Geotechnical Investigation Report

New Maumee River Crossing
PID No. 22984
Roadway and Structure Foundation Exploration
Napoleon, OH

May 5, 2015

Prepared for:
Henry County
Transportation Improvement District
660 North Perry Street, Suite 202
Napoleon, Ohio 43545

Mannik Smith Group

GEOTECHNICAL INVESTIGATION REPORT

NEW MAUMEE RIVER CROSSING
PID NO. 22984
ROADWAY AND STRUCTURE FOUNDATION EXPLORATION

MAY 5, 2015

*PREPARED BY: ______________________
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Mannik Smith GROUP

Mannik Smith GROUP

May 5, 2015

Mr. Patrick McColley, PE
Executive Director
Henry County Transportation Improvement District
660 North Perry Street, Suite 202
Napoleon, Ohio 43545

Re: Geotechnical Exploration Report – Structure Foundation and Roadway
New Maumee River Crossing
PID No. 22984
Napoleon, Ohio

Dear Mr. McColley:

The Mannik & Smith Group, Inc. has finalized our geotechnical investigation for the New Maumee River Crossing project located in the City of Napoleon, Henry County, Ohio. This Geotechnical Investigation Report presents our analyses and recommendations for the proposed bridge, embankments and associated roadway improvements.

We trust that this report addresses your project needs. We appreciate the opportunity to work with you on this very important project and look forward to providing additional services in the future. Please contact us if you have any questions or if we can be of further assistance.

Sincerely,

Christopher A. Riharb, EIT
Project Engineer

Jeffrey L. Snyder, PE
Senior Geotechnical Engineer

Enclosures

Submitted: (1) Electronic Copy via email
File

EXECUTIVE SUMMARY

The Mannik & Smith Group, Inc., (MSG) was retained by the Henry County Transportation Improvement District (Henry County) to conduct a geotechnical exploration for the proposed New Maumee River Crossing project in Napoleon, Ohio. The project location is depicted in Figure 1 *Site Location Map*. This report describes the exploration, presents MSG's geotechnical engineering evaluation and recommendations for the foundations and embankment construction and discusses plan subgrade stabilization methods and pavement design recommendations.

Twenty-eight (28) soil borings, identified as B-001-0-13 through B-026-0-13 (hereafter referred to as B-001 through B-026), were drilled on site for geotechnical investigation purposes, between April 22, 2014 and June 12, 2014. Borings B-001 through B-005 and B-013 through B-026 (except for B-016) were drilled during MSG's first mobilization from April 22, 2014 to April 29, 2014. Borings B-006 through B-012 (barge drilling) and B-016 were drilled during MSG's second mobilization from June 3, 2014 to June 12, 2014. The boring locations are shown on Figure 2 *Soil Boring Location Map*. The soil overburden consists primarily of deposits of fine-grained soil (i.e., silty clay) with layers of sands and gravels overlying shale bedrock. Please refer to Section 5 and Appendices A and B for further details for the subsurface profile.

Uncontrolled fill material consisting of very loose sandy silt (A-4a) overlying concrete rubble, brick and block debris was encountered in Boring B-013 and identified in a large area located between East Riverview Avenue and the Maumee River. The uncontrolled fill will have to be excavated, replaced with engineered granular fill and compacted as per Section 6.2.

We understand that a cap-and-column type pier system is currently planned for support of the pier foundations to be located within the river. Therefore, drilled shafts socketed into bedrock are planned for support of the piers. Alternately, the piers may be founded on shallow spread footings keyed into bedrock if the pier system is revised to a solid wall type pier system. The bridge abutments are planned to be supported on a driven H pile foundation system.

The drilled shaft socket for the bridge piers are designed for a factored column load of 1,300 kips and requires a diameter of 5.5 feet and 11 feet of socket into the shale bedrock. The drilled shaft above the bedrock would be 6 inches larger in diameter than the socket, i.e. 6 feet. The longitudinal reinforcement used in the design consists of 20 #11 longitudinal bars with a 6 inch cover in the rock socket section and a 9 inch cover in the section above. The vertical displacement at the top of the pile is expected to be less than 1/10 in.

If shallow foundations are planned for support of the pier systems, it is recommended that the pier foundations bearing on the natural shale bedrock (Approximate Elev. 631.0 to 634.8) at the river bottom be designed for a factored bearing resistance of 23 kips per square foot (ksf) for the strength limit state and a factored bearing resistance of 20 ksf for the service limit state. The provided bearing resistances assume the foundations will be protected from scour. Additionally, we recommend the use of a coefficient of friction for sliding resistance of 0.51.

Driven H-piles for the abutments should be driven to refusal in the shale bedrock and at least one row battered to provide lateral resistance. Please refer to Table 6.6 for pile capacities and Table 6.7 for estimated pile lengths and tip elevations.

Design recommendations for the bridge pier and abutment foundations are provided in more detail in Section 6.9.

Recommendations for the plan subgrades and pavement design recommendations are included in Section 6.11. MSG developed recommendations in accordance with the latest update of the ODOT OGE GB1 document. It is anticipated that localized undercuts will be required. Please refer to Table 6.9 for approximate stations for undercutting on each roadway alignment. Table C.1 indicates that 33 percent of the roadway borings (4 out of 12) may require subgrade remediation. GB1 indicates that if it is determined that 30 percent or more of the subgrade area requires stabilization, consideration should be given to performing a global stabilization of the entire project limits. However, given the relatively low amount of roadway improvements (roughly less than a mile), global stabilization may not be warranted for this project. Table C.1 indicates that global remediation using chemical stabilization is an option for lime stabilization with a global remediation depth of 12 inches. Note that chemical stabilization is generally not cost-effective for local and/or discontinuous remediation zones. However, if proof rolling identifies continuous unsuitable soils, global stabilization should be considered.

Based on the GB1 analysis and the plan subgrades, a design CBR value of 6 percent was determined for the project. Should a concrete pavement section be considered, a modulus of subgrade reaction design value of 150 pci is recommended.

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1.0 INTRODUCTION

The Mannik & Smith Group, Inc., (MSG) was retained by the Henry County Transportation Improvement District (Henry County) to conduct a geotechnical exploration for the proposed New Maumee River Crossing project in Napoleon, Ohio.

The project location is depicted in Figure 1 *Site Location Map*. This report describes the exploration, presents MSG's geotechnical engineering evaluation and recommendations for the foundations and embankment construction and discusses plan subgrade stabilization methods and pavement design recommendations.

2.0 PROJECT DESCRIPTION AND SCOPE

The project involves constructing a new bridge over the Maumee River near the City of Napoleon to provide a connection between SR 110 on the south side of the river to Riverview Avenue on the north side of the river by extending Industrial Drive southward to SR 110. To ease traffic congestion, roundabouts are planned for the intersection of SR 110 and the extended Industrial Drive as well as at Industrial Drive and Riverview Avenue. Please note that the geotechnical exploration was planned based on a previous alignment with no roundabouts. Should the final approved alignment significantly vary, additional borings and analysis may be warranted.

Once in place, the new bridge and extended Industrial Drive corridor will provide a vital direct link between the two industrial/office park areas of Napoleon/Henry County that are currently separated by the Maumee River. It will also allow direct access to the major US 24/US 6 arterial corridors for existing businesses.

The purpose of the geotechnical exploration was to establish the subsurface soil and groundwater conditions at the site that would assist in conducting a geotechnical evaluation and providing geotechnical recommendations for the proposed improvements.

The exploration was performed in accordance with the scope of work included in the November 2013 MSG cost proposal. The exploration included twenty-eight (28) geotechnical borings totaling 370.3 linear feet of drilling and sampling. Representative soil samples were tested to develop parameters for use in geotechnical analyses and in the development of design and stabilization recommendations. The boring locations are shown on Figure 2 *Soil Boring Location Map*.

3.0 AVAILABLE INFORMATION

The following sections document the available information for the project site including the site geology and review of available historical information.

3.1 Site Geology

The project site is located within the Maumee Lake Plains Physiographic region of Ohio which generally consists of Pleistocene-age silt and clay lacustrine deposits and/or deltaic sediments overlying glacial till and Devonian-age limestone and shale bedrock. The close proximity of the site to the Maumee River indicates the site may contain river alluvium with overbank deposits. Floodplains and terraces flank the Maumee River with overburden soils generally consisting of silty and clayey floodplain deposits or sandy and loamy soils in the terraces. Nearby water well logs indicate the overburden soils consist of clay and gravel overlying shale that was encountered at depths ranging from 30 to 40 feet below ground surface (bgs). Drift thickness mapping indicates the overburden is approximately 15 to 45 feet thick and potentially as shallow as the ground surface within the riverbed.

3.2 Available Information

MSG prepared a Structure Type Study for the HEN-IND-00.00 bridge and submitted it to the Henry County Engineer's Office in June 2014. The following key items in relation to the geotechnical aspects of the project were noted from the study:

- The proposed bridge will be supported on drilled shafts anchored into the bedrock. Due to the proximity of the bedrock to the ground surface the drilled shafts can be used at the piers and the abutments can be founded on capped pile foundations.
- The base flood elevation within the Maumee River at the existing condition is at Elevation 656. The calculated existing 100-year water elevation immediately upstream of the proposed bridge location is 656.63.
- The proposed structure alternative incorporates use of driven piles, drilled shafts and Type C slope protection which reduces the risk associated with scour.

4.0 SUBSURFACE EXPLORATION PROGRAM

Details regarding the exploration are summarized below. Results of field and laboratory testing conducted as part of the investigation are also summarized below.

4.1 Drilling Procedures

Twenty-eight (28) soil borings, identified as B-001-0-13 through B-026-0-13 (hereafter referred to as B-001 through B-026), were drilled on site for geotechnical investigation purposes, between April 22, 2014 and June 12, 2014. Borings B-001 through B-005 and B-013 through B-026 (except B-016) were drilled during MSG's first mobilization from April 22, 2014 to April 29, 2014. Borings B-006 through B-012 (barge drilling) and B-016 were drilled during MSG's second mobilization from June 3, 2014 to June 12, 2014.

The embankment borings, B-001 through B-004 and B-014 were drilled along the proposed Industrial Drive alignment. The borings were performed to depths according to the Ohio Department of Transportation (ODOT) Specifications for Geotechnical Explorations (SGE) requirements for Type B1 borings.

The roadway borings, B-015 through B-026, were drilled within and adjacent to the existing pavement of East Riverview Avenue, SR 110, and Industrial Drive. Note that Boring B-015 was performed outside of the existing Industrial Drive pavement, but along the proposed alignment. One boring was performed at each end of the project and at a spacing of approximately 400 feet (or less) for the entire length of the proposed roadway modifications according to SGE requirements for Type A borings.

The structure borings, B-005 through B-013-1, were drilled at each approximate foundation location for the proposed bridge carrying Industrial Drive over the Maumee River. The borings were performed to depths according to SGE requirements for Type E1 borings.

A track mounted Geoprobe® 7822DT drill rig was used to advance the borings by mechanically turning 4¼-inch inner diameter hollow-stem augers into the soil material and driving the split spoon sampler. All drilling activities were performed in general accordance with ASTM D1452 (auger borings). In accordance with the ODOT SGE, the hammer system on the drilling rig has been calibrated in accordance with ASTM D4633 to determine the drill rod energy ratio.

Soil sampling was conducted using the Standard Penetration Test (SPT) in general accordance with ASTM D1586. A standard 2-inch outer diameter split-spoon sampler was driven 18 inches into the soil with blows of a 140-pound hammer falling 30 inches. The sum of the number of hammer blows required to drive the sampler the second and third six-inch intervals was recorded and designated the "standard penetration resistance", or blow count, in units of blows per foot (bpf). This standard penetration resistance is corrected for the energy ratio of the drill rig hammer as determined from the aforementioned hammer calibration, which results in the N_{60} value.

The corrected penetration resistance or N_{60} value, when properly evaluated, is an index of the soil's strength and density and is a measure of the soil's ability to support foundations. Split-spoon sampling intervals were varied depending on the boring type and proposed top of subgrade relative to the existing top of subgrade. A representative of MSG visually classified the split-spoon soil samples in the field (ASTM D2488), conducted pocket penetrometer tests and logged the borings.

At the two abutment locations (B-005 and B-013-1) 10 feet of bedrock was cored and at the bridge pier locations (B-006 to B-012) 5 to 20 feet of bedrock was cored. All coring activities were performed using a NW conventional diamond-bit core barrel in accordance with ASTM D2113. A representative of MSG visually classified the recovered rock core samples in the field, prepared a rock core log, and placed the samples in rock core boxes.

The results of the field explorations have been summarized on the boring logs provided in Appendix A.

Prior to backfilling, each open bore hole was observed for groundwater. The borings were backfilled primarily with auger cuttings mixed with medium bentonite chips upon the completion of drilling. Borings within the existing pavement were backfilled with bentonite to the bottom of the pavement with the remainder of the borings then backfilled with asphalt cold patch and tamped in-place using a hammer. Soil samples and rock cores were delivered to MSG's soils laboratory for further examination and the assignment of laboratory testing on selected samples.

4.2 Laboratory Testing Program

Each split-spoon sample recovered from the borings was examined and visually classified. This examination was performed to select samples for further laboratory evaluation, to verify conditions identified within field boring logs, and to perform visual-manual classification of samples not subjected to further laboratory testing. During the examination process, the geotechnical engineer finalized the soil boring logs.

Laboratory index testing consisted of moisture content, gradation, and plasticity. Natural moisture content determinations were performed on each sample in accordance with ASTM D2216. Soil gradation analyses, including sieve and hydrometer analyses for clayey soils, were performed on a representative portion of the split-spoon samples in accordance with ASTM D422 as modified by ODOT. In accordance with the August 2013 update of the ODOT Office of Geotechnical Engineering (OGE) Geotechnical Bulletin – GB1 "Plan Subgrades", one sample near the top of the proposed subgrade in each roadway boring was tested for sulfate content using the test method TEX-145-E "Determining Sulfate Content in Soils – Colorimetric Method" as published by the Texas Department of Transportation. Strength testing of select cohesive soil samples included Unconsolidated-Undrained (U-U) Triaxial Compression Test in accordance with ASTM D2850. Strength testing on select rock samples included Unconfined Compressive Strength in accordance with ASTM 7012, Method C.

Our laboratory testing program consisted of the following:

- 95 moisture content tests;
- 40 Atterberg Limits tests;
- 39 gradation analyses;
- 12 Sulfate Content tests;
- Two (2) unconsolidated-undrained triaxial compression tests;
- Two (2) one-dimensional consolidation tests; and,
- Nine (9) unconfined compressive strength tests for intact rock cores.

Results of the laboratory testing are included in Appendix B. Test results are generally discussed in the following sections.

5.0 EXPLORATION FINDINGS

The subsurface soil and groundwater conditions encountered in the borings drilled at the site are shown in detail on the Soil Boring Logs contained in Appendix A. Notes and symbols illustrating the soil classification criteria, and terminology used in the boring logs are also included in Appendix A.

The following sections describe subsurface conditions in terms of major soil strata for the purposes of geotechnical exploration. The soil boundaries indicated are inferred from non-continuous sampling and observations of the drilling and/or sampling resistance. The subsurface conditions discussed in the following paragraphs and those shown on the boring logs represent an estimate of the subsurface conditions based on interpretation of the field and laboratory data using normally accepted geotechnical engineering judgment. The subsurface conditions described herein may vary beyond the boring locations and at different times of the year.

5.1 Soil Profile – SR 110

The subsurface conditions encountered in the borings for SR 110 (B-017 to B-021) are discussed in the following sections. At the ground surface of all the borings except B-020, 10 inches of asphalt pavement underlain by 4 inches of aggregate base was encountered. At boring B-020, the surficial material consisted of 3 inches of topsoil. The soil overburden consists primarily of deposits of clay. There were layers of sand and gravel under the pavement sub-base encountered in the borings B-017 and B-019.

5.1.1 Soil Unit 1 – Loose to Medium Dense Gravel and Sand

Soil Unit 1 consists of medium dense, gray coarse and fine sand (A-3a) and loose, gray gravel with sand and silt (A-2-4) found below the pavement from 1.2 to 4.2 feet bgs at boring B-017 and from 1.2 and 2.7 feet bgs at boring B-019, respectively. The N_{60} values ranged from 10 to 22 bpf with an average of 18 bpf. The moisture contents were between 6 and 21 percent with an average of 13 percent.

5.1.2 Soil Unit 2 – Stiff to Hard Cohesive Soils

Soil Unit 2 consists predominantly of stiff to hard, brown and/or gray clay with variable amounts of silt. The soil unit was encountered below Soil Unit 1 at B-017 and B-019 and below the pavement in the other boring locations and continued to depths of 6.2 to 7.2 feet (boring termination depths). The soil unit was identified as A-7-6 at borings B-017, B-018, B-020 and B-021. The soil unit was identified as A-6b at borings B-017, B-019 and B-021 and as A-6a at borings B-018 and B-021. The N_{60} values ranged from 10 to 60 bpf with an average of 32 bpf. The pocket penetrometer tests results were between 2.25 and 4.5+ tsf. The moisture contents were between 13 and 27 percent with an average of 19 percent.

5.2 Soil Profile – Industrial Drive

The subsurface conditions encountered in the borings for Industrial Drive (B-001 to B-016) are discussed in the following sections. At the ground surface at borings B-001 through B-005, 12 inches of topsoil was encountered. At boring B-013-1, the surficial material consisted of 4 inches of topsoil. At boring B-014, the surficial material consisted of 12 inches of gravel backfill. At boring B-015, 6 inches of topsoil was encountered at the ground surface. At boring B-016, 8 inches of asphalt pavement overlying 12 inches of aggregate base was encountered. The soil overburden consists primarily of deposits of silty clay. There were layers of sandy silt found below the surficial material in some borings. The bedrock was identified to be shale. At B-013, very loose brown sandy silt fill was underlain by concrete rubble. Refusal in the concrete rubble was encountered at 4 feet bgs.

5.2.1 Soil Unit 1 – Loose to Medium Dense Sandy Silt

Soil Unit 1 consists predominantly of loose to medium dense, brown or gray non-cohesive sandy silt (A-4a). The soil unit was encountered below the surficial material in borings B-003, B-004 and B-013-1. The soil unit was encountered to depths of 2.5 to 6 feet. The N_{60} values ranged from 6 to 12 bpf with an average of 9 bpf. However at B-004, very loose sandy silt with an N_{60} value of 3 was encountered between the depths of 3.5 and 6 feet bgs. The moisture contents of the unit were between 14 and 21 percent with an average of 19 percent. The soil unit at B-013-1 had trace organic content and the water content was determined to be 47 percent.

5.2.2 Soil Unit 2 – Soft to Medium Stiff Cohesive Soils

Soil Unit 2 consists predominantly of soft to medium stiff, brown and/or gray silty clay. The soil unit was identified as A-6b in borings B-001 and B-002 between depths of 1 and 2.5 feet bgs. The soil unit was identified as A-4a in borings B-005 between depths of 1 and 2.5 feet bgs. At boring B-013-1 the soil unit was identified as a combination of A-6a, A-6b and A-4b soils between depths of 3.5 and 18 feet bgs. The N_{60} values ranged from 3 to 7 bpf with an average of 5 bpf. However a layer of very soft silty clay (A-6b) was found at B-013-1 between depths of 6 and 7.5 feet bgs with an N_{60} value of 1. The pocket penetrometer tests results were between 0 and 3.0 tsf. The moisture contents were between 17 and 26 percent with an average of 22 percent.

5.2.3 Soil Unit 3 – Stiff to Hard Cohesive Soils

Soil Unit 3 consists predominantly of stiff to hard, brown and/or gray silty clay. The soil unit was encountered below Soil Unit 1 or Soil Unit 2 and was identified up to depths of 8 to 20 feet where the borings were terminated or bedrock was encountered. The soil unit was identified as A-6a in borings B-001 to B-005 and B-013-1 to B-015. The soil unit was identified as A-4a in borings B-004 and B-005. The soil unit was identified as A-6b in borings B-014 and B-016. The soil unit was identified as A-7-6 in borings B-014 to B-016. The soil unit was identified as A-4b in boring B-013-1. The N_{60} values ranged from 9 to 55 bpf with an average of 25 bpf. The pocket penetrometer tests results were between 2.0 and 4.5+ tsf. The moisture contents were between 9 and 26 percent with an average of 16 percent.

5.2.4 Rock Unit 1 – Weak to Strong Shale

Rock Unit 1 consists of weak to strong, brown to black shale. These formations were found at depths of 22 feet bgs and 19.2 feet bgs at borings B-005 and B-013-1, respectively, and at the surface for the river borings B-006 through B-012. The RQD of the rock cores were between 0 and 75 percent with an average value of 29 percent. Nine (9) unconfined compressive strength tests were performed on the rock cores. The unconfined compressive strength was between 1,423 and 7,676 psi with an average value of 4,633 psi. The rock formations were found to be slightly to severely weathered.

5.3 Soil Profile – East Riverview Avenue

The subsurface conditions encountered in the borings for Riverview Avenue (B-022 to B-026) are discussed in the following sections. At the ground surface 10 inches of asphalt pavement over 4 inches of aggregate base was encountered at all the borings. The soil overburden consists primarily of deposits of silty clay. There were layers of sandy silt, sand or gravel found below the surficial material.

5.3.1 Soil Unit 1 – Loose to Medium Dense Gravel

Soil Unit 1 consists of loose to medium dense, brown or gray gravel (A-1-a and A-2-4) found at borings B-023 and B-025. This deposit is encountered below the pavement and continues to a depth of 2.7 feet. The N_{60} values were between 22 and 31 bpf with an average of 27 bpf. The moisture contents of the unit were between 3 and 16 percent with an average of 10 percent.

5.3.2 Soil Unit 2 – Medium Dense to Dense Sandy Silt and Sand

Soil Unit 2 consists of medium dense to dense, brown and/or gray sandy soils (A-3 and A-4a). These deposits were found at all the boring locations except B-025 below the surficial material or Soil Unit 1 with a thickness of about 1.5 feet. The soil unit is identified as A-4a in borings B-022, B-023 and B-026. The soil unit was identified as A-3 in boring B-024. The N_{60} values were between 16 and 34 bpf with an average of 22 bpf. The moisture contents were between 2 and 21 percent with an average of 10 percent.

5.3.3 Soil Unit 3 – Stiff to Hard Cohesive Soils

Soil Unit 3 consists predominantly of stiff to hard, brown and/or gray silty clay. These deposits were found at all the borings below Soil Units 1 or 2. The soil unit was encountered to the boring termination depths of 7.2 feet bgs. The soil unit was identified as A-4a, A-6a, A-6b and/or A-7-6 in all the borings. The N_{60} values were between 18 and 63 bpf with an average of 38 bpf. The moisture contents were between 14 and 25 percent with an average of 21 percent.

5.4 Problematic Soils

The following sections outline problematic or unsuitable soils encountered during the subsurface exploration.

5.4.1 Uncontrolled Fill

Uncontrolled fill material consisting of very loose sandy silt (A-4a) overlying concrete rubble, brick and block debris was encountered in boring B-013. There is a large fill area located between East Riverview Avenue and the Maumee River. See Figure 2 for more details. While performing drilling operations, the current property owner stated to MSG personnel that he has been dumping concrete debris and fill in this area for several years in order to establish a level finish grade.

5.4.2 Very Soft to Soft Silty Clay

Soft brown silty clay (A-6b) was encountered in B-001 from 1 to 3 feet bgs. At B-005, soft to medium stiff brown sandy silt (A-4a) was encountered from 0.8 to 8.5 feet bgs. At B-013-1, very soft to medium stiff brown and dark brown silt, silt and clay, and silty clay (A-4b, A-6a, and A-6b) was encountered from 3.5 to 18 feet bgs.

5.4.3 Very Loose to Loose Sandy Silt

A layer of loose brown sandy silt (A-4a) was encountered in B-003 from 1 to 6 feet bgs. At B-004, very loose to loose brown or dark gray sandy silt (A-4a) was encountered from 1 to 8.5 feet bgs. At B-013-1, a layer of loose brown sandy silt (A-4a) was encountered from 0.3 to 3.5 feet bgs. Additionally, a layer of loose gravel with sand and silt (A-2-4) was encountered in Boring B-019 from 1.2 to 2.7 feet bgs.

5.5 Groundwater

Groundwater was encountered in four of the borings during drilling activities: B-002, B-003, B-005 and B-013-1. Water levels were measured in these four borings at the completion of drilling and ranged from approximately 2.5 to 16 feet bgs. Changes in soil color, from brown to gray, are generally indicative of the median water table. The groundwater elevation fluctuates and is naturally at a seasonal high during the winter and spring and is usually lower in the summer and early fall.

The water levels were measured in the river borings and indicated that the river elevations varied between Elevation 638 and 641 at the time of drilling.

6.0 ANALYSES AND RECOMMENDATIONS

The following evaluations and conclusions are based on interpretations of field and laboratory data obtained during the geotechnical exploration and MSG's experience with similar soils and subsurface conditions. Where comments are made with regard to construction or the proposed development, they are provided in order to highlight aspects of construction that could potentially affect the design of the project. Contractors bidding on or undertaking the work should make their own interpretations of the factual results of the investigation as it affects their construction methods, equipment capabilities, costs, schedule, sequencing and the like.

A qualified geotechnical consultant should be retained for this project to monitor subsurface conditions, subgrade, and foundation preparation activities to verify that suitable materials are in place. This report and evaluation reflects only the geotechnical aspects of the subsurface conditions at the site. Review and evaluation of environmental aspects of subsurface conditions is beyond the scope of this report.

6.1 Site Preparation and Embankment Construction

Before proceeding with earthwork operations, topsoil, vegetation, root systems, pavements, existing foundations, uncontrolled fill materials and other deleterious materials should be stripped from the entire footprints of the proposed embankments. Uncontrolled fill material consisting of very loose sandy silt (A-4a) overlying concrete rubble, brick and block debris was encountered in Boring B-013 and identified in a large area located between East Riverview Avenue and the Maumee River. The uncontrolled fill will have to be excavated, replaced with engineered granular fill and compacted as per Section 6.2. Areas exposed by stripping operations, on which subgrade preparations are to be performed, should be scarified to a minimum depth of 8 inches and compacted in accordance with the recommendations provided in Section 6.2. It is also recommended that the embankment foundation subgrades be inspected by the on-site geotechnical engineer or his/her designated representative to identify any weak, wet, organic or otherwise unsuitable soils. Depending on the severity of distress encountered during subgrade inspections, compaction of the subgrade surface with a vibratory sheep's foot roller, vibratory smooth drum roller or undercutting to an acceptable subgrade surface and backfilling with compacted lifts of drier materials, should be adequate to stabilize the subgrade. If these activities fail to stabilize the subgrade, the use of granular backfill with a geotextile separation layer and/or geogrid may be required. The backfill material should consist of suitable embankment material (Item 703.16 of the ODOT 2013 Construction and Material Specifications or CMS).

The proposed embankment may require placement of new fill on existing sloping surfaces. Prior to placement of this new fill, benches should be cut into the existing embankments. Where the sloping surfaces are flatter than 4:1 (H:V), benching of the existing ground surface should be performed in accordance with Item 203.05 of the ODOT 2013 CMS. If the ground surface is steeper than 4:1 (H:V), then benching should be performed in accordance with ODOT Geotechnical Bulletin GB2, "Special Benching and Sidehill Embankment Fills", dated July 22, 2013.

6.2 Fill Placement

All new fill should consist of inorganic soil that is free from all deleterious materials and construction debris and should be compacted in accordance with Item 203 or if within 12 inches of the proposed roadway subgrade level, Item 204 of the ODOT CMS. Fill materials should not be placed in a frozen condition or upon frozen subgrades. Compaction requirements for new fill are provided in ODOT Item 203.07.B (or Item 204.03 if within 12 inches of roadway subgrade level) where specifications are provided for the minimum percent compaction based on the dry unit weight of the soil type being used as fill. The soil should be compacted to within 2 percent of the optimum moisture content. Coarse crushed granular material is recommended as fill for replacement of undercut areas, if necessary. For undercut areas, the coarse crushed granular material may consist of natural aggregate materials or geotechnical engineer approved equivalent. Typical lift thickness utilized for this material is 8 inches. As an alternative, in very soft or loose subgrade areas, the use of a geotextile for separation and/or geogrid in addition to the coarse crushed granular material can be considered.

Compaction equipment and methods used should be appropriate for the types of fill materials being placed. Granular materials should be compacted using vibratory or non-vibratory smooth-drum rollers. Fine-grained soils should be compacted using a segmental peel or "sheepsfoot" compactor. For restricted access areas, such as utility trenches, fill should be placed in 3 to 6 inch loose lifts and compacted utilizing portable compaction equipment.

A qualified geotechnical consultant should be retained to monitor fill placement to assure compaction requirements are achieved and that suitable fill materials are being used. Based on the soil borings, on-site soils may be suitable for reuse but will likely require moisture conditioning prior to reuse.

6.3 Excavation

Activities at the site such as the installation/relocation of utilities may require excavations at significant depths below the ground surface. Slope height, slope inclination, and excavation depth (including utility trench excavations) should in no case exceed those specified in local, state, or federal safety regulations (see especially *OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926 Subpart P*). Such regulations are strictly enforced and, if not followed, the contractor, earthwork subcontractor, or utility subcontractors could be liable for substantial penalties.

The native soils encountered during the investigation were generally clayey soils and sandy silts (A-6, A-7, and A-4). Based upon the data obtained, these soils would generally be classified as Type B, cohesive soils with unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf. Simple side slopes for open excavations in these materials must be no steeper than 1 horizontal to 1 vertical (1H:1V). Flatter side slopes may be required in areas of loose, soft and/or saturated soils.

As an alternative to sloping, excavations may be properly braced against lateral movement. If any excavation, including a utility trench, is extended to a depth of more than 20 feet, OSHA requires that a Professional Engineer design the side slopes of such excavations.

6.4 Bridge Design Information

As discussed in the Structure Type Study dated June 30, 2014, Structure Alternative C was recommended for the new Maumee River Crossing. This alternative consists of providing 72-inch WF72-49 Prestressed concrete I-beams with a cast-in-place deck superstructure. The span arrangement is 8 spans each about 117.5 feet in length. It is planned that the abutments will be founded upon capped H pile foundations and the piers will be founded upon drilled shaft foundations socketed into bedrock. At the time of the Structure Type Study, it was assumed that there was approximately 6 feet of overburden soils overlying bedrock in the river channel bottom, thus drilled shafts would be used for pier foundations. However, based on the exploratory findings overburden soils were not encountered and the river channel bottom consists of bedrock; therefore, shallow spread footings keyed into bedrock are feasible to support the pier system if a solid wall type pier system will be used. We understand that a cap-and-column type pier is currently planned for the bridge piers with drilled shafts socketed into bedrock to support the pier columns. The drilled shafts are designed to support a maximum factored axial load of 1,300 kips/shaft. The drilled shafts are also designed to withstand an extreme event loading and maximum bending moment loading cases. The extreme event loading consists of an axial loading of 824 kips/shaft, lateral load of 145 kips/shaft and a bending moment of 528 ft-kips/shaft. The maximum bending moment loading case consists of an axial load of 762 kips/shaft, lateral load of 71 kips/shaft and a bending moment of 2,781 ft-kips/shaft.

6.5 Embankment Slope Stability and Settlement

In general, settlement evaluations indicate that embankment foundation material settlement should not be problematic as the relative magnitude is small. However, sufficient settlement is induced by the proposed fill to consider downdrag forces on the pile foundations. Time required to reach 90% of the estimated consolidation or to reach less than 0.4 inches so that downdrag forces on the piles can be considered negligible is most likely too long to provide a reasonable construction schedule. Some remedial steps can be taken during construction to lessen the time requirements for consolidation, if a shorter time duration is desired. Details regarding the settlement analyses are presented below.

Slope stability analyses performed on the worst case embankment cross sections and side slope “sliver” fills resulted in factors of safety that exceeded the required safety factor against slope failure of at least 1.3 for both short and long term scenarios. Details regarding stability analyses for the embankments are presented below.

6.6 Settlement

Some construction related settlement of the embankment fill should be expected due to its own weight. Typically, for a properly construction embankment, the majority of settlement of the embankment fill material occurs during construction and does not usually present long term issues. However, if cohesive embankment fill material is placed and compacted wet of the optimum moisture content, excessive pore pressures within the embankment fill material could be generated resulting in excessive long term settlement. Therefore, it is recommended that a geotechnical engineer or his/her representative observe the construction of the embankment to ensure proper procedures are followed.

Typical long term settlement of a properly constructed, well compacted cohesive embankment fill material ranges from 0.2-0.4% of the total embankment height. Settlement of the proposed embankment fill material could be expected to range from 0.25-0.5 inches for the eastern embankment and 0.5-1.0 inches for the western embankment based off of the current proposed embankment heights.

Table 6.1 below contains the soil settlement parameters used in the settlement analysis. The following paragraphs discuss how the settlement parameters were determined.

Table 6.1 Soil Settlement Parameters Summary

Location	Material	Moist Unit Weight (pcf)	Precon. Stress (s'_p) (ksf)	Initial Void Ratio (e_0)	Compression Index (Cc)	Recomp. Index (Cr)	Coefficient of Consolidation, Cv @ 50% (cm^2/s)
Cross Section at STA 39+00	Embankment[2]	125					
	Sandy Silt Medium[3]	132	3.5	0.493	0.120	0.025	1.16e-2[1]
	Sandy Silt Stiff[3]	132	14.7	0.493	0.110	0.022	3.41e-3[1]
	Silty Clay Stiff[3]	132	14.8	0.506	0.140	0.035	2.27e-3[1]
	Sandy Silt Hard[4]	135	21.5[3]	0.430	0.082	0.038	4.27e-3
	Shale Bedrock[5]	120					
Cross Section at STA 49+25	Embankment[2]	125					
	Silty Clay Stiff[3]	132	9.1	0.493	0.120	0.024	1.5e-3[1]
	Silty Clay Very Stiff[3]	132	14.8	0.506	0.140	0.035	2.63e-4[1]
	Silty Clay Hard[4]	124	3.0[3]	0.636	0.140	0.031	1.37e-4
	Shale Bedrock[5]	120					

1 – Estimated from Figure 4 in the NAVFAC DM-7.1
2 – Settlement of embankment fill material not considered
3 – Settlement Parameters estimated from empirical relationships with index properties
4 – Settlement parameters interpolated from laboratory consolidation test results
5 – Bedrock is considered to be relatively “incompressible” due to the loads used for this analysis

One-dimensional laboratory consolidation tests were conducted to establish compressibility parameters on relatively undisturbed soil samples representative of the major foundation soil units in the embankment locations. Compressibility parameters used in settlement analysis of the major foundation materials are based on interpretation of the laboratory data and have been developed for design considerations. The coefficient of consolidation was established for the anticipated stress range resulting from the proposed embankment construction for this depth interval. Index testing and standard penetration test data have been demonstrated to be strong indicators of soil physical properties. Therefore, compressibility parameters for minor foundation soil units, where consolidation tests were not performed, were estimated using empirical relationships between index properties and physical settlement parameters. The coefficient of consolidation for minor foundation soil units was estimated from Figure 4 in the NAVFAC DM-7.1, 1982 guide using the Liquid Limit.

Estimates of total foundation material settlement have been calculated in a spreadsheet using the Cons-Boussinesq stress distribution. Critical sections were generally established based on the typical section at the maximum fill height with the representative subsurface stratigraphy established using the nearest boring(s). The time rate of consolidation was calculated on the spreadsheet using calculated and estimated coefficients of consolidation. In the case where multiple layers were present with differing estimated/calculated coefficients of consolidation, a weighted average coefficient of consolidation representative of the entire thickness of the compressible soil unit was calculated and utilized in the calculation. Table 6.2 below contains the results of the settlement analyses.

Table 6.2 Embankment Foundation Material Settlement Summary

Location	Embankment Height (ft.)	Total Estimated Settlement (in)	90% Settlement Value (in)	Estimated Time to Reach 90% Settlement Value (days)
Cross Section at STA 39+00	13.7	1.6	1.4	205
Cross Section at STA 49+25	16.6	2.0	1.8	1,900

Time required to reach 90% of the estimated consolidation listed in Table 6.2 is too long to provide a reasonable construction schedule at STA 49+25. If a shorter construction schedule is desired, design alternatives such as a surcharge loading, wick drains, and/or a granular drainage layer, may accelerate settlement rates. Settlement platforms and routine monitoring may also be merited at select locations to observe and record settlement during construction.

If embankments are constructed according to the plans and left to sit for a construction season (approximately 270 days after reaching the full height), then 95% of the full estimated settlement of 1.6 inches (1.5 inches) may be achieved at Section STA 39+00 and 39% of the full estimated settlement of 2.0 inches (0.8 inches) may be achieved at Section STA 49+25. Therefore, assuming all settlement of the embankment material itself has taken place during construction; differential settlement of the pavements with respect to the bridge decks at the eastern and western abutments may be approximately 0.1 inches and 1.2 inches, respectively. Significant variation in the estimated time rate of settlement may occur if subsurface sand lenses and seams are present that were not encountered in the borings where discontinuous sampling was performed. Therefore, it is recommended that a settlement platform be installed and monitored at each abutment location to assist in the determination of the magnitude and rate of settlement and evaluation of potential additional settlement that may occur after construction of the pavement section. The settlement and time rate of consolidation calculation spreadsheet is included in Appendix C.

6.7 Slope Stability

The stability of the proposed side slope “sliver” fills and embankments were analyzed using SLIDE. The SLIDE program analyzes circular, block, and randomly shaped failure surfaces. Analyses were conducted at critical sections, generally established based on typical cross-sections at maximum fill locations, and incorporated the underlying soil stratigraphy as established by the subsurface exploration. Slope stability was assessed for both short-term (undrained) and long-term (drained) conditions.

Undisturbed soil samples obtained from the embankment locations were tested in the laboratory to establish total and effective stress parameters representing short and long-term undrained and drained conditions, respectively, that would be present immediately following construction and as excessive pore pressures dissipate. Effective stress parameters, for other soil units not laboratory tested for long-term strength parameters, were based upon empirical relationships from U.S. Navy, 1971 and Ladd, et al, 1977. The following conservative assumptions were made while estimating the effective stress parameters:

- 0 psf cohesion was assumed for over-consolidated clay materials;
- The strength envelope for over-consolidated and normally consolidated materials were considered identical beyond the pre-consolidation pressure; and,
- The strength envelope for an over-consolidated material with an assumed cohesion of 0 psf was assumed to have the same friction angle below the preconsolidation pressure as above the preconsolidation pressure.

The strength parameters utilized for stability analyses are generally conservative, using the lowest representative results. Strength values were assumed for fill materials according to those presented in ODOT GB6 based on anticipated soil fill material type. However, cohesion values for future embankment fill material, as presented in GB6, were reduced to a minimum value which would achieve an acceptable factor of safety. Table 6.3 below contains the soil strength parameters used in the stability analysis.

Table 6.3 Soil Strength Parameters Summary

Location	Material	Moist Unit Weight (pcf)	Cohesion (c) (psf)	Internal Angle of Friction (degrees)
Drained Conditions[1]				
Cross Section at STA 39+00	Embankment[2]	120	400 / 6[3]	30
	Sandy Silt Medium Stiff	132	0	33
	Sandy Silt Stiff	132	0	33
	Silty Clay	132	0	30
	Sandy Silt Hard	135	0	33
	Shale Bedrock[4]	120	50,000	40
Cross Section at STA 106+00 (Same as STA 39+00 from elev. 646.7 to rock)	Embankment[2]	120	400 / 0[3]	30
	Silty Clay Soft	125	0	30
	Silt and Clay Stiff	125	0	30
	Silt and Clay Hard	130	0	30
	Sandy Silt Stiff	132	0	33
	Silty Clay	132	0	30
	Sandy Silt Hard	135	0	33
	Shale Bedrock	120	50,000	40
Cross Section at STA 49+25	Embankment[2]	120	400 / 3[3]	30
	Silty Clay Stiff	132	0	30
	Silty Clay Very Hard	132	0	30
	Silty Clay 2 Very Hard	132	0	30
	Shale Bedrock[4]	120	50,000	40

Location	Material	Moist Unit Weight (pcf)	Cohesion (c) (psf)	Internal Angle of Friction (degrees)
Cross Section at STA 593+00 (Same as STA 49+25 from elev. 673.3 to rock)	Embankment[2]	120	400 / 250[3]	30
	Clay Stiff	120	0	28
	Silty Clay Hard	120	0	30
	Silty Clay Stiff	132	0	30
	Silty Clay Very Hard	132	0	30
	Silty Clay 2 Very Hard	132	0	30
	Shale Bedrock[4]	120	50,000	40
Undrained Conditions				
Cross Section at STA 39+00	Embankment[2]	120	1,700	0
	Sandy Silt Medium Stiff	132	500	0
	Sandy Silt Stiff	132	2,000	0
	Silty Clay	132	2,500	0
	Sandy Silt Hard	135	3,000	0
	Shale Bedrock[4]	120	50,000	40
Cross Section at STA 106+00 (Same as STA 39+00 from elev. 646.7 to rock)	Embankment[2]	120	1,700	0
	Silty Clay Soft	125	500	0
	Silt and Clay Stiff	125	2,000	0
	Silt and Clay Hard	130	4,000	0
	Sandy Silt Stiff	132	2,000	0
	Silty Clay	132	2,500	0
	Sandy Silt Hard	135	3,000	0
	Shale Bedrock[4]	120	50,000	40
Cross Section at STA 49+25	Embankment[2]	120	1,700	0
	Silty Clay Stiff	132	2,000	0
	Silty Clay Very Hard	132	4,500	0
	Silty Clay 2 Very Hard	132	6,000	0
	Shale Bedrock[4]	120	50,000	40
Cross Section at STA 593+00 (Same as STA 49+25 from elev. 673.3 to rock)	Embankment[2]	120	1,700	0
	Clay Stiff	120	1,650	0
	Silty Clay Hard	120	4,500	0
	Silty Clay Stiff	132	2,000	0
	Silty Clay Very Hard	132	4,500	0
	Silty Clay 2 Very Hard	132	6,000	0
	Shale Bedrock[4]	120	50,000	40

1 – Based on empirical relationships from U.S. Navy, 1971 and Ladd, et al, 1977
2 – Embankment strength parameters as presented in ODOT GB 6 for the anticipated soil type to be used for fill
3 - Embankment cohesion per GB6 / Lowest cohesion value for acceptable FS
4 – Conservatively estimated from historic published data

Results of the analyses indicated embankments with a 2:1 side slope were stable in both the short and long term, with factors of safety against failure greater than 1.3. However, embankment side slopes of 2.5:1 should be considered for long term maintenance due to historic issues with local A-7-6 soils sloughing on the slopes if A-7-6 material will potentially be used as embankment fill. Table 6.4 on the next page contains the results of the embankment stability analyses.

Table 6.4 Embankment Stability Analyses Summary

Embankment STA 39+00 Side Slopes 2:1		
Conditions	Drained[1]	Undrained
Factor of Safety (Circular Failure Surface)	2.58 / 1.31	2.98
Embankment STA 106+00 Side Slope "Sliver" Fill		
Conditions	Drained[1]	Undrained
Factor of Safety (Circular Failure Surface)	3.95 / 2.38	10.51
Embankment STA 49+25 Side Slopes 2:1		
Conditions	Drained[1]	Undrained
Factor of Safety (Circular Failure Surface)	2.38 / 1.31	5.74
Embankment STA 593+00 Side Slope "Sliver" Fill		
Conditions	Drained[1]	Undrained
Factor of Safety (Circular Failure Surface)	1.36 / 1.30	6.45

1- Embankment FS with cohesion per GB6 / FS with Lowest cohesion value noted in Table 6.3

As shown in Tables 6.3 and 6.4, negligible amounts of cohesion (0 to 6 psf) were required to achieve a minimum factor of safety of 1.3 except at Sta. 593+00 of Riverview Avenue where a drained cohesion of 250 psf was required. Therefore, we recommend that consolidated undrained (CU) triaxial compression testing be performed per ASTM D4767 on remolded samples of proposed fill material to verify the material will achieve a minimum drained cohesion (c') of 250 psf and drained internal angle of friction (ϕ') of 30 degrees. This should apply to all fill material proposed for the project regardless of the location the fill will be used.

6.8 Embankment Construction Recommendations

Soft and excessively yielding embankment foundation materials may prove to be problematic during embankment construction activities and could potentially reduce embankment stability factors of safety below the acceptable limit in severe cases. Therefore, MSG recommends undercutting embankment foundation material in areas with an "N" value of less than 10 blows per foot (bpf), where present.

Item 203 of the ODOT CMS provides recommendations for earthwork and embankment construction. It should be noted that Item 203 does not include requirements for proof rolling. Therefore, proof rolling does not need to be performed in embankment foundation subgrade areas. It is only required in pavement subgrade areas. However, proof rolling in embankment foundation areas may assist in identifying potentially soft areas where undercutting and replacement is recommended prior to placement of new embankment fill.

6.9 Foundations

Design and construction recommendations are presented in the following sections. The analyses and recommendations for drilled shafts, spread footings and driven H piles in this section are in accordance with the 2007 ODOT "Bridge Design Manual" last revised January 2015 (ODOT BDM) and the 2012 AASHTO "LRFD Bridge Design Specifications" (2012 AASHTO).

6.9.1 Bridge Pier Foundations – Drilled Shaft Foundations

MSG has developed the foundation recommendations presented herein based on the geotechnical investigation and the shale bedrock encountered during drilling operations. The recommendations in this section are valid should the pier foundations be supported on drilled shaft foundations.

The drilled shafts were designed for a combination of end bearing and residual skin friction in accordance with Section 10.8 of 2012 AASHTO LRFD manual. The drilled shaft socket is designed for a factored column load of 1,300 kips and requires a diameter of 5.5 feet and 11 feet of socket into the shale bedrock. The drilled shaft above the bedrock would be 6 inches larger in diameter than the socket, i.e. 6 feet. The longitudinal reinforcement used in the design consists of 20 #11 longitudinal bars with a 6 inch cover in the rock socket section and a 9 inch cover in the section above. The vertical displacement at the top of the pile is expected to be less than 1/10 in.

Section 202.2.3.3 of 2007 ODOT BDM requires that the skin friction in the upper 2 feet of the rock socket be neglected. A scour analysis was not performed. However, we do not anticipate the scour to exceed a value which would affect the current design which ignores the skin friction in the upper 5 feet.

The depth of rock socket was evaluated to verify the adequacy to withstand the anticipated lateral loads. An LPILE analysis was performed to evaluate the load combinations for an extreme event and maximum bending moment case loading. The extreme event loading consists of an axial loading of 824 kips/shaft, lateral load of 145 kips/shaft and a bending moment of 528 ft-kips/shaft. The maximum bending moment loading case consists of an axial load of 762 kips/shaft, lateral load of 71 kips/shaft and a bending moment of 2,781 ft-kips/shaft. The highest estimated lateral deflection was estimated to be 0.3 inches at the top of the shaft. The maximum bending moment developed was found to be about 3,250 kips-ft and a maximum shear force of 1, 075 kips. The results of the LPILE analysis can be found in Appendix C.

The Unconfined Compressive Strength (UCS) of the shale bedrock used for design is 2,700 psi which is weighted average of all the UCS results. More weight has been given to the lower UCS results obtained on shale samples at B-006 and B-009. Due to the low UCS results in the laboratory, we recommend O-cell testing be performed in a test shaft in the proximity of B-006 or B-009 to ensure that the design resistance is obtained in the rock at these locations.

Table 6.5 summarizes the drilled shaft nominal and factored resistances and factored loads for the highest design column loads. The O-cell testing should ensure that the nominal bearing and side resistance is obtained in the bedrock.

Table 6.5 Drilled Shaft Design Summary

Type of Resistance used for design	Depth of Rock Socket (ft)	Diameter of Drilled Shaft Socket (ft)	Nominal Bearing Resistance (ksf)	Nominal Side Resistance (ksf)	Factored Total Resistance (kips)	Factored Strength Load including weight of shaft (kips)
End Bearing & Side Resistance	11	5.5	91.5	5.5	1403	1384

6.9.2 Drilled Shaft Foundation Construction Recommendations

In general, the drilled shafts should be constructed in accordance with Item 524 of 2013 ODOT CMS. Since the shafts are primarily end bearing, it is recommended that the drilled shafts be installed at a center-to-center spacing of no closer than two (2) shaft diameters. We anticipate that an auger equipped with rock teeth and a core barrel may be required in excavating the shafts for the foundations. It will be necessary to use a drilled shaft rig capable of generating sufficient torque and downward force to excavate the bedrock.

Due to the fact that the drilled shafts are to be installed on the riverbed, it will likely be required to dewater the shaft excavations. Temporary casings for the drilled shafts could be utilized to prevent an influx of rock fragments due to potential caving during excavation. The casing should extend a minimum of 12 inches above the water to prevent the shaft concrete from water action during placement of concrete. Placing concrete using approved tremie or pumping methods should be anticipated. The casing shall be removed during concrete placement to develop adequate skin friction. Precautions should be taken to maintain the structural integrity of the shafts and prevent the caving of material during the removal of the casing. To prevent the entry of rock and water into the shafts, an adequate level of concrete level shall be maintained (at least 4 feet) above the bottom of the casing while removing the casing.

O-cell tests should be performed in the proximity of B-006 or B-009 as outlined by section 17.2.2.2 of 2010 FHWA GEC 10, Drilled Shafts: Construction Procedures and LRFD Design Methods. If the tests fail to meet the design values, larger dimension and/or deeper drilled shafts shall be adopted after consulting the geotechnical design engineer. It is recommended that the O-cell tests be performed on a test shaft as opposed to a production shaft due to the potential for damage to the shaft during the testing process which could impact the integrity and performance on the shaft.

All drilled shaft construction should be observed by a qualified geotechnical engineer or an experienced technician working under the direction of the engineer. The inspector shall ensure that the drilled shafts are installed plumb, the shafts are sufficiently clean and dry prior to concrete placement and shall check the quality of bedrock encountered to ensure a suitable bearing surface. The bedrock socket should be directly observed by the inspector and verification of the clean-out may be performed by visual inspection device (MiniSID) facilitated by the contractor. The geotechnical engineer in charge of the on-site inspection shall contact the design engineer upon encountering an unsuitable bearing material which may affect the resistance of the drilled shafts.

6.9.3 Bridge Pier Foundations – Shallow Foundations

MSG has developed the foundation recommendations presented herein based on the geotechnical investigation and the shale bedrock encountered during drilling operations. The recommendations in this section are valid should the pier foundations be supported on shallow foundations.

Based upon our review of the existing soil conditions in the planned foundation areas, it is recommended that the foundations bearing on the natural shale bedrock (Approximate Elev. 631.0 to 634.8) at the river bottom be designed for a factored bearing resistance of 23 kips per square foot (ksf) for the strength limit state and a factored bearing resistance of 20 ksf for the service limit state. The provided bearing resistances assume the foundations will be protected from scour. Additionally, we recommend the use of a coefficient of friction for sliding resistance of 0.51. Footings shall be designed and constructed in accordance with the ODOT BDM.

The footing sizes should be based upon the anticipated structural loads in comparison to the aforementioned recommended factored bearing resistance. MSG recommends the footings be keyed 3 inches into competent rock.

A qualified geotechnical consultant, prior to the placement of reinforcing steel and concrete, should evaluate foundation excavations to verify that an adequate bearing material is present and that all debris, mud, and loose, frozen or water-softened soils are removed. All footings should bear on clean, competent bedrock.

6.9.4 Shallow Foundation Construction Recommendations

Foundations should be constructed as soon as is practical after foundation excavation and dewatering activities. If the foundation excavations will be left open for an extended period of time, a thin mat of lean concrete should be placed over the bottom to minimize damage to the bearing surface from weather or construction activities. Water should not be allowed to pond in any excavation. Foundation concrete should not be placed on frozen or flooded subgrade.

It is anticipated that cofferdams would need to be constructed to facilitate footing construction activities. It is recommended that cofferdams be anchored into the bedrock river bottom and grouted or sealed in place to prevent seepage. Cofferdam design is beyond the scope of this report.

6.9.5 Scour Protection for Pier Foundations

It is recommended that the bridge pier foundations be protected from scour if shallow foundations are constructed. MSG recommends that rip-rap (Item 703.19B or equivalent) be installed around the foundations and grouted in place.

Regular inspection, maintenance and repair of the scour protection should be performed during the life of the structure as loss of rock channel protection may occur over time.

6.9.6 Bridge Abutment Foundations – Driven Piles

MSG understands the H piles will be driven to refusal in bedrock. Per Section 202.2.3.2.a of the ODOT 2007 “Bridge Design Manual” (BDM, last updated July 2014), refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. The factored resistance for piles driven to refusal in bedrock is usually governed by the structural resistance. Per Section 202.2.3.2.a of the ODOT BDM, MSG has provided the maximum factored structural resistance ($R_{R\ max}$) for HP10X42, HP12X53 and HP14X73 pile sections in Table 6.6 using the following assumptions:

- The piles are axially loaded with negligible moment;
- Loss of section due to deterioration throughout the life of the structure is not appreciable;
- The steel yield strength is 50 ksi;
- The pile is fully braced along its entire length; and
- Using a structural resistance factor (ϕ_c) of 0.5 per Article 6.5.4.2 the 2012 AASHTO LRFD Bridge Design Specifications (6th Edition).

Additional vertical loading on the piles induced by downdrag force is anticipated to be a concern due to settlement caused by the embankment fill. For the purpose of the downdrag analysis and per FHWA guidelines, it is assumed that that downdrag force will be equivalent to the skin friction along the entire embedded length of the piles from which point more than 0.4 inches of settlement is expected to occur. Since loading information for the abutments was not available at the time of this report, the factored downdrag load was applied to the maximum factored resistance of the pile to provide a recommended net factored resistance per pile.

Table 6.6 Factored Axial Compressive Resistance of H Piles

H Pile Section	Max. Factored Resistance $R_{R\,max}$ (kips/pile)	Factored Downdrag Load DD (kips/pile)	Net Factored Resistance $R_{R\,net}$ (kips/pile)
HP10X42	310	30	280
HP12X53	380	36	344
HP14x73	530	43	487

It has been assumed that scour protection will be provided for the abutments as discussed in Section 6.9.9. Therefore, no reductions in factored axial resistance of the piles have been made for scour.

As discussed in Section 4.0, bedrock was encountered at depths ranging from 19.2 feet bgs to 22 feet bgs (Elev. 631.3 to 633.2) at the abutment locations. It is anticipated that the driven H piles will penetrate up to 3 feet into the shale bedrock before reaching a refusal condition. Table 6.7 provides of summary of the estimated tip elevations and anticipated pile lengths for cost estimating purposes. For quantity estimates (e.g. pile pay length), it is recommended that it be assumed the piles will penetrate up to 3 feet into bedrock prior to encountering refusal. As shown in Table 6.7, the piles are estimated to be a maximum of 21.5 feet long for the rear abutment and 29.5 feet long for the forward abutment.

Table 6.7 Summary of Pile Tip Elevation Estimates and Depth Recommendations

Abutment Location	Station	Nearest Boring	Boring Ground Elev. (ft.)	Pile Top Elevation (ft.)	Top Elevation of Bedrock (ft.)[1]	Pile Tip Elev. (ft.)[2]	Min. Pile Length (ft.)[3]	Max. Pile Length (ft.)[2]
Rear	39+35	B-005	655.2	651.7	633.2	630.2	19.5	21.5
Forward	48+75	B-013-1	650.5	657.78	631.3	628.3	27.5	29.5

1 – Based on the soil borings.
2 – If pile driving refusal is encountered after 3 feet of penetration into bedrock.
3 – If pile driving refusal is encountered after 1 foot of penetration into bedrock.

6.9.7 Driven Pile Construction Recommendations

Static or dynamic load testing is not required for piles driven to refusal on bedrock. The appropriate pile hammer should be selected in accordance with Item 507.04 of the 2013 ODOT CMS to avoid over-stressing the piles during driving. Prior to commencement of pile driving operations, the contractor should be required to submit equipment specifications to the County to allow for the proposed pile hammer, along with induced stresses in the pile, to be evaluated using wave equation analyses. FHWA limits compressive or tensile driving stresses to 90 percent of the yield strength (F_y). If this stress limit is anticipated to be exceeded with the wave equation analysis, investigation of alternative pile hammers or cushions should be performed to reduce the possibility of damaging the piles during driving operations. Pile driving may result in slight heave of previously driven piles. To avoid detrimental effects, all of the piles should be re-tapped at the end of the pile driving activities. The 2007 ODOT BDM states the pile points should not be used for piles bearing in shale bedrock.

6.9.8 Driven Pile Lateral Resistance

It is recommended that at least a portion of the piles be battered. ODOT prefers battered piles be inclined at 1:4 (H:V). However, Section 303.4.2.4 of the 2007 ODOT BDM permits a batter inclination as much as 1:3 (H:V) in cases where sufficient resistance is not achievable at 1:4 (H:V).

Additional lateral resistance of the foundations may be obtained by considering the passive soil resistance on the pile cap. It is understood the pile cap is 3 feet thick with the base of the pile cap at about Elev. 651.7 for the rear abutment and Elev. 657.78 for the forward abutment.

