REPORT OF LANDSLIDE EXPLORATION
MRG-78-10.96 (TASK 10G) (FINAL)

PID: 118670
Morgan County, Ohio

December 30, 2024

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Project Number: 175578434

Revision	Description	Author	Date	Quality Check	Date	Independent Review	Date
01	Draft	G. Khatri	8/7/24	J. Swindler	8/7/24	E. Kistner	8/8/24
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Executive Summary

A landslide is located along State Route (SR) 78, approximate 7 miles southwest of McConnelsville near straight line mileage 10.96 in Morgan County, Ohio. The landslide head scarp is near the center of roadway, and the toe of the landslide is located downhill (southeast) from SR 78. The landslide affects approximately 250 feet of the road. The Ohio Department of Transportation (ODOT) is planning to repair and stabilize the roadway where the landslide is located. The proposed remediation design consists of a drilled shaft wall beyond the southeast shoulder of SR 78. Stantec Consulting Services Inc. (Stantec) was contracted by ODOT to perform the geotechnical exploration, analysis, and preliminary drilled shaft wall design for this project.

Four borings were advanced to obtain geotechnical data for the proposed landslide stabilization. Three borings (B-001-0-24, B-002-0-24, and B-003-0-24) were advanced along the eastbound lane of the road, and one boring (B-002-1-24) was advanced in the westbound shoulder. Two dynamic cone penetrometer tests (D-001-0-24 and D-002-0-24) were completed on the downslope of the embankment.

The surface materials encountered in the borings consisted of approximately 1 to 3.5 feet of pavement material (asphalt and aggregate base). Below the surface material, the soil was fine-grained, classifying as silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). The fine-grained soils were described as soft to hard, brown to gray, damp to moist, and medium plasticity. Bedrock was encountered at depths of 6.5 to 20 feet. The bedrock was a weathered shale underlain by interbedded shale (90 percent) and sandstone (10 percent) or claystone. The shale was described as gray to brown, weak, highly weathered, highly fractured and thinly laminated to laminated. The sandstone was described as strong, moderately to highly weathered, moderately fractured, and thick bedded. The claystone was described as brown to red, weak, highly weathered, highly fractured, and laminated. The borings were terminated after coring approximately 10 to 20 feet in the bedrock. Groundwater was not observed in any of the borings.

A drilled shaft wall is recommended beyond the shoulder of SR 78 approximately 23 feet right of the centerline from Station 577+50 to 580+00 to protect the roadway from future movement caused by the landslide. The recommended drilled shaft wall configuration includes 3-foot diameter drilled shafts reinforced with W24x131 steel beams at 5.75-foot center-to-center spacing. The reinforced drilled shafts should be socketed at least 10 feet into bedrock. To protect against loss of material through the drilled shaft wall, unreinforced plug drilled shafts are recommended to be installed between the reinforced drilled shafts from the existing grade to the top of bedrock. To provide additional roadway shoulder, the W-sections should extend upward to parallel the elevation of SR 78, and concrete lagging should be installed between the W-Sections above grade to retain backfill.

Acronyms / Abbreviations

ASTM	American Society for Testing and Materials
DCP	Dynamic Cone Penetration
ER	Energy Ratio
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
RQD	Rock Quality Designation
SGE	Specifications for Geotechnical Exploration
SPT	Standard Penetration Test
SR	State Route
TIMS	Traffic Information Management System
UC	Unconfined Compression
UCR	Unconfined Compression Strength for Rock Core
USDA	United States Department of Agriculture

1 INTRODUCTION

A landslide is located along State Route (SR) 78 approximately 7 miles southwest of McConnelsville near straight line mileage 10.96 in Union Township, Morgan County, Ohio. The landslide head scarp is near the centerline of roadway, and the toe of the landslide is located downhill (southeast) from SR 78. The landslide is occurring along a gently curving portion of SR 78 that is aligned southwest-northeast near two unnamed tributaries of West Branch Wolf Creek. The landslide affects approximately 250 feet of the road. A previous repair using driven piles and guardrail as lagging between the piles was done at the site on the southeast side of SR 78.

The Ohio Department of Transportation (ODOT) is planning to repair and stabilize the roadway where the landslide is located. The proposed remediation design consists of a drilled shaft wall located downslope of the existing pile wall between the existing pile wall and the existing right-of-way. Stantec Consulting Services Inc. (Stantec) was contracted by ODOT to perform the geotechnical exploration, analysis and preliminary drilled shaft wall design for this project. Figure 1 shows the site vicinity.

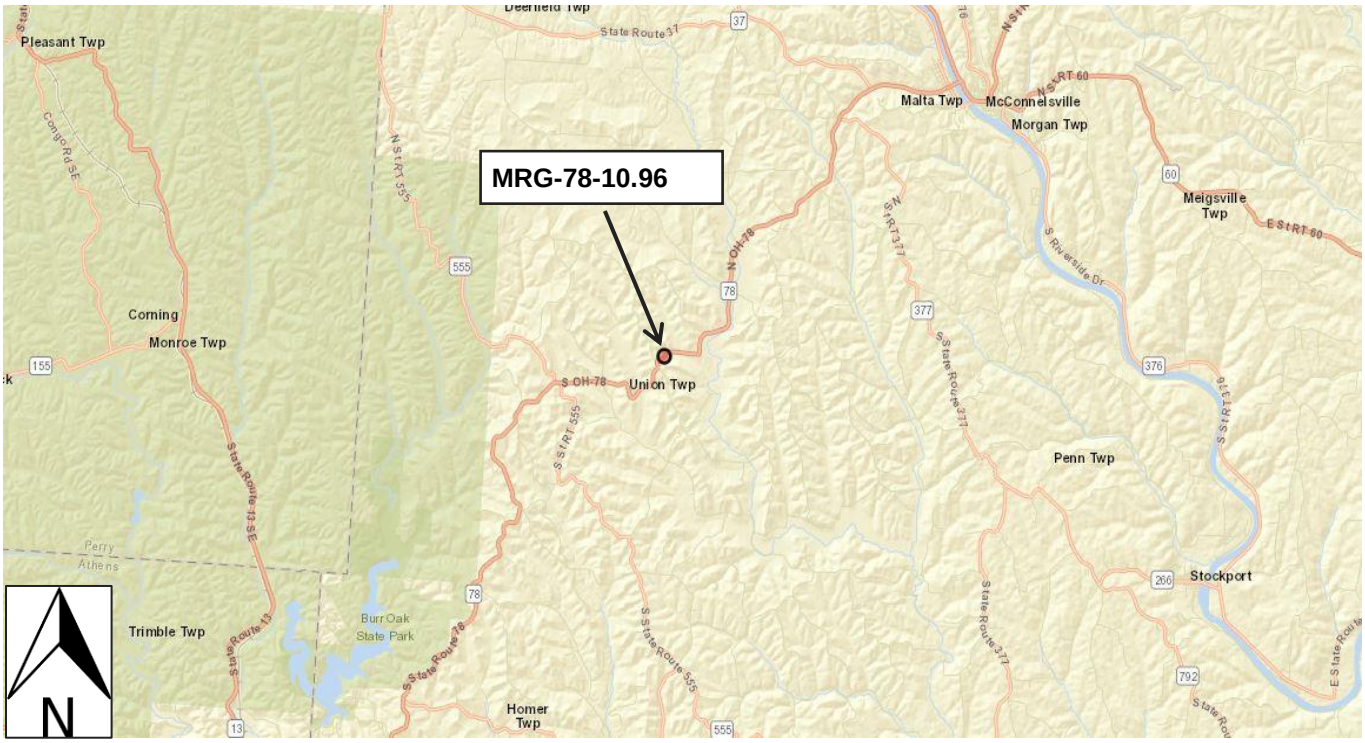


Figure 1: Site Vicinity

(Ohio Department of Natural Resources Interactive Mapping)

2 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The *Physiographic Regions of Ohio Map* (Ohio Department of Natural Resources (ODNR), 1998) indicates that the project is located within the Marietta Plateau Region of the Allegheny Plateaus. The Marietta Plateau Region is described as a dissected plateau with mostly fine-grained rocks with red shales and red soils relatively common. Landslides and remnants of the ancient lacustrine clay filled Teays drainage system are common. The region consists of Pennsylvanian-age Upper Conemaugh Group through Permian-age Dunkard Group bedrock with cyclic sequences of red and gray shales and siltstones, sandstones, limestones, and coals. The soils are composed of Pleistocene (Teays) age Milford clay, red and brown silty-clay loam colluvium, and landslide deposits. The region has high relief (generally 350 to 600 feet) with elevations of 515 to 1,400 feet.

2.2 SOIL GEOLOGY

According to the *Quaternary Geology of Ohio* map (ODNR, 1999), the project site is underlain by colluvium from the Cenozoic era. These soils, which are derived from local bedrock in unglaciated areas, includes scattered areas of residuum, weathered material, landslides, and bedrock outcrop. The soil survey (*Web Soil Survey of Morgan County, Ohio*, United States Department of Agriculture [USDA], 2024) indicates that the project site is underlain by soils from the Lowell-Gilpin Complex (35 to 70 percent slopes) on the west end and from the Guernsey-Upshur Complex (12 to 20 percent slopes) on the east end. Lowell-Gilpin Complex soils primarily consist of 20 inches of silty clay loam underlain by 24 inches of channery clay, terminating at weathered bedrock. The soil is typically well-drained with moderately high capacity of transmitting water. Guernsey-Upshur Complex soils primarily consist of up to 14 inches of silt loam or silty clay loam, underlain by up to 66 inches of silty clay or channery silty clay, terminating at weathered bedrock. This soil is moderately well-drained with a moderately low to moderately high capacity to transmit water. The Drift Thickness Map of Ohio (ODNR, 2004) suggests that the project site is an unglaciated region.

2.3 BEDROCK GEOLOGY

Bedrock mapping (*Ohio Geology Interactive Map*, ODNR, 2024) and *Descriptions of Geologic Map Units* (ODNR, 2011) indicate that the overburden soils at the project site are underlain primarily by sedimentary bedrock of the Pennsylvanian system from the Conemaugh Group. The bedrock in this system is comprised of shale, siltstone, sandstone, mudstone, and lesser amounts of limestone and coal. The bedrock is described as shades of gray, green, red, brown, and black and exhibits thickness between 350 to 490 feet. The diagnostic feature of the rock includes multicolored mudstones, rare coal beds, thin to thick marine shale and limestone in the lower two-thirds of the unit, and rapid vertical and horizontal changes in rock type.

According to the *Ohio Mine Locator* (ODNR, 2023), there is a single abandoned coal mine within a 2-mile radius of the project footprint. There are several abandoned underground mines and surface mines producing coal west of the project site. The closest of these mines is an underground coal mine located 2.9 miles from the project area. The *Karst Interactive Map* (ODNR, 2023) indicates there are no known karst features in Morgan County.

2.4 HYDROLOGY

Buck Run and Hedgehog Creek located less than 1.5 miles east of the site, flow south into West Branch Wolf Creek. West Branch Wolf Creek flows approximately 25 miles southeast into the Muskingum River in Beverly, Ohio. The Muskingum River then flows approximately 11 miles east into the Ohio River near Carlington, Ohio.

2.5 HYDROGEOLOGY

The *Ohio Geology Interactive Map* (ODNR, 2024) shows that the site is underlain by a sand and gravel aquifer, which has a yield of 0 to 5 gallons per minute. According to the *Groundwater Resources of Morgan County Map* (ODNR, 2023), the project site is in an area where wells yield 1 to 50 gallons per minute

A search was performed using the ODNR *Ohio Water Wells Map* (2023) to determine if any water wells are located near the project site. Eleven water wells have been drilled within a 1-mile radius of the project footprint. The well logs indicate a bedrock depth ranging from 1 to 45 feet. The bedrocks encountered at these wells were described as shale, limestone, and/or sandstone. The logs also indicate a considerable variation of the static water depth in the area surrounding the site, ranging from 3 to 54 feet.

2.6 SEISMIC

A review of the seismic data available in the project vicinity was completed using the ODNR *Ohio Earthquake Epicenters Map* (2023). Overall, Ohio has a relatively limited amount of seismic activity. Within a 10-mile radius of the project, there have been two earthquake epicenters with magnitude of 1.8 and 3.9. The available data reviewed included events that occurred in Ohio from 1804 to present day.

2.7 SITE RECONNAISSANCE

Stantec representatives visited the site on April 5, 2024, to make observations and evaluate access to proposed boring locations. The land surrounding the project site can be described as rural with some residential buildings in the vicinity. The pavement was observed to be in fair condition, however, there is longitudinal cracking near the head scarp of the landslide. Previous repairs and asphalt resurfacing was observed within the vicinity of the landslide. The landslide affects approximately 225 feet of the road.

3 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Traffic Information Management System (TIMS) provides documentation for three geotechnical explorations performed along SR 78. The MRG-78-10.30 project, completed in 2005, was for geohazard (landslide) rehabilitation located approximately 0.6 miles southwest of the site. The exploration consisted of four borings. Fill material was observed in all the borings to a depth of 4.8 to 7 feet. The fill was described as medium stiff to stiff, brown to gray silty clay (A-6b). Below the fill, soils were predominantly classified as gravel with sand, silt and clay (A-2-6), silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). Bedrock was encountered at depths of 14.5 to 20 feet and described as gray to brown, thin to medium bedded, clay shale.

The MRG-78-10.20, completed in 1991, was another project for geohazard remediation, located approximately 0.76 miles southwest of the project site. The exploration consisted of four borings and encountered overburden soils predominantly classified as sandy silt (A-4a), silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). Bedrock was encountered at depths ranging from 7.5 to 41 ft and was described and gray to brown shale.

3.2 PROJECT EXPLORATION PROGRAM

Four borings were advanced to obtain geotechnical data for the proposed landslide stabilization. Three borings (B-001-0-24, B-002-0-24, and B-003-0-24) were advanced along the eastbound lane of the road, and one boring (B-002-1-24) was advanced in the westbound shoulder. Two dynamic cone penetration (DCP) tests (D-001-0-24 and D-002-0-24) were performed on the downslope of the suspected landslide near its toe. A summary of these borings is shown in Table 1. Boring locations are shown on the site plan in Appendix A.

Table 1. Boring Summary

Boring No.	Station (feet)*	Offset (feet)*	Ground Surface Elevation (feet)*	Top of Bedrock Elevation (feet)*	Bottom of Boring Elevation (feet)
B-001-0-24	577+69	7.0 Rt	934.4	927.9	905.9
B-002-0-24	578+75	6.0 Rt	926.3	917.3	889.8
B-002-1-24	578+62	9.0 Lt	927.3	918.5	915.1
B-003-0-24	579+86	6.0 Rt	914.3	894.3	872.3
D-001-0-24	578+24	45.0 Rt	917.0	908.5	908.5
D-002-0-24	579+10	40.0 Rt	912.0	891.4	891.4

*(Note: Survey information was not available for D-001-0-24 and D-002-0-24. The station, offset, and ground surface elevation were approximated using Google Earth).

The borings were advanced in accordance with the ODOT Specifications for Geotechnical Explorations (SGE). The borings were performed by Ohio TestBor with a Mobile B57 track-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. Standard Penetration Test (SPT) sampling was performed at 2.5-foot in borings B-001-0-24, B-002-0-24, B-003-0-24 while continuous sampling was performed in B-002-1-24. SPT sampling was continued until bedrock was encountered. Undisturbed Shelby tube (ST) samples were obtained at various depths. The energy ratio (ER) of the Mobile B57 automatic hammer and drill rod system was measured to be 91% on January 3, 2023.

The depths and elevations of the SPTs with the corresponding N_{60}-values are shown on the boring logs in Appendix A.

Upon encountering competent bedrock, approximately 10 to 20 feet of rock coring was performed in borings B-001-0-24, B-002-0-24, and B-003-0-24 using NQ2-size equipment. Recovery, core loss, and rock quality designation (RQD) values were recorded as percentages for each coring run. These values are shown on the boring logs contained in Appendix A.

The materials encountered were logged by a geotechnical engineer from Stantec, with attention given to soil type, consistency, and moisture content. The borings were checked for the presence of groundwater during drilling and at its conclusion with the depth of water recorded. The borings were sealed with soil cuttings and bentonite chips to the termination depth and capped with asphalt cold patch where necessary.

DCP testing was performed using a dual mass automatic dynamic cone penetrometer in accordance with ASTM D6951. The model of the penetrometer was a Pagani DPM 30 with a 66-pound hammer falling from a height of 7.88 inches to drive a cone point with a 60-degree tip. The number of hammer blows required to advance the DCP rod was recorded on the logs provided in Appendix A.

The soil samples obtained from the borings were returned to a geotechnical laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples reflecting each of the main soil horizons. The engineering classification tests conducted on the samples were sieve and hydrometer analysis (ASTM D422) and Atterberg limits (ASTM D4318). The samples were classified according to the ODOT classification method.

Two undisturbed Shelby tubes were extruded in the laboratory and one sample was subjected to unconfined compression (UC) testing (ASTM D2166). Four rock core samples were subjected to unconfined compressive strength of rock core (UCR) testing (ASTM D7012)

The results of laboratory testing are included in Appendix A.

4 FINDINGS

The surface materials encountered in the borings consisted of approximately 1 to 3.5 feet of pavement material (asphalt and aggregate base). Below the surface material, the soil was fine-grained, classifying as silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). These fine-grained soils were described as soft to hard, brown to gray, and damp to moist with medium plasticity (plasticity index of 13 to 22, average of 17). The N_{60} values (SPT blow counts normalized to a 60 percent hammer efficiency) ranged from 0 to 53 blows per foot (bpf) with an average of 15 bpf. The natural moisture content ranged from 2 to 30 percent with an average of 17 percent.

Bedrock was encountered at depths of 6.5 to 20 feet (Elevation 894.3 to 927.9 feet), with bedrock surface elevations dipping from west to east in the borings. Directly beneath the overburden soil, the bedrock in B-001-0-24 was augered to a depth of 18.5 feet (Elevation 915.9 feet) and was described as brown to gray weathered shale. Interbedded shale (90 percent) and sandstone (10 percent) was next observed in the boring to the termination depth. The recovery ranged from 92 to 96 percent and the RQD ranged from 16 to 34 percent. UCR testing within this interbedded shale and sandstone yielded a strength of 8,760 psi.

Beneath the overburden soil in B-002-0-24, bedrock was augered to a depth of 16.5 feet (Elevation 909.8 feet) and was described as brown to gray weathered shale. Beneath the weathered shale, claystone described as brown, gray to red, highly weathered, weak, fine-grained, laminated, and highly fractured was encountered to the boring termination depth. The recovery of each run was 100 percent and the RQD ranged from 18 to 64 percent. UCR testing was performed on three samples from this stratum, yielding strengths of 47 to 162 psi. Coring was not performed in boring B-002-1-24.

Bedrock was deeper in B-003-0-24 and the bedrock was observed to be weaker and softer than in the other borings. After encountering bedrock at a depth of 20 feet and augering through soft bedrock to a depth of 40 feet, coring within boring B-003-0-24 was terminated after 2 feet due to issues with the water pressure regulator valve in the drill rig.

Groundwater was not observed in any of the borings during drilling activities, but this may be obscured by the addition of water during rock coring. Boring logs, photographs of the rock core, and laboratory testing results are presented in Appendix A.

Two dynamic cone penetration (DCP) tests (D-001-0-24 and D-002-0-24) were performed on the downslope of the suspected landslide near its toe. Penetrometer rods were refused at depths of 8.5 feet and 20.7 feet in D-001-0-24 and D-002-0-24 respectively. The DCP test results are presented in Appendix A.

5 ANALYSIS AND RECOMMENDATIONS

5.1 GENERAL

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

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

5.2 DRILLED SHAFT WALL

It appears the landslide is occurring along a gently curved portion of SR 78 that is aligned southwest-northeast near two unnamed tributaries of West Branch Wolf Creek. ODOT has indicated that a drilled shaft wall downhill of SR 78, between the previous lagging wall and the existing right-of-way, is the preferred repair.

To estimate the failure surface of the landslide, a back analysis was performed using conventional, limit equilibrium methods as implemented in GeoStudio SLOPE/W 2018 R2 software. A cross section was developed at approximate Station 578+60 using information from borings B-002-0-24 and B-002-1-24, as well as information from DCP-001-0-24 and DCP-002-0-24. The selection of this cross section is deemed a representation of where the landslide has occurred based on the field exploration and site visit. A subsurface stratigraphy consisting of cohesive soil and bedrock was modeled based on the soil and rock encountered in the borings. A failure surface along the soil-bedrock interface appeared to replicate the failure observed at the site. Therefore, a 2-foot layer of weak soil was modeled. The analysis cross section is shown in Appendix B.

The foundation soils were given shear strength parameters based on recommendations from the ODOT Geotechnical Design Manual (GDM). It was assumed that the soil layers had zero drained cohesion at the time of failure. To achieve a factor of safety of 1.0, the friction angle of the weak layer was adjusted to 15.1 degrees. The material parameter derivations and results of the slope stability back analysis is provided in Appendix B.

The UA Slope program was used to estimate the loading on the drilled shaft wall. The analysis cross section and failure surface developed in the slope stability back analysis was modeled in the UA Slope program. As described in the ODOT GDM, existing conditions without the drilled shafts were analyzed and a drained friction angle of 15.2 degrees in the weak zone was required to achieve a factor of safety of 1.00. This closely resembles the back analysis results within the SLOPE/W model.

Using the same material parameters to achieve the factor of safety of 1.00 in the UA Slope program, the proposed drilled shaft wall geometry was analyzed. The drilled shaft wall was modelled approximately 23 feet right of the centerline of SR 78 and it was assumed that fill would be placed behind the wall to rebuild the shoulder after wall construction. Fill material was assigned a cohesion of 250 pounds per square foot (psf), a friction angle of 28 degrees, and a unit weight of 125 pounds per cubic foot (pcf) based on ODOT GDM Table 500-2. A drilled shaft wall consisting of 3-foot diameter drilled shafts at 5.75 feet center-to-center spacing was analyzed. Unreinforced plug drilled shafts are recommended to be installed between the reinforced drilled shafts; therefore, it was assumed that the drilled shafts would take the full loading from the uphill slices without any arching or load transfer to the downhill slices. The resulting unfactored load on the wall was 78 kips per shaft. The results of UA Slope analyses are presented in Appendix C.

The loading estimated from UA Slope Program combined with a traffic surcharge live load of 250 psf was modelled as a trapezoidal distributed load in a drilled shaft analysis using LPile v2022 software. The boring and the laboratory testing results were used to estimate the soil and rock parameters. It was assumed that downhill soil above the assumed failure depth would provide no passive resistance because the sliding surface is at the soil-bedrock interface, and it was assumed that some movement would continue along that plane creating a gap between the soil and the drilled shafts. A weak layer of claystone was modelled with an unconfined compressive strength of 90 psi, which was determined based on the testing of severely weathered claystone. The analysis was performed at both Service (I) and Strength (I) Limit States.

The analysis resulted in a deflection of 1.92 inches at Service (I) Limit State and a maximum moment of 1083.3 kip-feet at Strength (I) Limit State. The maximum shear was taken as 292.9 kips at Strength (I) Limit State. Calculations indicate that the W24X131 section has adequate capacity to withstand the maximum moment and shear values estimated from LPile. The results of the LPile analysis and associated calculates are presented in Appendix D.

5.3 RECOMMENDATIONS

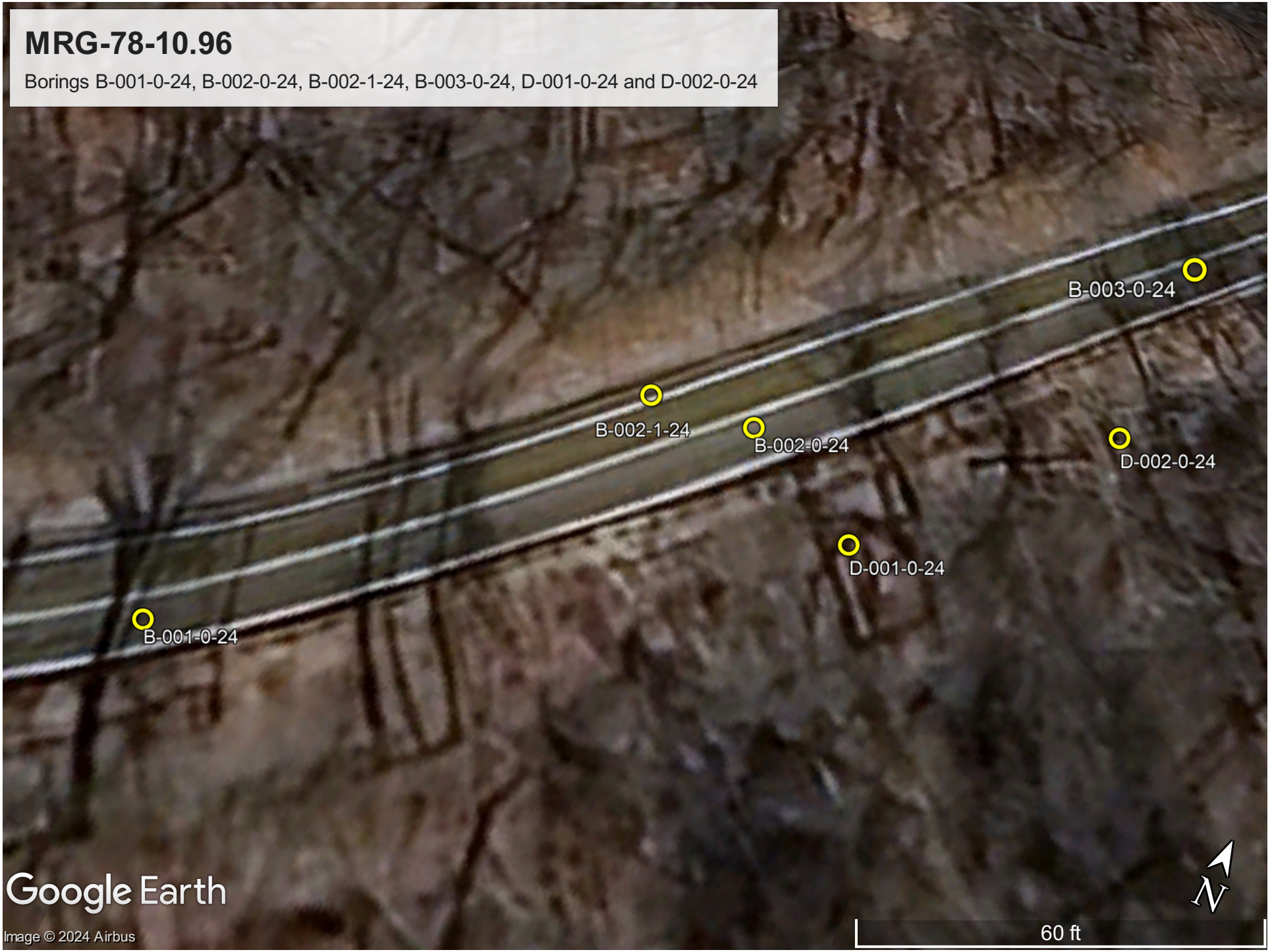
Using the results of the analysis discussed in Section 5.2, it is estimated that 3-foot diameter shafts installed at 5.75 feet center-to-center spacing socketed 10 feet into bedrock would adequately resist the anticipated loading of the failed slope. A W24x131 steel beam was modeled as reinforcement for the drilled shafts. To protect against loss of material through the drilled shaft wall, unreinforced plug drilled shafts are recommended to be installed between the reinforced drilled shafts from the existing grade to the top of bedrock.

The wall length can be estimated to extend from approximate Station 577+50 to 580+00, for a total length of about 250 feet, at an offset of 23 feet left of centerline. Before the final design, the required length should be re-evaluated based on observations of slope instability. To provide additional roadway shoulder, the W-sections should extend above the ground surface to an elevation consistent with the SR 78 elevation, and concrete lagging should be installed between the W-sections above grade to retain backfill.

Lengths of steel sections and drilled shafts along the length of the wall may vary based on depth to bedrock and proposed grade. The borings indicate a dipping top of rock elevation from west to east. The W-section lengths are estimated to be 22 to 35 feet.

