Structure Foundation Exploration
MED-3-24.33 Culvert Replacement
PID 106354
Hinckley, Medina County, Ohio
S&ME Project No. 1117-18-009

PREPARED FOR:

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August 10, 2018

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Attention: Mr. Sheldon Schlabach, P.E.

Reference: **Structure Foundation Exploration – Final Report**
MED-3-24.33 Culvert Replacement
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Dear Mr. Schlabach:

In accordance with our proposal dated December 1, 2017, which was authorized by Engineering Associates (EA) on February 23, 2018, S&ME, Inc. (S&ME) has completed a Geotechnical Exploration for the existing MED-3-24.33 culvert replacement project in Medina County, Ohio. The approximate location of this project is illustrated on the Vicinity Map included as Plate 1 in Appendix A of this report.

In accordance with Section 701 of the current ODOT Specifications for Geotechnical Explorations (SGE), S&ME is herewith submitting a "final" version of this report, which is also to be provided to the ODOT District Geotechnical Engineer. This final report has incorporated final design information provided by EA as well as ODOT review comments dated June 6, 2018. Additionally, ODOT Structure Foundation Exploration sheets have been prepared and are included as Appendix D of this report.

We appreciate the opportunity to be of service. Please do not hesitate to contact our office if you have any questions concerning this report.

Respectfully submitted,

S&ME, Inc.

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Submitted: One (1) electronic copy via email in pdf format

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1.0 Executive Summary

It is proposed to replace the existing 4-sided box culvert (Structure No. MED-3-2433) carrying an unnamed tributary of the East Branch Rocky River beneath Ridge Road (SR 3) with a concrete elliptical culvert. The replacement culvert structure is proposed to be constructed with an inlet elevation near El. 868.0 and an outlet near El. 867.48. Additionally, the existing roadway embankment is to be reconstructed with flatter, 3(H):1(V) side slopes. At the request of ODOT District 3, two (2) culvert and two (2) embankment borings were drilled for this project.

Fill and/or Possible/Probable Fill materials were encountered in each of the borings to depths ranging from approximately 3 feet to 11.7 feet below the existing grade. The fill materials were composed of stiff to hard SILTY CLAY (A-6b), medium-dense GRAVEL WITH SAND (A-1-b), or medium-dense COARSE AND FINE SAND (A-3a). Brick fragments, organic fragments, and a chemical odor were noted within the fill materials in all of the borings except Boring B-003.

Natural soils were encountered beneath the fill materials to the termination depths of the borings. The natural soils consisted for the most part of stiff to hard SILT AND CLAY (A-6a) or SILTY CLAY (A-6b) with a few very-soft to medium-stiff zones, and in Boring B-003, 0.8-foot to 2.5-foot thick layers of COARSE AND FINE SAND (A-3a) and SANDY SILT (A-4a). The cohesive soils were underlain by medium-dense to very-dense COARSE AND FINE SAND (A-3a), SANDY SILT (A-4a) and/or SILT (A-4b).

Based on the results of the borings, the subsurface conditions appear suitable for supporting the planned replacement culvert on natural soil. S&ME recommends factored bearing resistances (q_R) of 4.0 ksf (service limit) and 5.4 ksf (strength limit), be used during design of the replacement culvert and any wing- or headwall walls bearing in natural very-stiff to hard soil.

Based on soil encountered at the existing subgrade level in the approach embankment borings, S&ME recommends a CBR value of 6% be used for design of new pavement at this project site. Based on ODOT Geotechnical Bulletin GB1 procedures, localized subgrade remediation consisting of roughly 12 inches of “excavate and replace” remediation may be required. Additional discussion regarding pavement subgrade remediation is presented in Section 6.2 of this report.

The regrading of the existing embankment side slopes to a 3(H):1(V) slope rate will require Special Benching in accordance with ODOT Geotechnical Bulletin GB2. Section 6.6.3 of this report includes additional discussion and recommendations pertaining to the construction of these flattened embankment slopes.

2.0 Introduction

S&ME understands that ODOT District 3 desires to replace the existing 4-sided box culvert (No. MED-3-2433) beneath Ridge Road (SR 3) with a new concrete elliptical culvert. A 4-sided box culvert was originally considered to replace the existing structure; however, the concrete elliptical culvert was selected by others as the preferred alternative. EA has provided drawings for the proposed elliptical culvert design has dimensions of 63" x 98", and will follows essentially the same alignment as the existing culvert. The culvert length is greater than the existing culvert to accommodate flattened embankments slopes at an inclination of 3(H):1(V) on both sides of the roadway. S&ME also understands that little to no adjustment of the roadway profile is planned as part of this project.

A proposed culvert replacement designated MED-94-20.11 is also included in the subject PID; however, as this replacement culvert will be less than 5 feet in diameter and will be supported on half-height headwalls, no geotechnical exploration was requested at that culvert location by ODOT District 3.

3.0 Geology and Observations of the Project

3.1 Geology and Hydrogeology

The project sites are within a previously glaciated portion of Ohio, and within the Killbuck-Glaciated Pittsburgh Plateau physiographic region. This region is characterized by clay to loam till of the Wisconsinan-age underlain by Mississippian and Pennsylvanian-age shales, sandstones and conglomerates. The ground surface elevation at the SR 3 culvert crossing is approximately El. 884. According to the Medina County Soil Survey as performed by the United States Department of Agriculture (USDA), the soils at the SR 3 site are primarily composed of Lobdell Silt Loam (Le) which is derived from alluvium deposits with approximately equal percentages of sands and fines (silts/clays). Bedrock topography mapping suggest that the SR 3 site is located over the sideslopes of a glacially carved buried valley, with the uppermost bedrock anticipated near El. 650.

According to ODNR groundwater resource mapping, the site lies in an area with relatively low groundwater yields (between 3 to 15 gallons per minute) characterized by glacial deposits overlaying shale or sandstone, or yields from shale bedrock. Water yields within the glacial till are found within variable coarse sands and gravels deposits. Groundwater Pollution Potential mapping suggests the project site lies in an area characterized by buried valley conditions and/or varying thicknesses of glacial till that overlie sandstone or shale bedrock. The pollution potential is moderate with a range of 83 to 115.

A review of the ODNR "Ohio Karst Areas" map indicates the site lies in an area not known to contain karst features. A review of the ODNR "Landslides in Ohio" map reveals the site is in an area of low incidence and low susceptibility to landslides, and the ODNR "Abandoned Underground Mines of Ohio" map indicates these sites lie in areas with no mapped abandoned mines near the area of the project site.

3.2 Site Reconnaissance

Site reconnaissance visits were made by S&ME personnel on November 13, 2017, and March 8, 2018, to observe the existing culvert and project vicinity and to field mark the boring locations. The MED-3-24.33 structure carries an unnamed tributary of the East Branch Rocky River at a depth of approximately 14.5 feet beneath Ridge Road. An area of existing embankment on the south side of the culvert and on the west side of Ridge Road is showing evidence of either instability or surface sloughing from erosion, although it does not appear that an active "landslide" has occurred.

3.3 Historic Information

S&ME searched the on-line ODOT Transportation Information Mapping System (TIMS) records for historic boring information for the existing bridge: however, no available historic boring records were located for this site.

4.0 Exploration

4.1 Field Investigation

On March 21 and 22, 2018, S&ME performed four (4) borings designated B-001-0-18 through B-004-0-18 (hereafter referred to as B-001 through B-004) to explore the existing soils in the area of the proposed replacement culvert, the potentially unstable slope south of the culvert, and the pavement/embankment north of the culvert. The embankment borings north and south of the culvert (B-001 and B-004) were extended to depths of 20 feet below the existing ground surface, while Borings B-002 and B-003 were performed at the culvert and were extended to depths of 45 feet. B-001 and B-003 were advanced in the southbound lane and Borings B-002 and B-004 were advanced in the northbound lane. The approximate locations of the borings are shown on the Plan of Borings included as Plate 2 of Appendix A. The exact locations and ground surface elevations at each boring location were obtained by EA and provided to S&ME.

The borings were performed using an ATV-mounted drilling rig using a 3¼-inch I.D. hollow-stem auger. Disturbed (but representative) soil samples were obtained by lowering a 2-inch O.D. split-barrel sampler to the bottom of the boring and then driving the sampler into the soil with blows from a 140-pound hammer freely falling 30 inches (AASHTO T206 - Standard Penetration Test, SPT). In accordance with the current ODOT Specifications for Geotechnical Explorations (SGE), the hammer system on the drill rig had been calibrated in accordance with ASTM D4633 to determine the drill rod energy ratio (77.8%). Sampling intervals ranged from being continuously sampled (subgrade or scour zone sampling) to 5-foot intervals as required by the ODOT SGE. At the time of the field work, a three-sided replacement culvert was still being considered, and as such, continuous scour-zone sampling was performed.

In the field, experienced S&ME personnel performed the following duties: 1) examined and preserved all recovered samples; 2) prepared a log of each boring; 3) recorded seepage and groundwater observations and measurements; 4) obtained hand penetrometer measurements in soil samples exhibiting cohesion; and, 5) provided liaison between the field work and the Engineers so that any modifications to the exploration program could be expeditiously implemented in the event that unusual or unanticipated conditions were encountered. All recovered samples were transported to the soils laboratory of S&ME for further examination and testing.

4.2 Laboratory Testing

In the laboratory, all soil samples were visually identified and tested for natural moisture content, with liquid/plastic limit determinations and grain-size analyses being performed on selected representative specimens. The results of the laboratory index tests are recorded numerically on individual boring logs.

Based upon the results of the laboratory testing program, the field logs were modified, if necessary, and copies of the laboratory corrected boring logs are submitted as Plates 4 through 9 of Appendix A. Shown on these logs are: descriptions of the soil stratigraphy encountered; depths from which samples were preserved; sampling efforts (blow-counts) required to obtain the specimens in the borings; calculated N_{60} values; laboratory testing results; seepage and groundwater observations made at the time of drilling; and, values of hand-penetrometer measurements made in soil samples exhibiting cohesion. For your reference, hand-penetrometer values are roughly equivalent to the unconfined compressive strength of the cohesive fraction of the soil sample.

Soils have been classified in general accordance with Section 603 of the ODOT SGE, and described in general accordance with Section 602. An explanation of the symbols and terms used on the boring logs, definitions of the special adjectives used to denote the minor soil components, and information pertaining to sampling and identification are presented on Plate 3 of Appendix A. Group Indices determined from the results of the laboratory testing program are also provided on the boring logs.

5.0 Findings

Please refer to the boring logs included in Appendix A for a summary of the pavement, soil and groundwater/seepage conditions encountered at the boring locations. Inferences should not be made to the subsurface conditions in the areas between or away from the borings without performance of additional borings or other field verification.

5.1 Existing Pavement Thicknesses and Surficial Materials

Thickness of existing pavement and surficial materials was determined during drilling and are summarized in Table 5-1.

Table 5-1 Summary of Pavement and Base Materials

Boring No.	Asphalt (in.)	Brick Frags.//Pavers (in.)	Granular Base (in.)
B-001	11	--	7
B-002	14	2	2
B-003	15	3	
B-004	14	4	--

5.2 General Subsurface Conditions

The following is a summary of the subsurface conditions encountered below the pavement and base materials in the four (4) borings performed for this exploration:

Fill and/or Possible/Probable Fill materials were encountered in each of the borings to depths ranging from approximately 3 feet to 11.7 feet below the existing grade. The fill materials were composed of stiff to hard SILTY CLAY (A-6b), medium-dense GRAVEL WITH SAND (A-1-b), or medium-dense COARSE AND FINE SAND (A-3a). Brick fragments, organic fragments, and a chemical odor were noted within the fill materials in all of the borings except Boring B-003.

Natural soils were encountered beneath the fill materials to the termination depths of the borings. The natural soils consisted for the most part of stiff to hard SILT AND CLAY (A-6a) or SILTY CLAY (A-6b) with a few very-soft to medium-stiff zones and, in Boring B-003, 0.8-foot to 2.5-foot thick layers of COARSE AND FINE SAND (A-3a) and SANDY SILT (A-4a). Boring B-001 was terminated within these cohesive soils. Borings B-002 through B-004 were terminated after penetrating 3.3 to 11.2 feet into granular soils consisting of medium-dense to very-dense COARSE AND FINE SAND (A-3a), SANDY SILT (A-4a) and SILT (A-4b).

5.3 Groundwater Observations

During drilling, groundwater was encountered at depths ranging from 12.5 to 38.5 feet in Borings B-002 through B-004. Upon completion of drilling and after the augers had been removed, water was measured at 15.0 feet in Boring B-003. No groundwater was encountered in Boring B-001 during drilling.

All groundwater levels and seepage measurements should be considered as temporary, short-term observations and should not be assumed to be representative of the long-term static groundwater level. Groundwater levels can fluctuate due to seasonal variations in precipitation, construction activities, etc.

5.4 Scour Zone Grain Size Test Results

Plate 10 of Appendix A summarizes the D_{50} and D_{95} particle sizes determined from the results of the gradation testing performed on the soil samples recovered from the continuously sampled scour zone on either side of the culvert in Borings B-002 and B-003.

6.0 Analyses and Recommendations

6.1 General Discussion

S&ME understands that ODOT District 3 desires to replace the existing 4-sided box culvert beneath Ridge Road (SR 3) with a new concrete elliptical culvert. The new culvert is anticipated to follow the same or similar alignment as the existing culvert. Minimal to no regrading of the roadway is anticipated. Additionally, repairs to the "unstable" slope on the west side of SR 3 south of the culvert are proposed.

6.2 Subgrade Support Parameters

Plate 3 in Appendix B is an ODOT Geotechnical Bulletin GB1 spreadsheet (Ver. 14.2) created by the ODOT Office of Geotechnical Engineering (OGE) to summarize the soil type (by ODOT/HRB classification), group indices, depth, blow-counts, and Atterberg Limit values of the proposed subgrade soils encountered in the borings drilled for this project. This table also computes an average of the estimated values of the California Bearing Ratio (CBR) for the soils encountered at or below the anticipated subgrade level of the proposed roadway profile.

Based on the preliminary profile information provided by EA at the time of this report, the following average California Bearing Ratio (CBR) is computed by the ODOT GB1 spreadsheet for the anticipated subgrade soils encountered during this investigation:

CBR: 6%

Based on this average value, and Section 203.1 of the current ODOT Pavement Design Manual, the following value of Resilient Modulus (M_R) may be used during new pavement section design for this project.

M_R: 7,200 psi

These subgrade support values may be used during pavement design for this project provided that the entire proposed pavement subgrade is prepared in strict accordance with Item 204 of the 2016 ODOT Construction and Materials Specifications (CMS), and that all borrow soil placed within 3 feet of the final subgrade level of a new fill embankment is capable of providing average subgrade support parameters which meet or exceed the above values. This subgrade evaluation also assumes that the subgrade for the new roadways is composed of the materials encountered in the borings. If, at the time of construction, it is determined that the subgrade consists of materials different than those encountered in the borings, the pavement design subgrade criteria should be reviewed and, if necessary, modified.

6.3 Unsuitable Subgrade Materials

None of the borings performed during this investigation encountered soil within 3 feet of the proposed subgrade level which ODOT GB1 considers to be unsuitable either by classification (A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b), or which has a Liquid Limit value in excess of 65%.

If deposits of unsuitable soils such as silt or organic materials are encountered during earthwork or proofrolling operations, S&ME recommends that test pits or hand sampling methods be used to further investigate and delineate the extent of these deposits. Any silt (A-4b) deposits present within 3 feet of the proposed subgrade level should be removed (ODOT CMS Item 203.03.A).

Existing underground utility lines are present beneath and adjacent to the existing roadway, and the type of material used and the relative compactness of backfill within any such utility trenches are unknown. Some instability of utility trench backfill may occur during earthwork operations and/or proofrolling, and some recompaction of granular utility trench backfill may become necessary. Additionally, if water has accumulated within the utility backfill, the subgrade soil in the vicinity of any saturated utility trenches may have become sufficiently weak, soft, and/or wet that proofrolling may identify these additional areas as requiring over-excavation and replacement. In any case, care should be taken not to disturb any shallow utilities during proofrolling and over-excavation activities.

Particular attention should also be given to the existing overbank areas at the toe of the existing roadway embankment, as unstable or unsuitable (e.g., soft, saturated, possibly organic) soil requiring removal may be present. S&ME recommends that these areas be closely examined prior to commencing earthwork operations, and all weak, wet, or organic soil should be removed prior to commencing fill placement. See Section 6.6.1 for further recommendations regarding embankment foundation preparation in this area.

Because of the variable nature of fill materials and soil stratigraphy in general, it is possible that other areas of unsuitable organic or silt materials that were not encountered in any of the borings may be encountered during earthwork and proofrolling operations. Visual observation of the proofrolling procedures by the Geotechnical Engineer of Record may potentially result in a reduction of over-excavation of unsuitable soils in these areas. Additionally, S&ME recommends that construction traffic be minimized or restricted once the planned soil subgrade level has been exposed or attained.

6.4 ODOT GB1 Subgrade Analysis

ODOT's Geotechnical Bulletin GB1 "Plan Subgrades" indicates that a comparison of the laboratory-measured moisture content to the estimated optimum moisture content of the subgrade soil, along with the normalized blow-count (N_{60}) from SPT sampling, may be used as an indicator of the potential need for subgrade treatment or remediation of unstable subgrade soil. The acceptable options presented by GB1 to remediate and establish a stable soil subgrade are either to "excavate and replace", or chemical stabilization.

Plate 4 in Appendix B summarizes the laboratory-measured moisture content of the samples obtained from each boring with respect to their estimated optimum moisture contents, along with the lowest N value (N_{60L}) obtained from the Standard Penetration Tests performed in each of these borings. This table also indicates the recommended Item 204 "excavate and replace" depths per GB1 at each boring location, along with an overall assessment of the suitability of various types of chemical stabilization on this project.

Plate 4 indicates that one of the borings (B-001) performed as part of this investigation encountered soil at or just below the proposed subgrade level with characteristics defined as problematic (excessive soil moisture content and a low N_{60} value) and which require remediation by the procedures recommended in GB1. This boring was located to the south of the existing culvert, near the area of "unstable" side slope. The results of the GB1 table indicate that provisions for 12 inches of subgrade remediation over-excavation and replacement be anticipated in the area of Boring B-001. Therefore, S&ME recommends that provisions for 12 inches of "excavate and replace" subgrade remediation be made in these areas:

- SR 3 – Southern project limit to Sta. 1285+00

If, however, ODOT District 3 indicates a desire the entire roadway subgrade to be chemically stabilized, cement should be utilized as the chemical additive, as A-3a sand was encountered at the approximate subgrade level in Boring B-004. Based on the S&ME recommends that the subgrade chemical stabilization extend to a depth of 14 inches below the proposed subgrade level and be performed in accordance with Item 206 "Chemically Stabilized Subgrade" of the 2016 ODOT Construction and Material Specifications (CMS). Additionally, if cement stabilization is performed, all borrow soil placed within 16 inches of the proposed subgrade level in widened embankments shall have a Plasticity Index less than 20.S&ME also recommends that the mixture design for the chemically stabilized soil subgrade be performed in accordance with ODOT CMS Item 206.06 and ODOT Supplement 1120. Regardless of the method of subgrade remediation used, the remediation should extend to at least 18 inches beyond the edges of the roadway, including paved shoulders.

The subgrade remediation depths in the GB1 table are based on the conditions encountered in the borings during this subsurface investigation. However, because the required amount of remediation is dependent on the moisture content of the subgrade soil at the time of construction, ODOT Geotechnical Bulletin GB1 states that the ultimate decision on required remediation depths and limits should be based on observations during either proofrolling or test-rolling operations.

6.5 Additional Subgrade Remediation Considerations

Because of the moisture sensitive nature of the cohesive soils (A-6a, A-6b) encountered in the majority of borings, S&ME recommends construction traffic be minimized once the required subgrade level has been attained. Construction traffic resulting from cyclical haul routes or limited access points may increase the quantity of soil identified by proofrolling as requiring removal, particularly during periods of moist weather.

In accordance with Section F of ODOT GB1, where "excavate and replace" is used for subgrade remediation, Item 712.09 Geotextile Fabric Type D is to be placed at the bottom of the undercuts, and Item 204 Granular Material is to be used to backfill the over-excavations. S&ME recommends that Item 204 Granular Material, Type B or C be utilized. It should also be noted, however, that ODOT GB1 specifies that Item 204 Granular Material Type B without a geotextile fabric be utilized to backfill undercuts performed in the vicinity of any underdrains.

It is also recommended that over-excavated subgrade areas backfilled with granular soil be drained to an underdrain, catch basin, or pipe. Additionally, as "excavate and replace" is to be used for remediation, Plan Note G121 from the ODOT L&D Manual, Vol. 3, should be used in the General Notes. If, however, chemical stabilization is selected, additional pay items to be included in the plans are provided in Section G of ODOT Geotechnical Bulletin GB1.

6.6 Earthen Embankment Construction

Preliminary profile information provided indicates the majority of the proposed roadway will be constructed at a profile elevation approximately the same as the existing roadway profile. Additional fill placement, however, will be required on the sides of the existing roadway embankments to flatten the slopes to 3(H):1(V), and also address the potentially "unstable" area on the west side of the road to south of the culvert.