6.9.9 Scour Protection for Abutment

It is recommended that the foreslopes between the river and the abutments/wingwalls be protected from scour. MSG understands that ODOT Type C Rock Channel Protection (Item 703.19B) will be placed on the sloped embankments. Regular inspection, maintenance and repair of the scour protection should be performed during the life of the structure as loss of rock channel protection may occur over time.

6.10 Lateral Earth Pressures – Engineered Fill

Lateral earth pressures (horizontal stresses) are developed during soil displacements (or strains). Lateral earth pressure for design of bridge abutments and retaining walls is determined utilizing an earth pressure coefficient to relate horizontal stress to vertical stress. Three separate earth pressure coefficients are utilized to determine lateral earth pressure: at rest; active; and passive. Active earth pressure addresses displacement of a vertical soil face away from the retained soil. Passive earth pressure addresses displacement against the retained soil. At rest earth pressure addresses a negligible displacement scenario. Applied horizontal stress can be determined by multiplying the appropriate earth pressure coefficient by the applied vertical stress. Earth pressure coefficients are a direct function of the internal friction of a soil. Laboratory testing to determine internal friction angles for soil was not performed. However, index laboratory and field data obtained can be utilized to approximate earth pressure coefficients based upon empirical relationships.

To minimize lateral earth pressures, the zone adjacent to any walls should be backfilled with granular soils and the fill should be effectively drained. To provide effective drainage, a zone of free-draining gravel per ODOT Item 518.03 should be used directly adjacent to the walls for a minimum thickness of 18 inches in accordance with ODOT Item 518.05. This granular zone should drain to weepholes or a pipe drainage system to prevent hydrostatic pressures from developing against the walls.

The type of backfill beyond the free-draining granular zone will govern that magnitude of the pressure to be used for structural design. Clean granular soil (Item 703.16.C) is recommended as the backfill material against retaining structures to minimize lateral earth pressures. Based on the use of clean granular soil, an active earth pressure coefficient (K_a) of 0.33 and a passive earth pressure coefficient (K_p) of 3.0 may be used for cantilevered walls (free head). For restrained walls (fixed head), an at-rest earth pressure coefficient (K_o) of 0.5 may be used. For remolded clay, the lateral earth pressure coefficients are: K_o = 0.6, K_a = 0.4, and K_p = 2.5 (refer to Table 6.8).

Table 6.8 Lateral Earth Pressure Coefficients – Engineered Fill

Soil Parameters	Engineered Fill Material Type	
	Granular Soil (Item 703.16C)	Clay
Unit Weight (pcf)	125	130
Angle of Internal Friction, degrees	30	25
At Rest Pressure Coefficient, K_o	0.5	0.6
Active Pressure Coefficient, K_a	0.33	0.4
Passive Pressure Coefficient, K_p*	3.0	2.5

**The passive pressure in the upper 3.0 feet should be neglected.*

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 130 pounds per cubic foot (pcf) is recommended.

6.11 Plan Subgrades

The recommendations in the following sections are in general accordance with the August 2013 GB1 document. We understand that the profiles of Industrial Drive, East Riverview Avenue and SR 110 will remain relatively consistent with the existing conditions (except for the new embankments for Industrial Drive). Preliminary profiles developed by MSG were utilized to estimate the proposed top of subgrade at the boring locations. Once the profile and cross-sections are finalized, revisions to the following recommendations may be warranted. MSG utilized an ODOT-provided spreadsheet to perform subgrade analyses for the roadway in accordance with the ODOT GB1. The GB1 analysis calculations (i.e. the spreadsheet) for the Industrial Drive, East Riverview Avenue and SR 110 modifications are included as Table C.1 in Appendix C. Average N_L values calculated within the GB1 spreadsheet are used to comprehensively characterize the strata of the proposed subgrade soils.

The following sections summarize MSG's analysis and design recommendations specific to subgrade treatments.

6.11.1 Subgrade Moisture Content

The majority of the proposed subgrade soils for the roadway exceed the theoretical optimum moisture content by at least by 3%. The relative impermeability of the A-6 and A-7 soils is expected to limit the further reduction of moisture content in advance of construction; therefore, installation of "construction" underdrains is not likely to be cost effective.

Excessive moisture in the proposed subgrades soils is best addressed by undercutting, which is further discussed in Section 6.9.3. However, comprehensive use of permanent underdrains is recommended to effectively drain the pavement subbase and prevent softening of subgrade soils in the proposed new pavement for Industrial Drive, East Riverview Avenue and SR 110.

6.11.2 Unsuitable Soils

Within the planned subgrade areas, none of the borings performed during this geotechnical exploration encountered soils with an ODOT classification of SILT (A-4b) or organic soils (A-8) which are considered unsuitable for use as a subgrade soil. If, however, deposits of silt or organic soils are encountered during subgrade preparation or proof roll operations, MSG recommends the lateral and depth extent of the silt or organic deposits be further delineated using test pits or hand sampling methods

Any unsuitable materials including A-4b materials, organic soils (A-8) or soils with an ODOT classification of A-2-5, A-5 or A-7-5 encountered within three (3) feet of the proposed subgrade level should be removed and replaced with granular material or ODOT Item 204 Embankment if the entire depth of unsuitable material is removed. The unsuitable materials should be completely removed to a maximum depth of 3 feet below the proposed top of subgrade.

MSG recommends that special attention be given during proof rolling operations to the soil located in any existing ditch lines in the proposed widened areas of SR 110 and Industrial Drive.

Because of the wide spacing between the exploration borings, it is possible there are areas of unsuitable or organic subgrade soils that were not encountered in this investigation that may be encountered during subgrade preparation and proof roll operations. Visual observation of the proof rolling operations by a geotechnical engineer or his/her designated representative may result in a partial reduction of the amount of undercutting of unsuitable soils that could be required if such areas are encountered.

6.11.3 ODOT GB1 Subgrade Analysis and Remediation Recommendations

GB1 currently allows three different methods of subgrade remediation including the following: 1) undercut and replacement with granular material, 2) reduced undercut along with geogrid and granular material, and, 3) chemical stabilization. Table C.1 in Appendix C summarizes the laboratory-measured moisture content in comparison with the optimum moisture content for each sample and the lowest N_{60} value at each boring location. This table also provides the depth of undercut/replacement or chemical stabilization as recommended by Figure B of the GB1 document.

Table 6.9 provides a summary of our subgrade remediation recommendations based on Table C.1 and ODOT Item 204. The approximate limits (by station) of the undercuts are also provided.

Table 6.9 Recommended Subgrade Remediation per GB1 (Table C.1)

Alignment	Boring(s)	Undercut/ Replacement	Undercut/Replacement with Geogrid	Approximate Station Limits of Remediation*
SR 110	B-019 & B-020	15 inches	N/A	Sta. 102+05 to 108+38
East Riverview Ave.	B-024	12 inches	N/A	Sta. 592+96 to 596+06
Industrial Drive	B-015	16 inches	12 inches	Sta. 50+30 to 53+30

**Remediation should extend beyond the proposed lateral roadway limits to 18 inches beyond the edge of the pavement surface, paved shoulders, or paved medians, including under new curbs and gutters.*

Table C.1 indicates that 33 percent of the roadway borings (4 out of 12) may require subgrade remediation. GB1 indicates that if it is determined that 30 percent or more of the subgrade area requires stabilization, consideration should be given to performing a global stabilization of the entire project limits. However, given the relatively low amount of roadway improvements (roughly less than a mile), global stabilization may not be warranted for this project. Table C.1 indicates that global remediation using chemical stabilization is an option for lime stabilization with a global remediation depth of 12 inches. Note that chemical stabilization is generally not cost-effective for local and/or discontinuous remediation zones. However, if proof rolling identifies continuous unsuitable soils, global stabilization should be considered. Moreover, a minimum remediation width of 8 feet is typically required due to the equipment used to perform the remediation. GB1 also precludes the use of chemical stabilization if the amount of sulfates present in the subgrade soils exceeds 3,000 parts per million (PPM). MSG performed sulfate tests using the TEX-145-E discussed in Section 4.2. For all samples tested, sulfates were below 3,000 PPM. Therefore, chemical stabilization is a viable option for this project. The results of the sulfate tests are provided in Appendix B.

The actual depths and limits of undercut should be determined during proof rolling operations and should be performed under the direction of the project geotechnical engineer or his designated on-site representative. Final proof rolling of the subgrade surface can be used to determine acceptability and the lateral limit of undercutting.

MSG recommends that construction traffic be minimized once the proposed subgrade level has been attained. If construction traffic is allowed to traverse over the exposed subgrades, the quantity of soil identified as requiring removal or other remediation based on proof rolling operations may increase.

Refer to Section F of the GB1 document for additional guidance regarding the performance of undercuts, placement of geotextile and/or geogrid and required backfill material types.

ODOT's Supplemental Specification 861 provides specifications for a generic geogrid if undercutting and use of geogrid is used to remediate the pavement subgrades. In ODOT's "Plan Preparation with Proprietary Geogrid as an Alternate" document dated August 12, 2010, procedures are provided for designing and specifying proprietary geogrid as an alternate to generic geogrid in the design plans. Specifying proprietary geogrid in the design plans may result in cost savings compared to the generic geogrid stabilization option. Design of the subgrade remediation using proprietary geogrid is outside the scope of this geotechnical investigation.

6.12 Pavement Design

6.12.1 Flexible (Asphalt) Pavement

The pavement design for the roadway is controlled by the pavement subgrade. The pavement subgrade for the SR 110, East Riverview Avenue and Industrial Drive modifications are governed by the depth of the undercutting or chemical stabilization. Based on the GB1 analysis utilizing soil intervals at the approximate elevation of the undercutting along the alignments, a California Bearing Ratio (CBR) value of 6 percent was determined for the roadways.

Any roadway subgrade "fill" material (if required) is assumed to be compacted to at least 100 percent of maximum dry density as determined by the Standard Proctor (ASTM D698).

6.12.2 Rigid (Concrete) Pavement

Should a concrete pavement section be considered, a modulus of subgrade reaction (k) design value of 150 pounds per cubic inch (pci) is recommended for the clayey soils. Concrete pavements should be supported on at least 8 inches of clean granular materials in order to reduce pumping at the joints.

6.13 Groundwater Control and Drainage

Subsurface drainage components should be included to control groundwater seepage associated with walls. Excavation into the subsurface soils will increase the potential for groundwater infiltration. However, MSG anticipates the generally low permeability of the on-site soils will restrict groundwater infiltration. Seepage water that does accumulate in cohesive soils should be able to be removed by pumping from prepared sumps. Excavations into granular soils may result in larger amounts of groundwater infiltration that may require installation of well points to control infiltration. The amount and type of dewatering required during construction will depend on the weather and groundwater at the time of construction, depth of excavation,

excavation location, and the effectiveness of the contractor's techniques in preventing surface water runoff from entering open excavations. Note that significant dewatering efforts and cofferdams may be required for foundation construction at the pier locations.

Proper management of surface water flows should also be implemented.

7.0 CLOSURE

The evaluations, conclusions and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the geotechnical investigation, our understanding of the project and our experience with similar sites and subsurface conditions. Data used during this exploration included:

- Twenty-eight (28) exploratory borings performed during this study;
- Observations of the project site by MSG staff;
- Results of laboratory soil testing completed to date;
- Published and historic soil and geologic data for the area; and,
- Preliminary proposed roadway profiles.

The subsurface conditions discussed in this report and those shown on the boring logs represent an estimate of the subsurface conditions based on interpretation of the boring data using normally accepted geotechnical engineering judgments. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. As variations in the soil profile are encountered, additional subsurface sampling and testing may be necessary to provide data required to reevaluate the recommendations of this report. MSG is not responsible for independent conclusions, opinions, or recommendations made by others based upon information presented in this report.

The project plans and specifications should be reviewed by the geotechnical engineer to confirm that the geotechnical aspects are generally consistent with the recommendations of this report. In addition, site subgrade preparation, structural fill compaction activities, and foundation installation activities should be monitored by the geotechnical engineer.

FIGURES

FIGURE 1 – SITE LOCATION MAP
FIGURE 2 – SOIL BORING LOCATION MAP

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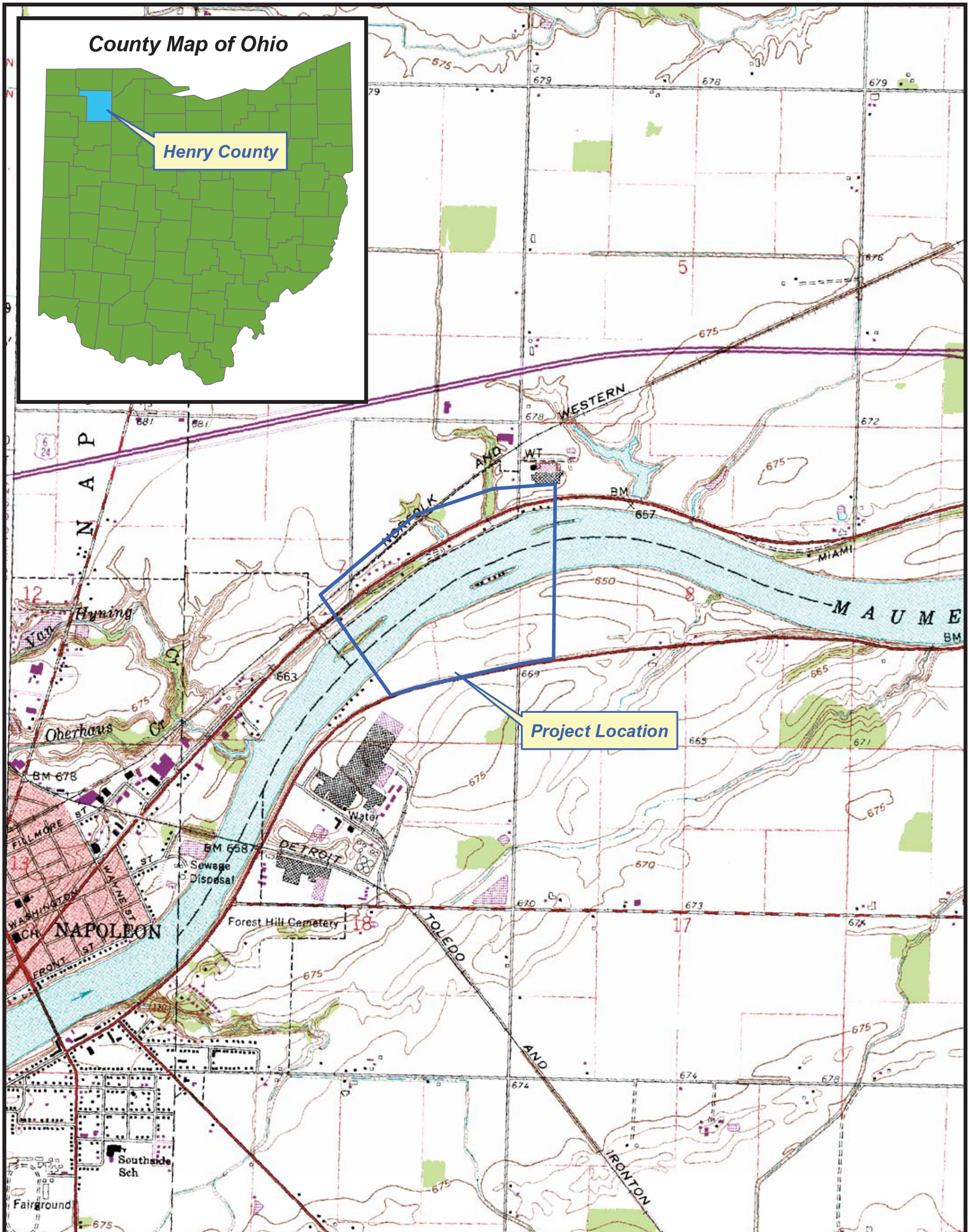

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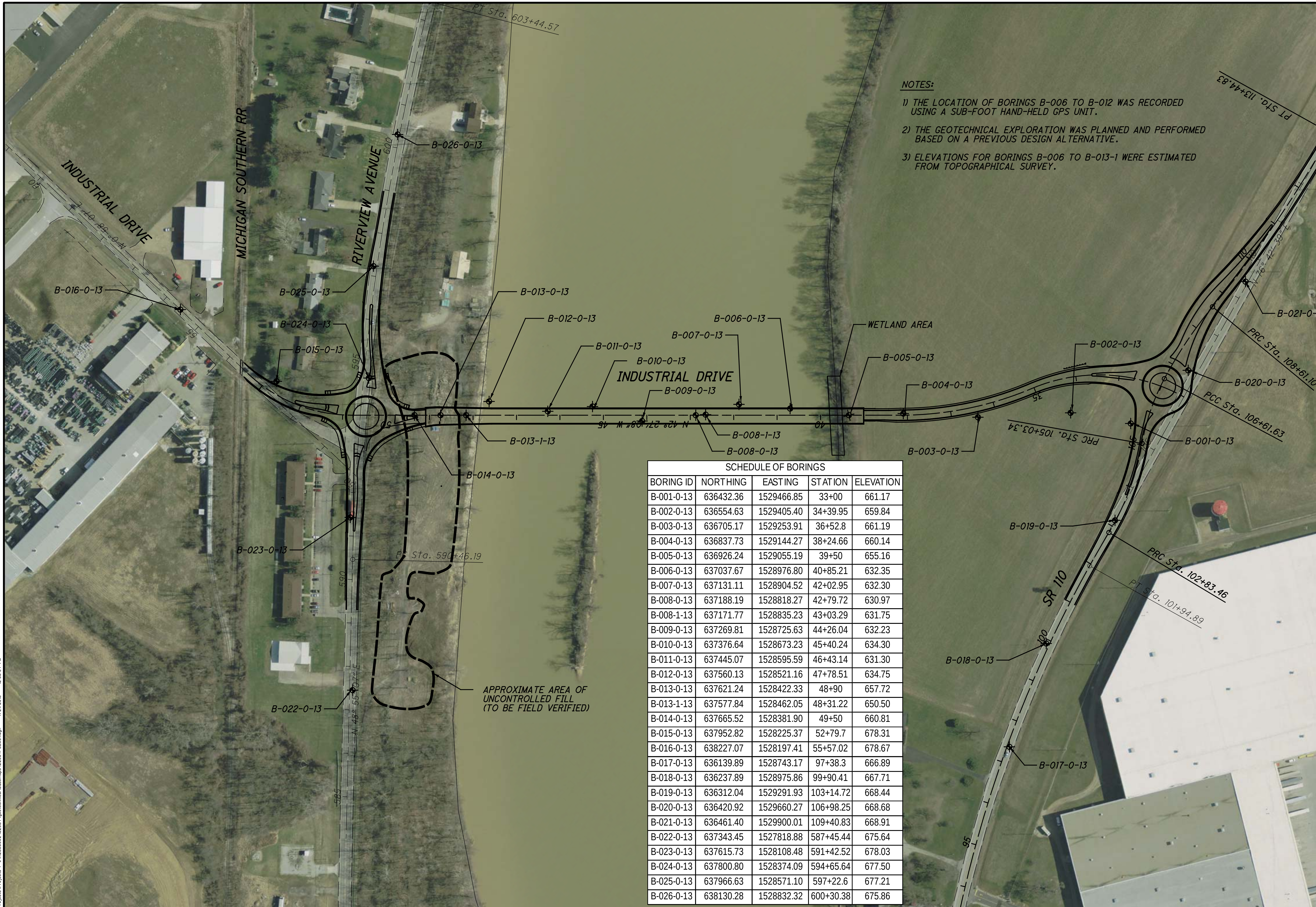
Figure 1: Site Location Map
Proposed Maumee River Crossing
Napoleon, Ohio

Notes

USGS Quadrangle, 7.5' Series Topographic Napoleon East, OH 1960, Revised 1977

Feet 0 1,000 2,000

Path: W:\Projects\Projects F-J\H2530001\22984\roadway\engapps\GIS\H2530001_siteloc.mxd



NOTES:

1) THE LOCATION OF BORINGS B-006 TO B-012 WAS RECORDED USING A SUB-FOOT HAND-HELD GPS UNIT.

2) THE GEOTECHNICAL EXPLORATION WAS PLANNED AND PERFORMED BASED ON A PREVIOUS DESIGN ALTERNATIVE.

3) ELEVATIONS FOR BORINGS B-006 TO B-013-1 WERE ESTIMATED FROM TOPOGRAPHICAL SURVEY.

SCHEDULE OF BORINGS

BORING ID	NORTHING	EASTING	STATION	ELEVATION
B-001-0-13	636432.36	1529466.85	33+00	661.17
B-002-0-13	636554.63	1529405.40	34+39.95	659.84
B-003-0-13	636705.17	1529253.91	36+52.8	661.19
B-004-0-13	636837.73	1529144.27	38+24.66	660.14
B-005-0-13	636926.24	1529055.19	39+50	655.16
B-006-0-13	637037.67	1528976.80	40+85.21	632.35
B-007-0-13	637131.11	1528904.52	42+02.95	632.30
B-008-0-13	637188.19	1528818.27	42+79.72	630.97
B-008-1-13	637171.77	1528835.23	43+03.29	631.75
B-009-0-13	637269.81	1528725.63	44+26.04	632.23
B-010-0-13	637376.64	1528673.23	45+40.24	634.30
B-011-0-13	637445.07	1528595.59	46+43.14	631.30
B-012-0-13	637560.13	1528521.16	47+78.51	634.75
B-013-0-13	637621.24	1528422.33	48+90	657.72
B-013-1-13	637577.84	1528462.05	48+31.22	650.50
B-014-0-13	637665.52	1528381.90	49+50	660.81
B-015-0-13	637952.82	1528225.37	52+79.7	678.31
B-016-0-13	638227.07	1528197.41	55+57.02	678.67
B-017-0-13	636139.89	1528743.17	97+38.3	666.89
B-018-0-13	636237.89	1528975.86	99+90.41	667.71
B-019-0-13	636312.04	1529291.93	103+14.72	668.44
B-020-0-13	636420.92	1529660.27	106+98.25	668.68
B-021-0-13	636461.40	1529900.01	109+40.83	668.91
B-022-0-13	637343.45	1527818.88	587+45.44	675.64
B-023-0-13	637615.73	1528108.48	591+42.52	678.03
B-024-0-13	637800.80	1528374.09	594+65.64	677.50
B-025-0-13	637966.63	1528571.10	597+22.6	677.21
B-026-0-13	638130.28	1528832.32	600+30.38	675.86

HORIZONTAL SCALE IN FEET

DRAWN BY HMW

CHECKED CAR

NEW MAUMEE RIVER CROSSING
CITY OF NAPOLEON, HENRY COUNTY, OHIO

FIGURE 2: SOIL BORING LOCATION MAP

APPENDIX A

Soil Boring Logs

EXHIBIT A -
GENERAL SOIL SAMPLE NOTES

Unless noted, all terms utilized herein refer to the Standard Definitions presented in ASTM D 653.

Standard Penetration Test (ASTM D 1586) - A 2.0" outside-diameter, 1-3/8" inside-diameter split barrel sampler is driven into undisturbed soil by means of a 140-pound weight falling freely through a vertical distance of 30 inches. The sampler is normally driven three successive 6-inch increments. The total number of blows required for the final 12 inches of penetration is the Standard Penetration Resistance (N).

COHESIVE SOILS			COHESIONLESS SOILS	
Consistency	**Approximate Range of (N_{60})**	**Unconfined Compressive Strength (psf)**	**Density Classification**	**Approximate Range of (N_{60})**
Very Soft	<2	Below 500	Very Loose	0-4
Soft	2-4	500-1,000	Loose	5-10
Medium Stiff	5-8	1,000-2,000	Medium Dense	11-30
Stiff	9-15	2,000-4,000	Dense	31-50
Very Stiff	16-30	4,000-8,000	Very Dense	Over 50
Hard	>30	>8,000		

If clay content is sufficient so that clay dominates soil properties, clay becomes the principal noun with the other major soil constituent as modifier: i.e., silty clay. Other minor soil constituents may be included in accordance with the classification breakdown for cohesionless soils: i.e., silty clay, trace sand, little gravel.

CLASSIFICATION

The major soil constituent is the principal noun, i.e. sand, silt, gravel. The second major soil constituent and other minor constituents are reported as follows:

Description	percentage by weight
Trace	0% to 10%
Little	10% to 20%
Some	20% to 35%
"And"	35% to 50%

PARTICLE SIZES

Boulders		- Greater than 12 inches (300 mm)
Cobbles		- 3 inches (75 mm) to 12 inches (300 mm)
Gravel:	Coarse	- ¾ inches (19.0 mm) to 3 inches (75 mm)
	Fine	- No. 10 (2.0 mm) to ¾ inches (19.0 mm)
Sand:	Coarse	- No. 40 (0.42 mm) to No. 10 (2.0 mm)
	Fine	- No. 200 (0.074 mm) to No. 40 (0.42 mm)
Silt		- 0.005 mm to No. 200 (0.074 mm)
Clay		- Less than 0.005 mm

SAMPLE DESIGNATIONS

AS	Auger Sample - Directly from auger flight	ST	Shelby Tube Sample - 3 inch diameter unless otherwise
BS	Miscellaneous Samples - Bottle or Bag	PS	Piston Sample - 3 inch diameter unless otherwise noted
MC	Macro-Core Sample - 2.25-inch O.D., 1.75-inch I.D. polyethylene liner; 5-feet long	RC	Rock Core - NX core unless otherwise noted
LB	Large-Bore (micro-core) Sample - with 1 inch diameter, 2 foot long polyethylene liner	CS	CME Continuous Sampler – 5 feet long, 3 inch diameter unless
SS	Split Spoon Sample, 1-inch or 2-inch outer-	HA	Hand Auger
LS	Split Spoon Sample (SS) with 3-inch long liner	DP	Drive Point
NR	No Recovery	CM	Coring Machine

The Mannik & Smith Group, Inc.
2365 Haggerty Road South
Canton, Michigan 48188
Telephone: 734-397-3100
Fax: 734-397-3131

KEY TO SYMBOLS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

A-1-A: Ohio DOT: A-1-a, gravel and/or stone fragments

A-2-4: Ohio DOT: A-2-4, gravel and/or stone fragments with sand and silt

A-3: Ohio DOT: A-3, fine sand

A-3A: Ohio DOT: A-3a, coarse and fine sand

A-4A: Ohio DOT: A-4a, sandy silt

A-4B: Ohio DOT: A-4b, silt

A-6A: Ohio DOT: A-6a, silt and clay

A-6B: Ohio DOT: A-6b, silty clay

A-7-6: Ohio DOT: A-7-6, clay

CONCRETE: Concrete

PAVEMENT OR BASE: Ohio DOT: Pavement or Aggregate base

SHALE: Ohio DOT: Shale

TOPSOIL: Ohio DOT: Sod and Topsoil

SAMPLER SYMBOLS

NX or NQ Rock Core

Thin Walled Undisturbed Sample

WELL CONSTRUCTION SYMBOLS

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)
TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION

▽ Water Level at Time Drilling, or as Shown
▼ Water Level at End of Drilling, or as Shown
▼ Water Level After 24 Hours, or as Shown

KEY TO SYMBOLS - OH DOT.GDT - 5/4/15 09:48 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

EXHIBIT B -
GENERAL ROCK SAMPLE NOTES

Rock core barrels are either single- or double-tubed type. The most common barrel type is the N-series including the NX and NQ barrels. The rock cores for NX and NQ barrels are typically 2-1/8 inches and 1-7/8 inches in diameter, respectively.

The Rock Quality Designation (RQD) is an index of the frequency of fractures in the bedrock. The RQD value is determined by summing the total length of all core pieces which are at least 4 inches long and dividing by the total length of the core run or total thickness of the rock unit. The literature suggests there is a reasonable relationship between the quality of the rock and the RQD value for engineering purposes. Rock quality is classified as follows:

RQD (%)	General Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 – 100	Excellent

STRENGTH OF BEDROCK

Description	Field or Lab Evaluation	Range of Unconfined Compressive Strength Values (psi)
Extremely Strong	Rock cannot be scratch by a knife or sharp pick. Chipping of hand specimens requires repeated hard blows from a geologist hammer.	>30,000
Very Strong	Rock cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires repeated hard blows from a geologist hammer.	15,000 to 30,000
Strong	Rock can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach a hand specimen. Sharp and resistant edges are present on hand specimens.	7,500 to 15,000
Moderately Strong	Rock can be scratched with a knife or pick. Grooves or gouges to 0.25 inches deep can be excavated by hard blows from a geologist's pick. Requires moderate hammer blows to detach a hand specimen.	3,600 to 7,500
Slightly Strong	Rock can be grooved or gouged 0.05 inches deep by firm pressure of a knife or pick point and can be excavated in small chips to about 1-inch maximum size pieces by hard blows from the point of a geologist's pick.	1,500 to 3,600
Weak	Rock can be grooved or gouged readily by a knife or pick, and can be excavated in small fragments by moderate blows from a pick point. Small, thin pieces can broken by finger pressure.	750 to 1,500
Very Weak	Rock can be carved with a knife or can be excavated readily with a point of a pick. Pieces 1 inch or more in thickness can broken by finger pressure. Rock can be scratched by a fingernail.	40 to 750

DEGREE OF FRACTURING IN BEDROCK

Description	Average Spacing Between Natural Fractures
Unfractured	>10 ft.
Intact	3 ft. to 10 ft.
Slightly Fractured	1 ft. to 3 ft.
Moderately	4 in. to 12 in.
Fractured	2 in. to 4 in.
Highly Fractured	< 2 in.

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 33+00, CL	EXPLORATION ID B-001-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 661.2 (MSL) EOB: 15.0 ft.	PAGE 1 OF 1
START: 4/24/14 END: 4/24/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 636432.356 N, 1529466.854 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 661.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	660.2	0–1																
Soft, brown **SILTY CLAY**, little sand, trace gravel; moist	658.2	1–3	1 1 2	4	67	SS-1	0.75	2	3	16	35	44	37	18	19	21	A-6b (12)	
Stiff to very stiff, brown mottled with gray **SILT AND CLAY**, little sand, trace gravel; damp	652.7	3–8.5	2 3 6	13	50	SS-2	2.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
			5 7 11	27	0	SS-3	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
Hard, brown mottled with gray **SILT AND CLAY**, little sand, trace gravel; damp	646.2	8.5–15	5 8 15	34	61	SS-4	4.50	5	6	13	35	41	29	15	14	14	A-6a (10)	
			7 10 13	34	94	SS-5	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		EOB 15	5 9 11	30	25	SS-6	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/24/14 END: 4/24/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT/ST	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 34+40, 8 RT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 659.8 (MSL) EOB: 15.0 ft. COORD: 636554.632 N, 1529405.397 E	EXPLORATION ID B-002-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 659.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	658.8	0 – 1																
Medium stiff, brown **SILTY CLAY**, trace sand; moist		1 – 2.5 (▼ at ~2.5)	1 2 2	6	33	SS-1	2.00	-	-	-	-	-	-	-	-	21	A-6b (V)	
	656.3	3																
Very stiff, gray **SILT AND CLAY**, some sand, trace gravel; moist to damp		3.5 – 5.5			100	ST-1	4.5+	3	6	15	35	41	29	16	13	22	A-6a (9)	
		6 – 7.5	4 7 9	24	61	SS-2	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
		8 (W)																
		8.5 – 10	3 8 11	28	72	SS-3	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
		11 – 12.5	4 7 11	27	0	SS-4	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
	644.8	13.5 – 15 (EOB 15)	3 8 11	28	83	SS-5	4.5+	3	5	14	35	43	28	16	12	16	A-6a (9)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/24/14 END: 4/24/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 36+53, 5 LT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 661.2 (MSL) EOB: 15.0 ft. COORD: 636705.174 N, 1529253.905 E	EXPLORATION ID B-003-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 661.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	660.2	0 – 1																
Loose, brown **SANDY SILT**, little clay, trace gravel; damp		1 – 2.5	2 3 3	9	67	SS-1	-	-	-	-	-	-	-	-	-	21	A-4a (V)	
		4 – 5 (▼ at 3.5)	2 3 3	9	61	SS-2	-	1	4	50	34	11	NP	NP	NP	14	A-4a (2)	
	655.2																	
Very stiff to hard, gray **SILT AND CLAY**, little sand, trace gravel; damp		6 – 7.5	9 6 9	22	78	SS-3	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)	
		8.5 – 10	4 8 12	30	78	SS-4	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
		11 – 12.5	5 9 13	33	78	SS-5	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)	
	646.2	13.5 – 15 (EOB 15)	5 8 14	33	44	SS-6	4.5+	3	4	10	41	42	27	16	11	14	A-6a (8)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 38+25, 4 RT	EXPLORATION ID B-004-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 660.1 (MSL) EOB: 15.0 ft.	PAGE 1 OF 1
START: 4/24/14 END: 4/24/14	SAMPLING METHOD: SPT/ST	ENERGY RATIO (%): 89.3	COORD: 636837.733 N, 1529144.268 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 660.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	659.1																	
Loose to very loose, brown **SANDY SILT**, some clay; damp		1 2	1 3 3	9	44	SS-1	-	-	-	-	-	-	-	-	-	19	A-4a (V)	
		3																
		4 5	0 0 2	3	83	SS-2	-	0	2	29	46	23	NP	NP	NP	21	A-4a (7)	
	654.1																	
Loose, dark gray **SANDY SILT**, little clay; moist		6 7	1 2 2	6	56	SS-3	-	-	-	-	-	-	-	-	-	16	A-4a (V)	
					94	ST-1	-	0	0	41	45	14	22	18	4	11	A-4a (5)	
	651.6	8																
Very stiff, gray **SANDY SILT**, and clay; damp		9 10	6 8 8	24	83	SS-4	-	-	-	-	-	-	-	-	-	14	A-4a (V)	
	649.1																	
Very stiff, gray **SILT AND CLAY**, little sand, trace gravel; damp		11 12	5 10 14	36	72	SS-5	4.5+	4	5	11	40	40	27	15	12	13	A-6a (9)	
		13																
		14	5 7 13	30	56	SS-6	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
	645.1	EOB 15																

NOTES: SHELBY TUBE ST-1 OBTAINED IN OFFSET HOLE FROM 6.0' TO 7.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:37 - W:\PROJECTS\PROJECTS F-JH2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/23/14 END: 4/23/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / M. WELKER DRILLING METHOD: 4.25" HSA / NW SAMPLING METHOD: SPT/ST/NW CORE BARREL	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 39+50, CL ALIGNMENT: INDUSTRIAL DR. ELEVATION: 655.2 (MSL) EOB: 32.5 ft. COORD: 636926.243 N, 1529055.188 E	EXPLORATION ID B-005-0-13 PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 655.2	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	654.4																	
Soft to medium stiff, brown **SANDY SILT**, some clay; damp		1–2.5	1 2 2	6	61	SS-1	1.50	0	1	25	45	29	25	16	9	17	A-4a (8)	
		3.5–5	1 2 1	4	94	SS-2	-	-	-	-	-	-	-	-	-	21	A-4a (V)	
	646.7	6–7.5	1 1 4	7	83	SS-3	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
Very stiff, brown **SANDY SILT**, some clay, little gravel; damp	644.2	8.5–10	3 5 6	16	39	SS-4	3.00	14	5	19	39	23	23	16	7	17	A-4a (5)	
Very stiff, gray **SILTY CLAY**, trace sand and gravel; damp	641.7	11–12.5	4 8 10	27	17	SS-5	-	-	-	-	-	-	-	-	-	18	A-6b (V)	
Hard, dark gray **SANDY SILT**, some clay, trace gravel; damp		13.5–15			89	ST-1	4.5+	9	10	16	36	29	21	13	8	16	A-4a (6)	
		16–17.5 (W)	12 18 26	65	78	SS-6	-	-	-	-	-	-	-	-	-	9	A-4a (V)	
		18.5–20	19 25 33	86	89	SS-7	-	-	-	-	-	-	-	-	-	8	A-4a (V)	
	633.2	21–22	12 50/6"	-	78	SS-8	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
SHALE, dark brown to black, slightly to moderately weathered, thinly laminated, weak to moderately strong		22.5–																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:37 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PID: 22984	BR ID: N/A	PROJECT: HEN-IND-0000	STATION / OFFSET: 39+50, CL	START: 4/23/14	END: 4/23/14	PG 2 OF 2	B-005-0-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark brown to black, slightly to moderately weathered, thinly laminated, weak to moderately strong *(continued)*		25	8		72	RC-1											CORE	
		26																
		27																
		28																
		29																
		30	9		100	RC-2											CORE	
		31																
	622.7	32 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 1 BAG BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 40+85, 15 RT	EXPLORATION ID B-006-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / N. BREIJAK	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: NW	CALIBRATION DATE: 5/10/13	ELEVATION: 632.4 (MSL) EOB: 20.0 ft.	PAGE 1 OF 1
START: 6/10/14 END: 6/10/14	SAMPLING METHOD: NW CORE BARREL	ENERGY RATIO (%): 89.3	COORD: 637037.666 N, 1528976.800 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 632.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark gray to gray, moderately weathered, slightly strong to strong		0–5	22		97	RC-1											CORE	
-Unconfined compressive strength (Qu) = 1,423 psi Becomes severely weathered and weak		5–10	45		100	RC-2											CORE	
Becomes moderately weathered and strong		10–15	17		83	RC-3											CORE	
-Unconfined compressive strength (Qu) = 1,641 psi	612.4	15–20 (EOB 20)	62		100	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 639 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 6/5/14 END: 6/5/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / N. BREIJAK DRILLING METHOD: NW SAMPLING METHOD: NW CORE BARREL	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 42+03, 25 RT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 632.3 (MSL) EOB: 20.0 ft. COORD: 637131.112 N, 1528904.521 E	EXPLORATION ID B-007-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 632.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark brown to gray, moderately weathered, slightly strong to strong		0–5	9		90	RC-1											CORE	
-Unconfined compressive strength (Qu) = 4,446 psi		5–10	29		83	RC-2											CORE	
		10–15	42		48	RC-3											CORE	
	612.3	15–20 EOB	43		80	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 639 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:37 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 6/4/14 END: 6/4/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / N. BREIJAK DRILLING METHOD: NW SAMPLING METHOD: NW CORE BARREL	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 42+80, 1 RT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 631.0 (MSL) EOB: 5.0 ft. COORD: 637188.193 N, 1528818.266 E	EXPLORATION ID B-008-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark gray-brown, moderately weathered, slightly strong to strong	626.0	1 2 3 4 EOB 5	11		100	RC-1											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 638 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 43+03, CL	EXPLORATION ID B-008-1-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / N. BREIJAK	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: NW	CALIBRATION DATE: 5/10/13	ELEVATION: 631.8 (MSL) EOB: 20.0 ft.	PAGE 1 OF 1
START: 6/12/14 END: 6/12/14	SAMPLING METHOD: NW CORE BARREL	ENERGY RATIO (%): 89.3	COORD: 637171.773 N, 1528835.231 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark gray-brown, moderately weathered, strong		0–5	0		100	RC-1											CORE	
Becomes highly weathered and slightly strong Becomes severly weathered and weak -Unconfined compressive strength (Qu) = 4,862 psi		5–10	35		83	RC-2											CORE	
		10–15	0		43	RC-3											CORE	
	611.8	15–20 (EOB 20)	0		0	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 639 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 6/11/14 END: 6/11/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / N. BREIJAK DRILLING METHOD: NW SAMPLING METHOD: NW CORE BARREL	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 44+26, 13 LT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 632.2 (MSL) EOB: 20.0 ft. COORD: 637269.805 N, 1528725.628 E	EXPLORATION ID B-009-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 632.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark gray to gray, moderately weathered, weak to strong		0 - 5	23		95	RC-1											CORE	
		5 - 10	37		100	RC-2											CORE	
		10 - 15	40		100	RC-3											CORE	
-Unconfined compressive strength (Qu) = 1,451 psi	612.2	15 - 20 (EOB)	65		100	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 640 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:37 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 45+40, 20 RT	EXPLORATION ID B-010-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / N. BREIJAK	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: NW	CALIBRATION DATE: 5/10/13	ELEVATION: 634.3 (MSL) EOB: 20.0 ft.	PAGE 1 OF 1
START: 6/6/14 END: 6/6/14	SAMPLING METHOD: NW CORE BARREL	ENERGY RATIO (%): 89.3	COORD: 637376.638 N, 1528673.227 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 634.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark gray to gray, moderately to severely weathered, weak to strong		0–5	7		100	RC-1											CORE	
-Unconfined compressive strength (Qu) = 7,676 psi		5–10	10		97	RC-2											CORE	
		10–15	23		100	RC-3											CORE	
	614.3	15–20 EOB	45		98	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 640 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 46+43, 9 RT	EXPLORATION ID B-011-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / N. BREIJAK	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: NW	CALIBRATION DATE: 5/10/13	ELEVATION: 631.3 (MSL) EOB: 10.0 ft.	PAGE 1 OF 1
START: 6/6/14 END: 6/6/14	SAMPLING METHOD: NW CORE BARREL	ENERGY RATIO (%): 89.3	COORD: 637445.066 N, 1528595.585 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark brown-gray, moderately to highly weathered, strong to weak -Unconfined compressive strength (Qu) = 4,644 psi		0–5	27		100	RC-1											CORE	
	621.3	5–10 EOB	17		100	RC-2											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 640 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 6/7/14 END: 6/7/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / N. BREIJAK DRILLING METHOD: NW SAMPLING METHOD: NW CORE BARREL	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 47+79, 32 RT ALIGNMENT: INDUSTRIAL DR. ELEVATION: 634.8 (MSL) EOB: 20.0 ft. COORD: 637560.130 N, 1528521.160 E	EXPLORATION ID B-012-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 634.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark brown-dark gray, moderately weathered, weak to strong -Unconfined compressive strength (Qu) = 5,539 psi		0–5	13		100	RC-1											CORE	
		5–10	18		100	RC-2											CORE	
Unconfined compressive strength (Qu) = 6,652 psi		10–15	40		92	RC-3											CORE	
	614.8	15–20 (EOB 20)	8		83	RC-4											CORE	

NOTES: BORING PERFORMED ON BARGE, WATER LEVEL IN RIVER ESTIMATED AT ELEVATION 641 FEET DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NATURAL COLLAPSE

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/22/14 END: 4/22/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 48+90, CL ALIGNMENT: INDUSTRIAL DR. ELEVATION: 657.7 (MSL) EOB: 4.0 ft. COORD: 637621.240 N, 1528422.325 E	EXPLORATION ID B-013-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 657.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
Very loose, brown **SANDY SILT**, little gravel, trace clay; damp (FILL)	655.5	1 2	1 3 50/4"	-	38	SS-1	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
CONCRETE RUBBLE	653.7	3 EOB 4																

NOTES: REFUSAL IN CONCRETE RUBBLE AT 4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 48+31, CL	EXPLORATION ID B-013-1-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA / NW	CALIBRATION DATE: 5/10/13	ELEVATION: 650.5 (MSL) EOB: 30.0 ft.	PAGE 1 OF 2
START: 4/22/14 END: 4/22/14	SAMPLING METHOD: SPT/ST/NW CORE BARREL	ENERGY RATIO (%): 89.3	COORD: 637577.840 N, 1528462.050 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 650.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	650.2																	
Loose, brown **SANDY SILT**, some clay, trace organics; damp	647.0	1–2	2 4 4	12	100	SS-1	-	-	-	-	-	-	-	-	-	47	A-4a (V)	
Medium stiff, dark brown **SILT AND CLAY**, some sand; damp	644.5	4–5	2 2 2	6	39	SS-2	1.25	0	1	28	41	30	30	16	14	17	A-6a (9)	
Very soft to soft, dark brown **SILTY CLAY**, trace sand; moist		6–7	0 0 1	1	100	SS-3	0.00	-	-	-	-	-	-	-	-	27	A-6b (V)	
	640.5	8.5–10 (▼ W)	0 0 2	3	100	SS-4	1.00	-	-	-	-	-	-	-	-	26	A-6b (V)	
Soft to medium stiff, brown mottled with gray **SILTY CLAY**, trace sand; moist	637.0	10–12			100	ST-1	0.50	0	0	8	56	36	32	16	16	27	A-6b (10)	
Soft, brown **SILT**, some clay and sand; wet	632.5	13.5–15	0 0 2	3	100	SS-5	0.25	0	0	22	53	25	25	15	10	26	A-4b (8)	
Hard, brown **SILT**, some clay and sand; wet	631.3	18.5–19	20 50/2"	-	100	SS-6	-	-	-	-	-	-	-	-	-	10	A-4b (V)	
SHALE, dark brown to brown, slightly to moderately weathered, thinly laminated, weak to moderately strong		20–24	43		95	RC-1											CORE	

PID: 22984	BR ID: N/A	PROJECT: HEN-IND-0000	STATION / OFFSET: 48+31, CL	START: 4/22/14	END: 4/22/14	PG 2 OF 2	B-013-1-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 626.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
SHALE, dark brown to brown, slightly to moderately weathered, thinly laminated, weak to moderately strong *(continued)*	620.5	25 26 27 28 29 EOB 30	47		100	RC-2											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 1 BAG BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 49+50, CL	EXPLORATION ID B-014-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: INDUSTRIAL DR.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 660.8 (MSL) EOB: 20.0 ft.	PAGE 1 OF 1
START: 4/23/14 END: 4/23/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 637665.517 N, 1528381.896 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 660.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
GRAVEL	659.8																	
Stiff to very stiff, brown mottled with gray **SILT AND CLAY**, some sand, trace gravel; damp			8 5 8	19	78	SS-1	4.5+	5	7	13	32	43	32	17	15	15	A-6a (10)	
			3 4 6	15	17	SS-2	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
	653.3		3 5 6	16	50	SS-3	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
Stiff to very stiff, gray **SILTY CLAY**, little sand, trace gravel; damp	649.8		3 4 5	13	50	SS-4	4.5+	2	5	12	34	47	37	16	21	20	A-6b (12)	
Stiff to very stiff, gray **CLAY**, some silt, trace gravel; damp			2 3 6	13	61	SS-5	3.00	-	-	-	-	-	42	18	24	20	A-6b (V)	
	645.8		3 5 12	25	83	SS-6	4.50	-	-	-	-	-	-	-	-	13	A-6b (V)	
Hard, brown **SILTY CLAY**, little sand, trace gravel; damp	642.3		5 10 17	40	78	SS-7	4.5+	-	-	-	-	-	-	-	-	17	A-6b (V)	
Hard, gray **SILTY CLAY**, little sand, trace gravel; damp	640.8	EOB 20	10 15 22	55	89	SS-8	4.5+	-	-	-	-	-	-	-	-	9	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/25/14 END: 4/25/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 52+80, CL ALIGNMENT: INDUSTRIAL DR. ELEVATION: 678.3 (MSL) EOB: 10.0 ft. COORD: 637952.823 N, 1528225.366 E	EXPLORATION ID B-015-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 678.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	677.8																	
Stiff, brown **SILT AND CLAY**, little sand; damp	675.3	1–2	1 2 4	9	67	SS-1	2.50	-	-	-	-	-	-	-	-	19	A-6a (V)	
Very stiff, brown **CLAY**, trace silt, sand and gravel; damp	672.3	4–5	1 5 8	19	67	SS-2	4.50	1	3	3	10	83	48	23	25	26	A-7-6 (16)	
Hard, brown **SILT AND CLAY**, little sand and trace gravel; damp		6–7	4 9 13	33	83	SS-3	4.50	4	6	11	30	49	32	17	15	17	A-6a (10)	
	668.3	9–EOB 10	7 12 18	45	100	SS-4	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:38 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 6/3/14 END: 6/3/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / N. BREIJAK DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 55+57, CL ALIGNMENT: INDUSTRIAL DR. ELEVATION: 678.7 (MSL) EOB: 7.7 ft. COORD: 638227.110 N, 1528197.360 E	EXPLORATION ID B-016-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 678.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	678.0																	
AGGREGATE BASE	677.0	1																
Stiff, dark gray **SILTY CLAY**, trace sand and gravel; moist		2–3	7 5 5	15	78	SS-1	3.50	-	-	-	-	-	-	-	-	22	A-6b (V)	
	674.0	4	3 6 7	19	89	SS-2	3.00	1	1	3	44	51	39	19	20	25	A-6b (12)	
Stiff, dark gray mottled with brown **CLAY**, and silt, trace sand and gravel; moist		5–6	5 5 5	15	44	SS-3	2.50	1	1	4	37	57	44	20	24	28	A-7-6 (14)	
	671.0	7 EOB	3 4 7	16	78	SS-4	3.00	-	-	-	-	-	-	-	-	26	A-7-6 (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 97+38, 5 RT	EXPLORATION ID B-017-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 110	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 666.9 (MSL) EOB: 7.2 ft.	PAGE 1 OF 1
START: 4/29/14 END: 4/29/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 636139.886 N, 1528743.168 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 666.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	666.1																	
AGGREGATE BASE	665.7	1																
Medium dense, gray **COARSE AND FINE SAND**, little gravel, trace silt; damp		2	14 9 6	22	56	SS-1	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
	662.7	3–4	5 6 9	22	11	SS-2	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
Very stiff, brown **CLAY**, some silt, little sand, trace gravel; damp	661.2	5	6 6 9	22	78	SS-3	2.50	5	5	14	27	49	41	23	18	22	A-7-6 (11)	
Very stiff, brown **SILTY CLAY**, some sand, trace gravel; damp	659.7	6–7 EOB	10 10 10	30	67	SS-4	2.50	2	6	15	32	45	40	19	21	22	A-6b (12)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 99+90, 8 LT	EXPLORATION ID B-018-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 110	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 667.7 (MSL) EOB: 7.2 ft.	PAGE
START: 4/29/14 END: 4/29/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 636237.894 N, 1528975.860 E	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 667.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	666.9																	
AGGREGATE BASE	666.5	1																
Very stiff, dark gray **CLAY**, some gravel and silt, trace sand; dry	665.0	2	20 14 10	36	72	SS-1	4.5+	-	-	-	-	-	-	-	-	13	A-7-6 (V)	
Stiff, gray **SILT AND CLAY**, and sand, trace gravel; moist	663.5	3, 4	9 5 5	15	67	SS-2	4.50	2	10	35	20	33	26	12	14	16	A-6a (5)	
Very stiff, gray **CLAY**, little silt and sand, trace gravel; damp		5	4 4 9	19	67	SS-3	2.25	1	2	10	16	71	49	20	29	27	A-7-6 (17)	
	660.5	6, 7 (EOB)	7 7 10	25	78	SS-4	3.50	-	-	-	-	-	-	-	-	20	A-7-6 (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/29/14 END: 4/29/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 103+15, CL ALIGNMENT: SR 110 ELEVATION: 668.4 (MSL) EOB: 7.2 ft. COORD: 636312.038 N, 1529291.934 E	EXPLORATION ID B-019-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 668.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	667.6																	
AGGREGATE BASE	667.2	1																
Loose, light gray **GRAVEL WITH SAND AND SILT**, little clay; damp	665.7	2	7 3 4	10	61	SS-1	-	42	18	10	14	16	23	14	9	16	A-2-4 (0)	
Hard, brown mottled with gray **SILTY CLAY**, little sand, trace gravel; damp		3, 4	3 10 13	34	56	SS-2	4.5+	6	6	8	24	56	39	19	20	17	A-6b (12)	
		5	12 12 20	48	67	SS-3	4.5+	-	-	-	-	-	-	-	-	16	A-6b (V)	
	661.2	6, EOB 7	18 19 20	58	78	SS-4	4.5+	-	-	-	-	-	-	-	-	15	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 106+98, 21 LT	EXPLORATION ID B-020-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 110	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 668.7 (MSL) EOB: 6.3 ft.	PAGE 1 OF 1
START: 4/29/14 END: 4/29/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 636420.916 N, 1529660.274 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 668.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL	668.4																	
Stiff to very stiff, brown **CLAY**, little silt and sand; moist		1	1 3 4	10	61	SS-1	4.5+	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
	665.4	2–3	3 4 8	18	42	SS-2	4.5+	0	2	11	18	69	49	21	28	23	A-7-6 (17)	
Hard, brown mottled with gray **CLAY**, little silt, trace sand and gravel; dry to damp		4	6 11 15	39	56	SS-3	4.5+	1	2	3	16	78	48	24	24	23	A-7-6 (15)	
Becomes brown	662.4	5–6 EOB	15 20 20	60	78	SS-4	4.5+	-	-	-	-	-	-	-	-	15	A-7-6 (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 109+41, 6 LT	EXPLORATION ID B-021-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 110	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 668.9 (MSL) EOB: 7.2 ft.	PAGE 1 OF 1
START: 4/29/14 END: 4/29/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 636461.405 N, 1529900.005 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 668.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	668.1																	
AGGREGATE BASE	667.7	1																
Very stiff, dark brown **SILT AND CLAY**, and sand, little gravel; moist		2	20 10 5	22	56	SS-1	4.5+	13	9	30	23	25	28	15	13	18	A-6a (4)	
	664.7	3–4	3 4 7	16	61	SS-2	3.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
Hard, gray **CLAY**, little silt, trace sand and gravel; damp	663.2	5	8 10 14	36	67	SS-3	4.5+	3	4	5	16	72	47	25	22	22	A-7-6 (14)	
Hard, brown mottled with gray **SILTY CLAY**, trace sand and gravel; damp	661.7	6–7 EOB	14 15 20	52	78	SS-4	4.5+	-	-	-	-	-	-	-	-	15	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/28/14 END: 4/28/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 587+45, 7 RT ALIGNMENT: RIVERVIEW AVE. ELEVATION: 675.6 (MSL) EOB: 7.2 ft. COORD: 637343.455 N, 1527818.884 E	EXPLORATION ID B-022-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 675.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	674.8																	
AGGREGATE BASE	674.4	1																
Dense, dark brown **SANDY SILT**, some gravel; dry	672.9	2	25 15 8	34	56	SS-1	-	-	-	-	-	-	-	-	-	3	A-4a (V)	
Very stiff, brown **CLAY**, and silt, trace sand and gravel; damp		3–4	4 5 7	18	56	SS-2	4.00	6	4	5	35	50	44	19	25	23	A-7-6 (15)	
	669.9	5	5 5 7	18	67	SS-3	4.50	-	-	-	-	-	-	-	-	14	A-7-6 (V)	
Very stiff, light gray **SILT AND CLAY**, some sand, little gravel; damp	668.4	6–7 EOB	9 9 9	27	61	SS-4	4.50	15	10	17	23	35	32	17	15	17	A-6a (7)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 591+43, 9 LT	EXPLORATION ID B-023-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: RIVERVIEW AVE.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 678.0 (MSL) EOB: 7.2 ft.	PAGE 1 OF 1
START: 4/28/14 END: 4/28/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 637615.734 N, 1528108.483 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 678.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	677.2																	
AGGREGATE BASE	676.8	1																
Medium dense, dark brown **GRAVEL**, some sand, trace silt and clay; dry	675.3	2	15 10 5	22	61	SS-1	-	66	18	7	7	2	NP	NP	NP	3	A-1-a (0)	
Very stiff, gray mottled with brown **SANDY SILT**, little clay; moist	673.8	3 4	3 3 8	16	61	SS-2	3.25	-	-	-	-	-	-	-	-	21	A-4a (V)	
Hard, brown **SILTY CLAY**, trace sand; damp		5	8 12 13	37	89	SS-3	4.50	0	4	5	19	72	40	20	20	22	A-6b (12)	
	670.8	6 EOB 7	14 15 20	52	83	SS-4	4.50	-	-	-	-	-	-	-	-	24	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 594+66, 9 RT	EXPLORATION ID B-024-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: RIVERVIEW AVE.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 677.5 (MSL) EOB: 7.2 ft.	PAGE 1 OF 1
START: 4/28/14 END: 4/28/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 637800.802 N, 1528374.091 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 677.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	676.7																	
AGGREGATE BASE	676.3	1																
Medium dense, brown **FINE SAND**, trace coarse sand, silt and clay; damp	674.8	2	16 8 5	19	72	SS-1	-	0	5	85	9	1	NP	NP	NP	14	A-3 (0)	
Stiff, gray mottled with brown **CLAY**, and silt, trace sand and gravel; moist	673.3	3 / 4	2 3 6	13	67	SS-2	3.00	1	0	1	41	57	49	22	27	25	A-7-6 (17)	
Hard, brown **SILTY CLAY**, trace sand; damp		5	2 7 14	31	100	SS-3	4.50	-	-	-	-	-	-	-	-	24	A-6b (V)	
	670.3	6 / 7 EOB	10 12 16	42	50	SS-4	4.50	-	-	-	-	-	-	-	-	23	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/20/15 16:38 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