APPENDIX A

BORING AND DCP LOCATIONS, BORING AND DCP LOGS, ROCK CORE PHOTOGRPAHS AND RESULTS OF LABORATORY TESTING


MRG-78-10.96
Borings B-001-0-24, B-002-0-24, B-002-1-24, B-003-0-24, D-001-0-24 and D-002-0-24
B-003-0-24
B-002-1-24
B-002-0-24
D-002-0-24
D-001-0-24
B-001-0-24
Google Earth
Image © 2024 Airbus
N
60 ft

PROJECT: MRG-SR 78-10.96	DRILLING FIRM / OPERATOR: OHIIO TESTBOR / CS	DRILL RIG: MOBIL B57	STATION / OFFSET: 577+69, 7' RT.
TYPE: GEOHAZARD EXPLORATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 78
PID: 118670 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/3/23	ELEVATION: 934.4 (MSL) EOB: 28.5 ft.
START: 7/15/24 END: 7/15/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 90*	LAT / LONG: 39.595199, -81.947751

EXPLORATION ID B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 934.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
PAVEMENT AND BASE	933.2																	
STIFF, BROWN TO GRAY, **CLAY**, TRACE GRAVEL, LITTLE SAND, "AND" SILT, DAMP	930.9		4 3 4	11	60	SS-1	2.50	6	4	8	37	45	46	29	17	23	A-7-6 (12)	
HARD, BROWN TO GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP	927.9	TR	5 8 20	42	100	SS-2	4.50	17	9	7	44	23	38	25	13	13	A-6a (8)	
			50/5"	-	100	SS-3	-	-	-	-	-	-	-	-	-	2	A-6a (V)	
SHALE, BROWN TO GRAY, HIGHLY WEATHERED, AUGERED.			13 43 50/4"	-	100	SS-4	-	-	-	-	-	-	-	-	-	7	Rock (V)	
			15 50/4"	-	100	SS-5	-	-	-	-	-	-	-	-	-	8	Rock (V)	
			50/5"	-	100	SS-6	-	-	-	-	-	-	-	-	-	6	Rock (V)	
	915.9																	
INTERBEDDED SHALE (90%) AND SANDSTONE (10%), RQD 25%, REC. 95%; **SHALE**, BROWN TO GRAY, HIGHLY WEATHERED, WEAK, FINE TO MEDIUM GRAINED, LAMINATED, HIGHLY FRACTURED; **SANDSTONE**, BROWN TO GRAY, MODERATELY WEATHERED, MODERATELY STRONG, FINE GRAINED, THICK BEDDED, MODERATELY FRACTURED.			16		92	NQ2-1											CORE	

PID: 118670	SFN: N/A	PROJECT: MRG-SR 78-10.96	STATION / OFFSET: 577+69, 7' RT.	START: 7/15/24	END: 7/15/24	PG 2 OF 2	B-001-0-24

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
FROM 26.5 FEET TO 26.9 FEET, UCR = 8760 PSI	909.4	26	34		96	NQ2-2											CORE	
	905.9	27																
		EOB 28																

NOTES: NO GROUNDWATER ENCOUNTERED DURING DRILLING. STATION, OFFSET AND ELEVATION ARE APPROXIMATE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTING MIXED WITH BENTONITE CHIPS

PROJECT: MRG-SR 78-10.96	DRILLING FIRM / OPERATOR: OHIO TESTBOR / CS	DRILL RIG: MOBIL B57	STATION / OFFSET: 578+75, 6' RT.
TYPE: GEOHAZARD EXPLORATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 78
PID: 118670 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/3/23	ELEVATION: 926.3 (MSL) EOB: 36.5 ft.
START: 7/16/24 END: 7/16/24	SAMPLING METHOD: SPT/NQ2	ENERGY RATIO (%): 90*	LAT / LONG: 39.595427, -81.947518

EXPLORATION ID: B-002-0-24

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
PAVEMENT AND BASE	926.3																	
	922.8																	
VERY SOFT, BROWN, **CLAY**, "AND" GRAVEL, TRACE SAND, SOME SILT, DAMP TO MOIST			0 0 0	0	33	SS-1	4.50	-	-	-	-	-	-	-	-	30	A-7-6 (V)	
					75	ST-2	4.50	44	1	5	28	22	47	29	18	7	A-7-6 (6)	
	918.3																	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, DAMP	917.3	TR	10 50/3"	-	100	SS-3	-	-	-	-	-	-	-	-	-	11	A-6a (V)	
SHALE, BROWN TO GRAY, HIGHLY WEATHERED, AUGERED.			50/4"	-	100	SS-4	4.50	-	-	-	-	-	-	-	-	2	Rock (V)	
			25 50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	5	Rock (V)	
			50/4"	-	100	SS-6	-	-	-	-	-	-	-	-	-	3	Rock (V)	
	909.8																	
CLAYSTONE, BROWN GRAY TO RED, HIGHLY WEATEHRED WEATHERED, WEAK, FINE GRAINED, LAMINATED, HIGHLY FRACTURED; RQD 43%, REC 100%.			40		100	NQ2-1											CORE	
FROM 20.6 FEET TO 21 FEET, UCR = 64 PSI			18		100	NQ2-2											CORE	

PID: 118670	SFN: N/A	PROJECT: MRG-SR 78-10.96	STATION / OFFSET: 578+75, 6' RT.	START: 7/16/24	END: 7/16/24	PG 2 OF 2	B-002-0-24

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
CLAYSTONE, BROWN GRAY TO RED, HIGHLY WEATEHRED WEATHERED, WEAK, FINE GRAINED, LAMINATED, HIGHLY FRACTURED; RQD 43%, REC 100%. *(continued)*	901.3	26																
		27																
		28																
FROM 29.0 FEET TO 29.4 FEET, UCR = 162 PSI		29	52		100	NQ-3											CORE	
		30																
		31																
		32																
		33																
		34	64		100	NQ-4											CORE	
FROM 35.1 FEET TO 35.5 FEET, UCR = 47 PSI		35																
	889.8	36 EOB																

NOTES: NO GROUNDWATER ENCOUNTERED DURING DRILLING. STATION, OFFSET AND ELEVATION ARE APPROXIMATE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTING MIXED WITH BENTONITE CHIPS

PROJECT: MRG-SR 78-10.96	DRILLING FIRM / OPERATOR: OHIO TESTBOR / CS	DRILL RIG: MOBIL B57	STATION / OFFSET: 578+62, 9' LT.	EXPLORATION ID B-002-1-24
TYPE: GEOHAZARD EXPLORATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 78	
PID: 118670 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/3/23	ELEVATION: 927.3 (MSL) EOB: 12.2 ft.	PAGE 1 OF 1
START: 7/15/24 END: 7/15/24	SAMPLING METHOD: SPT/NQ2	ENERGY RATIO (%): 90*	LAT / LONG: 39.595422, -81.947587	

MATERIAL DESCRIPTION AND NOTES	ELEV. 927.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
PAVEMENT AND BASE	926.1	1																
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, TRACE GRAVEL, SOME SAND, DAMP	922.8	2	4 3 3	9	73	SS-1	1.00	7	7	15	45	26	36	21	15	20	A-6a (9)	
		3	2 8 12	30	80	SS-2	-	-	-	-	-	-	-	-	-	17	A-6a (V)	
VERY STIFF TO HARD, BROWN TO GRAY, **SILTY CLAY**, SOME GRAVEL, SOME SAND, DAMP TO MOIST	918.5	4 5 6 7	4 4 8	18	100	SS-3	1.50	15	6	7	35	37	40	24	16	25	A-6b (10)	
			6 13 22	53	100	SS-4	4.50	-	-	-	-	-	-	-	-	11	A-6b (V)	
		8	10 15 50/4"	-	100	SS-5	4.50	-	-	-	-	-	-	-	-	9	A-6b (V)	
		TR 9	35 50/2"	-	100	SS-6	-	-	-	-	-	-	-	-	-	4	Rock (V)	
SHALE, GRAY TO REDDISH BROWN, HIGHLY WEATHERED, AUGERED.		10																
		11	50/4"	-	100	SS-7	-	-	-	-	-	-	-	-	-	4	Rock (V)	
	915.1	EOB 12	50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	3	Rock (V)	

NOTES: NO GROUNDWATER ENCOUNTERED DURING DRILLING. STATION, OFFSET AND ELEVATION ARE APPROXIMATE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTING MIXED WITH BENTONITE CHIPS

PROJECT: MRG-SR 78-10.96	DRILLING FIRM / OPERATOR: OHIO TESTBOR / CS	DRILL RIG: MOBIL B57	STATION / OFFSET: 579+86, 6' RT.
TYPE: GEOHAZARD EXPLORATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 78
PID: 118670 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/3/23	ELEVATION: 914.3 (MSL) EOB: 42.0 ft.
START: 7/17/24 END: 7/17/24	SAMPLING METHOD: SPT/NQ2	ENERGY RATIO (%): 90*	LAT / LONG: 39.595681, -81.947299

EXPLORATION ID B-003-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 914.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
PAVEMENT AND BASE	913.0																	
STIFF, GRAY, **CLAY**, SOME GRAVEL, LITTLE TO SOME SAND, SOME SILT, DAMP TO MOIST @SS-1:DRY			7 3 3	9	22	SS-1	-	24	12	11	24	29	43	25	18	4	A-7-6 (7)	
			2 3 4	11	53	SS-2	2.50	24	12	11	24	29	43	25	18	23	A-7-6 (7)	
FROM 6.0 FEET TO 8.0 FEET, UC = 0.73 TSF	906.3				75	ST-3	3.00	26	3	8	22	41	48	27	21	27	A-7-6 (11)	
STIFF TO VERY STIFF, GRAY TO BROWN, **SILTY CLAY**, TRACE GRAVEL, SOME SAND, DAMP			2 4 4	12	87	SS-4	2.50	7	12	14	35	32	38	22	16	19	A-6b (9)	
			3 5 6	17	53	SS-5	2.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
	901.3																	
VERY STIFF TO HARD, BROWN TO GRAY, **CLAY**, DAMP			2 3 5	12	100	SS-6	2.75	0	1	3	41	55	49	27	22	26	A-7-6 (15)	
			3 5 6	17	100	SS-7	3.00	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
	894.3	TR	5 8 19	41	60	SS-8	4.50	-	-	-	-	-	-	-	-	13	A-7-6 (V)	
SHALE, BROWN TO RED, HIGHLY WEATHERED, AUGERED.			10 19 24	65	47	SS-9	4.50	-	-	-	-	-	-	-	-	12	Rock (V)	
			10 15 20	53	80	SS-10	4.50	-	-	-	-	-	-	-	-	12	Rock (V)	

PID: 118670	SFN: N/A	PROJECT: MRG-SR 78-10.96	STATION / OFFSET: 579+86, 6' RT.	START: 7/17/24	END: 7/17/24	PG 2 OF 2	B-003-0-24

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
SHALE, BROWN TO RED, HIGHLY WEATHERED, AUGERED. *(continued)*	889.3	26																
		27	11 19 23	63	47	SS-11	4.50	-	-	-	-	-	-	-	-	7	Rock (V)	
		28																
		29	7 16 17	50	80	SS-12	4.50	-	-	-	-	-	-	-	-	12	Rock (V)	
		30																
		31																
		32	9 13 14	41	87	SS-13	4.50	-	-	-	-	-	-	-	-	13	Rock (V)	
		33																
		34	7 20 33	80	100	SS-14	4.50	-	-	-	-	-	-	-	-	12	Rock (V)	
		35																
		36																
		37	14 28 44	108	93	SS-15	4.50	-	-	-	-	-	-	-	-	11	Rock (V)	
		38																
		39	15 30 43	110	100	SS-16	4.50	-	-	-	-	-	-	-	-	13	Rock (V)	
	874.3	40																
CLAYSTONE, RED, HIGHLY WEATHERED, WEAK, FINE GRAINED, LAMINATED, HIGHLY FRACTURED; RQD 54%, REC 75%.		41	55		75	NQ2											CORE	
	872.3	EOB 42																

NOTES: NO GROUNDWATER ENCOUNTERED DURING DRILLING. STATION, OFFSET AND ELEVATION ARE APPROXIMATE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTING MIXED WITH BENTONITE CHIPS

Dynamic Cone Penetrometer Log Sheet

Location Information

Client	Stantec Consulting Services Inc.	Pavement Material	AC
State	OH	Pavement Thickness	
Location	MRG-78-10.96mm	Base Material	
Penetrometer Operators	JAK	Base Thickness	
Start Time		SubBase material	
Finish Time		SubBase Thickness	
Penetrometer test #	1	Date 7/16//2024	Data Recorder
Other Information			

in depth	ft depth	cm depth	Pre Blows		SPT N-Value		in depth	ft depth	cm depth	Pre Blows		SPT N-Value
3.94	0.33	10	2		1.532		200.79	16.73	510			#VALUE!
7.87	0.66	20	3		2.298		204.72	17.06	520			#VALUE!
11.81	0.98	30	4		3.064		208.66	17.38	530			#VALUE!
15.75	1.31	40	4		3.064		212.60	17.71	540			#VALUE!
19.69	1.64	50	1		0.766		216.54	18.04	550			#VALUE!
23.62	1.97	60	0.2		0.1532		220.47	18.37	560			#VALUE!
27.56	2.30	70	0.2		0.1532		224.41	18.70	570			#VALUE!
31.50	2.62	80	0.2		0.1532		228.35	19.02	580			#VALUE!
35.43	2.95	90	0.2		0.1532		232.28	19.35	590			#VALUE!
39.37	3.28	100	0.2		0.1532		236.22	19.68	600			#VALUE!
43.31	3.61	110	0.2		0.1532		240.16	20.01	610			#VALUE!
47.24	3.94	120	2		1.532		244.09	20.34	620			#VALUE!
51.18	4.26	130	0.2		0.1532		248.03	20.66	630			#VALUE!
55.12	4.59	140	2		1.532		251.97	20.99	640			#VALUE!
59.06	4.92	150	2		1.532		255.91	21.32	650			#VALUE!
62.99	5.25	160	3		2.298		259.84	21.65	660			#VALUE!
66.93	5.58	170	5		3.83		263.78	21.98	670			#VALUE!
70.87	5.90	180	9		6.894		267.72	22.30	680			#VALUE!
74.80	6.23	190	10		7.66		271.65	22.63	690			#VALUE!
78.74	6.56	200	41		31.406		275.59	22.96	700			#VALUE!
82.68	6.89	210	35		26.81		279.53	23.29	710			#VALUE!
86.61	7.22	220	16		12.256		283.46	23.62	720			#VALUE!
90.55	7.54	230	23		17.618		287.40	23.94	730			#VALUE!
94.49	7.87	240	136		104.176		291.34	24.27	740			#VALUE!
98.43	8.20	250	127		97.282		295.28	24.60	750			#VALUE!
102.36	8.53	260	50		38.3		299.21	24.93	760			#VALUE!
106.30	8.86	270			0		303.15	25.26	770			#VALUE!
110.24	9.18	280			0		307.09	25.58	780			#VALUE!
114.17	9.51	290			0		311.02	25.91	790			#VALUE!
118.11	9.84	300			0		314.96	26.24	800			#VALUE!
122.05	10.17	310			0		318.90	26.57	810			#VALUE!
125.98	10.50	320			0		322.83	26.90	820			#VALUE!
129.92	10.82	330			0		326.77	27.22	830			#VALUE!
133.86	11.15	340			0		330.71	27.55	840			#VALUE!
137.80	11.48	350			0		334.65	27.88	850			#VALUE!
141.73	11.81	360			0		338.58	28.21	860			#VALUE!
145.67	12.14	370			0		342.52	28.54	870			#VALUE!
149.61	12.46	380			0		346.46	28.86	880			#VALUE!
153.54	12.79	390			0		350.39	29.19	890			#VALUE!
157.48	13.12	400			0		354.33	29.52	900			#VALUE!
161.42	13.45	410			0		358.27	29.85	910			#VALUE!
165.35	13.78	420			0		362.20	30.18	920			#VALUE!
169.29	14.10	430			0		366.14	30.50	930			#VALUE!
173.23	14.43	440			0		370.08	30.83	940			#VALUE!
177.17	14.76	450			0		374.02	31.16	950			#VALUE!
181.10	15.09	460			0		377.95	31.49	960			#VALUE!
185.04	15.42	470			0		381.89	31.82	970			#VALUE!
188.98	15.74	480			0		385.83	32.14	980			#VALUE!
192.91	16.07	490			0		389.76	32.47	990			#VALUE!
196.85	16.40	500			0		393.70	32.80	1000			#VALUE!

Dynamic Cone Penetrometer Log Sheet

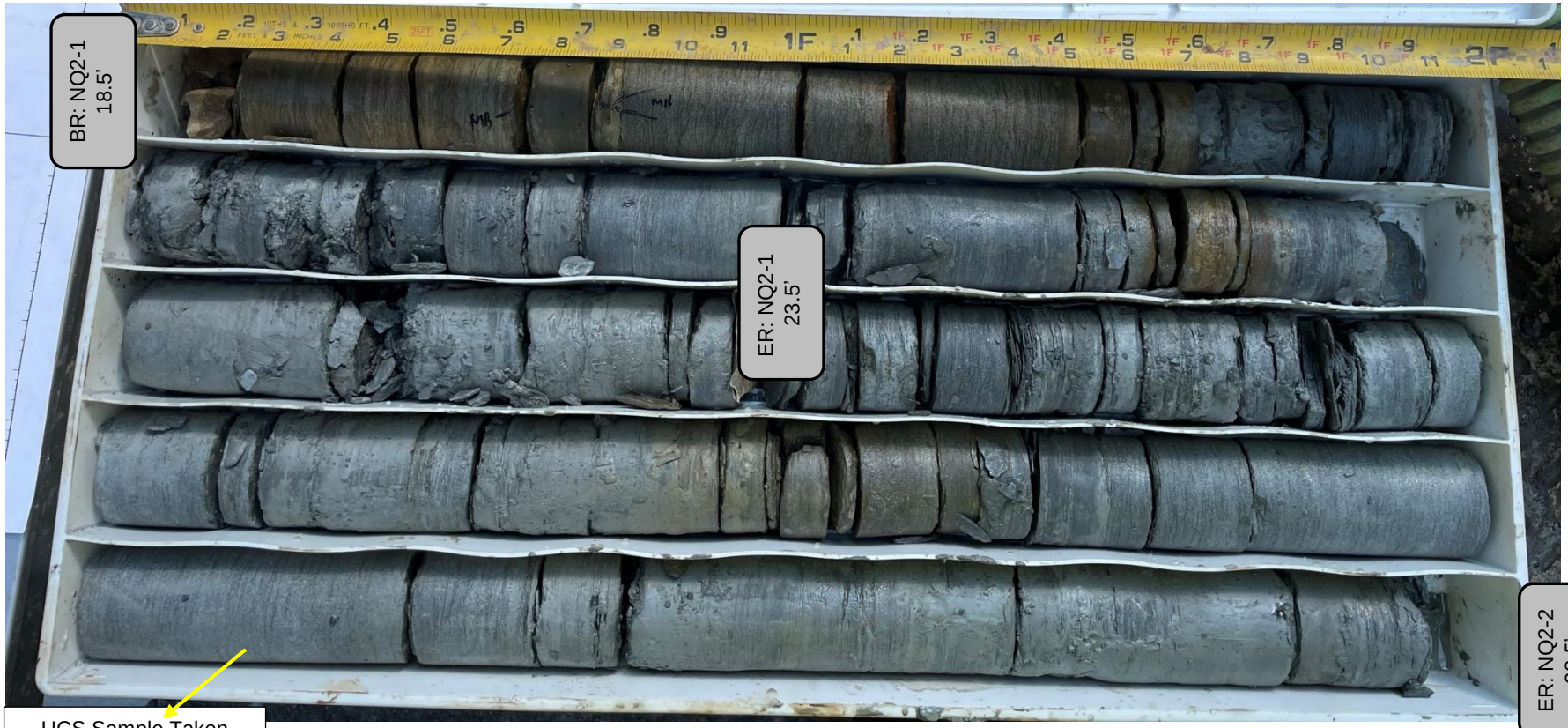
Location Information

Client	Stantec Consulting Services Inc.	Pavement Material	AC
State	OH	Pavement Thickness	
Location	MRG-78-10.96mm	Base Material	
Penetrometer Operators	JAK	Base Thickness	
Start Time		SubBase material	
Finish Time		SubBase Thickness	
Penetrometer test #	2	Date 7/16//2024	Data Recorder
Other Information			

in depth	ft depth	cm depth	Pre Blows		SPT N-Value		in depth	ft depth	cm depth	Pre Blows		SPT N-Value
3.94	0.33	10	4		3.064		200.79	16.73	510	19		14.554
7.87	0.66	20	3		2.298		204.72	17.06	520	24		18.384
11.81	0.98	30	4		3.064		208.66	17.38	530	32		24.512
15.75	1.31	40	3		2.298		212.60	17.71	540	30		22.98
19.69	1.64	50	6		4.596		216.54	18.04	550	26		19.916
23.62	1.97	60	10		7.66		220.47	18.37	560	18		13.788
27.56	2.30	70	11		8.426		224.41	18.70	570	21		16.086
31.50	2.62	80	13		9.958		228.35	19.02	580	34		26.044
35.43	2.95	90	8		6.128		232.28	19.35	590	37		28.342
39.37	3.28	100	15		11.49		236.22	19.68	600	27		20.682
43.31	3.61	110	12		9.192		240.16	20.01	610	32		24.512
47.24	3.94	120	11		8.426		244.09	20.34	620	42		32.172
51.18	4.26	130	9		6.894		248.03	20.66	630	50		38.3
55.12	4.59	140	5		3.83		251.97	20.99	640			#VALUE!
59.06	4.92	150	7		5.362		255.91	21.32	650			#VALUE!
62.99	5.25	160	4		3.064		259.84	21.65	660			#VALUE!
66.93	5.58	170	5		3.83		263.78	21.98	670			#VALUE!
70.87	5.90	180	6		4.596		267.72	22.30	680			#VALUE!
74.80	6.23	190	5		3.83		271.65	22.63	690			#VALUE!
78.74	6.56	200	10		7.66		275.59	22.96	700			#VALUE!
82.68	6.89	210	12		9.192		279.53	23.29	710			#VALUE!
86.61	7.22	220	5		3.83		283.46	23.62	720			#VALUE!
90.55	7.54	230	5		3.83		287.40	23.94	730			#VALUE!
94.49	7.87	240	6		4.596		291.34	24.27	740			#VALUE!
98.43	8.20	250	6		4.596		295.28	24.60	750			#VALUE!
102.36	8.53	260	6		4.596		299.21	24.93	760			#VALUE!
106.30	8.86	270	6		4.596		303.15	25.26	770			#VALUE!
110.24	9.18	280	7		5.362		307.09	25.58	780			#VALUE!
114.17	9.51	290	6		4.596		311.02	25.91	790			#VALUE!
118.11	9.84	300	7		5.362		314.96	26.24	800			#VALUE!
122.05	10.17	310	6		4.596		318.90	26.57	810			#VALUE!
125.98	10.50	320	11		8.426		322.83	26.90	820			#VALUE!
129.92	10.82	330	12		9.192		326.77	27.22	830			#VALUE!
133.86	11.15	340	9		6.894		330.71	27.55	840			#VALUE!
137.80	11.48	350	10		7.66		334.65	27.88	850			#VALUE!
141.73	11.81	360	17		13.022		338.58	28.21	860			#VALUE!
145.67	12.14	370	12		9.192		342.52	28.54	870			#VALUE!
149.61	12.46	380	13		9.958		346.46	28.86	880			#VALUE!
153.54	12.79	390	12		9.192		350.39	29.19	890			#VALUE!
157.48	13.12	400	11		8.426		354.33	29.52	900			#VALUE!
161.42	13.45	410	14		10.724		358.27	29.85	910			#VALUE!
165.35	13.78	420	12		9.192		362.20	30.18	920			#VALUE!
169.29	14.10	430	16		12.256		366.14	30.50	930			#VALUE!
173.23	14.43	440	21		16.086		370.08	30.83	940			#VALUE!
177.17	14.76	450	23		17.618		374.02	31.16	950			#VALUE!
181.10	15.09	460	24		18.384		377.95	31.49	960			#VALUE!
185.04	15.42	470	19		14.554		381.89	31.82	970			#VALUE!
188.98	15.74	480	16		12.256		385.83	32.14	980			#VALUE!
192.91	16.07	490	15		11.49		389.76	32.47	990			#VALUE!
196.85	16.40	500	14		10.724		393.70	32.80	1000			#VALUE!

Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242

B-001-0-24



Run #:	Depth		Recovery		RQD	
NQ2-1	18.5'	23.5'	55''/60''	92%	10''/60''	16%
NQ2-2	23..5'	28.5'	58''/60''	96%	20''/60''	34%
MRG-78-10.96, PID 118670						

Stantec
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B-002-0-24

Run #:	Depth		Recovery		RQD	
NQ2-1	16.5'	21.5'	60''/60''	100%	24''/60''	40%
NQ2-2	21.5'	26.5''	60''/60''	100%	11''/60''	18%
MRG-78-10.96, PID 118670						

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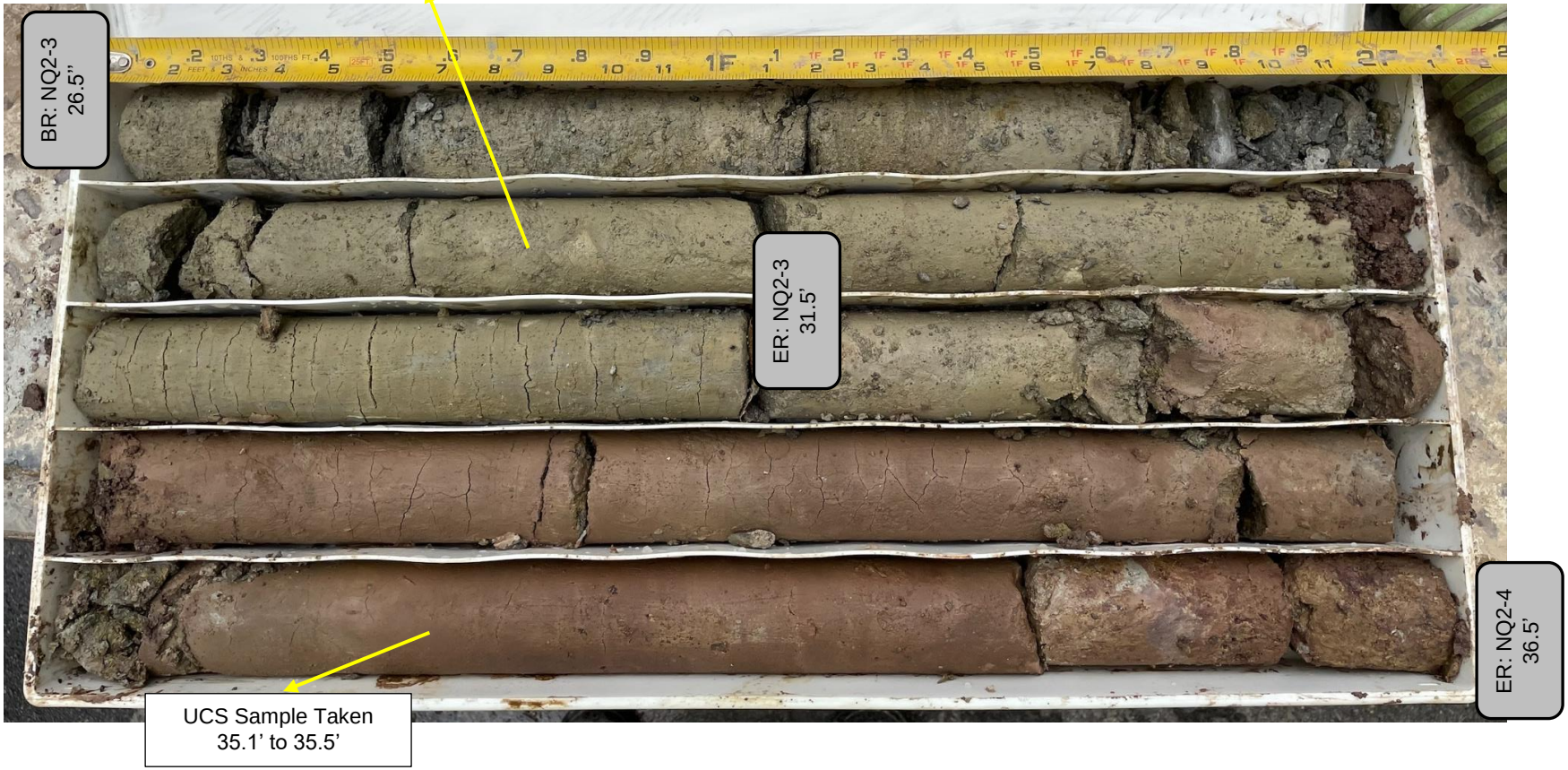
Cincinnati, OH 45242

B-002-0-24



Run #:	Depth		Recovery		RQD	
NQ2-4	26.5’	31.5’	60’’/60’’	100%	31’’/60’’	52%
NQ2-5	31.5’	36.5’	60’’/60’’	100%	38’’/60’’	64%
MRG-78-10.96, PID 118670						

