STRUCTURE FOUNDATION EXPLORATION

Culvert Replacements

WIL-127-12.43/15.09 PID 114748

Jefferson and Brady Townships (Near West Unity), Williams County, Ohio

Submitted to ODOT District 2

Date ***August 21, 2025***

Prepared by CT consultants engineers • architects • planners a verdantas company

(CT Project No. 241804)

Ohio Department of Transportation

Culvert Replacements
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Jefferson and Brady Twps. (Near West Unity), Williams County, Ohio

Structure Foundation Exploration

ODOT District 2
Bowling Green, Ohio

August 21, 2025

CT Project No. 241804

consultants
engineers • architects • planners
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August 21, 2025 **CT Project No. 241804**

Ms. Jorey Summersett, P.E.
Contract Manager, District 2
ODOT District 2
317 East Poe Road
Bowling Green, Ohio 43402

Final Report
Structure Foundation Exploration
Culvert Replacements
WIL-127-12.43/15.09, PID 114748
Jefferson and Brady Townships (Near West Unity), Williams County, Ohio

Dear Ms. Summersett,

CT Consultants, Inc. (CT), has prepared the report of our structure foundation exploration at the site of the referenced project. This exploration was performed in general accordance with CT Proposal No. P241804 dated May 30, 2024 and authorized by you via a signed Task Order Authorization, dated June 13, 2024, referencing Encumbrance number 742863.

This report contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, and our recommendations for design soil parameters for culvert headwalls. A "draft" version of this report was on March 4, 2025. Review comments were provided on April 4, 2025. Additional correspondence regarding potential alternatives for foundation subgrade preparation due to existing underground utilities occurred during July 2025. Responses to the ODOT comments and questions are incorporated into this final report.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,

CT Consultants, Inc.

Cole Olson
Geotechnical Staff

Christopher P. Iott, P.E.
Senior Project Manager

STATE OF OHIO
CHRISTOPHER P IOTT
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REGISTERED
PROFESSIONAL ENGINEER

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FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
CULVERT REPLACEMENTS
WIL-127-12.43/15.09, PID 114748
JEFFERSON AND BRADY TOWNSHIPS (NEAR WEST UNITY), WILLIAMS COUNTY, OHIO

FOR

ODOT DISTRICT 2
317 EAST POE ROAD
BOWLING GREEN, OHIO 43402

SUBMITTED

AUGUST 21, 2025
CT PROJECT NO. 241804

CT CONSULTANTS, INC.
1915 NORTH 12TH STREET
TOLEDO, OHIO 43604
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EXECUTIVE SUMMARY

This structure foundation exploration report has been prepared for the PID 114748 culvert replacements along US Route 127, southwest of West Unity at Straight Line Mile (SLM) 12.43 in Jefferson Township, and northeast of West Unity at SLM 15.09 in Brady Township, Wood County, Ohio. This exploration included drilling four test borings, two at each culvert location, and performance of two independent pavement cores at the SLM 12.43 site. The two borings performed at the SLM 15.09 site were extended through pavement which included coring prior to auger advancement. This exploration also included laboratory testing and evaluations of design soil properties for design of culvert headwalls. A summary of the conclusions and recommendations of this study are as follows:

1. At the Straight Line Mile (SLM) 12.43 site, the surface materials encountered in Boring B-001 consisted of approximately 5 inches of topsoil. Distinct surface materials were not present at the location of Boring B-002, which was performed just beyond edge of roadway. The surface materials encountered in stand-alone pavement cores X-001 and X-002 consisted of approximately 13.25 inches and 14.5 inches of asphalt underlain by 4 inches and 4½ inches of aggregate base materials, respectively. At the SLM 15.09 site, the surface materials encountered in Borings B-003 and B-004 consisted of approximately 8 inches and 9 inches of asphalt, respectively, underlain by 1 inch and 3 inches of aggregate base materials, respectively.

2. At SLM 12.43, the subsoils encountered in the borings underlying the surface materials can be generally described as predominantly cohesive soils with interbedded layers of granular soil encountered in Boring B-001. Underlying the topsoil in Boring B-001, **loose** granular soils were encountered to a depth of 3½ feet (Elev. 778±). In the upper profile of Boring B-002, from the surface to a depth of 6 feet (Elev. 778±), predominantly **soft** to medium stiff cohesive soils were encountered. A layer of predominantly very stiff to hard cohesive soils was encountered underlying the layer of granular soils in Boring B-001 and underlying the layer of soft to medium stiff cohesive soils in Boring B-002. This cohesive layer extended to depths of approximately 19 feet (Elev. 762±) in Boring B-001, as well as to a depth of 23½ feet (Elev. 760±) in Boring B-002. Underlying the very stiff to hard cohesive soils, hard cohesive soils were encountered to a depth of 23½ feet (Elev. 758±) in Boring B-001 and to termination at a depth of 30 feet (Elev. 754±) in Boring B-002. Underlying the hard cohesive soils in Boring B-001, dense to very dense granular soils were encountered to termination at a depth of 30 feet (Elev. 751±).

3. At SLM 15.09, the subsoils encountered in the borings underlying the pavement materials can be generally described as interbedded layers of granular and cohesive soils. Layers of **very loose** to medium dense granular soils interbedded with medium stiff to stiff cohesive soil were encountered underlying the pavement materials in Borings B-003 and B-004 to depths of 21 feet (Elev. 766±) and 18½ feet (Elev. 768±),

respectively. A layer of predominantly very stiff to hard cohesive soils was encountered underlying the layer of granular soils in Boring B-001 and underlying the layer of soft to medium stiff cohesive soils in Boring B-002. This cohesive layer extended to depths of approximately 19 feet (Elev. 762±) in Boring B-001, as well as to a depth of 23½ feet (Elev. 760±) in Boring B-002. Underlying the very stiff to hard cohesive soils, hard cohesive soils were encountered to a depth of 23½ feet (Elev. 758±) in Boring B-001 and to termination at a depth of 30 feet (Elev. 754±) in Boring B-002. Underlying the hard cohesive soils in Boring B-001, dense to very dense granular soils were encountered to termination at a depth of 30 feet (Elev. 751±).

4. At SLM 12.43, headwall foundation bearing soils meet the minimum requirement for use of standard headwalls of undrained shear strength (s_u) of 1,500 pounds per square foot (psf) for the cohesive soils. The underlying lower profile granular soils also meet the minimum required internal angle of friction (ϕ) of 28 degrees.

5. At SLM 15.09, headwall foundation bearing soils **do not** meet the minimum requirement for use of standard headwalls of undrained shear strength (s_u) of 1,500 pounds per square foot (psf) for the cohesive soils. The underlying lower profile granular soils meet the minimum required internal angle of friction (ϕ) of 28 degrees. Undercutting and replacement with new engineered fill will be required to encounter suitable soils for standard ODOT headwall design. These undercuts are anticipated to be on the order of 4½ to 5 feet below planned headwall foundation bearing elevations. It is our understanding that flowable controlled-density fill is planned to be specified for backfill of undercuts due to the proximity of existing underground utilities that will remain underlying the new headwall foundations. Otherwise, the undrained shear strengths presented in Section 5.1.2 could be used for special headwall design to avoid undercutting.

6. Based on the soil characteristics and groundwater conditions encountered in the borings performed at the Straight Line Mile (SLM) 12.43 and 15.09 locations, it is our opinion that the “normal” groundwater level will generally be encountered at approximate Elevs. 775 to 772 and Elevs. 779 to 776, respectively. Excavation to install headwall foundations to Elevs. 774± to 773± are anticipated to extend below the “normal” groundwater level at both sites.

7. If construction does not occur during a particularly wet period, adequate control of groundwater seepage into shallow excavations above the groundwater level should be achievable by minor dewatering systems, such as pumping from prepared sumps. At the SLM 12.43 site, excavations below the “normal” groundwater level are anticipated to generally encounter cohesive soils which may not produce flowing water but would be expected to produce some water seepage. At the SLM 15.09 site, granular soils are present below the “normal” groundwater elevations and within depths of excavation for headwall installation. Therefore, coffer dams are anticipated

to be required for excavations at this site. Coffer dams may also be required at both sites to divert flow in waterways during construction.

This executive summary highlights our evaluations and recommendations and should only be utilized in conjunction with the accompanying report, including the detailed findings, conclusions, and qualifications presented herein.

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APPENDICES

1.0 INTRODUCTION

This geotechnical exploration report has been prepared for the culvert replacements along US Route 127 (US 127) near West Unity, Williams County, Ohio, designated as WIL-127-12.43/15.09 PID 114748. One culvert (SFN 1806949) is located approximately 2 miles southwest of West Unity at Straight Line Mile (SLM) 12.43 in Jefferson Township. The other culvert (SFN 181325) is located approximately ½ mile northeast of West Unity at SLM 15.09 in Brady Township. The general location of each site is shown on the attached Site Location Map (Plate 1.0).

This study was performed in accordance with CT Proposal No. P241804, dated May 30, 2024, and was authorized by Ms. Jorey Summersett of ODOT District 2 via a signed Task Order Authorization, dated June 13, 2024, referencing Encumbrance No. 742863.

1.1 Purpose and Scope of Exploration

The purpose of this exploration was to evaluate the subsurface conditions relative to design of headwalls for replacement culverts at the referenced locations. To accomplish this, four (4) test borings, two (two) at each site, as well as two (2) stand-alone pavement cores at the Straight Line Mile (SLM) 12.43 site were performed. The two borings performed at the SLM 15.09 site were extended through pavement which included coring prior to auger advancement. Additionally, we performed field and laboratory soil testing, as well as review of available geologic and soils data for the project areas.

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures utilized to evaluate the subsurface conditions at the site, and presents our findings from the field and laboratory testing.

This report includes a description of the existing surface cover, subsurface soils, and groundwater conditions encountered in the borings.

Appendix B includes pertinent ODOT Geotechnical Engineering Design Checklists that apply to the scope of this report.

The scope of this study did not include an environmental assessment of the surface or subsurface materials at this site.

1.2 Proposed Construction

It is our understanding that the existing culverts will each be replaced with a precast reinforced concrete box culvert. The WIL -127-12.43 culvert dimensions were indicated to be 9 feet in span and 6 feet in rise and will include standard full height Type B headwalls per ODOT Design Data Sheet HWDD-1, dated July 20, 2018. The bottom of culvert will bear at approximately Elev. 774.65. Therefore, headwall foundations are expected to bear at approximate Elev. 773.15.

The WIL -127-15.09 culvert dimensions were indicated to be 7 feet in span and 7 feet in rise and will include standard full height Type A headwalls per ODOT Design Data Sheet HWDD-1, dated July 20, 2018. The bottom of culvert will bear at approximately Elev. 774.96. Therefore, headwall foundations are expected to bear at approximate Elev. 773.46.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 General Geology and Hydrogeology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) indicate that the project site is located on the border of Central Ohio Clayey Till Plain and Maumee Lake Plains Physiographic Regions. Within the Central Ohio Clayey Till Plain region, the geologic deposits consist of Wisconsinan-age glacial till and lacustrine materials overlying Paleozoic-age carbonate rocks. Within the Maumee Lake Plains region, the geologic deposits consist of Pleistocene-age silt, clay, and wave-planed clayey till overlying Silurian- and Devonian-age carbonate rocks and shales.

The glacial till, also referred to as moraine, was deposited by the advance and retreat of glacial ice. Due to the weight of the ice mass, the till deposits are moderately to highly over-consolidated, that is, the existing soil deposits have experienced a previous vertical stress significantly higher than the present effective vertical stress due to the remaining overlying soil strata in the profile. The till may contain cobbles and/or boulders left in the till soil matrix. Additionally, seams of granular soils may also be encountered within glacial tills. These granular seams may or may not be water bearing. The lacustrine soils consist of lake-laid deposits that exhibit much lower previous vertical stress than the till deposits.