6.6.1 Embankment Foundation Preparation

Prior to commencing earthwork operations, it is recommended that all existing pavement, granular base, sod, topsoil, vegetation, and other miscellaneous materials be completely removed from the sides of the existing embankments, including the areas outside the existing embankment where flattening the sides slopes will increase the width of the base of the embankment footprint. Following the removal of these materials, it is recommended that the entire exposed subgrade and embankment foundation surface be examined by the Geotechnical Engineer of Record or their designated representative to identify any weak, wet, organic, or otherwise unsuitable soils that were not encountered during the subsurface investigation, especially in "at-grade" and fill areas. Any such materials identified should be removed and replaced with suitable compacted fill (Item 203, or Item 204 when within 12 inches of the proposed subgrade). Recommendations for existing ditches have been previously presented in Section 6.3, "Unsuitable Subgrade Materials" of this report.

Plan information provided by EA indicates that additional fill will be required on the sides of the existing SR 3 embankment to flatten to side slopes to an inclination of 3H:1V. Where new fill is to be placed to widen the earthen approach embankments, S&ME recommends that all vegetation, topsoil, pavement, and miscellaneous materials be removed from the sides and top of the existing roadway embankment, and also from the footprint of any embankment widening areas. Prior to the placement of any new fill in embankment widening areas, S&ME recommends that consideration be given to specifying the entire exposed embankment foundation in the widening areas be test rolled in accordance with ODOT Construction and Material Specifications (CMS) Item 204.06 to detect any unstable (e.g., soft, wet or weak) zones or unsuitable zones beneath the new fill area.

6.6.2 Final Subgrade Preparation

Once the desired subgrade elevation has been attained in all "at-grade" areas, and after over-excavation of all existing unsuitable subgrade materials has been completed, the subgrade soil beneath the entire roadway and shoulder pavement area should be scarified and recompacted to a depth of 12 inches below the subgrade level in accordance with ODOT Item 204.03. During recompaction, the moisture content of the subgrade soil should be maintained or adjusted in accordance with ODOT Item 203.07.A.

Following scarification and recompaction of the subgrade in these "at-grade" areas, it is strongly recommended that construction traffic be restricted from traveling on the compacted subgrade until final acceptance proofrolling has been performed. Cohesive subgrade soils subjected to repeated moisture fluctuations, which may occur as a result of exposure to rainfall and/or surface water runoff, may exhibit subgrade instability.

6.6.3 "Unstable" Slope Area

During project site meetings with District 3 personnel, an area of potential embankment instability was observed on the western embankment slope to the south of the culvert and above the existing drainage swale feeding down to the culvert inlet. As such, Boring B-001 was performed to investigate the conditions in this area and to determine if the embankment slope was "unstable".

The soil stratigraphy encountered in Boring B-001 indicates stiff to hard cohesive soils to the termination depth of the boring. No weak or significantly wet layers or zones were identified during the exploration or by laboratory testing. Based on our observations at the site and the soils encountered at Boring B-001, S&ME does not believe that the existing embankment slope is unstable, but that some sloughing of the near surface soil and ground cover has occurred in this area as a result of erosion occurring within the existing ditch. As a result of this erosion, the embankment side slopes above the ditch appear to be steeper than 2(H):1(V). S&ME recommends that erosion control measures or a drainage pipe be implemented to reduce or eliminate the erosion which is occurring at the toe of the embankment slope. These erosion control measures, in conjunction with the proposed embankment widening to a slope inclination of 3H:1V, are anticipated to minimize the potential for any future slope instability in this area.

6.6.4 Special Benching

After the existing pavement, granular base, sod, topsoil, vegetation, and other miscellaneous and unsuitable materials have been removed from the sides of the existing embankment, and following the test rolling in the embankment widening area, it is recommended that horizontal benches be cut into the existing embankment side slopes prior to commencing fill placement, to permit placement and compaction of new fill in horizontal lifts.

Because the sides of the existing roadway embankments are generally sloped steeper than 4(H):1(V), S&ME recommends that Special Benching be performed in accordance with ODOT Geotechnical Bulletin GB2, "Special Benching and Sidehill Embankment Fills" (ODOT GB2) dated July 17, 2015, where sidehill fills are required. Sketches illustrating several Special Benching configurations for sidehill fills on various slopes are included in Figures 1, 2 and 3 on pages 3 and 6 of the ODOT GB2 document. These configurations require a minimum distance of 8 feet between the crest of the bench back-slopes and the face of the new slope to permit compaction and grading equipment to work on a horizontal surface.

To minimize the amount of the existing roadway embankment fill that must be removed to provide sufficient width (minimum 8-foot width) for the compaction equipment during Special Benching, S&ME recommends that consideration be given to utilizing the approach outlined in Figure 1A of the GB2 document to construct an over-steepened slope of temporary fill near the top of the embankment. Once this over-steepened fill has been placed and properly compacted (ODOT CMS Items 203 and 204) to the top of new embankment, the excess portion of the temporary fill may then be "shaved" off to the final designed embankment configuration. The use of smaller (narrower) compaction equipment may be considered to reduce the minimum width (8 feet) between the crest of the bench back-slopes and the face of the new slope.

As stated in the ODOT GB-2, wherever "Special Benching" is used, Plan Note G109 from the ODOT L&D Manual, Vol. 3, should be included in the General Notes. During "Special Benching" procedures, S&ME also recommends the following:

1. Only one bench be exposed at any given time and that excavation of the next bench not be permitted until embankment fill placement and compaction have been completed to the top of the backslope of the previous bench; and,
2. The length of any given bench that is exposed should not exceed the quantity of embankment fill which may be properly placed and compacted in one day.

Where new fill is to be placed on an existing ground surface with a slope that is between 4(H):1(V) and 8(H):1(V), benching of the existing ground surface should be performed in accordance with Item 203.05 of the ODOT CMS.

6.7 Foundations

The preferred MED-3-24.33 replacement structure at this site is a concrete elliptical culvert supported on half-height headwalls. The culvert inlet will be near El. 868.0 and near El. 867.48 at the outlet. The elliptical culvert is approximately 63" x 98" and essentially follows the same alignment as the existing culvert. The new culvert length will be longer than the existing culvert to accommodate the planned flattened embankments slopes at an inclination of 3(H):1(V) on both sides of the roadway. Based on the proposed culvert geometry and information provided by EA, S&ME anticipates that the culvert base and any associated headwall foundations for the culvert will bear in the very-stiff to hard natural SILT AND CLAY (A-6a) encountered at or below approximate El. 865. It is recommended that spread foundations be founded at least 12 inches below any riprap placed for scour protection or in accordance with local frost code requirements, whichever is deeper. It is not within our scope of work to evaluate the scour potential at the site. All of the existing foundations should be removed prior to the construction of the planned culvert foundations.

Table 6-1 summarizes the recommended nominal and factored bearing resistances (q_n and q_R) at the service and strength limit states for spread foundations bearing on the natural very-stiff to hard cohesive soil. In order to achieve the recommended factored bearing resistances provided in Table 6-1, the bearing surfaces should be carefully cleaned prior to placement of concrete.

Table 6-1: Recommended Bearing Capacities (Nominal and Factored) for Spread Footings – Service and Strength Limit States

Location	Proposed Bearing Elevation (ft)	Limit State	Preliminary Nominal Bearing Resistance, q_n (ksf)	Resistance Factor, φ_b	Preliminary Factored Bearing Resistance, q_R (ksf)
Inlet	865	Service	4.0	1.0	4.0
		Strength	10.7	0.5	5.4
Outlet	865	Service	4.0	1.0	4.0
		Strength	10.7	0.5	5.4

If stiff or weaker soil are present at or just below the proposed bottom of foundation elevation, the material should be over-excavated and the foundation lowered to bear on suitable soils, or the over-excavation below plan foundation bearing elevation should be backfilled in accordance with the most current ODOT CMS. S&ME also recommends that spread foundations bear at least 12 inches below any rip rap placed as scour protection, and that sufficient longitudinal reinforcing steel be provided to strengthen continuous footings against any abrupt differential settlements.

It is recommended that any water flowing from the creek/ditch should be diverted away from the foundation excavation area during excavation and construction of the culvert and associated wing wall foundations. The foundation bearing surfaces should be kept dry and free from standing water during all construction activities. The cohesive soils encountered at the approximate bearing elevation can become weak and compressible when exposed to water. If the foundation materials become wet or loose, additional excavation may be necessary prior to placing foundation concrete. Sumps may be required to pump water accumulations (seepage) from the foundation excavations since the foundations will extend below the level of any possible water in the stream.

6.8 Sliding Resistance

Sliding resistance to lateral loads is provided by the weight of the structure in combination with the friction developed along the bottom of the foundations at the footing/soil interface as well as from passive resistance from the soil. The factored resistance against failure by sliding (R_R) should be determined using Eq. 10.6.3.4-1 of the AASHTO LRFD Bridge Design Specifications. Because of variations in the consistency of soil encountered in the borings at the anticipated foundation bearing level, S&ME recommends that cast-in-place shallow spread foundations be designed using a Factored Sliding Resistance of 1,700 pounds per square foot.

6.9 Eccentricity

Eccentricity of the culvert footings/foundation should be checked in accordance with AASHTO LRFD Article 10.6.3.3 for footings on soil.

6.10 Settlement

Varying settlement is anticipated along the length of the culvert due to the placement of additional fill to widen the side slopes to an inclination of 3(H):1(V). Soil parameters for use in the settlement calculations were estimated using published correlations to soil types, SPT N-values, and index properties. The settlement at five select points along the length of the culvert was calculated using the methods outlined in the FHWA HI-88-099 Soils and Foundations Workshop Manual - Second Edition (1993). Estimated total settlement beneath the proposed culvert are provided in Table 6-2. Calculations are included in Appendix B. The settlements shown in Table 6-2 assume that the site preparation and foundation construction are performed in accordance with the recommendations provided in this report.

Table 6-2 Summary of Estimated Settlement along the Culvert (inches)

Inlet	35′ Lt.*	SR 3 Centerline	27′ Rt.*	Outlet
0.5	0.9	0.1	1.3	0.6

*Locations of the existing culvert inlet and outlet where the greatest amount of new fill will be placed.

6.11 Lateral Earth Pressures

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

To minimize lateral earth pressures, the zone behind wingwalls (if any) and culvert should be backfilled with granular soil, and the backfill should be effectively drained. For effective drainage, a zone of free-draining gravel (ODOT CMS Item 518.03) should be used directly behind the structure for a minimum thickness of 18 inches in accordance with ODOT CMS Item 518.05. This granular zone should drain to either weepholes or a pipe, so that hydrostatic pressures do not develop against the walls.

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

It is recommended that granular backfill be used behind the culvert structures. The backfill should be placed in a wedge formed by the back of the structure and a line rising from the base of the structure base at an angle no greater than 60 degrees from the horizontal. Granular backfill behind the structure should be compacted in accordance with ODOT Item 203, "Roadway Excavation and Embankment", of the most recent CMS. Over-compaction in areas directly behind the walls should be avoided as this might cause damage to the structure.

If proper drainage is used and the granular backfill is placed and compacted in the wedge described previously, an equivalent fluid unit weight of 55 pounds per cubic foot (pcf) may be used assuming an "at rest" earth pressure condition, meaning wall movements less than 0.25 percent of the wall height is permitted (such as the sidewalls of the culvert). If proper drainage is not provided, an "at rest" equivalent fluid unit weight of 90 pcf is recommended for use during design.

For wingwalls, wall movement greater than 0.25 percent the height of the wall (H) occurs, the active earth pressure condition should be utilized. If proper drainage is incorporated and granular backfill is provided and compacted as specified, an equivalent fluid unit weight of 35 pcf may be used. Without proper drainage, but with granular backfill and permissible wall movement, an equivalent fluid unit weight of 80 pcf should be used.

Compacted cohesive materials tend alternatively to shrink, expand and creep over periods of time and create significant lateral pressures on any adjacent structures. Cohesive materials also require a greater amount of movement to mobilize an active earth pressure condition. To mobilize the active earth pressure condition in cohesive materials, wall movement 1.0 percent of the height of the wall (H) must occur. Because of the long-term adverse effects, it is recommended that, if proper drainage (ODOT CMS Item 518.03) is provided, equivalent fluid unit weights of 65 pcf (active) and 90 pcf (at-rest) be used for design of the structure resisting the lateral loads imparted by drained, cohesive backfill. Without proper drainage, S&ME recommends that the structural design be performed using equivalent fluid unit weights of 95 pcf (active) and 110 pcf (at-rest).

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

6.12 Construction and Groundwater Considerations

During this exploration, groundwater was encountered between 12.5 to 38.5 feet in the borings. Also, water levels in the stream/ditches are about 14 feet below the road surface and should be expected to fluctuate after periods of rain or thawing of snow. As such, it is anticipated the long term groundwater level in the immediate vicinity of the proposed culvert will be approximately the same as, and vary with, the level of water in the creek.

The surface water and groundwater should be controlled during construction, as the cohesive soil that will likely be present at and just below the proposed foundation level will typically exhibit instability in the presence of water and construction vibrations. S&ME recommends that the sides and bottoms of all excavations be closely monitored during the construction of the structure. If the soils at the bottom of an excavation become disturbed by construction activity or channel flow, it is recommended that the disturbed material be undercut and replaced in accordance with the recommendations provided in Section 6.2 of this report, or be removed and the footing elevation be lowered to more suitable bearing soils.

It is recommended that all excavations for the proposed structure foundation be protected from stream, groundwater, and storm water flow. Even with stream flow diversion, provisions for pumping from sumps should be made for the expected larger groundwater flows that may be encountered in excavations extending below the level of water in the stream.

Some water seepage may also emanate from any granular seams or zones that are encountered in excavations performed above the level of water in the stream; however, the quantity of water is anticipated to be limited and may likely be controlled by bailing or with portable pumps.

Additionally, all excavations should be either sloped back or braced in accordance with the most recent OSHA excavation guidelines.

6.13 Scour Countermeasures

It is recommended that the base of the culvert and any headwall/wingwall foundations be protected from erosion of soil by scour during periods of elevated flow. It is recommended that below-grade cutoff walls be installed at both ends of the culvert to at least the anticipated scour depth so that stream flow does not pass beneath, and result in the loss of support by piping, of the base of the culvert. If rock channel protection (rip rap) is to be utilized, it is recommended that foundations be protected from the flow during the design event using, as a minimum, rip rap of a size and layer thickness in accordance with Section 203.3, "Scour", of the ODOT *Bridge Design Manual* (BDM). The rip rap should be placed across the entire channel bottom from the ends of the culvert to at least 10 feet beyond (downstream). Additionally, rip rap should be placed in a continuous manner so that no portions of the foundations or creek banks below the design storm water surface are exposed to elevated water flow.

Rip rap is not a permanent or absolute countermeasure against, nor does it totally eliminate, the potential for scour. Therefore, specifications which include the use of rip rap must also contain provisions for routine maintenance of the rip rap blanket so that the design blanket thickness is preserved over the design life of the structure. Additionally, in all cases where rip rap is used for scour control, the structure should be monitored during and inspected after periods of high flow.

7.0 Final Considerations and Report Limitations

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

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

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

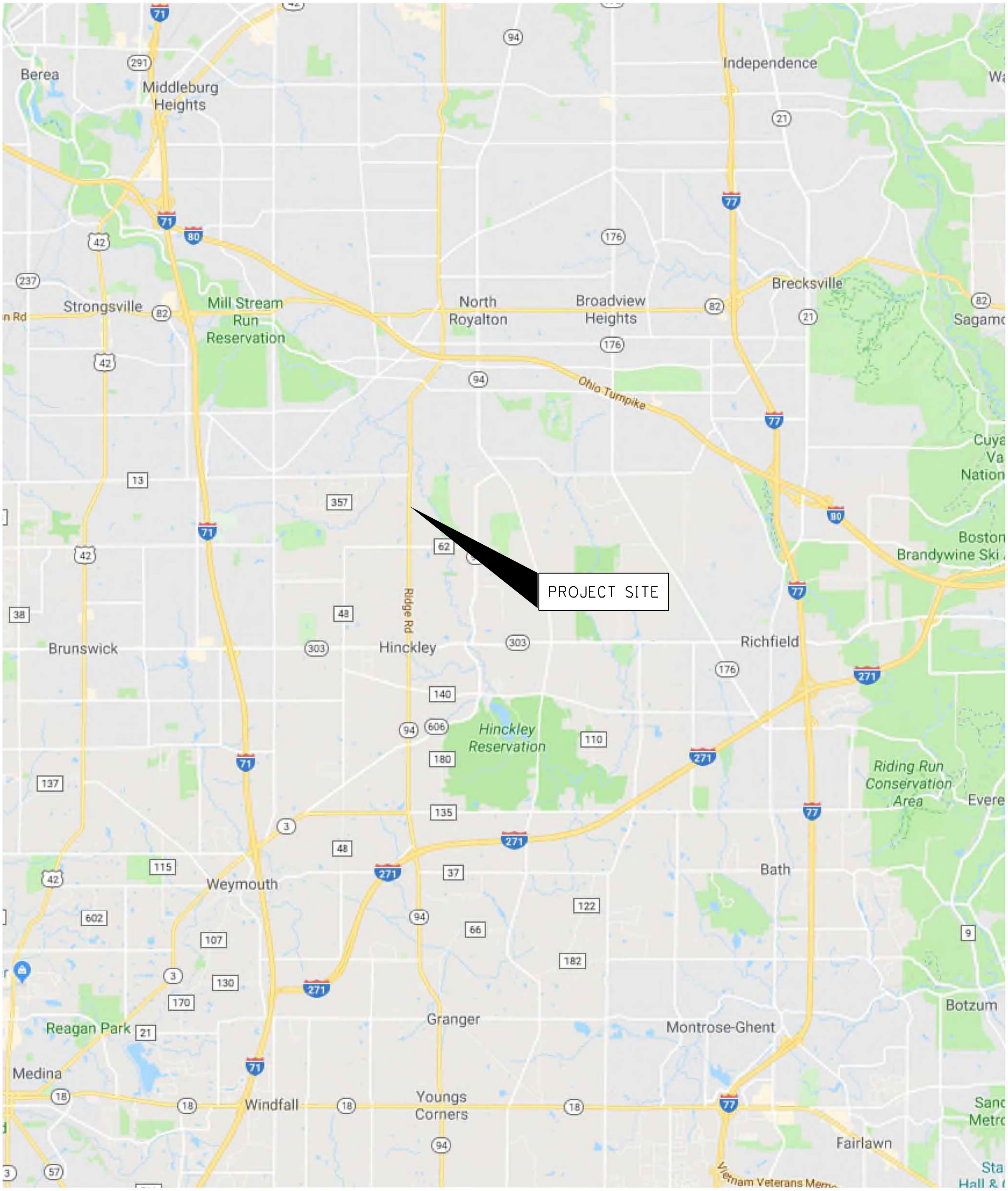
Unless specifically noted otherwise, our field exploration program did not include an assessment of regulatory compliance, environmental conditions or pollutants or presence of any biological materials (mold, fungi, bacteria).

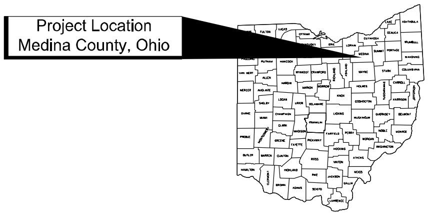
If there is a concern about these items, other studies should be performed. S&ME can provide a proposal and perform these services if requested.

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

Appendices

Appendix A





N

0 1.2 2.4

SCALE IN MILES

Vicinity Map

MED-3-24.33
Medina County, Ohio

Project: 1117-18-009
Drawing Date: 5-16-2018
Revision Date: 5-16-2018
Drawn By: KAH
Approved By: BKS
Scale: GRAPHIC

WWW.SMEINC.COM

ENGINEERING LICENSE NO: F-0176

PLATE 1

Plan of Borings

Structure Foundation Exploration Report
MED-3-24.33
Medina County, Ohio

SCALE:	Graphic
DATE:	8-10-2018
PROJECT NUMBER	1117-18-009
PLATE NO.	2

Drawing Path: S:\Projects\2018\GEO\1117-18-009 MED-3-24.34\CAD\Construction\Plan of Borings.dwg

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

SAMPLING DATA

▮ - Blocked-in “SAMPLES” column indicates sample was attempted and recovered within this depth interval.

▯ - Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a “Standard” 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches. The raw “blowcount” or “N” is equal to the sum of the second and third 6-inch increments of penetration. Addition of one of the following symbols indicates the use of a split-barrel other than the 2” O.D. sampler:

- $\boxed{\text{2S}}$ - 2½"O.D. split-barrel sampler
- $\boxed{\text{3S}}$ - 3" O.D. split-barrel sampler

N_{60} - Corrected Blowcount = [(Drill Rod Energy Ratio) / (0.60 Standard)] X N_{raw}

P - Shelby tube sampler, 3” O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2” - Number of blows (50) to drive a split-barrel sampler a certain number of inches (2), other than the normal 6-inch increment.

