



Geotechnical Baseline Report

SC 72 (Carlisle Chester Hwy) Bridge
Replacement over Cox Creek

Union County, SC
March 22, 2023



March 22, 2023

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

Dear Mr. Harris,

We have completed the Geotechnical Baseline Report for the SC 72 (Carlisle Chester Hwy.) Bridge Replacement over Cox Creek in Union County, SC. Please call at your convenience if you have questions or comments. HDR appreciates the opportunity to provide geotechnical engineering services to the South Carolina Department of Transportation.

Sincerely,
HDR

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



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

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1 Introduction

This Geotechnical Baseline Report (GBR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed SC 72 Bridge Replacement over Cox Creek, in Union County, South Carolina. The proposed bridge intends to replace the existing bridge over Cox Creek on Carlisle Chester Highway.

This Geotechnical Baseline Report was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM). Geotechnical data including standard penetration testing (SPT), cone penetration testing (CPT), bulk sampling, rock cores, shear wave velocity measurements, and a variety of laboratory tests are presented herein to provide geological features and site conditions for the design of the proposed bridge. Preliminary geotechnical considerations for design and construction are also included in this report.

1.1 Project Description

The project site is located east of Carlisle, approximately a quarter of a mile west of the intersection of SC 72 with State Road S-44-113. It is bound to the east by State Road S-44-113 and to the west by Janie Glymph Goree Blvd. A Site Vicinity Map is included in Appendix A.

The existing creek crossing is a triple 10'×8' reinforced concrete box culvert widened on each side with a bridge. The existing structure is approximately 52 feet in length and 44 feet wide and will be removed and replaced with a new bridge along a shifted alignment. The proposed single span replacement bridge will be approximately 110 feet in length and will accommodate two 12-foot lanes with 10-foot shoulders. Construction is anticipated to be completed in stages to avoid closing/detouring the existing bridge.

2 Investigative Procedures

The geotechnical subsurface exploration at the project site was performed by F&ME Consultants in November 2022. The subsurface investigation consisted of standard penetration test (SPT) borings, rock core samples, bulk sample soil collection, CPTs, and shear wave velocity measurements with MASW testing.

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

2.1 Drilling and Sampling

A total of two (2) SPT borings were performed during the subsurface investigation, B-33 and B-34. Auger refusal was encountered in both borings at depths of 18.5 feet and 18.0 feet, respectively. Advancement of the bridge borings B-33 and B-34 below auger refusal

was accomplished with NQ rock coring techniques. These were terminated at depths of 28.5 feet and 28.0 feet.

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

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

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

2.2 Cone Penetrometer Testing

Two (2) cone penetrometer tests (CPT-15 and CPT-16) were performed by F&ME Consultants, Inc., one near each end bent of the existing bridge. Upon encountering refusal, the CPTs were terminated at depths of 14.8 feet and 12.1 feet. CPT sounding logs are included in Appendix B.

2.3 MASW Survey

Shear wave velocity measurements were obtained by F&ME Consultants from one (1) Multi-Channel Analysis of Surface Waves, MASW-8, performed on the existing bridge end where boring B-33 was drilled. Active survey data was obtained by a sledgehammer striking an aluminum block and polyethylene block and recording of the resulting vibrations. Passive survey data consisted of the collection of ambient background vibrations resulting from drilling equipment. The resulting shear-wave data from this investigation produced an average shear-wave velocity of 1525.3 ft/sec for the 0 to 100-foot interval. The MASW survey report is included in Appendix B.

2.4 Groundwater Conditions

The stabilized groundwater level recorded approximately 24 hours after completion of investigation operations indicated a groundwater depth of 11.6 feet and 11.0 feet for boring B-33 and B-34, respectively. These depths correspond to elevations 328.6 feet and 329.3 feet.

Groundwater level was recorded at the time of completion of soil drilling and/or rock coring at borings B-33 and B-34 at depths of 10.0 feet and 8.2 feet. These depths correspond to elevations 330.2 feet and 332.1 feet.

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

2.5 Field Testing Summary

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

Table 2-1. Field Soil Testing Summary

| Test Hole No. | Station ^a | Offset (ft) | Latitude | Longitude | Top of Boring Elevation (ft) | Test Type | Total Depth (ft) |
|---------------|----------------------|-------------|----------|-----------|------------------------------|-----------|------------------|
| B-33 | 70+84 | 52 LT | 34.59537 | -81.44177 | 340.2 | SPT/RC | 28.5 |
| B-34 | 71+96 | 55 LT | 34.59534 | -81.44214 | 340.3 | SPT/RC | 28.0 |
| BS-1 | 70+84 | 64 LT | 34.59533 | -81.44176 | 339.4 | BULK | 5.0 |
| CPT-15 | 70+91 | 56 LT | 34.59535 | -81.44179 | 340.1 | CPT | 14.8 |
| CPT-16 | 71+94 | 56 LT | 34.59534 | -81.44213 | 340.3 | CPT | 12.1 |
| MASW-8 | near boring B-33 | | | | | MASW | 100.0 |

^a Stations based on latest SC 72 alignment.

3 Laboratory Test Program

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

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

Table 3-1. Laboratory Testing Summary

| Test Type | Quantity |
|-------------------------------------|----------|
| Natural Moisture Content | 8 |
| Atterberg Limits | 8 |
| Grain Size Analysis with Hydrometer | 2 |
| Grain Size Analysis with #200 Wash | 2 |
| #200 Wash | 4 |
| CU Triaxial | 1 |
| Unconfined Compression of Rock | 2 |

Table 3-1. Laboratory Testing Summary

| Test Type | Quantity |
|------------------|----------|
| Standard Proctor | 1 |
| Corrosion Series | 1 |

3.1 Soil and Rock Properties

Split spoon soil samples from the preliminary geotechnical subsurface site exploration for this bridge site were grouped and classified into AASHTO and USCS soil classifications. According to the AASHTO Soil Classification System, the classifications of these samples ranged from A-2-4 to A-7-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty sand (SM) to sandy fat clay (CH). Tested samples yielded liquid limits ranging from 0 to 51 and plasticity indices ranging from 0 to 30.

Corrosion series test were performed on select split spoon samples. Standard proctor testing and remolded CU triaxial tests were performed on the collected bulk sample. Finally, two (2) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 21,890 psi to 22,800 psi. Results of laboratory testing are included in Appendix C.

4 Subsurface Conditions

4.1 Regional Geology

The bridge site is located on SC 72 in Union County, South Carolina and crosses over Cox Creek which is part of the Broad River watershed (DHEC, 2016). The bridge site lies within the Piedmont Physiographic Province of South Carolina. The Piedmont Province is bounded by the Blue Ridge Physiographic Province to the west and the Upper Coastal Plain Province to the east. Elevations throughout the Piedmont vary from 300 feet to 1,400 feet. The Piedmont Province is characterized by gently rolling topography, deeply weathered bedrock, few rock outcrops and complex geology with a multitude of rock types formed during the Paleozoic Era (250 to 570 MYA). The geology of this region is further complicated by the Alleghanian orogeny (325 to 260 MYA), the mountain building event which helped to form the present-day Appalachian Mountain chain, and subsequent deformation/metamorphism of the region (Butler, 1991). Soils overlying bedrock in the Piedmont are typically considered to be residual soil (soil weathered in place from bedrock). However, Cox Creek provides a transport mechanism for soil eroded from higher elevations to be carried downstream and deposited at banks of the particular bridge site. The contact between soil and bedrock is not strongly defined and is often marked by an intermediate transition zone. The materials of this zone can be soil, partially decomposed rock, and fragments of the underlying bedrock.

4.2 Soil and Rock Stratification

In general, the soil profile is dominated by silty sand and sandy lean clay. These comprise the roadway fill and residual soils overlying the granodiorite bedrock. Bedrock was intercepted within a depth of 18.0 feet to 18.5 feet from the existing ground.

Roadway fill consisting of firm sandy lean clay, medium sandy fat clay and soft lean clay with sand was interpreted to range from depths of 1.9 feet to 8.0 feet of the profile. Alluvium was interpreted as medium sandy fat clay and soft lean clay with sand. Residual soil underlying the roadway fill and alluvial soils ranges from loose to medium dense silty sand to very dense poorly-graded gravel. The thickness of the residual zone ranged from 10.0 feet to 10.5 feet. Granodiorite makes up the bedrock underlying the project site. Recovered rock core was in general fresh to moderately weathered. Discontinuities were spaced very close to close, with planar, slickensided to rough joint surfaces. Rock core recovery ranged from 90 to 97 percent, RQD ranged from 59 to 93 percent, and rock unconfined compression testing revealed very strong rock with values ranging from 21,890 psi to 22,800 psi.

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

Table 4-1. Soil and Rock Stratification

| Geology | Top of Layer Elev. (ft) | USCS Soil Type | SPT-N ⁽¹⁾ | Plasticity Index ⁽¹⁾ | Fines Content ⁽¹⁾ | REC / RQD |
|--------------|-------------------------|----------------|----------------------|---------------------------------|------------------------------|----------------------------------|
| Roadway Fill | 338 | CL | 5-6 (6) | 20 | 63-66 (64.6) | - |
| Alluvium | 336 | CH, CL | 3-5 (4) | 14-30 (22) | 66-72 (69) | - |
| Residuum | 332 | SM, GP, SC | 5-100+ (75) | 0-10 (3) | 30-44 (39) | - |
| Rock | 322 | - | - | - | - | 90-97% / 59-93% (94%) / (75%) |

⁽¹⁾ Values in parentheses indicate the average of the values in the range

5 Seismic Conditions

The proposed bridge is classified as OC II. Per SCDOT GDM 2022, the bridge approach embankments shall be designed to meet the performance limits that are established by the design team based on the performance objectives for the bridge.

5.1 Acceleration Design Response Spectrum (ADRS)

The shear wave velocity results, as measured from the MASW test, were provided to SCDOT (Pre-Construction Support - Geotechnical Design Section). SCDOT used these results to determine the site amplification factors that would be used to correct for site effects the bedrock motion determined from regional probabilistic seismic hazard maps.

SCDOT provided a “3-Point Acceleration Design Response Spectrum” data sheet that included pseudo-spectral accelerations (PSA) for 5% critical damping and at selected frequencies, consistent with a Geologically Realistic condition (shear wave velocity, $V_s=2,500$ fps). PSA values were provided for the:

- Functional Evaluation Earthquake (FEE): 15% probability of exceedance in 75 years;
- Safety Evaluation Earthquake (SEE): 3% probability of exceedance in 75 years.

Table 5-1 below summarizes the peak ground acceleration (PGA), the short period acceleration (S_{DS}), and one-second period acceleration (S_{D1}) for the FEE and SEE earthquakes for the ground surface. A copy of the “3-Point Acceleration Design Response Spectrum” output form presenting the PSA data at the B-C boundary and the results of the ADRS analysis are included in Appendix D.

Table 5-1. Seismic Design Parameters

| Seismic Design parameter | FEE | SEE |
|--------------------------|--------|--------|
| PGA | 0.01 g | 0.02 g |
| S_{DS} | 0.02 g | 0.04 g |
| S_{D1} | 0.00 g | 0.01 g |

5.2 Shear Strength Loss (SSL)

Based on a preliminary review of the physical properties of the site soils, these do not appear to be susceptible to shear strength loss during the design earthquake.

6 Design and Construction Considerations

6.1 Foundations

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

For piles driven to practical refusal, their resistance will be limited by their structural resistance. Reinforced pile tips will be required to penetrate to dense soils and rock. The wave equation analysis should be performed for predicting the drivability of piles along with estimating stresses during driving and, in general, verifying the ability of the Contractor’s selected hammer to drive the piles to the desired penetration while preventing overstressing.

Due to the potential of encountering shallow rock at the pile locations, pile pre-drilling may be required for the pile installation. The water table level may have an impact on the pre-drilled hole stability. If unstable soil conditions are encountered at these locations, temporary casing may be required to stabilize the pre-drilled holes.

Excavation for bridge foundations is expected to encounter PWR zones overlying bedrock as well as very hard rock conditions within the competent bedrock.

6.2 Embankment Slopes

Slope stability issues may occur if the new bridge approach embankments are built over the soft/loose alluvial soils encountered at the site. Assessment of the slope stability of the bridge approach embankments and evaluation of any necessary ground improvement measures must be explored during the design phase of the project.

6.3 Corrosion and Deterioration

Corrosion testing of a representative split spoon sample was performed by F&ME Consultants and the results are included in Appendix C. The full corrosion and deterioration testing results included pH, resistivity, chlorides and sulfates content and are summarized in Table 6-1 below.

Table 6-1. Corrosion Series Laboratory Testing Summary

| Test Hole No. | Alignment | Station | Offset | Sample Depth (ft) | Chloride (ppm) | Sulfate (ppm) | pH | Restivity (ohm-cm) |
|---------------|-----------|---------|--------|-------------------|----------------|---------------|------|--------------------|
| B-34 | SC 72 | 71+96 | 55 LT | 2.0-8.0 | 70.12 | 55.0 | 6.94 | 2,484 |

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

6.4 Embankment Construction

Some fill quantities may be required for construction of the embankments on this project. Assuming that the majority of embankment construction will utilize the available on-site materials, a bulk sample obtained from the top 5 ft of existing embankment material along the alignment was used to provide a better characterization of the material locally available. The bulk samples were tested for soil classification and was also remolded and compacted to 95% of the Standard Proctor prior to being tested under CU Triaxial Compression. Results are summarized in Table 6-2 below.

Table 6-2. Bulk Sample Testing Summary

| Sample No. | Station | Offset (ft) | Sample Depth (ft) | USCS Soil Type | Compaction | | Shear Strength | | | |
|------------|---------|-------------|-------------------|----------------|----------------------|-----------------------|----------------|-------------|---------|------------|
| | | | | | Optimum Moisture (%) | Max Dry Density (pcf) | c' (psf) | ϕ' (°) | c (psf) | ϕ (°) |
| BS-1 | 70+84 | 64 LT | 0.0-5.0 | SM | 13.0 | 117.8 | 0 | 36.5 | 225 | 10.9 |

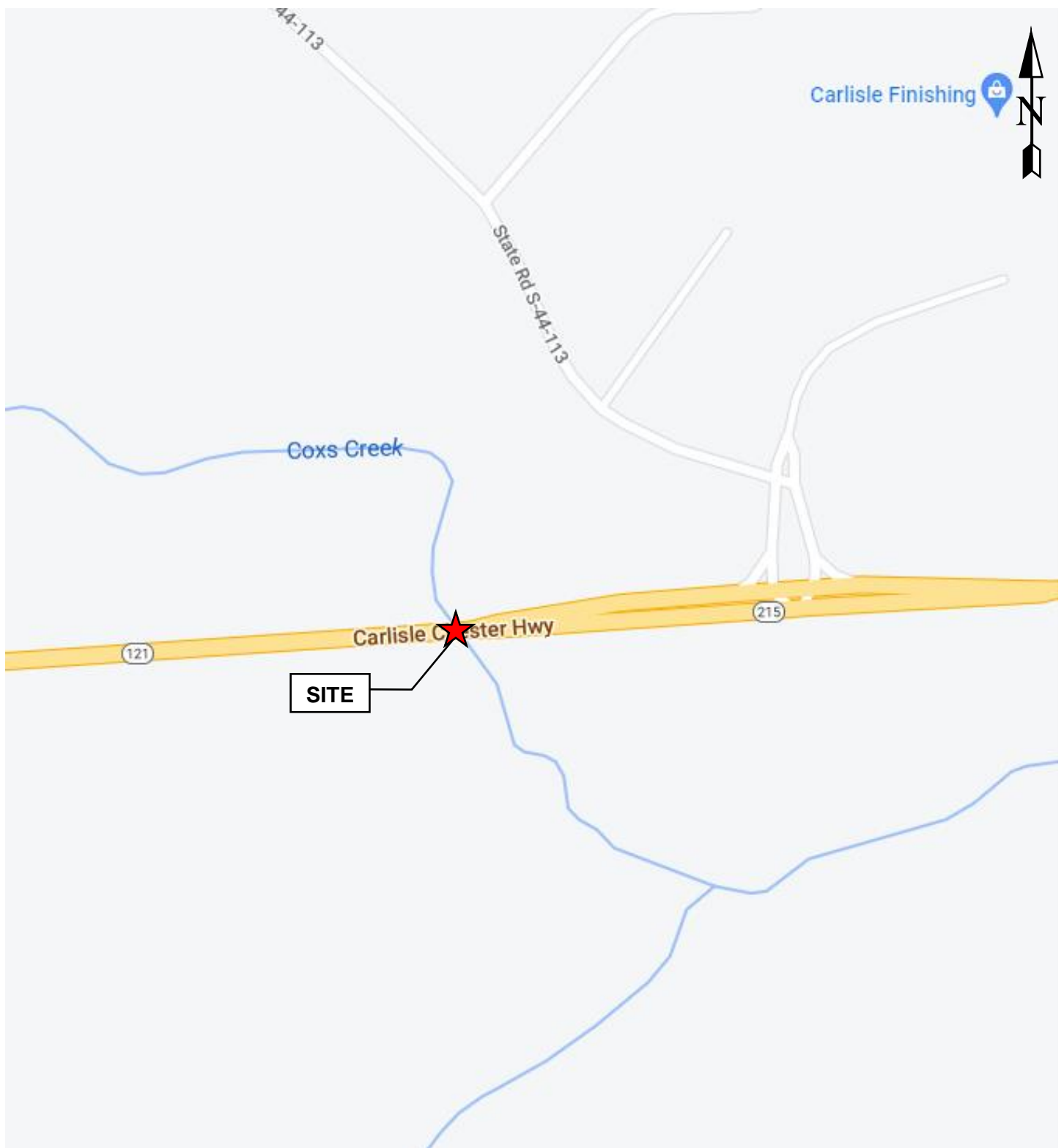
7 Limitations to Report

This report has been prepared in general accordance with procedures in SCDOT GDM Chapter 21 and generally accepted soil and foundation engineering practices for specific application to the proposed SC 72 Bridge over Cox Creek in Union County, South Carolina. No other warranty expressed or implied is made. The Geotechnical Engineer of Record for the project must review the data submitted in this report and develop their own interpretation of the testing results as they apply to design. The subsurface investigation logs included herein, do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to perform additional subsurface exploration based upon on-site observations of the conditions.

8 References

- Butler, J.R. (1991). "Metamorphism". In Horton, J.W., Jr., and Zullo, V.A., Eds., the Geology of the Carolinas: Knoxville, University of Tennessee Press: 127.
- DHEC, SC, et al. "DHEC S.C. Watershed Atlas" *Live Healthy S.C.*, 14 Apr. 2016, <https://gis.dhec.sc.gov/watersheds/>
- SCDNR "Geologic Map of South Carolina", March 2012
<https://www.dnr.sc.gov/geology/>
- SCDOT (2022) "Geotechnical Design Manual", Version 3.0;
<https://www.scdot.org/business/pdf/geotech/SCDOT-Geotechnical-Design-Manual-2022.pdf>

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



HDR ENGINEERING INC.
OF THE CAROLINAS

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

SC 72 (Carlisle Chester Hwy) over Coxs Creek

COUNTY

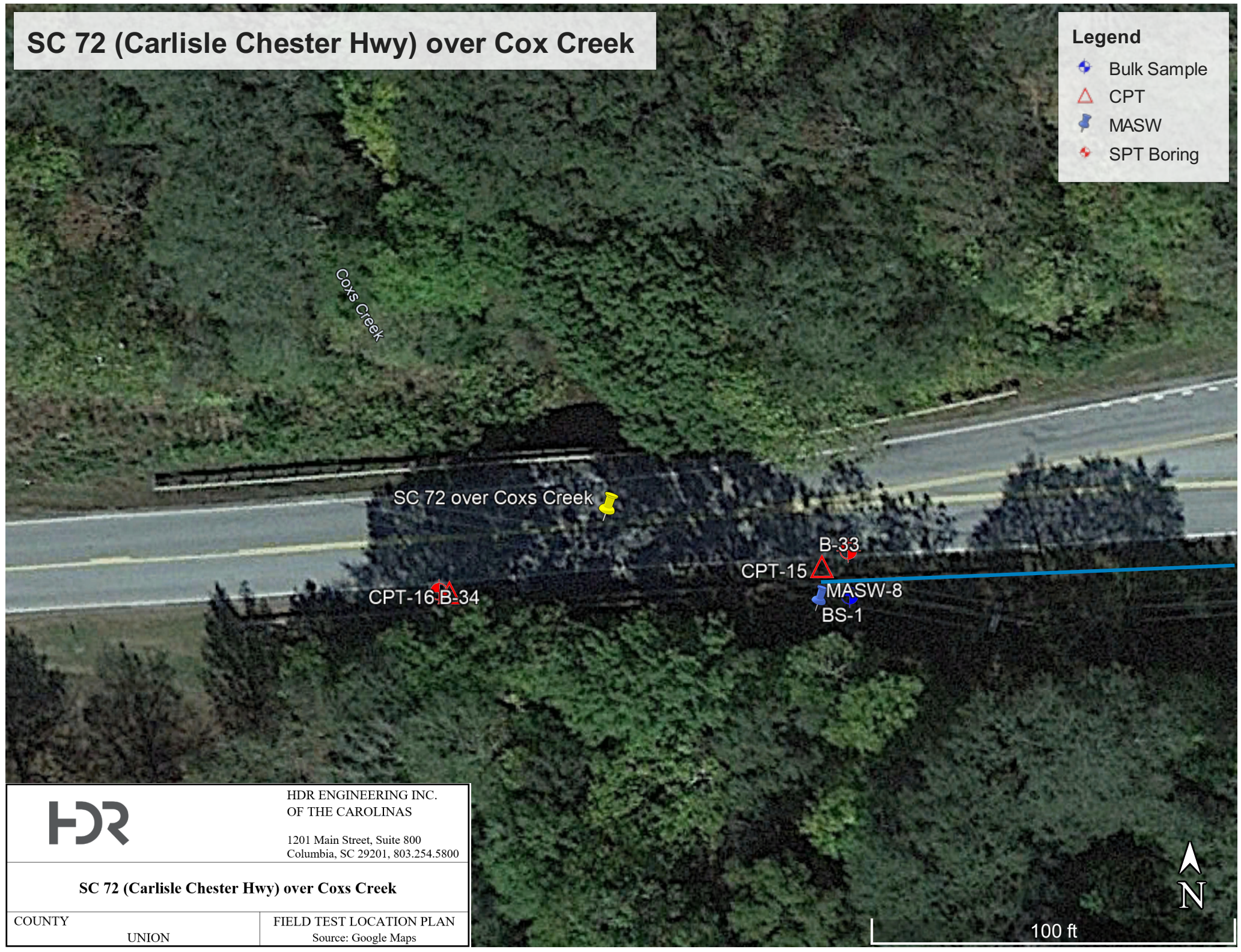
UNION

SITE VICINITY MAP

Source: Google Maps

SC 72 (Carlisle Chester Hwy) over Cox Creek

- Legend**
- Bulk Sample
 - CPT
 - MASW
 - SPT Boring



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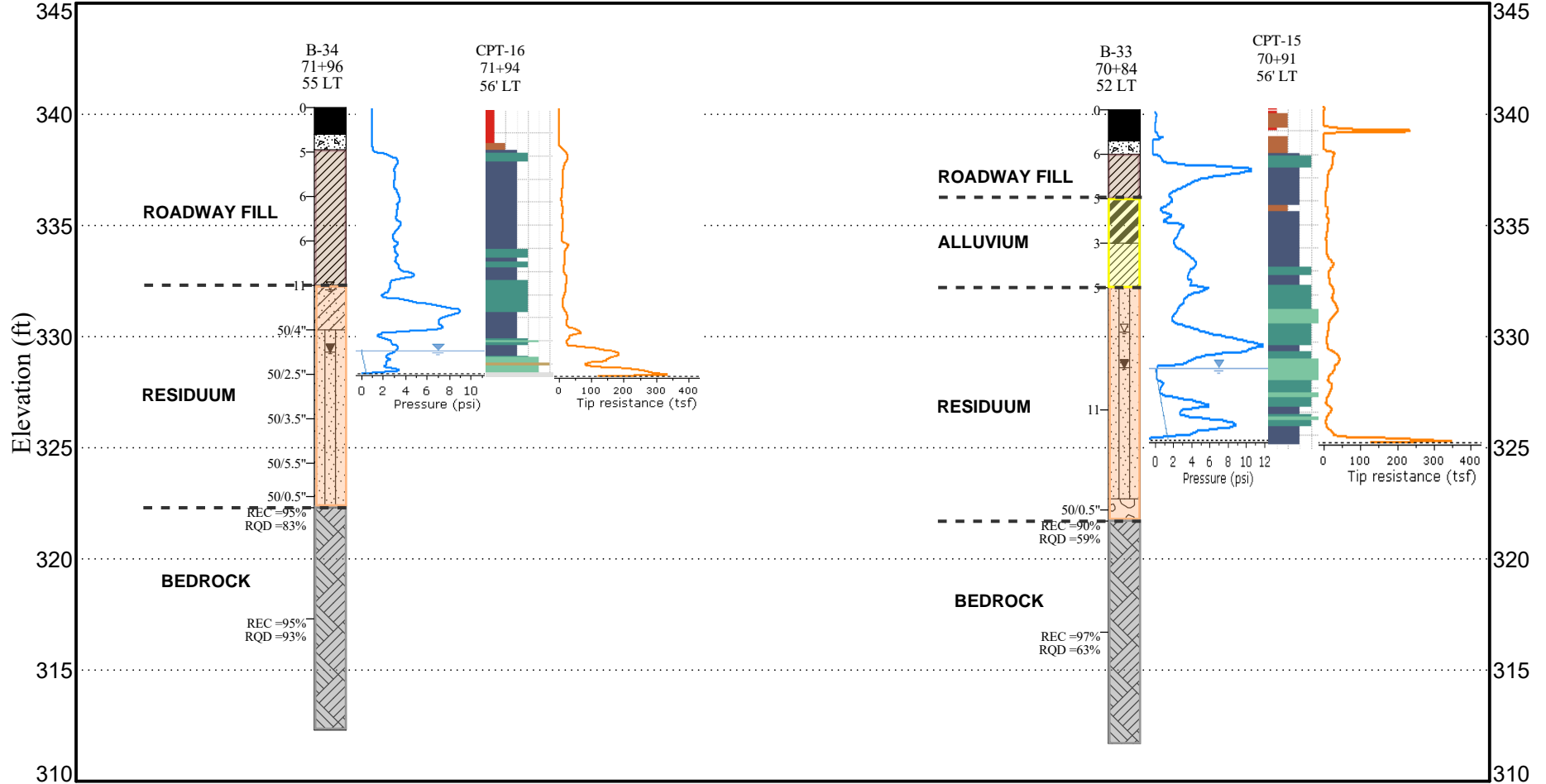
SC 72 (Carlisle Chester Hwy) over Cox Creek