PROJECT: HEN-IND-0000	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 597+23, 8 LT	EXPLORATION ID B-025-0-13
TYPE: NEW ALIGNMENT	SAMPLING FIRM / LOGGER: MSG / J. FAITEL	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: RIVERVIEW AVE.	
PID: 22984 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/10/13	ELEVATION: 677.2 (MSL) EOB: 7.2 ft.	PAGE 1 OF 1
START: 4/28/14 END: 4/28/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	COORD: 637966.627 N, 1528571.100 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 677.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	676.4																	
AGGREGATE BASE	676.0	1																
Medium dense, light gray **GRAVEL WITH SAND AND SILT**, some clay; damp	674.5	2	25 17 4	31	83	SS-1	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
Very stiff, brown mottled with gray **SILT AND CLAY**, little sand, trace gravel; damp	673.0	3, 4	5 7 13	30	67	SS-2	4.50	2	6	7	38	47	33	18	15	19	A-6a (10)	
Hard, brown **SILTY CLAY**, trace sand and gravel; damp		5	10 13 22	52	56	SS-3	4.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
	670.0	6, EOB 7	18 19 23	63	78	SS-4	4.50	-	-	-	-	-	-	-	-	22	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

PROJECT: HEN-IND-0000 TYPE: NEW ALIGNMENT PID: 22984 BR ID: N/A START: 4/28/14 END: 4/28/14	DRILLING FIRM / OPERATOR: MSG / R. SCHIPPERT SAMPLING FIRM / LOGGER: MSG / J. FAITEL DRILLING METHOD: 4.25" HSA SAMPLING METHOD: SPT	DRILL RIG: GEOPROBE 7822DT HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 5/10/13 ENERGY RATIO (%): 89.3	STATION / OFFSET: 600+30, 5 LT ALIGNMENT: RIVERVIEW AVE. ELEVATION: 675.9 (MSL) EOB: 7.2 ft. COORD: 638130.283 N, 1528832.319 E	EXPLORATION ID B-026-0-13 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 675.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
ASPHALT	675.1																	
AGGREGATE BASE	674.7	1																
Medium dense, dark brown **SANDY SILT**, some gravel; dry	673.2	2	20 7 6	19	50	SS-1	-	-	-	-	-	-	-	-	-	2	A-4a (V)	
Hard, brown mottled with gray **SILTY CLAY**, trace sand; moist	671.7	3, 4	8 10 15	37	50	SS-2	4.50	-	-	-	-	-	-	-	-	23	A-6b (V)	
Hard, brown **CLAY**, some silt, little sand, trace gravel; damp		5	14 15 20	52	78	SS-3	4.50	3	5	8	22	62	41	20	21	17	A-7-6 (13)	
	668.7	6, 7 EOB	16 16 20	54	89	SS-4	4.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS; SOIL CUTTINGS

APPENDIX B

SOIL LABORATORY TEST DATA

The Mannik & Smith Group, Inc.
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Canton, MI 48188
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SUMMARY OF LABORATORY RESULTS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-001-0-13	1.0	37	18	19	9.5	79	CL	21.4			
B-001-0-13	3.5							17.1			
B-001-0-13	8.5	29	15	14	19	76	CL	13.9			
B-001-0-13	11.0							13.7			
B-001-0-13	13.5							14.0			
B-002-0-13	1.0							21.0			
B-002-0-13	3.5	29	16	13	19	76	CL	22.4			
B-002-0-13	6.0							13.7			
B-002-0-13	8.5							13.1			
B-002-0-13	13.5	28	16	12	9.5	78		16.4			
B-003-0-13	1.0							20.9			
B-003-0-13	3.5	NP	NP	NP	9.5	45	SM	14.3			
B-003-0-13	6.0							13.6			
B-003-0-13	8.5							13.2			
B-003-0-13	11.0							13.7			
B-003-0-13	13.5	27	16	11	9.5	83	CL	13.5			
B-004-0-13	1.0							19.1			
B-004-0-13	3.5	NP	NP	NP	4.75	69	ML	21.4			
B-004-0-13	6.0							15.5			
B-004-0-13	6.0	22	18	4	4.75	59	CL-ML	11.4			
B-004-0-13	8.5							14.3			
B-004-0-13	11.0	27	15	12	19	80	CL	12.7			
B-004-0-13	13.5							14.9			
B-005-0-13	1.0	25	16	9	9.5	74	CL	16.6			
B-005-0-13	3.5							20.9			
B-005-0-13	6.0							17.9			
B-005-0-13	8.5	23	16	7	37.5	62	CL-ML	16.7			
B-005-0-13	11.0							17.7			
B-005-0-13	13.5	21	13	8	19	65	CL	16.4			
B-005-0-13	16.0							8.6			
B-005-0-13	18.5							8.2			
B-005-0-13	21.0							10.0			
B-013-1-13	1.0							47.1			
B-013-1-13	3.5	30	16	14	9.5	71	CL	16.9			
B-013-1-13	6.0							27.3			
B-013-1-13	8.5							25.7			
B-013-1-13	10.0	32	16	16	4.75	92	CL	27.0			
B-013-1-13	13.5	25	15	10	2	78	CL	25.5			
B-013-1-13	18.5							9.9			
B-014-0-13	1.0	32	17	15	19	75	CL	14.8			
B-014-0-13	3.5							15.4			
B-014-0-13	6.0							16.7			
B-014-0-13	8.5	37	16	21	9.5	81	CL	19.5			

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SUMMARY OF LABORATORY RESULTS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-014-0-13	11.0	42	18	24				20.3			
B-014-0-13	13.5							13.3			
B-014-0-13	16.0							17.4			
B-014-0-13	18.5							8.9			
B-015-0-13	1.0							19.1			
B-015-0-13	3.5	48	23	25	4.75	93	CL	25.5			
B-015-0-13	6.0	32	17	15	9.5	79	CL	16.8			
B-015-0-13	8.5							14.4			
B-016-0-13	1.7							22.3			
B-016-0-13	3.2	39	19	20	9.5	95	CL	24.8			
B-016-0-13	4.7	44	20	24	9.5	94	CL	28.0			
B-016-0-13	6.2							25.6			
B-017-0-13	1.2							6.4			
B-017-0-13	2.7							21.2			
B-017-0-13	4.2	41	23	18	19	76	CL	21.6			
B-017-0-13	5.7	40	19	21	9.5	77	CL	22.0			
B-018-0-13	1.2							12.8			
B-018-0-13	2.7	26	12	14	9.5	53	CL	15.5			
B-018-0-13	4.2	49	20	29	9.5	87	CL	26.7			
B-018-0-13	5.7							19.7			
B-019-0-13	1.2	23	14	9	37.5	30	SC	15.5			
B-019-0-13	2.7	39	19	20	19	80	CL	17.0			
B-019-0-13	4.2							15.7			
B-019-0-13	5.7							15.2			
B-020-0-13	0.3							20.5			
B-020-0-13	1.8	49	21	28	9.5	87	CL	22.8			
B-020-0-13	3.3	48	24	24	9.5	94	CL	22.9			
B-020-0-13	4.8							15.2			
B-021-0-13	1.2	28	15	13	19	48	SC	18.1			
B-021-0-13	2.7							17.2			
B-021-0-13	4.2	47	25	22	9.5	88	CL	22.4			
B-021-0-13	5.7							15.0			
B-022-0-13	1.2							3.4			
B-022-0-13	2.7	44	19	25	19	85	CL	22.5			
B-022-0-13	4.2							14.1			
B-022-0-13	5.7	32	17	15	19	58	CL	16.6			
B-023-0-13	1.2	NP	NP	NP	37.5	9	GW-GM	2.5			
B-023-0-13	2.7							21.4			
B-023-0-13	4.2	40	20	20	9.5	91	CL	22.4			
B-023-0-13	5.7							24.3			
B-024-0-13	1.2	NP	NP	NP	4.75	10	SP-SM	13.5			
B-024-0-13	2.7	49	22	27	4.75	98	CL	24.9			
B-024-0-13	4.2							23.7			

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SUMMARY OF LABORATORY RESULTS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-024-0-13	5.7							23.4			
B-025-0-13	1.2							15.9			
B-025-0-13	2.7	33	18	15	9.5	85	CL	18.5			
B-025-0-13	4.2							18.8			
B-025-0-13	5.7							22.4			
B-026-0-13	1.2							1.5			
B-026-0-13	2.7							22.7			
B-026-0-13	4.2	41	20	21	19	84	CL	17.3			
B-026-0-13	5.7							14.6			

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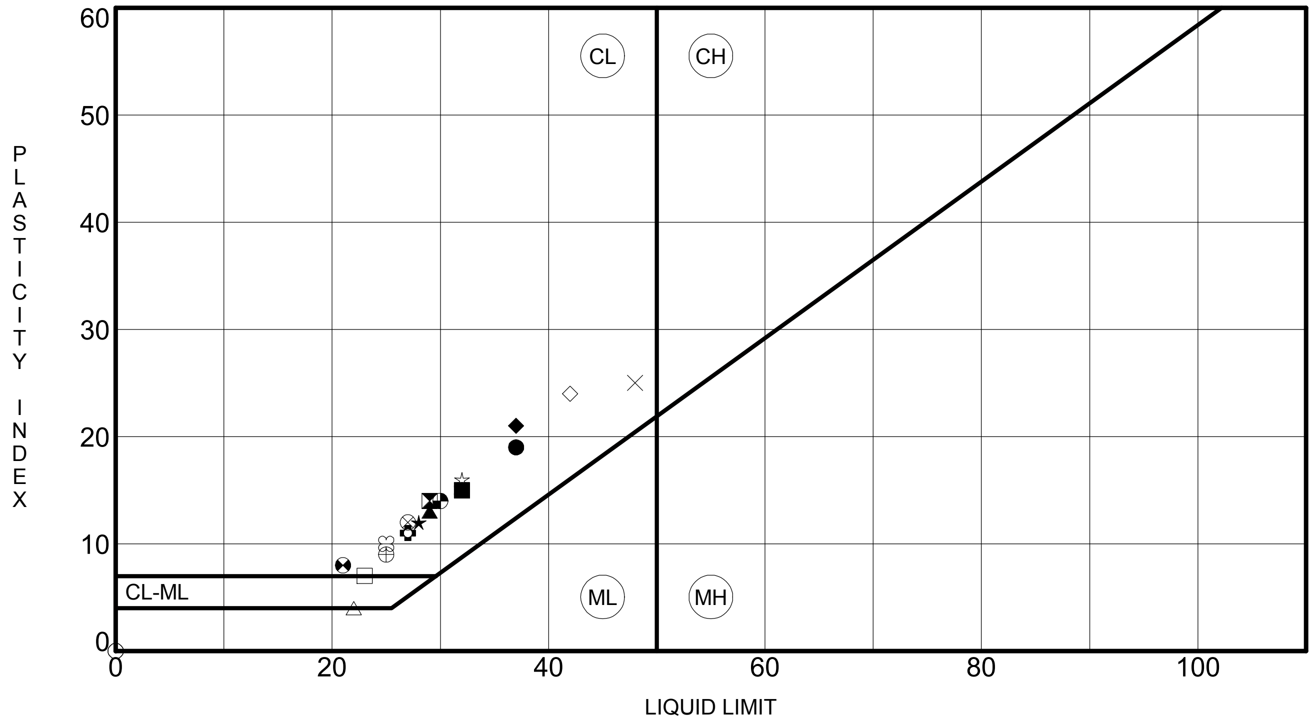
ATTERBERG LIMITS' RESULTS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification		LL	PL	PI	Fines	Classification
B-001-0-13	1.0	37	18	19	79	A-6b
B-001-0-13	8.5	29	15	14	76	A-6a
B-002-0-13	3.5	29	16	13	76	A-6a
B-002-0-13	13.5	28	16	12	78	A-6a
B-003-0-13	3.5	NP	NP	NP	45	A-4a
B-003-0-13	13.5	27	16	11	83	A-6a
B-004-0-13	3.5	NP	NP	NP	69	A-4a
B-004-0-13	6.0	22	18	4	59	A-4a
B-004-0-13	11.0	27	15	12	80	A-6a
B-005-0-13	1.0	25	16	9	74	A-4a
B-005-0-13	8.5	23	16	7	62	A-4a
B-005-0-13	13.5	21	13	8	65	A-4a
B-013-1-13	3.5	30	16	14	71	A-6a
B-013-1-13	10.0	32	16	16	92	A-6b
B-013-1-13	13.5	25	15	10	78	A-4b
B-014-0-13	1.0	32	17	15	75	A-6a
B-014-0-13	8.5	37	16	21	81	A-6b
B-014-0-13	11.0	42	18	24		
B-015-0-13	3.5	48	23	25	93	A-7-6
B-015-0-13	6.0	32	17	15	79	A-6a

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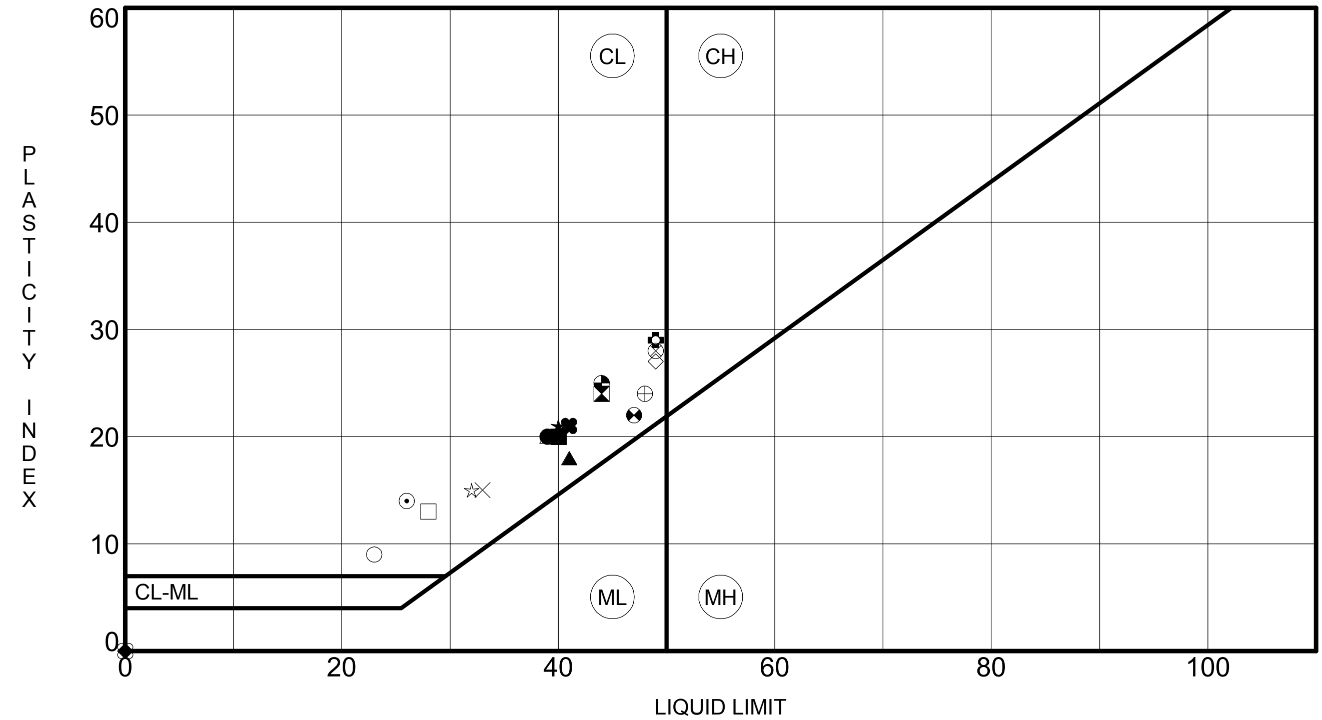
ATTERBERG LIMITS' RESULTS

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**B-016-0-13**	**3.2**	**39**	**19**	**20**	**95**	**A-6b**
⧗	**B-016-0-13**	**4.7**	**44**	**20**	**24**	**94**	**A-7-6**
▲	**B-017-0-13**	**4.2**	**41**	**23**	**18**	**76**	**A-7-6**
★	**B-017-0-13**	**5.7**	**40**	**19**	**21**	**77**	**A-6b**
⊙	**B-018-0-13**	**2.7**	**26**	**12**	**14**	**53**	**A-6a**
✿	**B-018-0-13**	**4.2**	**49**	**20**	**29**	**87**	**A-7-6**
○	**B-019-0-13**	**1.2**	**23**	**14**	**9**	**30**	**A-2-4**
△	**B-019-0-13**	**2.7**	**39**	**19**	**20**	**80**	**A-6b**
⊗	**B-020-0-13**	**1.8**	**49**	**21**	**28**	**87**	**A-7-6**
⊕	**B-020-0-13**	**3.3**	**48**	**24**	**24**	**94**	**A-7-6**
□	**B-021-0-13**	**1.2**	**28**	**15**	**13**	**48**	**A-6a**
◉	**B-021-0-13**	**4.2**	**47**	**25**	**22**	**88**	**A-7-6**
◕	**B-022-0-13**	**2.7**	**44**	**19**	**25**	**85**	**A-7-6**
☆	**B-022-0-13**	**5.7**	**32**	**17**	**15**	**58**	**A-6a**
✣	**B-023-0-13**	**1.2**	**NP**	**NP**	**NP**	**9**	**A-1-a**
■	**B-023-0-13**	**4.2**	**40**	**20**	**20**	**91**	**A-6b**
◆	**B-024-0-13**	**1.2**	**NP**	**NP**	**NP**	**10**	**A-3**
◇	**B-024-0-13**	**2.7**	**49**	**22**	**27**	**98**	**A-7-6**
×	**B-025-0-13**	**2.7**	**33**	**18**	**15**	**85**	**A-6a**
✖	**B-026-0-13**	**4.2**	**41**	**20**	**21**	**84**	**A-7-6**

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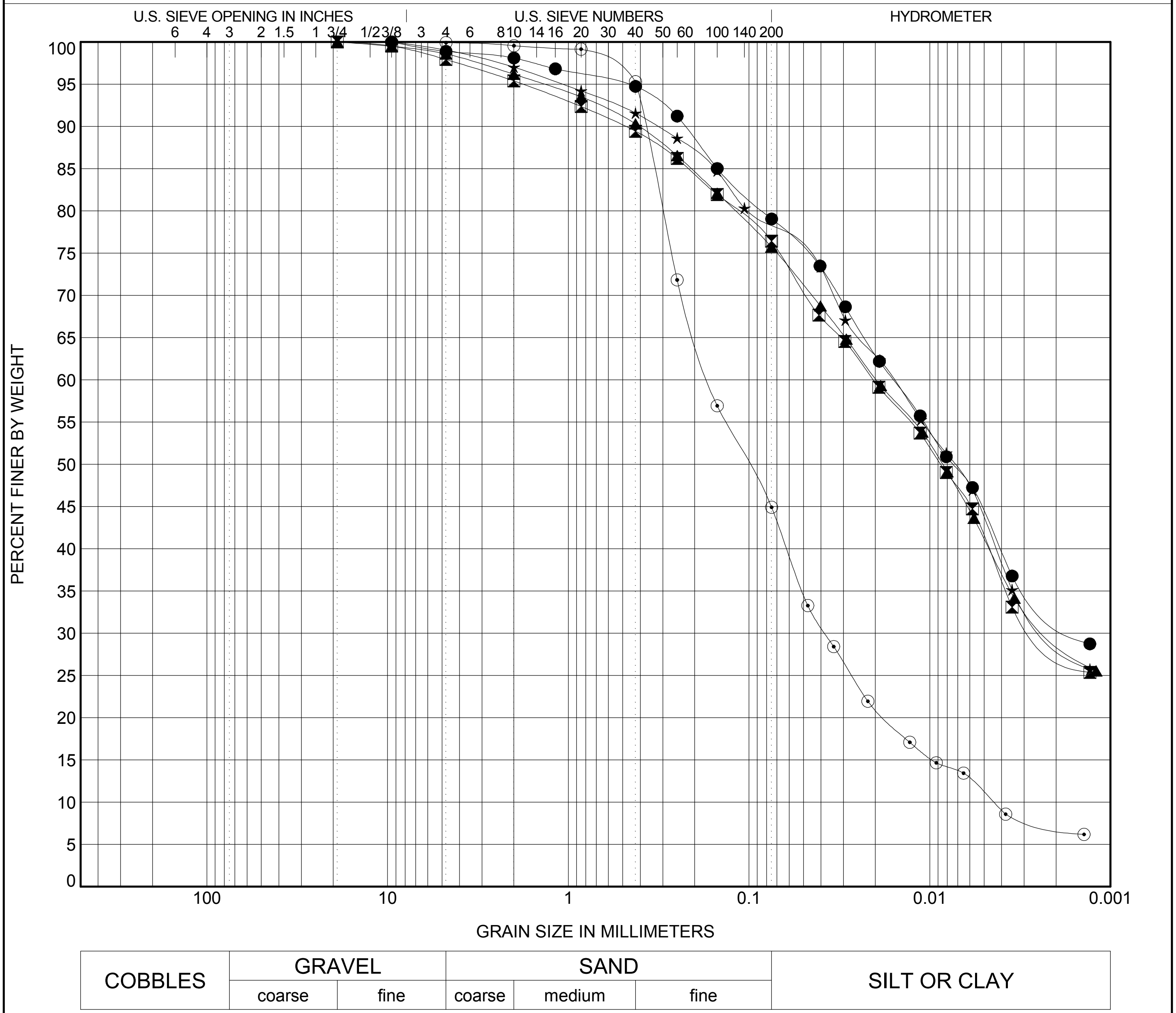
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-001-0-13	1.0	A-6b	37	18	19		
⧗	B-001-0-13	8.5	A-6a	29	15	14		
▲	B-002-0-13	3.5	A-6a	29	16	13		
★	B-002-0-13	13.5	A-6a	28	16	12		
⊙	B-003-0-13	3.5	A-4a	NP	NP	NP	1.93	37.47

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-001-0-13	1.0	9.5	0.016	0.002		2	19	35	44
⧗	B-001-0-13	8.5	19	0.02	0.002		5	19	35	41
▲	B-002-0-13	3.5	19	0.02	0.002		3	21	35	41
★	B-002-0-13	13.5	9.5	0.016	0.002		3	19	35	43
⊙	B-003-0-13	3.5	9.5	0.167	0.038	0.004	1	54	34	11

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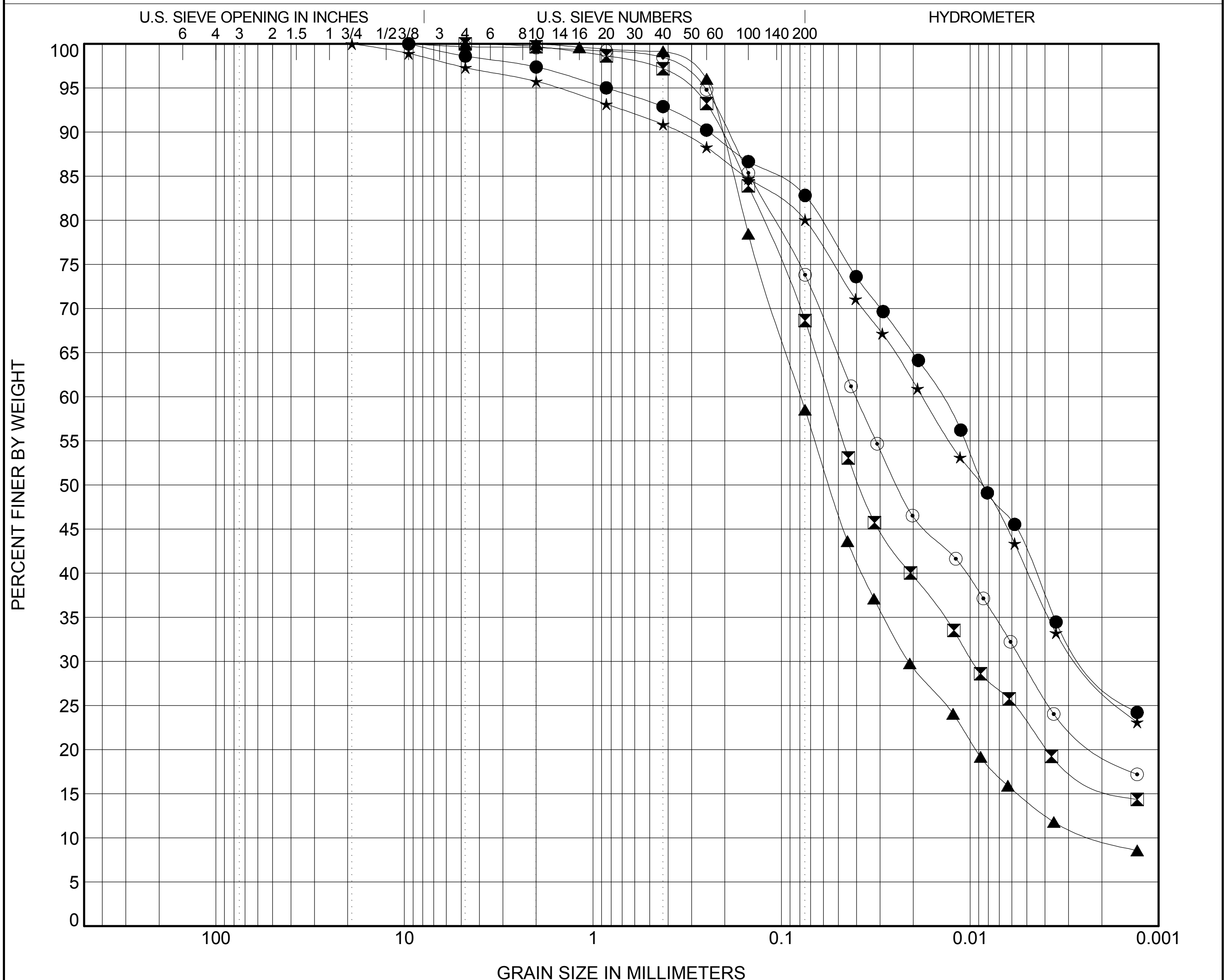
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● B-003-0-13	13.5	A-6a	27	16	11		
⧗ B-004-0-13	3.5	A-4a	NP	NP	NP		
▲ B-004-0-13	6.0	A-4a	22	18	4	2.79	38.74
★ B-004-0-13	11.0	A-6a	27	15	12		
⊙ B-005-0-13	1.0	A-4a	25	16	9		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-003-0-13	13.5	9.5	0.014	0.002		3	14	41	42
⧗ B-004-0-13	3.5	4.75	0.056	0.01		0	31	46	23
▲ B-004-0-13	6.0	4.75	0.079	0.021	0.002	0	41	45	14
★ B-004-0-13	11.0	19	0.018	0.003		4	16	40	40
⊙ B-005-0-13	1.0	9.5	0.04	0.005		0	26	45	29

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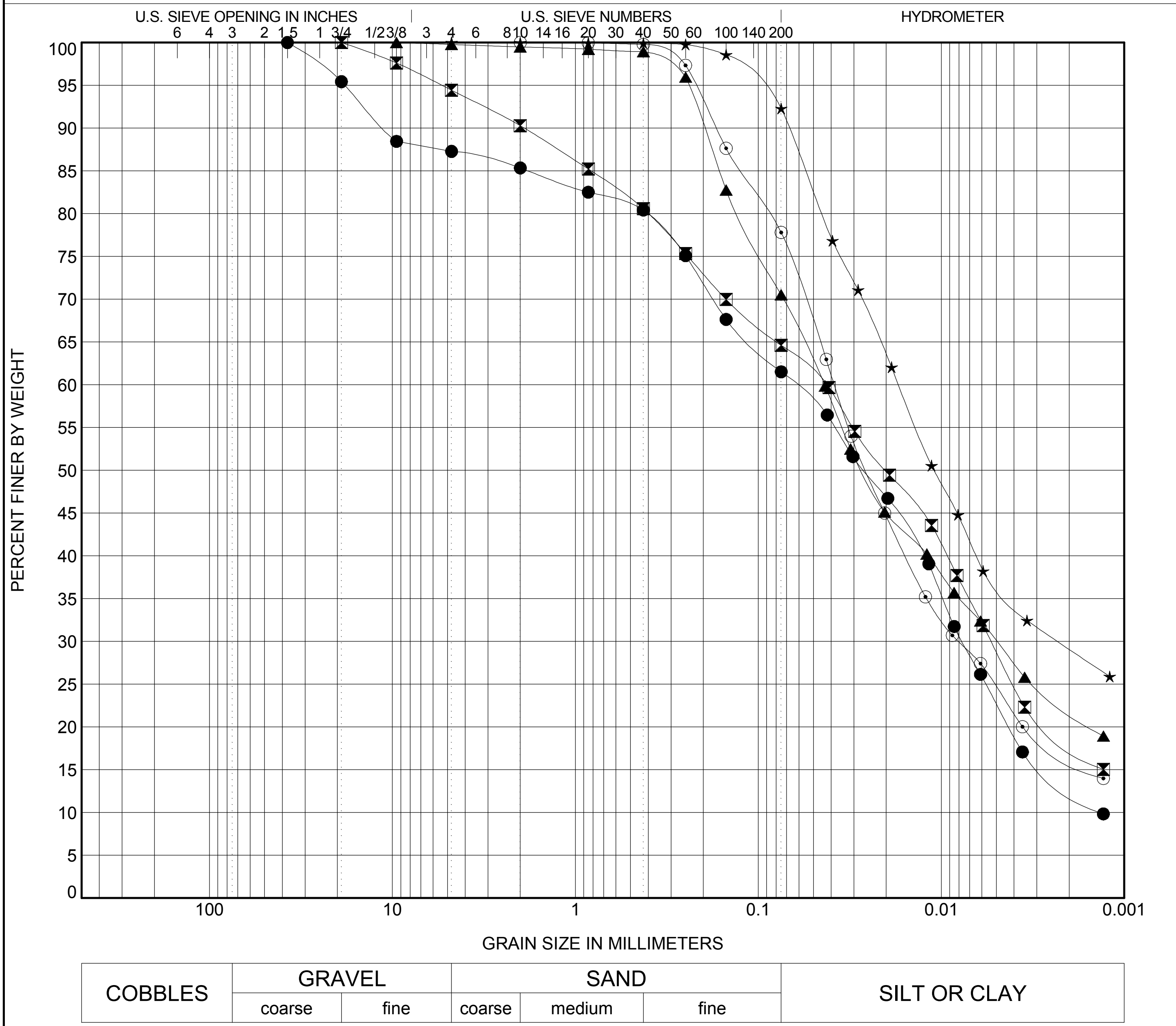
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**B-005-0-13**	**8.5**	**A-4a**	**23**	**16**	**7**	**0.70**	**47.35**
⧗	**B-005-0-13**	**13.5**	**A-4a**	**21**	**13**	**8**		
▲	**B-013-1-13**	**3.5**	**A-6a**	**30**	**16**	**14**		
★	**B-013-1-13**	**10.0**	**A-6b**	**32**	**16**	**16**		
⊙	**B-013-1-13**	**13.5**	**A-4b**	**25**	**15**	**10**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-005-0-13**	**8.5**	**37.5**	**0.063**	**0.008**	**0.001**	**14**	**24**	**39**	**23**
⧗	**B-005-0-13**	**13.5**	**19**	**0.043**	**0.005**		**9**	**26**	**36**	**29**
▲	**B-013-1-13**	**3.5**	**9.5**	**0.043**	**0.005**		**0**	**29**	**41**	**30**
★	**B-013-1-13**	**10.0**	**4.75**	**0.017**	**0.002**		**0**	**8**	**56**	**36**
⊙	**B-013-1-13**	**13.5**	**2**	**0.038**	**0.008**		**0**	**22**	**53**	**25**

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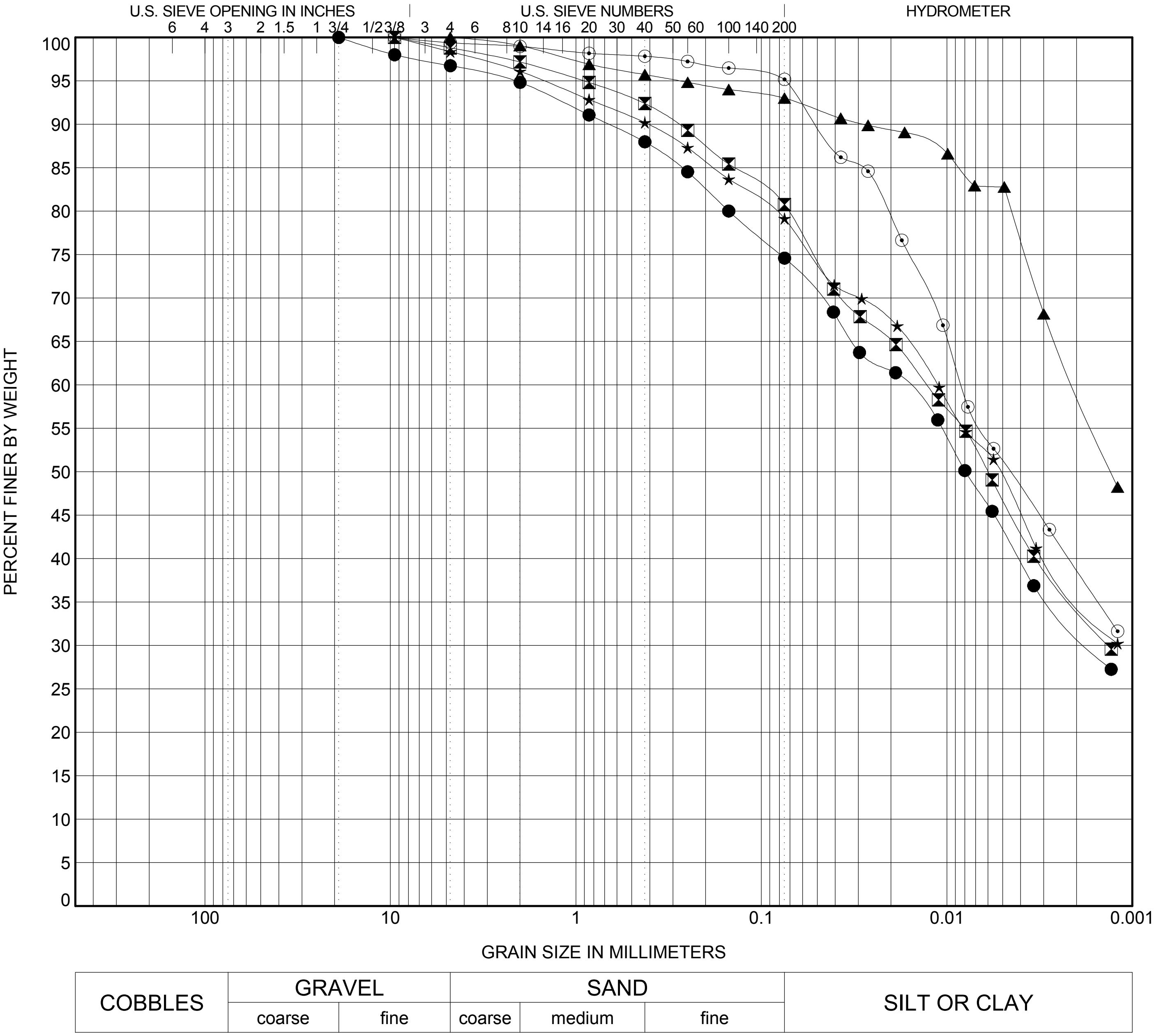
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	B-014-0-13	1.0	A-6a	32	17	15		
⧗	B-014-0-13	8.5	A-6b	37	8	29		
▲	B-015-0-13	3.5	A-7-6	48	23	25		
★	B-015-0-13	6.0	A-6a	32	17	15		
⊙	B-016-0-13	3.2	A-6b	39	19	20		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-014-0-13	1.0	19	0.017	0.002		5	20	32	43
⧗	B-014-0-13	8.5	9.5	0.013	0.001		2	17	34	47
▲	B-015-0-13	3.5	4.75	0.002			1	6	10	83
★	B-015-0-13	6.0	9.5	0.011			4	17	30	49
⊙	B-016-0-13	3.2	9.5	0.008			1	4	44	51

The Mannik & Smith Group, Inc.
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Canton, MI 48188
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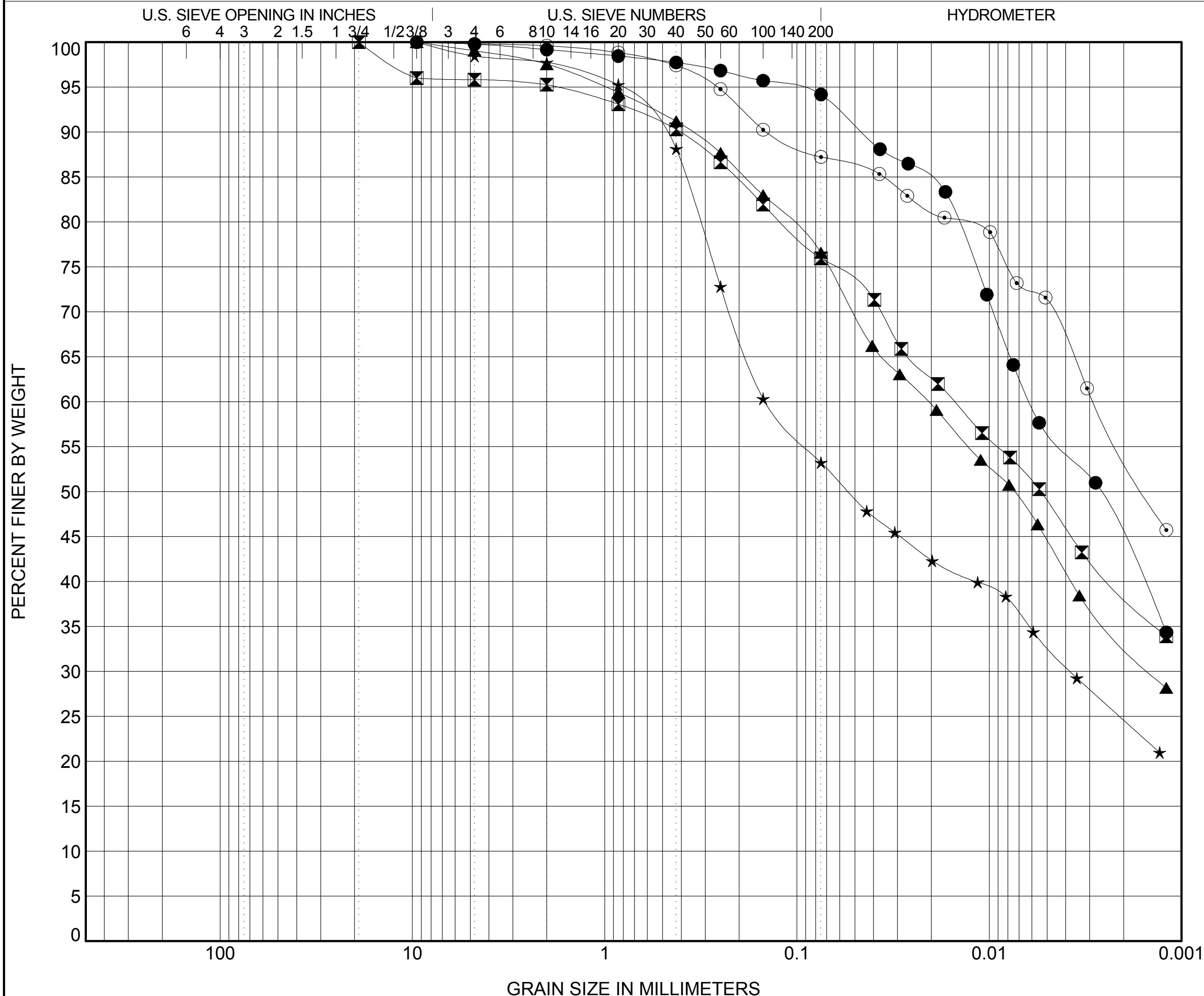
Fax: 734-397-3131

GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



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<tr><td rowspan="2">COBBLES</td><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td rowspan="2">SILT OR CLAY</td></tr>
<tr><td>coarse</td><td>fine</td><td>coarse</td><td>medium</td><td>fine</td></tr>
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	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-016-0-13**	**4.7**	**A-7-6**	**44**	**20**	**24**		
⧗	**B-017-0-13**	**4.2**	**A-7-6**	**41**	**23**	**18**		
▲	**B-017-0-13**	**5.7**	**A-6b**	**40**	**19**	**21**		
★	**B-018-0-13**	**2.7**	**A-6a**	**26**	**12**	**14**		
⊙	**B-018-0-13**	**4.2**	**A-7-6**	**49**	**20**	**29**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-016-0-13**	**4.7**	**9.5**	**0.006**			**1**	**5**	**37**	**57**
⧗	**B-017-0-13**	**4.2**	**19**	**0.015**			**5**	**19**	**27**	**49**
▲	**B-017-0-13**	**5.7**	**9.5**	**0.021**	**0.001**		**2**	**21**	**32**	**45**
★	**B-018-0-13**	**2.7**	**9.5**	**0.145**	**0.004**		**2**	**45**	**20**	**33**
⊙	**B-018-0-13**	**4.2**	**9.5**	**0.003**			**1**	**12**	**16**	**71**

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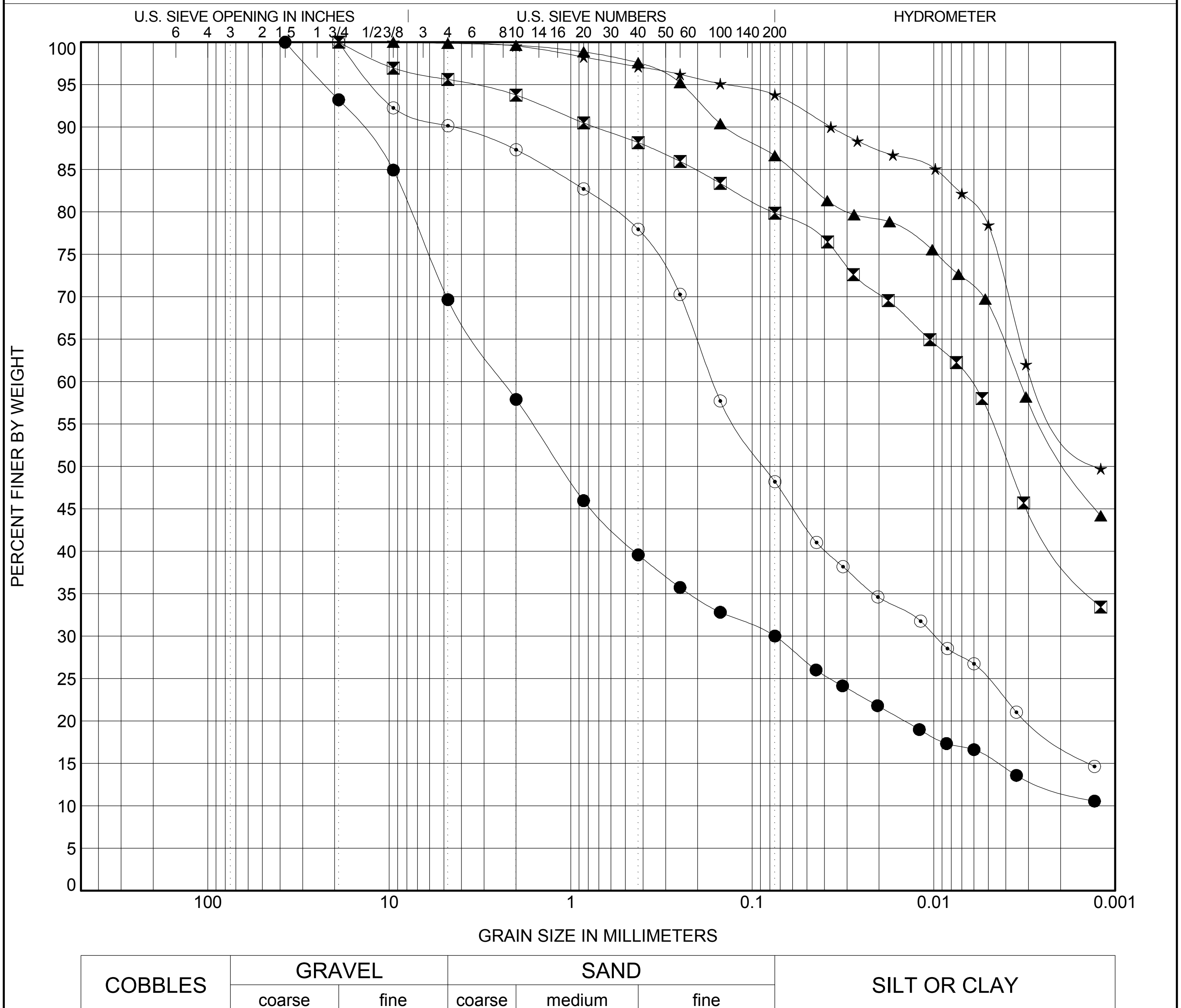
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**B-019-0-13**	**1.2**	**A-2-4**	**23**	**14**	**9**		
⧗	**B-019-0-13**	**2.7**	**A-6b**	**39**	**19**	**20**		
▲	**B-020-0-13**	**1.8**	**A-7-6**	**49**	**21**	**28**		
★	**B-020-0-13**	**3.3**	**A-7-6**	**48**	**24**	**24**		
⊙	**B-021-0-13**	**1.2**	**A-6a**	**28**	**15**	**13**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-019-0-13**	**1.2**	**37.5**	**2.335**	**0.075**		**42**	**28**	**14**	**16**
⧗	**B-019-0-13**	**2.7**	**19**	**0.006**			**6**	**14**	**24**	**56**
▲	**B-020-0-13**	**1.8**	**9.5**	**0.003**			**0**	**13**	**18**	**69**
★	**B-020-0-13**	**3.3**	**9.5**	**0.003**			**1**	**5**	**16**	**78**
⊙	**B-021-0-13**	**1.2**	**19**	**0.165**	**0.01**		**13**	**39**	**23**	**25**

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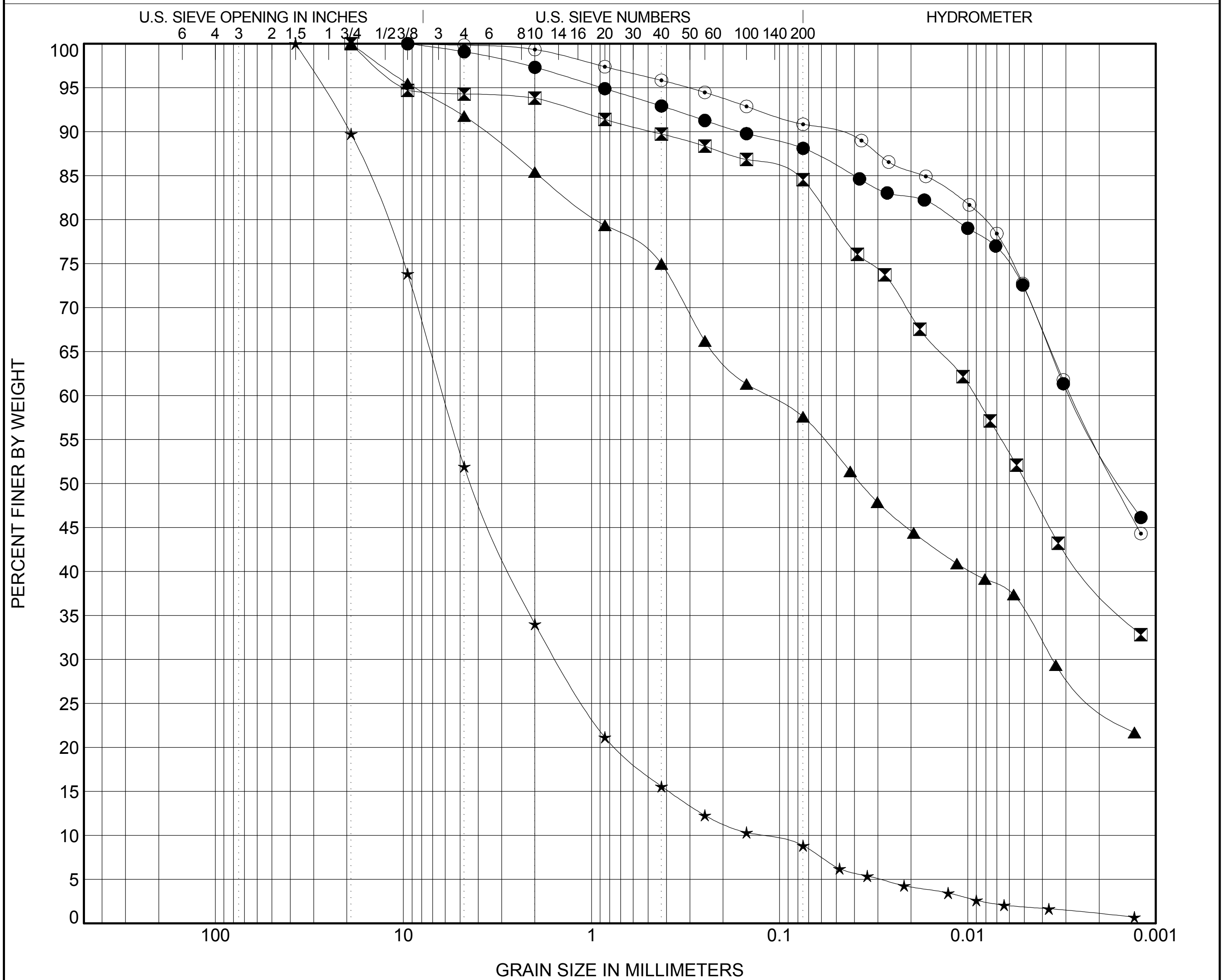
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	B-021-0-13	4.2	A-7-6	47	25	22		
⧗	B-022-0-13	2.7	A-7-6	44	19	25		
▲	B-022-0-13	5.7	A-6a	32	17	15		
★	B-023-0-13	1.2	A-1-a	NP	NP	NP	2.97	47.62
⊙	B-023-0-13	4.2	A-6b	40	20	20		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-021-0-13	4.2	9.5	0.003			3	9	16	72
⧗	B-022-0-13	2.7	19	0.009			6	9	35	50
▲	B-022-0-13	5.7	19	0.117	0.004		15	27	23	35
★	B-023-0-13	1.2	37.5	6.131	1.53	0.129	66	25	7	2
⊙	B-023-0-13	4.2	9.5	0.003			0	9	19	72

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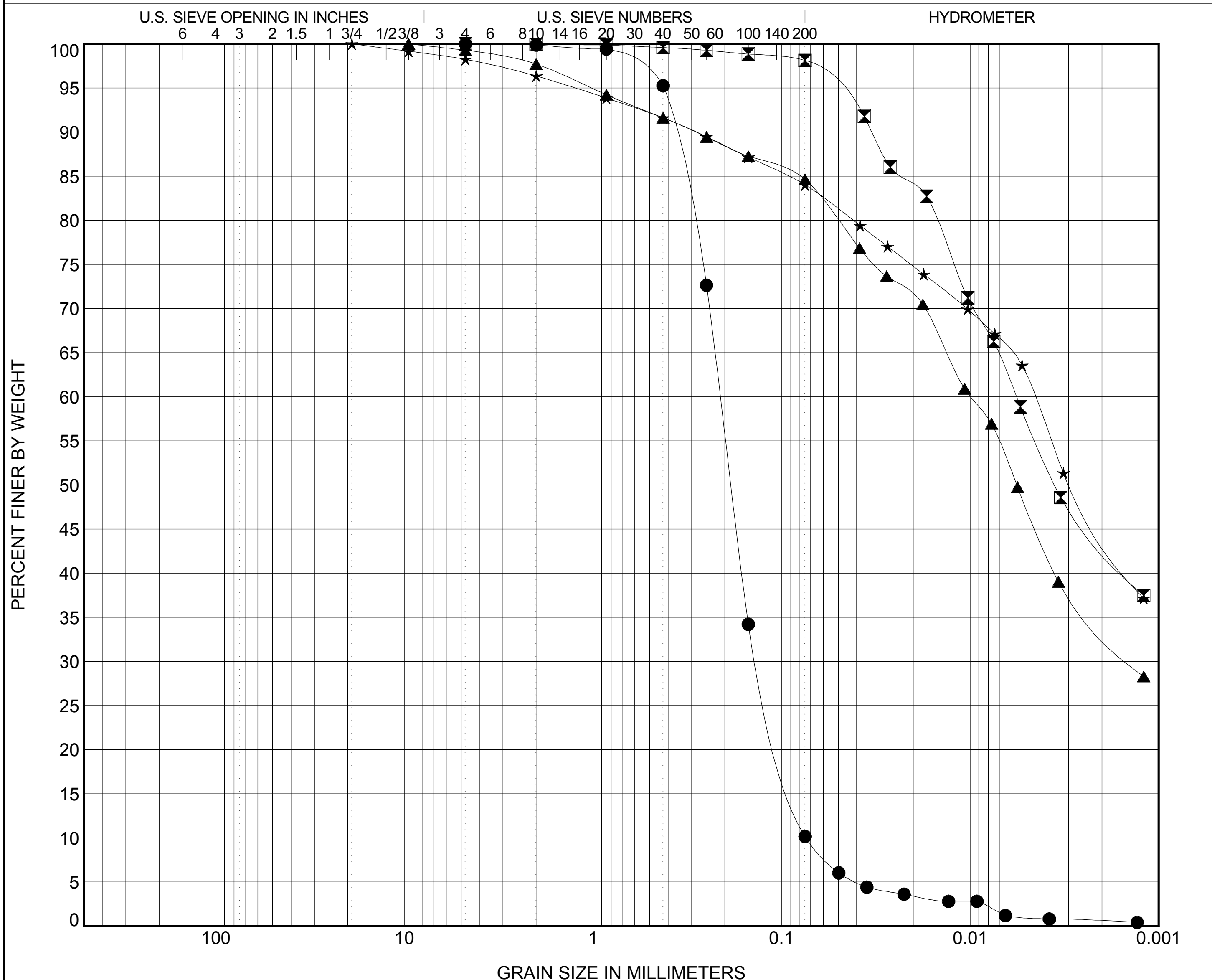
GRAIN SIZE DISTRIBUTION

PROJECT HEN-IND-0000 **PID** 22984

OGE NUMBER N/A **PROJECT TYPE** New Alignment



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	B-024-0-13	1.2	A-3	NP	NP	NP	1.13	2.86
⧗	B-024-0-13	2.7	A-7-6	49	22	27		
▲	B-025-0-13	2.7	A-6a	33	18	15		
★	B-026-0-13	4.2	A-7-6	41	20	21		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-024-0-13	1.2	4.75	0.211	0.133	0.074	0	90	9	1
⧗	B-024-0-13	2.7	4.75	0.006			1	1	41	57
▲	B-025-0-13	2.7	9.5	0.01	0.001		2	13	38	47
★	B-026-0-13	4.2	19	0.005			3	13	22	62

GRAIN SIZE - OH DOT.GDT - 8/14/14 17:52 - W:\PROJECTS\PROJECTS F-J\H2530002\22984\GEOTECHNICAL\LAB\UPDATED.GPJ

Mannik Smith GROUP
Civil Engineering, Surveying and Environmental Consulting
TOLEDO MONROE CANTON DETROIT CLEVELAND

Sulfate Content in Soil - Colorimetric Method

TEX-145-E

Project Name: Maumee River Crossing PID 22984 Project No: H2530002

ANALYTICAL RESULTS

Sulfate by TxDOT-145-E

Sample ID	Sulfate	Units	Detection Limit	Date Collected	Date Analyzed
B-015 (SS-1)	1275	mg/l (ppm)	70	4/25/2014	7/1/2014
B-016 (SS-4)	1140	mg/l (ppm)	70	6/3/2014	7/1/2014
B-017 (SS-2)	560	mg/l (ppm)	70	4/29/2014	7/1/2014
B-018 (SS-1)	500	mg/l (ppm)	70	4/29/2014	7/1/2014
B-019 (SS-3)	760	mg/l (ppm)	70	4/29/2014	7/1/2014
B-020 (SS-1)	2160	mg/l (ppm)	70	4/29/2014	7/1/2014
B-021 (SS-2)	660	mg/l (ppm)	70	4/29/2014	7/1/2014
B-022 (SS-1)	160	mg/l (ppm)	70	4/28/2014	7/1/2014
B-023 (SS-2)	1300	mg/l (ppm)	70	4/28/2014	7/1/2014
B-024 (SS-3)	2880	mg/l (ppm)	70	4/28/2014	7/1/2014
B-025 (SS-1)	200	mg/l (ppm)	70	4/28/2014	7/1/2014
B-026 (SS-2)	1140	mg/l (ppm)	70	4/28/2014	7/1/2014

Notes and Definitions

ND Analyte NOT DETECTED at or above reporting limit

Tested By: MJG Checked By: TR/SD

Remarks: None

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-006-0-13 RC-2
Depth: 5-10'
Sample Diameter: 2.056 (inch)
Sample Length: 3.186 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-006-0-13 RC-2	2.06	3.19	3.33	4,735	1,423	204.9

Tested By: MG

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-006-0-13 RC-4
Depth: 15-20'
Sample Diameter: 1.898 (inch)
Sample Length: 3.29 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-006-0-13 RC-4	1.90	3.29	2.84	4,655	1,641	236.4

Tested By: MG

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-007-0-13 RC-2
Depth: 5-10'
Sample Diameter: 2.05 (inch)
Sample Length: 4.245 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-007-0-13 RC-2	2.05	4.25	3.31	14,710	4,446	640.3

