

Final Geohazard Exploration Report

LAW-243-11.28

Landslide Remediation

Lawrence County, OH

October 3, 2025

Prepared for:

Ohio Department of Transportation – District 9
650 Eastern Ave.
Chillicothe, OH 45601

By:

HDR

9999 Carver Rd.
Suite 210
Cincinnati, OH 45202

Table of Contents

EXECUTIVE SUMMARY	1
1 INTRODUCTION	2
2 GEOLOGY AND OBSERVATIONS.....	2
2.1 Project Setting	2
2.2 Soil and Geologic Setting	3
2.2.1 Project Soils.....	3
2.2.2 Bedrock Geology	3
3 EXPLORATION	4
3.1 Previous Explorations	4
3.2 Site Reconnaissance	4
3.3 Subsurface Exploration.....	4
3.4 Laboratory Testing.....	5
4 FINDINGS.....	6
4.1 Encountered Subsurface Conditions.....	6
4.2 Inclinator Readings	6
5 ANALYSES AND RECOMMENDATIONS.....	7
5.1 Determination of Soil Parameters	7
5.2 Consideration of Design Alternatives	7
5.3 Buried Drilled Shaft Wall Design	9
6 LIMITATIONS	10
7 REFERENCES	10

Appendices

Appendix A. Exhibits

- Exhibit No. 1 Site Vicinity Map
- Exhibit No. 2 Physiographic Regions of Ohio
- Exhibit No. 3 Surficial Geology
- Exhibit No. 4a Soil Survey Map (Soil Types)
- Exhibit No. 4b Soil Survey Map (Corrosion of Concrete)
- Exhibit No. 4c Soil Survey Map (Corrosion of Steel)
- Exhibit No. 4d Soil Survey Map (pH Levels)
- Exhibit No. 5 Bedrock Geology Map
- Exhibit No. 6 Bedrock Topography Map
- Exhibit No. 7a Mine Map
- Exhibit No. 7b Historic Mine Information
- Exhibit No. 8 Boring Location Plan

Appendix B. Boring Logs, Rock Core Photos, and Inclinometer Data

- Boring Logs
- Rock Core Photos
- Inclinometer Logs and Plots

Appendix C. Laboratory Testing

- Soil Unconfined Compressive Strength (ASTM D2166)
- Rock Unconfined Compressive Strength (ASTM D7012)
- Rock Point Load Test (ASTM D5731)

Appendix D. Preliminary Analyses

- Determination of Strength Parameters
- Slope Stability – Existing Condition
- Option 1: Buried Drilled Shaft Wall
- Option 3: Earthwork

Appendix E. Final Analyses

- Structural Capacity Check and Reinforcing Design
- Buried Drilled Shaft Wall Detail

EXECUTIVE SUMMARY

This final report summarizes the results of the geohazard exploration program performed in support of the landslide repair along State Route 243 (SR 243) near Mile Marker 11.28 in Lawrence County, Ohio. The report includes the geotechnical information obtained from the borings and laboratory testing performed under this current study. The explorations, along with the laboratory test results, are presented in more detail in Section 3 of this report as well as in Appendices B and C.

Based on HDR's assessment of the borings, the generalized soil profile, as encountered in the borings, consists of colluvium and residuum, which generally increases in strength with depth, over claystone and siltstone bedrock containing minor amounts of shale, limestone, and coal. Further discussion on the encountered subsurface conditions is located in Section 4.

Feasible alternatives to remediate the landslide were developed and provided to ODOT for discussion and ultimately, selection of the preferred alternative to be carried forward for final design. The preferred alternative is a buried drilled shaft wall reinforced with a rebar cage. The king shafts are 3 feet in diameter, spaced at approximately 6 feet on center, with 3-foot diameter unreinforced plug piles located between them. The king shafts are to extend a minimum of 15 feet into residual/weathered claystone. Details on the various alternatives and the engineering analyses performed in support of these alternatives are outlined in Section 5 and in Appendices D and E. Specific recommendations related to the buried drilled shaft wall are located in Section 5.3.

1 INTRODUCTION

This final report summarizes the results of the geotechnical study performed by HDR Engineering Inc. (HDR) in support of the landslide repair along State Route 243 (SR 243) near Mile Marker 11.28 in Lawrence County, Ohio. The project location is shown on the Site Vicinity Map (Exhibit No. 1 in Appendix A).

Based on observations gathered during the site reconnaissance performed on February 12, 2025, coupled with the findings from the geotechnical explorations performed from April 16 through 21, 2025, four feasible alternatives to remediate the landslide along with supporting analyses were submitted to the District in a draft report dated September 19, 2025. From discussions with the District following their review of the draft report and supplemental calculations provided by HDR on September 26, 2025, a buried drilled shaft wall utilizing steel reinforcing cages was selected as the preferred alternative to stabilize the landslide and repair SR 243.

The geotechnical services performed under this study were carried out in general accordance with ODOT's *Specifications for Geotechnical Explorations* (SGE) and *Geotechnical Design Manual* (GDM) dated January 2025. The scope of work relative to this report include:

- a review of the available soil and geologic information within the project area,
- the results of a subsurface exploration program to evaluate the existing subsurface conditions within the slide area,
- the laboratory testing on selected soil samples in accordance with the requirements of the SGE and GDM,
- the descriptions and interpretations of the encountered subsurface conditions at the project site,
- characterization of a generalized soil profile along with development of the design soil strength parameters,
- geotechnical engineering evaluations and analyses, and
- the development of this final report.

This report presents the descriptions and interpretations of the encountered subsurface conditions at the site, the engineering analyses, the feasible and preferred options to remediate the landslide, and geotechnical recommendations to assist in the development of the construction plans.

2 GEOLOGY AND OBSERVATIONS

2.1 Project Setting

This project is located within the southern portion of Lawrence County, Ohio in a rural setting surrounded by wooded, residential parcels. Elevations along the existing roadway profile range from about El. 665 at the west end of the project near the crest of the ridge to El. 625 at the east

end of the project site. Across the project site, the elevations range from about El. 675 near the existing residential structure located at the intersection of SR 243 and Leffing Well Road (TR 346) at the western end of the site to approximately El. 610 in the drainage swale running along the south side of the roadway near the eastern end of the site.

2.2 Soil and Geologic Setting

A review of the Physiographic Regions of Ohio map (Ohio Division of Geological Survey, 1998) indicates that the project site is located within the Marietta Plateau region of the Allegheny (Kanawha) Plateaus section of the Appalachian Plateaus province (Exhibit No. 2 in Appendix A). The Marietta Plateau region is described as dissected, high-relief terrain prone to landslide activity and mainly composed of fine-grained rocks, red shales, and red residual soils. Soils in the Marietta Plateau region are identified as Pleistocene (Teays)-age Minford clays and/or red and brown colluvial silty-clay loam landslide deposits. Elevations in this region generally range from 650 to 1400 feet above sea level. Bedrock is identified as the Pennsylvanian-age Conemaugh Group through the Permian-age Dunkard Group, containing cyclic sequences of red and gray shales, siltstones, sandstones, limestones, and coals. Drainage in the south-central part of the county is accommodated by Symmes Creek and its tributaries, which drain into the Ohio River near Chesapeake, Ohio, approximately 5 miles downstream of the project site. The project site is directly drained by a ditch or swale that runs along the south side of SR 243, which eventually drains into Symmes Creek approximately 0.4 miles east of the project site. According to the Surficial Geology map (Exhibit No. 3 in Appendix A), surficial soils at the site consist of primarily Cenozoic Colluvium deposits (Cc), bordered by Holocene alluvial deposits (a) to the east.

2.2.1 Project Soils

The USDA Soil Survey of Lawrence County indicates the most prevalent surficial soil types within the project limits are the Upshur-Gilpin complex (UgF, 40 to 70 percent slopes) as shown in Exhibit No. 4a. Soils of the Upshur-Gilpin complex consist of 55 percent Upshur and similar soils, 25 percent Gilpin and similar soils, and 20 percent minor components (Weikert, Vandalia, and Rarden soils). Upshur soils generally consist of slightly decomposed plant material, silt loam, silty clay, and channery silty clay loam derived from clayey shale. These soils are typically located along hillslopes with a moderately low to moderately high water capacity. Gilpin soils generally consist of slightly decomposed plant material, channery silt loam, silty clay loam, and very channery silty clay loam derived from siltstone. These soils are typically located along hillslopes with a moderately low to moderately high water capacity. As shown on Exhibit Nos. 4b through 4d in Appendix A, the soil survey indicates the soils within the project area are considered to have high risk of corrosion to steel, moderate risk of corrosion to concrete, and have a pH level of 6.4.

2.2.2 Bedrock Geology

As shown on the Bedrock Geology Map (Exhibit No. 5 in Appendix A), the bedrock geology mapped within the project area is the Pennsylvanian-age Conemaugh Group (IPc). The Conemaugh Group generally consists of shale, siltstone, sandstone, and mudstone, with minor amounts of limestone and coal. Bedrock elevations in the project area, as shown on the Bedrock Topography Map (Exhibit No. 6 in Appendix A), are above 550 feet.

The main coal seam of note within the Conemaugh Group is the Mahoning No. 7a coal. Mapping available from ODNR indicates most mining activity is greater than 2 miles from the site. However, there is one mine point with unknown extents, designated as LE-OGS-091, mapped about 0.2 mile west of the site as shown on the Mine Map (Exhibit No. 7a in Appendix A). The stratigraphic section for this location, measured in 1911, indicates the mined commodity to be the Wilgus Coal, with a thickness ranging from 12 to 36 inches. Based on the stratigraphic section and ODNR information on historic coal seams (Exhibit No. 7b in Appendix A), the Wilgus Coal is located at the base of the Cambridge Limestone within the Conemaugh Group.

3 EXPLORATION

3.1 Previous Explorations

Review of ODOT's Transportation Information Mapping System (TIMS) revealed only the locations of previous landslide locations within the project area. The closest exploration from a past geotechnical study is approximately 0.2 mile to the east of the project limits.

3.2 Site Reconnaissance

A geotechnical site reconnaissance of the project area was performed by HDR on February 12, 2025, as well as during the exploration program. The LAW-243-11.28 project site is located in a rural setting surrounded by predominantly wooded hillsides. The existing terrain generally slopes downward from the northwest to the southeast, while SR 243 itself runs downslope from west to east across the terrain. A natural drainage ditch/swale is located to the south of SR 243, and a residence is located to the northwest of the project site. Two township roads intersect SR 243 near the west end of the site; TR 346 to the north of SR 243 and Sutton Mt Taber Ridge Road (TR 250) to the south. Overhead electric lines cross the roadway on either end of the project extents. A 24-inch corrugated plastic culvert crosses beneath the roadway near Sta. 597+75, outletting into the ditch below the roadway, and appeared to have been recently installed. Pavement along SR 243 was visually observed to contain distress throughout the project extents, with the most pronounced scarps located between approximately Sta. 595+70 and 596+60. The pavement near the culvert contained a patch, which also exhibited signs of distress. The cracks generally ran at an angle to the roadway centerline, indicating the direction of movement to be skewed and more or less following the hillside topography. At the time of drilling, hydrophilic vegetation was observed growing on most of the slope below the roadway.

3.3 Subsurface Exploration

Four borings were drilled as part of the geotechnical exploration program to assess the subsurface conditions within the LAW-243-11.28 project limits. The locations of the test borings are shown on the Boring Location Plan (Exhibit No. 8) in Appendix A. The test borings were located and marked in the field by HDR. These as-drilled locations are reflected on the boring plan, boring logs and Table 3-1.

Table 3-1. Summary of Borings

Boring Number	Boring Type ¹	Alignment	Station	Offset	Surface (El., feet)	Bottom of Borehole (El., feet)
B-001-0-25	C5	SR 243	596+05	16 ft Rt	653.4	598.9
B-002-0-25	C5	SR 243	597+06	16 ft Rt	641.9	595.4
B-002-1-25	C5	SR 243	597+07	7 ft Lt	642.7	613.9
B-003-0-25	C5	SR 243	598+08	15 ft Rt	629.8	588.8
Notes:						
¹ ODOT Boring Designations: Landslide Evaluation Borings (C5)						

The borings were drilled by Central Star Drilling under the supervision of an HDR geotechnical engineer between April 16 and 21, 2025 with a Diedrich D50 track rig. The rig was calibrated on June 24, 2024 and had an energy ratio of 80.9%. All borings were drilled in general accordance with the Specifications for Geotechnical Explorations (ODOT revised January 2025) utilizing 3.25-inch internal diameter hollow stem augers (Borings B-001-0-25, B-002-0-25, and B-003-0-25) or 2.25-inch diameter hollow stem augers (Boring B-002-1-25) to advance the borings through the soil overburden and into the underlying weathered claystone.

Sampling of the soils was accomplished in accordance with the *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D 1586). Sampling was performed continuously in Borings B-001-0-25, B-002-0-25, and B-003-0-25, and at 2.5-foot intervals in Boring B-002-1-25. In the split-barrel sampling procedure, a standard 2-inch outside diameter split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a typical 18-inch penetration is recorded as the standard penetration test (SPT) resistance or N_{SPT} -value. The N_{SPT} -value is then corrected to an energy ratio of 60%, termed N_{60} , which is used for design. Samples of the weaker claystone, as encountered in the borings, were also achieved by the split-barrel sampling procedure until encountering sampler refusal (50 blows in 6 inches or less of penetration). Undisturbed soil samples were also collected in Borings B-001-0-25, B-002-0-25, and B-003-0-25 as directed by the geotechnical engineer in accordance with the *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes* (ASTM D587). Additional sampling of the bedrock was then performed in Borings B-001-0-25, B-002-0-25, and B-003-0-25 in accordance with the *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation* (ASTM D 2113) using an NQ2-size double tube-swivel barrel with a diamond bit. After the completion of drilling, inclinometers were installed in Borings B-001-0-25 and B-002-0-25. The boring logs, rock core photos, and inclinometer readings are included in Appendix B.

3.4 Laboratory Testing

HDR selected representative soil samples for laboratory testing to confirm the field classification and to assess the various engineering properties of the soils. Soil index testing was performed by National Engineering & Architectural Services, Inc. (NEAS) and included 62 natural moisture content tests (per ASTM D 2216), 28 Atterberg limit determinations (per ASTM D 4318), and 28 grain size analyses (per ASTM D 422). The results of the soil index tests are presented on the final boring logs located in Appendix B. In addition to the soil index testing, 3 soil unconfined compression tests (per ASTM D 2166), 3 rock unconfined compression tests (per ASTM D 7012), and one rock point load test (per ASTM D5731) were performed. Results of these tests are presented on the individual laboratory sheets included in Appendix C.

4 FINDINGS

4.1 Encountered Subsurface Conditions

The generalized soil profile, as encountered in the borings, consists of colluvium and residuum, which generally increases in strength with depth, over claystone and siltstone bedrock containing minor amounts of shale, limestone, and coal.

Surficial materials consisting of 2 inches of topsoil was encountered in Borings B-001-0-25, B-002-0-25, and B-003-0-25. Sampling through the existing pavement was performed at Boring B-002-1-25. The pavement section for SR 243 was comprised of 14 inches of asphalt underlain by 6 inches of granular base at this location.

A thin layer of granular soil comprised of very loose to medium dense Gravel with Sand (A-1-b) was encountered below the surface materials in Borings B-001-0-25 and B-002-1-25 to depths of 1.5 to 3.5 feet below existing grade. Cohesive fill comprised of medium stiff to stiff Silty Clay (A-6b) was encountered in Boring B-003-0-25 to depths of 3.3 feet below grade. The fill was noted to have an organic odor below a depth 1.5 feet. Colluvium comprised of very soft to medium stiff Silt and Clay (A-6a), Silty Clay (A-6b), and Clay (A-7-6) was encountered beneath these layers in Borings B-001-0-25, B-002-1-25, and B-003-0-25, or the surface material in Boring B-002-0-25, to depths of 6 to 11.5 feet below existing grade. The N_{60} values ranged from 4 to 9 blows per foot (bpf). Below the colluvium, residuum comprised of medium stiff to hard Silty Clay (A-6b) and Clay (A-7-6) was encountered to the top of bedrock. The N_{60} values within the residuum ranged from 9 to greater than 50 bpf, but as the bedrock at the site consists primarily of claystone, the delineation as to the top of bedrock is considered gradual. The top of rock as indicated on the boring logs is delineated where the N_{SPT} -value was consistently greater than 50/6" of penetration. However, review of the moisture contents as well as the inclinometer results would indicate the top of the claystone to be higher than noted.

Groundwater was not encountered in any of the borings during drilling. However, trace amounts of water were encountered during sampling in Borings B-001-0-25, B-002-0-25, and B-003-0-25 at depths of 4.5 to 6 feet, 7 to 8.5 feet, and 6.5 feet, respectively. The addition of water during the rock coring process precluded readings after the completion of drilling. As the borings were sealed or fitted with instrumentation immediately upon completion, delayed water readings were not obtained after pulling tooling. Groundwater levels and possible perched water conditions can vary throughout the year depending on precipitation and other seasonal variations.

4.2 Inclinometer Readings

Inclinometer readings were obtained by ODOT starting on April 24, 2025, with these readings concluding on July 17, 2025. As indicated on the inclinometer plots included in Appendix B, the readings at Inclinometer B-001-0-25 indicate about 0.12 inch of movement has occurred from the initial reading on April 24th through the last reading on July 17th. The depth of movement in Inclinometer B-001-0-25 is about 12 to 14 feet below the top of casing (El. 640.9 to El. 638.9), near the boundary of soft to medium stiff silt and clay and the underlying stiff to hard clay. The moisture contents generally range between 17 and 23 within the uppermost 13 feet of the boring,

but lower to values of 13 or less below 13 feet (El. 640.4) within the very stiff to hard clay soils. The readings at Inclinator B-002-0-25 are similar, indicating about 0.15 inch of movement through the July 17th readings. The depth of movement occurs at about 10 and 14 feet below the top of casing (El. 631.7 to El. 627.7), near the boundary of the medium stiff to stiff silty clay/clay and the underlying hard clay. The decrease in moisture contents with depth is more gradual within this boring, ranging from 17 to 26 within the uppermost 14.5 feet of the boring, but lower to values of 16 or less below 14.5 feet (El. 627.4) within the hard clay soils.

