# Structure Foundation Exploration
# PIK-CR8-5.75 Bridge (Drybone Road)
# Pike County, Ohio
# S&ME Project No. 213410

PREPARED FOR:

**Pike County Engineer**
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PREPARED BY:


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**December 9, 2021**

December 9, 2021

Pike County Engineer
502 Pike Street
Waverly, OH 45690

Attention: Mr. Denny T. Salisbury, PE, PS

Reference: **Structure Foundation Exploration**
**PIK-CR8-5.75 Drybone Road Bridge Replacement**
Cynthiana, Pike County, Ohio
S&ME Project No. 213410

Dear Mr. Salisbury:

S&ME, Inc. (S&ME) has completed a Structure Foundation Exploration in accordance with our proposal dated May 14, 2021, which was authorized on May 14, 2021, S&ME, Inc. (S&ME) for the PIK-CR8-5.75 (Dry Bone Road) bridge replacement in Cynthiana, Pike County, Ohio.

This report contains the information obtained from the borings and laboratory test results, as well as our analyses and recommendations for the planned replacement structure at this site. ODOT Soil Profile plan sheets will be submitted under separate cover once plan and profile drawings are provided.

We appreciate having been given the opportunity to be of service. Please do not hesitate to contact us if you have any questions regarding this submission.

Respectfully,

**S&ME, Inc.**

Christopher Yohe

Christopher L. Yohe PE (KY)
Senior Engineer

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# Table of Contents

1.0 Introduction ........ 1
2.0 Geology and Observations of the Project ........ 1
2.1 Available Information ........ 2
2.2 Reconnaissance ........ 2
3.0 Exploration ........ 3
3.1 Field Investigation ........ 3
3.2 Laboratory Testing ........ 4
4.0 Findings ........ 4
4.1 Subsurface Stratigraphy ........ 4
4.2 Groundwater Observations ........ 5
5.0 Analyses and Recommendations ........ 5
5.1 General Discussion ........ 5
5.2 Site Preparation and New Fill Placement ........ 5
5.3 Foundation Recommendations ........ 5
*5.3.1 Cast-in-Place (CIP) Reinforced Piles ........ 6*
5.3.1.1 Pile Setup and Restrike Program ........ 6
5.3.1.2 CIP Pile Installation Recommendations ........ 7
*5.3.2 H-Piles to Bedrock ........ 7*
5.4 Downdrag Considerations ........ 8
5.5 Group Effects ........ 8
5.6 Lateral Loading ........ 9
5.7 Lateral Earth Pressures ........ 10
5.8 Seismic Site Classification ........ 11
5.9 Scour Countermeasures ........ 11
6.0 Final Considerations ........ 11

## List of Figures

Figure 2-1: Surficial Geology ........ 2

# List of Tables

Table 3-1 – Unconfined Compressive Strength (UCS) Testing Results ........ 4
Table 6-1: Summary of Ultimate Static CIP Pipe Pile Analyses for Axial Loads ........ 6
Table 6-2: Maximum Factored Structural Resistance of H-Piles ........ 8
Table 6-3: LPile 2019 Input Parameters for Strata in Boring B-001 (Rear Abutment) ........ 9
Table 6-4: LPile 2019 Input Parameters for Strata in Boring B-002 (Forward Abutment) ........ 10

# Appendices

## Appendix A

Plate No.

Vicinity Map ........ 1
Plan of Borings ........ 2
Explanation of Symbols and Terms Used on Boring Logs for Soil and Rock ........ 3-4
Boring Logs ........ 5-12
Water Well Logs ........ 13-15
Field Testing Procedures ........ 16

## Appendix B

Plate No.

Summary of Laboratory Testing ........ 1-2
Grain Size Curves ........ 3-6
Unconfined Compressive Strength Testing ........ 7-9
Lab Testing Procedures ........ 10

## Appendix C

Plate No.

Calculations ........ 1-6

# 1.0 Introduction

S&ME understands that the existing single span bridge carrying County Route (CR) 8 (Drybone Road) over Baker Fork is to be replaced with a single span bridge supported on new abutments positioned behind the existing abutments. The project is located within the locally known "mud flats area" of Pike County. This section of CR8-5.75 (Drybone Rd) bridge is to remain a two-lane rural roadway. The project length is limited to the bridge replacement. The project location is shown on Figure 1 in Appendix A to this report.

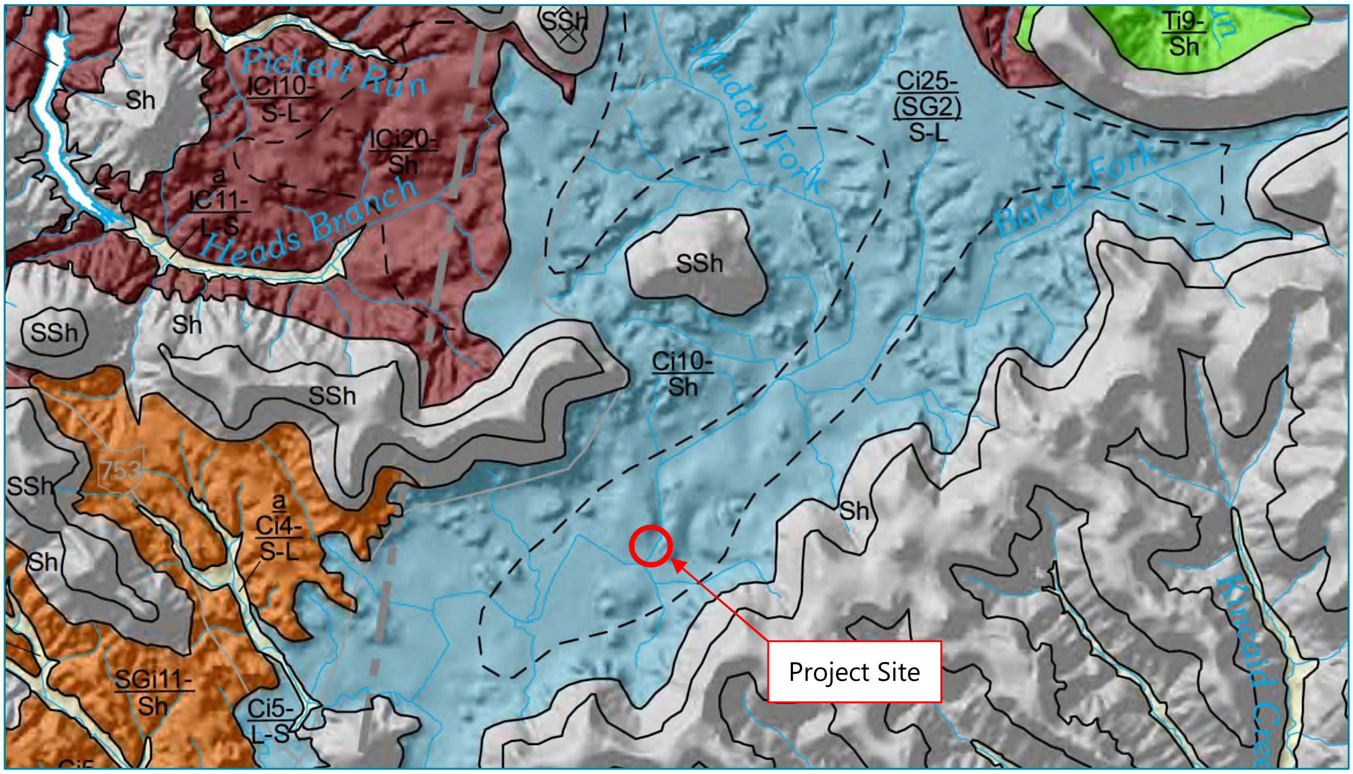
No plans for the replacement structure were available and we understand that this project will be delivered via the Design-Build ODOT Let program. At the time of this report the project limits and depth of scour were not known.

This Structure Foundation Exploration report presents the findings, analysis, and recommendations related to the pavement replacement and subgrade preparation for this project. The geotechnical exploration of this site was performed in accordance with the January 2021 update to the ODOT Specifications for Geotechnical Explorations (SGE).

# 2.0 Geology and Observations of the Project

Geologic references indicate that this project site is located within the Shawnee-Mississippian Plateau physiographic region. Surficial geology mapping indicates that lacustrine deposits (ancient Lake Bainbridge) consisting of laminated clays (Illinoian) including Minford Clays, are present along edges of the lacustrine deposits are thin layers of colluvial sand, silt, and gravel. Geologic bedrock mapping (Bedrock Geology of the Bainbridge, Ohio Quadrangle, Ohio Department of Natural Resources (ODNR)) indicates the uppermost bedrock consists of the Ohio and Olentangy Shales of the Devonian system. ODNR bedrock topography mapping indicates bedrock is around elevation El. 800 in this area. However, the borings did not encounter bedrock at the termination depth of 100 feet (El. 789). Additionally, water well logs obtained from the ODNR Water Well Viewer indicates that the three (3) closest water wells installed around the existing bridge encountered bedrock between depths of 122 and 135 feet below existing grades. Copies of the reviewed water well logs are included in Appendix B to this report. The locations of the water well logs are shown on Boring Location Plan (Figure 2) in Appendix A to this report.

We also reviewed the Surficial Geology of the Hillsboro 30 x 60-Minute Quadrangle in Ohio map (dated 01/2016). Figure 2-1 on the following page shows the project location overlain on the Surficial Geology map, which indicates the overburden thickness in this area ranges from 100 to 250 feet below existing grades.




## Figure 2-1: Surficial Geology

A review of the ODNR "Ohio Karst Areas" map indicates the site lies in an area not known to contain karst features. A review of the ODNR "Landslides in Ohio" map reveals the site is in an area susceptible to landslides due to the Bedford Shale, and the ODNR "Abandoned Underground Mines of Ohio" map indicates the site lies in an area with no mapped abandoned mines.

## 2.1 Available Information

Based on review of the ODOT Transportation Information Management System (TIMS) webpage, no historic boring logs were located within the project area. Profile information was not available from the original construction.

## 2.2 Reconnaissance

On March 30, 2021, S&ME performed a site reconnaissance to stake the planned boring locations. The site consists of an existing single-span bridge which crosses over Baker Fork and off-road sections covered with grass, shrubs, and trees. We observed spalling concrete on the bridge deck and concrete cracking on the abutments. A photograph of the existing bridge site is presented on the next page.


Date: 3/30/2021

Photographer: Rebecca Scherzinger, PE

| **Description** | PIK-CR8-5.75PIK-CR8-5.75 |
|---|---|

# 3.0 Exploration

## 3.1 Field Investigation

From July 13 to 15, 2021, two (2) borings were performed for the bridge replacement to explore the subsurface conditions in the area of the planned replacement structure. The borings were numbered B-001-0-21 and B-002-0-21. The locations of the borings are shown on the Plan of Borings included as Figure 2 of Appendix A.

The borings (B-001-0-21 and B-002-0-21) were performed by a truck-mounted drilling rig using a 3¼-inch I.D. hollow-stem auger to advance the borings between sampling attempts. Disturbed but representative soil samples were obtained by lowering a 2-inch O.D. split-barrel sampler through the auger stem or casing to the bottom of the boring and then driving the sampler into the soil with blows from a 140-pound hammer freely falling 30 inches (ASTM D1586 - Standard Penetration Test). SPT samples were examined immediately after recovery and representative portions were preserved in airtight glass jars. Undisturbed (Shelby) tube samples were obtained by hydraulically pressing a seamless steel tube into the soil. The undisturbed samples were waxed and capped in the field.

In accordance with the current ODOT SGE, the hammer system on the drill rig had been calibrated in accordance with ASTM D4633 to determine the drill rod energy ratio (81.8%). At the completion of drilling, the borings were backfilled in accordance with ODOT specifications.

In the field, experienced S&ME personnel performed the following: 1) examined the samples recovered from the borings; 2) preserved representative portions of samples in airtight glass jars; 3) prepared a log of each boring; 4) made seepage and groundwater observations; 5) made hand-penetrometer measurements in soil specimens exhibiting cohesion; and, 6) provided liaison between the field work and the Engineer so the exploration program could be modified in the event unusual or unexpected subsurface conditions were encountered. The recovered samples were transported to the laboratory of S&ME for further examination and testing.

### 3.2 Laboratory Testing

In the laboratory, the soil samples were visually identified, and soil samples were tested for natural moisture content. Classification testing (liquid/plastic limit determinations and grain-size analyses) was also performed on selected representative specimens. Three (3) unconfined compressive strength tests were performed on selected Shelby tube samples. The results of the unconfined compressive strength tests are provided in Table 3-1 below. The results of the laboratory index tests are recorded numerically on individual boring logs and the results of the strength tests are presented in Appendix B.

**Table 3-1: Unconfined Compressive Strength (UCS) Testing Results**

| Boring | Depth (ft) | Soil Description | UCS (psf) |
|---|---|---|---|
| B-001-0-21 | 35.0 – 37.0 | Silty Clay (A-6b) | 3,145 |
| B-001-0-21 | 58.5 – 60.5 | Silty Clay (A-6b) | 4,874 |
| B-002-0-21 | 13.5 – 15.5 | Clay (A-7-6) | 1,798 |

## 4.0 Findings

### 4.1 Subsurface Stratigraphy

The surficial material in B-001-0-21 consisted of 2.5 inches of fill, gravel with sand, silt, and clay. Below this surficial layer to a depth of 15 feet, B-001-0-21 encountered medium stiff to stiff silt and clay (A-6a) with variable amount of fine to coarse sand and gravels. From a depth of 15 to 20 feet, B-001-021 encountered a medium stiff silt (A-4b) layer. Immediately below that layer, was a layer of stiff to very stiff silt and clay (A-6a) to a depth of 27 feet. From 27 feet to 35 feet, the boring encountered soft clay (A-7-6) layer. Boring B-001-0-21 encountered stiff to very stiff silty clay (A-6b) between depths of 35 and 47 feet. Below 47 feet, the boring encountered medium stiff to stiff clay (A-7-6) and silty clay (A-6b) layers to the termination depth of 100 feet.

The surficial material in B-002-0-21 consisted of fill materials topsoil, silty clay (A-6b), with minor percentages of fine to coarse sand and gravel to a depth of 5.5 feet. Below that layer the boring generally encountered layers of stiff to very stiff silty clay (A-6b) and silt and clay (A-6a) to a depth of 17 feet. Following that layer, a layer of very stiff silt (A-4b) was encountered to a depth of 18.5 feet. Below the silt layer, boring B-002-0-21 encountered layers of soft to very stiff clay (A-7-6) and silty clay (A-6b) to the termination depth of 100 feet.

### 4.2 Groundwater Observations

Groundwater was observed during drilling, B-001-0-21 encountered groundwater at a depth of 28.5 feet. B-002-0-21 encountered ground water at a depth of 13.5 feet. The borings were grouted upon completion; therefore, long term groundwater readings were not obtained. Groundwater levels and can fluctuate due to seasonal variations in precipitation, construction activities, and the level in Baker Fork.

## 5.0 Analyses and Recommendations

### 5.1 General Discussion

Based on discussions with Mr. Denny Salisbury, PE, PS (PCEO), S&ME understands that the existing single-span bridge will be replaced with a new singe-span bridge which will be supported on new abutments located behind the existing abutments. Only minor approach roadway work is anticipated. We understand that the bridge will be delivered through the Design-Build, ODOT-Let delivery method. At the time of this report the structure replacement type, span, and scour depth was unknown. The following sections of this report present our geotechnical recommendations for the new PIK-CR8-5.75 bridge.

### 5.2 Site Preparation and New Fill Placement

Grading information was not available at the time of this report; however, only minor cut and fill is anticipated to match existing grades beyond the replacement bridge. Site preparation prior to fill placement should include the removal of existing pavement materials, organic soil, vegetation including the entire root systems of trees, and any areas of weak or wet materials. The existing abutment structures should also be completely removed prior to construction of the new abutments.

New fill material placed for embankments should consist of inorganic soil free of all miscellaneous materials, cobbles and boulders. The new fill should be placed in uniform, thin layers. Embankment construction should be in accordance with ODOT Construction and Materials Specification Items 203 and 204. Borrow materials should not be placed in a frozen condition or upon a frozen surface, and any sloping surfaces steeper than 4(H):1(V) on which new fill is to be placed should first be benched in accordance with the procedures outlined in the ODOT Geotechnical Bulletin GB2, *Special Benching and Sidehill Embankment Fills*.