Tested By: MG

TR

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TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-008-1-13 RC-2
Depth: 5-10'
Sample Diameter: 2.039 (inch)
Sample Length: 4.775 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-008-1-13 RC-2	2.04	4.78	3.27	15,915	4,862	700.2

Tested By: MG

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-009-0-13 RC-4
Depth: 15-20'
Sample Diameter: 2.052 (inch)
Sample Length: 4.67 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-009-0-13 RC-4	2.05	4.67	3.31	4,810	1,451	208.9

Tested By: MG

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-010-0-13 RC-2
Depth: 5-10'
Sample Diameter: 2.047 (inch)
Sample Length: 4.178 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-010-0-13 RC-2	2.05	4.18	3.30	25,320	7,676	1,105.3

Tested By: MG

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-011-0-13 RC-1
Depth: 0-5'
Sample Diameter: 2.044 (inch)
Sample Length: 4.181 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-011-0-13 RC-1	2.04	4.18	3.29	15,275	4,644	668.8

Tested By: MG

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name:	Maumee River Crossing	Project Number:	H2530002
Sample Number:	B-012-0-13 RC-1	Depth:	0-5'
Sample Diameter:	2.048 (inch)		
Sample Length:	4.084 (inch)		

Sample ID	**Diameter (inches)**	**Length (inches)**	**Area**	**Max Load (lbs)**	**Strength (psi)**	**Strength (ksf)**
B-012 RC-1	2.05	4.08	3.30	18,290	5,539	797.6

Tested By: KL

TR

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UNCONFINED STRENGTH OF INTACT ROCK - METHOD C
D7012

Project Name: Maumee River Crossing
Project Number: H2530002
Sample Number: B-012-0-13 RC-3
Depth: 10-15'
Sample Diameter: 2.056 (inch)
Sample Length: 3.186 (inch)

Sample ID	Diameter (inches)	Length (inches)	Area	Max Load (lbs)	Strength (psi)	Strength (ksf)
B-012-0-13 RC-3	2.06	3.19	3.33	22,135	6,652	957.8

Tested By: MG

TR

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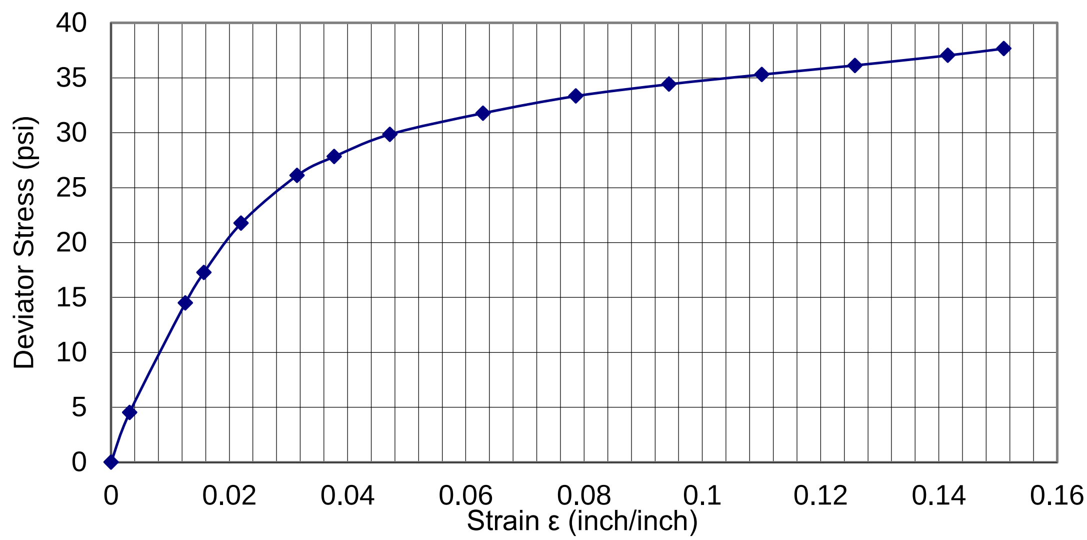
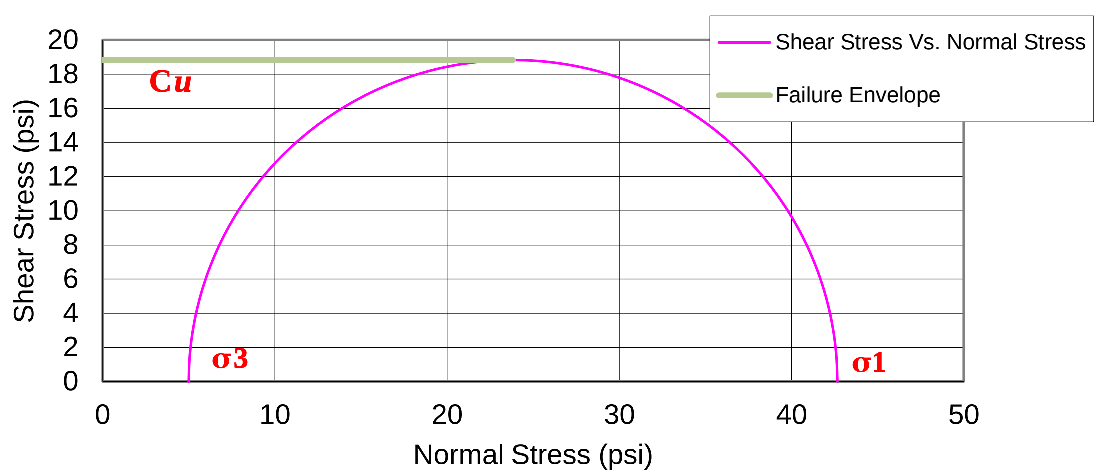
MAUMEE
COLUMBUS
CLEVELAND
TRAVERSE CITY

Civil Engineering, Surveying and Environmental Consulting

Unconsolidated-Undrained Triaxial Compression Test ASTM D2850

Project Name:	Maumee River Crossing PID 22984			Project No:	H2530002
Sample No:	B-002-ST1			Date:	5/27/2014
Visual Description of Soil:	Gray Silty Clay			Depth:	3.5-5.0'
Wet Unit Wt. (lb/ft^3):	132.51	Dry Unit Wt.(lb/ft^3):	108.24	MC %:	22.43
Specific Gravity	2.70	Loading Rate(inch/min)	0.050	Void Ratio:	0.557
Chamber Pressure (psi)	5	Deviator Stress q_u (psi)	37.66	Cu (psi)	18.83





Tested By:	KL	Reviewed By:	TR/CAR	Date:	6/4/2014

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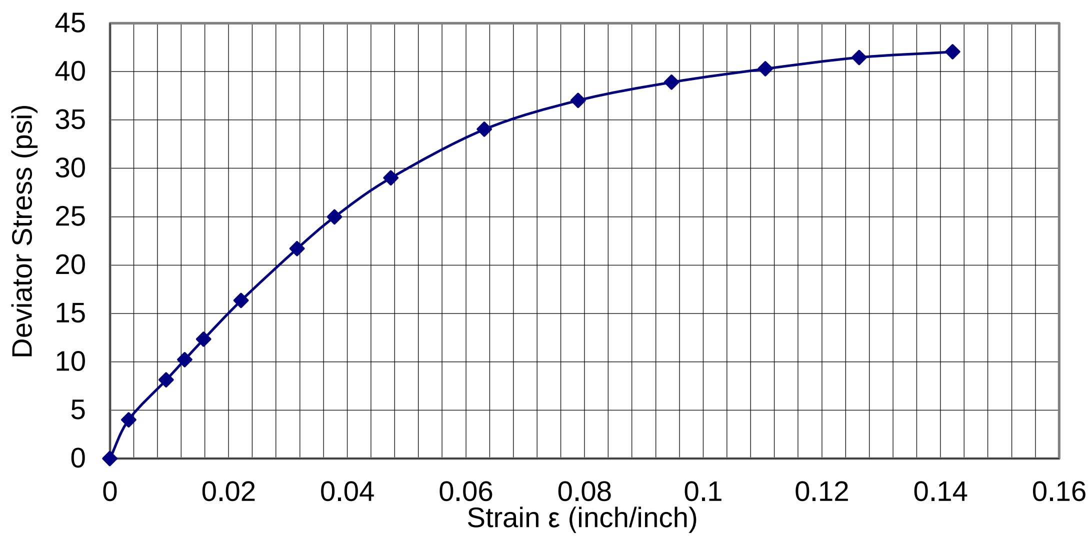
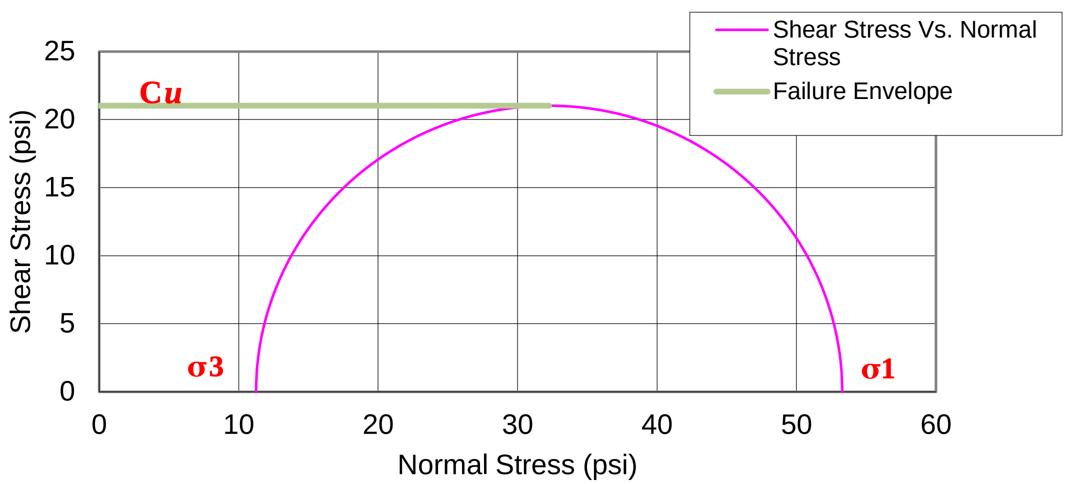
CLEVELAND
TRAVERSE CITY

Civil Engineering, Surveying and Environmental Consulting

Unconsolidated-Undrained Triaxial Compression Test
ASTM D2850

Project Name:	Maumee River Crossing PID 22984			Project No:	H2530002
Sample No:	B-005-ST1			Date:	5/27/2014
Visual Description of Soil:	Gray Sandy Silt, some Clay			Depth:	13.5-15.0'
Wet Unit Wt. (lb/ft^3):	135.03	Dry Unit Wt.(lb/ft^3):	113.73	MC %:	18.73
Specific Gravity	2.70	Loading Rate(inch/min)	0.050	Void Ratio:	0.481
Chamber Pressure (psi)	11.25	Deviator Stress q_u (psi)	42.04	Cu (psi)	21.01





Tested By:	KL	Reviewed By:	TR	Date:	6/4/2014

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TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

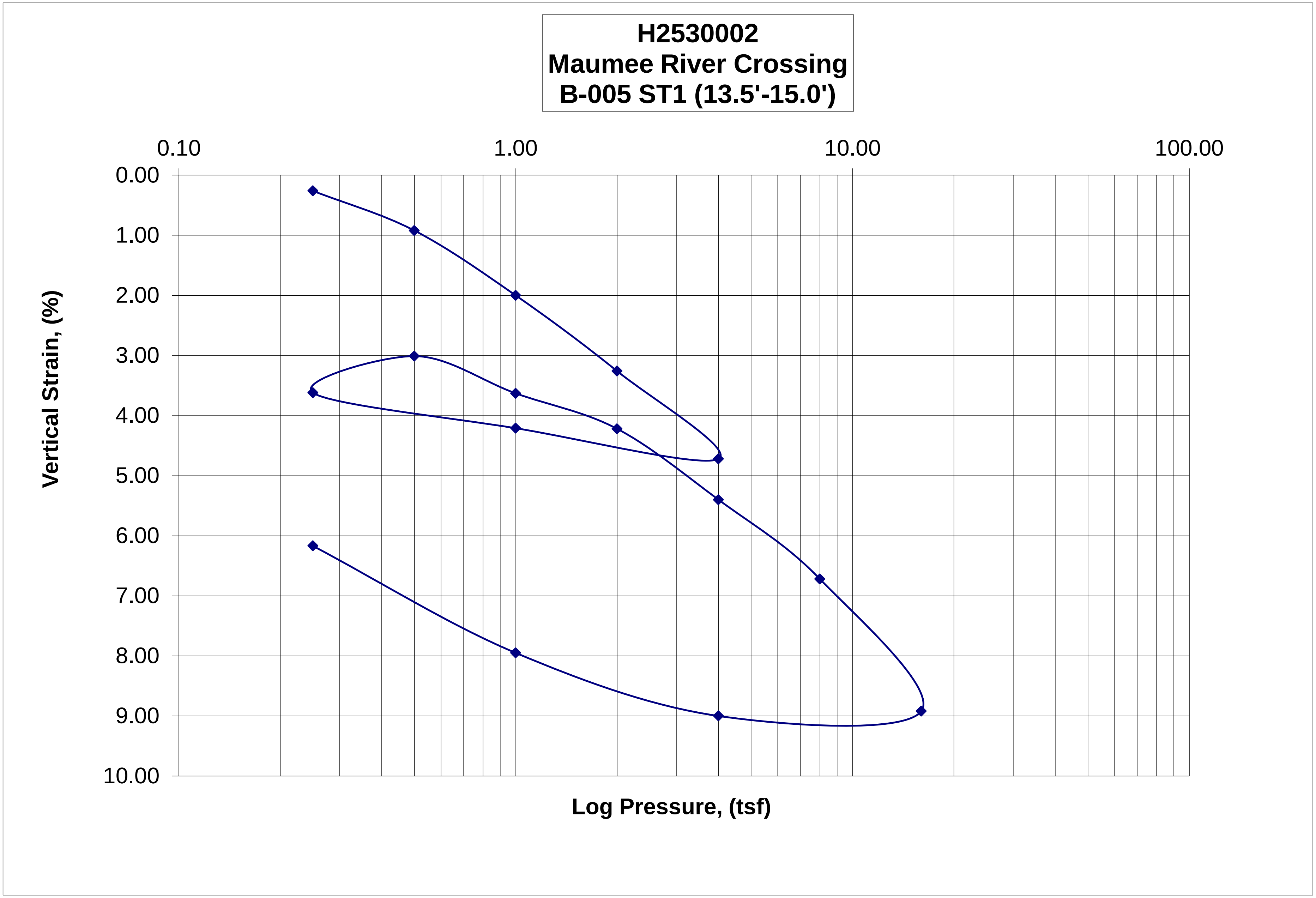
AASHTO R18

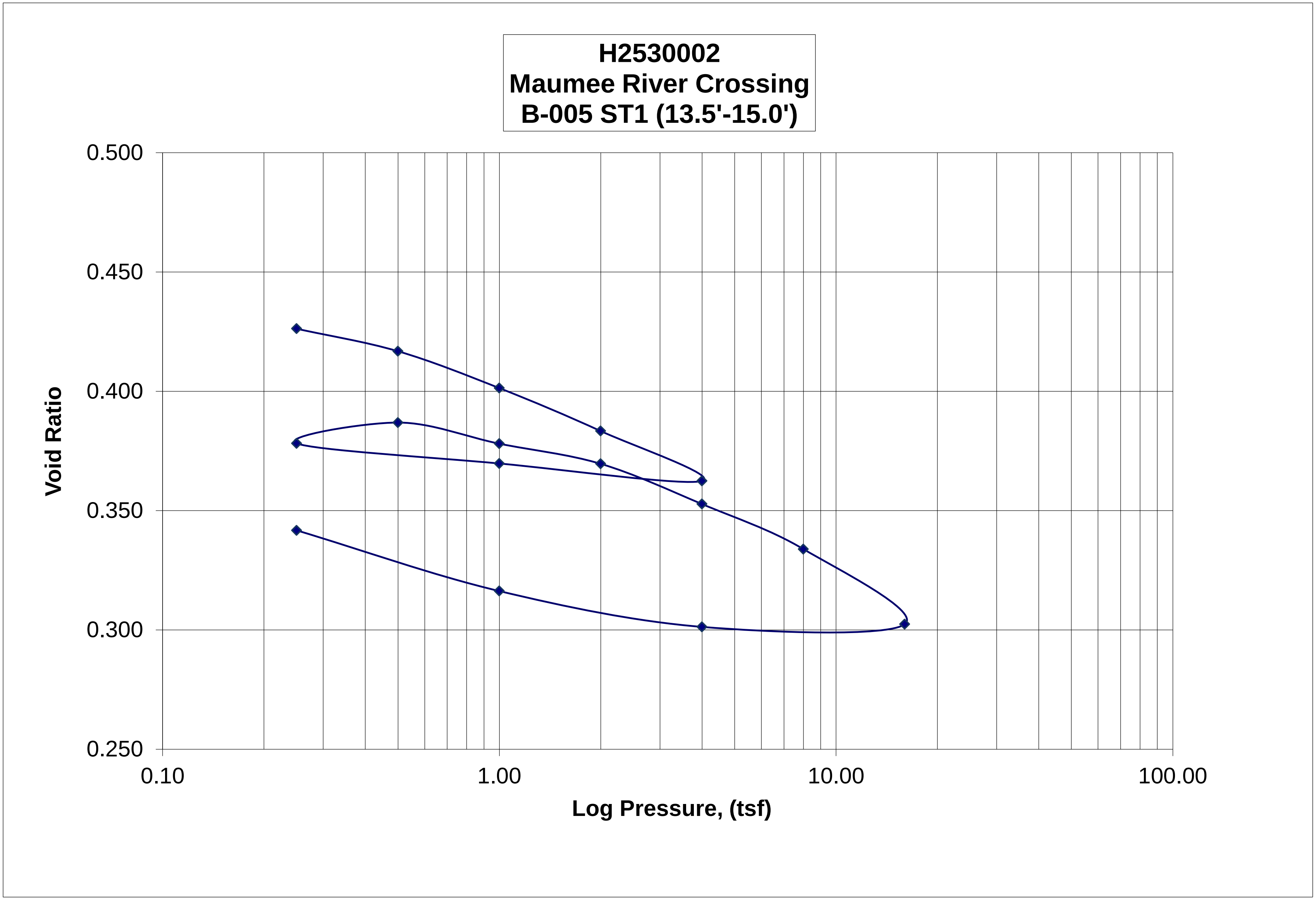
One-Dimensional Consolidation Properties of Soils ASTM D2435

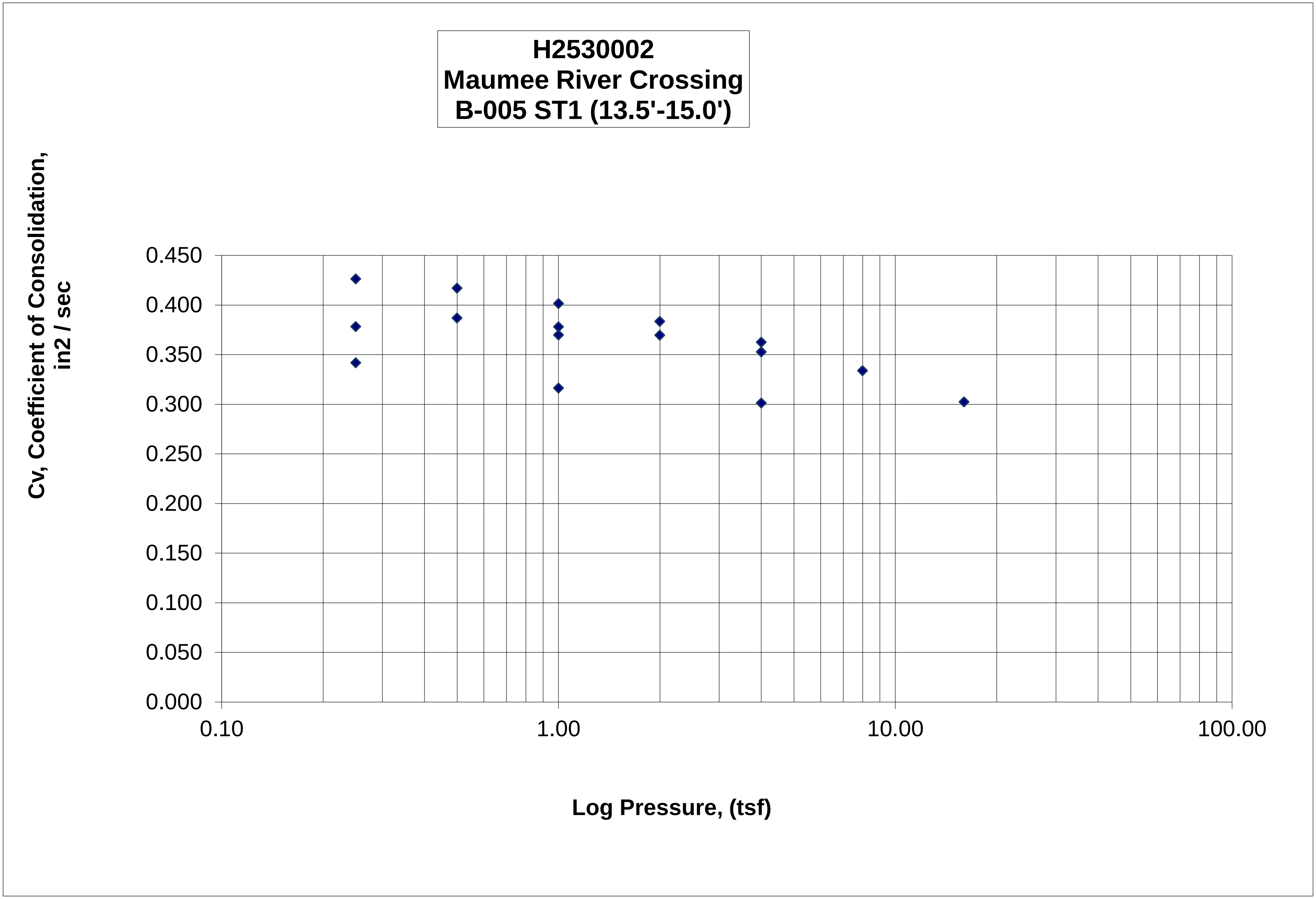
Project Name:	Maumee River Crossing PID 22984	Project Number:	H2530002
Sample Number:	B-005-ST1	Sample Depth:	13.5'-15'
Soil Classification:	A-4a	Specific Gravity (G):	2.71
		Method Used:	Floating Ring

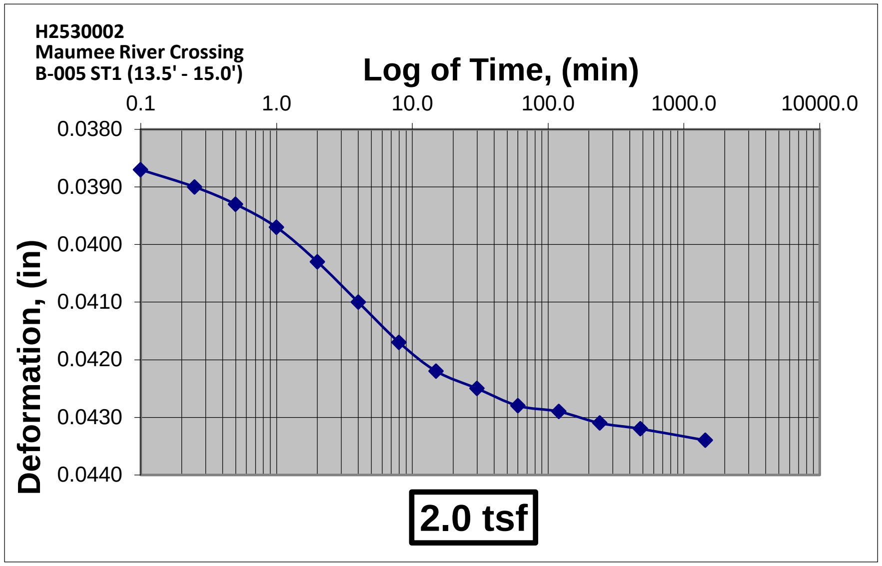
d_0= Initial zero reading, (in)	0		
Hs= (cm)	1.75	0.70	(in)
H0= (in)	1.00		
A= (in^2)	4.91	31.91	(cm^2)

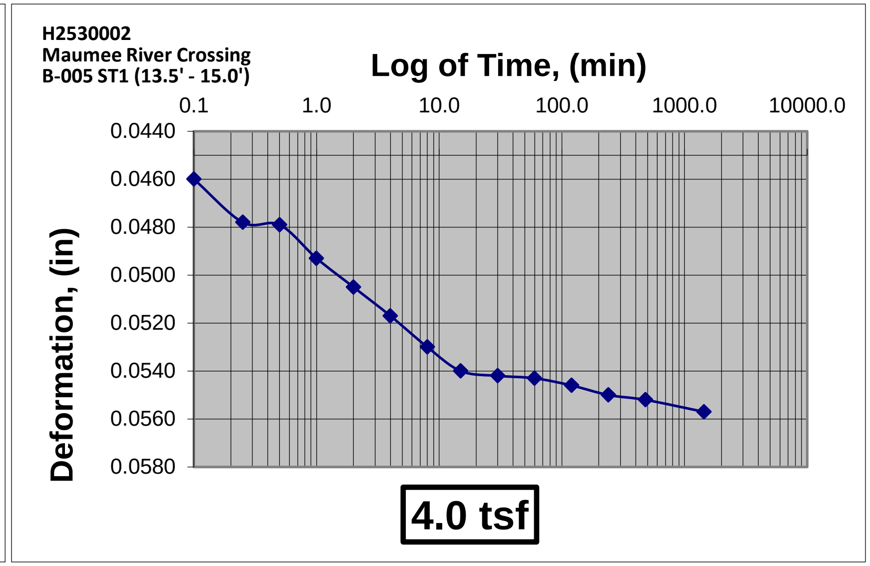
Load Increment, Pressure (tsf)	(psi)	Deformation @ end of loading or Δ H (in)	Height of sample at the end of loading (in)	Height of Voids, (in)	Strain (Δ H/Ho) (%)	Coefficient of Compressibility a_v (m^2/N)	Void Ratio	Permeability (cm/sec)	Coefficient of Consolidation, Cv @ 50% (in^2/sec)	Coefficient of Consolidation, Cv @ 50% (cm^2/sec)
seating load	0.69	0.000	1.000	0.30	0.00		0.430			
0.25	1.20	0.003	0.997	0.30	0.26	2.09E-05	0.426	3.819E-05	4.090E-03	2.659E-02
0.50	2.00	0.009	0.991	0.29	0.92	3.39E-05	0.417	9.811E-06	6.477E-04	4.210E-03
1.00	3.60	0.020	0.980	0.28	2.00	2.77E-05	0.401	1.803E-05	1.445E-03	9.394E-03
2.00	6.70	0.033	0.967	0.27	3.26	1.67E-05	0.383	1.962E-05	2.584E-03	1.679E-02
4.00	13.00	0.047	0.953	0.25	4.72	9.52E-06	0.362	3.305E-06	7.533E-04	4.897E-03
1.00	3.60	0.042	0.958	0.26	4.21	2.23E-06	0.370	7.362E-08	7.061E-05	4.589E-04
0.25	1.20	0.036	0.964	0.26	3.62	1.01E-05	0.378	1.190E-05	2.531E-03	1.645E-02
0.50	2.00	0.030	0.970	0.27	3.01	-3.13E-05	0.387	-7.471E-06	5.157E-04	3.352E-03
1.00	3.60	0.036	0.964	0.26	3.63	1.59E-05	0.378	1.245E-05	1.702E-03	1.106E-02
2.00	6.70	0.042	0.958	0.26	4.22	7.82E-06	0.370	1.368E-06	3.782E-04	2.458E-03
4.00	13.00	0.054	0.946	0.25	5.40	7.69E-06	0.353	2.656E-06	7.418E-04	4.822E-03
8.00	25.60	0.067	0.933	0.23	6.72	4.30E-06	0.334	9.759E-07	4.812E-04	3.128E-03
16.00	50.80	0.089	0.911	0.21	8.92	3.59E-06	0.302	9.500E-07	5.543E-04	3.603E-03
4.00	13.00	0.090	0.910	0.21	9.00	-8.69E-08	0.301	-2.884E-07	6.777E-03	4.405E-02
1.00	3.60	0.080	0.921	0.22	7.95	4.59E-06	0.316	5.184E-06	2.306E-03	1.499E-02
0.25	1.20	0.062	0.938	0.24	6.17	3.05E-05	0.342	1.924E-05	1.304E-03	8.477E-03

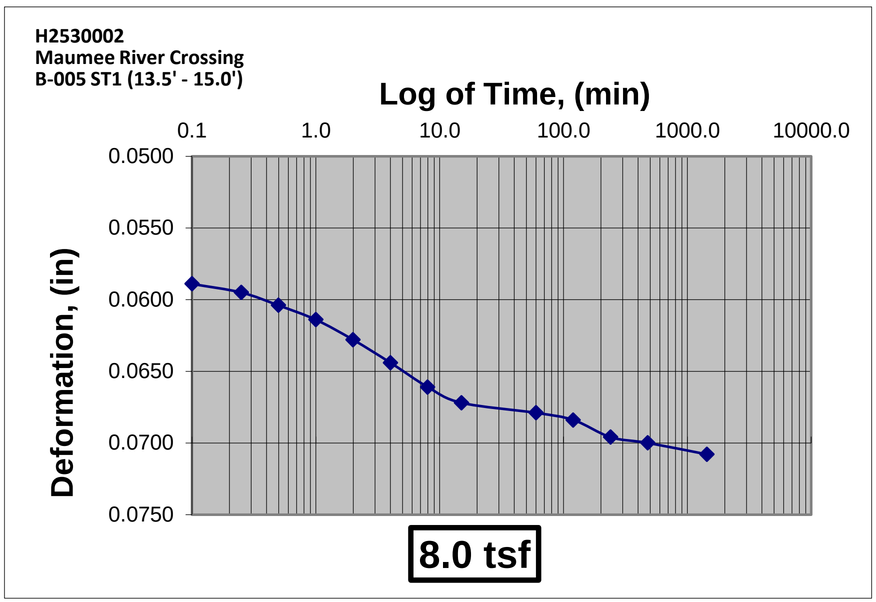

H2530002
Maumee River Crossing
B-005 ST1 (13.5'-15.0')
0.10
1.00
10.00
100.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Vertical Strain, (%)
Log Pressure, (tsf)

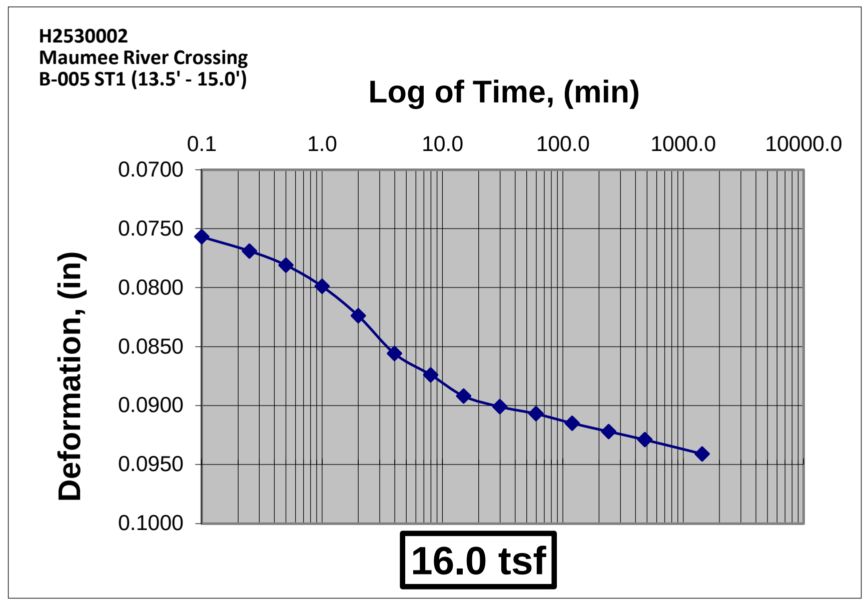

H2530002
Maumee River Crossing
B-005 ST1 (13.5'-15.0')
Void Ratio
0.500
0.450
0.400
0.350
0.300
0.250
0.10
1.00
10.00
100.00
Log Pressure, (tsf)


H2530002
Maumee River Crossing
B-005 ST1 (13.5'-15.0')
Cv, Coefficient of Consolidation, in2 / sec
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.10
1.00
10.00
100.00
Log Pressure, (tsf)


H2530002
Maumee River Crossing
B-005 ST1 (13.5' - 15.0')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
0.0380
0.0390
0.0400
0.0410
0.0420
0.0430
0.0440
Deformation, (in)
2.0 tsf


H2530002
Maumee River Crossing
B-005 ST1 (13.5' - 15.0')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
0.0440
0.0460
0.0480
0.0500
0.0520
0.0540
0.0560
0.0580
Deformation, (in)
4.0 tsf


H2530002
Maumee River Crossing
B-005 ST1 (13.5' - 15.0')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
0.0500
0.0550
0.0600
0.0650
0.0700
0.0750
Deformation, (in)
8.0 tsf


H2530002
Maumee River Crossing
B-005 ST1 (13.5' - 15.0')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
0.0700
0.0750
0.0800
0.0850
0.0900
0.0950
0.1000
Deformation, (in)
16.0 tsf

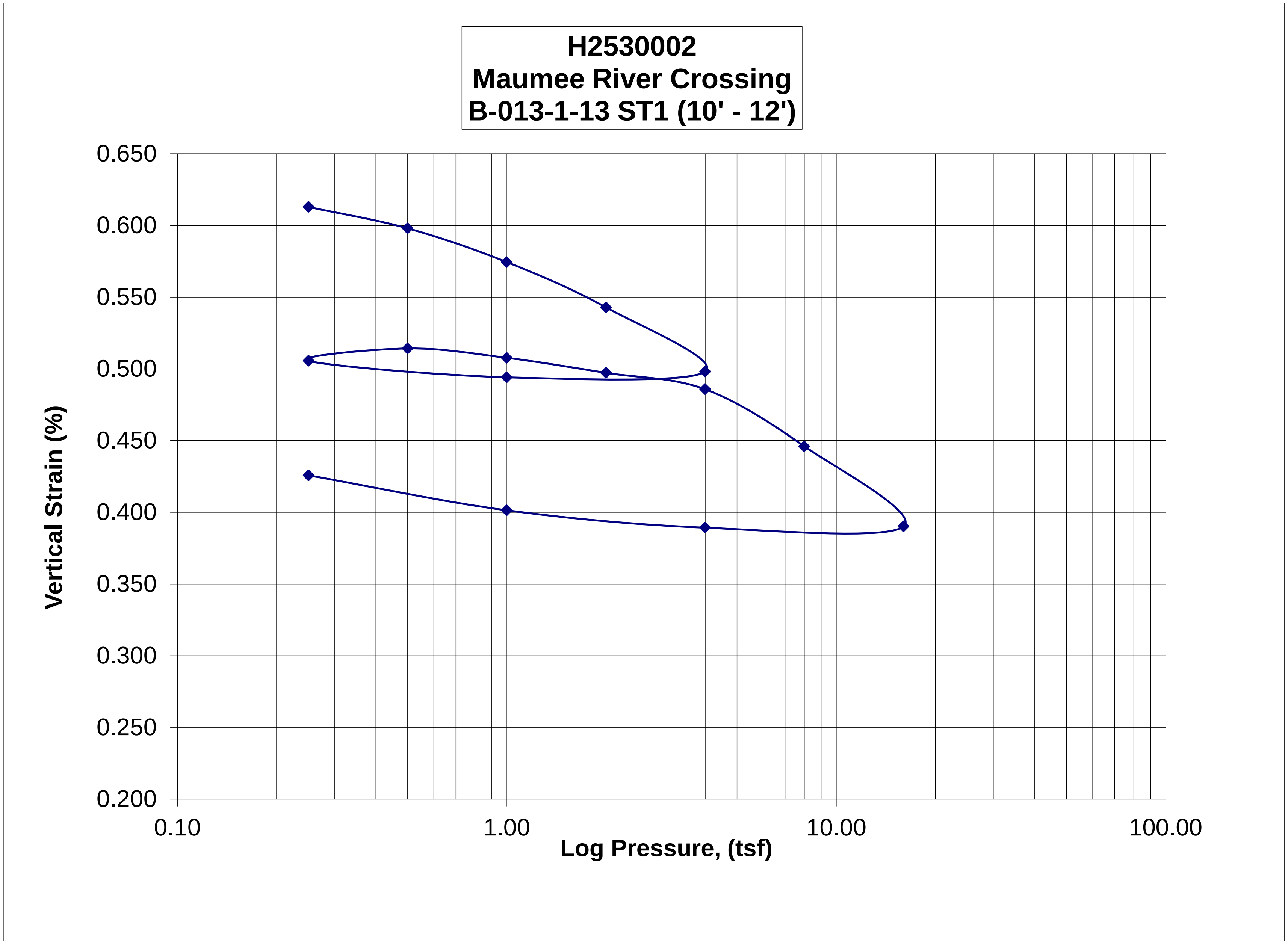
Civil Engineering, Surveying and Geoenvironmental Consulting
TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

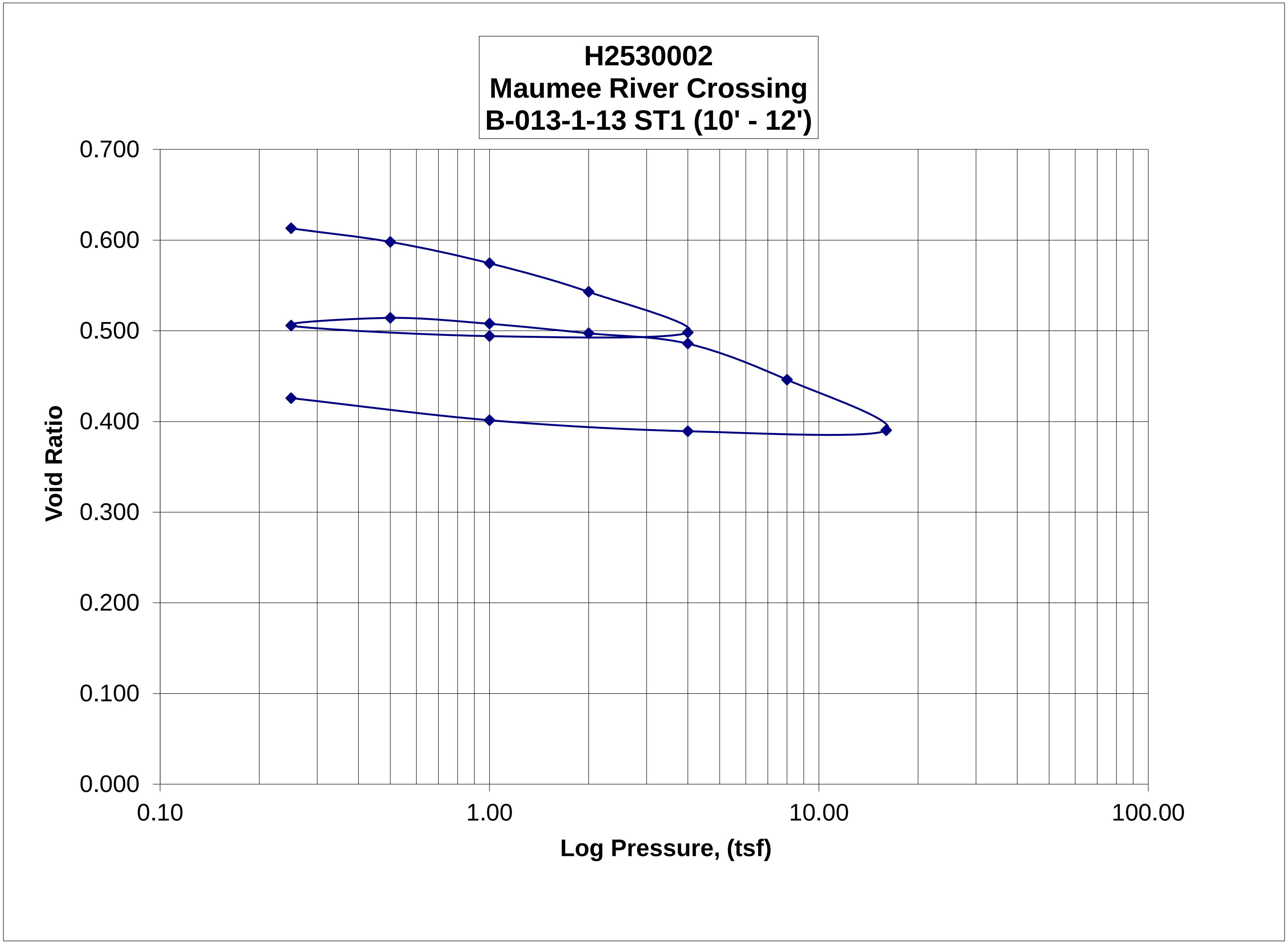
One-Dimensional Consolidation Properties of Soils ASTM D2435

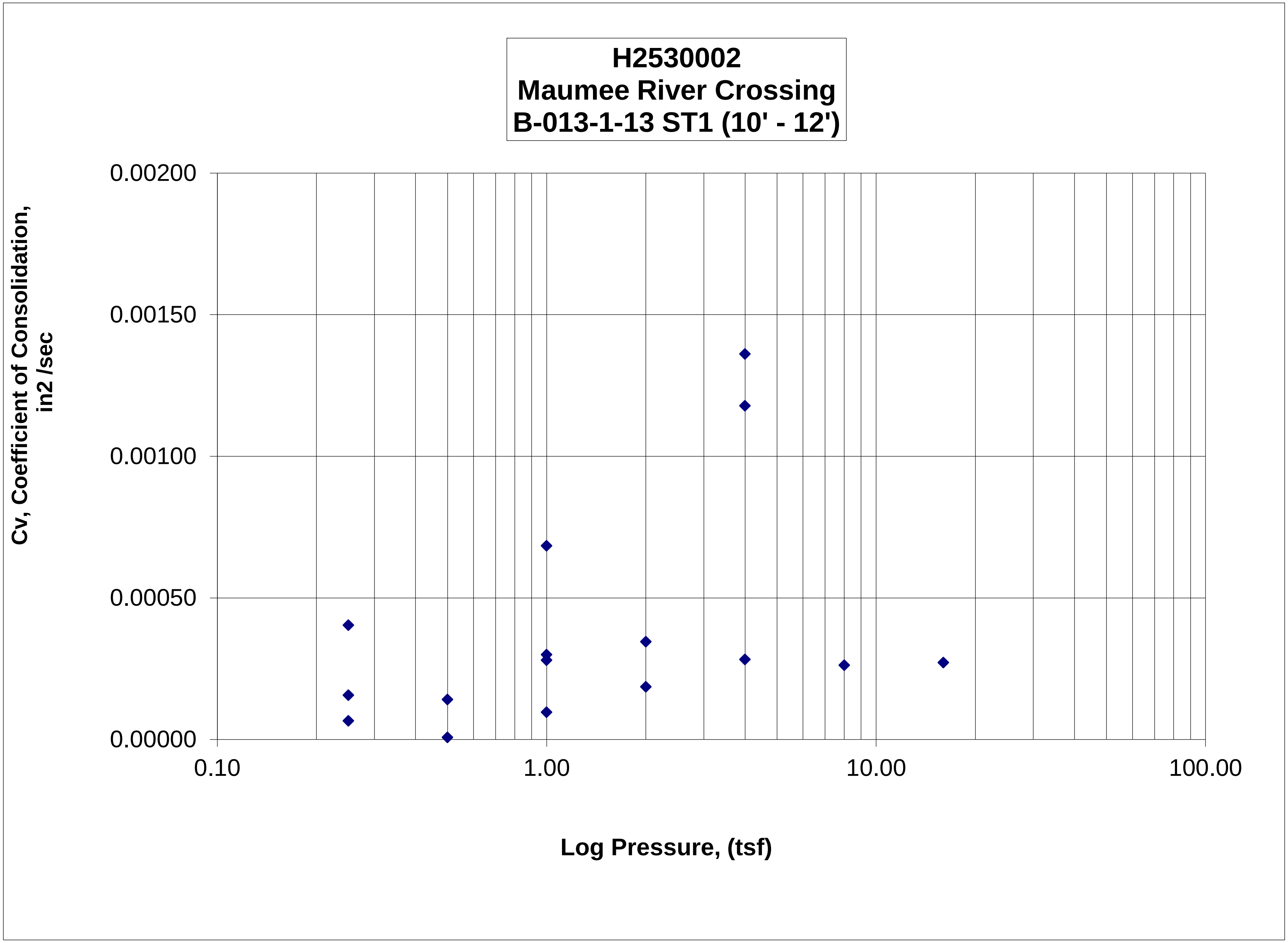
Project Name:	Maumee River Crossing	Project Number:	H2530002
Sample Number:	B-013-1-13 ST1	Sample Depth:	10'-12'
Soil Classification:	A-6b	Specific Gravity (G):	2.71
		Method Used:	Floating Ring

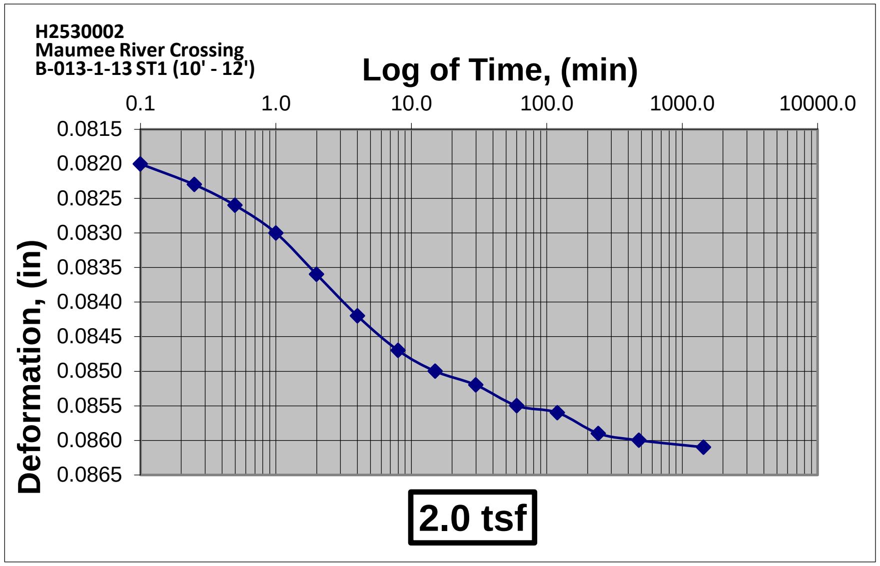
d_0= Initial zero reading, (in)	0		
Hs= (cm)	1.53	0.61	(in)
H0= (in)	1.00		
A= (in^2)	4.91	31.91	(cm^2)

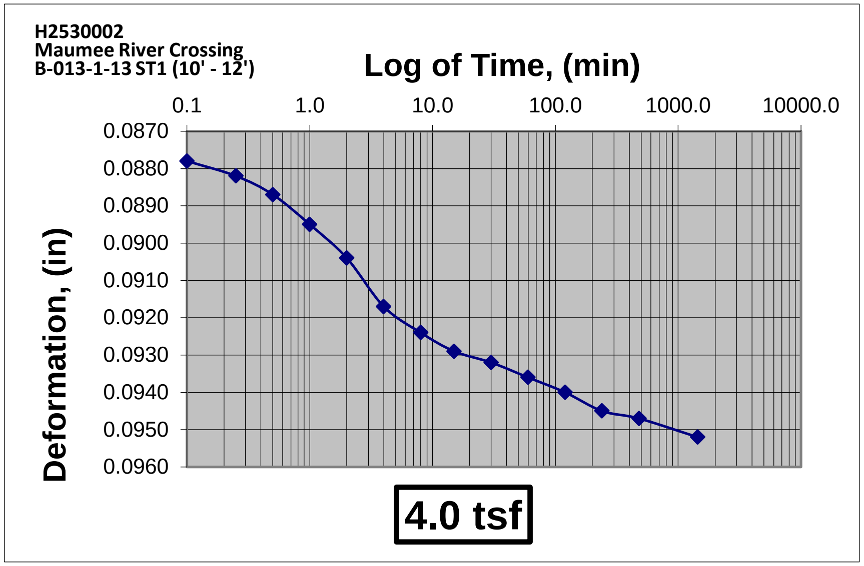
Load Increment, Pressure (tsf)	(psi)	Deformation @ end of loading or Δ H (in)	Height of sample at the end of loading (in)	Height of Voids, (in)	Strain (Δ H/Ho) (%)	Coefficient of Compressibility a_v (m^2/N)	Void Ratio	Permeability (cm/sec)	Coefficient of Consolidation, Cv @ 50% (in^2/sec)	Coefficient of Consolidation, Cv @ 50% (cm^2/sec)
seating load	0.69	0.000	1.000	0.39	0.00		0.636			
0.25	1.40	0.014	0.986	0.37	1.40	9.26E-05	0.613	1.458E-05	4.037E-04	2.624E-03
0.50	2.20	0.023	0.977	0.37	2.31	5.34E-05	0.598	1.463E-07	6.925E-06	4.502E-05
1.00	3.80	0.038	0.963	0.35	3.75	4.23E-05	0.574	1.625E-06	9.634E-05	6.262E-04
2.00	6.90	0.057	0.943	0.33	5.68	2.92E-05	0.543	2.202E-06	1.859E-04	1.208E-03
4.00	13.30	0.084	0.916	0.30	8.42	2.01E-05	0.498	2.345E-06	2.821E-04	1.834E-03
1.00	3.80	0.087	0.913	0.30	8.66	-1.19E-06	0.494	-3.453E-07	6.836E-04	4.443E-03
0.25	1.40	0.080	0.920	0.31	7.96	1.37E-05	0.506	3.859E-07	6.600E-05	4.290E-04
0.50	2.20	0.074	0.926	0.31	7.43	-3.11E-05	0.514	-1.861E-06	1.412E-04	9.179E-04
1.00	3.80	0.078	0.922	0.31	7.83	1.17E-05	0.508	1.385E-06	2.800E-04	1.820E-03
2.00	6.90	0.085	0.915	0.30	8.47	9.70E-06	0.497	1.415E-06	3.450E-04	2.243E-03
4.00	13.30	0.092	0.908	0.30	9.17	5.14E-06	0.486	2.979E-06	1.361E-03	8.850E-03
8.00	25.90	0.116	0.884	0.27	11.60	9.06E-06	0.446	1.019E-06	2.622E-04	1.704E-03
16.00	51.30	0.150	0.850	0.24	15.02	6.33E-06	0.390	7.572E-07	2.715E-04	1.765E-03
4.00	13.30	0.151	0.849	0.24	15.07	-6.18E-08	0.389	-3.341E-08	1.178E-03	7.658E-03
1.00	3.80	0.143	0.857	0.25	14.33	3.66E-06	0.401	5.022E-07	2.990E-04	1.944E-03
0.25	1.40	0.128	0.872	0.26	12.84	2.92E-05	0.426	2.069E-06	1.559E-04	1.013E-03

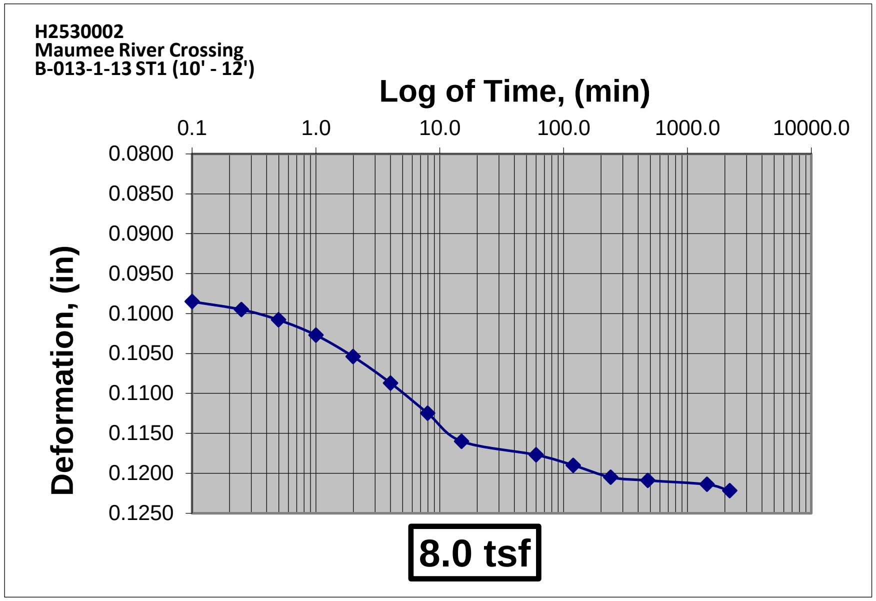

H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
0.650
0.600
0.550
0.500
0.450
0.400
0.350
0.300
0.250
0.200
Vertical Strain (%)
0.10
1.00
10.00
100.00
Log Pressure, (tsf)


H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Void Ratio
0.10
1.00
10.00
100.00
Log Pressure, (tsf)


H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
0.00200
0.00150
0.00100
0.00050
0.00000
Cv, Coefficient of Consolidation, in2 /sec
0.10
1.00
10.00
100.00
Log Pressure, (tsf)


H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
Deformation, (in)
0.0815
0.0820
0.0825
0.0830
0.0835
0.0840
0.0845
0.0850
0.0855
0.0860
0.0865
2.0 tsf


H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
Deformation, (in)
0.0870
0.0880
0.0890
0.0900
0.0910
0.0920
0.0930
0.0940
0.0950
0.0960
4.0 tsf


H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
Deformation, (in)
0.0800
0.0850
0.0900
0.0950
0.1000
0.1050
0.1100
0.1150
0.1200
0.1250
8.0 tsf

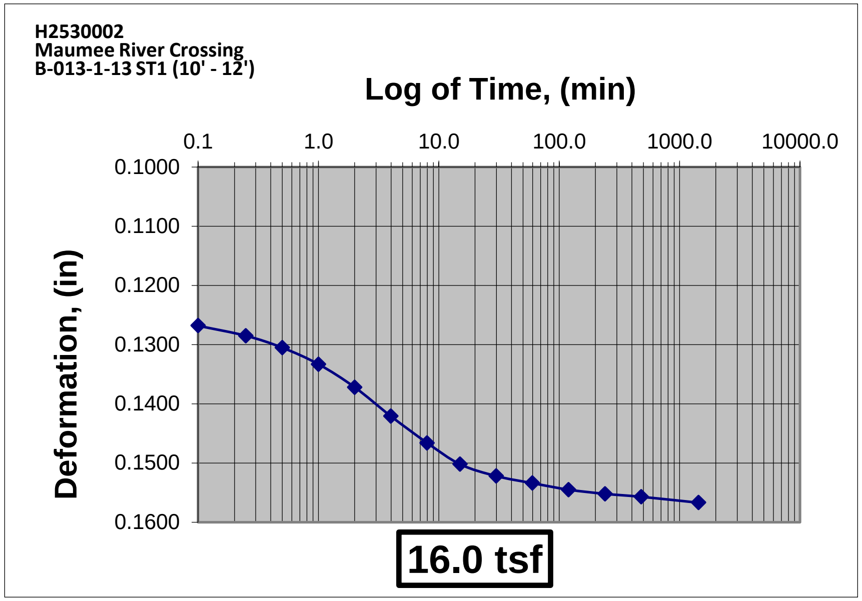

H2530002
Maumee River Crossing
B-013-1-13 ST1 (10' - 12')
Log of Time, (min)
0.1
1.0
10.0
100.0
1000.0
10000.0
Deformation, (in)
0.1000
0.1100
0.1200
0.1300
0.1400
0.1500
0.1600
16.0 tsf

Photo 1: B-005-0-13 Rock Core

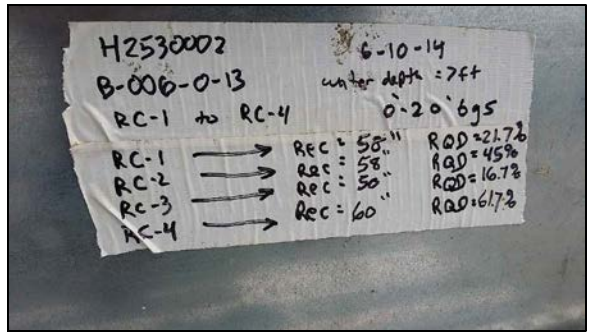


Photo 2: B-006-0-13 Rock Core

Photo 3: B-006-0-13 Rock Core – Left

Photo 4: B-006-0-13 Rock Core – Left Center

Photo 5: B-006-0-13 Rock Core – Right Center

Photo 6: B-006-0-13 Rock Core – Right

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Photo 7: B-007-0-13 Rock Core