SD - Split-barrel sampler (S) advanced by weight of drill rods (D).

SH - Split-barrel sampler (S) advanced by combined weight of rods and drive Hammer (H).

SOIL DESCRIPTIONS

All soils have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor components, as follows:

Adjective	Percent by Weight
trace	1 to 10
little	11 to 20
some	21 to 35
“and”	36 to 50

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

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

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

PROJECT: MED-3-24.33
TYPE: CULVERT REPLACEMENT
PID: 106354 BR ID: MED-3-2434
START: 3/21/18 END: 3/21/18

DRILLING FIRM / OPERATOR: S&ME / A. MESSER
SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: S&ME ATV D50
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/20/17
ENERGY RATIO (%): 77.8

STATION / OFFSET: 1284+19, 9' LT
ALIGNMENT: SR 3
ELEVATION: 885.0 (MSL) EOB: 20.0 ft.
LAT / LONG: 41.269841 N, 81.744884 W

EXPLORATION ID
B-001-0-18
PAGE
1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 885.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT - 11 INCHES	884.1																	
GRANULAR BASE - 7 INCHES	883.5																	
POSSIBLE FILL: Hard dark-brown mottled with gray **SILTY CLAY**, trace fine to coarse sand, trace fine gravel, few wood fragments, damp.	882.0		3 4 5	12	39	SS-1	4.5+	3	4	6	29	58	38	19	19	20	A-6b (12)	
Stiff to very-stiff brown **SILTY CLAY**, trace to little fine to coarse sand, trace fine gravel, few gray silt seams, few pockets of hard silty clay, damp.			2 3 3	8	56	SS-2	2.5-4.5	4	3	5	29	59	37	21	16	23	A-6b (10)	
			1 2 2	5	33	SS-3	1.25-2.0	-	-	-	-	-	-	-	-	25	A-6b (V)	
			2 3 5	10	83	SS-4	1.5-3.5	8	6	7	23	56	39	20	19	22	A-6b (12)	
			2 5 6	14	67	SS-5	3.0-4.0	-	-	-	-	-	-	-	-	25	A-6b (V)	
	873.0		1 2 5	9	28	SS-6	2.75-3.75	-	-	-	-	-	-	-	-	22	A-6b (V)	
Stiff to very-stiff gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, few hard zones, damp.			3 4 5	12	100	SS-7	1.6-2.1	8	6	10	31	45	28	15	13	17	A-6a (9)	
			3 5 7	16	0	SS	-	-	-	-	-	-	-	-	-	-		
	865.0	EOB 20	2 5 5	13	100	SS-8	2.5-4.5+	-	-	-	-	-	-	-	-	17	A-6a (V)	

NOTES:
- No seepage or groundwater encountered during drilling.
- Borehole was observed to be dry at completion.

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

S&ME JOB: 1117-18-009

PROJECT: MED-3-24.33
TYPE: CULVERT REPLACEMENT
PID: 106354 BR ID: MED-3-2434
START: 3/22/18 END: 3/22/18

DRILLING FIRM / OPERATOR: S&ME / A. MESSER
SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: S&ME ATV D50
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/20/17
ENERGY RATIO (%): 77.8

STATION / OFFSET: 1284+92, 8' RT
ALIGNMENT: SR 3
ELEVATION: 882.9 (MSL) EOB: 45.0 ft.
LAT / LONG: 41.270091 N, 81.744881 W

EXPLORATION ID
B-002-0-18

PAGE
1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 882.9	DEPTHS
ASPHALT - 14 INCHES	881.7	
BRICK - 2 INCHES	881.6	
GRANULAR BASE - 2 INCHES	881.4	
PROBABLE FILL: Very-stiff brown **SILTY CLAY**, little fine to coarse sand, trace fine gravel, chemical odor, damp.	879.8	
PROBABLE FILL: Very-stiff light-gray **SILTY CLAY**, some fine to coarse sand, little fine gravel, damp.	876.2	
PROBABLE FILL: Stiff brown **SILTY CLAY**, little to some fine to coarse sand, trace fine gravel, few granite fragments, slight chemical odor, damp.	871.2	
Very-stiff to hard gray **SILT AND CLAY**, little fine to coarse sand, trace fine to coarse gravel, few stiff zones above 15', damp.		W

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
2 5 5	13	39	SS-1	3.1-4.0	-	-	-	-	-	-	-	-	21	A-6b (V)	
2 4 5	12	44	SS-2	3.25	14	13	13	19	41	37	18	19	19	A-6b (9)	
4 5 2	9	61	SS-3	1.0-2.0	-	-	-	-	-	-	-	-	23	A-6b (V)	
5 5 7	16	56	SS-4	1.5-2.5	-	-	-	-	-	-	-	-	17	A-6a (V)	
2 2 5	9	100	SS-5	3.0-4.25	10	5	10	33	42	-	-	-	16	A-6a (V)	
2 3 6	12	39	SS-6	3.0-3.75	5	5	10	38	42	27	16	11	16	A-6a (8)	
4 5 8	17	100	SS-7	3.5-4.5+	4	6	10	36	44	-	-	-	16	A-6a (V)	
4 5 9	18	94	SS-8	3.75-4.5+	7	5	10	36	42	-	-	-	16	A-6a (V)	
3 7 11	23	94	SS-9	4.1-4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
4 6 9	19	100	SS-10	3.25-3.75	5	6	11	36	42	27	16	11	15	A-6a (8)	
5 7 12	25	100	SS-11	2.5-3.75	-	-	-	-	-	-	-	-	15	A-6a (V)	

S&ME JOB: 1117-18-009

PID: 106354	BR ID: MED-3-2434	PROJECT: MED-3-24.33	STATION / OFFSET: 1284+92, 8' RT	START: 3/22/18	END: 3/22/18	PG 2 OF 2	**B-002-0-18**

MATERIAL DESCRIPTION AND NOTES	ELEV. 852.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
Very-stiff to hard gray **SILT AND CLAY**, little fine to coarse sand, trace fine to coarse gravel, few stiff zones above 15', damp. *(continued)*	849.4	31 32 33	4 6 7	17	100	SS-12	3.5	4	5	9	40	42	27	16	11	17	A-6a (8)	
Medium-dense gray **COARSE AND FINE SAND**, trace to little silt, trace fine gravel, trace clay, wet.	846.2	34 35 36	5 9 9	23	67	SS-13	-	-	-	-	-	-	-	-	-	20	A-3a (V)	
Dense gray **SANDY SILT**, little clay, little fine gravel, wet.		37 38 W 39 40 41 42 43	8 12 14	34	78	SS-14	-	12	18	26	31	13	NP	NP	NP	16	A-4a (2)	
	837.9	44 EOB 45	6 13 14	35	78	SS-15	-	-	-	-	-	-	-	-	-	19	A-4a (V)	

NOTES:
- Groundwater encountered at 15.0' and 38.5' during drilling.
- After removal of augers, boring caved at 3.0' and was observed to be dry.

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

S&ME ODOT LOG (8.5X11) - SGE 07/2018 - OH DOT.GDT - 8/10/18 13:36 - T:\RESOURCES\CS\01 - LABORATORY\02 - GINTW\PROJECTS\111718009.GPJ

PROJECT: MED-3-24.33	DRILLING FIRM / OPERATOR: S&ME / A. MESSER	DRILL RIG: S&ME ATV D50	STATION / OFFSET: 1285+11, 8' LT	EXPLORATION ID **B-003-0-18**
TYPE: CULVERT REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN	HAMMER: CME AUTOMATIC	ALIGNMENT: SR 3	
PID: 106354 BR ID: MED-3-2434	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 10/20/17	ELEVATION: 882.2 (MSL) EOB: 45.0 ft.	PAGE 1 OF 2
START: 3/22/18 END: 3/22/18	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.8	LAT / LONG: 41.270039 N, 81.744822 W	

MATERIAL DESCRIPTION AND NOTES	ELEV. 882.2	DEPTHS
ASPHALT - 15 INCHES	880.9	
GRANULAR BASE - BRICK FRAGMENTS - BRICK PAVERS - 3 INCHES	880.7	
PROBABLE FILL: Medium-dense brown and gray **GRAVEL WITH SAND**, little silt, trace clay, dry.	879.2	
POSSIBLE FILL: Medium-stiff brown **SILTY CLAY**, trace to little fine to coarse sand, trace fine gravel, few roots, damp to moist.	870.5	
Medium-dense brown **SANDY SILT**, some clay, little fine gravel, damp.	868.0	W
Medium-dense gray **COARSE AND FINE SAND**, little silt, trace clay, trace fine gravel, wet.	867.2	
Very-stiff to hard brown **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp. - Zone with some fine to coarse gravel from 16.5' to 18.0'.	861.2	
Very-stiff gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp.		

DEPTHS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
43 7 6	17	33	SS-1	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
3 4 3	9	44	SS-2	0.5-1.0	-	-	-	-	-	-	-	-	33	A-6b (V)	
4 5 4	12	0	SS	-	-	-	-	-	-	-	-	-	-		
2 3 5	10	72	SS-3A	-	11	12	34	21	22	26	16	10	21	A-4a (2)	
			SS-3B	-	-	-	-	-	-	-	-	-	18	A-3a (V)	
4 6 8	18	100	SS-4	3.5-4.25	7	5	10	34	44	-	-	-	19	A-6a (V)	
3 4 5	12	39	SS-5	-	32	9	9	21	29	-	-	-	18	A-6a (V)	
4 2 10	16	94	SS-6	4.0-4.5+	5	6	11	44	34	34	19	15	19	A-6a (10)	
4 8 4	16	100	SS-7	4.5+	9	6	10	36	39	-	-	-	17	A-6a (V)	
4 7 11	23	94	SS-8	2.5-3.25	-	-	-	-	-	-	-	-	13	A-6a (V)	
4 8 13	27	100	SS-9	3.7-4.0	9	6	10	35	40	27	16	11	15	A-6a (8)	
4 7 13	26	100	SS-10	3.5	-	-	-	-	-	-	-	-	19	A-6a (V)	

S&ME JOB: 1117-18-009

PID: 106354 | BR ID: MED-3-2434 | PROJECT: MED-3-24.33 | STATION / OFFSET: 1285+11, 8' LT | START: 3/22/18 | END: 3/22/18 | PG 2 OF 2 | **B-003-0-18**

MATERIAL DESCRIPTION AND NOTES	ELEV. 852.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)
								GR	CS	FS	SI	CL	LL	PL	PI		
Very-stiff gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp. *(continued)*	849.2	31 32 33	6 8 14	29	100	SS-11	2.25-3.5	-	-	-	-	-	-	-	-	16	A-6a (V)
Stiff gray **SILTY CLAY**, trace fine to coarse sand, trace fine gravel, wet.	845.5	34 35 36	3 4 9	17	100	SS-12	1.3-1.75	1	2	4	32	61	35	19	16	25	A-6b (10)
Dense gray **COARSE AND FINE SAND**, little silt, trace fine gravel, trace clay, damp.	840.5	37 38 39 40 41	4 11 14	32	100	SS-13	-	-	-	-	-	-	-	-	-	14	A-3a (V)
Dense gray **SILT**, little clay, little fine to coarse sand, trace fine gravel, damp.	837.2	42 43 44 EOB 45	5 10 14	31	78	SS-14	-	1	1	16	64	18	NP	NP	NP	21	A-4b (8)

NOTES:
- No seepage encountered during drilling.
- Groundwater encountered at 14.0' during drilling.
- After removal of augers, boring caved at 28.5' and water was measured at 15.0'.

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

S&ME JOB: 1117-18-009

PROJECT: MED-3-24.33	DRILLING FIRM / OPERATOR: S&ME / A. MESSER	DRILL RIG: S&ME ATV D50	STATION / OFFSET: 1285+93, 8' RT	EXPLORATION ID **B-004-0-18**
TYPE: CULVERT REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN	HAMMER: CME AUTOMATIC	ALIGNMENT: SR 3	
PID: 106354 BR ID: MED-3-2434	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 10/20/17	ELEVATION: 881.9 (MSL) EOB: 20.0 ft.	PAGE 1 OF 1
START: 3/22/18 END: 3/22/18	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.8	LAT / LONG: 41.270316 N, 81.744819 W	

MATERIAL DESCRIPTION AND NOTES	ELEV. 881.9	DEPTHS
ASPHALT - 14 INCHES	880.7	
BRICK FRAGMENTS - BRICK PAVERS - 4 INCHES	880.4	
FILL: Medium-dense brown **COARSE AND FINE SAND**, little fine to coarse gravel, trace silt, trace clay, few brick fragments, damp.	878.9	
FILL: Stiff brown and gray **SILTY CLAY**, little fine to coarse sand, trace fine gravel, few brick fragments, damp.	875.6	
Very-soft to medium-stiff gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp to moist.	873.9	
Very-stiff to hard brownish-gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp.	871.4	
Soft to medium-stiff gray **SILTY CLAY**, little fine to coarse sand, trace fine gravel, damp.	870.3	
Stiff brown mottled with gray **SILT AND CLAY**, trace fine to coarse sand, trace fine gravel, damp.	868.9	W
Hard light-brown becoming gray **SILT AND CLAY**, little fine to coarse sand, trace fine gravel, damp.	865.2	
Very-dense brown **COARSE AND FINE SAND**, trace to little silt, trace to little fine gravel, trace clay, wet.	863.9	
Dense gray **COARSE AND FINE SAND**, trace fine gravel, trace silt, trace clay, wet.	861.9	EOB 20

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
10-5-4	12	28	SS-1	-	-	-	-	-	-	-	-	-	15	A-3a (V)
3-2-3	6	61	SS-2	1.1-1.5	3	4	9	38	46	38	18	20	23	A-6b (12)
2-2-3	6	33	SS-3	1.0	-	-	-	-	-	-	-	-	30	A-6b (V)
1-1-2	4	56	SS-4A	1.1-1.2	-	-	-	-	-	-	-	-	24	A-6b (V)
			SS-4B	0.0-0.5	4	7	12	36	41	31	17	14	25	A-6a (10)
4-6-8	18	67	SS-5	2.6-4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)
2-2-4	8	72	SS-6A	0.5	-	-	-	-	-	-	-	-	19	A-6b (V)
			SS-6B	1.1-1.5	-	-	-	-	-	-	-	-	21	A-6a (V)
3-6-8	18	78	SS-7	4.5+	-	-	-	-	-	-	-	-	21	A-6a (V)
5-15-21	47	89	SS-8A	4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)
			SS-8B	-	-	-	-	-	-	-	-	-	21	A-3a (V)
3-10-12	29	56	SS-9	-	-	-	-	-	-	-	-	-	11	A-3a (V)

NOTES:
- Groundwater encountered at 12.5' during drilling.
- After removal of augers, boring caved at 4.0' and was observed to be dry.

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

S&ME ODOT LOG (8.5X11) - SGE 07/2018 - OH DOT.GDT - 8/10/18 13:36 - T:\RESOURCES\CS\01 - LABORATORY\02 - GINTW\PROJECTS\111718009.GPJ

PLATE 9

Scour Zone Grain-Size Information
Culvert Borings
MED-3-24.33 over Unnamed Tributary to East Branch Rocky River
Medina County, Ohio

Boring Number	Location	Sample Depth	Sample Elevation (MSL)	D50 (mm)	D95 (mm)
B-002-0-18	Culvert Outlet	15.0 - 16.5	867.2 - 865.7	0.0094	10.4614
		16.5 - 18.0	865.7 - 864.2	0.0087	1.7125
		18.0 - 19.5	864.2 - 862.7	0.0078	1.5597
		19.5 - 21.0	862.7 - 861.2	0.0089	3.8854
B-003-0-18	Culvert Inlet	15.0 - 16.5	867.9 - 866.4	0.0079	3.4762
		16.5 - 18.0	866.4 - 864.9	0.0791	32.6699
		18.0 - 19.5	864.9 - 863.4	0.0128	2.2403
		19.5 - 21.0	863.4 - 861.9	0.011	4.8308

Important Information About Your
Geotechnical Engineering Report

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

Geotechnical Findings Are Professional Opinions

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

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

Geotechnical Findings Are Professional Opinions

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

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

Services Are Performed for Specific Projects

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

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

Geo-Environmental Issues

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

Geotechnical Recommendations Are Not Final

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

Portion obtained with permission from “Important Information About Your Geotechnical Engineering Report”, ASFE, 2004

Appendix B

Version 2.0 (7/7/15)

Project No 1117-18-009
Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replace.
Desc. Culvert @ Sta 1285+00
Inlet/Outlet Headwalls

Sheet 1 of 1
Calc. By BKS **Date** 8/8/18
Check By RSW **Date** 8/9/18

LRFD BEARING RESISTANCE CALCULATION

SOIL PARAMETERS

Structure	Boring ID	Soil Layer	Depth (ft)	Description	SPT N (lb/ft)	D_w (ft)	γ_m (pcf)	w_n (%)	Φ (deg.)	C (psf)
Inlet	B-003-0-18	5	18	Vst-Hd Silt and Clay (A-6a)	12	14	125	18	0	4000
Outlet	B-002-0-18	4	17	Vst-Hd Silt and Clay (A-6a)	12	15	125	16	0	2000

FOOTING

BEARING RESISTANCE COEFFICIENTS

Structure	D_f (ft)	B (ft)	L (ft)	Nc (1)	Nq (1)	Nγ (1)	Sc (2)	Sq (2)	Sγ (2)	Dq (3)	Cwq (4)	Cwγ (4)
Inlet	3	1.7	12.6	5.14	1.00	0.00	1.026	1.000	1.000	1.0	0.5	0.5
Outlet	3	1.7	12.6	5.14	1.00	0.00	1.026	1.000	1.000	1.0	0.5	0.5

NOMINAL BEARING RESISTANCE

Structure	q_N (ksf)
Inlet	21.3
Outlet	10.7

$$q_N = cN_c s_c i_c + \gamma D_f N_q s_q d_q i_q C_{wq} + \frac{1}{2}\gamma B N_\gamma s_\gamma i_\gamma C_{w\gamma}$$

BEARING RESISTANCE FACTORS

Limit State	Resistance Factor	
Service	1.0	Article 10.5.5.1
Strength	**0.5**	Table 10.5.5.2.2-1 (cohesive)
Strength	0.45	Table 10.5.5.2.2-1 (non-cohesive)

FACTORED BEARING RESISTANCE

Limit State	q_R (ksf)		
	Inlet Headwall	Outlet Headwall	
Service	4.0	4.0	Table C10.6.2.6.1-1
Strength	10.6	5.4	

REFERENCES

AASHTO LRFD Bridge Design Specifications, 6th Edition, Section 10: Foundations.

1. Bearing Capacity Factors Nc, Nq, and Nγ obtained from Table 10.6.3.1.2a-1.
2. Shape Correction Factors Sc, Sq, and Sγ obtained from Table 10.6.3.1.2a-3.
3. Depth Correction Factor Dq obtained from Table 10.6.3.1.2a-4.
4. Groundwater Correction Coefficients Cwq and Cwγ obtained from Table 10.6.3.1.2a-2.

PLATE 1

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

MED-3-24.33
106354

Culvert replacement with roadway subgrade remediation and embankment widening

S&ME, Inc.