### 5.3 Foundation Recommendations

Information provided by PCEO indicates that the existing abutments are supported on pile foundations. This project is to be a Design-Build, ODOT-Let project; therefore, foundation type has not been determined at the time of this report. Based on the borings and anticipated depth to bedrock, we recommend the new bridge abutments be supported on driven cast-in-place (CIP), reinforced piles or H-piles driven to refusal in the bedrock, which was not encountered in our borings to a termination depth of 100-feet below existing grades. Recommendations for both CIP piles, and H-piles are provided in the following sections.

### 5.3.1 *Cast-in-Place (CIP) Reinforced Piles*

S&ME understands that 12-, 14-, and 16-inch nominal diameter CIP piles may be considered for the replacement bridge. No loading information was available at the time of this report. The estimated pile resistance presented in Table 6-1 are based on a tip Elevation of 794 and a resistance factor, $\phi_{dyn}$, of 0.7 as specified in the 2020 ODOT *Bridge Design Manual* (*BDM*).

The computer program RSPile (Ver. 3.008) developed by Rocscience, Inc., was used to perform the analyses summarized above. The estimated pile resistances are presented in Table 6-1. The output for the analysis scenarios described above are included in Appendix C. The Ultimate Bearing Value (UBV) and estimated tip elevations will need to be revised if the maximum factored axial loads per pile differ from those presented in Table 6-1.

**Table 5-1: Summary of Ultimate Static CIP Pipe Pile Analyses for Axial Loads**

| Foundation Element | Proposed CIP Pipe Pile Diam. (inches) | Pile Length (ft) | Unfactored Pile Resistance (kips)* | Resistance Factor, $\phi_{dyn}$** | Factored Pile Resistance (kips) |
|---|---|---|---|---|---|
| Rear Abutment | 12 | 95 | 312 | 0.7 | 218 |
| Rear Abutment | 14 | 95 | 362 | 0.7 | 253 |
| Rear Abutment | 16 | 95 | 413 | 0.7 | 289 |
| Forward Abutment | 12 | 95 | 245 | 0.7 | 171 |
| Forward Abutment | 14 | 95 | 282 | 0.7 | 197 |
| Forward Abutment | 16 | 95 | 320 | 0.7 | 224 |

*The values presented consider no scour at the abutments.

**Considers PDA testing during construction.

The 2020 ODOT *BDM* specifies that the design UBV for all piles at each substructure unit be developed based on the highest factored load anticipated on any pile supporting that substructure unit. Additionally, if the piles are to be subjected to a bending moment, S&ME recommends that the ultimate structural capacity of the piles be evaluated to determine the reduced maximum axial structural capacity of the pile section. This reduced value should not exceed the maximum UBV value used in design.

S&ME estimates that settlement of individual piles will be less than ½-inch provided the piles are designed and installed in accordance with ODOT specifications and the recommendations presented in this report. All piles should be installed at a center-to-center spacing no closer than 2.5 pile diameters in accordance with AASHTO specifications.

#### 5.3.1.1 Pile Setup and Restrike Program

During pile installation, the clayey and silty soils encountered in the borings at this site will exhibit a temporary decrease in strength because of an increase in internal pore water pressure caused by the pile driving vibrations.

With time, however, the excess pore water pressure will dissipate, resulting in an increase in the strength of the silty soil ("pile set-up").

#### 5.3.1.2 CIP Pile Installation Recommendations

The estimated pile tip elevations in Table 6-1 were determined using information obtained from the soil borings in conjunction with static pile analysis methods. The actual depths to which individual piles are driven in the field should be a function of the driving criteria determined in accordance with ODOT *CMS* Item 523, "Dynamic Load Test".

The ODOT *BDM* requires a dynamic load test (Item 523) for each required UBV for each pile size or type. Item 523 consists of performing dynamic load tests on at least two piles for each UBV at the beginning of construction and performing subsequent CAPWAP analyses (wave matching) on the data obtained from at least one of the dynamic tests for each UBV. Establishment of the pile driving criteria (final blow count as modified by specific pile hammer ram stroke, bounce chamber pressure, etc.) used for the production piles should be based on the results of the PDA testing and CAPWAP analyses performed during the test pile phase.

The piles, pile driving equipment, and pile installation procedures should conform to ODOT *CMS* Item 507. The hammer type should be selected in accordance with ODOT *CMS* Item 507.04 to avoid over-stressing the piles (i.e., not exceeding 90% of the maximum yielding stress ($f_y$) of the pile which is 35 ksi for CIP piles).

Once a pile type has been identified, a pile drivability analyses of the piles should be performed. Prior to the commencement of pile driving, the contractor should be required to submit proposed pile driving equipment specifications and the proposed pile hammer and/or cushions meet the minimum rated energy provided above, without exceeding the stated pile stresses to reduce the possibility of damage to the pile. Pile driving may also result in slight heave of previously driven piles. To avoid detrimental effects, all piles should be re-tapped prior to the completion of pile driving activities.

If the bottom of pile cap elevations are modified, the proposed culvert structure is reconfigured, or the axial capacity is attained before penetration of 80% of the estimated depth (see ODOT *CMS* Item 507.04), S&ME should be given the opportunity to review and revise our foundation recommendations, if warranted.

### 5.3.2 *H-Piles to Bedrock*

Based on the available boring logs, water well logs, and geologic mapping, bedrock is anticipated to be encountered between 120 and 140 feet below existing grades. **If the Design-Build contractor wishes to install H-pile driven to refusal on bedrock, we recommend performing additional boring to confirm the depth to bedrock.**

According to Section 202.2.3.2.a of the 2007 ODOT Bridge Design Manual (BDM) including January 2021 updates, the factored resistance for piles driven to refusal (or bearing) on bedrock is typically governed by the structural resistance of the piles. The ODOT BDM recommends a maximum factored structural resistance ($R_{Rmax}$) value which is given in Table 6-2 on the following page for typically used pile sizes. These $R_{Rmax}$ values incorporate AASHTO criteria and factors for driven piles; namely that each H-pile is axially loaded with negligible moment, the steel has a yield strength of 50 ksi, the structural resistance factor ($\Phi_c$) is 0.5 (for damage due to severe driving conditions) per Article 6.5.4.2 of the AASHTO LRFD Bridge Design Specifications, and each pile is fully supported by soil along its length.

### Table 6-2: Maximum Factored Structural Resistance of H-Piles

| H Pile Size | Maximum Factored Structural Resistance ($Rr_{max}$) |
|---|---|
| HP10x42 | 310 kips |
| HP12x53 | 380 kips |
| HP14x73 | 530 kips |

For H-piles bearing on bedrock, practical refusal is defined as less than 1 inch of penetration for 20 blows of a properly sized pile hammer. The hammer type should be selected in accordance with Item 507.04 "Driving of Piles", of the 2021 ODOT Construction and Material Specifications (CMS). Testing research has shown that steel H-piles driven to this degree of penetration in rock cannot be forced deeper by static load and, when loaded to the yield point of the steel, will fail instead of the rock. It is also recommended that H-piles be installed at a center-to-center spacing of no less than 2.5 times the largest diagonal dimension of the H-section (AASHTO requirements). For H-piles installed in this manner, it is estimated that the total settlement of the H-piles will be limited to the elastic compression of the structural members.

Prior to commencing pile driving operations, the contractor should be required to submit equipment specifications to the state so that the proposed pile hammer can be evaluated by a wave equation analysis. If excessive (FHWA limits driving stresses to 90 percent of $f_y$) compressive or tensile stresses are predicted with a wave equation analysis, alternative pile hammers and/or cushions should be investigated prior to pile installation to reduce the potential for pile damage during driving. Pile driving may also result in slight uplift of previously driven piles. All piles should be re-tapped prior to completing pile driving activities.

In accordance with Section 202.2.3.2.a of the 2020 ODOT BDM (including July updates), steel points should not be used to protect the tips of H-piles driven to refusal on the anticipated shale bedrock.

## 5.4 Downdrag Considerations

We understand that the vertical profile of the roadway and span of the structure are to remain essentially unchanged. Accordingly, no additional loading to the piles in the form of downdrag is anticipated.

## 5.5 Group Effects

All piles should be installed at a center-to-center spacing not be less than 2.5 pile diameters in accordance with AASHTO *LRFD* Article 10.7.1.2. The distance from the side of any pile to the nearest edge of the pile cap shall not be less than 9 inches. The tops of piles shall project at least 12 inches into the pile cap after all damaged material has been removed.

In accordance with Article 10.7.3.9 of the AASHTO *LRFD*, if the pile cap is in firm contact with the ground, no reduction in group efficiency is required when piles are installed in cohesive soils with the proper 2.5 diameter center-to-center spacing. In cohesionless soils, no reduction in efficiency factor is anticipated if the piles are spaced no closer than 2.5 diameters apart (center-to-center). It is anticipated that a group efficiency of 1.0 would be applicable if the proper pile spacing is achieved as noted above.

## 5.6 Lateral Loading

Section 305.3.2.1 of the 2020 ODOT BDM, Section 305.3.2.1 directs that a p-y (lateral load) analysis should be performed to assess lateral stability and excess deflection of the piles under a free-standing bridge loading with no soil support above the design scour elevation (El. 1051) and/or the check scour elevation (El. 1050). These analyses were not included in our scope of work for this project and should be performed by the project structural engineer. To assist with these analyses, we have provided soil support parameters in Table 6-2 and Table 6-3 that can be used to perform the lateral load analyses.

### Table 5-3: LPile 2019 Input Parameters for Strata in Boring B-001 (Rear Abutment)

| Stratum | Depth Interval (ft.) | p-y Soil Model | Effective Unit Weight (pcf)* | $S_u$ (psf) |
|---|---|---|---|---|
| Silt and Clay (A-6a) | 0 – 13.5 | Stiff Clay w/ Free Water (Reese) | 115 | 2,000 |
| Silt and Clay (A-6a) | 13.5 – 15.0 | Stiff Clay w/ Free Water (Reese) | 53 | 2,000 |
| Silt (A-4a) | 15.0 – 20.0 | Cemented Silt | 48 | 750 |
| Silt and Clay (A-6a) | 20.0 – 27.0 | Stiff Clay w/ Free Water (Reese) | 53 | 1,000 |
| Clay (A-7-6) | 27.0 – 35.0 | Stiff Clay w/ Free Water (Reese) | 53 | 250 |
| Silty Clay (A-6b) | 35.0 – 47.0 | Stiff Clay w/ Free Water (Reese) | 53 | 1,500 |
| Clay (A-7-6) | 47.0 – 57.0 | Stiff Clay w/ Free Water (Reese) | 53 | 750 |
| Silty Clay (A-6b) | 57.0 – 72.0 | Stiff Clay w/ Free Water (Reese) | 58 | 2,000 |
| Clay (A-7-6) | 72.0 – 100.0 | Stiff Clay w/ Free Water (Reese) | 58 | 1,000 |

*Groundwater estimated to be 13.5 feet below grades.

### Table 5-4: LPile 2019 Input Parameters for Strata in Boring B-002 (Forward Abutment)

| Stratum | Depth Interval (ft.) | p-y Soil Model | Effective Unit Weight (pcf)* | $S_u$ (psf) |
|---|---|---|---|---|
| Silty Clay (A-6b) | 0 – 5.5 | Stiff Clay w/ Free Water (Reese) | 120 | 1,500 |
| Silt and Clay (A-6a) | 5.5 – 13.5 | Stiff Clay w/ Free Water (Reese) | 115 | 1,000 |
| Silt and Clay (A-6a) | 13.5 – 15.5 | Stiff Clay w/ Free Water (Reese) | 53 | 1,000 |
| Silty Clay (A-6b) | 15.5 – 17.0 | Stiff Clay w/ Free Water (Reese) | 53 | 2,500 |
| Silt (A-4a) | 17.0 – 18.5 | Cemented Silt | 48 | 3,000 |
| Clay (A-7-6) | 18.5 – 32.0 | Stiff Clay w/ Free Water (Reese) | 53 | 750 |
| Silty Clay (A-6b) | 32.0 – 42.0 | Stiff Clay w/ Free Water (Reese) | 58 | 3,000 |
| Clay (A-7-6) | 42.0 – 100.0 | Stiff Clay w/ Free Water (Reese) | 58 | 750 |

* Groundwater estimated to be 13.5 feet below grades.

## 5.7 Lateral Earth Pressures

The proposed abutments must be designed to withstand lateral earth pressures, as well as hydrostatic pressures, that may develop behind the structures. The magnitude of the lateral earth pressures varies based on soil type, permissible wall movement, and the configuration of the backfill.

To minimize lateral earth pressures, the zone behind abutment walls should be backfilled with granular soil, and the backfill should be effectively drained. For effective drainage, a zone of free-draining gravel (ODOT *CMS* Item 518.03) should be used directly behind the structures for a minimum thickness of 24 inches in accordance with ODOT *CMS* Item 518.05. This granular zone should drain to either weepholes or a pipe, so that hydrostatic pressures do not develop against the walls.

The type of backfill beyond the free-draining granular zone, however, will govern the magnitude of the pressure to be used for structural design. Pressures of a relatively low magnitude will be developed by using granular backfill, whereas a cohesive (clay) backfill will result in the development of much higher pressures.

To minimize lateral pressures, it is recommended that granular backfill be used behind the abutments and any wingwalls. The backfill should be placed in a wedge formed by the back of the structure and a line rising from the base of the wall abutment foundations at an angle no greater than 60 degrees from horizontal. Granular backfill behind the structures should be compacted in accordance with ODOT *CMS* Item 203, "Embankment Compaction".

Over-compaction in areas directly behind the walls should be avoided, as this might cause damage to the structure.

If proper drainage is provided and compacted granular backfill is provided as described above, an equivalent fluid unit weight of 35 lb/ft$^3$ (pcf) may be used if movement equivalent to 0.25 percent of the height of the abutment or wingwall (H) is allowed to occur. Such movement is considered sufficient to mobilize an active earth pressure condition, and the resultant lateral force should be taken as acting at 0.33H. If this movement is not anticipated or cannot occur, it is recommended that an "at-rest" equivalent fluid unit weight of 55 pcf be used.

Compacted cohesive materials tend alternatively to shrink, expand, and creep over periods of time and create significant lateral pressures on any adjacent structures. Cohesive materials also require a greater amount of movement to mobilize an active earth pressure condition. For these reasons, if proper drainage (ODOT *CMS* Item 518) is provided and a wall movement exceeding 1.0 percent of the height of the abutment or wingwall (H) is allowed to occur, an equivalent fluid unit weight of 65 pcf may be used for design of the abutment walls to resist the lateral loads imparted by drained cohesive backfill. If this amount of movement is not anticipated or cannot occur, it is recommended that an "at-rest" equivalent fluid unit weight of 95 pcf be used.

The structures must also be designed to withstand the surcharge effect of traffic in addition to the vertical load resulting from the weight of any fill and pavement to be placed over the structures. To estimate vertical loading, a total unit weight of 125 pcf and 135 pcf may be used for compacted cohesive and granular soil, respectively.

### 5.8 Seismic Site Classification

Based on the subsurface stratigraphy encountered within the borings, it is the opinion of S&ME that this site is best characterized by AASHTO *LRFD* Table 3.10.3.1-1 as seismic site class E.

### 5.9 Scour Countermeasures

S&ME recommends that scour protection be designed, such as placing appropriately sized rip-rap. Rip-rap used for this purpose should be properly sized based on the anticipated channel velocities. However, rip-rap is not a permanent countermeasure against, nor does it totally eliminate the potential for scour. For this reason, it is strongly recommended that the project plans and specifications also contain provisions for routine maintenance of the rip-rap blanket to ensure that the design blanket thickness is preserved over the design life of the abutments. Additionally, in all cases where rip-rap is used for scour protection, the bridge must be monitored during and inspected after, periods of high flow.

Gradation testing was performed in the scour zone (6-feet below the creek bed) for use during scour depth computations (by others). The results of the gradation testing are included in Plate 1 of Appendix B.

## 6.0 Final Considerations

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other representation or warranty either express or implied, is made.

We relied on project information given to us to develop our conclusions and recommendations. If project information described in this report is not accurate, or if it changes during project development, we should be notified of the changes so that we can modify our recommendations based on this additional information if necessary.

