REPORT OF GEOTECHNICAL EXPLORATION

(FINAL)

SEN-23-7.42 Culvert Replacement

PID: 107691
Seneca County, Ohio

Date:

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Prepared for:

Ohio Department of Transportation, District 2

Bowling Green, Ohio

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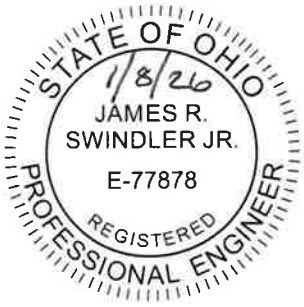


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Executive Summary

The Ohio Department of Transportation (ODOT) plans to replace an existing culvert for a branch of Wolf Creek along U.S. Route 23 south of Fostoria in Seneca County, Ohio. Stantec Consulting Services Inc. conducted a geotechnical exploration to evaluate subsurface conditions and provide design recommendations for the proposed box culvert structure.

Site Conditions and Geology
The project site lies within the Central Ohio Clayey Till Plain, characterized by clayey till and glacial lake deposits. Subsurface soils consist primarily of fine-grained materials such as silt, silty clay, and clay loam, underlain by dolomite bedrock from the Silurian age. No significant karst activity is anticipated, though monitoring during construction is recommended.

Exploration and Testing
Two borings were advanced near the culvert inlet and outlet locations. Laboratory testing included soil classification, Atterberg limits, grain-size analysis, and strength tests (unconsolidated undrained, consolidated undrained triaxial, unconfined compression). Results indicate stiff to very stiff fine-grained soils with low to moderate plasticity and undrained shear strengths averaging 0.5 tsf. Groundwater was encountered between 26 and 35 feet below the surface. Bedrock was encountered at depths ranging from 36 to 38 feet. Bedrock samples exhibited high compressive strength (8,200 to 10,350 psi).

Design Recommendations

- **Culvert Foundation:** The proposed box culvert (102 ft long, 12 ft wide, 5 ft high) will require spread footings at elevations of 790 to 792 feet. To meet ODOT Standard Drawing HW-1.1 requirements, a 2-ft undercut with geogrid reinforcement and No. 57 stone backfill is recommended. Alternatively, site-specific bearing capacities were calculated, with undrained conditions controlling design (controlling factored capacity of 3.8 ksf).

- **Excavation and Safety:** Excavated soils classify as OSHA Type C; slopes should be 1.5:1 (horizontal to vertical).

- **Dewatering:** Anticipate stream diversion and sump pumping during footing installation.

- **Subgrade Treatment:** Global stabilization is required due to unstable subgrade soil. Recommended treatment: Item 204 Excavate and Replace to 12-inch depth with geotextile fabric. Chemical stabilization is not advised.

Acronyms / Abbreviations

Acronym / Abbreviation	Full Name
ASTM	American Society for Testing and Materials
ER	Energy Ratio
CR	County Route
GDM	Geotechnical Design Manual
KSF	Kips per Square Foot
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
PSI	Pounds per Square Inch
SGE	Specifications for Geotechnical Explorations
SPT	Standard Penetration Test
SLM	Straight Line Mileage
SR	State Route
TIMS	Traffic Information Mapping System
TSF	Tons per Square Feet
US	United States
USDA	United States Department of Agriculture
UU	Unconfined Undrained

1 INTRODUCTION

The Ohio Department of Transportation (ODOT) is planning to replace a culvert for a branch of Wolf Creek on United States (US) Route 23 (Fostoria-Carey Rd) south of Fostoria in Seneca County, approximately 0.75 miles north of the intersection of US Route 23 with US Route 224.

Stantec Consulting Services Inc. (Stantec) was contracted to perform the geotechnical exploration and provide design recommendations for the project. Figure 1 shows the site vicinity.

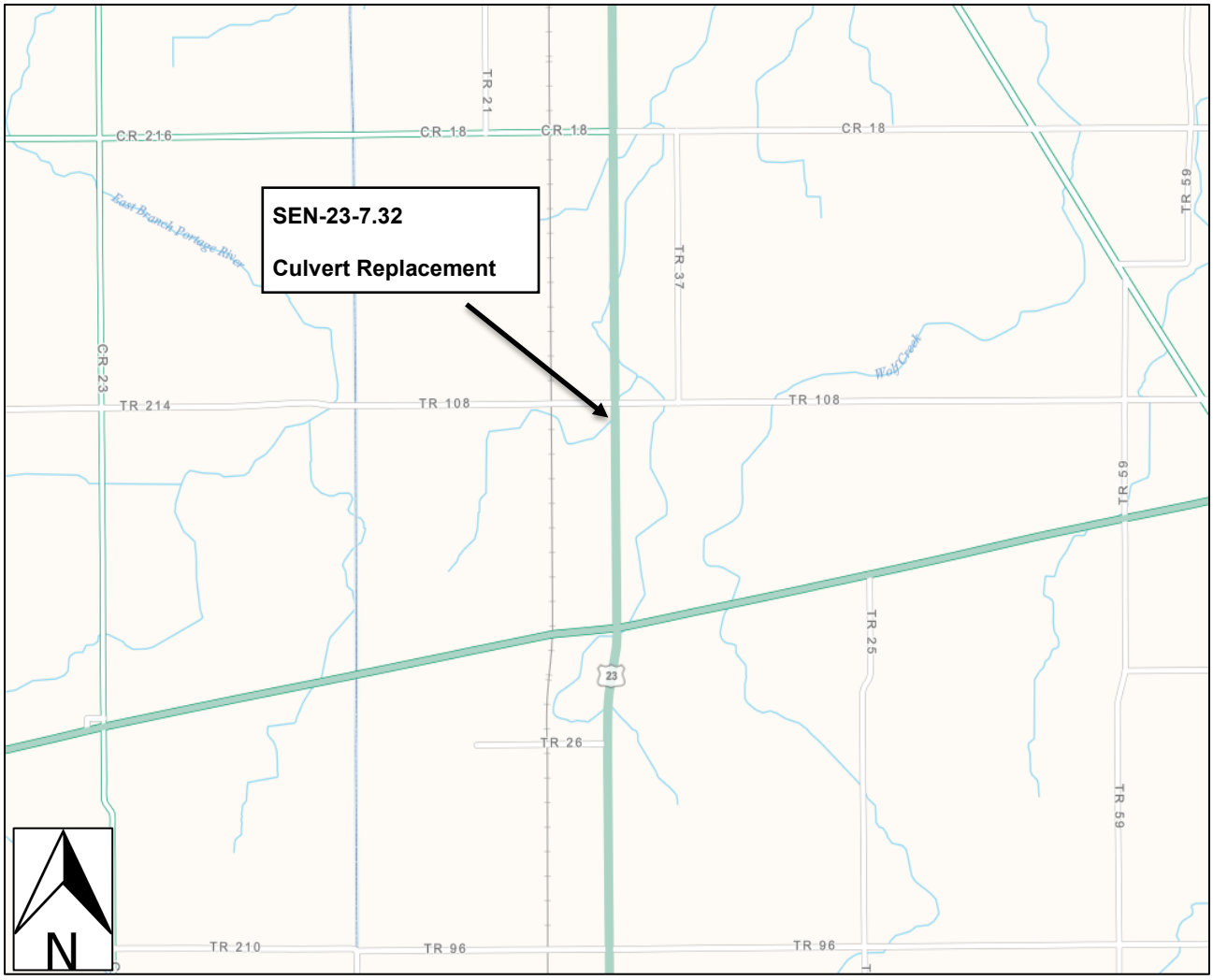


Figure 1: Site Vicinity (from ODOT Traffic Information Mapping System (TIMS, 2025))

2 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The *Physiographic Regions of Ohio Map* (Ohio Department of Natural Resources (ODNR), 1998) indicates that the project site is located within the Central Ohio Clayey Till Plain. The Central Ohio Clayey Till Plain is described as a surface of clayey till and well-defined moraines with intervening flat-lying ground moraines and intermorainal lake basins. The region consists of a dozen silt, clay and till-filled lake basins with no boulder belts ranging in area from a few to 200 square miles and with few large streams having limited sand and gravel outwash. The region has moderate relief (generally about 100 feet) with elevations of 700 to 1150 feet.

2.2 SOIL GEOLOGY

According to the *Quaternary Geology of Ohio Map* (ODNR, 1999), the project site is underlain by clayey till (Hiram, Yorkshire, Lake tills) from the Late Wisconsinan era. These soils are lake-planed moraine, very flat, planted by waves in glacial lakes and consist of small patches of sand, silt, or clay on the surface in many areas. The soil survey (*Web Soil Survey of Seneca County, Ohio*, United States Department of Agriculture, 2025) indicates that the project site is comprised of soils known as Blount silt. These soils are typically silt loam, silty clay, and clay loam. The soil is described as poorly drained with low to moderately high capacity of transmitting water. The *Ohio Geology Interactive Map* (ODNR, 2025) indicates that the project site consists of 51 to 80 feet of glaciated till.

2.3 BEDROCK GEOLOGY

Bedrock mapping (*Ohio Geology Interactive Map*, ODNR, 2025) and *Descriptions of Geologic Map Units* (ODNR, 2011) indicate that the overburden soils at the project site are underlain by sedimentary rock of the Greenfield Dolomite from the Silurian age. The Greenfield Dolomite group consists of argillaceous dolomite and is described as olive gray to yellow brown with thickness ranging from 0 to 80 feet. The diagnostic feature is the absence of shale laminae when compared to overlying unit and sedimentary breccia zones.

According to the *Ohio Oil and Gas Well Viewer Map* (ODNR, 2025), there are up to 15 active or inactive oil and gas wells within 5 miles of the project site. The drilling logs for two inactive wells, located approximately 2 to 3 miles southeast of the site, show a top of bedrock (“Big Lime”) elevation of 750 to 778 feet, which correlates well to the top of bedrock elevation shown on the boring logs in Appendix A. Additional oil and gas wells in the area do not have detailed logs.

According to the *Ohio Mine Locator* (ODNR, 2025), there are three active surface mines producing limestone located approximately 7 to 8 miles south of the site.