Prepared By: Brian K. Sears, P.E.
Date prepared: 5/15/2018

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NO. OF BORINGS: 2

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-18	SR 3	1284+19	9'	Lt.	ATV D50	78	885.0	883.7	1.3 C
2	B-004-0-18	SR 3	1285+93	8'	Rt.	ATV D50	78	881.9	880.6	1.3 C

PLATE 3

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B 001-0 18	SS-1	1.5	3.0	0.2	1.7	12		4.5	38	19	19	29	58	87	20	16	A-6b	12			N_{60} & Mc		12''	**Geotextile Option:** 12''
		SS-2	3.0	4.5	1.7	3.2	8		2.5	37	21	16	29	59	88	23	16	A-6b	10			N_{60} & Mc			
		SS-3	4.5	6.0	3.2	4.7	5		1.25								16	A-6b	16						
		SS-4	6.0	7.5	4.7	6.2	10	5	1.5	39	20	19	23	56	79	22	16	A-6b	12						
2	B 004-0 18	SS-1	1.5	3.0	0.2	1.7	12		-							15	8	A-3a	0						
		SS-2	3.0	4.5	1.7	3.2	6		1.1	38	18	20	38	46	84	23	16	A-6b	12			HP & Mc			
		SS-3	4.5	6.0	3.2	4.7	6		1							30	16	A-6b	16						
		SS-4A/B	6.0	7.5	4.7	6.2	4	4	0.5	31	17	14	36	41	77	25	14	A-6a	10						

PID: 106354

County-Route-Section: MED-3-24.33
No. of Borings: 2

Geotechnical Consultant: S&ME, Inc.
Prepared By: Brian K. Sears, P.E.
Date prepared: 5/15/2018

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	Option
	Lime Stabilization	Option
206	Depth	16''

Excavate and Replace Stabilization Options	
Global Geotextile Override(N60L): Override(HP):	 15'' 12''
Global Geogrid Override(N60L): Override(HP):	 0'' 0''

Design CBR	6

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	25%	HP ≤ 0.5	13%
$N_{60} < 12$	75%	0.5 < HP ≤ 1	13%
$12 \leq N_{60} < 15$	25%	1 < HP ≤ 2	38%
$N_{60} \geq 20$	0%	HP > 2	25%
M+	38%		
Rock	0%		
Unsuitable	0%		

Excavate and Replace at Surface	
Average	12''
Maximum	12''
Minimum	12''

% Proposed Subgrade Surface	
Unstable & Unsuitable	75%
Unstable	75%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	8	5	1.76	37	19	18	31	52	83	23	15	11
Maximum	12	5	4.50	39	21	20	38	59	88	30	16	16
Minimum	4	4	0.50	31	17	14	23	41	77	15	8	0

Classification Counts by Sample

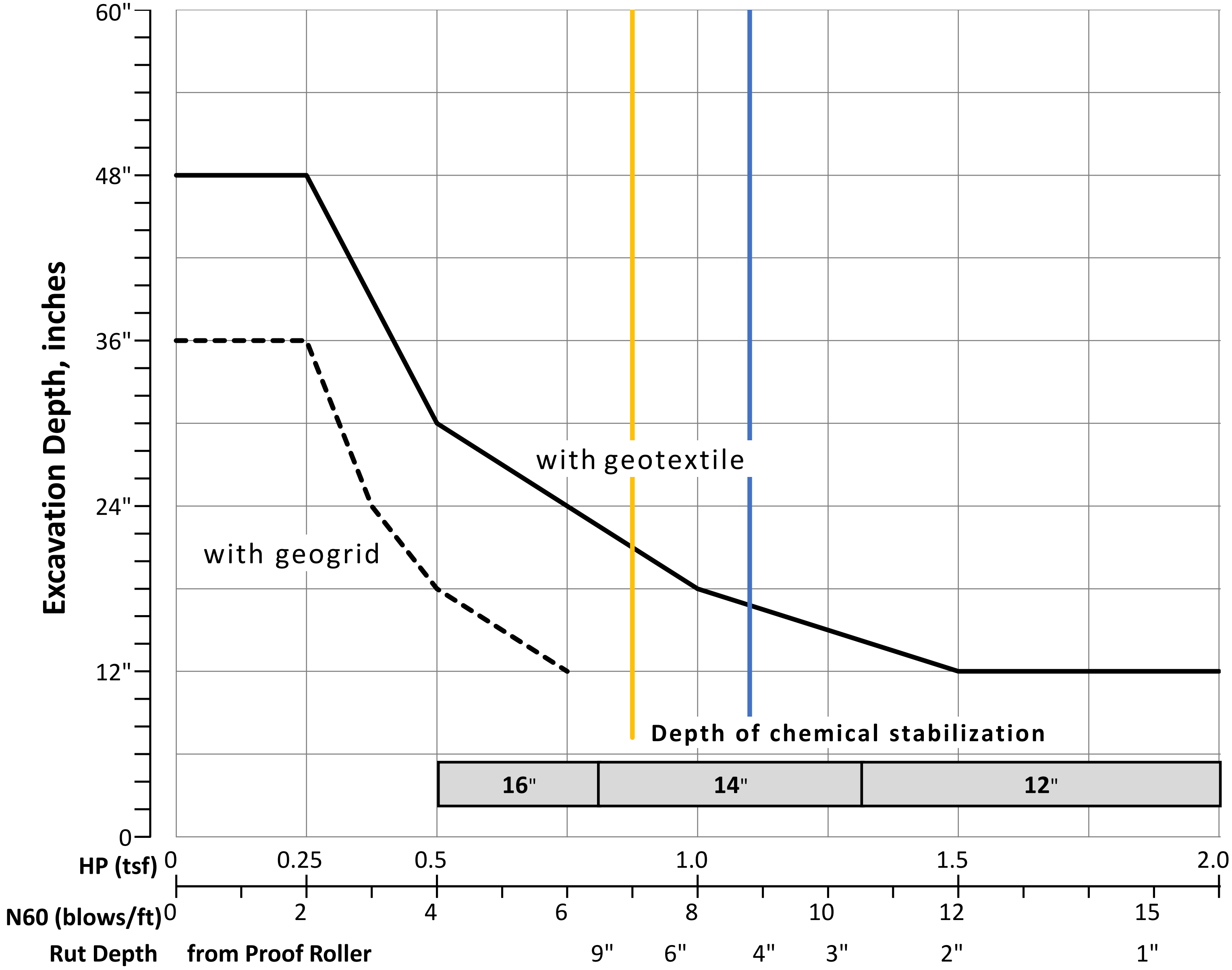
ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	0	0	0	0	0	1	0	0	0	1	6	0	0	0	0	8
Percent	0%	0%	0%	0%	0%	0%	0%	0%	13%	0%	0%	0%	13%	75%	0%	0%	0%	0%	100%
% Rock|Cohesive|Granular	0%	13%									88%								100%
Surface Class Count	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	4
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	75%	0%	0%	0%	0%	100%

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
1.76	1.10	☑ HP
4.50	7.00	☑ N60L

Average HP

Average N_{60L}

PLATE 6

SOIL PARAMETER SUMMARY

Version 1.0 (6/9/2015)

= User Entry Required

S&ME Project No. 1117-18-009
Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacement
Culvert Desc. MED-3-2433

Calculated By BKS Date 5/16/18
Check By RSW Date 5/17/18

Sheet 1 of 4

Inlet

Boring No: B-003-0-18 **Ground Elev:** 868 MSL D_{GWT}: 0 ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1	6	A-6a	16	188	1.792	29	-	125	18	34	19	15	-0.067	0.6	0.19	0.019	Soil profile beginning at a depth of 15 feet
2	18	A-6a	26	751	1.329	35	-	125	16	27	16	11	0	0.6	0.15	0.015	in Boring B-003-0-18
3	21.7	A-6b	17	1242	1.161	20	-	125	25	35	19	16	0.375	0.6	0.21	0.021	
4	26.7	A-3a	32	1514	1.095	35	93	125	14	-	-	-	-	-	-	-	
5	30	A-4b	31	1774	1.042	32	57	125	21	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

35' Left

Boring No: B-003-0-18 **Ground Elev:** 868 MSL D_{GWT}: 0 ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1	6	A-6a	16	188	1.792	29	-	125	18	34	19	15	-0.067	0.6	0.19	0.019	Soil profile beginning at a depth of 15 feet
2	18	A-6a	26	751	1.329	35	-	125	16	27	16	11	0	0.6	0.15	0.015	in Boring B-003-0-18
3	21.7	A-6b	17	1242	1.161	20	-	125	25	35	19	16	0.375	0.6	0.21	0.021	
4	26.7	A-3a	32	1514	1.095	35	93	125	14	-	-	-	-	-	-	-	
5	30	A-4b	31	1774	1.042	32	57	125	21	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

SOIL PARAMETER SUMMARY

Version 1.0 (6/9/2015)

🟩 = User Entry Required

S&ME Project No. 1117-18-009
Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacement
Culvert Desc. MED-3-2433

Calculated By BKS Date 5/16/18
Check By RSW Date 5/17/18

Sheet 2 of 4

SR 3 Centerline

Boring No: B-002-0-18 **Ground Elev:** 882.9 MSL D_{GWT}: 14 ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1	3	A-6b	13	188	1.792	23	-	125	21	-	-	-	-	0.6	0.18	0.018	
2	6.7	A-6b	12	607	1.401	17	-	125	19	37	18	19	0.053	0.6	0.18	0.018	
3	11.7	A-6b	9	1151	1.187	11	-	125	23	-	-	-	-	0.6	0.18	0.018	
4	23	A-6a	15	1961	1.008	15	-	125	16	27	16	11	0	0.6	0.15	0.015	
5	33.5	A-6a	20	2643	0.909	18	-	125	15	27	16	11	-0.091	0.6	0.15	0.015	
6	36.5	A-3a	23	3058	0.86	20	65	120	20	-	-	-	-	-	-	-	
7	45	A-4a	34	3410	0.823	28	73	125	17	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

27' Right

Boring No: B-002-018 **Ground Elev:** 868 MSL D_{GWT}: 0 ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1	8	A-6a	15	250	1.697	25	-	125	21	-	-	-	-	0.6	0.21	0.021	Soil profile beginning at a depth of 15 feet
2	18.5	A-6a	20	829	1.296	26	-	125	19	37	18	19	0.053	0.6	0.21	0.021	in Boring B-002-0-18
3	21.5	A-3a	23	1244	1.161	27	80	120	23	-	-	-	-	-	-	-	
4	30	A-4a	34	1596	1.077	37	90	125	16	27	16	11	0	-	-	-	
5						-	-		-	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

SOIL PARAMETER SUMMARY

Version 1.0 (6/9/2015)

= User Entry Required

S&ME Project No.	1117-18-009
Client	Engineering Associates, Inc.
Project	MED-3-24.33 Culvert Replacement
Culvert Desc.	MED-3-2433

Calculated By	BKS	Date	5/16/18
Check By	RSW	Date	5/17/18

Outlet

Boring No: B-002-018 **Ground Elev:** 868 MSL D_{GWT}**:** 0 ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1	8	A-6a	15	250	1.697	25	-	125	21	-	-	-	-	0.6	0.21	0.021	Soil profile beginning at a depth of 15 feet
2	18.5	A-6a	20	829	1.296	26	-	125	19	37	18	19	0.053	0.6	0.21	0.021	in Boring B-002-0-18
3	21.5	A-3a	23	1244	1.161	27	80	120	23	-	-	-	-	-	-	-	
4	30	A-4a	34	1596	1.077	37	90	125	16	27	16	11	0	-	-	-	
5						-	-		-	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

Boring No: **Ground Elev:** MSL D_{GWT}**:** ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1						-	-		-	-	-	-	-	-	-	-	
2						-	-		-	-	-	-	-	-	-	-	
3						-	-		-	-	-	-	-	-	-	-	
4						-	-		-	-	-	-	-	-	-	-	
5						-	-		-	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

SOIL PARAMETER SUMMARY

Version 1.0 (6/9/2015)

= User Entry Required

S&ME Project No. 1117-18-009
Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacement
Culvert Desc. MED-3-2433

Calculated By BKS Date 5/16/18
Check By RSW Date 5/17/18

Sheet 4 of 4

Boring No: ________ **Ground Elev:** ____ MSL D_{GWT}: ____ ft

Soil Layer	Depth (ft)	Description	N (bpf)	σ'_o (psf)	C_N (1)	N'	C' (2)	γ_m (pcf)	w_n (%)	LL	PL	PI	LI	e_0 (3)	Cc (4)	Cr (5)	Comments
1						-	-		-	-	-	-	-	-	-	-	
2						-	-		-	-	-	-	-	-	-	-	
3						-	-		-	-	-	-	-	-	-	-	
4						-	-		-	-	-	-	-	-	-	-	
5						-	-		-	-	-	-	-	-	-	-	
6						-	-		-	-	-	-	-	-	-	-	
7						-	-		-	-	-	-	-	-	-	-	
8						-	-		-	-	-	-	-	-	-	-	
9						-	-		-	-	-	-	-	-	-	-	
10						-	-		-	-	-	-	-	-	-	-	
11						-	-		-	-	-	-	-	-	-	-	

REFERENCES

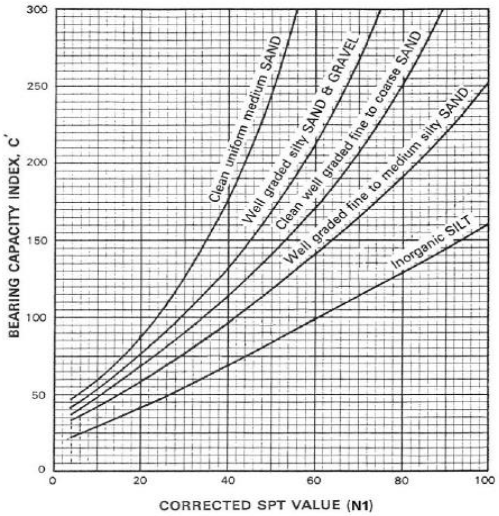
1. Equation 10.4.6.2.4-1 (see right) of 2012 AASHTO LRFD Bridge Design Specifications, Sixth Edition
2. From Figure 10.6.2.4.2-1 of 2012 AASHTO LRFD Bridge Design Specifications, Sixth Edition (see below).
3. e_o estimated from one or both of the following references:

$$e_o = \frac{w_n G_s}{S}$$

where G_s = 2.7 and Saturation (S) = 100%

FHWA-HI-88-099 Soils and Foundations Workshop Manual - 2nd Edition, 1994

Reproduction of Table 1.4 from Principles of Foundation Engineering, 5th Edition (Das, 2004)	
Material Type	Void Ratio, e_o
Loose uniform sand	0.8
Dense uniform sand	0.45
Loose angular-grained silty sand	0.65
Dense angular-grained silty sand	0.4
Stiff clay	0.6
Soft clay	0.9 - 1.4
Loess	0.9
Soft organic clay	2.5 - 3.2
Glacial till	0.3



Equation 10.4.6.2.4-1 $C_N = [0.77 \log_{10}(40/\sigma'_v)], and\ C_N < 2.0$

4. C_c determined as average value from the following methods.

$C_c = 0.009(LL - 10)$ Terzaghi and Peck (1967)

$C_c = 0.37(e_o + 0.003LL + 0.0004W_n - 0.34)$ Azzouz et al. (1976)

$C_c = 0.046 + 0.0104PI$ Nakase et al. (1988)

$C_c = 0.00234(LL)(G_s)$ Nagaraj and Srinivasa Murthy (1985,1986)

$C_c = 0.01W_n$ Kulhawy and Mayne (1990)

5. C_r determined as: $C_r = 0.1C_c$

Note: The ratio of Cr to Cc generally ranges from 0.05 to 0.1. Based on previous experience with Ohio soils, a ratio of 0.1 is believed to most closely approximate the value of Cr.

PLATE 10

Version 1.0 (6/9/2015)

Client	Engineering Associates, Inc.	Job No	1117-18-009		
Project	MED-3-24.33 Culvert Replacement	Sheet	1	of	2
Desc.	MED-3-2433	Calc. By	BKS	Date	5/16/2018
	Inlet	Check By	RSW	Date	5/17/2018

SETTLEMENT ANALYSIS - STRESS INCREASE UNDER RECTANGULAR LOADING

Depth, z = 28.3 ft

Block ID	Height	Unit Weight	Applied Stress	Block Width	Block Length	Width Factor	Length Factor	Influence Factor	Multiplier (see below)	Stress Increase
	ft	pcf	psf	ft	ft	L/z	B/z			psf
	H	γ_m	q	B	L	m	n	I	x	Δq
1	2	125	250	15.5	150	5.3003534	0.5477032	0.1467	2.0	73.4
2	2	125	250	17	150	5.3003534	0.6007067	0.1563	2.0	78.1
3	2	125	250	17.5	150	5.3003534	0.6183746	0.1592	2.0	79.6
4	2	125	250	21.5	150	5.3003534	0.7597173	0.1800	2.0	90.0
5	2	125	250	24	150	5.3003534	0.8480565	0.1903	2.0	95.2
6	2	125	250	28	150	5.3003534	0.9893993	0.2036	2.0	101.8
7	2	125	250	32	150	5.3003534	1.130742	0.2136	2.0	106.8
8	-2	125	-250	3	150	5.3003534	0.1060071	0.0335	2.0	-16.7
9	-2	125	-250	6.5	150	5.3003534	0.229682	0.0706	2.0	-35.3
10	-2	125	-250	11.5	150	5.3003534	0.4063604	0.1169	2.0	-58.4
11	-2	125	-250	17	150	5.3003534	0.6007067	0.1563	2.0	-78.1
12	-2	125	-250	23	150	5.3003534	0.8127208	0.1864	2.0	-93.2
13	-2	125	-250	29	150	5.3003534	1.024735	0.2064	2.0	-103.2
14	0	0	0	0	0	0	0	0.0000	2.0	0.0
15	0	0	0	0	0	0	0	0.0000	2.0	0.0
16	0	0	0	0	0	0	0	0.0000	2.0	0.0
17	0	0	0	0	0	0	0	0.0000	2.0	0.0
18	0	0	0	0	0	0	0	0.0000	2.0	0.0
19	0	0	0	0	0	0	0	0.0000	2.0	0.0
20	0	0	0	0	0	0	0	0.0000	2.0	0.0

Net Stress Increase: 239.8 psf

Multiplier Rules: When the point in question is below the...

1. Corner of rectangular area, multiplier is 1.0.
2. Midpoint of the edge of rectangular area, multiplier is 2.0.
3. Center of rectangular area, multiplier is 4.0.

Hint: Use negative unit weight (or height) if you are using superposition to subtract an area.

EQUATIONS

$$q = H\gamma_m \qquad m = \frac{L}{z} \qquad n = \frac{B}{z} \qquad \Delta q = qIx$$

$$I = \frac{1}{2\pi}\left[\frac{mn}{\sqrt{m^2+n^2+1}}\ \frac{m^2+n^2+2}{m^2+n^2+m^2n^2+1} + \sin^{-1}\frac{mn}{\sqrt{m^2+n^2+m^2n^2+1}}\right]$$

(see Fadum, 1948)

Version 1.0 (6/9/2015)

Client: Engineering Associates, Inc.
Project: MED-3-24.33 Culvert Replacemen
Desc.: MED-3-2433
Inlet
Job No: 1117-18-009
Sheet: 2 of 2
Calc. By: BKS Date: 5/16/2018
Check By: RSW Date: 5/17/2018

SETTLEMENT ANALYSIS - CONSOLIDATION SETTLEMENT

Groundwater Table: D = 0 feet

🟩 = User Entry Required

Soil Properties: Settlement calculated at layer mid-point

No.	Bottom of Layer (ft)	Soil Type	γ_{soil} (pcf)	σ'_p (psf)	σ'_o (psf)	$\Delta\sigma(z)$ (psf)	σ'_f (psf)	Cohesion-less Soils C'	Cohesive Soils e_o	C_c	C_r
1	6	A-6a	125	2000	188	152	340		0.6	0.19	0.019
2	18	A-6a	125	2000	751	255	1006		0.6	0.15	0.015
3	21.7	A-6b	125	2000	1242	262	1504		0.6	0.21	0.021
4	26.7	A-3a	125	1514	1514	252	1766.1	93			
5	30	A-4b	125	1774	1774	240	2013.8	57			
6											
7											
8											
9											
10											
11											

No.	Settlement, S_e / S_c (ft)	(inch)
1	0.018	0.22
2	0.014	0.17
3	0.004	0.05
4	0.004	0.05
5	0.003	0.04
6		
7		
8		
9		
10		
11		

Total Settlement

0.043 feet

0.5 inches

Boring Profile

B-003-0-18

Overconsolidated Soils - Case I ($\sigma'_o + \Delta\sigma(z) \leq \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o} C_r \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Modified from Eqn. 1.66 [1]

Overconsolidated Soils - Case II ($\sigma'_o + \Delta\sigma(z) > \sigma'_p$)

$$S_c = \left[\frac{H_c}{(1+e_0)}\right]\left[C_r \log\left(\frac{\sigma'_p}{\sigma'_0}\right) + C_c \log\left(\frac{\sigma'_f}{\sigma'_p}\right)\right]$$

Eqn. 10.6.2.4.3-1 [2]

Normally Consolidated Soils ($\sigma'_o = \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o}\left(C_c \log\left(\frac{\sigma'_f}{\sigma'_o}\right)\right)$$

Eqn. 10.6.2.4.3-2 [2]

Cohesionless Soils ($\sigma'_o = \sigma'_p$)

$$S_e = H_c \frac{1}{C'} \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Eqn. 10.6.2.4.2-3 [2]

[1] *Principles of Foundation Engineering, 4th Edition, Das (1999).*

[2] *2012 AASHTO LRFD, 6th Edition.*

Version 1.0 (6/9/2015)

Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacement
Desc. MED-3-2433
35' Left

Job No 1117-18-009
Sheet 1 of 2
Calc. By BKS Date 5/16/2018
Check By RSW Date 5/17/2018

SETTLEMENT ANALYSIS - STRESS INCREASE UNDER RECTANGULAR LOADING

Depth, z = 28.3 ft

Block ID	Height	Unit Weight	Applied Stress	Block Width	Block Length	Width Factor	Length Factor	Influence Factor	Multiplier (see below)	Stress Increase
	ft	pcf	psf	ft	ft	L/z	B/z			psf
	H	γ_m	q	B	L	m	n	I	x	Δq
1	2	125	250	15.5	150	5.3003534	0.5477032	0.1467	2.0	73.4
2	2	125	250	17	150	5.3003534	0.6007067	0.1563	2.0	78.1
3	2	125	250	16	150	5.3003534	0.565371	0.1500	2.0	75.0
4	2	125	250	16	150	5.3003534	0.565371	0.1500	2.0	75.0
5	-2	125	-250	3	150	5.3003534	0.1060071	0.0335	2.0	-16.7
6	-2	125	-250	6	150	5.3003534	0.2120141	0.0655	2.0	-32.8
7	-2	125	-250	11	150	5.3003534	0.3886926	0.1127	2.0	-56.3
8	2	125	250	2	150	5.3003534	0.0706714	0.0224	2.0	11.2
9	2	125	250	6	150	5.3003534	0.2120141	0.0655	2.0	32.8
10	2	125	250	9	150	5.3003534	0.3180212	0.0949	2.0	47.5
11	2	125	250	12	150	5.3003534	0.4240283	0.1210	2.0	60.5
12	2	125	250	18	150	5.3003534	0.6360424	0.1621	2.0	81.1
13	-2	125	-250	7	150	5.3003534	0.2473498	0.0757	2.0	-37.8
14	-2	125	-250	14	150	5.3003534	0.4946996	0.1363	2.0	-68.1
15	0	0	0	0	0	0	0	0.0000	2.0	0.0
16	0	0	0	0	0	0	0	0.0000	2.0	0.0
17	0	0	0	0	0	0	0	0.0000	2.0	0.0
18	0	0	0	0	0	0	0	0.0000	2.0	0.0
19	0	0	0	0	0	0	0	0.0000	2.0	0.0
20	0	0	0	0	0	0	0	0.0000	2.0	0.0

Multiplier Rules: When the point in question is below the...