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B-003-0-24

Run #:	Depth		Recovery		RQD	
NQ2-1	40.0'	42.0'	18''/24''	75%	13''/24''	55%
MRG-78-10.96, PID 118670						

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Moisture Content of Soil

ASTM D 2216

Project Name MRG-78-10.96 (Landslide Exploration)

Project Number 175578434

Tested By JP

Test Method ASTM

Maximum Particle Size in Sample	No. 10	No. 4	3/8"	3/4"	1 1/2"	3"
Recommended Minimum Mass (g)	20	100	500	2,500	10,000	50,000

Material Type: Stratified, Laminated, Lensed, Homogeneous, Disturbed

Source	Lab ID	Date Tested	Material Type	Maximum Particle Size	Material Excluded Amount	Material Excluded Size	Pass Min. Mass? (Y/N)	Can Weight (g)	Wet Soil & Can Weight (g)	Dry Soil & CanWeight (g)	Moisture Content (%)
B-001-0-24, 1.5'-3.0'	217	7/24/24	Dist	No. 10			Yes	20.92	52.68	46.66	23.4
B-001-0-24, 4.0'-5.5'	218	7/24/24	Dist	No. 10			Yes	21.05	52.66	49.11	12.7
B-001-0-24, 6.0'-7.5'	219	7/24/24	Dist	No. 10			Yes	21.71	112.26	110.11	2.4
B-001-0-24, 8.5'-10.0'	220	7/24/24	Dist	No. 10			Yes	20.88	88.67	83.98	7.4
B-001-0-24, 11.0'-12.5'	221	7/24/24	Dist	No. 10			Yes	20.97	83.44	78.73	8.2
B-001-0-24, 13.5'-15.0'	222	7/24/24	Dist	No. 10			Yes	20.93	134.77	128.55	5.8
B-002-0-24, 3.5'-5.0'	223	7/24/24	Dist	No. 10			Yes	31.25	61.86	54.81	29.9
B-002-0-24, 8.5'-10.0'	224	7/24/24	Dist	No. 10			Yes	20.65	75.79	70.45	10.7
B-002-0-24, 11.0'-12.5'	225	7/24/24	Dist	No. 10			Yes	32.32	132.75	130.90	1.9
B-002-0-24, 13.5'-15.0'	226	7/24/24	Dist	No. 10			Yes	32.09	104.23	101.10	4.5
B-002-0-24, 16.0'-17.5'	227	7/24/24	Dist	No. 10			Yes	21.26	121.37	118.57	2.9
B-002-1-24, 1.5'-3.0'	228	7/24/24	Dist	No. 10			Yes	21.19	51.71	46.53	20.4
B-002-1-24, 3.0'-4.5'	229	7/24/24	Dist	No. 10			Yes	21.05	96.57	85.81	16.6
B-002-1-24, 4.5'-6.0'	230	7/24/24	Dist	No. 10			Yes	20.72	50.99	44.90	25.2
B-002-1-24, 6.0'-7.5'	231	7/24/24	Dist	No. 10			Yes	21.08	121.76	111.79	11.0
B-002-1-24, 7.5'-9.0'	232	7/24/24	Dist	No. 10			Yes	20.78	91.89	85.82	9.3
B-002-1-24, 9.0'-10.5'	233	7/24/24	Dist	No. 10			Yes	21.11	97.33	94.12	4.4
B-002-1-24, 10.5'-12.0'	234	7/24/24	Dist	No. 10			Yes	21.19	104.44	101.54	3.6
B-002-1-24, 12.0'-13.5'	235	7/24/24	Dist	No. 10			Yes	20.89	75.85	74.46	2.6
B-003-0-24, 1.5'-3.0'	237	7/24/24	Dist	No. 10			Yes	20.78	51.11	49.89	4.2
B-003-0-24, 3.5'-5.0'	238	7/24/24	Dist	No. 10			Yes	20.84	50.97	45.30	23.2
B-003-0-24, 8.5'-10.0'	239	7/24/24	Dist	No. 10			Yes	21.17	52.68	47.76	18.5
B-003-0-24, 11.0'-12.5'	240	7/24/24	Dist	No. 10			Yes	20.96	107.79	94.98	17.3
B-003-0-24, 13.5'-15.0'	241	7/24/24	Dist	No. 10			Yes	21.04	72.76	62.11	25.9
B-003-0-24, 16.0'-17.5'	242	7/24/24	Dist	No. 10			Yes	20.93	54.45	48.65	20.9
B-003-0-24, 18.5'-20.0'	243	7/24/24	Dist	No. 10			Yes	20.93	117.11	106.07	13.0
B-003-0-24, 21.0'-22.5'	244	7/24/24	Dist	No. 10			Yes	20.80	95.46	87.25	12.4
B-003-0-24, 23.5'-25.0'	245	7/24/24	Dist	No. 10			Yes	21.20	80.05	73.56	12.4

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Moisture Content of Soil

ASTM D 2216

Project Name MRG-78-10.96 (Landslide Exploration)

Project Number 175578434

Tested By JP

Test Method ASTM

Maximum Particle Size in Sample	No. 10	No. 4	3/8"	3/4"	1 1/2"	3"
Recommended Minimum Mass (g)	20	100	500	2,500	10,000	50,000

Material Type: Stratified, Laminated, Lensed, Homogeneous, Disturbed

Source	Lab ID	Date Tested	Material Type	Maximum Particle Size	Material Excluded Amount	Material Excluded Size	Pass Min. Mass? (Y/N)	Can Weight (g)	Wet Soil & Can Weight (g)	Dry Soil & CanWeight (g)	Moisture Content (%)
B-003-0-24, 26.0'-27.5'	246	7/24/24	Dist	No. 10			Yes	20.80	54.01	51.98	6.5
B-003-0-24, 28.5'-30.0'	247	7/24/24	Dist	No. 10			Yes	20.91	74.61	69.08	11.5
B-003-0-24, 31.0'-32.5'	248	7/24/24	Dist	No. 10			Yes	31.57	95.51	88.36	12.6
B-003-0-24, 33.5'-35.0'	249	7/24/24	Dist	No. 10			Yes	20.78	127.13	116.20	11.5
B-003-0-24, 36.0'-37.5'	250	7/24/24	Dist	No. 10			Yes	32.03	143.16	131.79	11.4
B-003-0-24, 38.5'-40.0'	251	7/24/24	Dist	No. 10			Yes	20.85	59.34	54.92	13.0

Stantec

Moisture Content of Soil

ASTM D 2216

Project Name MRG-78-10.96 (Landslide Exploration)

Project Number 175578434

Tested By JP

Test Method ASTM

Maximum Particle Size in Sample	No. 10	No. 4	3/8"	3/4"	1 1/2"	3"
Recommended Minimum Mass (g)	20	100	500	2,500	10,000	50,000

Material Type: Stratified, Laminated, Lensed, Homogeneous, Disturbed

Source	Lab ID	Date Tested	Material Type	Maximum Particle Size	Material Excluded Amount	Material Excluded Size	Pass Min. Mass? (Y/N)	Can Weight (g)	Wet Soil & Can Weight (g)	Dry Soil & CanWeight (g)	Moisture Content (%)
B-002-0-24, 6.0'-8.0'	252	8/1/24	Dist	No. 10			Yes	21.27	91.27	86.77	6.9
B-003-0-24, 6.0'-8.0'	253	8/1/24	Dist	No. 10			Yes	21.07	81.64	68.94	26.5

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Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-001-0-24, 1.5'-3.0'	Lab ID	217
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 23.4

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	98.4
No. 4	4.75	97.7
No. 10	2	93.3
No. 40	0.425	89.5
No. 200	0.075	81.7
	0.02	60.0
	0.005	44.5
	0.002	32.5
Estimated	0.001	24.9

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	2.3	6.7
Coarse Sand	4.4	3.8
Medium Sand	3.8	---
Fine Sand	7.8	7.8
Silt	37.2	37.2
Clay	44.5	44.5

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	46
Plastic Limit:	29
Plasticity Index:	17
Activity Index:	0.5

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: ML

Group Name: Silt with Sand

ODOT Classification A-7-6 (12)

Description: Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-001-0-24, 1.5'-3.0'	Lab ID	217

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	JP
Test Date	07-25-2024
Date Received	07-24-2024

Maximum Particle Size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	98.4
No. 4	97.7
No. 10	93.3

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

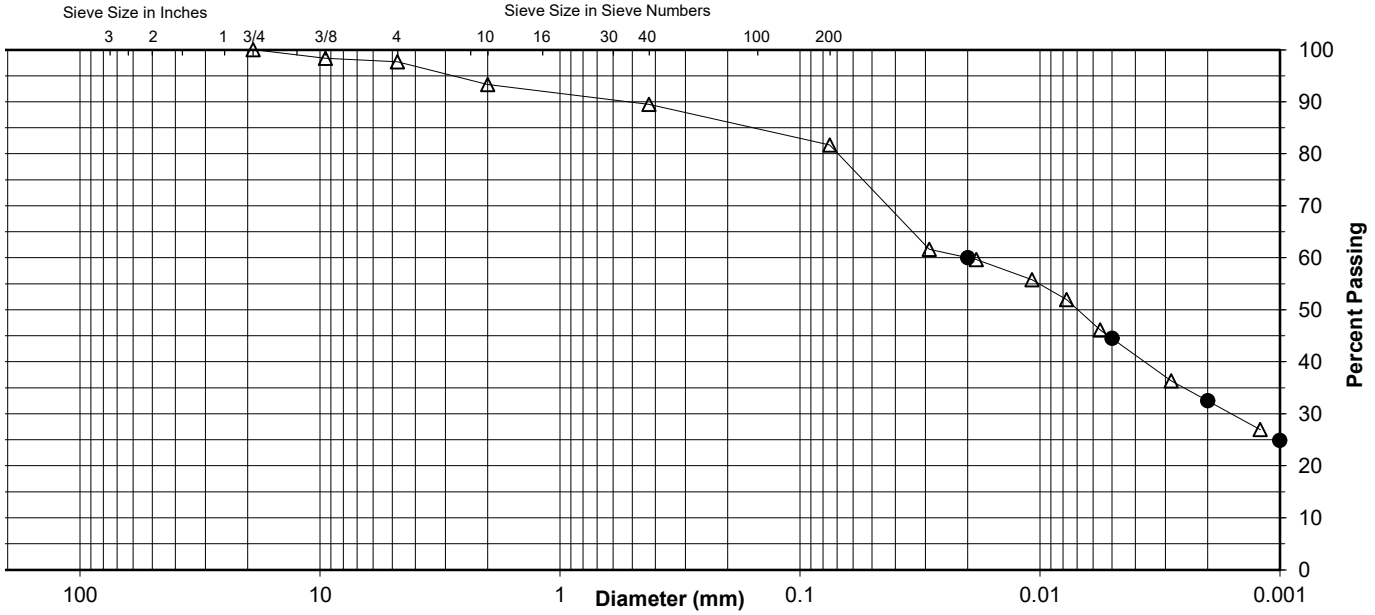
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	89.5
No. 200	81.7
0.02 mm	60.0
0.005 mm	44.5
0.002 mm	32.5
0.001 mm	24.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	2.3	4.4	3.8	7.8	37.2	44.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	6.7	3.8	7.8	49.2	32.5



Comments

Reviewed By REL

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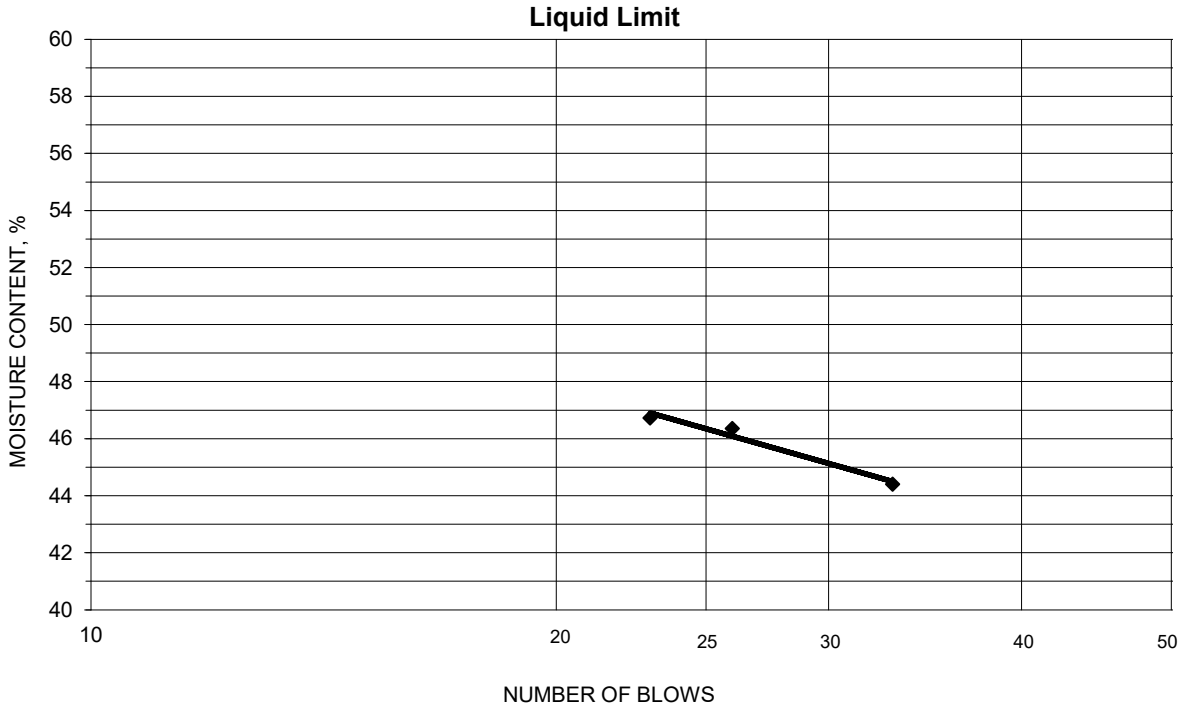
ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-001-0-24, 1.5'-3.0'			Lab ID	217
				% + No. 40	11
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	08-06-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.42	17.28	10.56	23	46.7	
20.07	17.21	11.04	26	46.4	
19.64	16.86	10.60	33	44.4	46



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
23.04	20.26	10.66	29.0	29	17
22.57	20.04	11.07	28.2		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-001-0-24, 4.0'-5.5'	Lab ID	218
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 12.7

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	93.1
3/8"	9.5	91.5
No. 4	4.75	89.8
No. 10	2	83.3
No. 40	0.425	74.3
No. 200	0.075	66.9
	0.02	42.0
	0.005	22.5
	0.002	13.2
Estimated	0.001	8.0

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	10.2	16.7
Coarse Sand	6.5	9.0
Medium Sand	9.0	---
Fine Sand	7.4	7.4
Silt	44.4	44.4
Clay	22.5	22.5

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	38
Plastic Limit:	25
Plasticity Index:	13
Activity Index:	1.0

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: ML

Group Name: Sandy Silt

ODOT Classification A-6a (8)

Description: Silt and Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: MRG-78-10.96 (Landslide Exploration)
Project Number: 175578434
Source: B-001-0-24, 4.0'-5.5'
Lab ID: 218

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: NU
Test Date: 07-25-2024
Date Received: 07-24-2024

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	93.1
3/8"	91.5
No. 4	89.8
No. 10	83.3

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

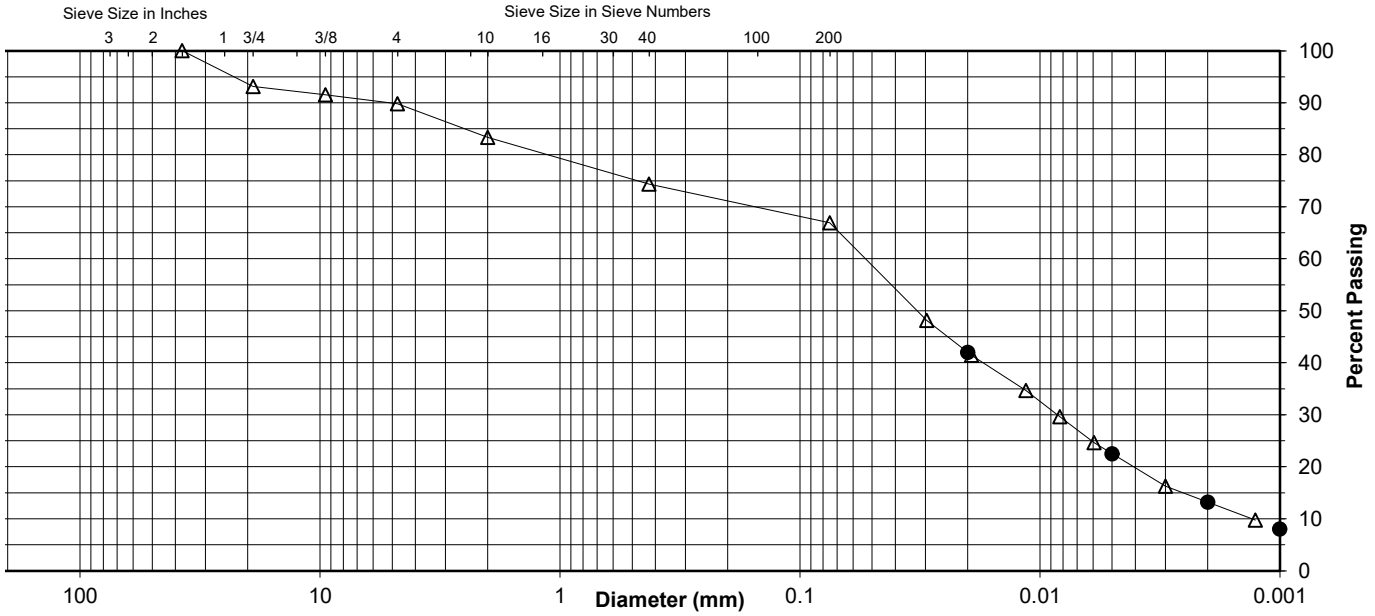
Specific Gravity: 2.7

Dispersed Using: Apparatus A - Mechanical, for 1 Minute

No. 40	74.3
No. 200	66.9
0.02 mm	42.0
0.005 mm	22.5
0.002 mm	13.2
0.001 mm	8.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	6.9	3.3	6.5	9.0	7.4	44.4	22.5
AASHTO	Gravel			Coarse Sand	Fine Sand	Silt	Clay
	16.7			9.0	7.4	53.7	13.2



Comments:

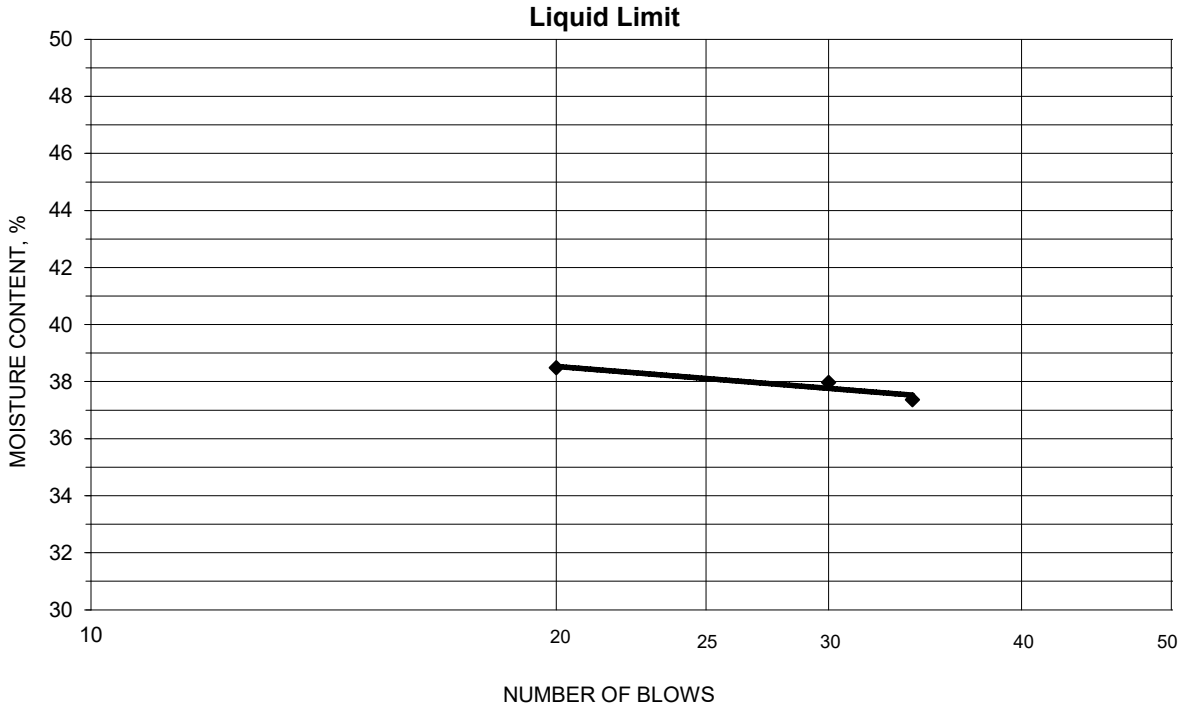
Reviewed By: REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-001-0-24, 4.0'-5.5'			Lab ID	218
				% + No. 40	26
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	08-05-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.85	18.11	10.99	20	38.5	
21.31	18.50	11.10	30	38.0	
19.60	17.16	10.63	34	37.4	38



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
23.36	20.90	11.07	25.0	25	13
23.01	20.58	10.65	24.5		

Remarks: _____

Reviewed By REL

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Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-002-1-24, 1.5'-3.0'	Lab ID	228
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 20.4

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	98.2
No. 4	4.75	96.7
No. 10	2	93.2
No. 40	0.425	86.1
No. 200	0.075	70.9
	0.02	41.1
	0.005	26.3
	0.002	18.8
Estimated	0.001	13.0

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	3.3	6.8
Coarse Sand	3.5	7.1
Medium Sand	7.1	---
Fine Sand	15.2	15.2
Silt	44.6	44.6
Clay	26.3	26.3

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	36
Plastic Limit:	21
Plasticity Index:	15
Activity Index:	0.8

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol:	CL
Group Name:	Lean Clay with Sand
ODOT Classification	A-6a (9)
Description:	Silt and Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-002-1-24, 1.5'-3.0'	Lab ID	228

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	NU
Test Date	07-25-2024
Date Received	07-24-2024

Maximum Particle Size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	98.2
No. 4	96.7
No. 10	93.2

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

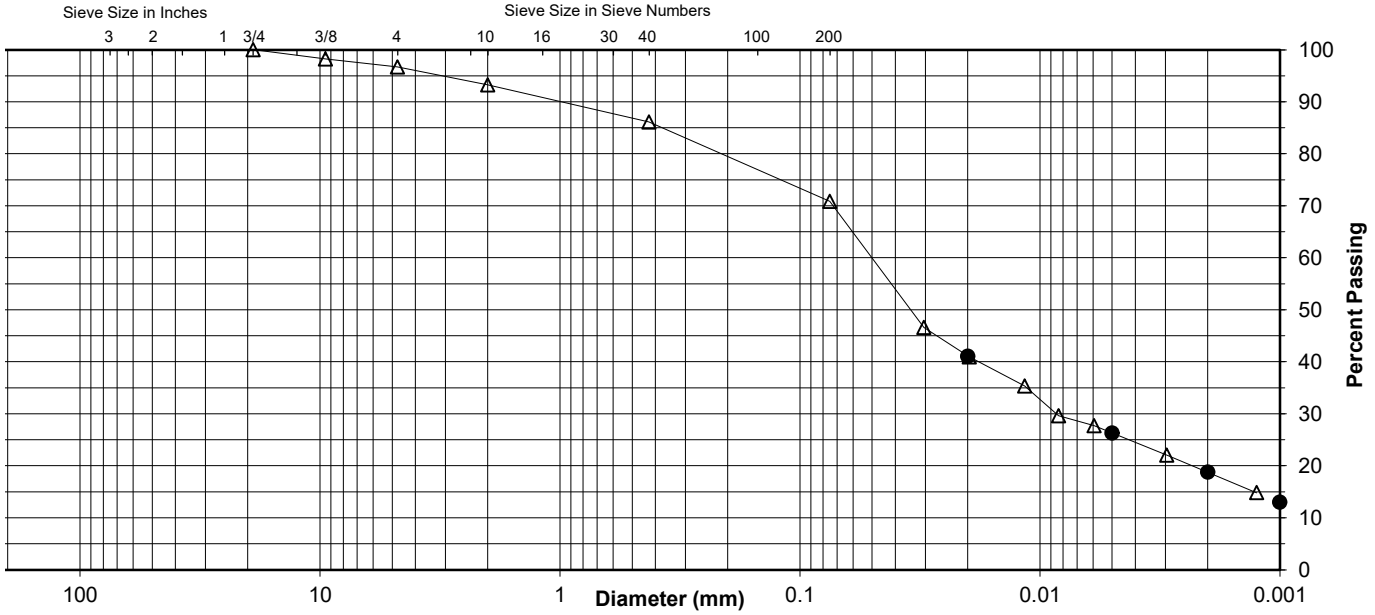
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	86.1
No. 200	70.9
0.02 mm	41.1
0.005 mm	26.3
0.002 mm	18.8
0.001 mm	13.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	3.3	3.5	7.1	15.2	44.6	26.3

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	6.8	7.1	15.2	52.1	18.8



Comments

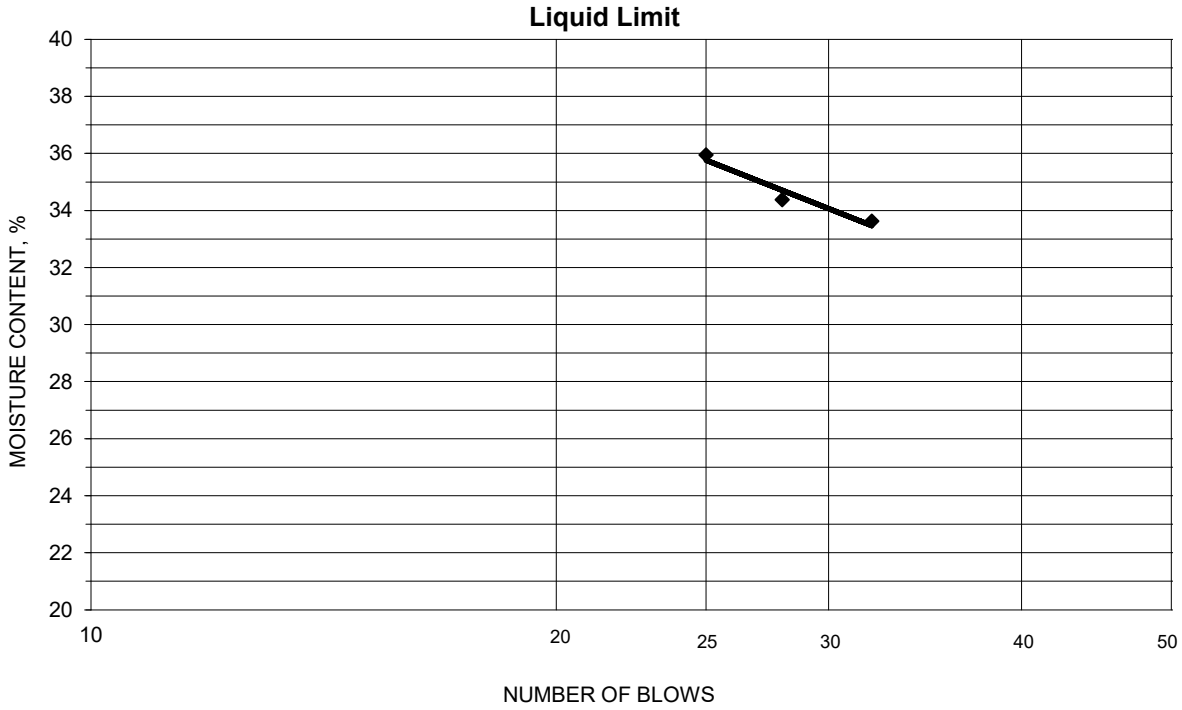
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-002-1-24, 1.5'-3.0'			Lab ID	228
				% + No. 40	14
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	07-26-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.36	17.02	10.51	25	35.9	
19.24	17.04	10.64	28	34.4	
19.83	17.51	10.61	32	33.6	36



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
23.02	20.92	11.03	21.2	21	15
23.14	20.94	10.54	21.2		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-002-1-24, 4.5'-6.0'	Lab ID	230
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 25.2

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	96.3
No. 4	4.75	95.3
No. 10	2	85.2
No. 40	0.425	78.8
No. 200	0.075	71.9
	0.02	55.6
	0.005	37.3
	0.002	24.5
Estimated	0.001	16.3