The *Karst Interactive Map* (ODNR, 2025) indicates the project site is in Silurian- and/or Devonian-age carbonate bedrock overlain by more than 20 feet of glacial drift and/or alluvium. The depth to bedrock (36 to 38 feet) shown on the boring logs in Appendix A agree with this estimate. Karst activity is not expected to be a concern at the site, but the ground surface during construction should be monitored for the possible development of surface subsidences. Five suspected karst (not verified) are reported about 6 to 7 miles south of the project site. However, the depth to Silurian- and/or Devonian-age carbonate rock at these locations is less than 20 feet, not reflective of the conditions at the project site.

2.4 HYDROLOGY

Drainage from the site location flows to Wolf Creek located approximately 0.5 miles east of the project site. Wolf Creek and tributaries flow approximately 21 miles northeast before joining Sandusky River. The Sandusky River flows approximately 35 miles north and outlets into Lake Erie.

2.5 HYDROGEOLOGY

The *Ohio Geology Interactive Map* shows that the site is underlain by the Tiffin Ground Moraine Aquifer (sand and gravel aquifer), which has a yield of 5 to 25 gallons per minute. According to the *Groundwater Resources of Seneca County Map* (ODNR, 2025), the project site is in an area where wells with yields of 10 to 40 gallons per minute can be achieved.

A search of the ODNR *Ohio Water Wells Map* (2025) reveals eight water wells have been drilled within a 0.5-mile radius of the project site. The well logs indicate that bedrock depth ranges from 23 to 56 feet. The bedrock encountered at these wells were described as limestone and dolomite. The logs also indicate that static water depth in the area ranges from 12 to 17 feet.

2.6 SEISMIC

A review of the seismic data available in the project vicinity was completed using the ODNR *Ohio Earthquake Epicenters Map* (2025). Overall, Ohio has a relatively limited amount of seismic activity. Within a 7-mile radius of the project, there have been three earthquake epicenters with magnitudes of 2.3 to 2.8. The available data reviewed included events that occurred in Ohio from 1886 to present day.

2.7 SITE RECONNAISSANCE

Stantec representatives visited the site on May 13, 2025, to record observations and mark borehole locations. The land surrounding the project site was described as primarily rural with some residential properties and business locations nearby. The US 23 pavement was observed to have longitudinal cracking and rutting. Flow within the creek was minimal, with stagnant water present at the culvert invert beneath the roadway. The areas where the culvert is planned are covered with grass.

3 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Transportation Information Maps System (TIMS) website provides documentation for two geotechnical explorations performed near the culvert replacement project.

WYA-23-24.92, SEN-23-(0.00)(6.69) was an exploration for the roadway along US 23 drilled in 1954 in Wyandot and Seneca counties. The project consisted of about 255 shallow subgrade borings. The overburden soils were classified as gravel with sand, silt and clay (A-2-6), coarse and fine sand (A-3a), sandy silt (A-4a), silt (A-4b), silt and clay (A-6a), and clay (A-7-6). Auger refusal was encountered at several borings, and the bedrock was described as dolomite or sandstone.

SEN-23-8.33 was an exploration for roadway and bridge structures along US 23 bypass around Fostoria, Ohio, in 1979. The project consisted of about 250 borings, including 72 borings for bridges and cut/fill slopes. The overburden soils were classified as gravel with sand and silt (A-2-4), coarse and fine sand (A-3a), sandy silt (A-4a), silt (A-4b), silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). Bedrock was described as limestone or dolomite.

3.2 PROJECT EXPLORATION PROGRAM

Stantec advanced two borings to obtain geotechnical data for the proposed culvert replacement. Two borings were advanced for the culvert at diagonally opposite ends, one in the shoulder of the northbound lane and the other in the shoulder of the southbound lane.

These borings were marked and staked using the approximate location of the culvert provided by District 2. The boring on the roadway shoulder was marked with paint and the offroad boring was staked and flagged with white ribbon. No survey was performed for the boring locations, but approximate locations were recorded using phone GPS application after completion. Elevations, stations, and offsets were determined using the existing topographic contour maps and basemaps provided by ODOT. A summary of these borings is shown in Table 1. Boring locations are shown on the plan and profile sheets in Appendix A.

Table 1. Boring Summary

Boring No.	Station (feet)	Offset (feet)[1]	Alignment	Ground surface Elevation (feet)[1]	Bottom of Boring Elevation (feet)
B-001-0-25	391+29	24 Lt.	US 23	801.3	759.6
B-002-0-25	391+99	14 Rt.	US 23	801.5	757.8

[1]Elevation and Offset are obtained using Google Earth

The borings were performed with a CME 55T track-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. The Standard Penetration Test (SPT) sampling was performed at 2.5-foot intervals to a depth of 20 feet below the existing ground surface, then at 5-foot intervals thereafter until bedrock was encountered. The energy ratio (ER) of the CME-55 automatic hammer and drill rod system was measured to be 93.7 percent on November 13, 2024. The depths and elevations of the SPTs with the corresponding N_{60}-values are shown on the boring logs in Appendix A.

The materials encountered were logged by a geotechnical engineer, with attention given to soil type, consistency, and moisture. The borings were checked for the presence of groundwater during drilling with the depth of water recorded. The borings were sealed with cement/bentonite grout, then capped with asphalt cold patch for borings performed in the roadway or auger cuttings for the boring performed within grassy areas.

The soil samples obtained from the borings were returned to Stantec's geotechnical laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples taken near proposed subgrade and samples reflecting each of the main soil horizons. The engineering classification tests conducted on the samples were sieve and hydrometer analysis (ASTM D 422) and Atterberg limits (ASTM D 4318). Unconsolidated Undrained (UU) triaxial (ASTM D 2850) tests, Consolidated Undrained (CU) triaxial (ASTM D 4767) tests, and Unconfined Compressive Strength (UCS) (ASTM D2166) tests were performed for selected Shelby tube samples. The samples were classified according to the ODOT classification method. Results from Stantec's laboratory program are shown on the boring logs and detailed laboratory reports are provided in Appendix A.

4 FINDINGS

The surface materials encountered included approximately 6 inches of topsoil in the offroad boring and approximately 8 inches of asphalt, underlain by approximately 6 inches of aggregate base in the roadway boring. Fine-grained soils with low to moderate plasticity were typically encountered beneath the surface materials.

The fine-grained soils were classified as sandy silt (A-4a), silt (A-4b), silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). The soils were described as brown to gray, stiff to very stiff (SPT N_{60} values ranging from 9 to 29 blows per foot (bpf) with an average of 16 bpf), damp to moist (moisture content of 11 to 27 percent with an average of 18 percent) and having low to moderate plasticity (plasticity indices (PI) of 7 to 30 with an average of 17). A UU triaxial test was performed at a depth of 5.5 to 6.0 feet in B-001-0-25. The test resulted in an undrained shear strength of 0.5 tons per square foot (tsf). A CU triaxial test was performed at a depth of 10.0 to 12.0 feet in B-002-0-25. The test resulted in undrained strength of 0.0 tsf with a friction angle of 35.3 degrees and drained strength of 0.1 tsf with a friction angle of 26.1 degrees. Similarly, UCS tests were performed at a depth of 5.0 to 5.5 feet in B-001-0-25 and 5.4 to 5.9 feet in B-002-0-25, both resulted in a strength of 1.2 tsf.

Groundwater was encountered at depths of 26 feet (Elevation 775.3 feet) in B-001-0-25 to 35 feet (Elevation 766.5 feet) in B-002-0-25.

Bedrock at the site was encountered at depth of 36.5 feet (Elevation 764.8 feet) and 38.0 feet (Elevation 763.5 feet) in borings B-001-0-25 and B-002-0-25, respectively. Five feet of coring was performed in each of the boring. The bedrock was described as dolomite, light brown to light yellowish tan, strong, moderately weathered, fine-grained, thin bedded, and highly to moderately fractured. Unconfined compressive strength of rock tests were completed on the specimens in B-001-0-25 and B-002-0-25 resulting in a compressive strengths of 8,200 and 10,350 pounds per square inch (psi), respectively.

5 ANALYSIS AND RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow are based on the information discussed in this report and the interpretation of the subsurface conditions encountered at the site during the fieldwork. If future design changes are made, Stantec should be notified so that such changes can be reviewed, and the recommendations amended as necessary.

These conclusions and recommendations are based on data and subsurface conditions from the borings advanced during this exploration using the degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions.

5.2 CULVERT

The existing culvert is planned to be replaced by a box culvert that is 102 feet long, 12 feet wide and 5 feet high. Bearing capacity calculations were performed at the inlet and outlet for the culvert utilizing information obtained from borings B-001-0-25 (inlet) and B-002-0-25 (outlet) and laboratory testing. The spread footings for the headwalls and wingwalls of the culvert are planned to be at an elevation of 790 to 792 feet. The spread footing sizes for the headwalls and wingwalls are 5 feet wide by 33 feet long.

It is assumed that the culvert foundation design will follow drawings and notes from ODOT Standard Bridge Drawing HW-1.1 “Full-Height Headwalls”. As such, the lab provided drained shear strength parameters do not meet the minimum requirement for a foundation placed at approximate elevation 790 to 792 feet. To use this standard drawing for design, it is recommended a 2-foot undercut be performed at the bearing elevation, a geogrid placed at the base of the undercut to provide increased capacity, then the excavation backfilled with No. 57 stone in 8-inch loose lifts until the bearing elevation is reestablished. According to the Occupational Safety and Health Administration (OSHA) 1946 Subpart P App A – *Soil Classification*, excavated soils most closely fall under Type C. Sloped excavations thus require a 1.5:1 horizontal to vertical slope according to OSHA 1926 Subpart P App B – *Sloping and Benching*.