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

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

S&ME should be retained to review the final plans and specifications to confirm that earthwork, foundation, and other recommendations are properly interpreted and implemented. The recommendations in this report are contingent on S&ME's review of final plans and specifications followed by our observation and monitoring of earthwork and foundation construction activities.

## Important Information About Your

# Geotechnical Engineering Report

*Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.*

### Geotechnical Findings Are Professional Opinions

Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

### Geotechnical Findings Are Professional Opinions

Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

### Services Are Performed for Specific Projects

Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project.

Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

### Geo-Environmental Issues

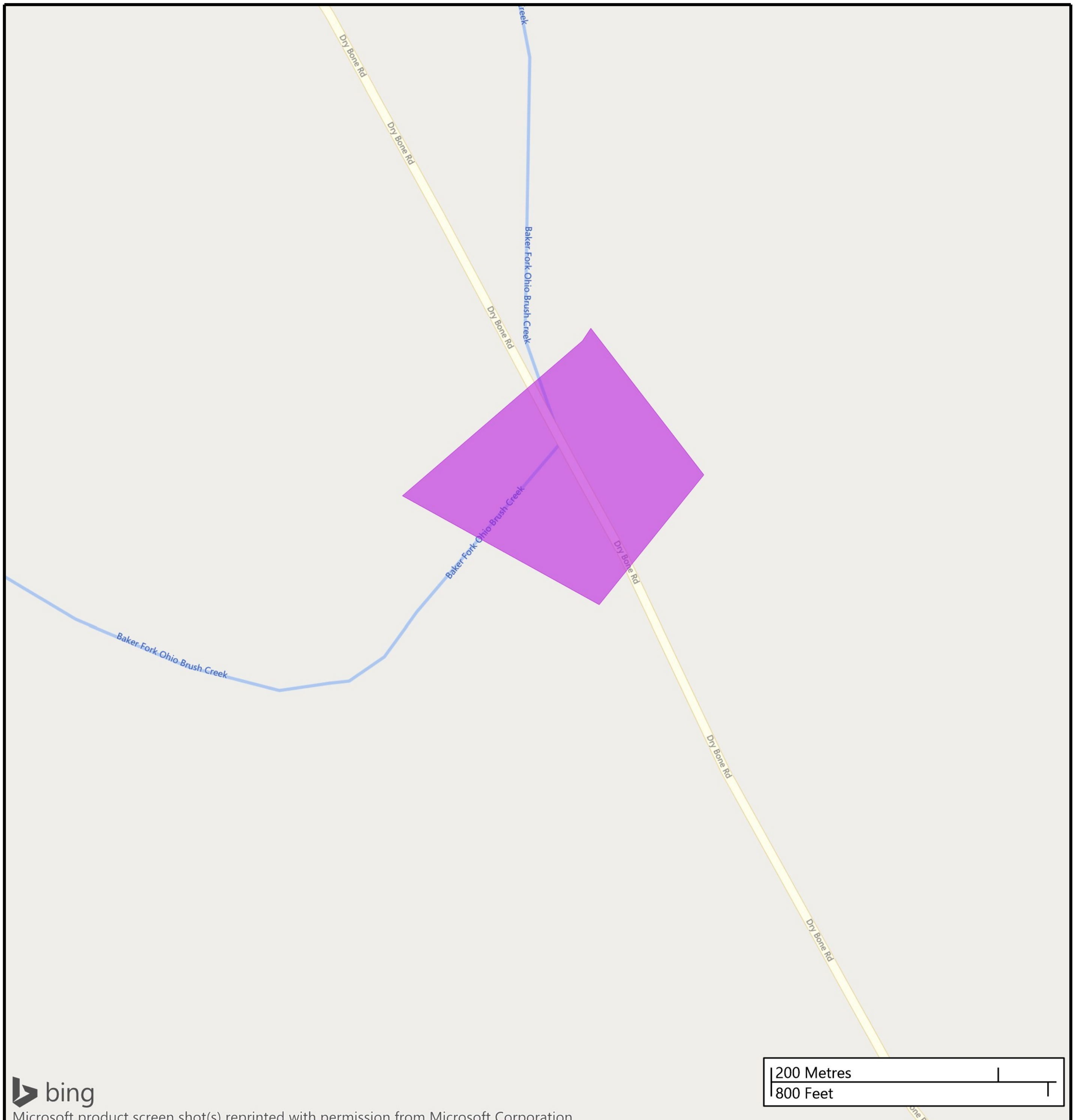
The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

### Geotechnical Recommendations Are Not Final

Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.

# Appendices

# Appendix A – Figures and Boring Logs






Legend

Project Bounds

Notes:

N

VICINITY MAP

PIK-CR8-5.75 Bridge

| SCALE: | FIGURE NO. |
|---|---|
| 1:5000 | 1 |
| DATE: | |
| Aug 17 2021 | |
| PROJECT NUMBER: | |
| 213410 | |


N

Legend

- Boring Locations
- Water Well Locations

Notes:

| | | | |
|---|---|---|---|
| BORING LOCATION PLAN | SCALE: | 1:4000 | FIGURE NO. |
| | DATE: | Dec 06 2021 | 2 |
| PIK-CR8-5.75 Bridge | PROJECT NUMBER: | 213410 | |

## EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

### SAMPLING DATA

| | | |
|---|---|---|
| ▮ | - | Indicates sample was attempted within this depth interval. |
| 2<br>3<br>5 | - | The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches (SPT). The raw "blowcount" or "N" is equal to the sum of the second and third 6-inch increments of penetration. |
| $N_{60}$ | - | Corrected Blowcount = [(Drill Rod Energy Ratio) / (0.60 Standard)] X N |
| SS | - | Split-barrel sampler, any size. |
| ST | - | Shelby tube sampler, 3″ O.D., hydraulically pushed. |
| R | - | Refusal of sampler in very-hard or dense soil, or on a resistant surface. |
| 50-0.3′ | - | Number of blows (50) to drive a split-barrel sampler a certain distance (0.3 feet), other than the normal 6-inch increment. |

### DEPTH DATA

| | | |
|---|---|---|
| W | - | Depth of water or seepage encountered during drilling. |
| ▼ AD | - | Depth to water in boring after drilling (AD) is terminated. |
| ▼ 5 days | - | Depth to water in monitoring well or piezometer in boring a certain number of days (5) after termination of drilling. |
| TR | - | Depth to top of rock. |

### SOIL DESCRIPTIONS

Soils have been classified in general accordance with Section 603 of the most recent ODOT SGE, and described in general accordance with Section 602, including the use of special adjectives to designate approximate percentages of minor components as follows:

| Adjective | Percent by Weight |
|---|---|
| trace | 1 to 10 |
| little | 10 to 20 |
| some | 20 to 35 |
| "and" | 35 to 50 |

The following terms are used to describe density and consistency of soils:

| Term (Granular Soils) | Blows per foot ($N_{60}$) |
|---|---|
| Very-loose | Less than 5 |
| Loose | 5 to 10 |
| Medium-dense | 11 to 30 |
| Dense | 31 to 50 |
| Very-dense | Over 50 |

| Term (Cohesive Soils) | Qu (tsf) |
|---|---|
| Very-soft | Less than 0.25 |
| Soft | 0.25 to 0.5 |
| Medium-stiff | 0.5 to 1.0 |
| Stiff | 1.0 to 2.0 |
| Very-stiff | 2.0 to 4.0 |
| Hard | Over 4.0 |

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 11/19/21 10:21 - T:\GEO\PROJECTS\2021\213410_PCEO_PIK-CR8-5.75 BRIDGE_CYNTHIANA OHFIELD DATA\213410_PIK-CR8-5.

S&ME JOB: 213410

| | | | | |
|---|---|---|---|---|
| PROJECT: PIK-CR8-5.75 BRIDGE | DRILLING FIRM / OPERATOR: S&ME / BRUMMAGE | DRILL RIG: S&ME D-50 (R-63) | STATION / OFFSET: | EXPLORATION ID B-001-0-21 |
| TYPE: STRUCTURE FOUNDATION | SAMPLING FIRM / LOGGER: S&ME / K. HELTON | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: CR8 | |
| PID: SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/12/19 | ELEVATION: 889.0 (MSL) EOB: 100.0 ft. | PAGE 1 OF 3 |
| START: 7/12/21 END: 7/13/21 | SAMPLING METHOD: SPT / ST | ENERGY RATIO (%): 90* | LAT / LONG: 39.148270, -83.339704 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 889.0 |
|---|---|
| **TOPSOIL - 8.5 inches** | 888.2 |
| FILL: Medium dense brown and reddish-brown, **GRAVEL WITH SAND, SILT, AND CLAY**, contains weathered shale and sandstone fragments, damp. | 886.5 |
| Medium-stiff to very-stiff, light-brown mottled with reddish brown **SILT AND CLAY**, some fine to coarse sand, moist. | 871.0 |
| Very-stiff, gray, **SILT**, little fine sand, trace to little clay, varved, moist. | 869.0 |
| Stiff to very-stiff, gray, **SILT AND CLAY**, contains pockets of clay, moist. | 862.0 |
| Soft, gray, **CLAY**, little silt, moist. | 854.0 |

W 860.5

DEPTHS: 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 32.5

| SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 3 11 | 21 | 72 | SS-1 | - | 44 | 24 | 9 | 7 | 16 | 39 | 27 | 12 | 15 | A-2-6 (0) | |
| 2 3 4 | 11 | 44 | SS-2 | 2.0 | - | - | - | - | - | - | - | - | 17 | A-6a (V) | |
| 2 3 5 | 12 | 67 | SS-3 | 2.5 | 0 | 2 | 24 | 37 | 37 | 30 | 17 | 13 | 18 | A-6a (9) | |
| 3 3 6 | 14 | 100 | SS-4 | 2.8 | - | - | - | - | - | - | - | - | 21 | A-6a (V) | |
| 2 3 4 | 11 | 100 | SS-5 | 1.8 | - | - | - | - | - | - | - | - | 24 | A-6a (V) | |
| 2 4 6 | 15 | 100 | SS-6 | 2.5 | 0 | 1 | 0 | 58 | 41 | - | - | - | 23 | A-6a (V) | |
| 2 4 5 | 14 | 100 | SS-7 | 0.5-1.75 | 0 | 0 | 0 | 35 | 65 | - | - | - | 26 | A-6a (V) | |
| 2 3 4 | 11 | 100 | SS-8 | 0.5-0.75 | 0 | 1 | 1 | 38 | 60 | - | - | - | 26 | A-6a (V) | |
| 6 8 6 | 21 | 100 | SS-9 | 3.5-4.0 | 0 | 0 | 0 | 78 | 22 | 24 | 19 | 5 | 25 | A-4b (8) | |
| 2 3 5 | 12 | 100 | SS-10 | 1.0 | 0 | 0 | 0 | 57 | 43 | 27 | 16 | 11 | 23 | A-6a (8) | |
| 3 4 4 | 12 | 89 | SS-11 | 3.5 | - | - | - | - | - | - | - | - | 21 | A-6a (V) | |
| 2 3 4 | 11 | 100 | SS-12 | 0.25-0.50 | - | - | - | - | - | - | - | - | 30 | A-7-6 (V) | |
| 0 0 | 5 | 100 | SS-13 | 0.25-0.50 | - | - | - | - | - | - | - | - | 26 | A-7-6 (V) | |

S&ME JOB: 213410

| PID: | SFN: N/A | PROJECT: PIK-CR8-5.75 BRIDGE | STATION / OFFSET: | START: 7/12/21 | END: 7/13/21 | PG 2 OF 3 | B-001-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 854.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stiff to very-stiff, gray, **SILTY CLAY**, moist.<br>$Q_u$=3,145 psf (depth 35 - 37 feet) | | | 3 | | 100 | ST-14 | 1.0-2.25 | 0 | 0 | 0 | 39 | 61 | 37 | 17 | 20 | 28 | A-6b (12) | |
| | | 37.5 | | | | | | | | | | | | | | | | |
| | | 40.0 | 0 3 6 | 14 | 100 | SS-15 | 3.5 | - | - | - | - | - | - | - | - | 26 | A-6b (V) | |
| | | 42.5 | | | | | | | | | | | | | | | | |
| | | 45.0 | 2 4 6 | 15 | 100 | SS-16 | 1.5-2.0 | - | - | - | - | - | - | - | - | 24 | A-6b (V) | |
| | 842.0 | | | | | | | | | | | | | | | | | |
| Medium-stiff to stiff, gray, **CLAY**, little silt, moist. | | 47.5 | | | | | | | | | | | | | | | | |
| | | 50.0 | 2 3 4 | 11 | 100 | SS-17 | 0.75-1.5 | 0 | 0 | 0 | 20 | 80 | 47 | 21 | 26 | 29 | A-7-6 (16) | |
| | | 52.5 | | | | | | | | | | | | | | | | |
| | | 55.0 | 2 3 5 | 12 | 100 | SS-18 | 0.5 | - | - | - | - | - | - | - | - | 29 | A-7-6 (V) | |
| | 832.0 | | | | | | | | | | | | | | | | | |
| Medium-stiff, gray, **SILTY CLAY**, contains silt seams and lenses, moist.<br>$Q_u$=4,874 psf (depth 58.5 - 60.5 feet) | | 57.5 | | | | | | | | | | | | | | | | |
| | | 60.0 | | | 100 | ST-19 | 2.0-2.5 | 0 | 0 | 0 | 47 | 53 | 37 | 17 | 20 | 23 | A-6b (12) | |
| | | 62.5 | | | | | | | | | | | | | | | | |
| | | 65.0 | 2 2 3 | 8 | 100 | SS-20 | 0.5 | - | - | - | - | - | - | - | - | 29 | A-6b (V) | |
| | | 67.5 | | | | | | | | | | | | | | | | |
| | | 70.0 | 3 4 6 | 15 | 100 | SS-21 | 0.50-1.0 | 0 | 0 | 0 | 25 | 75 | 37 | 20 | 17 | 30 | A-6b (11) | |
| | 817.0 | | | | | | | | | | | | | | | | | |

S&ME JOB: 213410

| PID: | SFN: N/A | PROJECT: PIK-CR8-5.75 BRIDGE | STATION / OFFSET: | START: 7/12/21 | END: 7/13/21 | PG 3 OF 3 | B-001-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 816.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Medium-stiff to stiff, gray, **CLAY**, little silt, moist. *(continued)* | | | | | | | | | | | | | | | | | | |
| | | 75.0 | 3 3 5 | 12 | 100 | SS-22 | 0.50-1.0 | - | - | - | - | - | - | - | - | 32 | A-7-6 (V) | |
| | | 77.5 | | | | | | | | | | | | | | | | |
| | | 80.0 | 3 4 4 | 12 | 100 | SS-23 | 0.50-0.75 | - | - | - | - | - | - | - | - | 32 | A-7-6 (V) | |
| | | 82.5 | | | | | | | | | | | | | | | | |
| | | 85.0 | 4 4 6 | 15 | 100 | SS-24 | 0.5 | - | - | - | - | - | - | - | - | 31 | A-7-6 (V) | |
| | | 87.5 | | | | | | | | | | | | | | | | |
| | | 90.0 | 4 5 7 | 18 | 100 | SS-25 | 0.5 | 0 | 0 | 0 | 19 | 81 | 48 | 21 | 27 | 30 | A-7-6 (16) | |
| | | 92.5 | | | | | | | | | | | | | | | | |
| | | 95.0 | 4 5 6 | 17 | 100 | SS-26 | 0.50-1.0 | - | - | - | - | - | - | - | - | 30 | A-7-6 (V) | |
| | | 97.5 | | | | | | | | | | | | | | | | |
| | 789.0 | EOB 100.0 | 4 6 6 | 18 | 100 | SS-27 | 0.50-1.0 | - | - | - | - | - | - | - | - | 31 | A-7-6 (V) | |