1. Corner of rectangular area, multiplier is 1.0.
2. Midpoint of the edge of rectangular area, multiplier is 2.0.
3. Center of rectangular area, multiplier is 4.0.

Net Stress Increase: 322.7 psf

Hint: Use negative unit weight (or height) if you are using superposition to subtract an area.

EQUATIONS

$$q = H\gamma_m \qquad m = \frac{L}{z} \qquad n = \frac{B}{z} \qquad \Delta q = qIx$$

$$I = \frac{1}{2\pi}\left[\frac{mn}{\sqrt{m^2+n^2+1}}\;\frac{m^2+n^2+2}{m^2+n^2+m^2n^2+1} + \sin^{-1}\frac{mn}{\sqrt{m^2+n^2+m^2n^2+1}}\right]$$

(see Fadum, 1948)

Version 1.0 (6/9/2015)

Client	Engineering Associates, Inc.	Job No	1117-18-009		
Project	MED-3-24.33 Culvert Replacemen	Sheet	2	of	2
Desc.	MED-3-2433	Calc. By	BKS	Date	5/16/2018
	35' Left	Check By	RSW	Date	5/17/2018

SETTLEMENT ANALYSIS - CONSOLIDATION SETTLEMENT

Groundwater Table: D = 0 feet

🟩 = User Entry Required

Soil Properties: Settlement calculated at layer mid-point

No.	Bottom of Layer (ft)	Soil Type	γ_{soil} (pcf)	σ'_c (psf)	σ'_o (psf)	$\Delta\sigma(z)$ (psf)	σ'_f (psf)	Cohesion-less Soils	Cohesive Soils		
								C'	e_o	C_c	C_r
1	6	A-6a	125	2000	188	482	670		0.6	0.19	0.019
2	18	A-6a	125	2000	751	460	1210.8		0.6	0.15	0.015
3	21.7	A-6b	125	2000	1242	394	1635.6		0.6	0.21	0.021
4	26.7	A-3a	125	1514	1514	355	1869.1	93			
5	30	A-4b	125	1774	1774	323	2096.7	57			
6											
7											
8											
9											
10											
11											

Settlement, S_e / S_c

No.	(ft)	(inch)
1	0.039	0.47
2	0.023	0.28
3	0.006	0.07
4	0.005	0.06
5	0.004	0.05
6		
7		
8		
9		
10		
11		

Total Settlement

0.077 feet

0.9 inches

Boring Profile

B-003-0-18

Overconsolidated Soils - Case I ($\sigma'_o + \Delta\sigma(z) \leq \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o} C_r \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Modified from Eqn. 1.66 [1]

Overconsolidated Soils - Case II ($\sigma'_o + \Delta\sigma(z) > \sigma'_p$)

$$S_c = \left[\frac{H_c}{(1+e_0)}\right]\left[C_r \log\left(\frac{\sigma'_p}{\sigma'_0}\right) + C_c \log\left(\frac{\sigma'_f}{\sigma'_p}\right)\right]$$

Eqn. 10.6.2.4.3-1 [2]

Normally Consolidated Soils ($\sigma'_o = \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o}\left(C_c \log\left(\frac{\sigma'_f}{\sigma'_o}\right)\right)$$

Eqn. 10.6.2.4.3-2 [2]

Cohesionless Soils ($\sigma'_o = \sigma'_p$)

$$S_e = H_c \frac{1}{C'} \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Eqn. 10.6.2.4.2-3 [2]

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[1] *Principles of Foundation Engineering, 4th Edition, Das (1999).*

[2] *2012 AASHTO LRFD, 6th Edition.*

Version 1.0 (6/9/2015)

Client: Engineering Associates, Inc.
Project: MED-3-24.33 Culvert Replacement
Desc.: MED-3-2433
SR 3 Centerline

Job No: 1117-18-009
Sheet: 1 of 2
Calc. By: BKS Date: 5/16/2018
Check By: RSW Date: 5/17/2018

SETTLEMENT ANALYSIS - STRESS INCREASE UNDER RECTANGULAR LOADING

Depth, z = 17.3 ft

Block ID	Height	Unit Weight	Applied Stress	Block Width	Block Length	Width Factor	Length Factor	Influence Factor	Multiplier (see below)	Stress Increase
	ft	pcf	psf	ft	ft	L/z	B/z			psf
	H	γ_m	q	B	L	m	n	I	x	Δq
1	14	125	1750	50	150	8.6705202	2.8901734	0.2461	2.0	861.4
2	14	125	1750	51	150	8.6705202	2.9479769	0.2463	2.0	862.1
3	-2	125	-250	28	150	8.6705202	1.6184971	0.2331	2.0	-116.5
4	-2	125	-250	31	150	8.6705202	1.7919075	0.2367	2.0	-118.3
5	-2	125	-250	33.5	150	8.6705202	1.9364162	0.2390	2.0	-119.5
6	-2	125	-250	38	150	8.6705202	2.1965318	0.2420	2.0	-121.0
7	-2	125	-250	43.5	150	8.6705202	2.5144509	0.2444	2.0	-122.2
8	-2	125	-250	45	150	8.6705202	2.6011561	0.2448	2.0	-122.4
9	-2	125	-250	47	150	8.6705202	2.716763	0.2454	2.0	-122.7
10	-2	125	-250	35.5	150	8.6705202	2.0520231	0.2405	2.0	-120.2
11	-2	125	-250	37	150	8.6705202	2.1387283	0.2414	2.0	-120.7
12	-2	125	-250	40	150	8.6705202	2.3121387	0.2430	2.0	-121.5
13	-2	125	-250	41	150	8.6705202	2.3699422	0.2434	2.0	-121.7
14	-2	125	-250	44	150	8.6705202	2.5433526	0.2445	2.0	-122.3
15	-2	125	-250	46	150	8.6705202	2.6589595	0.2451	2.0	-122.6
16	-2	125	-250	47	150	8.6705202	2.716763	0.2454	2.0	-122.7
17	0	0	0	0	0	0	0	0.0000	2.0	0.0
18	0	0	0	0	0	0	0	0.0000	2.0	0.0
19	0	0	0	0	0	0	0	0.0000	2.0	0.0
20	0	0	0	0	0	0	0	0.0000	2.0	0.0

Net Stress Increase: 29.2 psf

Multiplier Rules: When the point in question is below the...

1. Corner of rectangular area, multiplier is 1.0.
2. Midpoint of the edge of rectangular area, multiplier is 2.0.
3. Center of rectangular area, multiplier is 4.0.

Hint: Use negative unit weight (or height) if you are using superposition to subtract an area.

EQUATIONS

$$q = H\gamma_m \qquad m = \frac{L}{z} \qquad n = \frac{B}{z} \qquad \Delta q = qIx$$

$$I = \frac{1}{2\pi}\left[\frac{mn}{\sqrt{m^2+n^2+1}}\,\frac{m^2+n^2+2}{m^2+n^2+m^2n^2+1} + \sin^{-1}\frac{mn}{\sqrt{m^2+n^2+m^2n^2+1}}\right]$$

(see Fadum, 1948)

Version 1.0 (6/9/2015)

Client	Engineering Associates, Inc.	Job No	1117-18-009
Project	MED-3-24.33 Culvert Replacemen	Sheet	2 of 2
Desc.	MED-3-2433	Calc. By	BKS
		Date	5/16/2018
	SR 3 Centerline	Check By	RSW
		Date	5/17/2018

CULVERT/EMBANKMENT SETTLEMENT ANALYSIS

Groundwater Table: D = 14 feet

🟩 = User Entry Required

Soil Properties: Settlement calculated at layer mid-point

No.	Bottom of Layer (ft)	Soil Type	γ_{soil} (pcf)	σ'c (psf)	σ'o (psf)	Δσ(z) (psf)	σ'f (psf)	Cohesion-less Soils C'	Cohesive Soils eo	Cc	Cr
1	3	A-6b	125	2000	188	0	188		0.6	0.18	0.018
2	6.7	A-6b	125	2000	607	0	607.01		0.6	0.18	0.018
3	11.7	A-6b	125	2000	1151	0	1151.01		0.6	0.18	0.018
4	23	A-6a	125	3000	1961	29	1990.2		0.6	0.15	0.015
5	33.5	A-6a	125	3000	2643	80	2722.6		0.6	0.15	0.015
6	36.5	A-3a	120	3058	3058	110	3168.4	65			
7	45	A-4a	125	3410	3410	132	3541.8	73			
8											
9											
10											
11											

Settlement, S_e / S_c

No.	(ft)	(inches)
1	0.000	0.00
2	0.000	0.00
3	0.000	0.00
4	0.001	0.01
5	0.001	0.01
6	0.001	0.01
7	0.002	0.02
8		
9		
10		
11		

Total Settlement

0.005 feet

0.1 inches

Boring Profile

B-002-0-18

Overconsolidated Soils - Case I ($\sigma'_o + \Delta\sigma(z) \leq \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o} C_r \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Modified from Eqn. 1.66 [1]

Overconsolidated Soils - Case II ($\sigma'_o + \Delta\sigma(z) > \sigma'_p$)

$$S_c = \left[\frac{H_c}{(1+e_0)}\right]\left[C_r \log\left(\frac{\sigma'_p}{\sigma'_0}\right) + C_c \log\left(\frac{\sigma'_f}{\sigma'_p}\right)\right]$$

Eqn. 10.6.2.4.3-1 [2]

Normally Consolidated Soils (σ'o = σ'p)

$$S_c = \frac{H_c}{1+e_o}\left(C_c \log\left(\frac{\sigma'_f}{\sigma'_o}\right)\right)$$

Eqn. 10.6.2.4.3-2 [2]

Cohesionless Soils (σ'o = σ'p)

$$S_e = H_c \frac{1}{C'} \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Eqn. 10.6.2.4.2-3 [2]

[1] *Principles of Foundation Engineering, 4th Edition, Das (1999).*

[2] *2012 AASHTO LRFD, 6th Edition.*

Version 1.0 (6/9/2015)

Client: Engineering Associates, Inc.
Project: MED-3-24.33 Culvert Replacement
Desc.: MED-3-2433
27' Right

Job No: 1117-18-009
Sheet: 1 of 2
Calc. By: BKS Date: 5/16/2018
Check By: RSW Date: 5/17/2018

SETTLEMENT ANALYSIS - STRESS INCREASE UNDER RECTANGULAR LOADING

Depth, z = 25.7 ft

Block ID	Height	Unit Weight	Applied Stress	Block Width	Block Length	Width Factor	Length Factor	Influence Factor	Multiplier (see below)	Stress Increase
	ft	pcf	psf	ft	ft	L/z	B/z			psf
	H	γ_m	q	B	L	m	n	I	x	Δq
1	2	125	250	23.5	150	5.8365759	0.9143969	0.1971	2.0	98.5
2	2	125	250	20	150	5.8365759	0.7782101	0.1823	2.0	91.2
3	2	125	250	16	150	5.8365759	0.6225681	0.1600	2.0	80.0
4	2	125	250	12	150	5.8365759	0.4669261	0.1305	2.0	65.2
5	2	125	250	6.5	150	5.8365759	0.2529183	0.0772	2.0	38.6
6	2	125	250	1	150	5.8365759	0.0389105	0.0124	2.0	6.2
7	-2	125	-250	2	150	5.8365759	0.077821	0.0247	2.0	-12.3
8	-2	125	-250	1	150	5.8365759	0.0389105	0.0124	2.0	-6.2
9	2	125	250	2.5	150	5.8365759	0.0972763	0.0308	2.0	15.4
10	2	125	250	5.5	150	5.8365759	0.2140078	0.0661	2.0	33.1
11	2	125	250	10	150	5.8365759	0.3891051	0.1128	2.0	56.4
12	-2	125	-250	7	150	5.8365759	0.2723735	0.0827	2.0	-41.3
13	0	0	0	0	0	0	0	0.0000	2.0	0.0
14	0	0	0	0	0	0	0	0.0000	2.0	0.0
15	0	0	0	0	0	0	0	0.0000	2.0	0.0
16	0	0	0	0	0	0	0	0.0000	2.0	0.0
17	0	0	0	0	0	0	0	0.0000	2.0	0.0
18	0	0	0	0	0	0	0	0.0000	2.0	0.0
19	0	0	0	0	0	0	0	0.0000	2.0	0.0
20	0	0	0	0	0	0	0	0.0000	2.0	0.0

Net Stress Increase: 424.7 psf

Multiplier Rules: When the point in question is below the...

1. Corner of rectangular area, multiplier is 1.0.
2. Midpoint of the edge of rectangular area, multiplier is 2.0.
3. Center of rectangular area, multiplier is 4.0.

Hint: Use negative unit weight (or height) if you are using superposition to subtract an area.

EQUATIONS

$$q = H\gamma_m \qquad m = \frac{L}{z} \qquad n = \frac{B}{z} \qquad \Delta q = qIx$$

$$I = \frac{1}{2\pi}\left[\frac{mn}{\sqrt{m^2+n^2+1}}\ \frac{m^2+n^2+2}{m^2+n^2+m^2n^2+1} + \sin^{-1}\frac{mn}{\sqrt{m^2+n^2+m^2n^2+1}}\right]$$

(see Fadum, 1948)

Version 1.0 (6/9/2015)

Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacemen
Desc. MED-3-2433
27' Right

Job No 1117-18-009
Sheet 2 of 2
Calc. By BKS Date 5/16/2018
Check By RSW Date 5/17/2018

CULVERT/EMBANKMENT SETTLEMENT ANALYSIS

Groundwater Table: D = 0 feet

🟩 = User Entry Required

Soil Properties: Settlement calculated at layer mid-point

No.	Bottom of Layer (ft)	Soil Type	γ_{soil} (pcf)	σ'c (psf)	σ'o (psf)	Δσ(z) (psf)	σ'f (psf)	Cohesion-less Soils	Cohesive Soils		
								C'	eo	Cc	Cr
1	8	A-6a	125	2000	250	742	992		0.6	0.21	0.021
2	18.5	A-6a	125	2000	829	592	1421.4		0.6	0.21	0.021
3	21.5	A-3a	120	1244	1244	492	1736.1	80			
4	30	A-4a	125	1596	1596	425	2020.7	90			
5											
6											
7											
8											
9											
10											
11											

Settlement, S_e / S_c

No.	(ft)	(inches)
1	0.063	0.76
2	0.032	0.38
3	0.005	0.06
4	0.010	0.12
5		
6		
7		
8		
9		
10		
11		

Total Settlement

0.110 feet

1.3 inches

Boring Profile

B-002-018

Overconsolidated Soils - Case I ($\sigma'_o + \Delta\sigma(z) \leq \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o} C_r \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Modified from Eqn. 1.66 [1]

Overconsolidated Soils - Case II ($\sigma'_o + \Delta\sigma(z) > \sigma'_p$)

$$S_c = \left[\frac{H_c}{(1+e_0)}\right]\left[C_r \log\left(\frac{\sigma'_p}{\sigma'_0}\right) + C_c \log\left(\frac{\sigma'_f}{\sigma'_p}\right)\right]$$

Eqn. 10.6.2.4.3-1 [2]

Normally Consolidated Soils ($\sigma'_o = \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o}\left(C_c \log\left(\frac{\sigma'_f}{\sigma'_o}\right)\right)$$

Eqn. 10.6.2.4.3-2 [2]

Cohesionless Soils ($\sigma'_o = \sigma'_p$)

$$S_e = H_c \frac{1}{C'} \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Eqn. 10.6.2.4.2-3 [2]

[1] *Principles of Foundation Engineering, 4th Edition, Das (1999).*

[2] *2012 AASHTO LRFD, 6th Edition.*

Version 1.0 (6/9/2015)

Client Engineering Associates, Inc.
Project MED-3-24.33 Culvert Replacement
Desc. MED-3-2433
Outlet

Job No 1117-18-009
Sheet 1 of 2
Calc. By BKS Date 5/16/2018
Check By RSW Date 5/17/2018

SETTLEMENT ANALYSIS - STRESS INCREASE UNDER RECTANGULAR LOADING

Depth, z = 25.7 ft

Block ID	Height	Unit Weight	Applied Stress	Block Width	Block Length	Width Factor	Length Factor	Influence Factor	Multiplier (see below)	Stress Increase
	ft	pcf	psf	ft	ft	L/z	B/z			psf
	H	γ_m	q	B	L	m	n	I	x	Δq
1	2	125	250	21.5	150	5.8365759	0.8365759	0.1891	2.0	94.6
2	2	125	250	23	150	5.8365759	0.8949416	0.1952	2.0	97.6
3	2	125	250	23	150	5.8365759	0.8949416	0.1952	2.0	97.6
4	2	125	250	24	150	5.8365759	0.9338521	0.1989	2.0	99.4
5	2	125	250	24.5	150	5.8365759	0.9533074	0.2006	2.0	100.3
6	2	125	250	29	150	5.8365759	1.1284047	0.2135	2.0	106.7
7	2	125	250	33	150	5.8365759	1.2840467	0.2217	2.0	110.9
8	-2	125	-250	4	150	5.8365759	0.155642	0.0487	2.0	-24.4
9	-2	125	-250	7	150	5.8365759	0.2723735	0.0827	2.0	-41.3
10	-2	125	-250	12	150	5.8365759	0.4669261	0.1305	2.0	-65.2
11	-2	125	-250	18	150	5.8365759	0.7003891	0.1720	2.0	-86.0
12	-2	125	-250	24	150	5.8365759	0.9338521	0.1989	2.0	-99.4
13	-2	125	-250	30	150	5.8365759	1.1673152	0.2158	2.0	-107.9
14	0	0	0	0	0	0	0	0.0000	2.0	0.0
15	0	0	0	0	0	0	0	0.0000	2.0	0.0
16	0	0	0	0	0	0	0	0.0000	2.0	0.0
17	0	0	0	0	0	0	0	0.0000	2.0	0.0
18	0	0	0	0	0	0	0	0.0000	2.0	0.0
19	0	0	0	0	0	0	0	0.0000	2.0	0.0
20	0	0	0	0	0	0	0	0.0000	2.0	0.0

Net Stress Increase: 282.8 psf

Multiplier Rules: When the point in question is below the…

1. Corner of rectangular area, multiplier is 1.0.
2. Midpoint of the edge of rectangular area, multiplier is 2.0.
3. Center of rectangular area, multiplier is 4.0.

Hint: Use negative unit weight (or height) if you are using superposition to subtract an area.