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	4.7	14.8
Coarse Sand	10.1	6.4
Medium Sand	6.4	---
Fine Sand	6.9	6.9
Silt	34.6	34.6
Clay	37.3	37.3

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	40
Plastic Limit:	24
Plasticity Index:	16
Activity Index:	0.7

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: CL

Group Name: Lean Clay with Sand

ODOT Classification A-6b (10)

Description: Silty Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: MRG-78-10.96 (Landslide Exploration)
Project Number: 175578434
Source: B-002-1-24, 4.5'-6.0'
Lab ID: 230

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: NU
Test Date: 07-25-2024
Date Received: 07-24-2024

Maximum Particle Size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	96.3
No. 4	95.3
No. 10	85.2

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

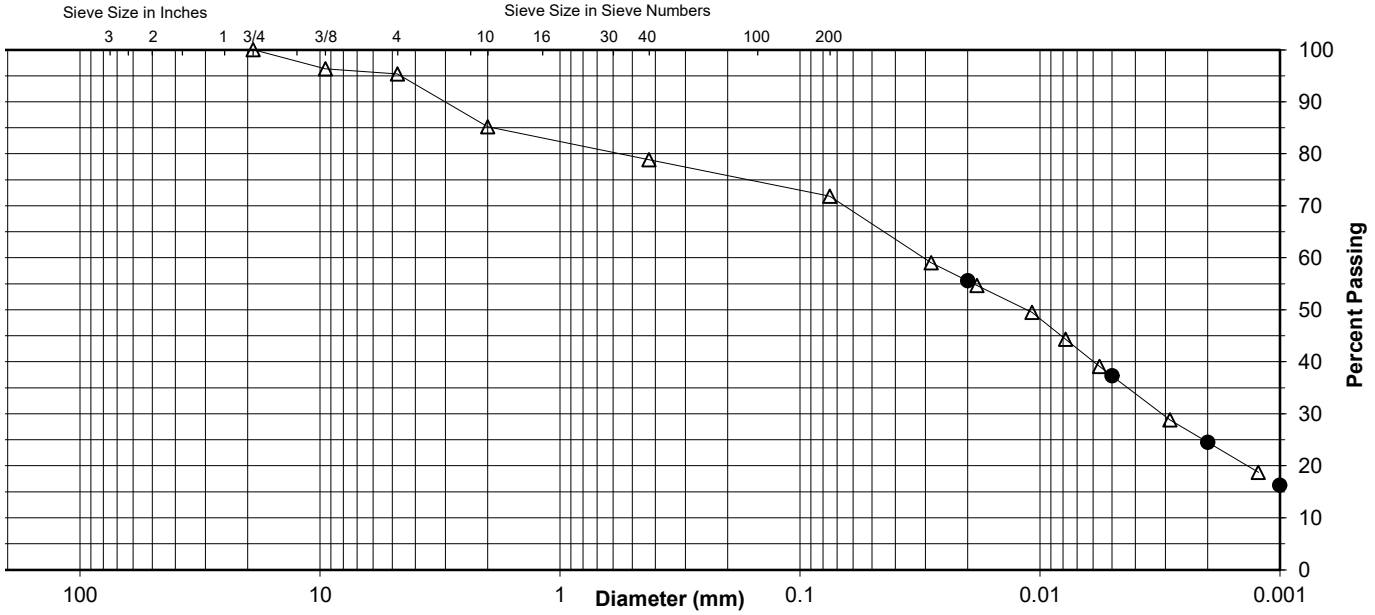
Dispersed Using: Apparatus A - Mechanical, for 1 Minute

No. 40	78.8
No. 200	71.9
0.02 mm	55.6
0.005 mm	37.3
0.002 mm	24.5
0.001 mm	16.3

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	0.0	4.7	10.1	6.4	6.9	34.6	37.3

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	14.8	6.4	6.9	47.4	24.5



Comments:

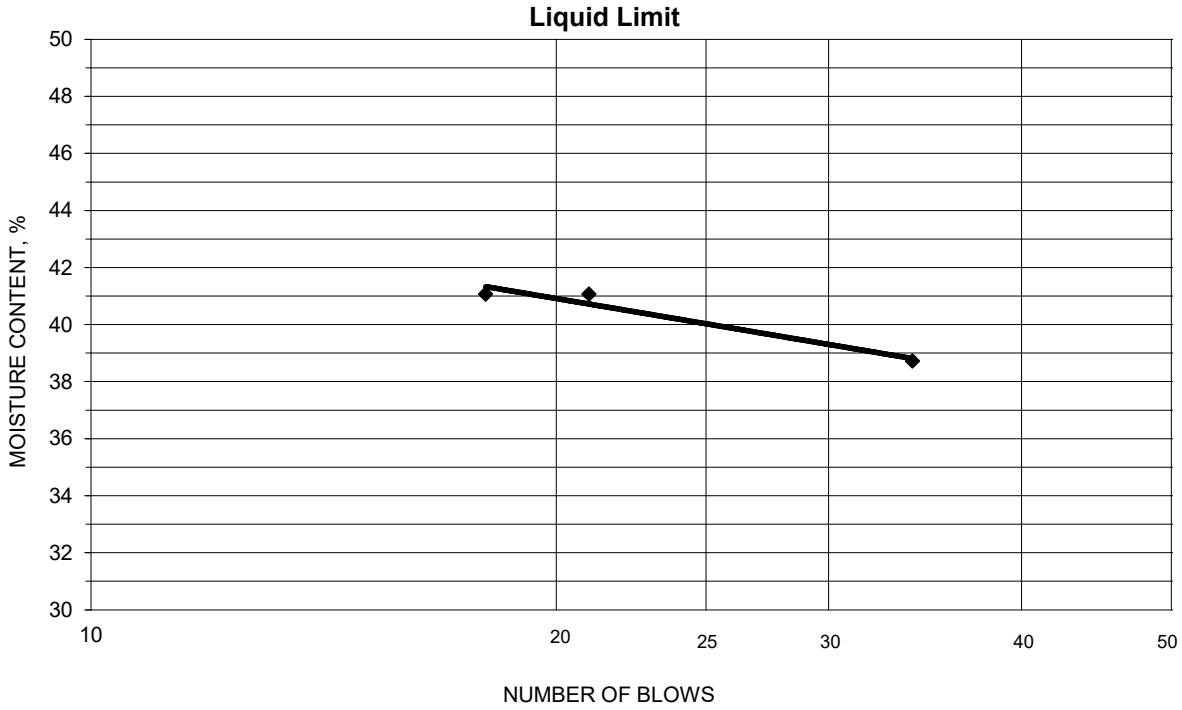
Reviewed By: REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-002-1-24, 4.5'-6.0'			Lab ID	230
				% + No. 40	21
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	07-26-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.00	17.38	11.00	18	41.1	
21.34	18.35	11.07	21	41.1	
20.40	17.67	10.62	34	38.7	40



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
23.33	20.97	11.06	23.8	24	16
23.59	21.21	11.05	23.4		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 1.5'-3.0', 3.5'-5.0'	Lab ID	236
Sample Type	SPT Composite	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 13.7

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	93.6
No. 4	4.75	86.5
No. 10	2	75.8
No. 40	0.425	63.6
No. 200	0.075	53.1
	0.02	41.2
	0.005	29.3
	0.002	23.2
Estimated	0.001	18.4

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	13.5	24.2
Coarse Sand	10.7	12.2
Medium Sand	12.2	---
Fine Sand	10.5	10.5
Silt	23.8	23.8
Clay	29.3	29.3

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	43
Plastic Limit:	25
Plasticity Index:	18
Activity Index:	0.8

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: CL

Group Name: Sandy Lean Clay

ODOT Classification A-7-6 (7)

Description: Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 1.5'-3.0', 3.5'-5.0'	Lab ID	236

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	NU
Test Date	07-26-2024
Date Received	07-24-2024

Maximum Particle Size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	93.6
No. 4	86.5
No. 10	75.8

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

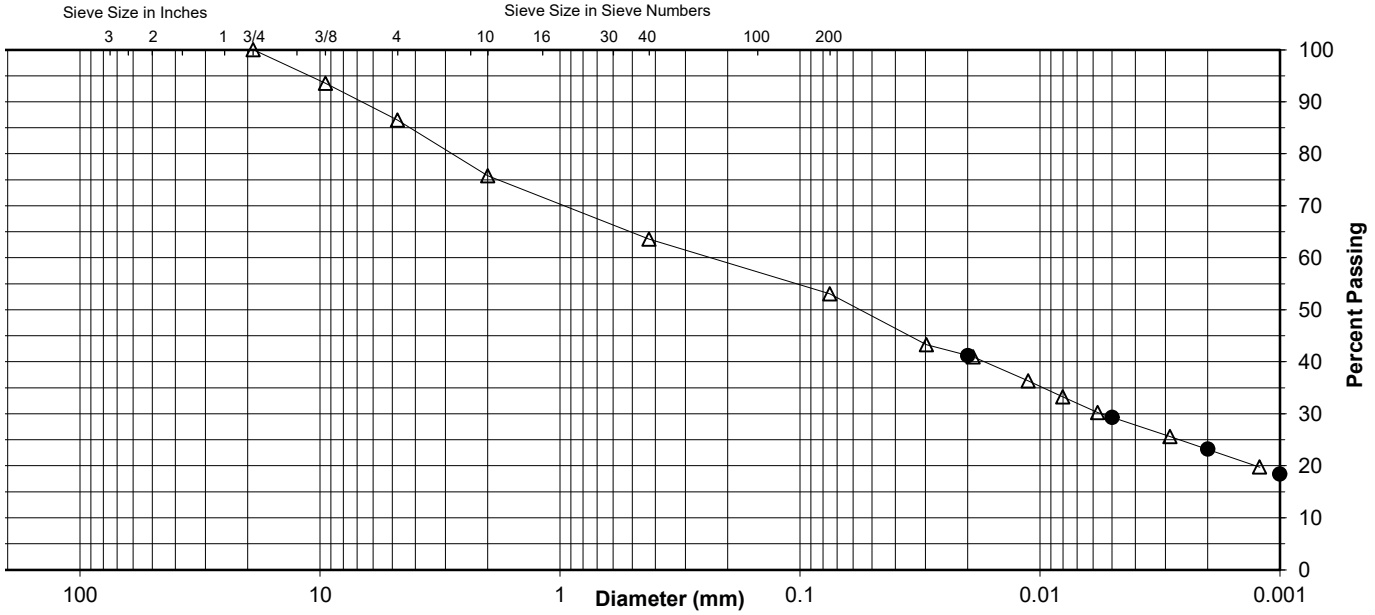
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	63.6
No. 200	53.1
0.02 mm	41.2
0.005 mm	29.3
0.002 mm	23.2
0.001 mm	18.4

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	0.0	13.5	10.7	12.2	10.5	23.8	29.3

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	24.2	12.2	10.5	29.9	23.2



Comments

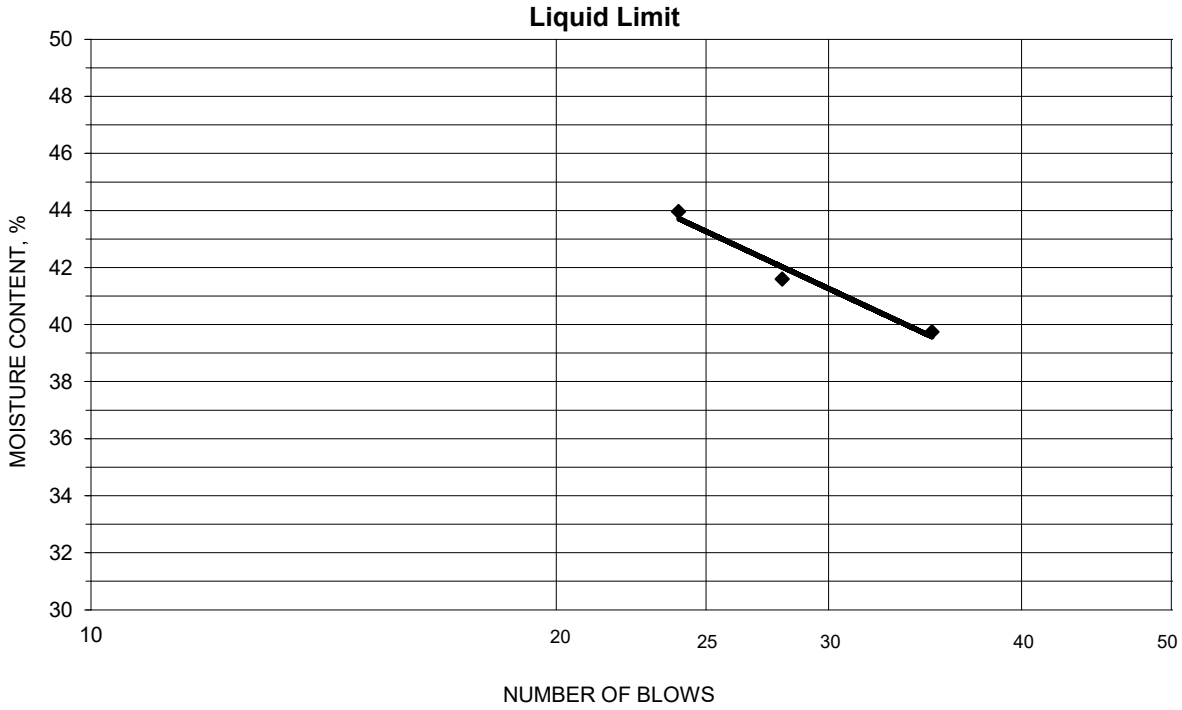
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-003-0-24, 1.5'-3.0', 3.5'-5.0'			Lab ID	236
				% + No. 40	36
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	08-05-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.71	17.76	11.05	24	44.0	
19.93	17.33	11.08	28	41.6	
20.95	18.14	11.07	35	39.7	43



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
22.13	19.91	11.00	24.9	25	18
22.19	20.03	11.07	24.1		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 8.5'-10.0'	Lab ID	239
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 18.5

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
3/8"	9.5	100.0
No. 4	4.75	99.6
No. 10	2	93.0
No. 40	0.425	80.8
No. 200	0.075	66.8
	0.02	45.2
	0.005	32.4
	0.002	25.6
Estimated	0.001	21.2

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	0.4	7.0
Coarse Sand	6.6	12.2
Medium Sand	12.2	---
Fine Sand	14.0	14.0
Silt	34.4	34.4
Clay	32.4	32.4

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	38
Plastic Limit:	22
Plasticity Index:	16
Activity Index:	0.6

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol:	CL
Group Name:	Sandy Lean Clay
ODOT Classification	A-6b (9)
Description:	Silty Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 8.5'-10.0'	Lab ID	239

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	NU
Test Date	07-25-2024
Date Received	07-24-2024

Maximum Particle Size: 3/8" Sieve

Sieve Size	% Passing
3/8"	100.0
No. 4	99.6
No. 10	93.0

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

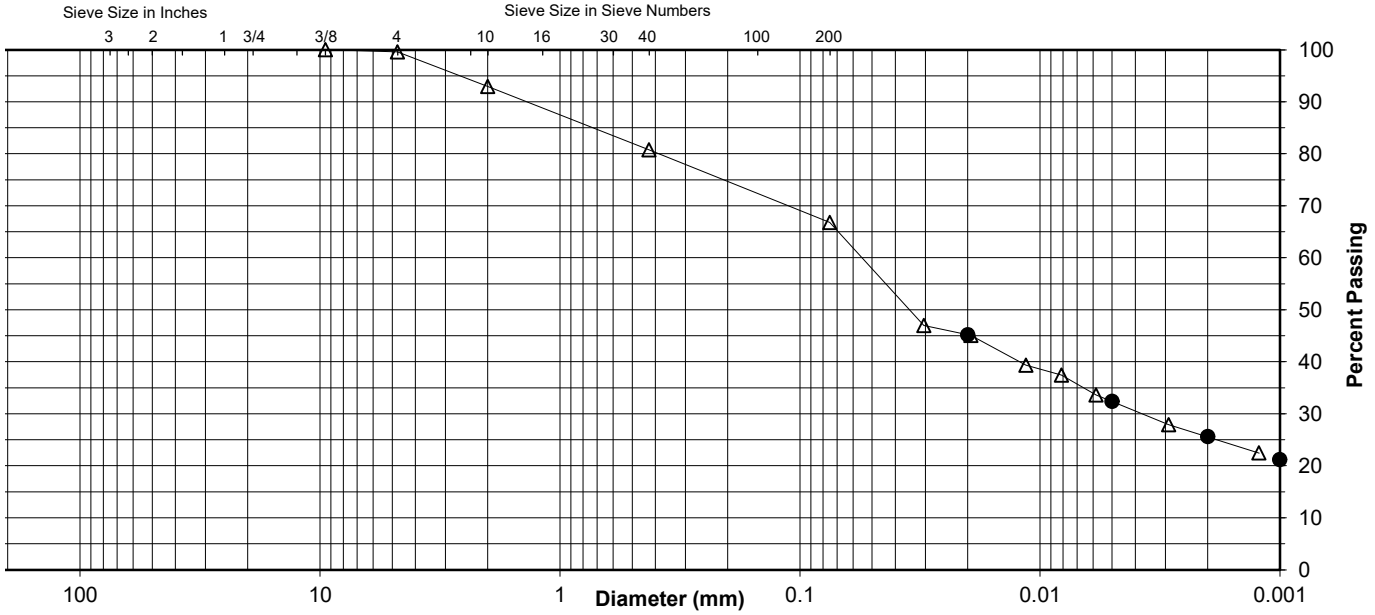
Specific Gravity 2.7

Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	80.8
No. 200	66.8
0.02 mm	45.2
0.005 mm	32.4
0.002 mm	25.6
0.001 mm	21.2

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.4	6.6	12.2	14.0	34.4	32.4
AASHTO	Gravel			Coarse Sand	Fine Sand	Silt	Clay
	7.0			12.2	14.0	41.2	25.6



Comments

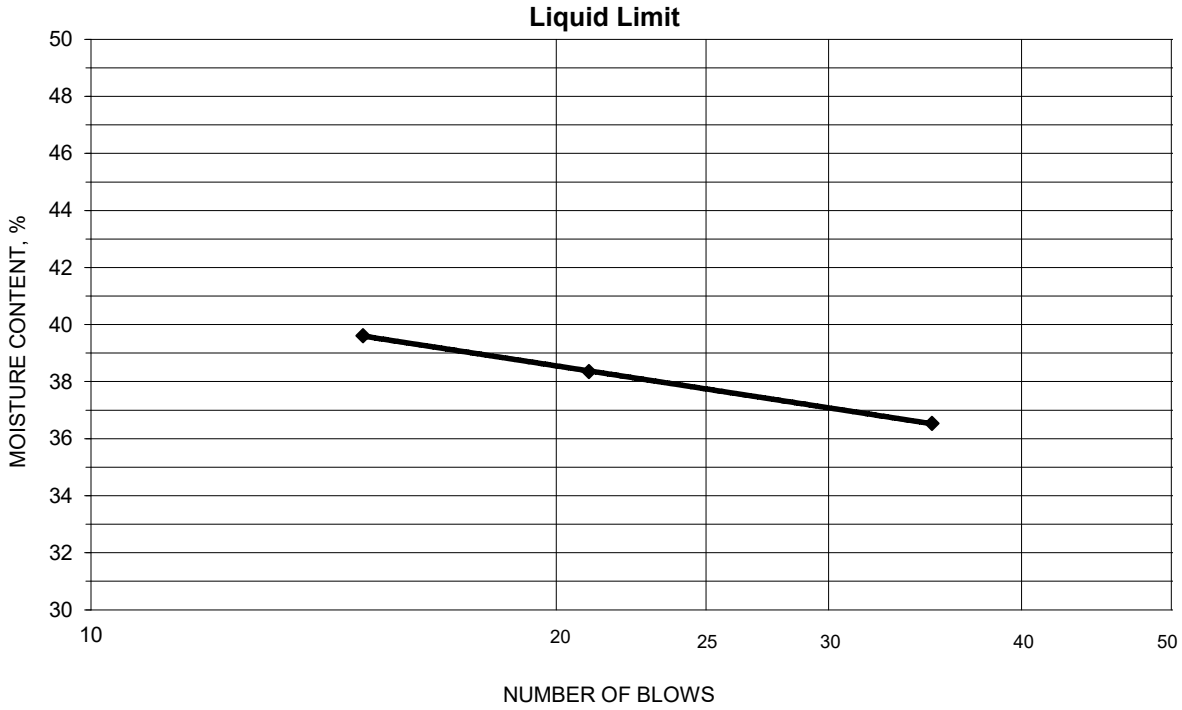
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-003-0-24, 8.5'-10.0'			Lab ID	239
				% + No. 40	19
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	07-26-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.23	17.58	10.89	15	39.6	
19.40	16.98	10.67	21	38.4	
19.40	17.04	10.58	35	36.5	38



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
21.06	19.24	10.92	21.9	22	16
21.63	19.67	10.85	22.2		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 13.5'-15.0'	Lab ID	241
Sample Type	SPT	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 25.9

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	99.5
No. 40	0.425	98.4
No. 200	0.075	95.6
	0.02	88.9
	0.005	55.2
	0.002	42.4
Estimated	0.001	25.6

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	0.0	0.5
Coarse Sand	0.5	1.1
Medium Sand	1.1	---
Fine Sand	2.8	2.8
Silt	40.4	40.4
Clay	55.2	55.2

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	49
Plastic Limit:	27
Plasticity Index:	22
Activity Index:	0.5

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol:	CL
Group Name:	Lean Clay
ODOT Classification	A-7-6 (15)
Description:	Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 13.5'-15.0'	Lab ID	241

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	JP
Test Date	07-25-2024
Date Received	07-24-2024

Maximum Particle Size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	99.5

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

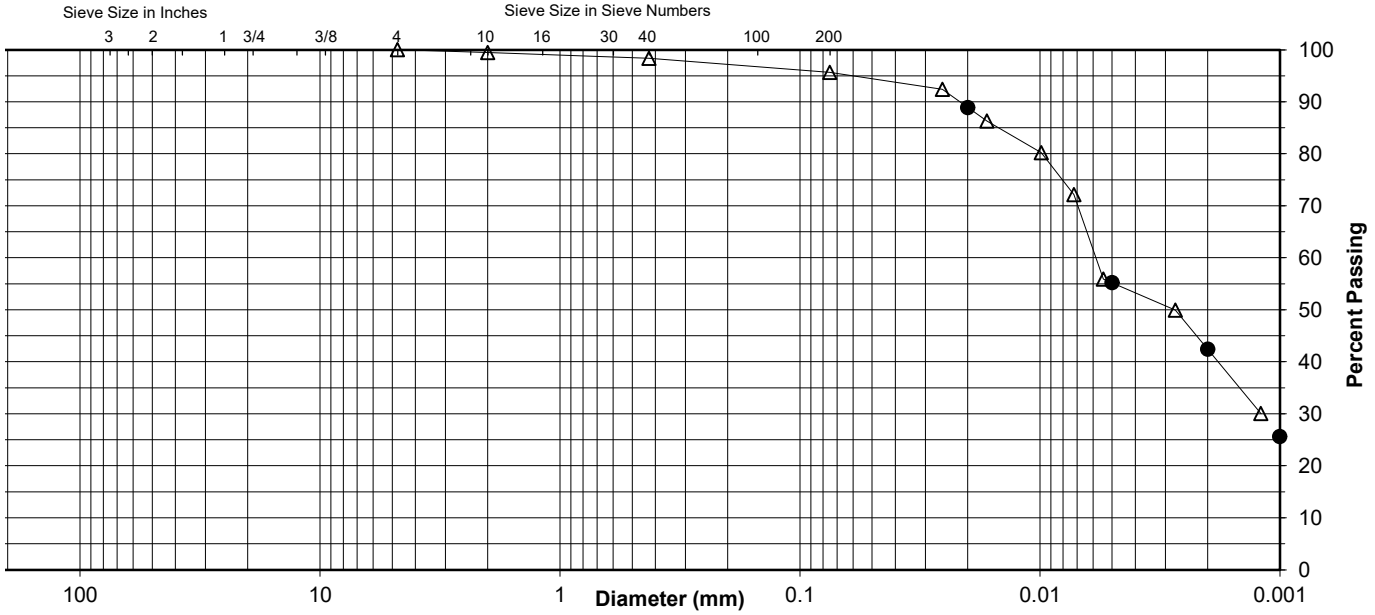
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	98.4
No. 200	95.6
0.02 mm	88.9
0.005 mm	55.2
0.002 mm	42.4
0.001 mm	25.6

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.5	1.1	2.8	40.4	55.2

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.5	1.1	2.8	53.2	42.4



Comments

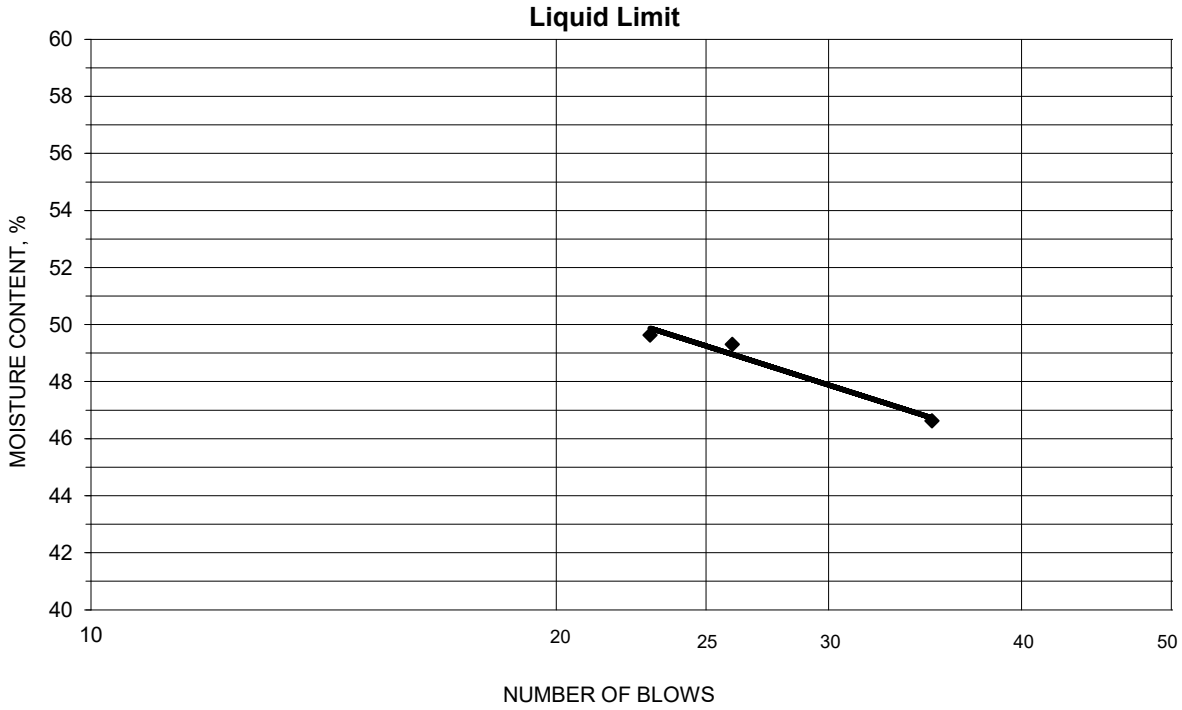
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-003-0-24, 13.5'-15.0'			Lab ID	241
				% + No. 40	2
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	07-26-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.07	16.38	10.96	23	49.6	
18.56	16.09	11.08	26	49.3	
20.47	17.36	10.69	35	46.6	49



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
23.28	20.65	11.00	27.3	27	22
23.06	20.39	10.50	27.0		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-002-0-24, 6.0'-8.0'	Lab ID	252
Sample Type	ST	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 6.9

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	92.2
3/8"	9.5	78.7
No. 4	4.75	70.5
No. 10	2	55.5
No. 40	0.425	54.5
No. 200	0.075	49.8
	0.02	39.6
	0.005	21.6
	0.002	14.5
Estimated	0.001	9.8

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	29.5	44.5
Coarse Sand	15.0	1.0
Medium Sand	1.0	---
Fine Sand	4.7	4.7
Silt	28.2	28.2
Clay	21.6	21.6

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	47
Plastic Limit:	29
Plasticity Index:	18
Activity Index:	1.2

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: GM

Group Name: Silty Gravel with Sand

ODOT Classification A-7-6 (7)

Description: Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-002-0-24, 6.0'-8.0'	Lab ID	252

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	JP
Test Date	08-02-2024
Date Received	07-24-2024

