CTL Engineering, Inc.
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AN EMPLOYEE OWNED COMPANY

Consulting Engineers • Testing • Inspection Services • Analytical Laboratories

Established 1927

February 12, 2024

Pike County Engineer's Office
502 Pike Street
Waverly, Ohio 45690

Attention: Mr. Denny Salisbury, P.E., P.S.
Pike County Engineer

Reference: Structure Foundation Exploration – Final Report
PIK-CR57-00.62 Culvert Replacement
PID No. 118834
Pike County, Ohio
CTL Project No. 23050023COL

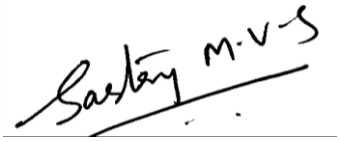
Dear Mr. Salisbury,

CTL Engineering, Inc. has completed the Structure Foundation Exploration for the above referenced project. A pdf copy of the Final report is being submitted.

Thank you for the opportunity to work with you on this project. If you have any questions or need further information, please feel free to contact our office.

Respectfully Submitted

CTL ENGINEERING, INC.



Sastry Malladi, P.E
Project Engineer

STRUCTURE FOUNDATION EXPLORATION- FINAL REPORT

PIK-CR57-00.62 CULVERT REPLACEMENT
PIKE COUNTY, OHIO
CTL PROJECT NO. 23050023COL

PREPARED FOR:

PIKE COUNTY ENGINEER'S OFFICE
502 PIKE STREET
WAVERLY, OHIO 45690

PREPARED BY:

CTL ENGINEERING, INC.
2860 FISHER ROAD
COLUMBUS, OHIO 43204
Phone 614-276-8123
Fax 614-276-6377

February 12, 2024

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

The project involves the replacement of the existing corrugated metal pipe culvert on County Road 57 (Beaver Pike Road) over a tributary to Fourmile Creek in Pike County, Ohio. The replacement structure will be a 65-foot long reinforced concrete box culvert.

Two (2) test borings, identified as B-001-0-23 and B-002-0-23, were drilled for this project. The borings exhibited soils described as gravel and/or stone fragments with sand and silt (A-2-4), sandy silt (A-4a) or clay (A-7-6). Both borings encountered bedrock at depths of 13.5 feet below existing grade. The bedrock was described as shale or siltstone.

According to the plans, the proposed culvert invert ranges from 626.45 to 625.06 feet. It is understood that a cushion of granular bedding material will be placed immediately below the bottom of the proposed culvert. In general, medium dense sandy silt (A-4a) or loose to dense gravel and stone fragments with sand and silt (A-2-4) soils were encountered near the bottom of the proposed culvert. It is recommended that existing soils below the proposed culvert should be uniformly excavated down to elevation 624.5 and replaced with granular bedding material up to the bottom of the proposed culvert. The headwall and wingwall foundations may extended to the underlying coreable siltstone bedrock.

As an alternative to extending the foundations to the top of coreable bedrock, the soils and augerable bedrock encountered below the proposed foundations can be overexcavated and backfilled with lean concrete, low strength mortar (LSM) or granular bedding material. Please refer to the *Analyses and Recommendation* section of this report for additional details.

II. INTRODUCTION

The project involves the replacement of the existing corrugated metal pipe culvert on County Road 57 (Beaver Pike Road) over a tributary to Fourmile Creek in Pike County, Ohio. The replacement structure will be a 65-foot long reinforced concrete box culvert. This is a Final Report.

III. GEOLOGY AND OBSERVATIONS OF THE PROJECT

According to the Ohio Department of Natural Resources, *Physiographic Regions of Ohio*, the site lies on the Shawnee-Mississippian Plateau physiographic region. According to the *Bedrock Geologic Map of Ohio (2006)*, the bedrock below the site consists of Lower Mississippian age and Upper Devonian age Sunbury Shale, Berea Sandstone and Bedford Shale.

According to web-based mapping from *United States Department of Agriculture, Natural Resources Conservation Service*, the soils in the project area mainly consist of Stendal silt loam, occasionally flooded (Ss) and Wyatt silty clay loam, eroded (Wya3C2). According to the *Soil Survey of Ottawa County, Ohio*, these soils exhibit very low to high permeability.

According to the ODNR website, no mapped deep mines are located below the project area.

According to the Ohio Karst Areas map prepared by the Ohio Department of Natural Resources (ODNR), no karst features were mapped within the project area.

A most recent site visit was performed on March 23, 2022, by personnel from CTL Engineering. At the time of the site visit, the existing pavement exhibited some transverse cracks within the project limits. Erosion was noted in the creek channel both upstream and downstream from the structure. Evidence of piping was noted on the roadway surface above the culvert. It is understood that the County has been placing asphalt periodically to plug the piping.

IV. EXPLORATION

Two (2) borings designated as B-001-0-23 and B-002-0-23 were performed for this project. The borings were extended through the pavement of CR 57.

The borings were drilled and cored to depths of 19.0 feet each. Bedrock was encountered at a depth of 13.5 feet below existing grade in each boring. The bedrock was cored to a depth of 19.0 feet below existing grade in both borings. The borings were drilled at the approximate locations indicated on the appended Soil Profile sheets under Appendix A.

The borings were performed with a track mounted drill rig utilizing hollow stem augers (HSA) between March 28 and March 29, 2023. Standard penetration tests were conducted using a 140-pound automatic hammer, falling 30 inches, to drive 2-inch O.D. split barrel samplers. The energy transfer ratio associated with the automatic SPT hammer was 81.5 percent. The hammer was calibrated in October 2021.

Soil samples obtained were preserved in glass jars, visually classified in the field and laboratory, and tested for natural moisture content. Representative soil samples were subjected to laboratory testing including grain size distribution, Atterberg limits, hand penetrometer and sulfate testing. Representative rock samples were subjected to unconfined compressive strength testing.

Rock coring was performed in both borings using an NQ size, double tube core barrel with a diamond bit. The recovered rock from the coring operations was visually described and

the Rock Quality Designation (RQD) and percent core loss values were determined. A representative sample of the recovered rock was subjected to compressive strength testing.

The survey information at the test boring locations was provided by 2LMN.

V. FINDINGS

Both borings encountered 12 inches of asphalt over 8 inches of aggregate base.

Below the surface cover, the borings encountered both cohesive and granular soils to depths of 13.5 feet below existing grade. The soils were described as gravel and/or stone fragments with sand and silt (A-2-4), sandy silt (A-4a) or clay (A-7-6). These soils exhibited standard penetration N_{60} values ranging from 5 blows per foot (bpf) to 50 blows for 5 inches of penetration, with natural moisture content values ranging from 10 to 26 percent.

Beneath the soil overburden, both borings exhibited top of bedrock at a depth of 13.5 feet below existing grade. This depth corresponds to an elevations of 622.9 and 623.2 feet in borings B-001-0-23 and B-002-0-23, respectively. The bedrock was described as shale or siltstone. Split spoon refusal was encountered within the bedrock.

Rock coring was performed in both borings from depths of 14.0 to 19.0 feet each. The rock coring was performed using a double tube core barrel with a diamond bit. The recovered rock from the coring operations was described as shale or siltstone, and exhibited an RQD value of 35 to 45 percent, and a core recovery value of 47 to 70 percent.

Compressive strength and unit weight testing were performed on selected bedrock samples. The laboratory test results are summarized in Table 1 below.

Table 1: Laboratory Results – Rock Compressive Strength and Unit Weight

Boring	Sample	Elevation (ft)	Compressive Strength (psi)	Unit Weight (lbs/ft^3)
B-001-0-23	NQ-1	622.1-621.5	13,640	170.2
B-002-0-23	NQ-1	622.3-621.9	8,410	187.5

Groundwater was encountered during drilling in boring B-001-0-23 at a depth of 11.5 feet below existing grade. This depth corresponds to an elevation of 624.9 feet. No groundwater was encountered in B-002-0-23.

As mentioned above, evidence of piping was noted on the roadway surface above the culvert. It is understood that the County has been placing asphalt periodically to plug the piping. Based on the findings from the test boring B-001-0-23 which is performed just off the existing culvert, it is our opinion that the loose granular soils encountered between elevation 630.4 and 625.4 are the primary reason for the observed piping.

VI. ANALYSES AND RECOMMENDATIONS

Based on the soil and rock data obtained from the field and laboratory testing, the following recommendations are provided for the proposed structure and roadway.

A. Creek Bed Material

For the purpose of scour analysis, the D_{50} and type of creek bed materials encountered are shown in Table 2 below.

Table 2. D_{50} Values

Boring No.	Sample No.	Elevation (feet)	D_{50} (mm)	Soil Type
B-001-0-23	SS-4	627.9-626.4	0.236	A-2-4
B-002-0-23	SS-4	628.2-626.7	0.056	A-4a
	SS-5	625.7-624.2	0.069	A-4a

B. Foundation Support

It is understood that the replacement structure will be a 65-foot long reinforced concrete box culvert.

According to the plans, the proposed culvert invert ranges from 626.45 to 625.06 feet. It is understood that a cushion of granular bedding material will be placed immediately below the bottom of the proposed culvert. In general, medium dense sandy silt (A-4a) or loose to dense gravel and stone fragments with sand and silt (A-2-4) soils were encountered near the bottom of the proposed culvert. It is recommended that existing soils below the proposed culvert should be uniformly excavated down to elevation 624.5 and replaced with granular bedding material up to the bottom of the proposed culvert.

According to the plans, the headwall foundations will be constructed approximately 2.1 feet below the proposed invert levels. This footing bearing level is at or slightly above the top of encountered augerable siltstone and shale bedrock in the test borings. It is recommended the bottom of footings be extended down to the top of coreable bedrock (elevation 622.4 in boring B-001-0-23 and 622.7 in boring B-002-0-23).

Bearing resistance calculations are provided in Appendix D and are summarized in Table 3.