Bedrock in the project area is broadly mapped on the “Geologic Map of Ohio” as Waverly (Shales, sandstone and limestone). At the Straight Line Mile (SLM) 12.43 and 15.09 sites, top of bedrock is mapped to be at approximately Elevs. 570 and 600, respectively, corresponding to approximately 215 feet and 185 feet below roadway grades, respectively.

Review of the ODNR “Ohio Karst Areas” map indicated that the site is not in an area of probable karst.

The USDA Soil Conservation Service (SCS) Web Soil Survey indicates that the near-surface soils in the SLM 12.43 project area are mapped as shoals loam. These soils are comprised of loamy alluvium formed on flood plains. The near surface soils in the SLM 15.09 project area are mapped as millgrove loam. These soils are comprised of outwash formed on flats.

Review of the Ohio Department of Natural Resources (ODNR) Map of Mines indicated no historic mining activity in the vicinity of either culvert site. The closest indicated previous mining is located approximately 3 miles northeast and more than 1 mile southeast of the SLM 12.43 and 15.09 sites, respectively.

2.2 Site Reconnaissance

2.2.1 WIL-127-12.43

CT performed site reconnaissance on June 27, 2024. The site in the vicinity of the culvert is located in a predominantly rural residential and agricultural area. In the immediate area of the culvert, pavement along US 127 was observed to generally be in good condition.

Concrete associated with the culvert was spalling with exposed steel reinforcement (rebar). The existing concrete box culvert was rectangular in cross-sectional shape. The box culvert dimensions were approximately 10 feet span and 9 feet rise. The ditch bottom was approximately 9 to 10 feet below the road surface. At the time of this reconnaissance, water levels in the ditch were approximately 6 to 7 inches deep.

Overhead utility lines were observed along both sides of US 127, offset approximately 10 to 15 feet from the pavement edge.

2.2.2 WIL-127-15.09

CT performed site reconnaissance on June 27, 2024. The site in the vicinity of the culvert consists of predominantly rural residential area.

In the immediate area of the culvert, pavement along US 127 was observed to be in generally fair condition, albeit heavily weathered. Pavement distresses were generally limited to a few transverse cracks either side of the culvert, and longitudinal cracks along the edges of the pavement. Approximately 1 to 2 inches of separation was observed for some cracks at the edge of pavement. The observed cracks were not sealed.

The slopes from the road to the ditch had multiple areas of erosion rills from runoff. Riprap was present at the southwestern quadrant of the culvert location.

The existing concrete box culvert was rectangular in cross-sectional shape. The box culvert dimensions were approximately 7 feet span and by 9½ feet rise.

The ditch bottom was approximately 9½ to 10 feet below the road surface. At the time of this reconnaissance, water levels in the ditch were generally 8 to 9 inches deep.

Overhead utility lines were observed along the both side of US 127, offset approximately 10 to 15 feet from the pavement edge.

3.0 EXPLORATION

3.1 Historic Borings

Review of ODOT records indicated that no historic borings were performed within the project areas.

3.2 Project Exploration Program

Four (4) test borings, designated as Borings B-001-0-24 through B-004-0-24 and two (2) stand-alone pavement cores, designated as X-001-0-24 and X-002-0-24, were performed for this exploration. The two borings performed at the SLM 15.09 site were extended through pavement which included coring prior to auger advancement.

The cores and borings were drilled by DLZ under the direction of CT Consultants on July 2 and 3, 2024. The stand-alone pavement cores were performed by DLZ on August 15, 2024. These borings are fully designated as Borings B-001-0-24, B-002-0-24, B-003-0-24 and B-004-0-24. The stand-alone cores are designated as X-001-0-24 and X-002-0-24. The cores and borings are designated in accordance with ODOT protocol, but the -0-24 portion of the nomenclature is generally omitted in the discussions within this report.

For WIL-127-12.43, Borings B-001 and B-002 were located beyond the existing roadway southeast of the roadway near the inlet and northwest of the roadway near the outlet, respectively. Pavement cores X-001and X-002 were performed in the northbound and southbound lanes near B-001 and B-002, respectively. For WIL-127-15.09, Borings B-003 and B-004 were performed in the northbound lane, south of the culvert, and in the southbound lane, north of the culvert, respectively. The existing site features and approximate locations of the cores and borings are presented on the Test Boring Location Plans (Plates 2.1 and 2.2).

Stationing and offsets were obtained from plans provided by ODOT District 2. Latitude, Longitude, and ground surface elevations were surveyed by CT using a hand-held GPS unit. The accuracy from the handheld GPS device was generally found to be approximately 2 to 6 inches horizontal, and approximately 4 to 12 inches vertical. These data are presented on the Logs of Test Borings.

The four culvert borings (B-001 through B-004) were performed as Type E2b structure borings per geotechnical investigative procedures outlined in Ohio Department of

Transportation (ODOT) "Specifications for Geotechnical Explorations" (SGE). These borings were terminated at the planned depth of 30 feet below existing grades, which meets ODOT criteria of approximately 20 feet below invert depth for Type E2b culvert borings. Borings B-003 and B-004 were terminated at a depth of 29.8 feet after split-spoon refusal (SSR, 50 or more blows for 6 inches or less penetration during a Standard Penetration Test) occurred over the final planned sample interval.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is essential that a geotechnical engineer be retained to provide soil engineering services during the site preparation, excavation, and foundation phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.3 Boring Methods

The four (4) test borings performed during this exploration were drilled with a track-mounted CME 45 drill rig utilizing 3¼-inch inside diameter hollow-stem augers. During auger advancement of the test borings, split-spoon drive samples were generally taken at 2½-foot intervals to a depth of 30 feet. The samples were sealed in jars and transported to our laboratory for further classification and testing.

The two (2) stand-alone pavement cores X-001 and X-002 were obtained using a nominal 4-inch diameter core barrel. The two (2) pavement cores at the locations of Borings B-003 and B-004 were obtained using a nominal 8-inch diameter core barrel. The cores are presented on the Photographic Logs of Pavement Cores attached to this report.

During auger advancement in the test borings, split-spoon (SS) soil samples were obtained by the Standard Penetration Test Method (ASTM D 1586). The Standard Penetration Test (SPT) consists of driving a 2-inch outside diameter split-spoon sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments, with the number of blows per increment being recorded. The number of blows per increment was recorded at each depth interval, and these data are presented under the "SPT" column on the Logs of Test Borings attached to this report. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance, or N_m-value, and is typically reported in blows per foot (bpf). The N_m-values were corrected to an equivalent rod energy ratio of 60 percent, N_{60}. The calibrated hammer/rod energy ratio for the CME 45 track-mounted drill rig was 89.2 percent, and was last calibrated on February 1, 2024. The N_{60}-values are presented on the attached Logs of Test Borings.

Soil conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. In conjunction with published data and typical correlations, the N_{60}-values can be evaluated as a measure of soil compactness/consistency as well as shear strength.

Field and laboratory data were incorporated into gINT™ software for presentation purposes. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

3.4 Laboratory Testing Program

All samples were visually or manually classified in accordance with the ODOT Soil Classification System. All samples of the subsoils were also tested in our laboratory for moisture content (ASTM D 2216). Unconfined compressive strength tests (ASTM D 2166) were performed for selected samples. Unconfined compressive strength estimates were obtained for the remaining intact cohesive samples using a calibrated hand penetrometer. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 6913 and D 7928) were performed on selected samples to determine soil classification and index properties. These test results are presented on the Logs of Test Borings and Grain Size Distribution sheets.

4.0 FINDINGS

4.1 General Site Conditions

At the Straight Line Mile (SLM) 12.43 site, the surface materials encountered in Boring B-001 consisted of approximately 5 inches of topsoil. Distinct surface materials were not present at the location of Boring B-002, which was performed just beyond edge of roadway. The surface materials encountered in stand-alone pavement cores X-001 and X-002 consisted of approximately 13.25 inches and 14.5 inches of asphalt underlain by 4 inches and 4½ inches of aggregate base materials, respectively.

At the SLM 15.09 site, the surface materials encountered in Borings B-003 and B-004 consisted of approximately 8 inches and 9 inches of asphalt, respectively, underlain by 1 inch and 3 inches of aggregate base materials, respectively.

4.2 General Soil Conditions

4.2.1 WIL-127-12.43

Based on the results of our field and laboratory tests, the subsoils encountered in the borings underlying the surface materials can be generally described as predominantly cohesive soils with interbedded layers of granular soil encountered in Boring B-001.

Underlying the topsoil in Boring B-001, **loose** granular soils were encountered to a depth of 3½ feet (Elev. 778±). The granular soil consisted of fine sand (A-3). An SPT N_{60}-value of 7 blows per foot (bpf) and a moisture content of 16 percent were determined for the recovered sample.

In the upper profile of Boring B-002, from the surface to a depth of 6 feet (Elev. 778±), predominantly **soft** to medium stiff cohesive soils were encountered. These cohesive soils consisted of sandy silt (A-4a) as well as silt and clay (A-6a). SPT N_{60}-values ranged from 4 to 7 bpf. Hand penetrometer results ranged from 1.25 to 2 tons per square foot (tsf). An unconfined compressive strength of 1,280 psf was determined for a selected sample. Moisture contents ranged from 20 to 21 percent.

A layer of predominantly very stiff to hard cohesive soils was encountered underlying the layer of granular soils in Boring B-001 and underlying the layer of soft to medium stiff cohesive soils in Boring B-002. This cohesive layer extended to depths of approximately 19 feet (Elev. 762±) in Boring B-001, as well as to a depth of 23½ feet (Elev. 760±) in Boring B-002. These cohesive soils consisted of sandy silt (A-4a), silt and clay (A-6a), and silty clay (A-6b). SPT N_{60}-values generally ranged from 16 to 45 bpf. Hand penetrometer values ranged from 3.25 to 4.5 tsf. An unconfined compressive strength of 8,130 psf was determined for a recovered sample. Moisture contents generally ranged from 11 to 16 percent.

Underlying the very stiff to hard cohesive soils, hard cohesive soils were encountered to a depth of 23½ feet (Elev. 758±) in Boring B-001 and to termination at a depth of 30 feet (Elev. 754±) in Boring B-002. These cohesive soils consisted of sandy silt (A-4a). SPT N_{60}-values ranged from 64 to 129 bpf. Moisture contents generally ranged from 6 to 13 percent. A zone of medium dense granular soils was encountered within this layer in Boring B-001 from approximately 19 to 21 feet (Elev. 760±).

Underlying the hard cohesive soils in Boring B-001, dense to very dense granular soils were encountered to termination at a depth of 30 feet (Elev. 751±). The granular soil consisted of coarse and fine sand (A-3a) and fine sand (A-3). SPT N_{60}-values ranged from 49 to 73 bpf, and split-spoon refusal (SSR, 50 or more blows for 6 inches or less penetration). Moisture contents ranged from 6 to 12 percent.

Additional descriptions of the stratigraphy encountered in the borings are presented on the Logs of Test Borings.

4.2.2 WIL-127-15.09

Based on the results of our field and laboratory tests, the subsoils encountered in the borings underlying the pavement materials can be generally described as interbedded layers of granular and cohesive soils.