EQUATIONS

$$q = H\gamma_m \qquad m = \frac{L}{z} \qquad n = \frac{B}{z} \qquad \Delta q = qIx$$

$$I = \frac{1}{2\pi}\left[\frac{mn}{\sqrt{m^2+n^2+1}}\,\frac{m^2+n^2+2}{m^2+n^2+m^2n^2+1} + \sin^{-1}\frac{mn}{\sqrt{m^2+n^2+m^2n^2+1}}\right]$$

(see Fadum, 1948)

Version 1.0 (6/9/2015)

Client	Engineering Associates, Inc.	Job No	1117-18-009		
Project	MED-3-24.33 Culvert Replacemen	Sheet	2	of	2
Desc.	MED-3-2433	Calc. By	BKS	Date	5/16/2018
	Outlet	Check By	RSW	Date	5/17/2018

CULVERT/EMBANKMENT SETTLEMENT ANALYSIS

Groundwater Table: D = 0 feet

🟩 = User Entry Required

Soil Properties: Settlement calculated at layer mid-point

No.	Bottom of Layer (ft)	Soil Type	γ_{soil} (pcf)	σ'c (psf)	σ'o (psf)	Δσ(z) (psf)	σ'f (psf)	Cohesion-less Soils C'	Cohesive Soils e_o	C_c	C_r
1	8	A-6a	125	2000	250	156	406		0.6	0.21	0.021
2	18.5	A-6a	125	2000	829	265	1094		0.6	0.21	0.021
3	21.5	A-3a	120	1244	1244	287	1530.9	80			
4	30	A-4a	125	1596	1596	283	1878.8	90			
5											
6											
7											
8											
9											
10											
11											

Settlement, S_e / S_c

No.	(ft)	(inches)
1	0.022	0.26
2	0.017	0.20
3	0.003	0.04
4	0.007	0.08
5		
6		
7		
8		
9		
10		
11		

Total Settlement

0.049 feet

0.6 inches

Boring Profile

B-002-018

Overconsolidated Soils - Case I ($\sigma'_o + \Delta\sigma(z) \leq \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o} C_r \log(\frac{\sigma'_f}{\sigma'_o})$$

Modified from Eqn. 1.66 [1]

Overconsolidated Soils - Case II ($\sigma'_o + \Delta\sigma(z) > \sigma'_p$)

$$S_c = \left[\frac{H_c}{(1+e_0)}\right]\left[C_r \log(\frac{\sigma'_p}{\sigma'_0}) + C_c \log(\frac{\sigma'_f}{\sigma'_p})\right]$$

Eqn. 10.6.2.4.3-1 [2]

Normally Consolidated Soils ($\sigma'_o = \sigma'_p$)

$$S_c = \frac{H_c}{1+e_o}\left(C_c \log\left(\frac{\sigma'_f}{\sigma'_o}\right)\right)$$

Eqn. 10.6.2.4.3-2 [2]

Cohesionless Soils ($\sigma'_o = \sigma'_p$)

$$S_e = H_c \frac{1}{C'} \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Eqn. 10.6.2.4.2-3 [2]

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[1] *Principles of Foundation Engineering, 4th Edition, Das (1999).*

[2] *2012 AASHTO LRFD, 6th Edition.*

Appendix C

II. Reconnaissance and Planning Checklist

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

Reconnaissance			
[✓ Y] N X	1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance: ☐ Roadway plans ☐ Structures plans ☐ Geohazards plans	
[✓ Y] N X	2	Based on Section 302.2 in the SGE, has the Geotechnical Red Flag Summary, or in its absence, the resources listed in Section 202 of the SGE, been reviewed as part of the office reconnaissance?	Red Flag Summary was not prepared. Suggested resources were reviewed.
[✓ Y] N X	3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	
[✓ Y] N X	4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	

II. Reconnaissance and Planning Checklist

Planning - General			
[✓ Y] N X	5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and existing subsurface exploration work been considered?	
[✓ Y] N X	6	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings?	
[✓ Y] N X	7	Has the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	
[✓ Y] N X	8	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	
Y N [✓ X]	9	Have any previous geotechnical explorations been utilized to the fullest extent possible?	No previous explorations were identified.
[✓ Y] N X	10	Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	
		The schedule of borings should present the following information for each boring:	
[✓ Y] N X		☐ exploration identification number	
[✓ Y] N X		☐ location by station and offset	
[✓ Y] N X		☐ estimated amount of rock and soil, including the total for each for the entire program.	
Planning – Exploration Number			
[✓ Y] N X	11	Have the coordinates, stations and offsets of all explorations (borings, probes, test pits, etc.) been identified?	
[✓ Y] N X	12	Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	
Y N [✓ X]	13	When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	No previous explorations were identified.

Notes:

II. Reconnaissance and Planning Checklist

Planning – Boring Types	
[✓ Y] N X 14 Based on Sections 303.3 to 303.76 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project? Check all boring types utilized for this project: X Existing Subgrades (Type A) ☐ Roadway Borings (Type B) X Embankment Foundations (Type B1) ☐ Cut Sections (Type B2) ☐ Sidehill Cut Sections (Type B3) ☐ Sidehill Cut-Fill Sections (Type B4) ☐ Sidehill Fill Sections on Unstable Slopes (Type B5) ☐ Geohazard Borings (Type C) ☐ Lakes, Ponds, and Low-Lying Areas (Type C1) ☐ Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2) ☐ Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3) ☐ Underground Mines (C4) ☐ Landslides (Type C5) ☐ Karst (Type C6) ☐ Proposed Underground Utilities (Type D) ☐ Structure Borings (Type E) ☐ Bridges (Type E1) X Culverts (Type E2 a,b,c) ☐ Retaining Walls (Type E3 a,b,c) ☐ Noise Barrier (Type E4) ☐ High Mast Lighting Towers (Type E5) ☐ Buildings and Salt Domes (Type E6)	

Notes:

III.B. Embankments Checklist

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

Settlement			
[✓ Y] N X	1	If soil conditions and project requirements warrant, have settlement issues been addressed? If not applicable (X), go to Question **14**	
[✓ Y] N X	2	Have consolidation properties of the foundation soils been determined? Check methods used: ☐ laboratory consolidation tests X empirical correlations with moisture content and Atterberg values ☐ other	
[✓ Y] N X	3	Have calculations been performed to estimate the total expected embankment settlement and the time of consolidation? Check method used: ☐ EMBANK or equivalent software X hand calculations	Time rate of settlement has not been determined.
[✓ Y] N X	4	If differing foundation soil and/or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate consolidation at locations representative of the most critical conditions?	
Y N [✓ X]	5	Have the total settlement and the time of consolidation analyses indicated acceptable values at all locations for the scope of the embankment work?	To be determined by others.
Y N [✓ X]	6	If total settlement or time of consolidation is unacceptable, have the stations and lateral extent of the problem areas been defined?	To be determined by others.
Y N [✓ X]	7	Has a method been chosen as a solution to the settlement issues? Check methods used: ☐ waiting periods with monitoring ☐ drainage blanket and wick drains ☐ surcharge (preloading) ☐ removal and replacement of weak soil ☐ lowering proposed grade / change alignment ☐ lightweight fill ☐ other List Other items:	To be determined by others.

III.B. Embankments Checklist

Y N [✓ X]	8	Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)?	To be determined by others.
Y N [✓ X]	9	Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others?	To be determined by others.
Y N [✓ X]	10	Have all necessary notes, specifications, and details for the chosen solution been determined?	To be determined by others.
Y N [✓ X]	11	Have the need, locations, type, plan notes, and reading schedule for settlement platforms been determined?	To be determined by others.
Y N [✓ X]	12	Have the effects of the predicted settlement and the chosen solution been determined and accounted for on the construction schedule?	To be determined by others.
Y N [✓ X]	13	Has the effect of any foundation soil consolidation (including differential settlement) been evaluated with regard to adjacent structures (e.g., bridges, buildings, culverts, utilities) which will also undergo settlement and be subject to stresses induced by the consolidation of the surrounding soil?	To be determined by others.

Notes :

Stage 1:

III.B. Embankments Checklist

Stability			
Y N [✓ X]	14	If soil conditions and project requirements warrant, have stability issues been addressed? If not applicable (X), go to Question **29**	Side slopes of embankments are being flattened to 3H:1V, which will increase stability. Special Benching recommendations are provided in Section 6.6.3. of the report.
Y N X	15	Has the total (short term) and effective (long term) shear strength of the foundation soils been determined? Check method used: ☐ laboratory shear tests ☐ estimation from SPT or field tests	
Y N X	16	Have the values of shear strength for proposed embankment fill material, as determined from <u>Geotechnical Bulletin 6 Shear Strength of Proposed Embankments</u> (GB 6), been used in the stability analyses?	
Y N X	17	Have calculations been performed to determine the F.S. for stability? Check method used: ☐ GSTABL7, or equivalent software ☐ hand calculations	
	18	Have the following F.S. been met or exceeded, as determined by the calculations, for the given stability conditions:	
Y N X		a 1.30 for short term condition	
Y N X		b 1.30 for long term condition	
Y N X		c 1.10 for rapid drawdown, flood condition	
Y N X		d 1.50 for embankment supporting bridge abutments (not on deep foundations)	
Y N X	19	When differing soil or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate the stability at locations representative of the most critical conditions?	
Y N X	20	If the F.S. was not met or exceeded, have the stations and lateral extent of the problem areas been defined?	
Y N X	21	Has a method been chosen as a solution to the stability issues? Check the method(s) used: ☐ flattening slopes ☐ counterberm	

III.B. Embankments Checklist

- ☐ lightweight embankment
- ☐ reinforced soil slope
- ☐ soil nailing
- ☐ drainage blanket and wick drains
- ☐ removal of soft soil, adding shear key
- ☐ reduced grade / change alignment
- ☐ stage construction
- ☐ controlled rate of fill placement
- ☐ drilled shaft slope stabilization
- ☐ other List Other items:

Y N X 22 Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)?

Y N X 23 Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others?

Y N X 24 Have all necessary notes, specifications, and details for the chosen solution been determined?

Y N X 25 Have the need, location, type, plan notes, and reading schedule for piezometers and inclinometers been determined?

Y N X 26 If piezometers will be used, has the critical pressure value been determined and the appropriate information included in the plans?

Y N X 27 Have the effects of the stability solution been determined and accounted for on the construction schedule?

Y N X 28 Has the effect of the stability solution been evaluated with regard to structures (e.g., bridges, buildings, culverts, utilities) which may be subject to unusual stresses or require special construction considerations?

Notes:

Stage 1:

III.B. Embankments Checklist

Sidehill Fills					
[✓ Y] N X	29		If soil conditions and project requirements warrant, have sidehill fill issues been addressed? If not applicable (X), go to Question **34**	
[✓ Y] N X	30		In accordance with <u>Geotechnical Bulletin 2: Special Benching and Sidehill Embankment Fills (GB 2),</u> have sidehill fills been evaluated to determine if special benching or shear keys are needed?	
	31		In accordance with GB 2, if special benching or shear keys are required, has	
Y N [✓ X]		a	Plan Note G110 from L&D3 been included in the General Notes?	To be performed by others.
Y N [✓ X]		b	quantities for both excavation and embankment been calculated for the benched areas and added to the plan General Quantities?	To be performed by others
Y N [✓ X]		c	the special benching or shear keys been indicated on the appropriate cross sections?	To be performed by others
[✓ Y] N X	32		Have water bearing zones been identified and their impact addressed?	
Y N [✓ X]	33		Have subsurface drainage controls been adequately addressed?	To be performed by others.

Notes:

Stage 1:

III.B. Embankments Checklist

Special			
Y N [✓ X]	34	Have all of the environmental factors, including wetlands, stream mitigation, and landfills, been considered and incorporated prior to design and analysis of embankment settlement and stability, including EPA or other government agencies' involvement, mitigation, or special design or construction considerations?	To be performed by others.
	35	If an embankment is to be placed through standing water or over weak, wet soils (with or without a fabric separator), the fill should be placed by the method of end dumping to a given height above the standing water or until compaction is achievable over the soft soil. If end dumping is to be specified,	
Y N [✓ X]		a has the material type for the fill to be end dumped been specified?	To be performed by others.
Y N [✓ X]		b has the need for a fabric separator or filter layer been determined?	To be performed by others.
Y N [✓ X]		c has the height of fill to be end dumped been determined?	To be performed by others.
Y N [✓ X]		d have all notes and specifications for end dumping been developed?	To be performed by others.

Notes:

Stage 1:

III.C. Subgrade Checklist

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

If you do not have any subgrade work on the project, you do not have to fill out this checklist.

[✓ Y] N X	1	Has the subsurface investigation adequately characterized the soil or rock according to <u>Geotechnical Bulletin 1: Plan Subgrades (GB1)?</u>	
Y N [✓ X]	2	If soils classified as A-2-5, A-4b, A-5, A-7-5, A-8a, or A-8b, or having a LL>65, are present at the proposed subgrade (soil profile), do the plans specify that these materials need to be removed and replaced or chemically stabilized?	
Y N [✓ X]		a If these materials are to be removed and replaced, have the station limits, depth, and lateral limits for the planned removal been provided?	
Y N [✓ X]	3	If there is any rock, shale, or coal present at the proposed subgrade (CMS 204.05), do the plans specify the removal of the material?	
Y N [✓ X]		a If removal of any rock, shale, or coal is required, have the station limits, depth, and lateral limits for the planned removal of the material at proposed subgrade been provided?	
[✓ Y] N X	4	In accordance with GB1, do the SPT values and existing moisture contents for the proposed subgrade soils indicate the need for subgrade stabilization?	
[✓ Y] N X		a If removal and replacement is applicable, has the detail of subgrade removal been shown on the plans, including depth of removal, station limits, lateral extent, replacement material, and plan notes (Item 204 – Subgrade Compaction and Proof Rolling)?	Details by others. See Section 6.4.
[✓ Y] N X		b If chemical stabilization is applicable, has the detail of this treatment been shown on the plans, including depth, percentage of chemical, station limits, lateral extent, and plan notes? Indicate type of subgrade treatment specified: X cement treatment ☐ lime treatment ☐ lime kiln dust ☐ other	Details by others. See Section 6.4.
Y N [✓ X]	5	If drainage or groundwater is an issue with the proposed subgrade, has an appropriate drainage system (e.g., pipe, underdrains) been provided?	To be performed by others.
Y N [✓ X]	6	Has an appropriate quantity of Proof Rolling been included in the plans (CMS 204.06)?	To be performed by others.
[✓ Y] N X	7	Has a design CBR value been provided?	

IV.A Foundations/Structures - Non-bridge Applications

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

If you do not have such a foundation or structure on the project, you do not have to fill out this checklist.

Soil and Bedrock Strength Data

[✓ Y] N X 1 Has the shear strength of the foundation soils been determined?

Check method used:

☐ laboratory shear tests

X estimation from SPT or field tests

[✓ Y] N X 2 Have sufficient soil shear strength, consolidation, and other parameters been determined so that the required allowable loads for the foundation/structure can be designed?

Y N [✓ X] 3 Has the shear strength of the foundation bedrock been determined?

Check method used:

☐ laboratory shear tests

☐ other List Other items:

Notes:

Stage 1:

IV.A Foundations/Structures - Non-bridge Applications

Spread Footings

[✓ Y] N	4	Are there spread footings on the project? If no, go to Question **11**	
[✓ Y] N X	5	Has the recommended bottom of footing elevation and reason for this recommendation been provided?	
Y N [✓ X]		a Has the recommended bottom of footing elevation taken scour from streams or other water flow into account?	Scour to be determined by others.
	6	Were representative sections analyzed for the entire length of the structure for the following:	
[✓ Y] N X		a bearing capacity?	See Section 6.7.
[✓ Y] N X		b sliding?	See Section 6.8.
[✓ Y] N X		c overturning?	See Section 6.9.
[✓ Y] N X		d settlement?	See Section 6.10.
Y N [✓ X]	7	Has the need for a shear key been evaluated?	To be determined by others.
Y N [✓ X]		a If needed, have the details been included in the plans?	To be determined by others.
Y N [✓ X]	8	If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing "stepped" to accommodate them?	
[✓ Y] N X	9	Has the recommended allowable soil or rock bearing pressure been provided?	See Section 6.7.
Y N [✓ X]	10	If weak soil is present at the proposed foundation level, has the removal / treatment of this soil been developed and included in the plans?	See Section 6.7.
Y N [✓ X]		a Have the procedure and quantities related to this removal / treatment been included in the plans?	To be determined by others.

Notes:

Stage 1:

IV.A Foundations/Structures - Non-bridge Applications

Pile Structures			
Y [✓ N]	11	Are there piles on the project?	
		If no, go to Question **17**	
Y N	12	Has an appropriate pile type been selected?	
		Check the type selected:	
		☐ H-pile (driven)	
		☐ H-pile (drilled)	
		☐ Cast In-place Concrete	
		☐ other List Other items:	
Y N X	13	Have the estimated pile length or tip elevation and section (diameter) been specified?	
		Check method used:	
		☐ SPILE, DRIVEN, or equivalent software	
		☐ hand calculations	
	14	If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:	
Y N X		a Lateral load capacity and maximum deflection of the piles?	
Y N X		b Vertical load capacity and maximum settlement of the piles?	
Y N X		c Negative skin friction on piles driven through new embankment or soft foundation layers?	
Y N X		d Potential for and impact of lateral squeeze from soft foundation soils?	
Y N X	15	If piles are to be driven to bedrock, have “pile points” been recommended to assure secure contact with the rock surface, as per BDM 202.2.3.2.a?	
Y N X	16	If subsurface obstacles exist, has preboring been recommended to avoid these obstructions?	

Notes:

Stage 1:

IV.A Foundations/Structures - Non-bridge Applications

Drilled Shafts

Y [✓ N]	17	Are there drilled shafts on the project? If no, go to the next checklist.	
Y N X	18	Have the drilled shaft diameter and embedment length been specified?	
Y N X	19	Have the recommended drilled shaft diameter and embedment been developed based on side friction and end bearing for vertical loading situations?	
	20	For shafts undergoing lateral loading, have the following been determined:	
Y N X		a. maximum lateral shear	
Y N X		b. maximum bending moment	
Y N X		c. maximum deflection	
Y N X		d. reinforcement design	
Y N X	21	Generally, bedrock sockets are 6" smaller in diameter than the soil embedment section of the drilled shaft. Has this factor been accounted for in the drilled shaft design?	
Y N X	22	If a bedrock socket is required below soil embedment, have separate quantities been estimated based on shaft diameters and materials to be excavated?	
Y N X	23	Has the site been assessed for groundwater influence?	
Y N X		a If yes, if artesian flow is a potential concern, does the design address control of groundwater flow during construction?	
Y N X	24	If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans?	

Notes:

Stage 1

VI.B. Structure Foundation Exploration Checklist

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

General Presentation

[✓ Y] N X	1	Has the geotechnical information for explorations involving structures only (no roadway) been presented as plan drawings in the form of a Structure Foundation Exploration?	
[✓ Y] N X	2	Have structures explored as part of the same construction project been presented together under the same cover sheet?	
[✓ Y] N X	3	Has a paper copy and electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Included in Appendix D.
[✓ Y] N X	4	Has the geotechnical specification (title and date) under which the work was performed been clearly identified on every submission (reports, plans, etc.)?	
[✓ Y] N X	5	Has the first complete version of all documents being submitted been labeled as ‘Draft’?	
[✓ Y] N X	6	Subsequent to ODOT’s review and approval, has the complete version of the revised documents being submitted been labeled as ‘Final’?	
[✓ Y] N X	7	Have the electronic copies of the final geotechnical plan sheets been submitted as TIFF images?	
[✓ Y] N X	8	Have the plan sheets been prepared using the size, lettering, format, file management, and CADD standards as prescribed in the applicable sections of the ODOT CADD Engineering Standards Manual?	
[✓ Y] N X	9	Has a scale of 1”=1’ been used for cover sheets and laboratory test data sheets?	

VI.B. Structure Foundation Exploration Checklist

Cover Sheet

10 Has the following general information been provided on the cover sheet

[✓ Y] N X a. Brief description of the project?

[✓ Y] N X b. Brief presentation of geological and topographical information? Include comments on structure and pavement conditions.

[✓ Y] N X c. Brief presentation of boring and sampling methods? Include date of last calibration and drill rod energy ratio as a percent for the hammer systems used.

[✓ Y] N X d. Summary of general soil, bedrock, and groundwater conditions, including a generalized interpretation of findings?

[✓ Y] N X e. Statement of where original drawings and data may be inspected?

[✓ Y] N X f. Statement of where soil or rock samples may be inspected, if applicable?

[✓ Y] N X g. Initials of personnel and dates they performed field reconnaissance, subsurface exploration and preparation of the soil profile?

[✓ Y] N X 11 Has a Legend been provided on the cover sheet?

12 Have the following items been included in the Legend:

[✓ Y] N X a. Symbols and usual descriptions for only the soil and bedrock types encountered, as per the Soil and Rock Symbology Chart in Appendix D of the SGE?

[✓ Y] N X b. All miscellaneous symbols and acronyms, used on any of the sheets, defined?

[✓ Y] N X c. The number of soil samples for each classification that were mechanically classified and visually described?

[✓ Y] N X 13 Has a Location Map, showing the beginning and end stations for the project, been shown on the cover sheet, sized per the L&D Manual?

[✓ Y] N X 14 If sampling and testing for a scour analysis was performed, has this data been shown in tabular form?

VI.B. Structure Foundation Exploration Checklist

Plan and Profile				
[✓ Y] N X	15		Has the plan and profile view been shown at the same scale as the Site Plan for the proposed structure (when possible)?	
Y [✓ N] X	16		Has the plan and profile been presented along the flowline for culverts?	
	17		Has the following information been shown in a roadway plan drawing:	
[✓ Y] N X		a	Existing surface features described in Section 702.5.1?	
[✓ Y] N X		b	Proposed construction items, as described in Section 702.5.2?	
[✓ Y] N X		c	Project and historic boring locations, with appropriate exploration targets and exploration identification numbers?	
Y N [✓ X]		d	Notes regarding observations not readily shown by drawings?	
[✓ Y] N X	18		Have the existing ground surface contours been presented?	
[✓ Y] N X	19		Has all the subsurface data been presented in the form of a profile along the centerline or baseline?	
	20		Have the graphical boring logs been correctly shown, as follows:	
[✓ Y] N X		a.	Location and depth of boring indicated by a heavy dashed vertical line?	
[✓ Y] N X		b.	Exploration identification number above the boring	
[✓ Y] N X		c.	Logs indicate soil and bedrock layers with symbols 0.4” wide and centered on the heavy dashed vertical line where possible?	
[✓ Y] N X		d.	Bedrock exposures with 0.4” wide symbols, but without a heavy dashed vertical line.	
[✓ Y] N X		e.	Soil and bedrock symbols as per ODOT Soil and Rock Symbology chart (SGE - Appendix D)?	
Y N [✓ X]		f.	Historical borings shown in same manner with the exploration identification number above the boring?	
[✓ Y] N X	21		Have the proposed profile and existing groundline been shown on the profile view, according to ODOT CADD standards?	

