FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE ROS-772-0764 (CROSSING RALSTON RUN)
PID: 118518
ROSS COUNTY, OHIO

Prepared For:

Woolpert
One Easton Oval Suite 400
Columbus, OH 43219

Prepared by:

NATIONAL ENGINEERING AND ARCHITECTURAL SERVICES INC.
2800 Corporate Exchange Drive, Suite 240
Columbus, Ohio 43231

NEAS PROJECT 24-0004

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EXECUTIVE SUMMARY

The Ohio Department of Transportation (ODOT) District 9 has proposed a bridge replacement project (ROS-772-7.64 PID# 118518) for the planned replacement of the existing bridge carrying SR-772 over Ralston Run, Ross County, Ohio. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction.

National Engineering and Architectural Services Inc. (NEAS) has been contracted to perform geotechnical engineering services for the project. The purpose of the geotechnical engineering services is to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project. As part of the referenced explorations, NEAS advanced 2 project borings and conducted laboratory testing to characterize the soils for engineering purposes. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction.

The subsurface profile at the proposed bridge replacement site generally consists of primarily very stiff to hard cohesive fine materials and some medium dense to very dense granular materials. Bedrock was encountered in both the project and historical borings. In the project borings, bedrock was encountered at a depth of 17.5 feet below ground surface (757.3 feet above mean sea level) at the rear abutment, and at 8.7 feet below ground surface (768.2 feet above mean sea level) at the forward abutment. Additionally, bedrock was discovered in the historical borings between depths of 3.5 feet and 7.0 feet below ground surface (with elevations ranging from 761.3 feet to 762.7 feet above mean sea level).

Based on our subgrade analysis, the average N_{60L} value at the project site is larger than 15 blows per foot. there is no need for subgrade stabilization according to ODOT GDM Section 600 (ODOT, 2024).

A foundation review was completed for a deep foundation system for the referenced replacement bridge based on the following design information: 1) the Site Plan for the Bridge conducted by Woolpert; 2) historical plans and subsurface exploration; and 3) load and scour information provided by Woolpert.

Per instructions from the ODOT OGE and District 9, no scour will occur below the pile cap footing. Therefore, scour will not influence the design of deep foundation.

In accordance with BDM Section 305.3.5.7 and GDM Section 1305, piles placed in prebored holes should extend a minimum of 5 feet into bedrock if bedrock exists within 10 ft of the bottom of pile cap and if the unconfined compressive strength of bedrock exceeds 1,500 psi. Based on our lab testing, the unconfined compressive strength of shale at the proposed bridge site is significantly greater than 1,500 psi. Therefore, the pile should extend at least 5-ft into bedrock for both rear and forward abutments. Additionally, to ensure integral flexibility for the abutments, a 5-ft granular layer should be provided beneath the pile caps. Therefore, the prebored holes should extend at least 5-ft into bedrock at each pile and provide at least 10.0 ft from bottom of footing to bottom of prebored holes.

The project site is classified as Site Class of D - Stiff Soil.

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1. INTRODUCTION

1.1. General

National Engineering and Architectural Services Inc. (NEAS) presents our Structure Foundation Exploration Report for the planned replacement of the existing bridge carrying SR 772 over Ralston Run, Ross County, Ohio. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction. Our recommendations are in accordance with ODOT's 2020 LRFD Bridge Design Manual (BDM) (ODOT, 2024), ODOT's 2024 Geotechnical Design Manual (GDM) (ODOT, 2024).

The exploration was conducted in general accordance with NEAS, Inc.'s proposal to Woolpert dated November 17, 2023, and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2024).

The scope of work performed included: 1) a review of published geotechnical information; 2) performing 2 total test borings; 3) laboratory testing of soil samples in accordance with the SGE; 4) performing geotechnical engineering analysis to assess foundation design and construction considerations; and 5) development of this summary report.

1.2. Proposed Construction

The existing ROS-772-7.64 bridge is a three (3) span non-composite prestressed concrete box beam superstructure supported on reinforced concrete substructure on spread footing. The existing bridge is approximately 96 ft in length with an approximate roadway width of 38 ft.

It is our understanding that the proposed structure is a single span composite deck bridge on AASHTO Type 3 prestressed I-beam superstructure. The proposed bridge spans 75 ft from center to center of bearing, with a roadway width of 36'-1 ½".

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Columbus Lowland Till Plains, a subdivision of the Southern Ohio Loamy Till Plain. This is a moderately low relief (25 ft) lowland surrounded in all directions by relative uplands, having a broad regional slope toward the Scioto Valley, containing many larger streams. Elevations of the region range from 600 to 850 ft above mean sea level (amsl) (950 ft amsl near Powell Moraine). The geology within this region is described as Wisconsinan-age till that is high lime in the west to medium-lime in the east. The geology is also described as containing extensive outwash in Scioto Valley overlying deep Devonian- to Mississippian-age carbonate rocks, shales and siltstones (ODGS, 1998).

Based on the Quaternary geology map of Ohio, the geology at the project site is mapped as Dissected ground moraine occurs on ridgetops and mixed with weathered bedrock as colluvium on slopes (Pavey, et al 1999).

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the project area consists of shale and sandstone, of the Sunbury Shale, Berea Sandstone and Bedford Shale formation. The upper 10 to 50 feet shale; black to brown, weathers light brown; carbonaceous; thin, planar bedding. Underlain by 10 to 50 feet sandstone; brown, weathers light brown to reddish brown; thin to thick bedded, planar to lenticular bedding; minor shale interbeds. Basal 80 to 100 feet shale and interbedded sandstone; gray to brown, weathers light gray to light brown; thin to medium bedded, planar to lenticular bedding; thick. Interval thickness ranges from 100 to 200 feet. The bedrock is relatively level throughout the project (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected to be around 750 to 850 ft amsl, putting bedrock at depths of between 20 and 70 ft below ground surface (bgs).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2015) as primarily Clifty silt loam series. The Clifty silt loam series is comprised of both coarse- and fine-grained soils and classifies as A-1, A-2, and A-4, type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the nearby Ralston Run as it is the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of the Ralston Run may be generally representative of the local groundwater table. However, it should be noted that perched groundwater systems may be existent in areas due to the presence of fine-grained soils making it difficult for groundwater to permeate to the phreatic surface.

The project is located within a special flood hazard area (Zone A), by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2016). Mining and Oil/Gas Production

2.3. Mining and Oil/Gas Production

No abandoned underground mines are noted on ODNR's Abandoned Underground Mine Locator within the immediate vicinity of the project site (ODNR [1], 2024).

According to the ODNR's Ohio Oil & Gas Locator map, no oil or gas wells are located in the immediate vicinity of the project site (ODNR [2], 2024).

2.4. Historical Records and Previous Phases of Project Exploration

A historic record search was performed through ODOT's Transportation Information Management System (TIMS). The following report/plans were available for review and evaluation for this report:

- Bridge design foundation report and project Boring Log for ROS-772-7.85, dated August 29, 1973.
- Bridge design foundation report Project Boring Logs for ROS-772-0778, dated May 21, 1973.

Two historical soil borings (B-002-0-73, and B-007-0-73) that were drilled as part of the 1973 Structure Exploration for ODOT project ROS-772-7.78 were reviewed and are utilized in our report and analysis. A summary of the historic borings and previous project borings information (location, elevation, etc.) is provided in Table 1, and their locations are depicted on the Site Plan provided in Appendix A. The historic borings and previous project borings utilized within this report are provided in Appendix A. It should be noted that the elevations in NAVD 88 are typically lower than they are in NGVD 29; herein the elevations in NAVD 88 are 0.5 feet lower than they are in NGVD 29.

Table 1: Historic Boring and Previou Project Boring Summary

Boring Number	Location (Sta/offset)	Latitude	Longitude	Elevation (NGVD 29) (ft)	Elevation (NAVD 88) (ft)	Existing Substructure	Elevation of Top of Bedrock (NGVD 29) (ft)	Elevation of Top of Bedrock (NAVD 88) (ft)
B-002-0-73	416+00, 10' RT	39.255912	-83.049509	765.3	764.8	Rear Abutment	761.8	761.3
B-007-0-73	417+05, 27' LT	39.256177	-83.049705	770.2	769.7	Forward Abutment	763.2	762.7

2.5. Field Reconnaissance

A field reconnaissance visit for the overall project area was conducted on January 31st, 2024. Site conditions, including the existing land conditions and pavement conditions were noted and photographed during the visit. Photographs of notable features and a summary of our observations are provided below.

1) Land Use and Cover

The land use of most of the project area consists of ODOT ROW (Right of Way), single family homes, and woodland.

2) Bridge Carrying SR-772 over Ralston Run (SFN: 7105363)

The existing bridge carrying SR-772 over Ralston Run is a 3 span, continuous prestressed concrete, multiple box beam bridge with 2 lanes of traffic on a concrete cast-in-place deck with an asphalt wearing course. The bridge sits atop concrete pedestal type abutments and concrete cantilever piers on spread footings set on Shale bedrock. Bedrock in the project area is a laminated to very thinly bedded black shale with intersecting high angle joint discontinuities striking 056° and 320° dipping 80°NW and 78°SW respectively (Photograph 1). At the time of the visit, there was evidence of some scouring at the base of the Northern pier (Photograph 2). The spill through slopes were observed to be covered in riprap with some signs of erosion at the lower edges near each pier. The piers were observed to be in fair condition with some evidence of pitting erosion at each footing and minor surface cracking (Photograph 3). The underside of the bridge deck was observed to be in fair condition with evidence of heavy efflorescence (Photograph 4). Heavy spalling, hollow cavities, exposed rebar, and detached rebar were observed at each side of the outer box beams (Photographs 5 & 6). Both abutments were observed to be in fair condition with some evidence of cracking and minor spalling (Photographs 6 & 7). The existing pavement condition was observed to be in good condition with no signs of surface wear (Photograph 8). The roadway is relatively level and drains to the South-Southeast. To the Northeast of the bridge some signs of slope instability with hummocky terrain and curving trees indicating movement were observed (Photographs 9 & 10). There were no other apparent signs of distress due to geotechnical concerns during our field reconnaissance visit.