Layers of **very loose** to medium dense granular soils interbedded with medium stiff to stiff cohesive soil were encountered underlying the pavement materials in Borings B-003 and B-004 to depths of 21 feet (Elev. 766±) and 18½ feet (Elev. 768±), respectively. The granular soils consisted of coarse and fine sand (A-3a), non-plastic sandy silt (A-4a), and fine sand (A-3). SPT N_{60}-values ranged from 4 to 18 blows per foot (bpf). Moisture contents ranged from 12 to 21 percent. The cohesive soils consisted of silt and clay (A-6a), and silty clay (A-6b). SPT N_{60}-values generally ranged from 4 to 7 bpf. Hand penetrometer results ranged from 1.25 to 3.75

tsf. Unconfined compressive strengths for selected samples ranged from 1,815 to 3,270 psf. Moisture contents ranged from 10 to 23 percent.

Underlying the interbedded loose to medium dense granular soils and medium stiff to stiff cohesive soils, a layer of predominantly dense to very dense granular soils was encountered to depths of 26 feet (Elev. 762±) in Boring B-003 and approximately 27 feet (Elev. 760±) in Boring B-004. The granular soils consisted of coarse and fine sand (A-3a), fine sand (A-3), and non-plastic sandy silt (A-4a). SPT N_{60}-values generally ranged from 27 to 106 bpf. Moisture contents ranged from 16 to 23 percent.

Underlying the dense to very dense granular soils, a layer of predominantly hard cohesive soil was encountered in Borings B-003 and B-004 to termination at a depth of 30 feet (Elevs. 758± to 757±). These cohesive soils consisted of sandy silt (A-4a), as well as silt and clay (A-6a). The SPT resulted in split-spoon refusal (SSR, 50 or more blows for 6 inches or less penetration). A hand penetrometer for an intact sample was 4.5 tsf. Moisture contents ranged from 11 to 17 percent.

Additional descriptions of the stratigraphy encountered in the borings are presented on the Logs of Test Borings.

4.3 Groundwater Conditions

4.3.1 WIL-127-12.43

During our site reconnaissance on June 27, 2024, water was present in the waterway at approximate Elev. 775 to 774. During this exploration, groundwater was initially encountered during drilling and at the completion of drilling at Elev. 755.9 in Boring B-001. Groundwater was not encountered during drilling in Boring B-002. It should be noted that the boreholes were drilled and sealed within the same day, and stabilized water levels may not have occurred over this limited time period.

Apart from streamflow influences in the ditch, it is our opinion that the “normal” groundwater level can generally be expected at approximate Elevs. 775 to 772. However, groundwater elevations can fluctuate with seasonal and climatic influences, and will also be particularly affected locally by water levels in the waterway. Therefore, groundwater conditions may vary at different times of the year from those encountered during this exploration.

4.3.2 WIL-127-15.09

During our site reconnaissance on June 27, 2024, water was present in the waterway at approximate Elev. 778. During this exploration, groundwater was initially encountered during drilling and observed upon completion of drilling at Elev. 771.1 in Boring B-003. Groundwater was not encountered during drilling in Boring B-004. It should be noted that the boreholes were drilled and sealed within the same day, and stabilized water levels may not have occurred over this limited time period.

Apart from streamflow influences in the ditch, it is our opinion that the “normal” groundwater level can generally be expected at approximate Elevs. 779 to 776. However, groundwater elevations can fluctuate with seasonal and climatic influences, and will also be particularly affected locally by water levels in the waterway. Therefore, groundwater conditions may vary at different times of the year from those encountered during this exploration.

4.4 Remedial Measures

The soil conditions encountered at the Straight Line Mile (SLM) 12.43 site are considered generally suitable for support of headwalls using typical ODOT designs.

At the SLM 15.09 site, undercutting and replacement with new engineered fill will be required to encounter suitable soils for standard ODOT headwall design. These undercuts are anticipated to be on the order of 4½ to 5 feet below planned headwall foundation bearing elevations. It is our understanding that flowable controlled-density fill is planned to be specified for backfill of undercuts due to the proximity of existing underground utilities that will remain underlying the new headwall foundations. Otherwise, the undrained shear strengths presented in Section 5.1.2 could be used for special headwall design to avoid undercutting.

Based on the soil characteristics and groundwater conditions encountered in the borings performed at the Straight Line Mile (SLM) 12.43 and 15.09 locations, it is our opinion that the “normal” groundwater level will generally be encountered at approximate Elevs. 775 to 772 and Elevs. 779 to 776, respectively. Excavation to install headwall foundations to Elevs. 774± to 773± are anticipated to extend below the “normal” groundwater level at both sites.

If construction does not occur during a particularly wet period, adequate control of groundwater seepage into shallow excavations above the groundwater level should be achievable by minor dewatering systems, such as pumping from prepared sumps. At the SLM 12.43 site, excavations below the “normal” groundwater level are anticipated to generally encounter cohesive soils which may not produce flowing water but would be expected to produce some water seepage. At the SLM 15.09 site, granular soils are present below the “normal” groundwater elevations and within depths of excavation for headwall installation. Therefore, coffer dams are anticipated to be required for excavations at this site. Coffer dams may also be required at both sites to divert flow in waterways during construction.

In addition to dewatering measures, the contractor may need to incorporate a thin mat of lean concrete over the bottom of the excavation to avoid loss of subgrade strength and excessive undercutting of the bearing soils from groundwater seepage or surface run off.

5.0 ANALYSES AND RECOMMENDATIONS

The following analysis and recommendations are based on our understanding of the proposed construction and upon the data obtained during our exploration. If the project information or location as outlined is incorrect or should change significantly, a review of these recommendations should be made by CT.

5.1 Soil Parameters for Headwall Support

5.1.1 WIL-127-12.43

It was indicated that Type B ODOT standard concrete headwalls for precast box culverts (Sheet HWDD-1) will be utilized for this project. The bottom of culvert will bear at approximately Elev. 774.65. Therefore, headwall foundations are expected to bear at approximate Elev. 773.15.

Based on the conditions encountered in the borings, the soils at the anticipated headwall foundation bearing elevation are expected to consist of predominantly very stiff to hard native cohesive soils. In Boring B-001, which was performed southeast of US Route 127, interbedded zones of medium dense to very dense granular soils were encountered starting approximately 11½ feet below the headwall bearing elevation.

The standard concrete headwalls are indicated to be based on design using a minimum undrained shear strength (s_u), or cohesion (c), of 1,500 pounds per square foot (psf) when the walls are bearing on cohesive soils. The average s_u or c value for the encountered cohesive soils at and within influence of the headwall bearing was 2,390 psf or greater, which meets the minimum design requirement.

The standard concrete headwalls are indicated to be based on design using a minimum internal angle of friction (ϕ) of 28 degrees for granular bearing soils. The ϕ value for the medium dense to very dense granular soils present in the lower portion of the subsurface profile in Boring B-001 is 36.5 degrees or greater, which meets the minimum design requirement.

5.1.2 WIL-127-15.09

It was indicated that Type A ODOT standard concrete headwalls for precast box culverts (Sheet HWDD-1) will be utilized for this project. The bottom of culvert will bear at approximately Elev. 774.96. Therefore, headwall foundations are expected to bear at approximate Elev. 773.46.

Based on the conditions encountered in the borings, the soils at the anticipated headwall foundation bearing elevation are expected to consist of predominantly medium stiff to stiff native cohesive soils. Interbedded medium dense to very dense granular soils were encountered starting approximately 4 to 6 feet below the headwall bearing elevation.

The standard concrete headwalls are indicated to be based on design using a minimum undrained shear strength (s_u), or cohesion (c), of 1,500 pounds per square foot (psf) when the walls are bearing on cohesive soils. The average s_u or c value for the medium stiff to stiff cohesive bearing soils are recommended as 1,160 psf and 1,060 psf for B-003 and B-004, respectively, located east and west of US Route 127, respectively. These values **do not** meet the minimum design requirement.

The standard concrete headwalls are indicated to be based on design using a minimum internal angle of friction (ϕ) of 28 degrees when the walls are bearing on granular soils. The ϕ value for the medium dense to very dense granular bearing soils encountered in the lower soil profile in the borings is 34.5 degrees or greater, which meets the minimum design requirement.

Based on the conditions encountered in Borings B-003 and B-004, overexcavation to approximately Elevs. 769 and 768½, respectively, corresponding to approximately 4½ feet and 5 feet, respectively, would be required to encounter suitable soils that meet the minimum design for standard headwalls. Otherwise, the undrained shear strengths presented above could be used for special headwall design to avoid undercutting.

Where unsuitable bearing soils are encountered during headwall installation, over-excavation should extend through these materials to suitable bearing soils. The base of the over-excavation should be widened 1 foot for every foot of depth, centered longitudinally along the headwall. The over-excavated areas should be backfilled with dense-graded aggregate. The aggregate should be placed and compacted as described in Section 5.2.5. After over-excavation of unsuitable soils, a design ϕ value for granular new "embankment" fill may be estimated as 32 degrees per ODOT GDM Table 500-2, which meets the minimum design requirement for standard headwalls bearing on granular soils. Alternatively, the over-excavated areas could be backfilled with flowable controlled-density fill having a minimum compressive strength of 300 psi. It is our understanding that flowable controlled-density fill is planned to be specified for backfill of undercuts due to the proximity of existing underground utilities that will remain underlying the new headwall foundations. The suitability of the flowable controlled-density fill for backfill in proximity to the underground utilities, which are indicated to be PVC pipes, should be verified with pipe manufacturers.

5.2 Construction

5.2.1 Sedimentation and Erosion Control

In planning the implementation of earthwork operations, special consideration should be given to provide measures to prevent or reduce soil erosion and the subsequent sedimentation into nearby waterways. These measures may include some or all of the following:

1. Scheduling of earthwork operations such that erodible areas are kept as small as possible and are exposed for the shortest possible time.
2. Using special grading practices, along with diversion or interceptor structures, to reduce the amount of run-off water from an erodible area.
3. Providing vegetative buffer zones, filter berms, or sedimentation basins to trap sediment from surface run-off water.

A specific and detailed soil erosion and sedimentation control program and permits may be required by local, state, or federal regulatory agencies.

5.2.2 Site Preparation

Prior to proceeding with construction operations, all structures, pavements, topsoil, root systems, vegetation, and other deleterious non-soil materials should be removed from the proposed construction areas.

5.2.3 Temporary Excavations and Permanent Slopes

The sides of the temporary excavations for headwall installation should be adequately sloped to provide stable sides and safe working conditions. Otherwise, the excavation must be properly braced against lateral movements. In any case, applicable Occupational Safety and Health Administration (OSHA) standards must be followed. It is the responsibility of the installation contractor to develop appropriate installation methods and specify pertinent equipment prior to commencement of work, and to obtain the services of a geotechnical engineer to design or approve sloped or benched excavations and/or lateral bracing systems as required by OSHA criteria.

It should be noted that granular soils were encountered in the upper soil profile, above headwall bearing elevations, at both sites. Additionally, headwall installation is anticipated near or deeper below the anticipated "normal" groundwater level. As such, seepage may occur in open excavations for headwall installation which could affect the stability of the excavation slopes. Provisions should be made for the headwall installation to proceed as a sloped-bank excavation, or as a steeper trench-type cut with properly designed and installed lateral bracing. Any excavations greater than 20 feet deep should be evaluated by a registered professional engineer.

If the excavation is to be performed with sloped banks, adequate stable slopes must be provided in accordance with OSHA criteria. The soils encountered in the test borings within the anticipated depth of excavations are anticipated to include OSHA Type C soils (granular soils). For temporary excavations in Type C soils, side slopes must be constructed no steeper than 1½H:1V. **At the project sites, we expect the majority of temporary excavations will require a 1½H:1V slope. In all cases, flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.**

For permanent excavations and slopes, we recommend that grades generally be no steeper than 3H:1V.

5.2.4 Construction Dewatering and Groundwater Control

Groundwater conditions encountered during our exploration are summarized in Section 4.3.