Table 3. Spread Footings Unfactored Bearing Resistance

Bearing Material	Approximate Elevation, feet	Unfactored Bearing Resistance, q_n ksf
Existing Overburden Soils	Above 622.5±	Not Recommended
Shale/Siltstone Bedrock	B-001-0-23 At or Below 622.4	119.7*
	B-002-0-23 At or Below 622.7	120.9*

** Note, if the strength of the existing rock is higher than the strength of the concrete used with construction of the footings, the Strength Limit State Design should be based on the weaker of the concrete and rock materials.*

The resistance factors in Table 4 should be used for Bearing Resistance. The resistance factors were obtained from AASHTO Table 10.5.5.2.2-1.

Table 4: Spread Footing Resistance Factors for Bearing Resistance

Material Type	Resistance Factors
Shale and Siltstone	0.45

As an alternative to extending the foundations to the top of coreable bedrock, the soils and augerable bedrock encountered below the proposed foundations can be overexcavated and backfilled with lean concrete, low strength mortar (LSM) or granular bedding material. If the lean concrete or LSM is used as backfill, then the Strength Limit State Design should be based on the strength of the lean concrete or LSM.

If granular bedding material is selected as backfill material, it is recommended that Type 1 granular Bedding (703.11) wrapped with Type D Geotextile Fabric (712.09) be used as granular bedding material for this project. It is CTL's opinion that the Type 1 granular bedding material would exhibit a minimum required friction angle of 28 degrees. The bearing resistance calculations are attached to the report under Appendix D. A friction angle of 28 degrees was utilized for the granular backfill material while computing the bearing resistance calculations. These values are summarized in Table 5 below.

Table 5. Bearing Resistance Values

Parameter	Bearing Resistance
Nominal (q_n) Ksf	4.6
Resistance Factor (φ_b)	0.55
Factored ($q_{R)}$, Ksf	2.5

All bearing surfaces should be kept clean and dry until concrete is placed and should also be observed and approved by the Geotechnical Engineer or their designated representative. Surface water and groundwater should be expected during excavation and construction of spread footings. Dewatering within the excavation should be anticipated and it is anticipated to be controlled using sump and pump methods. Temporary cofferdams may need to be constructed to facilitate excavation and construction of the spread footings.

Lateral Design & Sliding

The active pressure on the walls can be determined using an equivalent friction angle of 30 degrees and a total unit weight of 120 pounds per cubic foot (pcf) for the retained soils.

For sliding calculations, per AASHTO Table C10.4.6.4-1, for Medium Friction (siltstone) bedrock, the typical range for friction angles is from 27 to 34 degrees. A friction angle of 27 degrees may be used for sliding on the siltstone bedrock.

A resistance factor of 1.0 should be used for sliding. This resistance factor was obtained from AASHTO Table 11.5.7-1.

C. General Construction and Earthwork

1. Site preparation and earthwork should be performed in accordance with the ODOT Construction and Material Specifications, and applicable sections of the ODOT GDM.

2. Embankment side slopes should be seeded and vegetation growth permitted to limit erosion, sloughing and slope failure.

3. Temporary excavations in excess of 4 feet in depth should be sloped or shored according to OSHA requirements.

VII. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL Engineering should be notified so that our recommendations can modified, if required.

VIII. TESTING AND OBSERVATION

During the design process, it is recommended that CTL Engineering work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

CTL Engineering is not responsible for independent conclusions, opinions and recommendations made by others based on the data and recommendations provided in this report. It is recommended that CTL be retained to provide construction quality control services on this project. If CTL Engineering is not retained for these services, CTL shall assume no responsibility for compliance with the design concepts or recommendations provided.

IX. CLOSING

This report has been prepared for the exclusive use by the client for use only on this project. Our services have been performed in accordance with generally accepted Geotechnical Engineering principles and practices. No warranty is either expressed or implied.

CTL Engineering's assignment does not include, nor does this geotechnical report address the environmental aspects of this particular site.

Specific design and construction recommendations have been provided in this report. Therefore, the report should be used in its entirety.

Respectfully Submitted,

CTL ENGINEERING, INC.

Sastry Malladi, P.E
Project Engineer

Evan Holcombe, P.E.
Geotechnical Engineer

APPENDIX A
GEOTECHNICAL SHEETS

PROJECT DESCRIPTION

REPLACEMENT OF AN EXISTING CORRUGATED METAL PIPE CULVERT BENEATH COUNTY ROAD 57 (BEAVER PIKE ROAD) IN PIKE COUNTY, OHIO. THE PROPOSED REPLACEMENT STRUCTURE WILL BE A 65-FOOT LONG, 6-FOOT BY 4-FOOT REINFORCED CONCRETE BOX CULVERT.

HISTORIC RECORDS

NO HISTORIC GEOTECHNICAL RECORDS WERE FOUND FOR THIS PROJECT.

GEOLOGY

ACCORDING TO PHYSIOGRAPHIC MAPS (ODNR, 1998), THE PROJECT SITE LIES WITHIN THE SHAWNEE-MISSISSIPPIAN PLATEAU. ACCORDING TO BEDROCK GEOLOGIC MAP OF OHIO (2006), THE BEDROCK UNDERLYING THE SITE CONSISTS OF LOWER MISSISSIPPIAN-AGE AND UPPER DEVONIAN-AGE SUNBURY SHALE, BEREA SANDSTONE AND BEDFORD SHALE.

RECONNAISSANCE

A SITE VISIT WAS PERFORMED BY PERSONNEL FROM CTL ENGINEERING ON MARCH 23, 2022. AT THE TIME OF THE SITE VISIT, THE EXISTING PAVEMENT EXHIBITED SOME TRANSVERSE CRACKS WITHIN THE PROJECT LIMITS. EROSION WAS NOTED IN THE CREEK CHANNEL BOTH UPDSTREAM AND DOWNSTREAM FROM THE STRUCTURE. EVIDENCE OF PIPING WAS NOTED ON THE ROADWAY SURFACE ABOVE THE CULVERT.

SUBSURFACE EXPLORATION

PROJECT LABELED B-001-0-23 AND B-002-0-23. THE BORINGS WERE DRILLED USING A TRACK MOUNTED ROTARY DRILL RIG AND 3.25-INCH I.D. HOLLOW STEM AUGERS TO ADVANCE THE BORINGS THROUGH THE SOIL. THE HAMMER SYSTEM USED WAS LAST CALIBRATED IN OCTOBER 2021, AND THE AVERAGE DRILL ROD RATIO (ER) WAS 81.5 PERCENT. DISTURBED SAMPLES WERE COLLECTED IN ACCORDANCE WITH THE STANDARD PENETRATION TEST AT 2.5-FOOT INTERVALS FOR THE SOIL DEPTH OF THE BORINGS. THE BORINGS WERE ADVANCE INTO BEDROCK AND SAMPLED USING AN NQ WIRELINE CORE BARREL.

EXPLORATION FINDINGS

THE TWO BORINGS FOR THIS PROJECT WERE DRILLED THROUGH THE EXISTING PAVEMENT OF C.R. 57 AND ENCOUNTERED APPROXIMATELY 12 INCHES OF ASPHALT PAVEMENT OVER 8 INCHES OF AGGREGATE BASE. MATERIAL DESCRIBED AS FILL WAS ENCOUNTERED TO DEPTHS OF 3.5 FEET BELOW GRADE IN EACH BORING, CONSISTING OF COHESIVE SOILS (A-4A, A-7-6). BENEATH THE FILL, COHESIVE AND GRANULAR SOILS (A-2-4, A-4A, AND A-7-6) WHICH WERE MEDIUM STIFF TO VERY STIFF WERE OBSERVED. SHALE AND SILTSTONE BEDROCK WAS ENCOUNTERED AT A DEPTH OF 13.5 FEET BELOW GRADE IN BOTH BORINGS. THE SILTSTONE WAS DESCRIBED AS GRAY, SLIGHTLY WEATHERED AND SLIGHTLY TO MODERATELY STRONG AND THE SHALE WAS DESCRIBED AS GRAY, SEVERELY TO HIGHLY WEATEHRED AND VERY WEAK TO SLIGHTLY STRONG.

GROUNDWATER WAS ENCOUNTERED DURING DRILLING IN BORING B-001-0-23 AT A DEPTH OF 11.5 FEET BELOW EXISTING GRADE. THIS DEPTH CORRESPONDS TO AN ELEVATION OF 624.9. NO GROUNDWATER WAS ENCOUNTERED IN B-002-0-23.

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 2023.

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./VISUAL	
	GRAVEL AND/OR STONE FRAGMENTS W/SAND AND SILT	A-2-4 (0)	1	2
	SANDY SILT	A-4a (4)	3	0
	CLAY	A-7-6 (11)	2	2
		TOTAL	6	4
	SHALE	VISUAL		
	SILTSTONE	VISUAL		
XXXXX	PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		

EXPLORATION LOCATION - PLAN VIEW

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

N_{60} — INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

W — INDICATES FREE WATER ELEVATION.

X/Y/D" — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X = NUMBER OF BLOWS FOR 6 INCHES (UNCORRECTED). Y/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" PENETRATION AT REFUSAL.

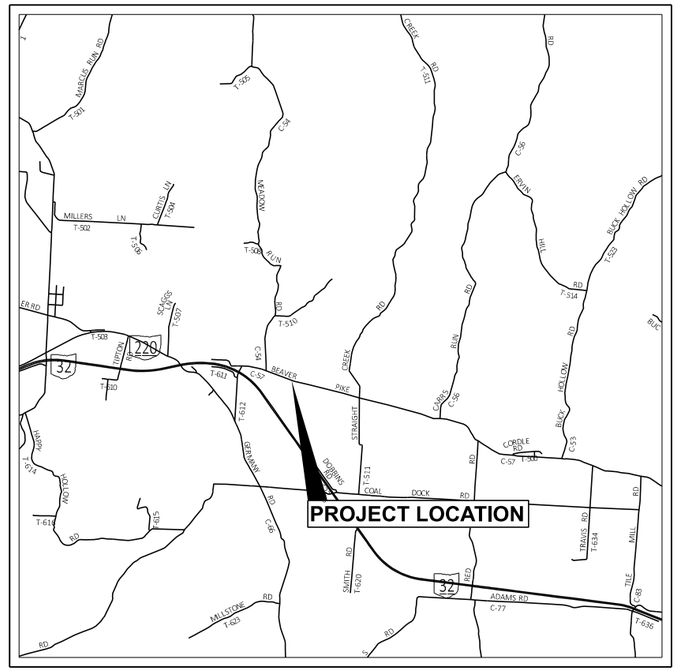
WC — INDICATES WATER CONTENT IN PERCENT.