NOTES:
Encountered groundwater at 28.5 feet.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE CHIPS; PLASTIC HOLE CLOSURE DEVICE

| | | | | |
|---|---|---|---|---|
| PROJECT: PIK-CR8-5.75 BRIDGE | DRILLING FIRM / OPERATOR: S&ME / BRUMMAGE | DRILL RIG: S&ME D-50 (R-63) | STATION / OFFSET: | EXPLORATION ID B-002-0-21 |
| TYPE: STRUCTURE FOUNDATION | SAMPLING FIRM / LOGGER: S&ME / K. HELTON | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: CR8 | |
| PID: SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/12/19 | ELEVATION: 889.0 (MSL) EOB: 100.0 ft. | PAGE 1 OF 3 |
| START: 7/14/21 END: 7/15/21 | SAMPLING METHOD: SPT / ST | ENERGY RATIO (%): 90* | LAT / LONG: 39.148382, -83.339814 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 889.0 |
|---|---|
| **TOPSOIL - 8.5 inches** | 888.2 |
| FILL: Stiff to very-stiff, brown and gray. **SILTY CLAY**, little fine to coarse sand, trace gravel, contains roots, damp. | 883.5 |
| Stiff to very-stiff, brown mottled with gray **CLAY**, some silt, little fine sand, contains iron oxide stains, damp.<br><br>$Q_u$=1,798 psf (depth 13.5 - 15.5 feet) | 872.0 |
| Very-stiff, brown and gray, **SILT**, trace fine sand, trace clay, varved, moist. | 870.5 |
| Medium-stiff, gray, **CLAY**, little silt, trace fine sand, varved, moist. | 857.0 |
| Very-stiff, gray, **SILTY CLAY**, trace fine sand, contains fine sand and silt seams and lenses, varved, damp. | |

DEPTHS: 2.5, 5.0, 7.5, 10.0, 12.5, W 875.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 32.5

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 4 5 | 14 | 50 | SS-1 | 2.0-2.5 | 3 | 4 | 13 | 37 | 43 | 39 | 18 | 21 | 20 | A-6b (12) |
| 2 3 5 | 12 | 50 | SS-2 | 1.5 | - | - | - | - | - | - | - | - | 28 | A-6b (V) |
| 3 3 4 | 11 | 100 | SS-3 | 2.5 | - | - | - | - | - | - | - | - | 18 | A-6b (V) |
| | | 0 | ST-4 | - | - | - | - | - | - | - | - | - | - | A-6b (V) |
| 2 3 5 | 12 | 100 | SS-5 | 2.8 | - | - | - | - | - | - | - | - | 22 | A-6b (V) |
| | | 83 | ST-6 | - | 0 | 0 | 10 | 34 | 56 | 43 | 20 | 23 | 25 | A-7-6 (14) |
| 3 6 9 | 23 | 100 | SS-7 | 2.5 | 0 | 0 | 1 | 43 | 56 | 39 | 20 | 19 | 22 | A-6b (12) |
| 4 6 10 | 24 | 100 | SS-8 | 3.5-4.0 | 0 | 0 | 1 | 66 | 33 | - | - | - | 24 | A-4b (V) |
| 3 4 4 | 12 | 100 | SS-9 | 0.5 | 0 | 0 | 0 | 54 | 46 | - | - | - | 24 | A-7-6 (V) |
| 0 2 2 | 6 | 100 | SS-10 | 0.50-0.75 | - | - | - | - | - | - | - | - | 25 | A-7-6 (V) |
| | | 96 | ST-11 | 0.50-1.25 | - | - | - | - | - | - | - | - | 24 | A-7-6 (V) |
| 3 3 4 | 11 | 100 | SS-12 | 0.50-1.0 | 0 | 0 | 0 | 30 | 70 | - | - | - | 23 | A-7-6 (V) |
| 4 6 | 20 | 100 | SS-13 | 3.0 | - | - | - | - | - | - | - | - | 23 | A-6b (V) |

S&ME JOB: 213410

| PID: | SFN: N/A | PROJECT: PIK-CR8-5.75 BRIDGE | STATION / OFFSET: | START: 7/14/21 | END: 7/15/21 | PG 2 OF 3 | B-002-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 854.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very-stiff, gray, **SILTY CLAY**, trace fine sand, contains fine sand and silt seams and lenses, varved, damp. *(continued)* | | 853.5 | 7 | | | | | | | | | | | | | | | |
| | | 37.5 | | | | | | | | | | | | | | | | |
| | | 40.0 | 10 9 12 | 32 | 100 | SS-14 | 3.0 | - | - | - | - | - | - | - | - | 23 | A-6b (V) | |
| | 847.0 | | | | | | | | | | | | | | | | | |
| Soft to stiff, gray, **CLAY**, little to some silt, trace fine sand, contains fine sand and silt lenses, varved, moist. | | 42.5 | | | | | | | | | | | | | | | | |
| | | 45.0 | 0 0 2 | 3 | 100 | SS-15 | 1.5-2.0 | 0 | 0 | 0 | 33 | 67 | 41 | 19 | 22 | 25 | A-7-6 (13) | |
| | | 47.5 | | | | | | | | | | | | | | | | |
| | | 50.0 | 0 2 3 | 8 | 100 | SS-16 | 1.0 | - | - | - | - | - | - | - | - | 39 | A-7-6 (V) | |
| | | 52.5 | | | | | | | | | | | | | | | | |
| | | 55.0 | 0 0 2 | 3 | 100 | SS-17 | 0.5 | 0 | 0 | 0 | 15 | 85 | 50 | 22 | 28 | 33 | A-7-6 (17) | |
| | | 57.5 | | | | | | | | | | | | | | | | |
| | | 60.0 | 0 0 3 | 5 | 100 | SS-18 | 0.50-1.0 | - | - | - | - | - | - | - | - | 32 | A-7-6 (V) | |
| | | 62.5 | | | | | | | | | | | | | | | | |
| | | 65.0 | 0 1 1 | 3 | 100 | SS-19 | 0.5 | 0 | 0 | 0 | 33 | 67 | 43 | 21 | 22 | 30 | A-7-6 (13) | |
| | | 67.5 | | | | | | | | | | | | | | | | |
| | | 70.0 | 0 0 2 | 3 | 100 | SS-20 | 0.5 | - | - | - | - | - | - | - | - | 32 | A-7-6 (V) | |

| PID: | SFN: N/A | PROJECT: PIK-CR8-5.75 BRIDGE | STATION / OFFSET: | START: 7/14/21 | END: 7/15/21 | PG 3 OF 3 | B-002-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 816.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soft to stiff, gray, **CLAY**, little to some silt, trace fine sand, contains fine sand and silt lenses, varved, moist. *(continued)* | | 75.0 | 0 0 2 | 3 | 100 | SS-21 | 0.5 | 0 | 0 | 0 | 24 | 76 | 45 | 22 | 23 | 30 | A-7-6 (14) | |
| | | 77.5 | | | | | | | | | | | | | | | | |
| | | 80.0 | 0 0 3 | 5 | 100 | SS-22 | 0.5 | - | - | - | - | - | - | - | - | 30 | A-7-6 (V) | |
| | | 82.5 | | | | | | | | | | | | | | | | |
| | | 85.0 | 0 0 4 | 6 | 100 | SS-23 | 0.3 | 0 | 0 | 0 | 27 | 73 | - | - | - | 37 | A-7-6 (V) | |
| | | 87.5 | | | | | | | | | | | | | | | | |
| | | 90.0 | 0 3 5 | 12 | 100 | SS-24 | 0.50-0.75 | - | - | - | - | - | - | - | - | 31 | A-7-6 (V) | |
| | | 92.5 | | | | | | | | | | | | | | | | |
| | | 95.0 | 0 2 3 | 8 | 100 | SS-25 | 0.5 | - | - | - | - | - | - | - | - | 31 | A-7-6 (V) | |
| | | 97.5 | | | | | | | | | | | | | | | | |
| | 789.0 | EOB 100.0 | 0 3 6 | 14 | 100 | SS-26 | 0.50-0.75 | - | - | - | - | - | - | - | - | 31 | A-7-6 (V) | |

NOTES:
Encountered groundwater at 13.5 feet.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE CHIPS; PLASTIC HOLE CLOSURE DEVICE

# Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Soil and Water
Phone: 614-265-6740 Fax: 614-265-6767

**Well Log Number:** 994773

View Image of Original Well Log

**ORIGINAL OWNER AND LOCATION**

**Original Owner Name:** *PHILIP WEAVER*

**County:** *PIKE* **Township:** *PERRY* **Section Number:**

**Address:** *5690 DRY BONE RD* **Lot Number:**

**City:** **State:** *OH* **Zip Code:** *45133*

**Location Number:** **Location Map Year:** **Location Area:**

**Latitude:** *39.149997* **Longitude:** *-83.33826*

**CONSTRUCTION DETAILS**

**Borehole Diameter: 1:** *6 in.* **2:** **Borehole Depth: 1:** *132 ft.* **2:** **Depth to Bedrock:**

**Casing Diameter: 1:** *6 in.* **2:** **Casing Length: 1:** *130 ft.* **2:** **Casing Thickness: 1:** *0.188 in.* **2:**

**Casing Height Above Ground:** **Aquifer Type:** *LIMESTONE*

**Date of Completion:** *12/30/2005* **Total Depth:** *132 ft.* **Well Use:** *DOMESTIC*

**Driller's Name:** *Walter's Well Drilling*

**Screen Diameter:** **Slot Size:** **Screen Length:**

**Type:** **Material:**

**Set Between:**

**Gravel Pack Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed:**

**Grout Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed**

**WELL TEST DETAILS**

**Static Water Level:** *50 ft.* **Test Rate:** *18 gpm* **Associated Reports**

**Drawdown:** *60 ft.* **Test Duration:** *1 hrs.*

**COMMENTS:** *DGS adjusted bedrock depth based on surficial mapping.*

**WELL LOG**

| Formations | From | To |
|---|---|---|
| CLAY | 0 | 130 |
| LIMESTONE | 130 | 132 |

Printing Tips (opens in new window)
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Well log questions - Web site questions - Web policies

# Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Soil and Water
Phone: 614-265-6740 Fax: 614-265-6767

**Well Log Number:** 1007941

View Image of Original Well Log

**ORIGINAL OWNER AND LOCATION**

**Original Owner Name:** *MATTHEW ZIMMERMAN*

**County:** *PIKE* **Township:** *PERRY* **Section Number:**

**Address:** *5837 DRY BONE RD* **Lot Number:**

**City:** **State:** *OH* **Zip Code:** *45660*

**Location Number:** **Location Map Year:** **Location Area:**

**Latitude:** *39.148781* **Longitude:** *-83.344354*

**CONSTRUCTION DETAILS**

**Borehole Diameter: 1:** *6 in.* **2:** **Borehole Depth: 1:** *145 ft.* **2:** **Depth to Bedrock:**

**Casing Diameter: 1:** *6 in.* **2:** **Casing Length: 1:** *135 ft.* **2:** **Casing Thickness: 1:** *0.188 in.* **2:**

**Casing Height Above Ground:** **Aquifer Type:** *LIMESTONE*

**Date of Completion:** *6/18/2009* **Total Depth:** *145 ft.* **Well Use:** *DOMESTIC*

**Driller's Name:** *Walter's Well Drilling*

**Screen Diameter:** **Slot Size:** **Screen Length:**

**Type:** **Material:**

**Set Between:**

**Gravel Pack Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed:**

**Grout Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed**

**WELL TEST DETAILS**

**Static Water Level:** *37 ft.* **Test Rate:** *20 gpm* **Associated Reports**

**Drawdown:** *71 ft.* **Test Duration:** *1 hrs.*

**COMMENTS:** *DGS adjusted bedrock depth based on surficial mapping.*

**WELL LOG**

| Formations | From | To |
|---|---|---|
| CLAY | 0 | 135 |
| LIMESTONE | 135 | 148 |

Printing Tips (opens in new window)

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Well log questions - Web site questions - Web policies

# Water Well Log and Drilling Report

Ohio Department of Natural Resources
Division of Soil and Water
Phone: 614-265-6740 Fax: 614-265-6767

**Well Log Number:** 1013501

View Image of Original Well Log

## ORIGINAL OWNER AND LOCATION

**Original Owner Name:** *CALEB WEAVER*

**County:** *PIKE* **Township:** *PERRY* **Section Number:**

**Address:** *5690 DRY BONE RD* **Lot Number:**

**City:** **State:** *OH* **Zip Code:** *45133*

**Location Number:** **Location Map Year:** **Location Area:**

**Latitude:** *39.147144* **Longitude:** *-83.336565*

## CONSTRUCTION DETAILS

**Borehole Diameter: 1:** *6 in.* **2:**

**Borehole Depth: 1:** *135 ft.* **2:**

**Depth to Bedrock:**

**Casing Diameter: 1:** *6 in.* **2:**

**Casing Length: 1:** *122 ft.* **2:**

**Casing Thickness: 1:** *0.188 in.* **2:**

**Casing Height Above Ground:** **Aquifer Type:** *LIMESTONE*

**Date of Completion:** *9/10/2010* **Total Depth:** *135 ft.* **Well Use:** *DOMESTIC*

**Driller's Name:** *Walter's Well Drilling*

**Screen Diameter:** **Slot Size:** **Screen Length:**

**Type:** **Material:**

**Set Between:**

**Gravel Pack Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed:**

**Grout Material/Size:** **Vol/Wt Used:**

**Method of Installation:** **Placed**

## WELL TEST DETAILS

**Static Water Level:** *46 ft.* **Test Rate:** *18 gpm* **Associated Reports**

**Drawdown:** *80 ft.* **Test Duration:** *2 hrs.*

**COMMENTS:** *DGS adjusted bedrock depth based on surficial mapping.*

## WELL LOG

| Formations | From | To |
|---|---|---|
| CLAY | 0 | 59 |
| CLAY & SAND | 59 | 122 |
| LIMESTONE | 122 | 135 |

Printing Tips (opens in new window)

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Well log questions - Web site questions - Web policies

# FIELD TESTING PROCEDURES

Field Operations: The general field procedures employed by S&ME, Inc. are summarized in ASTM D 420 which is entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in situ methods as well as borings.

Borings are drilled to obtain subsurface samples using one of several alternate techniques depending upon the subsurface conditions. These techniques are:

a. Continuous 2-1/2 or 3-1/4 inch I.D. hollow stem augers;
b. Wash borings using roller cone or drag bits (mud or water);
c. Continuous flight augers (ASTM D 1425).

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by a field engineer who is on site to direct the drilling operations and log the recovered samples. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D 2488 and prepares the final boring records that are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. The final boring records are included with this report. The detailed data collection methods using during this study are discussed on the following pages.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and penetration testing were performed in accordance with ASTM D 1586.

The borings were made by mechanically twisting a 5-5/8" outer diameter auger into the soil. At regular intervals, the drilling tools were removed and samples obtained with a standard 1.4 inch I.D., 2 inch O.D., split tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance".

Representative portions of the samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Soil Auger Soundings: Soil auger soundings were made at the site at the locations shown on the attached Boring Location Plan. The soundings were performed by mechanically twisting a steel auger into the soil. However, unlike the soil test borings, a smaller diameter solid stem auger was used and no split-spoon samples were obtained. The driller provided a general description of the soil encountered by observing the soils brought to the surface by the twisting auger. The auger was advanced until refusal materials were encountered and the refusal depth was noted by the driller. The auger is then withdrawn and the depths to water or caved materials are then measured and recorded by the driller.