VI.B. Structure Foundation Exploration Checklist

[✓ Y] N X 22 Have the locations of the proposed structure foundation elements been shown on the profile view?

[✓ Y] N X 23 Have the offsets from centerline or baseline been indicated above the borings in the profile view?

24 Has the following information been provided adjacent to the graphical logs or bedrock exposure:

[✓ Y] N X a. Thickness, to the nearest 0.1’, of sod/topsoil or other shallow surface material written above the boring (with corresponding symbology at top of log)?

[✓ Y] N X b. Moisture content, to nearest whole percent, with the text aligned with the bottom of the sample? Label this column as ‘WC’ at bottom of boring.

[✓ Y] N X c. N_{60}, aligned with bottom of sample? Label this column as ‘N_{60}’ at bottom of boring.

[✓ Y] N X d. Free water indicated by a horizontal line with a ‘w’ attached, and static water indicated by a shaded equilateral triangle, point down?

Y N [✓ X] e. Visual description of any uncontrolled fill or interval not adequately defined by a graphical symbol?

Y N [✓ X] f. Organic content with modifiers, per 603.5?

Y N [✓ X] g. Designate a plastic soil with moisture content equal to or greater than the liquid limit minus three with a 1/8” solid black circle adjacent to the moisture content?

[✓ Y] N X h. Designate a non-plastic soil with moisture content exceeding 25% or exceeding 19% but appearing wet initially, with a 1/8” open circle with a horizontal line through it adjacent to the moisture content?

Y N [✓ X] i. The reason for discontinuing a boring prior to reaching the planned depth indicated immediately below the boring?

VI.B. Structure Foundation Exploration Checklist

Boring Logs

[✓ Y] N X 25 Have the boring logs of all structure borings been shown on the sheet(s) following the plan and profile views?

[✓ Y] N X 26 Has a scale of 1”=1’ been used for the boring log sheets?

[✓ Y] N X 27 Have the boring logs been developed by integrating the driller’s field logs, laboratory test data, and visual descriptions?

28 Has the following boring information been included in the heading of each boring log:

- [✓ Y] N X a. Exploration identification number?
- [✓ Y] N X b. Project designation (C-R-S) and PID?
- [✓ Y] N X c. Bridge identification (if applicable)?
- [✓ Y] N X d. Centerline or baseline name, station, offset, and surface elevation?
- [✓ Y] N X e. Coordinates?
- [✓ Y] N X f. Method of drilling?
- [✓ Y] N X g. Static and free water-level observations?
- [✓ Y] N X h. Date started and date completed?
- [✓ Y] N X i. Method and material (including quantity) used for backfilling or sealing, including type of instrumentation, if any?
- [✓ Y] N X j. Date of last calibration and drill rod energy ratio (ER) in percent for the hammer system(s) used?

29 Has the following boring information been included in each boring log:

- [✓ Y] N X a. A depth and elevation scale?
- [✓ Y] N X b. Indication of stratum change?
- [✓ Y] N X c. Description of material in each stratum?
- [✓ Y] N X d. Depth of bottom of boring?
- [✓ Y] N X e. Depth of boulders or cobbles, if encountered?
- [✓ Y] N X f. Caving depth?
- [✓ Y] N X g. Artesian water level and height of rise?
- [✓ Y] N X h. Running sand?
- [✓ Y] N X i. Cavities or other unusual conditions?
- [✓ Y] N X j. Depth interval represented by sample?
- [✓ Y] N X k. Sample number and type?

VI.B. Structure Foundation Exploration Checklist

[✓ Y] N X l. Percent recovery for each sample?

[✓ Y] N X m. Measured blow counts for each 6 inches of drive for split spoon samples?

[✓ Y] N X n. N_{60} to the nearest whole number?

[✓ Y] N X o. Particle-size analysis?

[✓ Y] N X p. Liquid limit, plastic limit, plasticity index?

[✓ Y] N X q. Water content?

[✓ Y] N X r. ODOT soil classifications, with ‘Visual’ in parentheses for those samples visually classified?

Y N [✓ X] s. Bedrock descriptions?

Y N [✓ X] t. Run rock core percent recovery?

Y N [✓ X] u. Run RQD?

Y N [✓ X] v. Unit rock core percent recovery?

Y N [✓ X] w. Unit RQD?

Y N [✓ X] x. SDI, if applicable?

Y N [✓ X] y. Rock compressive strength test results, if applicable?

Y N [✓ X] 30 Have all undisturbed test results been displayed in graphical format on the sheet(s) following the boring log sheet(s)?

Notes:

Stage 1:

VI.D. Geotechnical Reports

C-R-S: MED-3-24.33	PID: 106354	Reviewer: BKS	Date: 8/8/18

General

[✓ Y] N X 1 Has the first complete version of a geotechnical report being submitted been labeled as ‘Draft’?

[✓ Y] N X 2 Subsequent to ODOT’s review and approval, has the complete version of the revised geotechnical report being submitted been labeled ‘Final’?

[✓ Y] N X 3 Have all geotechnical reports being submitted been titled correctly as prescribed in Section 705.1 of the SGE?

Report Body

[✓ Y] N X 4 Do all geotechnical reports being submitted contain an Executive Summary as described in Section 705.2 of the SGE?

[✓ Y] N X 5 Do all geotechnical reports being submitted contain an Introduction as described in Section 705.3 of the SGE?

[✓ Y] N X 6 Do all geotechnical reports being submitted contain a section titled "Geology and Observations of the Project," as described in Section 705.4 of the SGE?

[✓ Y] N X 7 Do all geotechnical reports being submitted contain a section titled "Exploration," as described in Section 705.5 of the SGE?

[✓ Y] N X 8 Do all geotechnical reports being submitted contain a section titled "Findings," as described in Section 705.6 of the SGE?

[✓ Y] N X 9 Do all geotechnical reports being submitted contain a section titled "Analyses and Recommendations," as described in Section 705.7 of the SGE?

VI.D. Geotechnical Reports

Appendices	
[✓ Y] N X 10 Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 705.8 of the SGE?	
[✓ Y] N X 11 Do the Appendices present a site Boring Plan showing all boring locations as described in Section 705.8.1 of the SGE?	
[✓ Y] N X 12 Do the Appendices include boring logs as described in Section 705.8.2 of the SGE?	
Y N [✓ X] 13 Do the Appendices present reports of undisturbed test data as described in Section 705.8.3 of the SGE?	
[✓ Y] N X 14 Do the Appendices present calculations in a logical format to support recommendations as described in Section 705.8.4 of the SGE?	

Notes:

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

MED-3-24.33

106354

Culvert replacement with roadway subgrade remediation and embankment widening

S&ME, Inc.

Prepared By: **Brian K. Sears, P.E.**

Date prepared: **August 8, 2018**

BORING LOG LOCATION SUMMARY

Boring ID	Latitude	Longitude	Filename Log	Filename Plan	Filename Profile
B-001-0-18	41.269841	-81.744884			
B-002-0-18	41.270039	-81.744822			
B-003-0-18	41.270091	-81.744881			
B-004-0-18	41.270316	-81.744819			

Appendix D

PROJECT DESCRIPTION

THE EXISTING 4-SIDED BOX CULVERT BENEATH RIDGE ROAD (SR 3) IS BEING REPLACED WITH A 63" X 98", TYPE A, CONCRETE ELLIPTICAL CULVERT THAT WILL FOLLOW ESSENTIALLY THE SAME ALIGNMENT AS THE EXISTING CULVERT. THE PROPOSED CULVERT WILL BE 102 FEET LONG COMPARED TO THE EXISTING CULVERT LENGTH OF APPROXIMATELY 62 FEET TO ACCOMMODATE FLATTENED EMBANKMENTS SLOPES AT AN INCLINATION OF 3(H):1(V) ON BOTH SIDES OF THE ROADWAY. LITTLE TO NO ADJUSTMENT OF THE ROADWAY PROFILE IS PLANNED AS PART OF THIS PROJECT.

HISTORIC RECORDS

THE ON-LINE ODOT TRANSPORTATION INFORMATION MAPPING SYSTEM (TIMS) RECORDS WERE SEARCHED FOR HISTORIC BORING INFORMATION FOR THE EXISTING BRIDGE: HOWEVER, NO AVAILABLE HISTORIC BORING RECORDS WERE LOCATED FOR THIS SITE.

GEOLOGY

THE PROJECT SITE IS WITHIN A PREVIOUSLY GLACIATED PORTION OF OHIO, AND WITHIN THE KILLBUCK-GLACIATED PITTSBURGH PLATEAU PHYSIOGRAPHIC REGION. THIS REGION IS CHARACTERIZED BY CLAY TO LOAM TILL OF THE WISCONSINAN-AGE UNDERLAIN BY MISSISSIPPIAN AND PENNSYLVANIAN-AGE SHALES, SANDSTONES AND CONGLOMERATES. THE GROUND SURFACE ELEVATION AT THE CULVERT CROSSING IS APPROXIMATELY EL. 884. ACCORDING TO THE MEDINA COUNTY SOIL SURVEY AS PERFORMED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA), THE SOILS ARE PRIMARILY COMPOSED OF LOBDELL SILT LOAM (LE) WHICH IS DERIVED FROM ALLUVIUM DEPOSITS WITH APPROXIMATELY EQUAL PERCENTAGES OF SANDS AND FINES (SILTS/CLAYS). BEDROCK TOPOGRAPHY MAPPING SUGGEST THAT THE SITE IS LOCATED OVER THE SIDESLOPES OF A GLACIALLY CARVED BURIED VALLEY, WITH THE UPPERMOST BEDROCK ANTICIPATED NEAR EL. 650.

ACCORDING TO ODNR GROUNDWATER RESOURCE MAPPING, THE SITE LIES IN AN AREA CHARACTERIZED BY GLACIAL DEPOSITS OVERLAYING SHALE OR SANDSTONE, OR YIELDS FROM SHALE BEDROCK. GROUNDWATER POLLUTION POTENTIAL MAPPING SUGGESTS THE PROJECT SITE LIES IN AN AREA CHARACTERIZED BY BURIED VALLEY CONDITIONS AND/OR VARYING THICKNESSES OF GLACIAL TILL THAT OVERLIE SANDSTONE OR SHALE BEDROCK.

A REVIEW OF THE ODNR "OHIO KARST AREAS" MAP INDICATES THE SITE LIES IN AN AREA NOT KNOWN TO CONTAIN KARST FEATURES. A REVIEW OF THE ODNR "LANDSLIDES IN OHIO" MAP REVEALS THE SITE IS IN AN AREA OF LOW INCIDENCE AND LOW SUSCEPTIBILITY TO LANDSLIDES, AND THE ODNR "ABANDONED UNDERGROUND MINES OF OHIO" MAP INDICATES THESE SITES LIE IN AREAS WITH NO MAPPED ABANDONED MINES NEAR THE AREA OF THE PROJECT SITE.

RECONNAISSANCE

SITE RECONNAISSANCE VISITS WERE MADE BY S&ME PERSONNEL ON NOVEMBER 13, 2017, AND MARCH 8, 2018, TO OBSERVE THE EXISTING CULVERT AND PROJECT VICINITY AND TO FIELD MARK THE BORING LOCATIONS. THE MED-3-24.34 STRUCTURE CARRIES AN UNNAMED TRIBUTARY OF THE EAST BRANCH ROCKY RIVER AT A DEPTH OF APPROXIMATELY 14.5 FEET BENEATH RIDGE ROAD (SR 3). AN AREA OF EXISTING EMBANKMENT ON THE SOUTH SIDE OF THE CULVERT AND ON THE WEST SIDE OF RIDGE ROAD IS SHOWING EVIDENCE OF EITHER INSTABILITY OR SURFACE SLOUGHING FROM EROSION, ALTHOUGH IT DOES NOT APPEAR THAT AN ACTIVE "LANDSLIDE" HAS OCCURRED.

SUBSURFACE EXPLORATION

ON MARCH 21 AND 22, 2018, S&ME PERFORMED FOUR (4) BORINGS DESIGNATED B-001-0-18 THROUGH B-004-0-18 (HEREAFTER REFERRED TO AS B-001 THROUGH B-004) TO EXPLORE THE EXISTING SOILS IN THE AREA OF THE PROPOSED REPLACEMENT CULVERT, THE POTENTIALLY UNSTABLE SLOPE SOUTH OF THE CULVERT, AND THE PAVEMENT/EMBANKMENT NORTH OF THE CULVERT. THE EMBANKMENT BORINGS NORTH AND SOUTH OF THE CULVERT (B-001 AND B-004) WERE EXTENDED TO DEPTHS OF 20 FEET BELOW THE EXISTING GROUND SURFACE, WHILE BORINGS B-002 AND B-003 WERE PERFORMED AT THE CULVERT AND WERE EXTENDED TO DEPTHS OF 45 FEET.

THE BORINGS WERE PERFORMED USING AN ATV-MOUNTED DRILLING RIG USING A 3-1/4-INCH I.D. HOLLOW-STEM AUGER. DISTURBED (BUT REPRESENTATIVE) SOIL SAMPLES WERE OBTAINED BY LOWERING A 2-INCH O.D. SPLIT-BARREL SAMPLER TO THE BOTTOM OF THE BORING AND THEN DRIVING THE SAMPLER INTO THE SOIL WITH BLOWS FROM A 140-POUND HAMMER FREELY FALLING 30 INCHES (AASHTO T206 - STANDARD PENETRATION TEST, SPT). IN ACCORDANCE WITH THE CURRENT ODOT SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS (SGE), THE HAMMER SYSTEM ON THE DRILL RIG HAD BEEN CALIBRATED IN ACCORDANCE WITH ASTM D4633 TO DETERMINE THE DRILL ROD ENERGY RATIO (84.7%). SAMPLING INTERVALS RANGED FROM BEING CONTINUOUSLY SAMPLED (SUBGRADE OR SCOUR ZONE SAMPLING) TO 5-FOOT INTERVALS AS REQUIRED BY THE ODOT SGE. AT THE TIME OF THE FIELD WORK, A THREE-SIDED REPLACEMENT CULVERT WAS BEING CONSIDERED, AND AS SUCH, CONTINUOUS SCOUR-ZONE SAMPLING WAS PERFORMED.

LEGEND

	DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
▩	*GRAVEL WITH SAND*	*A-1-b*	*--*	*1*
⛆	*COARSE AND FINE SAND*	*A-3a*	*--*	*6*
▥	*SANDY SILT*	*A-4a*	*2*	*1*
⊞	*SILT*	*A-4b*	*1*	*--*
▨	*SILT AND CLAY*	*A-6a*	*7*	*17*
▤	*SILTY CLAY*	*A-6b*	*6*	*9*
		TOTAL	*16*	*34*
☒	PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	*VISUAL*		
⊕	BORING LOCATION - PLAN VIEW			
⋮	DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.			
WC	INDICATES WATER CONTENT IN PERCENT.			
N_{60}	INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.			
W—	INDICATES FREE WATER ELEVATION.			
⊖	INDICATES A NON-PLASTIC MATERIAL WITH A MOISTURE CONTENT GREATER THAN 25 % OR GREATER THAN 19 % WITH A WET APPEARANCE.			
NP	INDICATES A NON-PLASTIC SAMPLE.			
SS	INDICATES A SPLIT SPOON SAMPLE, STANDARD PENETRATION TEST.			

EXPLORATION FINDINGS

PAVEMENT AND BASE MATERIALS WERE ENCOUNTERED IN EACH OF THE BORINGS TO A DEPTH OF APPROXIMATELY 18 INCHES BELOW THE EXISTING GRADE. THE ASPHALT THICKNESS RANGED FROM 11 TO 15 INCHES AND WAS UNDERLAIN BY BRICK AND/OR GRANULAR BASE.

FILL AND/OR POSSIBLE/PROBABLE FILL MATERIALS WERE ENCOUNTERED IN EACH OF THE BORINGS TO DEPTHS RANGING FROM APPROXIMATELY 3 FEET TO 11.7 FEET BELOW THE EXISTING GRADE. THE FILL MATERIALS WERE COMPOSED OF STIFF TO HARD SILTY CLAY (A-6b), MEDIUM-DENSE GRAVEL WITH SAND (A-1-b), OR MEDIUM-DENSE COARSE AND FINE SAND (A-3a). BRICK FRAGMENTS, ORGANIC FRAGMENTS, AND A CHEMICAL ODOR WERE NOTED WITHIN THE FILL MATERIALS IN ALL OF THE BORINGS EXCEPT BORING B-003.

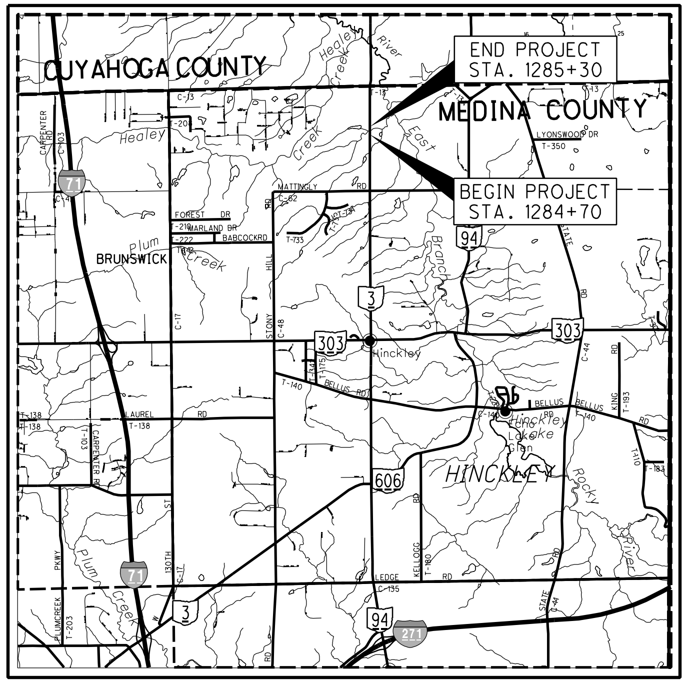
NATURAL SOILS WERE ENCOUNTERED BENEATH THE FILL MATERIALS TO THE TERMINATION DEPTHS OF THE BORINGS. THE NATURAL SOILS CONSISTED FOR THE MOST PART OF STIFF TO HARD SILT AND CLAY (A-6a) OR SILTY CLAY (A-6b) WITH A FEW VERY-SOFT TO MEDIUM-STIFF ZONES AND, IN BORING B-003, 0.8-FOOT TO 2.5-FOOT THICK LAYERS OF COARSE AND FINE SAND (A-3a) AND SANDY SILT (A-4a). BORING B-001 WAS TERMINATED WITHIN THESE COHESIVE SOILS. BORINGS B-002 THROUGH B-004 WERE TERMINATED AFTER PENETRATING 3.3 TO 11.2 FEET INTO GRANULAR SOILS CONSISTING OF MEDIUM-DENSE TO VERY-DENSE COARSE AND FINE SAND (A-3a), SANDY SILT (A-4a) AND SILT (A-4b).

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JULY 2017.

AVAILABLE INFORMATION

ALL AVAILABLE SOIL AND BEDROCK INFORMATION THAT CAN BE CONVENIENTLY SHOWN ON THE GEOTECHNICAL EXPLORATION SHEETS HAS BEEN SO REPORTED. ADDITIONAL EXPLORATIONS MAY HAVE BEEN MADE TO STUDY SOME SPECIAL ASPECT OF THE PROJECT. COPIES OF THIS DATA, IF ANY, MAY BE INSPECTED IN THE DISTRICT DEPUTY DIRECTOR'S OFFICE OR THE OFFICE OF GEOTECHNICAL ENGINEERING AT 1980 WEST BROAD STREET.