Photo 8: B-007-0-13 Rock Core – Left

Photo 9: B-007-0-13 Rock Core – Left Center

Photo 10: B-007-0-13 Rock Core – Right Center

Photo 11: B-006-0-13 Rock Core – Right

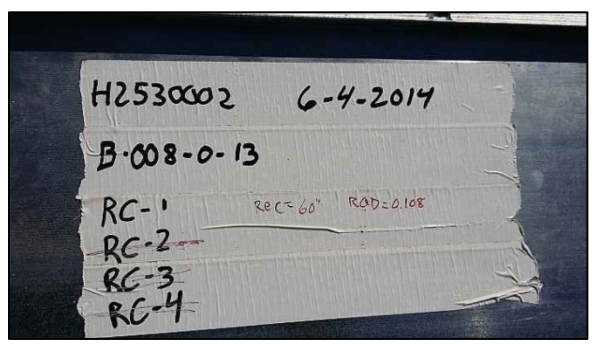

Photo 12: B-008-0-13 Rock Core (6/4/14)

Photo 13: B-008-0-13 Rock Core – Left (6/4/14)

Photo 14: B-008-0-13 Rock Core – Left Center (6/4/14)

Photo 15: B-008-0-13 Rock Core – Right Center (6/4/14)

Photo 16: B-008-0-13 Rock Core – Right (6/4/14)

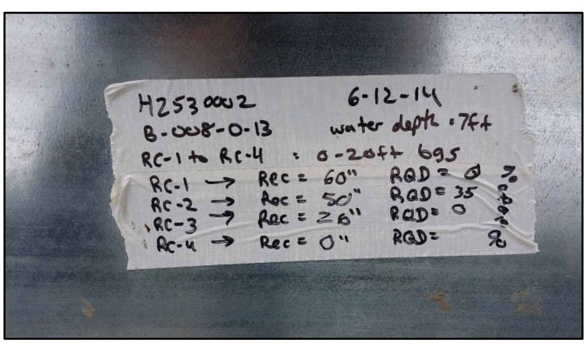

Photo 17: B-008-0-13 Rock Core (6/12/14)

Photo 18: B-008-0-13 Rock Core – Left (6/12/14)

Photo 19: B-008-0-13 Rock Core – Left Center (6/12/14)

Photo 20: B-008-0-13 Rock Core – Right Center (6/12/14)

Photo 21: B-008-0-13 Rock Core – Right (6/12/14)

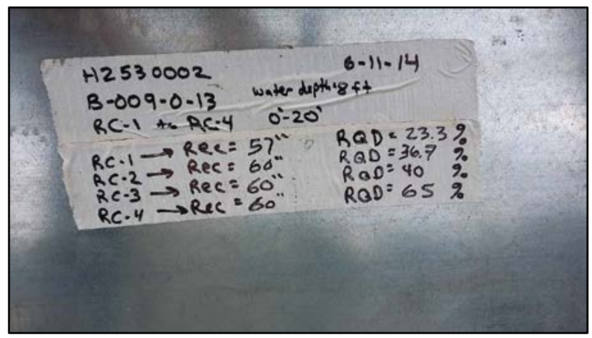

Photo 22: B-009-0-13 Rock Core

Photo 23: B-009-0-13 Rock Core – Left

Photo 24: B-009-0-13 Rock Core – Center

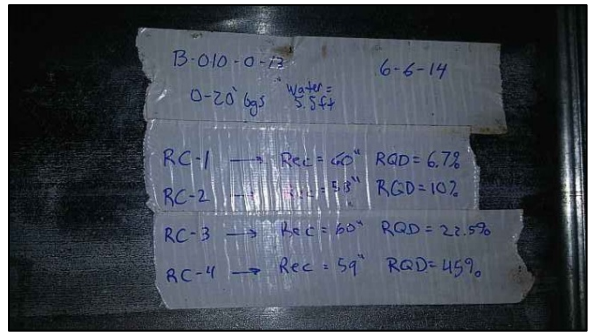

Photo 25: B-009-0-13 Rock Core - Right

Photo 26: B-010-0-13 Rock Core

Photo 27: B-010-0-13 Rock Core – Left

Photo 28: B-010-0-13 Rock Core – Left Center

Photo 29: B-010-0-13 Rock Core – Right Center

Photo 30: B-010-0-13 Rock Core – Right

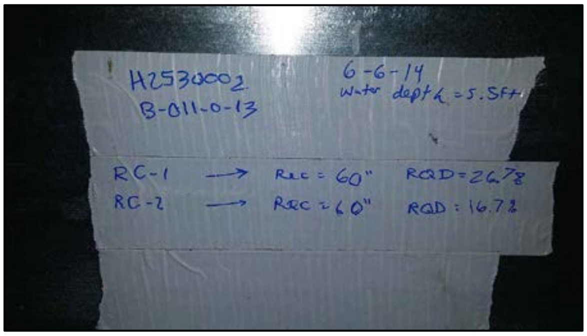

Photo 31: B-011-0-13 Rock Core

Photo 32: B-011-0-13 Rock Core – Left

Photo 33: B-011-0-13 Rock Core – Left Center

Photo 34: B-011-0-13 Rock Core - Center

Photo 35: B-011-0-13 Rock Core – Right Center

Photo 36: B-011-0-13 Rock Core - Right

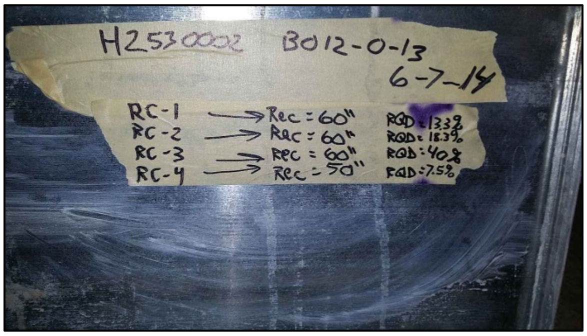

Photo 37: B-012-0-13 Rock Core

Photo 38: B-012-0-13 Rock Core – Left

Photo 39: B-012-0-13 Rock Core – Center

Photo 40: B-012-0-13 Rock Core – Right

Photo 41: B-013-1-13 Rock Core

APPENDIX C

CALCULATIONS

NEW MAUMEE RIVER CROSSING – PID NO. 22984

BRIDGE PIERS – SHALLOW SPREAD FOOTINGS

– SERVICE STATE FACTORED BEARING RESISTANCE

AASHTO LRFD TABLE C10.6.2.6.1-1 → WEATHERED SHALE

PRESUMPTIVE BEARING RESISTANCE = 20 ksf

– STRENGTH LIMIT STATE FACTORED BEARING RESISTANCE –

- METHOD 1 – CARTER & KULHAWY (1988) pp 27 OF FHWA-IF-025

$q_n = [s^{0.5} + (m s^{0.5} + s)^{0.5}] q_u$ (Eq. 11.7)

ROCK TYPE = 8
ROCK IS FAIR TO POOR
$m = 0.10$
$s = 5.5 \times 10^{-5}$
$q_u = 4250$ psi

B-011 UCS 0'-5' = 4644 psi
B-012 UCS 0'-5' = 5539 psi
AVERAGE ALL = 4,250 psi

$q_n = \left[(5.5 \times 10^{-5})^{0.5} + \left((0.1 \times 5.5 \times 10^{-5})^{0.5} + 5.5 \times 10^{-5} \right)^{0.5} \right] 4250\,psi = 151.4\,psi = \underline{21.8\,ksf}$

- METHOD 2 – RULE OF THUMB REDUCTION FACTOR

$q_{ALL} = 0.15\,(q_u)$
$= 0.15(4250\,psi) = 637.5\,psi = \underline{91.8\,ksf}$

- METHOD 3 – ASSUME HARD CLAY

$q_n = 9\,S_u = 9(4.5\,ksf) = \underline{40.5\,ksf}$

AVERAGE $= (21.8 + 91.8 + 40.5\,ksf) / 3 = \underline{51.4\,ksf}$

- FACTORED BEARING RESISTANCE

$q_R = \phi q_N$

$\phi = 0.45$ AASHTO LRFD TABLE 10.5.5.2.2-1

$q_R = 0.45(51.4\,ksf)$

$q_R = 23.13$ ksf ⇒ REPORT $q_R = 23$ ksf

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JOB H2530002

SHEET NO. 2 OF 2

CALCULATED BY CAR DATE 8/6/14

CHECKED BY JLS DATE 8/14/14

SCALE

COEFFICIENT OF FRICTION - SLIDING RESISTANCE

SHALE BEDROCK $\phi = 27°$ AASHTO TABLE C10.4.6.4-1

$\tan(27) = \underline{\underline{0.51}}$

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JOB H2530002
SHEET NO. 1 OF
CALCULATED BY CAR DATE 4/21/15
CHECKED BY JLS DATE 5/4/15
SCALE

PILE DOWNDRAG - REAR ABUTMENT

PILE CAP — 651.7 (0)

SOFT/MS CLAY — γ = 120 pcf, C = 750 psf — 646.7 (5)

V. STIFF CLAY — γ = 128 pcf, C = 1200 psf — 644.2 (7.5)

643.2 (8.5) → 0.4" SETTLEMENT

V. STIFF CLAY — γ = 130 pcf, C = 2200 psf — 641.7 (10)

HARD SANDY SILT — γ = 135 psf, C = 2350 — ∇ 638.7 (13) — 633.2 (18.5)

SHALE — γ = 145 pcf, C = 288,000 psf

TOTAL SETTLEMENT = 1.59"

> 0.4" CAN CAUSE DOWNDRAG

1.59" - 0.4" = 1.19" → OCCURS @ 643.2 (8.5' BELOW CAP)

HP10 x 42

ULT SKIN FROM DRIVEN: 21.3 KIP

DD = 21.3 KIP (1.4) = 30 KIP/PILE

HP12 x 53

ULT SKIN FROM DRIVEN: 25.8 KIP

DD = 25.8 KIP (1.4) = 36 KIP/PILE

HP 14 x 73

ULT SKIN FROM DRIVEN: 30.5

DD = 30.5 KIP (1.4) = 43 KIP/PILE

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: W:\PROJECTS\PROJEC~2\H2530002\22984\GEOTEC~1\ENGAPPS\DRIVEN\REARABUT.DVN
Project Name: Industrial Drive Project Date: 04/21/2015
Project Client: Henry County
Computed By: C. Riharb
Project Manager: R. Bertz

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	13.00 ft
	- Driving/Restrike	13.00 ft
	- Ultimate:	13.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	5.00 ft	0.00%	120.00 pcf	750.00 psf	T-79 Steel
2	Cohesive	2.50 ft	0.00%	128.00 pcf	1200.00 psf	T-79 Steel
3	Cohesive	2.50 ft	0.00%	130.00 pcf	2200.00 psf	T-79 Steel
4	Cohesive	8.50 ft	0.00%	135.00 pcf	2350.00 psf	T-79 Steel
5	Cohesive	10.00 ft	0.00%	145.00 pcf	288000.00 psf	T-79 Steel

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	10.24 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	10.29 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	17.68 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	17.74 Kips
9.99 ft	Cohesive	N/A	N/A	1149.11 psf	27.14 Kips
10.01 ft	Cohesive	N/A	N/A	1103.58 psf	27.21 Kips
18.49 ft	Cohesive	N/A	N/A	1266.87 psf	62.63 Kips
18.51 ft	Cohesive	N/A	N/A	966.76 psf	62.70 Kips
27.51 ft	Cohesive	N/A	N/A	1141.85 psf	96.58 Kips
28.49 ft	Cohesive	N/A	N/A	1160.91 psf	100.90 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	4.58 Kips	4.60 Kips
4.99 ft	10.24 Kips	4.58 Kips	14.82 Kips
5.01 ft	10.29 Kips	7.33 Kips	17.62 Kips
7.49 ft	17.68 Kips	7.33 Kips	25.01 Kips
7.51 ft	17.74 Kips	13.44 Kips	31.18 Kips
9.99 ft	27.14 Kips	13.44 Kips	40.58 Kips
10.01 ft	27.21 Kips	14.35 Kips	41.57 Kips
18.49 ft	62.63 Kips	14.35 Kips	76.98 Kips
18.51 ft	62.70 Kips	1759.14 Kips	1821.84 Kips
27.51 ft	96.58 Kips	1759.14 Kips	1855.72 Kips
28.49 ft	100.90 Kips	1759.14 Kips	1860.04 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	10.24 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	10.29 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	17.68 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	17.74 Kips
9.99 ft	Cohesive	N/A	N/A	1149.11 psf	27.14 Kips
10.01 ft	Cohesive	N/A	N/A	1103.58 psf	27.21 Kips
18.49 ft	Cohesive	N/A	N/A	1266.87 psf	62.63 Kips
18.51 ft	Cohesive	N/A	N/A	966.76 psf	62.70 Kips
27.51 ft	Cohesive	N/A	N/A	1141.85 psf	96.58 Kips
28.49 ft	Cohesive	N/A	N/A	1160.91 psf	100.90 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	4.58 Kips	4.60 Kips
4.99 ft	10.24 Kips	4.58 Kips	14.82 Kips
5.01 ft	10.29 Kips	7.33 Kips	17.62 Kips
7.49 ft	17.68 Kips	7.33 Kips	25.01 Kips
7.51 ft	17.74 Kips	13.44 Kips	31.18 Kips
9.99 ft	27.14 Kips	13.44 Kips	40.58 Kips
10.01 ft	27.21 Kips	14.35 Kips	41.57 Kips
18.49 ft	62.63 Kips	14.35 Kips	76.98 Kips
18.51 ft	62.70 Kips	1759.14 Kips	1821.84 Kips
27.51 ft	96.58 Kips	1759.14 Kips	1855.72 Kips
28.49 ft	100.90 Kips	1759.14 Kips	1860.04 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	10.24 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	10.29 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	17.68 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	17.74 Kips
9.99 ft	Cohesive	N/A	N/A	1149.11 psf	27.14 Kips
10.01 ft	Cohesive	N/A	N/A	1103.58 psf	27.21 Kips
18.49 ft	Cohesive	N/A	N/A	1266.87 psf	62.63 Kips
18.51 ft	Cohesive	N/A	N/A	966.76 psf	62.70 Kips
27.51 ft	Cohesive	N/A	N/A	1141.85 psf	96.58 Kips
28.49 ft	Cohesive	N/A	N/A	1160.91 psf	100.90 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	4.58 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	7.33 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	13.44 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	14.35 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	1759.14 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	4.58 Kips	4.60 Kips
4.99 ft	10.24 Kips	4.58 Kips	14.82 Kips
5.01 ft	10.29 Kips	7.33 Kips	17.62 Kips
7.49 ft	17.68 Kips	7.33 Kips	25.01 Kips
7.51 ft	17.74 Kips	13.44 Kips	31.18 Kips
9.99 ft	27.14 Kips	13.44 Kips	40.58 Kips
10.01 ft	27.21 Kips	14.35 Kips	41.57 Kips
18.49 ft	62.63 Kips	14.35 Kips	76.98 Kips
18.51 ft	62.70 Kips	1759.14 Kips	1821.84 Kips
27.51 ft	96.58 Kips	1759.14 Kips	1855.72 Kips
28.49 ft	100.90 Kips	1759.14 Kips	1860.04 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: W:\PROJECTS\PROJEC~2\H2530002\22984\GEOTEC~1\ENGAPPS\DRIVEN\REARABUT.DVN
Project Name: Industrial Drive   Project Date: 04/21/2015
Project Client: Henry County
Computed By: C. Riharb
Project Manager: R. Bertz

PILE INFORMATION

Pile Type: H Pile - HP12X53
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	13.00 ft
	- Driving/Restrike	13.00 ft
	- Ultimate:	13.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	5.00 ft	0.00%	120.00 pcf	750.00 psf	T-79 Steel
2	Cohesive	2.50 ft	0.00%	128.00 pcf	1200.00 psf	T-79 Steel
3	Cohesive	2.50 ft	0.00%	130.00 pcf	2200.00 psf	T-79 Steel
4	Cohesive	8.50 ft	0.00%	135.00 pcf	2350.00 psf	T-79 Steel
5	Cohesive	10.00 ft	0.00%	145.00 pcf	288000.00 psf	T-79 Steel

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	12.33 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	12.40 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	21.30 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	21.38 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	32.41 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	32.49 Kips
18.49 ft	Cohesive	N/A	N/A	1208.64 psf	73.20 Kips
18.51 ft	Cohesive	N/A	N/A	907.87 psf	73.29 Kips
27.51 ft	Cohesive	N/A	N/A	1054.32 psf	110.97 Kips
28.49 ft	Cohesive	N/A	N/A	1070.26 psf	115.71 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	6.65 Kips	6.68 Kips
4.99 ft	12.33 Kips	6.65 Kips	18.99 Kips
5.01 ft	12.40 Kips	10.64 Kips	23.04 Kips
7.49 ft	21.30 Kips	10.64 Kips	31.94 Kips
7.51 ft	21.38 Kips	19.51 Kips	40.89 Kips
9.99 ft	32.41 Kips	19.51 Kips	51.92 Kips
10.01 ft	32.49 Kips	20.84 Kips	53.33 Kips
18.49 ft	73.20 Kips	20.84 Kips	94.04 Kips
18.51 ft	73.29 Kips	2554.02 Kips	2627.31 Kips
27.51 ft	110.97 Kips	2554.02 Kips	2664.99 Kips
28.49 ft	115.71 Kips	2554.02 Kips	2669.73 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	12.33 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	12.40 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	21.30 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	21.38 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	32.41 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	32.49 Kips
18.49 ft	Cohesive	N/A	N/A	1208.64 psf	73.20 Kips
18.51 ft	Cohesive	N/A	N/A	907.87 psf	73.29 Kips
27.51 ft	Cohesive	N/A	N/A	1054.32 psf	110.97 Kips
28.49 ft	Cohesive	N/A	N/A	1070.26 psf	115.71 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	6.65 Kips	6.68 Kips
4.99 ft	12.33 Kips	6.65 Kips	18.99 Kips
5.01 ft	12.40 Kips	10.64 Kips	23.04 Kips
7.49 ft	21.30 Kips	10.64 Kips	31.94 Kips
7.51 ft	21.38 Kips	19.51 Kips	40.89 Kips
9.99 ft	32.41 Kips	19.51 Kips	51.92 Kips
10.01 ft	32.49 Kips	20.84 Kips	53.33 Kips
18.49 ft	73.20 Kips	20.84 Kips	94.04 Kips
18.51 ft	73.29 Kips	2554.02 Kips	2627.31 Kips
27.51 ft	110.97 Kips	2554.02 Kips	2664.99 Kips
28.49 ft	115.71 Kips	2554.02 Kips	2669.73 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.02 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	12.33 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	12.40 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	21.30 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	21.38 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	32.41 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	32.49 Kips
18.49 ft	Cohesive	N/A	N/A	1208.64 psf	73.20 Kips
18.51 ft	Cohesive	N/A	N/A	907.87 psf	73.29 Kips
27.51 ft	Cohesive	N/A	N/A	1054.32 psf	110.97 Kips
28.49 ft	Cohesive	N/A	N/A	1070.26 psf	115.71 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	6.65 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	10.64 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	19.51 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	20.84 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	2554.02 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	6.65 Kips	6.68 Kips
4.99 ft	12.33 Kips	6.65 Kips	18.99 Kips
5.01 ft	12.40 Kips	10.64 Kips	23.04 Kips
7.49 ft	21.30 Kips	10.64 Kips	31.94 Kips
7.51 ft	21.38 Kips	19.51 Kips	40.89 Kips
9.99 ft	32.41 Kips	19.51 Kips	51.92 Kips
10.01 ft	32.49 Kips	20.84 Kips	53.33 Kips
18.49 ft	73.20 Kips	20.84 Kips	94.04 Kips
18.51 ft	73.29 Kips	2554.02 Kips	2627.31 Kips
27.51 ft	110.97 Kips	2554.02 Kips	2664.99 Kips
28.49 ft	115.71 Kips	2554.02 Kips	2669.73 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: W:\PROJECTS\PROJEC~2\H2530002\22984\GEOTEC~1\ENGAPPS\DRIVEN\REARABUT.DVN
Project Name: Industrial Drive Project Date: 04/21/2015
Project Client: Henry County
Computed By: C. Riharb
Project Manager: R. Bertz

PILE INFORMATION

Pile Type: H Pile - HP14X73
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	13.00 ft
	- Driving/Restrike	13.00 ft
	- Ultimate:	13.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	5.00 ft	0.00%	120.00 pcf	750.00 psf	T-79 Steel
2	Cohesive	2.50 ft	0.00%	128.00 pcf	1200.00 psf	T-79 Steel
3	Cohesive	2.50 ft	0.00%	130.00 pcf	2200.00 psf	T-79 Steel
4	Cohesive	8.50 ft	0.00%	135.00 pcf	2350.00 psf	T-79 Steel
5	Cohesive	10.00 ft	0.00%	145.00 pcf	288000.00 psf	T-79 Steel

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.03 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	14.60 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	14.67 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	25.20 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	25.30 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	38.35 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	38.45 Kips
18.49 ft	Cohesive	N/A	N/A	1156.78 psf	84.55 Kips
18.51 ft	Cohesive	N/A	N/A	855.41 psf	84.65 Kips
27.51 ft	Cohesive	N/A	N/A	976.36 psf	125.95 Kips
28.49 ft	Cohesive	N/A	N/A	989.53 psf	131.07 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	9.30 Kips	9.33 Kips
4.99 ft	14.60 Kips	9.30 Kips	23.90 Kips
5.01 ft	14.67 Kips	14.89 Kips	29.56 Kips
7.49 ft	25.20 Kips	14.89 Kips	40.09 Kips
7.51 ft	25.30 Kips	27.29 Kips	52.59 Kips
9.99 ft	38.35 Kips	27.29 Kips	65.65 Kips
10.01 ft	38.45 Kips	29.15 Kips	67.61 Kips
18.49 ft	84.55 Kips	29.15 Kips	113.71 Kips
18.51 ft	84.65 Kips	3573.00 Kips	3657.65 Kips
27.51 ft	125.95 Kips	3573.00 Kips	3698.95 Kips
28.49 ft	131.07 Kips	3573.00 Kips	3704.07 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.03 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	14.60 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	14.67 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	25.20 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	25.30 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	38.35 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	38.45 Kips
18.49 ft	Cohesive	N/A	N/A	1156.78 psf	84.55 Kips
18.51 ft	Cohesive	N/A	N/A	855.41 psf	84.65 Kips
27.51 ft	Cohesive	N/A	N/A	976.36 psf	125.95 Kips
28.49 ft	Cohesive	N/A	N/A	989.53 psf	131.07 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	9.30 Kips	9.33 Kips
4.99 ft	14.60 Kips	9.30 Kips	23.90 Kips
5.01 ft	14.67 Kips	14.89 Kips	29.56 Kips
7.49 ft	25.20 Kips	14.89 Kips	40.09 Kips
7.51 ft	25.30 Kips	27.29 Kips	52.59 Kips
9.99 ft	38.35 Kips	27.29 Kips	65.65 Kips
10.01 ft	38.45 Kips	29.15 Kips	67.61 Kips
18.49 ft	84.55 Kips	29.15 Kips	113.71 Kips
18.51 ft	84.65 Kips	3573.00 Kips	3657.65 Kips
27.51 ft	125.95 Kips	3573.00 Kips	3698.95 Kips
28.49 ft	131.07 Kips	3573.00 Kips	3704.07 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	622.50 psf	0.03 Kips
4.99 ft	Cohesive	N/A	N/A	622.50 psf	14.60 Kips
5.01 ft	Cohesive	N/A	N/A	904.00 psf	14.67 Kips
7.49 ft	Cohesive	N/A	N/A	904.00 psf	25.20 Kips
7.51 ft	Cohesive	N/A	N/A	1120.00 psf	25.30 Kips
9.99 ft	Cohesive	N/A	N/A	1120.00 psf	38.35 Kips
10.01 ft	Cohesive	N/A	N/A	1072.50 psf	38.45 Kips
18.49 ft	Cohesive	N/A	N/A	1156.78 psf	84.55 Kips
18.51 ft	Cohesive	N/A	N/A	855.41 psf	84.65 Kips
27.51 ft	Cohesive	N/A	N/A	976.36 psf	125.95 Kips
28.49 ft	Cohesive	N/A	N/A	989.53 psf	131.07 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
4.99 ft	Cohesive	N/A	N/A	N/A	9.30 Kips
5.01 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	14.89 Kips
7.51 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
9.99 ft	Cohesive	N/A	N/A	N/A	27.29 Kips
10.01 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.49 ft	Cohesive	N/A	N/A	N/A	29.15 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips
28.49 ft	Cohesive	N/A	N/A	N/A	3573.00 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	9.30 Kips	9.33 Kips
4.99 ft	14.60 Kips	9.30 Kips	23.90 Kips
5.01 ft	14.67 Kips	14.89 Kips	29.56 Kips
7.49 ft	25.20 Kips	14.89 Kips	40.09 Kips
7.51 ft	25.30 Kips	27.29 Kips	52.59 Kips
9.99 ft	38.35 Kips	27.29 Kips	65.65 Kips
10.01 ft	38.45 Kips	29.15 Kips	67.61 Kips
18.49 ft	84.55 Kips	29.15 Kips	113.71 Kips
18.51 ft	84.65 Kips	3573.00 Kips	3657.65 Kips
27.51 ft	125.95 Kips	3573.00 Kips	3698.95 Kips
28.49 ft	131.07 Kips	3573.00 Kips	3704.07 Kips

DRILLED SHAFT CAPACITY CALCULATIONS

Project No:	H2530002
Project Name:	Henry County River Crossing Design
References:	2012 AASHTO LRFD Bridge Design Specifications
	2010 FHWA GEC 10; Drilled Shafts: Construction Procedures & LRFD Design Methods
	1999 O'Neill & Reese, Drilled Shafts: Construction Procedures and Design Methods
Computed by:	SD
Date:	2/10/2015
Checked by:	JLS
Date:	4/21/15

BORING SUMMARY

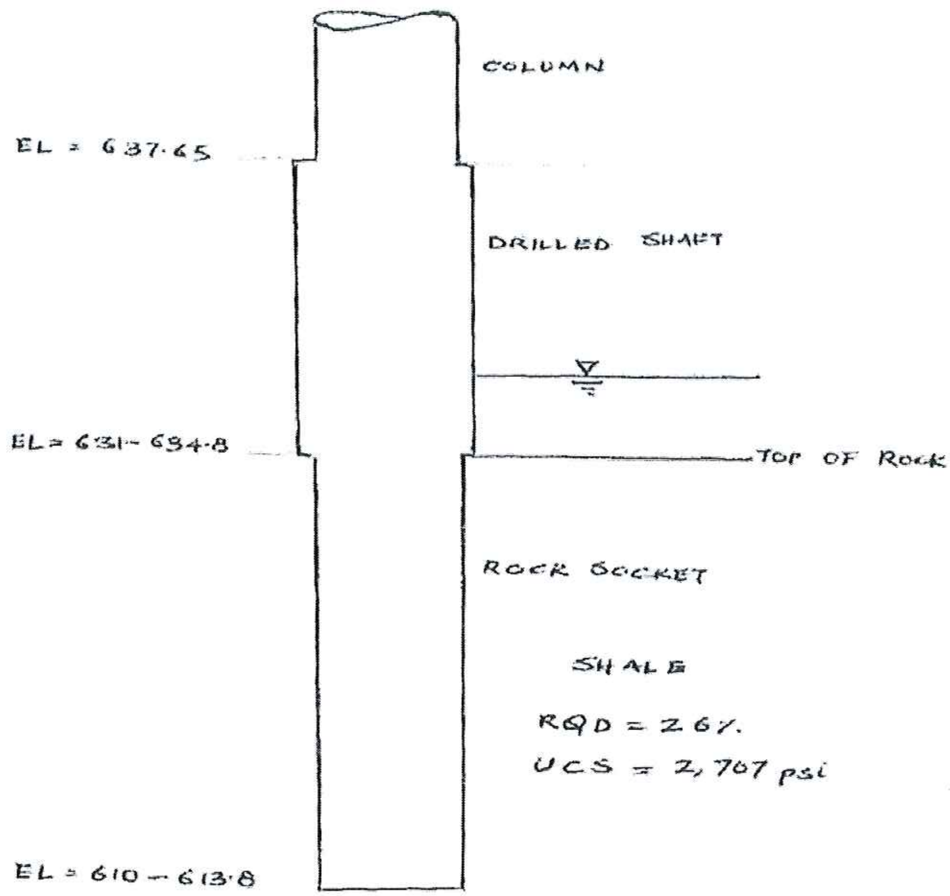
Summary of properties of shale encountered in borings in the vicinity of the drilled shaft locations

Boring	Property	Depth (ft)				
		0-5	5-10	10-15	15-20	Average
B-006-0-13	RQD	22	45	17	62	36.5
	UCS (psi)[1]	-	1423	-	1641	1532
	Joint spacing (in)	2.0	3.1	1.9	4.2	2.8
B-007-0-13	RQD	9	29	42	43	30.75
	UCS (psi)	-	4446	-	-	4446
	Joint spacing (in)	1.6	2.3	2.9	3.0	2.4
B-008-1-13	RQD	0	35	0	0	8.75
	UCS (psi)	-	4862	-		4862
	Joint spacing (in)	1.4	2.6	1.4	1.4	1.7
B-009-0-13	RQD	23	37	40	65	41.25
	UCS (psi)[1]	-	-	-	1451	1451
	Joint spacing (in)	2.1	2.7	2.8	4.4	3.0
B-010-0-13	RQD	7	10	23	45	21.25
	UCS (psi)	-	7676	-	-	7676
	Joint spacing (in)	1.5	1.6	2.1	3.1	2.1
B-011-0-13	RQD	27	17			22
	UCS (psi)	-	4644			4644
	Joint spacing (in)	2.2	1.9	1.4	1.4	1.7
B-012-0-13	RQD	13	18	40	8	19.75
	UCS (psi)	-	5539	-	6652	6095.5
	Joint spacing (in)	1.7	1.9	2.8	1.6	2.0
Design	RQD	**25.8**				
	UCS (ksf/psi)[2]	**390**			**2707**	

1. Unconfined Compressive Strength (UCS) tests at Borings B-006-0-13 and B-009-0-13 are determined to be low relative to the other boring locations
2. The weighted average (70% weight assigned to values at B-006 and B-009) of the UCS.

Project No:	H2530002
Computed by:	SD
Date:	2/10/2015
Checked by:	JLS
Date:	4/21/15

SOIL PROFILE



1. Elevation of top of bedrock varies at the various drilled shaft locations.
2. Depth of Rock socket decided based on the analyses below.
3. The drilled shaft above the bedrock is covered with casing to prevent inflow of water during placing of concrete.
4. The normal high water elevation is 636.65 feet

Project No:	H2530002
Computed by:	SD
Date:	2/10/2015
Checked by:	J/LS
Date:	4/21/15

MATERIAL AND LOAD PARAMETERS

ROCK PROPERTIES

Unit Weight of Shale (pcf)	141	
Design UCS (ksf)	390	
Average RQD (%)	26	
Average spacing of joints (in)	2.24	
Discontinuity of aperture (in)	0.1	
Geological Strength Index (GSI)	36	Ref: FHWA GEC10 Figure 3-10
Elastic Modulus of Intact Rock (ksi)	1420	Ref: AASHTO LRFD Table C10.4.6.5-1

CONCRETE PROPERTIES

Unit Weight of Concrete (pcf)	150
Elastic Modulus of Concrete (ksi)	3500
Concrete Compressive strength (ksi)	4

DESIGN COLUMN LOADS

Design Factored Service Column Load (kips)	980
Design Factored Strength Column Load (kips)	1300

ROCK MASS RATING (RMR)

Ref: AASHTO LRFD Table 10.4.5.4-1 to 3

Parameter	Value	RMR
UCS (ksf)	390	5
RQD (%)	26	8
Spacing of joints (in)	2.2	10
Condition of joints[1]	4	6
Groundwater condition	moist	7
Rating for foundation[2]	fair	-7

RMR		**29**
Rock Mass Class	Poor rock	**IV**

1. Joint aperture size estimated to be approximately 0.1 inches
2. Joints are found to be fairly horizontal

Project No:	H2530002
Computed by:	SD
Date:	2/10/2015
Checked by:	JLS
Date:	4/21/15

RESISTANCE DESIGN

END BEARING RESISTANCE DESIGN

Ref: FHWA GEC10

UCS, qu (ksf)	390	
Spacing between discontinuities, sv (in)	2.24	
Discontinuity aperture, td (in)	0.1	
Socket diameter, B (ft)[1]	**5.5**	
Depth of socket embedment, D (ft)[1]	**11**	
Geological strength Index, GSI	36	Figure 3-10
s	0.00082	Eq: 3-27
mi	6	Table 3-8
mb	0.61	Eq: 3-26
a	0.51	Eq: 3-28
Unit weight of Shale (pcf)	141	
Vertical effective stress at the bearing surface, σvb' (ksf)	1.55	
A	21.96	Eq: 13-24
End Bearing resistance, qBN (ksf)	**91.52**	Eq: 13-25

SIDE RESISTANCE DESIGN

Ref: O' Neill & Reese (1999)

UCS, qu (ksf)	390	
Atmospheric pressure, pa (ksf)	2.12	
Socket diameter, B (ft)[1]	5.5	
Depth of socket embedment, D (ft)[1]	11	
Depth of resistance (ft)[2]	6	
Concrete compressive strength (ksi)	4	
The depth to half of socket embedment, Z* (ft)	5.5	
Density of shale (pcf)	141	
Stress at z*, σn (ksf)	0.51	Eq: 11.23
σn/Pa	0.24	
Design UCS, qu (Mpa)	19	
α (30°)	0.05	Fig: 11.5
φrc (°)	20	Pg: B-42
α (φrc°)	0.03	

Project No:	H2530002
Computed by:	SD
Date:	2/10/2015
Checked by:	JLS
Date:	4/21/15

φ	0.45	Table: 11.4
fmax	5.5	Eq: 11.21
Side Resistance qs (ksf)	**5.5**	Pg: B-42

COMBINED END BEARING AND SIDE RESISTANCE

Ref: AASHTO LRFD

Resistance factor for end bearing, φqp	0.5	Table 10.5.5.2.4-1
Resistance factor for side resistance, φqs	0.55	Table 10.5.5.2.4-1
End Bearing resistance (ksf)	91.5	
Side Resistance (ksf)	5.5	
Height of drilled shaft above bedrock (ft)[3]	6.7	
Unit weight of Concrete (pcf)	150	
Weight of Drilled shaft (kips)[4]	67.4	
Factored Strength Column Load (kips)	1300	
Factored Strength Load plus shaft weight (kips)	**1384**	
Total Factored Resistance (kips)	**1403**	**<<OK>>**

Minimum Depth of Rock Socket Required (ft)[5]	8.25
Diameter of Rock Socket (ft)[1]	**5.5**
Depth of Rock Socket (ft)[1]	**11**

1. The socket diameter and depth of socket embedment determined from the trial and error evaluation of the combined factored resistance with the factored design load
2. The resistance of top 5 feet of rock is neglected. This would incorporate loss of side resistance due to scour effects
3. The maximum height of drilled shaft above bedrock from all the drilled shaft locations
4. A load factor of 1.25 is assumed for the drilled shaft weight based on Table 3.4.1-2
5. The depth of rock socket should be greater than 1.5 times the diamater

Project No:	H2530002
Computed by:	SD
Date:	2/10/2015
Checked by:	JLS
Date:	4/21/15

SETTLEMENT CALCULATION

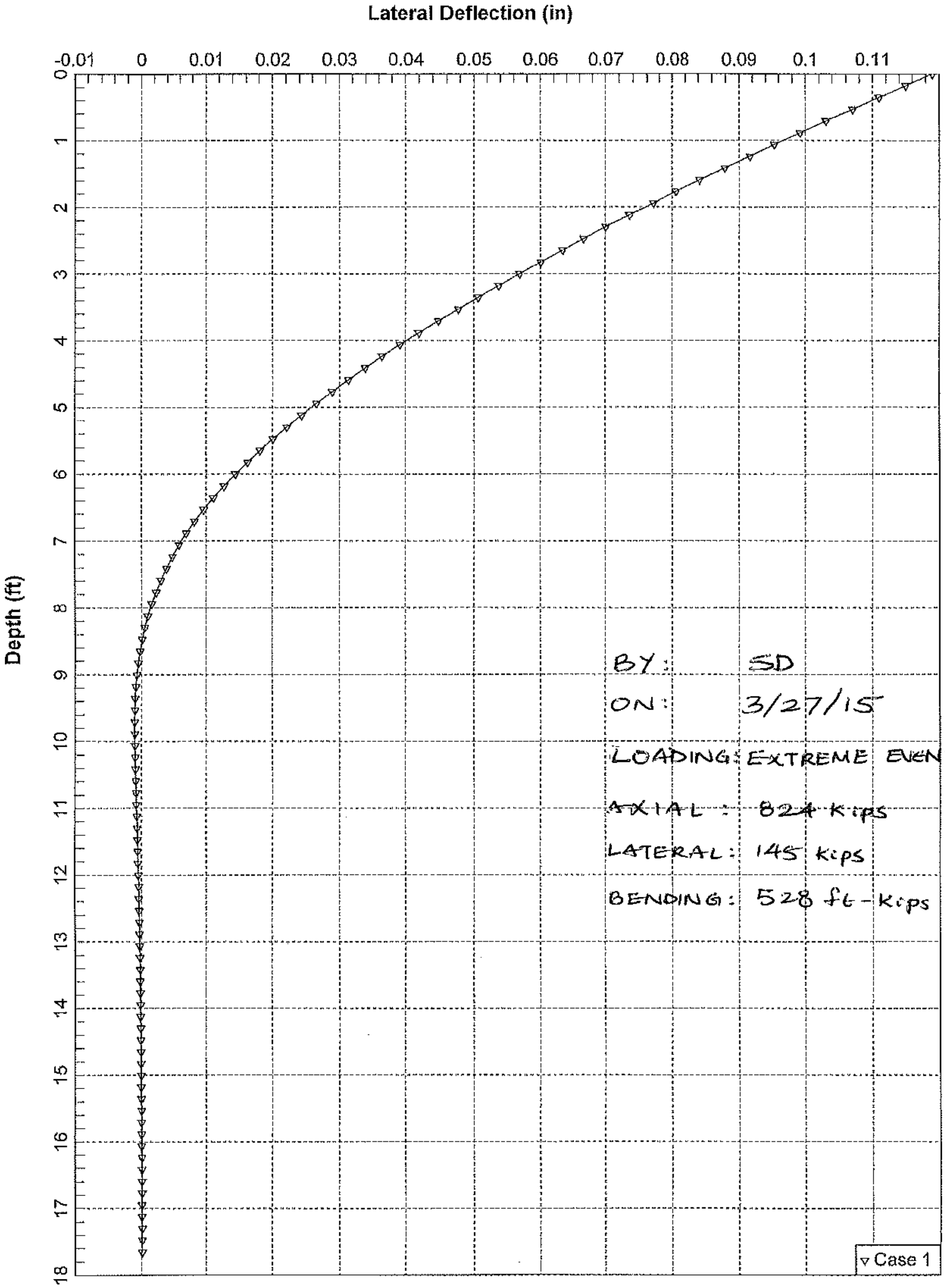
Ref: O' Neill & Reese (1999)

Depth of socket embedment, D (ft)	11	
Socket diameter, B (ft)	5.5	
UCS, qu (ksf)	390	
Service load (kips)	980	
Unit weight of concrete (pcf)	150	
Weight of the shaft (kips)	67	
Factor M[1]	0.8	Fig: B.11
Normal effective stress, σn (ksf)	0.7	Eq: B.38
faa[2]	6	Eq: B.36a
Elastic modulus of intact rock, Ei (ksi)	1420	
Elastic modulus of the rock, Em (ksi)	71	Table 10.4.6.5-1
n[3]	0.12	
Elastic modulus of concrete, Ec (ksi)	3500	
Ω	1.14	Eq: C.20
Γ	0.55	Eq: C.21
Socket head displacement, Wt (ft)[4]	0.007	
Hf	0.72	Eq: C.22
Net bearing stress, qB (ksf)	13.41	Eq: C.24
Load at the top from disp, QT (kips)[4]	**1077**	Eq: C.25
Load applied at top (kips)[4]	**1064**	

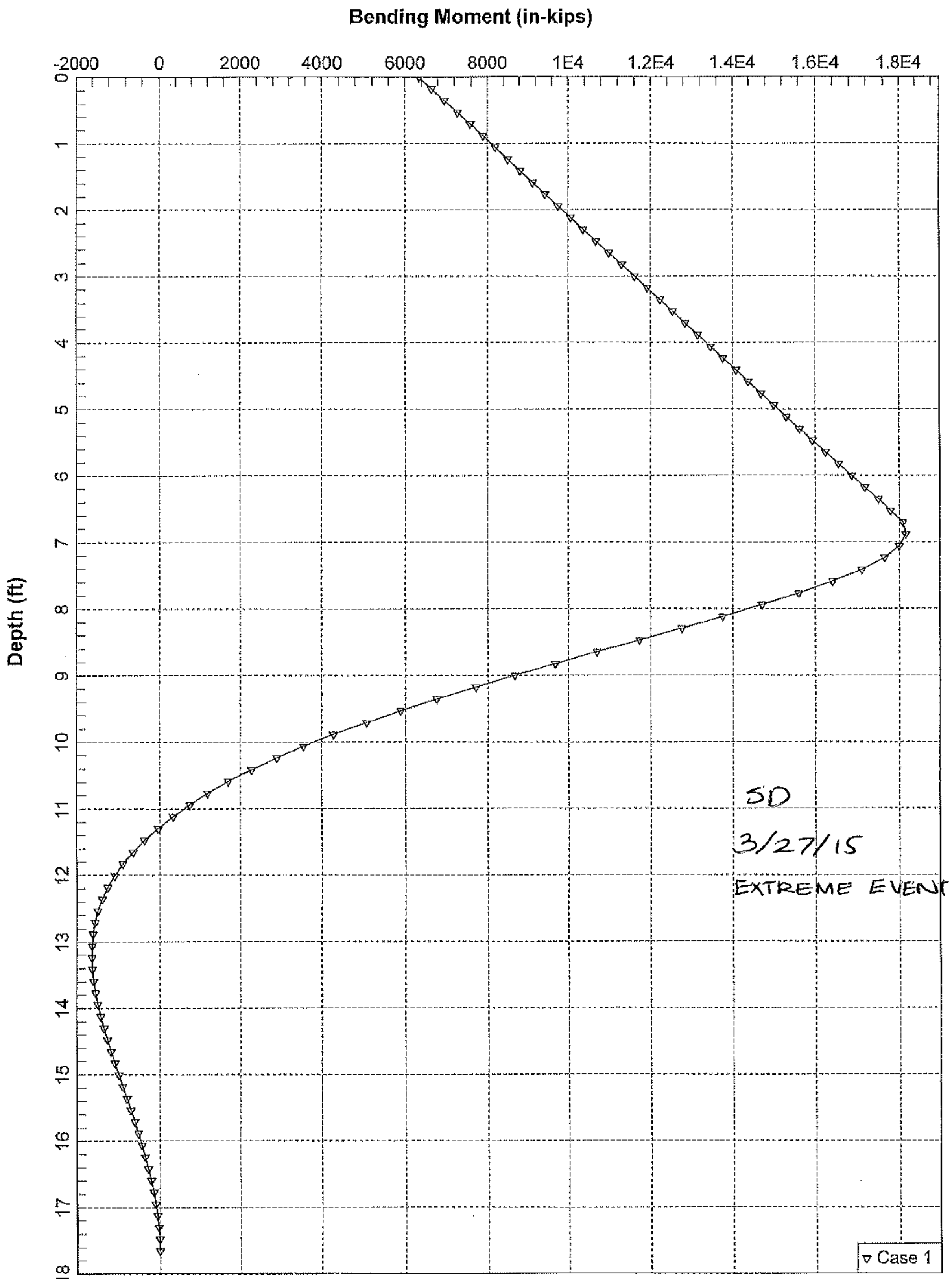
Displacement at service load (in) **0.08**

1. The concrete used for the drilled shaft is assumed to have a slump of 150 mm
2. The drilled shaft is assumed to be smooth; i.e. no artificial roughness is introduced at the interface between the rock and the shaft
3. Assume elastic settlement
4. The socket displacement is determined by trial and error equating the load developed due to the displacement with the design factored service load

Extreme Event I Loading



Extreme Event I Loading



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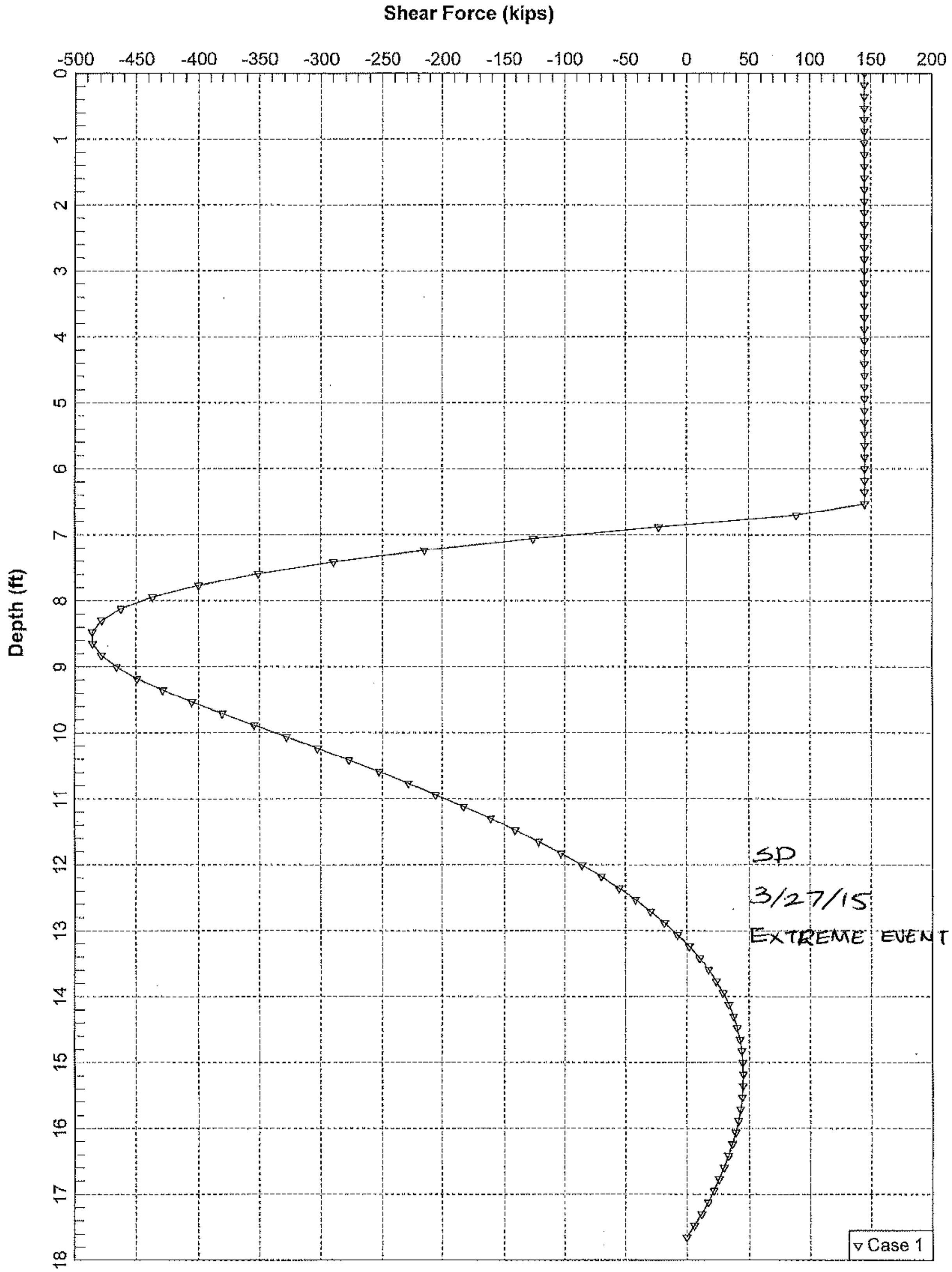

Pier 7 Combined loading_5.5D_11L_EEI.lpo

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LPILE Plus for Windows, Version 5.0 (5.0.38)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

===

This program is licensed to:

Sulaiman Dawood
The Mannik & Smith Group, Inc.

Path to file locations: W:\Projects\Projects F-J\H2530002\22984\geotechnical\Sulaiman - Drilled Shaft Reference Files\Drilled Shaft Analysis\LPILE\5.5D + 11L - Revised\Extreme Event I\
Name of input data file: Pier 7 Combined loading_5.5D_11L_EEI.lpd
Name of output file: Pier 7 Combined loading_5.5D_11L_EEI.lpo
Name of plot output file: Pier 7 Combined loading_5.5D_11L_EEI.lpp
Name of runtime file: Pier 7 Combined loading_5.5D_11L_EEI.lpr

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Time and Date of Analysis

Date: March 27, 2015 Time: 17:52:35

Problem Title

Pier 7 Combined Loading Analysis_5.5D_11L

Program Options

Units Used in Computations - US Customary Units: Inches, Pounds

Basic Program Options:

Analysis Type 3:
- Computation of Nonlinear Bending Stiffness and Ultimate Bending Moment Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments = 100
- Maximum number of iterations allowed = 100
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 1.0000E+02 in

Printing Options:
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (spacing of output points) = 1

Pile Structural Properties and Geometry

Pile Length = 211.80 in

Depth of ground surface below top of pile = 79.80 in

Slope angle of ground surface = .00 deg.

Structural properties of pile defined using 4 points

Point	Depth X in	Pile Diameter in	Moment of Inertia in**4	Pile Area Sq.in	Modulus of Elasticity lbs/Sq.in
1	0.0000	70.75000000	1319167.	4071.5000	3500000.
2	79.8000	70.75000000	1319167.	4071.5000	3500000.
3	79.8000	66.00000000	931420.2000	3421.2000	3500000.
4	211.8000	66.00000000	931420.2000	3421.2000	3500000.

Please note that because this analysis makes computations of ultimate moment capacity and pile response using nonlinear bending stiffness that the above values of moment of inertia and modulus of are not used for any computations other than total stress due to combined axial loading and bending.

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997
Distance from top of pile to top of layer = 79.800 in
Distance from top of pile to bottom of layer = 275.000 in
Initial modulus of rock at top of layer = 7.1000E+04 lbs/in**2
Initial modulus of rock at bottom of layer = 7.1000E+04 lbs/in**2

(Depth of lowest layer extends 63.20 in below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 2 points

Point Depth X Eff. Unit Weight

No.	in	lbs/in**3
1	79.80	.04490
2	275.00	.04490

Shear Strength of Soils

Shear strength parameters with depth defined using 2 points

Point No.	Depth X in	Cohesion c lbs/in**2	Angle of Friction Deg.	E50 or k_rm	RQD %
1	79.800	2700.00000	.00	.00050	26.0
2	275.000	2700.00000	.00	.00050	26.0

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) Values of E50 are reported for clay strata.
(3) Default values will be generated for E50 when input values are 0.
(4) RQD and k_rm are reported only for weak rock strata.

Loading Type

Static loading criteria was used for computation of p-y curves.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Shear force at pile head   =   145000.000 lbs
Bending moment at pile head =   6336000.000 in-lbs
Axial load at pile head   =   824000.000 lbs

Non-zero moment at pile head for this load case indicates the pile-head may rotate under the applied pile-head loading, but is not a free-head (zero moment) condition.

Computations of Ultimate Moment Capacity and Nonlinear Bending Stiffness

---

Number of pile sections = 2

Pile Section No. 1

**** WARNING ****

An unreasonable input value for concrete cover thickness has been specified.
The input value is either smaller than 0.8 inches or larger than 8 inches.
You should check your input for correctness.

The sectional shape is a circular drilled shaft (bored pile).

Outside Diameter = 70.7500 In

Material Properties:

Compressive Strength of Concrete = 4.000 Kip/In**2
Yield Stress of Reinforcement = 60. Kip/In**2
Modulus of Elasticity of Reinforcement = 29000. Kip/In**2
Number of Reinforcing Bars = 20
Area of Single Bar = 1.56000 In**2
Number of Rows of Reinforcing Bars = 11
Area of Steel = 31.200 In**2
Percentage of Steel Reinforcement = .794 percent
Cover Thickness (edge to bar center) = 8.375 In

Unfactored Axial Squash Load Capacity = 22925.80 Kip

Distribution and Area of Steel Reinforcement

Row Number	Area of Reinforcement In**2	Distance to Centroidal Axis In
1	1.560000	26.3750
2	3.120000	25.0841
3	3.120000	21.3378
4	3.120000	15.5028
5	3.120000	8.1503
6	3.120000	.0000
7	3.120000	-8.1503
8	3.120000	-15.5028
9	3.120000	-21.3378
10	3.120000	-25.0841
11	1.560000	-26.3750

Axial Thrust Force = .00 lbs

Bending Moment in-lbs	Bending Stiffness lb-in2	Bending Curvature rad/in	Maximum Strain in/in	Neutral Axis Position inches	Max. Concrete Stress psi	Max. Steel Stress psi
4418885.	4.418885E+12	.00000100	.00003537	35.37498313	125.32460	764.87549
4418885.	8.837770E+11	.00000500	.00008570	17.14048392	294.28715	6468.37982
6927355.	7.697061E+11	.00000900	.00015474	17.19365221	521.72855	11629.20674
9981163.	7.677818E+11	.00001300	.00022422	17.24806875	741.94219	

16777.22804

13018906.	7.658180E+11	.00001700	.00029416	17.30376726	954.80311	21911.99268
16040079.	7.638133E+11	.00002100	.00036458	17.36081523	1160.18064	27033.01346
19044143.	7.617657E+11	.00002500	.00043548	17.41928011	1357.93701	32139.77184
22030517.	7.596730E+11	.00002900	.00050690	17.47922939	1547.92639	37231.71799
24998570.	7.575324E+11	.00003300	.00057884	17.54073054	1729.99408	42308.27077
27947670.	7.553424E+11	.00003700	.00065134	17.60388476	1903.97851	47368.78154
30877138.	7.531009E+11	.00004100	.00072442	17.66879326	2069.70786	52412.55468
33682840.	7.485076E+11	.00004500	.00079594	17.68748313	2222.37318	57501.58437
36412674.	7.431158E+11	.00004900	.00086744	17.70286685	2365.71160	60000.00000
38269106.	7.220586E+11	.00005300	.00093642	17.66821975	2495.01363	60000.00000
39508719.	6.931354E+11	.00005700	.00099726	17.49579388	2601.41931	60000.00000
40739790.	6.678654E+11	.00006100	.00105846	17.35180765	2701.75820	60000.00000
41568880.	6.395212E+11	.00006500	.00111551	17.16163653	2788.97622	60000.00000
42312466.	6.132241E+11	.00006900	.00117193	16.98448759	2869.48333	60000.00000
43050064.	5.897269E+11	.00007300	.00122864	16.83071786	2944.69094	60000.00000
43781523.	5.685912E+11	.00007700	.00128565	16.69678503	3014.51678	60000.00000
44194539.	5.456116E+11	.00008100	.00133828	16.52203137	3073.61957	60000.00000
44622811.	5.249742E+11	.00008500	.00139582	16.42139620	3132.82747	60000.00000
45010280.	5.057335E+11	.00008900	.00144751	16.26411790	3180.74877	60000.00000
45393950.	4.881070E+11	.00009300	.00149945	16.12316793	3224.15282	60000.00000
45773422.	4.718910E+11	.00009700	.00155166	15.99652213	3262.96401	60000.00000
46148927.	4.569201E+11	.00010100	.00160415	15.88262862	3297.11618	60000.00000
47695359.	3.640867E+11	.00013100	.00198432	15.14744872	3390.16770	60000.00000
48777242.	3.029642E+11	.00016100	.00235672	14.63803166	3396.76604	60000.00000
49168148.	2.574249E+11	.00019100	.00271520	14.21568781	3384.92455	60000.00000
49456854.	2.237867E+11	.00022100	.00310334	14.04228359	3383.93634	60000.00000
49653145.	1.978213E+11	.00025100	.00347049	13.82664162	3399.27954	60000.00000
49813601.	1.772726E+11	.00028100	.00384688	13.68997616	3369.62671	60000.00000

Unfactored (Nominal) Moment Capacity at Concrete Strain of 0.003 = 49379.98607 In-Kip

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Computations of Ultimate Moment Capacity and Nonlinear Bending Stiffness

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Number of pile sections = 2

Pile Section No. 2

The sectional shape is a circular drilled shaft (bored pile).