Soil auger soundings provide a rapid, economical method of obtaining the approximate bedrock depth, groundwater depth, and general soil conditions at locations where detailed soil testing and sampling is not required.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious soils are encountered (clayey soils) the amount of water seepage into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table may also be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring water level reported on the boring records is determined by field crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, etc. Additional water table readings are generally obtained at least 24 hours after the borings are completed. The time lag of at least 24 hours is used to permit stabilization of the ground water table which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface. Occasionally the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

# Appendix B – Laboratory Testing

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | SAMPLE (#) | Top Depth (ft) | MC % | LL % | PL % | PI % | AGGREGATE % | COARSE SAND % | FINE SAND % | SILT % | CLAY % | SILT/CLAY % | D / 50 mm | D / 95 mm | H R B ODOT CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-001-0-21 | 1 | 1.50 | 15 | 39 | 27 | 12 | 44 | 24 | 9 | 7 | 16 | | 1.3783 | 11.5435 | A-2-6 (0) |
| B-001-0-21 | 2 | 3.50 | 17 | | | | | | | | | | | | A-6a (V) |
| B-001-0-21 | 3 | 6.00 | 18 | 30 | 17 | 13 | 0 | 2 | 24 | 37 | 37 | | 0.0132 | 0.2800 | A-6a (9) |
| B-001-0-21 | 4 | 8.50 | 21 | | | | | | | | | | | | A-6a (V) |
| B-001-0-21 | 5 | 11.00 | 24 | | | | | | | | | | | | A-6a (V) |
| B-001-0-21 | 6 | 13.50 | 23 | | | | 0 | 1 | 0 | 58 | 41 | | 0.0075 | 0.0609 | A-6a (V) |
| B-001-0-21 | 7 | 15.00 | 26 | | | | 0 | 0 | 0 | 35 | 65 | | | 0.0522 | A-6a (V) |
| B-001-0-21 | 8 | 16.50 | 26 | | | | 0 | 1 | 1 | 38 | 60 | | | 0.0605 | A-6a (V) |
| B-001-0-21 | 9 | 18.00 | 25 | 24 | 19 | 5 | 0 | 0 | 0 | 78 | 22 | | 0.0135 | 0.0632 | A-4b (8) |
| B-001-0-21 | 10 | 20.50 | 23 | 27 | 16 | 11 | 0 | 0 | 0 | 57 | 43 | | 0.0071 | 0.0592 | A-6a (8) |
| B-001-0-21 | 11 | 23.50 | 21 | | | | | | | | | | | | A-6a (V) |
| B-001-0-21 | 12 | 28.50 | 30 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 13 | 33.50 | 26 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 14 | 35.00 | 28 | 37 | 17 | 20 | 0 | 0 | 0 | 39 | 61 | | | 0.0533 | A-6b (12) |
| B-001-0-21 | 15 | 38.50 | 26 | | | | | | | | | | | | A-6b (V) |
| B-001-0-21 | 16 | 43.50 | 24 | | | | | | | | | | | | A-6b (V) |
| B-001-0-21 | 17 | 48.50 | 29 | 47 | 21 | 26 | 0 | 0 | 0 | 20 | 80 | | | 0.0357 | A-7-6 (16) |
| B-001-0-21 | 18 | 53.50 | 29 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 19 | 58.50 | 23 | 37 | 17 | 20 | 0 | 0 | 0 | 47 | 53 | | | 0.0562 | A-6b (12) |
| B-001-0-21 | 20 | 63.50 | 29 | | | | | | | | | | | | A-6b (V) |
| B-001-0-21 | 21 | 68.50 | 30 | 37 | 20 | 17 | 0 | 0 | 0 | 25 | 75 | | | 0.0422 | A-6b (11) |
| B-001-0-21 | 22 | 73.50 | 32 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 23 | 78.50 | 32 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 24 | 83.50 | 31 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 25 | 88.50 | 30 | 48 | 21 | 27 | 0 | 0 | 0 | 19 | 81 | | | 0.0362 | A-7-6 (16) |
| B-001-0-21 | 26 | 93.50 | 30 | | | | | | | | | | | | A-7-6 (V) |
| B-001-0-21 | 27 | 98.50 | 31 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 1 | 1.00 | 20 | 39 | 18 | 21 | 3 | 4 | 13 | 37 | 43 | | 0.0087 | 0.8500 | A-6b (12) |
| B-002-0-21 | 2 | 3.50 | 28 | | | | | | | | | | | | A-6b (V) |
| B-002-0-21 | 3 | 6.00 | 18 | | | | | | | | | | | | A-6b (V) |

PROJECT PIK-CR8-5.75
LOCATION PIK-CR8-5.75 Bridge
JOB NO. 21-3410
DATE 11/19/21

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | SAMPLE (#) | Top Depth (ft) | MC % | LL % | PL % | PI % | AGGREGATE % | COARSE SAND % | FINE SAND % | SILT % | CLAY % | SILT/CLAY % | D / 50 mm | D / 95 mm | H R B ODOT CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-002-0-21 | 4 | 8.50 | | | | | | | | | | | | | A-6b (V) |
| B-002-0-21 | 5 | 11.00 | 22 | | | | | | | | | | | | A-6b (V) |
| B-002-0-21 | 6 | 13.50 | 25 | 43 | 20 | 23 | 0 | 0 | 10 | 34 | 56 | | | 0.1704 | A-7-6 (14) |
| B-002-0-21 | 7 | 15.50 | 22 | 39 | 20 | 19 | 0 | 0 | 1 | 43 | 56 | | | 0.0593 | A-6b (12) |
| B-002-0-21 | 8 | 17.00 | 24 | | | | 0 | 0 | 1 | 66 | 33 | | 0.0100 | 0.0634 | A-4b (V) |
| B-002-0-21 | 9 | 18.50 | 24 | | | | 0 | 0 | 0 | 54 | 46 | | 0.0059 | 0.0582 | A-7-6 (V) |
| B-002-0-21 | 10 | 21.00 | 25 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 11 | 23.50 | 24 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 12 | 28.50 | 23 | | | | 0 | 0 | 0 | 30 | 70 | | | 0.0477 | A-7-6 (V) |
| B-002-0-21 | 13 | 33.50 | 23 | | | | | | | | | | | | A-6b (V) |
| B-002-0-21 | 14 | 38.50 | 23 | | | | | | | | | | | | A-6b (V) |
| B-002-0-21 | 15 | 43.50 | 25 | 41 | 19 | 22 | 0 | 0 | 0 | 33 | 67 | | | 0.0492 | A-7-6 (13) |
| B-002-0-21 | 16 | 48.50 | 39 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 17 | 53.50 | 33 | 50 | 22 | 28 | 0 | 0 | 0 | 15 | 85 | | | 0.0284 | A-7-6 (17) |
| B-002-0-21 | 18 | 58.50 | 32 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 19 | 63.50 | 30 | 43 | 21 | 22 | 0 | 0 | 0 | 33 | 67 | | | 0.0502 | A-7-6 (13) |
| B-002-0-21 | 20 | 68.50 | 32 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 21 | 73.50 | 30 | 45 | 22 | 23 | 0 | 0 | 0 | 24 | 76 | | | 0.0341 | A-7-6 (14) |
| B-002-0-21 | 22 | 78.50 | 30 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 23 | 83.50 | 37 | | | | 0 | 0 | 0 | 27 | 73 | | | 0.0450 | A-7-6 (V) |
| B-002-0-21 | 24 | 88.50 | 31 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 25 | 93.50 | 31 | | | | | | | | | | | | A-7-6 (V) |
| B-002-0-21 | 26 | 98.50 | 31 | | | | | | | | | | | | A-7-6 (V) |

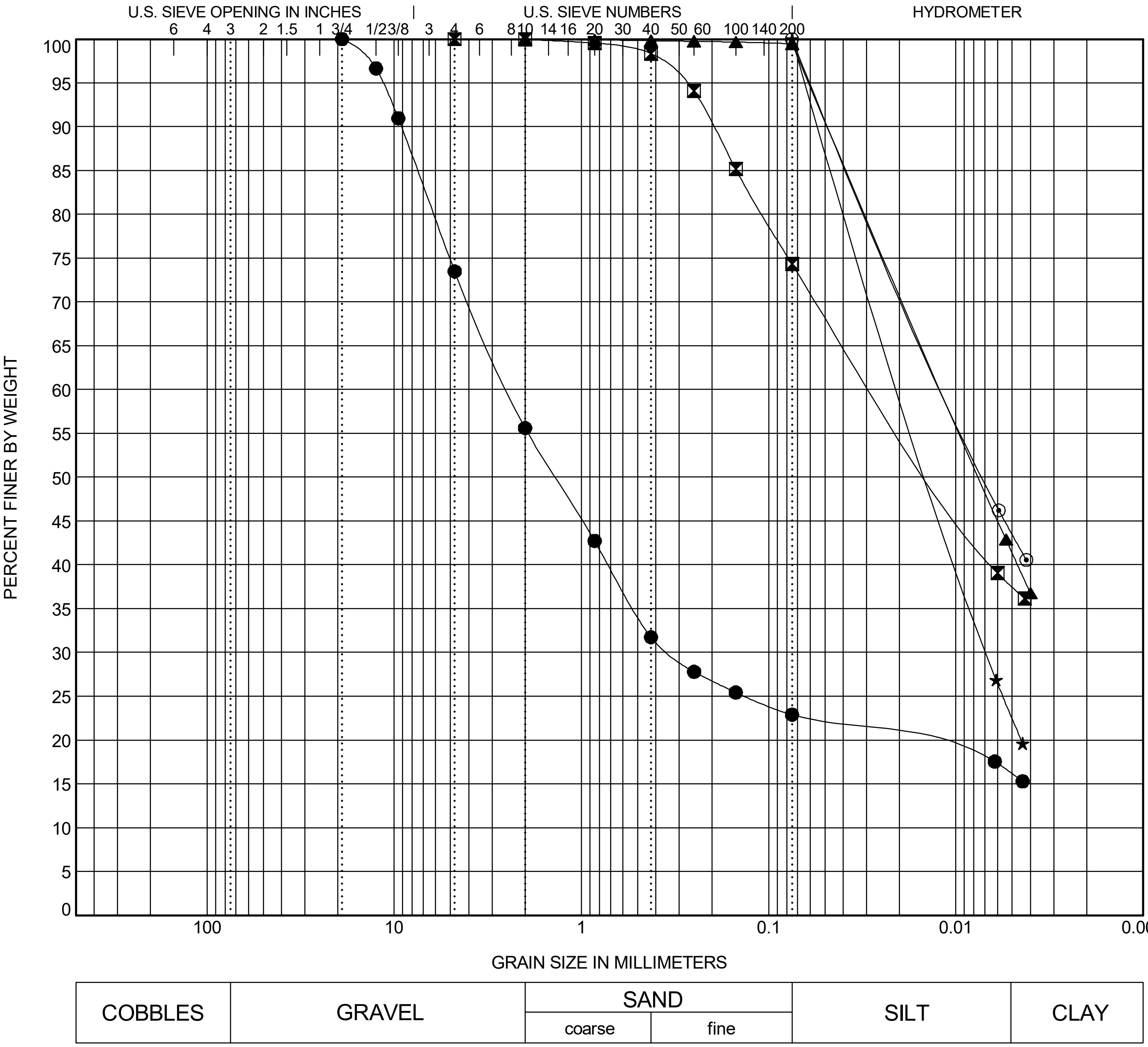
PROJECT PIK-CR8-5.75
LOCATION PIK-CR8-5.75 Bridge
JOB NO. 21-3410 DATE 11/19/21

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** PIK-CR8-5.75 BRIDGE **PID**

**OGE NUMBER** PIK-CR8-5.75 **PROJECT TYPE** STRUCTURE FOUNDATION




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-001-0-21 | 1.0 | **A-2-6 ~ SILTY SAND with GRAVEL(SM)** | 39 | 27 | 12 |
| ⌧ B-001-0-21 | 6.0 | **A-6a ~ LEAN CLAY with SAND(CL)** | 30 | 17 | 13 |
| ▲ B-001-0-21 | 13.5 | **~** | | | |
| ★ B-001-0-21 | 18.0 | **A-4b ~ SILTY CLAY(CL-ML)** | 24 | 19 | 5 |
| ⊙ B-001-0-21 | 20.5 | **A-6a ~ LEAN CLAY(CL)** | 27 | 16 | 11 |

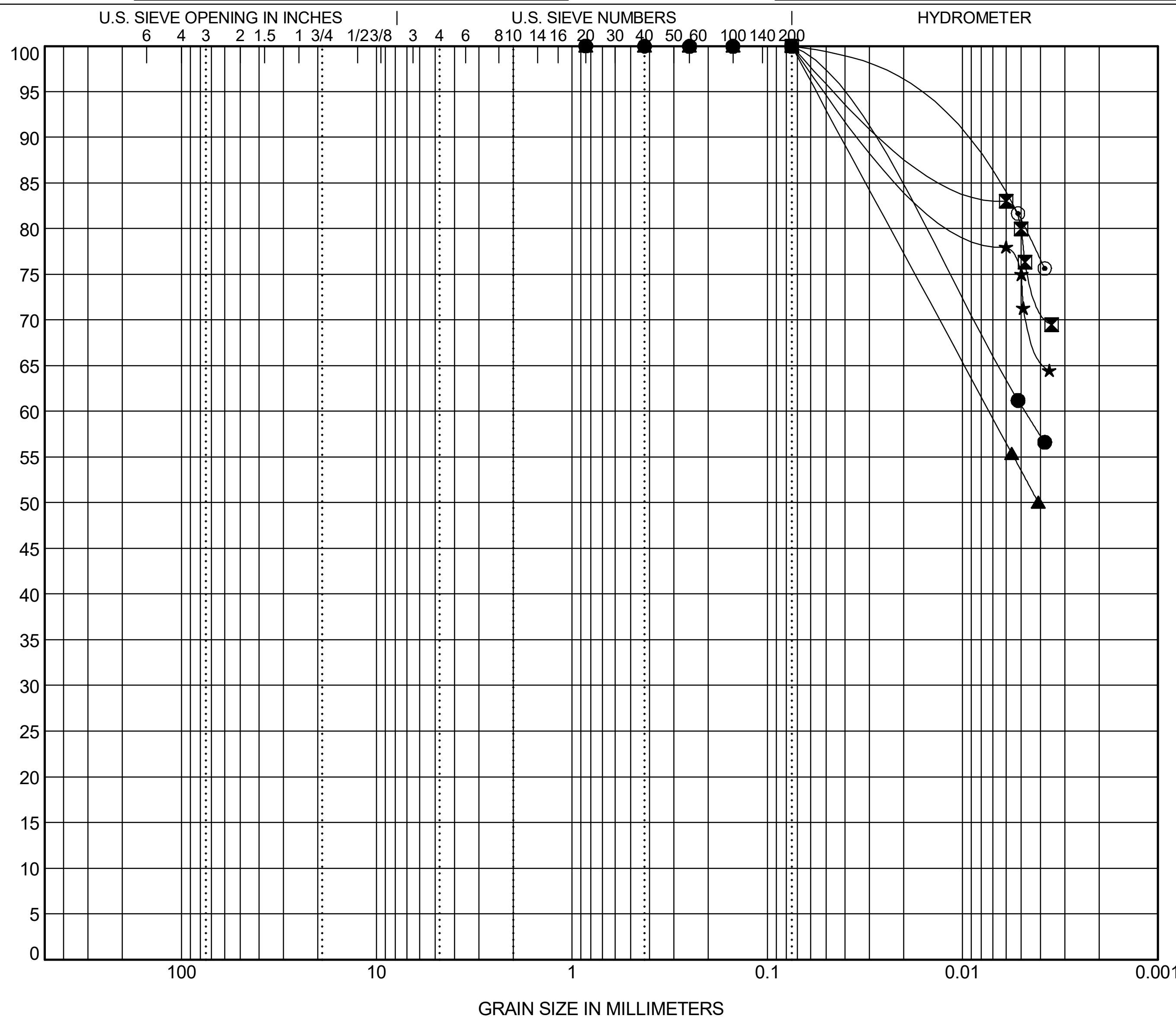
| Specimen Identification | | D95 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-001-0-21 | 1.0 | 11.544 | 1.378 | 0.337 | | 44 | 24 | 9 | 7 | 16 | | |
| ⌧ B-001-0-21 | 6.0 | 0.28 | 0.013 | | | 0 | 2 | 24 | 37 | 37 | | |
| ▲ B-001-0-21 | 13.5 | 0.061 | 0.008 | | | 0 | 1 | 0 | 58 | 41 | | |
| ★ B-001-0-21 | 18.0 | 0.063 | 0.013 | 0.007 | | 0 | 0 | 0 | 78 | 22 | | |
| ⊙ B-001-0-21 | 20.5 | 0.059 | 0.007 | | | 0 | 0 | 0 | 57 | 43 | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** PIK-CR8-5.75 BRIDGE **PID**

**OGE NUMBER** PIK-CR8-5.75 **PROJECT TYPE** STRUCTURE FOUNDATION




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

| | Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-001-0-21** | **35.0** | **A-6b ~ LEAN CLAY(CL)** | **37** | **17** | **20** |
| ⊠ | **B-001-0-21** | **48.5** | **A-7-6 ~ LEAN CLAY(CL)** | **47** | **21** | **26** |
| ▲ | **B-001-0-21** | **58.5** | **A-6b ~ LEAN CLAY(CL)** | **37** | **17** | **20** |
| ★ | **B-001-0-21** | **68.5** | **A-6b ~ LEAN CLAY(CL)** | **37** | **20** | **17** |
| ⊙ | **B-001-0-21** | **88.5** | **A-7-6 ~ LEAN CLAY(CL)** | **48** | **21** | **27** |