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

PARTICLE SIZE DEFINITIONS

	12"		3"		2.0 mm		0.42 mm		0.074 mm		0.005 mm	
BOULDERS		COBBLES		GRAVEL		COARSE SAND		FINE SAND		SILT		CLAY
					No. 10 SIEVE		No. 40 SIEVE		No. 200 SIEVE			

SUMMARY OF D_{50} SOIL PARTICLE SIZES

BORING NO.	LOCATION	SAMPLE DEPTH	SAMPLE ELEVATION	D_{50} (mm)	D_{95} (mm)
B-002-0-18	CULVERT OUTLET	15.0' - 16.5'	867.2 - 865.7	0.0094	10.4614
		16.5' - 18.0'	865.7 - 864.2	0.0087	1.7125
		18.0' - 19.5'	864.2 - 862.7	0.0078	1.5597
		19.5' - 21.0'	862.7 - 861.2	0.0089	3.8854
B-003-0-18	CULVERT INLET	15.0' - 16.5'	867.9 - 866.4	0.0079	3.4762
		16.5' - 18.0'	866.4 - 864.9	0.0791	32.6699
		18.0' - 19.5'	864.9 - 863.4	0.0128	2.2403
		19.5' - 21.0'	863.4 - 861.9	0.011	4.8308

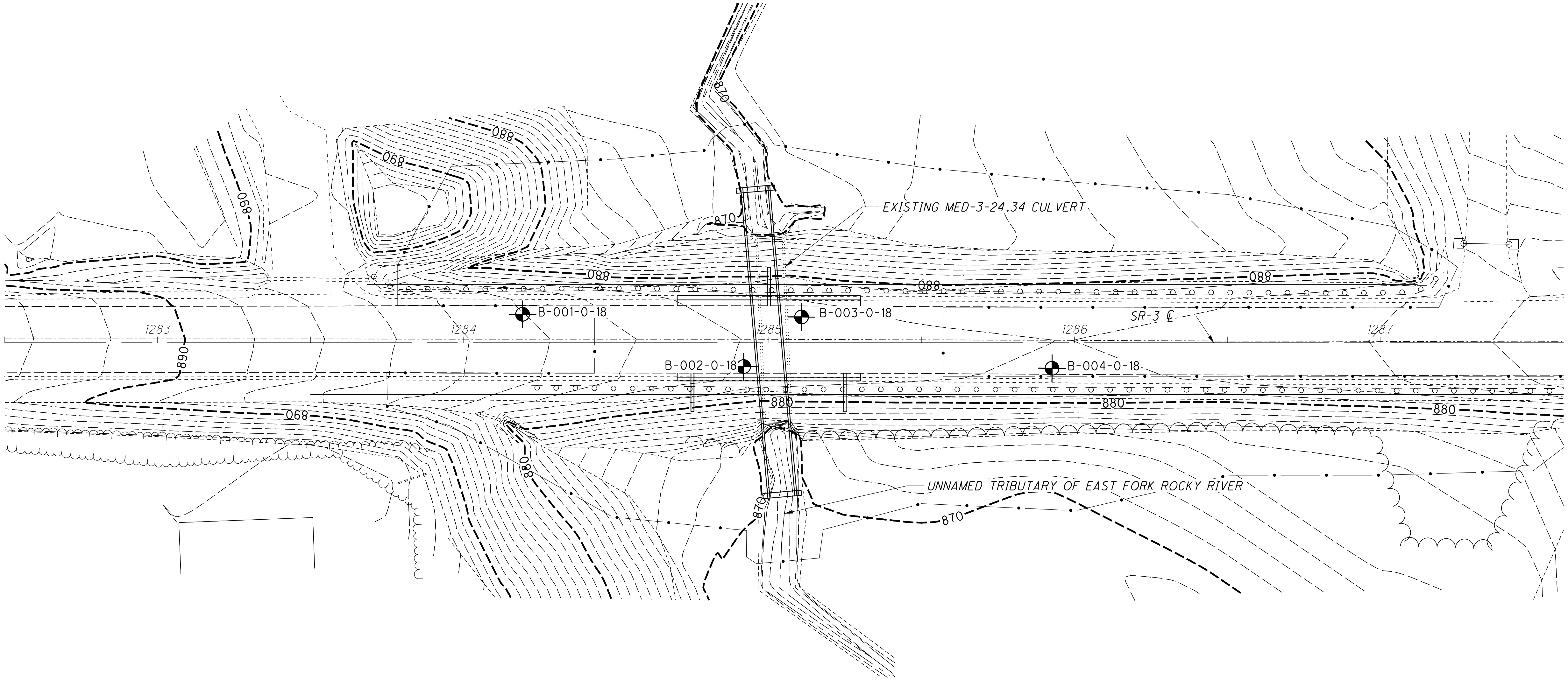
RECON. - S&ME 11/13/17, 3/8/18
DRILLING - S&ME 3/21/18 - 3/22/18
DRAWN - KAH 5/16/18 - 5/18/18, KJD 8/10/18
REVIEWED - BKS 5/17/18 - 5/18/18, 8/10/18

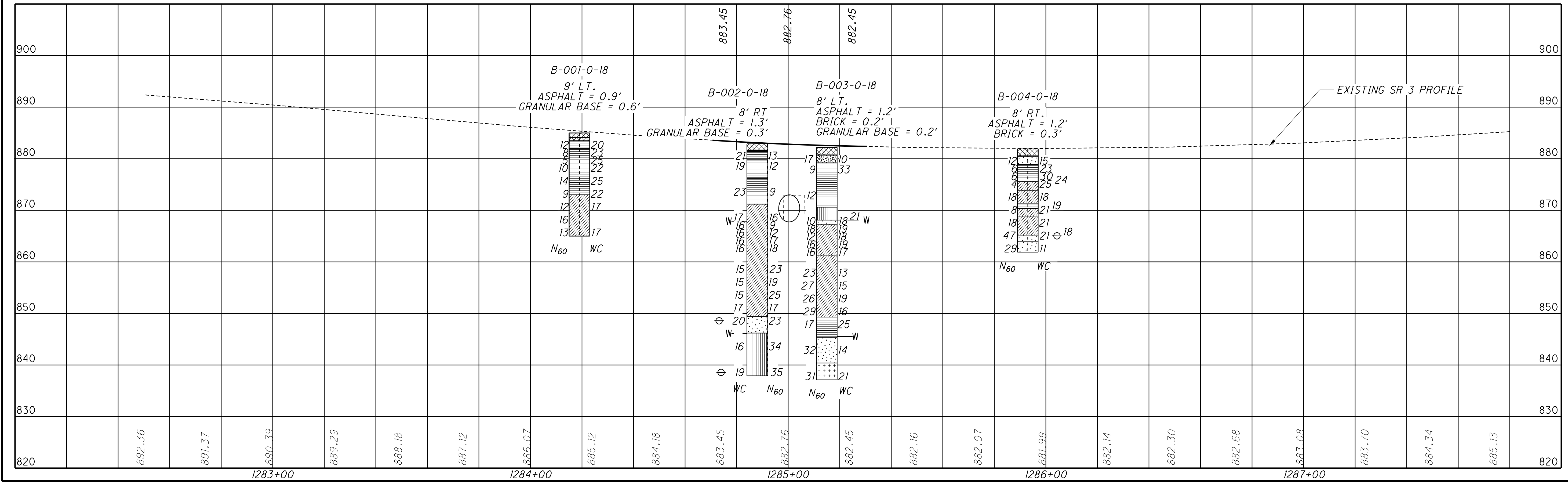
BRIAN KEITH SEARS
74693

PID NO. 106354

STRUCTURE FOUNDATION EXPLORATION
BR. NO MED-3-2433 OVER E. BRANCH OF ROCKY RIVER

MED-3-24.33





CALCULATED KAH
CHECKED BKS

HORIZONTAL SCALE IN FEET

0 20 40

STRUCTURE FOUNDATION EXPLORATION
BR. NO MED-3-2433 OVER TRIBUTARY OF EAST BRANCH OF ROCKY RIVER

MED-3-24.33

2/5

S:\Projects\2018\GEO\1117-18-009 MED-3-24.34\CAD\Structure Foundation Sheets\ODOT STRUCTURE P-N-P (106354_IP001).dgn Sheet 8/10/2018 12:54:42 kdohlen

PROJECT: MED-3/94-24.33/20.11
TYPE: CULVERT REPLACEMENT
PID: 106354 BR ID: MED-3-2433
START: 3/21/18 END: 3/21/18
DRILLING FIRM / OPERATOR: S&ME / A. MESSER
SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT
DRILL RIG: S&ME ATV D50
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/20/17
ENERGY RATIO (%): 77.8
STATION / OFFSET: 1284+19, 9' LT
ALIGNMENT: SR 3
ELEVATION: 885.0 (MSL) EOB: 20.0 ft.
LAT / LONG: 41.269841 N, 81.744884 W
EXPLORATION ID B-001-0-18
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 885.0
ASPHALT - 11 INCHES	884.1
GRANULAR BASE - 7 INCHES	883.5
POSSIBLE FILL: Hard dark-brown mottled with gray SILTY CLAY, trace fine to coarse sand, trace fine gravel, few wood fragments, damp.	882.0
Stiff to very-stiff brown SILTY CLAY, trace to little fine to coarse sand, trace fine gravel, few gray silt seams, few pockets of hard silty clay, damp.	873.0
Stiff to very-stiff gray SILT AND CLAY, little fine to coarse sand, trace fine gravel, few hard zones, damp.	865.0

DEPTHS: EOB 20

SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
3 4 5	12	39	SS-1	4.5+	3	4	6	29	58	38	19	19	20	A-6b (12)
2 3 3	8	56	SS-2	2.5-4.5	4	3	5	29	59	37	21	16	23	A-6b (10)
1 2 2	5	33	SS-3	1.25-2.0	-	-	-	-	-	-	-	-	25	A-6b (V)
2 3 5	10	83	SS-4	1.5-3.5	8	6	7	23	56	39	20	19	22	A-6b (12)
2 5 6	14	67	SS-5	3.0-4.0	-	-	-	-	-	-	-	-	25	A-6b (V)
1 2 5	9	28	SS-6	2.75-3.75	-	-	-	-	-	-	-	-	22	A-6b (V)
3 4 5	12	100	SS-7	1.6-2.1	8	6	10	31	45	28	15	13	17	A-6a (9)
3 5 7	16	0	SS	-	-	-	-	-	-	-	-	-	-	
2 5 5	13	100	SS-8	2.5-4.5+	-	-	-	-	-	-	-	-	17	A-6a (V)

NOTES:
- No seepage or groundwater encountered during drilling.
- Borehole was observed to be dry at completion.

NOTES: NONE
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

PROJECT: MED-3/94-24.33/20.11
TYPE: CULVERT REPLACEMENT
PID: 106354 BR ID: MED-3-2434
START: 3/22/18 END: 3/22/18
DRILLING FIRM / OPERATOR: S&ME / A. MESSER
SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT
DRILL RIG: S&ME ATV D50
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/20/17
ENERGY RATIO (%): 77.8
STATION / OFFSET: 1285+93, 8' RT
ALIGNMENT: SR 3
ELEVATION: 881.9 (MSL) EOB: 20.0 ft.
LAT / LONG: 41.270316 N, 81.744819 W
EXPLORATION ID B-004-0-18
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 881.9
ASPHALT - 14 INCHES	880.7
BRICK FRAGMENTS - BRICK PAVERS - 4 INCHES	880.4
FILL: Medium-dense brown COARSE AND FINE SAND, little fine to coarse gravel, trace silt, trace clay, few brick fragments, damp.	878.9
FILL: Stiff brown and gray SILTY CLAY, little fine to coarse sand, trace fine gravel, few brick fragments, damp.	875.6
Very-soft to medium-stiff gray SILT AND CLAY, little fine to coarse sand, trace fine gravel, damp to moist.	873.9
Very-stiff to hard brownish-gray SILT AND CLAY, little fine to coarse sand, trace fine gravel, damp.	871.4
Soft to medium-stiff gray SILTY CLAY, little fine to coarse sand, trace fine gravel, damp.	870.3
Stiff brown mottled with gray SILT AND CLAY, trace fine to coarse sand, trace fine gravel, damp.	868.9
Hard light-brown becoming gray SILT AND CLAY, little fine to coarse sand, trace fine gravel, damp.	865.2
Very-dense brown COARSE AND FINE SAND, trace to little silt, trace to little fine gravel, trace clay, wet.	863.9
Dense gray COARSE AND FINE SAND, trace fine gravel, trace silt, trace clay, wet.	861.9

DEPTHS: W 12; EOB 20

SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
10 5 4	12	28	SS-1	-	-	-	-	-	-	-	-	-	15	A-3a (V)
3 2 3	6	61	SS-2	1.1-1.5	3	4	9	38	46	38	18	20	23	A-6b (12)
2 2 3	6	33	SS-3	1.0	-	-	-	-	-	-	-	-	30	A-6b (V)
1 1 2	4	56	SS-4A	1.1-1.2	-	-	-	-	-	-	-	-	24	A-6b (V)
			SS-4B	0.0-0.5	4	7	12	36	41	31	17	14	25	A-6a (10)
4 6 8	18	67	SS-5	2.6-4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)
2 2 4	8	72	SS-6A	0.5	-	-	-	-	-	-	-	-	19	A-6b (V)
			SS-6B	1.1-1.5	-	-	-	-	-	-	-	-	21	A-6a (V)
3 6 8	18	78	SS-7	4.5+	-	-	-	-	-	-	-	-	21	A-6a (V)
5 15 21	47	89	SS-8A	4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)
			SS-8B	-	-	-	-	-	-	-	-	-	21	A-3a (V)
3 10 12	29	56	SS-9	-	-	-	-	-	-	-	-	-	11	A-3a (V)

NOTES:
- Groundwater encountered at 12.5' during drilling.
- After removal of augers, boring caved at 4.0' and was observed to be dry.

NOTES: NONE
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

3/5

MED-3-24.33

STRUCTURE FOUNDATION EXPLORATION
LOGS OF BORINGS B-001-0-18 & B-004-0-18

DRAWN KAH
CHECKED BKS

PROJECT: MED-3/94-24.33/20.11
TYPE: CULVERT REPLACEMENT
PID: 106354 BR ID: MED-3-2433
START: 3/22/18 END: 3/22/18

DRILLING FIRM / OPERATOR: S&ME / A. MESSER
SAMPLING FIRM / LOGGER: S&ME / K. DOHLEN
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: S&ME ATV D50
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/20/17
ENERGY RATIO (%): 77.8

STATION / OFFSET: 1284+92, 8' RT
ALIGNMENT: SR 3
ELEVATION: 882.9 (MSL) EOB: 45.0 ft.
LAT / LONG: 41.270091 N, 81.744881 W

EXPLORATION ID
B-002-0-18

PAGE
1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 882.9
ASPHALT - 14 INCHES	881.7
BRICK - 2 INCHES	881.6
GRANULAR BASE - 2 INCHES	881.4
PROBABLE FILL: Very-stiff brown SILTY CLAY, little fine to coarse sand, trace fine gravel, chemical odor, damp.	879.8
PROBABLE FILL: Very-stiff light-gray SILTY CLAY, some fine to coarse sand, little fine gravel, damp.	876.2
PROBABLE FILL: Stiff brown SILTY CLAY, little to some fine to coarse sand, trace fine gravel, few granite fragments, slight chemical odor, damp.	871.2
Very-stiff to hard gray SILT AND CLAY, little fine to coarse sand, trace fine to coarse gravel, few stiff zones above 15', damp.	849.4
Medium-dense gray COARSE AND FINE SAND, trace to little silt, trace fine gravel, trace clay, wet.	846.2
Dense gray SANDY SILT, little clay, little fine gravel, wet.	837.9

DEPTHS: W at 15; W at 38.5; EOB at 45

SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
2 5 5	13	39	SS-1	3.1-4.0	-	-	-	-	-	-	-	-	21	A-6b (V)
2 4 5	12	44	SS-2	3.25	14	13	13	19	41	37	18	19	19	A-6b (9)
4 5 2	9	61	SS-3	1.0-2.0	-	-	-	-	-	-	-	-	23	A-6b (V)
5 5 7	16	56	SS-4	1.5-2.5	-	-	-	-	-	-	-	-	17	A-6a (V)
2 2 5	9	100	SS-5	3.0-4.25	10	5	10	33	42	-	-	-	16	A-6a (V)
2 3 6	12	39	SS-6	3.0-3.75	5	5	10	38	42	27	16	11	16	A-6a (8)
4 5 8	17	100	SS-7	3.5-4.5+	4	6	10	36	44	-	-	-	16	A-6a (V)
4 5 9	18	94	SS-8	3.75-4.5+	7	5	10	36	42	-	-	-	16	A-6a (V)
3 7 11	23	94	SS-9	4.1-4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)
4 6 9	19	100	SS-10	3.25-3.75	5	6	11	36	42	27	16	11	15	A-6a (8)
5 7 12	25	100	SS-11	2.5-3.75	-	-	-	-	-	-	-	-	15	A-6a (V)
4 6 7	17	100	SS-12	3.5	4	5	9	40	42	27	16	11	17	A-6a (8)
5 9 9	23	67	SS-13	-	-	-	-	-	-	-	-	-	20	A-3a (V)
8 12 14	34	78	SS-14	-	12	18	26	31	13	NP	NP	NP	16	A-4a (2)
6 13 14	35	78	SS-15	-	-	-	-	-	-	-	-	-	19	A-4a (V)

NOTES:
- Groundwater encountered at 15.0' and 38.5' during drilling.
- After removal of augers, boring caved at 3.0' and was observed to be dry.

NOTES: NONE
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

MED-3-24.33

STRUCTURE FOUNDATION EXPLORATION
LOG OF BORING B-002-0-18

DRAWN KAH
CHECKED BKS

PROJECT:	MED-3/94-24.33/20.11	DRILLING FIRM / OPERATOR:	S&ME / A. MESSER	DRILL RIG:	S&ME ATV D50
TYPE:	CULVERT REPLACEMENT	SAMPLING FIRM / LOGGER:	S&ME / K. DOHLEN	HAMMER:	CME AUTOMATIC
PID: 106354 BR ID: MED-3-2433		DRILLING METHOD:	3.25" HSA	CALIBRATION DATE:	10/20/17
START: 3/22/18 END: 3/22/18		SAMPLING METHOD:	SPT	ENERGY RATIO (%):	77.8

STATION / OFFSET: 1285+11, 8' LT
ALIGNMENT: SR 3
ELEVATION: 882.2 (MSL) EOB: 45.0 ft.
LAT / LONG: 41.270039 N, 81.744822 W

EXPLORATION ID B-003-0-18
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 882.2	DEPTHS	SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT – 15 INCHES	880.9																	
GRANULAR BASE – BRICK FRAGMENTS – BRICK PAVERS – 3 INCHES	880.7																	
PROBABLE FILL: Medium-dense brown and gray GRAVEL WITH SAND, little silt, trace clay, dry.	879.2		43 7 6	17	33	SS-1	–	–	–	–	–	–	–	–	–	10	A-1-b (V)	
POSSIBLE FILL: Medium-stiff brown SILTY CLAY, trace to little fine to coarse sand, trace fine gravel, few roots, damp to moist.	870.5		3 4 3	9	44	SS-2	0.5–1.0	–	–	–	–	–	–	–	–	33	A-6b (V)	
			4 5 4	12	0	SS	–	–	–	–	–	–	–	–	–	–		
Medium-dense brown SANDY SILT, some clay, little fine gravel, damp.	868.0	W	2 3 5	10	72	SS-3A	–	11	12	34	21	22	26	16	10	21	A-4a (2)	
Medium-dense gray COARSE AND FINE SAND, little silt, trace clay, trace fine gravel, wet.	867.2					SS-3B	–	–	–	–	–	–	–	–	–	18	A-3a (V)	
Very-stiff to hard brown SILT AND CLAY, little fine to coarse sand, trace fine gravel, damp. – Zone with some fine to coarse gravel from 16.5' to 18.0'.	861.2		4 6 8	18	100	SS-4	3.5–4.25	7	5	10	34	44	–	–	–	19	A-6a (V)	
			3 4 5	12	39	SS-5	–	32	9	9	21	29	–	–	–	18	A-6a (V)	
			4 2 10	16	94	SS-6	4.0–4.5+	5	6	11	44	34	34	19	15	19	A-6a (10)	
			4 8 4	16	100	SS-7	4.5+	9	6	10	36	39	–	–	–	17	A-6a (V)	
Very-stiff gray SILT AND CLAY, little fine to coarse sand, trace fine gravel, damp.	849.2		4 7 11	23	94	SS-8	2.5–3.25	–	–	–	–	–	–	–	–	13	A-6a (V)	
			4 8 13	27	100	SS-9	3.7–4.0	9	6	10	35	40	27	16	11	15	A-6a (8)	
			4 7 13	26	100	SS-10	3.5	–	–	–	–	–	–	–	–	19	A-6a (V)	
			6 8 14	29	100	SS-11	2.25–3.5	–	–	–	–	–	–	–	–	16	A-6a (V)	
Stiff gray SILTY CLAY, trace fine to coarse sand, trace fine gravel, wet.	845.5		3 4 9	17	100	SS-12	1.3–1.75	1	2	4	32	61	35	19	16	25	A-6b (10)	
Dense gray COARSE AND FINE SAND, little silt, trace fine gravel, trace clay, damp.	840.5		4 11 14	32	100	SS-13	–	–	–	–	–	–	–	–	–	14	A-3a (V)	
Dense gray SILT, little clay, little fine to coarse sand, trace fine gravel, damp.	837.2	EOB	5 10 14	31	78	SS-14	–	1	1	16	64	18	NP	NP	NP	21	A-4b (8)	

NOTES:
- No seepage encountered during drilling.
- Groundwater encountered at 14.0' during drilling.
- After removal of augers, boring caved at 28.5' and water was measured at 15.0'.

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; PLASTIC HOLE PLUG DEVICE; SOIL CUTTINGS

5/5

MED-3-24.33

STRUCTURE FOUNDATION EXPLORATION
LOG OF BORING B-003-0-18

DRAWN KAH
CHECKED BKS