5 ANALYSES AND RECOMMENDATIONS

5.1 Determination of Soil Parameters

Soil parameters were developed primarily from laboratory tests, supplemented by published correlations with SPT data and plasticity indices, recorded pocket penetrometer readings, and our engineering experience and judgement. To further assist in the development of the soil parameters, slope stability analyses were also conducted to back-calculate the long-term (drained) strength parameters for the encountered soils. The back-calculation analyses, performed through a skewed cross-section perpendicular to the direction of slope movement at Sta. 597+11.99, provided a means of recreating the existing condition failure surface by adjusting a set of initially assigned soil strength parameters until the calculated Factor of Safety (FS) was at or below 1.0 (indicating failure). Slope stability analyses were performed using Slope/W software, a program within the GeoStudio 2022 software suite by GeoSlope International, Ltd. Slope/W modeled a series of trial searches to determine the critical mode of failure based on a Morganstern-Price stability model using the optimization feature, which generates a hybrid circular and transitional failure shape. A graphical representation of this analysis and the soil profile as determined from the subsurface explorations is located in Appendix E. A summary of the recommended strength parameters is provided in Table 5-1. Details of the soil parameter development are located in Appendix D.

Table 5-1. Recommended Design Soil Strength Parameters

Material	Unit Wt.		Undrained Shear Strength		Drained Shear Strength	
	γ_m (pcf)	γ_T (pcf)	S_u (psf)	ϕ' (°)	c' (psf)	ϕ' (°)
CMS-203 Embankment (Assumed A-7-6)	115	125	2000	0	200	26
Soft to Medium Stiff Cohesive	120	130	400	0	60	20
Medium Stiff to Stiff Cohesive	115	125	900	0	80	21
Stiff to Very Stiff Cohesive	115	125	2600	0	160	23
Hard Cohesive	130	140	4000	0	350	27

5.2 Consideration of Design Alternatives

Based on the observations made during the site reconnaissance and the inclinometer readings, the slope movement affecting SR 243 is occurring at a skew to the roadway, rather than perpendicular to the roadway centerline. To arrest this movement, several potential options to buttress the roadway were considered. Some of the options were eliminated prior to performing

analyses. Other options underwent design analyses and were included or eliminated based on the results of the analyses. A brief discussion on the options considered is included below.

- Option 1: A buried drilled shaft wall with plug piles between the shafts. This option consists of construction of a buried drilled shaft wall to arrest the movement of the slide mass, with plug piles installed between the king shafts to prevent soil migration between the shafts. Two options were considered for the needed reinforcing:
 - Option 1a: Reinforcing using a rebar cage. To accommodate the skewed direction of movement, the king shafts would be reinforced with rebar cages. This reinforcement provides a symmetrical cross-section with no preferred direction for deflection, shear, and moment capacity.
 - Option 1b: Reinforcing using an H- or W- section. Consideration was also given to reinforcing the king shafts with a steel beam section. As the beams are completely contained within concrete, torsion is not a concern as with the soldier pile and lagging wall option (Option 2), but the skewed direction of movement would apply a portion of the force along the weak axis of the piles as the strong axis is typically placed perpendicular to the roadway.
- Option 2: A soldier pile and lagging wall using an H- or W- section as reinforcing. This option is similar to the buried drilled shaft wall, but has a portion of the steel piles above ground with lagging in between the beams. Due to the skewed direction of movement, this option would either require the strong axis of the piles to be placed perpendicular to the direction of movement for the maximum capacity, or would be subject to a torsion force if the strong axis was placed perpendicular to the roadway. This option was eliminated prior to performing analyses.
- Option 3: An excavation and replacement of the slide mass with Item 203 Embankment and a rock fill shear key. This option considers excavation of a majority of the slide mass, keying/benching the excavation into stable material, adding bench drains, and reconstructing the slope with embankment and rock fill. A few considerations for this option include:
 - The toe of the roadway slope extends beyond the right of way across most of the project limits. As such, there may be a need for a temporary easement or permanent ROW acquisition.
 - Due to the change in elevation across the site, the shear key and bench elevations would need to be adjusted while moving towards the south.
 - The existing ditch elevation is anticipated to be about 5 to 7 feet higher than the bottom of shear key elevation, which would likely require the drainage gallery to extend downhill, parallel to the roadway. Depending on the project extents and elevations, it may be possible to tie into the outlet of the 24-inch CPP near Sta. 598+00.
 - If the road is to remain open during construction, temporary pavement may need to be constructed within a portion of the ditch on the north side of the road.
- Option 4: A soil nail wall. This option consists of a soil nail wall to arrest the slope below the roadway. As with Option 2, movement would be occurring at an angle across the nails and may invoke additional shear and torsional forces. This option was eliminated prior to performing analyses.

Of these potential options to remediate the slide, two were considered feasible for further development and preliminary analyses were performed. These two are:

- Option 1: Construction of a buried drilled shaft wall
 - Option 1a: The preliminary design using rebar reinforcing allows for 3-foot diameter shafts spaced at approximately 6 feet on center with 3-foot diameter plug piles between the king shafts. The king shafts would extend a minimum of 15 feet into the residual/weathered claystone. This results in a pile head deflection of 1 inch.
 - Option 1b: The preliminary design using a steel beam as reinforcing allows for the same shaft configuration as Option 1a. An HP 16x183 section would be required based on the preliminary analyses to achieve the required moment capacity along the weak axis. The pile head deflection is less than 0.5 inch.
- Option 3: The excavation and replacement of a portion of the slide mass with Item 203 embankment and a rock fill shear key
 - The preliminary design considers an 8-foot wide shear key that is keyed 3 feet into the residual/weathered claystone, with 1 bench located approximately half of the vertical distance between the bottom of the shear key and the top of the excavation. Analyses were performed for the perpendicular sections at Sta. 597+00 and 597+25 to establish geometry. The required factors of safety (1.3 for post-construction and 1.2 during construction) were able to be met. The elevation of the benches and the shear key would need to be adjusted/stepped with the changes in the roadway profile across the project extents.

The preliminary analyses for these options are presented in Appendix D.

Based on correspondence with the District Geotechnical Engineer on October 1, 2025, Option 1a, the buried drilled shaft wall using rebar cages as the reinforcement was selected as the preferred alternative to remediate the slope movement at the site. The only updates required for final design were structural verification of the drilled shaft reinforcement required to achieve the needed shear and moment capacities. These structural analyses are presented in Appendix E.

5.3 Buried Drilled Shaft Wall Design

The failure surface and soil profile previously established during the preliminary analyses and soil parameter determination was entered into the UA Slope Version 2.3 software program to determine the loads acting upon the wall. The wall centerline was considered at a 24-foot perpendicular offset downslope of the roadway centerline to allow for installation of guardrail along the edge of the roadway and a 5-foot clearance between the guardrail and the back of the proposed drilled shafts. This recommended offset also allows for continuity with the existing features (roadway section, etc.) located to the east and west of the project site. It is anticipated the wall would be approximately 315 feet in length, from roughly Sta. 595+25 to Sta. 598+40.

The downslope stability analysis in front of the wall exhibited a Factor of Safety less than the minimum target of 1.3, so the ground surface in front of the wall was lowered in the analyses to account for reduced soil resistance due to continued movement of the slope downslope of the wall. This resulted in a 6.5-foot exposed wall height. To retain the soil between the drilled shafts,

unreinforced plug piles should be installed to a minimum depth of 15 feet or to the top of the residual/weathered claystone layer, whichever is shallower, to retain the soil between the shafts.

Lateral wall analyses were performed using LPILE Version 2022 software by Ensoft, Inc. An allowable pile head deflection of 2 inches was adopted, and the drilled shaft extending a minimum of 15 feet into the residual/weathered claystone layer. A 6-foot pile spacing with 3-foot diameter king shafts and 3-foot diameter plug piles was adopted to maintain a consistent diameter across the project. The recommended wall design details are presented in Table 5-2 and in the buried drilled shaft wall detail presented in Appendix E. Any fill placed to re-establish the grade behind the wall should meet the requirements of ODOT Construction and Material Specifications (CMS) Item 203.

Table 5-2: Buried Drilled Shaft Wall Design

Wall C/L Offset (feet)	Center-to-Center Pile Spacing (feet)	Drilled Shaft Diameter (inches)	Reinforcing Steel		Calculated Deflection (inches)
			Longitudinal	Transverse	
24	6	36	13 #8 Bars	#5 Spiral Bar at 5 in. Pitch	0.97

6 LIMITATIONS

This report documents the findings and conclusions of HDR Engineering, Inc., for the geotechnical aspects related to the planning and design of the LAW-243-11.28 project in Lawrence County, Ohio. The report has been prepared for the use by ODOT for specific application to the project, in accordance with generally accepted engineering practice. No warranty, expressed or implied, is made. Any analyses or recommendations submitted are based on the field explorations performed at the locations indicated, on specific laboratory tests on individual samples taken during the exploration, and information obtained from outside sources. The report and analyses do not reflect variation that could occur between exploration locations or at other points in time. Variations in conditions, if any, may become evident during the construction period, at which time, a re-evaluation of the recommendations may become necessary. In the event of such changes, the recommendations and changes should be reviewed by HDR's geotechnical staff.

7 REFERENCES

Ohio Department of Natural Resources, Division of Geologic Survey, Link, R.T., (1997); *"Bedrock topography of the Huntington W. Va.-Ohio, quadrangle"*.

Ohio Department of Natural Resources, Division of Geological Survey, Larsen, G.E. (2015); *"Historic Nomenclature of Lower Pennsylvanian Stratigraphy in Ohio."* Open-File Report 2015-2.

Ohio Department of Natural Resources, Division of Geologic Survey, (2025); *"Mines of Ohio Interactive Map"*. <https://gis.ohiodnr.gov/MapView/?config=OhioMines>

Ohio Department of Natural Resources, Division of Geologic Survey, (2025); *"Ohio Geology Interactive Map"*. <https://gis.ohiodnr.gov/website/dgs/geologyviewer/>

Ohio Department of Natural Resources, Division of Geologic Survey, (1998); *"Physiographic Regions of Ohio"*.

State of Ohio Department of Transportation, (Updated January 2025); “*Specifications for Geotechnical Explorations*”.

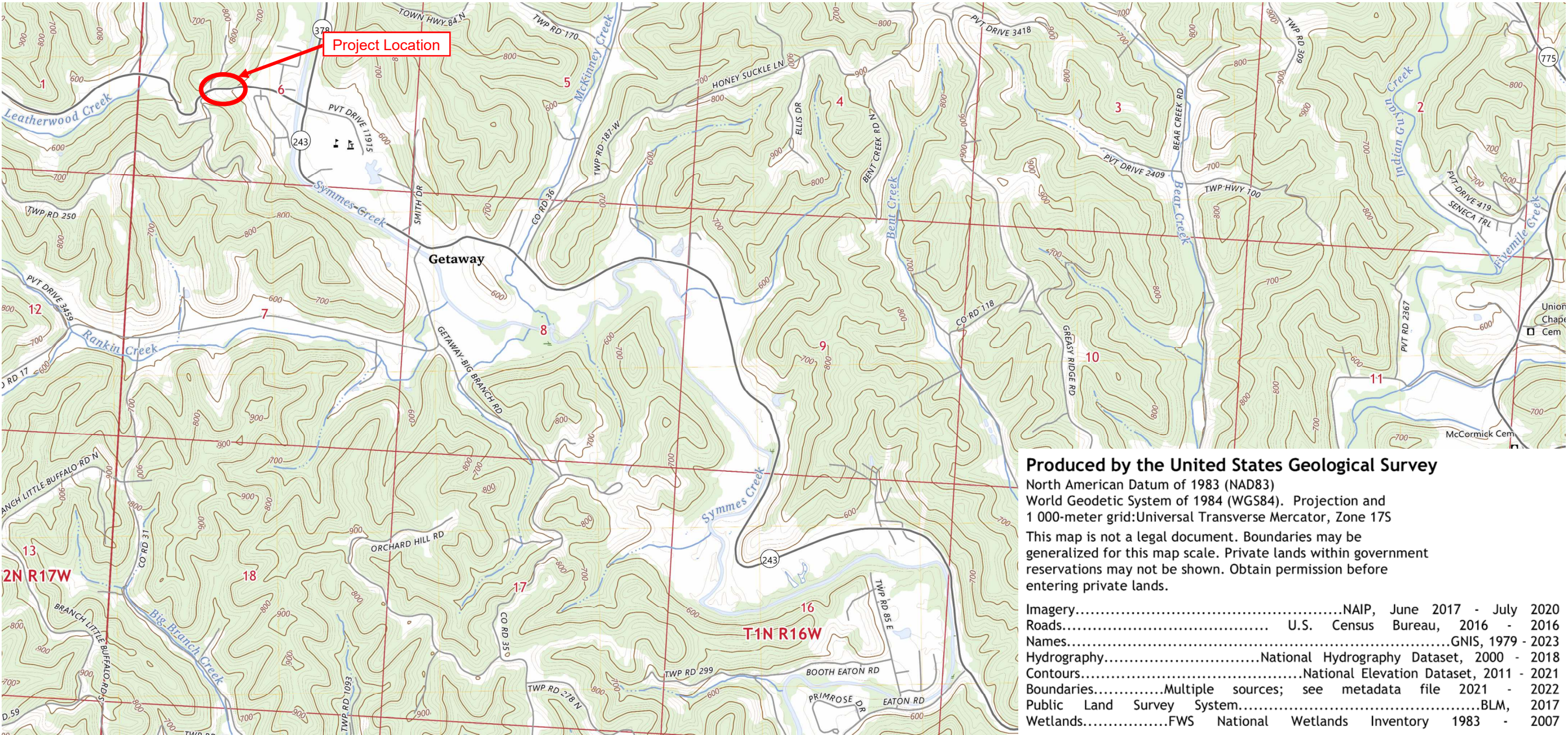
State of Ohio Department of Transportation, (Updated January 2025); “*Geotechnical Design Manual*”.

United States Department of the Interior, U.S. Geological Survey, (2023); “*The National Map, US Topo: Huntington, West Virginia, Ohio 7.5-minute series*”.

United States Department of Agriculture: Natural Resources Conservation Service, (2025); “*Web Soil Survey*”. <http://websoilsurvey.nrcs.usda.gov/app/>

Appendix A. Exhibits

Exhibit No. 1 Site Vicinity Map
Exhibit No. 2 Physiographic Regions of Ohio
Exhibit No. 3 Surficial Geology
Exhibit No. 4a Soil Survey Map (Soil Types)
Exhibit No. 4b Soil Survey Map (Corrosion of Concrete)
Exhibit No. 4c Soil Survey Map (Corrosion of Steel)
Exhibit No. 4d Soil Survey Map (pH Levels)
Exhibit No. 5 Bedrock Geology Map
Exhibit No. 6 Bedrock Topography Map
Exhibit No. 7a Mine Map
Exhibit No. 7b Historic Mine Information
Exhibit No. 8 Boring Location Plan



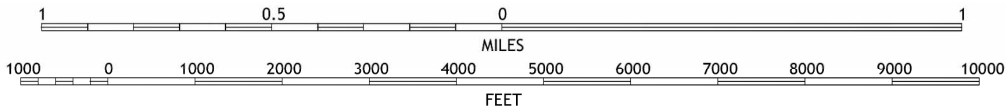
Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid:Universal Transverse Mercator, Zone 17S
This map is not a legal document. Boundaries may be
generalized for this map scale. Private lands within government
reservations may not be shown. Obtain permission before
entering private lands.

Imagery.....NAIP, June 2017 - July 2020
Roads..... U.S. Census Bureau, 2016 - 2016
Names.....GNIS, 1979 - 2023
Hydrography.....National Hydrography Dataset, 2000 - 2018
Contours.....National Elevation Dataset, 2011 - 2021
Boundaries.....Multiple sources; see metadata file 2021 - 2022
Public Land Survey System.....BLM, 2017
Wetlands.....FWS National Wetlands Inventory 1983 - 2007

UTM GRID AND 2023 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

7°21'
131 MILS
0°54'
16 MILS

U.S. National Grid
100,000 - m Square ID
LC
Grid Zone Designation 17S



CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988
This map was produced to conform with the
National Geospatial Program US Topo Product Standard.