TR — INDICATES TOP OF ROCK ELEVATION.

NP — INDICATES NON-PLASTIC SAMPLE.

SS — INDICATES A SPLIT-SPOON SAMPLE.

BEDROCK TEST SUMMARY				
BORING ID	SAMPLE ELEVATION	SAMPLE DEPTH	QU (PSI)	LITHOLOGY
B-001-0-23	622.1-621.5'	14.3'-14.9'	13,640	SILTSTONE
B-002-0-23	622.3'-621.9'	14.4'-15.0'	8,410	SILTSTONE



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. - SM 03/23/2022

DRILLING - CTL ENGINEERING 03/28/2023

DRAWN - N.K.S 10/06/2023

REVIEWED - SM 10/06/2023

GEOTECHNICAL PROFILE - CULVERT

PIK-CR57-00.62

DESIGN AGENCY

CTL ENGINEERING

2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER	N.K.S
REVIEWER	SM 10-06-23
PROJECT ID	118834
SUBSET / TOTAL	1 / 4
SHEET / TOTAL	P.28 / 31

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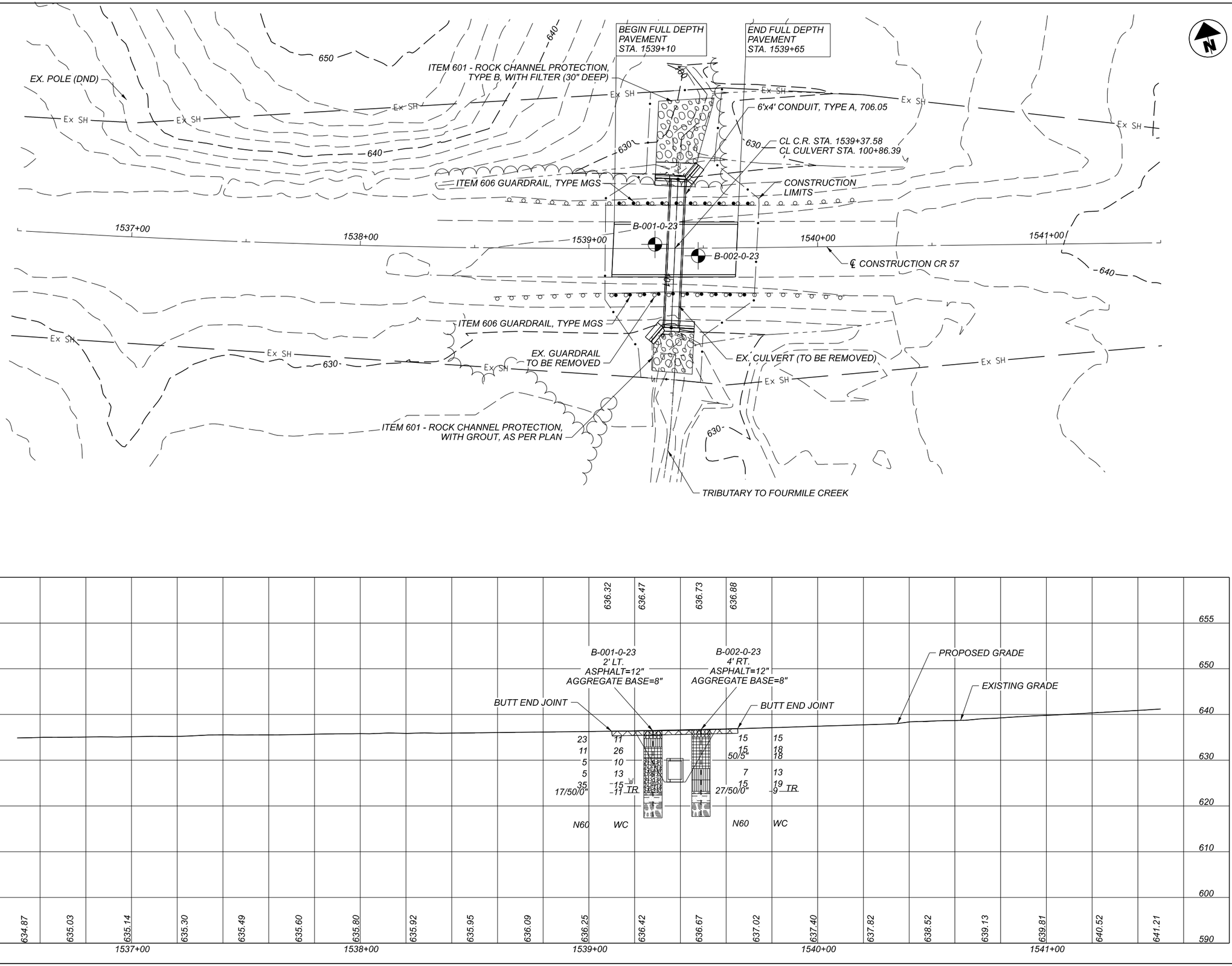

HORIZONTAL SCALE IN FEET
0 10 20 40

GEOTECHNICAL PROFILE - CULVERT

BRIDGE NO. - PIK-CR 57-00.62 OVER CR 57

PIK-CR 57-00.62

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DESIGN AGENCY
GTL ENGINEERING Inc
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER	N.K.S
REVIEWER	SM 10-06-23
PROJECT ID	118834
SUBSET	TOTAL 2 | 4
SHEET	TOTAL P.29 | 31

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PROJECT: PIK-CR57-00.62	DRILLING FIRM / OPERATOR: B.WRIGHT / B.WRIGHT	DRILL RIG: CME 55 #393	STATION / OFFSET: 1539+49, 4' RT.	EXPLORATION ID B-002-0-23
TYPE: CULVERT	SAMPLING FIRM / LOGGER: B.WRIGHT / B.WRIGHT	HAMMER: CME AUTOMATIC	ALIGNMENT: CR 57	
PID: 118834 SFN:	DRILLING METHOD: 4.25" HSA / NQ2	CALIBRATION DATE: 10/8/21	ELEVATION: 636.7 (MSL) EOB: 19.0 ft.	PAGE 1 OF 1
START: 3/29/23 END: 3/29/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 81.5	LAT / LONG: 39.050912, -82.914689	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (12")	636.7 / 635.7																	
AGGREGATE BASE, (8")	635.0																	
VERY STIFF, GRAY, **CLAY**, SOME SAND, SOME SILT, LITTLE GRAVEL, (FILL), DAMP		1–5	12 7 4	15	100	SS-1	2.75	14	16	11	21	38	41	20	21	15	A-7-6 (9)	
		5–6	6 5 6	15	67	SS-2	3.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
@6.0'; COBBLE ENCOUNTERED	628.2	6–7	50/5"	-	100	SS-3	3.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	625.7	8–10	1 2 3	7	89	SS-4	1.75	5	10	31	36	18	22	16	6	13	A-4a (4)	
MEDIUM DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST	623.2	11–12	2 3 8	15	67	SS-5	2.00	2	6	40	42	10	NP	NP	NP	19	A-4a (3)	
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.	622.7	TR 13–14	27 50/0"	-	200	SS-6	4.50	-	-	-	-	-	-	-	-	9	Rock (V)	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG; RQD 88%, REC 100%. @14.4'-14.8'; UCS = 8,410 PSI	620.7	14–16	35		47	NQ2-1											CORE	
SHALE, GRAY, HIGHLY WEATHERED, SLIGHTLY STRONG; RQD 0%, REC 11%.	617.7	EOB 16–19																

NOTES: NONE

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

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 9/29/23 14:34 - O:\PROJECT\2023\COL-05\23050023COL\REPORTS\LOGS\23050023COL.GPJ

CTL ENGINEERING INC

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	14.0'	19.0'	28/60	47%	21/60	35%

PIK-CR57-00.62

SHEET	TOTAL	SUBSET	TOTAL	PROJECT ID	REVIEWER	DESIGNER	DESIGN AGENCY
P-31	31	4	4	118834	SM 10-06-23	N.K.S	CTL ENGINEERING INC

GEOTECHNICAL PROFILE - CULVERT

BORING LOG AND ROCK CORE PHOTO FOR B-002-0-23

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 06-10-2023 TIME: 12:46:35 USER: hp
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PROJECT: PIK-CR57-00.62	DRILLING FIRM / OPERATOR: B.WRIGHT / B.WRIGHT	DRILL RIG: CME 55 #393	STATION / OFFSET: 1539+28, 2' LT.	EXPLORATION ID B-001-0-23
TYPE: CULVERT	SAMPLING FIRM / LOGGER: B.WRIGHT / B.WRIGHT	HAMMER: CME AUTOMATIC	ALIGNMENT: CR 57	
PID: 118834 SFN:	DRILLING METHOD: 4.25" HSA / NQ2	CALIBRATION DATE: 10/8/21	ELEVATION: 636.4 (MSL) EOB: 19.0 ft.	PAGE 1 OF 1
START: 3/28/23 END: 3/28/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 81.5	LAT / LONG: 39.050938, -82.914749	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (12")	636.4																	
AGGREGATE BASE (8")	635.4																	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, (FILL), DAMP	634.8		20 12 5	23	100	SS-1	2.50	7	17	18	33	25	27	17	10	11	A-4a (5)	
STIFF, BROWN AND GRAY, **CLAY**, "AND" SILT, TRACE SAND, MOIST	632.9		4 4 4	11	56	SS-2	1.75	0	2	4	46	48	44	23	21	26	A-7-6 (13)	
LOOSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	630.4		2 2 2	5	11	SS-3	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
			2 2 2	5	83	SS-4	0.50	25	14	33	18	10	19	16	3	13	A-2-4 (0)	
@11.0'; DENSE, BROWN		W 624.9	7 18 8	35	33	SS-5	4.50	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
	622.9																	
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.	622.4	TR	17 50/0"	-	100	SS-6	-	-	-	-	-	-	-	-	-	11	Rock (V)	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG; RQD 81%, REC 100%. @14.3'-14.9'; UCS = 13,640 PSI	620.6		45		70	NQ2-1											CORE	
SHALE, GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG; RQD 54%, REC 25%.	617.4	EOB																