Based on the soil characteristics and groundwater conditions encountered in the borings performed at the Straight Line Mile (SLM) 12.43 and 15.09 locations, it is our opinion that the "normal" groundwater level will generally be encountered at approximate Elevs. 775 to 772 and Elevs. 779 to 776, respectively. Excavation to install headwall foundations to Elevs. 774± to 773± are anticipated to extend below the "normal" groundwater level at both sites.

If construction does not occur during a particularly wet period, adequate control of groundwater seepage into shallow excavations above the groundwater level should be achievable by minor dewatering systems, such as pumping from prepared sumps. At the SLM 12.43 site, excavations below the “normal” groundwater level are anticipated to generally encounter cohesive soils which may not produce flowing water but would be expected to produce some water seepage. At the SLM 15.09 site, granular soils are present below the “normal” groundwater elevations and within depths of excavation for headwall installation. Therefore, coffer dams are anticipated to be required for excavations at this site. Coffer dams may also be required at both sites to divert flow in waterways during construction.

In addition to dewatering measures, the contractor may need to incorporate a thin mat of lean concrete over the bottom of the excavation to avoid loss of subgrade strength and excessive undercutting of the bearing soils from groundwater seepage or surface run off. For areas that require over-excavation and replacement with new granular engineered fill, the granular fill should be generally suitable as a working platform for preparation of steel reinforcement and placement of concrete as long as diligent dewatering activities are being provided. Installation of well points along with multiple sumps and pumps may be required, even with installation of the coffer dam.

5.2.5 Fill

Material for engineered fill or backfill required to achieve design grades should meet ODOT Item 203 “Embankment Fill” placement and compaction requirements.

6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of design and construction conditions for the culvert replacements has been based on our understanding of the site and project information and the data obtained during our field exploration. The general subsurface conditions were based on interpretation of the data obtained at specific boring locations. Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. This potential is increased for previously developed sites. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, CT assumes no responsibility for construction compliance with the design concepts or specifications.

The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate the recommendations of this report after on-site observations of the conditions.

Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. CT is not responsible for the conclusions, opinions, or recommendations of others based on this data.

PLATES

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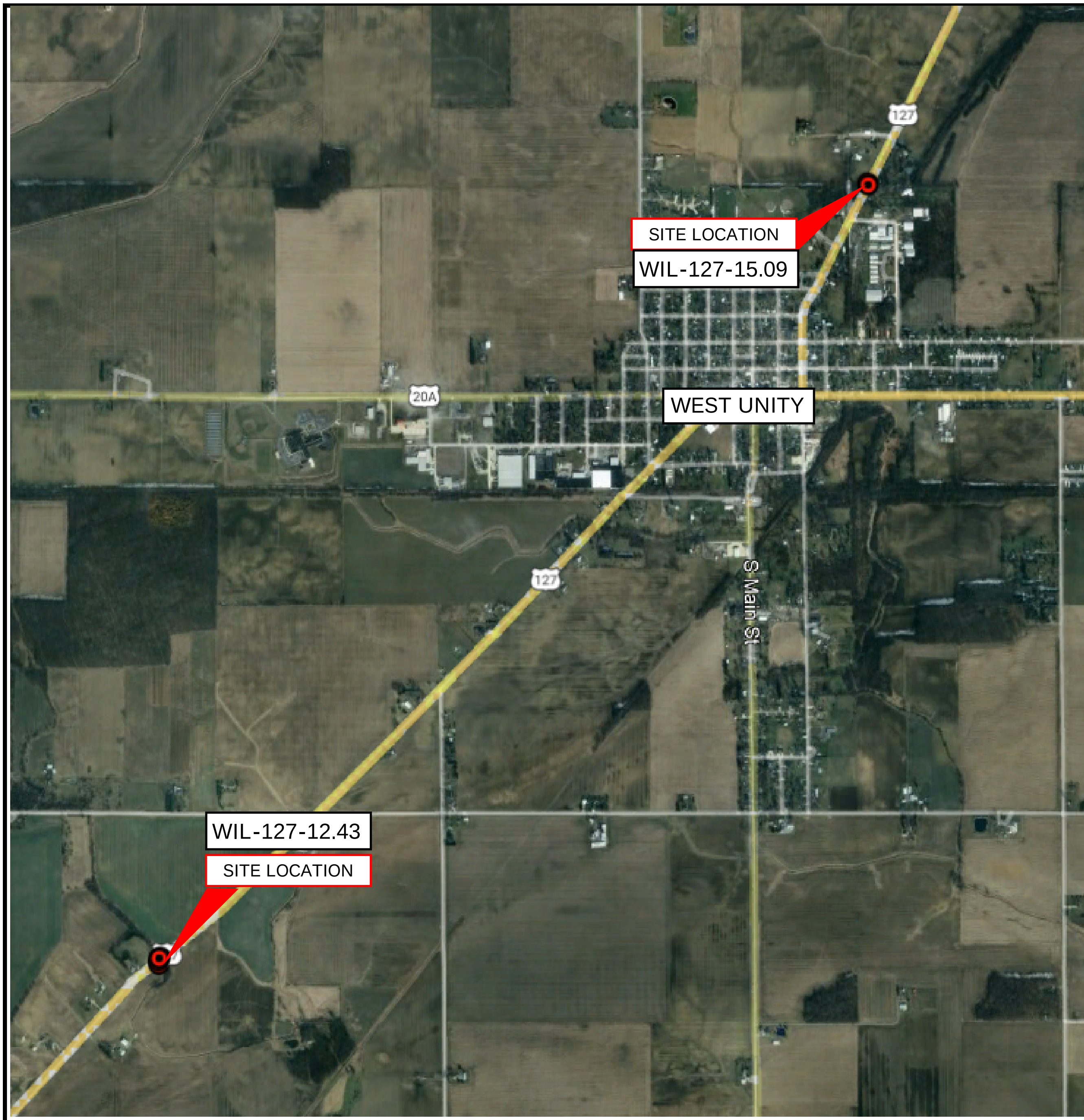

BASE AERIAL OBTAINED FROM GOOGLE EARTH IMAGE DATED FEBRUARY 18, 2024.

LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

0 2,000 4,000

PLATE 1.0
SITE LOCATION MAP

PROPOSED REPLACEMENT CULVERT
WIL-127-12.43/15.09 PID 114748
NEAR WEST UNITY , WILLIAMS COUNTY, OHIO

PREPARED FOR

ODOT DISTRICT 2

DRAWN	CRO / 02-04-025	CHECKED	CI / 02-04-025
REVISED		APPROVED	
JOB NO.	241804		
DRAWING NUMBER	241804–01G		

CT consultants
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BASE AERIAL OBTAINED FROM GOOGLE EARTH IMAGE DATED FEBRUARY 18, 2024.

PLATE 2.1
TEST BORING AND CORE LOCATION PLAN
PROPOSED CULVERT REPLACEMENT
WIL-127-12.43 PID 114748
NEAR WEST UNITY , WILLIAMS COUNTY, OHIO

PREPARED FOR

ODOT DISTRICT 2

DRAWN CRO / 02-04-025	CHECKED CI / 02-04-025
REVISED	APPROVED
JOB NO. 241804	CT consultants engineers • architects • planners a verdantas company
DRAWING NUMBER 241804–03G	

BASE AERIAL OBTAINED FROM GOOGLE EARTH IMAGE DATED FEBRUARY 18, 2024.

LEGEND

B-003-0-24 ⊕ APPROXIMATE TEST BORING LOCATION

APPROXIMATE SCALE - FEET

0 60 120

PLATE 2.2

TEST BORING LOCATION PLAN

PROPOSED CULVERT REPLACEMENT

WIL-127-15.09 PID 114748

NEAR WEST UNITY, WILLIAMS COUNTY, OHIO

PREPARED FOR

ODOT DISTRICT 2

DRAWN	CRO / 02-04-025	CHECKED	CI / 02-04-025
REVISED		APPROVED	
JOB NO.	241804		
DRAWING NUMBER	241804–02G		

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FIGURES

PROJECT: WIL-127-12.43/15.09	DRILLING FIRM / OPERATOR: DLZ / VAUL	DRILL RIG: DLZ CME 45 TRACK	STATION / OFFSET: 655+92, 43' RT.	EXPLORATION ID B-001-0-24
TYPE: CULVERT	SAMPLING FIRM / LOGGER: DLZ / KKC	HAMMER: CME AUTOMATIC	ALIGNMENT: US 127 CL	
PID: 114748 SFN: 1806949/1861325	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 2/1/24	ELEVATION: 781.4 (NAVD88) EOB: 30.0 ft.	PAGE
START: 7/3/24 END: 7/3/24	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.2	LAT / LONG: 41.566763, -84.461509	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 781.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
TOPSOIL - 5 INCHES	781.0																		
LOOSE, BROWN, **FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, SLIGHTLY ORGANIC, DAMP	777.9	1–3	3 3 2	7	89	SS-1	-	-	-	-	-	-	-	-	-	16	A-3 (V)	-	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP		4–5	3 6 8	21	94	SS-2	4.50	8	6	23	26	37	28	17	11	14	A-6a (6)	-	
@6': GRAY, SLIGHTLY ORGANIC		6–8	3 5 6	16	83	SS-3	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
@8.5': Qu = 56.5 PSI = 8,130 PSF		9–10	3 5 7	18	94	SS-4	4.50	2	5	17	26	50	31	18	13	16	A-6a (9)	-	
@11': LITTLE SAND	767.9	11–13	2 5 5	15	83	SS-5	4.50	-	-	-	-	-	-	-	-	16	A-6a (V)	-	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	765.4	14–15	2 4 5	13	94	SS-6	4.00	-	-	-	-	-	-	-	-	15	A-6b (V)	-	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	762.9	16–18	2 5 7	18	100	SS-7	4.50	-	-	-	-	-	-	-	-	12	A-6a (V)	-	
VERY STIFF, GRAY, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP	762.3	19–20	6 9 9	27	89	SS-8A	-	-	-	-	-	-	-	-	-	8	A-4a (V)	-	
MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE CLAY, TRACE GRAVEL, TRACE SILT, DAMP	760.4					SS-8B	-	-	-	-	-	-	-	-	-	19	A-3a (V)	-	
HARD, GRAY, **SANDY SILT**, SOME GRAVEL, TRACE CLAY, DAMP	757.9	21–23	9 14 29	64	89	SS-9	-	20	9	26	39	6	19	13	6	13	A-4a (2)	-	
VERY DENSE, GRAY, **FINE SAND**, SOME GRAVEL, TRACE SHALE FRAGMENTS, TRACE SILT, TRACE CLAY, DAMP	755.4	24–25 (▼ 755.9)	30 40 50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	6	A-3 (V)	-	
DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE GRAVEL, LITTLE SILT, TRACE CLAY, DAMP	752.9	26–28	21 17 16	49	100	SS-11	-	-	-	-	-	-	-	-	-	12	A-3a (V)	-	
VERY DENSE, GRAY, **FINE SAND**, SOME GRAVEL. TRACE SILT, TRACE CLAY, DAMP	751.4	29–30 EOB	7 18 31	73	94	SS-12	-	-	-	-	-	-	-	-	-	12	A-3 (V)	-	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 8 CF BENTONITE GROUT

PROJECT: WIL-127-12.43/15.09	DRILLING FIRM / OPERATOR: DLZ / VAUL	DRILL RIG: DLZ CME 45 TRACK	STATION / OFFSET: 656+65, 17' LT.	EXPLORATION ID B-002-0-24
TYPE: CULVERT	SAMPLING FIRM / LOGGER: DLZ / KKC	HAMMER: CME AUTOMATIC	ALIGNMENT: US 127 CL	
PID: 114748 SFN: 1806949/1861325	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 2/1/24	ELEVATION: 783.6 (NAVD88) EOB: 30.0 ft.	PAGE 1 OF 1
START: 7/3/24 END: 7/3/24	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.2	LAT / LONG: 41.567021, -84.461441	