1	2	3
4		5
6	7	8

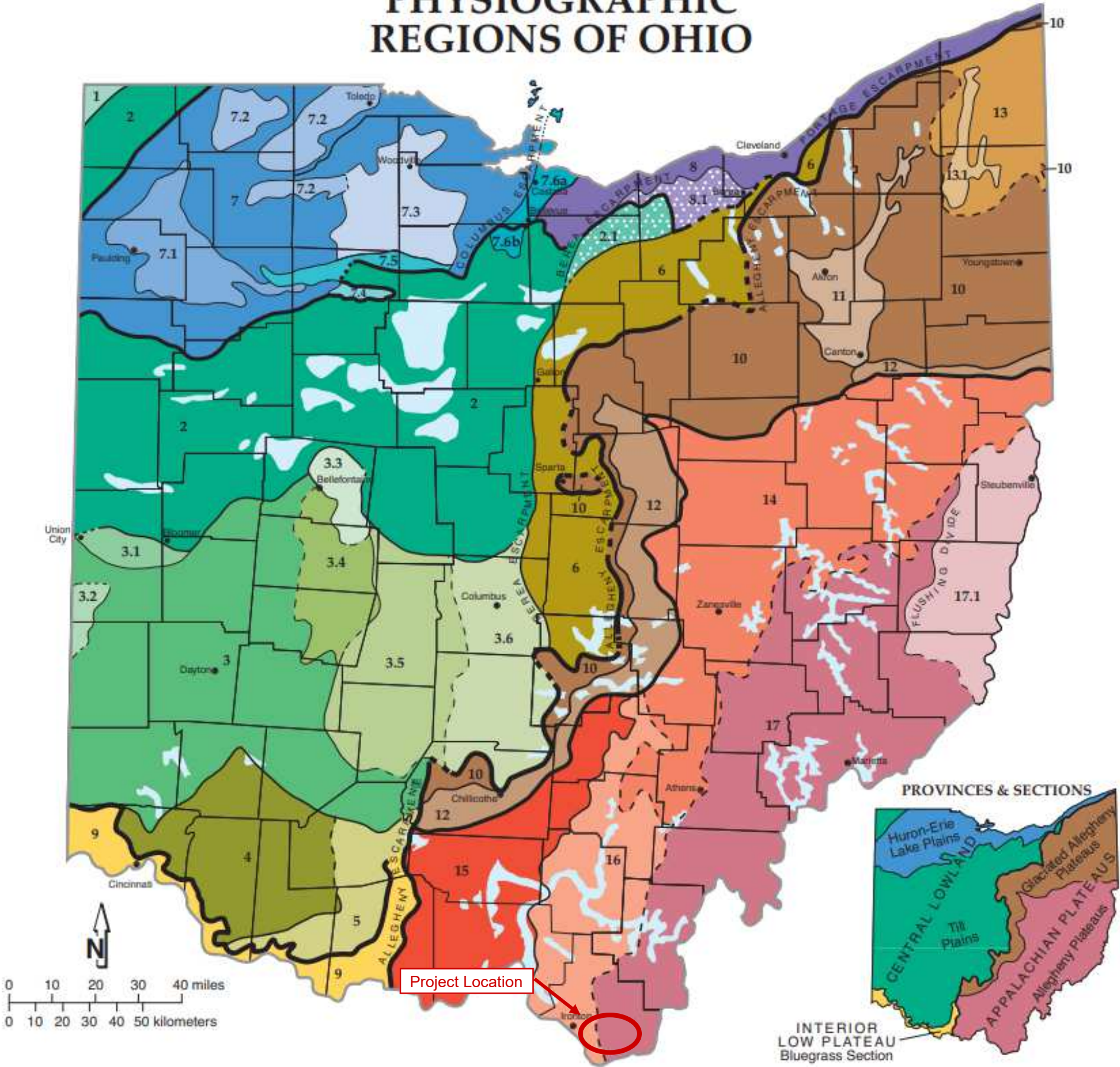
ADJOINING QUADRANGLES

1 Kitts Hill
2 Aid
3 Athalia
4 Catlettsburg
5 Barboursville
6 Burnaugh
7 Lavalette
8 Winslow

ROAD CLASSIFICATION	
Expressway	Local Connector
Secondary Hwy	Local Road
Ramp	4WD
Interstate Route	US Route
	State Route

HUNTINGTON, WV, OH
2023

PHYSIOGRAPHIC
REGIONS OF OHIO



Till Plains

- 1. Steuben Till Plain
- 2. Central Ohio Clayey Till Plain
 - 2.1. Berea Headlands of the Till Plain
- 3. Southern Ohio Loamy Till Plain
 - 3.1. Union City-Bloomer Transitional Terrain
 - 3.2. Whitewater Interlobate Plain
 - 3.3. Bellefontaine Upland
 - 3.4. Mad River Interlobate Plain
 - 3.5. Darby Plain
 - 3.6. Columbus Lowland
- 4. Illinoian Till Plain
- 5. Dissected Illinoian Till Plain
- 6. Galion Glaciated Low Plateau

Huron-Erie Lake Plains

- 7. Maumee Lake Plains
 - 7.1. Paulding Clay Basin
 - 7.2. Maumee Sand Plains
 - 7.3. Woodville Lake-Plain Reefs
 - 7.4. Findlay Embayment
 - 7.5. Fostoria Lake-Plain Shoals
 - 7.6a and 7.6b. Bellevue-Castalia Karst Plain
- 8. Erie Lake Plain
 - 8.1. Berea Headlands of the Erie Lake Plain

Bluegrass Section

- 9. Outer Bluegrass Region

Glaciated Allegheny Plateaus

- 10. Killbuck-Glaciated Pittsburgh Plateau
- 11. Akron-Canton Interlobate Plateau
- 12. Illinoian Glaciated Allegheny Plateau
- 13. Grand River Low Plateau
 - 13.1 Grand River Finger-Lake Plain

Allegheny Plateaus

- 14. Muskingum-Pittsburgh Plateau
- 15. Shawnee-Mississippian Plateau
- 16. Ironton Plateau
- 17. Marietta Plateau
 - 17.1. Little Switzerland Plateau

- Transitional boundary
- Lake basin/deposits outside Huron-Erie Lake Plains

Reference:

Ohio Division of Geological Survey, 1998
Physiographic Regions of Ohio,
Ohio Dept. of Natural Resources, Division of Geological Survey

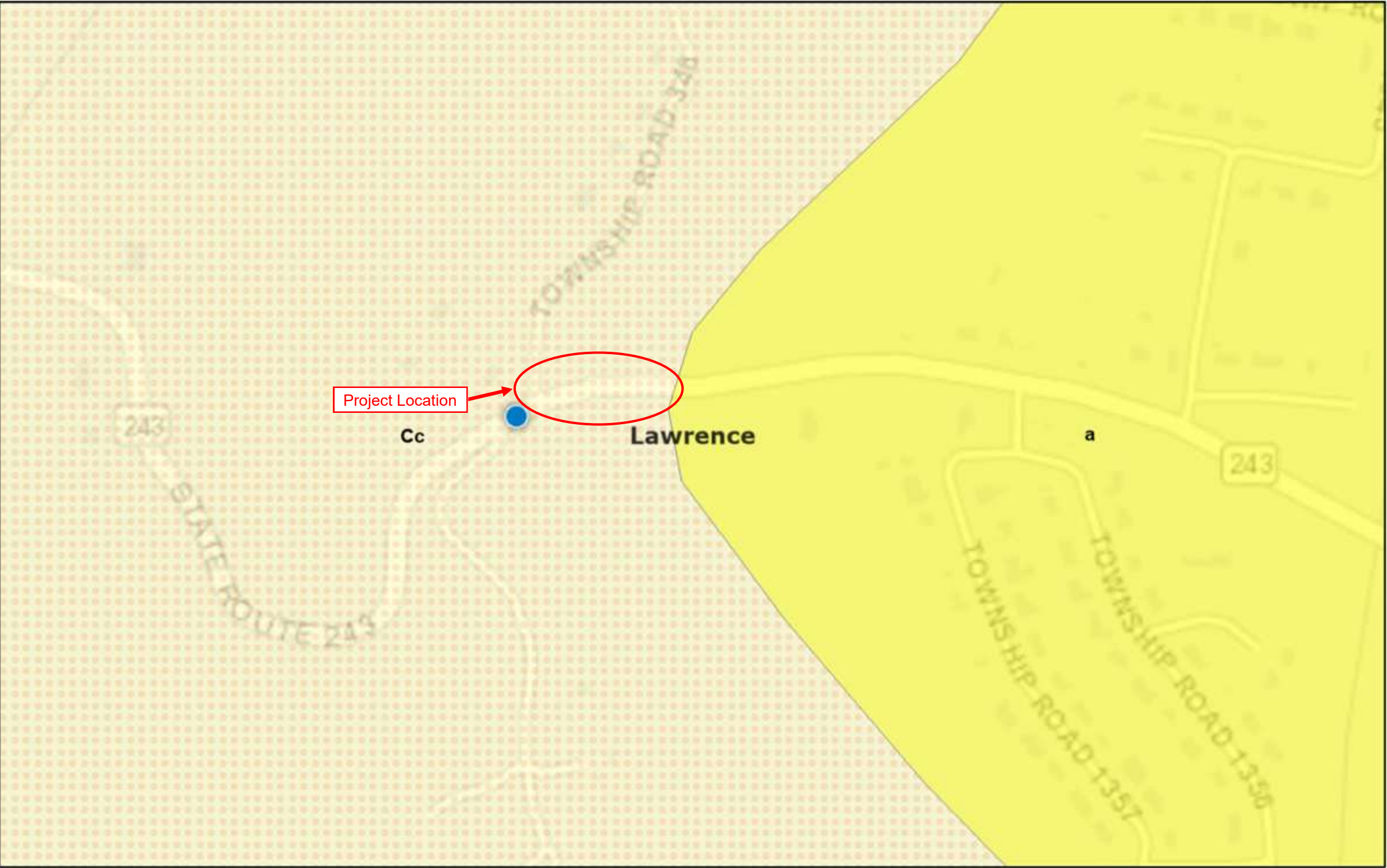
Calculated: AKB

Checked: DCM

Exhibit No. 2 : Physiographic Regions of Ohio

Project: LAW-243-11.28

PID: 123191



August 18, 2025

Quaternary Geology 500K

- a - Alluvium and alluvial terraces
- Cc - Colluvium derived from local bedrock in unglaciated areas
- Counties

1:4,514
0 0.03 0.06 0.12 mi
0 0.05 0.1 0.19 km
Esri, HERE, VITA, West Virginia GIS, Esri, HERE, Garmin, GeoTechnologies, Inc., Intermap, USGS, EPA

ODNR - Div. of Geosurvey

- Title: Ohio Geology Interactive Map
- Publishing Organization: [Ohio Department of Natural Resources, Division of Geological Survey](https://gis.ohiodnr.gov/website/dgs/geologyviewer/)
- URL: <https://gis.ohiodnr.gov/website/dgs/geologyviewer/>
- Accessed: August 18, 2025

Calculated: AKB	Exhibit No. 3 : Surficial Geology	Project: LAW-243-11.28 PID: 123191
Checked: DCM		



Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Map Unit Legend

Map Unit Symbol	Map Unit Name
UgF	Upshur-Gilpin complex, 40 to 70 percent slopes

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lawrence County, Ohio
Survey Area Data: Version 22, Aug 28, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 21, 2023—Aug 19, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Calculated: AKB

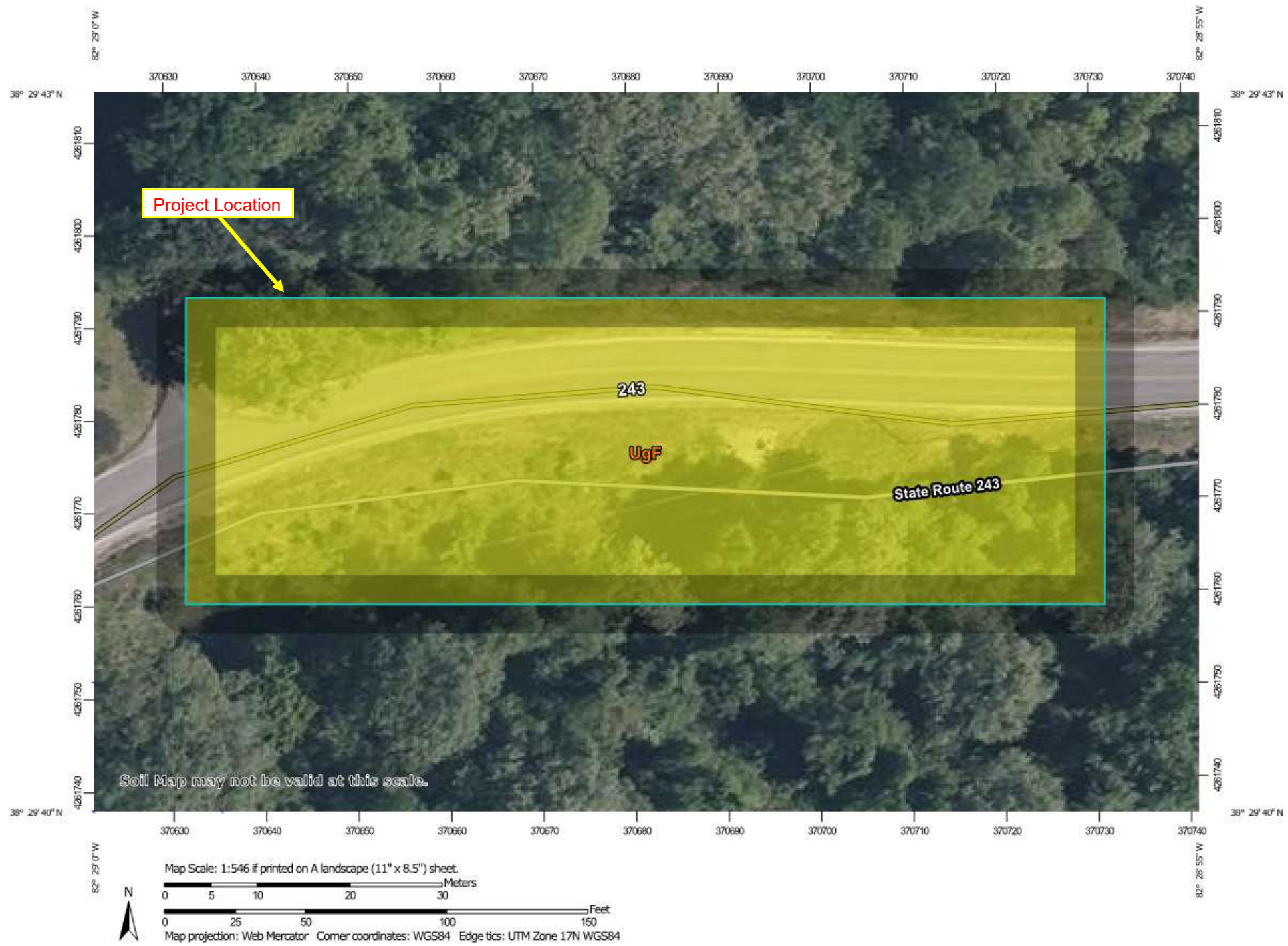
Checked: DCM

Exhibit No. 4a : Soil Survey Map

Soil Types

Project: LAW-243-11.28

PID: 123191



Area of Interest (AOI)

Area of Interest (AOI)

Soils
Soil Rating Polygons

High

Moderate

Low

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Table—Corrosion of Concrete

Map unit symbol	Map unit name	Rating
UgF	Upshur-Gilpin complex, 40 to 70 percent slopes	Moderate

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lawrence County, Ohio
Survey Area Data: Version 22, Aug 28, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 21, 2023—Aug 19, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Calculated: AKB

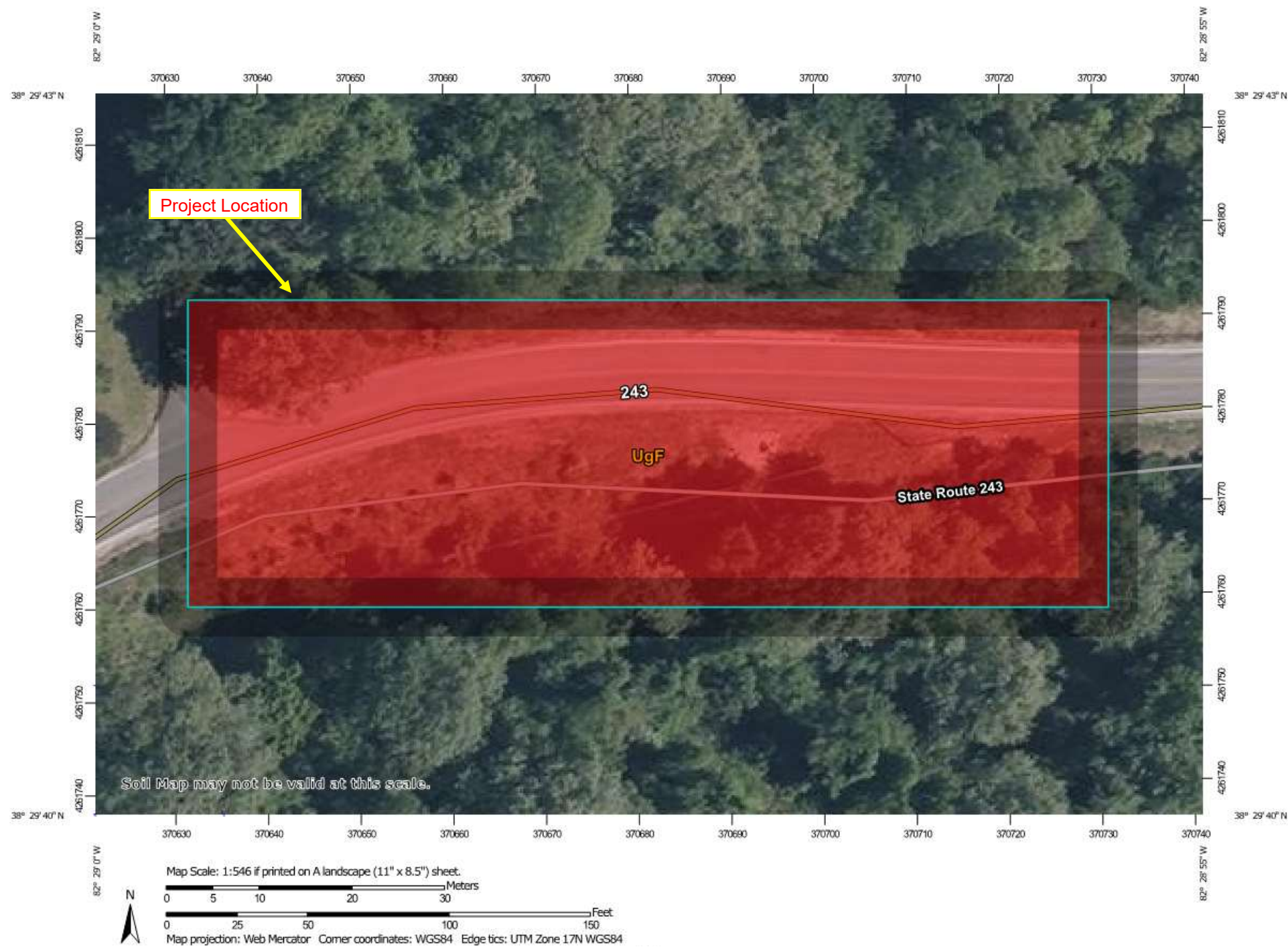
Checked: DCM

Exhibit No. 4b : Soil Survey Map

Corrosion of Concrete

Project: LAW-243-11.28

PID: 123191



Table—Corrosion of Steel		
Map unit symbol	Map unit name	Rating
UgF	Upshur-Gilpin complex, 40 to 70 percent slopes	High