NOTES: NONE

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

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/29/23 14:34 - O:\PROJECT\2023\COL-05\23050023COL\REPORTS\LOGS\23050023COL.GPJ

CTL ENGINEERING INC

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	14.0'	19.0'	42/60	70%	27/60	45%

PIK-CR57-00.62

SHEET	SUBSET	PROJECT ID	REVIEWER	DESIGNER
P-30	3	118834	SM 10-06-23	N.K.S
TOTAL 31	TOTAL 4			

CTL ENGINEERING INC
COLUMBUS, OHIO 43204
PHONE: (614)276-8577

DESIGN AGENCY

GEOTECHNICAL PROFILE - CULVERT

BORING LOG AND ROCK CORE PHOTO FOR B-001-0-23

APPENDIX B
TEST BORING RECORDS

PROJECT: PIK-CR57-00.62	DRILLING FIRM / OPERATOR: B.WRIGHT / B.WRIGHT	DRILL RIG: CME 55 #393	STATION / OFFSET: 1539+28, 2' LT.	EXPLORATION ID B-001-0-23
TYPE: CULVERT	SAMPLING FIRM / LOGGER: B.WRIGHT / B.WRIGHT	HAMMER: CME AUTOMATIC	ALIGNMENT: CR 57	
PID: 118834 SFN:	DRILLING METHOD: 4.25" HSA / NQ2	CALIBRATION DATE: 10/8/21	ELEVATION: 636.4 (MSL) EOB: 19.0 ft.	PAGE 1 OF 1
START: 3/28/23 END: 3/28/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 81.5	LAT / LONG: 39.050938, -82.914749	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (12")	636.4																	
	635.4																	
AGGREGATE BASE (8")	634.8		20 12 5	23	100	SS-1	2.50	7	17	18	33	25	27	17	10	11	A-4a (5)	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, (FILL), DAMP	632.9																	
STIFF, BROWN AND GRAY, **CLAY**, "AND" SILT, TRACE SAND, MOIST	630.4		4 4 4	11	56	SS-2	1.75	0	2	4	46	48	44	23	21	26	A-7-6 (13)	
LOOSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP			2 2 2	5	11	SS-3	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
			2 2 2	5	83	SS-4	0.50	25	14	33	18	10	19	16	3	13	A-2-4 (0)	
@11.0'; DENSE, BROWN		W 624.9	7 18 8	35	33	SS-5	4.50	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
	622.9	TR																
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.	622.4		17 50/0"	-	100	SS-6	-	-	-	-	-	-	-	-	-	11	Rock (V)	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG; RQD 81%, REC 100%. @14.3'-14.9'; UCS = 13,640 PSI	620.6		45		70	NQ2-1											CORE	
SHALE, GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG; RQD 54%, REC 25%.	617.4	EOB																

NOTES: NONE

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

PROJECT: PIK-CR57-00.62	DRILLING FIRM / OPERATOR: B.WRIGHT / B.WRIGHT	DRILL RIG: CME 55 #393	STATION / OFFSET: 1539+49, 4' RT.	EXPLORATION ID B-002-0-23
TYPE: CULVERT	SAMPLING FIRM / LOGGER: B.WRIGHT / B.WRIGHT	HAMMER: CME AUTOMATIC	ALIGNMENT: CR 57	
PID: 118834 SFN:	DRILLING METHOD: 4.25" HSA / NQ2	CALIBRATION DATE: 10/8/21	ELEVATION: 636.7 (MSL) EOB: 19.0 ft.	PAGE 1 OF 1
START: 3/29/23 END: 3/29/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 81.5	LAT / LONG: 39.050912, -82.914689	

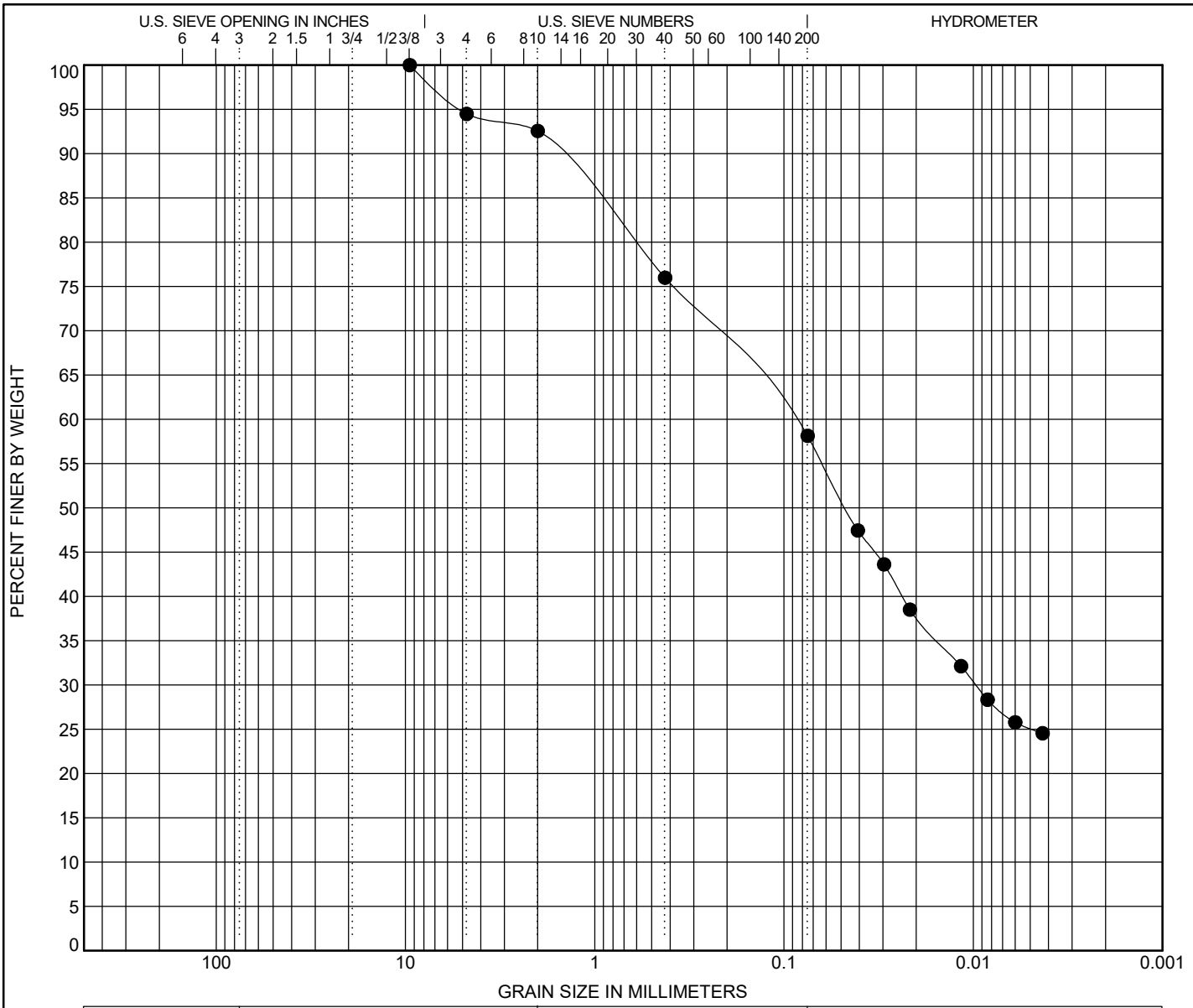
MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (12")	636.7 / 635.7																	
AGGREGATE BASE, (8")	635.0																	
VERY STIFF, GRAY, **CLAY**, SOME SAND, SOME SILT, LITTLE GRAVEL, (FILL), DAMP			12 7 4	15	100	SS-1	2.75	14	16	11	21	38	41	20	21	15	A-7-6 (9)	
			6 5 6	15	67	SS-2	3.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
@6.0'; COBBLE ENCOUNTERED	628.2		50/5"	-	100	SS-3	3.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	625.7		1 2 3	7	89	SS-4	1.75	5	10	31	36	18	22	16	6	13	A-4a (4)	
MEDIUM DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST	623.2		2 3 8	15	67	SS-5	2.00	2	6	40	42	10	NP	NP	NP	19	A-4a (3)	
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.	622.7	TR	27 50/0"	-	200	SS-6	4.50	-	-	-	-	-	-	-	-	9	Rock (V)	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG; RQD 88%, REC 100%. @14.4'-14.8'; UCS = 8,410 PSI	620.7		35		47	NQ2-1											CORE	
SHALE, GRAY, HIGHLY WEATHERED, SLIGHTLY STRONG; RQD 0%, REC 11%.	617.7	EOB																

NOTES: NONE

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

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/29/23 14:34 - O:\PROJECT\2023\COL-05\23050023COL\REPORTS\LOGS\23050023COL.GPJ

APPENDIX C
LABORATORY TEST RESULTS



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-001-0-23	**1.0**	**A-4a(5)**	**11**	**27**	**17**	**10**		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-001-0-23	**1.0**	**9.5**	**0.09**	**0.047**	**0.01**		**7**	**17**	**18**	**33**	**25**