Photograph 1: Bedrock at the bridge site

Photograph 2: Scour evidence at the base of the northern pier

Photograph 3: Center piers

Photograph 4: Underside of the bridge deck

Photograph 5: Bridge deck and box beam

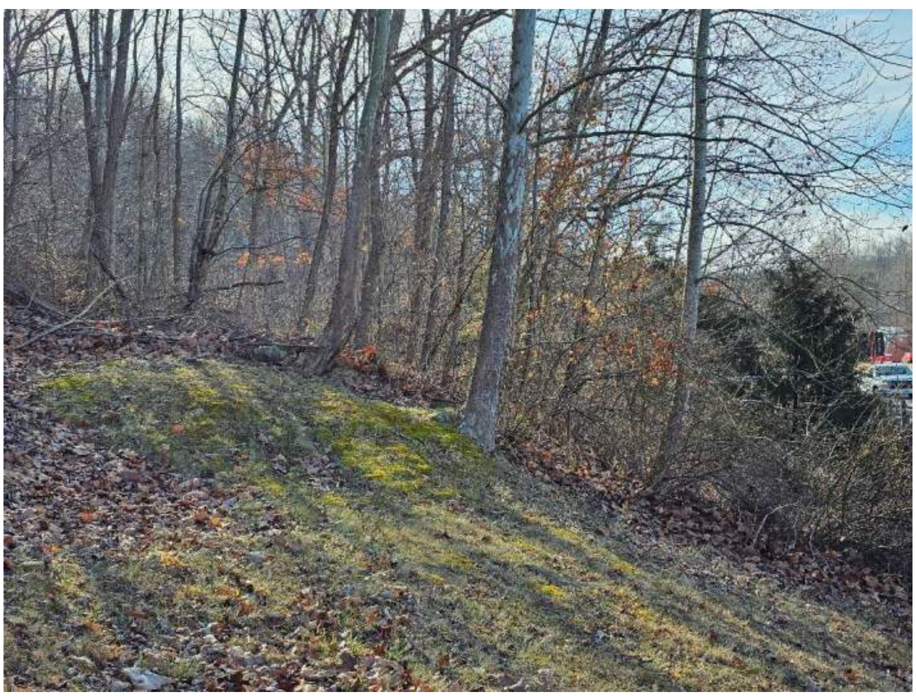
Photograph 6: Bridge deck and abutment

Photograph 7: Abutment

Photograph 8: Roadway Condition

Photograph 9: Northeast Slope

Photograph 10: Northeast Slope



3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The project subsurface exploration was conducted by NEAS on February 28, 2024, and included 2 borings drilled to depths range between 29.5 ft to 38.7 ft below ground surface. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. Borings were typically located within the planned project construction areas that were not restricted by underground utilities or dictated by terrain (e.g. steep embankment slopes). Project boring locations were in the field after drilling by project surveyor. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location and the corresponding ground surface elevation (surveyed by the project surveyors). The boring locations are depicted on the Site Plan provided in Appendix A. Latitude/Longitude, elevations and stationing and offsets of the borings are shown on Table 2 below.

Table 2: Project Boring Summary

Boring Number	Location (Sta/offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Substructure	Elevation of Top of Bedrock (NAVD 88) (ft)
B-001-0-23	415+73, 24' LT	39.255803	-83.049606	774.8	38.7	Rear Abutment	757.3
B-002-0-23	417+33, 17' RT	39.256257	-83.049566	776.9	29.5	Forward Abutment	768.2

Project borings were drilled using a CME 45B truck-mounted drilling rig utilizing 3.25-inch (inner diameter) hollow stem auger. In general, soil samples were recovered continuously to end of boring, using an 18-inch split spoon sampler (AASHTO T-206 "Standard Method for Penetration Test and Split Barrel Sampling of Soils."). The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist for possible laboratory testing. Standard penetration tests (SPT) were conducted using a CME auto hammer calibrated to be 72.6% efficient on January 24, 2022, as indicated on the boring logs.

Field /boring logs were prepared by drilling personnel, and included lithological description, SPT results recorded as blows per 6-inch increment of penetration and estimated unconfined shear strength values on specimens exhibiting cohesion (using a hand-penetrometer). Groundwater level observations were recorded both during and after the completion of drilling. These groundwater level observations are included on the individual boring logs. After completing the borings, the boreholes were backfilled with bentonite grout and patched with cold patch asphalt and/or quickset concrete where necessary and appropriate.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing, moisture content determinations and unconfined compressive strength testing. Data from the laboratory testing program was incorporated onto the boring logs (Appendix B).

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 33% of the samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

A final classification of the soil strata was made in accordance with AASHTO M-145 “Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes,” as modified by ODOT “Classification of Soils” once laboratory test results became available. The results of the soil classification are presented on the boring logs provided in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at varying intervals (i.e., continuous, 2.5-ft, or 5.0-ft intervals) in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are shown on the boring logs provided in Appendix B.

3.2.3. D_{50} Values for Scour Evaluation

Grain size distribution testing was performed on the obtained streambed samples to develop D_{50} values (i.e., the diameter in the particle-size distribution curve corresponding to 50 % finer). The calculated D_{50} values are shown in Table 3 below and the developed particle-size distribution curves are included with the associated boring log within Appendix B.

Table 3: D_{50} Values for Scour Evaluation

Boring Number	Specimen ID	Specimen Elevation (ft)	ODOT (Modified AASHTO) ~ USCS Classification	D_{50} (mm)	Scour Critical Shear Stress, τ_c (psf)	$D_{50, equiv}$ (mm)	Erosion Category (EC)
B-002-0-73	SS-1	761.8' - 761.3'	A-1-b ~ SILTY GRAVEL with SAND(GM)	2.611	0.055	2.611	2.700
B-007-0-73	SS-1	766.7' - 765.7'	A-6a ~ SILT(ML)	0.043	0.212	10.149	3.168
	SS-2	764.7' - 763.7'	A-6a ~ SILT(ML)	0.043	0.209	9.991	3.255
B-001-0-23	SS-1	773.3' - 771.8'	A-4a ~ SANDY LEAN CLAY with GRAVEL(CL)	0.052	0.290	13.875	2.975
	SS-2	770.3' - 768.8'	A-1-b ~ SILTY SAND with GRAVEL(SM)	2.611	0.055	2.611	2.700
	SS-3	768.8' - 767.3'	A-2-4 ~ SILTY SAND with GRAVEL(SM)	0.875	0.018	0.875	2.130
	SS-4	761.3' - 759.8'	A-2-6 ~ CLAYEY SAND with GRAVEL(SC)	0.880	0.061	2.913	3.075
B-002-0-23	SS-1	775.4' - 773.9'	A-4a ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)	0.102	0.069	3.314	2.501
	SS-2	773.9' - 772.4'	A-4a ~ SANDY LEAN CLAY with GRAVEL(CL)	0.058	0.100	4.776	2.754
	SS-3	772.4' - 770.9'	A-4a ~ SANDY LEAN CLAY(CL)	0.042	0.239	11.461	2.868
	SS-4	770.9' - 769.4'	A-6a ~ SANDY LEAN CLAY with GRAVEL(CL)	0.043	0.348	16.669	3.255

Based on our lab testing results, the equivalent D50 (mm) values of bedrock were estimated using the methods described in ODOT's BDM Section 305.2.1.2.b and ODOT's GDM Section 1302.1.3. The estimated equivalent D_{50} (mm) and Erodibility Index K for different layers of bedrock for both abutments are listed in the Table 4 below. The lab testing results, and the equivalent D_{50} (mm) calculation process are attached in Appendix D.

Table 4: Bedrock Equivalent D_{50} Values and Erodibility K

Boring Number	Rock Layer	Rock Layer Elevation (ft)	Rock Type	RQD (%)	Equivalent D_{50} (mm)	Erodibility Index K
B-001-0-23	Layer 1	757.3' - 756.0'	Shale	0	620.0	6.00
	Layer 2	756.0' - 750.6'	Shale	67	9712.7	1472.53
	Layer 3	750.6' - 736.1'	Shale	98	11746.7	2153.85
B-002-0-23	Layer 1	768.2' - 766.9'	Shale	0	679.2	7.20
	Layer 2	766.9' - 762.4'	Shale	53	9463.1	1397.80
	Layer 3	762.4' - 747.4'	Shale	97	12769.0	2545.05

3.2.4. Unconfined Compressive Strength of Rock Core

Unconfined Compressive Strength of rock core samples was conducted in accordance with ASTM D7012 "Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying Sates of Stress and Temperatures". The tests were performed on two rock core samples obtained during the exploration program. The results are summarized in Table 5 below and provided in Appendix C.

Table 5: Unconfined Compressive Strength of Rock Core Results

Boring ID	Depth (ft)	Elevation (ft)	Unconfined Compressive Strength (psi)	Stain at Failure (%)
B-001-0-23	19.1 - 19.5	755.7 - 755.3	7187	1.2
B-002-0-23	13.0 - 13.4	763.9 - 763.5	8648	1.9

3.2.5. Slake Durability Index Test

Slake During Index of rock core sample was conducted in accordance with ASTM D4644 "Standard Test Methods for Slake Durability of Shales and Other Similar Weak Rocks". The test was performed on one rock core sample obtained during the exploration program. The results are summarized in Table 6 below and provided in Appendix C.

Table 6: Slake Durability Index Test Results

Boring ID	Sample Number	Depth (ft)	Moisture Content (%)	Retained Material	Slake Durability Index (%)
B-002-0-23	NQ2-1	20.0 - 21.0	1.52	T1	99.2

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and/or on each boring log presented in Appendix B. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, and consideration of the geological history of the site.

4.1. Subsurface Conditions

The subsurface profile at the referenced site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile at the proposed bridge widening site generally consists of primarily very stiff to hard cohesive fine materials and some medium dense to very dense granular materials. Bedrock was encountered in both project borings and historic borings, ranging from depths of 3.5 ft to 17.5 ft below ground surface (with elevations between 757.3 ft and 768.2 ft above mean sea level).

4.1.1. Overburden Soil

At the proposed rear abutment, the subsurface soils encountered generally consisted of cohesive fine-grained soils underlain by non-cohesive coarse-grained soils. The cohesive fine-grained soils, classified as Sand Silt (A-4a), extend to 770.3 ft amsl. Underneath this layer, the stratum of granular soils ranges from elevations of 770.3 feet to 757.3 feet above mean sea level (amsl), classified as Gravel with Sand (A-1-b), Stone Fragments with Sand and Silt (A-2-4), and Stone Fragments with Sand, Silt, and Clay (A-2-6). The cohesive soils can be described as having a hard consistency based on N_{60} values between 16 and 38 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 4.25 and 4.50 tsf. Natural moisture contents of the cohesive soils ranged from 14 to 15 percent. The non-cohesive soils at the rear abutment location are described as having a relative compactness of medium dense to very dense correlating to N_{60} values between 16 and 54. The natural moisture content of the non-cohesive soils ranged from 7 to 14 percent.

At the proposed forward abutment, the subsurface soils encountered primarily consisted cohesive fine-grained soils extending to 768.2 ft. The cohesive soils are classified on the boring logs as Silt (A-4a), Silt and Clay (A-6a), and Clay (A-7-6). The cohesive soils can be described as having a very stiff to hard consistency based on N_{60} values between 11 and 31 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 2.50 and 4.50 tsf. Natural moisture contents of the cohesive soils ranged from 13 to 18 percent.

4.1.2. Groundwater

Groundwater measurements were taken during the drilling procedures and/or immediately following the completion of each borehole. Groundwater was not encountered in any of the project borings during drilling.

It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration.

4.1.3. Bedrock

Bedrock was discovered in the two project borings at terminating depths of 38.7 feet for the Rear abutment and 29.5 feet for the forward abutment. At the rear abutment, bedrock was encountered at a depth of 17.5 feet below ground surface (757.3 feet above mean sea level), while at the forward abutment, it was found at 8.7 feet below ground surface (768.2 feet above mean sea level). Additionally, bedrock was encountered in the historical borings between depths of 3.5 feet and 7.0 feet below ground surface (with elevations ranging from 761.3 feet to 762.7 feet above mean sea level).

Based on the exploration and testing conducted, bedrock at the project site was classified as slightly to moderately weathered, weak to slightly strong, fractured - highly fractured to intact, narrow to tight Shale.

Recovery of the bedrock core performed ranged from 95 to 100 percent while the Rock Quality Designation (RQD) values ranged from 53 to 100 percent.