COUNTY
UNION

FIELD TEST LOCATION PLAN
Source: Google Maps



100 ft



| BORING | ELEVATION | STATION | OFFSET |
|--------|-----------|---------|--------|
| B-33 | 340.2 | 70+84 | 52 LT |
| B-34 | 340.3 | 71+96 | 55 LT |
| | | | |
| | | | |
| | | | |
| | | | |

| | |
|--|--|
| | Roadway Fill - Sandy Lean Clay (CL/A-6) |
| | Alluvium - Sandy Fat Clay, Lean Clay with sand (CH, CL/A-7-6, A-6) |
| | Residuum - Clayey Sand, Silty Sand, Poorly-graded Gravel (SC, SM, GP/A-4, A-2-4, A-1-a) |
| | Bedrock - Granodiorite |



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OF THE CAROLINAS

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SUBSURFACE PROFILE

SC 72 over Coxs Creek
Union, SC County, South Carolina

PROJECT ID.
P041235

DATE
Feb 2023

PLATE
1

Appendix B. Boring Logs, Rock Core Photos, CPT Logs, MASW Profile

SOIL CLASSIFICATION CHART

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

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

SCDOT Soil Test Log Descriptors

a

-

Relative Density / Consistency Terms

| Relative Density ¹ | | | Consistency ² | | |
|-------------------------------|------------------|----------------|--------------------------|---|----------------|
| Descriptive Term | Relative Density | SPT Blow Count | Descriptive Term | Unconfined Compression Strength (q _u) (tsf) | SPT Blow Count |
| Very Loose | 0 to 15% | < 4 | Very Soft | <0.25 | <2 |
| Loose | 16 to 35% | 5 to 10 | Soft | 0.26 to 0.50 | 3 to 4 |
| Medium Dense | 36 to 65% | 11 to 30 | Firm | 0.51 to 1.00 | 5 to 8 |
| Dense | 66 to 85% | 31 to 50 | Stiff | 1.01 to 2.00 | 9 to 15 |
| Very Dense | 86 to 100% | >51 | Very Stiff | 2.01 to 4.00 | 16 to 30 |
| | | | Hard | >4.01 | > 31 |

b

Moisture Condition

| Descriptive Term | Criteria |
|------------------|---|
| Dry | Absence of moisture, dusty, dry to the touch |
| Moist | Damp but no visible water |
| Wet | Visible free water, usually in coarse-grained soils below the water table |

c

Color

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

d

Angularity¹

| Descriptive Term | Criteria |
|------------------|--|
| Angular | Particles have sharp edges and relatively plane sides with unpolished surfaces |
| Subangular | Particles are similar to angular description but have rounded edges |
| Subrounded | Particles have nearly plane sides but have well-rounded corners and edges |
| Rounded | Particles have smoothly curved sides and no edges |

e

HCl Reaction³

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

f

Cementation³

| Descriptive Term | Criteria |
|---------------------|--|
| Weakly Cemented | Crumbles or breaks with handling or little finger pressure |
| Moderately Cemented | Crumbles or breaks with considerable finger pressure |
| Strongly Cemented | Will not crumble or break with finger pressure |

g

Particle-Size Range¹

| Gravel | | Sand | |
|--------|--------------|--------|---------------|
| mm | Sieve size | mm | Sieve size |
| Fine | 4.76 to 19.1 | Fine | 0.074 to 0.42 |
| Coarse | 19.1 to 76.2 | Medium | 0.42 to 2.00 |
| | | Coarse | 4.00 to 4.76 |

h

Primary Soil Type^{1,2}

The primary soil type will be shown in all capital letters

i

USCS Soil Designation

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

j

AASHTO Soil Designation

Indicate AASHTO soil designation as defined in AASHTO M-145 and ASTM D-3282

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

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

³Use as required

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

SCDOT Soil Test Log Descriptors

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

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

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

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

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

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

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

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

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

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

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

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

q**Strike and Dip**

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

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

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

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

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

x**Roughness of Surface**

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

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

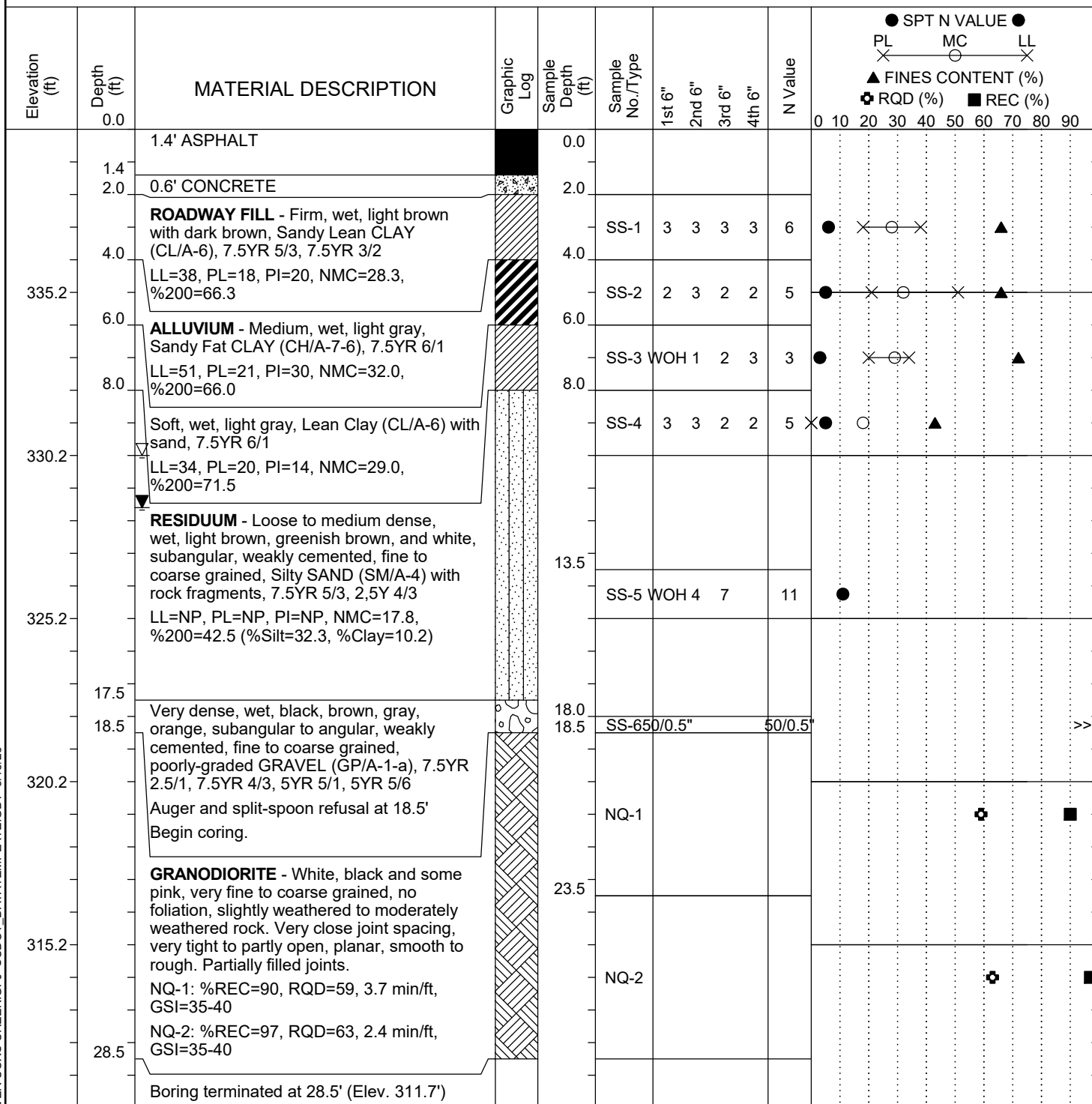


Appendix B. Subsurface Investigation

Boring Logs

SCDOT Soil Test Log

| | | | | | |
|---------------------------------|-----------------------|------------------------------|----------------|------------------------|-------------|
| Project ID: | P041235 | County: | Union, SC | Boring No.: | B-33 |
| Site Description: | SC 72 over Coxs Creek | | | Route: | SC 72 |
| Eng./Geo.: | B. Gedney/HDR | Boring Location: | 70+84 | Offset: | 52 LT |
| Elev.: | 340.2 ft | Latitude: | 34.59537 | Longitude: | -81.44177 |
| Date Started: | 11/21/2022 | | | | |
| Total Depth: | 28.5 ft | Soil Depth: | 18.5 ft | Core Depth: | 10.0 ft |
| Date Completed: | 11/21/2022 | | | | |
| Bore Hole Diameter (in): | 2.97" | Sampler Configuration | | Liner Required: | Y (N) |
| Liner Used: | Y (N) | | | | |
| Drill Machine: | CME 45B | Drill Method: | RW/NQ | Hammer Type: | Automatic |
| Energy Ratio: | 81.4% | | | | |
| Core Size: | NQ | Driller: | D. Harris/F&ME | Groundwater: | TOB 10.0 ft |
| 24HR | 11.6 ft | | | | |



LEGEND

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

SC DOT SC 72 OVER COXS CREEK.GPJ SCDOT_DATATEMPLATE.GDT 3/15/23

Rock Core Photos

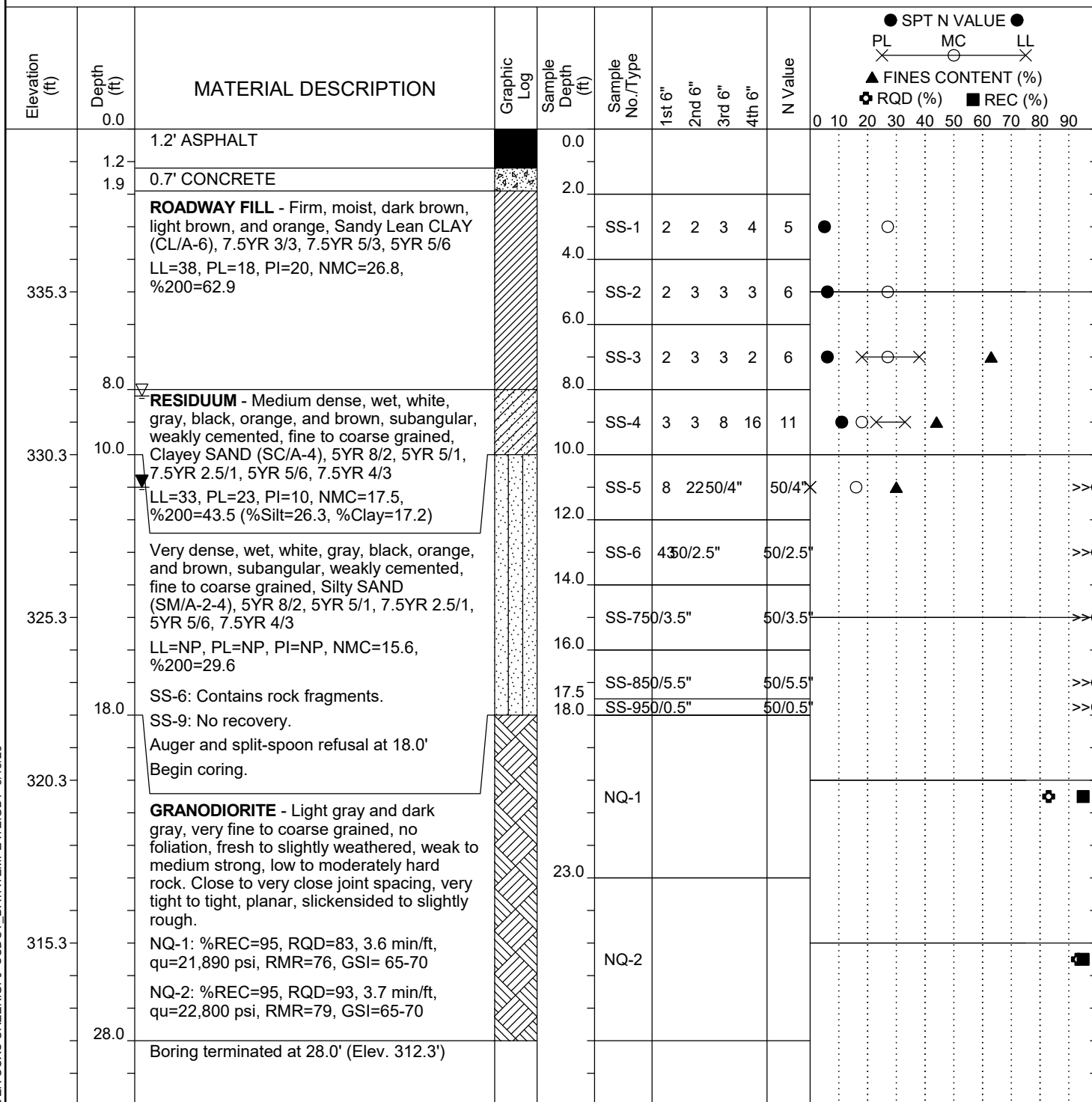
B-33

Box 1 of 1 (18.5' to 28.5')



SCDOT Soil Test Log

| | | | | | |
|---------------------------------|-----------------------|------------------------------|----------------|------------------------|------------|
| Project ID: | P041235 | County: | Union, SC | Boring No.: | B-34 |
| Site Description: | SC 72 over Coxs Creek | | | Route: | SC 72 |
| Eng./Geo.: | B. Gedney/HDR | Boring Location: | 71+96 | Offset: | 55 LT |
| Elev.: | 340.3 ft | Latitude: | 34.59534 | Longitude: | -81.44214 |
| Date Started: | 11/21/2022 | | | | |
| Total Depth: | 28 ft | Soil Depth: | 18.0 ft | Core Depth: | 10.0 ft |
| Date Completed: | 11/21/2022 | | | | |
| Bore Hole Diameter (in): | 2.97" | Sampler Configuration | | Liner Required: | Y (N) |
| Liner Used: | Y (N) | | | | |
| Drill Machine: | CME 45B | Drill Method: | RW/NQ | Hammer Type: | Automatic |
| Energy Ratio: | 81.4% | | | | |
| Core Size: | NQ | Driller: | D. Harris/F&ME | Groundwater: | TOB 8.2 ft |
| 24HR | 11 ft | | | | |



LEGEND

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

SC DOT SC 72 OVER COXS CREEK.GPJ SCDOT_DATATEMPLATE.GDT 3/15/23

Rock Core Photos
B-34
Box 1 of 1 (18.0' to 28.0')





Appendix B. Subsurface Investigation

CPT Logs

Total depth: 14.83 ft, Date: 11/17/2022

Surface Elevation: 340.10 ft

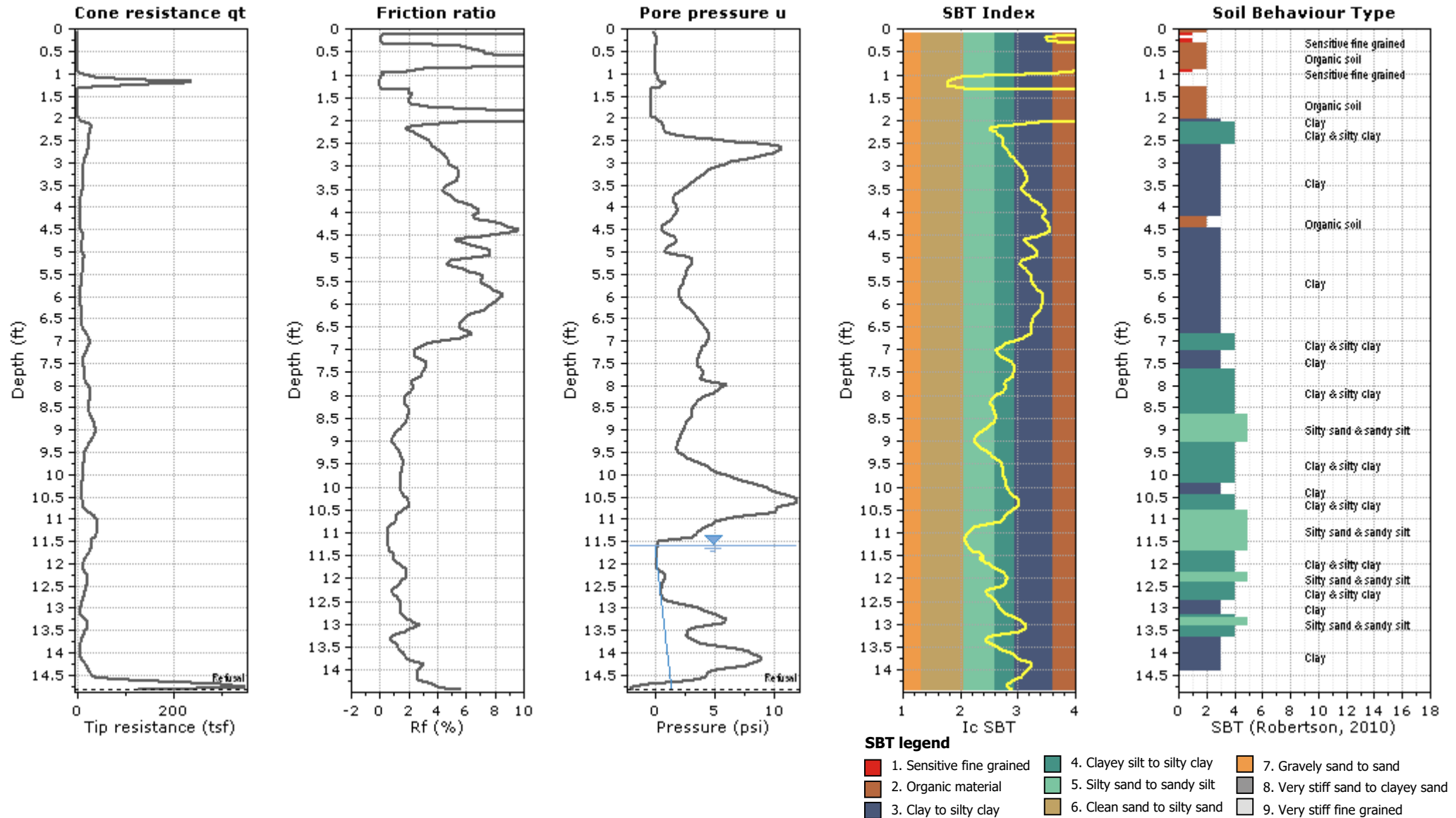
Coords: lat 34.595355° lon -81.441789°

Cone Type: DDG1330

Cone Operator: F&ME Consultants

Project: SC 72 over Cox Creek

Location: Union County, SC



Total depth: 12.05 ft, Date: 11/17/2022

Surface Elevation: 340.30 ft

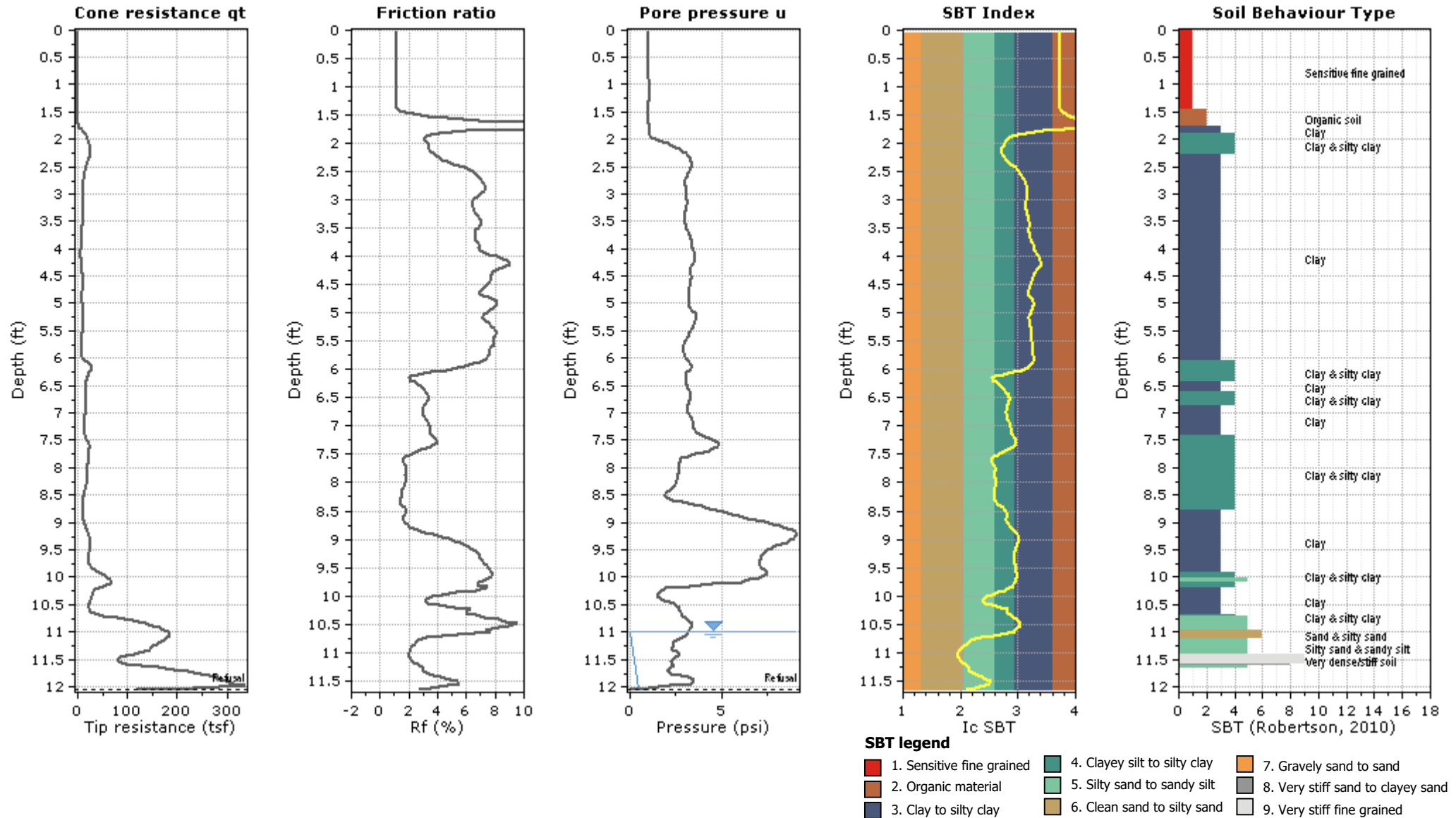
Coords: lat 34.595337° lon -81.442127°

Cone Type: DDG1330

Cone Operator: F&ME Consultants

Project: SC 72 over Cox Creek

Location: Union County, SC





Appendix B. Subsurface Investigation

Multichannel Analysis of Surface Waves (MASW)

February 28, 2023

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

Re: Report of Multi-Channel Analysis of Surface Waves
SC-72 Replacement Bridge over Cox Creek
Union County, South Carolina
F&ME Project No.: G6658.001

Dear Ms. Leon:

On January 17th, 2023, F&ME Consultants performed one (1) Multi-Channel Analysis of Surface Waves (MASW) test near the SC-72 bridge over Cox Creek to determine the average shear wave velocity to a depth of 100 feet at the location. A 16-channel Geometrics ES-3000 seismograph with 4.5 Hz geophones was used for data collection. Active and Passive survey data was obtained using a 225-foot linear array with 16 geophones spaced at 15 feet.

A 16-pound sledge hammer striking an aluminum block and a polyethylene block were used as the energy source for the active survey. Ten (10) active shots were performed at various distances (25, 50, and 100 feet) off the array ends. Resultant vibrations were recorded with a sample rate of 0.5 milliseconds and a recording length of 2 seconds after each hammer blow. The data was stacked five times at each location to minimize the effect of unknown ambient vibrations commonly referred to as noise. The stacking process increases the signal to noise ratio.

The passive survey consisted of the collection of ambient background vibrations, which consisted of drilling equipment. Fifty (50) recordings with a record length of 32 seconds and a sample rate of 2 milliseconds were made during this phase of data acquisition.