Outside Diameter = 66.0000 In

Material Properties:

Compressive Strength of Concrete	=	4.000 Kip/In**2
Yield Stress of Reinforcement	=	60. Kip/In**2
Modulus of Elasticity of Reinforcement	=	29000. Kip/In**2
Number of Reinforcing Bars	=	20
Area of Single Bar	=	1.56000 In**2
Number of Rows of Reinforcing Bars	=	11
Area of Steel	=	31.200 In**2
Percentage of Steel Reinforcement	=	.912 percent
Cover Thickness (edge to bar center)	=	6.000 In

Unfactored Axial Squash Load Capacity = 13397.98 Kip

Distribution and Area of Steel Reinforcement

Row Number	Area of Reinforcement In**2	Distance to Centroidal Axis In
1	1.560000	27.0000
2	3.120000	25.6785
3	3.120000	21.8435
4	3.120000	15.8702
5	3.120000	8.3435
6	3.120000	.0000
7	3.120000	-8.3435
8	3.120000	-15.8702
9	3.120000	-21.8435
10	3.120000	-25.6785
11	1.560000	-27.0000

Axial Thrust Force = .00 lbs

Bending Moment in-lbs	Bending Stiffness lb-in2	Bending Curvature rad/in	Maximum Strain in/in	Neutral Axis Position inches	Max. Concrete Stress psi	Max. Steel Stress psi
3705437.	3.705437E+12	.00000100	.00003311	33.10802507	117.37035	786.13273
3720426.	7.440852E+11	.00000500	.00008164	16.32827711	280.84570	6332.39980
6679092.	7.421213E+11	.00000900	.00014741	16.37856817	498.32784	

						11385.19368
9621591.	7.401224E+11	.00001300	.00021359	16.42999220	709.30100	16425.89290
12547462.	7.380860E+11	.00001700	.00028020	16.48258066	913.65344	21454.08768
15463898.	7.363761E+11	.00002100	.00034650	16.50001574	1108.98864	26491.49035
18349286.	7.339714E+11	.00002500	.00041362	16.54464197	1298.67655	31505.13449
21223434.	7.318426E+11	.00002900	.00048130	16.59647512	1481.71517	36502.36433
24079160.	7.296715E+11	.00003300	.00054943	16.64947271	1657.59430	41486.45451
26916016.	7.274599E+11	.00003700	.00061804	16.70376062	1826.18573	46456.86473
29733432.	7.252057E+11	.00004100	.00068714	16.75940180	1987.34903	51413.07113
32530727.	7.229051E+11	.00004500	.00075674	16.81642771	2140.93211	56354.56170
35220560.	7.187869E+11	.00004900	.00082616	16.86042452	2285.29980	60000.00000
37068186.	6.993997E+11	.00005300	.00088913	16.77598715	2408.24146	60000.00000
38435666.	6.743099E+11	.00005700	.00094811	16.63357973	2516.63988	60000.00000
39646698.	6.499459E+11	.00006100	.00100650	16.50001574	2617.72073	60000.00000
40637276.	6.251889E+11	.00006500	.00106430	16.37391043	2711.70700	60000.00000
41332323.	5.990192E+11	.00006900	.00111618	16.17658567	2790.59536	60000.00000
42021063.	5.756310E+11	.00007300	.00116831	16.00424910	2865.03782	60000.00000
42703399.	5.545896E+11	.00007700	.00122069	15.85309267	2934.97180	60000.00000
43361567.	5.353280E+11	.00008100	.00127303	15.71647596	2999.96965	60000.00000
43729561.	5.144654E+11	.00008500	.00132094	15.54048872	3054.95291	60000.00000
44159343.	4.961724E+11	.00008900	.00137060	15.40000105	3107.74363	60000.00000
44477883.	4.782568E+11	.00009300	.00142179	15.28805780	3157.64244	60000.00000
44823546.	4.620984E+11	.00009700	.00146904	15.14473772	3199.40934	60000.00000
45164763.	4.471759E+11	.00010100	.00151651	15.01491880	3237.40179	60000.00000
46868638.	3.577759E+11	.00013100	.00186734	14.25451040	3394.59162	60000.00000
47771027.	2.967145E+11	.00016100	.00219595	13.63943624	3386.76368	60000.00000
48416233.	2.534881E+11	.00019100	.00252928	13.24230051	3394.39234	60000.00000
48649701.	2.201344E+11	.00022100	.00286134	12.94722605	3389.78720	60000.00000
48800730.	1.944252E+11	.00025100	.00317535	12.65079832	3383.34527	60000.00000
48932144.	1.741357E+11	.00028100	.00349484	12.43713999	3394.51819	60000.00000
49047575.	1.577092E+11	.00031100	.00381927	12.28060198	3382.07251	60000.00000

Unfactored (Nominal) Moment Capacity at Concrete Strain of 0.003 = 48716.39258

Computed Values of Load Distribution and Deflection
for Lateral Loading for Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Specified shear force at pile head = 145000.000 lbs
Specified moment at pile head = 6336000.000 in-lbs
Specified axial load at pile head = 824000.000 lbs

Non-zero moment for this load case indicates the pile-head may rotate under the applied pile-head loading, but is not a free-head (zero moment)condition.

Depth X in	Deflect. y in	Moment M lbs-in	Shear V lbs	Slope S Rad.	Total Stress lbs/in**2	Flx. Rig. EI lbs-in**2	Soil Res. p lbs/in	Es*h F/L
0.000	.119022	6.34E+06	1.45E+05	-.001914	372.290	7.78E+11	0.000	0.000
2.118	.114987	6.65E+06	1.45E+05	-.001896	380.614	7.78E+11	0.000	0.000
4.236	.110989	6.96E+06	1.45E+05	-.001878	388.938	7.78E+11	0.000	0.000
6.354	.107032	7.27E+06	1.45E+05	-.001858	397.261	7.69E+11	0.000	0.000
8.472	.103117	7.58E+06	1.45E+05	-.001838	405.583	7.69E+11	0.000	0.000
10.590	.099246	7.89E+06	1.45E+05	-.001817	413.904	7.69E+11	0.000	0.000
12.708	.095421	8.20E+06	1.45E+05	-.001795	422.224	7.69E+11	0.000	0.000
14.826	.091644	8.51E+06	1.45E+05	-.001772	430.543	7.69E+11	0.000	0.000
16.944	.087917	8.82E+06	1.45E+05	-.001748	438.861	7.68E+11	0.000	0.000
19.062	.084241	9.13E+06	1.45E+05	-.001723	447.178	7.68E+11	0.000	0.000
21.180	.080618	9.44E+06	1.45E+05	-.001697	455.493	7.68E+11	0.000	0.000
23.298	.077051	9.75E+06	1.45E+05	-.001671	463.808	7.68E+11	0.000	0.000
25.416	.073541	1.01E+07	1.45E+05	-.001644	472.121	7.68E+11	0.000	0.000
27.534	.070089	1.04E+07	1.45E+05	-.001615	480.432	7.67E+11	0.000	0.000
29.652	.066698	1.07E+07	1.45E+05	-.001586	488.743	7.67E+11	0.000	0.000
31.770	.063369	1.10E+07	1.45E+05	-.001556	497.052	7.67E+11	0.000	0.000
33.888	.060105	1.13E+07	1.45E+05	-.001526	505.360	7.67E+11	0.000	0.000
36.006	.056907	1.16E+07	1.45E+05	-.001494	513.666	7.67E+11	0.000	0.000
38.124	.053776	1.19E+07	1.45E+05	-.001461	521.971	7.66E+11	0.000	0.000

40.242	.050716	1.22E+07	1.45E+05	-.001428	530.274	7.66E+11	0.000	0.000
42.360	.047727	1.25E+07	1.45E+05	-.001394	538.575	7.66E+11	0.000	0.000
44.478	.044811	1.28E+07	1.45E+05	-.001359	546.875	7.66E+11	0.000	0.000
46.596	.041971	1.32E+07	1.45E+05	-.001323	555.173	7.66E+11	0.000	0.000
48.714	.039208	1.35E+07	1.45E+05	-.001286	563.470	7.65E+11	0.000	0.000
50.832	.036523	1.38E+07	1.45E+05	-.001248	571.765	7.65E+11	0.000	0.000
52.950	.033920	1.41E+07	1.45E+05	-.001210	580.058	7.65E+11	0.000	0.000
55.068	.031399	1.44E+07	1.45E+05	-.001170	588.349	7.65E+11	0.000	0.000
57.186	.028962	1.47E+07	1.45E+05	-.001130	596.638	7.65E+11	0.000	0.000
59.304	.026612	1.50E+07	1.45E+05	-.001089	604.926	7.64E+11	0.000	0.000
61.422	.024349	1.53E+07	1.45E+05	-.001047	613.211	7.64E+11	0.000	0.000
63.540	.022177	1.56E+07	1.45E+05	-.001004	621.495	7.64E+11	0.000	0.000
65.658	.020097	1.59E+07	1.45E+05	-.000960	629.776	7.64E+11	0.000	0.000
67.776	.018110	1.62E+07	1.45E+05	-.000916	638.056	7.64E+11	0.000	0.000
69.894	.016218	1.66E+07	1.45E+05	-.000870	646.333	7.63E+11	0.000	0.000
72.012	.014424	1.69E+07	1.45E+05	-.000824	654.608	7.63E+11	0.000	0.000
74.130	.012729	1.72E+07	1.45E+05	-.000776	662.881	7.63E+11	0.000	0.000
76.248	.011135	1.75E+07	1.45E+05	-.000728	671.152	7.63E+11	0.000	0.000
78.366	.009643	1.78E+07	1.45E+05	-.000679	679.420	7.63E+11	0.000	0.000
80.484	.008257	1.81E+07	89042.	-.000629	882.040	7.34E+11	-52841.	1.36E+07
82.602	.006981	1.82E+07	-22374.	-.000576	884.559	7.34E+11	-52368.	1.59E+07
84.720	.005816	1.80E+07	-1.26E+05	-.000524	878.753	7.34E+11	-45394.	1.65E+07
86.838	.004760	1.76E+07	-2.15E+05	-.000473	865.729	7.34E+11	-38605.	1.72E+07
88.956	.003813	1.71E+07	-2.90E+05	-.000423	846.565	7.35E+11	-32081.	1.78E+07
91.074	.002970	1.64E+07	-3.51E+05	-.000374	822.300	7.35E+11	-25891.	1.85E+07
93.192	.002227	1.56E+07	-4.00E+05	-.000328	793.917	7.36E+11	-20092.	1.91E+07
95.310	.001579	1.47E+07	-4.37E+05	-.000285	762.338	7.37E+11	-14728.	1.97E+07
97.428	.001021	1.38E+07	-4.63E+05	-.000244	728.415	7.37E+11	-9833.982	2.04E+07
99.546	.000547	1.28E+07	-4.79E+05	-.000206	692.927	7.38E+11	-5432.166	2.10E+07
101.664	.000150	1.17E+07	-4.86E+05	-.000171	656.573	7.39E+11	-1536.076	2.17E+07
103.782	-.000176	1.07E+07	-4.86E+05	-.000138	619.973	7.39E+11	1849.962	2.23E+07
105.900	-.000436	9.68E+06	-4.79E+05	-.000109	583.665	7.40E+11	4729.693	

2.30E+07

108.018	-.000638	8.67E+06	-4.66E+05	-8.30E-05	548.108	7.41E+11	7113.994	2.36E+07
110.136	-.000788	7.70E+06	-4.49E+05	-5.96E-05	513.679	7.41E+11	9019.519	2.43E+07
112.254	-.000891	6.77E+06	-4.29E+05	-3.89E-05	480.682	7.42E+11	10468.	2.49E+07
114.372	-.000952	5.88E+06	-4.05E+05	-2.09E-05	449.349	7.42E+11	11486.	2.55E+07
116.490	-.000979	5.05E+06	-3.80E+05	-5.26E-06	419.839	7.43E+11	12101.	2.62E+07
118.608	-.000975	4.27E+06	-3.55E+05	8.03E-06	392.252	7.44E+11	12347.	2.68E+07
120.726	-.000945	3.55E+06	-3.29E+05	1.51E-05	366.626	3.71E+12	12255.	2.75E+07
122.844	-.000911	2.88E+06	-3.03E+05	1.70E-05	342.948	3.71E+12	12088.	2.81E+07
124.962	-.000873	2.27E+06	-2.77E+05	1.84E-05	321.191	3.71E+12	11853.	2.88E+07
127.080	-.000833	1.71E+06	-2.53E+05	1.96E-05	301.318	3.71E+12	11557.	2.94E+07
129.198	-.000790	1.20E+06	-2.28E+05	2.04E-05	283.282	3.71E+12	11207.	3.00E+07
131.316	-.000746	7.39E+05	-2.05E+05	2.10E-05	267.027	3.71E+12	10811.	3.07E+07
133.434	-.000701	3.29E+05	-1.83E+05	2.13E-05	252.490	3.71E+12	10374.	3.13E+07
135.552	-.000656	-35261.	-1.61E+05	2.13E-05	242.100	3.71E+12	9904.063	3.20E+07
137.670	-.000611	-3.55E+05	-1.41E+05	2.12E-05	253.415	3.71E+12	9407.376	3.26E+07
139.788	-.000566	-6.32E+05	-1.21E+05	2.10E-05	263.233	3.71E+12	8889.973	3.33E+07
141.906	-.000522	-8.69E+05	-1.03E+05	2.05E-05	271.639	3.71E+12	8357.615	3.39E+07
144.024	-.000479	-1.07E+06	-86024.	2.00E-05	278.717	3.71E+12	7815.684	3.45E+07
146.142	-.000437	-1.23E+06	-70049.	1.93E-05	284.552	3.71E+12	7269.159	3.52E+07
148.260	-.000397	-1.37E+06	-55232.	1.86E-05	289.232	3.71E+12	6722.592	3.58E+07
150.378	-.000359	-1.47E+06	-41568.	1.78E-05	292.844	3.71E+12	6180.097	3.65E+07
152.496	-.000322	-1.54E+06	-29045.	1.69E-05	295.473	3.71E+12	5645.346	3.71E+07
154.614	-.000287	-1.59E+06	-17643.	1.60E-05	297.205	3.71E+12	5121.558	3.78E+07
156.732	-.000254	-1.62E+06	-7335.302	1.51E-05	298.123	3.71E+12	4611.508	3.84E+07
158.850	-.000223	-1.62E+06	1908.749	1.42E-05	298.308	3.71E+12	4117.530	3.91E+07
160.968	-.000194	-1.61E+06	10126.	1.32E-05	297.838	3.71E+12	3641.524	3.97E+07
163.086	-.000167	-1.58E+06	17355.	1.23E-05	296.790	3.71E+12	3184.976	4.03E+07
165.204	-.000142	-1.53E+06	23639.	1.14E-05	295.235	3.71E+12	2748.966	4.10E+07
167.322	-.000119	-1.48E+06	29022.	1.06E-05	293.243	3.71E+12	2334.193	4.16E+07
169.440	-9.73E-05	-1.41E+06	33549.	9.75E-06	290.881	3.71E+12	1940.991	4.23E+07
171.558	-7.75E-05	-1.34E+06	37267.	8.97E-06	288.210	3.71E+12	1569.357	4.29E+07

173.676	-5.93E-05	-1.25E+06	40220.	8.23E-06	285.289	3.71E+12	1218.972	4.36E+07
175.794	-4.26E-05	-1.17E+06	42452.	7.53E-06	282.174	3.71E+12	889.227	4.42E+07
177.912	-2.74E-05	-1.07E+06	44007.	6.89E-06	278.919	3.71E+12	579.254	4.48E+07
180.030	-1.34E-05	-9.80E+05	44926.	6.31E-06	275.571	3.71E+12	287.949	4.55E+07
182.148	-6.43E-07	-8.84E+05	45246.	5.77E-06	272.177	3.71E+12	14.008	4.61E+07
184.266	1.11E-05	-7.88E+05	45002.	5.30E-06	268.781	3.71E+12	-244.051	4.68E+07
186.384	2.18E-05	-6.94E+05	44227.	4.87E-06	265.424	3.71E+12	-487.848	4.74E+07
188.502	3.17E-05	-6.01E+05	42949.	4.50E-06	262.144	3.71E+12	-719.119	4.81E+07
190.620	4.09E-05	-5.12E+05	41192.	4.18E-06	258.978	3.71E+12	-939.674	4.87E+07
192.738	4.94E-05	-4.27E+05	38978.	3.92E-06	255.962	3.71E+12	-1151.370	4.93E+07
194.856	5.75E-05	-3.47E+05	36322.	3.70E-06	253.129	3.71E+12	-1356.076	5.00E+07
196.974	6.51E-05	-2.73E+05	33239.	3.52E-06	250.511	3.71E+12	-1555.635	5.06E+07
199.092	7.24E-05	-2.06E+05	29736.	3.38E-06	248.141	3.71E+12	-1751.830	5.13E+07
201.210	7.94E-05	-1.47E+05	25820.	3.28E-06	246.049	3.71E+12	-1946.347	5.19E+07
203.328	8.63E-05	-96396.	21491.	3.21E-06	244.266	3.71E+12	-2140.732	5.26E+07
205.446	9.30E-05	-55684.	16750.	3.17E-06	242.824	3.71E+12	-2336.354	5.32E+07
207.564	9.97E-05	-25453.	11592.	3.14E-06	241.753	3.71E+12	-2534.359	5.39E+07
209.682	.000106	-6590.468	6011.259	3.14E-06	241.085	3.71E+12	-2735.628	5.45E+07
211.800	.000113	0.000	0.000	3.13E-06	240.851	3.71E+12	-2940.727	2.76E+07

Please note that because this analysis makes computations of ultimate moment capacity and pile response using nonlinear bending stiffness that the above values of total stress due to combined axial stress and bending may not be representative of actual conditions.

Output Verification:

Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      .11902250 in
Computed slope at pile head      =     -.00191411
Maximum bending moment           =      18168573. lbs-in
Maximum shear force              =  -486237.33504 lbs
Depth of maximum bending moment  =    82.60200000 in
Depth of maximum shear force     =      101.66400 in
Number of iterations             =              8
Number of zero deflection points =              2
```

Summary of Pile Response(s)

Definition of Symbols for Pile-Head Loading Conditions:

```
Type 1 = Shear and Moment,          y = pile-head displacment in
Type 2 = Shear and Slope,           M = Pile-head Moment lbs-in
Type 3 = Shear and Rot. Stiffness,  V = Pile-head Shear Force lbs
Type 4 = Deflection and Moment,     S = Pile-head Slope, radians
Type 5 = Deflection and Slope,      R = Rot. Stiffness of Pile-head in-lbs/rad
```

Load Type	Pile-Head Condition 1	Pile-Head Condition 2	Axial Load lbs	Pile-Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
1	V= 1.45E+05	M= 6.34E+06	824000.	.1190225	1.8169E+07	-486237.

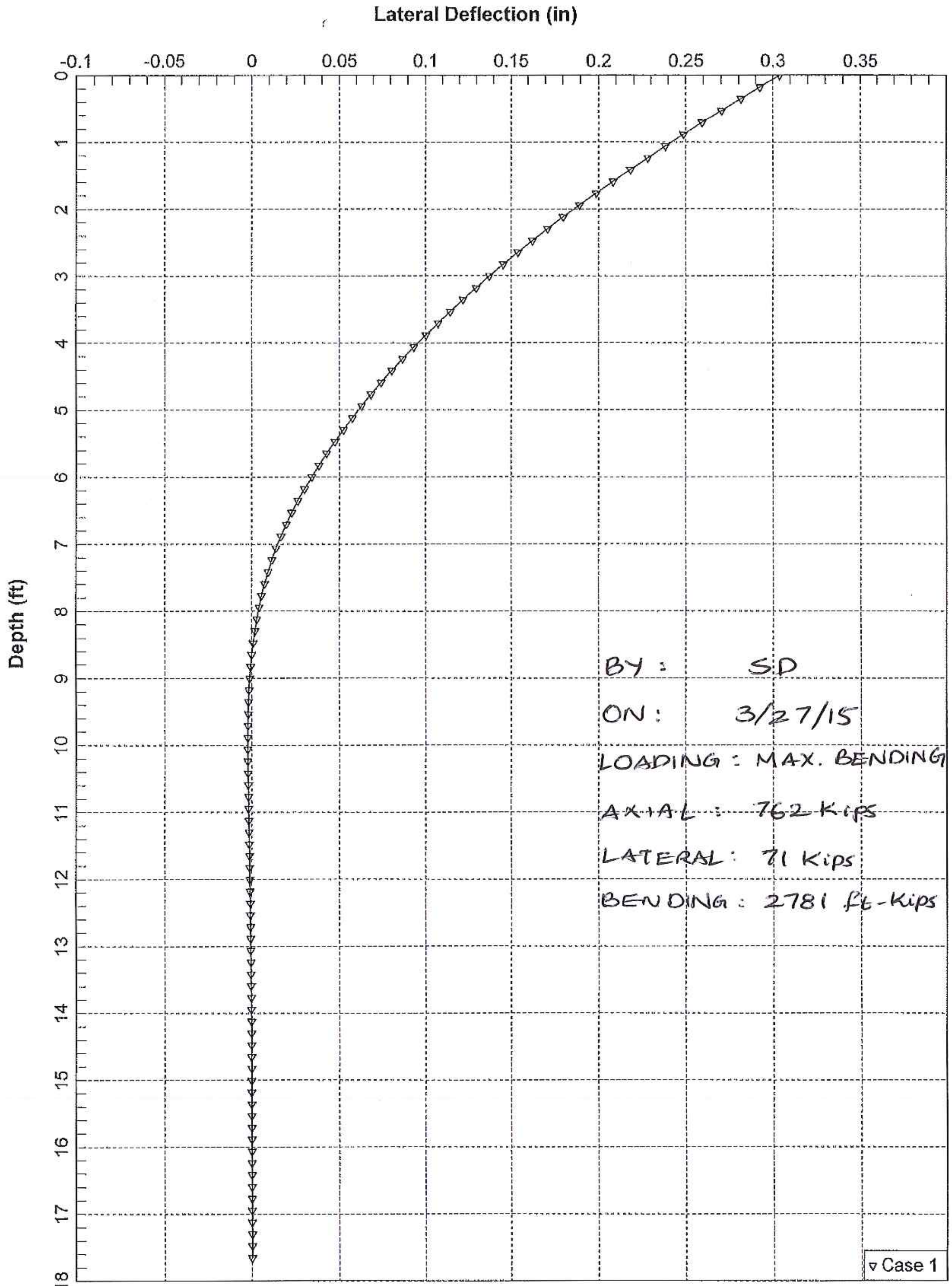
The analysis ended normally.

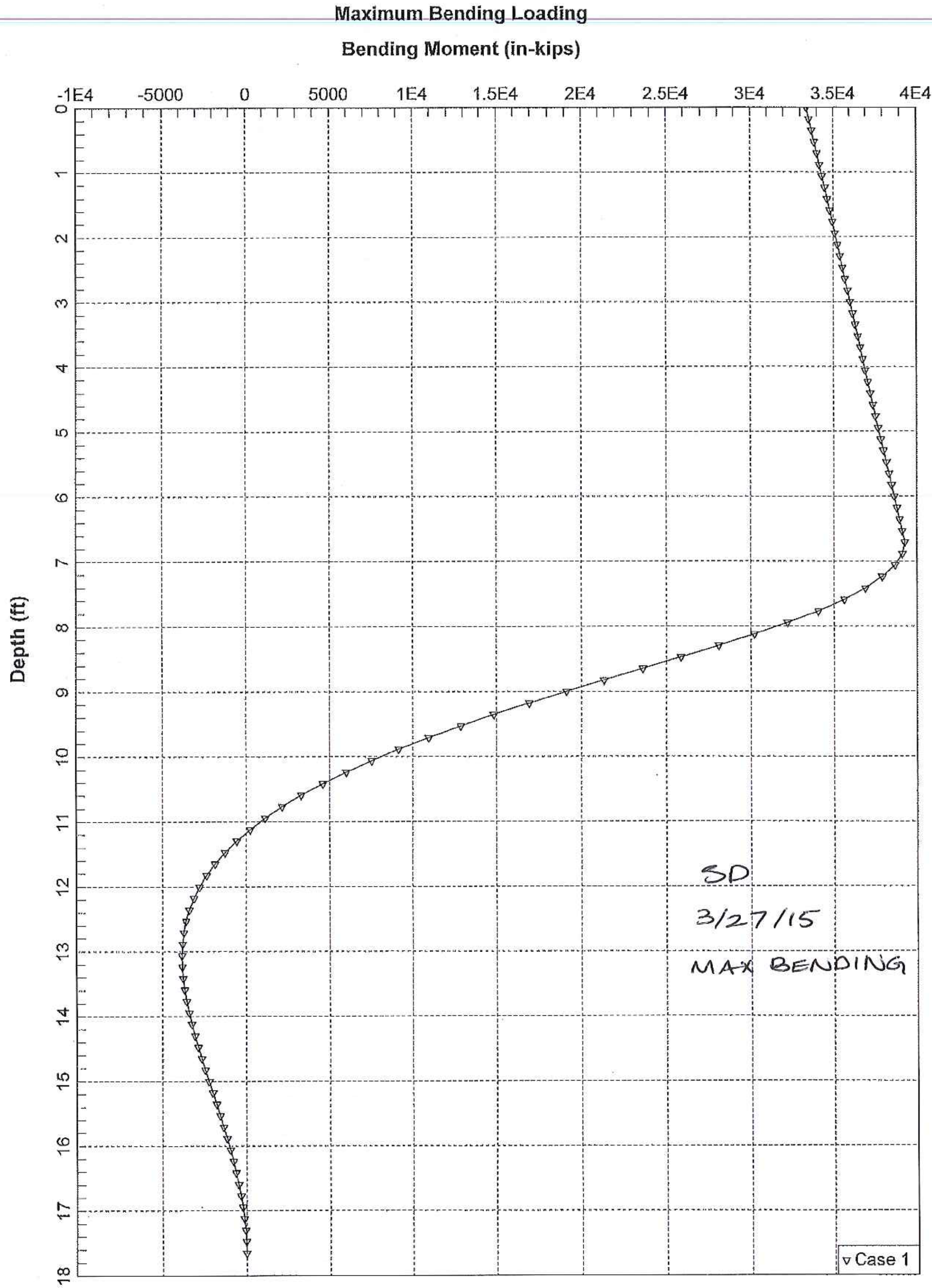
Summary of Warning Messages

**** WARNING ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. You should check your input data for correctness.

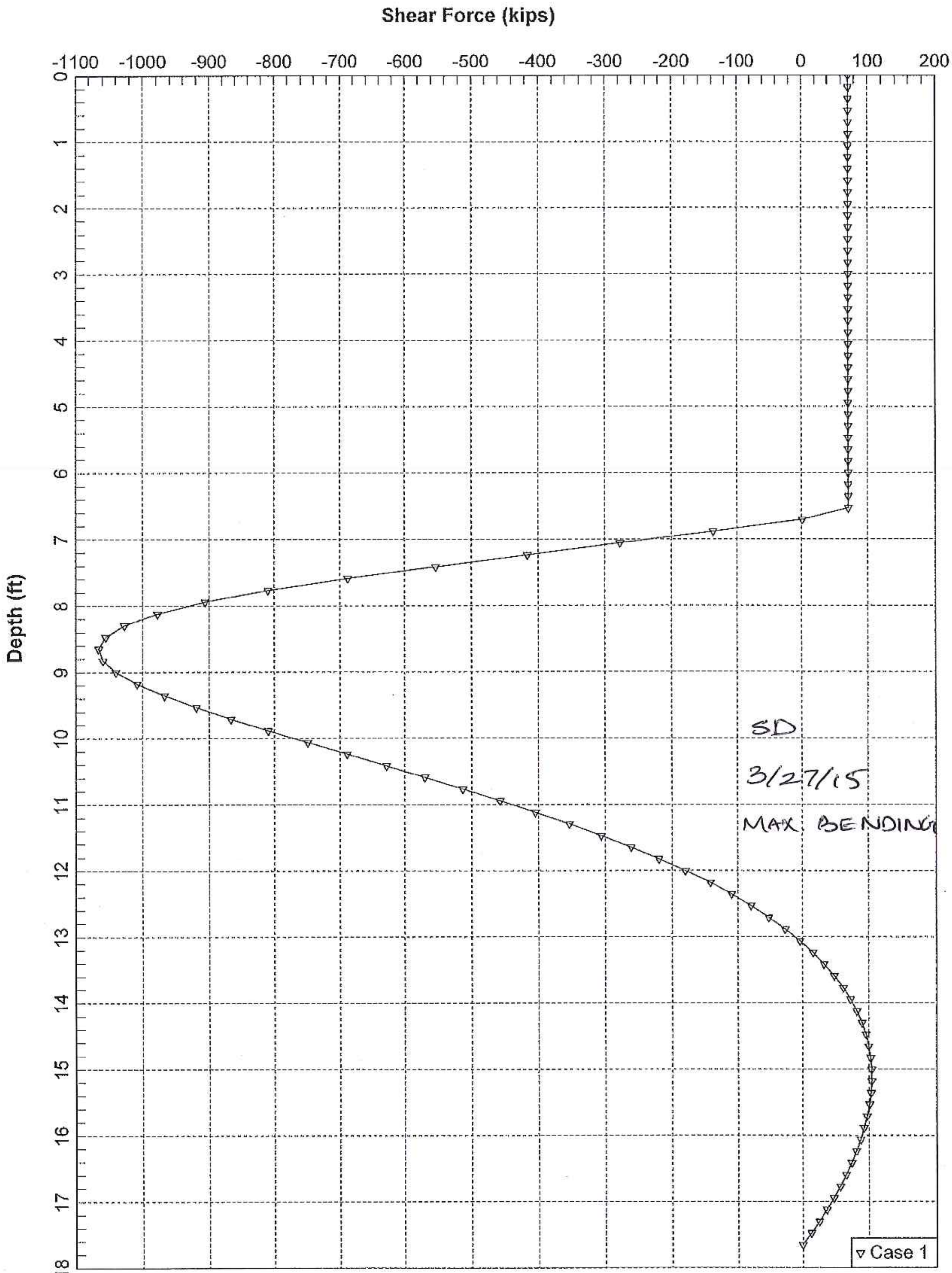
Maximum Bending Loading





Maximum Bending Loading
Bending Moment (in-kips)
-1E4
-5000
0
5000
1E4
1.5E4
2E4
2.5E4
3E4
3.5E4
4E4
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Case 1
SD
3/27/15
MAX BENDING

Maximum Bending Loading



Pier 7 Combined loading_5.5D_11L_MaxBend.lpo
===

LPILE Plus for Windows, Version 5.0 (5.0.38)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

===

This program is licensed to:

Sulaiman Dawood
The Mannik & Smith Group, Inc.

Path to file locations: W:\Projects\Projects F-J\H2530002\22984\geotechnical\Sulaiman - Drilled Shaft Reference Files\Drilled Shaft Analysis\LPILE\5.5D + 11L - Revised\Maximum Bending Moment\
Name of input data file: Pier 7 Combined loading_5.5D_11L_MaxBend.lpd
Name of output file: Pier 7 Combined loading_5.5D_11L_MaxBend.lpo
Name of plot output file: Pier 7 Combined loading_5.5D_11L_MaxBend.lpp
Name of runtime file: Pier 7 Combined loading_5.5D_11L_MaxBend.lpr

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Time and Date of Analysis

Date: March 27, 2015   Time: 17:55:37

Problem Title

Pier 7 Combined Loading Analysis_5.5D_11L

Program Options

Units Used in Computations - US Customary Units: Inches, Pounds

Basic Program Options:

Analysis Type 3:
- Computation of Nonlinear Bending Stiffness and Ultimate Bending Moment
  Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments = 100
- Maximum number of iterations allowed = 100
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 1.0000E+02 in

Printing Options:
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (spacing of output points) = 1

Pile Structural Properties and Geometry

Pile Length = 211.80 in

Depth of ground surface below top of pile = 79.80 in

Slope angle of ground surface = .00 deg.

Structural properties of pile defined using 4 points

Point	Depth X in	Pile Diameter in	Moment of Inertia in**4	Pile Area Sq.in	Modulus of Elasticity lbs/Sq.in
1	0.0000	70.75000000	1319167.	4071.5000	3500000.
2	79.8000	70.75000000	1319167.	4071.5000	3500000.
3	79.8000	66.00000000	931420.2000	3421.2000	3500000.
4	211.8000	66.00000000	931420.2000	3421.2000	3500000.

Please note that because this analysis makes computations of ultimate moment capacity and pile response using nonlinear bending stiffness that the above values of moment of inertia and modulus of are not used for any computations other than total stress due to combined axial loading and bending.

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997
Distance from top of pile to top of layer = 79.800 in
Distance from top of pile to bottom of layer = 275.000 in
Initial modulus of rock at top of layer = 7.1000E+04 lbs/in**2
Initial modulus of rock at bottom of layer = 7.1000E+04 lbs/in**2

(Depth of lowest layer extends 63.20 in below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 2 points

Point Depth X Eff. Unit Weight

No.	in	lbs/in**3
1	79.80	.04490
2	275.00	.04490

Shear Strength of Soils

Shear strength parameters with depth defined using 2 points

Point No.	Depth X in	Cohesion c lbs/in**2	Angle of Friction Deg.	E50 or k_rm	RQD %
1	79.800	2700.00000	.00	.00050	26.0
2	275.000	2700.00000	.00	.00050	26.0

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) Values of E50 are reported for clay strata.
(3) Default values will be generated for E50 when input values are 0.
(4) RQD and k_rm are reported only for weak rock strata.

Loading Type

Static loading criteria was used for computation of p-y curves.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Shear force at pile head   =   71000.000 lbs
Bending moment at pile head =   33372000.000 in-lbs
Axial load at pile head   =   762000.000 lbs

Non-zero moment at pile head for this load case indicates the pile-head may rotate under the applied pile-head loading, but is not a free-head (zero moment) condition.

Computations of Ultimate Moment Capacity and Nonlinear Bending Stiffness

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Number of pile sections = 2

Pile Section No. 1

**** WARNING ****

An unreasonable input value for concrete cover thickness has been specified.
The input value is either smaller than 0.8 inches or larger than 8 inches.
You should check your input for correctness.

The sectional shape is a circular drilled shaft (bored pile).

Outside Diameter = 70.7500 In

Material Properties:

Compressive Strength of Concrete	=	4.000	Kip/In**2
Yield Stress of Reinforcement	=	60.	Kip/In**2
Modulus of Elasticity of Reinforcement	=	29000.	Kip/In**2
Number of Reinforcing Bars	=	20	
Area of Single Bar	=	1.56000	In**2
Number of Rows of Reinforcing Bars	=	11	
Area of Steel	=	31.200	In**2
Percentage of Steel Reinforcement	=	.794	percent
Cover Thickness (edge to bar center)	=	8.375	In

Unfactored Axial Squash Load Capacity = 22925.80 Kip

Distribution and Area of Steel Reinforcement

Row Number	Area of Reinforcement In**2	Distance to Centroidal Axis In
1	1.560000	26.3750
2	3.120000	25.0841
3	3.120000	21.3378
4	3.120000	15.5028
5	3.120000	8.1503
6	3.120000	.0000
7	3.120000	-8.1503
8	3.120000	-15.5028
9	3.120000	-21.3378
10	3.120000	-25.0841
11	1.560000	-26.3750

Axial Thrust Force = .00 lbs

Bending Moment in-lbs	Bending Stiffness lb-in2	Bending Curvature rad/in	Maximum Strain in/in	Neutral Axis Position inches	Max. Concrete Stress psi	Max. Steel Stress psi
4418885.	4.418885E+12	.00000100	.00003537	35.37498313	125.32460	764.87549
4418885.	8.837770E+11	.00000500	.00008570	17.14048392	294.28715	6468.37982
6927355.	7.697061E+11	.00000900	.00015474	17.19365221	521.72855	11629.20674
9981163.	7.677818E+11	.00001300	.00022422	17.24806875	741.94219	

16777.22804

13018906.	7.658180E+11	.00001700	.00029416	17.30376726	954.80311	21911.99268
16040079.	7.638133E+11	.00002100	.00036458	17.36081523	1160.18064	27033.01346
19044143.	7.617657E+11	.00002500	.00043548	17.41928011	1357.93701	32139.77184
22030517.	7.596730E+11	.00002900	.00050690	17.47922939	1547.92639	37231.71799
24998570.	7.575324E+11	.00003300	.00057884	17.54073054	1729.99408	42308.27077
27947670.	7.553424E+11	.00003700	.00065134	17.60388476	1903.97851	47368.78154
30877138.	7.531009E+11	.00004100	.00072442	17.66879326	2069.70786	52412.55468
33682840.	7.485076E+11	.00004500	.00079594	17.68748313	2222.37318	57501.58437
36412674.	7.431158E+11	.00004900	.00086744	17.70286685	2365.71160	60000.00000
38269106.	7.220586E+11	.00005300	.00093642	17.66821975	2495.01363	60000.00000
39508719.	6.931354E+11	.00005700	.00099726	17.49579388	2601.41931	60000.00000
40739790.	6.678654E+11	.00006100	.00105846	17.35180765	2701.75820	60000.00000
41568880.	6.395212E+11	.00006500	.00111551	17.16163653	2788.97622	60000.00000
42312466.	6.132241E+11	.00006900	.00117193	16.98448759	2869.48333	60000.00000
43050064.	5.897269E+11	.00007300	.00122864	16.83071786	2944.69094	60000.00000
43781523.	5.685912E+11	.00007700	.00128565	16.69678503	3014.51678	60000.00000
44194539.	5.456116E+11	.00008100	.00133828	16.52203137	3073.61957	60000.00000
44622811.	5.249742E+11	.00008500	.00139582	16.42139620	3132.82747	60000.00000
45010280.	5.057335E+11	.00008900	.00144751	16.26411790	3180.74877	60000.00000
45393950.	4.881070E+11	.00009300	.00149945	16.12316793	3224.15282	60000.00000
45773422.	4.718910E+11	.00009700	.00155166	15.99652213	3262.96401	60000.00000
46148927.	4.569201E+11	.00010100	.00160415	15.88262862	3297.11618	60000.00000
47695359.	3.640867E+11	.00013100	.00198432	15.14744872	3390.16770	60000.00000
48777242.	3.029642E+11	.00016100	.00235672	14.63803166	3396.76604	60000.00000
49168148.	2.574249E+11	.00019100	.00271520	14.21568781	3384.92455	60000.00000
49456854.	2.237867E+11	.00022100	.00310334	14.04228359	3383.93634	60000.00000
49653145.	1.978213E+11	.00025100	.00347049	13.82664162	3399.27954	60000.00000
49813601.	1.772726E+11	.00028100	.00384688	13.68997616	3369.62671	60000.00000

Unfactored (Nominal) Moment Capacity at Concrete Strain of 0.003 = 49379.98607 In-Kip

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Computations of Ultimate Moment Capacity and Nonlinear Bending Stiffness
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Number of pile sections = 2

Pile Section No. 2

The sectional shape is a circular drilled shaft (bored pile).

Outside Diameter = 66.0000 In

Material Properties:

Compressive Strength of Concrete	=	4.000	Kip/In**2
Yield Stress of Reinforcement	=	60.	Kip/In**2
Modulus of Elasticity of Reinforcement	=	29000.	Kip/In**2
Number of Reinforcing Bars	=	20	
Area of Single Bar	=	1.56000	In**2
Number of Rows of Reinforcing Bars	=	11	
Area of Steel	=	31.200	In**2
Percentage of Steel Reinforcement	=	.912	percent
Cover Thickness (edge to bar center)	=	6.000	In

Unfactored Axial Squash Load Capacity = 13397.98 Kip

Distribution and Area of Steel Reinforcement

Row Number	Area of Reinforcement In**2	Distance to Centroidal Axis In
1	1.560000	27.0000
2	3.120000	25.6785
3	3.120000	21.8435
4	3.120000	15.8702
5	3.120000	8.3435
6	3.120000	.0000
7	3.120000	-8.3435
8	3.120000	-15.8702
9	3.120000	-21.8435
10	3.120000	-25.6785
11	1.560000	-27.0000

Axial Thrust Force = .00 lbs

Bending Moment in-lbs	Bending Stiffness lb-in2	Bending Curvature rad/in	Maximum Strain in/in	Neutral Axis Position inches	Max. Concrete Stress psi	Max. Steel Stress psi
3705437.	3.705437E+12	.00000100	.00003311	33.10802507	117.37035	786.13273
3720426.	7.440852E+11	.00000500	.00008164	16.32827711	280.84570	6332.39980
6679092.	7.421213E+11	.00000900	.00014741	16.37856817	498.32784	

						11385.19368
9621591.	7.401224E+11	.00001300	.00021359	16.42999220	709.30100	16425.89290
12547462.	7.380860E+11	.00001700	.00028020	16.48258066	913.65344	21454.08768
15463898.	7.363761E+11	.00002100	.00034650	16.50001574	1108.98864	26491.49035
18349286.	7.339714E+11	.00002500	.00041362	16.54464197	1298.67655	31505.13449
21223434.	7.318426E+11	.00002900	.00048130	16.59647512	1481.71517	36502.36433
24079160.	7.296715E+11	.00003300	.00054943	16.64947271	1657.59430	41486.45451
26916016.	7.274599E+11	.00003700	.00061804	16.70376062	1826.18573	46456.86473
29733432.	7.252057E+11	.00004100	.00068714	16.75940180	1987.34903	51413.07113
32530727.	7.229051E+11	.00004500	.00075674	16.81642771	2140.93211	56354.56170
35220560.	7.187869E+11	.00004900	.00082616	16.86042452	2285.29980	60000.00000
37068186.	6.993997E+11	.00005300	.00088913	16.77598715	2408.24146	60000.00000
38435666.	6.743099E+11	.00005700	.00094811	16.63357973	2516.63988	60000.00000
39646698.	6.499459E+11	.00006100	.00100650	16.50001574	2617.72073	60000.00000
40637276.	6.251889E+11	.00006500	.00106430	16.37391043	2711.70700	60000.00000
41332323.	5.990192E+11	.00006900	.00111618	16.17658567	2790.59536	60000.00000
42021063.	5.756310E+11	.00007300	.00116831	16.00424910	2865.03782	60000.00000
42703399.	5.545896E+11	.00007700	.00122069	15.85309267	2934.97180	60000.00000
43361567.	5.353280E+11	.00008100	.00127303	15.71647596	2999.96965	60000.00000
43729561.	5.144654E+11	.00008500	.00132094	15.54048872	3054.95291	60000.00000
44159343.	4.961724E+11	.00008900	.00137060	15.40000105	3107.74363	60000.00000
44477883.	4.782568E+11	.00009300	.00142179	15.28805780	3157.64244	60000.00000
44823546.	4.620984E+11	.00009700	.00146904	15.14473772	3199.40934	60000.00000
45164763.	4.471759E+11	.00010100	.00151651	15.01491880	3237.40179	60000.00000
46868638.	3.577759E+11	.00013100	.00186734	14.25451040	3394.59162	60000.00000
47771027.	2.967145E+11	.00016100	.00219595	13.63943624	3386.76368	60000.00000
48416233.	2.534881E+11	.00019100	.00252928	13.24230051	3394.39234	60000.00000
48649701.	2.201344E+11	.00022100	.00286134	12.94722605	3389.78720	60000.00000
48800730.	1.944252E+11	.00025100	.00317535	12.65079832	3383.34527	60000.00000
48932144.	1.741357E+11	.00028100	.00349484	12.43713999	3394.51819	60000.00000
49047575.	1.577092E+11	.00031100	.00381927	12.28060198	3382.07251	60000.00000

Unfactored (Nominal) Moment Capacity at Concrete Strain of 0.003 = 48716.39258

Computed Values of Load Distribution and Deflection
for Lateral Loading for Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Specified shear force at pile head = 71000.000 lbs
Specified moment at pile head = 33372000.000 in-lbs
Specified axial load at pile head = 762000.000 lbs

Non-zero moment for this load case indicates the pile-head may rotate under the applied pile-head loading, but is not a free-head (zero moment)condition.

Depth X in	Deflect. y in	Moment M lbs-in	Shear V lbs	Slope S Rad.	Total Stress lbs/in**2	Flx. Rig. EI lbs-in**2	Soil Res. p lbs/in	Es*h F/L
0.000	.304054	3.34E+07	71000.	-.005450	1082.063	7.49E+11	0.000	0.000
2.118	.292611	3.35E+07	71000.	-.005355	1086.330	7.49E+11	0.000	0.000
4.236	.281368	3.37E+07	71000.	-.005260	1090.592	7.49E+11	0.000	0.000
6.354	.270328	3.38E+07	71000.	-.005165	1094.850	7.48E+11	0.000	0.000
8.472	.259490	3.40E+07	71000.	-.005069	1099.104	7.48E+11	0.000	0.000
10.590	.248856	3.42E+07	71000.	-.004972	1103.354	7.47E+11	0.000	0.000
12.708	.238428	3.43E+07	71000.	-.004875	1107.600	7.47E+11	0.000	0.000
14.826	.228205	3.45E+07	71000.	-.004778	1111.841	7.47E+11	0.000	0.000
16.944	.218190	3.46E+07	71000.	-.004680	1116.078	7.47E+11	0.000	0.000
19.062	.208382	3.48E+07	71000.	-.004581	1120.311	7.46E+11	0.000	0.000
21.180	.198784	3.50E+07	71000.	-.004482	1124.540	7.46E+11	0.000	0.000
23.298	.189397	3.51E+07	71000.	-.004383	1128.765	7.46E+11	0.000	0.000
25.416	.180220	3.53E+07	71000.	-.004283	1132.985	7.45E+11	0.000	0.000
27.534	.171256	3.54E+07	71000.	-.004182	1137.200	7.45E+11	0.000	0.000
29.652	.162505	3.56E+07	71000.	-.004081	1141.412	7.45E+11	0.000	0.000
31.770	.153968	3.57E+07	71000.	-.003980	1145.619	7.44E+11	0.000	0.000
33.888	.145647	3.59E+07	71000.	-.003878	1149.821	7.44E+11	0.000	0.000
36.006	.137543	3.61E+07	71000.	-.003775	1154.019	7.44E+11	0.000	0.000
38.124	.129655	3.62E+07	71000.	-.003672	1158.213	7.43E+11	0.000	0.000

40.242	.121987	3.64E+07	71000.	-.003569	1162.402	7.43E+11	0.000	0.000
42.360	.114537	3.65E+07	71000.	-.003465	1166.587	7.42E+11	0.000	0.000
44.478	.107309	3.67E+07	71000.	-.003360	1170.768	7.40E+11	0.000	0.000
46.596	.100303	3.68E+07	71000.	-.003255	1174.943	7.38E+11	0.000	0.000
48.714	.093521	3.70E+07	71000.	-.003149	1179.114	7.36E+11	0.000	0.000
50.832	.086964	3.71E+07	71000.	-.003042	1183.281	7.34E+11	0.000	0.000
52.950	.080635	3.73E+07	71000.	-.002935	1187.443	7.33E+11	0.000	0.000
55.068	.074533	3.75E+07	71000.	-.002826	1191.600	7.31E+11	0.000	0.000
57.186	.068662	3.76E+07	71000.	-.002718	1195.753	7.29E+11	0.000	0.000
59.304	.063022	3.78E+07	71000.	-.002608	1199.900	7.27E+11	0.000	0.000
61.422	.057615	3.79E+07	71000.	-.002498	1204.043	7.26E+11	0.000	0.000
63.540	.052442	3.81E+07	71000.	-.002387	1208.182	7.24E+11	0.000	0.000
65.658	.047505	3.82E+07	71000.	-.002275	1212.315	7.22E+11	0.000	0.000
67.776	.042805	3.84E+07	71000.	-.002162	1216.444	7.19E+11	0.000	0.000
69.894	.038345	3.85E+07	71000.	-.002049	1220.567	7.16E+11	0.000	0.000
72.012	.034127	3.87E+07	71000.	-.001934	1224.686	7.12E+11	0.000	0.000
74.130	.030152	3.88E+07	71000.	-.001819	1228.800	7.08E+11	0.000	0.000
76.248	.026423	3.90E+07	71000.	-.001702	1232.909	7.05E+11	0.000	0.000
78.366	.022942	3.92E+07	71000.	-.001584	1237.012	7.01E+11	0.000	0.000
80.484	.019712	3.93E+07	1450.166	-.001462	1615.226	6.57E+11	-65675.	7.06E+06
82.602	.016750	3.92E+07	-1.38E+05	-.001336	1610.196	6.60E+11	-65846.	8.33E+06
84.720	.014055	3.87E+07	-2.77E+05	-.001211	1594.693	6.68E+11	-65691.	9.90E+06
86.838	.011619	3.80E+07	-4.16E+05	-.001091	1568.743	6.82E+11	-65185.	1.19E+07
88.956	.009434	3.70E+07	-5.53E+05	-.000976	1532.426	7.00E+11	-64292.	1.44E+07
91.074	.007485	3.57E+07	-6.88E+05	-.000867	1485.884	7.14E+11	-62957.	1.78E+07
93.192	.005760	3.41E+07	-8.09E+05	-.000764	1429.330	7.20E+11	-51959.	1.91E+07
95.310	.004247	3.22E+07	-9.06E+05	-.000667	1364.512	7.23E+11	-39603.	1.97E+07
97.428	.002934	3.02E+07	-9.78E+05	-.000576	1293.395	7.25E+11	-28252.	2.04E+07
99.546	.001808	2.81E+07	-1.03E+06	-.000491	1217.782	7.26E+11	-17962.	2.10E+07
101.664	.000856	2.59E+07	-1.06E+06	-.000412	1139.309	7.28E+11	-8762.769	2.17E+07
103.782	6.31E-05	2.36E+07	-1.07E+06	-.000340	1059.440	7.30E+11	-664.594	2.23E+07
105.900	-.000585	2.14E+07	-1.06E+06	-.000275	979.461	7.32E+11	6341.711	

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2.30E+07
 108.018  -.001102  1.91E+07 -1.04E+06  -.000216   900.487  7.33E+11    12282.
2.36E+07
 110.136  -.001502  1.70E+07 -1.01E+06  -.000164   823.461  7.35E+11    17196.
2.43E+07
 112.254  -.001798  1.49E+07 -9.68E+05  -.000119   749.166  7.37E+11    21137.
2.49E+07
 114.372  -.002004  1.29E+07 -9.20E+05 -7.88E-05   678.227  7.38E+11    24167.
2.55E+07
 116.490  -.002132  1.10E+07 -8.66E+05 -4.46E-05   611.128  7.39E+11    26356.
2.62E+07
 118.608  -.002193  9.19E+06 -8.09E+05 -1.58E-05   548.216  7.40E+11    27780.
2.68E+07
 120.726  -.002199  7.54E+06 -7.49E+05  8.12E-06   489.717  7.41E+11    28519.
2.75E+07
 122.844  -.002159  6.01E+06 -6.89E+05  2.75E-05   435.750  7.42E+11    28656.
2.81E+07
 124.962  -.002082  4.62E+06 -6.29E+05  4.26E-05   386.336  7.43E+11    28275.
2.88E+07
 127.080  -.001978  3.35E+06 -5.70E+05  5.02E-05   341.415  3.71E+12    27461.
2.94E+07
 129.198  -.001870  2.21E+06 -5.12E+05  5.17E-05   300.859  3.71E+12    26526.
3.00E+07
 131.316  -.001759  1.18E+06 -4.57E+05  5.27E-05   264.519  3.71E+12    25487.
3.07E+07
 133.434  -.001647  2.68E+05 -4.04E+05  5.31E-05   232.229  3.71E+12    24359.
3.13E+07
 135.552  -.001534 -5.34E+05 -3.54E+05  5.30E-05   241.647  3.71E+12    23159.
3.20E+07
 137.670  -.001422 -1.23E+06 -3.06E+05  5.25E-05   266.384  3.71E+12    21899.
3.26E+07
 139.788  -.001311 -1.83E+06 -2.61E+05  5.17E-05   287.641  3.71E+12    20595.
3.33E+07
 141.906  -.001203 -2.34E+06 -2.19E+05  5.05E-05   305.624  3.71E+12    19260.
3.39E+07
 144.024  -.001098 -2.76E+06 -1.80E+05  4.90E-05   320.547  3.71E+12    17904.
3.45E+07
 146.142  -.000995 -3.10E+06 -1.43E+05  4.73E-05   332.623  3.71E+12    16540.
3.52E+07
 148.260  -.000897 -3.37E+06 -1.10E+05  4.55E-05   342.071  3.71E+12    15178.
3.58E+07
 150.378  -.000803 -3.57E+06    -79077.  4.35E-05   349.106  3.71E+12    13826.
3.65E+07
 152.496  -.000713 -3.70E+06    -51206.  4.13E-05   353.944  3.32E+12    12493.
3.71E+07
 154.614  -.000628 -3.78E+06    -26122.  3.87E-05   356.796  2.79E+12    11194.
3.78E+07
 156.732  -.000549 -3.81E+06 -3727.720  3.57E-05   357.869  2.59E+12  9953.096
3.84E+07
 158.850  -.000477 -3.80E+06     16117.  3.26E-05   357.360  2.62E+12  8786.302
3.91E+07
 160.968  -.000411 -3.75E+06     33574.  2.97E-05   355.454  2.85E+12  7697.464
3.97E+07
 163.086  -.000351 -3.66E+06     48800.  2.73E-05   352.324  3.71E+12  6680.755
4.03E+07
 165.204  -.000295 -3.54E+06     61925.  2.52E-05   348.133  3.71E+12  5713.318
4.10E+07
 167.322  -.000244 -3.40E+06     73055.  2.32E-05   343.033  3.71E+12  4796.374
4.16E+07
 169.440  -.000197 -3.23E+06     82297.  2.13E-05   337.171  3.71E+12  3930.351
4.23E+07
 171.558  -.000154 -3.05E+06     89758.  1.95E-05   330.685  3.71E+12  3114.937
4.29E+07
```

173.676	-.000114	-2.85E+06	95544.	1.78E-05	323.703	3.71E+12	2349.138	4.36E+07
175.794	-7.82E-05	-2.64E+06	99760.	1.63E-05	316.347	3.71E+12	1631.336	4.42E+07
177.912	-4.53E-05	-2.43E+06	1.03E+05	1.48E-05	308.733	3.71E+12	959.355	4.48E+07
180.030	-1.54E-05	-2.21E+06	1.04E+05	1.35E-05	300.965	3.71E+12	330.523	4.55E+07
182.148	1.19E-05	-1.99E+06	1.04E+05	1.23E-05	293.145	3.71E+12	-258.263	4.61E+07
184.266	3.67E-05	-1.77E+06	1.03E+05	1.12E-05	285.366	3.71E+12	-810.467	4.68E+07
186.384	5.94E-05	-1.55E+06	1.01E+05	1.03E-05	277.716	3.71E+12	-1329.848	4.74E+07
188.502	8.02E-05	-1.34E+06	97211.	9.45E-06	270.277	3.71E+12	-1820.387	4.81E+07
190.620	9.94E-05	-1.14E+06	92862.	8.74E-06	263.128	3.71E+12	-2286.215	4.87E+07
192.738	.000117	-9.49E+05	87548.	8.14E-06	256.342	3.71E+12	-2731.545	4.93E+07
194.856	.000134	-7.69E+05	81309.	7.65E-06	249.989	3.71E+12	-3160.591	5.00E+07
196.974	.000150	-6.04E+05	74173.	7.26E-06	244.140	3.71E+12	-3577.496	5.06E+07
199.092	.000165	-4.55E+05	66163.	6.95E-06	238.858	3.71E+12	-3986.250	5.13E+07
201.210	.000179	-3.24E+05	57292.	6.73E-06	234.211	3.71E+12	-4390.610	5.19E+07
203.328	.000193	-2.13E+05	47565.	6.58E-06	230.261	3.71E+12	-4794.015	5.26E+07
205.446	.000207	-1.23E+05	36982.	6.48E-06	227.073	3.71E+12	-5199.499	5.32E+07
207.564	.000221	-55950.	25535.	6.43E-06	224.711	3.71E+12	-5609.597	5.39E+07
209.682	.000234	-14458.	13213.	6.41E-06	223.241	3.71E+12	-6026.249	5.45E+07
211.800	.000248	0.000	0.000	6.41E-06	222.729	3.71E+12	-6450.702	2.76E+07

Please note that because this analysis makes computations of ultimate moment capacity and pile response using nonlinear bending stiffness that the above values of total stress due to combined axial stress and bending may not be representative of actual conditions.