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	92.2
3/8"	78.7
No. 4	70.5
No. 10	55.5

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

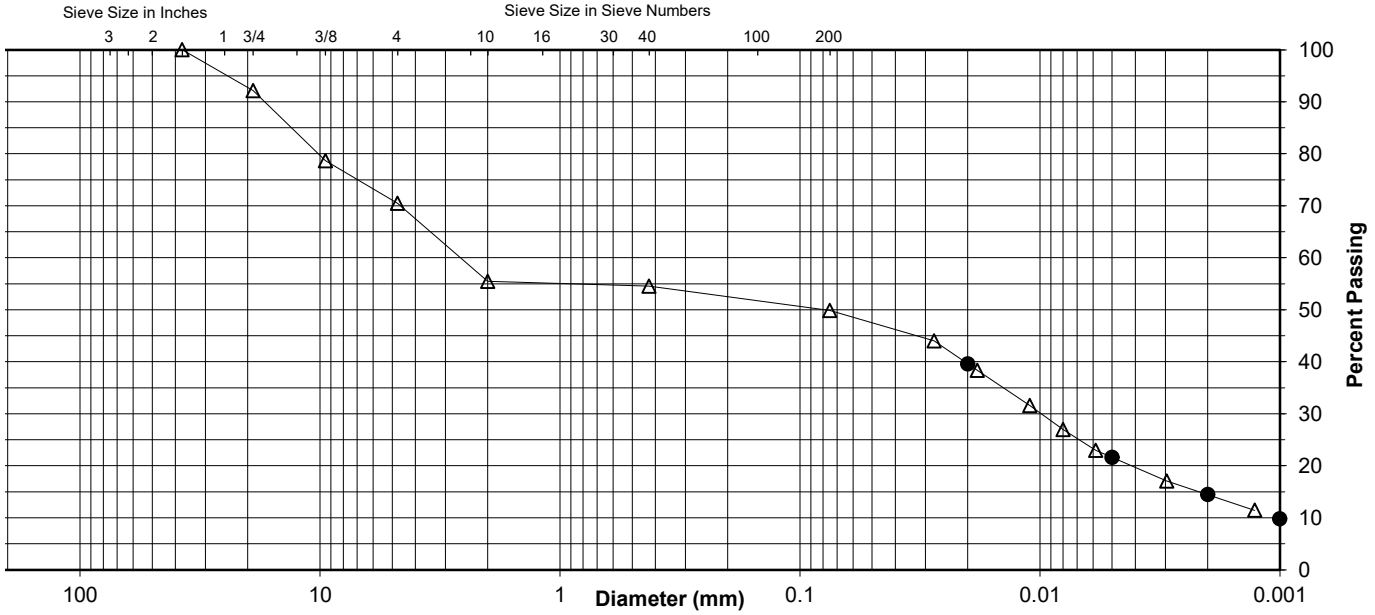
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	54.5
No. 200	49.8
0.02 mm	39.6
0.005 mm	21.6
0.002 mm	14.5
0.001 mm	9.8

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	7.8	21.7	15.0	1.0	4.7	28.2	21.6

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	44.5	1.0	4.7	35.3	14.5



Comments

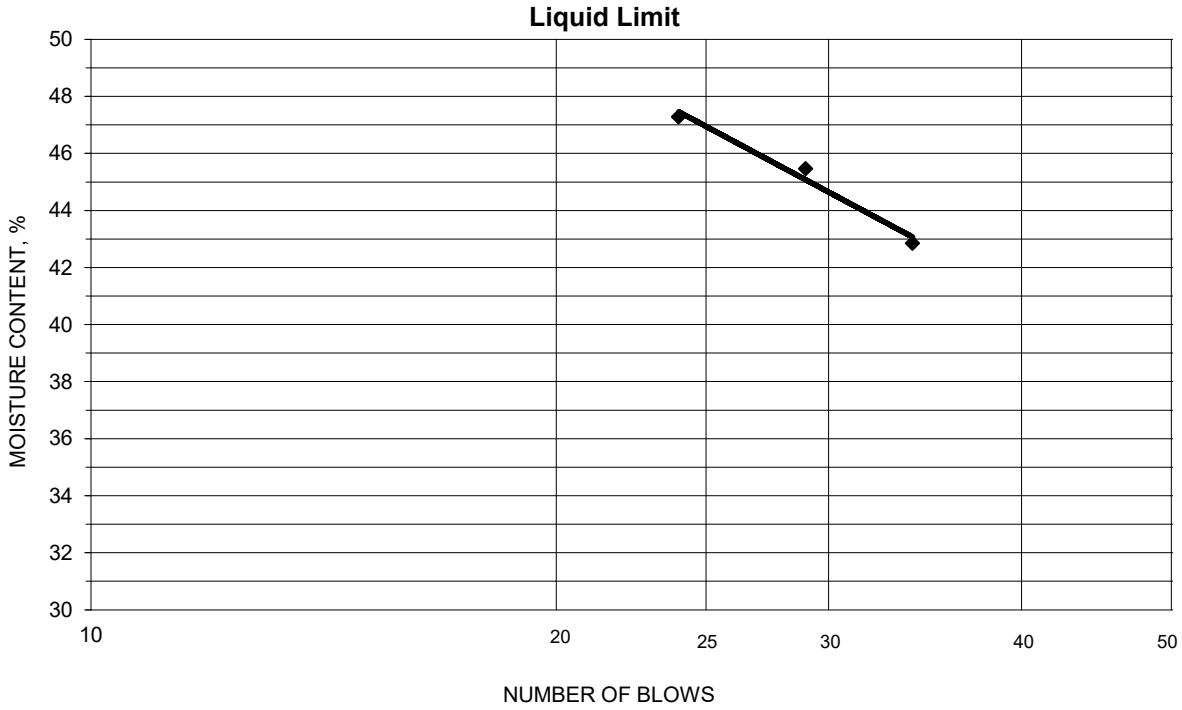
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-002-0-24, 6.0'-8.0'			Lab ID	252
				% + No. 40	45
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	08-05-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.29	17.33	11.07	24	47.3	
19.11	16.60	11.08	29	45.5	
19.74	17.13	11.04	34	42.9	47



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
20.70	18.42	10.56	29.0	29	18
21.79	19.31	10.57	28.4		

Remarks: _____

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 6.0'-8.0'	Lab ID	253
Sample Type	ST	Date Received	7-24-24
		Date Reported	8-5-24

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 26.5

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	97.1
3/8"	9.5	90.1
No. 4	4.75	87.4
No. 10	2	74.0
No. 40	0.425	71.4
No. 200	0.075	63.2
	0.02	55.9
	0.005	41.2
	0.002	32.9
Estimated	0.001	28.5

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	12.6	26.0
Coarse Sand	13.4	2.6
Medium Sand	2.6	---
Fine Sand	8.2	8.2
Silt	22.0	22.0
Clay	41.2	41.2

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit:	48
Plastic Limit:	27
Plasticity Index:	21
Activity Index:	0.6

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3):	N/A
Maximum Dry Density (kg/m^3):	N/A
Optimum Moisture Content (%):	N/A
Over Size Correction %:	N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%):	N/A
Compacted Dry Density (lb/ft^3):	N/A
Compacted Moisture Content (%):	N/A

Specific Gravity

Estimated

Particle Size:	No. 10
Specific Gravity at 20° Celsius:	2.70

Classification

Unified Group Symbol: CL

Group Name: Sandy Lean Clay

ODOT Classification A-7-6 (11)

Description: Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 6.0'-8.0'	Lab ID	253

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	JP
Test Date	08-02-2024
Date Received	07-24-2024

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	97.1
3/8"	90.1
No. 4	87.4
No. 10	74.0

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

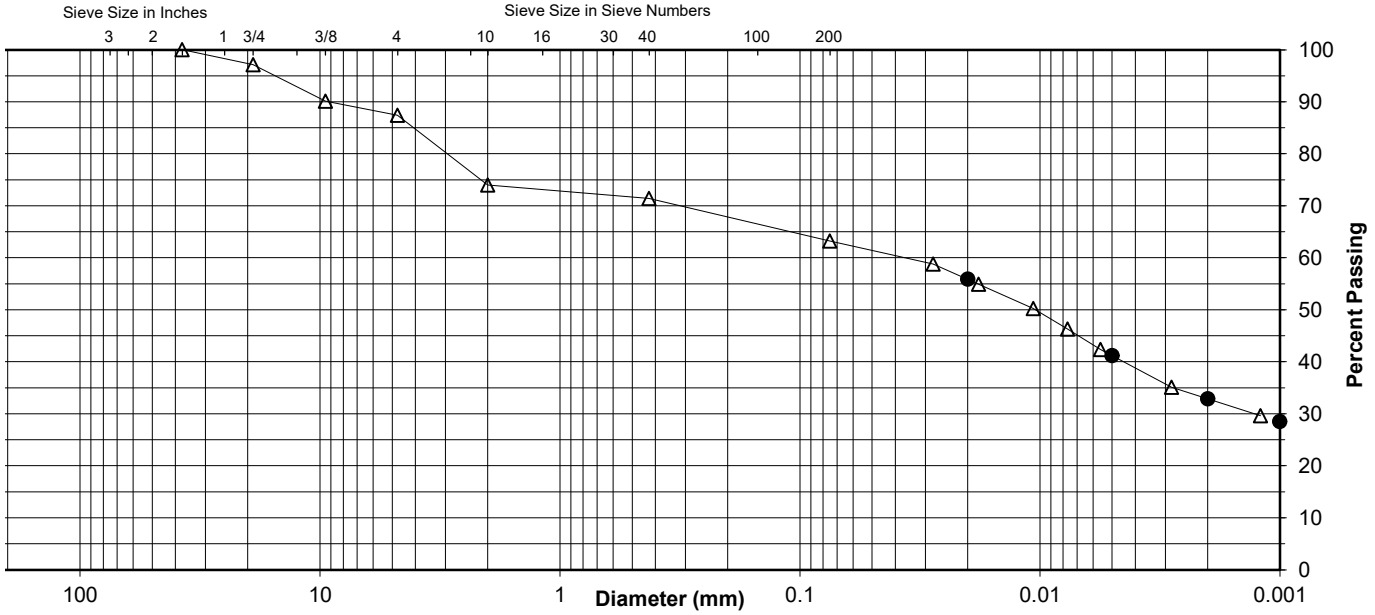
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	71.4
No. 200	63.2
0.02 mm	55.9
0.005 mm	41.2
0.002 mm	32.9
0.001 mm	28.5

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	2.9	9.7	13.4	2.6	8.2	22.0	41.2

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	26.0	2.6	8.2	30.3	32.9



Comments

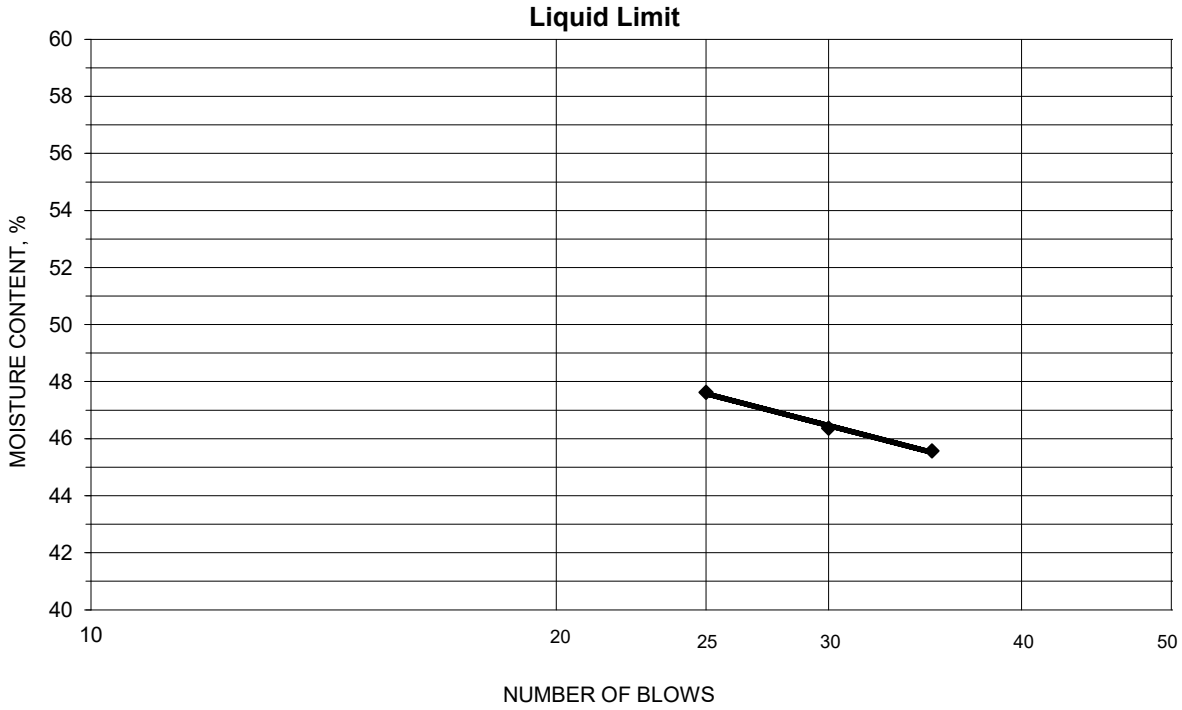
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	MRG-78-10.96 (Landslide Exploration)			Project No.	175578434
Source	B-003-0-24, 6.0'-8.0'			Lab ID	253
				% + No. 40	29
Tested By	NU	Test Method	ASTM D 4318 Method A	Date Received	07-24-2024
Test Date	08-05-2024	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.71	16.91	11.03	25	47.6	
19.99	16.99	10.52	30	46.4	
19.10	16.58	11.05	35	45.6	48



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
22.55	20.12	11.07	26.9	27	21
22.06	19.71	11.05	27.1		

Remarks: _____

Reviewed By REL

Stantec

Unconfined Compressive Strength of Cohesive Soil

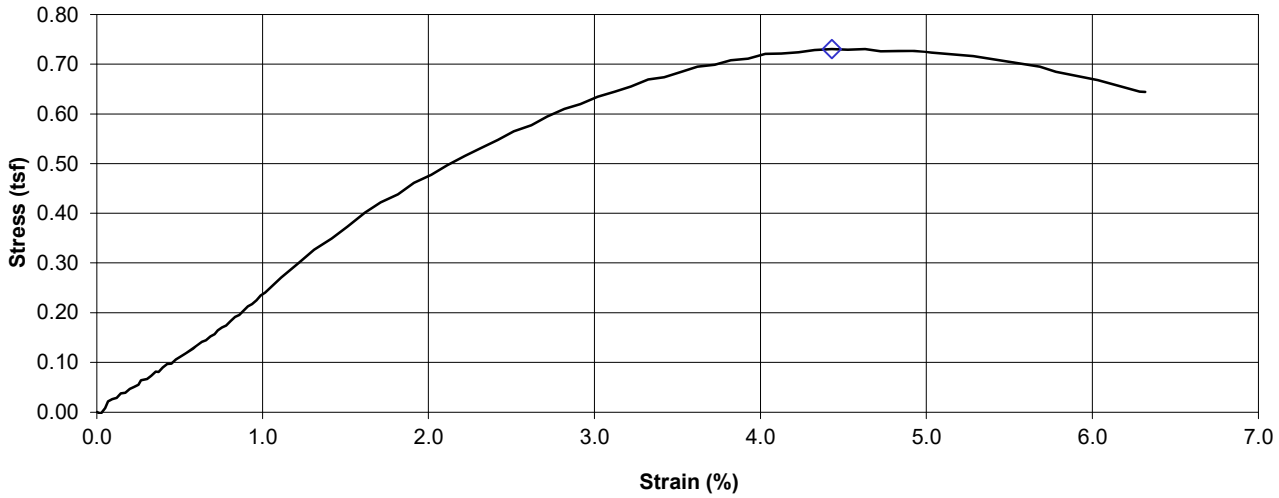
ASTM D 2166

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 6.0'-8.0'	Lab ID	253
Visual Description	Sandy Lean Clay (CL)		
		Recovered	1.4'
		Test Interval	6.8' - 7.4'

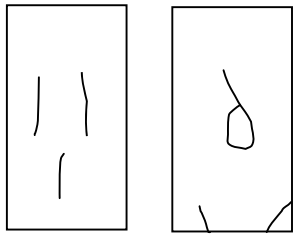
Specimen Type:	Undisturbed	LL	N/A	PL	N/A
				PI	N/A

Initial Wet Density (pcf)	126.7	Date Extruded	08/01/2024
Initial Moisture Content (%)	26.5	Date Tested	08/01/2024
Initial Dry Density (pcf)	100.1	Initial MC Taken	Before Test, From Trimmings
At Test Moisture Content (%)	26.5	At Test MC Taken	Before Test, From Trimmings
At Test Dry Density (pcf)	100.1		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	0.73
Average Height (in)	5.480	Undrained Shear Strength (tsf)	0.37
Average Diameter (in)	2.869	Strain at Maximum Stress (%)	4.4
Height to Diameter Ratio	1.9	Strain Rate to Failure (% / min.)	1.00

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf) N/A

Torvane Reading (kg/cm^2) N/A

Comments

Reviewed By REL

Template: tmp_uc_input.xlsm
Version: 20170217
Approved By: RJ

Stantec Consulting Services Inc.
Cincinnati, Ohio

Reported By: REL
Report Date: 08/06/2024

Stantec

Unconfined Compressive Strength of Cohesive Soil

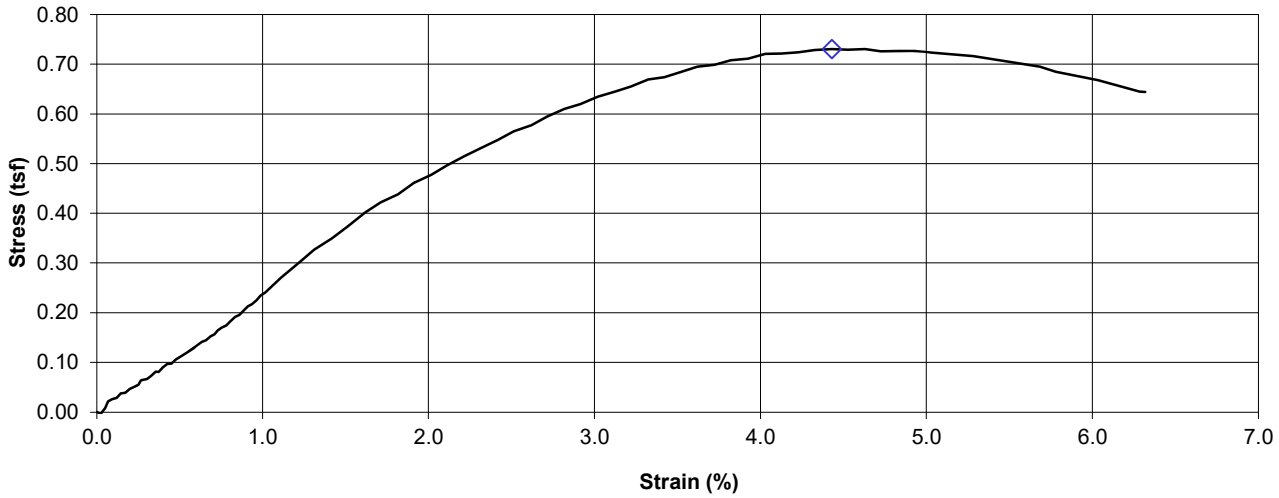
ASTM D 2166

Project Name	MRG-78-10.96 (Landslide Exploration)	Project Number	175578434
Source	B-003-0-24, 6.0'-8.0'	Lab ID	253
Visual Description	Sandy Lean Clay (CL)		
		Recovered	1.4'
		Test Interval	6.8' - 7.4'

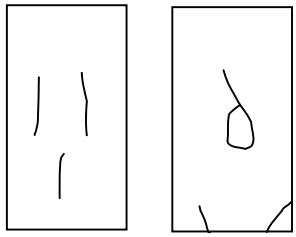
Specimen Type:	Undisturbed	LL	N/A	PL	N/A
				PI	N/A

Initial Wet Density (pcf)	126.7	Date Extruded	08/01/2024
Initial Moisture Content (%)	26.5	Date Tested	08/01/2024
Initial Dry Density (pcf)	100.1	Initial MC Taken	Before Test, From Trimmings
At Test Moisture Content (%)	26.5	At Test MC Taken	Before Test, From Trimmings
At Test Dry Density (pcf)	100.1		
Specific Gravity	N/A		
Degree of Saturation (%)	N/A	Unconfined Compressive Strength (tsf)	0.73
Average Height (in)	5.480	Undrained Shear Strength (tsf)	0.37
Average Diameter (in)	2.869	Strain at Maximum Stress (%)	4.4
Height to Diameter Ratio	1.9	Strain Rate to Failure (% / min.)	1.00

Stress vs. Strain



Failure Sketch



Pocket Penetrometer Reading (tsf) N/A

Torvane Reading (kg/cm^2) N/A

Comments

Reviewed By REL

Template: tmp_uc_input.xlsm
Version: 20170217
Approved By: RJ

Stantec Consulting Services Inc.
Cincinnati, Ohio

Reported By: REL
Report Date: 08/06/2024

Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

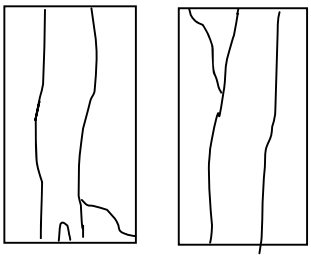
Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Shale, light grey, medium strong	Lab ID	UCR-254
Hole Number	B-001-0-24	Depth (ft) 26.5'-26.9'	Date Received 07/24/2024
Temperature (°C)	23.8	Moisture Condition	As Prepared, Moist
			Date Tested 08/02/2024

Side Planeness	N/A	Height (in)	4.466	Wet Unit Weight (pcf)	160.9
Perpendicularity	N/A	Diameter (in)	1.986	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.098	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	83
Peak Load (lbf)	27130
Failure Type	Cone and Split
Compressive Strength (psi)	8760
Compressive Strength (psf)	1261440
Compressive Strength (tsf)	631

Failure Sketches



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

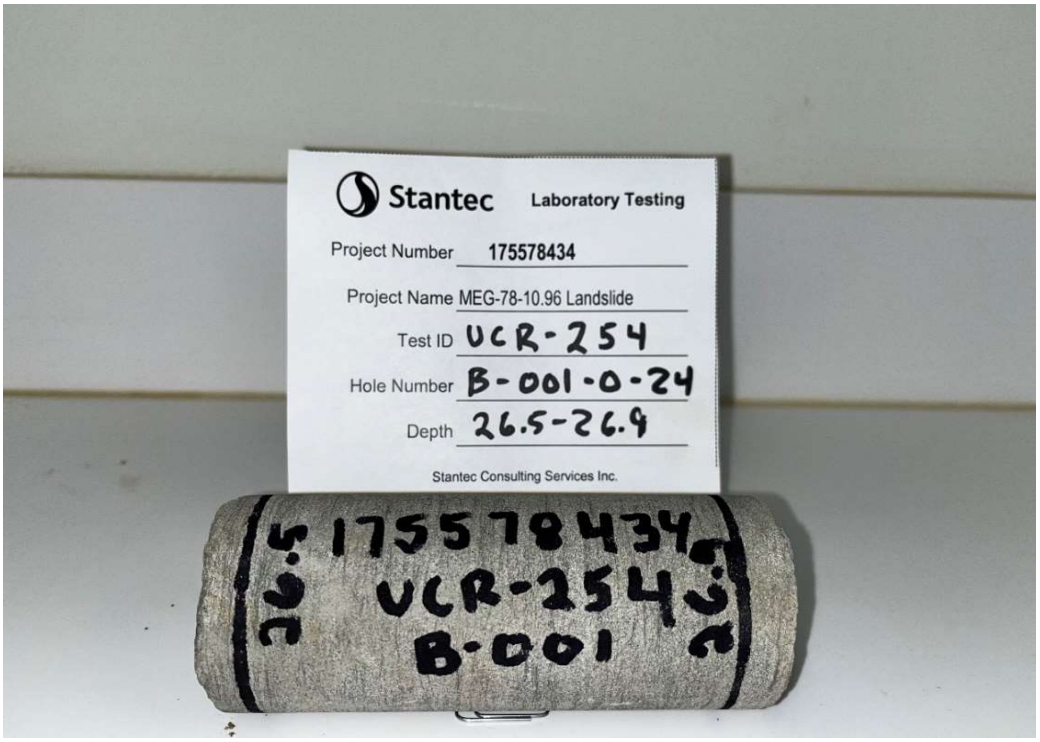
Reviewed By REL

Stantec

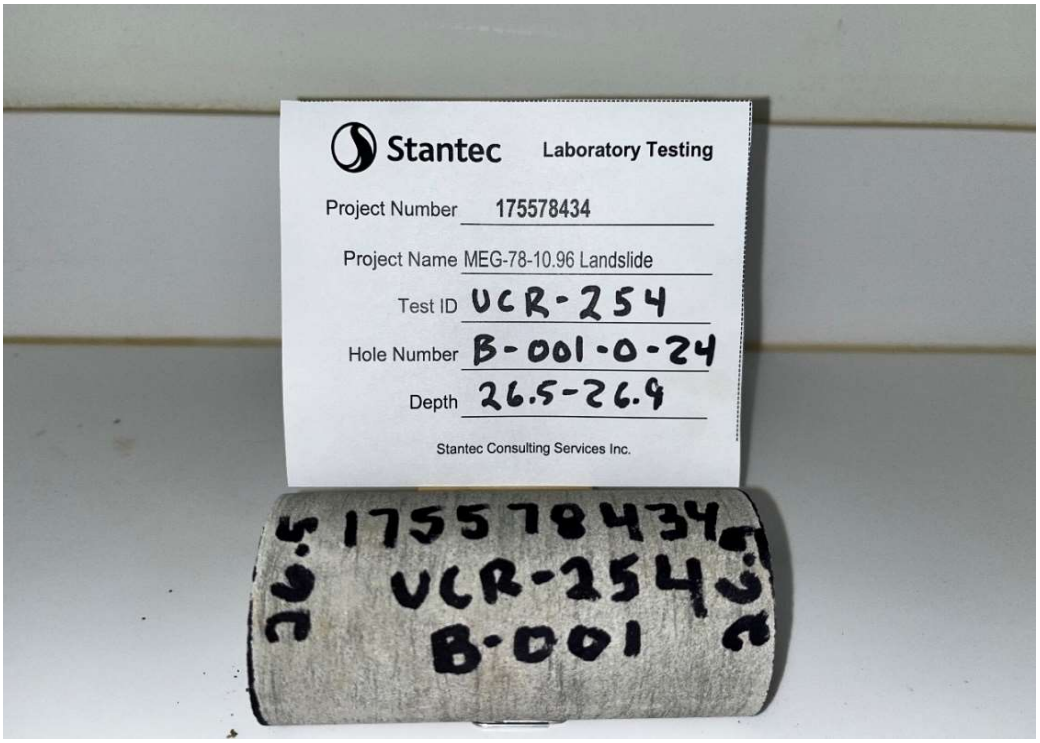
Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Shale, light grey, medium strong | Lab ID UCR-254
Hole Number B-001-0-24 | Depth (ft) 26.5'-26.9'
Test Type Uniaxial Compressive Strength of Intact Rock Core

As Received



Core Preparation



Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Shale, light grey, medium strong | Lab ID UCR-254
Hole Number B-001-0-24 | Depth (ft) 26.5'-26.9'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Core Preparation