Additionally, sandstone was encountered on the historical borings above shale, which was described as buff, firm, very fine-grained, joined with core loss ranging from 66 % to 72%.

5. ANALYSES AND RECOMMENDATIONS

We understand that this project entails replacing the existing bridge with a single span composite deck on beam superstructure. The proposed bridge spans 77 ft 4 inches from abutment to abutment, with a span length of 75 ft and a roadway width of 36 ft. The summary and results of our evaluation as well as recommendations presented in subsequent sections.

5.1. Soil Profile for Analysis

For analysis purposes, each boring log was reviewed, and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil and rock properties (with cited correlation/reference material) used in our evaluation is summarized per boring within Tables 7 and 8 below.

Table 7: B-001-0-23 Soil Profile

Rear Abutment : Soil Profile B-001-0-23							
Soil Description	Unit Weight$^{(1)}$ (pcf)	Moist Unit Weight$^{(1)}$ (pcf)	Saturated Unit Weight$^{(1)}$ (pcf)	Undrained Shear Strength$^{(2)}$ (psf)	Effective Cohesion$^{(3)}$ (psf)	Effective Friction Angle$^{(3)}$ (degrees)	Setup Factor (f_{su})
Sandy Silt Depth (774.8 ft - 770.3 ft)	115	115	125	2950	250	26	1.50
Gravel with Sand Depth (770.3 ft - 768.8 ft)	122	122	132	-	-	45	1.00
Gravel with Sand and Silt Depth (768.8 ft - 761.3 ft)	115	115	125	-	-	35	1.20
Gravel with Sand, Silt and Clay Depth (761.3 ft - 757.3 ft)	115	115	125	-	-	33	1.20
Notes: 1. Values interpreted from ODOT Geotechnical Design Manual (GDM) Section 405. 2. Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used. 3. Values interpreted from LRFD BDS Table 10.4.6.2.4-1 and ODOT GDM Table 400-3.							

Table 8: B-002-0-23 Soil Profile

Forward Abutment: Soil Profile B-002-0-23							
Soil Description	Unit Weight$^{(1)}$ (pcf)	Moist Unit Weight$^{(1)}$ (pcf)	Saturated Unit Weight$^{(1)}$ (pcf)	Undrained Shear Strength$^{(2)}$ (psf)	Effective Cohesion$^{(3)}$ (psf)	Effective Friction Angle$^{(3)}$ (degrees)	Setup Factor (f_{su})
Clay Depth (776.9 ft - 775.4 ft)	110	110	120	1350	150	22	2.00
Sandy Silt Depth (775.4 ft - 770.9 ft)	115	115	125	2600	250	26	1.50
Silt and Clay Depth (770.9 ft - 768.2 ft)	115	115	125	3400	250	26	1.50
Notes: 1. Values interpreted from ODOT Geotechnical Design Manual (GDM) Section 405. 2. Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used. 3. Values interpreted from LRFD BDS Table 10.4.6.2.4-1 and ODOT GDM Table 400-3.							

5.2. Pavement Design and Recommendations

The subgrade analysis was performed in accordance with ODOT's GDM criteria utilizing the ODOT provided*: Subgrade Analysis Spreadsheet* (SubgradeAnalysis.xls, Version 14.7 dated April 4, 2024).

Input information for the spreadsheet was based on the soil characteristics gathered during NEAS's subgrade exploration (i.e., SPT results, laboratory test results, etc.), and our geotechnical experience. For analysis purposes, the proposed roadway elevations were assumed to be the same as the existing roadway elevations.

A subgrade analysis was performed to identify the method, location, and dimensions (including depth) of recommended subgrade stabilization in the referenced project plan. Appropriate stabilization of the subgrade will ensure a constructible pavement buildup, enhance pavement performance over its life, and help reduce costly extra work change orders (ODOT SGE, 2024). In addition to identifying stabilization recommendations, pavement design parameters are also determined to aid in pavement section design. The subsections below present the results of our subgrade analysis including pavement design parameters and unsuitable/unstable subgrade conditions if any identified within the project limits. Subgrade analysis spreadsheet for the referenced roadway segment is provided in Appendix D.

5.2.1. Pavement Design Recommendations

It is our understanding that pavement analysis and design is to be performed to determine the proposed pavement sections for the segments within the project limits to undergo full depth replacement. A subgrade analysis was performed using the subgrade soil data obtained during our field exploration program to evaluate the soil characteristics and develop pavement parameters for use in pavement design. The subgrade analysis parameters recommended for use in pavement design are presented in Table 9 below. Provided in the table are ranges of maximum, minimum and average N_{60L} values for the indicated segments as well as the design CBR value recommended for use in pavement design.

Table 9: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Value	Design CBR
SR-772	19	17	18	8	8

5.2.2. Unsuitable/Unstable Subgrade

Per ODOT's GDM, the presence of select subgrade conditions may require some form of subgrade stabilization within the subgrade zone for new pavement construction. These unsuitable and unstable subgrade conditions generally include the presence of rock, specific soil types, weak soil conditions, and overly moist soil conditions. With respect to the planned roadways, these subgrade conditions are further discussed in the following subsections.

5.2.2.1. Rock

Rock was not encountered within the top 6 inches of the proposed grade in either of the borings performed; therefore, no specialized remediation efforts are necessary.

5.2.2.2. Prohibited Soils

Prohibited soil types, per the GDM, include A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, and soils with liquid limits greater than 65. No prohibited soils were encountered within the subgrade of the referenced project roadway.

5.2.2.3. Weak Soils

The GDM recommends subgrade stabilization for soils considered unstable in which the N_{60} value of a particular soil sample (SS) at a referenced boring location is less than 12 bpf and in some cases less than 15 bpf (i.e., where moisture content is greater than optimum plus 3 percent). Based on the specific N_{60} value at the subject boring, *Figure 600-1 - Subgrade Stabilization* within the GDM recommends a depth of subgrade stabilization for ODOT standard stabilization methods. It should be noted that although a soil sample's N_{60} value may meet the criteria to be considered an unstable soil, the depth in which the unstable soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed. For example, if the GDM recommends an excavate and replace of 12 inches within a weak soil underlying 18 inches of stable material, it would be unreasonable to recommend the removal of both the stable and unstable material for a total of 30 inches of excavate and replace.

5.2.2.4. High Moisture Content Soils

High moisture content soils are defined by the GDM as soils that exceed the estimated optimum moisture content (per Table 600-1 - Optimum Moisture Content within the ODOT GDM) for a given classification by 3 percent or more. Per the GDM, soils determined to be above the identified moisture content levels are a likely indication of the presence of an unstable subgrade and may require some form of subgrade stabilization. Similar to our analysis of unstable soils, although a soil sample's moisture content may meet the criteria to be considered high, the depth in which the high moisture soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed for stabilization recommendations. Summaries of the boring locations where high moisture content conditions were encountered within the limits of each proposed alignment are shown in Table 10 below.

Table 10: High Moisture Content Soils Summary

Boring ID	Soil Type	Moisture Content (%)	Optimum Moisture Content (%)	Depth Below Subgrade (ft)
B-001-0-23	A-4a	15	10	1.5 - 3.0

5.2.3. Stabilization Recommendations

According to our subgrade analysis, subgrade stabilization is not required per ODOT GDM Section 600 (ODOT, 2024). Detailed results of the subgrade analysis are provided in Appendix C.

5.3. Bridge Foundation Analysis and Recommendations

A foundation review was completed for a deep foundation system for the referenced replacement bridge based on the following design information: 1) the Site Plan for the Bridge conducted by Woolpert; 2) historical plans and subsurface exploration; and 3) load and scour information provided by Woolpert. Bedrock elevations ascend from west to east and from south to north.

5.3.1. Axially Loaded Pile Analysis

Deep foundations are proposed to support the substructures of the ROS-772-0764 bridge over Ralston Run. According to the site plan provided by Woolpert via email on December 30, 2024, the bottom of footing is approximately at an elevation of 762.50 ft for the rear abutment and 763.50 ft for the forward abutment. Bedrock was encountered at elevations of 757.30 ft and 768.20 ft in the project borings B-001-0-23 and B-002-0-23, respectively. In historical borings B-002-0-73 and B-007-0-73, bedrock was encountered at elevations of 761.30 ft and 762.70 ft (NAVD 88 datum), respectively.

HP-piles, typically used as end-bearing piles bearing on bedrock, provide high axial working capacity. Both abutments will be supported on HP 10x42 piles in prebored holes. Based on the bridge site plan on December 30, 2024, the Strength I axial loads for the abutment piles are 152 kips. For end-bearing HP-piles, axial resistance is determined by structural considerations. According to Section 305.3.3 of the ODOT Bridge Design Manual (BDM, 2024), the maximum factored structural resistance for HP 10x42 piles is 310 kips, which exceeds the required axial load.

Per instructions from the ODOT OGE and District 9, no scour will occur below the pile cap footing. Therefore, scour will not influence the design of deep foundation.

In accordance with BDM Section 305.3.5.7 and GDM Section 1305, piles placed in prebored holes should extend a minimum of 5 feet into bedrock if bedrock exists within 10 ft of the bottom of pile cap and if the unconfined compressive strength of bedrock exceeds 1,500 psi. Based on our lab testing, the unconfined compressive strength of shale at the proposed bridge site is significantly greater than 1,500 psi. Therefore, the pile should extend at least 5-ft into bedrock for both rear and forward abutments. Additionally, to ensure integral flexibility for the abutments, a 5-ft granular layer should be provided beneath the pile caps.

According to CMS 507.11, prebored holes should have a diameter ranging from 6 inches less to 2 inches more than the pile's diagonal dimension to ensure satisfactory pile driving results. Place Class QC Miscellaneous concrete in the prebored holes to a depth of 5 ft. Then, backfill the remaining prebored holes to the bottom of footing with granular material meeting the requirements of 703.11, structural backfill Type 2, except 100 percent of the material shall pass through a ¾-inch sieve.

5.3.2. Pile Foundation Recommendations

HP 10x42 piles shall be placed in prebored holes. The prebored holes should extend at least 5-ft into bedrock at each pile and provide at least 10.0 ft from bottom of footing to bottom of prebored holes.

Pile lengths based on: 1) the "Estimated Length" and "Order Length" definitions and formulas presented in Section 305.3.5.2 "Estimated Pile Length" of the BDM, are shown in Table 11. It is assumed that the piles will be supported from the elevations at the bottom of footing as shown in the site plan provided by Woolpert via email on December 17, 2024. The calculated 'estimated' length assumes penetration through a 2 ft embedment into the concrete footing for the abutments, and rounding up to the nearest 5 ft.

Table 11: Estimated Pile Lengths Summary

Substructure	Bottom of Pile Cap Elevation (ft amsl)	Assumed Pile Cutoff Elevation (ft amsl)	Top of Bedrock (ft amsl)	Pile Type	Nearby Borings	Geotechnical Pile Tip Elevation (ft amsl) (1)	Geotechnical Pile Length (ft)	Estimated Pile Length (ft)	Order Length (ft)
ROS-772-07.64									
Rear Abutment	762.5	764.5	761.3	HP 10x42	B-002-0-73	752.5	10.0	15	20
Forward Abutment	763.5	765.5	762.7	HP 10x42	B-007-0-73	753.5	10.0	15	20

Note:
1. 5 ft below top of bedrock or 10 ft below bottom of footing, whichever is lower.