If it is decided not to use the standard drawing as described above, site-specific bearing capacities were developed. Since the foundation soils at the inlet and outlet of the proposed culvert are cohesive at these elevations, the undrained and drained properties are different for the bearing capacity analysis. Undrained conditions control the bearing capacity design, as shown in the summary provided in Table 2 and the detailed calculations provided in Appendix B. A resistance factor of 0.45 was applied for footings in silt and clay (from Table 10.5.5.2.2-1 of the 2024 AASHTO LRFD) for headwall and wingwall design. For undrained conditions, laboratory testing at the bearing elevation was not performed. A conservative cohesion value of 1500 psf was selected based on the guidelines suggested in Section 404.1, published in the ODOT Geotechnical Design Manual (GDM) to estimate undrained shear strength based on N_{60} values, while the friction angle was assumed to be zero. A cohesion value of 200 psf and a friction angle of 26.1 degrees were selected from the CU test from boring B-002-0-25 for drained conditions.

Table 2. Culvert Bearing Capacity Analysis Results

Straight Line Mileage (SLM)	Unfactored, Undrained Bearing Capacity (kips per square foot [ksf])	Factored, Undrained Bearing Capacity (ksf)	Unfactored, Drained Bearing Capacity (ksf)	Factored, Drained Bearing Capacity (ksf)
7.42	8.4	3.8	14.0	6.3

A review of the boring logs indicates that groundwater is contained in fine-grained soil layers at depths of 26 feet and 35 feet, which is at greater depths below the foundation elevation. It should be anticipated that stream diversion and dewatering will be necessary to install the headwall footings. The dewatering plan should include temporary barriers or earth berms to isolate footing excavation from the stream flow and sump pumps to remove stream and groundwater infiltration into isolated areas.

5.3 SUBGRADE

The ODOT GDM outlines a procedure for estimating the methods and limits of subgrade treatment that will be required to stabilize pavement subgrade prior to construction of the pavement section. The procedure is based upon the results of the borings, field testing, and laboratory testing. Subgrade recommendations were requested by ODOT after drilling was completed, so the borings were advanced as culvert structure borings instead as subgrade borings. Sampling and laboratory testing could not be completed conforming to the ODOT SGE, however, a subgrade analysis was done using available data.

The subgrade analysis was completed for areas impacted by culvert construction in accordance with ODOT GDM. The subgrade analysis results are provided in Appendix C. Cut and fill depths were determined using OpenRoads basemapping provided by ODOT. An average N_{60L} of 9 was calculated from the data obtained from the borings. A design California Bearing Ratio (CBR) of 4 is recommended based on the subgrade analysis. According to the subgrade analysis, unstable subgrade soil is present in both of the borings. Thus, global subgrade stabilization is recommended. The recommended subgrade stabilization option is Item 204

Excavate and Replace to a depth of 12 inches with a geotextile. Chemical stabilization is not recommended due to the small work area and lack of sulfate results.

Any excavations for subgrade stabilization should extend 18 inches beyond the edge of the surface of the pavement, and Item 204 Geotextile Fabric should be placed underneath the fill material. If cut and fill slopes are required, slopes should be designed with gradients of 2:1 (horizontal to vertical) or flatter.

Appendix A Geotechnical Drawings (FINAL)

PROJECT DESCRIPTION

THIS PROJECT, SEN-23-7.42 IS THE EXPLORATION FOR REPLACING A CULVERT FOR A BRANCH OF WOLF CREEK ON UNITED STATES (US) ROUTE 23 (FOSTORIA-CAREY RD) SOUTH OF FOSTORIA IN SENECA COUNTY, APPROXIMATELY 0.75 MILES NORTH OF INTERSECTION OF US 23 WITH US ROUTE 224.

HISTORIC RECORDS

ODOT TIMS PROVIDES DOCUMENTATION FOR TWO GEOTECHNICAL EXPLORATIONS PERFORMED ALONG US 23 IN SENECA COUNTY.

WYA-23-24.92, SEN-23-(0.00)(6.69), DRILLED IN 1954, WAS AN EXPLORATION FOR A ROADWAY PROJECT LOCATED ALONG US 23 IN WYANDOT AND SENECA COUNTIES. THE PROJECT CONSISTED OF ABOUT 255 SHALLOW SUBGRADE BORINGS. THE OVERBURDEN SOILS WERE CLASSIFIED AS GRAVEL WITH SAND, SILT AND CLAY (A-2-6), COARSE AND FINE SAND (A-3A), SANDY SILT (A-4A), SILT (A-4B), SILT AND CLAY (A-6A), AND CLAY (A-7-6). AUGER REFUSAL WAS ENCOUNTERED AT SEVERAL BORINGS AND THE BEDROCK WAS DESCRIBED AS DOLOMITE AND SANDSTONE.

SEN-23-8.33 WAS AN EXPLORATION FOR ROADWAY AND BRIDGE STRUCTURES ALONG THE US 23 BYPASS NEAR FOSTORIA, OHIO, IN 1979. THE PROJECT CONSISTED OF ABOUT 250 BORINGS, INCLUDING 72 BORINGS FOR BRIDGES AND CUT/FILL SLOPES. THE OVERBURDEN SOILS WERE CLASSIFIED AS GRAVEL WITH SAND AND SILT (A-2-4), COARSE AND FINE SAND (A-3A), SANDY SILT (A-4A), SILT (A-4B), SILT AND CLAY (A-6A), SILTY CLAY (A-6B), AND CLAY (A-7-6). BEDROCK WAS DESCRIBED AS LIMESTONE AND DOLOMITE.

GEOLOGY

THE PROJECT SITE IS LOCATED WITHIN CENTRAL OHIO CLAYEY TILL PLAIN. THE CENTRAL OHIO CLAYEY TILL PLAIN IS DESCRIBED AS A SURFACE OF CLAYEY TILL AND WELL-DEFINED MORAINES WITH INTERVENING FLAT-LYING GROUND MORAINE AND INTERMORAINAL LAKE BASINS. THE REGION CONSISTS OF A DOZEN SILT, CLAY AND TILL FILLED LAKE BASIN WITH NO BOULDER BELTS RANGING IN AREA FROM A FEW TO 200 SQUARE MILES AND WITH FEW LARGE STREAMS HAVING LIMITED SAND AND GRAVEL OUTWASH.

THE GEOLOGY CONSISTS OF SILTY TO GRAVELLY WISCONSINAN-AGE WAVE PLANED CLAY TILL OVER DEEPLY COVERED SILURIAN-AGE DOLOMITE. THE REGION HAS LOW RELIEF (GENERALLY 10 TO 15 FEET) DECREASING WESTWARD WITH ELEVATIONS OF 750 TO 825 FEET. THE SOILS ARE UNDERLAIN BY BEDROCK OF GREENFIELD DOLOMITE FROM THE SILURIAN AGE. GREENFIELD DOLOMITE PRIMARILY CONSISTS OF ARGILLACEOUS DOLOMITE AND IS DESCRIBED AS OLIVE GRAY TO YELLOW BROWN IN COLOR WITH THICKNESS RANGING FROM 0 TO 80 FEET. THE DIAGNOSTIC FEATURES ARE THE ABSENCE OF SHALE LAMINAE WHEN COMPARED TO OVERLYING UNITS AND SEDIMENTARY BRECCIA ZONES.

RECONNAISSANCE

STANTEC REPRESENTATIVES VISITED THE SITE ON MAY 13, 2025, TO RECORD OBSERVATIONS AND MARK BOREHOLE LOCATIONS. THE LAND SURROUNDING THE PROJECT SITE WAS DESCRIBED AS PRIMARILY RURAL WITH SOME RESIDENT AND BUSINESS LOCATIONS NEARBY. THE US 23 PAVEMENT WAS OBSERVED TO BE IN FAIR TO POOR CONDITION. FLOW WITHIN THE CREEK WAS MINIMAL, WITH STAGNANT WATER PRESENT AT THE CULVERT INVERT BENEATH THE ROADWAY. THE AREAS WHERE THE CULVERT IS PLANNED ARE COVERED WITH GRASS.

SUBSURFACE EXPLORATION

STANTEC ADVANCED TWO BORINGS TO OBTAIN GEOTECHNICAL DATA FOR THE PROPOSED CULVERT REPLACEMENT. THE BORINGS WERE ADVANCED AT DIAGONALLY OPPOSITE ENDS OF THE CULVERT, ONE IN THE SHOULDER OF NORTHBOUND LANE AND OTHER IN THE SHOULDER BEHIND GUARDRAIL IN THE SOUTHBOUND LANE.

THE BORINGS WERE PERFORMED WITH A CME 55 TRACK-MOUNTED DRILL RIG USING 3¼-INCH INSIDE DIAMETER (ID) HOLLOW STEM AUGERS. THE STANDARD PENETRATION TEST (SPT) WAS PERFORMED AT 2.5-FOOT INTERVALS TO A DEPTH OF 20 FEET BELOW THE EXISTING GROUND SURFACE, THEN AT 5-FOOT INTERVALS THEREAFTER UNTIL BEDROCK WAS ENCOUNTERED. THE ENERGY RATIO (ER) OF CME 55 AUTOMATIC HAMMER AND DRILL ROD SYSTEM WAS MEASURED TO BE 93.7 PERCENT ON NOVEMBER 13, 2024.

EXPLORATION FINDINGS

THE SURFACE MATERIALS ENCOUNTERED INCLUDE APPROXIMATELY 6 INCHES OF TOPSOIL IN THE OFFROAD BORING AND APPROXIMATELY 8 INCHES OF ASPHALT, UNDERLAIN BY APPROXIMATELY 6 INCHES OF AGGREGATE BASE IN THE ROADWAY BORING. FINE-GRAINED SOILS WITH LOW TO MODERATE PLASTICITY WERE TYPICALLY ENCOUNTERED BENEATH THE SURFACE MATERIALS.