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

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



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

| Boring No. | Average Shear Wave Velocity (Vs100) |
|------------|-------------------------------------|
| MASW-8 | 1525.3 ft/sec |

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

Sincerely,

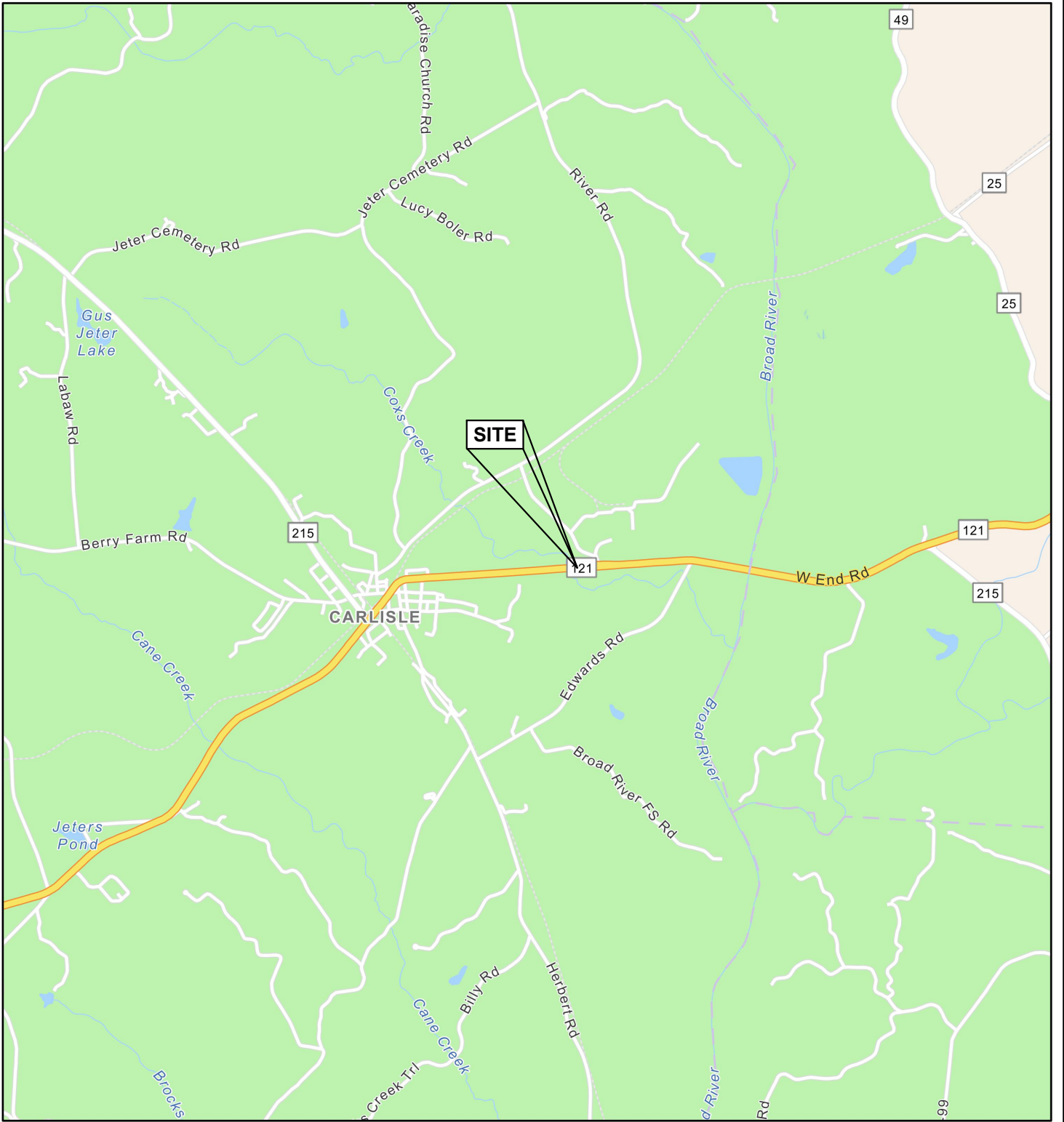
F&ME CONSULTANTS



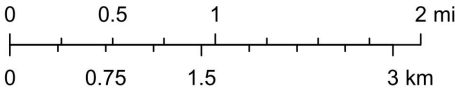
Alex M Chandler, EIT
Geotechnical Staff Professional



John F Hamilton, PE
Geotechnical Design Manager



1:72,000



F&ME CONSULTANTS, INC.
COLUMBIA, SC

| | | | |
|-------|-----|------|-------------------------|
| 4 | | | |
| 3 | | | |
| 2 | | | |
| 1 | | | |
| REV. | BY | DATE | DESCRIPTION OF REVISION |
| TOPO. | | DATE | |
| DWG. | CTC | DATE | 2.20.23 |
| R/W | | DATE | |

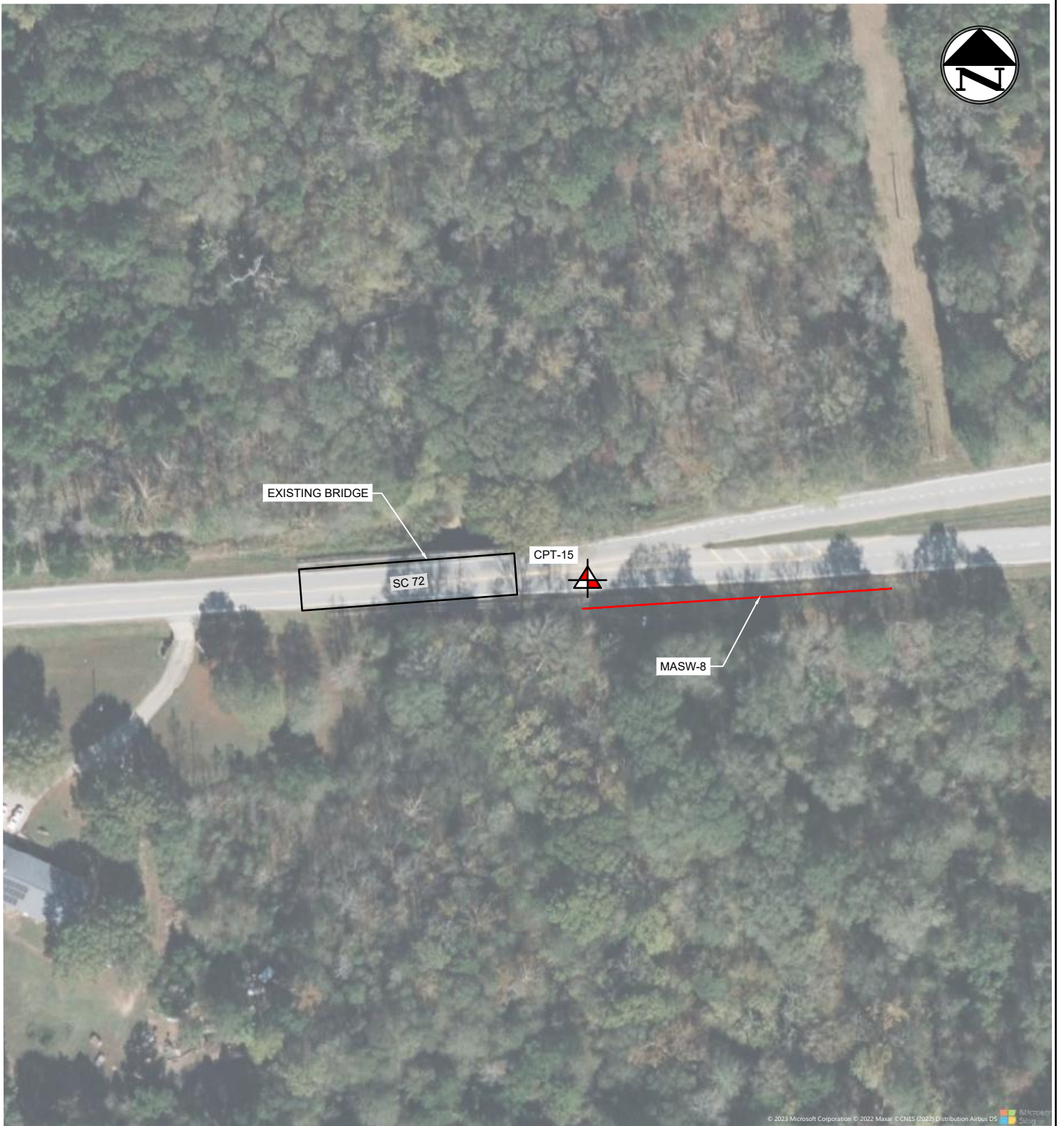
SC 72 OVER COX CREEK
UNION COUNTY, SOUTH CAROLINA

SITE VICINITY MAP

F&ME JOB NO. G6658.001

SCALE: AS NOTED

FIGURE 1



© 2023 Microsoft Corporation © 2022 Maxar © CNES (2023) Distribution Airbus DS



F&ME CONSULTANTS, INC.
COLUMBIA, SC

| | | | |
|-------|-----|--------------|-------------------------|
| 4 | | | |
| 3 | | | |
| 2 | | | |
| 1 | | | |
| REV. | BY | DATE | DESCRIPTION OF REVISION |
| TOPO. | | DATE | |
| DWG. | CTC | DATE 2.20.23 | GROUP ____ - ____ |
| R/W | | DATE | |

SC 72 OVER COX CREEK
UNION COUNTY, SOUTH CAROLINA

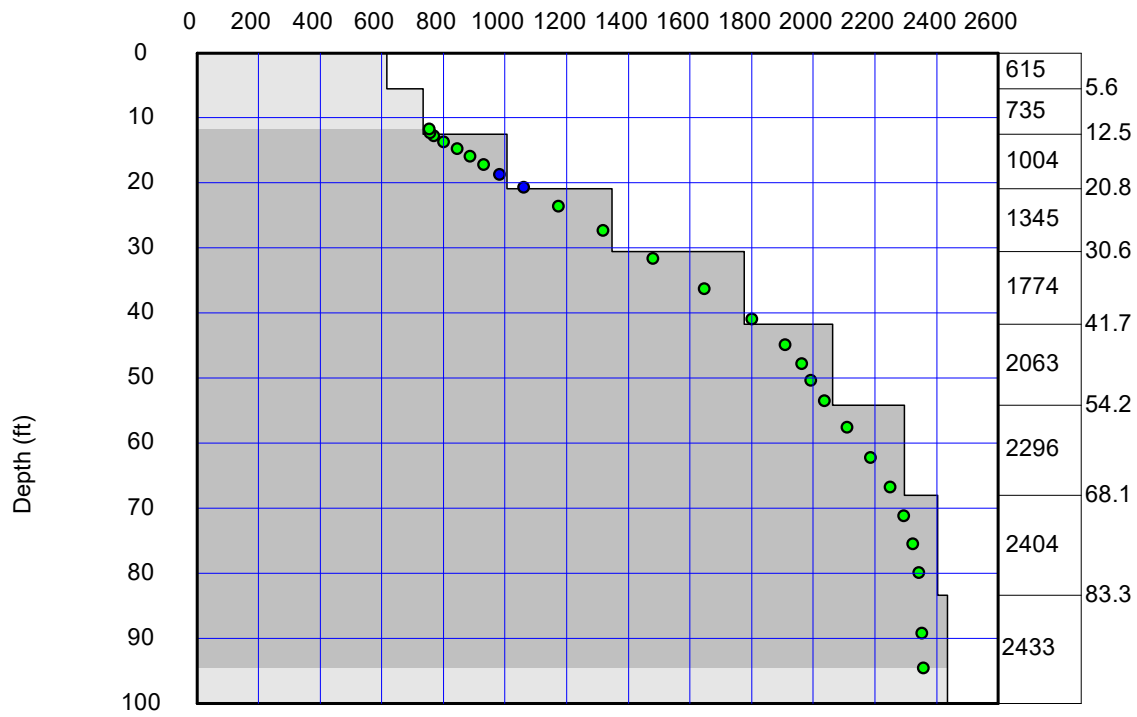
MASW LOCATION PLAN

F&ME JOB NO. G6658.001

SCALE: 1"=100'

FIGURE 2

S-wave velocity (ft/s)



S-wave velocity model (initial) : SC72RBOCoxCreek.rst

Average Vs 100ft = 1525.3 ft/sec

Appendix C. Laboratory Testing



SUMMARY OF LABORATORY RESULTS

PAGE 1 OF 1

PROJECT ID P041235

PROJECT NAME SC 72 over Coxs Creek

PROJECT COUNTY Union, SC

| Borehole | Depth | Liquid Limit | Plastic Limit | Plasticity Index | Maximum Size (mm) | %<#200 Sieve | Classification | Water Content (%) | Dry Density (pcf) | Saturation (%) | Void Ratio |
|----------|-------|--------------|---------------|------------------|-------------------|--------------|----------------|-------------------|-------------------|----------------|------------|
| B-33 | 2.0 | 38 | 18 | 20 | 0.075 | 66 | CL | 28.3 | | | |
| B-33 | 4.0 | 51 | 21 | 30 | 0.075 | 66 | CH | 32.0 | | | |
| B-33 | 6.0 | 34 | 20 | 14 | 0.075 | 72 | CL | 29.0 | | | |
| B-33 | 8.0 | NP | NP | NP | 0.075 | 43 | SM | 17.8 | | | |
| B-34 | 6.0 | 38 | 18 | 20 | 0.075 | 63 | CL | 26.8 | | | |
| B-34 | 8.0 | 33 | 23 | 10 | 0.075 | 44 | SC | 17.5 | | | |
| B-34 | 10.0 | NP | NP | NP | 0.075 | 30 | SM | 15.6 | | | |

Rock Coring Summary

PAGE 1 OF 1



PROJECT ID P041235

PROJECT NAME SC 72 over Coxs Creek

PROJECT COUNTY Union, SC

| Borehole | Core Run Number | Core Run Top Depth | REC (%) | RQD (%) | q _u (psi) | Poisson's Ratio | Secant Modulus (ksi) | Unit Weight (pcf) | RMR | GSI |
|----------|-----------------|--------------------|---------|---------|----------------------|-----------------|----------------------|-------------------|-----|-----|
| B-33 | NQ-1 | 18.5 | 90 | 59 | | | | | | 38 |
| B-33 | NQ-2 | 23.5 | 97 | 63 | | | | | | 38 |
| B-34 | NQ-1 | 18.0 | 95 | 83 | 21890 | 0.24 | 11700 | 181 | 76 | 68 |
| B-34 | NQ-2 | 23.0 | 95 | 93 | 22800 | 0.31 | 11400 | 181 | 79 | 68 |



INDEX PROPERTIES VERSUS DEPTH

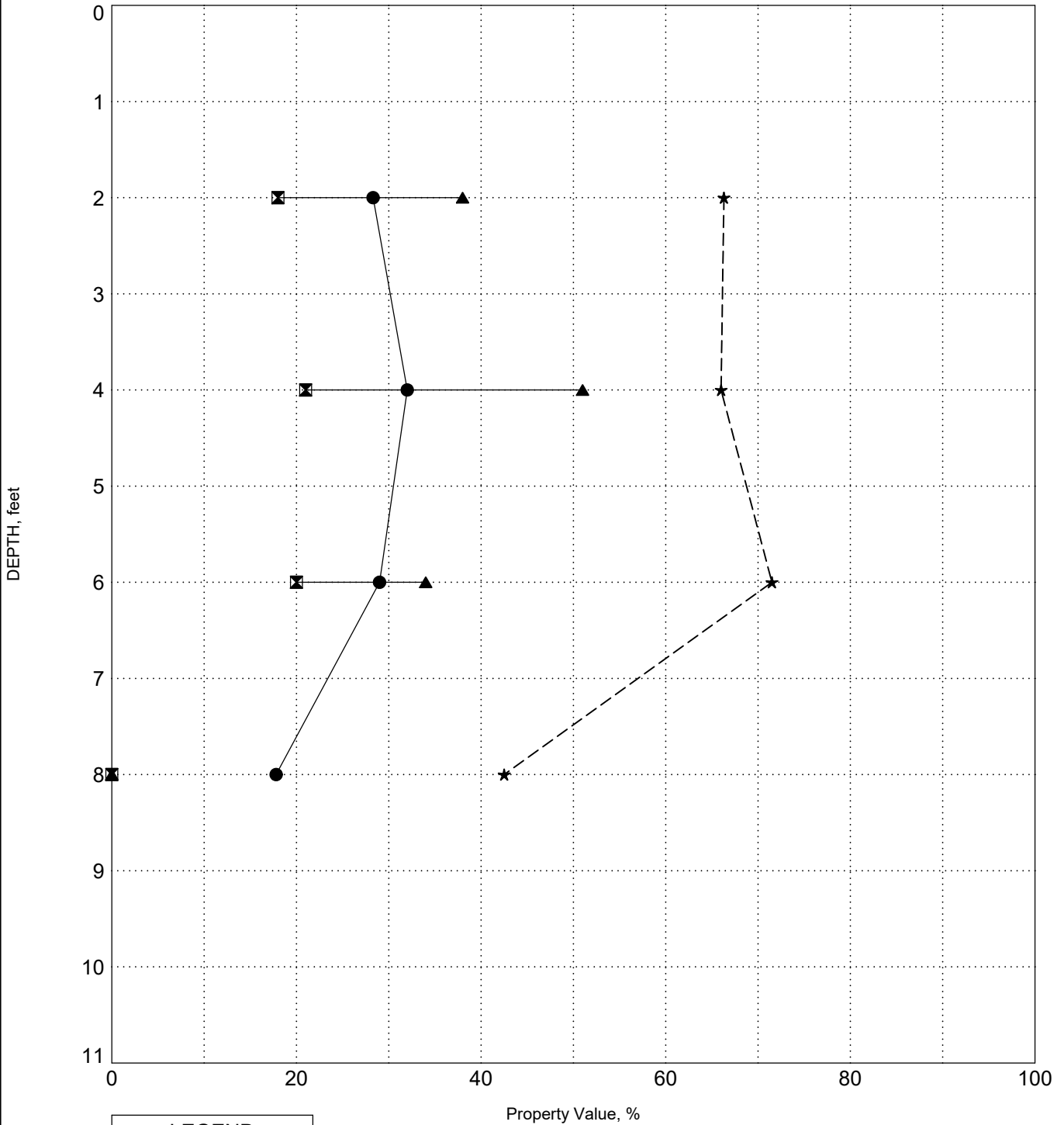
PROJECT ID P041235

PROJECT NAME SC 72 over Coxs Creek

PROJECT COUNTY Union, SC

SURFACE ELEVATION: 340.2

BORING B-33



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



INDEX PROPERTIES VERSUS DEPTH

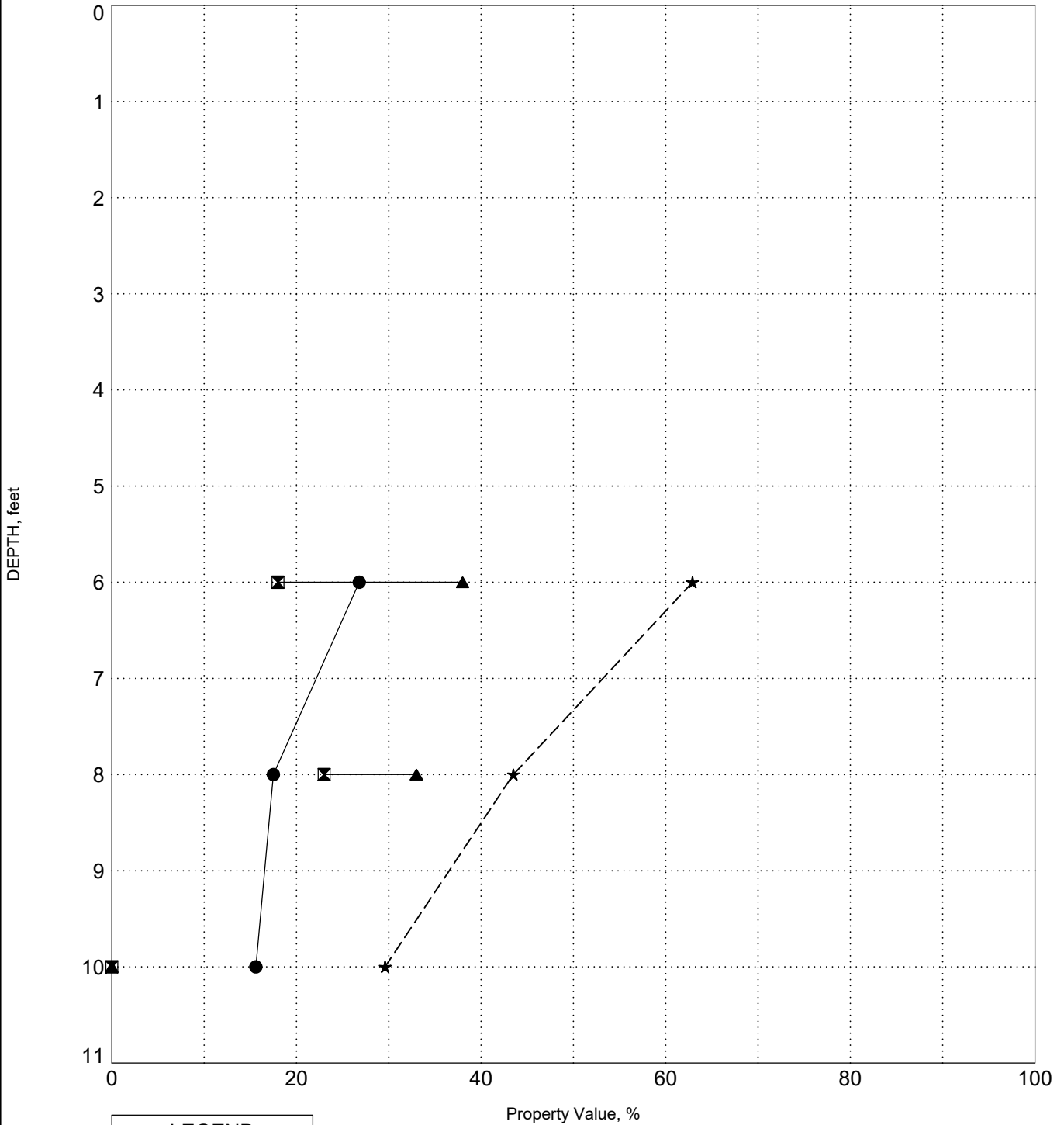
PROJECT ID P041235

PROJECT NAME SC 72 over Coxs Creek

PROJECT COUNTY Union, SC

SURFACE ELEVATION: 340.3

BORING B-34



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



Laboratory Testing Procedures

Grain Size Distribution

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

Hydrometer

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

Atterberg Limits

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

Moisture Content

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

Standard Proctor

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

Consolidated-Undrained Triaxial Test

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

Corrosion Series

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

Compressive Strength of Rock Cores

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



Appendix C. Laboratory Testing

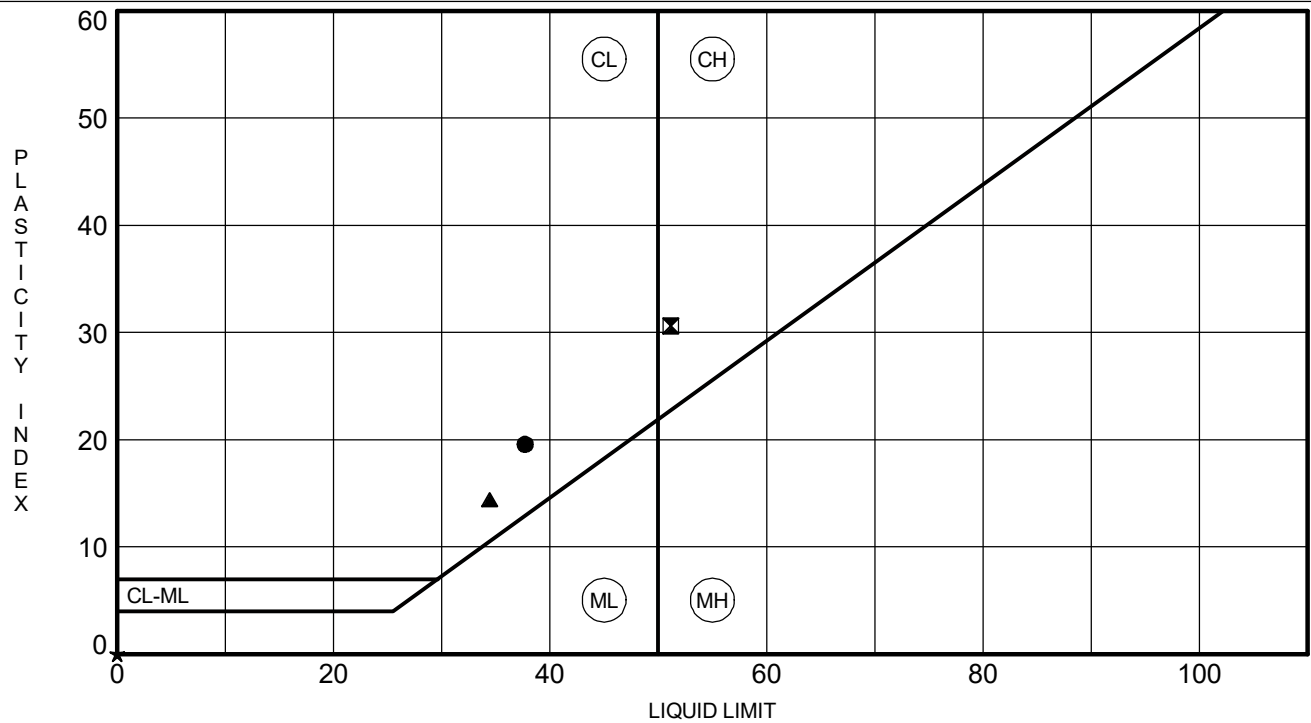
Split Spoon Samples



PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC

[illegible]