MATERIAL DESCRIPTION AND NOTES	ELEV. 783.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
MEDIUM STIFF, BROWN, **SILT AND CLAY**, SOME SAND, SOME GRAVEL, SLIGHTLY ORGANICS, MOIST	780.1		3 2 3	7	39	SS-1	2.00	23	11	22	22	22	27	16	11	20	A-6a (2)	-	
SOFT TO MEDIUM STIFF, BROWN, **SANDY SILT**, SOME GRAVEL, TRACE CLAY, WET Qu = 8.9 PSI = 1,280 PSF	777.6		2 1 2	4	72	SS-2	1.25	26	6	32	33	3	24	15	9	21	A-4a (0)	-	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, DAMP	775.1		2 8 9	25	83	SS-3	4.50	3	9	31	26	31	34	20	14	16	A-6a (6)	-	
VERY STIFF TO HARD, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	772.6		3 8 10	27	83	SS-4	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	-	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP	770.1		2 5 9	21	72	SS-5	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
STIFF TO VERY STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	767.6		1 3 5	12	83	SS-6	3.25	5	6	9	22	58	30	16	14	16	A-6a (10)	-	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	765.1		3 11 19	45	83	SS-7	-	-	-	-	-	-	-	-	-	12	A-4a (V)	-	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, SOME SAND, DAMP			2 7 11	27	89	SS-8	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	-	
@21': TRACE GRAVEL	760.1		9 13 15	42	78	SS-9	-	2	5	16	25	52	26	15	11	11	A-6a (8)	-	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, DAMP			8 20 29	73	89	SS-10	-	-	-	-	-	-	-	-	-	9	A-4a (V)	-	
			27 43 44	129	100	SS-11	-	-	-	-	-	-	-	-	-	6	A-4a (V)	-	
	753.6	EOB 30	26 37 36	109	83	SS-12	-	-	-	-	-	-	-	-	-	6	A-4a (V)	-	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 8 CF BENTONITE GROUT

PROJECT: WIL-127-12.43/15.09	DRILLING FIRM / OPERATOR: DLZ / VAUL	DRILL RIG: DLZ CME 45 TRACK	STATION / OFFSET: 796+72, 7' RT.	EXPLORATION ID B-003-0-24
TYPE: CULVERT	SAMPLING FIRM / LOGGER: DLZ / KKC	HAMMER: CME AUTOMATIC	ALIGNMENT: US 127 CL	
PID: 114748 SFN: 1806949/1861325	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 2/1/24	ELEVATION: 787.6 (NAVD88) EOB: 29.8 ft.	PAGE 1 OF 1
START: 7/2/24 END: 7/2/24	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.2	LAT / LONG: 41.593851, -84.428539	

MATERIAL DESCRIPTION AND NOTES	ELEV. 787.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
ASPHALT - 8 INCHES	786.9																		
AGGREGATE BASE - 1 INCH	786.8	1																	
VERY LOOSE, BROWN, **COARSE AND FINE SAND**, SOME CLAY, TRACE GRAVEL, TRACE SILT, MOIST	784.1	2–3	2 2 1	4	67	SS-1	-	-	-	-	-	-	-	-	-	12	A-3a (V)	-	
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, MOIST Qu = 22.7 PSI = 3,270 PSF		4–5	1 2 2	6	56	SS-2	3.50	-	-	-	-	-	-	-	-	16	A-6a (V)	-	
@6': "AND" SAND, TRACE GRAVEL	779.1	6–8	1 1 2	4	72	SS-3	1.75	1	3	39	38	19	27	16	11	21	A-6a (5)	-	
MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, MOIST	776.6	9–10	1 3 5	12	67	SS-4	-	-	-	-	-	-	-	-	-	20	A-3a (V)	-	
MEDIUM DENSE, GRAY, **FINE SAND**, TRACE SILT, TRACE CLAY, MOIST	774.1	11–13	3 7 5	18	61	SS-5	-	-	-	-	-	-	-	-	-	21	A-3 (V)	-	
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, MOIST	771.6	14–15	2 2 3	7	72	SS-6	1.25	-	-	-	-	-	-	-	-	22	A-6a (V)	-	
MEDIUM STIFF TO STIFF, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, MOIST Qu = 18.2 PSI = 2,620 PSF	769.1	16–18 (771.1)	1 2 3	7	89	SS-7	1.75	1	1	4	26	68	37	20	17	23	A-6b (11)	-	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, MOIST	766.6	19–20	2 3 6	13	100	SS-8	3.75	-	-	-	-	-	-	-	-	10	A-6b (V)	-	
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME CLAY, SOME GRAVEL, TRACE SILT, MOIST	764.1	21–23	5 12 26	56	78	SS-9	-	-	-	-	-	-	-	-	-	16	A-3a (V)	-	
DENSE, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	761.6	24–25	11 13 15	42	78	SS-10	-	7	4	35	44	10	NP	NP	NP	19	A-4a (4)	-	
HARD, GRAY, **SILT AND CLAY**, TRACE SAND, MOIST	759.1	26–28	9 13 20	49	89	SS-11	-	-	-	-	-	-	-	-	-	17	A-6a (V)	-	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE CLAY, MOIST	757.8	29 — EOB	13 50 50/3"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	A-4a (V)	-	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 8 CF BENTONITE GROUT

PROJECT: WIL-127-12.43/15.09 TYPE: CULVERT PID: 114748 SFN: 1806949/1861325 START: 7/2/24 END: 7/2/24	DRILLING FIRM / OPERATOR: DLZ / VAUL SAMPLING FIRM / LOGGER: DLZ / KKC DRILLING METHOD: 3.25" HSA SAMPLING METHOD: SPT	DRILL RIG: DLZ CME 45 TRACK HAMMER: CME AUTOMATIC CALIBRATION DATE: 2/1/24 ENERGY RATIO (%): 89.2	STATION / OFFSET: 796+95, 12' LT. ALIGNMENT: US 127 CL ELEVATION: 787.1 (NAVD88) EOB: 29.8 ft. LAT / LONG: 41.593927, -84.428562	EXPLORATION ID B-004-0-24 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 787.1	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
ASPHALT - 9 INCHES	786.3																		
AGGREGATE BASE - 3 INCHES	786.1																		
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	783.6	1 – 3	2 / 2 / 3	7	61	SS-1	3.50	-	-	-	-	-	-	-	-	15	A-6b (V)	-	
VERY LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE CLAY, TRACE GRAVEL, TRACE SILT, MOIST		4 – 5	1 / 1 / 2	4	67	SS-2	-	-	-	-	-	-	-	-	-	18	A-3a (V)	-	
@6': Loose	778.6	6 – 8	3 / 1 / 3	6	83	SS-3	-	-	-	-	-	-	-	-	-	17	A-3a (V)	-	
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST	776.1	9 – 10	2 / 3 / 5	12	72	SS-4	-	3	2	49	41	5	NP	NP	NP	19	A-4a (2)	-	
MEDIUM STIFF TO STIFF, GRAY, **SANDY SILT**, "AND"CLAY, WET		11 – 13	3 / 5 / 4	13	72	SS-5	1.00	0	2	6	41	51	23	20	3	21	A-4a (8)	-	
@13.5' LITTLE CLAY, Qu =12.6 PSI =1815 PSF		14 – 15	1 / 2 / 3	7	83	SS-6	1.75	-	-	-	-	-	-	-	-	22	A-4a (V)	-	
@16': LITTLE GRAVEL, DAMP	768.6	16 – 18	2 / 3 / 3	9	83	SS-7	2.00	12	9	27	40	12	19	14	5	11	A-4a (3)	-	
DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE CLAY, LITTLE SILT, MOIST	766.1	19 – 20	3 / 11 / 11	33	94	SS-8	-	-	-	-	-	-	-	-	-	16	A-3a (V)	-	
VERY DENSE, GRAY, **FINE SAND**, TRACE SILT, TRACE CLAY, MOIST		21 – 23	17 / 32 / 39	106	89	SS-9	-	-	-	-	-	-	-	-	-	17	A-3 (V)	-	
	761.1	24 – 25	22 / 31 / 40	106	83	SS-10	-	-	-	-	-	-	-	-	-	20	A-3 (V)	-	
MEDIUM DENSE, GRAY, **FINE SAND**, TRACE SILT, TRACE CLAY, MOIST	759.9	26 – 27	15 / 9 / 9	27	61	SS-11A	-	-	-	-	-	-	-	-	-	23	A-3 (V)	-	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, TRACE SAND, MOIST	758.6	28				SS-11B	4.50	-	-	-	-	-	-	-	-	17	A-6a (V)	-	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, MOIST	757.3	29 – EOB	14 / 38 / 50/3"	-	87	SS-12	4.50	-	-	-	-	-	-	-	-	11	A-4a (V)	-	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 8 CF BENTONITE GROUT

KEY TO SYMBOLS

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WIL-127-12.43/15.09 **PID** 114748
OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

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

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

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

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

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

PAVEMENT OR BASE: Ohio DOT: Pavement or Aggregate base

TOPSOIL: Ohio DOT: Sod and Topsoil

SAMPLER SYMBOLS

WELL CONSTRUCTION SYMBOLS

Bentonite: Bottom of hole

Asphalt or Concrete Pavement Patch

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)

TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION
Water Level at Time Drilling, or as Shown
Water Level at End of Drilling, or as Shown
Water Level After 24 Hours, or as Shown

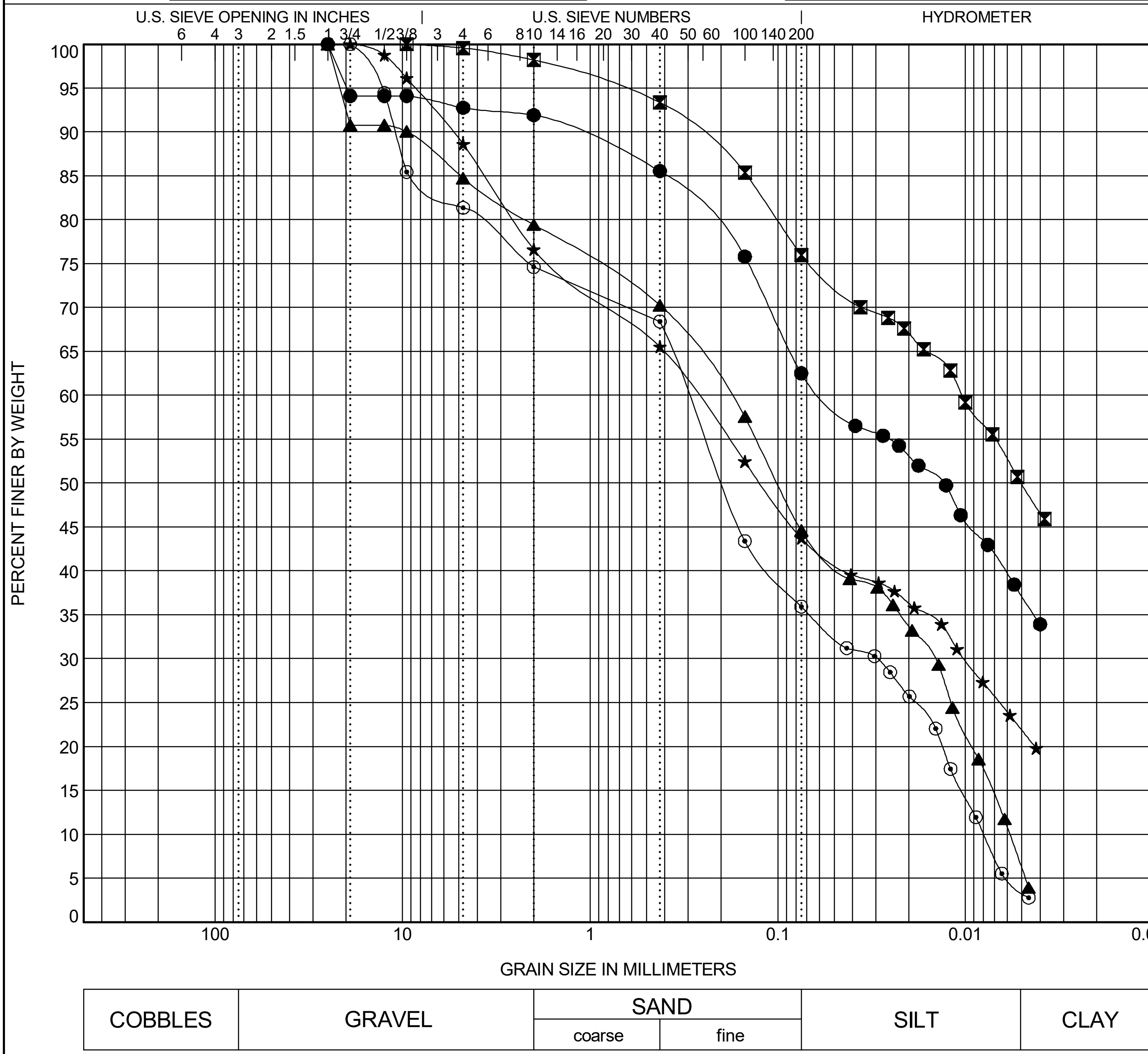
KEY TO SYMBOLS - OH DOT.GDT - 3/4/25 08:03 - X:\PROJECTS\241804.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WIL-127-12.43/15.09 **PID** 114748