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Scioto County, Ohio
Survey Area Data: Version 18, Jun 11, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 20, 2012—Mar 4, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- High
- Moderate
- Low
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Rating Options

Aggregation Method: Dominant Condition
Component Percent Cutoff: None Specified
Tie-break Rule: Higher



Soils

Soil Rating Polygons

	Ultra acid (pH < 3.5)		Moderately acid (pH 5.6 - 6.0)
	Extremely acid (pH 3.5 - 4.4)		Slightly acid (pH 6.1 - 6.5)
	Very strongly acid (pH 4.5 - 5.0)		
	Strongly acid (pH 5.1 - 5.5)		
	Moderately acid (pH 5.6 - 6.0)		
	Slightly acid (pH 6.1 - 6.5)		

Area of Interest (AOI)

Area of Interest (AOI)

Water Features

Streams and Canals

Transportation

Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Rating Options

Aggregation Method: Dominant Component
Component Percent Cutoff: None Specified
Tie-break Rule: Higher
Interpret Nulls as Zero: No
Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

Table—pH (1 to 1 Water)

Map unit symbol	Map unit name	Rating
UgF	Upshur-Gilpin complex, 40 to 70 percent slopes	6.4

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lawrence County, Ohio
Survey Area Data: Version 22, Aug 28, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 21, 2023—Aug 19, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Calculated: AKB

Checked: DCM

Exhibit No. 4d : Soil Survey Map

pH Levels

Project: LAW-243-11.28

PID: 123191

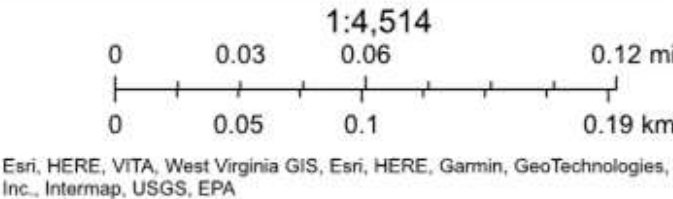


August 18, 2025

Bedrock Geology 24K

IPc - Conemaugh Group

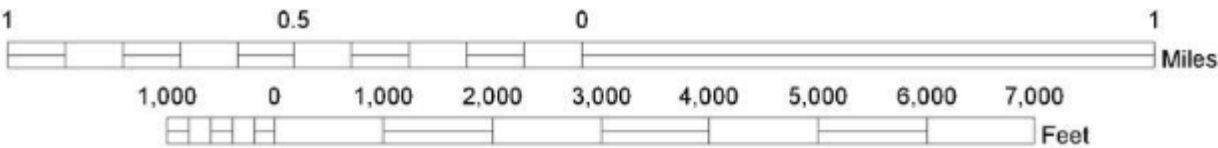
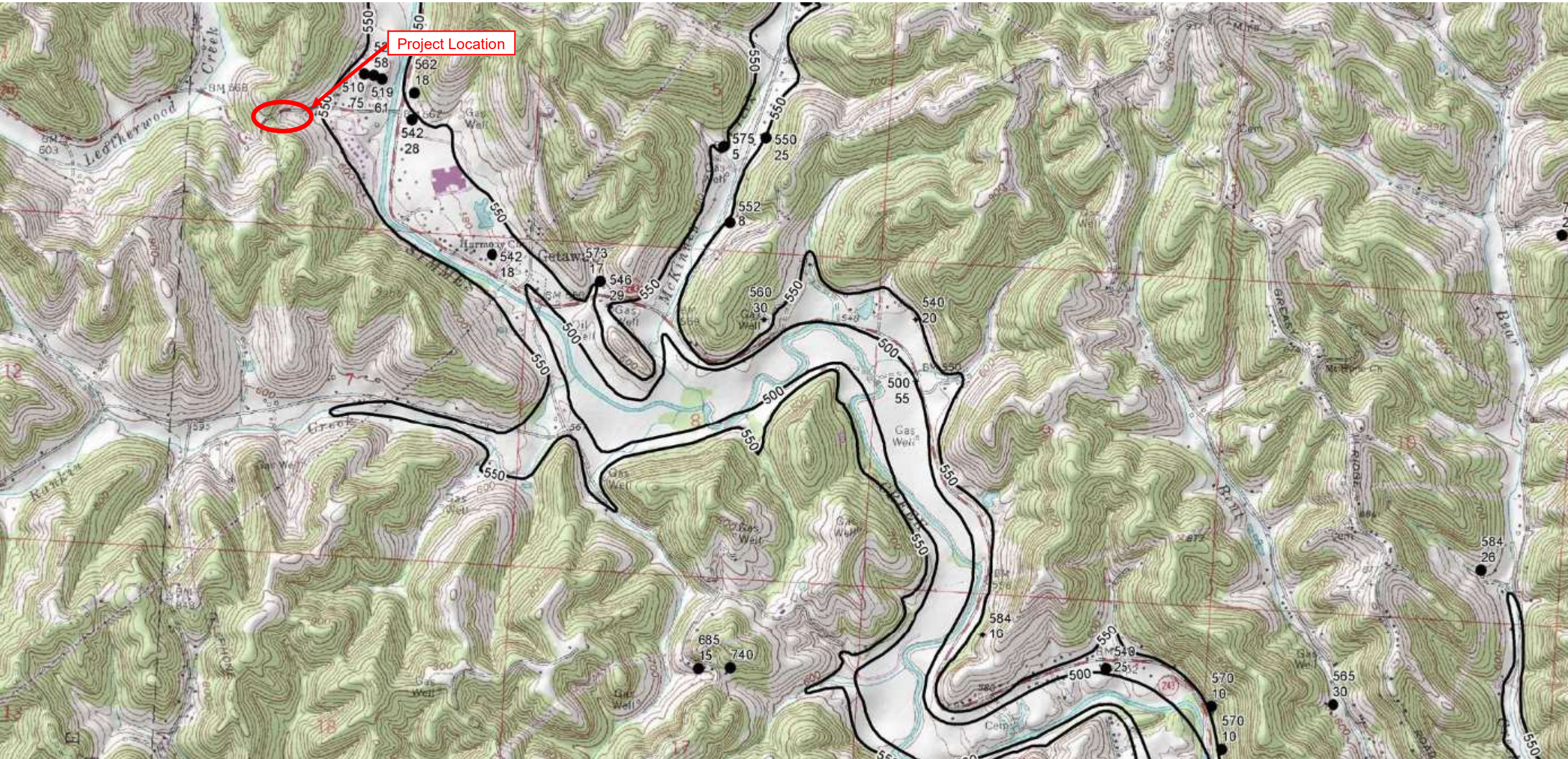
Counties



ODNR - Div. of Geosurvey

- Title: Ohio Geology Interactive Map
- Publishing Organization: [Ohio Department of Natural Resources, Division of Geological Survey](https://gis.ohiodnr.gov/website/dgs/geologyviewer/)
- URL: <https://gis.ohiodnr.gov/website/dgs/geologyviewer/>
- Accessed: August 18, 2025

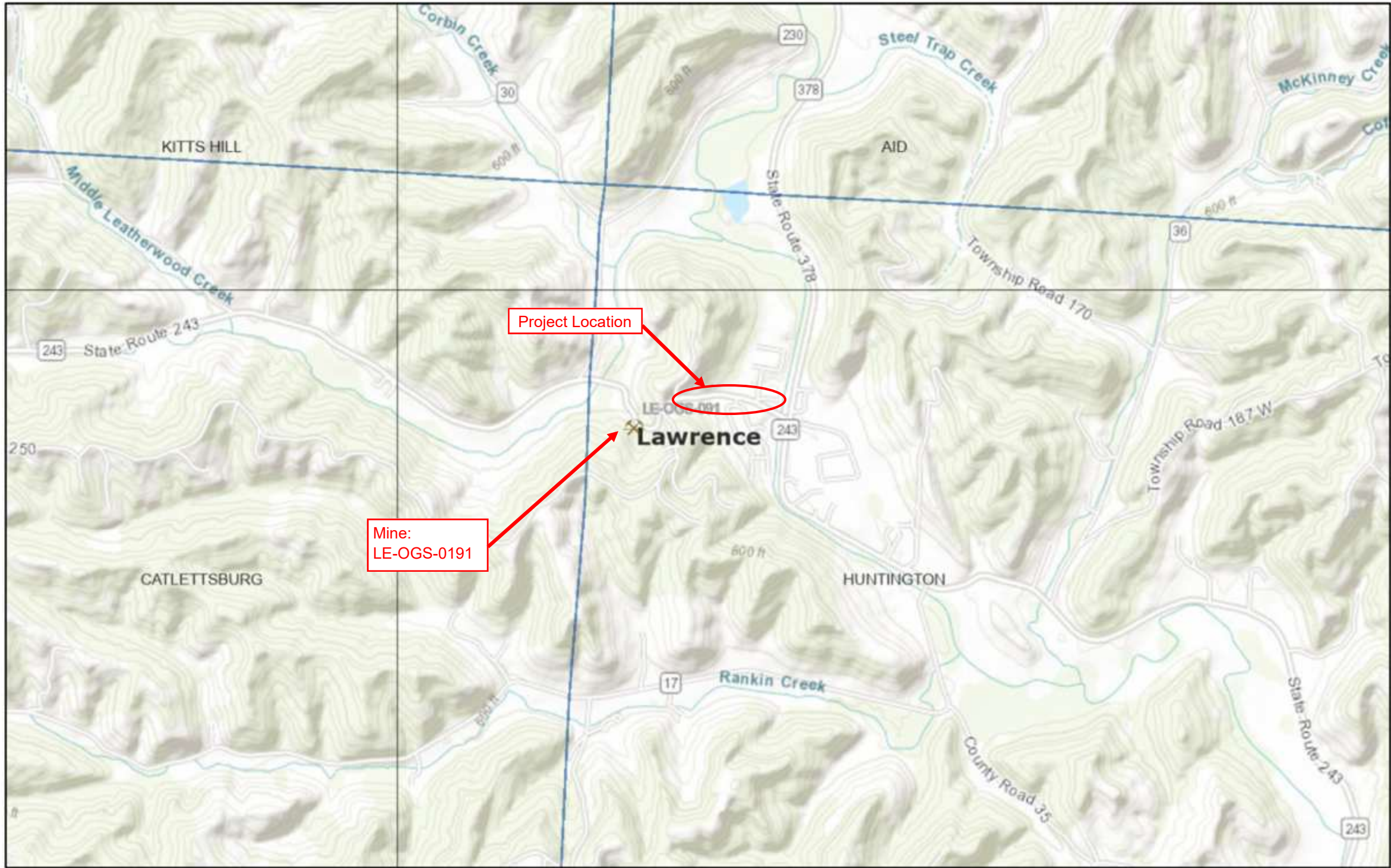
Calculated: AKB	Exhibit No. 5 : Bedrock Geology Map	Project: LAW-243-11.28
Checked: DCM		PID: 123191



LOCATION MAP

- **Title:** Bedrock topography of the Huntington, W. Va.-Ohio, quadrangle
- **Author(s):** Link, R.T.
- **Publishing Organization:** [Ohio Department of Natural Resources, Division of Geological Survey](#)
- **Series and Number:** Digital Map Series BT-3B Huntington
- **Publication Date:** 1997

Calculated: AKB	Exhibit No. 6 : Bedrock Topography Map	
Checked: DCM		
Project: LAW-243-11.28		PID: 123191

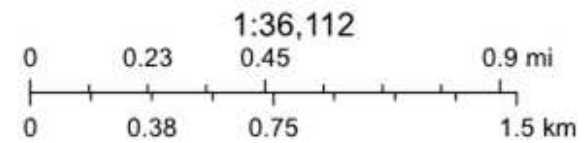


September 2, 2025

Quadrangle 24K (7.5 min)



Locations



VITA, West Virginia GIS, Esri, HERE, Garmin, INCREMENT P, USGS, METI/ NASA, NGA, EPA, USDA

Ohio Dept. of Natural Resources

- Title: Mines of Ohio Interactive Map
- Publishing Organization: [Ohio Department of Natural Resources, Division of Geological Survey](https://gis.ohiodnr.gov/MapViewer/?config=OhioMines)
- URL: <https://gis.ohiodnr.gov/MapViewer/?config=OhioMines>
- Accessed: September 2, 2025

Calculated: AKB

Checked: DCM

Exhibit No. 7a : Mine Map

Project: LAW-243-11.28

PID: 123191

Stratigraphic Section for Historic Mine LE-OGS-091

745/
Page 15

Field No. Page 15

Measured by D. Dale Condit

Date 1911

Stripped _____

STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

File No. 10344
County Lawrence
Township Union
Section SE - 6
Ref. GSO Bull. 17, p. 73
HUNTINGTON 7 1/2'
Quad. Guandot 15'
1 = 2,000,500
4 = 180,500

STRATIGRAPHIC SECTION

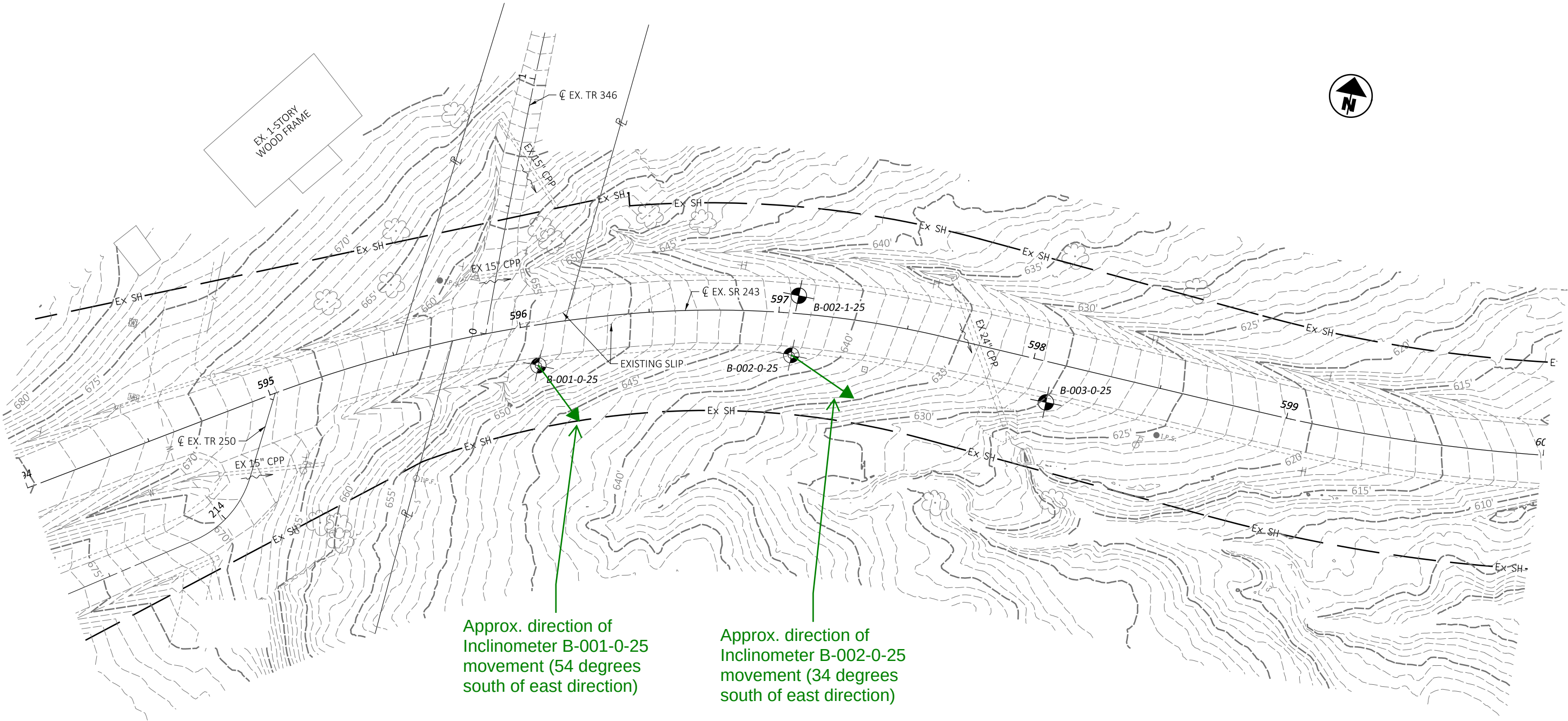
Exposures of the Cambridge and Brush Creek limestones and the Wilgus coal were found on the Alfred Ward farm, in section 6, Union Township. The coal, with a reported thickness of 1 to 3 feet, had been mined here and at other localities near Getaway. The following measurement was made on the Ward farm:

THE DIVISION OF GEOLOGICAL SURVEY MAKES NO AFFIRMATION CONCERNING THE COMPLETENESS AND ACCURACY OF THIS INFORMATION.