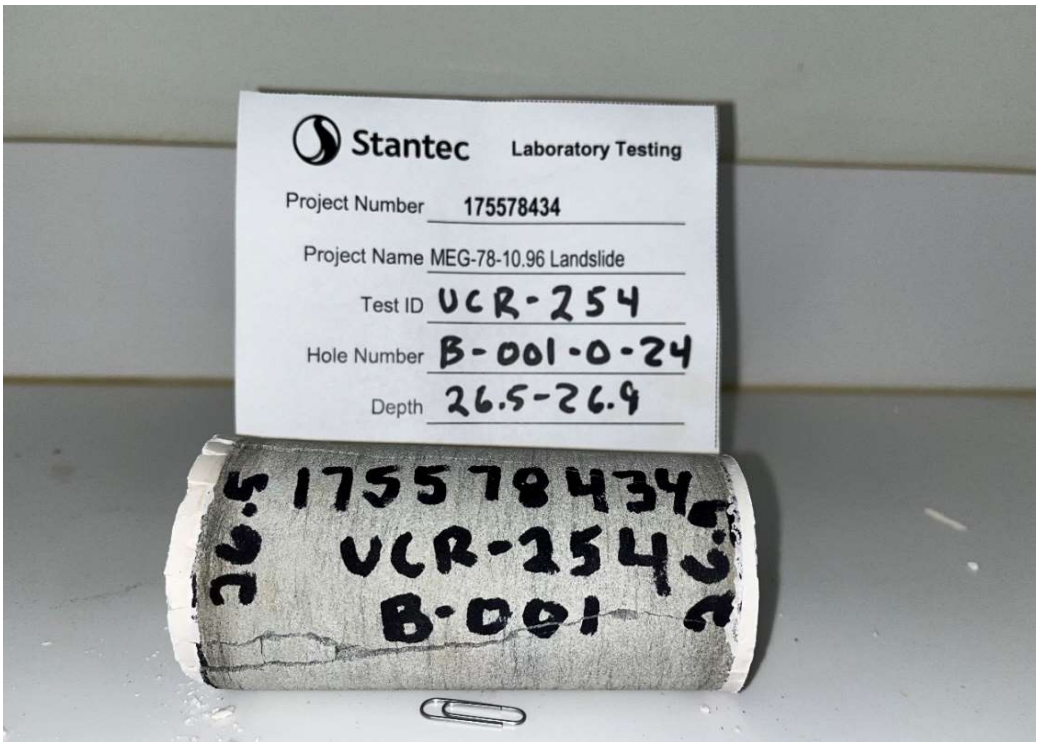
Post Test

Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Shale, light grey, medium strong | Lab ID UCR-254
Hole Number B-001-0-24 | Depth (ft) 26.5'-26.9'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Post Test



Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

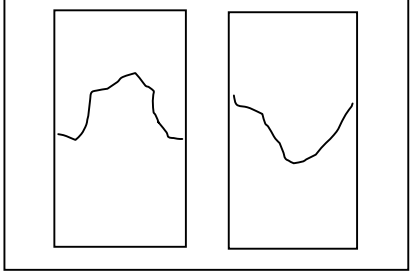
Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Shale/Claystone, dark grey, soft	Lab ID	UCR-255
Hole Number	B-002-0-24	Depth (ft) 20.6'-21.0'	Date Received 07/24/2024
Temperature (°C)	24.8	Moisture Condition	As Prepared, Moist
			Date Tested 08/02/2024

Side Planeness	N/A	Height (in)	4.746	Wet Unit Weight (pcf)	149.7
Perpendicularity	N/A	Diameter (in)	1.972	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.053	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	1
Peak Load (lbf)	195
Failure Type	Undetermined
Compressive Strength (psi)	64
Compressive Strength (psf)	9216
Compressive Strength (tsf)	5

Failure Sketches



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

Reviewed By REL

Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Shale/Claystone, dark grey, soft | Lab ID UCR-255
Hole Number B-002-0-24 | Depth (ft) 20.6'-21.0'
Test Type Uniaxial Compressive Strength of Intact Rock Core

As Received

Core Preparation

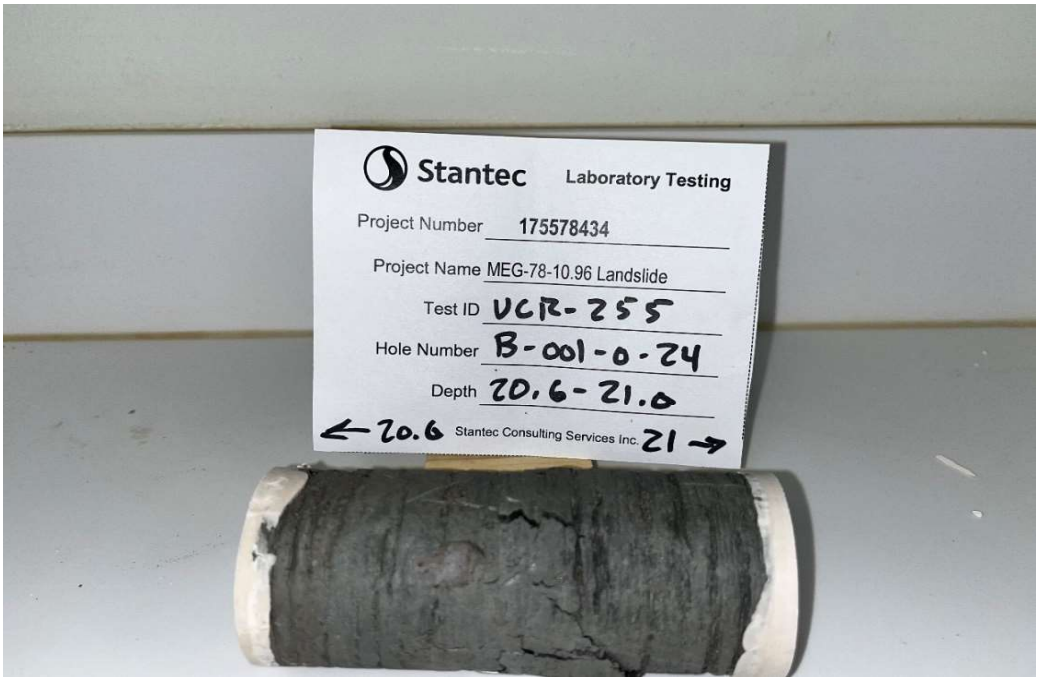
Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Shale/Claystone, dark grey, soft | Lab ID UCR-255
Hole Number B-002-0-24 | Depth (ft) 20.6'-21.0'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Core Preparation

Post Test



Stantec

Photo Report

Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Shale/Claystone, dark grey, soft	Lab ID	UCR-255
Hole Number	B-002-0-24	Depth (ft)	20.6'-21.0'
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Post Test

Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

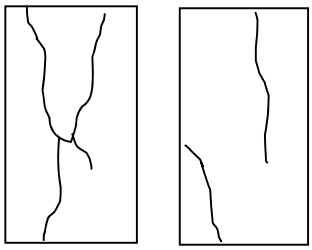
Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Claystone, dark brown, soft	Lab ID	UCR-256
Hole Number	B-002-0-24	Depth (ft) 29.0'-29.4'	Date Received 07/24/2024
Temperature (°C)	24.4	Moisture Condition	As Prepared, Moist
			Date Tested 08/02/2024

Side Planeness	N/A	Height (in)	4.621	Wet Unit Weight (pcf)	141.4
Perpendicularity	N/A	Diameter (in)	1.988	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.103	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	4
Peak Load (lbf)	503
Failure Type	Cone and Split
Compressive Strength (psi)	162
Compressive Strength (psf)	23328
Compressive Strength (tsf)	12

Failure Sketches



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

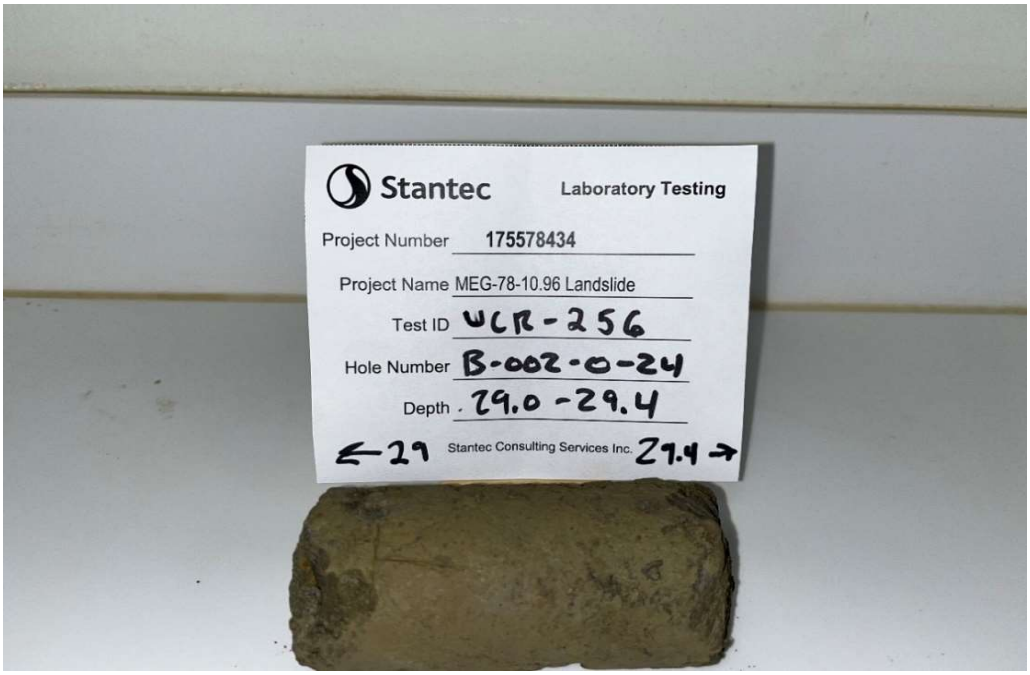
Reviewed By REL

Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Claystone, dark brown, soft | Lab ID UCR-256
Hole Number B-002-0-24 | Depth (ft) 29.0'-29.4'
Test Type Uniaxial Compressive Strength of Intact Rock Core

As Received



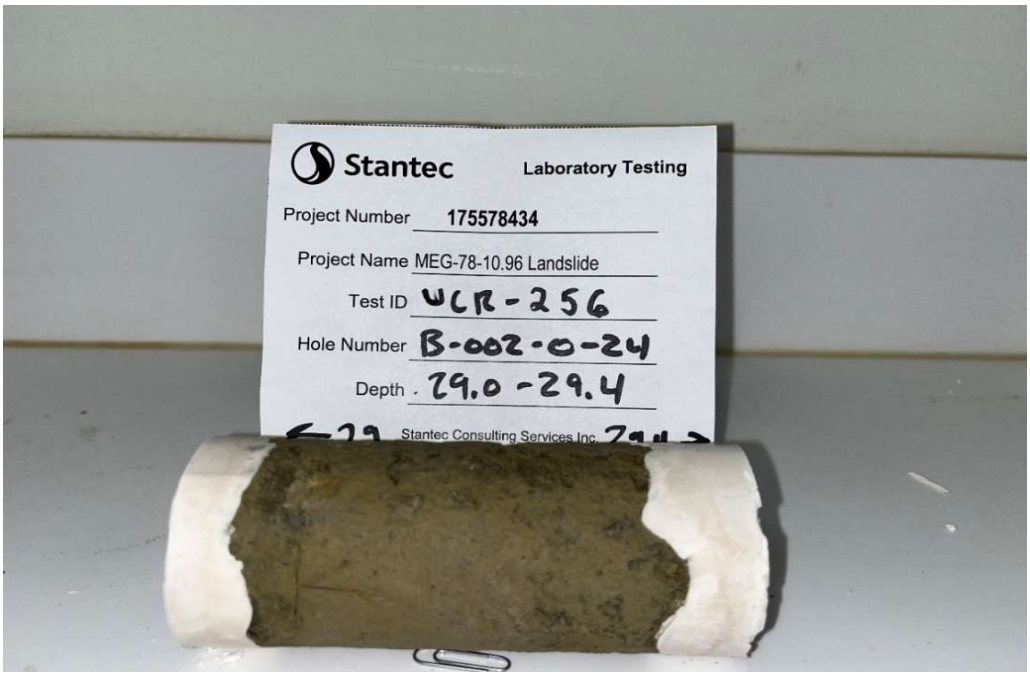
Core Preparation

Stantec

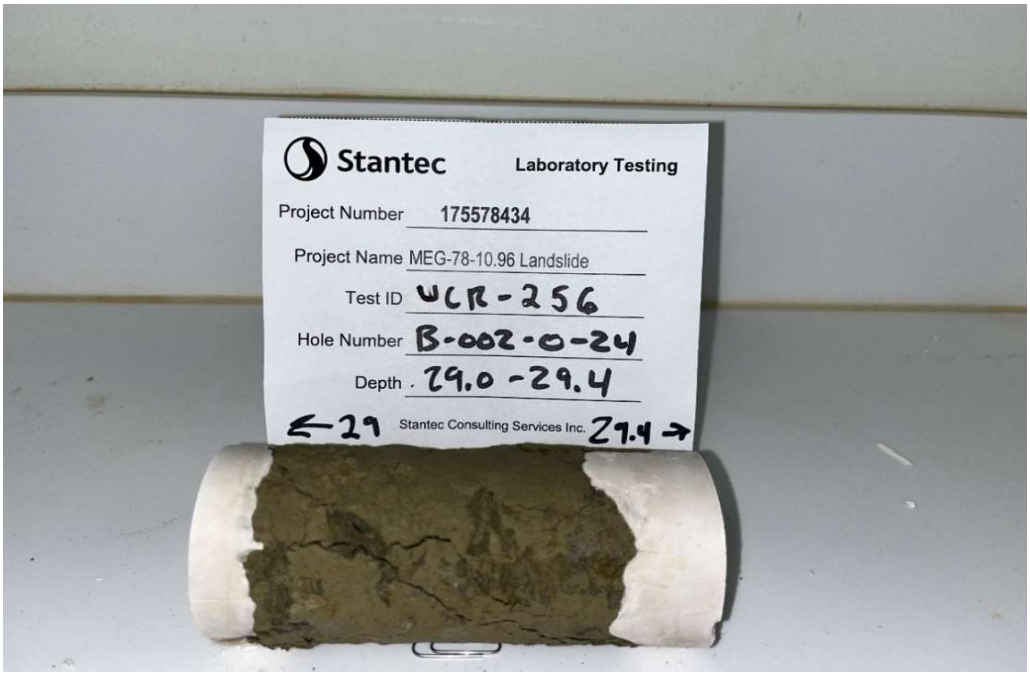
Photo Report

Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Claystone, dark brown, soft	Lab ID	UCR-256
Hole Number	B-002-0-24	Depth (ft)	29.0'-29.4'
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Core Preparation



Post Test

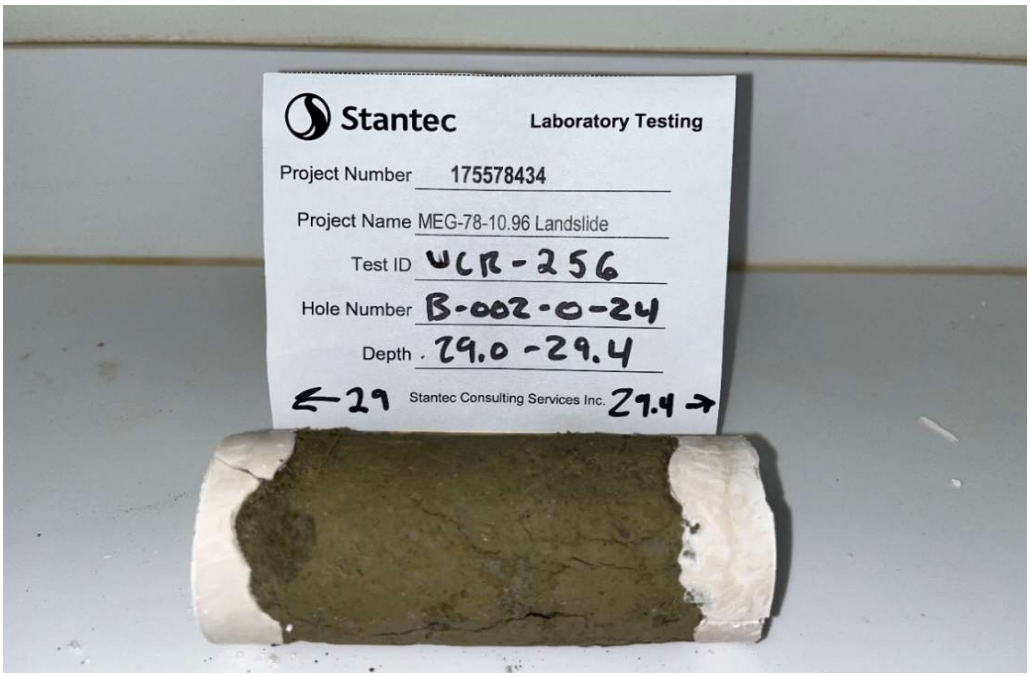


Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Claystone, dark brown, soft | Lab ID UCR-256
Hole Number B-002-0-24 | Depth (ft) 29.0'-29.4'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Post Test



Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

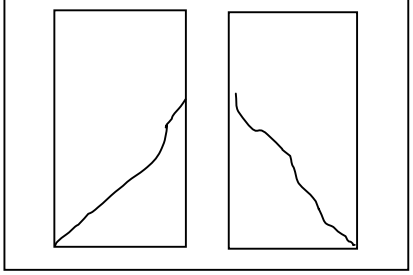
Project Name	MRG-78-10.96	Project Number	175578434
Lithology	Claystone, dark brown, soft	Lab ID	UCR-257
Hole Number	B-002-0-24	Depth (ft) 35.1'-35.5'	Date Received 07/24/2024
Temperature (°C)	24.4	Moisture Condition	As Prepared, Moist
			Date Tested 08/02/2024

Side Planeness	N/A	Height (in)	4.838	Wet Unit Weight (pcf)	141.6
Perpendicularity	N/A	Diameter (in)	2.025	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.222	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	1
Peak Load (lbf)	150
Failure Type	Shear
Compressive Strength (psi)	47
Compressive Strength (psf)	6768
Compressive Strength (tsf)	3

Failure Sketches



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

Reviewed By REL

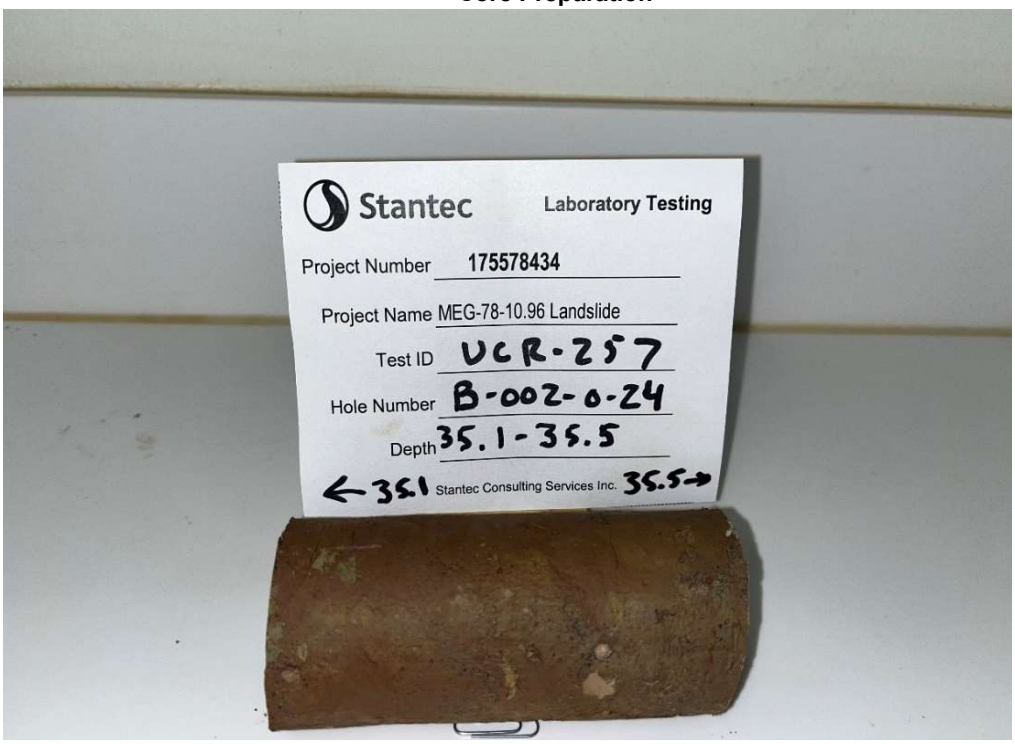
Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Claystone, dark brown, soft | Lab ID UCR-257
Hole Number B-002-0-24 | Depth (ft) 35.1'-35.5'
Test Type Uniaxial Compressive Strength of Intact Rock Core

As Received

Core Preparation

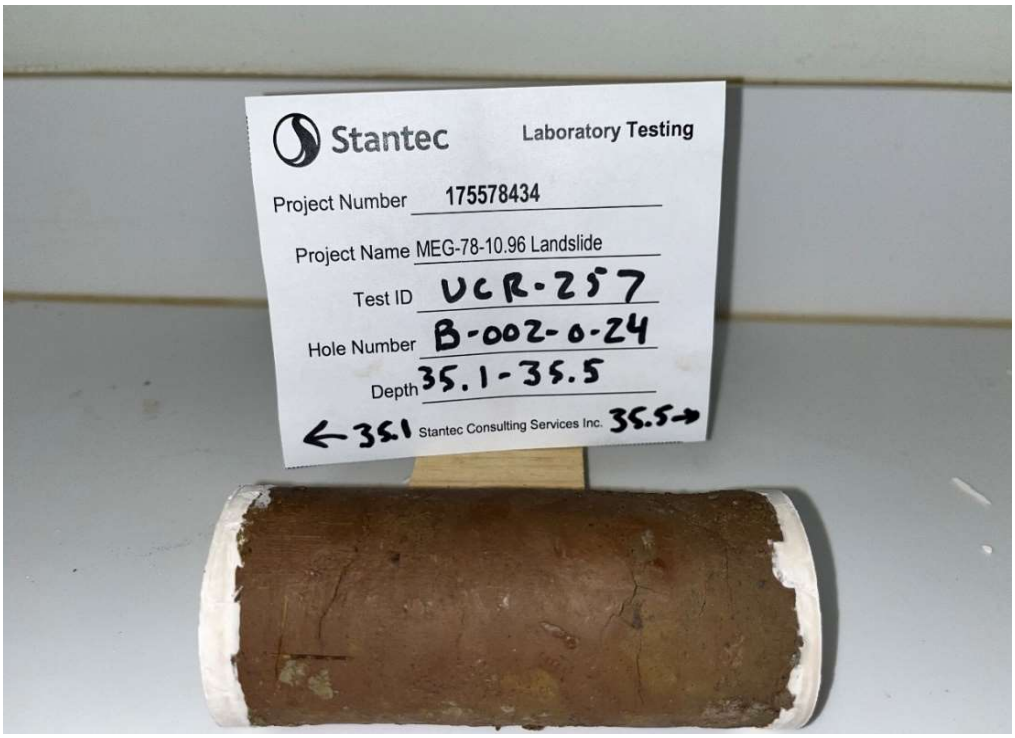


Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Claystone, dark brown, soft | Lab ID UCR-257
Hole Number B-002-0-24 | Depth (ft) 35.1'-35.5'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Core Preparation



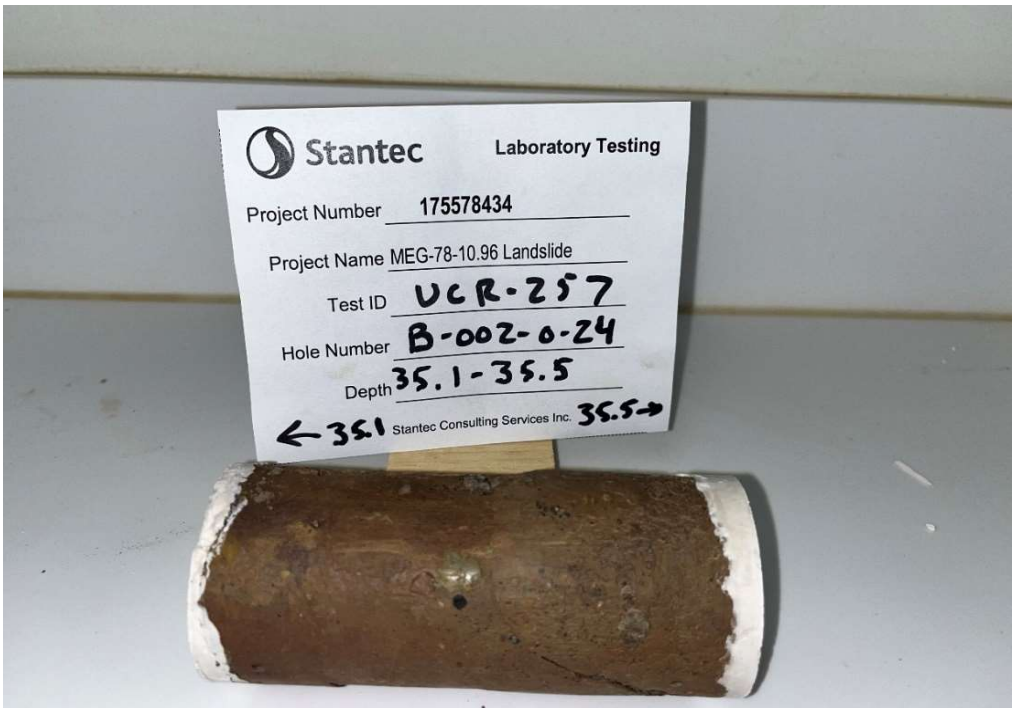
Post Test

Stantec

Photo Report

Project Name MRG-78-10.96 | Project Number 175578434
Lithology Claystone, dark brown, soft | Lab ID UCR-257
Hole Number B-002-0-24 | Depth (ft) 35.1'-35.5'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Post Test



APPENDIX B
SLOPE STABILITY ANALYSIS

MRG-78-10.96 landslide Exploration

Estimation of Soil and Rock Fill Parameters

Using B-002-0-24 and B-002-1-24 as the cross section was taken along them and are located in the middle of the slide with lower blow counts.