THE FINE-GRAINED SOILS WERE CLASSIFIED AS SANDY SILT (A-4A), SILT (A-4B), SILT AND CLAY (A-6A), SILTY CLAY (A-6B), AND CLAY (A-7-6). THE SOILS WERE DESCRIBED AS BROWN TO GRAY, STIFF TO VERY STIFF, DAMP TO MOIST AND HAVING LOW TO MODERATE PLASTICITY. AN UNCONFINED UNDRAINED (UU) TRIAXIAL TEST WAS PERFORMED AT A DEPTH OF 5.5 TO 6.0 FEET IN BORING B-001-0-25. THE TEST RESULTED IN AN UNDRAINED SHEAR STRENGTH OF 0.5 TONS PER SQUARE FOOT (TSF). A CONSOLIDATED UNDRAINED (CU) TRIAXIAL TEST WAS PERFORMED AT A DEPTH OF 10 TO 12 FEET IN BORING B-002-0-25. THE TEST RESULTED IN UNDRAINED STRENGTH OF 0.0 TSF WITH A FRICTION ANGLE OF 35.3 DEGREES AND DRAINED STRENGTH OF 0.1 TSF WITH A FRCITION ANGLE OF 26.1 DEGREES. SIMILARLY, UNCONFINED COMPRESSION STRENGTH (UCS) TEST PERFORMED AT A DEPTH OF 5.0 TO 5.5 FEET IN B-001-0-25 RESULTED IN STRENGTH OF 1.2 TSF AND ANOTHER TEST PERFORMED AT A DEPTH OF 5.4 TO 5.9 FEET IN B-002-0-25 RESULTED IN STRENGTH OF 1.2 TSF.

GROUNDWATER WAS ENCOUNTERED IN EACH BORING AT DEPTHS RANGING FROM 26 FEET (ELEVATION 775.3 FEET) IN BORING B-001-0-25 AND 35 FEET (ELEVATION 766.5 FEET) IN BORING B-002-0-25.

BEDROCK AT THE SITE WAS ENCOUNTERED AT DEPTHS OF 36.5 FEET (ELEVATION 764.8 FEET) AND 38.0 FEET (763.5 FEET) IN BORINGS B-001-0-25 AND B-002-0-25 RESPECTIVELY. FIVE FEET OF CORING WAS PERFORMED IN EACH BORING. THE BEDROCK WAS DESCRIBED AS LIGHT BROWN TO LIGHT YELLOWISH TAN DOLOMITE THAT IS MODERATELY WEATHERED, FINE-GRAINED, THIN BEDDED, AND HIGHLY TO MODERATELY FRACTURED.

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 JANUARY 2025 .

AVAILABLE INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

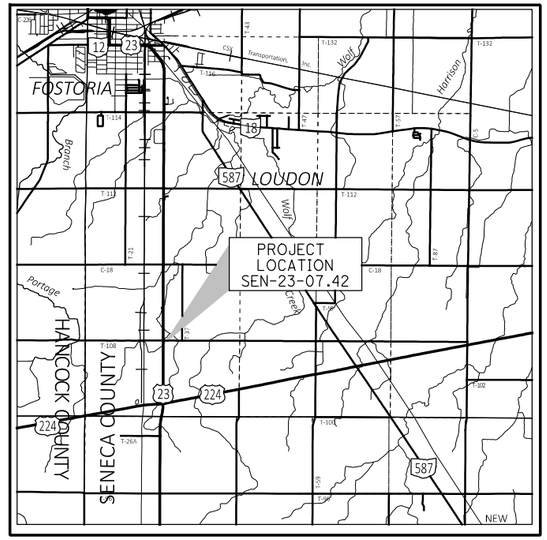
LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
COARSE AND FINE SAND	A-3a	0	1
SANDY SILT	A-4a	2	2
SILT	A-4b	1	3
SILT AND CLAY	A-6a	2	5
SILTY CLAY	A-6b	1	2
CLAY	A-7-6	2	4
	TOTAL	8	17
DOLOMITE	VISUAL		
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.
X/Y/Z	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X= NUMBER OF BLOWS FOR FIRST 6 INCHES. Y= NUMBER OF BLOWS FOR SECOND 6 INCHES. Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.
TR	INDICATES TOP OF ROCK.
SS	INDICATES A SPLIT SPOON SAMPLE.
ST	INDICATES A SHELBY TUBE SAMPLE.
₩	INDICATES FREE WATER ELEVATION.
Qu	INDICATES UNCONFINED COMPRESSIVE TEST (ROCK), ASTM D7012.
UCS	UNCONFINED COMPRESSIVE STRENGTH (SOIL) SHOWN IN (TSF).



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

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		

RECON. - JS & NU 05/13/25

DRILLING - AF & GK 06/17-23/2025

DRAWN - MJ 10/2025

REVIEWED - JRS 10/28/2025

GEOTECHNICAL PROFILE - CULVERT
SEN-23-07.42 OVER BRANCH OF WOLF CREEK

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER MSJ

REVIEWER JRS 10-28-25

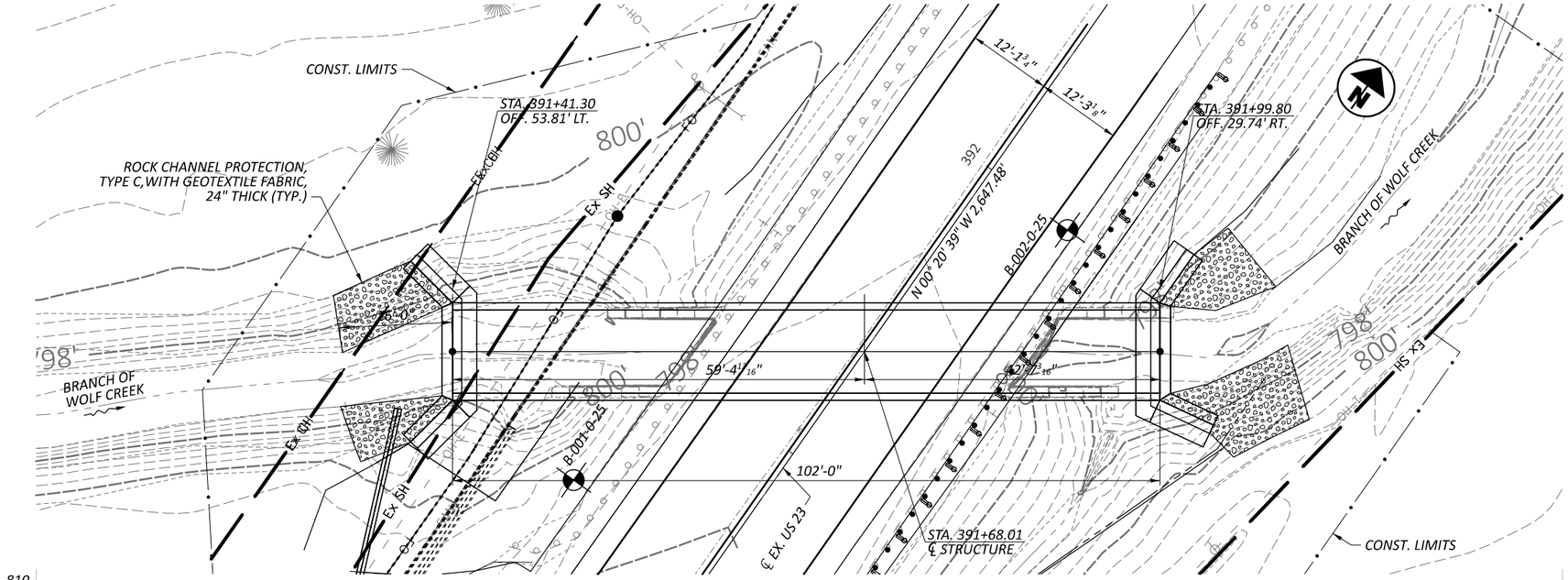
PROJECT ID 107691

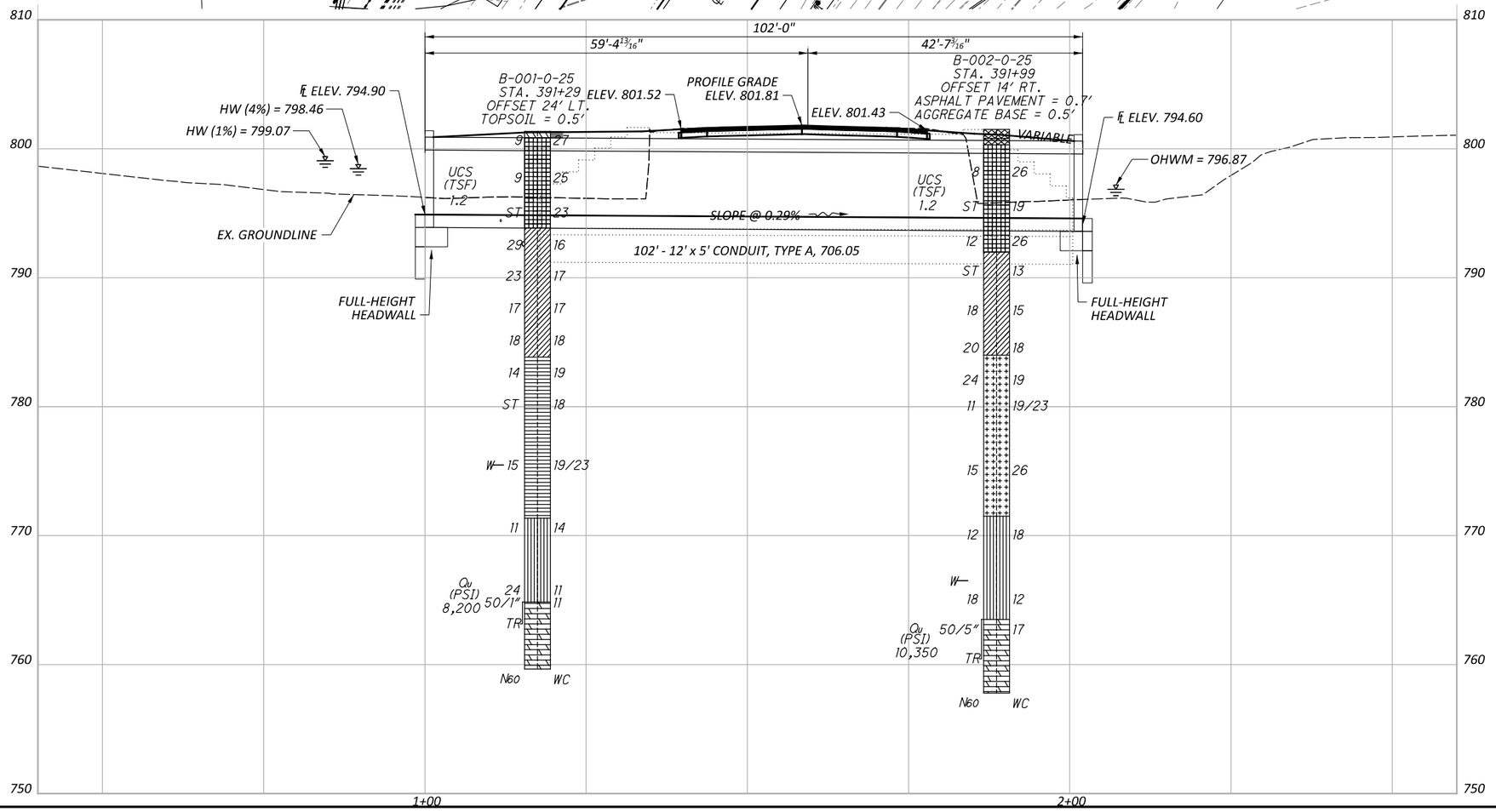
SUBSET 0 | TOTAL 0

SHEET P.1 | TOTAL 10

SEN-23-07.32

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HORIZONTAL SCALE IN FEET
0 5 10 20