20. Sandstone, unmeasured.			
19. Shale.	.12	0	
18. Sandstone, coarse-grained.	.40	0	
17. Carbonaceous streak.			
16. Shale.	.21	0	14
15. Sandstone, conglomeratic near base	.20	0	5
14. Interval	.53	0	7
13. Shale, sandy	.20	0	0
12. Clay.	.5	0	0
11. Ferruginous, calcareous, sandy rock.	3	0	0
10. Sandstone	.9	0	0
9. Clay shale, red and gray	.20	0	0
8. Limestone, gray, non-fossiliferous	1	6	0
7. Carbonaceous streak.			
6. Shale and red clay.	.51	0	7
5. Limestone, <u>Cambridge</u> , fossiliferous.	0	10	0
4. Shale.	5	0	0
3. Coal, <u>Wilgus</u>	1	6	130,440
2. Shale.	.12	0	4
1. Limestone, <u>Brush Creek</u> , fossiliferous.	0	10	0

STOUT & LAMBORN, 1924		STOUT, 1931
CONNELLSVILLE Ss.	UPPER DIVISION	CONNELLSVILLE Ss.
CLARKSBURG Coal		CLARKSBURG Coal
MORGANTOWN Ss.		MORGANTOWN Ss.
		ELKLICK Coal
		ELKLICK Ls. & Sh.
		BIRMINGHAM Sh.
		SKELLEY Ls.
		DUQUESNE Coal
		GAYSPORT Ls.
		AMES Ls.
AMES Ls.	CONEMAUGH SERIES	AMES Ls.
HARLEM Coal		HARLEM Coal
ROUND KNOB Sh.		ROUND KNOB Sh.
		SALTZBURG Ss.
		BARTON Coal
		EWING Ls.
		COW RUN Ss.
		PORTERSVILLE Ls.
ANDERSON Coal		ANDERSON Coal
		BLOOMFIELD Ls.
CAMBRIDGE Ls.	MIDDLE DIVISION	CAMBRIDGE Ls.
WILGUS Coal		WILGUS Coal
		BUFFALO Sh. & Ss.
BRUSH CREEK Ls.		BRUSH CREEK Ls.
BRUSH CREEK Coal		BRUSH CREEK Coal
MASON Coal		MASON Coal
UPPER MAHONING Ss.		UPPER MAHONING Ss.
MAHONING Coal		MAHONING (or GROFF) Coal
MAHONING or THORNTON Clay		THORNTON Clay
MAHONING Ls.		MAHONING Ls.
LOWER MAHONING Ss.		LOWER MAHONING Ss.
UPPER FREEPORT (or No. 7) Coal		UPPER FREEPORT (or No. 7) Coal
UPPER FREEPORT Ls.		UPPER FREEPORT Ls.

- Title: Historic Nomenclature of Lower Pennsylvanian Stratigraphy in Ohio
- Author(s): Larsen, G.E.
- Publishing Organization: [Ohio Division of Geological Survey](#)
- Series and Number: Open File Report 2015-2
- Publication Date: 2015



Approx. direction of
Inclinometer B-001-0-25
movement (54 degrees
south of east direction)

Approx. direction of
Inclinometer B-002-0-25
movement (34 degrees
south of east direction)



EXHIBIT NO. 8: BORING LOCATION PLAN
LAW-243-11.28

DESIGN AGENCY



DESIGNER

AKB

REVIEWER

DMV 09/11/25

PROJECT ID

123191

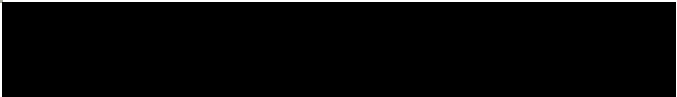
SHEET

1

TOTAL

1





Appendix B. Boring Logs, Rock Core Photos, and Inclinometer Data



Boring Logs

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS		DRILL RIG: DIEDRICH D-50		STATION / OFFSET: 596+05, 16' RT.				EXPLORATION ID B-001-0-25											
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB		HAMMER: AUTOMATIC HAMMER		ALIGNMENT: SR 243															
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 6/24/24		ELEVATION: 653.4 (MSL) EOB: 54.5 ft.				PAGE 1 OF 2											
START: 4/18/25 END: 4/21/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.9		LAT / LONG: 38.494916, -82.483383															
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	INCL.
			653.4								GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (2")			653.3			2															
VERY LOOSE, DARK BROWN, GRAVEL WITH SAND, LITTLE SILT, TRACE CLAY, TRACE ORGANICS, DAMP			651.9	1		2 1	4	11	SS-1	-	41	21	15	17	6	NP	NP	NP	9	A-1-b (0)	
SOFT TO MEDIUM STIFF, DARK BROWN, CLAY, SOME SAND, SOME SILT, LITTLE GRAVEL, DAMP			650.4	2		2 1 2	4	67	SS-2	0.75	17	13	13	27	30	42	22	20	22	A-7-6 (9)	
VERY SOFT TO SOFT, BROWN, SILT AND CLAY, SOME GRAVEL, SOME SAND, DAMP			648.9	3		2 1 2	4	39	SS-3	0.00	26	18	13	28	15	36	25	11	19	A-6a (2)	
SOFT, BROWN, SILTY CLAY, SOME SAND, LITTLE GRAVEL, MOIST				4		2 1 2	4	50	SS-4	0.25	-	-	-	-	-	-	-	-	23	A-6b (V)	
@4.5' - 6.0': trace water at bottom of spoon				5		2 1 2	4														
@6.6' - 7.1': qu = 803 psf				6																	
			644.9	7				38	ST-5	0.00	16	12	12	27	33	40	21	19	22	A-6b (9)	
				8																	
SOFT TO MEDIUM STIFF, BROWN, SILT AND CLAY, SOME SAND, TRACE LIMESTONE FRAGMENTS, DAMP				9		1 2 3	7	100	SS-6	0.25	5	14	15	38	28	34	21	13	21	A-6a (7)	
			641.9	10		2 2 2	5	72	SS-7	0.25	-	-	-	-	-	-	-	-	17	A-6a (V)	
STIFF TO VERY STIFF, RED-BROWN, CLAY, SOME SAND, SOME SILT, TRACE STONE FRAGMENTS, DAMP			640.4	11		2 4 6	13	72	SS-8	3.25	5	15	8	34	38	46	26	20	18	A-7-6 (13)	
VERY STIFF TO HARD, RED-BROWN, CLAY, "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, DAMP				12		5 11 20	42	100	SS-9	2.75	3	5	4	43	45	48	25	23	13	A-7-6 (15)	
			637.4	13		12 18 17	47	83	SS-10	-	-	-	-	-	-	-	-	-	13	A-7-6 (V)	
HARD, RED-BROWN, CLAY, "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, DAMP				14		12 21 32	71	100	SS-11	4.25	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
				15		20 32 40	97	100	SS-12	4.5+	1	1	2	41	55	48	25	23	11	A-7-6 (15)	
			631.4	16		22 32 47	107	100	SS-13	4.5+	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
HARD, BROWN, TRACE GRAY AND PURPLE, CLAY, SOME SILT, TRACE SAND, DAMP				17		27 28 35	85	100	SS-14	-	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
				18		13 27 35	84	100	SS-15	-	-	-	-	-	-	-	-	-	12	A-7-6 (V)	
			626.9	19		20 30 29	80	72	SS-16	-	0	1	0	28	71	51	26	25	14	A-7-6 (16)	
				20		20 40 50/5"	-	100	SS-17	-	-	-	-	-	-	-	-	-	12	A-7-6 (V)	
CLAYSTONE, BROWN TRACE GRAY, SEVERELY WEATHERED, VERY WEAK.				TR		26															
				27		30 50/6"	-	100	SS-18	-	-	-	-	-	-	-	-	-	13	Rock (V)	
				28		30 50/3"	-	100	SS-19	-	-	-	-	-	-	-	-	-	9	Rock (V)	
				29		40															

[illegible]

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/10/25 12:56 - C:\P\WORKING\EAST01\D442335\LAW-243-11.28 BORING LOGS.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER.

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS		DRIILL RIG: DIEDRICH D-50		STATION / OFFSET: 597+06, 16' RT.				EXPLORATION ID B-002-0-25									
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB		HAMMER: AUTOMATIC HAMMER		ALIGNMENT: SR 243													
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 6/24/24		ELEVATION: 641.9 (MSL) EOB: 46.5 ft.				PAGE 1 OF 2									
START: 4/17/25 END: 4/21/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.9		LAT / LONG: 38.494980, -82.483052													
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	INCL.
									GR	CS	FS	SI	CL	LL	PL	PI	WC		
TOPSOIL (2")		641.7		2															
SOFT TO MEDIUM STIFF, DARK BROWN TO BROWN, SILT AND CLAY, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP			1	1	4	44	SS-1	1.00	-	-	-	-	-	-	-	-	21	A-6a (V)	
			2	2															
			2	1	5	56	SS-2	0.25	16	21	15	25	23	35	20	15	18	A-6a (4)	
			3	3															
			4	2	4	50	SS-3	0.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
		636.9		1															
MEDIUM STIFF TO STIFF, DARK BROWN TO BROWN, CLAY, "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		634.9	5			58	ST-4	1.25	1	8	8	36	47	50	26	24	26	A-7-6 (16)	
@5.4' - 5.9': qu = 1990 psf			6																
MEDIUM STIFF TO STIFF, BROWN, SILT AND CLAY, SOME SAND, LITTLE STONE FRAGMENTS, DAMP		633.4	7	2															
@7.0' - 8.5': trace water in sample			8	3	9	67	SS-5	0.50	14	12	12	34	28	31	20	11	19	A-6a (6)	
			9	4															
MEDIUM STIFF TO STIFF, BROWN, SILTY CLAY, SOME SAND, LITTLE STONE FRAGMENTS, DAMP		631.9	10	2	8	61	SS-6	2.00	12	15	10	33	30	37	21	16	18	A-6b (8)	
			11	3															
STIFF, RED-BROWN, CLAY, SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		630.4	12	3	9	67	SS-7	1.25	8	8	3	23	58	56	25	31	19	A-7-6 (19)	
			13	5															
VERY STIFF TO HARD, GRAY TO PURPLE, CLAY, "AND" SILT, TRACE SAND, DAMP			14	2	20	72	SS-8	2.00	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
		627.4	15	6															
			16	9															
			17	5	34	78	SS-9	3.75	0	0	1	36	63	49	25	24	17	A-7-6 (15)	
			18	10															
			19	15	32	100	SS-10	4.00	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
			20	10															
			21	20	69	78	SS-11	-	-	-	-	-	-	-	-	-	10	A-7-6 (V)	
			22	31															
			23	10	116	100	SS-12	4.50	3	3	5	50	39	41	22	19	9	A-7-6 (12)	
			24	38															
			25	48															
			26	30															
			27	45															
			28	50/4"	-	100	SS-13	-	-	-	-	-	-	-	-	-	9	A-7-6 (V)	
			29	23															
			30	30															
		619.9	31	50/4"	-	100	SS-14	4.5+	-	-	-	-	-	-	-	-	8	A-7-6 (V)	
			32	50/5"	-	100	SS-15	-	-	-	-	-	-	-	-	-	10	Rock (V)	
CLAYSTONE, BROWN TO BROWN-GRAY, SEVERELY WEATHERED, VERY WEAK.			33																
			34																
			35	36															
			36	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	7	Rock (V)	
			37																
			38																
			39	50/5"	-	100	SS-17	-	-	-	-	-	-	-	-	-	6	Rock (V)	
		615.4	40																
			41																
CLAYSTONE, BROWN, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 26%, REC 100%.		612.6	42																
		611.9	43																
			44	20		100	NQ2-1											CORE	

MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	INCL.
									GR	CS	FS	SI	CL	LL	PL	PI			
@27.8' - 28.1': qu = 105 psi CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 0%, REC 100%. SILTSTONE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 54%, REC 98%. @32.2' - 32.3': 1" red brown claystone seam @36.7' - 38.1': highly fractured @38.3' - 39.3': qu = 1061 psi (point load test)																			

PROJECT: <u>LAW-243-11.28</u>	DRILLING FIRM / OPERATOR: <u>HDR / TS</u>	DRILL RIG: <u>DIEDRICH D-50</u>	STATION / OFFSET: <u>597+07, 7' LT.</u>	EXPLORATION ID <u>B-002-1-25</u>
TYPE: <u>LANDSLIDE</u>	SAMPLING FIRM / LOGGER: <u>CENTRAL STAR / AKB</u>	HAMMER: <u>AUTOMATIC HAMMER</u>	ALIGNMENT: <u>SR 243</u>	
PID: <u>123191</u> SFN: <u> </u>	DRILLING METHOD: <u>2.25" HSA</u>	CALIBRATION DATE: <u>6/24/24</u>	ELEVATION: <u>642.7 (MSL)</u> EOB: <u>28.8 ft.</u>	PAGE 1 OF 1
START: <u>4/16/25</u> END: <u>4/16/25</u>	SAMPLING METHOD: <u>SPT</u>	ENERGY RATIO (%): <u>80.9</u>	LAT / LONG: <u>38.495043, -82.483058</u>	

[illegible]

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS		DRILL RIG: DIEDRICH D-50		STATION / OFFSET: 598+08, 15' RT.		EXPLORATION ID: B-003-0-25												
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB		HAMMER: AUTOMATIC HAMMER		ALIGNMENT: SR 243		PAGE 1 OF 2												
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 6/24/24		ELEVATION: 629.8 (MSL) EOB: 41.0 ft.														
START: 4/16/25 END: 4/17/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.9		LAT / LONG: 38.494985, -82.482704														
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
		629.8								GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (2")		629.6			3															
MEDIUM STIFF TO STIFF, RED-BROWN, BROWN, AND GRAY, SILTY CLAY , SOME STONE FRAGMENTS, SOME SAND, DAMP (FILL)		628.3	1		2	7	72	SS-1	1.75	27	16	10	22	25	38	22	16	18	A-6b (4)	
			2		3															
STIFF, BROWN AND DARK BROWN, SILTY CLAY , SOME STONE FRAGMENTS, SOME SAND, NOTED ORGANIC ODOR, DAMP (FILL)		626.5	3		2	11	83	SS-2	1.50	27	18	11	20	24	40	21	19	18	A-6b (4)	
			4		6															
MEDIUM STIFF TO STIFF, RED-BROWN AND GRAY, CLAY , "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		623.8	5		2	7	83	SS-3	1.00	2	8	6	36	48	46	24	22	23	A-7-6 (14)	
			6		3															
SOFT TO MEDIUM STIFF, BROWN TO RED-BROWN, CLAY , SOME SAND, SOME SILT, TRACE STONE FRAGMENTS, MOIST		621.8	7		2	5	78	SS-4	0.25	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
			8		2															
@6.5': trace water in sand seams			9		1	4	100	SS-5	0.50	7	13	9	28	43	48	25	23	26	A-7-6 (14)	
			10		2															
MEDIUM STIFF TO STIFF, LIGHT BROWN TO RED-BROWN, CLAY , SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		616.8	11				67	ST-6	1.50	5	5	6	26	58	59	26	33	27	A-7-6 (20)	
			12		3															
@8.6' - 9.1': qu = 1414 psf			13		3	9	67	SS-7	1.75	-	-	-	-	-	-	-	-	27	A-7-6 (V)	
			14		4															
HARD, BROWN AND DARK BROWN, CLAY , "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		613.8	15		3	16	78	SS-8	2.25	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
			16		7															
			17		13	62	100	SS-9	4.5+	6	7	6	41	40	46	27	19	13	A-7-6 (13)	
			18		15															
			19		13	-	81	SS-10	4.5+	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
			20		20															
CLAYSTONE, BROWN, SEVERELY WEATHERED, VERY WEAK, ARENACEOUS.		610.8	21		50/6"	-	100	SS-11	-	-	-	-	-	-	-	-	-	6	Rock (V)	
			22																	
			23		50/4"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	Rock (V)	
			24																	
CLAYSTONE, BROWN, HIGHLY TO SEVERELY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 15%, REC 87%.		601.8	25		0		78	NQ2-1											CORE	
			26																	
			27																	
			28		22		97	NQ2-2											CORE	
			29																	
			30																	
			31																	
			32		18		82	NQ2-3											CORE	
			33																	
			34																	
			35																	
			36																	
			37																	
			38																	
			39																	
			40																	
			41																	
			42																	
			43																	
			44																	
			45																	
			46																	
			47																	
			48																	
			49																	
			50																	
			51																	
			52																	
			53																	
			54																	
			55																	
			56																	
			57																	
			58																	
			59																	
			60																	
			61																	
			62																	
			63																	
			64																	
			65																	
			66																	
			67																	
			68																	
			69																	
			70																	
			71																	
			72																	
			73																	
			74																	
			75																	
			76																	
			77																	
			78																	
			79																	
			80																	
			81																	
			82																	
			83																	
			84																	
			85																	
			86																	
			87																	
			88																	
			89																	
			90																	
			91																	
			92																	
			93																	
			94																	
			95																	
			96																	
			97																	
			98																	
			99																	
			100																	

MATERIAL DESCRIPTION AND NOTES	ELEV. 599.8	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
CLAYSTONE , GRAY, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 58%, REC 94%. <i>(continued)</i> @30.2' - 30.7': limestone interbed, gray, slightly weathered, moderately strong @30.7' - 31.1': qu = 237 psi	598.5	31	73		97	NQ2-4										CORE		
		32																
		33																
		34																
SHALE , BLACK, MODERATELY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, CARBONACEOUS, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED SURFACE, INTACT OR MASSIVE STRUCTURE, FAIR TO GOOD SURFACE; RQD 48%, REC 93%. @34.8': becomes highly fractured to fractured, blocky	592.7	35	0		81	NQ2-5										CORE		
		36																
		37																
		38																
	590.5	39																
COAL , BLACK, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, HIGHLY FRACTURED,	588.8	40	60		90	NQ2-6										CORE		
		41																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/10/25 12:56 - C:\P\WORKING\EAST01\1D422335\LAW-243-11.28 BORING LOGS.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 47 LB. CEMENT; 50 GAL. WATER