ATTERBERG LIMITS G6658.001 - SC-72 RBO COX CREEK.GPJ SCDOT DATA TEMPLATE 01 30 2015.GDT 1/10/23

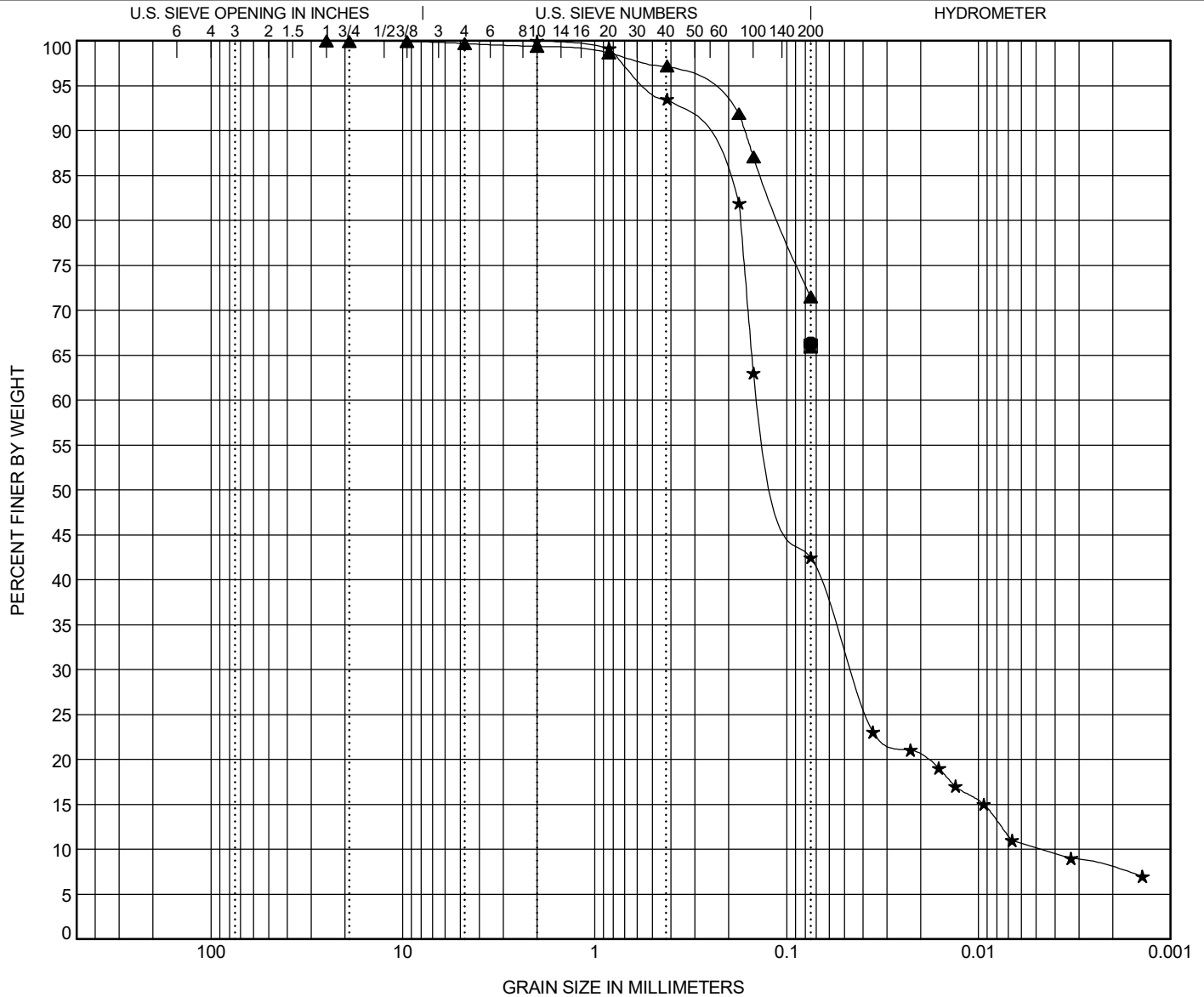


GRAIN SIZE DISTRIBUTION

PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC



F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 72 RBO Cox Creek **SCDOT PROJECT ID:** P041235
SAMPLE NUMBER: 22-3262 **DATE SAMPLE RECEIVED:** 12/15/2022
DESCRIPTION OF SOIL: VARIOUS
TESTED BY: CM & DH **DATE SETUP:** 12/16/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 12/19/2022

| | | | | | |
|--------------------|-----------|-----------|-----------|------------|--|
| BORING NO. | B-33 | B-33 | B-33 | B-33 | |
| SAMPLE NO. | SS-2 | SS-3 | SS-4 | SS-5 | |
| SAMPLE DEPTH (FT.) | 2.0 - 4.0 | 4.0 - 6.0 | 6.0 - 8.0 | 8.0 - 10.0 | |
| WATER CONTENT, W% | 28.3 | 32.0 | 29.0 | 17.8 | |

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

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

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



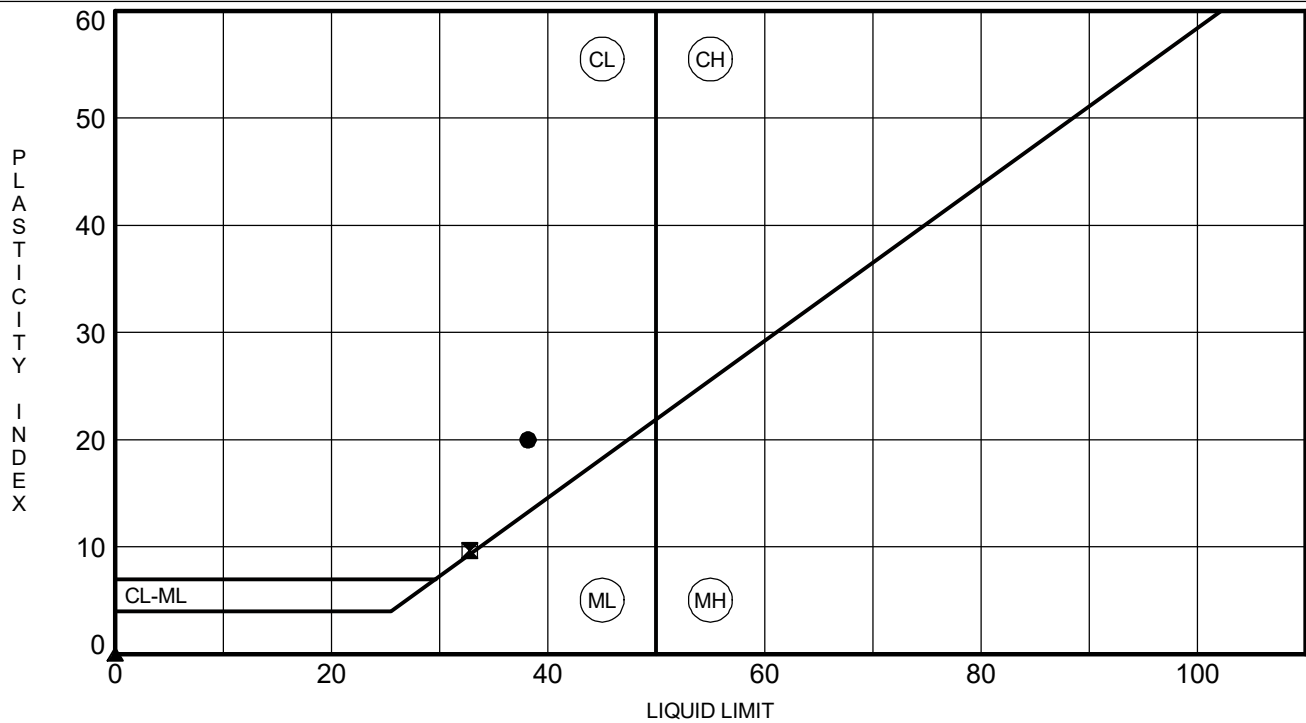
This report shall not be reproduced, except in full, without the written approval of F&ME Consultants, Inc.
211 Business Park Blvd., Columbia, SC 29203

ATTERBERG LIMITS' RESULTS

PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC

[illegible]

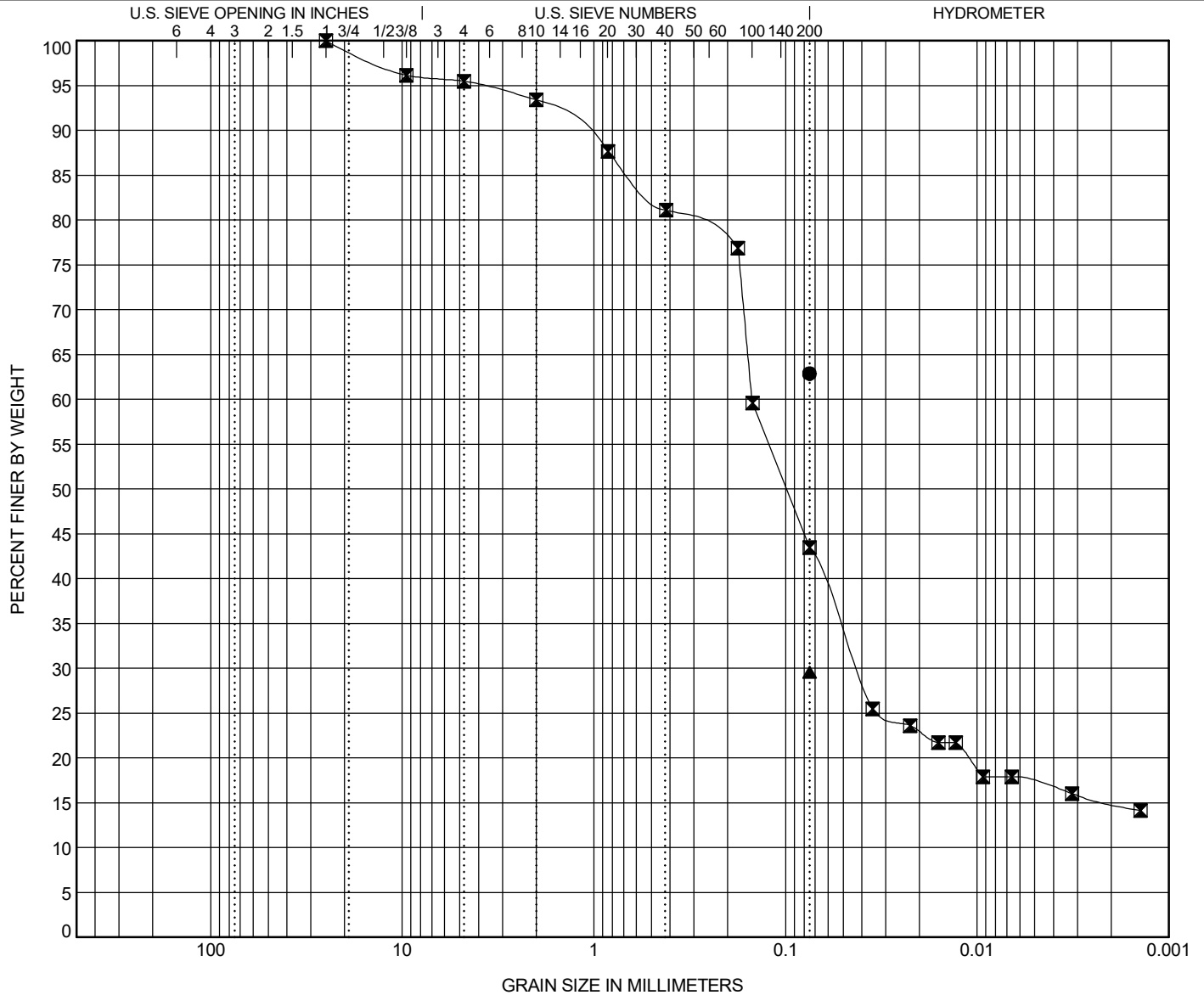


GRAIN SIZE DISTRIBUTION

PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC



| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---------|--------|------|--------|--------|------|--------------|
| | coarse | fine | coarse | medium | fine | |

| BOREHOLE | DEPTH | Classification | | | | | LL | PL | PI | Cc | Cu |
|----------|-------|--------------------------|------|-------|-----|---------|-------|-------|----|-------|----|
| ● B-34 | 8.0 | SANDY LEAN CLAY (CL/A-6) | | | | | 38 | 18 | 20 | | |
| ☒ B-34 | 10.0 | CLAYEY SAND (SC/A-4) | | | | | 33 | 23 | 10 | | |
| ▲ B-34 | 12.0 | SILTY SAND (SM/A-2-4) | | | | | NP | NP | NP | | |
| | | | | | | | | | | | |
| BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | | %Clay | |
| ● B-34 | 8.0 | 0.075 | | | | | | 62.9 | | | |
| ☒ B-34 | 10.0 | 25 | 0.15 | 0.042 | | 4.5 | 52.0 | 26.3 | | 17.2 | |
| ▲ B-34 | 12.0 | 0.075 | | | | | | 29.6 | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 72 RBO Cox Creek **SCDOT PROJECT ID:** P041235
SAMPLE NUMBER: 22-3263 **DATE SAMPLE RECEIVED:** 12/15/2022
DESCRIPTION OF SOIL: VARIOUS
TESTED BY: CM & DH **DATE SETUP:** 12/16/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 12/19/2022

| | | | | | |
|--------------------|----------------|------------|-------------|--|--|
| BORING NO. | B-34 | B-34 | B-34 | | |
| SAMPLE NO. | SS-2/SS-3/SS-4 | SS-5 | SS-6 | | |
| SAMPLE DEPTH (FT.) | 2.0 - 8.0 | 8.0 - 10.0 | 10.0 - 12.0 | | |
| WATER CONTENT, W% | 26.8 | 17.5 | 15.6 | | |

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

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

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



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211 Business Park Blvd., Columbia, SC 29203



January 16, 2023

Project No. 2022-896-001

Mr. Alex Abernethy
F&ME Consultants, Inc.
3112 Devine Street
Columbia, SC 29205

Transmittal
Laboratory Test Results
SC 72 Cox Cr. G6658.001

Please find attached the laboratory test results for the above referenced project. The tests were outlined on the Project Verification Form that was transmitted to your firm prior to the testing. The testing was performed in general accordance with the methods listed on the enclosed data sheets. The test results are believed to be representative of the samples that were submitted for testing and are indicative only of the specimens that were evaluated. We have no direct knowledge of the origin of the samples and imply no position with regard to the nature of the test results, i.e. pass/fail and no claims as to the suitability of the material for its intended use.

The test data and all associated project information provided shall be held in strict confidence and disclosed to other parties only with authorization by our Client. The test data submitted herein is considered integral with this report and is not to be reproduced except in whole and only with the authorization of the Client and Geotechnics. The remaining sample materials for this project will be retained for a minimum of 90 days as directed by the Geotechnics' Quality Program.

We are pleased to provide these testing services. Should you have any questions or if we may be of further assistance, please contact our office.

Respectfully submitted,
Geotechnics, Inc.

Nathan Melaro
Director of Operations

***We understand that you have a choice in your laboratory services
and we thank you for choosing Geotechnics.***

CHLORIDE ION CONTENT IN SOILS

AASHTO T 291 - 94 (2018) (Method B)

Client: F&ME Consultants, Inc.
 Client Reference: SC 72 Cox Cr. G6658.001
 Project No.: 2022-896-001
 Lab ID: 2022-896-001-001

Boring No.: B-34
 Depth (ft): 2.0-8.0'
 Sample No.: SS-2, SS-3 & SS-4
 Description: Brown Soil
 (- # 10 Sieve material)

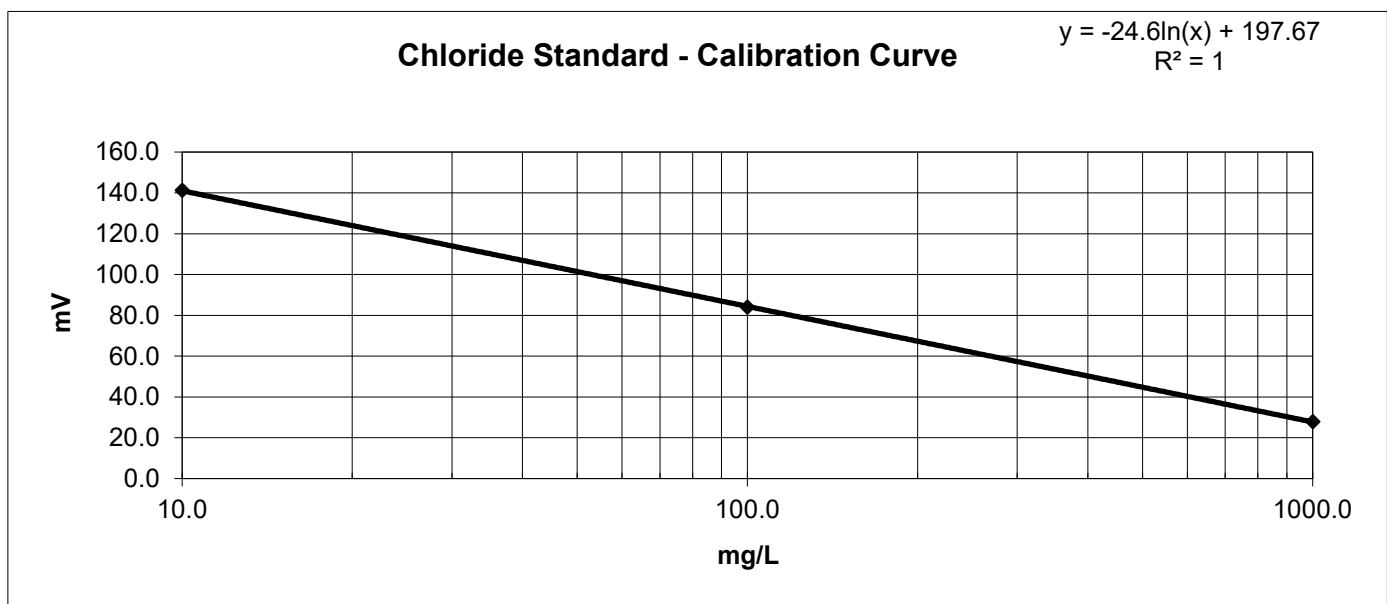
CHLORIDE STANDARD: CALIBRATION CURVE

| STANDARD | MILLIVOLTS (mV) |
|-------------|--------------------|
| 10.0 mg/L | 141.2 |
| 100.0 mg/L | 84.0 |
| 1000.0 mg/L | 27.9 |

MEASUREMENT OF CHLORIDES

| | | | |
|------------------------------|-------|---------------|---------------|
| Sample Weight (g): | 100.0 | CONCENTRATION | CONCENTRATION |
| Water added to Sample (ml): | 100.0 | (mg/L) | (mg/kg) |
| Size of Sample Aliquot (ml): | 25.0 | | |
| Sample Reading (mV): | 93.1 | 70.12 | 70.12 |

Notes: 1) Samples and standards were buffered by the addition of an equal volume of the 0.2 M KNO₃ solution (1:1 volume).
 2) Samples were dried for a minimum of 12 hours at 110 ± 5°C.



Notes:

Tested By JAM Date 1/12/23 Checked By JLK Date 1/13/23

F&ME CONSULTANTS
3112 Devine Street
Columbia, South Carolina 29205

pH Determination
(AASHTO T289)

| | | | |
|---------------------|---------------------------------|---------------------|------------|
| Project Name: | SC 72 RBO Cox Creek | SCDOT Project ID: | P041235 |
| Sample Location: | B-34 | Sample Elev./Depth: | 2.0 - 8.0 |
| Sample Description: | Sandy Lean <u>CLAY (CL/A-6)</u> | Date Sampled: | 12/15/2022 |
| Tested By: | R. Coldiron | Date Tested: | 12/30/2022 |

| | | | | |
|------------------|-----------|--|--|--|
| FME Lab ID No. | 22-3364 | | | |
| Sample ID | B-34 | | | |
| Depth (ft.) | 2.0 - 8.0 | | | |
| pH Value | 6.94 | | | |
| Temperature (°C) | 20.6 | | | |

Date Reviewed: 1/3/2023Reviewed By: J. Hiers

**SOIL RESISTIVITY
(AASHTO T288)**

| | | | |
|-------------------|---------------------------------|-------------------|------------|
| Project Name: | SC 72 RBO Cox Creek | SCDOT Project ID: | P041235 |
| Location: | Union County, SC | FME Lab ID No.: | 22-2793 |
| Sampled By: | HDR | Date Sampled: | 11/23/2022 |
| Soil Description: | Sandy Lean <u>CLAY (CL/A-6)</u> | Date Received: | 11/23/2022 |
| Tested By: | Corey Meyers | Date Tested: | 1/5/2023 |

| Boring No. | Sample Depth (ft.) | Minimum Soil Resistivity, Ω -cm |
|------------|--------------------|---|
| B-34 | 2.0 - 8.0 | 2,484 |

Date Reviewed: 1/10/2023 Reviewed By: J. Hiers

Water-Soluble Sulfate Ion Content in Soil

AASHTO T 290-95 (2020)

Client: F&ME Consultants, Inc.
 Client Reference: SC 72 Cox Cr. G6658.001
 Project No.: 2022-896-001
 Lab ID: 2022-896-001-001

Boring No.: B-34
 Depth (ft): 2.0-8.0'
 Sample No.: SS-2, SS-3 & SS-4
 Soil Description: Brown Soil

Sulfate Standard - Calibration Curve Spectrophotometer Readings

| <u>Sulfate Ion Concentrations (mg/L)</u> | | | | | | | | |
|--|------------|------|------|------|------|------|------|-------|
| 0.0 | 4.0 | 10.0 | 20.0 | 30.0 | 40.0 | 60.0 | 80.0 | 100.0 |
| <u>Spectrophotometer Readings (FAU)</u> | | | | | | | | |
| Underrange | Underrange | 8 | 18 | 36 | 61 | 126 | 165 | 247 |

Measurement of Barium Chloride Turbidity

(Sample contains 5.0 mL NaCl solution and 0.3 g BaCl₂·2H₂O)

Sample Weight (g): 100.0
 Water added to Sample (mL): 300.0
 Size of Sample Aliquot (mL): 50.0
 Sample Reading (FAU): 15

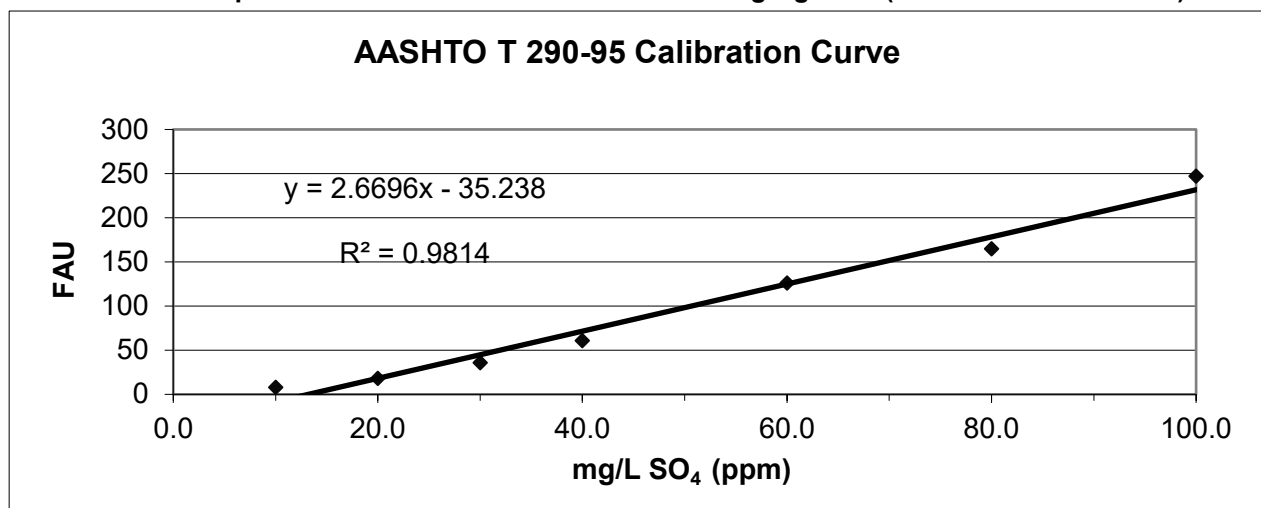
Sample Diluted: No

Sulfate Solution Added (ml): 5

Sample Moisture Content

Tare Number: 552
 Weight of Tare & Wet Sample (g): 184.88
 Weight of Tare & Dry Sample (g): 183.69
 Weight of Tare (g): 80.84
 Weight of Water (g): 1.19
 Weight of Dry Sample (g): 102.85
 Moisture Content (%): 1.16

| | | |
|-----------------------------------|-------|--|
| Sample Sulfate Ion Concentration: | 18.32 | mg/L SO ₄ (ppm) |
| Sample Sulfate Ion Content: | 55.0 | mg/Kg SO ₄ (not corrected for moisture) |
| Sample Sulfate Ion Content: | 55.6 | mg/Kg SO ₄ (corrected for moisture) |



Tested by: JAM Date: 1/13/23 Checked by: BRB Date: 1/16/2023

page 1 of 1 DCN: CT-S87 DATE: 3/5/2020 REVISION: 1



Appendix C. Laboratory Testing

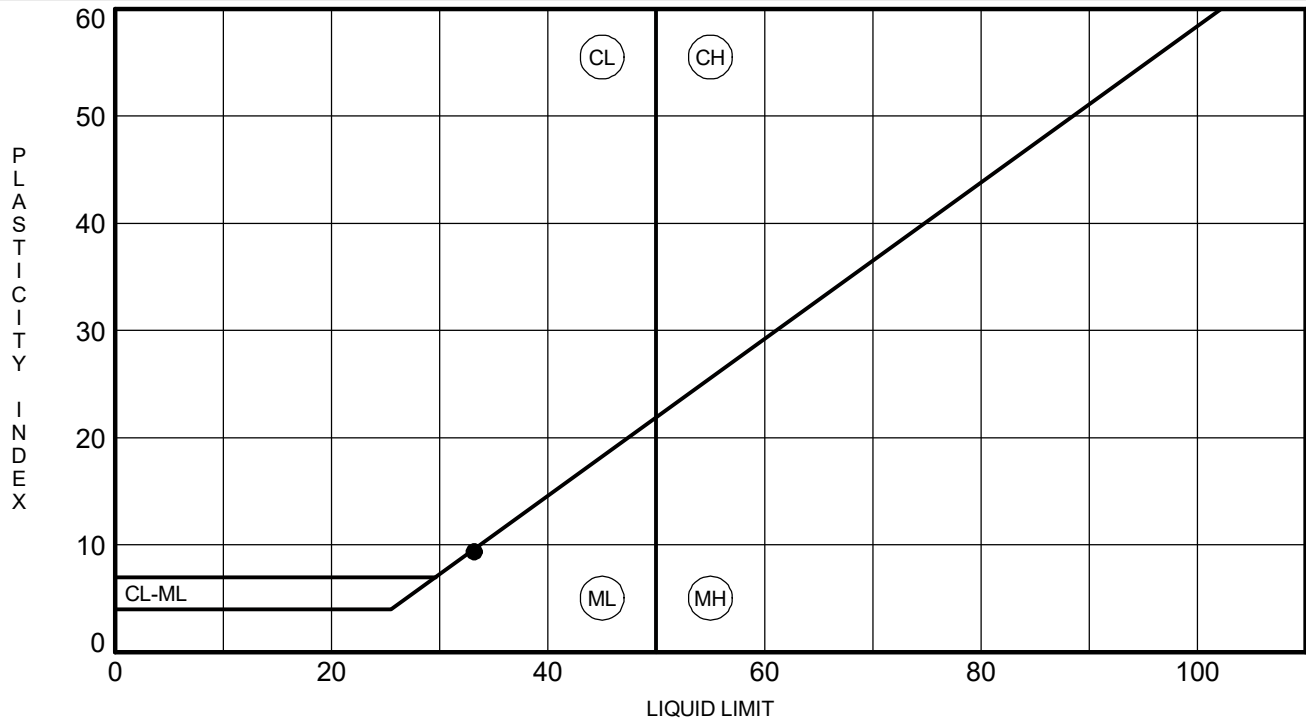
Bulk Samples

ATTERBERG LIMITS' RESULTS

PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC

[illegible]