Output Verification:

Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      .30405393 in
Computed slope at pile head      =     -.00545011
Maximum bending moment           =      39303033. lbs-in
Maximum shear force              =      -1065343. lbs
Depth of maximum bending moment  =    80.48400000 in
Depth of maximum shear force     =      103.78200 in
Number of iterations             =             11
Number of zero deflection points =              2
```

Summary of Pile Response(s)

Definition of Symbols for Pile-Head Loading Conditions:

Type 1 = Shear and Moment, y = pile-head displacment in
Type 2 = Shear and Slope, M = Pile-head Moment lbs-in
Type 3 = Shear and Rot. Stiffness, V = Pile-head Shear Force lbs
Type 4 = Deflection and Moment, S = Pile-head Slope, radians
Type 5 = Deflection and Slope, R = Rot. Stiffness of Pile-head in-lbs/rad

Load Type	Pile-Head Condition 1	Pile-Head Condition 2	Axial Load lbs	Pile-Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
1	V= 71000.	M= 3.34E+07	762000.	.3040539	3.9303E+07	-1065343.

The analysis ended normally.

Summary of Warning Messages

**** WARNING ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. You should check your input data for correctness.

TABLE C.1

Subgrade Analysis	
V. 12.00	12/30/11
Design CBR	6

Global Options		
320	R&R	Option
206	CS	No
	LS	Option
	LKD	No
206	Depth	NA

Total Borings	12
PID	22984
Location	HEN-IND-0000

Classification Counts by Sample

R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	1	0	1	2	2	0	0	0	3	0	0	8	14	0	17	0	0
	2%		2%	4%	4%				6%			17%	29%		35%		
0%	13%								88%								

Surface Class		
2-5	0	
4b	0	
5	0	
7-5	0	
7-6	2	17%
8a	0	
8b	0	
R	0	

% Borings	
N_{60L}<= 5	0%
<=10	25%
>=20	17%
M+	75%
R	0%

% Surface	
25%	
0%	25%

UC @ Surface
15.3
16
15

Rig	ER
A	89.3
B	
C	
D	
E	
F	
G	
H	

	N_{60}	N_{60L}	LL	PL	PI	% Silt	Clay	P 200	M	M_{OPT}	GI
Average	29.8	16.2			20.3		49.1		18.6	15.3	9.47
Maximum	63	30	49	25	29	44	83	98	29	22	17
Minimum	9	9	23	12	9	7	1	9	2	6	0

#	B #	Boring Location	Boring Depth	To	Cut Fill	Subgrade Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI	Comments	Problem w/ Class	Problem w/ MN	UC Class	UC MN	Analysis
1	B		1.2	2.7	0.0	1.2	2.7	9	6	15	A	22								6	8	3a	0						
	017-0		2.7	4.2		2.7	4.2	6	9	15		22								21	8	3a	0			M			No Treatment
	13	Sta. 97+38	4.2	5.7		4.2	5.7	6	9	15		22		41	23	18	27	49	76	22	20	7-6	11						Required
		5' Rt. of SR 110 CL	5.7	7.2		5.7	7.2	10	10	20		30	22	40	19	21	32	45	77	22	16	6b				M			
2	B		1.2	2.7	0.0	1.2	2.7	14	10	24	A	36								13	18	7-6	14						
	018-0		2.7	4.2		2.7	4.2	5	5	10		15		26	12	14	20	33	53	16	14	6a	5						No Treatment
	13	Sta. 99+90	4.2	5.7		4.2	5.7	4	9	13		19		49	20	29	16	71	87	27	18	7-6	17			M			Required
		8' Lt. of SR 110 CL	5.7	7.2		5.7	7.2	7	10	17		25								20	18	7-6							
3	B		1.2	2.7	0.0	1.2	2.7	3	4	7	A	10		23	14	9	14	16	30	16	10	2-4	0			N		15	
	019-0		2.7	4.2		2.7	4.2	10	13	23		34		39	19	20	24	56	80	17	16	6b	12						Undercut 1.25'
	13	Sta. 103+15	4.2	5.7		4.2	5.7	12	20	32		48								16	16	6b	10						
		SR 110 CL	5.7	7.2		5.7	7.2	19	20	39		58	10							15	16	6b							
4	B		0.3	1.2	0.0	0.3	1.2	3	4	7	A	10								21	18	7-6	14			N		15	
	020-0		1.2	2.7		1.2	2.7	4	8	12		18		49	21	28	18	69	87	23	18	7-6	17						Undercut 1.25'
	13	Sta. 106+98	2.7	4.2		2.7	4.2	11	15	26		39		48	24	24	16	78	94	23	21	7-6	15						
		21' Lt. of SR 110 CL	4.2	5.7		4.2	5.7	20	20	40		60	10							15	18	7-6	14						
5	B		1.2	2.7	0.0	1.2	2.7	10	5	15	A	22		28	15	13	23	25	48	18	14	6a	4						
	021-0		2.7	4.2		2.7	4.2	4	7	11		16								17	14	6a	8						No Treatment
	13	Sta. 109+41	4.2	5.7		4.2	5.7	10	14	24		36		47	25	22	16	72	88	22	22	7-6	14						Required
		6' Lt. of SR 110 CL	5.7	7.2		5.7	7.2	15	20	35		52	16							15	16	6b							
6	B		1.2	2.7	0.0	1.2	2.7	15	8	23	A	34								3	10	4a	5						
	022-0		2.7	4.2		2.7	4.2	5	7	12		18		44	19	25	35	50	85	23	18	7-6	15						No Treatment
	13	Sta. 587+45	4.2	5.7		4.2	5.7	5	7	12		18								14	18	7-6	14						Required
		7' Rt. of E. Riverview CL	5.7	7.2		5.7	7.2	9	9	18		27	18	32	17	15	23	35	58	17	14	6a							
7	B		1.2	2.7	0.0	1.2	2.7	10	5	15	A	22		NP	NP	NP	7	2	9	3	6	1a	0						
	023-0		2.7	4.2		2.7	4.2	3	8	11		16								21	10	4a	5			M			No Treatment
	13	Sta. 591+43	4.2	5.7		4.2	5.7	12	13	25		37		40	20	20	19	72	91	22	16	6b	12			M			Required
		9' Lt. of E. Riverview CL	5.7	7.2		5.7	7.2	15	20	35		52	16							24	16	6b				M			
8	B		1.2	2.7	0.0	1.2	2.7	8	5	13	A	19		NP	NP	NP	9	1	10	14	8	3	0			M			
	024-0		2.7	4.2		2.7	4.2	3	6	9		13		49	22	27	41	57	98	25	19	7-6	17			MN		12	Undercut 1'
	13	Sta. 594+66	4.2	5.7		4.2	5.7	7	14	21		31								24	16	6b	10			M			
		9' Lt. of E. Riverview CL	5.7	7.2		5.7	7.2	12	16	28		42	13							23	16	6b				M			
9	B		1.2	2.7	0.0	1.2	2.7	17	4	21	A	31								16	10	2-4	0			M			
	025-0		2.7	4.2		2.7	4.2	7	13	20		30		33	18	15	38	47	85	19	14	6a	10						No Treatment
	13	Sta. 597+23	4.2	5.7		4.2	5.7	13	22	35		52								19	16	6b	10						Required
		8' Lt. of E. Riverview CL	5.7	7.2		5.7	7.2	19	23	42		63	30							22	16	6b				M			
10	B		1.2	2.7	0.0	1.2	2.7	7	6	13	A	19								2	10	4a	5						
	026-0		2.7	4.2		2.7	4.2	10	15	25		37								23	16	6b	10			M			No Treatment
	13	Sta. 600+30	4.2	5.7		4.2	5.7	15	20	35		52		41	20	21	22	62	84	17	18	7-6	13						Required
		5' Lt. of E. Riverview CL	5.7	7.2		5.7	7.2	16	20	36		54	19							15	18	7-6							
11	B		0.5	3.5	0.0	1.0	3.0	2	4	6	A	9								19	14	6a	8			N		16	
	015-0		3.5	6.0		3.5	6.0	5	8	13		19		48	23	25	10	83	93	26	20	7-6	16			M			Undercut 1.33'
	13	52+80	6.0	8.5		6.0	8.5	9	13	22		33		32	17	15	30	49	79	17	14	6a							1' with geogrid
		Industrial Drive CL	8.5	10.0		8.5	10.0	12	18	30		45	9							14	14	6a							
12	B		1.7	3.2	0.0	1.7	3.2	5	5	10	A	15								22	16	6b	10			M			
	016-0		3.2	4.7		3.2	4.7	6	7	13		19		39	19	20	44	51	95	25	16	6b	12			M			No Treatment
	13	Sta. 55+57	4.7	6.2		4.7	6.2	5	5	10		15		44	20	24	37	57	94	28	18	7-6	14			M			Required
		Industrial Drive CL	6.2	7.7		6.2	7.7	4	7	11		16	15							29	18	7-6				M			

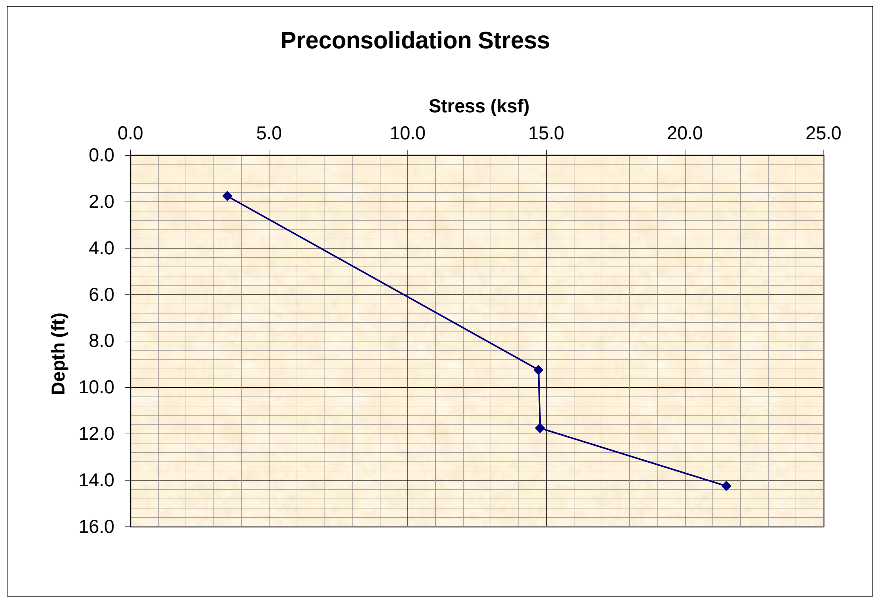
Henry County Maumee River Crossing

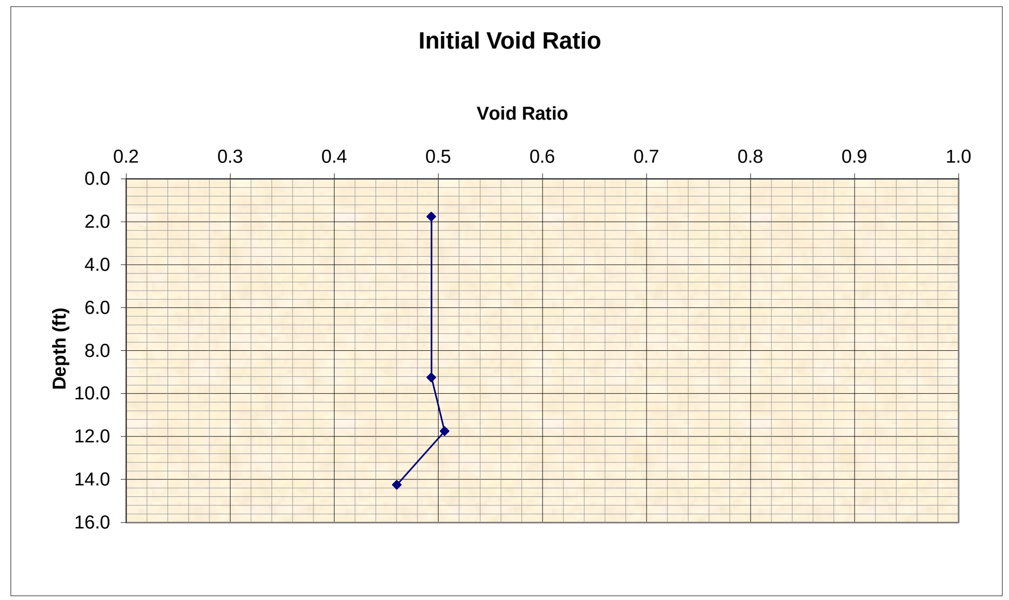
Index Property Correlation to Settlement Parameters STA 39+00

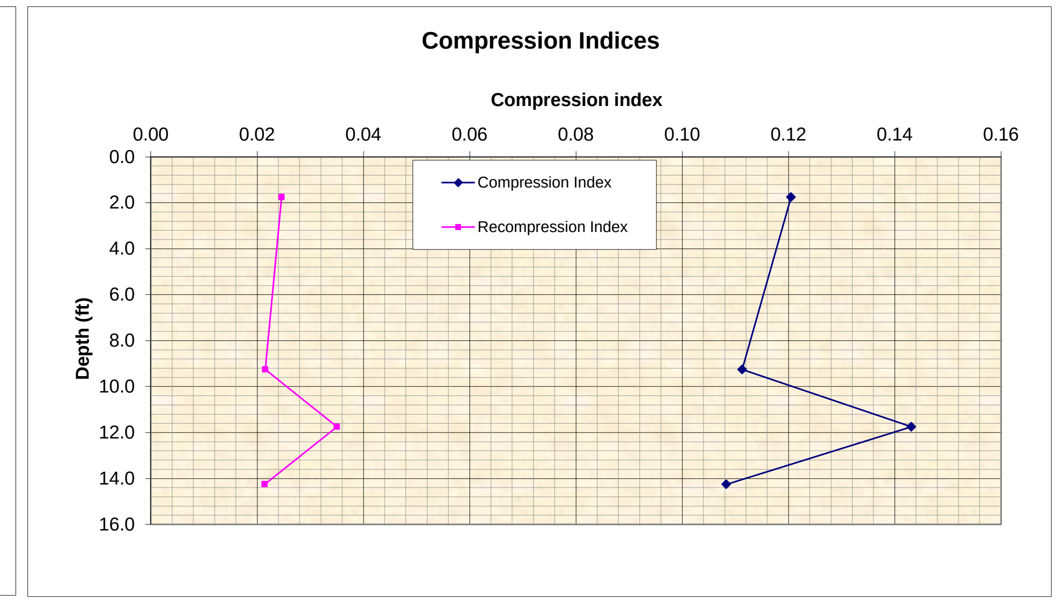
Boring	Sample	Depth Upper (ft)	Depth Lower (ft)	Depth Average (ft)	Assumed Surface Elev. (ft)	Assumed Sample Elev. (ft)	Water Content (%)	Bulk Density (pcf)	Dry Density (pcf)	Saturation*	Unconfined Comp. Str.* (psf)	Unconfined Shear Str. (psf)	~Percent Clay %<0.002 mm	Liquid Limit (%)	Plastic Limit (%)	Plastic. Index (%)	Liquid. Index	Precon. Stress (σ'_p) (ksf)	Initial Void Ratio (e_0)	Compression Index (Cc) Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Median 1-6	Recomp. Index (C_R) Method 1	Method 2	Method 3	Average 1-2
B-005-0-13	SS-1	1	2.5	1.8	100	98.3	*17.0*	*132.0*	112.8	93%	*1000*	500	*29.0*	25	16	9	0.11	3.5	0.493	0.14	0.09	0.12	0.12	0.13	0.12	0.12	0.024	0.031	0.018	0.025
B-005-0-13	SS-4	8.5	10	9.3	100	90.8	17.0	132	112.8	93%	*4000*	2000	23.0	23	16	7	0.14	14.7	0.493	0.12	0.08	0.12	0.12	0.11	0.10	0.11	0.019	0.029	0.017	0.022
B-005-0-13	SS-5	11	12.5	11.8	100	88.3	*18.0*	*132.0*	111.9	96%	*5000*	2500	*36.0*	32	16	16	0.13	14.8	0.506	0.20	0.10	0.12	0.12	0.17	0.22	0.14	0.043	0.040	0.021	0.035
B-005-0-13	ST-1	13.5	15	14.3	100	85.8	*17.0*	*135.0*	115.4	100%	*6000*	3000	*29.0*	21	13	8	0.50	21.5	0.460	0.10	0.07	0.11	0.11	0.12	0.11	0.11	0.022	0.026	0.016	0.021

* Saturation based specific gravity determined in the lab = 2.7

** Strength assumed based on standard penetration tests





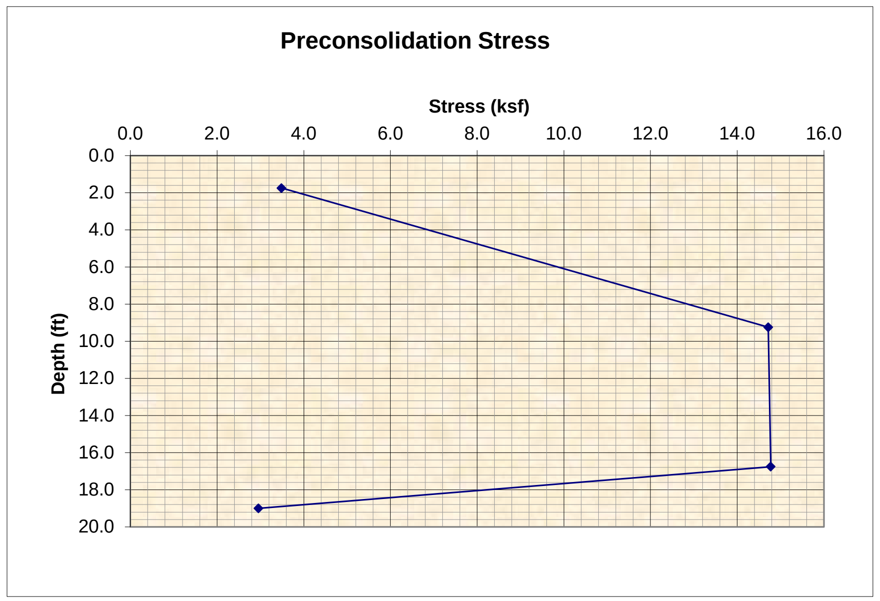


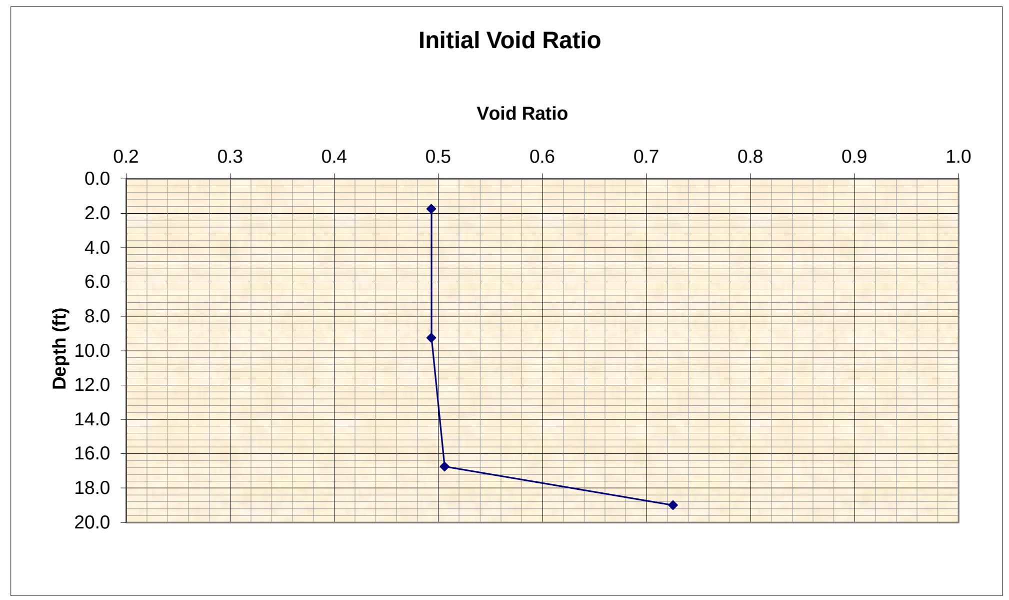
Index Property Correlation to Settlement Parameters STA 49+25

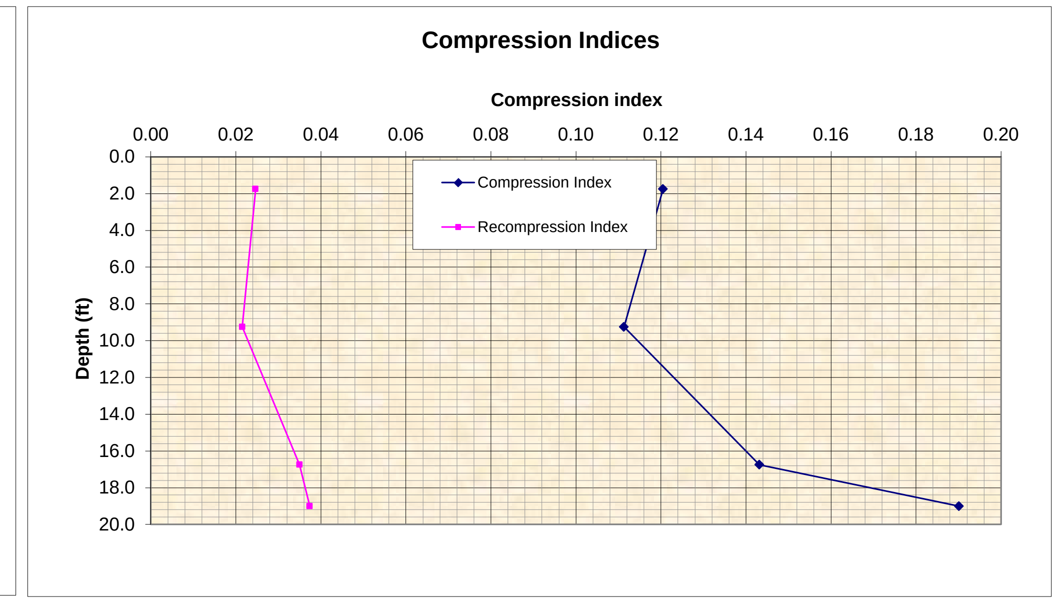
Boring	Sample	Depth Upper (ft)	Depth Lower (ft)	Depth Average (ft)	Assumed Surface Elev. (ft)	Assumed Sample Elev. (ft)	Water Content (%)	Bulk Density (pcf)	Dry Density (pcf)	Saturation*	Unconfined Comp. Str.* (psf)	Unconfined Shear Str. (psf)	~Percent Clay %<0.002 mm	Liquid Limit (%)	Plastic Limit (%)	Plastic. Index (%)	Liquid. Index	Precon. Stress (σ'_p) (ksf)	Initial Void Ratio (e_0)	Compression Index (Cc) Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Median 1-6	Recomp. Index (C_R) Method 1	Method 2	Method 3	Average 1-2
B-014-0-13	SS-1	1	2.5	1.8	100	98.3	*17.0*	*132.0*	112.8	93%	*1000*	500	*29.0*	25	16	9	0.11	3.5	0.493	0.14	0.09	0.12	0.12	0.13	0.12	0.12	0.024	0.031	0.018	0.025
B-014-0-13	SS-4	8.5	10	9.3	100	90.8	17.0	132	112.8	93%	*4000*	2000	23.0	23	16	7	0.14	14.7	0.493	0.12	0.08	0.12	0.12	0.11	0.10	0.11	0.019	0.029	0.017	0.022
B-014-0-13	SS-7	16	17.5	16.8	100	83.3	*18.0*	*132.0*	111.9	96%	*5000*	2500	*36.0*	32	16	16	0.13	14.8	0.506	0.20	0.10	0.12	0.12	0.17	0.22	0.14	0.043	0.040	0.021	0.035
B-013-1-13	ST-1	18	20	19.0	90	71.0	*27.0*	*124.0*	97.6	100%	*1000*	500	*36.0*	32	16	16	0.69	3.0	0.726	0.20	0.18	0.17	0.17	0.22	0.22	0.19	0.043	0.040	0.029	0.037

* Saturation based specific gravity determined in the lab = 2.7

** Strength assumed based on standard penetration tests







Henry County Maumee River Crossing Embankment STA 39+00

Consolidation Settlement (Boussinesq Stress Distribution)

Design Load and Embankment Geometry		
Load at Top of Embankment (q_0)	1.71	kips/ft
Horizontal Top Length (b)	22.6	ft
Horizontal Slope Length (a)	27.4	ft
Maximum Height of Embankment (H)	13.7	ft
Slope of Embankment (S)	2.0	:1
Angle of Embankment (θ)	26.6	degrees
Base Width of Embankment (B)	100	ft
Embank. Depth Below Original Ground Surf. (d_w)	0.00	(Surface=0.001)
Original Ground Surface Elevation	655.2	ft
Unit Weight of Embankment Soil (γ_f)	125	lbs/ft^3
Depth to Water (D_w)	22	ft
Elevation of Water	633.2	ft

Soil Stratigraphy Under Load			
Elevation			
Upper	Lower	Depth	Soil Layer
655.2	646.7	0	1
646.7	644.2	8.5	2
644.2	641.7	11	3
641.7	639	13.5	4
639		16.2	5

Use weighted Cv

8.5	0.39	3.00E-02	1.16E-02
2.5	0.11	3.00E-02	3.41E-03
2.5	0.11	2.00E-02	2.27E-03
8.5	0.39	1.11E-02	4.27E-03
22			**2.15E-02 weighted Cv cm2/sec**

3.34E-03 weighted Cv in2/sec

Foundation Soil Properties					
Soil Unit Beneath Foundation	1	2	3	4	5
Soil Unit Weight (γ_H'), psf	132	132	132	135	132
Initial Void Ratio (e_0)	0.493	0.493	0.506	0.43	
Recompression Index (C_R)	0.025	0.022	0.035	0.038	
Compression Index (C_C)	0.120	0.110	0.140	0.082	
Preconsolidation Pressure (σ_P), ksf	3.5	14.7	14.8	21.5	

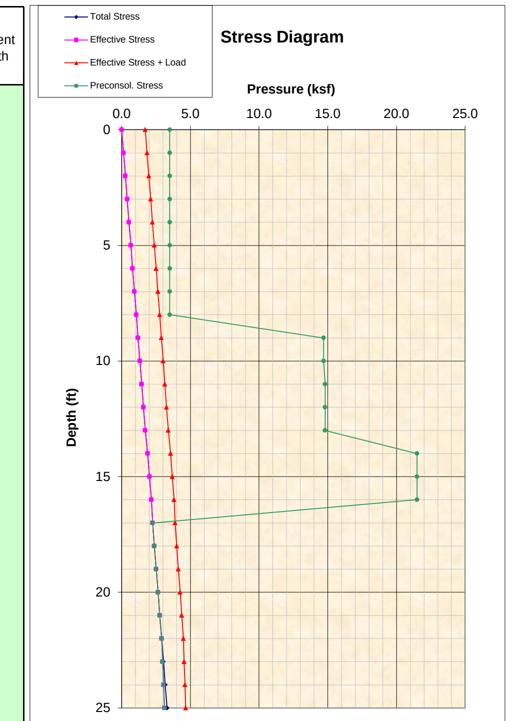
Time Rate of Consolidation		
Coeffcient of Consolidation, C_V @ 50%	3.3E-03	in^2/s
Coeffcient of Consolidation, C_V @ 50%	2.0E+00	ft^2/d
Number of Drainage Paths	1	
Total Thickness of Compressible Soil (ft)	22.0	ft

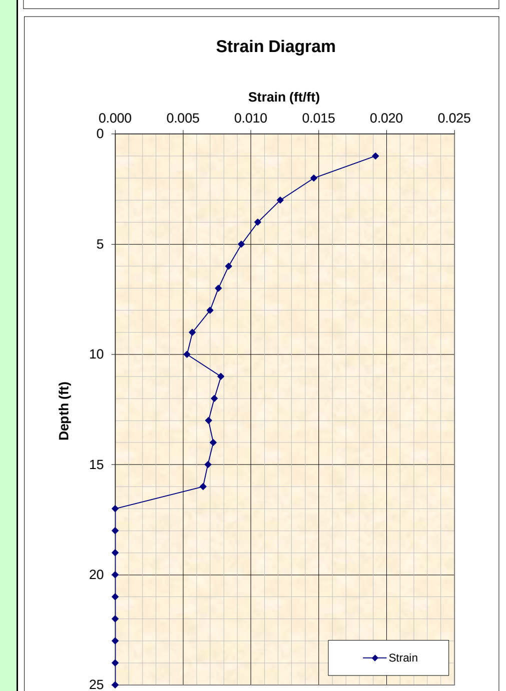
Settlement Over Time				
Time (t) (days)	(yrs)	Time Factor (T)	Percent Consolid.	Total Consolid. (in)
30	0.08	0.124	39.8%	0.63
60	0.16	0.248	56.2%	0.90
90	0.25	0.373	67.7%	1.08
120	0.33	0.497	76.2%	1.21
140	0.38	0.580	80.6%	1.28
160	**0.44**	**0.662**	**84.2%**	**1.34**
205	**0.56**	**0.849**	**90.0%**	**1.43**
270	0.74	1.118	94.9%	1.51
550	1.51	2.277	99.7%	1.59
1100	3.01	4.554	100.0%	1.59

Distance From Center of Embankment (x): 0

Elevation	Depth Below Surface	Depth Beneath Embank. (z)	α	β	α'	$\Delta\sigma_z$ (ksf)	z/B	$\Delta\sigma_z/q_0$	Soil Unit	Total Stress (σ_v) (ksf)	Pore Water Pressure (u) (ksf)	Effective Stress (σ'_v) (ksf)	($\sigma'_v+\Delta\sigma_z$)	Precon. Pressure (σ_p) (ksf)	Void Ratio (e_0)	Recomp Index (C_r)	Comp Index (C_c)	Strain 1 (ft)	Strain 2 (ft)	Strain	Settlement Per Interval (ft)	Settlement Per Interval (in)	Settlement At Depth (in)
655.2	0.0	0.0	0.00	3.14	0.00	1.71		1.00	1	0.00	0.00	0.00	1.71	3.50	0.493	0.025	0.12	0.000	0.000	0.000	0.000	0.00	0.00
654.2	1.0	1.0	0.02	3.05	0.02	1.71	0.01	1.00	1	0.13	0.00	0.13	1.84	3.50	0.493	0.025	0.12	0.019	0.000	0.019	0.000	0.00	0.00
653.2	2.0	2.0	0.05	2.97	0.05	1.71	0.02	1.00	1	0.26	0.00	0.26	1.98	3.50	0.493	0.025	0.12	0.015	0.000	0.015	0.017	0.20	0.20
652.2	3.0	3.0	0.07	2.88	0.07	1.71	0.03	1.00	1	0.40	0.00	0.40	2.11	3.50	0.493	0.025	0.12	0.012	0.000	0.012	0.013	0.16	0.36
651.2	4.0	4.0	0.10	2.79	0.10	1.71	0.04	1.00	1	0.53	0.00	0.53	2.24	3.50	0.493	0.025	0.12	0.011	0.000	0.011	0.011	0.14	0.50
650.2	5.0	5.0	0.12	2.71	0.12	1.71	0.05	1.00	1	0.66	0.00	0.66	2.37	3.50	0.493	0.025	0.12	0.009	0.000	0.009	0.010	0.12	0.62
649.2	6.0	6.0	0.14	2.62	0.14	1.71	0.06	1.00	1	0.79	0.00	0.79	2.50	3.50	0.493	0.025	0.12	0.008	0.000	0.008	0.009	0.11	0.72
648.2	7.0	7.0	0.16	2.54	0.16	1.71	0.07	1.00	1	0.92	0.00	0.92	2.63	3.50	0.493	0.025	0.12	0.008	0.000	0.008	0.008	0.10	0.82
647.2	8.0	8.0	0.18	2.46	0.18	1.70	0.08	0.99	1	1.06	0.00	1.06	2.76	3.50	0.493	0.025	0.12	0.007	0.000	0.007	0.007	0.09	0.91
646.2	9.0	9.0	0.20	2.38	0.20	1.70	0.09	0.99	2	1.19	0.00	1.19	2.89	14.70	0.493	0.022	0.11	0.006	0.000	0.006	0.006	0.08	0.98
645.2	10.0	10.0	0.22	2.31	0.22	1.69	0.10	0.99	2	1.32	0.00	1.32	3.01	14.70	0.493	0.022	0.11	0.005	0.000	0.005	0.005	0.07	1.05
644.2	11.0	11.0	0.24	2.24	0.24	1.69	0.11	0.99	3	1.45	0.00	1.45	3.14	14.80	0.506	0.035	0.14	0.008	0.000	0.008	0.007	0.08	1.13
643.2	12.0	12.0	0.25	2.17	0.25	1.68	0.12	0.98	3	1.58	0.00	1.58	3.27	14.80	0.506	0.035	0.14	0.007	0.000	0.007	0.008	0.09	1.22
642.2	13.0	13.0	0.27	2.10	0.27	1.68	0.13	0.98	3	1.72	0.00	1.72	3.39	14.80	0.506	0.035	0.14	0.007	0.000	0.007	0.007	0.09	1.30
641.2	14.0	14.0	0.28	2.03	0.28	1.67	0.14	0.97	4	1.89	0.00	1.89	3.56	21.50	0.43	0.038	0.08	0.007	0.000	0.007	0.007	0.08	1.39
640.2	15.0	15.0	0.29	1.97	0.29	1.66	0.15	0.97	4	2.02	0.00	2.02	3.68	21.50	0.43	0.038	0.08	0.007	0.000	0.007	0.007	0.08	1.47
639.2	16.0	16.0	0.31	1.91	0.31	1.65	0.16	0.96	4	2.16	0.00	2.16	3.81	21.50	0.43	0.038	0.08	0.006	0.000	0.006	0.007	0.08	1.55
638.2	17.0	17.0	0.32	1.85	0.32	1.64	0.17	0.96	5	2.24	0.00	2.24	3.88	2.24	0	0.000	0.00	0.000	0.000	0.000	0.003	0.04	1.59
637.2	18.0	18.0	0.33	1.80	0.33	1.63	0.18	0.95	5	2.38	0.00	2.38	4.01	2.38	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
636.2	19.0	19.0	0.34	1.74	0.34	1.62	0.19	0.95	5	2.51	0.00	2.51	4.13	2.51	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
635.2	20.0	20.0	0.34	1.69	0.34	1.61	0.20	0.94	5	2.64	0.00	2.64	4.25	2.64	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
634.2	21.0	21.0	0.35	1.64	0.35	1.59	0.21	0.93	5	2.77	0.00	2.77	4.37	2.77	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
633.2	22.0	22.0	0.36	1.60	0.36	1.58	0.22	0.92	5	2.90	0.00	2.90	4.49	2.90	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
632.2	23.0	23.0	0.36	1.55	0.36	1.57	0.23	0.92	5	3.04	0.06	2.97	4.54	2.97	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
631.2	24.0	24.0	0.37	1.51	0.37	1.56	0.24	0.91	5	3.17	0.12	3.04	4.60	3.04	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
630.2	25.0	25.0	0.37	1.47	0.37	1.54	0.25	0.90	5	3.30	0.19	3.11	4.65	3.11	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
629.2	26.0	26.0	0.38	1.43	0.38	1.53	0.26	0.89	5	3.43	0.25	3.18	4.71	3.18	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
628.2	27.0	27.0	0.38	1.39	0.38	1.51	0.27	0.88	5	3.56	0.31	3.25	4.77	3.25	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
627.2	28.0	28.0	0.38	1.36	0.38	1.50	0.28	0.88	5	3.70	0.37	3.32	4.82	3.32	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
626.2	29.0	29.0	0.38	1.32	0.38	1.48	0.29	0.87	5	3.83	0.44	3.39	4.88	3.39	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
625.2	30.0	30.0	0.38	1.29	0.38	1.47	0.30	0.86	5	3.96	0.50	3.46	4.93	3.46	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
624.2	31.0	31.0	0.39	1.26	0.39	1.45	0.31	0.85	5	4.09	0.56	3.53	4.98	3.53	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
623.2	32.0	32.0	0.39	1.23	0.39	1.44	0.32	0.84	5	4.22	0.62	3.60	5.04	3.60	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
622.2	33.0	33.0	0.39	1.20	0.39	1.42	0.33	0.83	5	4.36	0.69	3.67	5.09	3.67	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
621.2	34.0	34.0	0.39	1.17	0.39	1.41	0.34	0.82	5	4.49	0.75	3.74	5.15	3.74	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
620.2	35.0	35.0	0.39	1.15	0.39	1.39	0.35	0.81	5	4.62	0.81	3.81	5.20	3.81	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
619.2	36.0	36.0	0.39	1.12	0.39	1.38	0.36	0.81	5	4.75	0.87	3.88	5.26	3.88	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
618.2	37.0	37.0	0.39	1.10	0.39	1.36	0.37	0.80	5	4.88	0.94	3.95	5.31	3.95	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
617.2	38.0	38.0	0.38	1.07	0.38	1.35	0.38	0.79	5	5.02	1.00	4.02	5.37	4.02	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
616.2	39.0	39.0	0.38	1.05	0.38	1.33	0.39	0.78	5	5.15	1.06	4.09	5.42	4.09	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
615.2	40.0	40.0	0.38	1.03	0.38	1.32	0.40	0.77	5	5.28	1.12	4.16	5.48	4.16	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
614.2	41.0	41.0	0.38	1.01	0.38	1.31	0.41	0.76	5	5.41	1.19	4.23	5.53	4.23	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
613.2	42.0	42.0	0.38	0.99	0.38	1.29	0.42	0.75	5	5.54	1.25	4.30	5.59	4.30	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
612.2	43.0	43.0	0.38	0.97	0.38	1.28	0.43	0.75	5	5.68	1.31	4.37	5.64	4.37	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
611.2	44.0	44.0	0.37	0.95	0.37	1.26	0.44	0.74	5	5.81	1.37	4.44	5.70	4.44	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
610.2	45.0	45.0	0.37	0.93	0.37	1.25	0.45	0.73	5	5.94	1.44	4.50	5.75	4.50	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
609.2	46.0	46.0	0.37	0.91	0.37	1.23	0.46	0.72	5	6.07	1.50	4.57	5.81	4.57	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
608.2	47.0	47.0	0.37	0.90	0.37	1.22	0.47	0.71	5	6.20	1.56	4.64	5.86	4.64	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
607.2	48.0	48.0	0.37	0.88	0.37	1.21	0.48	0.71	5	6.34	1.62	4.71	5.92	4.71	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
606.2	49.0	49.0	0.36	0.86	0.36	1.19	0.49	0.70	5	6.47	1.68	4.78	5.98	4.78	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
605.2	50.0	50.0	0.36	0.85	0.36	1.18	0.50	0.69	5	6.60	1.75	4.85	6.03	4.85	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
603.2	52.0	52.0	0.36	0.82	0.36	1.15	0.52	0.67	5	6.86	1.87	4.99	6.15	4.99	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
601.2	54.0	54.0	0.35	0.79	0.35	1.13	0.54	0.66	5	7.13	2.00	5.13	6.26	5.13	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
599.2	56.0	56.0	0.35	0.77	0.35	1.11	0.56	0.65	5	7.39	2.12	5.27	6.38	5.27	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
597.2	58.0	58.0	0.34	0.74	0.34	1.08	0.58	0.63	5	7.66	2.25	5.41	6.49	5.41	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
595.2	60.0	60.0	0.33	0.72	0.33	1.06	0.60	0.62	5	7.92	2.37	5.55	6.61	5.55	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
593.2	62.0	62.0	0.33	0.70	0.33	1.04	0.62	0.60	5	8.18	2.50	5.69	6.72	5.69	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
591.2	64.0	64.0	0.32	0.68	0.32	1.01	0.64	0.59	5	8.45	2.62	5.83	6.84	5.83	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
589.2	66.0	66.0	0.32	0.66	0.32	0.99	0.66	0.58	5	8.71	2.75	5.97	6.96	5.97	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
587.2	68.0	68.0	0.31	0.64	0.31	0.97	0.68	0.57	5	8.98	2.87	6.11	7.08	6.11	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
585.2	70.0	70.0	0.31	0.62	0.31	0.95	0.70	0.56	5	9.24	3.00	6.24	7.20	6.24	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
583.2	72.0	72.0	0.30	0.61	0.30	0.93	0.72	0.55	5	9.50	3.12	6.38	7.32	6.38	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
581.2	74.0	74.0	0.30	0.59	0.30	0.92	0.74	0.53	5	9.77	3.24	6.52	7.44	6.52	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
579.2	76.0	76.0	0.29	0.58	0.29	0.90	0.76	0.52	5	10.03	3.37	6.66	7.56	6.66	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
577.2	78.0	78.0	0.29	0.56	0.29	0.88	0.78	0.51	5	10.30	3.49	6.80	7.68	6.80	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
575.2	80.0	80.0	0.28	0.55	0.28	0.86	0.80	0.50	5	10.56	3.62	6.94	7.80	6.94	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
573.2	82.0	82.0	0.28	0.54	0.28	0.85	0.82	0.49	5	10.82	3.74	7.08	7.93	7.08	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
571.2	84.0	84.0	0.27	0.53	0.27	0.83	0.84	0.49	5	11.09	3.87	7.22	8.05	7.22	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
569.2	86.0	86.0	0.27	0.51	0.27	0.82	0.86	0.48	5	11.35	3.99	7.36	8.17	7.36	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
567.2	88.0	88.0	0.27	0.50	0.27	0.80	0.88	0.47	5	11.62	4.12	7.50	8.30	7.50	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
565.2	90.0	90.0	0.26	0.49	0.26	0.79	0.90	0.46	5	11.88	4.24	7.64	8.42	7.64	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
563.2	92.0	92.0	0.26	0.48	0.26	0.77	0.92	0.45	5	12.14	4.37	7.78	8.55	7.78	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
561.2	94.0	94.0	0.25	0.47	0.25	0.76	0.94	0.44	5	12.41	4.49	7.92	8.68	7.92	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
559.2	96.0	96.0	0.25	0.46	0.25	0.75	0.96	0.44	5	12.67	4.62	8.05	8.80	8.05	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
557.2	98.0	98.0	0.25	0.45	0.25	0.73	0.98	0.43	5	12.94	4.74	8.19	8.93	8.19	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
555.2	100.0	100.0	0.24	0.44	0.24	0.72	1.00	0.42	5	13.20	4.87	8.33	9.06	8.33	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
553.2	102.0	102.0	0.24	0.44	0.24	0.71	1.02	0.41	5	13.46	4.99	8.47	9.18	8.47	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