5.4. Global Stability Analysis

Global stability should not be a concern due to shallow bedrock.

5.5. Seismic Site Class

Based on the results of the subsurface exploration, laboratory test data, and the AASHTO Site Class Definitions indicated in Table 3.10.3.1-1 of the *LRFD Bridge Design Specifications, 9th Edition* (AASHTO LRFD, 2020), the average Standard Penetration Test blow count $\overline{N}$ for B-001-0-23 and B-002-0-23 is 20 blows/ft and 21 blows/ft, respectively. Therefore, the project site is classified as Site Class of D - Stiff Soil, with $15<\overline{N}<50$ blows/ft.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of the proposed ROS-772-7.64 (PID# 118518), Ross County, Ohio. This report has been prepared for Woolpert, ODOT and their design consultants to be used solely in evaluating the soils underlying the indicated structures and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our field explorations, laboratory test results from representative soil samples, geotechnical engineering analyses and historical information. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes occur in the nature, design or location of the proposed structural work, the conclusions and recommendations contained in this report should not be considered valid until they are reviewed and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to Woolpert in performing this geotechnical exploration for the ROS-772-7.64 (PID# 118518) Replacement project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Chunmei (Melinda) He, Ph.D., P.E.	Zhao Mankoci, Ph.D., P.E.
Project Manager	*Geotechnical Engineer*

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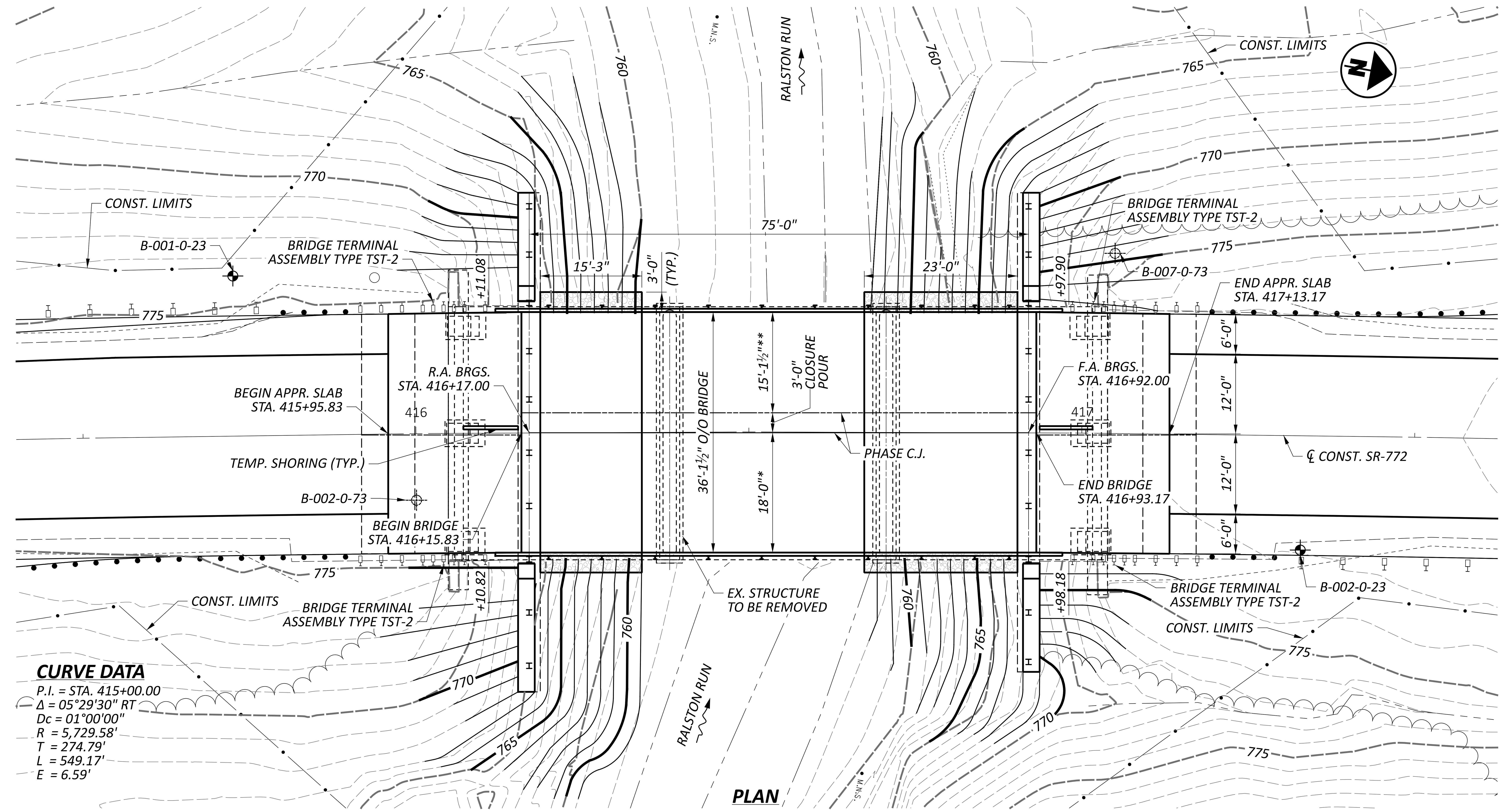
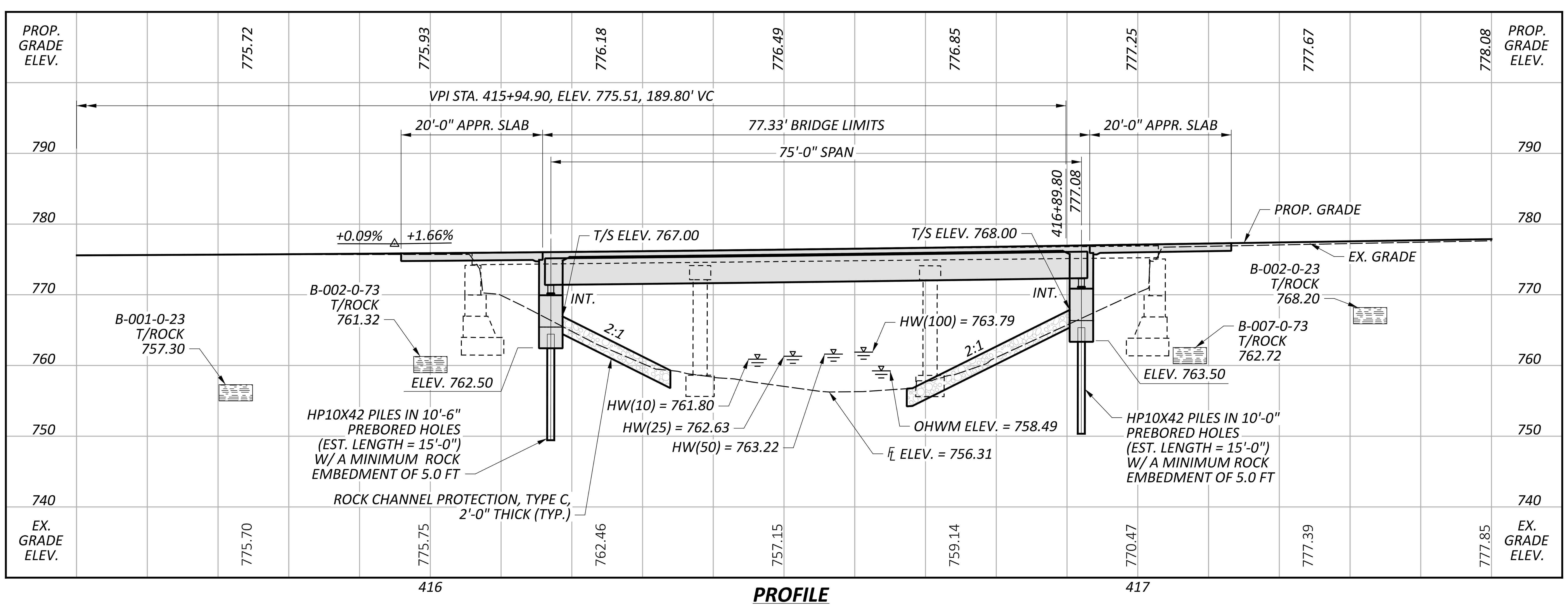
APPENDIX A

SITE PLAN



PLAN



PROFILE

BENCHMARK DATA

CPNT #2 STA. 415+94.02, ELEV. 774.67. OFF. 23.49' LEFT

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLAN SHEET P.02.

NOTES

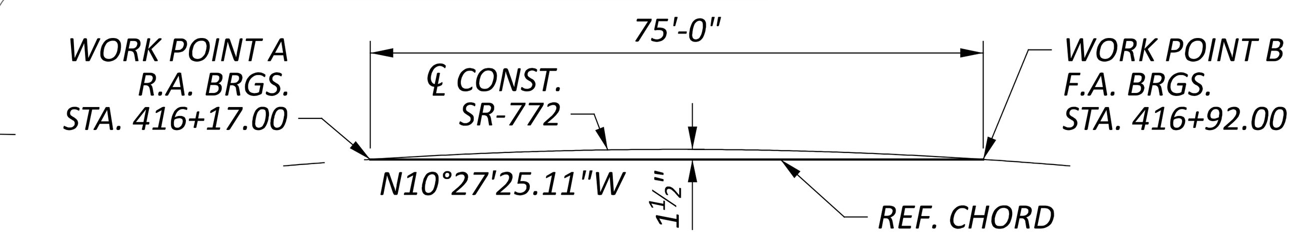
EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

DESIGN TRAFFIC:
2023 ADT = 2,295 2022 ADTT = 161
2043 ADT = 2,300 2043 ADTT = 161
DIRECTIONAL DISTRIBUTION = 64%

LEGEND

PROJECT BORING LOCATION — TYPE C RCP, 2'-0" THICK
HISTORIC BORING LOCATION
* - PHASE 1 CONSTRUCTION — 765 EXISTING CONTOURS
** - PHASE 2 CONSTRUCTION — 765 PROPOSED CONTOURS

REFERENCE CHORD DIAGRAM



HYDRAULIC DATA

DRAINAGE AREA = 5.44 SQ. MILES

Q (10) = 1,130 CFS	V (10) = 6.76 FT/S	DESIGN
Q (25) = 1,570 CFS	V (25) = 7.68 FT/S	SCOUR DESIGN
Q (50) = 1,940 CFS	V (50) = 8.32 FT/S	SCOUR CHECK
Q (100) = 2,340 CFS	V (100) = 8.91 FT/S	FEMA

STRUCTURE CLEARS THE 100 YEAR HW BY 7.35 FEET.
SCOUR DESIGN ELEVATION = 755.07 (25 YEAR), 754.77 (50 YEAR)

EXISTING STRUCTURE

TYPE: 3-SPAN NON-COMPOSITE PRESTRESSED CONCRETE BOX BEAM SUPERSTRUCTURE SUPPORTED ON REINFORCED CONCRETE SUBSTRUCTURES ON SPREAD FOOTINGS.