Layer	Boring	N_{60}
Fine-Grained Soil	B-001-0-24	11
	B-002-1-24	9
		18
	B-003-0-24	9
		11
		12
		12
		17
		17
Average N_{60}		**12.9**

Taking N_{60} = 12 for clay layer

Estimation of Soil Properties based on Table 400-4 and Section 404.1 (ODOT GDM)

Layer	N_{60}	ϒ (pcf)	c'	Φ'
Fine-Grained Soil	12.0	120	150	20

(c' and Φ' values are estimated based on field conditions and engineering judgement)

Selection of 2 feet thick soft zone

Based on ODOT GDM Section 704.5

Layer	ϒ (pcf)	c'	Φ'
Soft Zone	118	0	15.2

(ϒ is taken less than the fine-grained layer for the soft zone)

Selection of Rock Parameters for LPile Analysis

Rock Parameters basaed on lab testing

Unconfined Compressive Strength and Unit Weight of Bedrock

Boring	Depth	UC (psi)	Rock type	Avergae UC (psi)	Wet Unit Wt (pcf)
B-001-0-24	26.5' to 26.9'	8760	Shale	8760	160.9
B-002-0-24	20.6' to 21.0'	64	Claystone	91	149.7
B-002-0-24	29.0' to 29.4'	162			141.4
B-002-0-24	35.1' to 35.5'	47			141.6
Average				**91**	**144**

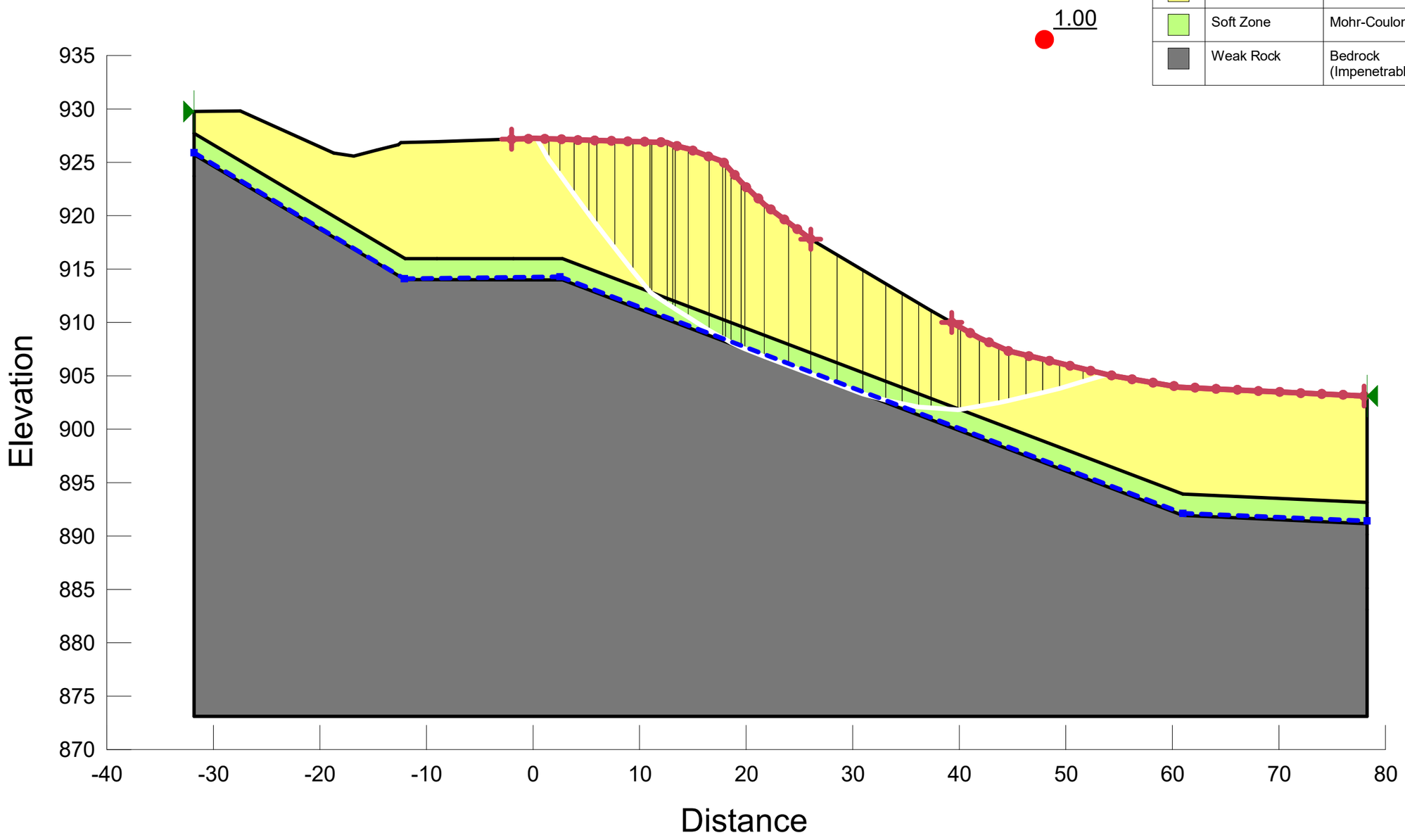
(Note: Taking average UC and Unit weight of of claystones from B-002-0-24 to be conseravtive)

RQD

Boring	Depth	Coring Length (in)	RQD length (in)	RQD (%)
B-001-0-24	18.5' to 23.5'	60	9.6	16.00
	23.5' to 28.5'	60	20.4	34.00
B-002-0-24	16.5' to 21.5'	60	24	40.00
	21.5' to 26.5'	60	10.8	18.00
	26.5' to 31.5'	60	31.2	52.00
	31.5' to 36.5'	60	38.4	64.00
B-003-0-24	40.0' to 42.0'	24	13.2	55.00
		384	**147.6**	**38.44**

(taking 38% RQD to be conservative)

MRG-78-10.96	**Slope Stability Analysis - FS = 1.00**	Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.
ODOT District 10		
Back Analysis	Slope Stability	



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Fine-Grained Soil	Mohr-Coulomb	120	150	20
	Soft Zone	Mohr-Coulomb	118	0	15.1
	Weak Rock	Bedrock (Impenetrable)			

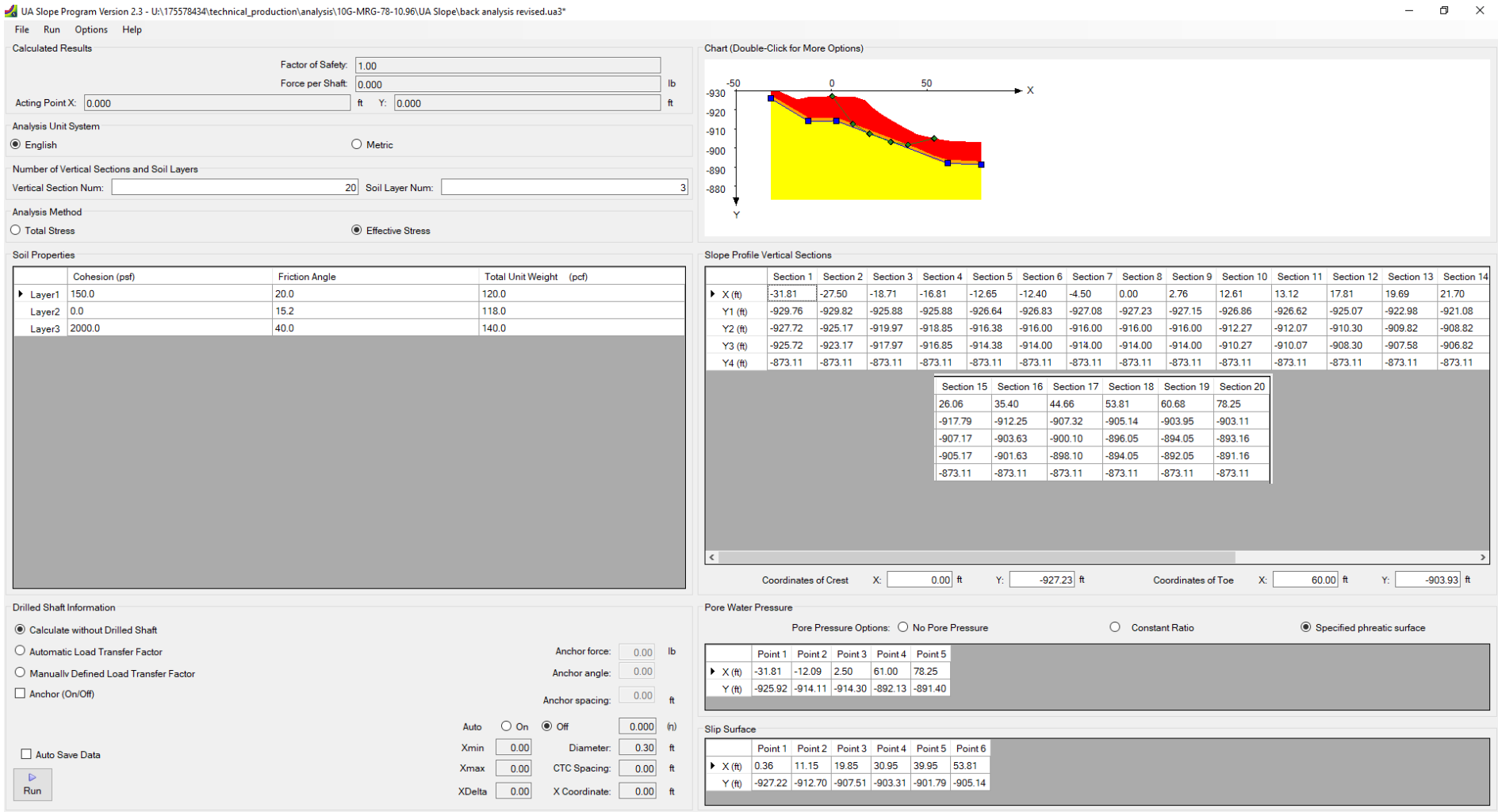
Project No. 175578434

Performed By: G. Khatri 08/06/2024
Checked By: J. Swindler 08/07/2024

APPENDIX C
UA SLOPE ANALYSIS

MRG-78-10.96

UA Slope: Back Analysis



Performed By: G. Khatri 08/06/2024
Checked By: J. Swindler 08/07/2024

MRG-78-10.96

UA Slope: Force Per Shaft

UA Slope Program Version 2.3 - U:\175578434\technical_production\analysis\10G-MRG-78-10.96\UA Slope\back analysis revised with shaft.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 3.45

Force per Shaft: 77608.035 lb

Acting Point X: 23.000 ft Y: -913.097 ft

Analysis Unit System

(•) English ( ) Metric

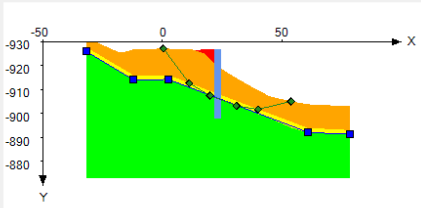
Number of Vertical Sections and Soil Layers

Vertical Section Num: 22 Soil Layer Num: 4

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	250.0	28.0	125.0
Layer2	150.0	20.0	120.0
Layer3	0.0	15.2	118.0
Layer4	2000.0	40.0	140.0

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14
X (ft)	-31.81	-27.50	-18.71	-16.81	-12.65	-12.40	-4.50	0.00	2.76	12.61	13.12	17.81	19.69	21.70
Y1 (ft)	-929.76	-929.82	-925.88	-925.58	-926.64	-926.83	-927.08	-927.23	-927.15	-926.86	-926.62	-926.86	-926.86	-926.86
Y2 (ft)	-929.77	-929.82	-925.88	-925.58	-926.64	-926.83	-927.08	-927.23	-927.15	-926.86	-926.62	-925.07	-922.98	-921.08
Y3 (ft)	-927.72	-925.17	-919.97	-918.85	-916.38	-916.00	-916.00	-916.00	-916.00	-912.27	-912.07	-910.30	-909.58	-908.82
Y4 (ft)	-925.72	-923.17	-917.97	-916.85	-914.38	-914.00	-914.00	-914.00	-914.00	-910.27	-910.07	-908.30	-907.58	-906.82
Y5 (ft)	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11

Section 15	Section 16	Section 17	Section 18	Section 19	Section 20	Section 21	Section 22
23.00	23.00	26.06	35.40	44.66	53.81	60.68	78.25
-926.86	-920.10	-917.79	-912.25	-907.32	-905.14	-903.95	-903.11
-920.10	-920.10	-917.79	-912.25	-907.32	-905.14	-903.95	-903.11
-908.33	-908.33	-907.17	-903.63	-900.10	-896.65	-894.05	-893.16
-906.33	-906.33	-905.17	-901.63	-898.10	-894.15	-892.05	-891.16
-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11	-873.11

Coordinates of Crest X: 0.00 ft Y: -927.23 ft Coordinates of Toe X: 60.00 ft Y: -903.93 ft

Drilled Shaft Information

( ) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

(•) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto ( ) On (•) Off 0.000 (n)

Xmin 0.00 Diameter: 3.00 ft

Xmax 0.00 CTC Spacing: 5.75 ft

XDelta 0.00 X Coordinate: 23.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

Pore Pressure Options: ( ) No Pore Pressure ( ) Constant Ratio (•) Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	-31.81	-12.09	2.50	61.00	78.25
Y (ft)	-925.92	-914.11	-914.30	-892.13	-891.40

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
X (ft)	0.36	11.15	19.85	30.95	39.95	53.81
Y (ft)	-927.22	-912.70	-907.51	-903.31	-901.79	-905.14

Performed By: G. Khatri 08/06/2024

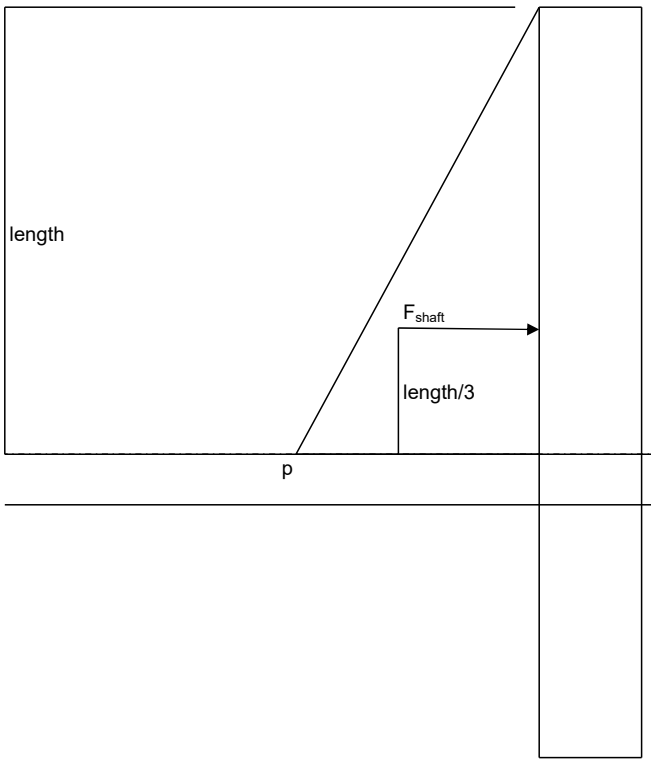
Checked By: J. Swindler 08/07/2024

APPENDIX D
LPILE ANALYSIS

SUMMARY OF DRILLED SHAFT CALCULATIONS

LOADING CONDITIONS

Loading conditions were evaluated using shaft loads determined from the UA SLOPE (Version 2.3) computer program. This shaft load, combined with an assumed traffic surcharge live load, was applied to the drilled shaft above the assumed failure surface. The drilled shaft was evaluated using LPILEv2022 which is a program for the analysis of piles and drilled shafts under lateral loads. Unfactored loads (Service I Limit State) were utilized to estimate shaft head deflection and factored loads (Strength I Limit State) were used to evaluate geotechnical resistance.



Projected Ground line Depth = 0.00

Note:
x_2 represents the maximum value of the triangular distributed load that will be used in LPILE determined from F_{shaft} from the University of Akron program.

Assumed Failure Surface Depth = 20.55

Top of Rock Depth = 20.55

Bottom of Drilled Shaft Depth = 30.55

Estimated Depth to Bedrock =	20.55	feet	UA Slope Input
Estimated Depth to Failure Surface=	20.55	feet	UA Slope Input
Shaft Size =	3	feet	UA Slope Input
Center to Center Spacing =	5.75	feet	UA Slope Input
F_{shaft} =	77,608	pounds	UA Slope Output
Factor of Safety =	3.45		UA Slope Output
p = (2*Fshaft)/H * (1 ft/12 in)	629	pounds per inch	

Performed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

DISTRIBUTED LOAD FOR LPILE INPUT

F_{live} = assumed traffic surcharge load =	250	psf
Phi =	20.0	degrees
K_a =	0.490	
x1 = F_{live} * s * Ka * (1 ft/12 in)	59	pounds per inch
x2 = [2*Fshaft/(Depth to Failure Surface)] + x1		

Service (I) Limit State:

x1 =	59	pounds per inch
x2 =	688	pounds per inch
Total Load =	92092	pounds

Strength (I) Limit State:

x1 =	103	pounds per inch (Load Factor = 1.75)
x2 =	1047	pounds per inch (Load Factor = 1.5)
Total Load =	154431	pounds

CHOOSE MATERIAL p-y CURVES for LPILE Program

Material Type	*Value*	*Units*	
Bedrock - Claysotone/Shale			
γ'=	82	pcf	based on UCR performed on soft shale/claystone
E=	8,100	psi	=90 x qu
qu=	90	psi	conservative for weak shale/claystone
RQD=	38	%	conservative for weak rock
Km=	0.00005		conservative for weak rock
p-y Modification Factor			
p = 0.64 (Spacing/Diameter)$^{0.34}$	0.80		

SHAFT CONCRETE AND STEEL MATERIAL PROPERTIES FOR LPILE

Parameter	*Value*		*Note*
f'_c =	4,000	psi	(ODOT Class S Concrete)
E_c =	3,604,997	psi	E_c = 57,000 * SQRT(f'c)
$f_{y\ steel}$=	50,000	psi	
$E_{\ steel}$=	2.9E+07	psi	

Performed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

LPILE VERSION 2022 RUNS

SERVICE (I) AND STRENGTH (I) LIMIT STATES

Purpose: Achieve a shaft head deflection of 2 inches or less for Service (I) Limit State. Recommend a rock socket length by observation of the shear and moment curves. Provide shear and moment design parameters for the selection of steel beam reinforcement.

Run ID	Filename	Reinforcement Description	Deflection at Pile Head (in)	Maximum Moment (in-lbs)	Average Shear per FHWA-NHI-10-01(lbs)
1	W24x131_3ftD_5.75ftCTC	W24x131	1.92	7,786,862	180,682
2	W24x131_3ftD_5.75ftCTC	W24x131	3.77	13,000,000	292,126

Based on the calculations and assumptions presented above, it appears a 36-inch diameter drilled shaft with a center-to-center spacing of 69 inches can provide tolerable deflections. A minimum 10-foot rock socket is recommended.

PROPERTIES OF SELECTED SECTIONS

Run ID	Source	Reinforcement Description	Area of Steel (in^2)	Moment of Inertia (in^4)	Section Modulus (in^3)
1 & 2	AISC Manual of Steel Construction	W24x131	38.6	4,020	329

Performed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

```
================================================================================

                    LPile for Windows, Version 2022-12.006

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\\us0268-ppfss01\shared_projects\175578434\technical_production\analysis\10G-MRG-78-10.96\LPile\3 ft dia 5.75 cc
spacing\revised\

Name of input data file:
MRG-78-10.96_3ft_5.75 cc_W24x131.lp12d

Name of output report file:
MRG-78-10.96_3ft_5.75 cc_W24x131.lp12o
```

Name of plot output file:
MRG-78-10.96_3ft_5.75 cc_W24x131.lp12p

Name of runtime message file:
MRG-78-10.96_3ft_5.75 cc_W24x131.lp12r

Date and Time of Analysis

Date: August 6, 2024 Time: 8:49:39

Problem Title

Project Name: MRG-78-10.96

Job Number: 175578434

Client: ODOT

Engineer: G. Khatri

Description: LPile Analysis for Drilled Shaft

Program Options and Settings

Perfomed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by multiple distributed lateral loads acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2

Total length of pile = 30.550 ft
Depth of ground surface below top of pile = 20.5500 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.9000
2	6.800	12.9000
3	6.800	36.0000
4	30.550	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile
Length of section = 6.800000 ft
AISC Section Type = W

AISC Section Name = W24X131

Pile width = 12.900000 in

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 23.750000 ft
Width of top of section = 36.000000 in
Width of bottom of section = 36.000000 in
Top Area = 34.400000 sq. in

Bottom Area	=	34.400000 sq. in
Moment of Inertia at Top	=	4020. in^4
Moment of Inertia at Bottom	=	4020. in^4
Elastic Modulus	=	29000000. psi

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	20.550000 ft
Distance from top of pile to bottom of layer	=	35.000000 ft
Effective unit weight at top of layer	=	81.600000 pcf
Effective unit weight at bottom of layer	=	81.600000 pcf
Uniaxial compressive strength at top of layer	=	90.000000 psi
Uniaxial compressive strength at bottom of layer	=	90.000000 psi
Initial modulus of rock at top of layer	=	8100. psi
Initial modulus of rock at bottom of layer	=	8100. psi
RQD of rock at top of layer	=	38.000000 %
RQD of rock at bottom of layer	=	38.000000 %
k rm of rock at top of layer	=	0.0000500
k rm of rock at bottom of layer	=	0.0000500

(Depth of the lowest soil layer extends 4.450 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi

1	Weak	20.5500	81.6000	90.0000	38.0000	5.00E-05	8100.
	Rock	35.0000	81.6000	90.0000	38.0000	5.00E-05	8100.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	59.000
2	26.700	688.000

Distributed lateral load intensity for Load Case 2 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	103.000
2	26.700	1047.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No	Yes
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Steel AISC Strong Axis:

Length of Section	=	6.800000 ft
Flange Width	=	12.900000 in
Section Depth	=	24.500000 in
Flange Thickness	=	0.960000 in
Web Thickness	=	0.605000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	38.600000 sq. in.

Moment of Inertia = 4020. in^4
Elastic Bending Stiffness = 116580000. kip-in^2
Plastic Modulus, Z = 370.000000in^3
Plastic Moment Capacity = Fy Z = 18500.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 1930.000 kips
Nominal Axial Tensile Capacity = -1930.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000568	660.9014790	116349762.	12.2500000	1.9977471	
0.00001136	1322.	116349762.	12.2500000	3.9954942	
0.00001704	1983.	116349762.	12.2500000	5.9932413	
0.00002272	2644.	116349762.	12.2500000	7.9909884	
0.00002840	3305.	116349762.	12.2500000	9.9887355	
0.00003408	3965.	116349762.	12.2500000	11.9864827	
0.00003976	4626.	116349762.	12.2500000	13.9842298	
0.00004544	5287.	116349762.	12.2500000	15.9819769	
0.00005112	5948.	116349762.	12.2500000	17.9797240	

Perfomed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

0.00005680	6609.	116349762.	12.2500000	19.9774711	
0.00006248	7270.	116349762.	12.2500000	21.9752182	
0.00006816	7931.	116349762.	12.2500000	23.9729653	
0.00007384	8592.	116349762.	12.2500000	25.9707124	
0.00007952	9253.	116349762.	12.2500000	27.9684595	
0.00008520	9914.	116349762.	12.2500000	29.9662066	
0.00009088	10574.	116349762.	12.2500000	31.9639538	
0.00009657	11235.	116349762.	12.2500000	33.9617009	
0.0001022	11896.	116349762.	12.2500000	35.9594480	
0.0001079	12557.	116349762.	12.2500000	37.9571951	
0.0001136	13218.	116349762.	12.2500000	39.9549422	
0.0001193	13879.	116349762.	12.2500000	41.9526893	
0.0001250	14540.	116349762.	12.2500000	43.9504364	
0.0001306	15201.	116349762.	12.2500000	45.9481835	
0.0001363	15862.	116349762.	12.2500000	47.9459306	
0.0001420	16523.	116349762.	12.2500000	49.9436777	
0.0001477	16968.	114888363.	12.2500000	50.0000000	Y
0.0001534	17154.	111851123.	12.2500000	50.0000000	Y
0.0001590	17244.	108419070.	12.2500000	50.0000000	Y
0.0001647	17324.	105168186.	12.2500000	50.0000000	Y
0.0001704	17397.	102087640.	12.2500000	50.0000000	Y
0.0001761	17462.	99165667.	12.2500000	50.0000000	Y
0.0001818	17522.	96394720.	12.2500000	50.0000000	Y
0.0001874	17576.	93763791.	12.2500000	50.0000000	Y
0.0001931	17625.	91261877.	12.2500000	50.0000000	Y
0.0001988	17671.	88881762.	12.2500000	50.0000000	Y
0.0002045	17712.	86616109.	12.2500000	50.0000000	Y
0.0002102	17751.	84457536.	12.2500000	50.0000000	Y
0.0002159	17786.	82397606.	12.2500000	50.0000000	Y
0.0002215	17818.	80431012.	12.2500000	50.0000000	Y
0.0002329	17876.	76757122.	12.2500000	50.0000000	Y
0.0002443	17926.	73392499.	12.2500000	50.0000000	Y
0.0002556	17970.	70302757.	12.2500000	50.0000000	Y
0.0002670	18008.	67453674.	12.2500000	50.0000000	Y
0.0002783	18042.	64820970.	12.2500000	50.0000000	Y
0.0002897	18072.	62381700.	12.2500000	50.0000000	Y
0.0003011	18098.	60115855.	12.2500000	50.0000000	Y
0.0003124	18122.	58005893.	12.2500000	50.0000000	Y
0.0003238	18143.	56035116.	12.2500000	50.0000000	Y
0.0003351	18162.	54192109.	12.2500000	50.0000000	Y
0.0003465	18179.	52465506.	12.2500000	50.0000000	Y

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0.0003579	18195.	50843593.	12.2500000	50.0000000 Y
0.0003692	18209.	49317062.	12.2500000	50.0000000 Y
0.0003806	18222.	47880019.	12.2500000	50.0000000 Y
0.0003919	18234.	46521248.	12.2500000	50.0000000 Y
0.0004033	18245.	45238568.	12.2500000	50.0000000 Y
0.0004147	18254.	44022289.	12.2500000	50.0000000 Y
0.0004260	18264.	42870877.	12.2500000	50.0000000 Y
0.0004374	18272.	41775785.	12.2500000	50.0000000 Y
0.0004487	18280.	40735990.	12.2500000	50.0000000 Y
0.0004601	18287.	39745903.	12.2500000	50.0000000 Y
0.0004715	18294.	38802144.	12.2500000	50.0000000 Y
0.0004828	18300.	37902797.	12.2500000	50.0000000 Y
0.0004942	18306.	37042855.	12.2500000	50.0000000 Y
0.0005055	18311.	36221025.	12.2500000	50.0000000 Y
0.0005169	18317.	35435319.	12.2500000	50.0000000 Y
0.0005283	18321.	34682162.	12.2500000	50.0000000 Y
0.0005396	18326.	33959956.	12.2500000	50.0000000 Y
0.0005510	18330.	33267531.	12.2500000	50.0000000 Y
0.0005623	18334.	32603083.	12.2500000	50.0000000 Y
0.0005737	18338.	31963442.	12.2500000	50.0000000 Y
0.0005851	18341.	31348555.	12.2500000	50.0000000 Y
0.0005964	18344.	30757091.	12.2500000	50.0000000 Y
0.0006078	18348.	30187738.	12.2500000	50.0000000 Y
0.0006192	18351.	29638484.	12.2500000	50.0000000 Y
0.0006305	18353.	29108574.	12.2500000	50.0000000 Y
0.0006419	18356.	28597422.	12.2500000	50.0000000 Y
0.0006532	18359.	28104049.	12.2500000	50.0000000 Y
0.0006646	18361.	27627543.	12.2500000	50.0000000 Y
0.0006760	18363.	27166572.	12.2500000	50.0000000 Y
0.0007214	18371.	25466100.	12.2500000	50.0000000 Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips

1	0.00000000	18371.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.9200	1.27E-04	0.00	-0.00805	2.04E-07	1.16E+11	0.00	0.00	60.7992
0.3055	1.8905	408.5575	232.7841	-0.00805	0.6555	1.16E+11	0.00	0.00	66.1970
0.6110	1.8610	1707.	488.6543	-0.00805	2.7385	1.16E+11	0.00	0.00	73.3940
0.9165	1.8315	3991.	770.9087	-0.00805	6.4041	1.16E+11	0.00	0.00	80.5910

1.2220	1.8020	7359.	1080.	-0.00805	11.8075	1.16E+11	0.00	0.00	87.7879
1.5275	1.7725	11907.	1415.	-0.00805	19.1039	1.16E+11	0.00	0.00	94.9849
1.8330	1.7430	17731.	1776.	-0.00805	28.4485	1.16E+11	0.00	0.00	102.1819
2.1385	1.7135	24928.	2164.	-0.00805	39.9965	1.16E+11	0.00	0.00	109.3789
2.4440	1.6840	33595.	2578.	-0.00805	53.9031	1.16E+11	0.00	0.00	116.5759
2.7495	1.6545	43830.	3019.	-0.00805	70.3235	1.16E+11	0.00	0.00	123.7729
3.0550	1.6250	55727.	3485.	-0.00804	89.4129	1.16E+11	0.00	0.00	130.9699
3.3605	1.5955	69385.	3979.	-0.00804	111.3264	1.16E+11	0.00	0.00	138.1668
3.6660	1.5660	84899.	4498.	-0.00804	136.2193	1.16E+11	0.00	0.00	145.3638
3.9715	1.5365	102368.	5045.	-0.00804	164.2467	1.16E+11	0.00	0.00	152.5608
4.2770	1.5071	121886.	5617.	-0.00803	195.5639	1.16E+11	0.00	0.00	159.7578
4.5825	1.4776	143552.	6216.	-0.00803	230.3260	1.16E+11	0.00	0.00	166.9548
4.8880	1.4482	167461.	6841.	-0.00802	268.6882	1.16E+11	0.00	0.00	174.1518
5.1935	1.4188	193711.	7493.	-0.00802	310.8057	1.16E+11	0.00	0.00	181.3487
5.4990	1.3894	222399.	8171.	-0.00801	356.8338	1.16E+11	0.00	0.00	188.5457
5.8045	1.3601	253620.	8875.	-0.00800	406.9275	1.16E+11	0.00	0.00	195.7427
6.1100	1.3307	287472.	9606.	-0.00800	461.2422	1.16E+11	0.00	0.00	202.9397
6.4155	1.3014	324051.	10363.	-0.00799	519.9329	1.16E+11	0.00	0.00	210.1367
6.7210	1.2722	363455.	11147.	-0.00798	583.1549	1.16E+11	0.00	0.00	217.3337
7.0265	1.2430	405779.	11957.	-0.00796	1817.	1.17E+11	0.00	0.00	224.5307
7.3320	1.2138	451121.	12793.	-0.00795	2020.	1.17E+11	0.00	0.00	231.7276
7.6375	1.1847	499577.	13656.	-0.00794	2237.	1.17E+11	0.00	0.00	238.9246
7.9430	1.1556	551245.	14545.	-0.00792	2468.	1.17E+11	0.00	0.00	246.1216
8.2485	1.1266	606220.	15460.	-0.00790	2714.	1.17E+11	0.00	0.00	253.3186
8.5540	1.0977	664599.	16402.	-0.00788	2976.	1.17E+11	0.00	0.00	260.5156
8.8595	1.0688	726480.	17370.	-0.00786	3253.	1.17E+11	0.00	0.00	267.7126
9.1650	1.0401	791959.	18365.	-0.00783	3546.	1.17E+11	0.00	0.00	274.9096
9.4705	1.0114	861132.	19386.	-0.00781	3856.	1.17E+11	0.00	0.00	282.1065
9.7760	0.9828	934097.	20433.	-0.00778	4183.	1.17E+11	0.00	0.00	289.3035
10.0815	0.9543	1010950.	21507.	-0.00775	4527.	1.17E+11	0.00	0.00	296.5005
10.3870	0.9260	1091787.	22607.	-0.00772	4889.	1.17E+11	0.00	0.00	303.6975
10.6925	0.8978	1176707.	23734.	-0.00768	5269.	1.17E+11	0.00	0.00	310.8945
10.9980	0.8697	1265804.	24887.	-0.00764	5668.	1.17E+11	0.00	0.00	318.0915
11.3035	0.8417	1359177.	26066.	-0.00760	6086.	1.17E+11	0.00	0.00	325.2884
11.6090	0.8139	1456921.	27272.	-0.00756	6524.	1.17E+11	0.00	0.00	332.4854
11.9145	0.7863	1559134.	28504.	-0.00751	6981.	1.17E+11	0.00	0.00	339.6824
12.2200	0.7589	1665912.	29762.	-0.00746	7459.	1.17E+11	0.00	0.00	346.8794
12.5255	0.7316	1777351.	31047.	-0.00740	7958.	1.17E+11	0.00	0.00	354.0764
12.8310	0.7046	1893550.	32358.	-0.00735	8479.	1.17E+11	0.00	0.00	361.2734
13.1365	0.6778	2014604.	33696.	-0.00729	9021.	1.17E+11	0.00	0.00	368.4704
13.4420	0.6512	2140609.	35060.	-0.00722	9585.	1.17E+11	0.00	0.00	375.6673