GEOTECHNICAL PROFILE - CULVERT
SEN-23-7.42 - U.S. 23 OVER BRANCH OF WOLF CREEK

SEN-23-7.42

MODEL: CL_Structure - Plan 1 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 11/21/2025 TIME: 9:13:08 AM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107691 PRODUCT: OpenRoadsDesigner 24.00.00.205
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DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	JRS 10-28-25
PROJECT ID	107691
SUBSET	0
TOTAL	0
SHEET	P.2
TOTAL	10

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 10/28/2025 TIME: 1:38:14 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107691 PRODUCT: OpenRoadsDesigner 24.00.00.205
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PROJECT: SEN-23-07.42
TYPE: STRUCTURE FOUNDATION
PID: 107691 SFN: N/A
START: 6/10/25 END: 6/11/25

DRILLING FIRM / OPERATOR: STANTEC / EC
SAMPLING FIRM / LOGGER: STANTEC / GK
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / ST / NQ2

DRILL RIG: CME 55T#3 (714)
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 11/13/24
ENERGY RATIO (%): 90*

STATION / OFFSET: 391+29, 24' LT.
ALIGNMENT: US 23
ELEVATION: 801.3 (MSL) EOB: 41.7 ft.
LAT / LONG: 41.093239, -83.401425

EXPLORATION ID B-001-0-25
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 801.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DARK BROWN, **TOPSOIL**, 6 INCHES	800.8																	
STIFF TO VERY STIFF, BROWN TO GRAY, **CLAY**, TRACE GRAVEL, LITTLE SAND, SOME SILT, MOIST			3 3 3	9	40	SS-1	-	-	-	-	-	-	-	-	-	27	A-7-6 (V)	
			2 3 3	9	87	SS-2	1.25	-	-	-	-	-	-	-	-	25	A-7-6 (V)	
FROM 5.0 FT. TO 5.5 FT., UCS = 1.2 TSF					75	ST-1	3.50	4	4	11	33	48	48	18	30	23	A-7-6 (18)	
	793.8																	
VERY STIFF, BROWN TO GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP			5 8 11	29	100	SS-3	4.00	-	-	-	-	-	-	-	-	16	A-6a (V)	
			6 8 7	23	100	SS-4	3.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
			4 5 6	17	87	SS-5	3.00	12	4	9	29	46	33	19	14	17	A-6a (10)	
			4 5 7	18	93	SS-6	3.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
	783.8																	
STIFF, BROWN TO GRAY, **SILTY CLAY**, TRACE GRAVEL, LITTLE SAND, MOIST			2 3 6	14	100	SS-7	2.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
					25	ST-2	1.75	3	5	10	32	50	35	16	19	18	A-6b (12)	
		W 775.3	5 5 5	15	33	SS-8A	1.75	-	-	-	-	-	-	-	-	19	A-6b (V)	
FROM 26.0 Ft. TO 26.5 FT., GRAY, FINE SAND SEAM, WET						SS-8B	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
	771.3																	
STIFF TO VERY STIFF, GRAY, **SANDY SILT**, TRACE GRAVEL, "AND" CLAY, DAMP			3 3 4	11	100	SS-9	2.00	6	6	17	35	36	22	15	7	14	A-4a (7)	
			5 8 8	24	100	SS-10	2.00	-	-	-	-	-	-	-	-	11	A-4a (V)	
	764.8	TR																
DOLOMITE, WEATHERED (AUGERABLE).	764.7		50/1"	-	100	SS-11	-	-	-	-	-	-	-	-	-	11	Rock (V)	
DOLOMITE, LIGHT BROWN, MODERATELY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, HIGHLY TO MODERATELY FRACTURED; RQD 25%, REC 100%, FROM 37.1 FT. TO 37.5 FT., UCR = 8,200 PSI			33		100	NQ2-1											CORE	
	759.6	EOB	0		100	NQ2-2											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; TREMIED CEMENT/BENTONITE GROUT

SHEET P.3 TOTAL 10
SUBSET 0 TOTAL 0
PROJECT ID 107691
REVIEWER JRS 10-28-25
DESIGNER MSJ
DESIGN AGENCY

Stantec
10200 Alliance Road,
Suite 200
Cincinnati, OH 45242
(513) 842-8200

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-001-0-25

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 10/28/2025 TIME: 1:39:15 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107691 PRODUCT: OpenRoadsDesigner 24.00.00.205
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B-001-0-25



Run #:	Depth		Recovery		RQD	
NQ2-1	36.6’	40.6’	48”/48”	100%	16”/48”	33%
NQ2-2	40.6’	41.7’	13”/13”	100%	0”/13”	0%
SEN-23-7.42 PID: 107691						

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-001-0-25 (ROCK CORE PHOTO)

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/11/2025 TIME: 5:01:25 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107691 PRODUCT: OpenRoadsDesigner 24.00.00.205
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PROJECT: SEN-23-07.42
TYPE: STRUCTURE FOUNDATION
PID: 107691 SFN: N/A
START: 6/10/25 END: 6/10/25

DRILLING FIRM / OPERATOR: STANTEC / EC
SAMPLING FIRM / LOGGER: STANTEC / GK
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / ST / NQ2

DRILL RIG: CME 55T#3 (714)
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 11/13/24
ENERGY RATIO (%): 90*

STATION / OFFSET: 391+99, 14' RT.
ALIGNMENT: US 23
ELEVATION: 801.5 (MSL) EOB: 43.7 ft.
LAT / LONG: 41.093385, -83.401278

EXPLORATION ID: B-002-0-25
PAGE: 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 801.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT, 8 INCHES	800.8																	
GRANULAR BASE, 6 INCHES	800.3																	
STIFF TO VERY STIFF, GRAY TO BROWN, **CLAY**, TRACE GRAVEL, LITTLE SAND, SOME SILT, MOIST																		
SS-1: MEDIUM STIFF			2 2 3	8	73	SS-1	1.50	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
FROM 5.4 FT. TO 5.9 FT., UCS = 1.2 TSF					65	ST-1	1.50	1	2	11	28	58	49	19	30	19	A-7-6 (18)	
	792.0		2 3 5	12	93	SS-2	3.00	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE GRAVEL, LITTLE SAND, DAMP TO MOIST					100	ST-2	2.00	4	5	11	34	46	29	15	14	13	A-6a (10)	
			3 4 8	18	100	SS-3	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
			2 5 8	20	100	SS-4	2.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
	784.0																	
STIFF TO VERY STIFF, GRAY, **SILT**, TRACE GRAVEL, TRACE SAND,, "AND" CLAY, MOIST			1 5 11	24	87	SS-5	2.00	2	1	9	52	36	24	15	9	19	A-4b (8)	
			1 2 5	11	87	SS-6A	1.50	-	-	-	-	-	-	-	-	19	A-4b (V)	
FROM 21.0 FT. TO 21.2 FT., GRAY, FINE GRAINED SAND SEAM, MOIST						SS-6B	-	-	-	-	-	-	-	-	-	23	A-4b (V)	
FROM 26.0 FT. TO 26.1 FT., GRAY SAND SEAM, DAMP			2 3 7	15	100	SS-7	3.25	-	-	-	-	-	-	-	-	26	A-4b (V)	
	771.5																	
STIFF TO VERY STIFF, GRAY, **SANDY SILT**, LITTLE GRAVEL, SOME CLAY, DAMP TO MOIST			2 3 5	12	100	SS-8	2.00	-	-	-	-	-	-	-	-	18	A-4a (V)	
		W 766.5	4 5 7	18	100	SS-9	2.50	15	15	14	31	25	24	14	10	12	A-4a (4)	
	763.5	TR																
DOLOMITE, WEATHERED (AUGERABLE).	763.1		50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	17	Rock (V)	
DOLOMITE, LIGHT YELLOWISH TAN, MODERATELY TO SLIGHTLY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, HIGHLY TO MODERATELY FRACTURED; RQD 87%, REC 100%. FROM 40.3 FT. TO 40.7 FT., UCR = 10,350 PSI			67		100	NQ2-1											CORE	
			97		100	NQ2-2											CORE	
	757.8	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; TREMIED CEMENT/BENTONITE GROUT

SHEET	SUBSET	PROJECT ID	REVIEWER	DESIGNER	DESIGN AGENCY
P.5 / TOTAL 10	0 / TOTAL 0	107691	JRS 10-28-25	MSJ	Stantec

10200 Alliance Road, Suite 200
Cincinnati, OH 45242
(513) 842-8200

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-002-0-25

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 10/28/2025 TIME: 1:41:03 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107691 PRODUCT: OpenRoadsDesigner 24.00.00.205
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B-002-0-25



Run #:	Depth		Recovery		RQD	
NQ2-1	38.4’	40.2’	22”/22”	100%	14”/22”	67%
NQ2-2	40.2’	43.7’	42”/42”	100%	41”/42”	97%
SEN-23-7.42 PID: 107691						