SPANS: 32'-0"±, 32'-0"±, 32'-0"±

ROADWAY: 38'-0"± F/F GUARDRAIL

LOADING: HS20-44

SKEW: 0°±

WEARING SURFACE: 2½"± ASPHALT CONCRETE

APPROACH SLABS: AS-1-72 (25'-0"± LONG)

ALIGNMENT: 01° 00' 00"± CURVE RIGHT

SUPERELEVATION: 0.017± FT/FT

STRUCTURE FILE NUMBER: 7105363

DATE BUILT: 1980

DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: SINGLE SPAN COMPOSITE DECK ON AASHTO TYPE 3 PRESTRESSED I-BEAM SUPERSTRUCTURE, SUPPORTED ON INTEGRAL ABUTMENTS ON H-PILES.

SPANS: 75'-0" C/C BRGS.

ROADWAY: 36'-1 ½" F/F TST RAILING

LOADING: HL93 AND 0.060 KSF FUTURE WEARING SURFACE

SKEW: NONE

WEARING SURFACE: 1" MONOLITHIC CONCRETE

APPROACH SLABS: 20'-0" LONG (AS-1-15, AS-2-15), TYPE A INSTALLATION

ALIGNMENT: 01° 00' 00" CURVE RIGHT

SUPERELEVATION: 0.025 FT/FT

DECK AREA: 2,794 SF

COORDINATES: LATITUDE 39° 15' 21.38" N
LONGITUDE 83° 02' 58.38" W

HORIZONTAL SCALE IN FEET 0 10 20 40

SITE PLAN
BRIDGE NO. ROS-772-0764
SR-772 OVER RALSTON RUN

SFN 7105364
DESIGN AGENCY
WOOLPERT

DESIGNER	CHECKER
JYM	TML
REVIEWER	
PES	12/02/24
PROJECT ID	
118518	
SUBSET 1	TOTAL 24
SHEET P.25	TOTAL 48

ROS-772-07.64

MODEL: Sheet_SurvFt PAPERSIZE: 34x22 (in.) DATE: 12/17/2024 TIME: 12:42:49 PM USER: Less
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APPENDIX B

BORING LOGS

PROJECT: ROS-772-7.64	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: CME 45B	STATION / OFFSET: 415+73, 24' LT.	EXPLORATION ID B-001-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-772	
PID: 118518 SFN: 7105363	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 774.8 (MSL) EOB: 38.7 ft.	PAGE 1 OF 2
START: 2/8/24 END: 2/8/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 72.6	LAT / LONG: 39.255803, -83.049606	

MATERIAL DESCRIPTION AND NOTES	ELEV. 774.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
10.0" ASPHALT AND 6.0" BASE	773.5	1	3-5-8	16	33	SS-1	4.25	-	-	-	-	-	-	-	-	15	A-4a (V)	
HARD, BROWN AND DARK BROWN, **SANDY SILT**, LITTLE TO SOME GRAVEL, LITTLE TO SOME CLAY, CONTAINS ASPHALT FRAGMENTS, DAMP **(FILL)**		2	6-6-8	17	78	SS-2	4.50	28	10	7	38	17	30	20	10	14	A-4a (4)	
	770.3	3-4	2-10-21	38	72	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	
VERY DENSE, DARK BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS ASPHALT FRAGMENTS, DAMP **(FILL)**	768.8	5	15-17-28	54	94	SS-4	-	55	17	12	13	3	NP	NP	NP	7	A-1-b (0)	
MEDIUM DENSE, ORANGISH BROWN AND BROWN, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, IRON STAINING, DAMP TO MOIST		6-7	10-12-8	24	94	SS-5	-	37	24	13	20	6	NP	NP	NP	10	A-2-4 (0)	
		8	9-8-9	21	11	SS-6	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
		9-10	10-8-6	17	22	SS-7	-	-	-	-	-	-	-	-	-	11	A-2-4 (V)	
		11	5-5-8	16	56	SS-8	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
	761.3	12-13	15-7-8	18	50	SS-9	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)	
MEDIUM DENSE, BROWN, **STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, DAMP		14	6-7-7	17	78	SS-10	-	38	23	7	18	14	33	22	11	14	A-2-6 (0)	
	757.3	15-17 TR																
SHALE, BLACK, SLIGHTLY TO MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, LAMINATED TO VERY THIN BEDDED, FISSILE, PYRITIC, BEDDING DISCONTINUITIES: LOW ANGLE, JOINT DISCONTINUITIES: HIGH ANGLE FROM 21.5'-23.3', 30.5'-30.8', AND 32.8'-33.1', FRACTURED TO INTACT, NARROW TO TIGHT, SLIGHTLY ROUGH, BLOCKY TO INTACT, GOOD SURFACE CONDITION; RQD 99.6%, REC 89.8%.		18-19	60/3"	-	100	SS-11	-	-	-	-	-	-	-	-	-	5	Rock (V)	
		19-24	67		100	NQ2-1											CORE	
		24-29	98		98	NQ2-2											CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 5/8/24 10:29 - P:\OHDOT_V2\WORKSETS\118518\400-ENGINEERING\GEOTECHNICAL\BASEMAPS\GINT\ROS-772-7.64.GPJ

PID: 118518	SFN: 7105363	PROJECT: ROS-772-7.64	STATION / OFFSET: 415+73, 24' LT.	START: 2/8/24	END: 2/8/24	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV. 744.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
SHALE, BLACK, SLIGHTLY TO MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, LAMINATED TO VERY THIN BEDDED, FISSILE, PYRITIC, BEDDING DISCONTINUITIES: LOW ANGLE, JOINT DISCONTINUITIES: HIGH ANGLE FROM 21.5'-23.3', 30.5'-30.8', AND 32.8'-33.1', FRACTURED TO INTACT, NARROW TO TIGHT, SLIGHTLY ROUGH, BLOCKY TO INTACT, GOOD SURFACE CONDITION; RQD 99.6%, REC 89.8%. *(continued)*	736.1	31 32 33 34 35 36 37 38 EOB	98		100	NQ2-3											CORE	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 50 GAL. BENTONITE GROUT

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	18.7'	24.2'	66"	100%	44.5"	67%

ROS-772-7.64

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

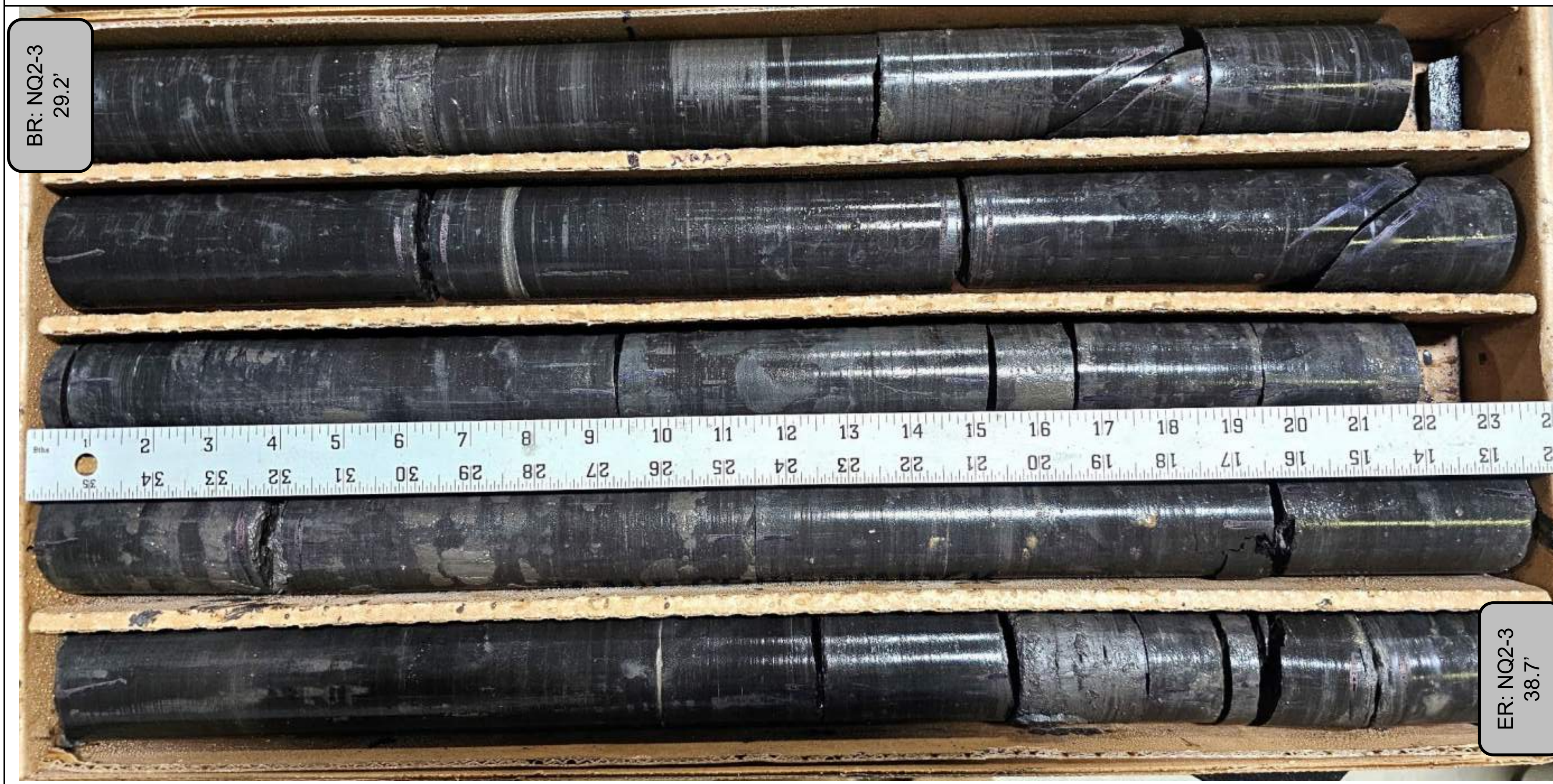
B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-2	24.2’	29.2’	59”	98%	59”	98%
ROS-772-7.64						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-23