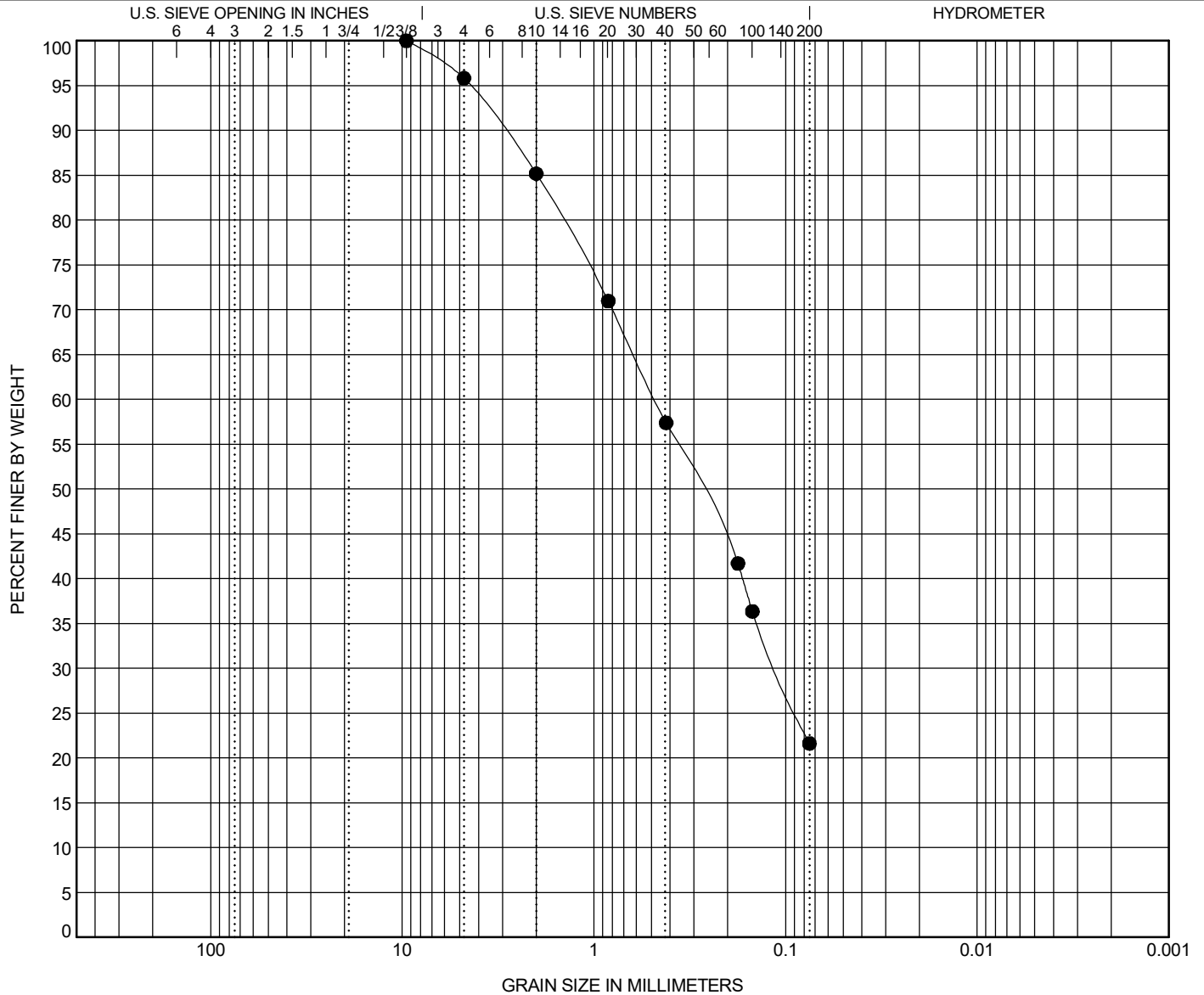


GRAIN SIZE DISTRIBUTION

PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC



| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---------|--------|------|--------|--------|------|--------------|
| | coarse | fine | coarse | medium | fine | |

| BOREHOLE | DEPTH | Classification | | | | | LL | PL | PI | Cc | Cu |
|----------|-------|-----------------------|------|-------|-----|---------|-------|-------|----|-------|----|
| ● BS-1 | 5.0 | SILTY SAND (SM/A-2-4) | | | | | 33 | 24 | 9 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | | %Clay | |
| ● BS-1 | 5.0 | 9.51 | 0.48 | 0.111 | | 4.2 | 74.2 | 21.6 | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 72 RBO Cox Creek **SCDOT PROJECT ID:** P041235
SAMPLE NUMBER: 22-3266 **DATE SAMPLE RECEIVED:** 12/15/2022
DESCRIPTION OF SOIL: Silty SAND (SM/A-2-4)
TESTED BY: CM & DH **DATE SETUP:** 12/16/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 12/19/2022

| | | | | | |
|--------------------|-----------|--|--|--|--|
| BORING NO. | BS-1 | | | | |
| SAMPLE NO. | -- | | | | |
| SAMPLE DEPTH (FT.) | 0.0 - 5.0 | | | | |
| WATER CONTENT, W% | 17.7 | | | | |

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

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

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



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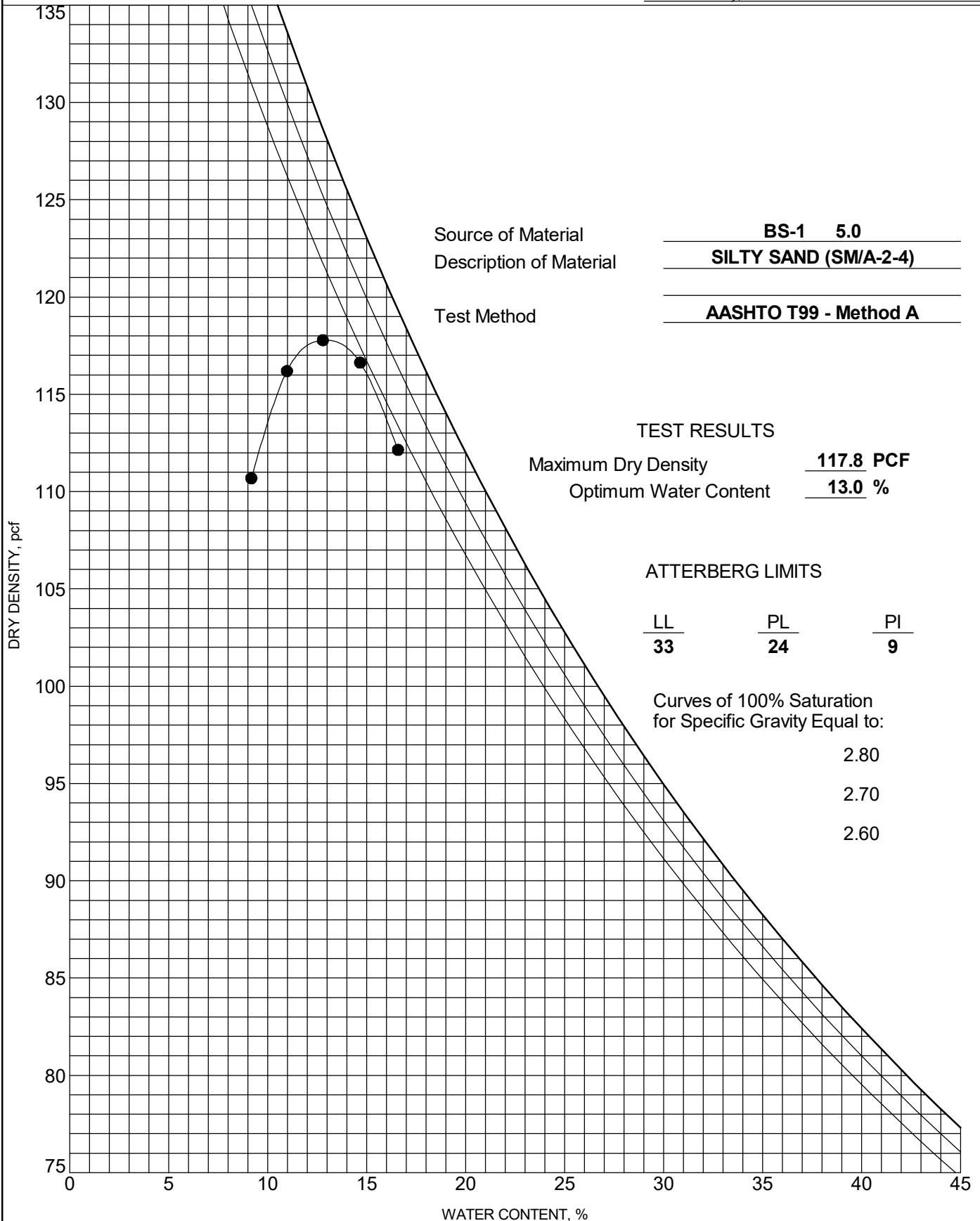


MOISTURE-DENSITY RELATIONSHIP

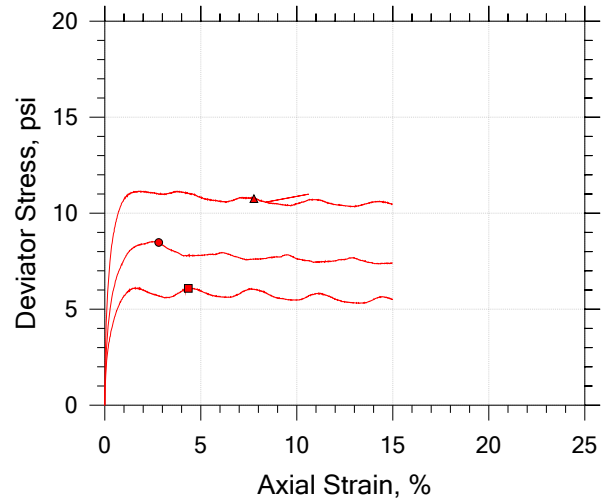
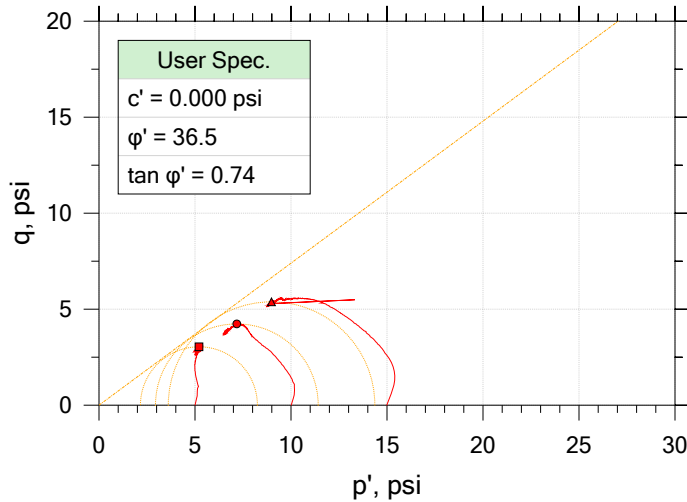
PROJECT ID P041235

PROJECT NAME SC 72 Bridge Replacement over Cox Creek

PROJECT COUNTY Union County, SC



Consolidated Undrained by AASHTO T297

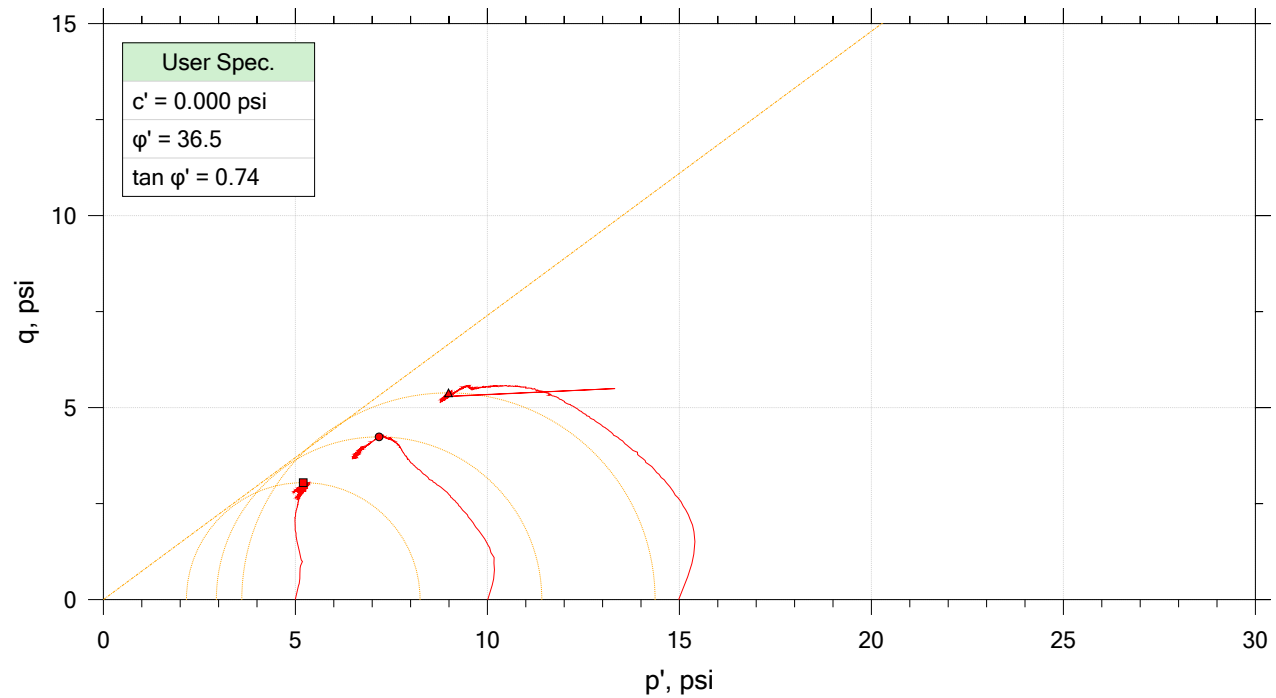
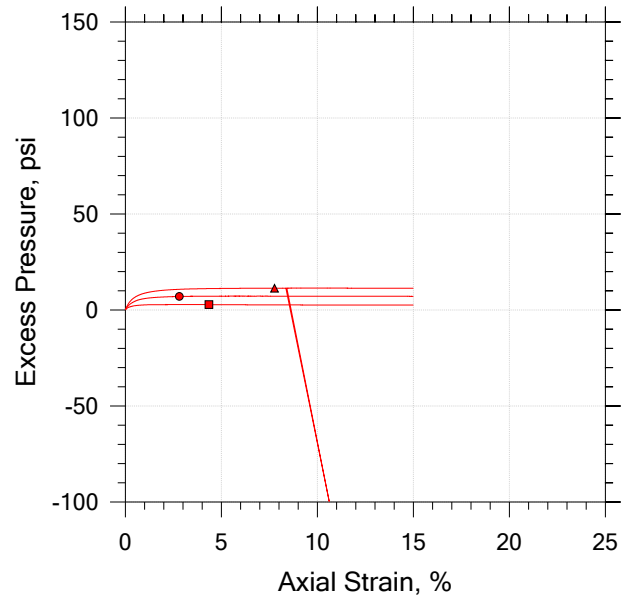
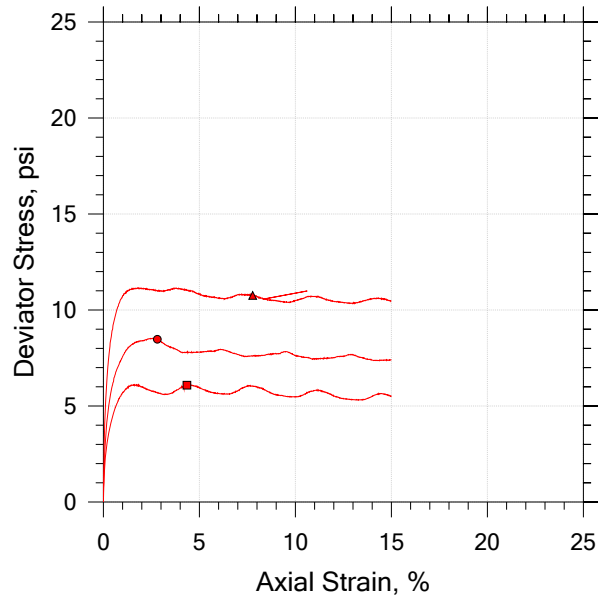


| | | | | |
|--|-------------|-------------|-------------|--|
| Symbol | ■ | ● | ▲ | |
| Sample ID | 22-3266 | 22-3266 | 22-3266 | |
| Depth | 0.0' - 5.0' | 0.0' - 5.0' | 0.0' - 5.0' | |
| Test Number | A | B | C | |
| Initial | | | | |
| Height, in | 6.000 | 6.000 | 6.000 | |
| Diameter, in | 2.800 | 2.800 | 2.800 | |
| Moisture Content (from Cuttings), % | 13.0 | 13.0 | 11.6 | |
| Dry Density, pcf | 112. | 112. | 113. | |
| Saturation (Wet Method), % | 70.0 | 69.8 | 65.1 | |
| Void Ratio | 0.497 | 0.498 | 0.479 | |
| Final | | | | |
| Moisture Content, % | 17.2 | 16.5 | 14.9 | |
| Dry Density, pcf | 115. | 116. | 120. | |
| Cross-Sectional Area (Method A), in ² | 6.035 | 5.975 | 5.906 | |
| Saturation, % | 100.0 | 100.0 | 100.0 | |
| Void Ratio | 0.461 | 0.441 | 0.400 | |
| Back Pressure, psi | 83.00 | 101.0 | 101.0 | |
| Vertical Effective Consolidation Stress, psi | 4.980 | 9.960 | 14.91 | |
| Horizontal Effective Consolidation Stress, psi | 4.999 | 10.01 | 14.98 | |
| Vertical Strain after Consolidation, % | 0.2029 | 0.7197 | 1.054 | |
| Volumetric Strain after Consolidation, % | 1.832 | 3.407 | 4.603 | |
| Time to 50% Consolidation, min | 0.8000 | 0.6000 | 2.000 | |
| Shear Strength, psi | 3.044 | 4.238 | 5.382 | |
| Strain at Failure, % | 4.35 | 2.81 | 7.77 | |
| Strain Rate, %/min | 0.05000 | 0.05000 | 0.05000 | |
| Deviator Stress at Failure, psi | 6.087 | 8.477 | 10.76 | |
| Effective Minor Principal Stress at Failure, psi | 2.160 | 2.939 | 3.603 | |
| Effective Major Principal Stress at Failure, psi | 8.247 | 11.42 | 14.37 | |
| B-Value | 0.95 | 0.95 | 0.95 | |


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

| | | | |
|--|--|------------------------|---------------------------|
| | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |

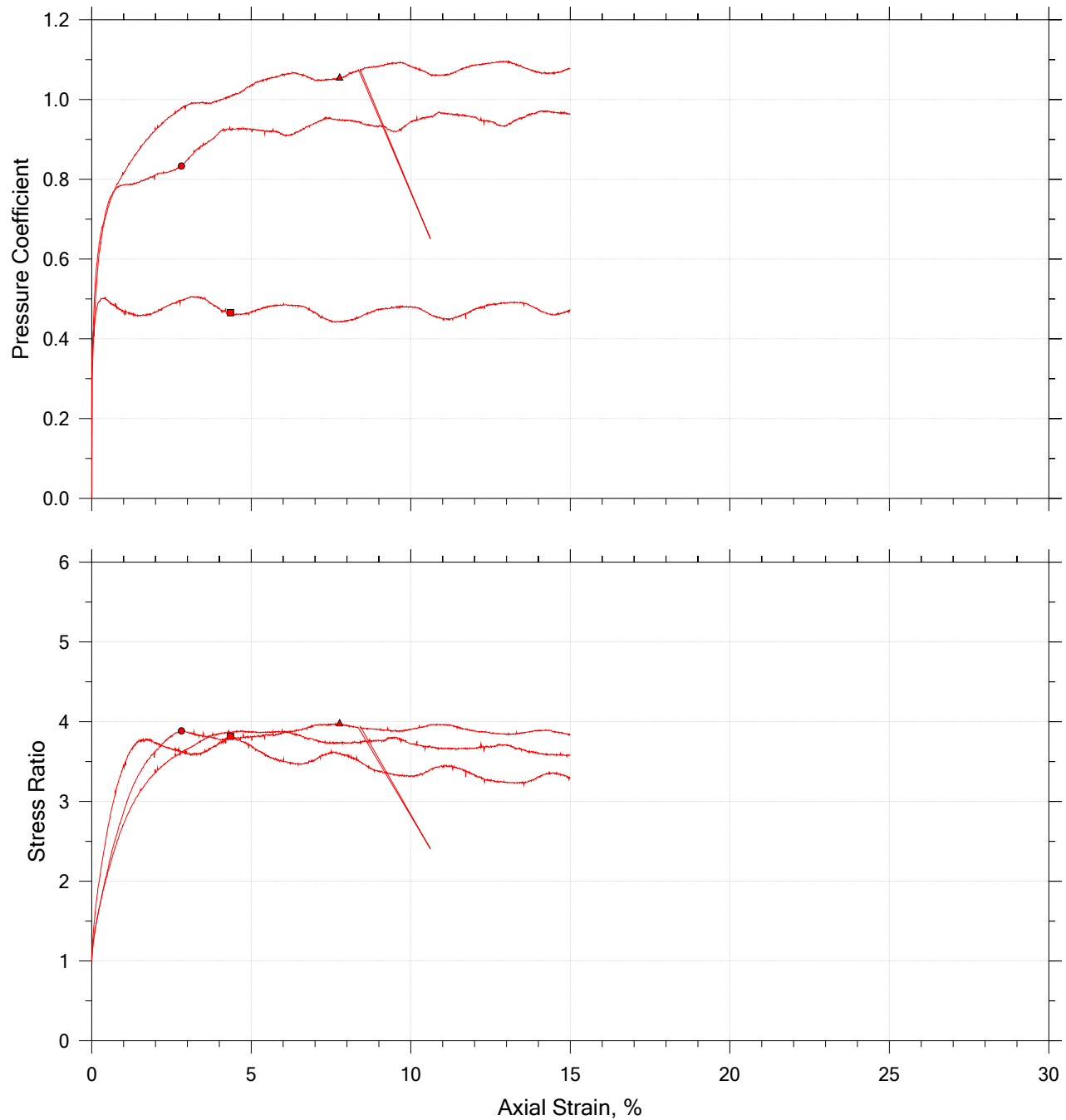
Consolidated Undrained by AASHTO T297




| | Sample No. | Test No. | Depth | Tested By | Test Date | Checked By | Check Date | Test File |
|---|------------|----------|-------------|-----------|------------|------------|------------|------------|
| ■ | 22-3266 | A | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2022 | BS-1.A.dat |
| ● | 22-3266 | B | 0.0' - 5.0' | RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.B.dat |
| ▲ | 22-3266 | C | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.C.dat |

| | | | |
|---|--|------------------------|---------------------------|
|  | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |

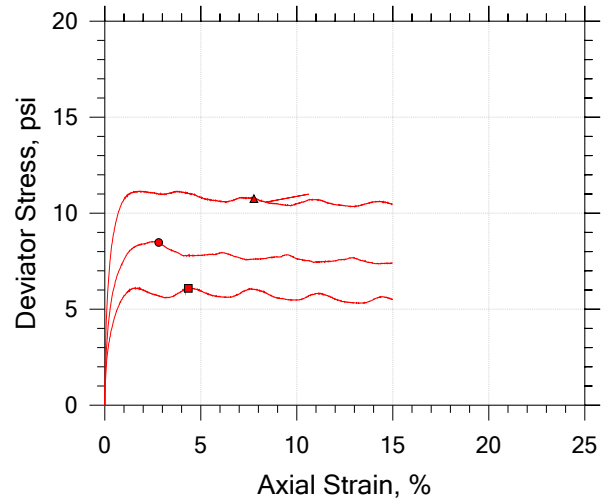
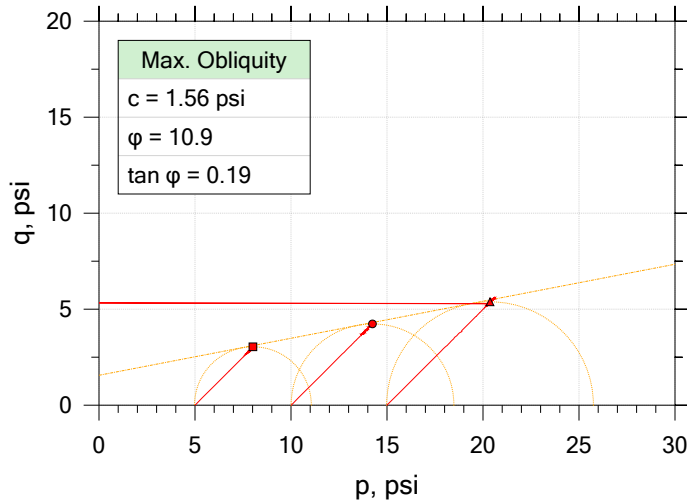
Consolidated Undrained by AASHTO T297



| | Sample No. | Test No. | Depth | Tested By | Test Date | Checked By | Check Date | Test File |
|---|------------|----------|-------------|-----------|------------|------------|------------|------------|
| ■ | 22-3266 | A | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2022 | BS-1.A.dat |
| ● | 22-3266 | B | 0.0' - 5.0' | RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.B.dat |
| ▲ | 22-3266 | C | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.C.dat |

| | | | |
|---|--|------------------------|---------------------------|
|  | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |