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13.7475	0.6248	2271664.	36450.	-0.00715	10172.	1.17E+11	0.00	0.00	382.8643
14.0530	0.5987	2407864.	37867.	-0.00708	10781.	1.17E+11	0.00	0.00	390.0613
14.3585	0.5729	2549307.	39310.	-0.00700	11415.	1.17E+11	0.00	0.00	397.2583
14.6640	0.5474	2696088.	40780.	-0.00692	12072.	1.17E+11	0.00	0.00	404.4553
14.9695	0.5222	2848305.	42276.	-0.00683	12754.	1.17E+11	0.00	0.00	411.6523
15.2750	0.4973	3006055.	43798.	-0.00674	13460.	1.17E+11	0.00	0.00	418.8493
15.5805	0.4728	3169434.	45347.	-0.00664	14191.	1.17E+11	0.00	0.00	426.0462
15.8860	0.4486	3338538.	46922.	-0.00654	14949.	1.17E+11	0.00	0.00	433.2432
16.1915	0.4249	3513465.	48523.	-0.00643	15732.	1.17E+11	0.00	0.00	440.4402
16.4970	0.4015	3694312.	50151.	-0.00632	16542.	1.17E+11	0.00	0.00	447.6372
16.8025	0.3786	3881174.	51805.	-0.00620	17378.	1.17E+11	0.00	0.00	454.8342
17.1080	0.3561	4074150.	53486.	-0.00607	18242.	1.17E+11	0.00	0.00	462.0312
17.4135	0.3340	4273335.	55193.	-0.00594	19134.	1.17E+11	0.00	0.00	469.2281
17.7190	0.3125	4478826.	56926.	-0.00580	20054.	1.17E+11	0.00	0.00	476.4251
18.0245	0.2915	4690720.	58686.	-0.00566	21003.	1.17E+11	0.00	0.00	483.6221
18.3300	0.2710	4909113.	60472.	-0.00551	21981.	1.17E+11	0.00	0.00	490.8191
18.6355	0.2511	5134103.	62285.	-0.00535	22989.	1.17E+11	0.00	0.00	498.0161
18.9410	0.2318	5365786.	64124.	-0.00519	24026.	1.17E+11	0.00	0.00	505.2131
19.2465	0.2131	5604259.	65989.	-0.00501	25094.	1.17E+11	0.00	0.00	512.4101
19.5520	0.1950	5849619.	67881.	-0.00483	26192.	1.17E+11	0.00	0.00	519.6070
19.8575	0.1776	6101962.	69799.	-0.00465	27322.	1.17E+11	0.00	0.00	526.8040
20.1630	0.1609	6361385.	71743.	-0.00445	28484.	1.17E+11	0.00	0.00	534.0010
20.4685	0.1450	6627984.	73714.	-0.00425	29678.	1.17E+11	0.00	0.00	541.1980
20.7740	0.1298	6901857.	70813.	-0.00403	30904.	1.17E+11	-2672.	75466.	548.3950
21.0795	0.1154	7147188.	62409.	-0.00381	32002.	1.17E+11	-3017.	95827.	555.5920
21.3850	0.1019	7359439.	52766.	-0.00358	32953.	1.17E+11	-3362.	120999.	562.7890
21.6905	0.08915	7534070.	41886.	-0.00335	33735.	1.17E+11	-3707.	152440.	569.9859
21.9960	0.07730	7666544.	29767.	-0.00311	34328.	1.17E+11	-4052.	192157.	577.1829
22.3015	0.06634	7752321.	16410.	-0.00287	34712.	1.17E+11	-4397.	242967.	584.3799
22.6070	0.05627	7786862.	1815.	-0.00262	34867.	1.17E+11	-4742.	308908.	591.5769
22.9125	0.04710	7765630.	-14018.	-0.00238	34771.	1.17E+11	-5086.	395893.	598.7739
23.2180	0.03883	7684085.	-31089.	-0.00214	34406.	1.17E+11	-5431.	512832.	605.9709
23.5235	0.03144	7537689.	-49398.	-0.00190	33751.	1.17E+11	-5776.	673585.	613.1678
23.8290	0.02492	7321903.	-68546.	-0.00166	32785.	1.17E+11	-5904.	868555.	620.3648
24.1345	0.01924	7035112.	-87795.	-0.00144	31501.	1.17E+11	-5846.	1113779.	627.5618
24.4400	0.01438	6678188.	-106691.	-0.00122	29902.	1.17E+11	-5725.	1459824.	634.7588
24.7455	0.01028	6252852.	-124984.	-0.00102	27998.	1.17E+11	-5532.	1972166.	641.9558
25.0510	0.00691	5761802.	-142379.	-8.30E-04	25799.	1.17E+11	-5249.	2785676.	649.1528
25.3565	0.00420	5208927.	-158495.	-6.57E-04	23324.	1.17E+11	-4848.	4233201.	656.3498
25.6620	0.00209	4599717.	-172754.	-5.03E-04	20596.	1.17E+11	-4251.	7459411.	663.5467
25.9675	5.10E-04	3942292.	-180682.	-3.69E-04	17652.	1.17E+11	-1408.	1.01E+07	670.7437

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26.2730	-6.14E-04	3274958.	-177558.	-2.55E-04	14664.	1.17E+11	1764.	1.05E+07	677.9407
26.5785	-0.00136	2640437.	-164518.	-1.62E-04	11823.	1.17E+11	4058.	1.09E+07	614.7236
26.8840	-0.00180	2068710.	-147178.	-8.82E-05	9263.	1.17E+11	4788.	9728486.	0.00
27.1895	-0.00201	1561327.	-129063.	-3.11E-05	6991.	1.17E+11	5095.	9300529.	0.00
27.4950	-0.00203	1122418.	-110031.	1.11E-05	5026.	1.17E+11	5288.	9538163.	0.00
27.8005	-0.00193	754578.	-90452.	4.06E-05	3379.	1.17E+11	5394.	1.03E+07	0.00
28.1060	-0.00174	459227.	-70621.	5.97E-05	2056.	1.17E+11	5425.	1.15E+07	0.00
28.4115	-0.00149	236782.	-50804.	7.06E-05	1060.	1.17E+11	5387.	1.33E+07	0.00
28.7170	-0.00122	86730.	-32562.	7.57E-05	388.3433	1.17E+11	4565.	1.37E+07	0.00
29.0225	-9.35E-04	-1964.	-17578.	7.70E-05	8.7948	1.17E+11	3609.	1.42E+07	0.00
29.3280	-6.53E-04	-42154.	-6213.	7.63E-05	188.7491	1.17E+11	2591.	1.46E+07	0.00
29.6335	-3.75E-04	-47516.	1324.	7.49E-05	212.7571	1.17E+11	1520.	1.48E+07	0.00
29.9390	-1.03E-04	-32445.	4879.	7.37E-05	145.2779	1.17E+11	419.1591	1.48E+07	0.00
30.2445	1.65E-04	-11742.	4425.	7.30E-05	52.5750	1.17E+11	-666.832	1.48E+07	0.00
30.5500	4.31E-04	0.00	0.00	7.28E-05	0.00	1.17E+11	-1747.	7423650.	0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	1.92003173	inches
Computed slope at pile head	=	-0.0080497	radians
Maximum bending moment	=	7786862.	inch-lbs
Maximum shear force	=	-180682.	lbs
Depth of maximum bending moment	=	22.60700000	feet below pile head
Depth of maximum shear force	=	25.96750000	feet below pile head
Number of iterations	=	28	
Number of zero deflection points	=	2	
Pile deflection at ground	=	0.14093823	inches

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	3.7698	1.42E-04	0.00	-0.01504	2.28E-07	1.16E+11	0.00	0.00	105.7003
0.3055	3.7147	710.2827	402.3463	-0.01504	1.1396	1.16E+11	0.00	0.00	113.8012
0.6110	3.6595	2950.	839.3400	-0.01504	4.7332	1.16E+11	0.00	0.00	124.6024
0.9165	3.6044	6864.	1316.	-0.01504	11.0137	1.16E+11	0.00	0.00	135.4036
1.2220	3.5493	12598.	1832.	-0.01504	20.2139	1.16E+11	0.00	0.00	146.2048
1.5275	3.4941	20297.	2388.	-0.01504	32.5668	1.16E+11	0.00	0.00	157.0060
1.8330	3.4390	30107.	2983.	-0.01504	48.3052	1.16E+11	0.00	0.00	167.8072
2.1385	3.3839	42171.	3618.	-0.01504	67.6622	1.16E+11	0.00	0.00	178.6084
2.4440	3.3287	56636.	4293.	-0.01504	90.8706	1.16E+11	0.00	0.00	189.4096
2.7495	3.2736	73646.	5007.	-0.01503	118.1634	1.16E+11	0.00	0.00	200.2108
3.0550	3.2185	93347.	5761.	-0.01503	149.7734	1.16E+11	0.00	0.00	211.0120
3.3605	3.1634	115884.	6554.	-0.01503	185.9335	1.16E+11	0.00	0.00	221.8132
3.6660	3.1083	141402.	7387.	-0.01502	226.8767	1.16E+11	0.00	0.00	232.6144
3.9715	3.0533	170047.	8260.	-0.01502	272.8358	1.16E+11	0.00	0.00	243.4156
4.2770	2.9982	201962.	9172.	-0.01501	324.0439	1.16E+11	0.00	0.00	254.2168
4.5825	2.9432	237294.	10124.	-0.01501	380.7337	1.16E+11	0.00	0.00	265.0180
4.8880	2.8882	276188.	11115.	-0.01500	443.1382	1.16E+11	0.00	0.00	275.8192
5.1935	2.8332	318789.	12146.	-0.01499	511.4904	1.16E+11	0.00	0.00	286.6204
5.4990	2.7783	365242.	13216.	-0.01498	586.0231	1.16E+11	0.00	0.00	297.4216
5.8045	2.7234	415692.	14327.	-0.01496	666.9692	1.16E+11	0.00	0.00	308.2228
6.1100	2.6686	470285.	15476.	-0.01495	754.5617	1.16E+11	0.00	0.00	319.0240
6.4155	2.6138	529165.	16666.	-0.01494	849.0334	1.16E+11	0.00	0.00	329.8252
6.7210	2.5591	592478.	17895.	-0.01492	950.6174	1.16E+11	0.00	0.00	340.6264
7.0265	2.5044	660368.	19163.	-0.01490	2957.	1.17E+11	0.00	0.00	351.4276
7.3320	2.4499	732982.	20471.	-0.01488	3282.	1.17E+11	0.00	0.00	362.2288
7.6375	2.3954	810464.	21819.	-0.01485	3629.	1.17E+11	0.00	0.00	373.0300
7.9430	2.3410	892959.	23206.	-0.01482	3998.	1.17E+11	0.00	0.00	383.8312
8.2485	2.2867	980613.	24633.	-0.01480	4391.	1.17E+11	0.00	0.00	394.6324
8.5540	2.2325	1073570.	26100.	-0.01476	4807.	1.17E+11	0.00	0.00	405.4336

8.8595	2.1784	1171977.	27606.	-0.01473	5248.	1.17E+11	0.00	0.00	416.2348
9.1650	2.1245	1275977.	29152.	-0.01469	5713.	1.17E+11	0.00	0.00	427.0360
9.4705	2.0707	1385716.	30737.	-0.01465	6205.	1.17E+11	0.00	0.00	437.8372
9.7760	2.0171	1501340.	32362.	-0.01460	6722.	1.17E+11	0.00	0.00	448.6384
10.0815	1.9637	1622993.	34026.	-0.01455	7267.	1.17E+11	0.00	0.00	459.4396
10.3870	1.9104	1750821.	35730.	-0.01450	7839.	1.17E+11	0.00	0.00	470.2407
10.6925	1.8574	1884969.	37474.	-0.01444	8440.	1.17E+11	0.00	0.00	481.0419
10.9980	1.8045	2025582.	39257.	-0.01438	9070.	1.17E+11	0.00	0.00	491.8431
11.3035	1.7519	2172805.	41080.	-0.01432	9729.	1.17E+11	0.00	0.00	502.6443
11.6090	1.6996	2326783.	42943.	-0.01424	10418.	1.17E+11	0.00	0.00	513.4455
11.9145	1.6475	2487662.	44845.	-0.01417	11139.	1.17E+11	0.00	0.00	524.2467
12.2200	1.5957	2655586.	46787.	-0.01409	11891.	1.17E+11	0.00	0.00	535.0479
12.5255	1.5442	2830701.	48768.	-0.01400	12675.	1.17E+11	0.00	0.00	545.8491
12.8310	1.4930	3013152.	50789.	-0.01391	13492.	1.17E+11	0.00	0.00	556.6503
13.1365	1.4422	3203085.	52849.	-0.01381	14342.	1.17E+11	0.00	0.00	567.4515
13.4420	1.3917	3400643.	54949.	-0.01371	15227.	1.17E+11	0.00	0.00	578.2527
13.7475	1.3417	3605973.	57089.	-0.01360	16146.	1.17E+11	0.00	0.00	589.0539
14.0530	1.2920	3819220.	59268.	-0.01348	17101.	1.17E+11	0.00	0.00	599.8551
14.3585	1.2428	4040528.	61487.	-0.01336	18092.	1.17E+11	0.00	0.00	610.6563
14.6640	1.1941	4270044.	63746.	-0.01323	19120.	1.17E+11	0.00	0.00	621.4575
14.9695	1.1459	4507911.	66044.	-0.01309	20185.	1.17E+11	0.00	0.00	632.2587
15.2750	1.0981	4754276.	68381.	-0.01294	21288.	1.17E+11	0.00	0.00	643.0599
15.5805	1.0510	5009283.	70759.	-0.01279	22430.	1.17E+11	0.00	0.00	653.8611
15.8860	1.0044	5273078.	73175.	-0.01263	23611.	1.17E+11	0.00	0.00	664.6623
16.1915	0.9584	5545806.	75632.	-0.01246	24832.	1.17E+11	0.00	0.00	675.4635
16.4970	0.9130	5827611.	78128.	-0.01228	26094.	1.17E+11	0.00	0.00	686.2647
16.8025	0.8683	6118640.	80664.	-0.01209	27397.	1.17E+11	0.00	0.00	697.0659
17.1080	0.8244	6419037.	83239.	-0.01189	28742.	1.17E+11	0.00	0.00	707.8671
17.4135	0.7811	6728947.	85854.	-0.01169	30130.	1.17E+11	0.00	0.00	718.6683
17.7190	0.7387	7048516.	88508.	-0.01147	31561.	1.17E+11	0.00	0.00	729.4695
18.0245	0.6970	7377888.	91202.	-0.01124	33035.	1.17E+11	0.00	0.00	740.2707
18.3300	0.6562	7717210.	93936.	-0.01101	34555.	1.17E+11	0.00	0.00	751.0719
18.6355	0.6163	8066626.	96709.	-0.01076	36119.	1.17E+11	0.00	0.00	761.8731
18.9410	0.5773	8426280.	99522.	-0.01050	37730.	1.17E+11	0.00	0.00	772.6743
19.2465	0.5393	8796320.	102374.	-0.01023	39387.	1.17E+11	0.00	0.00	783.4755
19.5520	0.5023	9176888.	105266.	-0.00995	41091.	1.17E+11	0.00	0.00	794.2767
19.8575	0.4664	9568132.	108198.	-0.00965	42842.	1.17E+11	0.00	0.00	805.0779
20.1630	0.4316	9970195.	111169.	-0.00934	44643.	1.17E+11	0.00	0.00	815.8791
20.4685	0.3979	1.04E+07	114180.	-0.00902	46492.	1.17E+11	0.00	0.00	826.6803
20.7740	0.3654	1.08E+07	112332.	-0.00869	48391.	1.17E+11	-2672.	26807.	837.4815
21.0795	0.3342	1.12E+07	104994.	-0.00834	50180.	1.17E+11	-3017.	33097.	848.2827

Perfomed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

21.3850	0.3042	1.16E+07	96431.	-0.00799	51838.	1.17E+11	-3362.	40510.	859.0839
21.6905	0.2756	1.19E+07	86644.	-0.00762	53346.	1.17E+11	-3707.	49303.	869.8851
21.9960	0.2484	1.22E+07	75631.	-0.00724	54683.	1.17E+11	-4052.	59800.	880.6863
22.3015	0.2226	1.25E+07	63394.	-0.00685	55829.	1.17E+11	-4397.	72421.	891.4875
22.6070	0.1982	1.27E+07	49931.	-0.00645	56764.	1.17E+11	-4742.	87716.	902.2887
22.9125	0.1752	1.28E+07	35244.	-0.00605	57468.	1.17E+11	-5086.	106410.	913.0899
23.2180	0.1538	1.29E+07	19333.	-0.00565	57921.	1.17E+11	-5431.	129474.	923.8911
23.5235	0.1338	1.30E+07	2196.	-0.00524	58103.	1.17E+11	-5776.	158234.	934.6923
23.8290	0.1154	1.30E+07	-16166.	-0.00483	57993.	1.17E+11	-6121.	194520.	945.4935
24.1345	0.09839	1.29E+07	-35752.	-0.00443	57572.	1.17E+11	-6466.	240923.	956.2947
24.4400	0.08290	1.27E+07	-56563.	-0.00403	56819.	1.17E+11	-6811.	301187.	967.0959
24.7455	0.06888	1.24E+07	-78599.	-0.00363	55715.	1.17E+11	-7156.	380878.	977.8971
25.0510	0.05628	1.21E+07	-101860.	-0.00324	54239.	1.17E+11	-7501.	488548.	988.6983
25.3565	0.04509	1.17E+07	-126345.	-0.00287	52371.	1.17E+11	-7846.	637886.	999.4995
25.6620	0.03524	1.12E+07	-152056.	-0.00251	50091.	1.17E+11	-8191.	851978.	1010.
25.9675	0.02669	1.06E+07	-178696.	-0.00217	47379.	1.17E+11	-8374.	1150402.	1021.
26.2730	0.01935	9876781.	-205020.	-0.00185	44224.	1.17E+11	-8040.	1523241.	1032.
26.5785	0.01315	9078083.	-230052.	-0.00155	40648.	1.17E+11	-7584.	2113947.	935.5487
26.8840	0.00800	8190038.	-254974.	-0.00128	36672.	1.17E+11	-6948.	3183921.	0.00
27.1895	0.00379	7208617.	-278657.	-0.00103	32277.	1.17E+11	-5973.	5774167.	0.00
27.4950	4.16E-04	6146925.	-292126.	-8.24E-04	27524.	1.17E+11	-1375.	1.21E+07	0.00
27.8005	-0.00225	5066746.	-284368.	-6.48E-04	22687.	1.17E+11	5608.	9127405.	0.00
28.1060	-0.00434	4061937.	-261586.	-5.05E-04	18188.	1.17E+11	6821.	5766414.	0.00
28.4115	-0.00595	3148797.	-235125.	-3.91E-04	14099.	1.17E+11	7615.	4690572.	0.00
28.7170	-0.00720	2338004.	-206077.	-3.05E-04	10469.	1.17E+11	8232.	4188712.	0.00
29.0225	-0.00819	1637842.	-174947.	-2.42E-04	7334.	1.17E+11	8751.	3918329.	0.00
29.3280	-0.00898	1055293.	-142017.	-2.00E-04	4725.	1.17E+11	9214.	3760689.	0.00
29.6335	-0.00965	596573.	-107582.	-1.74E-04	2671.	1.17E+11	9572.	3634858.	0.00
29.9390	-0.01026	266503.	-72221.	-1.61E-04	1193.	1.17E+11	9719.	3473191.	0.00
30.2445	-0.01083	67050.	-36348.	-1.55E-04	300.2223	1.17E+11	9852.	3334440.	0.00
30.5500	-0.01140	0.00	0.00	-1.54E-04	0.00	1.17E+11	9978.	1604800.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection             =     3.76980099 inches
Computed slope at pile head      =     -0.0150397 radians
Maximum bending moment           =      12976249. inch-lbs
Maximum shear force              =       -292126. lbs
Depth of maximum bending moment  =    23.52350000 feet below pile head
Depth of maximum shear force     =    27.49500000 feet below pile head
Number of iterations             =             57
Number of zero deflection points =              1
Pile deflection at ground        =     0.38923714 inches
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.9200	-0.00805	-180682.	7786862.
2	V, lb	0.00	M, in-lb	0.00	0.00	3.7698	-0.01504	-292126.	1.30E+07

Maximum pile-head deflection = 3.7698009889 inches
Maximum pile-head rotation = -0.0150397075 radians = -0.861712 deg.

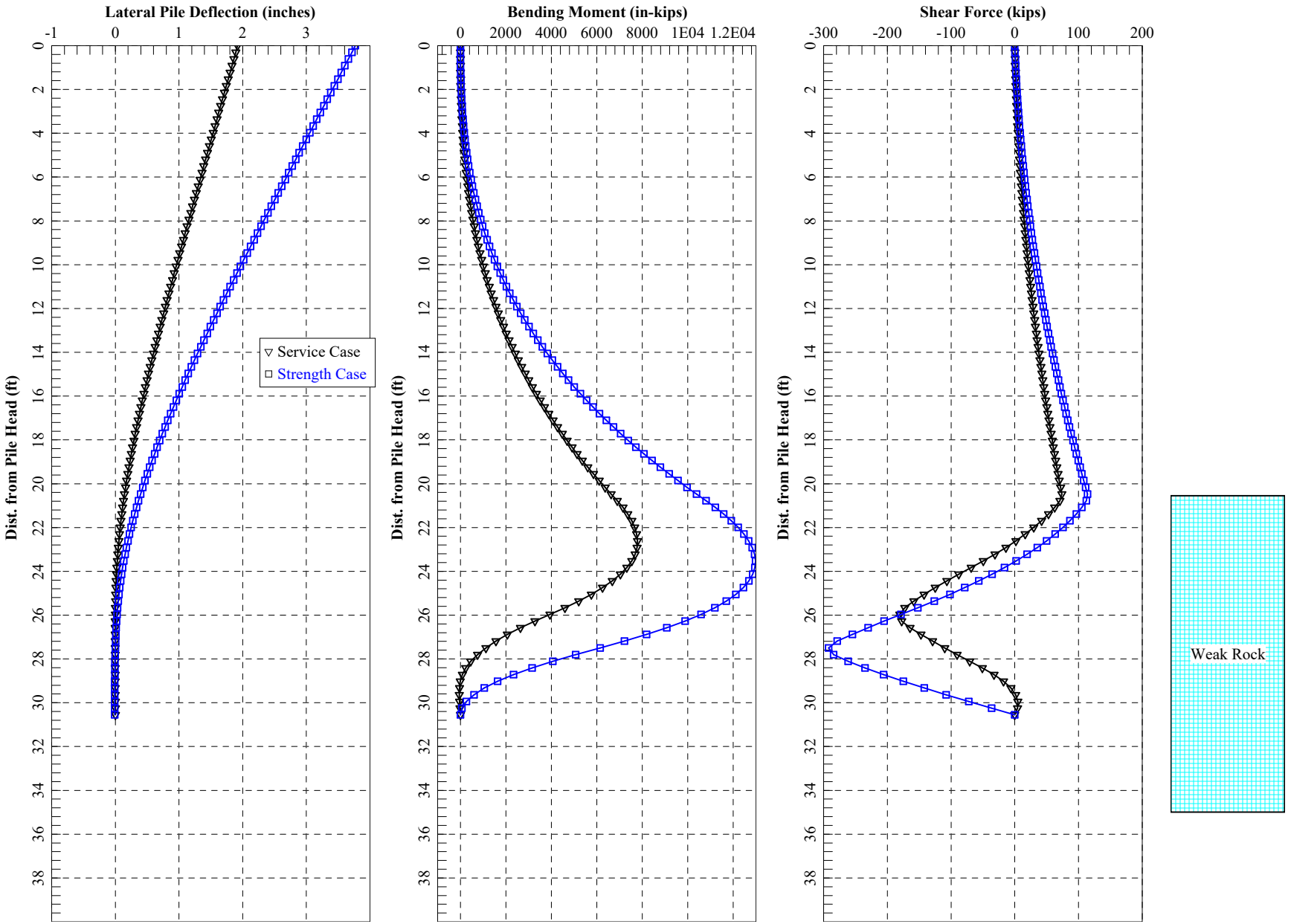
Summary of Warning Messages

The following warning was reported 1914 times

**** Warning ****

An unreasonable input value for compressive strength has been specified for a soil defined using the weak rock criteria. The input value is less than 100 psi. Please check your input data for correctness.

The analysis ended normally.



Performed by: G. Khatri 08/06/2024
Checked by: J. Swindler 08/07/2024

Stantec

CHECK FOR BEAM CLEARANCE

- Chosen beam size: W24x131
- d = 24.5 in
- b_f = 12.90 in
- $\sqrt{24.5^2+12.90^2}$ = 27.7 in
- 3-inch clearance for a drilled shaft size of 69 inches = 36 in - 2 (3 in) = 30 in
- 27.7 in < 30 in → **ACCEPTABLE**

CHECK FOR DEFLECTION

- Allowable Deflection – 2 inches
- W24x131 deflection from LPILE is 1.92 inches
- 1.92 in < 2 in → **ACCEPTABLE**

CHECK FOR SHEAR CAPACITY OF BEAM

- Section 6 of 8th edition of LRFD Bridge Design Manual
- Chosen beam size: W24x131
    - Maximum Shear from LPILE – 292.13 kips
- $V_n = C\ V_p$

$$V_p = 0.58 F_{yw} D t_w \qquad (6.10.9.3.2\text{-}3)$$

where:

d_o = transverse stiffener spacing (in.)
V_n = nominal shear resistance of the web panel (kip)
V_p = plastic shear force (kip)
C = ratio of the shear-buckling resistance to the shear yield strength

- $V_n = 1.0\ (0.58\ F_{yw}\ D\ t_w)$
- V_n = 1.0 (0.58) (50 ksi) (24.5 in) (0.605 in)
- V_n = 429.85 kips > 292.13 kips → **ACCEPTABLE**

Stantec

CHECK FOR BUCKLING OF BEAM

- Chosen beam size: W24x131

  - If $\frac{D}{t_w} \le 1.12\sqrt{\frac{Ek}{F_{yw}}}$, then:

$$C = 1.0 \qquad (6.10.9.3.2\text{-}4)$$

in which:

k = shear-buckling coefficient

$$= 5 + \frac{5}{\left(\frac{d_o}{D}\right)^2} \qquad (6.10.9.3.2\text{-}7)$$

- $k = 5 + \frac{5}{(\frac{69\text{in}}{24.5\text{ in}})^2} = 5.63$
- $1.12\sqrt{\frac{(29{,}000\text{ ksi})\ (5.63)}{50\text{ ksi}}} = 64.00$
- $\frac{D}{t_w} = \frac{24.5}{0.605} = 40.50 < 64.00 \rightarrow$ **ACCEPTABLE**

CHECK MOMENT CAPACITY

- Chosen beam size: W24x131
  - Beam stickup is approx. 6.8 feet for moment calculation
  - Maximum moment from LPILE – 1083.3 ft-kips
  - From “Steel Construction Manual”, AISC 14th Edition – an unbraced length of 6.8 feet for a W24x131 beam can support a moment capacity of approximately 1387 ft-kips, which is greater than 1083.3 ft-kips → **ACCEPTABLE**