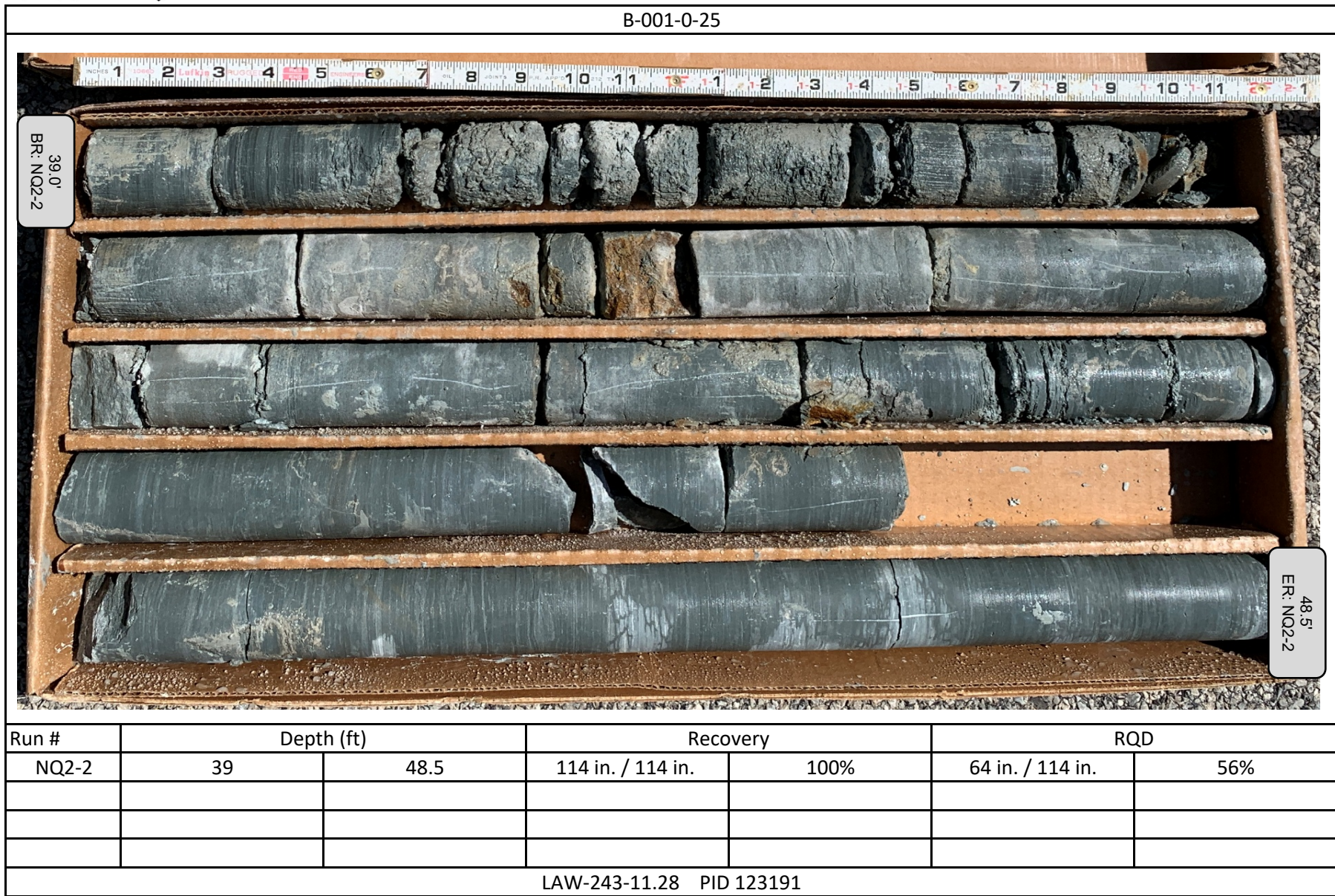


Rock Core Photos



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	34.5	39.0	54 in. / 54 in.	100%	23 in. / 54 in.	43%

LAW-243-11.28 PID 123191



Run #	Depth (ft)		Recovery		RQD	
NQ2-2	39	48.5	114 in. / 114 in.	100%	64 in. / 114 in.	56%

LAW-243-11.28 PID 123191

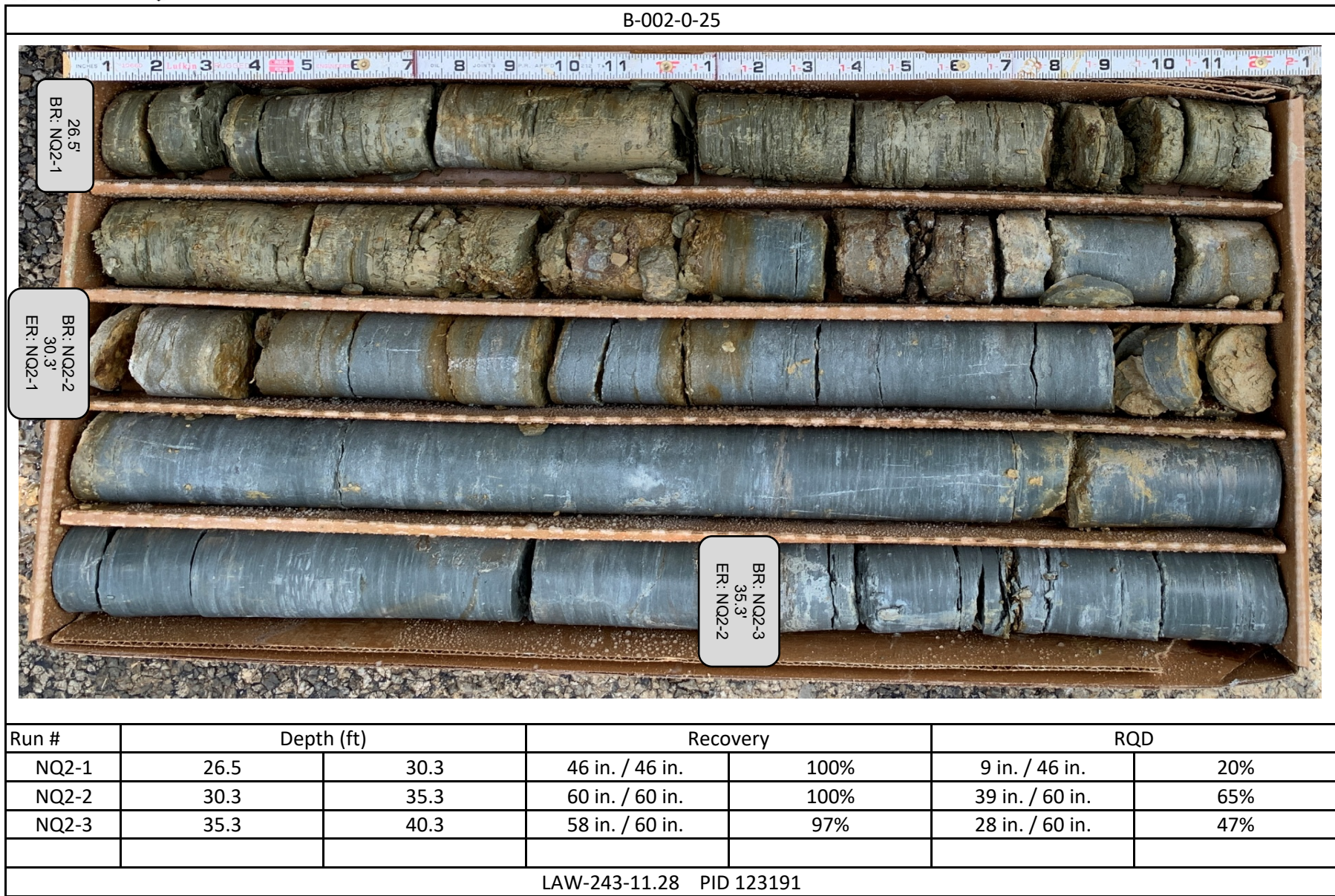


B-001-0-25



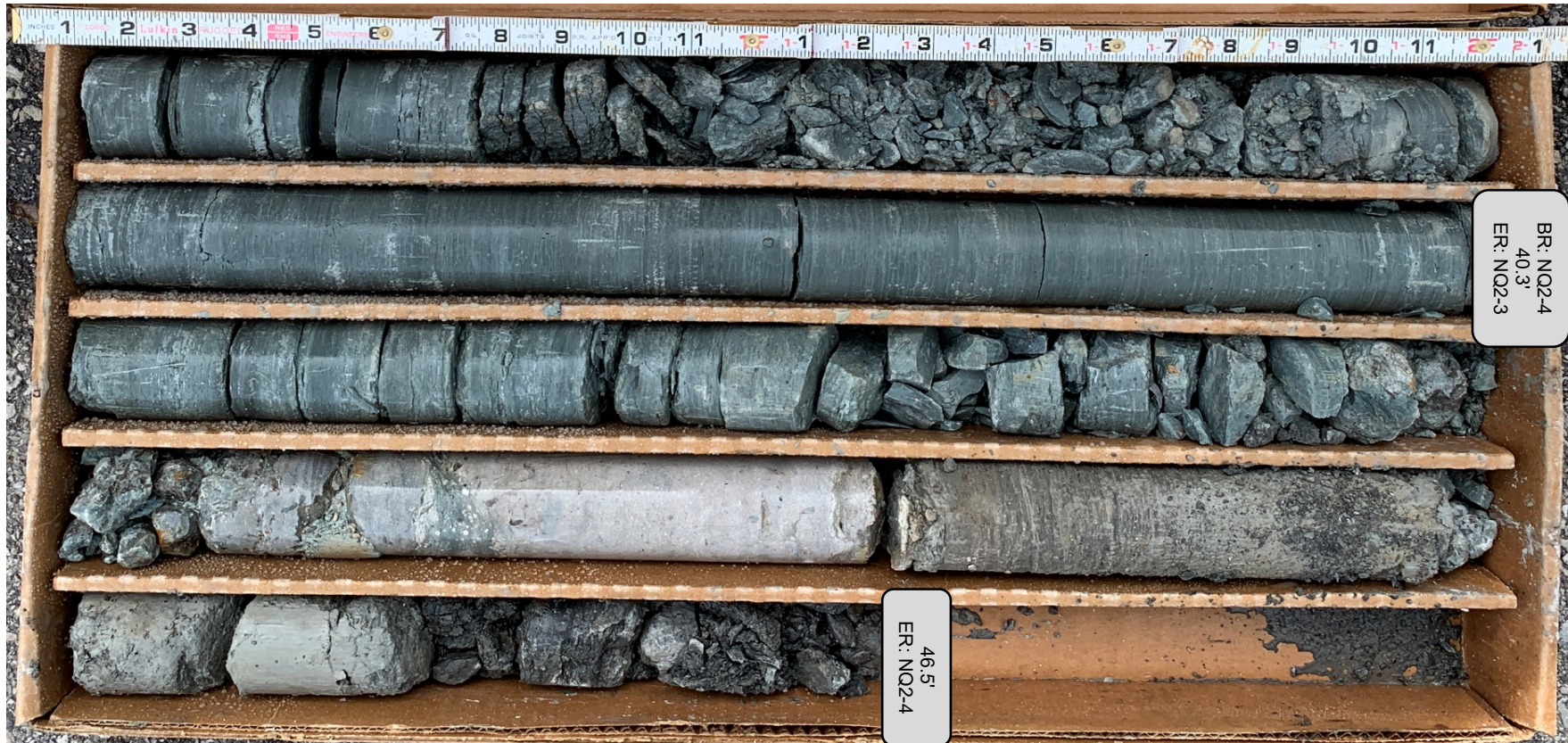
Run #	Depth (ft)		Recovery		RQD	
	48.5	54.5	59 in. / 72 in.	82%	13 in. / 72 in.	18%
NQ2-3						

LAW-243-11.28 PID 123191





B-002-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	35.3	40.3	58 in. / 60 in.	97%	28 in. / 60 in.	47%
NQ2-4	40.3	46.5	60 in. / 74 in.	81%	20 in. / 74 in.	27%

LAW-243-11.28 PID 123191



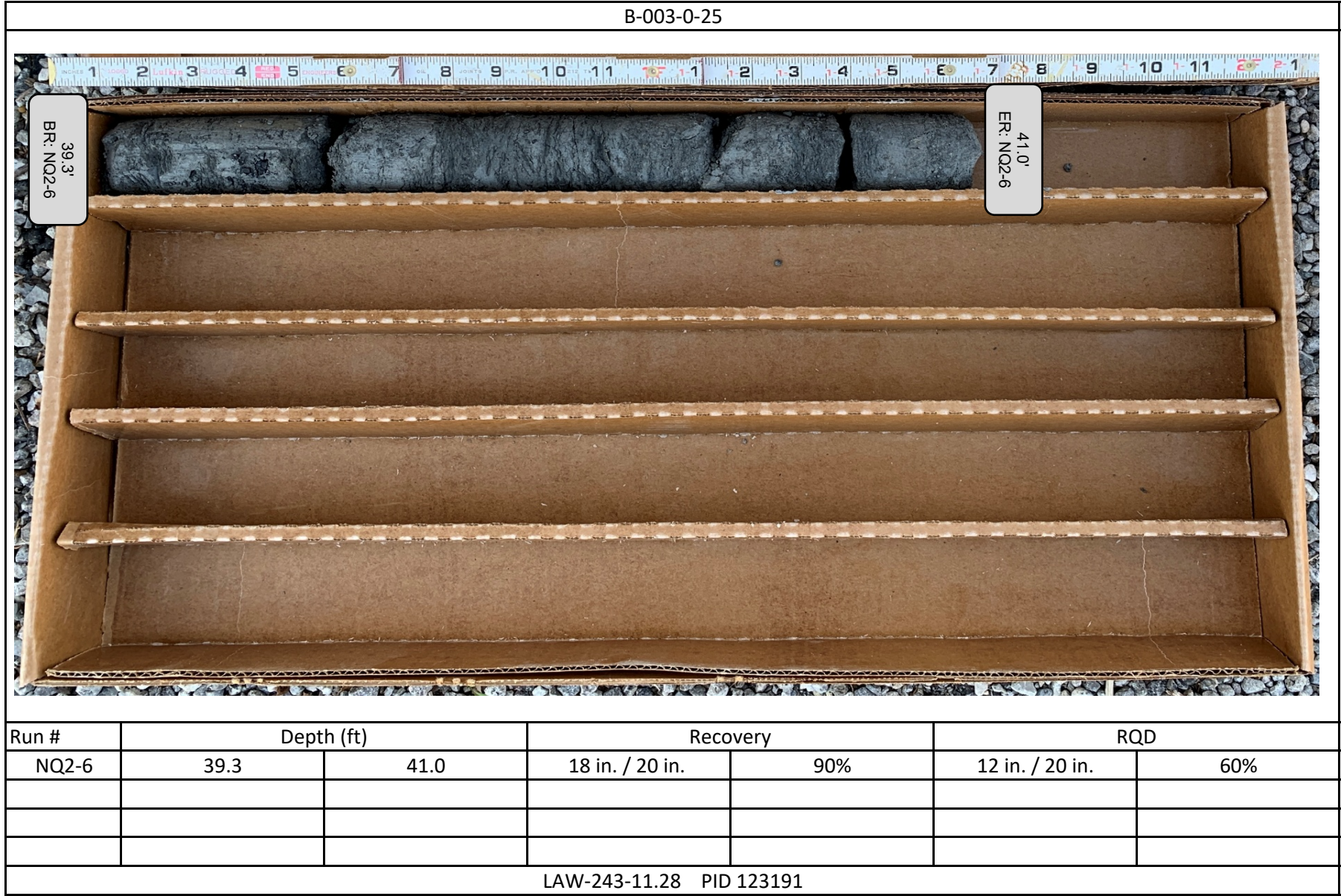


B-003-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-4	29.8	34.8	58 in. / 60 in.	97%	44 in. / 60 in.	73%
NQ2-5	34.8	39.3	44 in. / 54 in.	81%	0 in. / 54 in.	0%