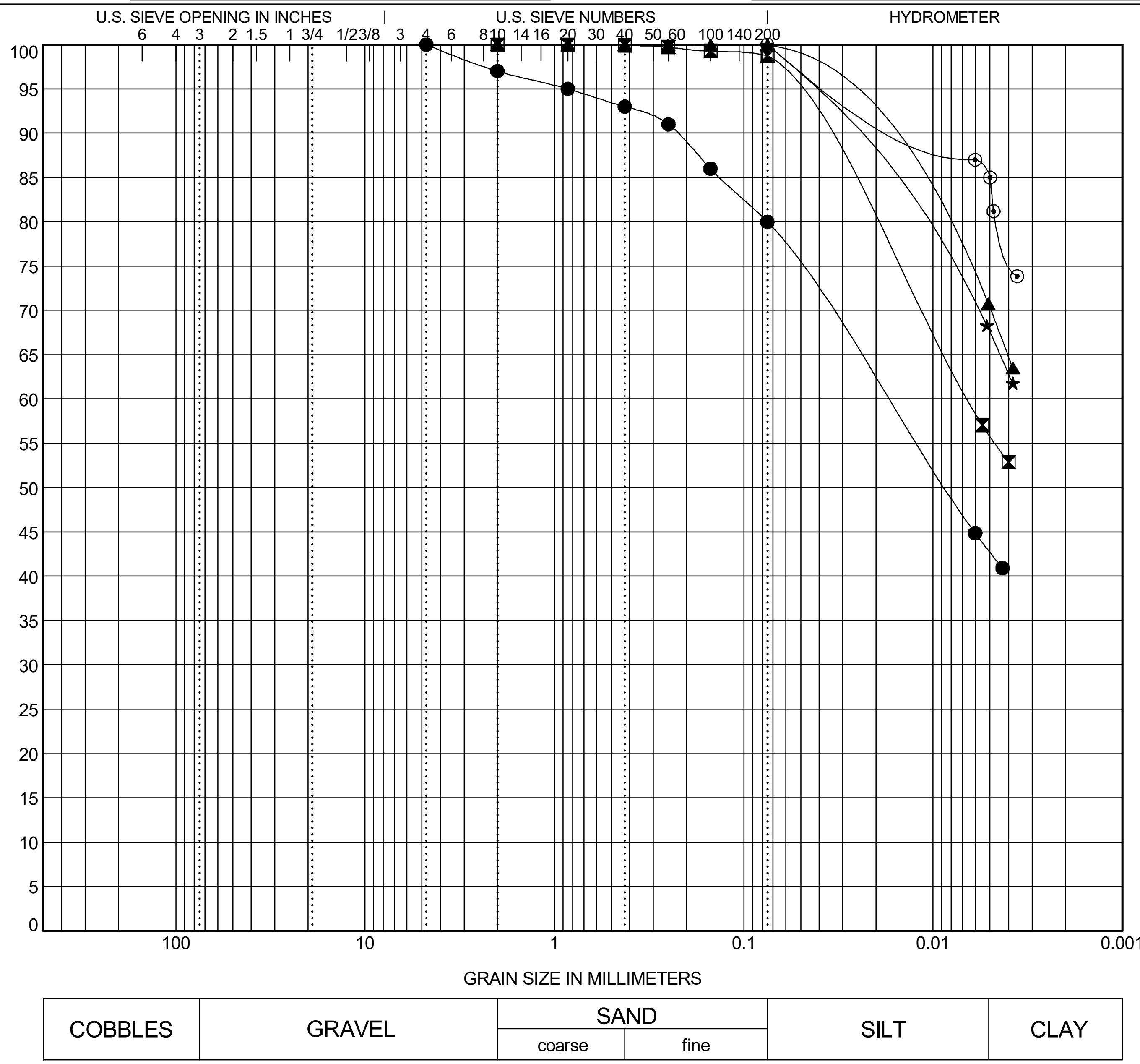
| | Specimen Identification | | D95 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-001-0-21** | **35.0** | **0.053** | | | | **0** | **0** | **0** | **39** | **61** | | |
| ⊠ | **B-001-0-21** | **48.5** | **0.036** | | | | **0** | **0** | **0** | **20** | **80** | | |
| ▲ | **B-001-0-21** | **58.5** | **0.056** | | | | **0** | **0** | **0** | **47** | **53** | | |
| ★ | **B-001-0-21** | **68.5** | **0.042** | | | | **0** | **0** | **0** | **25** | **75** | | |
| ⊙ | **B-001-0-21** | **88.5** | **0.036** | | | | **0** | **0** | **0** | **19** | **81** | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** PIK-CR8-5.75 BRIDGE **PID**

**OGE NUMBER** PIK-CR8-5.75 **PROJECT TYPE** STRUCTURE FOUNDATION




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-002-0-21** | **1.0** | **A-6b ~ LEAN CLAY with SAND(CL)** | **39** | **18** | **21** |
| ⧗ | **B-002-0-21** | **15.5** | **A-6b ~ LEAN CLAY(CL)** | **39** | **20** | **19** |
| ▲ | **B-002-0-21** | **28.5** | **~** | | | |
| ★ | **B-002-0-21** | **43.5** | **A-7-6 ~ LEAN CLAY(CL)** | **41** | **19** | **22** |
| ⊙ | **B-002-0-21** | **53.5** | **A-7-6 ~ FAT CLAY(CH)** | **50** | **22** | **28** |

| Specimen Identification | | | D95 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-002-0-21** | **1.0** | **0.85** | **0.009** | | | **3** | **4** | **13** | **37** | **43** | | |
| ⧗ | **B-002-0-21** | **15.5** | **0.059** | | | | **0** | **0** | **1** | **43** | **56** | | |
| ▲ | **B-002-0-21** | **28.5** | **0.048** | | | | **0** | **0** | **0** | **30** | **70** | | |
| ★ | **B-002-0-21** | **43.5** | **0.049** | | | | **0** | **0** | **0** | **33** | **67** | | |
| ⊙ | **B-002-0-21** | **53.5** | **0.028** | | | | **0** | **0** | **0** | **15** | **85** | | |

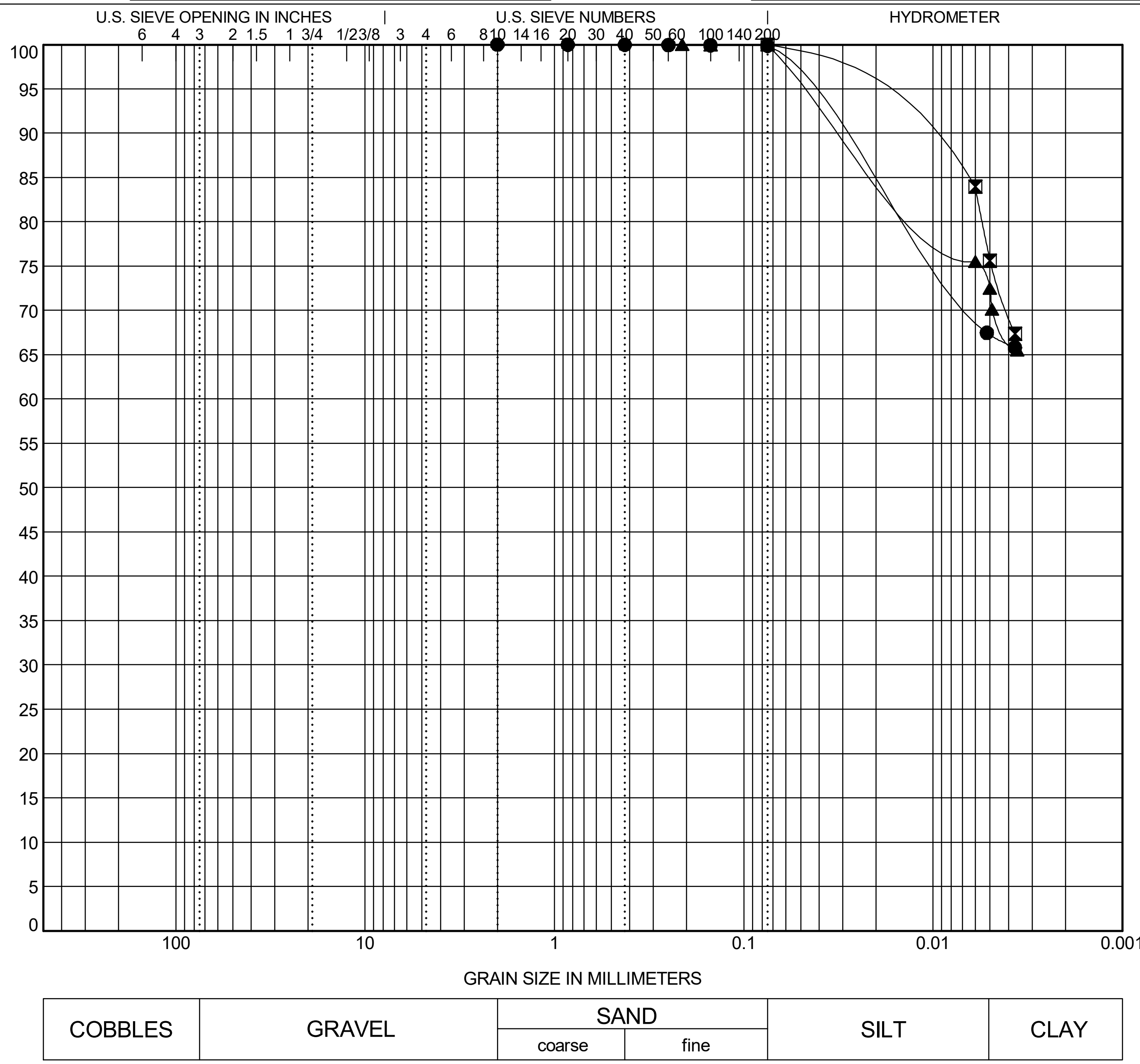
GRAIN SIZE (D95) - OH DOT.GDT - 8/11/21 09:24 - T:\GEO\PROJECTS\2021\213410_PCEO_PIK-CR8-5.75 BRIDGE_CYNTHIANA OH\FIELD_DATA\213410_PIK-CR8-5.75 BRIDGE_BORING LOGS.GPJ

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** PIK-CR8-5.75 BRIDGE **PID**

**OGE NUMBER** PIK-CR8-5.75 **PROJECT TYPE** STRUCTURE FOUNDATION




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | B-002-0-21 | 63.5 | **A-7-6 ~ LEAN CLAY(CL)** | 43 | 21 | 22 |
| ⧗ | B-002-0-21 | 73.5 | **A-7-6 ~ LEAN CLAY(CL)** | 45 | 22 | 23 |
| ▲ | B-002-0-21 | 83.5 | ~ | | | |
| | | | | | | |
| | | | | | | |

| Specimen Identification | | | D95 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-002-0-21 | 63.5 | 0.05 | | | | 0 | 0 | 0 | 33 | 67 | | |
| ⧗ | B-002-0-21 | 73.5 | 0.034 | | | | 0 | 0 | 0 | 24 | 76 | | |
| ▲ | B-002-0-21 | 83.5 | 0.045 | | | | 0 | 0 | 0 | 27 | 73 | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

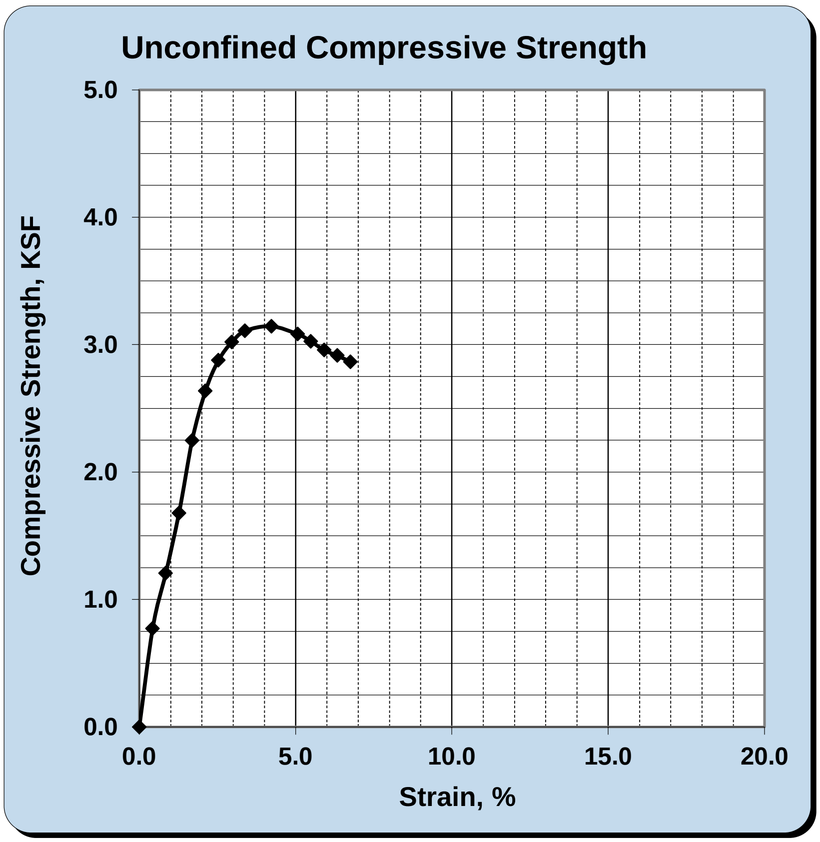
Form No. TR-D2166-01
Revision No. : 1
Revision Date: 08/16/17

# UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS

ASTM D2166

S&ME, Inc. Cincinnati: 862 East Crescentville Road, West Chester, OH 45246

| | | | |
|---|---|---|---|
| Project No.: | 213410 | Report Date: | 11/19/2021 |
| Project Name: | PIK-CR8-5.75 Bridge | Test Date(s): | 11/18/2021 |
| Client Name: | Pike County Engineer's Office | | |
| Client Address: | 502 Pike St., Waverly, Ohio | | |
| Location: | B-001-0-21 Sample No. ST-14 III | Sample Date: | 7/12-15/2021 |
| | | Depth: | 35.0'-37.0' |
| Sample Description: | Silty Clay (A-6b), gray | | |




**Failed Specimen**

Type of Sample: Intact
Source of Moisture Sample: Test Specimen

Liquid Limit: 37
Plasticity Index: 20
Height to Diameter Ratio: 2.1
Rate of Strain (%/min.): 0.92%
Strain at Failure: 4.2

Initial Dry Unit Weight: 104.2 pcf
Initial Water Content: 19.7%
Unconfined Compressive Strength, $q_u$: **3.145** KSF
Undrained Shear Strength, $s_u$: **1.573** KSF

*References / Comments / Deviations:*

| Paula J. Manning | Paula J. Manning | Project Manager | 11/19/2021 |
|---|---|---|---|
| *Technical Responsibility* | *Signature* | *Position* | *Date* |

Form No. TR-D2166-01
Revision No. : 1
Revision Date: 08/16/17

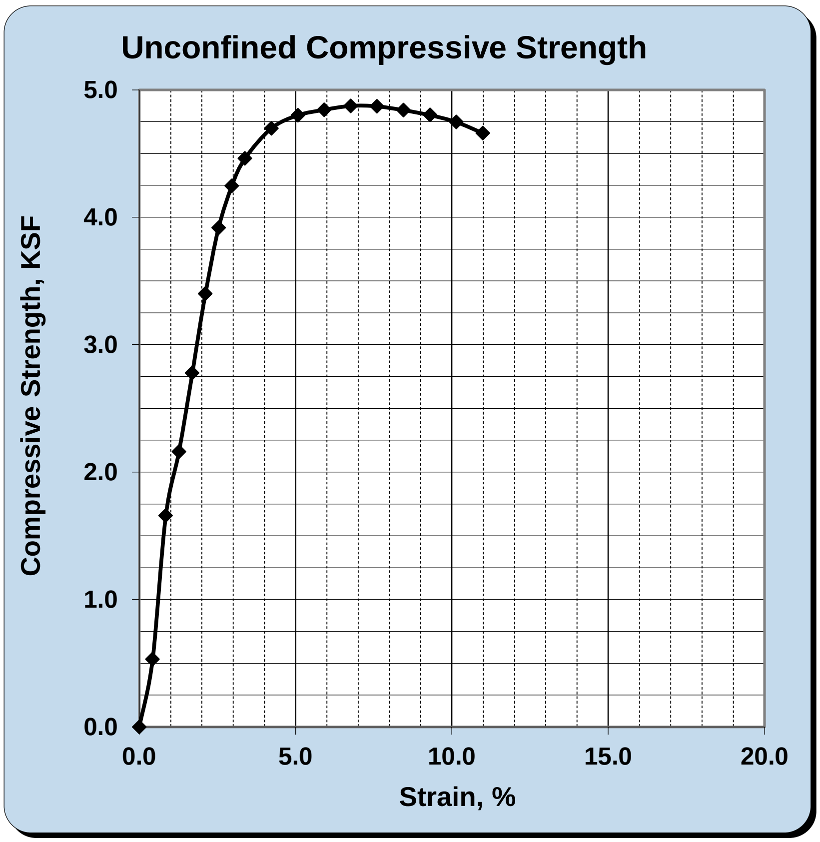
# UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS