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-002-0-25 (ROCK CORE PHOTO)

Unconfined Compressive Strength of Cohesive Soil

ASTM D 2166

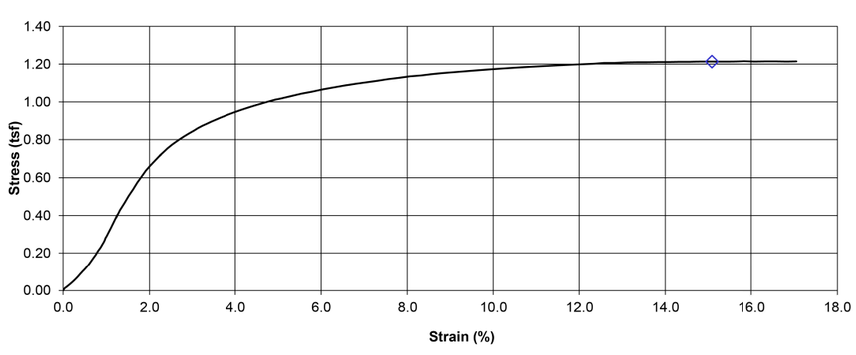
Project Name 02H_SEN-23-7.42 Project Number 175578434
Source B-001-0-25, 5.0'-7.0' Lab ID 840A
Visual Description Lean Clay with Sand (CL), brown, moist, firm

Recovered 1'
Test Interval 5.0' - 5.5'

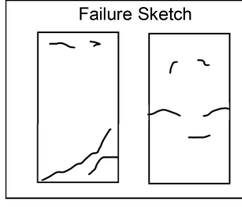
Specimen Type: Undisturbed LL 48 PL 18
PI 30
Date Extruded 06/18/2025
Date Tested 06/26/2025

Initial Wet Density (pcf)	123.6	Initial MC Taken	Before Test, From Trimmings
Initial Moisture Content (%)	23.0		
Initial Dry Density (pcf)	100.4		
At Test Moisture Content (%)	N/A	At Test MC Taken	N/A
At Test Dry Density (pcf)	N/A		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	1.21
Average Height (in)	5.780	Undrained Shear Strength (tsf)	0.61
Average Diameter (in)	2.873	Strain at Maximum Stress (%)	15.1
Height to Diameter Ratio	2.0	Strain Rate to Failure (% / min.)	1.00

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf) N/A
Torvane Reading (kg/cm^2) N/A

Comments
UW - 5.0'-5.5' (840A)
UW - 5.5'-6.0' (840B)
Classification data from same source:
Soil Classification: Clay A-7-6 (18)
%GR = 4, %CS = 4, %FS = 11, %SI = 33, %CL = 48
LL = 48, PL = 18, PI = 30

Reviewed By RHB

Unconfined Compressive Strength of Cohesive Soil

ASTM D 2166

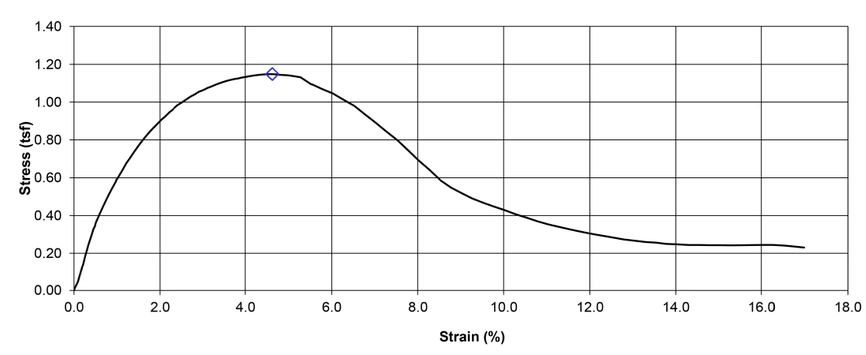
Project Name 02H_SEN-23-7.42 Project Number 175578434
Source B-002-0-25, 5.0'-7.0' Lab ID 842
Visual Description Lean Clay (CL), brown, moist, firm

Recovered 0.9'
Test Interval 5.4' - 5.9'

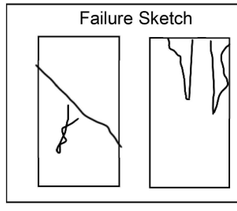
Specimen Type: Undisturbed LL 49 PL 19
PI 30
Date Extruded 06/19/2025
Date Tested 06/27/2025

Initial Wet Density (pcf)	128.4	Initial MC Taken	Before Test, From Trimmings
Initial Moisture Content (%)	19.1		
Initial Dry Density (pcf)	107.8		
At Test Moisture Content (%)	N/A	At Test MC Taken	N/A
At Test Dry Density (pcf)	N/A		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	1.15
Average Height (in)	5.995	Undrained Shear Strength (tsf)	0.57
Average Diameter (in)	2.873	Strain at Maximum Stress (%)	4.6
Height to Diameter Ratio	2.1	Strain Rate to Failure (% / min.)	1.00

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf) N/A
Torvane Reading (kg/cm^2) N/A

Comments
5.0'-5.4' - short
5.4'-5.9' - UW
Classification data from same source:
Soil Classification: Clay, A-7-6 (18)
%GR = 1, %CS = 2, %FS = 11, %SI = 28, %CL = 58
LL = 49, PL = 19, PI = 30

Reviewed By RHB

GEOTECHNICAL PROFILE - CULVERT
LABORATORY TEST DATA

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
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DESIGNER	MSJ
REVIEWER	JRS 10-28-25
PROJECT ID	107691
SUBSET / TOTAL	0 / 0
SHEET / TOTAL	P.7 / 10

SEN-23-07.42

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Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

Project Name 02H_SEN-23-7.42 | Project Number 175578434
Lithology Sandstone, light brown, strong | Lab ID UCR-1006
Hole Number B-001-0-25 | Depth (ft) 37.1'-37.5' | Date Received 06/25/2025

Temperature (°C) 25 | Moisture Condition As Prepared, Moist | Date Tested 07/15/2025

Side Planeness	N/A	Height (in)	4.554	Wet Unit Weight (pcf)	164.5
Perpendicularity	N/A	Diameter (in)	1.991	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.114	Moisture Content (%)	N/A
Parallelism	N/A				

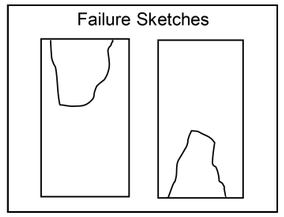
Dimensions were not confirmed.

Loading Rate (lbf/sec) 94
Peak Load (lbf) 25543

Failure Type Cone

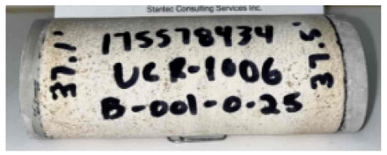
Compressive Strength (psi) 8200
Compressive Strength (psf) 1180800
Compressive Strength (tsf) 591

Failure Sketches



Comments Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

CORE PREP



POST TEST



Reviewed By REL

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

Project Name 02H_SEN-23-7.42 | Project Number 175578434
Lithology Sandstone, light brown, strong | Lab ID UCR-1007
Hole Number B-002-0-25 | Depth (ft) 30.3'-30.7' | Date Received 06/25/2025

Temperature (°C) 25 | Moisture Condition As Prepared, Moist | Date Tested 07/14/2025

Side Planeness	N/A	Height (in)	4.597	Wet Unit Weight (pcf)	158.2
Perpendicularity	N/A	Diameter (in)	1.992	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.118	Moisture Content (%)	N/A
Parallelism	N/A				

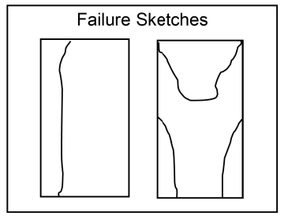
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Loading Rate (lbf/sec) 100
Peak Load (lbf) 32270

Failure Type Cone and Split

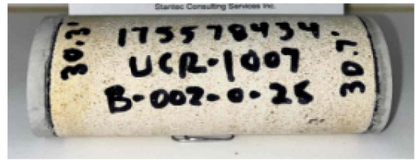
Compressive Strength (psi) 10350
Compressive Strength (psf) 1490400
Compressive Strength (tsf) 745

Failure Sketches



Comments Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

CORE PREP



POST TEST



Reviewed By REL

GEOTECHNICAL PROFILE - CULVERT
LABORATORY TEST DATA

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DESIGNER MSJ
REVIEWER JRS 10-28-25
PROJECT ID 107691
SUBSET 0 | TOTAL 0
SHEET P.8 | TOTAL 10

SEN-23-07.42

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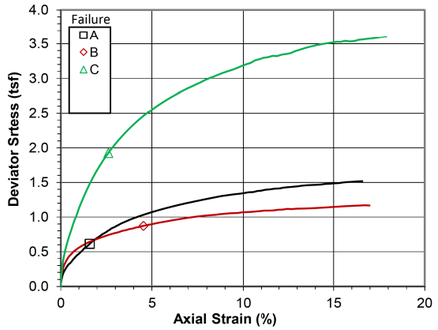
Consolidated Undrained Triaxial Compression

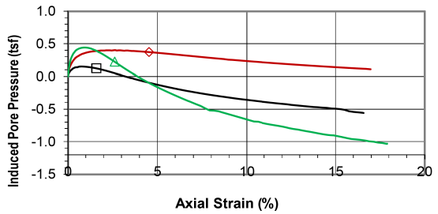
ASTM D 4767

Project Name 02H_SEN-23-7.42

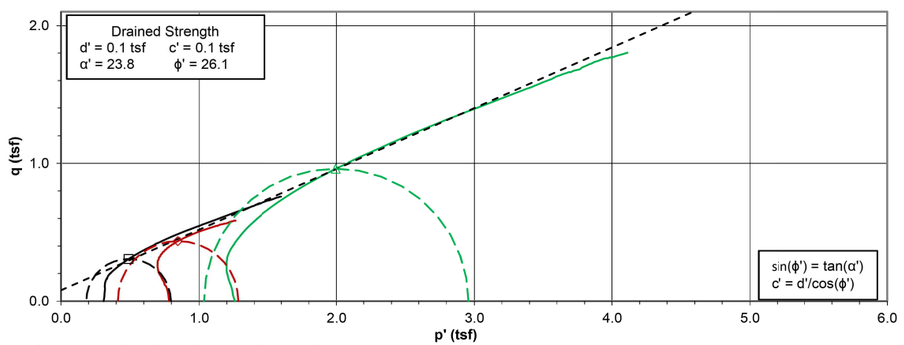
Project 175578434
Set ID 843

Test	Lab ID	Source	Description	Gs	LL	PL	PI
A	843	B-002-0-25, 11.1'-11.6'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14
B	843	B-002-0-25, 10.1'-10.6'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14
C	843	B-002-0-25, 10.6'-11.1'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14