CTL Engineering, Inc.
2860 Fisher Road
Columbus, Ohio 43204
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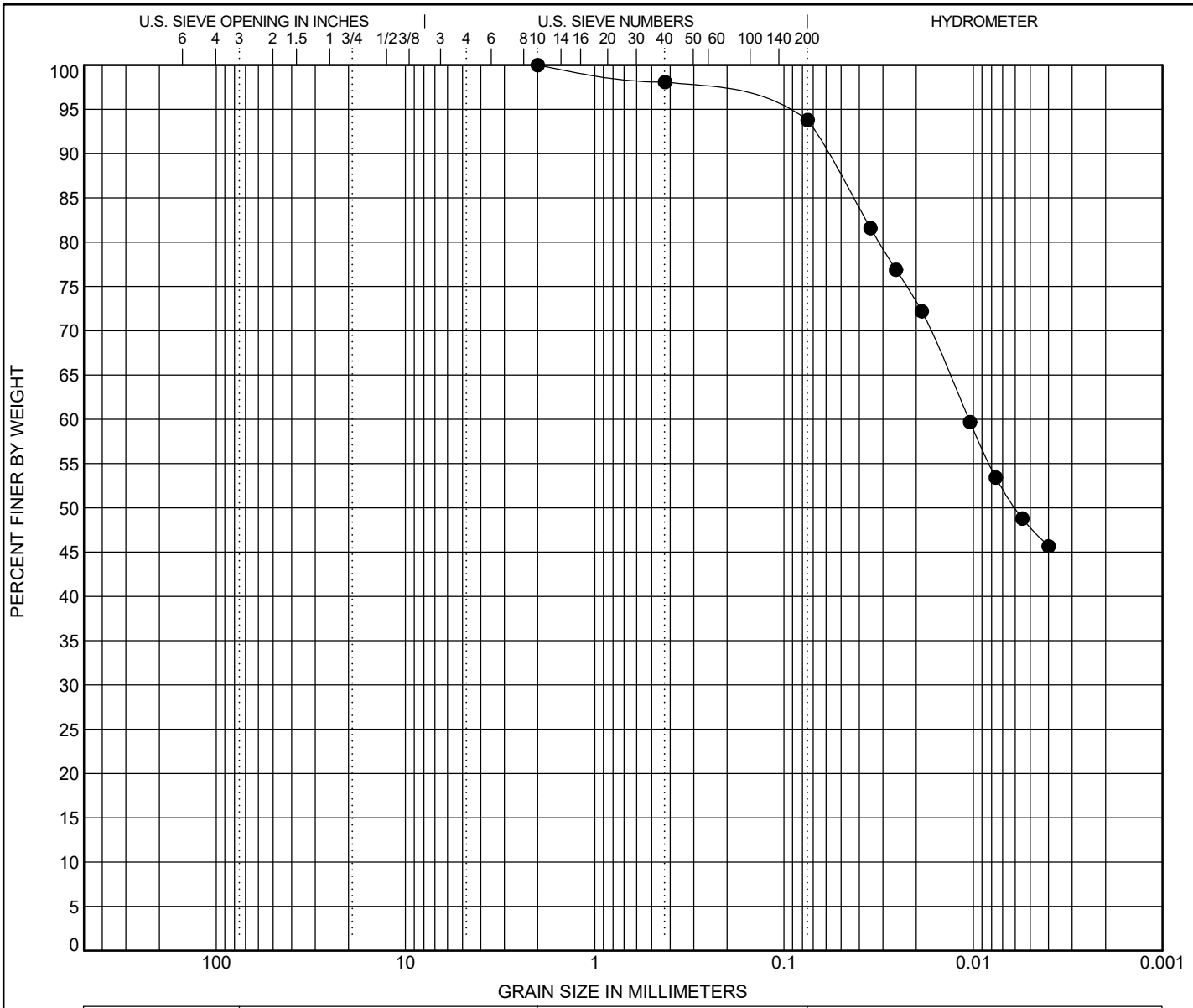
Fax: 614-276-6377

GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-001-0-23	**3.5**	**A-7-6(13)**	**26**	**44**	**23**	**21**		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-001-0-23	**3.5**	**2**	**0.011**	**0.006**			**0**	**2**	**4**	**46**	**48**

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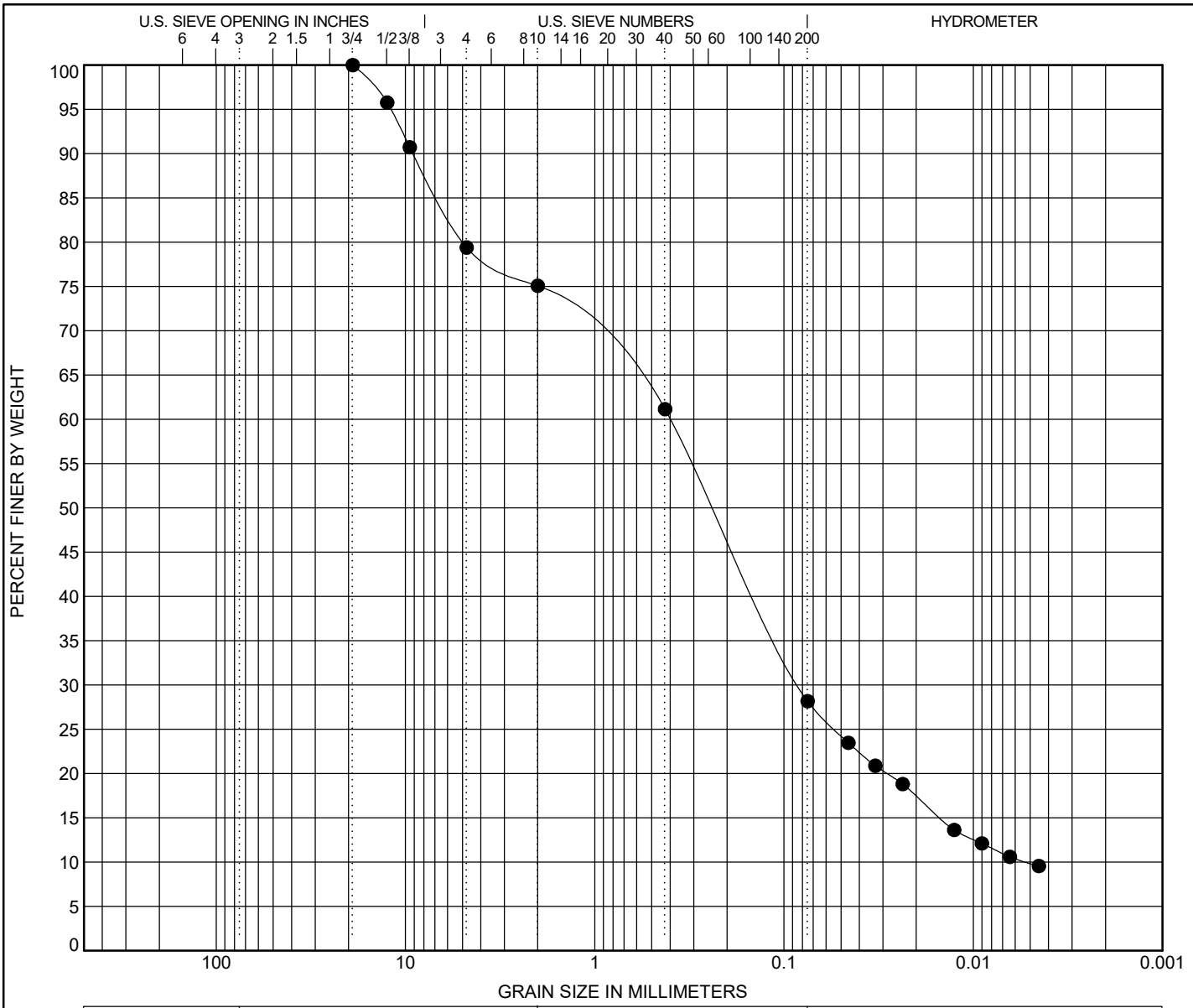
GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-001-0-23	**8.5**	**A-2-4(0)**	**13**	**19**	**16**	**3**	**3.26**	**76.52**

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-001-0-23	**8.5**	**19**	**0.4**	**0.236**	**0.083**	**0.005**	**25**	**14**	**33**	**18**	**10**