ASTM D2166

S&ME, Inc. Cincinnati: 862 East Crescentville Road, West Chester, OH 45246

| | | | |
|---|---|---|---|
| Project No.: | 213410 | Report Date: | 11/19/2021 |
| Project Name: | PIK-CR8-5.75 Bridge | Test Date(s): | 11/18/2021 |
| Client Name: | Pike County Engineer's Office | | |
| Client Address: | 502 Pike St., Waverly, Ohio | | |
| Location: | B-001-0-21 Sample No. ST-19 III | Sample Date: | 7/12-15/2021 |
| | | Depth: | 58.5'-60.5' |

Sample Description: Silty Clay (A-6b), gray




**Failed Specimen**

Type of Sample: Intact
Source of Moisture Sample: Test Specimen

Liquid Limit: 37
Plasticity Index: 20
Height to Diameter Ratio: 2.1
Rate of Strain (%/min.): 0.92%
Strain at Failure: 6.8

Initial Dry Unit Weight: 105.1 pcf
Initial Water Content: 22.3%
Unconfined Compressive Strength, $q_u$: **4.874** KSF
Undrained Shear Strength, $s_u$: **2.437** KSF

*References / Comments / Deviations:*

| Paula J. Manning | Paula J. Manning | Project Manager | 11/19/2021 |
|---|---|---|---|
| *Technical Responsibility* | *Signature* | *Position* | *Date* |

Form No. TR-D2166-01
Revision No. : 1
Revision Date: 08/16/17

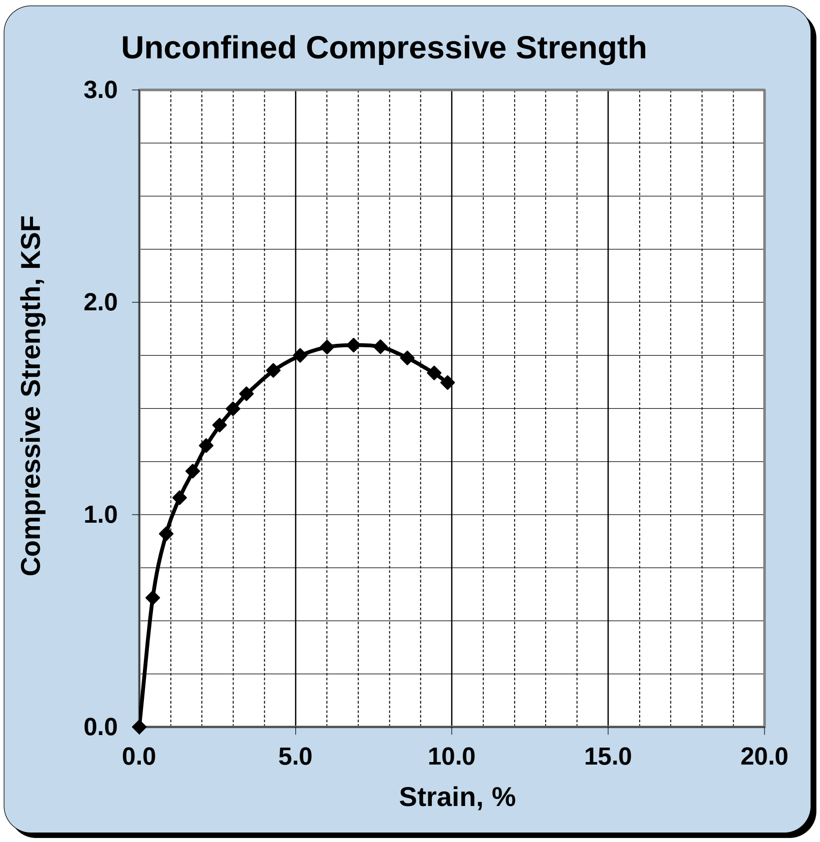
# UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS

ASTM D2166

S&ME, Inc. Cincinnati: 862 East Crescentville Road, West Chester, OH 45246

| | | | |
|---|---|---|---|
| Project No.: | 213410 | Report Date: | 11/19/2021 |
| Project Name: | PIK-CR8-5.75 Bridge | Test Date(s): | 11/18/2021 |
| Client Name: | Pike County Engineer's Office | | |
| Client Address: | 502 Pike St., Waverly, Ohio | | |
| Location: | B-002-0-21 Sample No. ST-6 II | Sample Date: | 7/12-15/2021 |
| | | Depth: | 13.5'-15.5' |

Sample Description: Clay (A-7-6), trace fine to coarse sand, brown mottled with gray




**Failed Specimen**

Type of Sample: Intact
Source of Moisture Sample: Test Specimen

Liquid Limit: 37
Plasticity Index: 20
Height to Diameter Ratio: 2.1
Rate of Strain (%/min.): 0.93%
Strain at Failure: 6.9

Initial Dry Unit Weight: 98.9 pcf
Initial Water Content: 25.0%
Unconfined Compressive Strength, $q_u$: **1.798** KSF
Undrained Shear Strength, $s_u$: **0.899** KSF

*References / Comments / Deviations:*

| Paula J. Manning | Paula J. Manning | Laboratory Manager | 11/19/2021 |
|---|---|---|---|
| *Technical Responsibility* | *Signature* | *Position* | *Date* |

## LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D 2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties obtained are presented in this report.

Compaction Tests: Compaction tests are run on representative soil samples to determine the dry density obtained by a uniform compactive effort at varying moisture contents. The results of the test are used to determine the moisture content and unit weight desired in the field for similar soils. Proper field compaction is necessary to decrease future settlements, increase the shear strength of the soil and decrease the permeability of the soil.

The two most commonly used compaction tests are the Standard Proctor test and the Modified Proctor test. They are performed in accordance with ASTM D 698 and D 1557, respectively. Generally, the Standard Proctor compaction test is run on samples from building or parking areas where small compaction equipment is anticipated. The Modified compaction test is generally performed for heavy structures, highways, and other areas where large compaction equipment is expected. In both tests a representative soil sample is placed in a mold and compacted with a compaction hammer. Both tests have three alternate methods.

| Test | Method | Hammer Wt./Fall | Mold Diam. | Run on Material Finer Than | No. of Layers | No. of Blows/Layer |
|---|---|---|---|---|---|---|
| Standard D 698 | A | 5.5 lb./12" | 4" | No. 4 sieve | 3 | 25 |
| | B | 5.5 lb./12" | 4" | 3/8" sieve | 3 | 25 |
| | C | 5.5 lb./12" | 6" | 3/4" sieve | 3 | 56 |

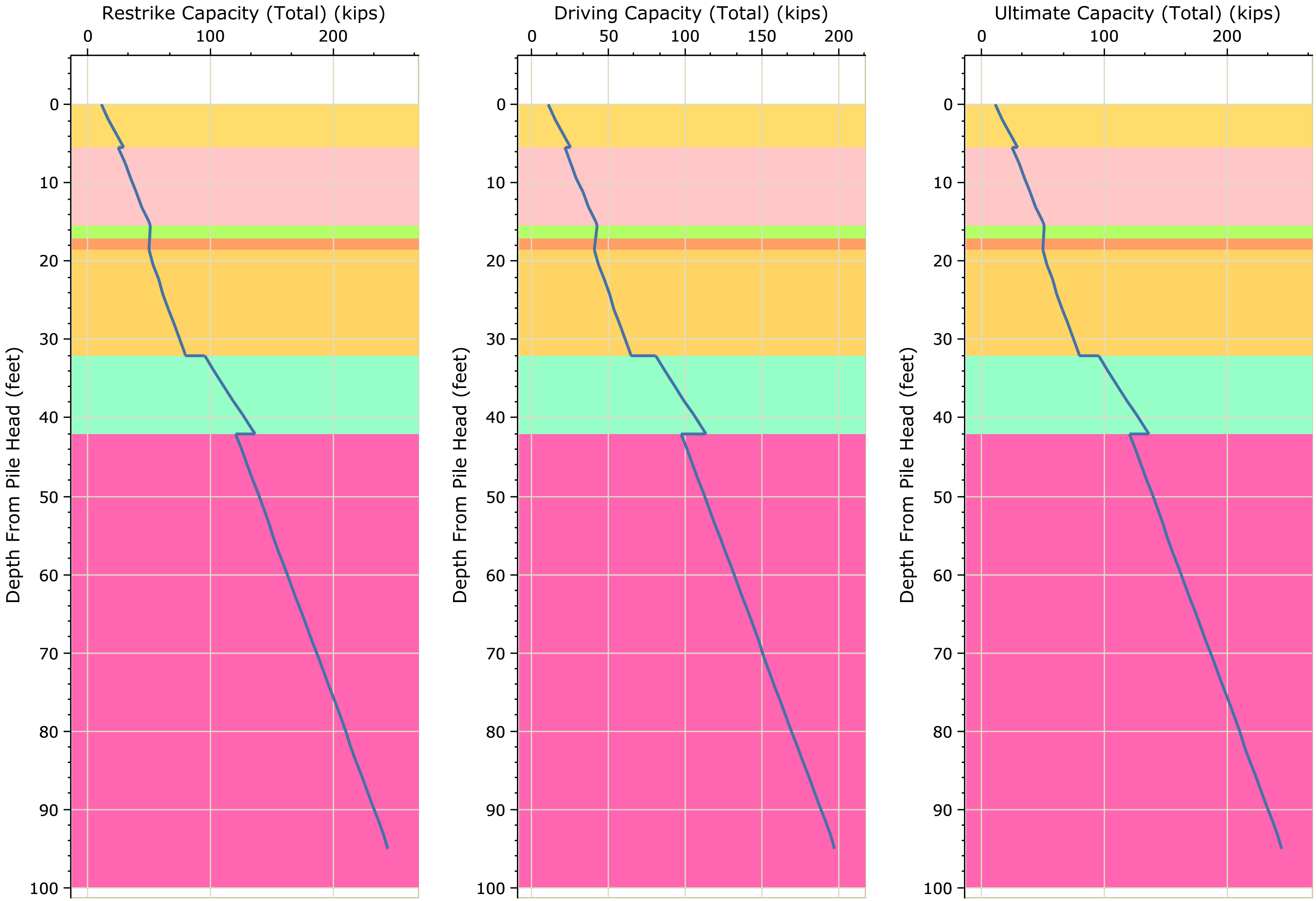
| Test | Method | Hammer Wt./Fall | Mold Diam. | Run on Material Finer Than | No. of Layers | No. of Blows/Layer |
|---|---|---|---|---|---|---|
| Standard D 1557 | A | 10 lb./18" | 4" | No. 4 sieve | 5 | 25 |
| | B | 10 lb./18" | 4" | 3/8" sieve | 5 | 25 |
| | C | 10 lb./18" | 6" | 3/4" sieve | 5 | 56 |

The moisture content and unit weight of each compacted sample is determined. Usually 4 to 5 such tests are run at different moisture contents. Test results are presented in the form of a dry unit weight versus moisture content curve. The compaction method used and any deviations from the recommended procedures are noted in this report.

Atterberg Limits: Portions of the samples are taken for Atterberg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D 4318.

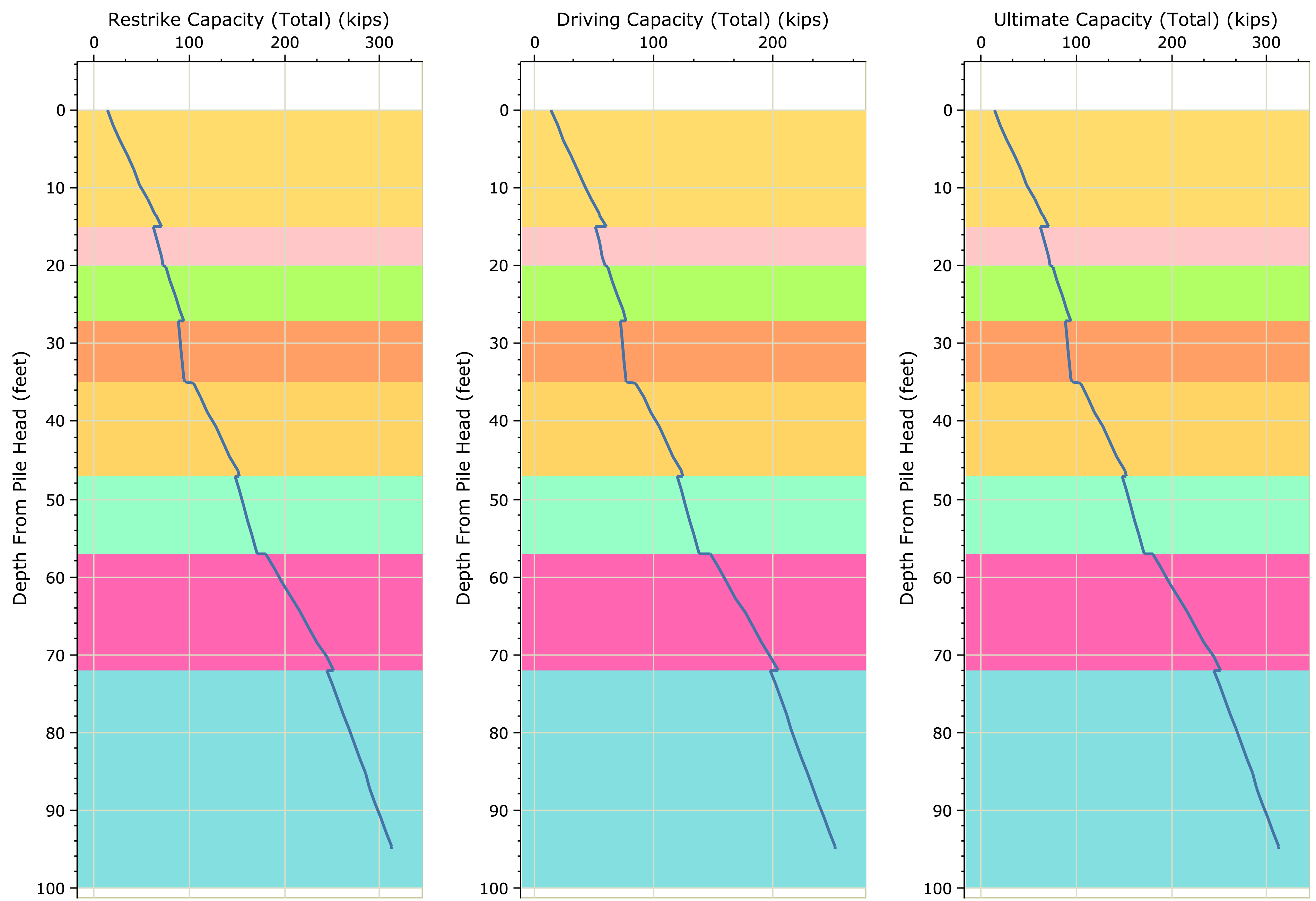
Moisture Content: The Moisture Content is determined according to ASTM D 2216.