Consolidated Undrained by AASHTO T297

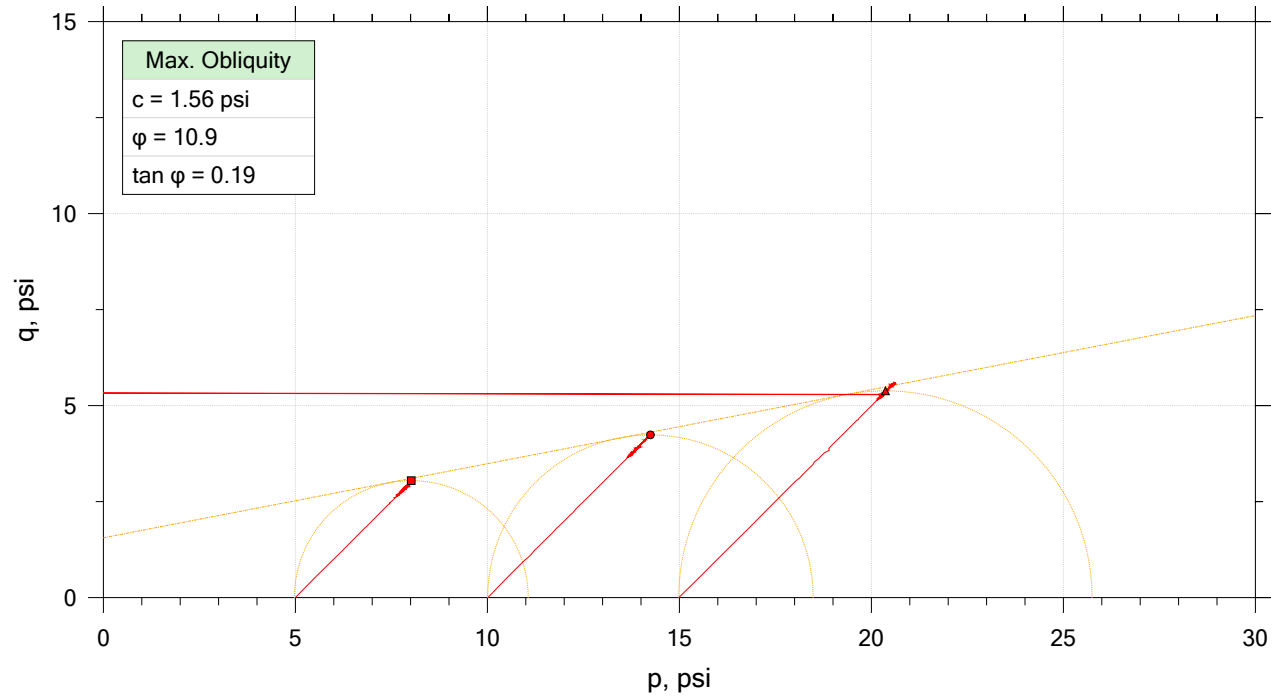
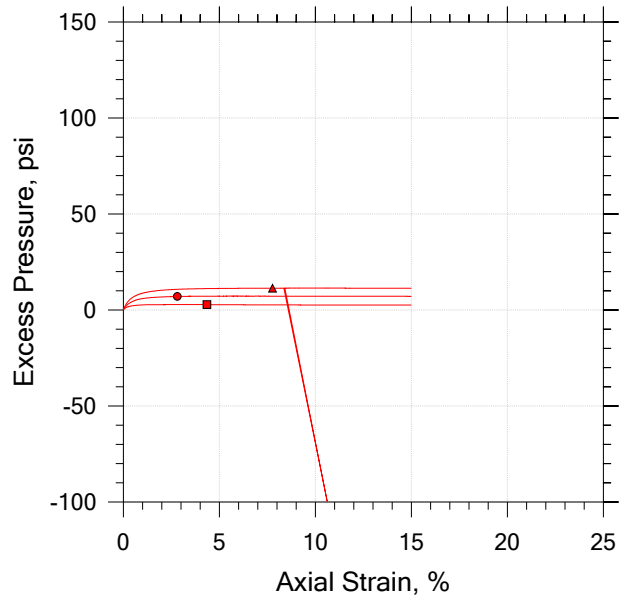
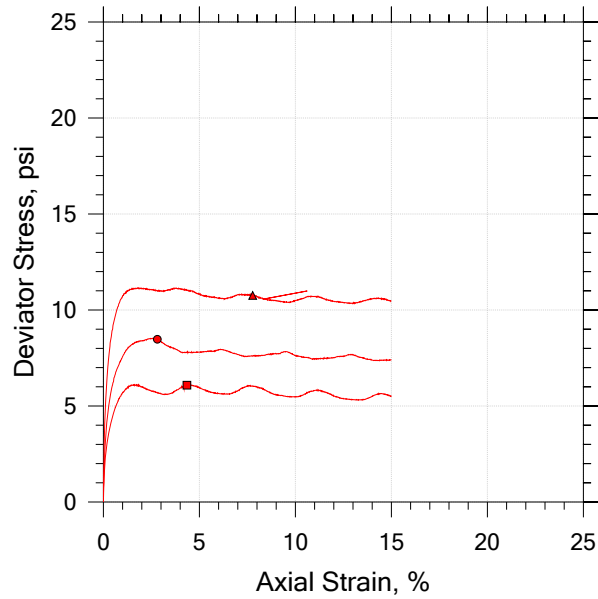


| | | | | |
|--|-------------|-------------|-------------|--|
| Symbol | ■ | ● | ▲ | |
| Sample ID | 22-3266 | 22-3266 | 22-3266 | |
| Depth | 0.0' - 5.0' | 0.0' - 5.0' | 0.0' - 5.0' | |
| Test Number | A | B | C | |
| Initial | | | | |
| Height, in | 6.000 | 6.000 | 6.000 | |
| Diameter, in | 2.800 | 2.800 | 2.800 | |
| Moisture Content (from Cuttings), % | 13.0 | 13.0 | 11.6 | |
| Dry Density, pcf | 112. | 112. | 113. | |
| Saturation (Wet Method), % | 70.0 | 69.8 | 65.1 | |
| Void Ratio | 0.497 | 0.498 | 0.479 | |
| Final | | | | |
| Moisture Content, % | 17.2 | 16.5 | 14.9 | |
| Dry Density, pcf | 115. | 116. | 120. | |
| Cross-Sectional Area (Method A), in ² | 6.035 | 5.975 | 5.906 | |
| Saturation, % | 100.0 | 100.0 | 100.0 | |
| Void Ratio | 0.461 | 0.441 | 0.400 | |
| Back Pressure, psi | 83.00 | 101.0 | 101.0 | |
| Vertical Effective Consolidation Stress, psi | 4.980 | 9.960 | 14.91 | |
| Horizontal Effective Consolidation Stress, psi | 4.999 | 10.01 | 14.98 | |
| Vertical Strain after Consolidation, % | 0.2029 | 0.7197 | 1.054 | |
| Volumetric Strain after Consolidation, % | 1.832 | 3.407 | 4.603 | |
| Time to 50% Consolidation, min | 0.8000 | 0.6000 | 2.000 | |
| Shear Strength, psi | 3.044 | 4.238 | 5.382 | |
| Strain at Failure, % | 4.35 | 2.81 | 7.77 | |
| Strain Rate, %/min | 0.05000 | 0.05000 | 0.05000 | |
| Deviator Stress at Failure, psi | 6.087 | 8.477 | 10.76 | |
| Effective Minor Principal Stress at Failure, psi | 2.160 | 2.939 | 3.603 | |
| Effective Major Principal Stress at Failure, psi | 8.247 | 11.42 | 14.37 | |
| B-Value | 0.95 | 0.95 | 0.95 | |


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

| | | | |
|--|--|------------------------|---------------------------|
| | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |

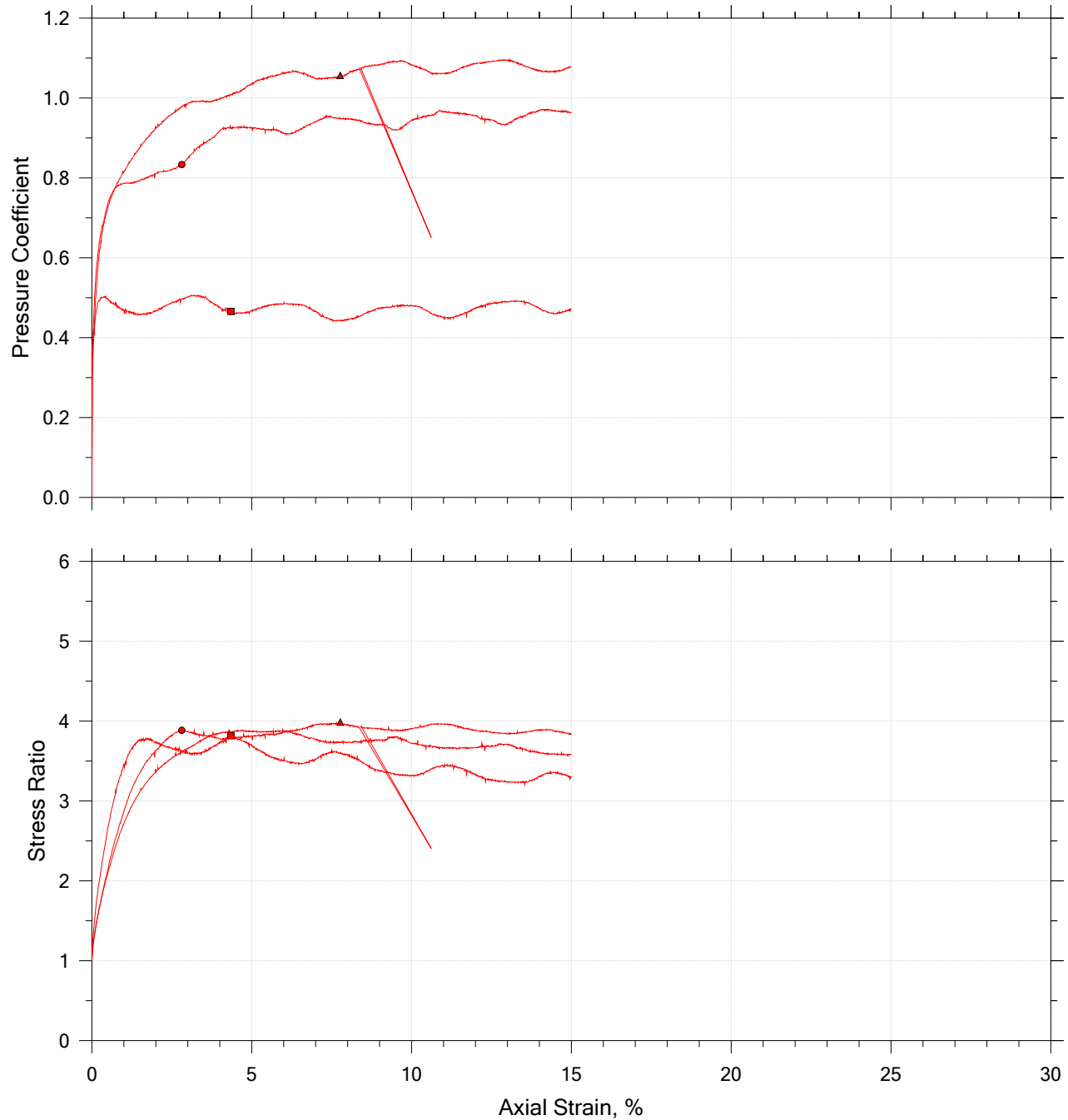
Consolidated Undrained by AASHTO T297




| | Sample No. | Test No. | Depth | Tested By | Test Date | Checked By | Check Date | Test File |
|---|------------|----------|-------------|-----------|------------|------------|------------|------------|
| ■ | 22-3266 | A | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2022 | BS-1.A.dat |
| ● | 22-3266 | B | 0.0' - 5.0' | RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.B.dat |
| ▲ | 22-3266 | C | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.C.dat |

| | | | |
|---|--|------------------------|---------------------------|
|  | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |

Consolidated Undrained by AASHTO T297



| | Sample No. | Test No. | Depth | Tested By | Test Date | Checked By | Check Date | Test File |
|---|------------|----------|-------------|-----------|------------|------------|------------|------------|
| ■ | 22-3266 | A | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2022 | BS-1.A.dat |
| ● | 22-3266 | B | 0.0' - 5.0' | RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.B.dat |
| ▲ | 22-3266 | C | 0.0' - 5.0' | WAP/RMC | 12/21/2022 | WAP/ WJG | 1/9/2023 | BS-1.C.dat |

| | | | |
|---|--|------------------------|---------------------------|
|  | Project Name: SC 72 RBO Cox Creek | Location: Union County | SCDOT Project ID: P041235 |
| | Boring Number: BS-1 | Tester: WAP/RMC | Checker: WAP/ WJG |
| | Sample Number: 22-3266 | Test Date: 12/21/2022 | Depth: 0.0' - 5.0' |
| | Test Number: ABC | Preparation: Remolded | Elevation: |
| | Description: Silty SAND (SM/A-2-4) LL=33, PL=24, PI=9, %200=21.6 | | |
| | Remarks: Max Dry Density=117.8 pcf, OMC=13.0%, Samples Molded at 95% | | |



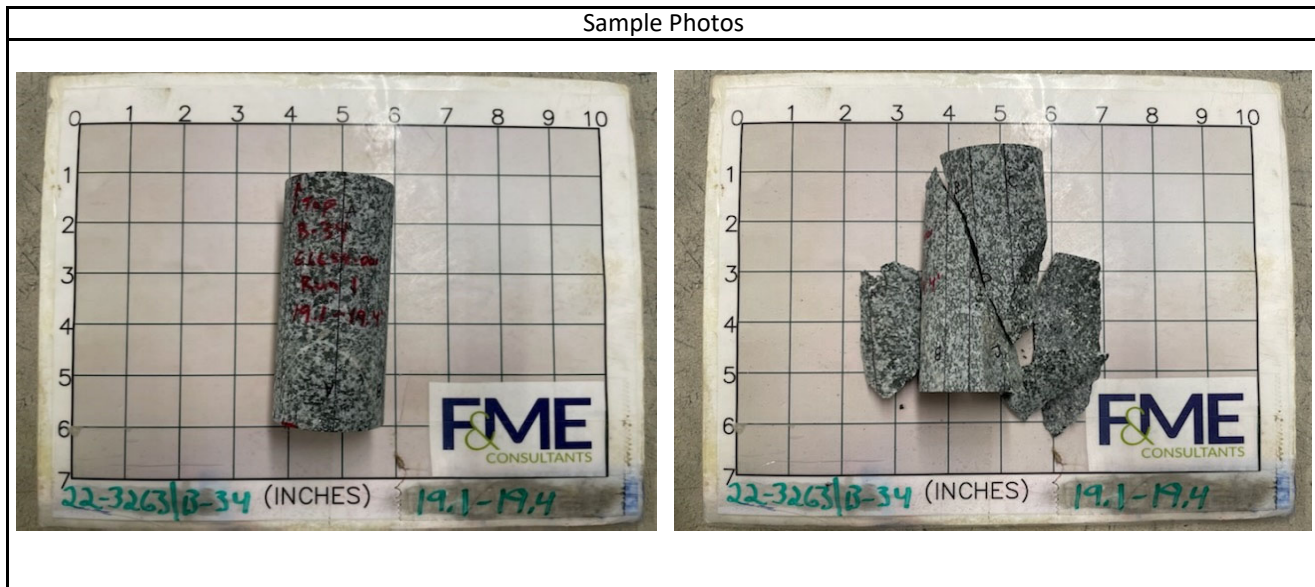
Appendix C. Laboratory Testing

Rock Cores

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

| | | | | | |
|-------------|-------------------------------|-----------------------|-------|-------------|-----------|
| Project | SC 72 RBO Cox Creek | | | Date | 1/13/2023 |
| Project No. | G6658.001 | Sample Diameter (in.) | 1.861 | Tested By | WAP |
| SCDOT ID | P041235 | Sample Length (in.) | 4.124 | Reviewed By | WJG |
| Boring | B-34 | Unit Weight (pcf) | 181.1 | Core Size | NQ |
| Sample No. | NQ-1 / 22-3263A | L/D Ratio | 2.22 | Recovery | 95% |
| Depth | 19.1' - 19.4' | Load Rate (psi/sec) | 20 | RQD | 83% |
| Description | White/Gray/Black Granodiorite | | | | |

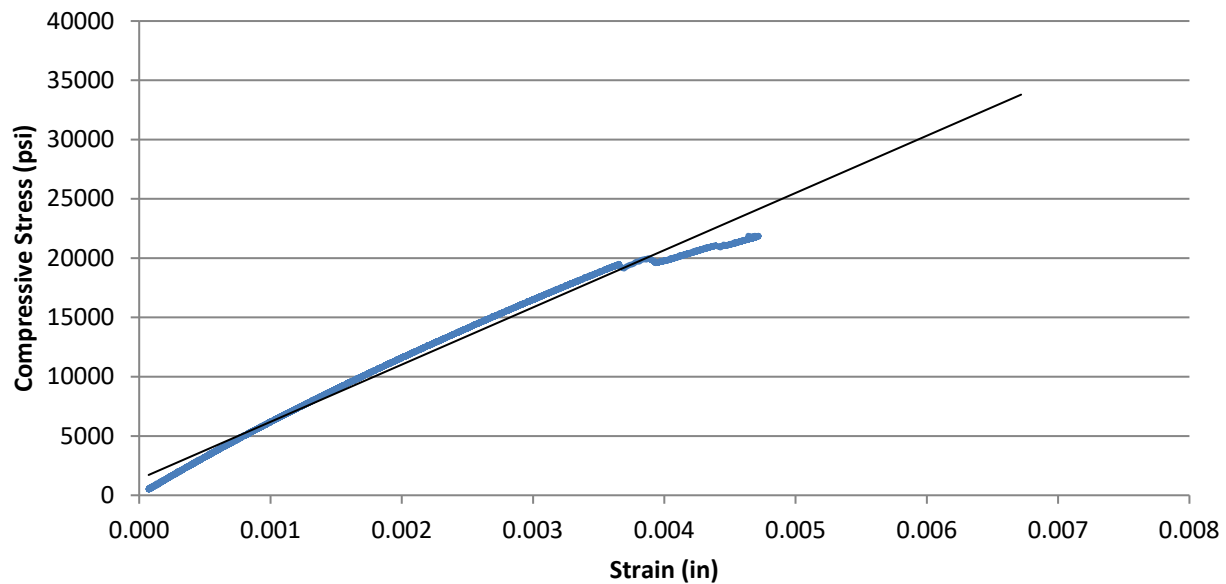
| Test Data | | | | | | |
|-------------------------|----------------------|--------|------------|--------------------------|------------------------------------|-----------------|
| Percent of Failure Load | Strain (10^{-6}) | | Load (lbs) | Compressive Stress (psi) | Secant Modulus $\times 10^6$ (psi) | Poisson's Ratio |
| | Axial | Radial | | | | |
| 10% | -334 | 74 | 5,937 | 2,182 | 13.09 | 0.22 |
| 20% | -689 | 157 | 11,917 | 4,381 | 12.72 | 0.23 |
| 30% | -1069 | 246 | 17,877 | 6,572 | 12.30 | 0.23 |
| 40% | -1465 | 338 | 23,881 | 8,779 | 11.98 | 0.23 |
| 50% | -1866 | 433 | 29,727 | 10,929 | 11.71 | 0.23 |
| 60% | -2305 | 546 | 35,736 | 13,138 | 11.40 | 0.24 |
| 70% | -2750 | 670 | 41,664 | 15,317 | 11.14 | 0.24 |
| 80% | -3221 | 827 | 47,647 | 17,517 | 10.88 | 0.26 |
| 90% | -3786 | 1582 | 53,559 | 19,690 | 10.40 | 0.42 |
| 100% | -4640 | 2052 | 59,534 | 21,887 | | |



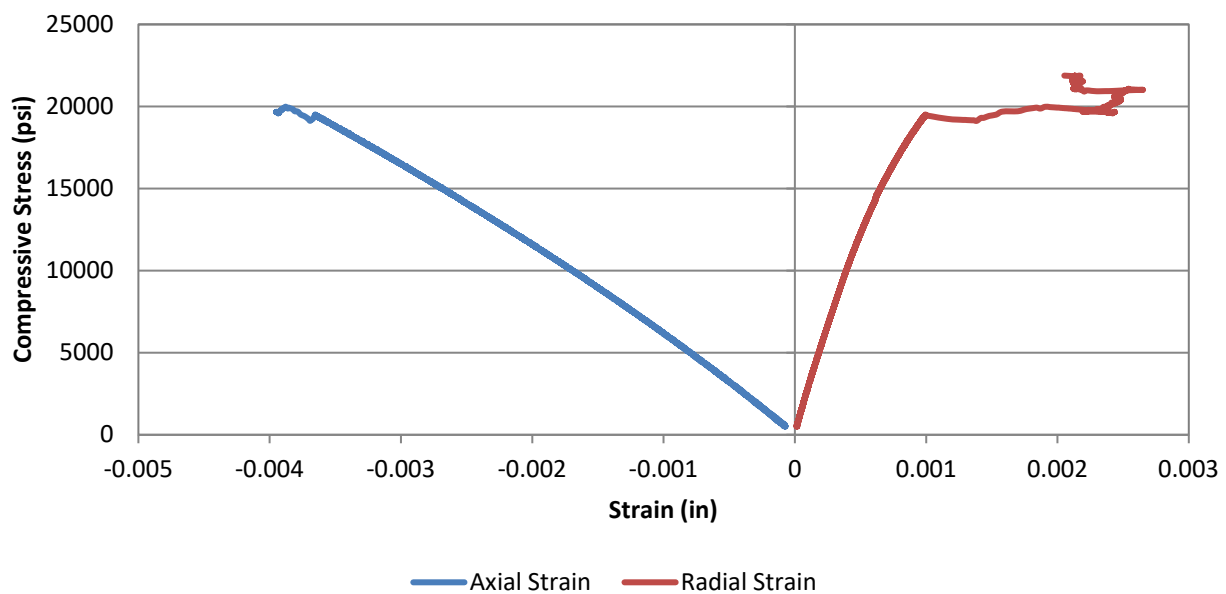
| Test Results | | | | |
|---------------------------------------|--|--------|----------------------------------|----------|
| Unconfined Compressive Strength (psi) | | 21,890 | Elastic Modulus (psi) | 1.17E+07 |
| | | | Poisson's Ratio in Elastic Range | 0.24 |
| Comments | Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. | | | |
| | | | | |

| | | | | | |
|-------------|-------------------------------|-----------------------|-------|-------------|-----------|
| Project | SC 72 RBO Cox Creek | | | Date | 1/13/2023 |
| Project No. | G6658.001 | Sample Diameter (in.) | 1.861 | Tested By | WAP |
| SCDOT ID | P041235 | Sample Length (in.) | 4.124 | Reviewed By | WJG |
| Boring | B-34 | Unit Weight (pcf) | 181.1 | Core Size | NQ |
| Sample No. | NQ-1 / 22-3263A | L/D Ratio | 2.22 | Recovery | 95% |
| Depth | 19.1' - 19.4' | Load Rate (psi/sec) | 20 | RQD | 83% |
| Description | White/Gray/Black Granodiorite | | | | |

Axial Stress vs. Strain



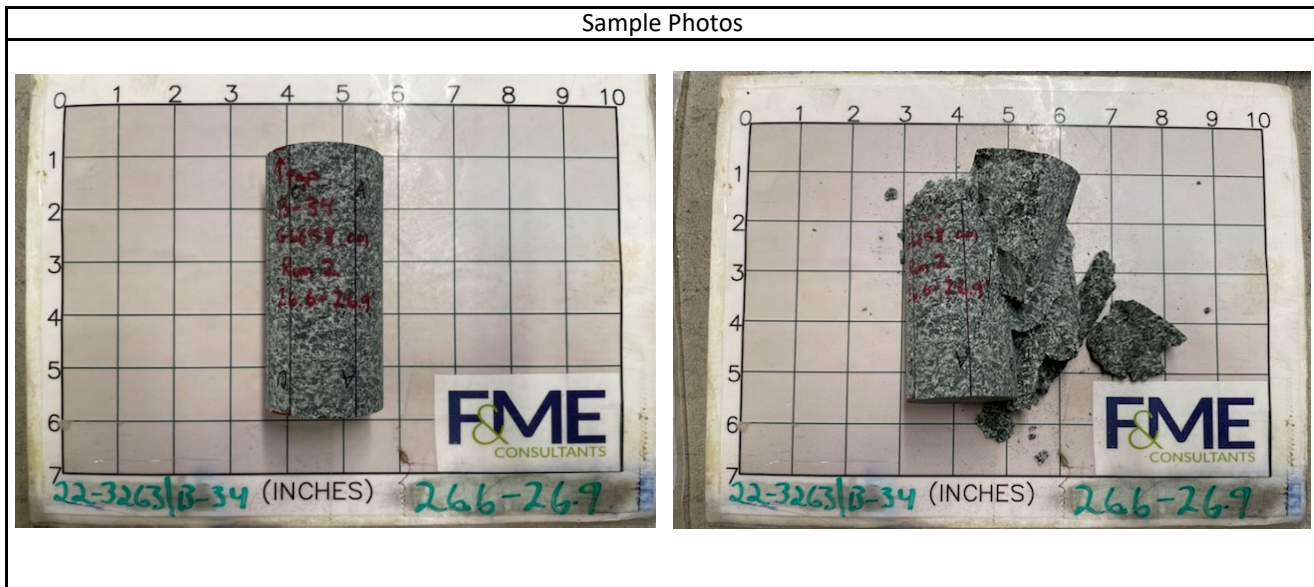
Stress vs. Strain



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

| | | | | | |
|-------------|-------------------------------|-----------------------|-------|-------------|-----------|
| Project | SC 72 RBO Cox Creek | | | Date | 1/13/2023 |
| Project No. | G6658.001 | Sample Diameter (in.) | 1.869 | Tested By | WAP |
| SCDOT ID | P041235 | Sample Length (in.) | 4.143 | Reviewed By | WJG |
| Boring | B-34 | Unit Weight (pcf) | 180.9 | Core Size | NQ |
| Sample No. | NQ-2 / 22-3263B | L/D Ratio | 2.22 | Recovery | 95% |
| Depth | 26.6' - 26.9' | Load Rate (psi/sec) | 30 | RQD | 93% |
| Description | White/Gray/Black Granodiorite | | | | |