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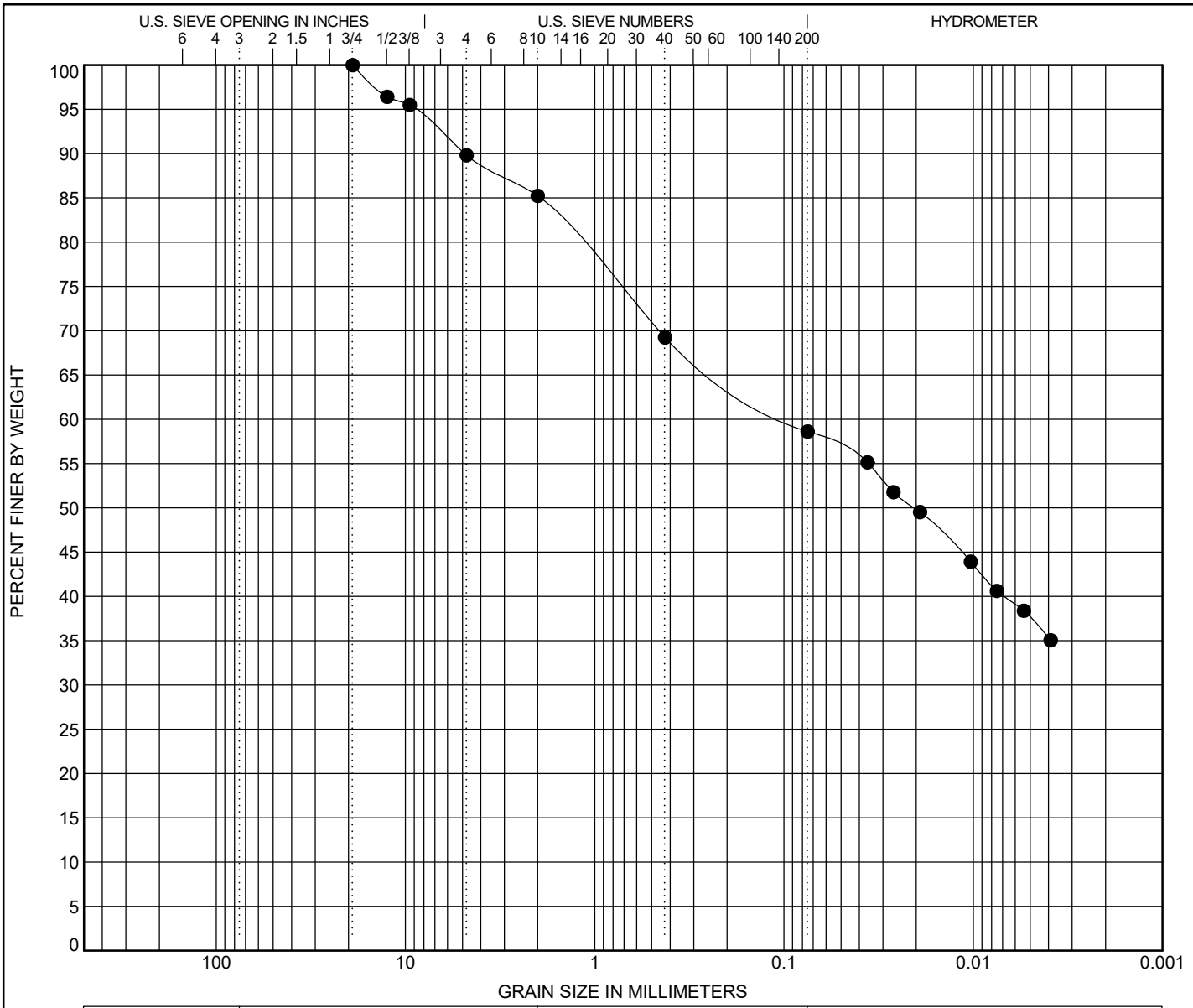
GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-002-0-23	**1.0**	**A-7-6(9)**	**15**	**41**	**20**	**21**		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-002-0-23	**1.0**	**19**	**0.094**	**0.02**			**14**	**16**	**11**	**21**	**38**

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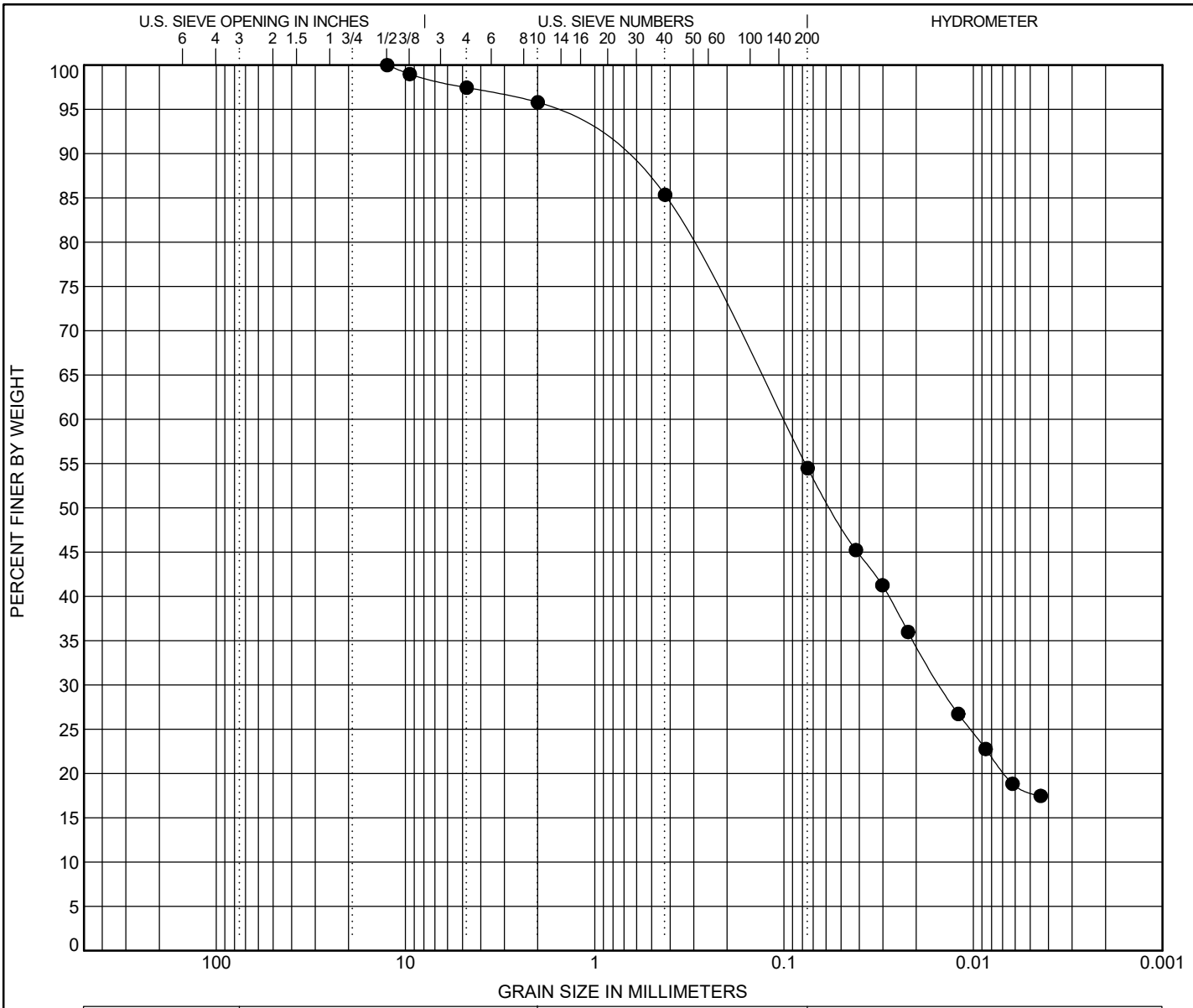
GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-002-0-23	**8.5**	**A-4a(4)**	**13**	**22**	**16**	**6**		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-002-0-23	**8.5**	**12.5**	**0.102**	**0.056**	**0.015**		**5**	**10**	**31**	**36**	**18**

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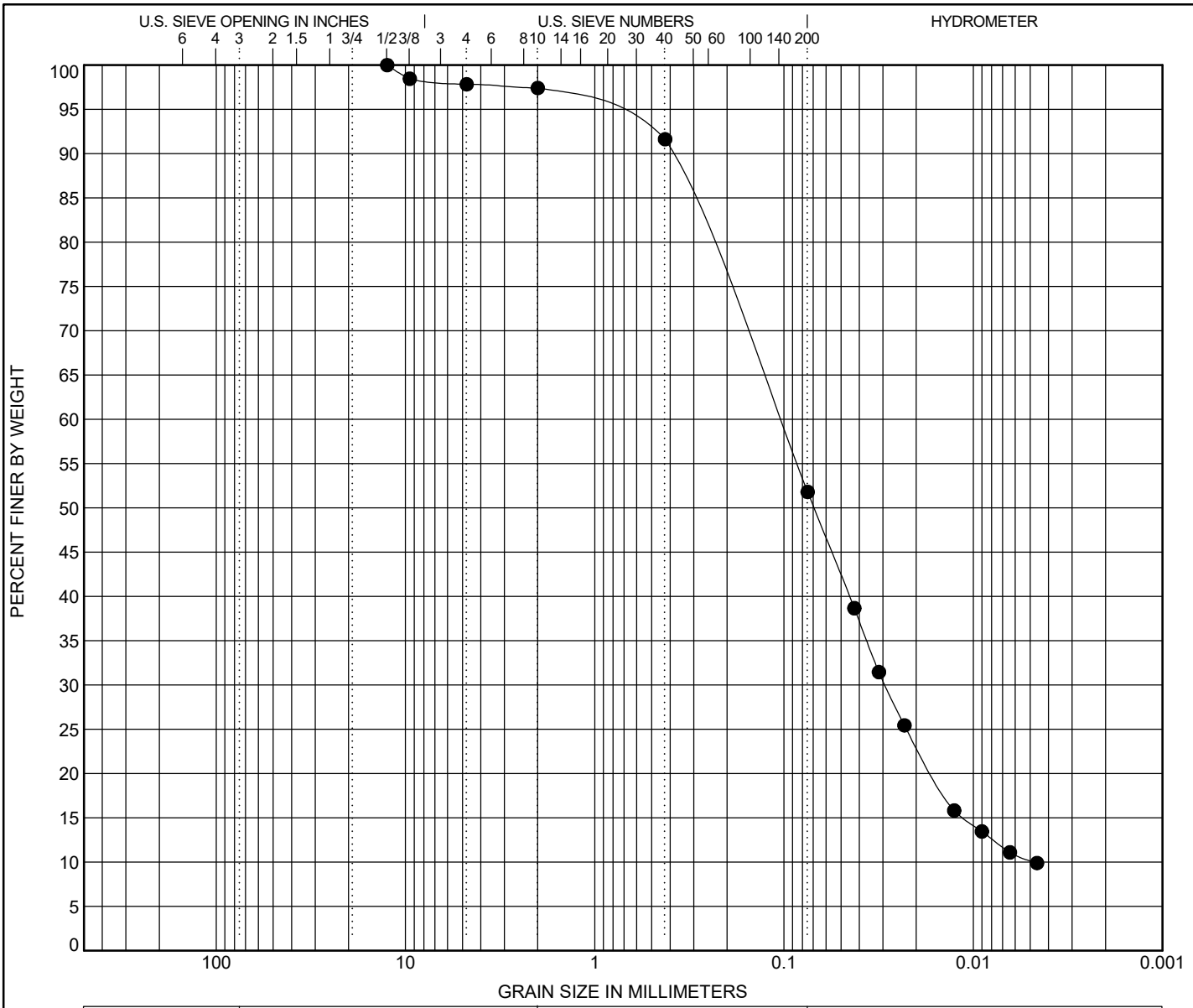
GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
B-002-0-23	**11.0**	**A-4a(0)**	**19**	**NP**	**NP**	**NP**	**1.68**	**22.63**