Specimen	A	B	C		
	Initial Specimen Conditions				
Average Height (in)	5.987	5.757	5.763		
Average Diameter (in)	2.882	2.865	2.872		
Moist Unit Weight (pcf)	135.3	131.0	136.3		
Moisture Content (%)	16.1	18.7	16.3		
Dry Unit Weight (pcf)	116.6	110.3	117.2		
Void Ratio	0.448	0.531	0.441		
Degree of Saturation (%)	97.2	95.7	100.1		
	Consolidated Specimen Conditions				
Moist Unit Weight (pcf)	135.2	132.0	136.0		
Moisture Content (%)	17.0	19.6	16.5		
Dry Unit Weight (pcf)	115.6	110.4	116.8		
Void Ratio	0.461	0.530	0.446		
Degree of Saturation (%)	100.0	100.0	100.0		
Eff. Con. Stress, σ_3' (tsf)	0.308	0.783	1.259		
	At Drained Failure				
Failure Criterion	Max. Eff. Prin. Stress Ratio				
Axial Strain (%)	1.594	4.539	2.613		
Deviator Stress (tsf)	0.612	0.871	1.923		
Induced Pore Press. (tsf)	0.123	0.374	0.225		
Minor Eff. Stress, σ_3' (tsf)	0.184	0.411	1.035		
Major Eff. Stress, σ_1' (tsf)	0.796	1.283	2.957		
Eff. Stress Ratio, σ_1'/σ_3'	4.325	3.118	2.858		
p' (tsf)	0.490	0.847	1.996		
q (tsf)	0.306	0.436	0.961		



Comments Soil Classification: Silt and Clay, A-6a (10)
%GR = 4, %CS = 5, %FS = 11, %SI = 34, %CL = 46
LL = 29, PL= 15, PI = 13

Reviewed By KG

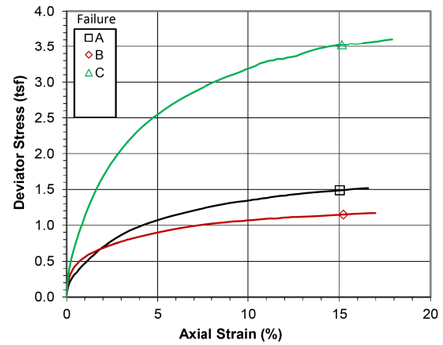
Consolidated Undrained Triaxial Compression

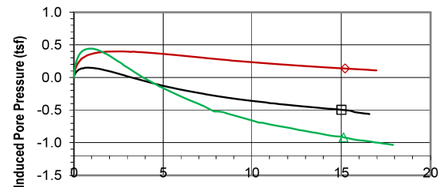
ASTM D 4767

Project Name 02H_SEN-23-7.42

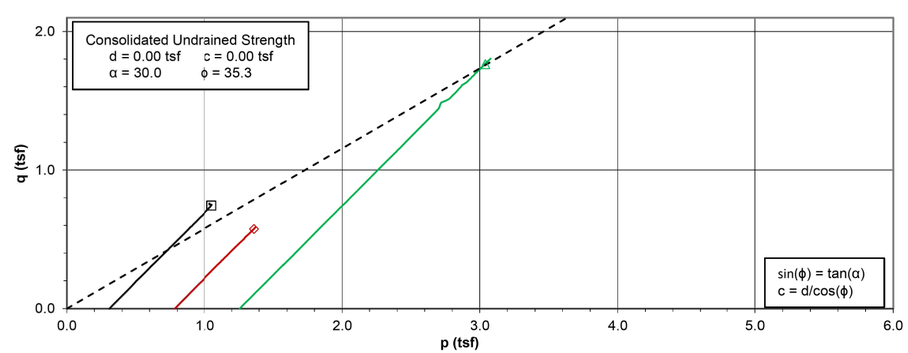
Project 175578434
Set ID 843

Test	Lab ID	Source	Description	Gs	LL	PL	PI
A	843	B-002-0-25, 11.1'-11.6'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14
B	843	B-002-0-25, 10.1'-10.6'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14
C	843	B-002-0-25, 10.6'-11.1'	Lean Clay with Sand (CL), gray, moist, firm	2.71	29	15	14





Specimen	A	B	C		
	Initial Specimen Conditions				
Average Height (in)	5.987	5.757	5.763		
Average Diameter (in)	2.882	2.865	2.872		
Moist Unit Weight (pcf)	135.3	131.0	136.3		
Moisture Content (%)	16.1	18.7	16.3		
Dry Unit Weight (pcf)	116.6	110.3	117.2		
Void Ratio	0.448	0.531	0.441		
Degree of Saturation (%)	97.2	95.7	100.1		
	Consolidated Specimen Conditions				
Moist Unit Weight (pcf)	135.2	132.0	136.0		
Moisture Content (%)	17.0	19.6	16.5		
Dry Unit Weight (pcf)	115.6	110.4	116.8		
Void Ratio	0.461	0.530	0.446		
Degree of Saturation (%)	100.0	100.0	100.0		
Eff. Con. Stress, σ_3' (tsf)	0.308	0.783	1.259		
	At Consolidated Undrained Failure				
Failure Criterion	Max. σ_D or 15% Strain				
Axial Strain (%)	15.018	15.215	15.135		
Deviator Stress (tsf)	1.486	1.149	3.526		
Min. Prin. Stress, σ_3 (tsf)	0.308	0.787	1.278		
Maj. Prin. Stress, σ_1 (tsf)	1.795	1.936	4.804		
p (tsf)	1.052	1.362	3.041		
q (tsf)	0.743	0.574	1.763		



Comments

GEOTECHNICAL PROFILE - CULVERT
LABORATORY TEST DATA

SEN-23-07.42

DESIGN AGENCY
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REVIEWER JRS 10-28-25
PROJECT ID 107691
SUBSET 0 TOTAL 0
SHEET P.9 TOTAL 10

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Unconsolidated Undrained Triaxial Compression

ASTM D 2850

Project Name 02H_SEN-23-7.42
Source B-001-0-25, 5.5'-6.0'
Description Lean Clay with Sand (CL), brown, moist, firm
Specimen Type Intact

Project No. 175578434
Lab ID 840
Test ID 840-A

Date Received 06/13/2025
Date Tested 06/27/2025

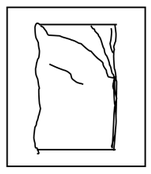
Specific Gravity 2.73
ASTM D 854, Dry

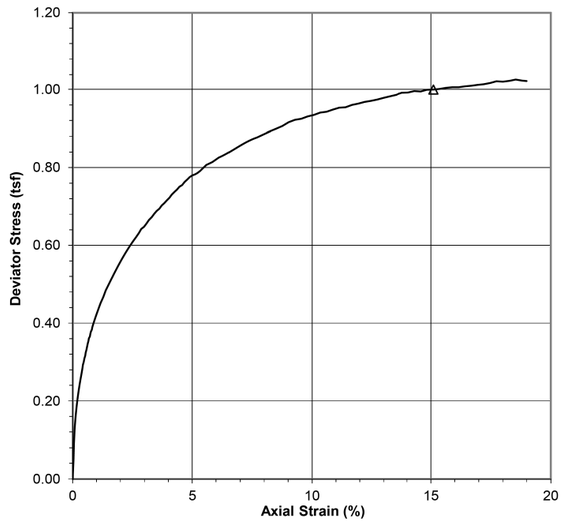
Liquid Limit 48
Plastic Limit 18
Plasticity Index 30
ASTM D 4318

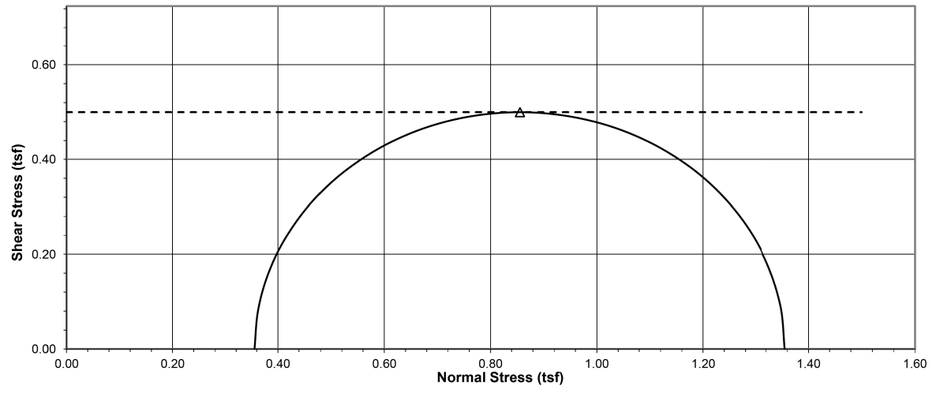
Target Test Parameters
Nominal Chamber Pressure (psi) 5
Actual Axial Strain Rate of Test (%/min) 1.055

At Unconsolidated Undrained Failure
Failure Criterion: 15% Axial Strain
Axial Strain (%) 15.10
Deviator Stress (tsf) 1.000
Minor Principal Stress, σ_3 (tsf) 0.356
Major Principal Stress, σ_1 (tsf) 1.355
Undrained Shear Strength, S_u (tsf) 0.500

Failure Sketch







Comments Soil Classification: Clay, A-7-6 (18)
%GR = 4, %CS = 4, %FS = 11, %SI = 33, %CL = 44
LL= 48, LL= 18, PI = 13