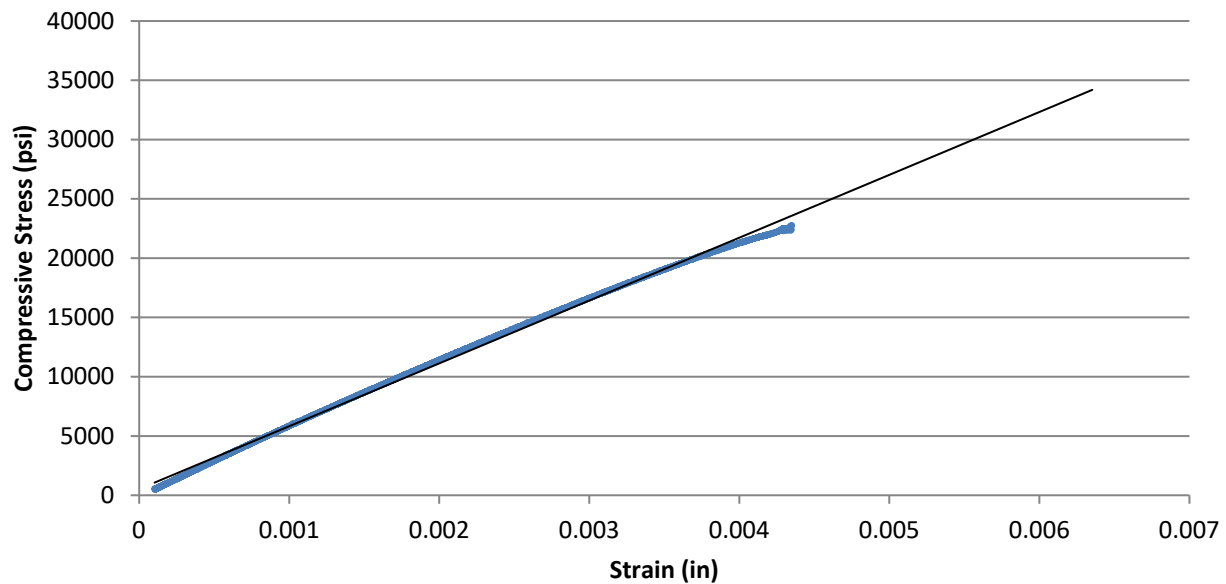
| Test Data | | | | | | |
|-------------------------|----------------------|--------|------------|--------------------------|------------------------------------|-----------------|
| Percent of Failure Load | Strain (10^{-6}) | | Load (lbs) | Compressive Stress (psi) | Secant Modulus $\times 10^6$ (psi) | Poisson's Ratio |
| | Axial | Radial | | | | |
| 10% | -398 | 108 | 6,268 | 2,284 | 11.49 | 0.27 |
| 20% | -780 | 219 | 12,571 | 4,582 | 11.75 | 0.28 |
| 30% | -1167 | 336 | 18,735 | 6,829 | 11.71 | 0.29 |
| 40% | -1581 | 469 | 25,019 | 9,119 | 11.53 | 0.30 |
| 50% | -1996 | 613 | 31,226 | 11,382 | 11.41 | 0.31 |
| 60% | -2422 | 775 | 37,525 | 13,678 | 11.29 | 0.32 |
| 70% | -2861 | 966 | 43,721 | 15,936 | 11.14 | 0.34 |
| 80% | -3338 | 1205 | 50,055 | 18,245 | 10.93 | 0.36 |
| 90% | -3818 | 1495 | 56,225 | 20,494 | 10.74 | 0.39 |
| 100% | -4350 | 2072 | 62,543 | 22,797 | | |



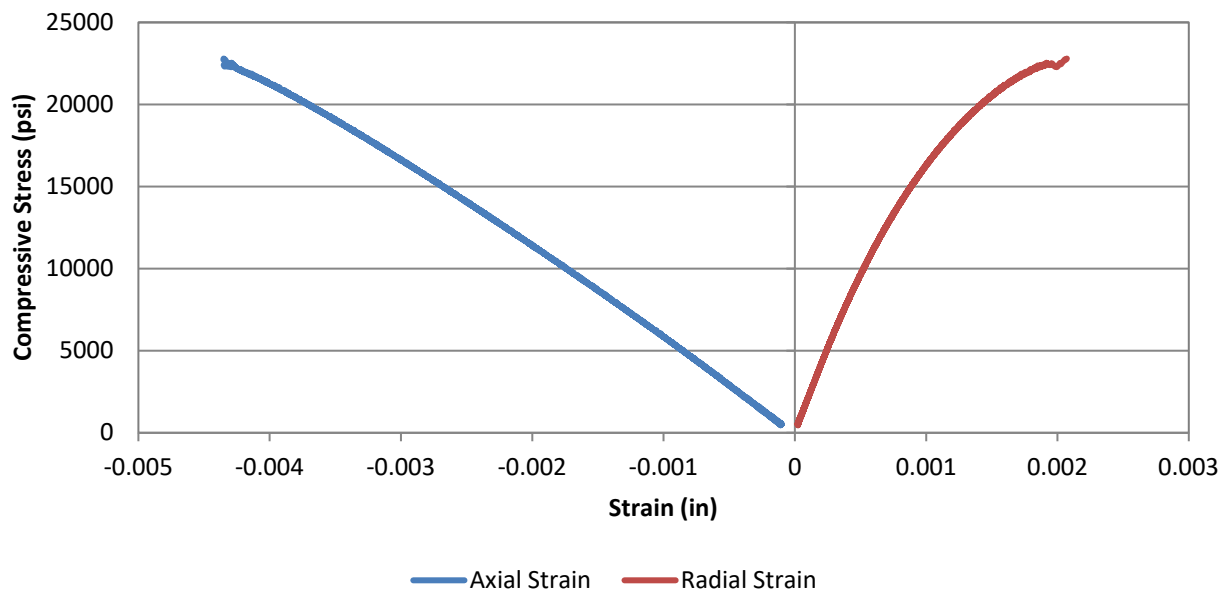
| Test Results | | | | |
|---------------------------------------|--|--------|----------------------------------|----------|
| Unconfined Compressive Strength (psi) | | 22,800 | Elastic Modulus (psi) | 1.14E+07 |
| | | | Poisson's Ratio in Elastic Range | 0.31 |
| Comments | Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. | | | |
| | | | | |

| | | | | | |
|-------------|-------------------------------|-----------------------|-------|-------------|-----------|
| Project | SC 72 RBO Cox Creek | | | Date | 1/13/2023 |
| Project No. | G6658.001 | Sample Diameter (in.) | 1.869 | Tested By | WAP |
| SCDOT ID | P041235 | Sample Length (in.) | 4.143 | Reviewed By | WJG |
| Boring | B-34 | Unit Weight (pcf) | 180.9 | Core Size | NQ |
| Sample No. | NQ-2 / 22-3263B | L/D Ratio | 2.22 | Recovery | 95% |
| Depth | 26.6' - 26.9' | Load Rate (psi/sec) | 30 | RQD | 93% |
| Description | White/Gray/Black Granodiorite | | | | |

Axial Stress vs. Strain



Stress vs. Strain



Appendix D. ADRS Curves

3-Point Acceleration Design Response Spectrum

SCDOT v3.1.1 - 11/29/2022

| | | | |
|-------------|----------------------|------------|------------|
| Project ID: | P041235 | Latitude: | 34.5954 |
| Route: | SC 72 | County: | 44 - Union |
| Project: | SC 72 over Cox Creek | | |
| | | Longitude: | 81.4420 |

| | |
|-----------|---------------------|
| Designer: | N. Harman - Support |
| Date: | 2/2/2023 |

| Design EQ | PGA | S _{DS} | S _{D1} | M _W | R | PGV | D ₅₋₉₅ | T' _o |
|-----------|------|-----------------|-----------------|----------------|--------|------------|-------------------|-----------------|
| | g | g | g | - | km | inches/sec | sec | sec |
| FEE | 0.01 | 0.02 | 0.00 | 7.30 | 212.50 | 0.18 | 51.71 | 0.03 |
| SEE | 0.02 | 0.04 | 0.01 | 6.33 | 127.67 | 0.42 | 28.82 | 0.09 |

| Fundamental Period of Structure, T ₀ | Range of Interest | | V _{s,H} * | H | T _{NH} | |
|---|--------------------|--------------------|--------------------|-------|--------------------------|--------------------------|
| | sec | | | | sec | |
| | 0.5*T ₀ | 2.0*T ₀ | | | (4*H)/V _{s,H} * | (6*H)/V _{s,H} * |
| sec | | | ft/sec | ft | | |
| 0.00 | 0.00 | 0.00 | 691.32 | 18.50 | 0.10 | 0.16 |
| 0.00 | 0.00 | 0.00 | H = B-C Boundary | | | |

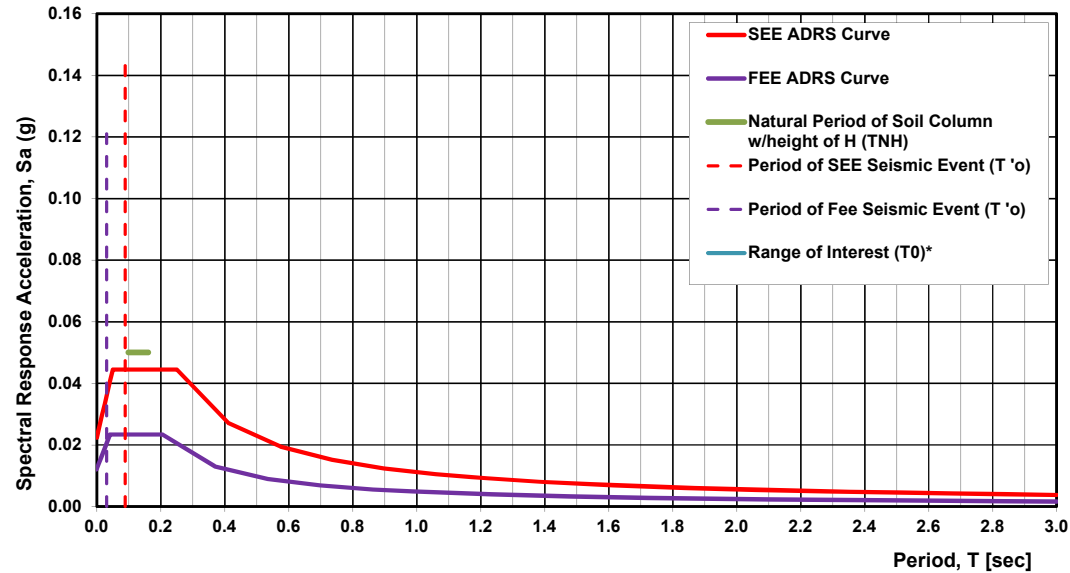
H = B-C Boundary

| | |
|-----------------------------------|-----------------------------------|
| Damping: | 5% |
| Geologic Condition: | Geologically Realistic (Q = 100)* |
| ADRS Location within Soil Column: | SCP |
| | At Ground Surface |

South Carolina Piedmont

*Same Geologic Condition as used in SCENARIO_PC (2006)

SC Seismic ADRS Curve



FEE Data

| T | S _a |
|------|----------------|
| 0.00 | 0.012 |
| 0.01 | 0.014 |
| 0.01 | 0.016 |
| 0.02 | 0.018 |
| 0.03 | 0.020 |
| 0.03 | 0.021 |
| 0.04 | 0.023 |
| 0.05 | 0.023 |
| 0.07 | 0.023 |
| 0.08 | 0.023 |
| 0.10 | 0.023 |
| 0.11 | 0.023 |
| 0.12 | 0.023 |
| 0.14 | 0.023 |
| 0.15 | 0.023 |
| 0.16 | 0.023 |
| 0.18 | 0.023 |
| 0.19 | 0.023 |
| 0.21 | 0.023 |
| 0.37 | 0.013 |
| 0.53 | 0.009 |
| 0.70 | 0.007 |
| 0.86 | 0.006 |
| 1.03 | 0.005 |
| 1.19 | 0.004 |
| 1.36 | 0.004 |
| 1.52 | 0.003 |
| 1.68 | 0.003 |
| 1.85 | 0.003 |
| 2.01 | 0.002 |
| 2.18 | 0.002 |
| 2.34 | 0.002 |
| 2.51 | 0.002 |
| 2.67 | 0.002 |
| 2.84 | 0.002 |
| 3.00 | 0.002 |

SEE Data

| T | S _a |
|------|----------------|
| 0.00 | 0.022 |
| 0.01 | 0.026 |
| 0.02 | 0.030 |
| 0.03 | 0.033 |
| 0.03 | 0.037 |
| 0.04 | 0.041 |
| 0.05 | 0.044 |
| 0.07 | 0.044 |
| 0.08 | 0.044 |
| 0.10 | 0.044 |
| 0.12 | 0.044 |
| 0.13 | 0.044 |
| 0.15 | 0.044 |
| 0.17 | 0.044 |
| 0.18 | 0.044 |
| 0.20 | 0.044 |
| 0.22 | 0.044 |
| 0.23 | 0.044 |
| 0.25 | 0.044 |
| 0.41 | 0.027 |
| 0.57 | 0.019 |
| 0.74 | 0.015 |
| 0.90 | 0.012 |
| 1.06 | 0.011 |
| 1.22 | 0.009 |
| 1.38 | 0.008 |
| 1.54 | 0.007 |
| 1.71 | 0.007 |
| 1.87 | 0.006 |
| 2.03 | 0.005 |
| 2.19 | 0.005 |
| 2.35 | 0.005 |
| 2.51 | 0.004 |
| 2.68 | 0.004 |
| 2.84 | 0.004 |
| 3.00 | 0.004 |

Appendix E. SPT Hammer Energy Calibration Report

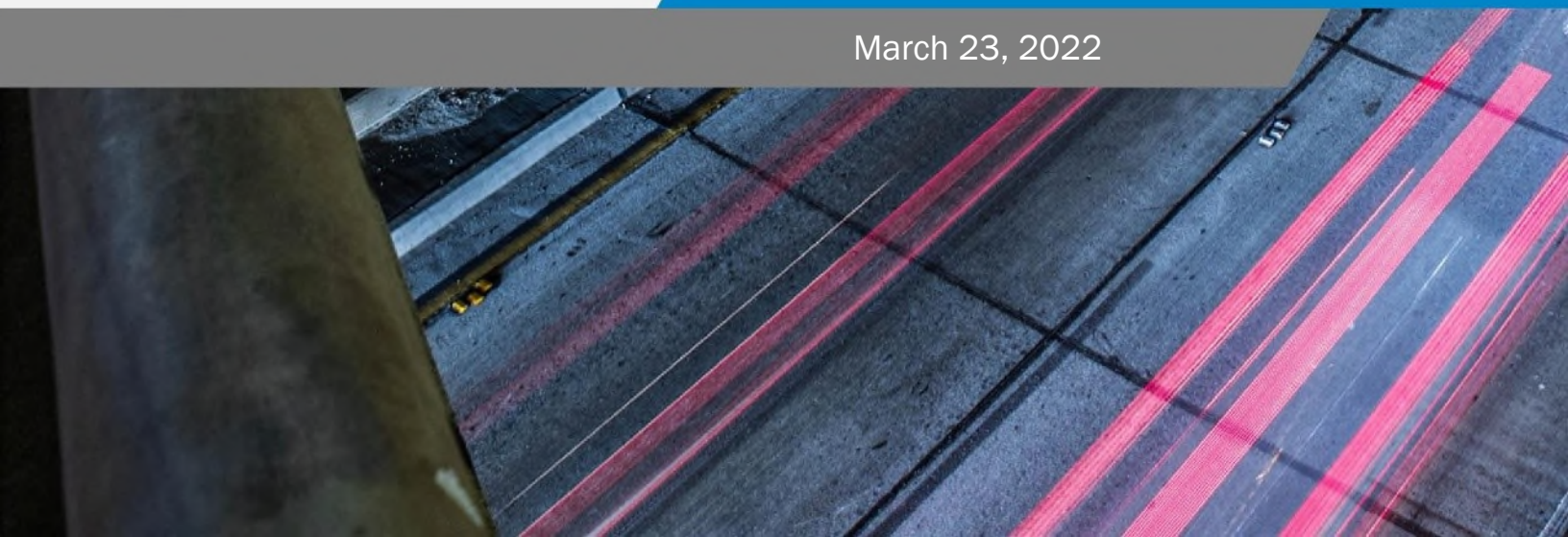


**CAROLINAS
GEOTECHNICAL
GROUP**

Report of SPT Hammer Energy

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

March 23, 2022





2400 Crownpoint Executive Drive
Suite 800
Charlotte, NC 28227



(980) 339-8684



contact@carolinasgeotech.com



www.carolinasgeotech.com

March 23, 2022

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

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

Dear Mr. Ford:

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

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

DYNAMIC TESTING METHODOLOGY

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

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

TESTING AND OBSERVATIONS

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

Table 1: SPT Field Data

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

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

DYNAMIC TESTING RESULTS

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

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

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

Table 2: Summary of Dynamic Testing Results

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

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

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

LIMITATIONS OF REPORT

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

CLOSING

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

Sincerely,
Carolinas Geotechnical Group, PLLC

DocuSigned by:

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

DocuSigned by:

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



Appendices:

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



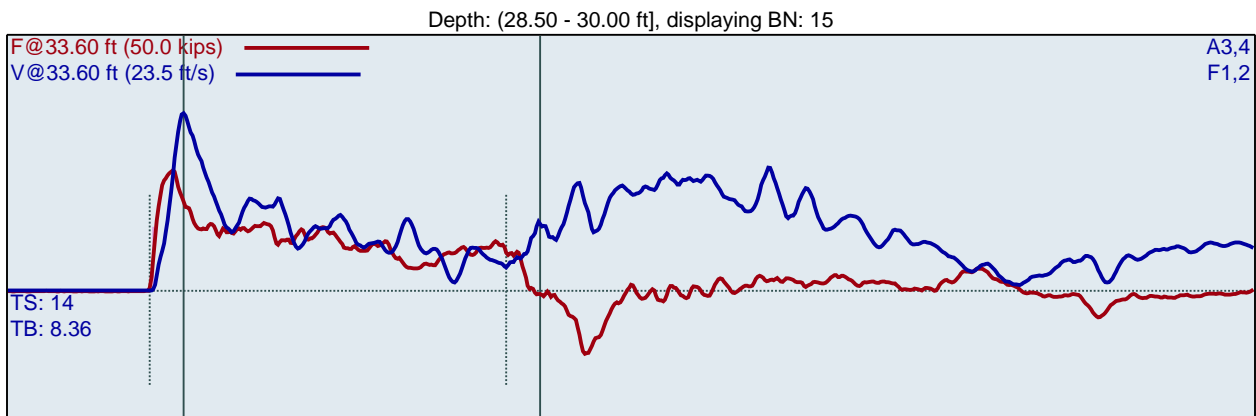
APPENDIX I

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

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

SP: 0.492 k/ft³
EM: 30000 ksi



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

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

BPM: Blows/Minute

FMX: Maximum Force

VMX: Maximum Velocity

DMX: Maximum Displacement

CSX: Compression Stress Maximum

DFN: Final Displacement

EFV: Maximum Energy

ETR: Energy Transfer Ratio - Rated

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

N-value: 13

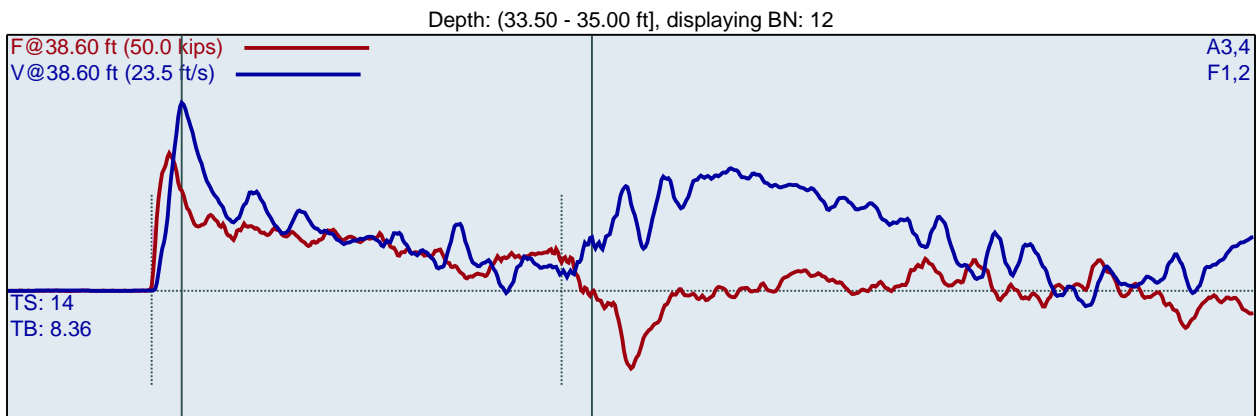
Sample Interval Time: 17.92 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

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

SP: 0.492 k/ft³
EM: 30000 ksi



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

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

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

N-value: 11

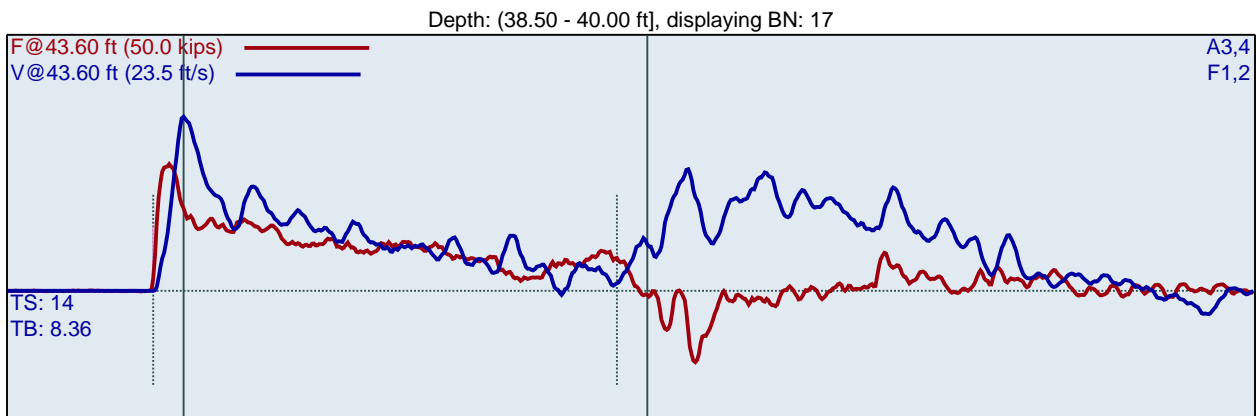
Sample Interval Time: 13.30 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

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

SP: 0.492 k/ft³
EM: 30000 ksi



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

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

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

N-value: 15

Sample Interval Time: 19.28 seconds.

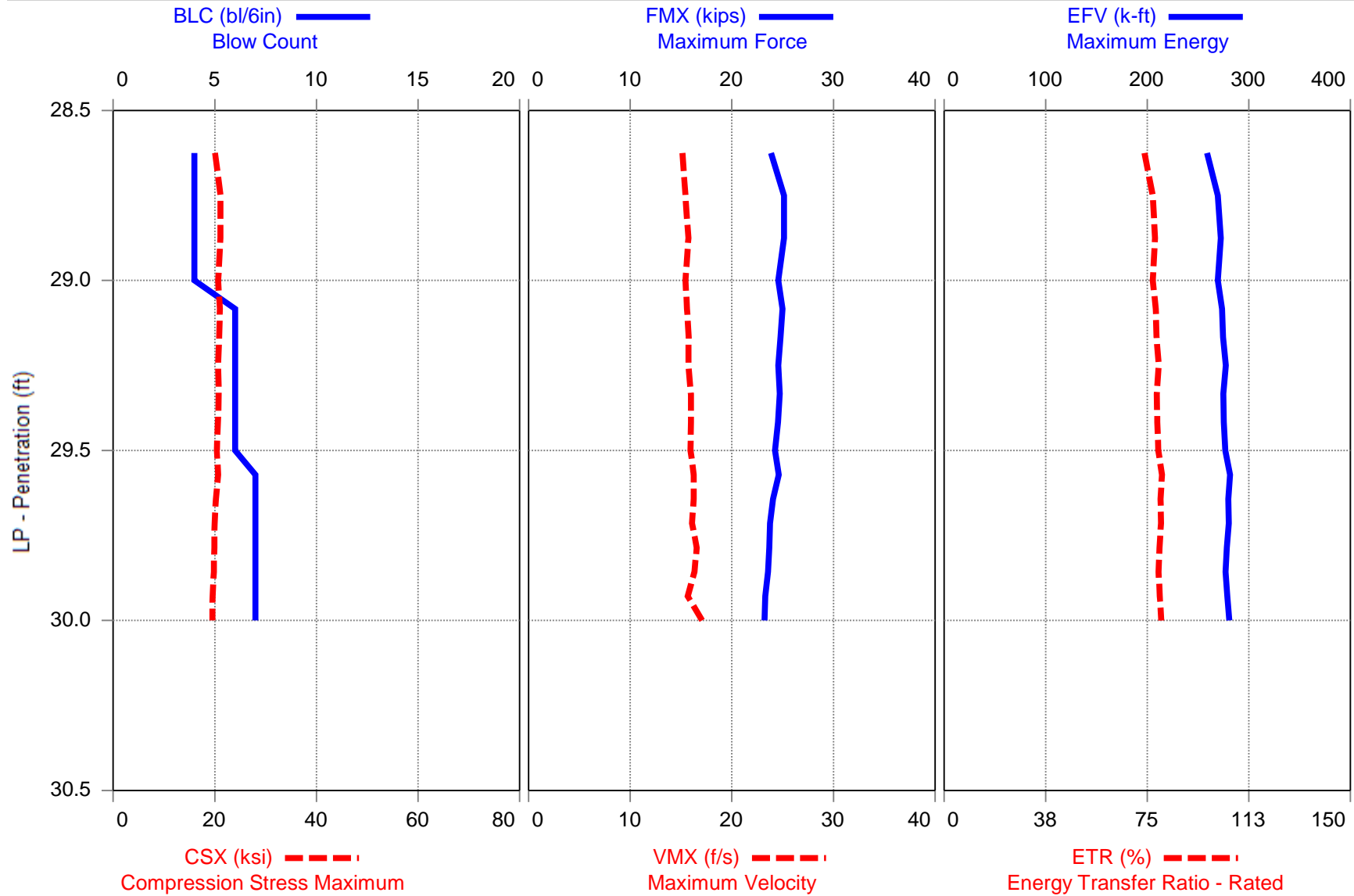
Summary of SPT Test Results

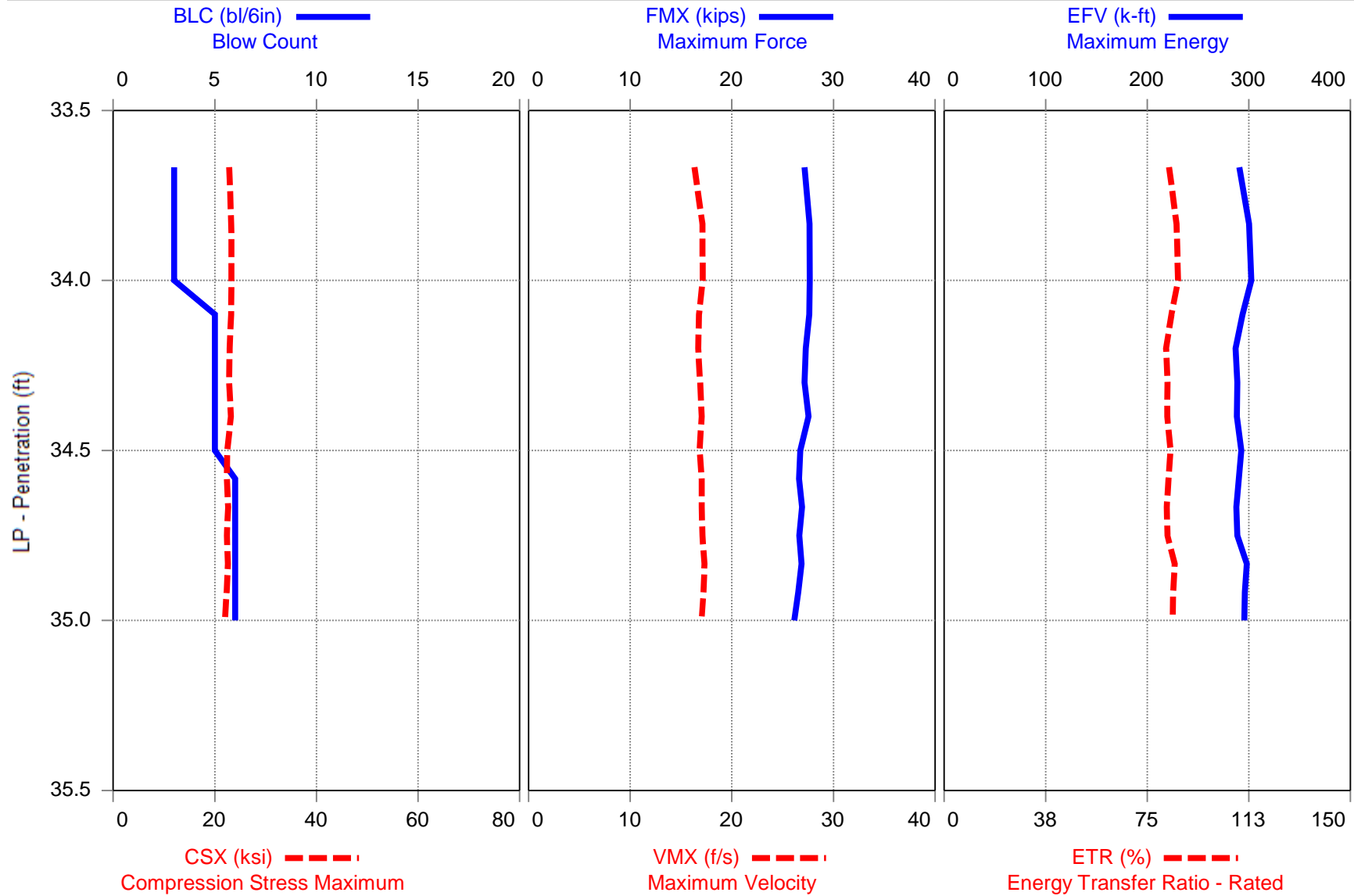
Project: CME 45B (SN 303304), Test Date: 3/11/2022