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
B-002-0-23	**11.0**	**12.5**	**0.107**	**0.069**	**0.029**	**0.005**	**2**	**6**	**40**	**42**	**10**

CTL ENGINEERING

CTL Engineering, Inc.
2860 Fisher Road
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Telephone: 614-276-8123
Fax: 614-276-6377

GRAIN SIZE DISTRIBUTION

Project: Pike County Engineers Office
Location:PIK COUNTY
CTL Project Number:

PROJECT NO:	23050023COL
DATE:	6/5/2023

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

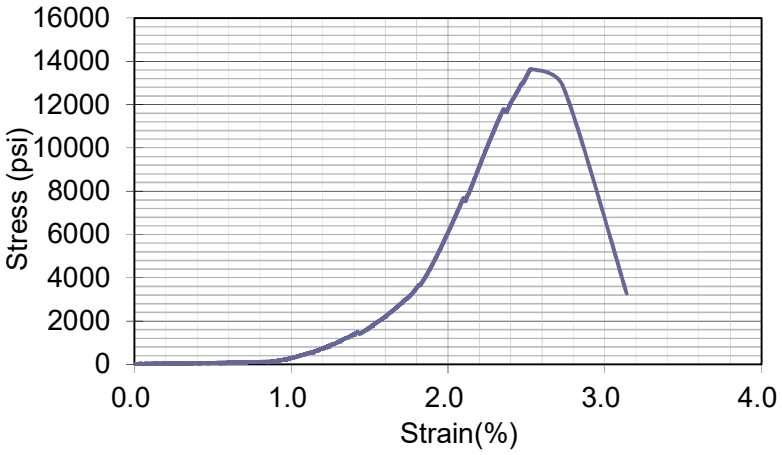
BORING NUMBER	B-001-0-23	TOP DEPTH(FT)	14.3	BOTTOM DEPTH(FT)	14.9
SAMPLE NUMBER	NQ2-1	DISTRICT	6	PID NO.	
COUNTY	PIK	ROUTE	57	SECTION	0.62

FORMATION	Mississippian Age
DESCRIPTION	Siltstone, Gray, Slightly Weathered, Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.016	1.820
2	4.016	1.880
3	4.026	1.958
AVERAGE	4.019	1.886

LENGTH/DIAMETER	2.1
CORRECTION FACTOR	1
AREA(IN^2)	2.8
MASS (GRAMS)	501.7
UNIT WEIGHT(LBS/FT^3)	170.2

RATE OF LOADING (in/min)
0.07
COMPRESSIVE STRENGTH (PSI)
13,640
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.82
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

PROJECT NO:	23050023COL
DATE:	6/5/2023

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

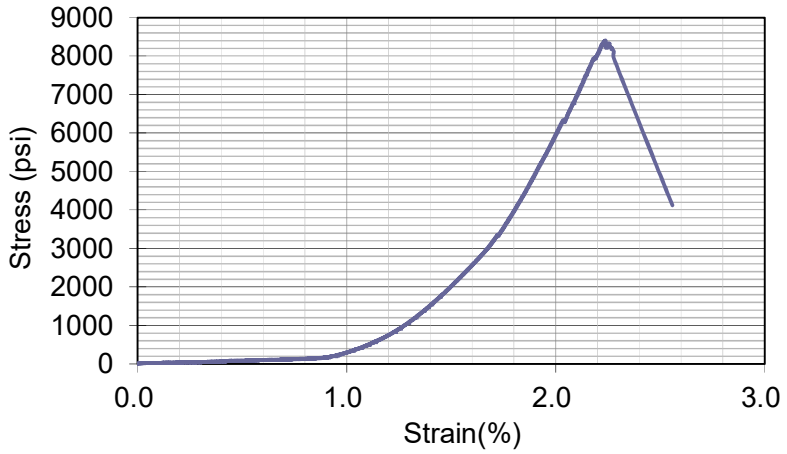
BORING NUMBER	B-002-0-23	TOP DEPTH(FT)	14.4	BOTTOM DEPTH(FT)	14.8
SAMPLE NUMBER	RUN-1	DISTRICT	6	PID NO.	
COUNTY	PIK	ROUTE	57	SECTION	0.62

FORMATION	Mississippian Age
DESCRIPTION	Siltstone, Gray, Slightly Weathered, Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.017	1.979
2	3.995	1.977
3	3.996	1.969
AVERAGE	4.003	1.975

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN^2)	3.1
MASS (GRAMS)	603.7
UNIT WEIGHT(LBS/FT^3)	187.5

RATE OF LOADING (in/min)
0.09
COMPRESSIVE STRENGTH (PSI)
8,410
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.50
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

APPENDIX D
BEARING RESISTANCE CALCULATIONS

Rock Mass Rating (RMR)

Pike County Engineers Office
PIK-CR57-00.62
Pike County, Ohio
CTL Project No.: 23050023COL

Engineer: EH/SM
Date: 13-Jun-2023
Boring/Fnd: B-001-0-23
Sample/Depth NQ2-1, 14' - 19'

Field RQD (%) = 45
Lab q_u (psi) = 13640
Lab γ (pcf) = 170.2
Lab PLSI (ksf) = n/a

AASHTO Table 10.4.6.4-1 - Geomechanics Classification of Rock Masses

	PARAMETER	RANGES OF VALUES							Rating
1	Strength of Intact Rock Material	Point Load Strength Index	> 175 ksf	85 - 175 ksf	45 - 85 ksf	20 - 45 ksf	For this low range - uniaxial compressive test is preferred		7
			> 1,200 psi	600 to 1,200 psi	300 to 600 psi	150 to 300 psi			
		Uniaxial Compressive Strength	> 4320 ksf	2160 - 4320 ksf	1080 - 2160 ksf	520 - 1080 ksf	215 - 520 ksf	70 - 215 ksf	20 - 70 ksf
			> 30,000 psi	15,000 to 30,000 psi	7,500 to 15,000 psi	3,600 to 7,500 psi	1,500 to 3,600 psi	500 to 1,500 psi	150 to 500 psi
	Relative Rating		15	12	7	4	2	1	0
2	Drill Core Quality (RQD)	90% to 100%	75% to 90%		50% to 75%		25% to 50%		< 25%	8
	Relative Rating	20	17		13		8		3	
3	Spacing of Joints	> 10 ft	3 to 10 ft.		1 to 3 ft.		2 in. to 1 ft.		< 2 in.	10
	Relative Rating	30	25		20		10		5	
4	Condition of Joints	- Very rough surfaces - Not continous - No separation - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Hard joint wall rock		- Slightly rough surfaces - Separation <0.05" - Soft joint wall rock		- Slickensides surfaces or - Gouge <0.2" thick or - Joints open 0.05-0.2" - Continous joints		- Soft gouge >0.2" thick or - Joints open >0.2" - Continuous joints	12
	Relative Rating	25	20		12		6		0	
5	Groundwater Conditions (use one of the three evaluation criteria as appropriate to the method of exploration)	Inflow per 30 ft tunnel length	None		< 400 gallons/hr.		400 to 2,000 gallons/hr.		> 2,000 gallons/hr.	7
		Ratio = joint water pressure / major principal stress	0		0.0 to 0.2		0.2 to 0.5		> 0.5	
		General Conditions	Completely Dry		Moist Only (interstitial water)		Water under Moderate Pressure		Severe Water Problems	
	Relative Rating		10		7		4		0	

Rock Mass Rating (RMR) = **44**

AASHTO Table 10.4.6.4-2 - Geomechanics Rating Adjustment for Joint Orientations

	Strike and Dip Orientations of Joints	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable	
Ratings	Tunnels	0	-2	-5	-10	-12	**0**
	Foundations	0	-2	-7	-15	-25	
	Slopes	0	-5	-25	-50	-60	

Adjusted Rock Mass Rating (RMR) = 44

AASHTO Table 10.4.6.4-3 - Geomechanics Rock Mass Classes Determined from Total Ratings

RMR	100 to 81	81 to 61	61 to 41	41 to 21	< 20	Class:
Class No.	I	II	III	IV	V	**III**
Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock	

ODOT GDM 1303.3.3 - Calculated Rock Mass Parameters

RMR =	44	see Adjusted Rock Mass Rating above	
c' =	4.58	c' = (0.104 x RMR) (ksf)	drained shear strength of rock mass
ϕ' =	27	ϕ' = ((RMR/2) + 5) (deg.)	internal friction angle of rock mass
s =	0.00198	s = exp((RMR-100)/9)	rock mass material constant defining intactness (quality) of rock mass
m =	1.3534	m=exp((RMR-100)/28)*m_i	rock mass material constant defining the shape of the Mohr's circle for uniaxial comp.
m_i =	10	Sandstone, m_i = 15	rock mass constant m for intact rock (where s = 100)
		Claystone/Shale, m_i = 10	
		Limestone/Dolomite, m_i = 7	
		Coal, m_i = 1	
E_m =	147819.08	$E_m = 144*145*10^{((RMR-10)/40)}$ (ksf)	

LRFD Strength Limit State Design for Bearing Resistance of Rock using Spread Footings

Pike County Engineers Office
PIK-CR57-00.62
Pike County, Ohio
CTL Project No.: 23050023COL

Engineer: EH/SM
Date: 13-Jun-2023
Boring/Fnd: B-001-0-23
Sample/Depth NQ2-1, 14' - 19'

ODOT GDM 1303.3.3 - Bearing Resistance of Bedrock (Moderately Strong or Less Strength Rock)

Does foundation bedrock meet ALL of following three conditions:

- bedrock surface under footing is not steeply sloping such that discontinuities would control the bearing resistance (a bedrock slope of 2H:1V or less)
- the foundation bedrock has a Rock Mass rating (RMR) ≤ 70
- the foundation bedrock is moderately strong or less in strength (qu ≤ 7500 psi)

if YES to all three conditions, then use the Terzaghi/Vesic/Munfakh method to calculate nominal bearing resistance in accordance with AASHTO LRFD 10.6.3.1.2a

assuming footing parameters of:

B =	10.0	footing width, ft.
D =	3.0	footing depth, ft.

