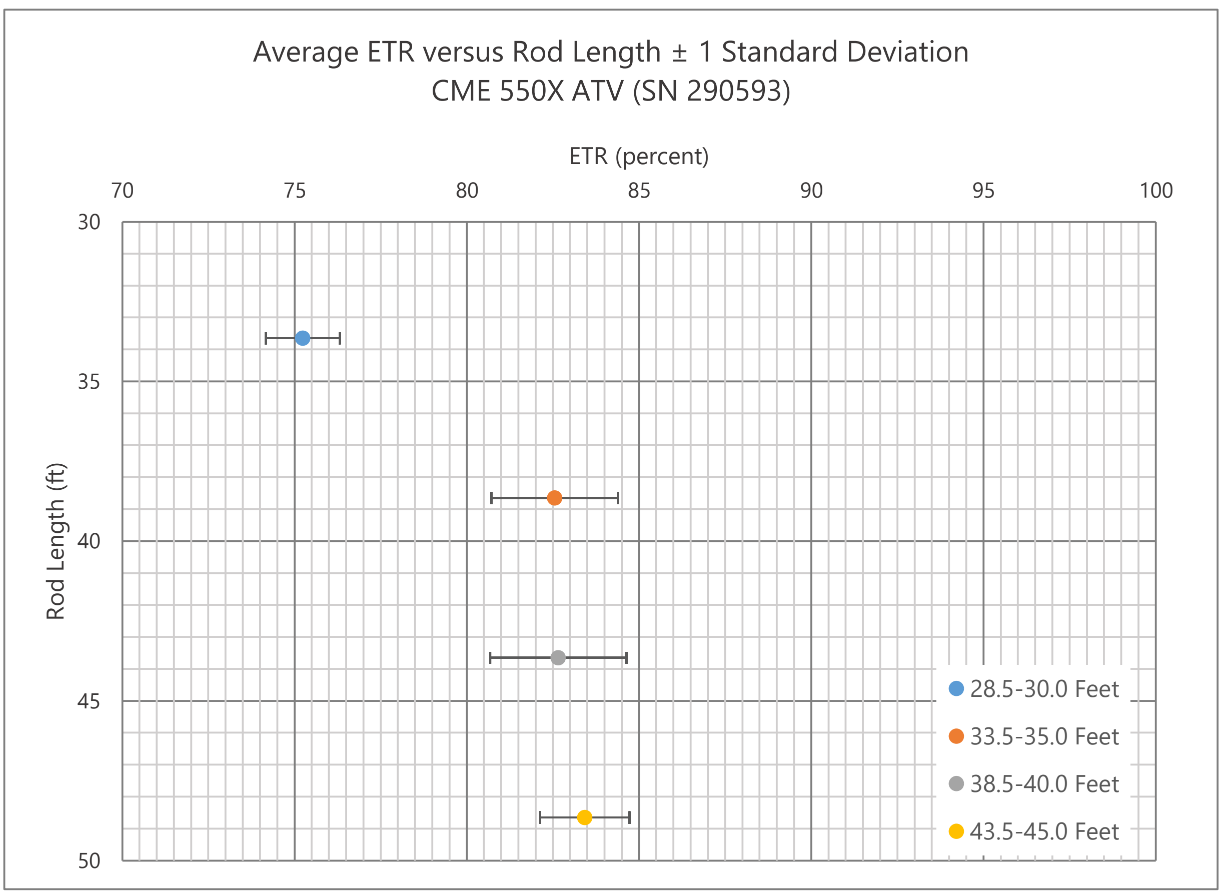
Project: CME-550X (SN 290593), Test Date: 5/5/2020

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 %
33.65	28.50	30.00	**7-9-11**	**20**	**27**	43.3	28	17.5	0.68	23.3	0.60	263	75.2
38.65	33.50	35.00	**7-11-14**	**25**	**33**	53.2	25	18.5	0.56	20.9	0.48	289	82.6
43.65	38.50	40.00	**9-10-12**	**22**	**29**	53.2	27	18.4	0.63	22.3	0.54	289	82.6
48.65	43.50	45.00	**10-10-11**	**21**	**28**	53.3	25	19.6	0.65	21.4	0.57	292	83.4
					Overall Average Values:	51.0	26	18.5	0.63	21.9	0.54	284	81.1
					Standard Deviation:	4.2	1	0.8	0.09	1.1	0.07	13	3.6
					Overall Maximum Value:	53.5	29	19.9	0.86	24.4	0.67	306	87.4
					Overall Minimum Value:	43.0	23	17.0	0.50	19.6	0.42	253	72.2


ETR versus Rod Length
CME 550X ATV (SN 290593)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30
35
40
45
50
28.5-30.0 Feet
33.5-35.0 Feet
38.5-40.0 Feet
43.5-45.0 Feet


Average ETR versus Rod Length ± 1 Standard Deviation
CME 550X ATV (SN 290593)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30
35
40
45
50
28.5-30.0 Feet
33.5-35.0 Feet
38.5-40.0 Feet
43.5-45.0 Feet