Run #:	Depth		Recovery		RQD	
NQ2-3	29.2'	38.7'	114"	100%	112"	98%

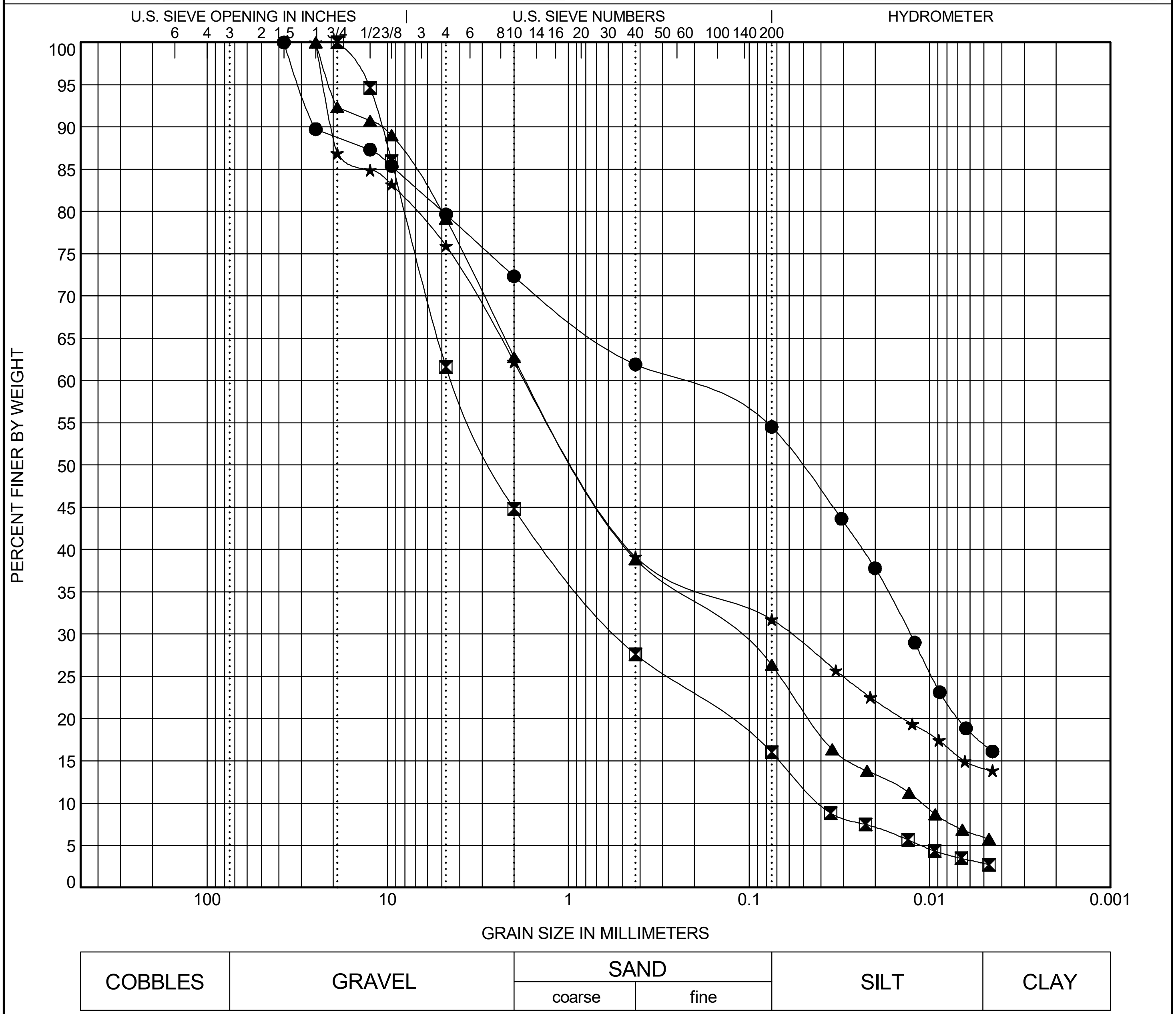
ROS-772-7.64

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT ROS-772-7.64 **PID**

OGE NUMBER 0 **PROJECT TYPE**



	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-001-0-23**	**1.5**	**A-4a ~ SANDY LEAN CLAY with GRAVEL(CL)**	**30**	**20**	**10**
⊠	**B-001-0-23**	**4.5**	**A-1-b ~ SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**
▲	**B-001-0-23**	**6.0**	**A-2-4 ~ SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**
★	**B-001-0-23**	**13.5**	**A-2-6 ~ CLAYEY SAND with GRAVEL(SC)**	**33**	**22**	**11**

	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-001-0-23**	**1.5**	**25.247**	**0.052**	**0.013**		**28**	**10**	**7**	**38**	**17**		
⊠	**B-001-0-23**	**4.5**	**10.792**	**2.611**	**0.527**	**0.04**	**55**	**17**	**12**	**13**	**3**	**1.58**	**109.14**
▲	**B-001-0-23**	**6.0**	**11.123**	**0.875**	**0.124**	**0.011**	**37**	**24**	**13**	**20**	**6**	**0.84**	**151.29**
★	**B-001-0-23**	**13.5**	**20.282**	**0.88**	**0.059**		**38**	**23**	**7**	**18**	**14**		

PROJECT: ROS-772-7.64	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: CME 45B	STATION / OFFSET: 417+33, 17' RT.	EXPLORATION ID B-002-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-772	
PID: SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 776.9 (MSL) EOB: 29.5 ft.	PAGE 1 OF 1
START: 2/8/24 END: 2/8/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 72.6	LAT / LONG: 39.256257, -83.049566	

MATERIAL DESCRIPTION AND NOTES	ELEV. 776.9	DEPTHS
10.0" ASPHALT AND 6.0" BASE	775.6	
VERY STIFF, BROWN AND ORANGISH BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, IRON STAINING, DAMP	775.4	
VERY STIFF TO HARD, BROWN AND ORANGISH BROWN, **SANDY SILT**, TRACE TO SOME GRAVEL, LITTLE TO SOME CLAY, IRON STAINING, SS-2 AND SS-3 CONTAIN NO INTACT SOIL FOR HP READINGS, DAMP	770.9	
VERY STIFF TO HARD, BROWN AND ORANGISH BROWN, **SILT AND CLAY**, LITTLE STONE FRAGMENTS, LITTLE SAND, IRON STAINING, DAMP TO MOIST	768.2	TR
SHALE, BLACK, MODERATELY WEATHERED, SLIGHTLY TO MODERATELY STRONG, LAMINATED TO VERY THIN BEDDED, FISSILE.	766.9	
SHALE, BLACK, SLIGHTLY TO MODERATELY WEATHERED, WEAK TO STRONG, LAMINATED TO VERY THIN BEDDED, FISSILE, PYRITIC, BEDDING DISCONTINUITIES: LOW ANGLE, JOINT DISCONTINUITIES: HIGH ANGLE FROM 11.5'-12.1' AND 21.3'-21.6', HIGHLY FRACTURED TO INTACT, NARROW TO TIGHT, SLIGHTLY ROUGH, BLOCKY TO INTACT, GOOD SURFACE CONDITION; RQD 85.3%, REC 97.6%. @13.0'-13.4'; Qu = 8648 PSI @ 1.9%	747.4	EOB

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
4-5-4	11	78	SS-1	2.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
6-10-9	23	72	SS-2	-	28	8	17	32	15	24	18	6	13	A-4a (2)	
7-5-11	19	56	SS-3	-	25	10	11	34	20	26	18	8	15	A-4a (4)	
8-6-11	21	89	SS-4	4.50	10	7	18	43	22	28	19	9	17	A-4a (6)	
6-9-11	24	89	SS-5	3.25	20	5	13	37	25	30	17	13	16	A-6a (7)	
5-9-17	31	67	SS-6	4.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
29-50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	14	Rock (V)	
53		100	NQ2-1											CORE	
93		95	NQ2-2											CORE	
100		100	NQ2-3											CORE	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 45 GAL. BENTONITE GROUT

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	10.0'	14.5'	54"	100%	28.5"	53%

ROS-772-7.64

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-2	14.5'	24.5'	114.5"	95%	111"	93%

ROS-772-7.64

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-002-0-23						

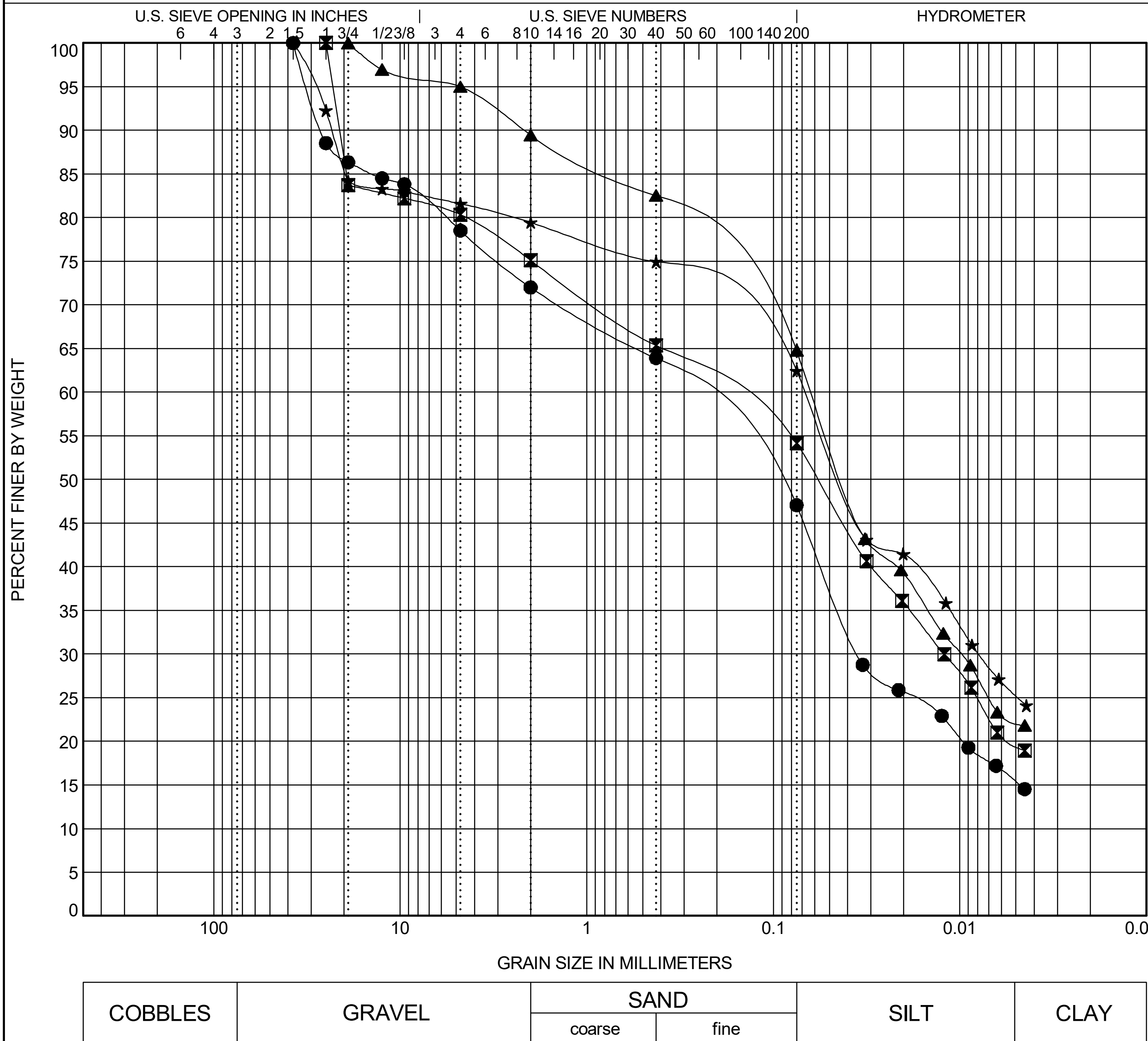
Run #:	Depth		Recovery		RQD	
NQ2-3	24.5'	29.5'	60"	100%	60"	100%
ROS-772-7.64						

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT ROS-772-7.64 **PID**

OGE NUMBER 0 **PROJECT TYPE**



Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-002-0-23	1.5	**A-4a ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)**	24	18	6
⊠ B-002-0-23	3.0	**A-4a ~ SANDY LEAN CLAY with GRAVEL(CL)**	26	18	8
▲ B-002-0-23	4.5	**A-4a ~ SANDY LEAN CLAY(CL)**	28	19	9
★ B-002-0-23	6.0	**A-6a ~ SANDY LEAN CLAY with GRAVEL(CL)**	30	17	13