$q_n = c'N_c+\gamma DN_q+0.5\gamma_t BN_\gamma$ nominal bearing resistance

where

c' =	4.58	drained shear strength of rock mass, ksf
ϕ' =	27	internal friction angle of rock mass, deg.
N_c =	23.9	cohesion bearing capacity factor
γ =	0.058	unit weight of soil above footing, kcf
N_q =	13.2	surcharge bearing capacity factor
γt =	0.108	unit weight of rock below footing, kcf
N_γ =	14.5	soil density factor

hence,

q_n = 119.67 ksf

and,

φ_b =	0.45	strength limit state resistance factor
q_R =	**53.85**	**strength limit state factored resistance, $\varphi_b * q_n$, ksf**

Rock Mass Rating (RMR)

Pike County Engineers Office	Engineer: EH/SM	Field RQD (%) = 35
PIK-CR57-00.62	Date: 13-Jun-2023	Lab q_u (psi) = 8410
Pike County, Ohio	**Boring/Fnd: B-002-0-23**	Lab γ (pcf) = 187.5
CTL Project No.: 23050023COL	**Sample/Depth NQ2-1, 14' - 19'**	Lab PLSI (ksf) = n/a

AASHTO Table 10.4.6.4-1 - Geomechanics Classification of Rock Masses

	PARAMETER		RANGES OF VALUES							Rating
1	Strength of Intact Rock Material	Point Load Strength Index	> 175 ksf	85 - 175 ksf	45 - 85 ksf	20 - 45 ksf	For this low range - uniaxial compressive test is preferred			7
			> 1,200 psi	600 to 1,200 psi	300 to 600 psi	150 to 300 psi				
		Uniaxial Compressive Strength	> 4320 ksf	2160 - 4320 ksf	1080 - 2160 ksf	520 - 1080 ksf	215 - 520 ksf	70 - 215 ksf	20 - 70 ksf	
			> 30,000 psi	15,000 to 30,000 psi	7,500 to 15,000 psi	3,600 to 7,500 psi	1,500 to 3,600 psi	500 to 1,500 psi	150 to 500 psi	
	Relative Rating		15	12	7	4	2	1	0	
2	Drill Core Quality (RQD)		90% to 100%	75% to 90%	50% to 75%	25% to 50%	< 25%			8
	Relative Rating		20	17	13	8	3			
3	Spacing of Joints		> 10 ft	3 to 10 ft.	1 to 3 ft.	2 in. to 1 ft.	< 2 in.			10
	Relative Rating		30	25	20	10	5			
4	Condition of Joints		- Very rough surfaces - Not continous - No separation - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Soft joint wall rock	- Slickensides surfaces or - Gouge <0.2" thick or - Joints open 0.05-0.2" - Continous joints	- Soft gouge >0.2" thick or - Joints open >0.2" - Continuous joints			12
	Relative Rating		25	20	12	6	0			
5	Groundwater Conditions (use one of the three evaluation criteria as appropriate to the method of exploration)	Inflow per 30 ft tunnel length	None	< 400 gallons/hr.	400 to 2,000 gallons/hr.	> 2,000 gallons/hr.				7
		Ratio = joint water pressure / major principal stress	0	0.0 to 0.2	0.2 to 0.5	> 0.5				
		General Conditions	Completely Dry	Moist Only (interstitial water)	Water under Moderate Pressure	Severe Water Problems				
	Relative Rating		10	7	4	0				

Rock Mass Rating (RMR) = **44**

AASHTO Table 10.4.6.4-2 - Geomechanics Rating Adjustment for Joint Orientations

Strike and Dip Orientations of Joints		Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable	
Ratings	Tunnels	0	-2	-5	-10	-12	**0**
	Foundations	0	-2	-7	-15	-25	
	Slopes	0	-5	-25	-50	-60	

Adjusted Rock Mass Rating (RMR) = 44

AASHTO Table 10.4.6.4-3 - Geomechanics Rock Mass Classes Determined from Total Ratings

RMR	100 to 81	81 to 61	61 to 41	41 to 21	< 20	**Class:**
Class No.	I	II	III	IV	V	**III**
Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock	

ODOT GDM 1303.3.3 - Calculated Rock Mass Parameters

RMR =	44	see Adjusted Rock Mass Rating above	
c' =	4.58	c' = (0.104 x RMR) (ksf)	drained shear strength of rock mass
ϕ' =	27	ϕ' = ((RMR/2) + 5) (deg.)	internal friction angle of rock mass
s =	0.00198	s = exp((RMR-100)/9)	rock mass material constant defining intactness (quality) of rock mass
m =	0.9473	m=exp((RMR-100)/28)*m_i	rock mass material constant defining the shape of the Mohr's circle for uniaxial comp.
m_i =	7	Sandstone, m_i = 15	rock mass constant m for intact rock (where s = 100)
		Claystone/Shale, m_i = 10	
		Limestone/Dolomite, m_i = 7	
		Coal, m_i = 1	
E_m =	147819.08	$E_m = 144*145*10^{((RMR-10)/40)}$ (ksf)	

LRFD Strength Limit State Design for Bearing Resistance of Rock using Spread Footings

Pike County Engineers Office
PIK-CR57-00.62
Pike County, Ohio
CTL Project No.: 23050023COL

Engineer: EH/SM
Date: 13-Jun-2023
Boring/Fnd: B-002-0-23
Sample/Depth NQ2-1, 14' - 19'

ODOT GDM 1303.3.3 - Bearing Resistance of Bedrock (Moderately Strong or Less Strength Rock)

Does foundation bedrock meet ALL of following three conditions:

- bedrock surface under footing is not steeply sloping such that discontinuities would control the bearing resistance (a bedrock slope of 2H:1V or less)
- the foundation bedrock has a Rock Mass rating (RMR) ≤ 70
- the foundation bedrock is moderately strong or less in strength (qu ≤ 7500 psi)

if YES to all three conditions, then use the Terzaghi/Vesic/Munfakh method to calculate nominal bearing resistance in accordance with AASHTO LRFD 10.6.3.1.2a

assuming footing parameters of:

B =	10.0	footing width, ft.
D =	3.0	footing depth, ft.

$q_n = c'N_c+\gamma DN_q+0.5\gamma_t BN_\gamma$ nominal bearing resistance

where

c' =	4.58	drained shear strength of rock mass, ksf
ϕ' =	27	internal friction angle of rock mass, deg.
N_c =	23.9	cohesion bearing capacity factor
γ =	0.058	unit weight of soil above footing, kcf
N_q =	13.2	surcharge bearing capacity factor
γt =	0.125	unit weight of rock below footing, kcf
N_γ =	14.5	soil density factor

hence,

q_n = 120.92 ksf

and,

φ_b =	0.45	strength limit state resistance factor
q_R =	**54.41**	**strength limit state factored resistance, $\varphi_b * q_n$, ksf**

Project	**PIK-CR57-00.62**	Alternative 3: Using Gravel beneath footing
Project No.	**23050023COL**	(Friction Angle = 28 deg.)
	DRAINED CONDITIONS	

Bearing Resistance- Strength Limit State

Cohesion, c	0.0	ksf	
Friction Angle, ϕ_b	28	Degrees	(Minimum Required)
Footing Width, B	5.00	feet	From Plans
Unit Wt. of Soil, γ	0.120	kcf	
Footing Length, L_f	25	ft	From Plans
Footing Embedment Depth, D_f	2.1	ft	From Plans
GW Depth Below Footing, D_W	0	ft	
Nom. Bearing Resistance, q_n	4.6	ksf	$=c_fN_cs_c+\gamma D_fN_qs_qd_qC_{Wq}+0.5\gamma BN_\gamma s_\gamma C_{W\gamma}$
Where			
N_c	25.8		
N_q	14.7		Table 10.6.3.1.2a-1
N_γ	16.7		
s_c	1.11		$=1+(B/L_f)*(N_q/N_c)$; or 1+(B/5Lf) for $\phi = 0$
s_q	1.11		$=1+(B/L_f)*\tan\phi_f$; or 1.0 for $\phi = 0$ Table 10.6.3.1.2a-3
s_γ	0.92		$=1-0.4*(B/L_f)$; or 1.0 for $\phi = 0$
C_{Wq}	0.50		Table 10.6.3.1.2a-2
$C_{W\gamma}$	0.50		
$1.5B+D_f$	9.60	ft	For Cw Check
D_f/B	0.42		For dq by Hansen 1970
d_q	1.13		Hansen 1970 or Table 10.6.3.1.2a-4
Fact. Bearing Resistance, q_r	2.5	ksf	$=\phi_b*q_n$
Resistance Factor, ϕ_b	0.55		Table 11.5.7-1

APPENDIX E
ROCK CORE PHOTO LOG

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	14.0'	19.0'	42/60	70%	27/60	45%
PIK-CR57-00.62						

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	14.0'	19.0'	28/60	47%	21/60	35%
PIK-CR57-00.62						

APPENDIX F
GEOTECHNCIAL CERTIFICATE OF REVIEW – FINAL PLANS

CTL Engineering, Inc.
2860 Fisher Road, P.O. Box 44548, Columbus, Ohio 43204-3538
Phone: 614/276-8123; Fax: 614/276-6377
Email: ctl@ctleng.com

February 12, 2024

Pike County Engineer's Office
502 Pike Street
Waverly, Ohio 45690

Attention: Mr. Denny Salisbury, P.E., P.S.
Pike County Engineer

Reference: Review of Final Plans
PIK-CR57-00.62 Culvert Replacement
PID: 118834
Pike County, Ohio
CTL Project No. 23050023COL

Dear Mr. Salisbury:

As the Geotechnical Engineer of Record for the subject project, I certify that I have reviewed the Final plans for the subject project.

Respectfully Submitted

CTL ENGINEERING, INC.

Sastry M.V.S

Sastry Malladi, P.E.
Project Engineer