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



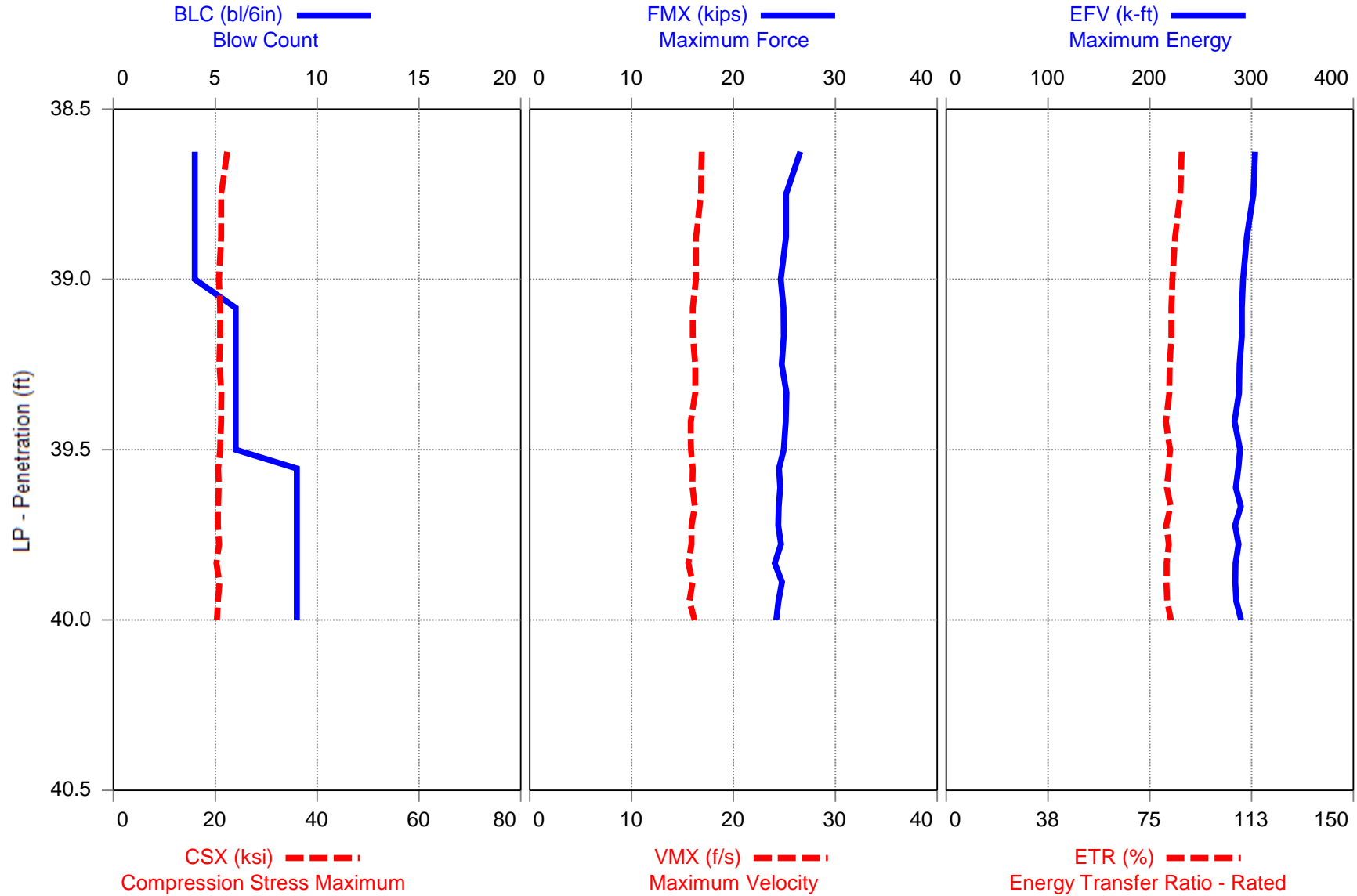
CME 45B (SN 303304) - 28.5 TO 30.0

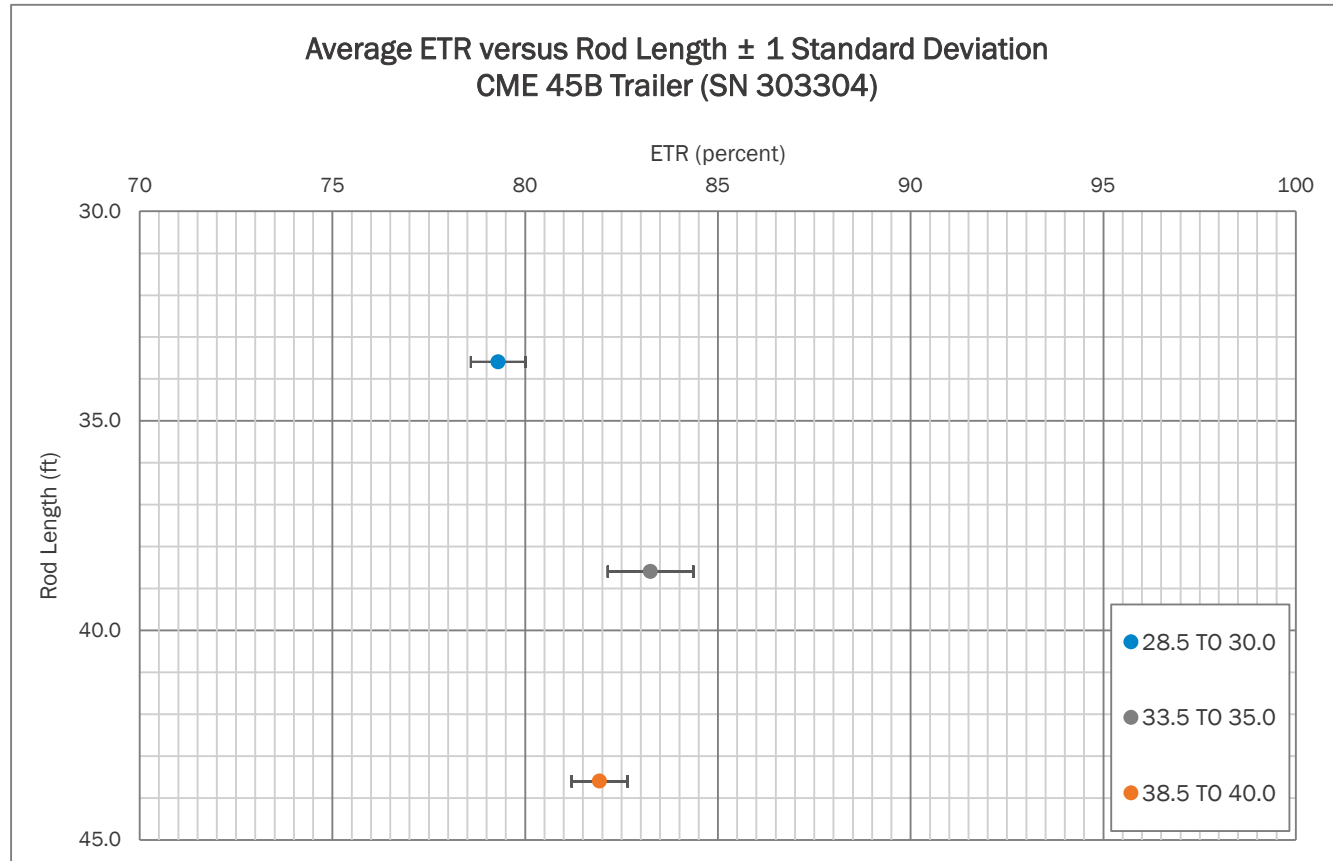
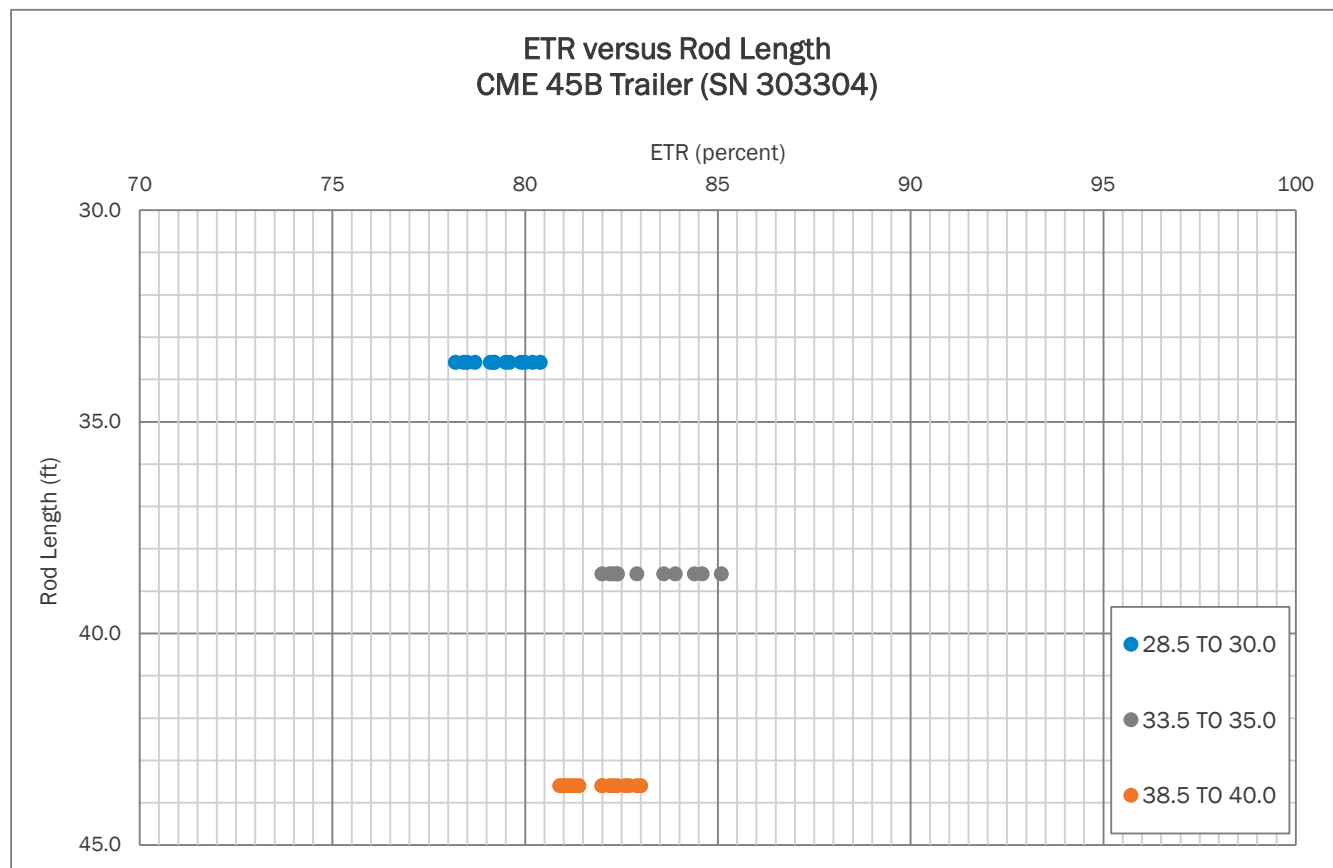






CME 45B (SN 303304) - 38.5 TO 40.0







APPENDIX II

SPT Hammer Energy Field Form

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

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

On-site Personnel

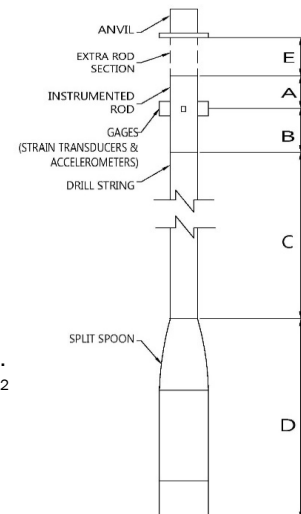
Drilling Company: BRECCIA CONSTRUCTION, LLC
 Rig Operator: D. HARRIS
 Engr/Geologist: N/A
 Client Rep.: N/A
 Analyzer Oper.: R. KRAL

Rig/Hammer Info

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

Rod Info

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



Gage Info

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

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

Notes:

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

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



Prepared By (print/signature)

3/11/2022
Date



Figure No. 1: Rear View of Drill Rig



Figure No. 2: Side View of Drill Rig



Figure No. 3: Serial Number Plate



Figure No. 4: Automatic Hammer

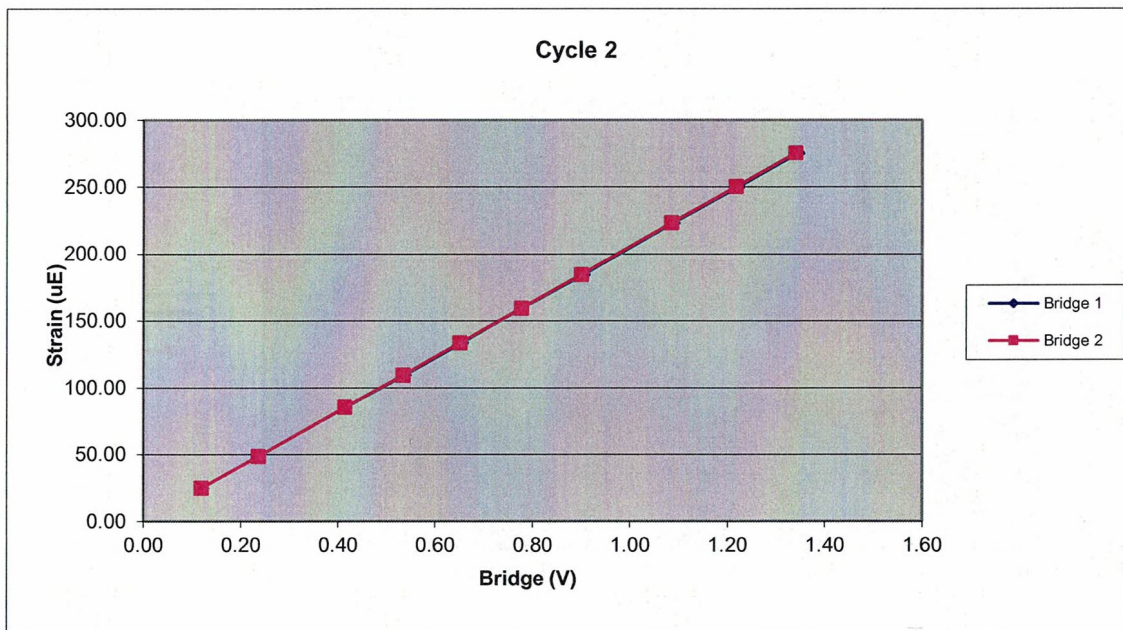


APPENDIX III

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

| Bridge 1 | | Bridge 2 | |
|---------------------------------|----------|---------------------------------|----------|
| Force Calibration (lb/V) | 7340.27 | Force Calibration (lb/V) | 7362.32 |
| Offset | 12.98 | Offset | 13.21 |
| Correlation | 1.000000 | Correlation | 0.999999 |
| Strain Calibration (μ E/V) | 204.74 | Strain Calibration (μ E/V) | 205.35 |
| Offset | -0.39 | Offset | -0.39 |
| Correlation | 0.999993 | Correlation | 0.999995 |

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



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

| Bridge 1 | | Bridge 2 | |
|---------------------------------|----------|---------------------------------|----------|
| Force Calibration (lb/V) | 7346.16 | Force Calibration (lb/V) | 7359.87 |
| Offset | 9.71 | Offset | 6.72 |
| Correlation | 0.999998 | Correlation | 0.999999 |
| Strain Calibration (μ E/V) | 205.65 | Strain Calibration (μ E/V) | 206.03 |
| Offset | 0.08 | Offset | -0.01 |
| Correlation | 0.999990 | Correlation | 0.999993 |

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



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

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

Calibrated by: 

Calibrated Date: 1/28/2021

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on 19Apr2021

Serial No: K10959 Temperature: 21.0 °C

Model: PR Humidity: 38%

Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR

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

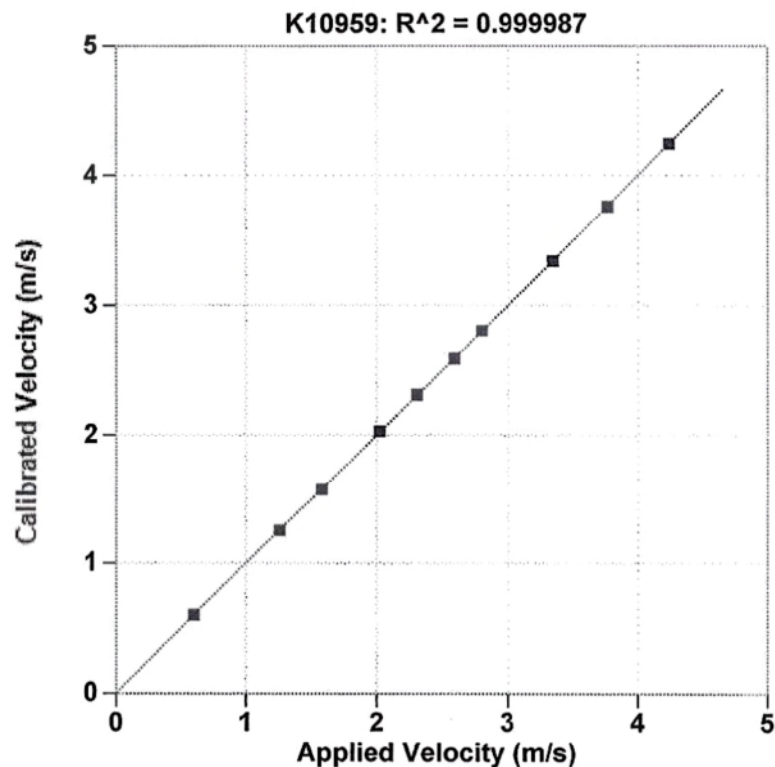
Ref Acc 1: 69096! Cal on: 27Jan2021
978 g's/volt

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

Operator: William Johnson

Signed

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



| Reference Velocity | S/N K10959 Velocity |
|--------------------|---------------------|
| m/s | m/s |
| 0.600 | 0.600 |
| 1.260 | 1.255 |
| 1.578 | 1.577 |
| 2.021 | 2.028 |
| 2.306 | 2.311 |
| 2.590 | 2.590 |
| 2.801 | 2.806 |
| 3.346 | 3.344 |
| 3.767 | 3.762 |
| 4.241 | 4.241 |

Maximum Acceleration: 938 g's

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



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

Serial No: K10960 Temperature: 20.0 °C

Model: PR Humidity: 28%

Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR

425.7 mv/5000g

(85.1 $\mu\text{v/g}$)

R²: 0.999987 [Chip programmed]

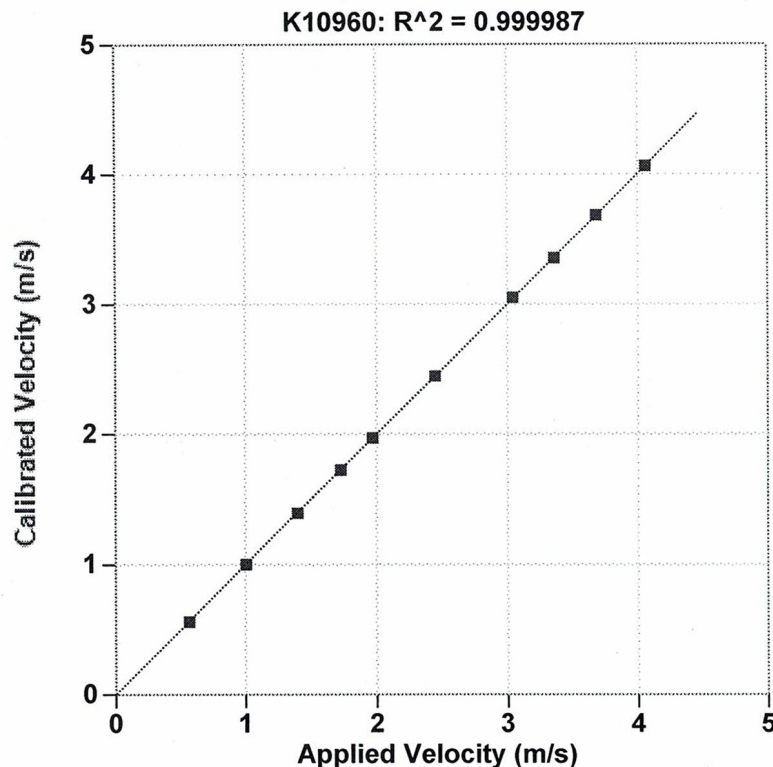
Operator: William Johnson

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

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


Signed

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



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

Maximum Acceleration: 889 g's

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on

MAR 2 2021

Serial No: K11957 Temperature: 20.0 °C

Model: PR Humidity: 27%

Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR

407.0 mv/5000g

(81.4 μ v/g)

R²: 0.999989 [Chip programmed]

Operator: William Johnson

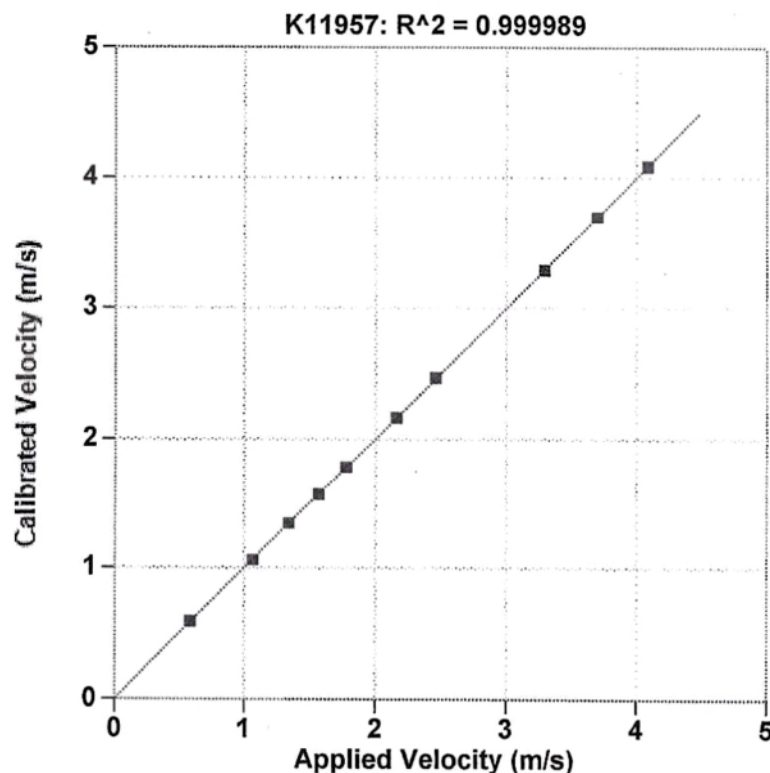
Ref Acc 1: 63479! Cal on: 22Jan2021
1079 g's/volt

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

William Johnson

Signed

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



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



APPENDIX IV



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


on the Dynamic Measurement and Analysis Proficiency Test.

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

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


Steven A. Hall, Executive Director
Pile Driving Contractors Association




Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2072