Reviewed KG

GEOTECHNICAL PROFILE - CULVERT
LABORATORY TEST DATA

SEN-23-07.42

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Cincinnati, OH 45242
(513) 842-8200

DESIGNER MSJ
REVIEWER JRS 10-28-25
PROJECT ID 107691
SUBSET 0 TOTAL 0
SHEET P.10 TOTAL 10

Appendix B Bearing Capacity Calculation

Bearing Capacity of Soil or Rock

Using AASHTO 2020 LRFD 10.6.3.1.2a

Performed by: Gokul Khatri 12/11/2025
Reviewed by: James Samples 12/11/2025

Using data from B-001-0-25 and B-002-0-25

Undrained

cohesion (c)=	1500	psf		
friction angle=	0	degrees		
γf=	122	pcf		
γq=	110	pcf		
Nc=	5.14	Cwq=	1	
Nq=	1	Cwγ=	1	
Nγ=	0			
Shape factors				
Bearing width (B)	5	ft		
Bearing length (L)	33	ft		
Bearing Depth (D)	4	ft		
Sc=	1.030303			
Sq=	1			
Sγ=	1			
Ncm=	5.2957576			
Nqm=	1			
Nγm=	0			
qn=	8383.6364	psf	8.383636	

Resistance factor (2024 LRFD Table 10.5.5.2.2-1):
0.45 for footings in silt and clay

qr=	3772.6364	psf	
	3.8	ksf	

Drained

cohesion (c)=	200	psf		
friction angle=	26	degrees		
γf=	122	pcf		
γq=	110	pcf		
Nc=	22.3	Cwq=	1	
Nq=	11.9	Cwγ=	1	
Nγ=	12.5			
Shape factors				
Bearing width (B)	5	ft		
Bearing length (L)	33	ft		
Bearing Depth (D)	4	ft		
Sc=	1.080853			
Sq=	1.074227			
Sγ=	0.939394			
Ncm=	24.10303			
Nqm=	12.7833			
Nγm=	11.74242			
qn=	14026.7	psf	14.0267	

Resistance factor (2024 LRFD Table 10.5.5.2.2-1):
0.45 for footings in silt and clay

qr=	6312.013	psf
	6.3	ksf

key

- lookup from within sheet
- pull from bearing design
- pull from logs/testing
- in sheet calculation
- from ODOT lookup
- results

Bearing Capacity by AASHTO 2020 LRFD 10.6.3.1.2a

$$q_n = cN_{cm} + \gamma_q D_f N_{qm} C_{wq} + 0.5\gamma_f B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a\text{-}1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a\text{-}2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a\text{-}3)$$

$$N_\gamma m = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a\text{-}4)$$

Assume load inclination factors are equal to 1.0, based on commentary in Section 10.3.1.2a.

Assume depth correction factor, d_q, is 1.0 based on Section 10.6.3.1.2a.

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Assume footing is below ground water depth

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1 + \left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1 - 0.4\left(\frac{B}{L}\right)$	$1 + \left(\frac{B}{L}\tan\phi_f\right)$

Appendix C Subgrade Analysis

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Design Manual Section 600

SEN-23-7.42
107691

Culvert Replacement at mile mark 7.42 of US 23 in Seneca County, Ohio

Stantec Consulting

Prepared By: James Samples
Date prepared: Wednesday, December 10, 2025

Stantec Consulting
10200 Alliance Road
Suite 300
Cincinnati, OH 45242
(513) 842-8204
james.samples@stantec.com

NO. OF BORINGS: 2

NO. OF DCPS: 0

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.81 7/21/2025

Add DCP Test Data Worksheets

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-25	US 23	391+29	24	Lt.	CME 55T#3 (714)	90	801.3	800.5	0.8 C
2	B-002-0-25	US 23	391+99	14	Rt.	CME 55T#3 (714)	90	801.5	800.7	0.8 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.81 7/21/2025

#	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 (Enter depth in inches)
			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	SS-1	0.0	1.5	-0.8	0.7	9									27	18	A-7-6	16			N_{60} & Mc		12"	
	001-0	SS-2	2.5	4.0	1.7	3.2	9		1.25							25	18	A-7-6	16			HP & Mc			
	25	ST-1	5.0	7.0	4.2	6.2			3.5	48	18	30	33	48	81	23	18	A-7-6	18						
		SS-3	8.0	9.5	7.2	8.7	29	9	4							16	14	A-6a							
2	B	SS-1	2.5	4.0	1.7	3.2	8		1.5							26	18	A-7-6	16			HP & Mc			
	002-0	ST-1	5.0	7.0	4.2	6.2			1.5	49	19	30	28	58	86	19	18	A-7-6	18						
	25	SS-2	8.0	9.5	7.2	8.7	12		3							26	14	A-6a							
		ST-2	10.0	12.0	9.2	11.2		8	2	29	15	14	34	46	80	13	14	A-6a							

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.81 7/21/2025

PID: 107691

County-Route-Section: SEN-23-7.42
No. of Borings: 2

Geotechnical Consultant: Stantec Consulting
Prepared By: James Samples
Date prepared: 12/10/2025

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	No
	Lime Stabilization	Option
206	Depth	14"

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	12"
Average(HP):	0"
Global Geogrid Average(N60L):	0"
Average(HP):	0"

Design CBR	4

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	60%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	0%	1 < HP ≤ 2	40%
$N_{60} \geq 20$	0%	HP > 2	0%
M+	60%		
Rock	0%		
Unsuitable Soil	0%		

Excavate and Replace at Surface	
Average	0"
Maximum	0"
Minimum	0"

% Proposed Subgrade Surface	
Unstable & Unsuitable	100%
Unstable	100%
Unsuitable (Soil & Rock)	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	13	9	2.39	42	17	25	32	51	82	22	17	17
Maximum	29	9	4.00	49	19	30	34	58	86	27	18	18
Minimum	8	8	1.25	29	15	14	28	46	80	13	14	16

Classification Counts by Sample

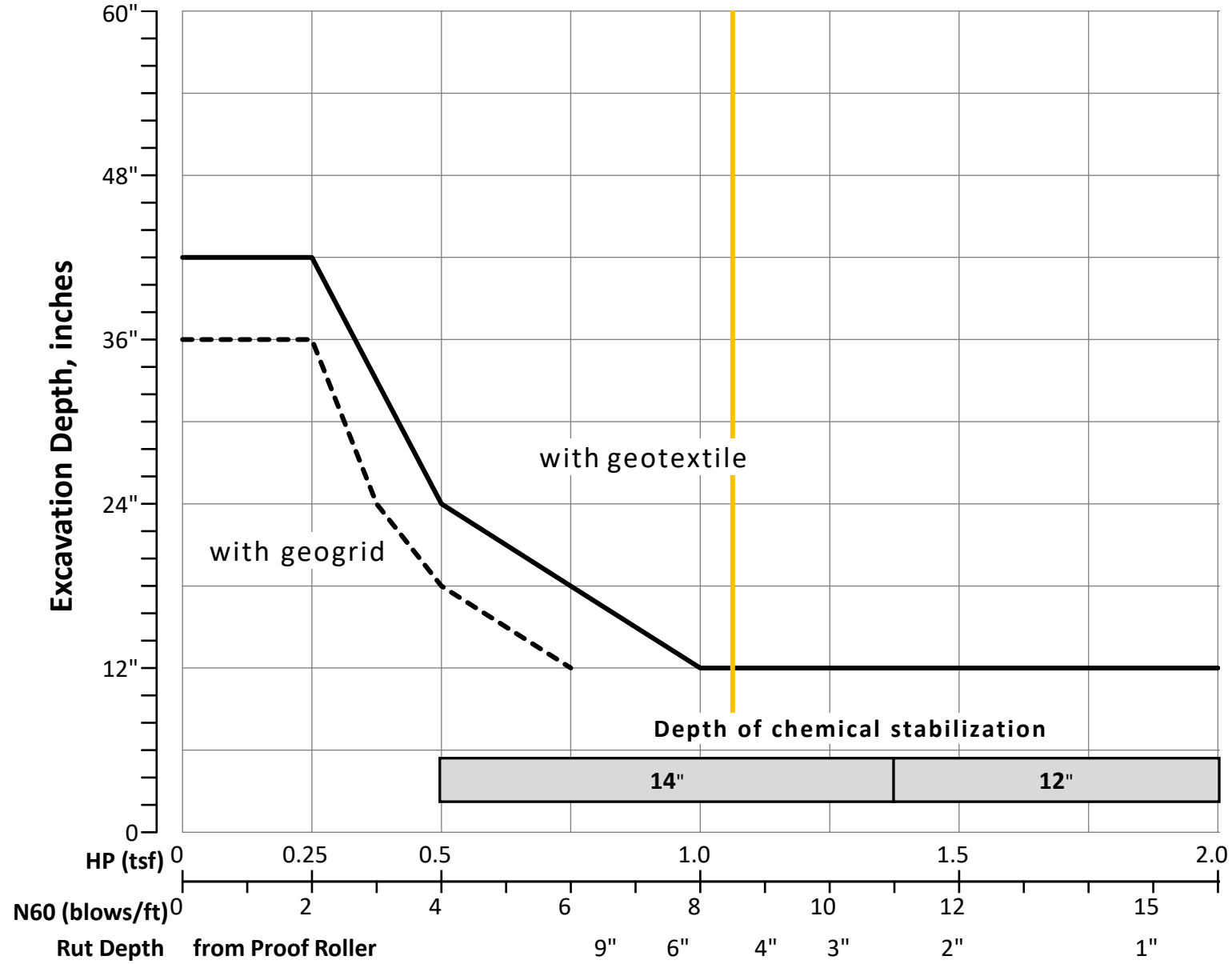
ODOT Class	UCF	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	5	0	0	8
Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	38%	0%	0%	63%	0%	0%	100%
% Rock|Granular|Cohesive	0%	0%	0%									100%								100%
Surface Class Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	100%

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.81 7/21/2025

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
2.39	0.50	☐ HP
8.50	6.00	☐ N60L

Average HP

Average N_{60L}