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-002-0-23	1.5	26.329	0.102	0.035		28	8	17	32	15		
⊠ B-002-0-23	3.0	21.121	0.058	0.012		25	10	11	34	20		
▲ B-002-0-23	4.5	2.183	0.042	0.01		10	7	18	43	22		
★ B-002-0-23	6.0	23.139	0.043	0.008		20	5	13	37	25		

GRAIN SIZE - OH DOT.GDT - 3/18/24 08:17 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\ROS-772-7.64\GINT FILES\ROS-772-7.64.GPJ

LOG OF BORING

Date Started 8-6-73 | Sampler Type SS | Dia 1 3/8" | Water Elev

Date Completed 8-7-73 | Casing Length 5' | Dia 3 1/2"

Boring No. B-2 | Station & Offset: 416+00, 10' RT. (REAR ABUTMENT) | Surface Elev 765.3'

Elev.	Depth	Std. Pen. (N)	Rec ft.	Loss ft.	Description	Sample No.	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
765.3	0														
762.8	2				TOP OF ROCK										
761.8		40/			BROWN SILTY SANDY GRAVEL	1	57	16	7	15	5	NP	NP	15	A-1-b
	4		1.2	0.3	SANDSTONE, BUFF, FIRM, VERY FINE-GRAINED, BROKEN AND JOINTED. CORE LOSS: 66%										
758.3	6														
	8		2.9	1.1	SHALE, DARK-GRAY, FIRM, CARBONACEOUS, FISSILE, BROKEN. CORE LOSS: 1%										
	10														
	12		5.0	0.0											
750.3	14				BOTTOM OF BORING										

LOG OF BORING

Date Started 8-8-73 | Sampler Type SS | Dia. 1-3/8" | Water Elev ______
Date Completed 8-8-73 | Casing Length 10' | Dia. 3-1/2"
Boring No. B-7 | Station & Offset 417+05',27'LT(FORWARD ABUTMENT) | Surface Elev 770.2'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
770.2	0														
767.7	2														
	4	3/5			BROWN SILT & CLAY	1	6	3	5	53	33	32	12	27	A-6a
765.2	6	4/7			BROWN CLAY WITH SHALE FRAGMENTS	2	26	6	5	35	28	32	13	21	A-6a
763.2					TOP OF ROCK										
	8														
	10		1.2	1.8	SANDSTONE, BUFF, FIRM, VERY FINE-GRAINED, BROKEN AND JOINTED. CORE LOSS: 72%										
758.2	12														
	14		3.2	1.8											
	16				SHALE, DARK-GRAY, FIRM, CARBONACEOUS, FISSILE, BROKEN AND JOINTED. NO CORE LOSS.										
	18		5.0	0.0											
750.2	20				BOTTOM OF BORING										

APPENDIX C

UNDISTURBED TEST DATA

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ROS-772-7.64, Boring Location: B-001-0-23, NQ2-1, Depth: 19.1-19.5ft)

Tested Date: 11/18/2024

Specimen Properties

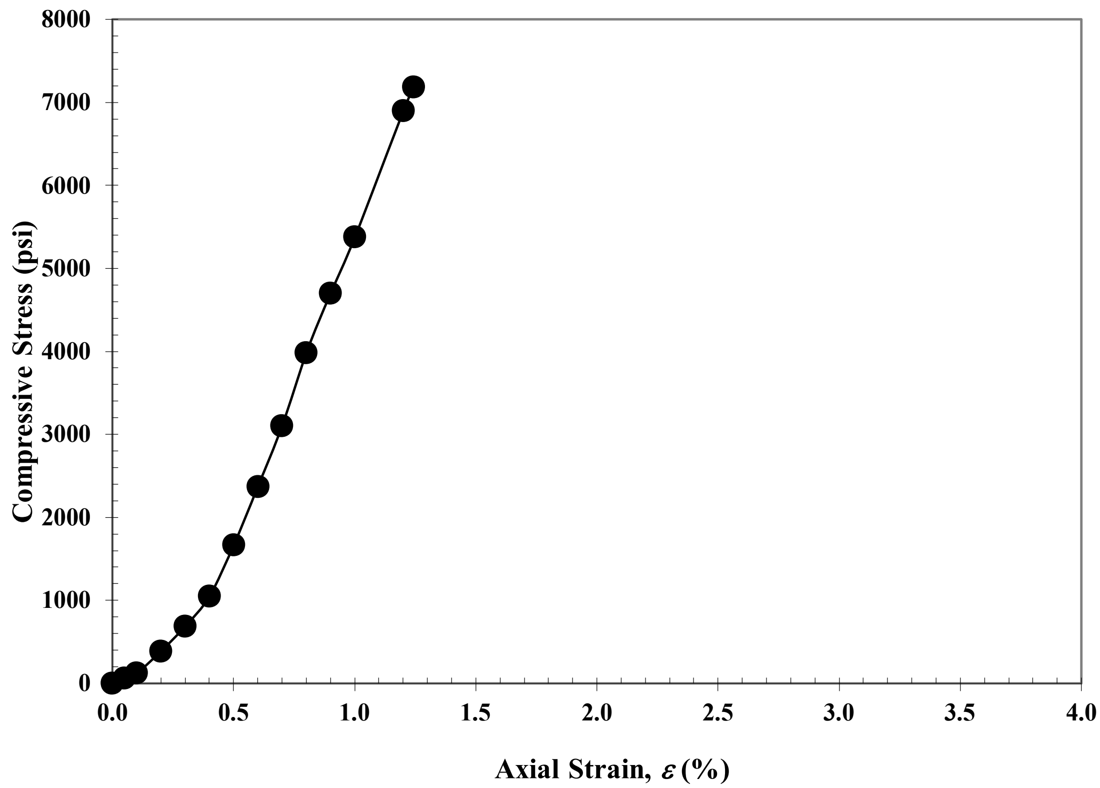
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.35
Length to Diameter Ratio:	2.21
Area, A (in^2):	3.04
Volume, V (in^3):	13.20
Wet Mass of Specimen (lb):	1.0
Moisture Content (%):	1.4
Dry Mass of Specimen (lb):	1.0
Wet Unit Weight, γ (lb/ft^3):	135.6
Dry Unit Weight, γ_d (lb/ft^3):	133.7

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **7187** **50** (MPa)

Strain (%): **1.2**



Notes: Shale, black, unweathered, moderately strong, slightly fissile.

NEAS
National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ROS-772-7.64, Boring Location: B-002-0-23, NQ2-1, Depth: 13.0-13.4ft)

Tested Date: 11/20/2024

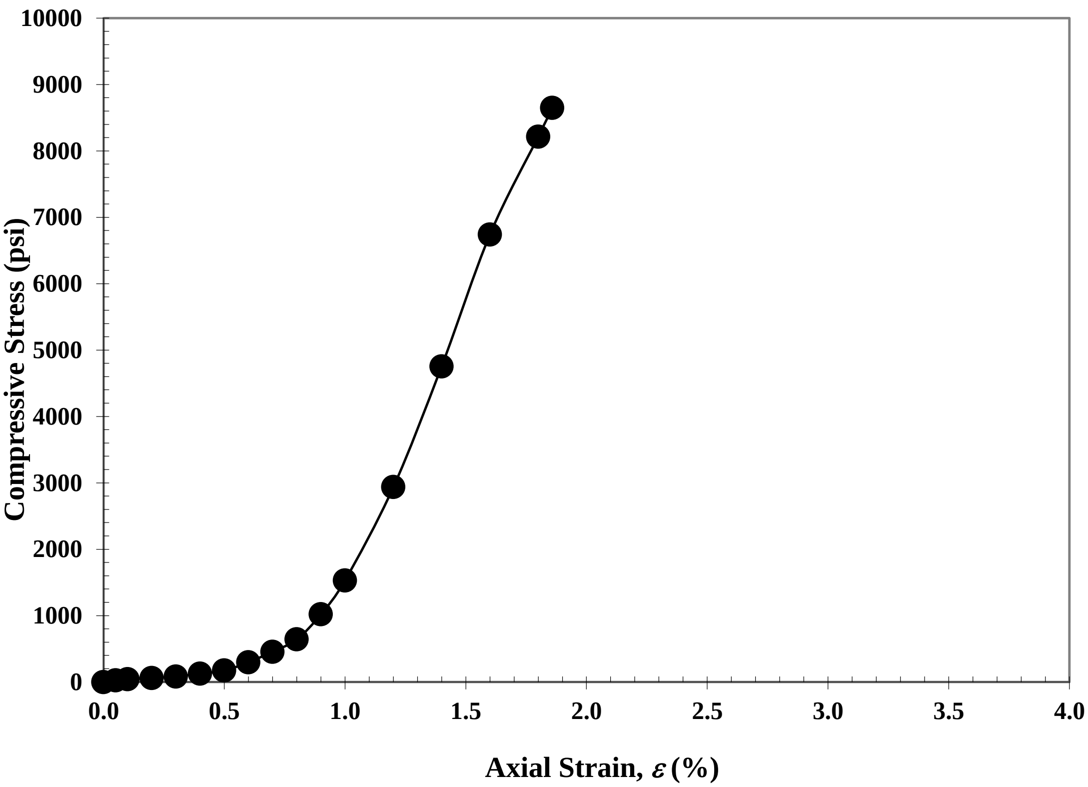
Specimen Properties

Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.04
Length to Diameter Ratio:	2.03
Area, A (in^2):	3.09
Volume, V (in^3):	12.47
Wet Mass of Specimen (lb):	1.0
Moisture Content (%):	1.5
Dry Mass of Specimen (lb):	1.0
Wet Unit Weight, γ (lb/ft^3):	135.8
Dry Unit Weight, γ_d (lb/ft^3):	133.9

Final Specimen Figure

Results

Unconfined Compressive Strength (psi):	**8648**	**60**	(MPa)
Strain (%):	**1.9**		



Notes: Shale, black, unweathered, strong, slightly fissile.