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-0-24	3.5	A-6a ~ SANDY LEAN CLAY(CL)	28	17	11
⧗	B-001-0-24	8.5	A-6a ~ LEAN CLAY with SAND(CL)	31	18	13
▲	B-001-0-24	21.0	A-4a ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)	19	13	6
★	B-002-0-24	1.0	A-6a ~ CLAYEY SAND(SC)	27	16	11
⊙	B-002-0-24	3.5	A-4a ~ CLAYEY SAND with GRAVEL(SC)	24	15	9

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-24	3.5	1.256	0.013			8	6	23	26	37		
⧗	B-001-0-24	8.5	0.274	0.005			2	5	17	26	50		
▲	B-001-0-24	21.0	9.438	0.1	0.015	0.006	20	9	26	39	6	0.20	31.58
★	B-002-0-24	1.0	5.393	0.123	0.01		23	11	22	22	22		
⊙	B-002-0-24	3.5	10.914	0.198	0.03	0.008	26	6	32	33	3	0.37	37.44

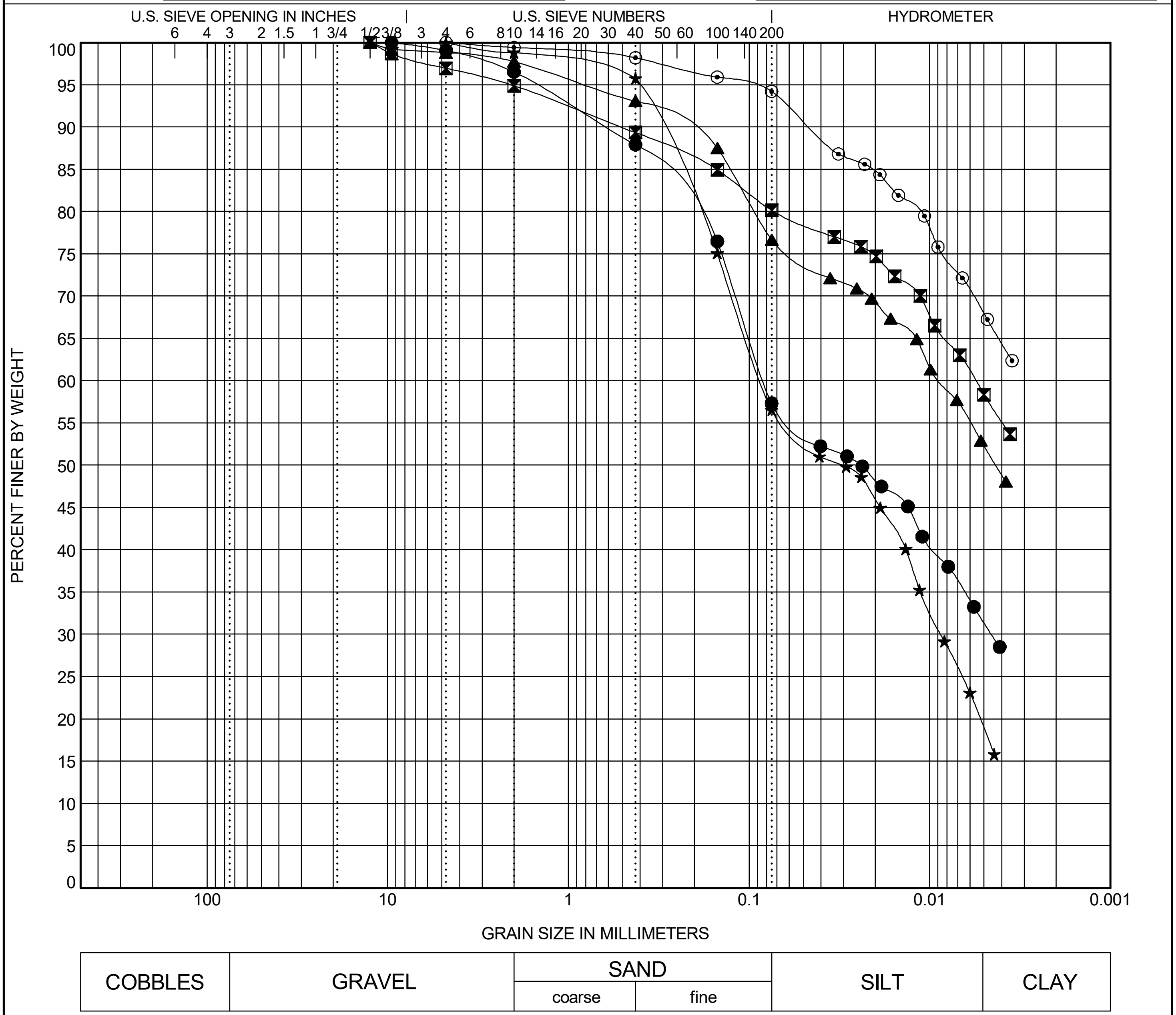
GRAIN SIZE - OH DOT.GDT - 3/4/25 08:02 - X:\PROJECTS\241804.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WIL-127-12.43/15.09 **PID** 114748

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-002-0-24	6.0	**A-6a ~ SANDY LEAN CLAY(CL)**	34	20	14
⊠ B-002-0-24	13.5	**A-6a ~ LEAN CLAY with SAND(CL)**	30	16	14
▲ B-002-0-24	21.0	**A-6a ~ LEAN CLAY with SAND(CL)**	26	15	11
★ B-003-0-24	6.0	**A-6a ~ SANDY LEAN CLAY(CL)**	27	16	11
⊙ B-003-0-24	16.0	**A-6b ~ LEAN CLAY(CL)**	37	20	17

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-002-0-24	6.0	0.618	0.024	0.005		3	9	31	26	31		
⊠ B-002-0-24	13.5	0.51				5	6	9	22	58		
▲ B-002-0-24	21.0	0.239	0.004			2	5	16	25	52		
★ B-003-0-24	6.0	0.318	0.03	0.009		1	3	39	38	19		
⊙ B-003-0-24	16.0	0.046				1	1	4	26	68		

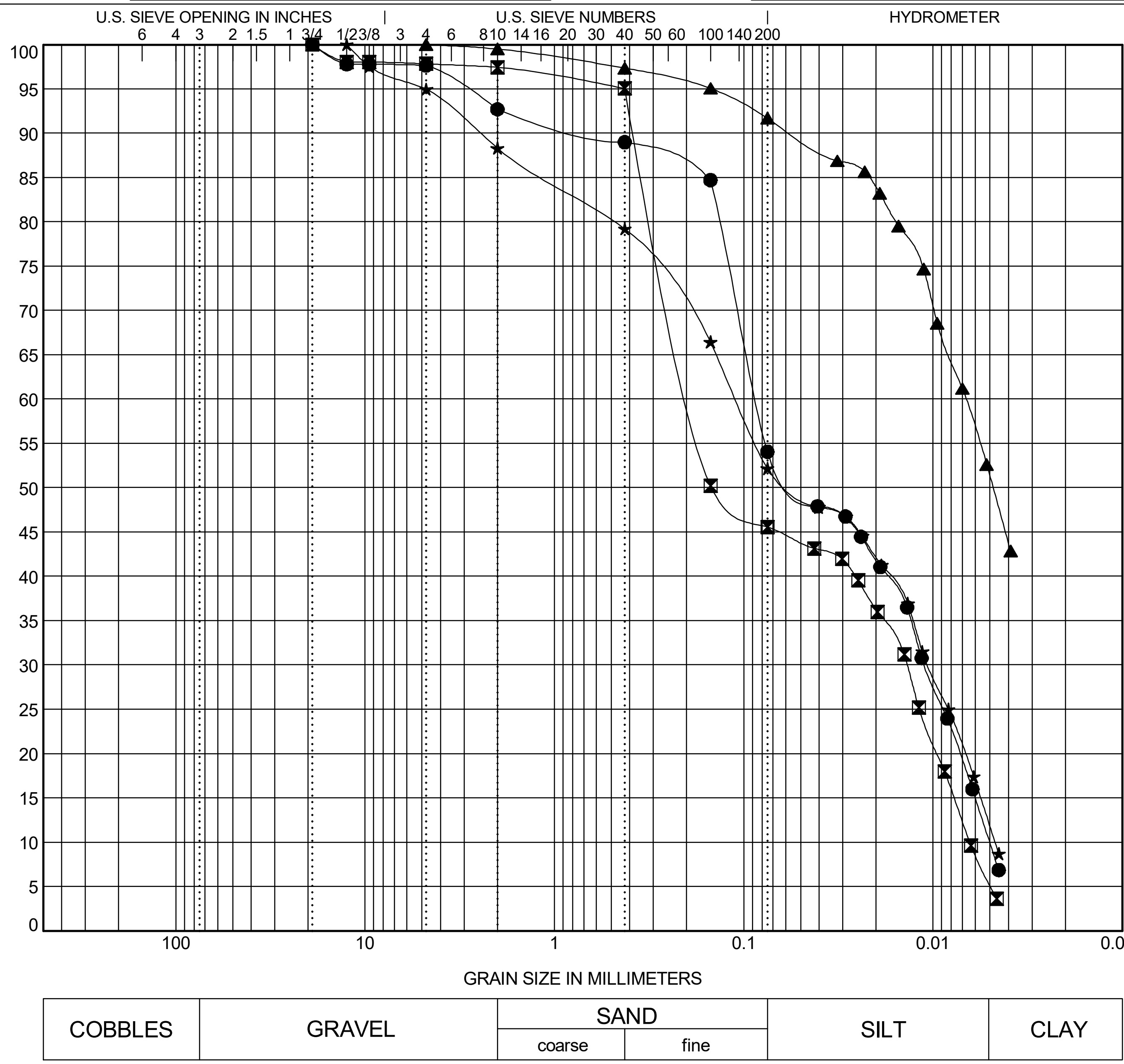
GRAIN SIZE - OH DOT.GDT - 3/4/25 08:02 - X:\PROJECTS\241804.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WIL-127-12.43/15.09 **PID** 114748

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-003-0-24	23.5	**A-4a ~ SANDY SILT(ML)**	NP	NP	NP
⊠ B-004-0-24	8.5	**A-4a ~ SILTY SAND(SM)**	NP	NP	NP
▲ B-004-0-24	11.0	**A-4a ~ SILT(ML)**	23	20	3
★ B-004-0-24	16.0	**A-4a ~ SANDY SILTY CLAY(CL-ML)**	19	14	5

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-003-0-24	23.5	0.649	0.05	0.011	0.005	7	4	35	44	10	0.29	17.06
⊠ B-004-0-24	8.5	0.378	0.145	0.014	0.006	3	2	49	41	5	0.16	29.42
▲ B-004-0-24	11.0	0.056	0.005			0	2	6	41	51		
★ B-004-0-24	16.0	2.49	0.055	0.011	0.005	12	9	27	40	12	0.22	23.29

CORE LOG for X-001-0-24

Project: Prop. Culvert Replacement WIL-127-12.43

Project Location: Jefferson Township, Williams County, OH

CT Project No. 241804

Core Date: August 15, 2024

ASPHALT THICKNESS (in)	=	13.25
AGGREGATE BASE THICKNESS (in)	=	4
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Apparent delamination at approximately 5.5 inches below top of pavement.