LAW-243-11.28 PID 123191



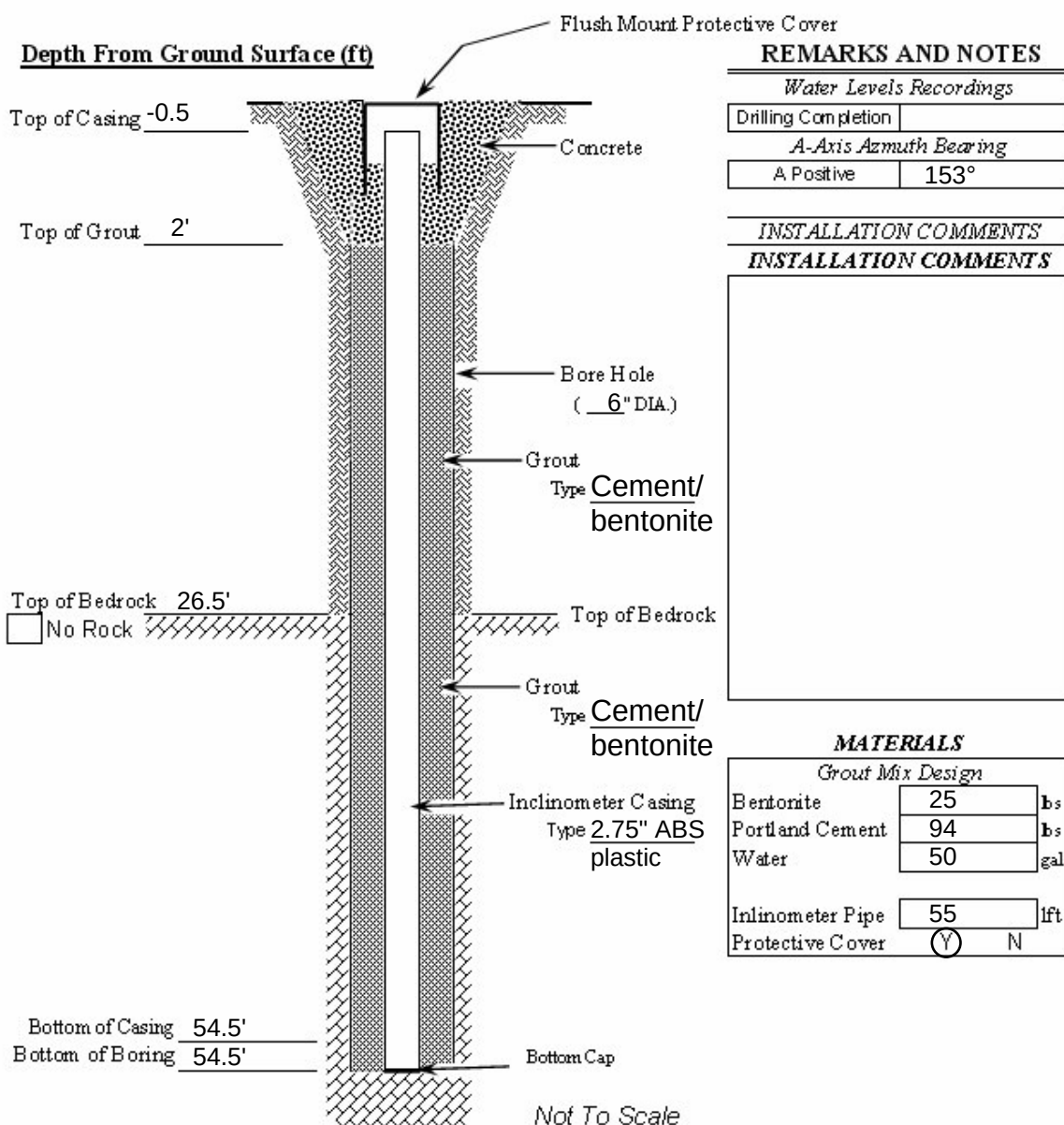


Inclinometer Logs and Plots



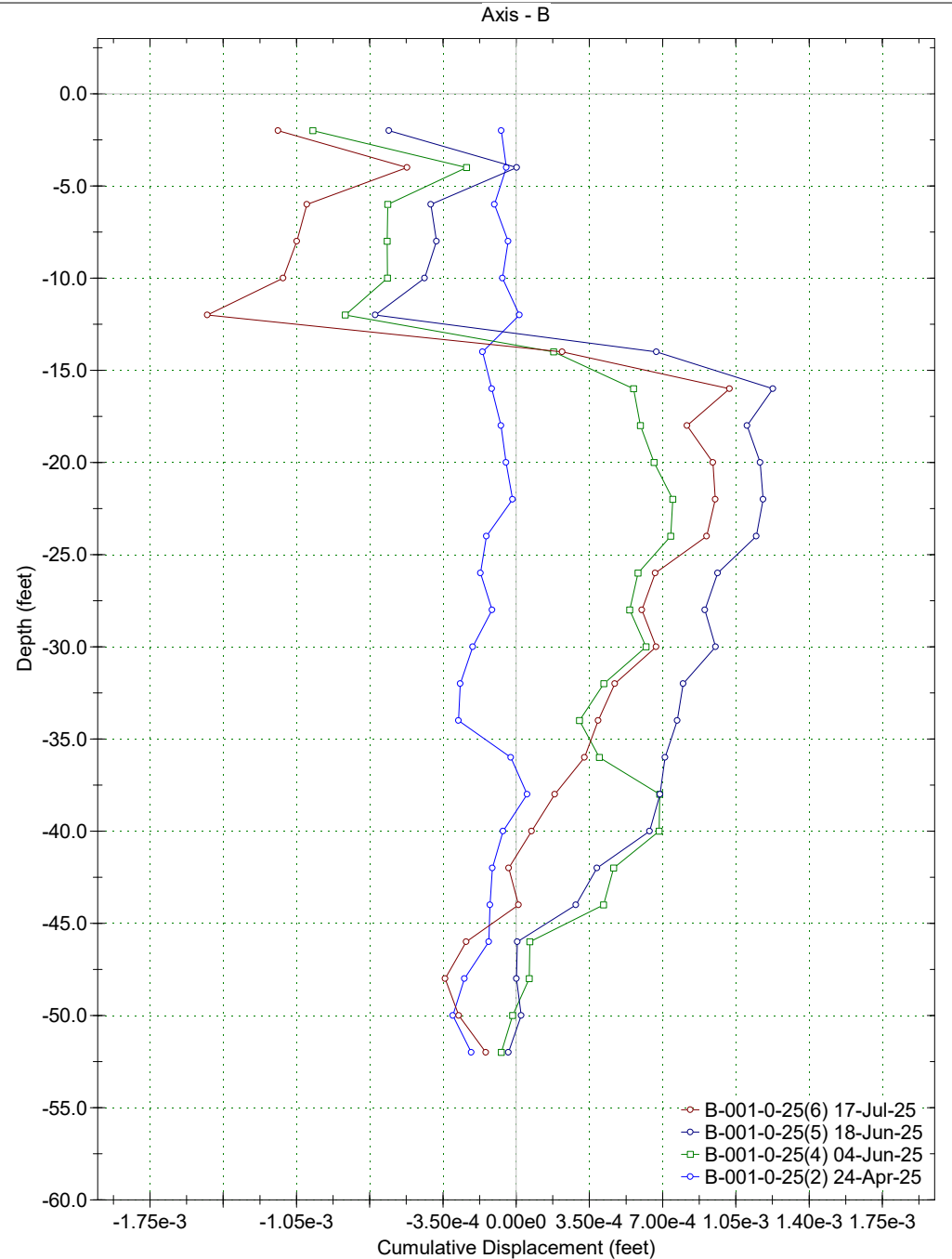
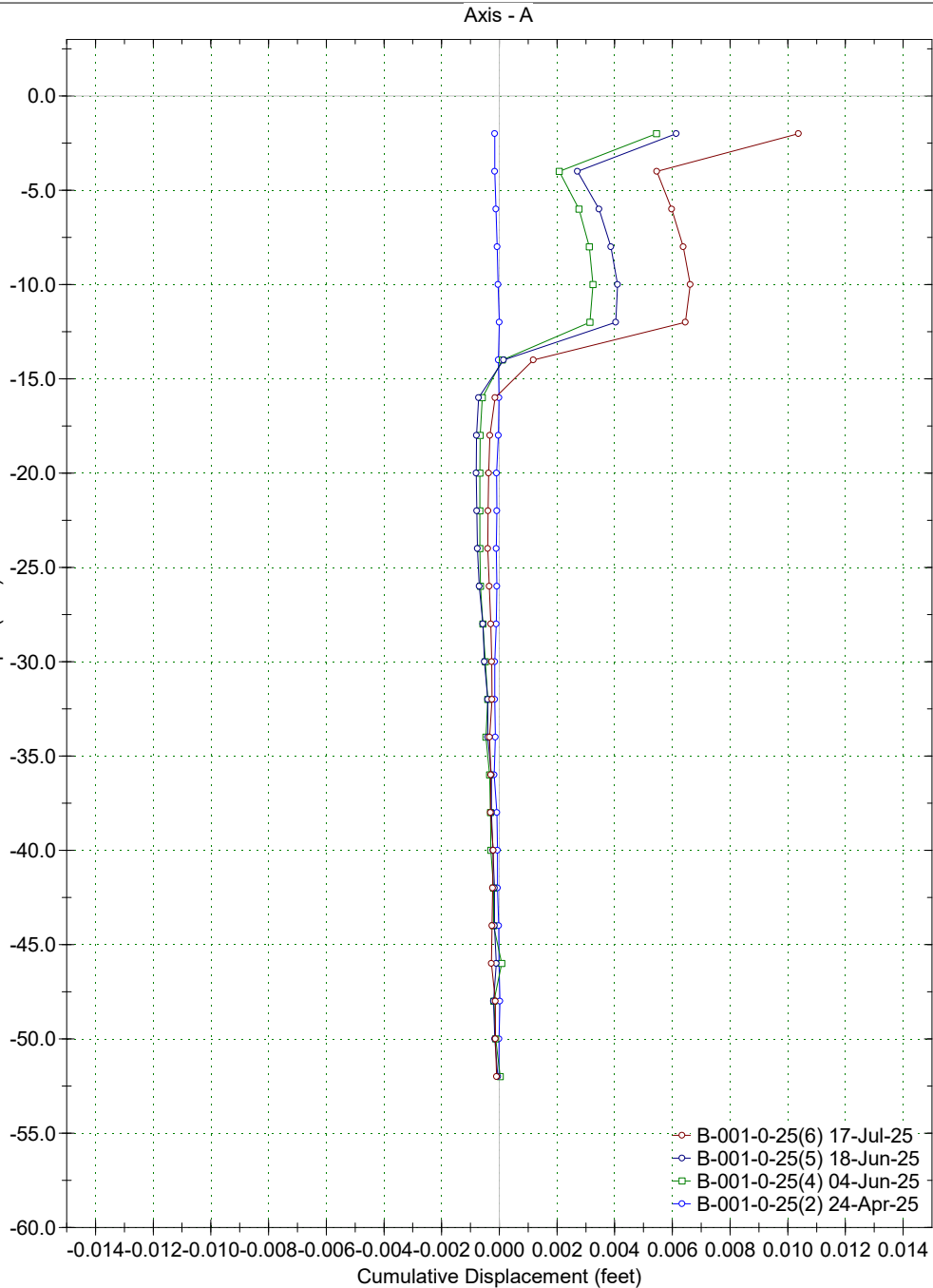
INCLINOMETER INSTALLATION REPORT

County-Route-Sect. LAW — 243 — 11.28 Piezometer Number B-001-0-25
PID Number 123191 Installation Date 4/18/25
Ground Elevation 653.4 Inspector Name A. Baratta
Location: Lat. 38.494916 Long. -82.483383
Station 596+05 Off-set 16' Off-set Direction Right



Borehole : B-001-25
Project : LAW-243-11.28
Location :
Northing :
Easting :
Collar :

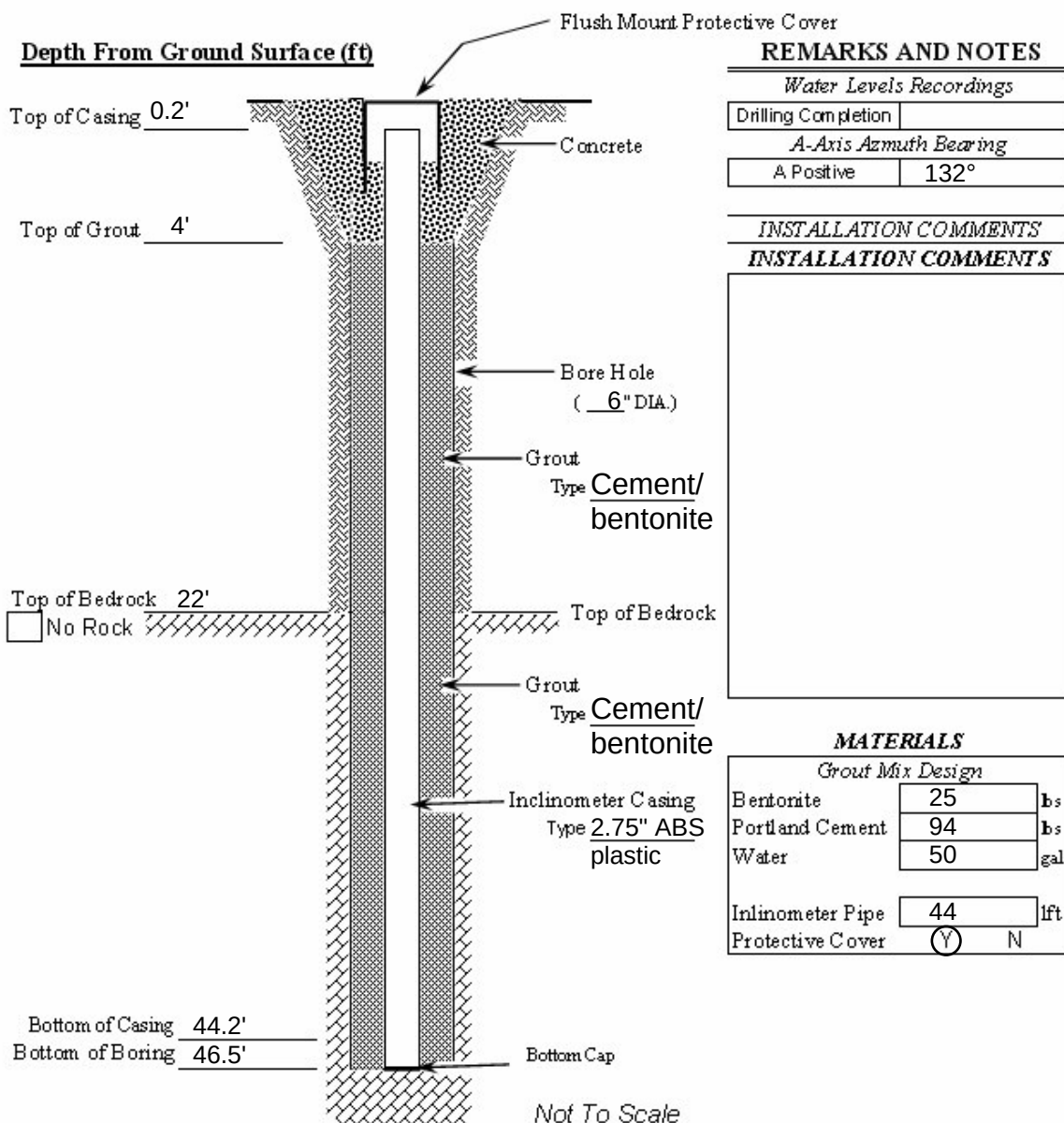
Spiral Correction : N/A
Collar Elevation : 0.00 feet
Reading Depth : 52.0 feet
A+ Groove Azimuth :
Base Reading : 2025 Apr 24 15:27
Applied Azimuth : 0.0 degrees





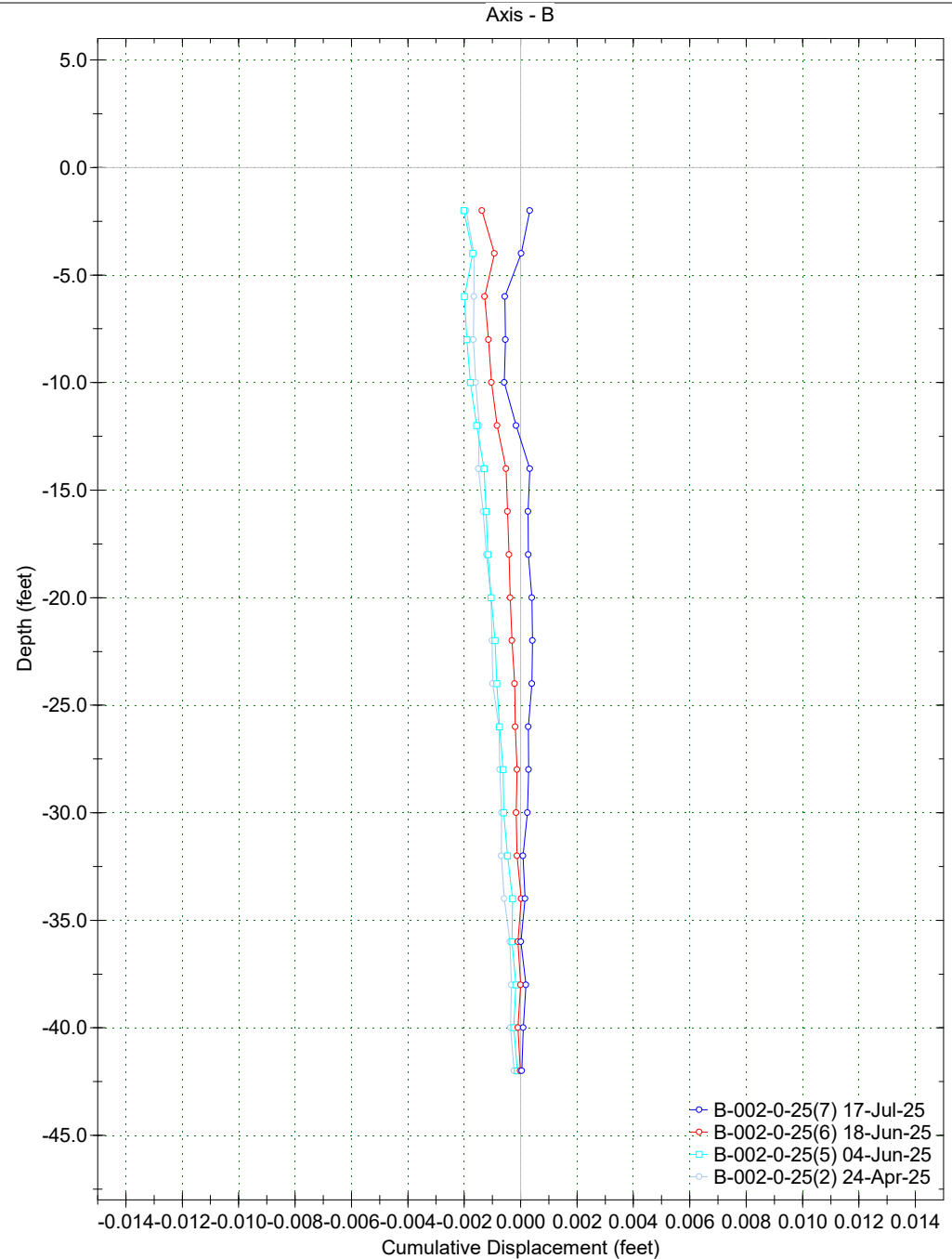
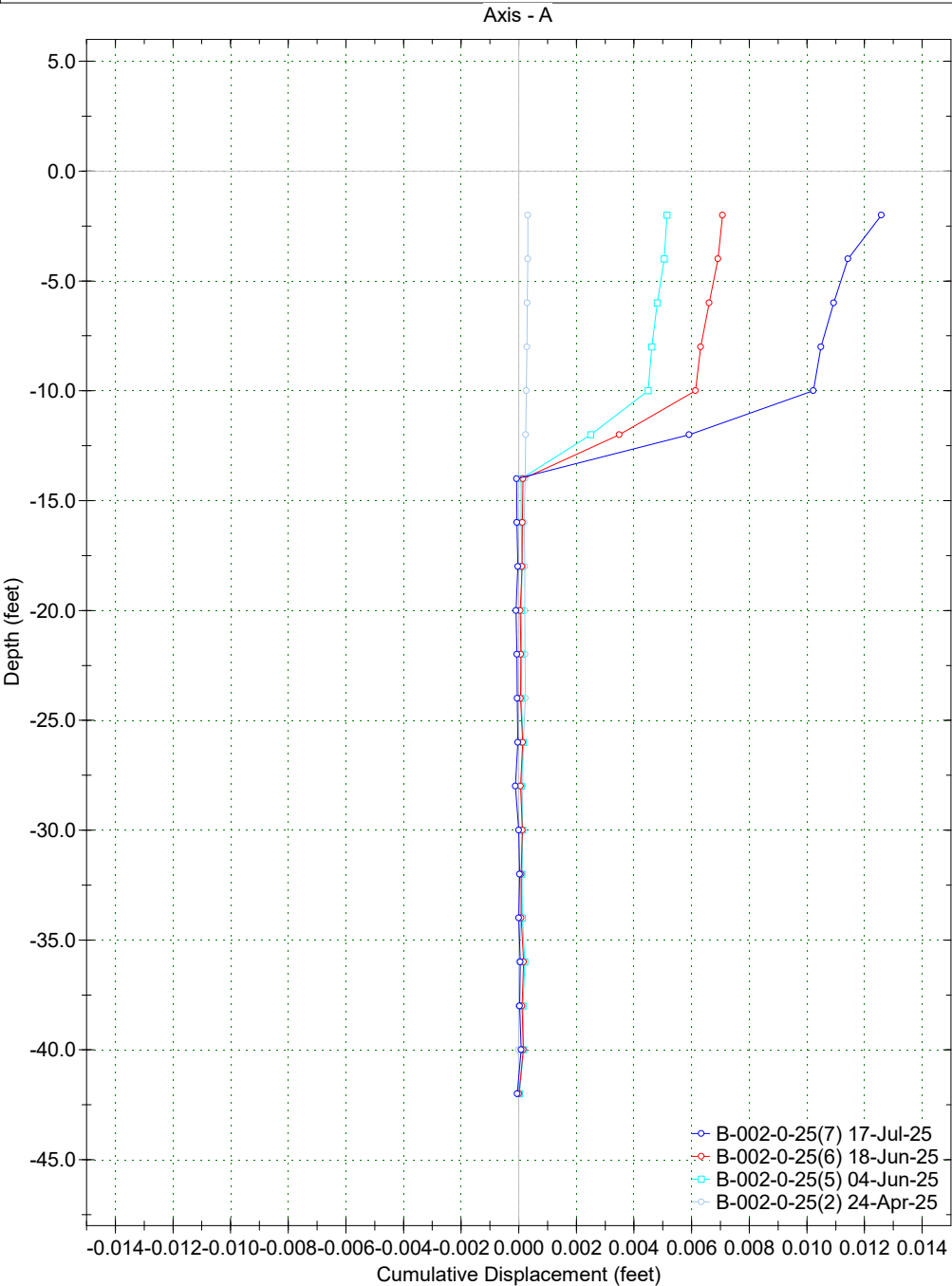
INCLINOMETER INSTALLATION REPORT