551.2	104.0	104.0	0.23	0.43	0.23	0.70	1.04	0.41	5	13.73	5.12	8.61	9.31	8.61	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
549.2	106.0	106.0	0.23	0.42	0.23	0.69	1.06	0.40	5	13.99	5.24	8.75	9.44	8.75	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
547.2	108.0	108.0	0.23	0.41	0.23	0.68	1.08	0.40	5	14.26	5.37	8.89	9.57	8.89	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59
545.2	110.0	110.0	0.22	0.41	0.22	0.67	1.10	0.39	5	14.52	5.49	9.03	9.70	9.03	0	0.000	0.00	0.000	0.000	0.000	0.000	0.00	1.59

Total Settlement 1.59





Henry County Maumee River Crossing Embankment STA 49+25

Consolidation Settlement (Boussinesq Stress Distribution)

Design Load and Embankment Geometry

Load at Top of Embankment (q_0)	2.08	kips/ft
Horizontal Top Length (b)	24.8	ft
Horizontal Slope Length (a)	33.2	ft
Maximum Height of Embankment (H)	16.6	ft
Slope of Embankment (S)	2.0	:1
Angle of Embankment (θ)	26.6	degrees
Base Width of Embankment (B)	116	ft
Embank. Depth Below Original Ground Surf. (d_w)	0.00	(Surface=0.001)
Original Ground Surface Elevation	660.8	ft
Unit Weight of Embankment Soil (γ_f)	125	lbs/ft³
Depth to Water (D_w)	20	ft
Elevation of Water	640.8	ft

Soil Stratigraphy Under Load

Elevation Upper	Elevation Lower	Depth	Soil Layer
660.8	645.8	0	1
645.8	642.3	15	2
642.3	640.8	18.5	3
640.8		20	4
0		660.8	5

Use weighted Cv

15	0.75	2.00E-03	1.50E-03
3.5	0.18	1.50E-03	2.63E-04
1.5	0.08	1.82E-03	1.37E-04
20		**1.90E-03**	**weighted Cv cm2/sec**

2.94E-04 Cv in2/sec

Foundation Soil Properties

Soil Unit Beneath Foundation	1	2	3	4	5
Soil Unit Weight (γ_H'), psf	132	132	124		
Initial Void Ratio (e_0)	0.493	0.506	0.636		
Recompression Index (C_R)	0.024	0.035	0.031		
Compression Index (C_C)	0.120	0.140	0.140		
Preconsolidation Pressure (σ_P), ksf	9.1	14.8	3.0		

Time Rate of Consolidation

Coeffcient of Consolidation, C_V @ 50%	2.9E-04	in²/s
Coeffcient of Consolidation, C_V @ 50%	1.8E-01	ft²/d
Number of Drainage Paths	1	
Total Thickness of Compressible Soil (ft)	20.0	ft

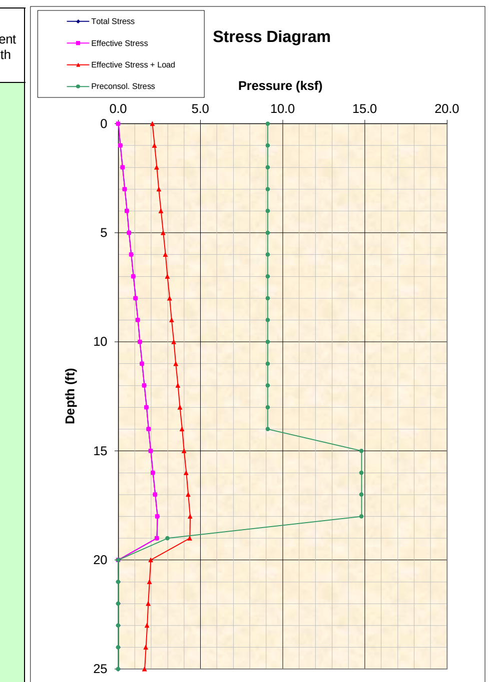
Settlement Over Time

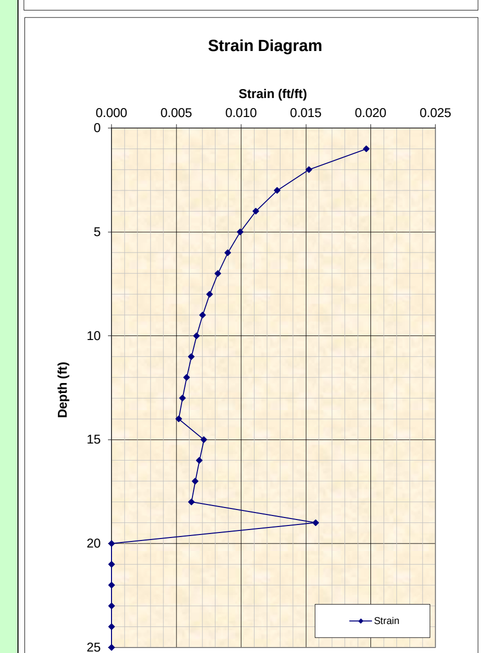
Time (t) (days)	Time (t) (yrs)	Time Factor (T)	Percent Consolid.	Total Consolid. (in)
30	0.08	0.013	13.0%	0.25
60	0.16	0.026	18.4%	0.36
90	0.25	0.040	22.5%	0.44
120	0.33	0.053	26.0%	0.51
270	0.74	0.119	39.0%	0.76
480	**1.31**	**0.212**	**51.9%**	**1.01**
1000	2.74	0.442	72.8%	1.42
1500	4.11	0.662	84.2%	1.64
1900	**5.20**	**0.839**	**89.8%**	**1.75**
1100	3.01	0.486	75.6%	1.47

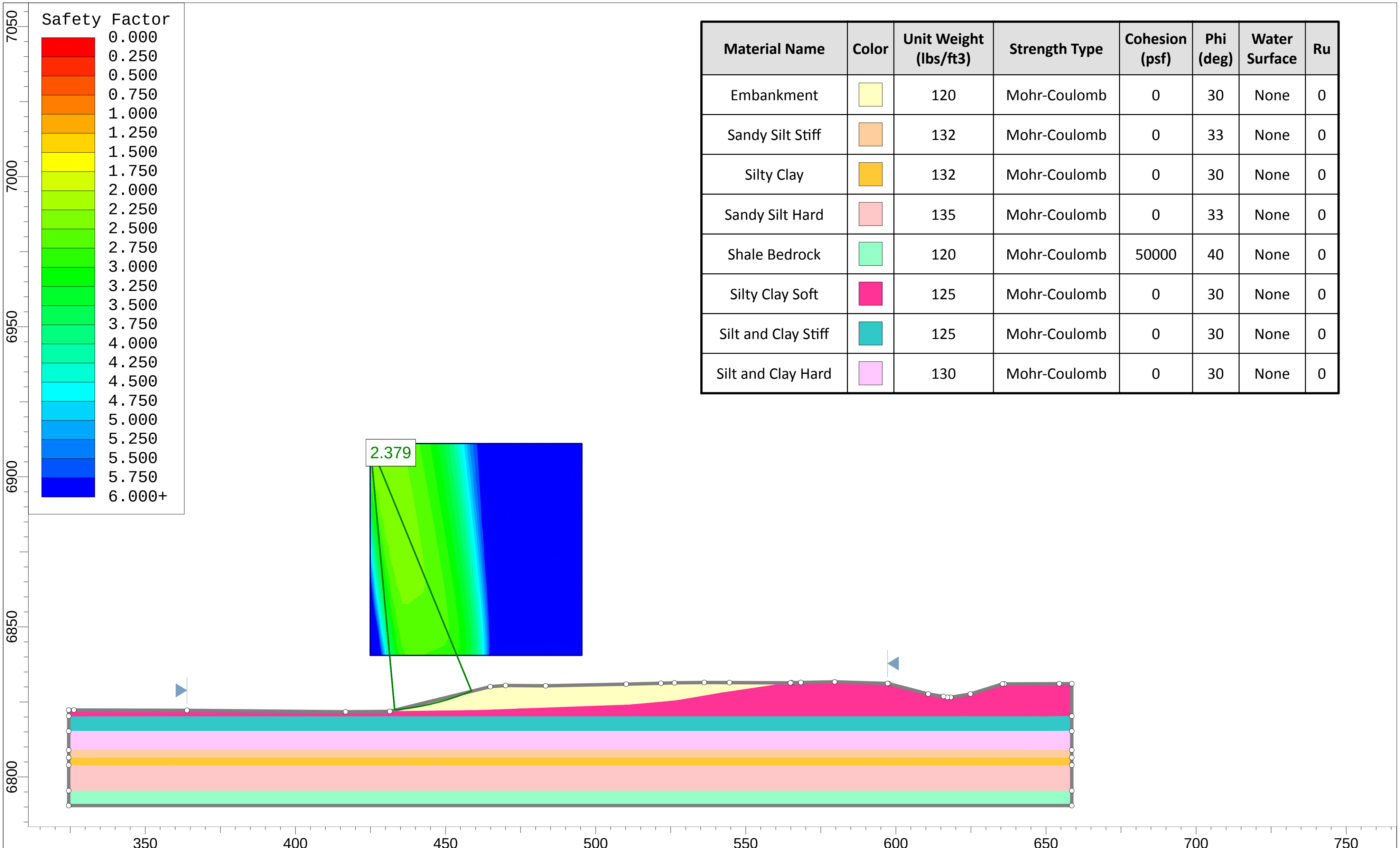
Distance From Center of Embankment (x): 0

Elevation	Depth Below Surface	Depth Beneath Embank. (z)	α	β	α'	$\Delta\sigma_z$ (ksf)	z/B	$\Delta\sigma_z/q_0$	Soil Unit	Total Stress (σ_v) (ksf)	Pore Water Pressure (u) (ksf)	Effective Stress (σ'_v) (ksf)	($\sigma'_v+\Delta\sigma_z$)	Precon. Pressure (σ_p) (ksf)	Void Ratio (e_0)	Recomp Index (C_r)	Comp Index (C_c)	Strain 1 (ft)	Strain 2 (ft)	Strain	Settlement Per Interval (ft)	Settlement Per Interval (in)	Settlement At Depth (in)
660.8	0.0	0.0	0.00	3.14	0.00	2.08		1.00	1	0.00	0.00	0.00	2.08	9.10	0.493	0.024	0.12	0.000	0.000	0.000	0.000	0.00	0.00
659.8	1.0	1.0	0.02	3.06	0.02	2.07	0.01	1.00	1	0.13	0.00	0.13	2.21	9.10	0.493	0.024	0.12	0.020	0.000	0.020	0.000	0.00	0.00
658.8	2.0	2.0	0.05	2.98	0.05	2.07	0.02	1.00	1	0.26	0.00	0.26	2.34	9.10	0.493	0.024	0.12	0.015	0.000	0.015	0.017	0.21	0.21
657.8	3.0	3.0	0.07	2.90	0.07	2.07	0.03	1.00	1	0.40	0.00	0.40	2.47	9.10	0.493	0.024	0.12	0.013	0.000	0.013	0.014	0.17	0.38
656.8	4.0	4.0	0.09	2.82	0.09	2.07	0.03	1.00	1	0.53	0.00	0.53	2.60	9.10	0.493	0.024	0.12	0.011	0.000	0.011	0.012	0.14	0.52
655.8	5.0	5.0	0.11	2.74	0.11	2.07	0.04	1.00	1	0.66	0.00	0.66	2.73	9.10	0.493	0.024	0.12	0.010	0.000	0.010	0.011	0.13	0.65
654.8	6.0	6.0	0.13	2.67	0.13	2.07	0.05	1.00	1	0.79	0.00	0.79	2.86	9.10	0.493	0.024	0.12	0.009	0.000	0.009	0.009	0.11	0.76
653.8	7.0	7.0	0.15	2.59	0.15	2.07	0.06	1.00	1	0.92	0.00	0.92	2.99	9.10	0.493	0.024	0.12	0.008	0.000	0.008	0.009	0.10	0.86
652.8	8.0	8.0	0.17	2.52	0.17	2.07	0.07	1.00	1	1.06	0.00	1.06	3.12	9.10	0.493	0.024	0.12	0.008	0.000	0.008	0.008	0.09	0.96
651.8	9.0	9.0	0.19	2.45	0.19	2.06	0.08	0.99	1	1.19	0.00	1.19	3.25	9.10	0.493	0.024	0.12	0.007	0.000	0.007	0.007	0.09	1.05
650.8	10.0	10.0	0.21	2.38	0.21	2.06	0.09	0.99	1	1.32	0.00	1.32	3.38	9.10	0.493	0.024	0.12	0.007	0.000	0.007	0.007	0.08	1.13
649.8	11.0	11.0	0.23	2.31	0.23	2.05	0.09	0.99	1	1.45	0.00	1.45	3.51	9.10	0.493	0.024	0.12	0.006	0.000	0.006	0.006	0.08	1.20
648.8	12.0	12.0	0.25	2.24	0.25	2.05	0.10	0.99	1	1.58	0.00	1.58	3.63	9.10	0.493	0.024	0.12	0.006	0.000	0.006	0.006	0.07	1.28
647.8	13.0	13.0	0.26	2.18	0.26	2.04	0.11	0.98	1	1.72	0.00	1.72	3.76	9.10	0.493	0.024	0.12	0.005	0.000	0.005	0.006	0.07	1.34
646.8	14.0	14.0	0.28	2.11	0.28	2.04	0.12	0.98	1	1.85	0.00	1.85	3.88	9.10	0.493	0.024	0.12	0.005	0.000	0.005	0.005	0.06	1.41
645.8	15.0	15.0	0.29	2.05	0.29	2.03	0.13	0.98	2	1.98	0.00	1.98	4.01	14.80	0.506	0.035	0.14	0.007	0.000	0.007	0.006	0.07	1.48
644.8	16.0	16.0	0.30	2.00	0.30	2.02	0.14	0.97	2	2.11	0.00	2.11	4.13	14.80	0.506	0.035	0.14	0.007	0.000	0.007	0.007	0.08	1.56
643.8	17.0	17.0	0.32	1.94	0.32	2.01	0.15	0.97	2	2.24	0.00	2.24	4.25	14.80	0.506	0.035	0.14	0.006	0.000	0.006	0.007	0.08	1.64
642.8	18.0	18.0	0.33	1.89	0.33	2.00	0.16	0.96	2	2.38	0.00	2.38	4.38	14.80	0.506	0.035	0.14	0.006	0.000	0.006	0.006	0.08	1.72
641.8	19.0	19.0	0.34	1.83	0.34	1.99	0.16	0.96	3	2.36	0.00	2.36	4.35	3.00	0.636	0.031	0.14	0.002	0.014	0.016	0.011	0.13	1.85
640.8	20.0	20.0	0.35	1.78	0.35	1.98	0.17	0.95	4	0.00	0.00	0.00	1.98	0.00	0	0.000	0.00	#DIV/0!	#DIV/0!	0.000	0.008	0.09	1.95
639.8	21.0	21.0	0.36	1.74	0.36	1.97	0.18	0.95	4	0.00	0.06	-0.06	1.90	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
638.8	22.0	22.0	0.36	1.69	0.36	1.95	0.19	0.94	4	0.00	0.12	-0.12	1.83	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
637.8	23.0	23.0	0.37	1.65	0.37	1.94	0.20	0.94	4	0.00	0.19	-0.19	1.75	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
636.8	24.0	24.0	0.38	1.60	0.38	1.93	0.21	0.93	4	0.00	0.25	-0.25	1.68	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
635.8	25.0	25.0	0.38	1.56	0.38	1.91	0.22	0.92	4	0.00	0.31	-0.31	1.60	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
634.8	26.0	26.0	0.39	1.52	0.39	1.90	0.22	0.92	4	0.00	0.37	-0.37	1.53	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
633.8	27.0	27.0	0.39	1.49	0.39	1.89	0.23	0.91	4	0.00	0.44	-0.44	1.45	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
632.8	28.0	28.0	0.40	1.45	0.40	1.87	0.24	0.90	4	0.00	0.50	-0.50	1.37	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
631.8	29.0	29.0	0.40	1.42	0.40	1.86	0.25	0.89	4	0.00	0.56	-0.56	1.30	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
630.8	30.0	30.0	0.40	1.38	0.40	1.84	0.26	0.89	4	0.00	0.62	-0.62	1.22	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
629.8	31.0	31.0	0.41	1.35	0.41	1.83	0.27	0.88	4	0.00	0.69	-0.69	1.14	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
628.8	32.0	32.0	0.41	1.32	0.41	1.81	0.28	0.87	4	0.00	0.75	-0.75	1.06	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
627.8	33.0	33.0	0.41	1.29	0.41	1.80	0.28	0.87	4	0.00	0.81	-0.81	0.98	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
626.8	34.0	34.0	0.41	1.26	0.41	1.78	0.29	0.86	4	0.00	0.87	-0.87	0.91	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
625.8	35.0	35.0	0.41	1.23	0.41	1.76	0.30	0.85	4	0.00	0.94	-0.94	0.83	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
624.8	36.0	36.0	0.41	1.21	0.41	1.75	0.31	0.84	4	0.00	1.00	-1.00	0.75	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
623.8	37.0	37.0	0.41	1.18	0.41	1.73	0.32	0.83	4	0.00	1.06	-1.06	0.67	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
622.8	38.0	38.0	0.41	1.16	0.41	1.72	0.33	0.83	4	0.00	1.12	-1.12	0.59	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
621.8	39.0	39.0	0.41	1.13	0.41	1.70	0.34	0.82	4	0.00	1.19	-1.19	0.51	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
620.8	40.0	40.0	0.41	1.11	0.41	1.68	0.34	0.81	4	0.00	1.25	-1.25	0.44	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
619.8	41.0	41.0	0.41	1.09	0.41	1.67	0.35	0.80	4	0.00	1.31	-1.31	0.36	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
618.8	42.0	42.0	0.41	1.07	0.41	1.65	0.36	0.80	4	0.00	1.37	-1.37	0.28	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
617.8	43.0	43.0	0.41	1.05	0.41	1.64	0.37	0.79	4	0.00	1.44	-1.44	0.20	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
616.8	44.0	44.0	0.41	1.03	0.41	1.62	0.38	0.78	4	0.00	1.50	-1.50	0.12	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
615.8	45.0	45.0	0.41	1.01	0.41	1.61	0.39	0.77	4	0.00	1.56	-1.56	0.05	0.00	0	0.000	0.00	#NUM!	#DIV/0!	0.000	0.000	0.00	1.95
614.8	46.0	46.0	0.41	0.99	0.41	1.59	0.40	0.77	4	0.00	1.62	-1.62	-0.03	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
613.8	47.0	47.0	0.40	0.97	0.40	1.57	0.41	0.76	4	0.00	1.68	-1.68	-0.11	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
612.8	48.0	48.0	0.40	0.95	0.40	1.56	0.41	0.75	4	0.00	1.75	-1.75	-0.19	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
611.8	49.0	49.0	0.40	0.94	0.40	1.54	0.42	0.74	4	0.00	1.81	-1.81	-0.27	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
610.8	50.0	50.0	0.40	0.92	0.40	1.53	0.43	0.74	4	0.00	1.87	-1.87	-0.34	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
608.8	52.0	52.0	0.39	0.89	0.39	1.50	0.45	0.72	4	0.00	2.00	-2.00	-0.50	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
606.8	54.0	54.0	0.39	0.86	0.39	1.47	0.47	0.71	4	0.00	2.12	-2.12	-0.65	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
604.8	56.0	56.0	0.39	0.83	0.39	1.44	0.48	0.69	4	0.00	2.25	-2.25	-0.80	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
602.8	58.0	58.0	0.38	0.81	0.38	1.41	0.50	0.68	4	0.00	2.37	-2.37	-0.96	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
600.8	60.0	60.0	0.38	0.78	0.38	1.39	0.52	0.67	4	0.00	2.50	-2.50	-1.11	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
598.8	62.0	62.0	0.37	0.76	0.37	1.36	0.53	0.66	4	0.00	2.62	-2.62	-1.26	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
596.8	64.0	64.0	0.37	0.74	0.37	1.33	0.55	0.64	4	0.00	2.75	-2.75	-1.41	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
594.8	66.0	66.0	0.36	0.72	0.36	1.31	0.57	0.63	4	0.00	2.87	-2.87	-1.56	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
592.8	68.0	68.0	0.36	0.70	0.36	1.28	0.59	0.62	4	0.00	3.00	-3.00	-1.71	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
590.8	70.0	70.0	0.35	0.68	0.35	1.26	0.60	0.61	4	0.00	3.12	-3.12	-1.86	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
588.8	72.0	72.0	0.35	0.66	0.35	1.24	0.62	0.60	4	0.00	3.24	-3.24	-2.01	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
586.8	74.0	74.0	0.34	0.65	0.34	1.22	0.64	0.59	4	0.00	3.37	-3.37	-2.15	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
584.8	76.0	76.0	0.34	0.63	0.34	1.19	0.66	0.57	4	0.00	3.49	-3.49	-2.30	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
582.8	78.0	78.0	0.33	0.62	0.33	1.17	0.67	0.56	4	0.00	3.62	-3.62	-2.45	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
580.8	80.0	80.0	0.33	0.60	0.33	1.15	0.69	0.55	4	0.00	3.74	-3.74	-2.59	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
578.8	82.0	82.0	0.32	0.59	0.32	1.13	0.71	0.55	4	0.00	3.87	-3.87	-2.74	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
576.8	84.0	84.0	0.32	0.57	0.32	1.11	0.72	0.54	4	0.00	3.99	-3.99	-2.88	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
574.8	86.0	86.0	0.31	0.56	0.31	1.09	0.74	0.53	4	0.00	4.12	-4.12	-3.03	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
572.8	88.0	88.0	0.31	0.55	0.31	1.07	0.76	0.52	4	0.00	4.24	-4.24	-3.17	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
570.8	90.0	90.0	0.30	0.54	0.30	1.06	0.78	0.51	4	0.00	4.37	-4.37	-3.31	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
568.8	92.0	92.0	0.30	0.53	0.30	1.04	0.79	0.50	4	0.00	4.49	-4.49	-3.45	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
566.8	94.0	94.0	0.29	0.52	0.29	1.02	0.81	0.49	4	0.00	4.62	-4.62	-3.60	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
564.8	96.0	96.0	0.29	0.51	0.29	1.00	0.83	0.48	4	0.00	4.74	-4.74	-3.74	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
562.8	98.0	98.0	0.29	0.50	0.29	0.99	0.84	0.48	4	0.00	4.87	-4.87	-3.88	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
560.8	100.0	100.0	0.28	0.49	0.28	0.97	0.86	0.47	4	0.00	4.99	-4.99	-4.02	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
558.8	102.0	102.0	0.28	0.48	0.28	0.96	0.88	0.46	4	0.00	5.12	-5.12	-4.16	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
556.8	104.0	104.0	0.27	0.47	0.27	0.94	0.90	0.45	4	0.00	5.24	-5.24	-4.30	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
554.8	106.0	106.0	0.27	0.46	0.27	0.93	0.91	0.45	4	0.00	5.37	-5.37	-4.44	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
552.8	108.0	108.0	0.27	0.45	0.27	0.91	0.93	0.44	4	0.00	5.49	-5.49	-4.58	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95
550.8	110.0	110.0	0.26	0.44	0.26	0.90	0.95	0.43	4	0.00	5.62	-5.62	-4.72	0.00	0	0.000	0.00	0.000	#DIV/0!	0.000	0.000	0.00	1.95

Total Settlement 1.95





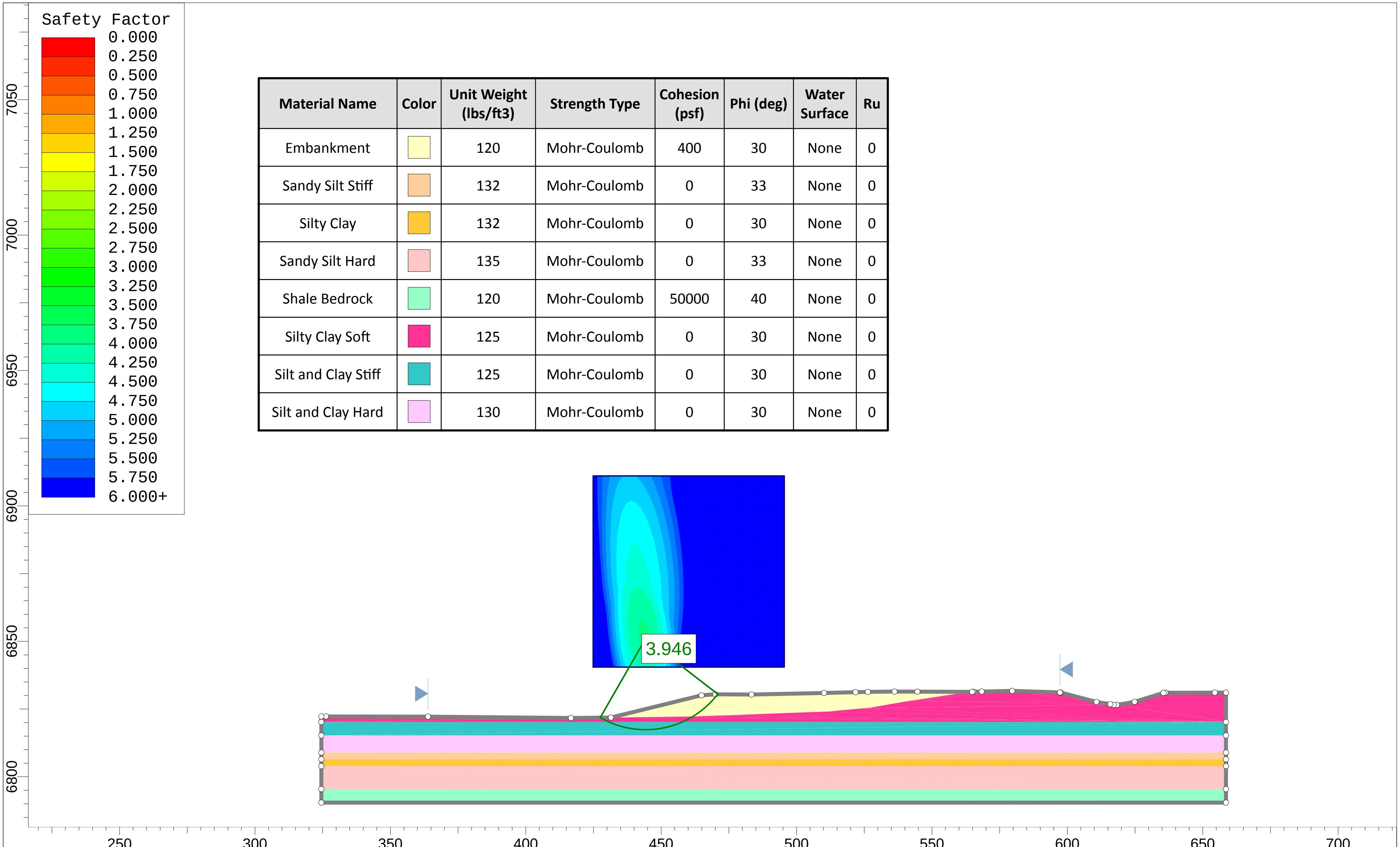


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Embankment		120	Mohr-Coulomb	0	30	None	0
Sandy Silt Stiff		132	Mohr-Coulomb	0	33	None	0
Silty Clay		132	Mohr-Coulomb	0	30	None	0
Sandy Silt Hard		135	Mohr-Coulomb	0	33	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	0
Silty Clay Soft		125	Mohr-Coulomb	0	30	None	0
Silt and Clay Stiff		125	Mohr-Coulomb	0	30	None	0
Silt and Clay Hard		130	Mohr-Coulomb	0	30	None	0

Mannik Smith GROUP
TECHNICAL SKILL. CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon
Analysis Description	STA 106+00 0 psf Cohesion Drained
Drawn By	GAB
Scale	1:531
Company	The Mannik & Smith Group, Inc.
Date	3/13/15
File Name	H2530002.STA 106+00. reduced cohesion Drained.GAB.slim

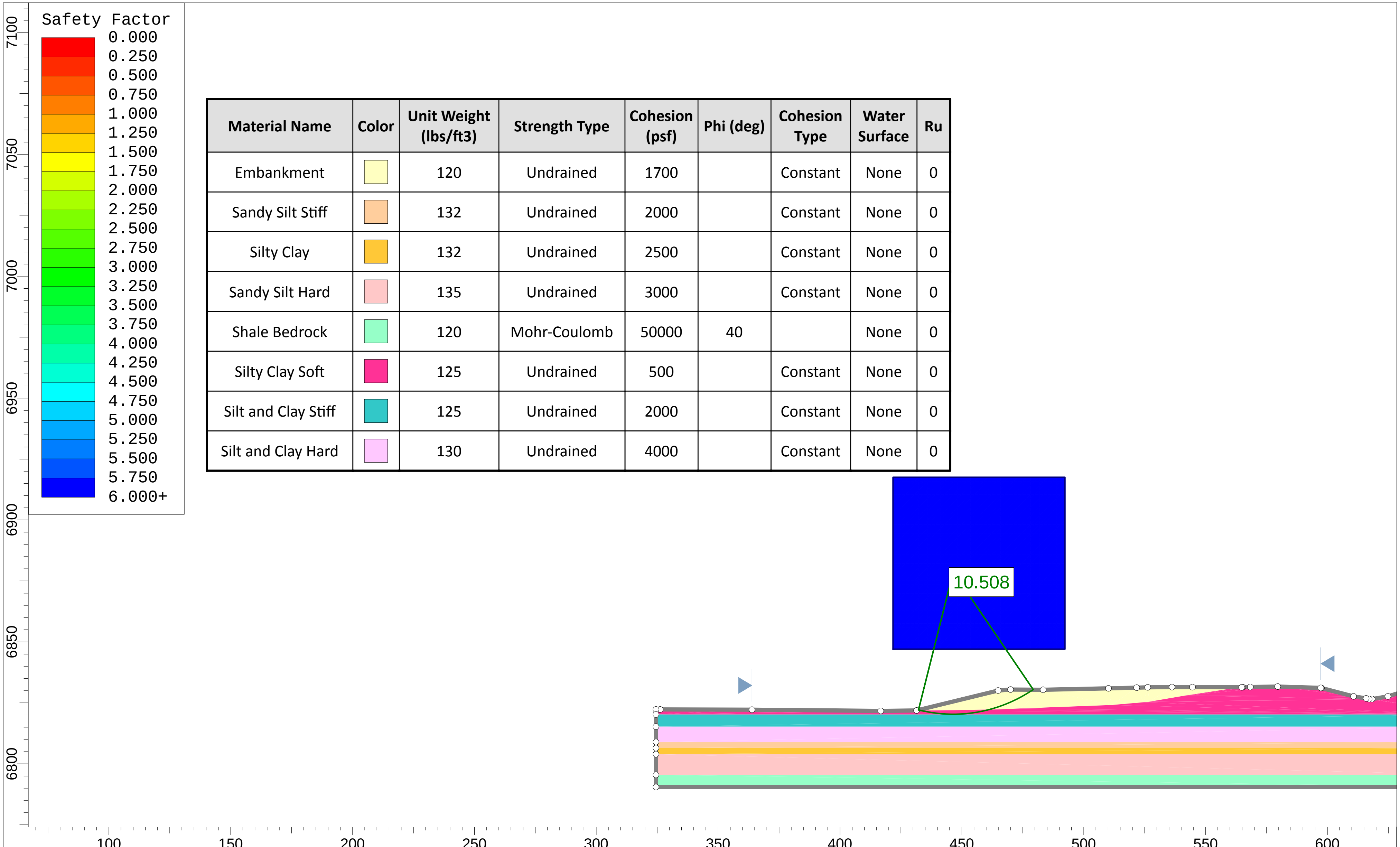


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Embankment		120	Mohr-Coulomb	400	30	None	0
Sandy Silt Stiff		132	Mohr-Coulomb	0	33	None	0
Silty Clay		132	Mohr-Coulomb	0	30	None	0
Sandy Silt Hard		135	Mohr-Coulomb	0	33	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	0
Silty Clay Soft		125	Mohr-Coulomb	0	30	None	0
Silt and Clay Stiff		125	Mohr-Coulomb	0	30	None	0
Silt and Clay Hard		130	Mohr-Coulomb	0	30	None	0

TECHNICAL SKILL.
CREATIVE SPIRIT.

SLIDEINTERPRET 6.015

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 106+00 Drained		
Drawn By GAB	*Scale* 1:588	*Company*	The Mannik & Smith Group, Inc.
Date	3/13/15	*File Name*	H2530002.STA 106+00.Drained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Ru
Embankment		120	Undrained	1700		Constant	None	0
Sandy Silt Stiff		132	Undrained	2000		Constant	None	0
Silty Clay		132	Undrained	2500		Constant	None	0
Sandy Silt Hard		135	Undrained	3000		Constant	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40		None	0
Silty Clay Soft		125	Undrained	500		Constant	None	0
Silt and Clay Stiff		125	Undrained	2000		Constant	None	0
Silt and Clay Hard		130	Undrained	4000		Constant	None	0

Mannik Smith GROUP
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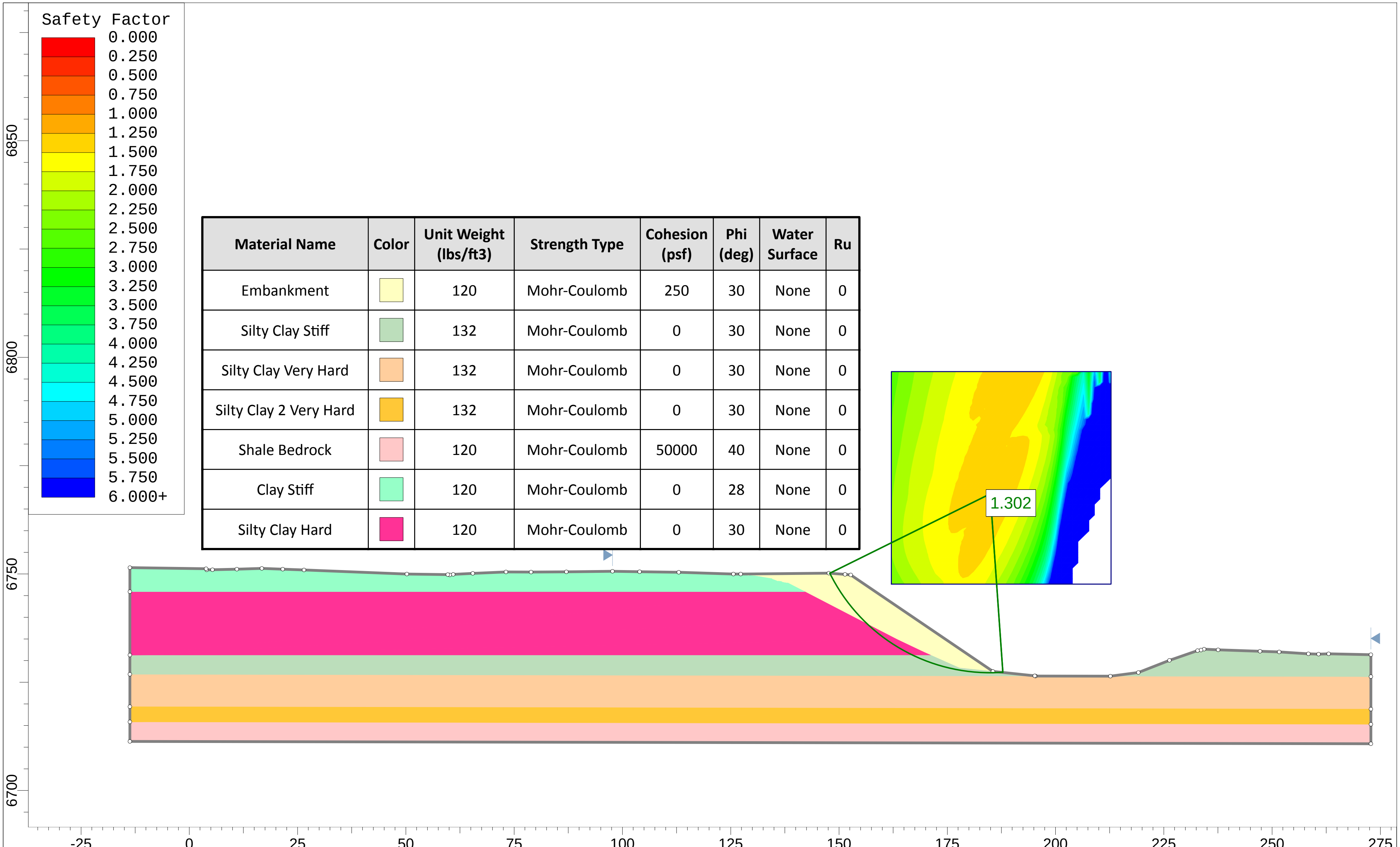
SLIDEINTERPRET 6.015

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 106+00 Undrained		
Drawn By	GAB	*Scale*	1:654
Company	The Mannik & Smith Group, Inc.		
Date	3/13/15	*File Name*	H2530002.STA 106+00.Undrained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Embankment		120	Mohr-Coulomb	250	30	None	0
Silty Clay Stiff		132	Mohr-Coulomb	0	30	None	0
Silty Clay Very Hard		132	Mohr-Coulomb	0	30	None	0
Silty Clay 2 Very Hard		132	Mohr-Coulomb	0	30	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	0
Clay Stiff		120	Mohr-Coulomb	0	28	None	0
Silty Clay Hard		120	Mohr-Coulomb	0	30	None	0

Mannik Smith GROUP
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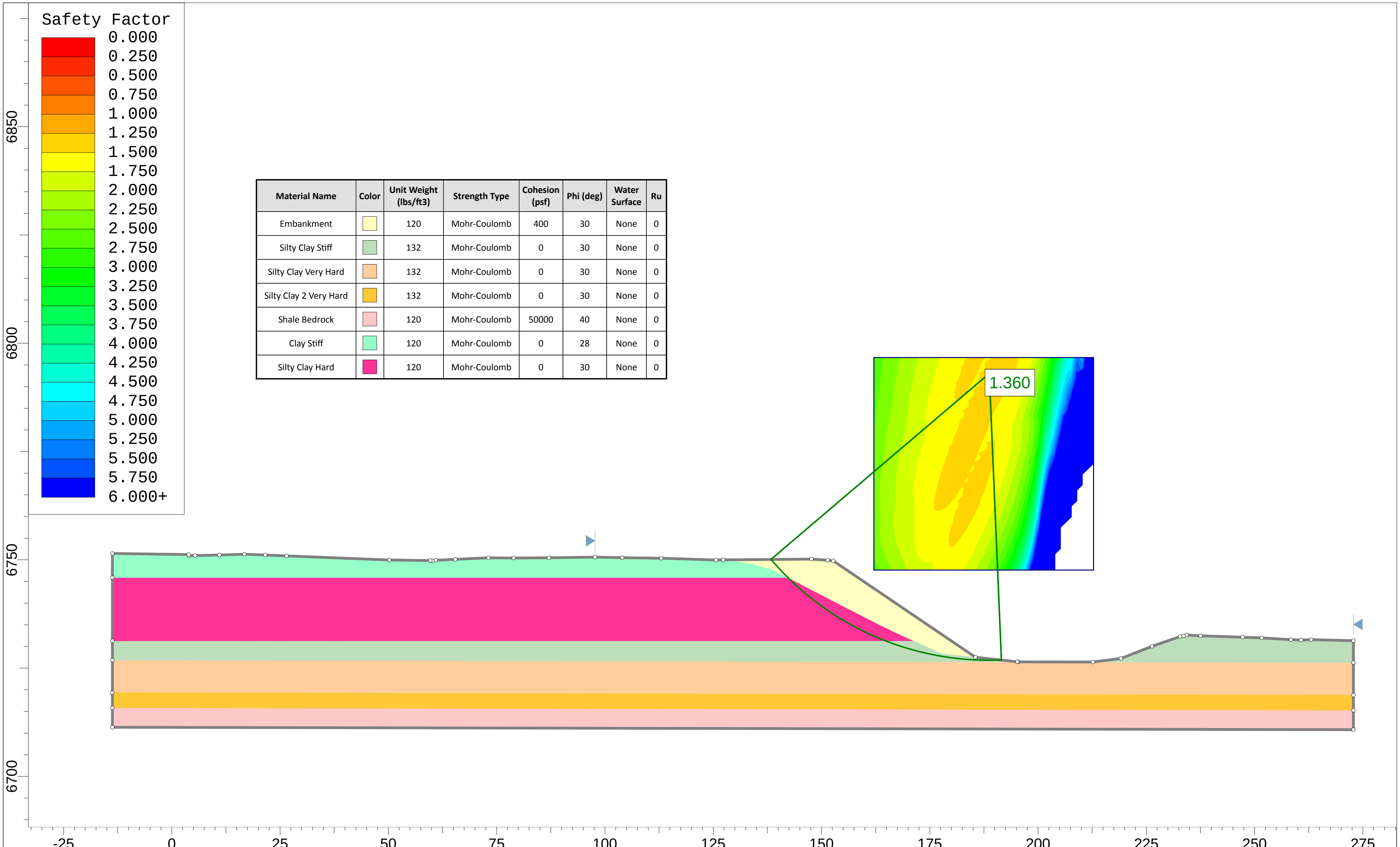
SLIDEINTERPRET 6.034

Project
Maumee River Crossing Napoleon

Analysis Description
STA 593+00 250 psf cohesion Drained

Drawn By GAB
Scale 1:368
Company

Date 3/13/15
File Name H2530002.STA 593+00.reduced cohesion deg drained.GAB.slim

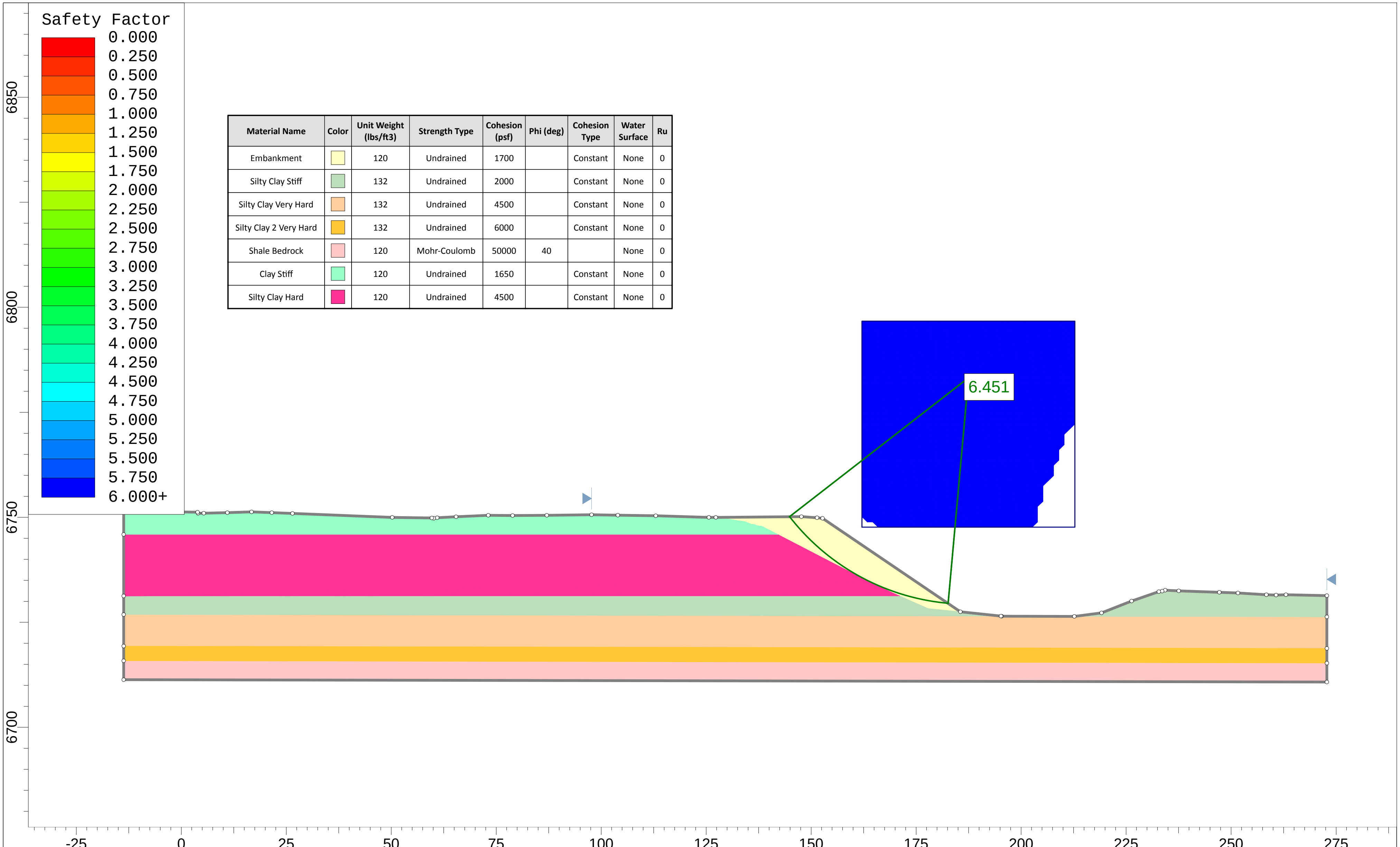


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Embankment		120	Mohr-Coulomb	400	30	None	0
Silty Clay Stiff		132	Mohr-Coulomb	0	30	None	0
Silty Clay Very Hard		132	Mohr-Coulomb	0	30	None	0
Silty Clay 2 Very Hard		132	Mohr-Coulomb	0	30	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	0
Clay Stiff		120	Mohr-Coulomb	0	28	None	0
Silty Clay Hard		120	Mohr-Coulomb	0	30	None	0

Mannik Smith GROUP
TECHNICAL SKILL. CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon
Analysis Description	STA 593+00 Drained
Drawn By	GAB
Scale	1:368
Company	
Date	3/13/15
File Name	H2530002.STA 593+00.drained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Ru
Embankment		120	Undrained	1700		Constant	None	0
Silty Clay Stiff		132	Undrained	2000		Constant	None	0
Silty Clay Very Hard		132	Undrained	4500		Constant	None	0
Silty Clay 2 Very Hard		132	Undrained	6000		Constant	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40		None	0
Clay Stiff		120	Undrained	1650		Constant	None	0
Silty Clay Hard		120	Undrained	4500		Constant	None	0

TECHNICAL SKILL.
CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project Maumee River Crossing Napoleon

Analysis Description STA 593+00 Undrained

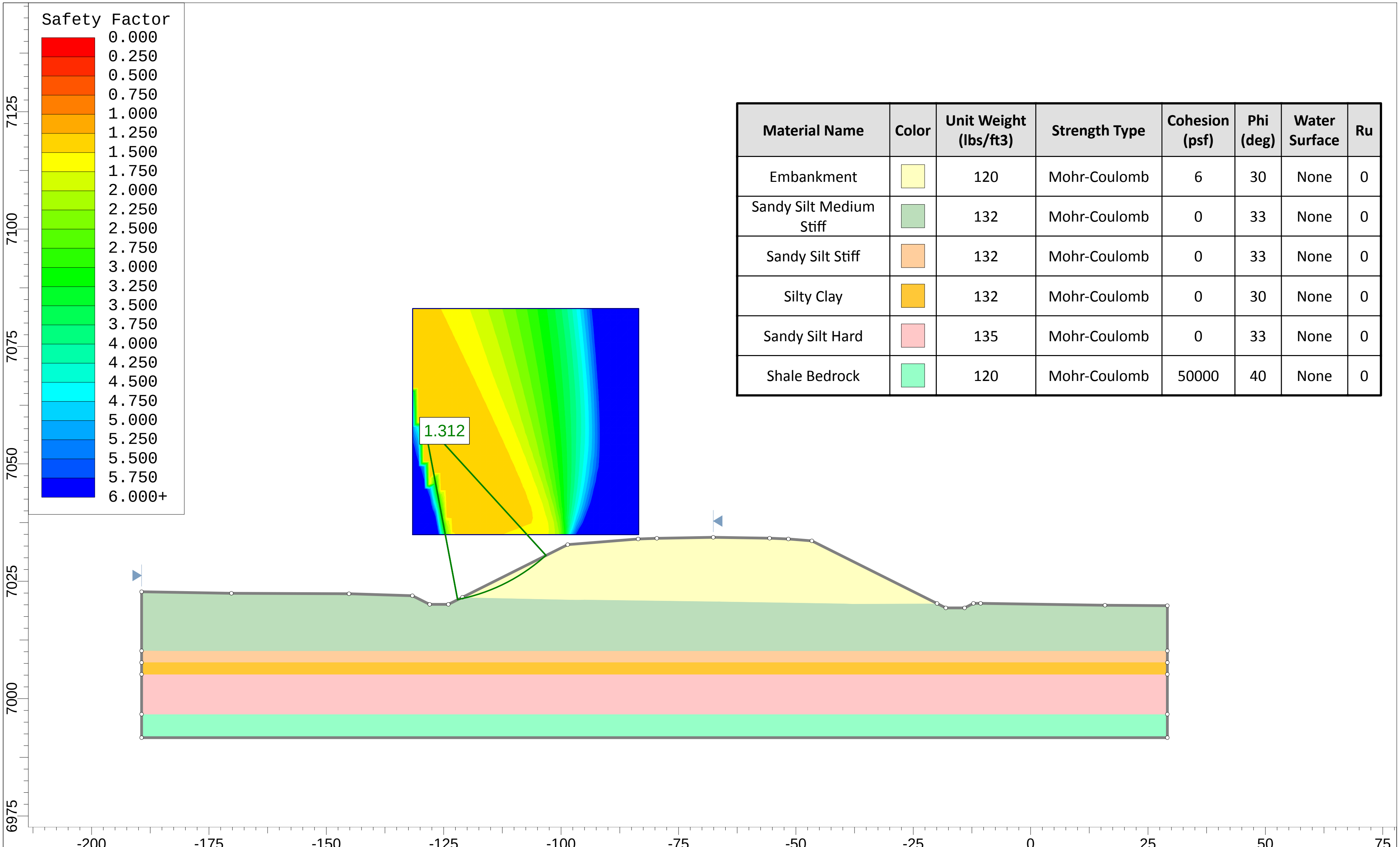
Drawn By GAB

Scale 1:379

Company

Date 3/13/15

File Name H2530002.STA 593+00.Undrained.GAB.slim

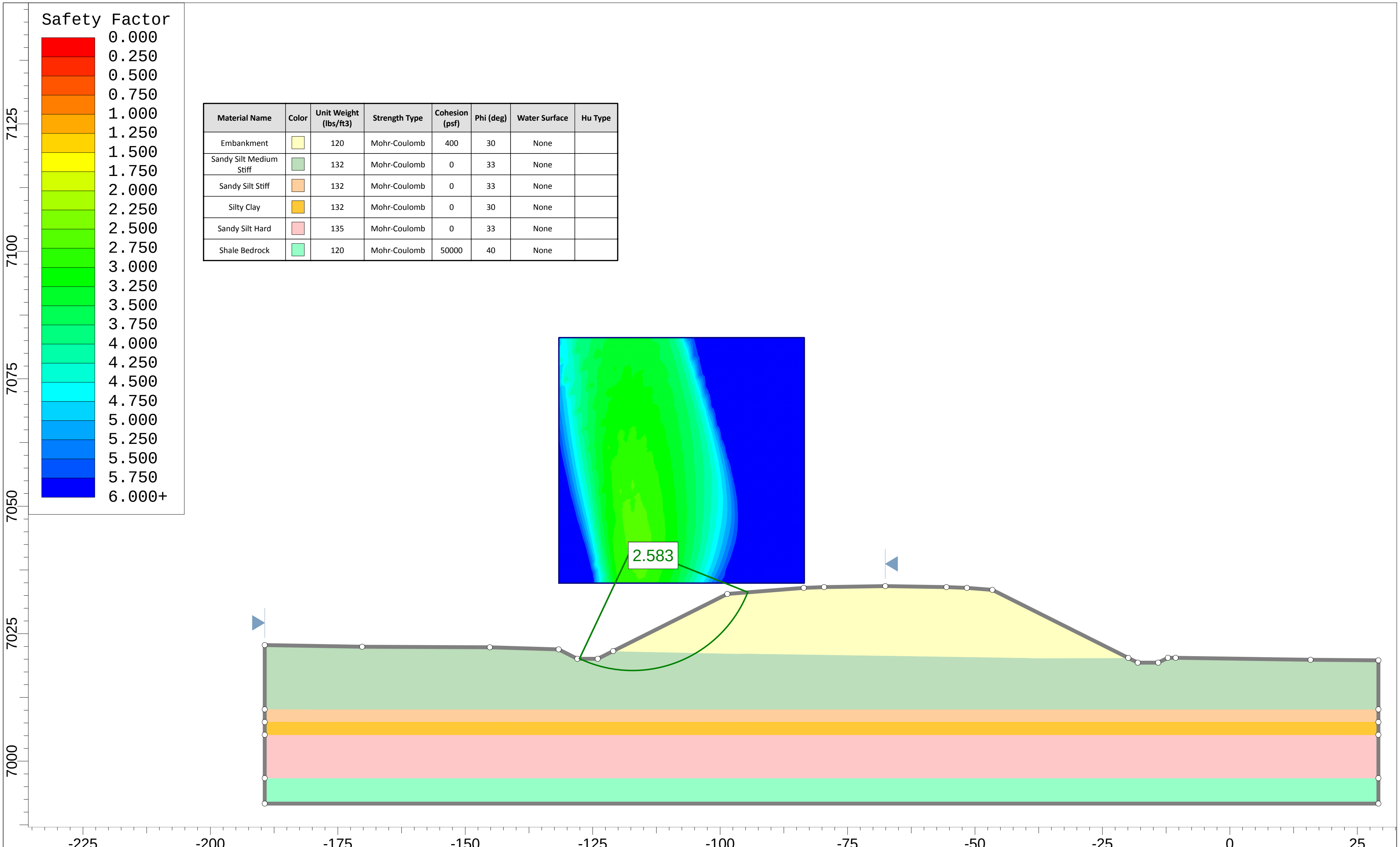


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Embankment		120	Mohr-Coulomb	6	30	None	0
Sandy Silt Medium Stiff		132	Mohr-Coulomb	0	33	None	0
Sandy Silt Stiff		132	Mohr-Coulomb	0	33	None	0
Silty Clay		132	Mohr-Coulomb	0	30	None	0
Sandy Silt Hard		135	Mohr-Coulomb	0	33	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	0

Mannik Smith GROUP
TECHNICAL SKILL. CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 39+00 6 psf cohesion Drained		
Drawn By GAB	*Scale* 1:339	*Company*	The Mannik & Smith Group, Inc.
Date	3/13/15	*File Name*	H2530002.STA39+00.reduced cohesion drained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type
Embankment		120	Mohr-Coulomb	400	30	None	
Sandy Silt Medium Stiff		132	Mohr-Coulomb	0	33	None	
Sandy Silt Stiff		132	Mohr-Coulomb	0	33	None	
Silty Clay		132	Mohr-Coulomb	0	30	None	
Sandy Silt Hard		135	Mohr-Coulomb	0	33	None	
Shale Bedrock		120	Mohr-Coulomb	50000	40	None	

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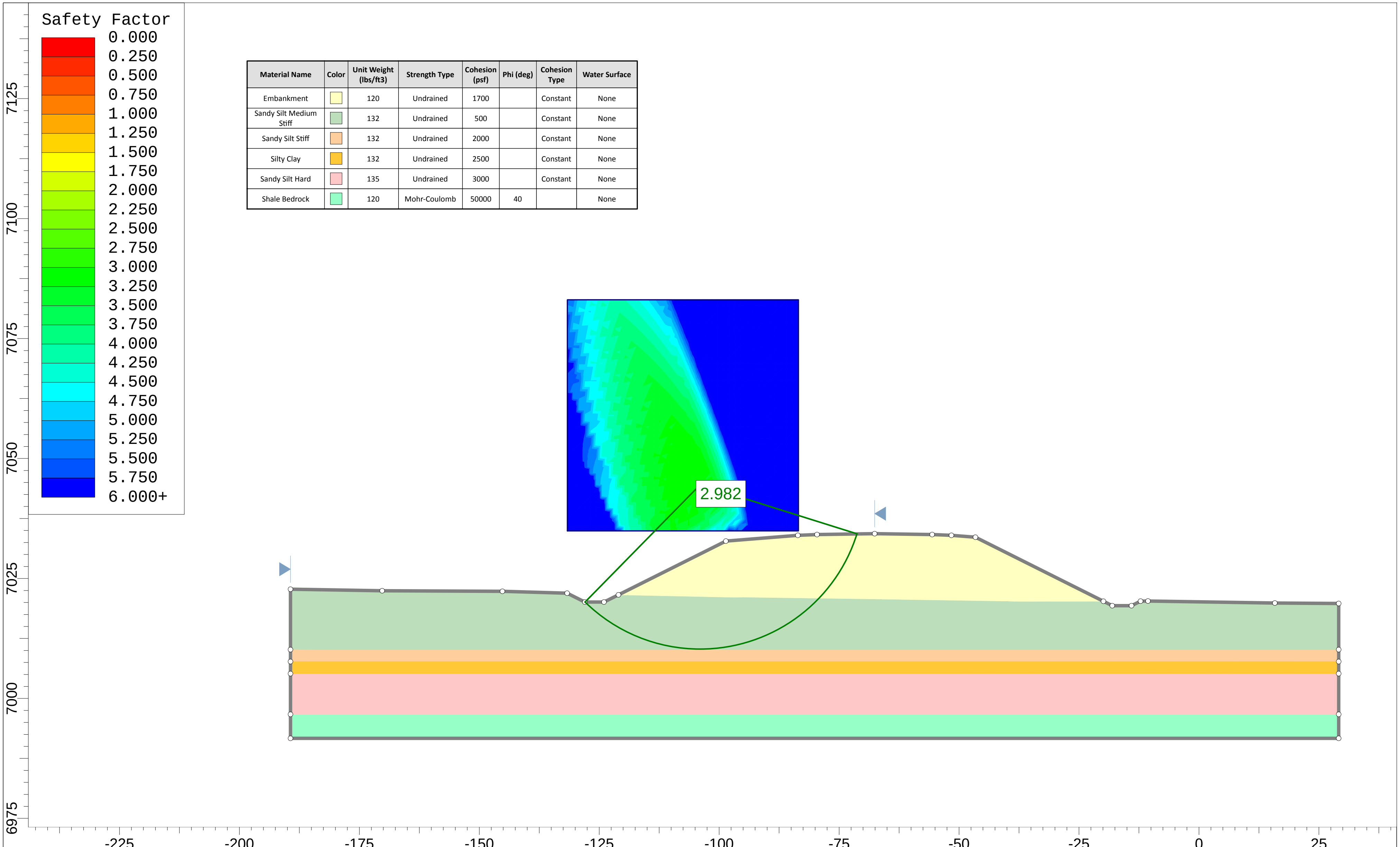
CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 39+00 Drained		
Drawn By	GAB	*Scale* 1:312	*Company* The Mannik & Smith Group, Inc.
Date	3/13/15	*File Name*	H2530002.STA39+00.drained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Embankment		120	Undrained	1700		Constant	None
Sandy Silt Medium Stiff		132	Undrained	500		Constant	None
Sandy Silt Stiff		132	Undrained	2000		Constant	None
Silty Clay		132	Undrained	2500		Constant	None
Sandy Silt Hard		135	Undrained	3000		Constant	None
Shale Bedrock		120	Mohr-Coulomb	50000	40		None

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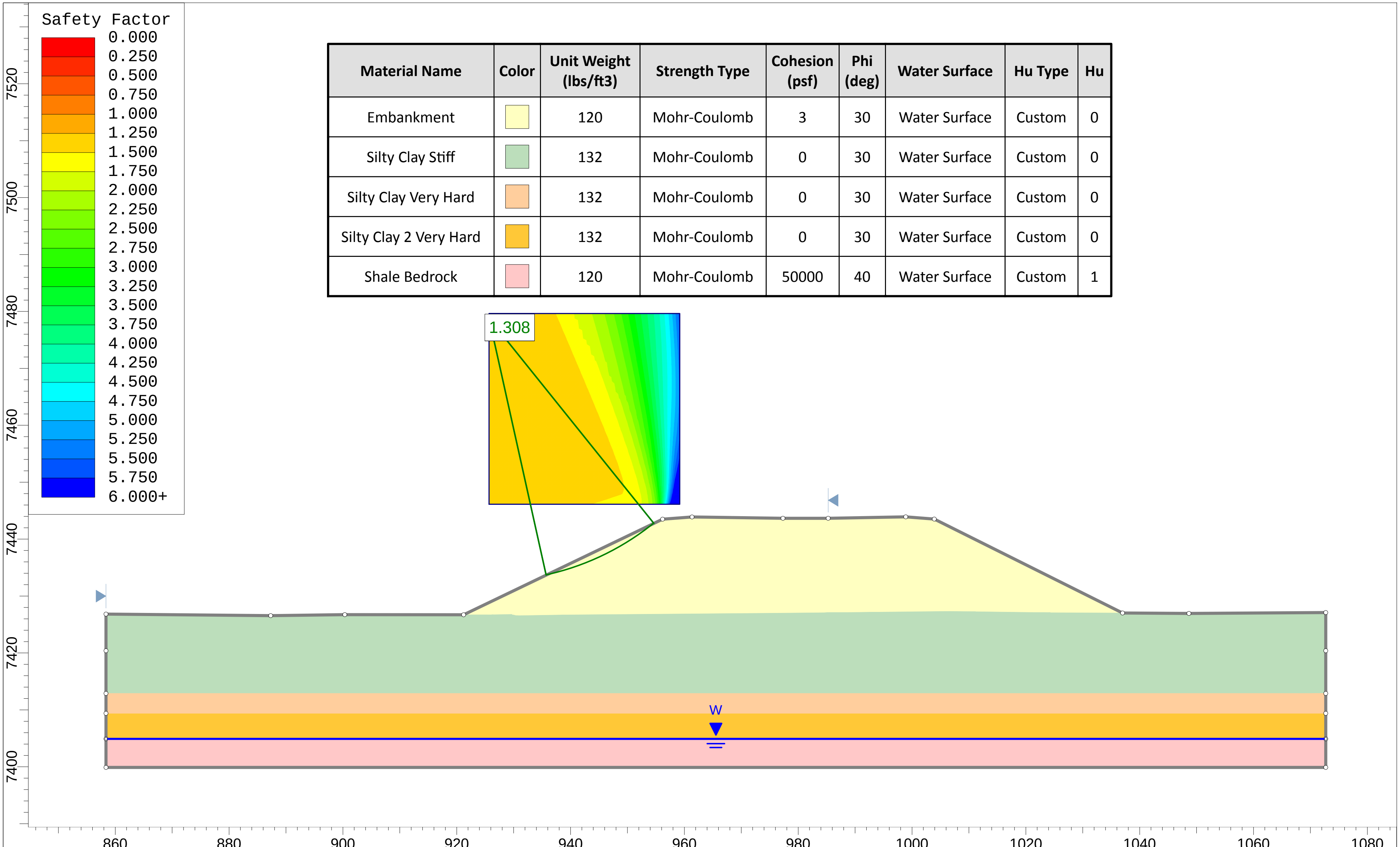
SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon
Analysis Description	STA 39+00 Undrained

Drawn By	GAB	*Scale*	1:332	*Company*	The Mannik & Smith Group, Inc.
Date	3/13/15			*File Name*	H2530002.STA39+00.Undrained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Embankment		120	Mohr-Coulomb	3	30	Water Surface	Custom	0
Silty Clay Stiff		132	Mohr-Coulomb	0	30	Water Surface	Custom	0
Silty Clay Very Hard		132	Mohr-Coulomb	0	30	Water Surface	Custom	0
Silty Clay 2 Very Hard		132	Mohr-Coulomb	0	30	Water Surface	Custom	0
Shale Bedrock		120	Mohr-Coulomb	50000	40	Water Surface	Custom	1

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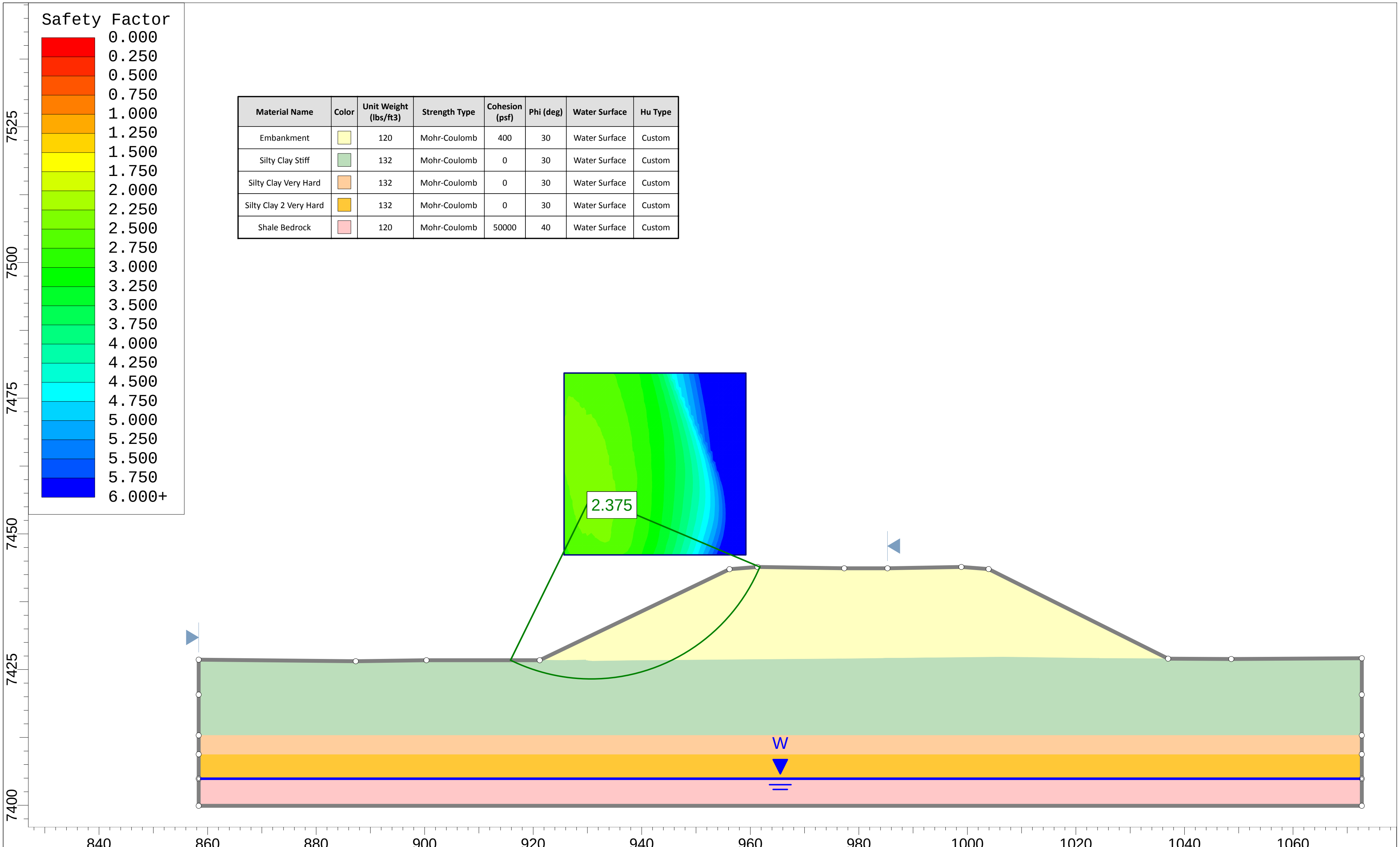
SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 49+25 3 psf cohesion Drained		
Drawn By	GAB	*Scale*	1:280
Company			
Date	3/16/15	*File Name*	H2530002.STA49+25.reduced cohesion drained.GAB.slim

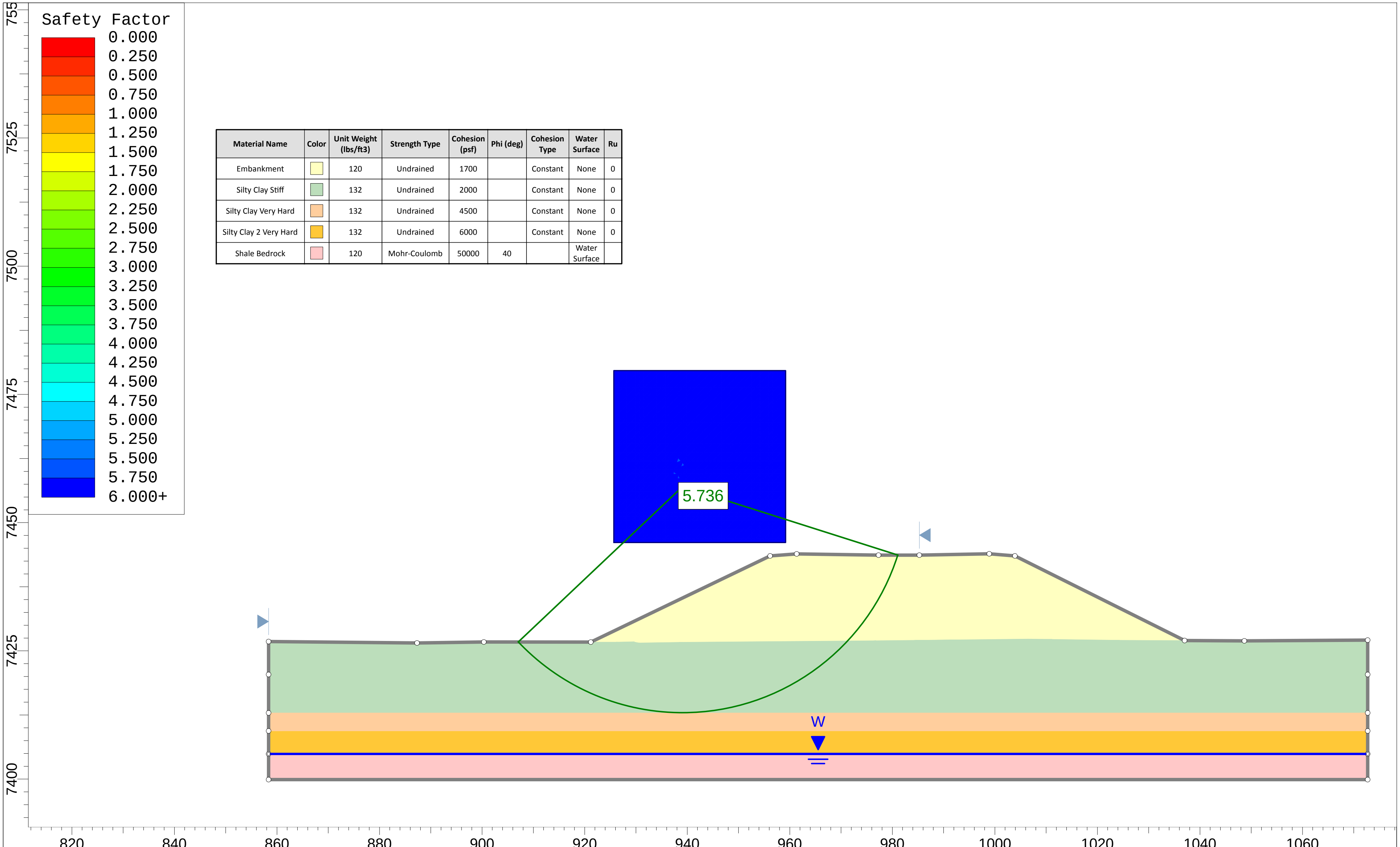


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type
Embankment		120	Mohr-Coulomb	400	30	Water Surface	Custom
Silty Clay Stiff		132	Mohr-Coulomb	0	30	Water Surface	Custom
Silty Clay Very Hard		132	Mohr-Coulomb	0	30	Water Surface	Custom
Silty Clay 2 Very Hard		132	Mohr-Coulomb	0	30	Water Surface	Custom
Shale Bedrock		120	Mohr-Coulomb	50000	40	Water Surface	Custom

Mannik Smith GROUP
TECHNICAL SKILL. CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon
Analysis Description	STA 49+25 Drained
Drawn By	GAB
Scale	1:294
Company	
Date	3/16/15
File Name	H2530002.STA49+25.drained.GAB.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Ru
Embankment		120	Undrained	1700		Constant	None	0
Silty Clay Stiff		132	Undrained	2000		Constant	None	0
Silty Clay Very Hard		132	Undrained	4500		Constant	None	0
Silty Clay 2 Very Hard		132	Undrained	6000		Constant	None	0
Shale Bedrock		120	Mohr-Coulomb	50000	40		Water Surface	

Mannik Smith GROUP
TECHNICAL SKILL. CREATIVE SPIRIT.

SLIDEINTERPRET 6.034

Project	Maumee River Crossing Napoleon		
Analysis Description	STA 49+25 Undrained		
Drawn By GAB	*Scale* 1:311	*Company*	
Date 3/16/15		*File Name* H2530002.STA49+25.Undrained.GAB.slim	