SLAKE DURABILITY TEST
ASTM D4644

NEAS
National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, Ohio 43213
614-892-0162

Tech	PJ	Checked	LR	Report Date:	11/27/2024
County	ROS	Route	772	Section	7.64
Boring Number	B-002-0-23	District	9	PID	
Station		Offset		Offset Direction	
Latitude		Longitude		Ground Elev. (Ft)	
Sample Number	NQ2-1	Top Depth	10	Bottom Depth	11

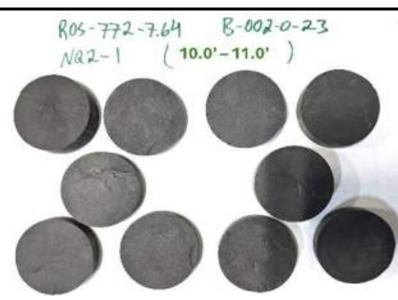
Description	SHALE, black, slightly weathered, strong, fissile

NATURAL MOISTURE DETERMINATION

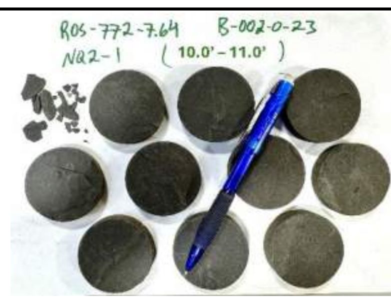
Pan ID	Sample Weight (g)	Tare Weight (g)		IN: 11/20/24	OUT: 11/20/24	Moisture Content (%)
C-23	506.82	237.03	Time	12:20	8:01	
			Mass	743.84	736.25	1.52%

Start Time (mil):	End Time (mil):		First Cycle (I_{d1})					
10:07	10:17		Drum ID	Tare Weight (g)		IN: 11/21/24	OUT: 11/21/24	Final Dry Mass (g)
Start Temp (ºC):	End Temp (ºC):	Avg. Temp (ºC)	A	1167.17	Time	10:27	13:15	
21.1	20.8	20.925			Mass	1675.52	1664.86	497.69

Start Time (mil):	End Time (mil):		Second Cycle (Id2)					
14:48	14:58		Drum ID	Tare Weight (g)		IN: 11/21/24	OUT: 11/22/24	Final Dry Mass (g)
Start Temp (ºC):	End Temp (ºC):	Avg. Temp (ºC)	A	1167.17	Time	15:07	9:05	
20.5	20.5	20.475			Mass	1673.86	1662.61	495.44



Before First Cycle



After Second Cycle

Slake Durability Index
$I_{d2}=\{(W_F-C)/(B-C)\}*100$

I_{d2} = **99.2%**

Retained Material
Type: **T 1**
(Reference Below)

WF = Drum mass + oven dried specimen after second cycle; B = Drum mass + specimen prior to test; C = Drum mass

From ASTM D4644

T 1	Retained pieces remain virtually unchanged

T 2	Retained material consists of large and small pieces

T 3	Retained material is exclusively small pieces

APPENDIX D

CALCULATION

BEDROCK D50 VALUES

ROCK CORE ID

Job Name: ROS-772-7.64 By: LR Date: 4/19/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-001-0-23	NQ2-1	18.7-24.2'	Shale	66"	66"	44.5"
					100%	67%
	NQ2-2	24.2-29.2'		60"	59"	59"
					98%	98%
	NQ2-3	29.2-38.7'		114"	114"	112"
					100%	98%
				240"	**239"**	**215.5"**
					100%	**90%**

Erodability Index (K) **K=(Ms)(RQD/Jn)(Jr/Ja)(Js)**	**Strength (Ms) = 50.0**
	Joint Set # (Jn) = 2.73
	Joint Roughness (Jr) = 2.0
	Joint Alteration (Ja) = 1.0
	Joint Orientation (Js) = 0.6

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 0$ — Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 50$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 0.1$$

Block Size Parameter (HEC-18, Eq. 4.18)

$$K_d := \frac{J_r}{J_a} = 2$$

Shear Strength Parameter (HEC-18, Eq. 4.19)

$$K := M_s \cdot K_b \cdot K_d \cdot J_s = 6$$

Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho}\right)^{\frac{2}{3}}$ $\tau c\_Pa = 620$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88} \, psf$ $\tau c\_psf = 12.9 \, psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 620$ Equivalent D50 (mm)

Objective: To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.

Method: In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b

Erodibility Index (K):

Givens:

$RQD := 67$ — Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 50$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 24.54$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 1472.53$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 9712.7$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ \boldsymbol{psf}$ $\tau c\_psf = 202.9\ \boldsymbol{psf}$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 9712.7$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 98$ Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 50$ Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 35.9$ Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 2153.85$ Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\dfrac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 11746.7$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \dfrac{1}{47.88}\ psf$ $\tau c\_psf = 245.3\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 11746.7$ Equivalent D50 (mm)

ROCK CORE ID

Job Name: ROS-772-7.64 By: LR Date: 4/19/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-002-0-23	NQ2-1	10.0-14.5'	Shale	54"	54"	28.5"
					100%	53%
	NQ2-2	14.5-24.5'		120"	114.5"	111"
					95%	93%
	NQ2-3	24.5-29.5'		60"	60"	60"
					100%	100%
				234"	**228.5"**	**119.5"**
					98%	**85%**

Erodability Index (K) **K=(Ms)(RQD/Jn)(Jr/Ja)(Js)**	**Strength (Ms) = 60.0**
	Joint Set # (Jn) = 2.73
	Joint Roughness (Jr) = 2.0
	Joint Alteration (Ja) = 1.0
	Joint Orientation (Js) = 0.6

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 0$ Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 60$ Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 0.1$ Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 7.2$ Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 679.2$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 14.2\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 679.2$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 53$ Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 60$ Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 19.41$ Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 1397.8$ Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 9463.1$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88} \, psf$ $\tau c\_psf = 197.6 \, psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 9463.1$ Equivalent D50 (mm)

Objective: To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.

Method: In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b

Erodibility Index (K):

Givens:

$RQD := 96.5$ Rock Quality Designation, Unit: Percentage

$J_n := 2.73$ Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 2.0$ Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 1.0$ Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 0.6$ Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 60$ Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0, 0.1, \frac{RQD}{J_n}\right) = 35.35$ Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 2545.05$ Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 12769$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 266.7\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 12769$ Equivalent D50 (mm)

SUBGRADE ANALYSIS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Design Manual Section 600

Instructions: Enter data in the shaded cells only.
(Enter state route number, project description,county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

ROS-772-7.64
118518

Replacement of the bridge carrying SR 772 over Ralston Run

NEAS, Inc.

Prepared By: Derar M. Tarawneh
Date prepared: Thursday, March 14, 2024

Chunmei (Melinda) He, Ph.D., P.E.
2800 Corporate Exchange Drive
Suite 240
Columbus, OH 43231
614.714.0299 Ext 111
che@neasinc.com

NO. OF BORINGS: 2

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-23	SR-772	415+73	24	LT	CME 45B	73	774.8	773.3	1.5 C
2	B-002-0-23	SR-772	417+33	17	RT	CME 45B	73	776.9	775.4	1.5 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V.14.7 4/4/2024

#	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	-1.5	0.0	16		4.25							15	10	A-4a	8						
	001-0	SS-2	1.5	3.0	0.0	1.5	17		4.5	30	20	10	38	17	55	14	15	A-4a	4						
	23	SS-3	3.0	4.5	1.5	3.0	38		4.5							15	10	A-4a	8			Mc			
		SS-4	4.5	6.0	3.0	4.5	54	17		NP	NP	NP	13	3	16	7	6	A-1-b	0						
2	B	SS-1	0.0	1.5	-1.5	0.0	11		2.5							18	18	A-7-6	16						
	002-0	SS-2	1.5	3.0	0.0	1.5	23			24	18	6	32	15	47	13	13	A-4a	2						
	23	SS-3	3.0	4.5	1.5	3.0	19			26	18	8	34	20	54	15	13	A-4a	4						
		SS-4	4.5	6.0	3.0	4.5	21	19	4.5	28	19	9	43	22	65	17	14	A-4a	6						

PID: 118518

County-Route-Section: ROS-772-7.64
No. of Borings: 2

Geotechnical Consultant: NEAS, Inc.
Prepared By: Derar M. Tarawneh
Date prepared: 3/14/2024

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

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

Design CBR	8

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	0%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	0%	1 < HP ≤ 2	0%
$N_{60} \geq 20$	67%	HP > 2	50%
M+	17%		
Rock	0%		
Unsuitable Soil	0%		

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

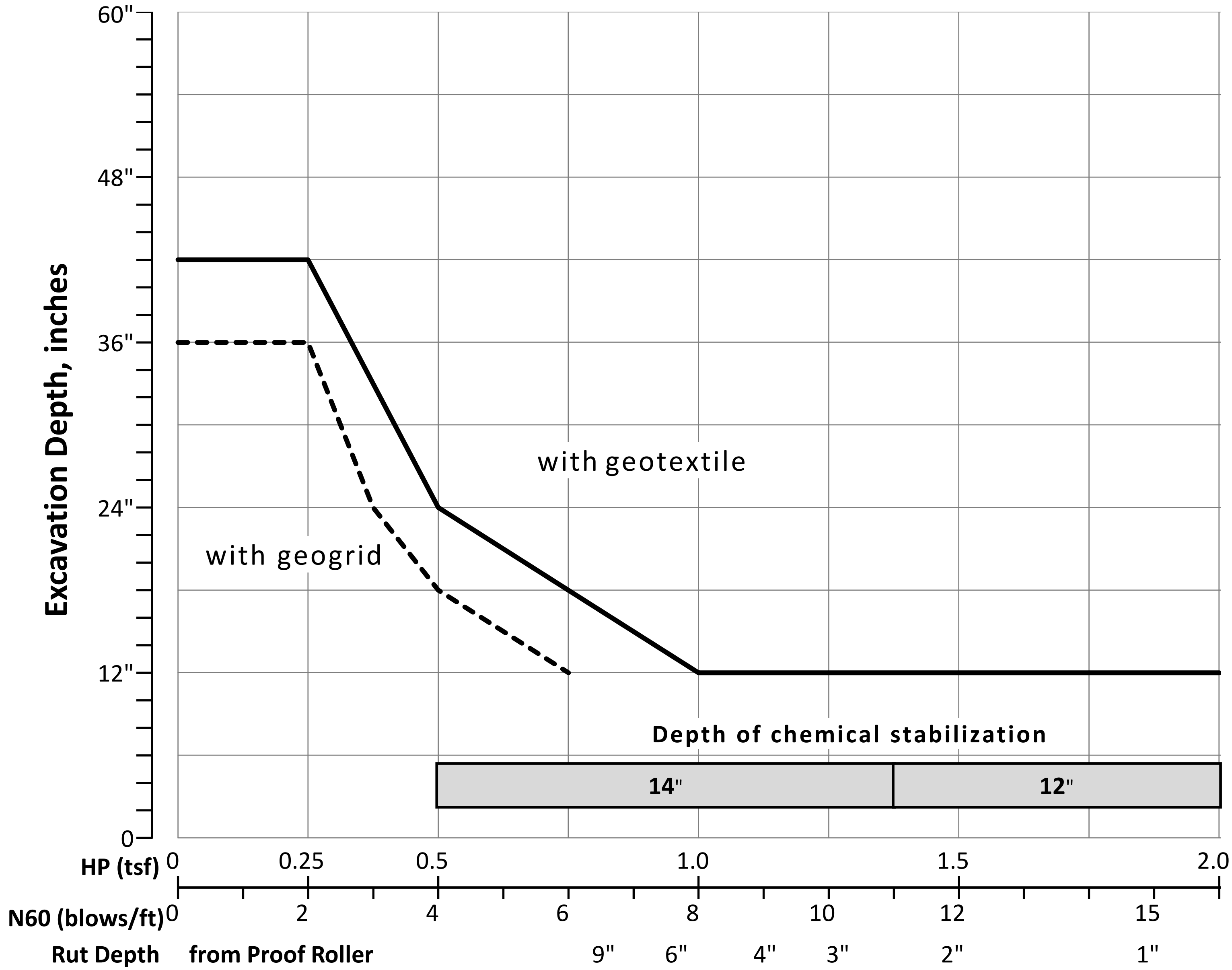
% Proposed Subgrade Surface	
Unstable & Unsuitable	17%
Unstable	17%
Unsuitable (Soil & Rock)	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	29	18	4.50	27	19	8	32	15	47	14	12	4
Maximum	54	19	4.50	30	20	10	43	22	65	18	18	16
Minimum	11	17	2.50	24	18	6	13	3	16	7	6	0

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	1	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	6
Percent	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	83%	0%	0%	0%	0%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	0%	100%									0%								100%
Surface Class Count	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	1	0	0	6
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	83%	0%	0%	0%	0%	0%	17%	0%	0%	100%

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
4.50	0.50	☐ HP
18.00	6.00	☐ N60L

Average HP

Average N_{60L}