# Appendix C – Calculations



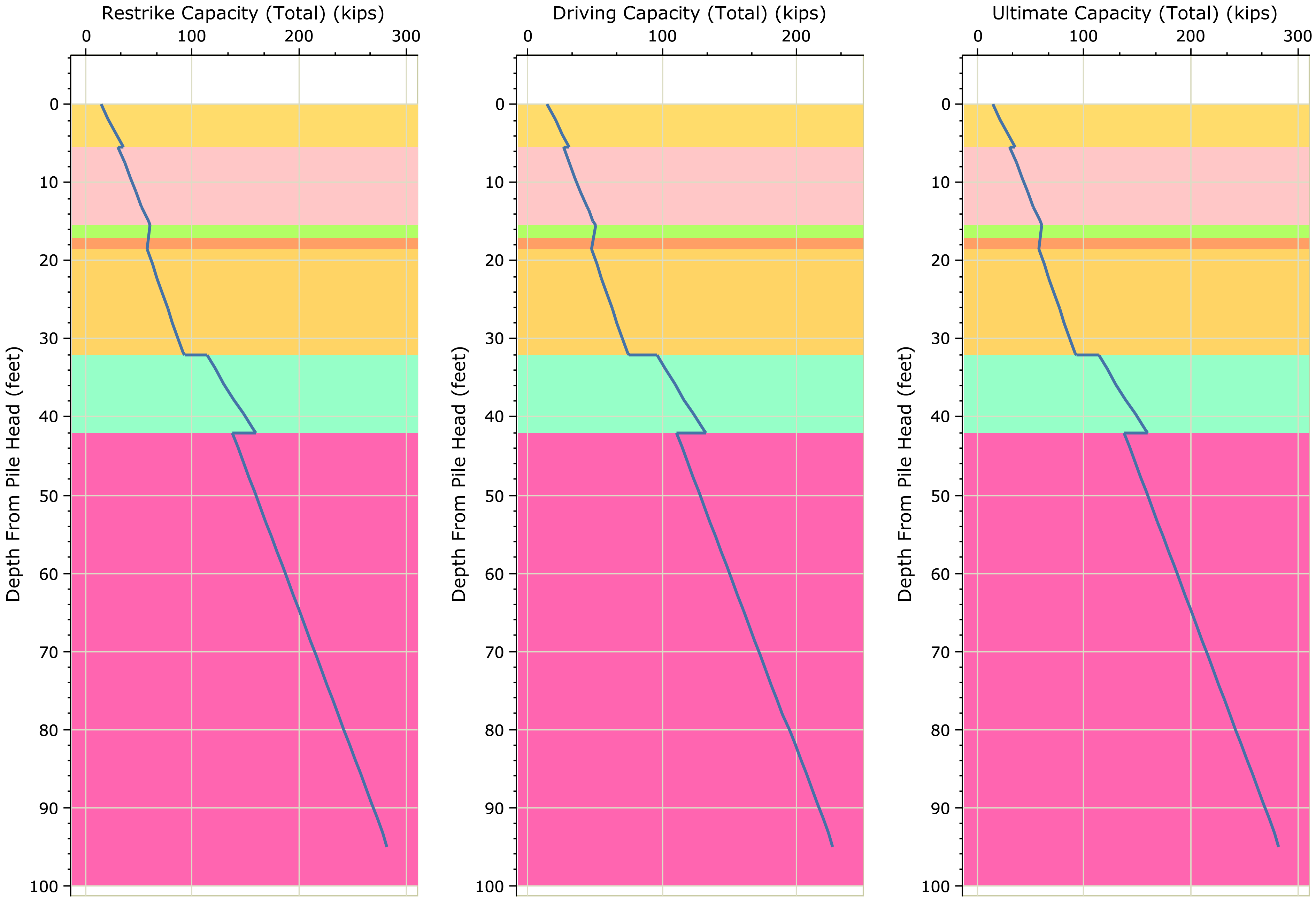

| | | | |
|---|---|---|---|
| Project | PIK-CR8-5.75 Bridge | | |
| Analysis Description | Forward Abutment (B-002) | | |
| Drawn By | CLY | Company | S&ME, Inc. |
| Date | 11/22/2021 | | 12-in Closed End Pipe Piles |

RSPILE 3.006

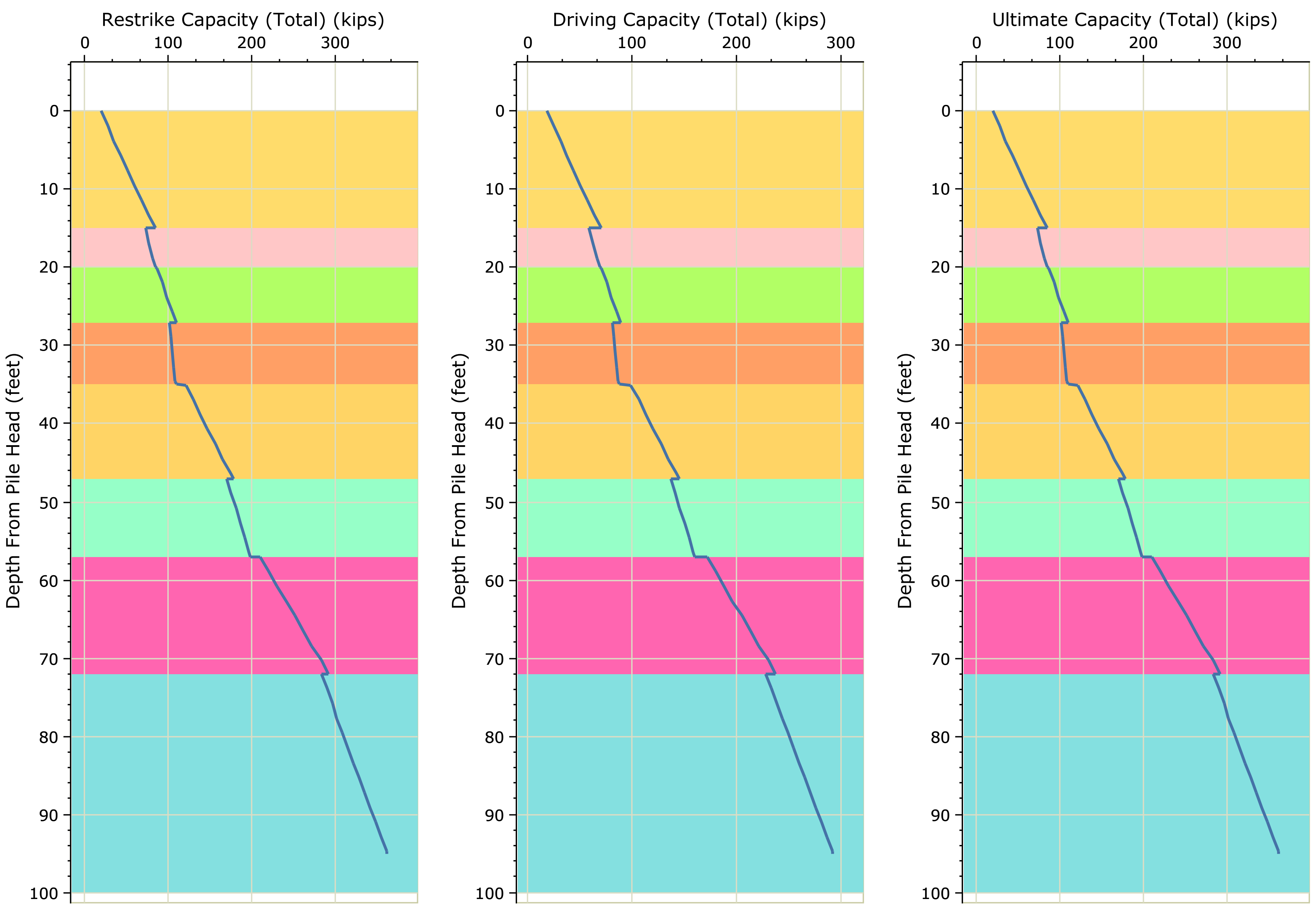



RSPILE 3.006

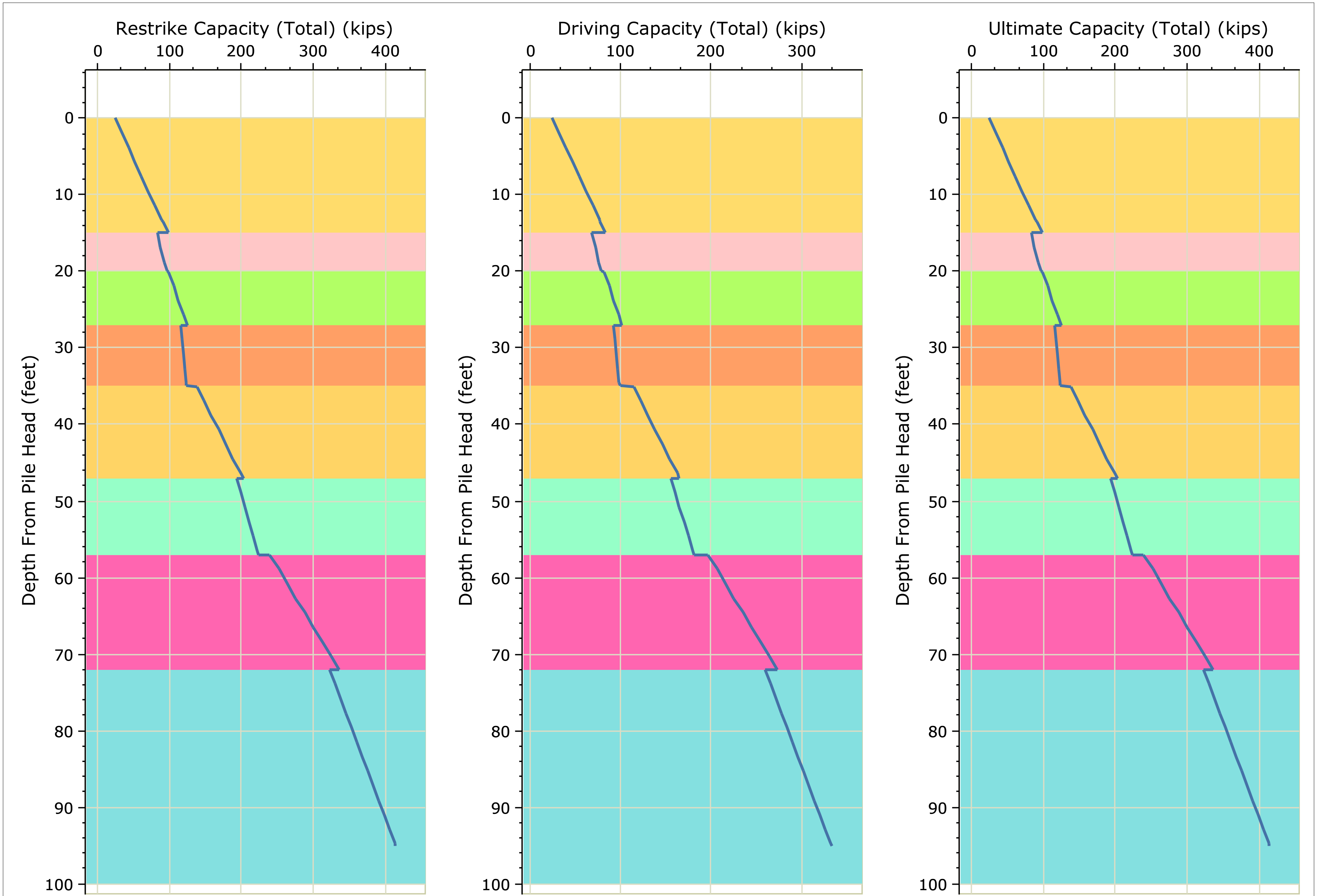
| | | | |
|---|---|---|---|
| *Project* | PIK-CR8-5.75 Bridge | | |
| *Analysis Description* | Rear Abutment (B-001) | | |
| *Drawn By* | CLY | *Company* | S&ME, Inc. |
| *Date* | 11/22/2021 | | 12-in Closed End Pipe Piles |



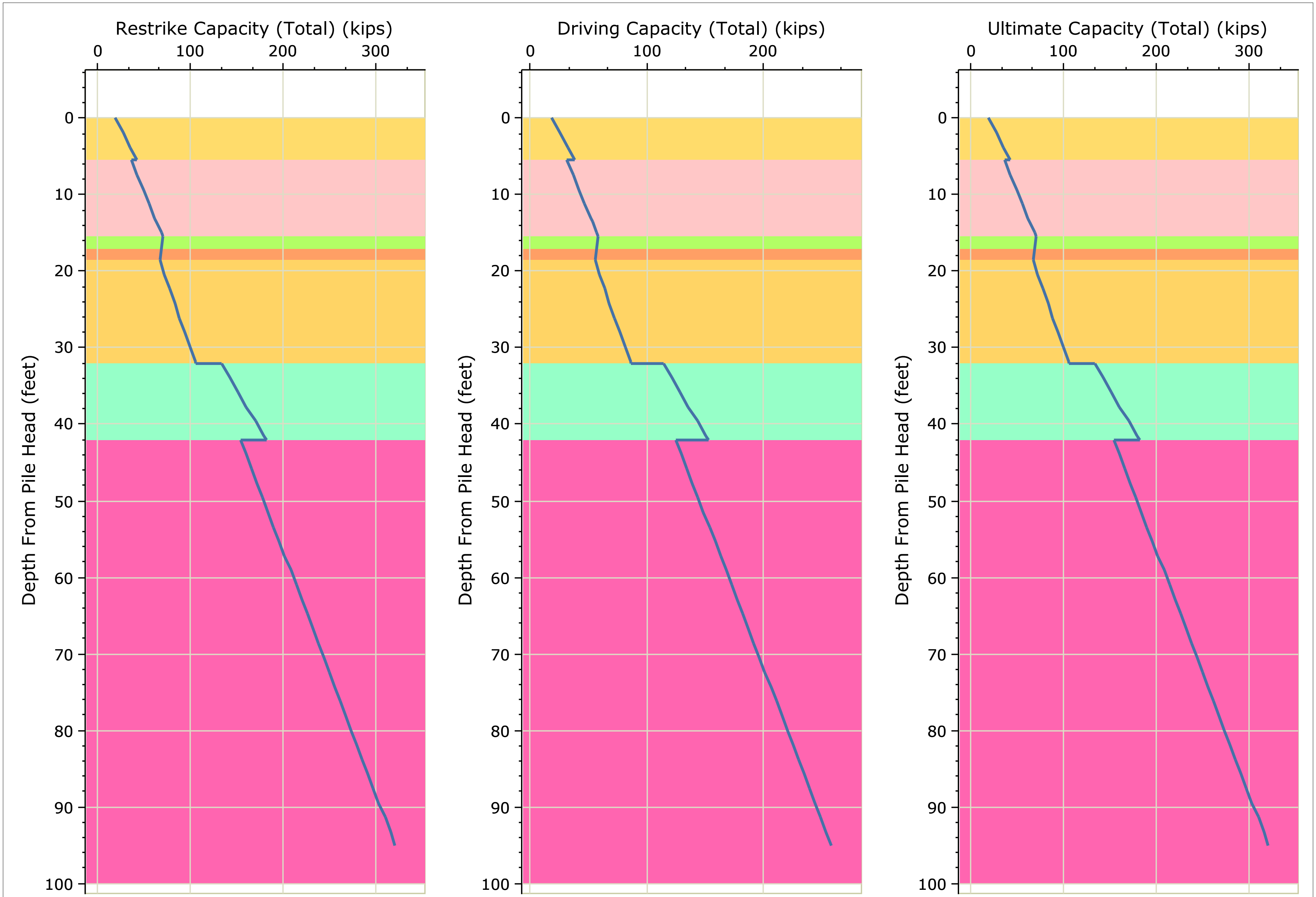

| | | | |
|---|---|---|---|
| RSPILE 3.006 | Project | PIK-CR8-5.75 Bridge | |
| | Analysis Description | Forward Abutment (B-002) | |
| | Drawn By | CLY | Company: S&ME, Inc. |
| | Date | 11/22/2021 | 14-in Closed End Pipe Piles |




| | | | |
|---|---|---|---|
| RSPILE 3.006 | Project | PIK-CR8-5.75 Bridge | |
| | Analysis Description | Rear Abutment (B-001) | |
| | Drawn By | CLY | Company: S&ME, Inc. |
| | Date | 11/22/2021 | 14-in Closed End Pipe Piles |




| | | | |
|---|---|---|---|
| RSPILE 3.006 | *Project* PIK-CR8-5.75 Bridge | | |
| | *Analysis Description* Rear Abutment (B-001) | | |
| | *Drawn By* CLY | *Company* S&ME, Inc. | |
| | *Date* 11/22/2021 | 16-in Closed End Pipe Pile | |




| | | | |
|---|---|---|---|
| Project | PIK-CR8-5.75 Bridge | | |
| Analysis Description | Forward Abutment (B-002) | | |
| Drawn By | CLY | Company | S&ME |
| Date | 11/22/2021 | | 16-in Closed End Pipe Piles |

RSPILE 3.006