CT consultants
engineers • architects • planners
a verdantas company

CORE LOG for X-002-0-24

Project: Prop. Culvert Replacement WIL-127-12.43

Project Location: Jefferson Township, Williams County, OH

CT Project No. 241804

Core Date: August 15, 2024

ASPHALT THICKNESS (in)	=	14.5
AGGREGATE BASE THICKNESS (in)	=	4.5
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

consultants
engineers • architects • planners
a verdantas company

CORE LOG for B-003-0-24

Project: Prop. Culvert Replacement WIL-127-15.09

Project Location: Brady Township, Williams County, OH

CT Project No. 241804

Core Date: July 2, 2025

ASPHALT THICKNESS (in)	=	8.0
AGGREGATE BASE THICKNESS (in)	=	1
CORE BARREL DIAMETER (in)	=	8.0

VISUAL DESCRIPTION:

CORE LOG for B-004-0-24

Project: Prop. Culvert Replacement WIL-127-15.09
Project Location: Brady Township, Williams County, OH
CT Project No. 241804
Core Date: July 2, 2025

ASPHALT THICKNESS (in)	=	9.0
AGGREGATE BASE THICKNESS (in)	=	3
CORE BARREL DIAMETER (in)	=	8.0

VISUAL DESCRIPTION:

Vertical cracks observed extending from the surface to a depth of approximately 2 inches.

APPENDIX A
Engineering Calculations

consultants
engineers • architects • planners
a verdantas company

CT No.:	**241804**											
Project:	**WIL-127-12.43/15.09, PID 114748**											
Calcs by:	**C. Olson**				**Reviewed by:**	**C. Iott**			**Revised Bearing Elevs.:**	**C. Iott**		
Date:	**2/19/2025**				**Date:**	**3/3/2025**			**Date:**	**6/19/2025**		
Subject:	**Average Shear Strength Evaluations for Cohesive Soils**											
											Recommended	
Top Depth	**Bottom Depth**	**Top Elev.**	**Bottom Elev.**	**Thickness**	**N60**	**Su=N60*125**	**HP**	**Su=HP*1000**	**Qu**	**Su=Qu/2**	**Su**	
(ft)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(bpf)**	**(psf)**	**(tsf)**	**(psf)**	**(psf)**	**(psf)**	**(psf)**	**Notes**
WIL-127-12.43			**Approx. Headwall Bearing Elev.:**		**773.15**							
Boring No.:	**B-001-0-24**		**Boring Ground Surface Elev.:**		**781.4**							
6	8.5	775.4	772.9	2.5	16	2000	4.5	4500	-	-	2000	
8.5	11	772.9	770.4	2.5	18	2250	4.5	4500	8130	4065	4065	Average Su ~3030 psf over ~1 width of foundation.
11	13.5	770.4	767.9	2.5	15	1875	4.5	4500	-	-	1875	
13.5	16	767.9	765.4	2.5	13	1625	4.0	4000	-	-	1625	Average Su ~2390 psf over ~2 times width of foundation.
16	18.5	765.4	762.9	2.5	18	2250	4.5	4500	-	-	2250	
18.5	19.1	762.9	762.3	0.6	18	2250	-	-	-	-	3375	
21	23.5	760.4	757.9	2.5	64	7586	-	-	-	-	7585	f1=5.6 using PI=6
For N60>52 bpf, Su calculated per Stroud (1974, 1989)										**Weighted Average Su (psf):**	**3083**	**Meets minimum Su=1500 psf requirement**
WIL-127-12.43			**Approx. Headwall Bearing Elev.:**		**773.15**							
Boring No.:	**B-002-0-24**		**Boring Ground Surface Elev.:**		**783.6**							
8.5	11	775.1	772.6	2.5	27	3375	4.5	4500	-	-	3375	
11	13.5	772.6	770.1	2.5	21	2625	4.5	4500	-	-	2625	
13.5	16	770.1	767.6	2.5	12	1500	3.25	3250	-	-	1500	Average Su ~2500 psf over ~1 width of foundation.
16	18.5	767.6	765.1	2.5	45	5625	-	-	-	-	5625	
18.5	21	765.1	762.6	2.5	27	3375	4.5	4500	-	-	3375	Average Su ~3300 psf over ~2 times width of foundation.
21	23.5	762.6	760.1	2.5	42	5250	-	-	-	-	5250	
23.5	26	760.1	757.6	2.5	73	8652	-	-	-	-	8650	f1=5.6 using PI=6 per sandy silt in B-001
26	28.5	757.6	755.1	2.5	129	15290	-	-	-	-	15290	f1=5.6 using PI=6 per sandy silt in B-001
28.5	30	755.1	753.6	1.5	109	12919	-	-	-	-	12915	f1=5.6 using PI=6 per sandy silt in B-001
For N60>52 bpf, Su calculated per Stroud (1974, 1989)										**Weighted Average Su (psf):**	**5848**	**Meets minimum Su=1500 psf requirement**
WIL-127-15.09			**Approx. Headwall Bearing Elev.:**		**773.46**							
Boring No.:	**B-003-0-24**		**Boring Ground Surface Elev.:**		**787.6**							
13.5	16	774.1	771.6	2.5	7	875	1.25	1250	-	-	1000	
16	18.5	771.6	769.1	2.5	7	875	1.75	1750	-	-	1000	
18.5	21	769.1	766.6	2.5	13	1625	3.75	3750	2620	1310	1500	Average Su ~1160 psf over ~1 width of foundation.
26	28.5	761.6	759.1	2.5	49	6125	-	-	-	-	6125	Average Su ~2400 psf over ~2 times width of foundation.
28.5	29.8	759.1	757.8	1.3	SSR	11852	-	-	-	-	11850	f1=5.6 using PI=5 per sandy silt in B-004, using N60=100
For N60>52 bpf, Su calculated per Stroud (1974, 1989)										**Weighted Average Su (psf):**	**3360**	**Although average condition full-depth meets minimum Su=1500 psf requirement, the average strength of the soils at and within 1 foundation width do not meet minimum requirements. Undercut about 4-1/2 feet to suitable cohesive soils, or special headwall design using Su=1160 psf.**

CT No.	**241804**											
Project:	**WIL-127-12.43/15.09, PID 114748**											
Calcs by:	**C. Olson**				**Reviewed by:**	**C. Iott**			**Revised Bearing Elevs.:**	**C. Iott**		
Date:	**2/19/2025**				**Date:**	**3/3/2025**			**Date:**	**6/19/2025**		
Subject:	**Average Shear Strength Evaluations for Cohesive Soils**											
											Recommended	
Top Depth	**Bottom Depth**	**Top Elev.**	**Bottom Elev.**	**Thickness**	**N60**	**Su=N60*125**	**HP**	**Su=HP*1000**	**Qu**	**Su=Qu/2**	**Su**	
(ft)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(bpf)**	**(psf)**	**(tsf)**	**(psf)**	**(psf)**	**(psf)**	**(psf)**	**Notes**
WIL-127-15.09				**Approx. Headwall Bearing Elev.:**	**773.46**							
Boring No.:	**B-004-0-24**			**Boring Ground Surface Elev.:**	**787.1**							
13.5	16	773.6	771.1	2.5	7	875	1.75	1750	1815	908	1000	
16	18.5	771.1	768.6	2.5	9	1125	2.0	2000	-	-	1125	Average Su ~1060 psf over ~1 width of foundation.
27.2	28.5	759.9	758.6	1.3	27	3375	4.5	4500	-	-	3375	
28.5	29.8	758.6	757.3	1.3	SSR	11852	4.5	4500	-	-	11850	f1=5.6 using PI=5 per shallower sandy silt, using N60=100
For N60>52 bpf, Su calculated per Stroud (1974, 1989)										**Weighted Average Su (psf):**	**3303**	**Although average condition full-depth meets minimum Su=1500 psf requirement, the soils at and within 1 foundation width do not meet minimum requirements. Undercut about 5 feet to suitable granular soils, or special headwall design using Su=1060 psf.**

CT No.	**241804**					
Project:	**WIL-127-12.43**					
Calcs by:	**C. Olson**		**Checked by:**	**C. Iott**		
Date:	**2/19/2025**		**Date:**	**3/3/2025**		
Calcs:	**Average Phi for culvert headwall bearing soils**					
Boring:	B-001-0-24					
GSE (ft):	781.4					
Long-Term GWT (ft):	775.4					
Approx. Headwall Bearing Elev. (ft):	774					
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 1	**Medium Dense A-3a**	19.1	21	762.3	760.4	27
Note:	**Approximately 11-1/2 ft below headwall bearing Elev.**					
Total Unit Wt (pcf):	128	GDM Table 400-4		**Use**	**125**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	20.05	ft				
sigma-v' (ksf):	1.53					
CN=	1.09	<2.0, use	1.09			
N160 (bpf)=	29					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
10	32.5					
30	37.5					
N160	Phi (deg)					
29	37.4	use	37	deg		
GDM Table 400-3 phi Adjustment						
A-3a	-0.5					
Phi (deg) =	**36.5**		**Greater than 28 deg**			
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 2	**Dense to Very Dense A-3 & A-3a**	23.5	30	757.9	751.4	49, 73, SSR
By inspection, this material has higher phi and total unit weight than the Granular Layer 1 material. Therefore, this material will also meet minimum requirements for standard headwall design.						

CT No.	**241804**					
Project:	**WIL-127-15.09**					
Calcs by:	**C. Olson**		**Checked by:**	**C. Iott**		
Date:	**2/19/2025**		**Date:**	**3/3/2025**		
Calcs:	**Average Phi for culvert headwall bearing soils**					
Boring:	B-003-0-24					
GSE (ft):	787.6					
Long-Term GWT (ft):	779.1					
Approx. Headwall Bearing Elev. (ft):	773					
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 1	**Very Dense A-3a**	21	23.5	766.6	764.1	56
Note:	**Approx. 6 ft below headwall bearing Elev.**					
Total Unit Wt (pcf):	135	GDM Table 400-4		**Use**	**135**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	22.25	ft				
sigma-v' (ksf):	1.79					
CN=	1.04	<2.0, use	1.04			
N160 (bpf)=	58					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
30	37.5					
50	40.5					
N160	Phi (deg)					
58	41.7	use	41.5	deg		
GDM Table 400-3 phi Adjustment						
A-3a	-0.5					
Phi (deg) =	**41.0**		**Greater than 28 deg**			
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 2	**Dense NP Sandy Silt (A-4a)**	23.5	26	764.1	761.6	42
Total Unit Wt (pcf):	130	GDM Table 400-4		**Use**	**130**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	24.75	ft				
sigma-v' (ksf):	1.96					
CN=	1.01	<2.0, use	1.01			
N160 (bpf)=	42					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
30	37.5					
50	40.5					
N160	Phi (deg)					
42	39.4	use	39.0	deg		
GDM Table 400-3 phi Adjustment						
A-4a	-2.5					
Phi (deg) =	**36.5**		**Greater than 28 deg**			

CT No.:	**241804**					
Project:	**WIL-127-15.09**					
Calcs by:	**C. Olson**		**Checked by:**	**C. Iott**		
Date:	**2/19/2025**		**Date:**	**3/3/2025**		
Calcs:	**Average Phi for culvert headwall bearing soils**					
Boring:	B-004-0-24					
GSE (ft):	787.1					
Long-Term GWT (ft):	776.1					
Approx. Headwall Bearing Elev. (ft):	773					
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 1	**Dense A-3a**	18.5	21	768.6	766.1	33
Note:	**Approx. 4 ft below headwall bearing Elev.**					
Total Unit Wt (pcf):	128	GDM Table 400-4		**Use**	**125**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	19.75	ft				
sigma-v' (ksf):	1.83					
CN=	1.03	<2.0, use	1.03			
N160 (bpf)=	34					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
30	37.5					
50	40.5					
N160	Phi (deg)					
34	38.1	use	38	deg		
GDM Table 400-3 phi Adjustment						
A-3a	-0.5					
Phi (deg) =	**37.5**		**Greater than 28 deg**			
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 2	**Very Dense A-3**	21	26	766.1	761.1	106
Total Unit Wt (pcf):	140	GDM Table 400-4		**Use**	**140**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	23.5	ft				
sigma-v' (ksf):	2.10					
CN=	0.99	<2.0, use	0.99			
N160 (bpf)=	104					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
30	37.5					
50	40.5					
N160	Phi (deg)					
104	48.7	use	46.5	deg		
GDM Table 400-3 phi Adjustment			Limiting so GDM max 45 deg is calculated			
A-3	-1.5		when applying phi adjustment.			
Phi (deg) =	**45.0**		**Greater than 28 deg**			

CT No.	**241804**					
Project:	**WIL-127-15.09**					
Calcs by:	**C. Olson**		**Checked by:**	**C. Iott**		
Date:	**2/19/2025**		**Date:**	**3/3/2025**		
Calcs:	**Average Phi for culvert headwall bearing soils**					
Boring:	B-004-0-24					
GSE (ft):	787.1					
Long-Term GWT (ft):	776.1					
Approx. Headwall Bearing Elev. (ft):	773					
Layer	**Soil Type**	**Top Depth (ft)**	**Bottom Depth (ft)**	**Top Elev. (ft)**	**Bottom Elev. (ft)**	**N60**
Granular Layer 3	**Medium Dense A-3**	26	27.2	761.1	759.9	27
Total Unit Wt (pcf):	128	GDM Table 400-4		**Use**	**125**	**pcf**
Internal Angle of Friction Determination (GDM 404.2):						
N160 (bpf)=CN*N60	AASHTO LRFD 10.4.6.2.4					
CN=0.77log(40/sigma-v'), with CN<2.0						
CN at	26.6	ft				
sigma-v' (ksf):	2.33					
CN=	0.95	<2.0, use	0.95			
N160 (bpf)=	26					
AASHTO LRFD Table 10.4.6.2.4-1						
N160	Mid-Range Phi (deg)					
10	32.5					
30	37.5					
N160	Phi (deg)					
26	36.4	use	36.0	deg		
GDM Table 400-3 phi Adjustment						
A-3	-1.5					
Phi (deg) =	**34.5**		**Greater than 28 deg**			

APPENDIX B

Engineering Checklists

consultants
engineers • architects • planners
a verdantas company

I. Geotechnical Design Checklists

Project: WIL-127-12.43/15.09	PDP Path:
PID: 114748	Review Stage:

Checklist	Included in This Submission
II. Reconnaissance and Planning	✓
III. A. Centerline Cuts III. B. Embankments III. C. Subgrade	
IV. A. Foundations of Structures IV. B. Retaining Wall	 ✓
V. A. Landslide Remediation V. B. Rockfall Remediation V. C. Wetland or Peat Remediation V. D. Underground Mine Remediation V. E. Surface Mine Remediation V. F. Karst Remediation	
VI. A. Geotechnical Profile VI. D. Geotechnical Reports	 ✓

II. Reconnaissance and Planning Checklist

C-R-S: WIL-127-12.43/15.09	PID: 114748	Reviewer: CPI	Date: 3/3/2025

Reconnaissance		(Y/N/X)	Notes:
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:	N	Borings performed at existing culverts to be replaced. Plans subsequently provided for the Geotechnical Profile preparation.
	Roadway plans		
	Structures plans	✓	
	Geohazards plans		
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	Y	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	
8	Have 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	
9	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	

II. Reconnaissance and Planning Checklist

Planning - General		(Y/N/X)	Notes:
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?	N	Sent to ODOT District 2 for Task Order, but proposal was not sent directly to the DGE.
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	N	Included in draft report but not in proposal.
c.	estimated amount of rock and soil, including the total for each for the entire program.	Y	
Planning – Exploration Number		**(Y/N/X)**	**Notes:**
11	Have the coordinates, stations and offsets of all explorations (borings, soundings, test pits, etc.) been identified?	Y	
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	
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?	X	No historic borings in the project areas.

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 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:		
	Existing Subgrades (Type A)		
	Roadway Borings (Type B)		
	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)		
	Rock Slope (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)		
	Bridges (Type E1)		
	Culverts (Type E2 a,b,c)	✓	
	Retaining Walls (Type E3 a and b)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

IV.B. Retaining Wall Checklist

C-R-S:	WIL-127-12.43/15.09	PID:	114748	Reviewer:	CPI	Date:	3/3/2025

If you do not have a retaining wall on the project, you do not have to fill out this checklist.

Soil Data and Preliminary Calculations		(Y/N/X)	Notes:
1	Has a justification study been performed to determine the necessity of a wall as opposed to ROW purchase or other project alternatives?	X	Headwalls for culverts.
2	Have the necessary soil strength parameters and unit weights been determined?	Y	
	Check method used:		
	laboratory shear tests	✓	
	estimation from SPT or field tests	✓	
3	Has the groundwater elevation been determined?	Y	
4	Have the proper loading conditions been determined?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
a.	If yes, check which loading conditions apply:		
	Backfill (Active Earth Pressure Loading):		
	Backfill (Apparent Earth Pressure (AEP) Loading for Ground Anchors):		
	Backfill (At-Rest Earth Pressure Loading):		
	Backfill (Flat, No Slope):		
	Backfill (Infinite Slope):		
	Backfill (Broken Back Slope):		
	Earth Surcharge:		
	Live Load Surcharge:		
	Other (describe):		
5	Have the correct Load Factors, Load Combinations, and Limit States been considered, per AASHTO LRFD 9th Ed. Articles 3.4.1, 10.5, and 11.5?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
6	Are earth pressure loads inclined at the soil-structure interaction friction angle, δ and has δ been determined per BDM 307.1.1?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
7	Have the correct Resistance Factors been considered, per AASHTO LRFD 9th Ed. Articles 10.5 and 11.5?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
8	If applicable, has the influence of groundwater been taken into account with regards to soil unit weights and active pressures?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
9	Has the Coulomb method been utilized to determine the lateral earth pressure?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
10	For preliminary wall design, have the design criteria and wall type selection process been followed as instructed in BDM 201.1.2.5?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
11	Was an economic analysis performed to evaluate the cost benefits of the chosen wall type compared to others?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
12	Were representative sections analyzed for the entire length of the retaining wall for the following:	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
a.	bearing resistance?		
b.	sliding resistance?		
c.	limiting eccentricity and overturning resistance? Analyze moment equilibrium about toe for non-gravity cantilever walls.		
d.	total and differential settlement?		
e.	overall (global) stability?		
13	If poor foundation soils are present, has a solution been determined with respect to the following:	Y	
a.	excessive settlement?		
b.	inadequate bearing resistance?	Y	Overexcavation and replacement
c.	inadequate sliding resistance?		
d.	overall (global) instability?		
14	For non-proprietary walls, each wall type has design recommendations which need to be determined. For the wall type being evaluated, have the following design recommendations been determined by accepted design methods or, where applicable, FHWA design guidelines:	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
a.	Rigid Gravity and Semigravity -- footing width and elevation, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance (BDM 307.1.5 & 307.2)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
b.	Drilled Shafts - diameter, spacing, embedment, arrangement and percent reinforcement, maximum moment and lateral shear, maximum deflection (see BDM 307.6)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
c.	Soldier Pile -pile size and type, drilled hole diameter, embedment, spacing, lagging design, facing, maximum moment and lateral shear, section modulus, maximum deflection	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
d.	Sheet Pile - pile size, embedment, maximum moment and lateral shear, section modulus, maximum deflection (BDM 307.7.1)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
e.	Cellular - type, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance, fill material (BDM 307.7.2)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
f.	Soil Anchor - load per anchor, number of rows, wale design, anchor inclination and minimum length, type of anchor, pile size, type, spacing, and embedment, maximum moment and lateral shear, section modulus, lagging design, facing (BDM 307.8)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
g.	Soil Nail - nail size, spacing, inclination, and length, loading per nail, facing (BDM 307.9)	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
15	Has the need for load testing of the retaining wall elements been evaluated?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard
a.	If needed, have details and plan notes for load testing been included in the plans?		
16	Proprietary wall designs require a special process for detail design, as outlined in BDM 307.3 and 307.4. Has this procedure been followed for this project?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
17	Temporary walls - have the same design requirements as permanent walls of the same type been followed, except the design service life is no more than three years (BDM 307.10)?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
18	The presence and quality of water behind the wall structure and in the backfill can be a major source of overloading and failure.	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
a.	Has the quality / chemistry of the groundwater been accounted for in the drainage system?		
b.	Has an adequate drainage system been included in the detail wall design?		
c.	If there is a water source behind the wall, has additional drainage been added to control the effect of this water source on the wall?		
19	Have the effects of the wall design and construction procedure been determined and accounted for on the construction schedule?		Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
20	Has the effect of the wall design and construction been evaluated with regard to structures (e.g., bridges, culverts, buildings, utilities), which may be subject to unusual stresses or require special design or construction considerations?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
Plans and Contract Documents		**(Y/N/X)**	**Notes:**
21	Have all the necessary notes, specifications, special provisions, and details for the construction of the wall system been included in the plans?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
22	Have the need, location, type, plan notes, and reading schedule for any instrumentation been determined and included in the plans?	X	Headwalls for culverts. Foundation soils evaluation for potential use of standard headwalls.
	Check the types of instrumentation specified:		
	settlement cells		
	settlement platforms		
	inclinometers		
	monitoring wells / piezometers		
	load cells		
	strain gages		
	other (describe other types)		

VI.B. Geotechnical Reports

C-R-S: WIL-127-12.43/15.09	PID: 114748	Reviewer: CPI	Date: 8/21/2025

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	This is the FINAL Submittal
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	Y	The gINT project file is being included with this final report submittal.
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:	Y	
a.	an Executive Summary as described in Section 706.2 of the SGE?	Y	
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	X	No undisturbed samples were obtained.
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	Y	