County-Route-Sect. LAW — 243 — 11.28 Piezometer Number B-002-0-25
PID Number 123191 Installation Date 4/17/25
Ground Elevation 641.9 Inspector Name A. Baratta
Location: Lat. 38.494980 Long. -82.483052
Station 597+06 Off-set 16' Off-set Direction Right



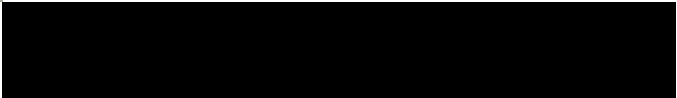
Borehole : B-002-25
Project : LAW-243-11.28
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 feet
Reading Depth : 42.0 feet
A+ Groove Azimuth :
Base Reading : 2025 Apr 24 14:41
Applied Azimuth : 0.0 degrees





Appendix C. Laboratory Testing





Soil Unconfined Compressive Strength (ASTM D2166)

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-001-0-25, ST-5, Depth: 6.6-7.1 ft)

Tested Date: 5/7/2025

Specimen Properties

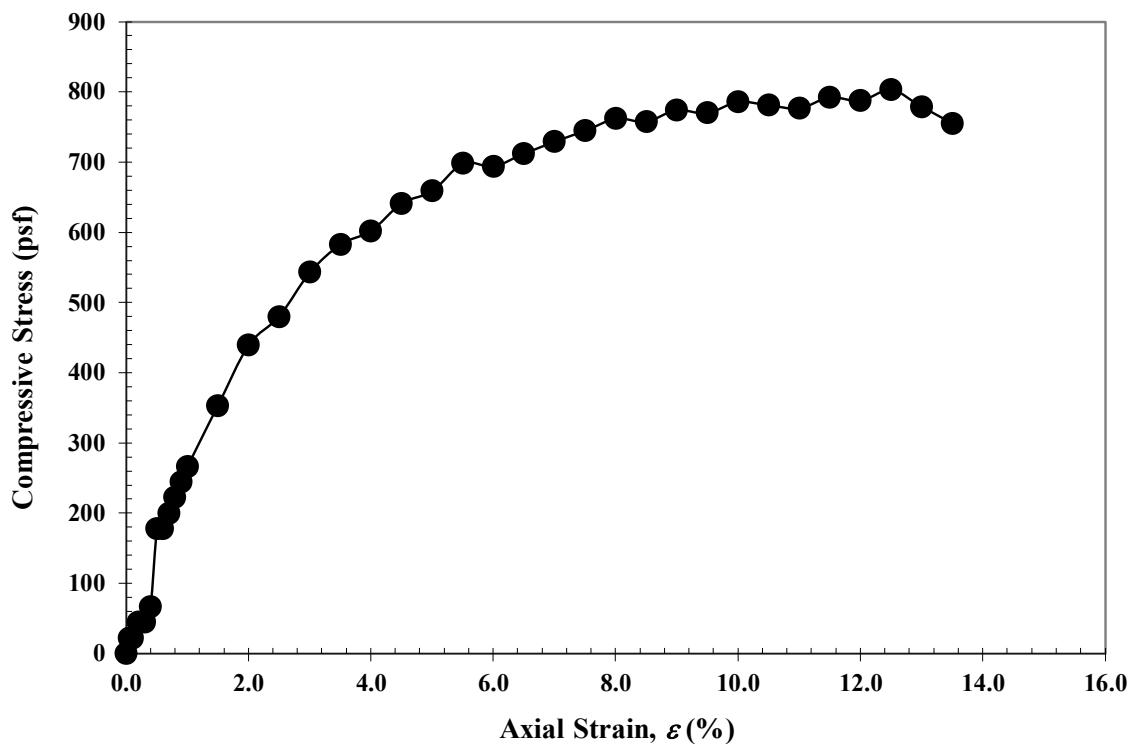
Average Dia., D_{avg} (in):	2.86
Average Height, H_{avg} (in):	5.71
Area, A (in ²):	6.43
Volume, V (in ³):	36.75
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	23.2
Dry Mass of Specimen (lb):	2.2
Wet Unit Weight, γ (lb/ft ³):	128.1
Dry Unit Weight, γ_d (lb/ft ³):	104.0

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	803
Strain (%):	12.5



Notes: Soft, brown, SILTY CLAY, some sand, little gravel, moist. Specimen contains gravel >1/6 specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-002-0-25, ST-4, Depth: 5.4-5.9 ft)

Tested Date: 5/8/2025

Specimen Properties

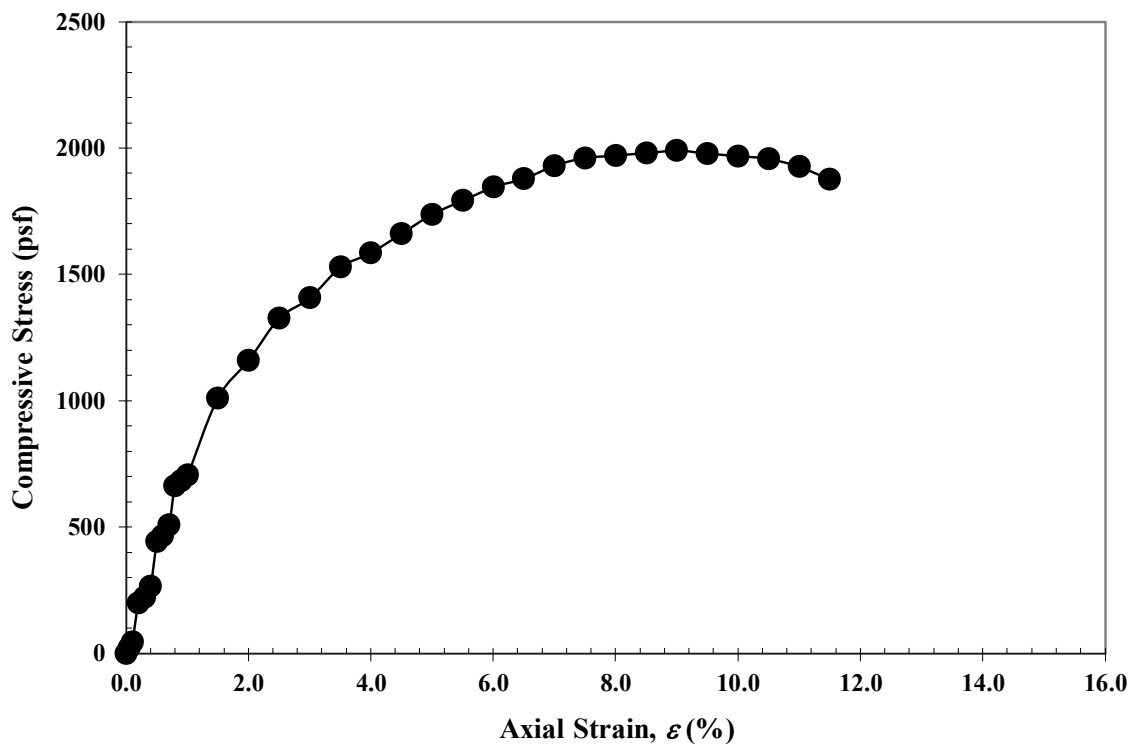
Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.75
Area, A (in ²):	6.45
Volume, V (in ³):	37.12
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	25.9
Dry Mass of Specimen (lb):	2.1
Wet Unit Weight, γ (lb/ft ³):	124.1
Dry Unit Weight, γ_d (lb/ft ³):	98.6

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	1990
Strain (%):	9.0



Notes: Medium stiff, brown, CLAY, "and" silt, little sand, trace gravel, moist.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-003-0-25, ST-6, Depth: 8.6-9.1 ft)

Tested Date: 5/8/2025

Specimen Properties

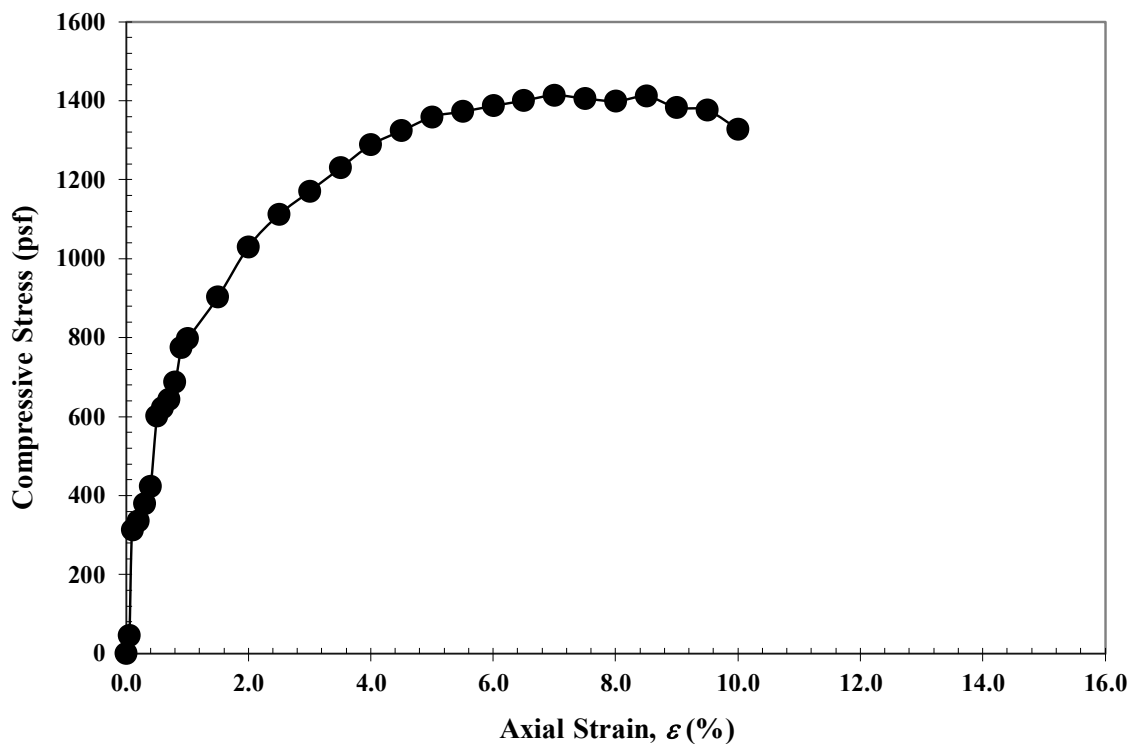
Average Dia., D_{avg} (in):	2.86
Average Height, H_{avg} (in):	5.74
Area, A (in ²):	6.44
Volume, V (in ³):	36.98
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	25.9
Dry Mass of Specimen (lb):	2.1
Wet Unit Weight, γ (lb/ft ³):	124.3
Dry Unit Weight, γ_d (lb/ft ³):	98.7

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	1414
Strain (%):	7.0



Notes: Medium stiff, brown, CLAY, some silt, little sand, trace gravel, moist. Specimen contains gravel $>1/6$ specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166.

Rock Unconfined Compressive Strength (ASTM D7012)

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

(Project: LAW-243-11.28, Boring Location: B-001-0-25, NQ2-2, Depth: 45.2 - 45.6ft)

Tested Date: 5/6/2025

Specimen Properties

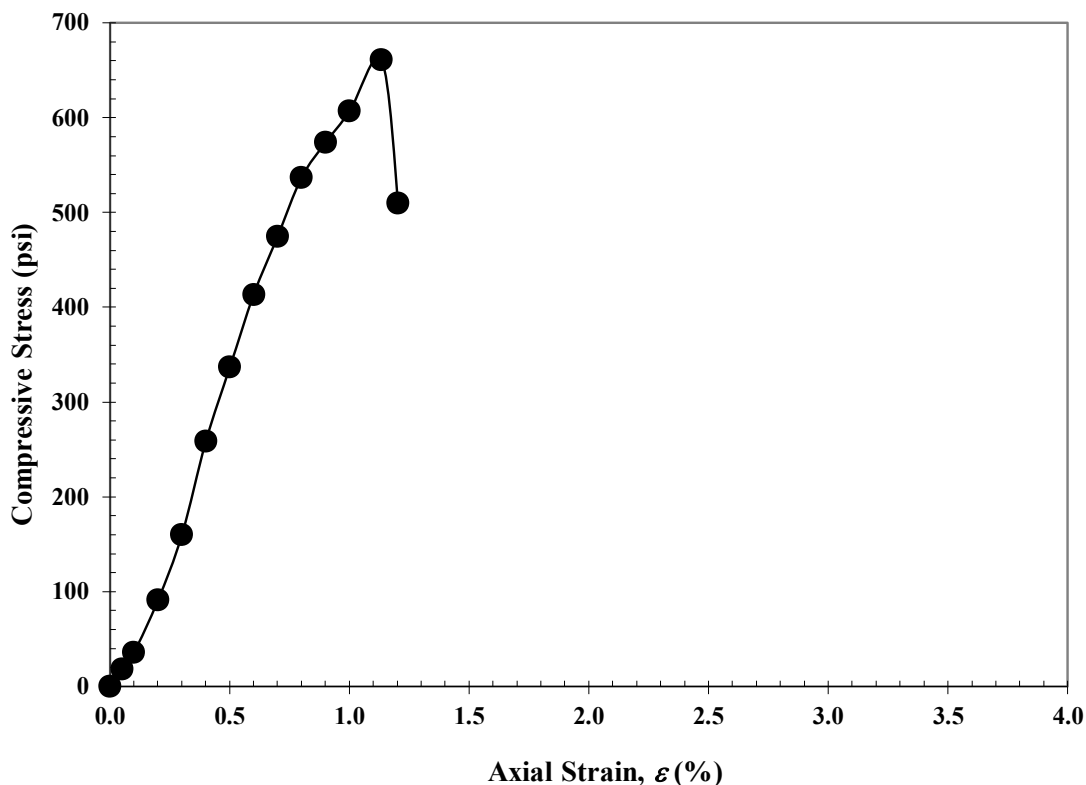
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.41
Length to Diameter Ratio:	2.23
Area, A (in ²):	3.08
Volume, V (in ³):	13.58
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	3.3
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft ³):	161.8
Dry Unit Weight, γ_d (lb/ft ³):	156.6

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	661	5	(MPa)
Strain (%):	1.1		



Notes: Siltstone, gray, slightly weathered, very weak.

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

(Project: LAW-243-11.28, Boring Location: B-002-0-25, NQ2-1, Depth: 27.8 - 28.1ft)

Tested Date: 5/6/2025

Specimen Properties

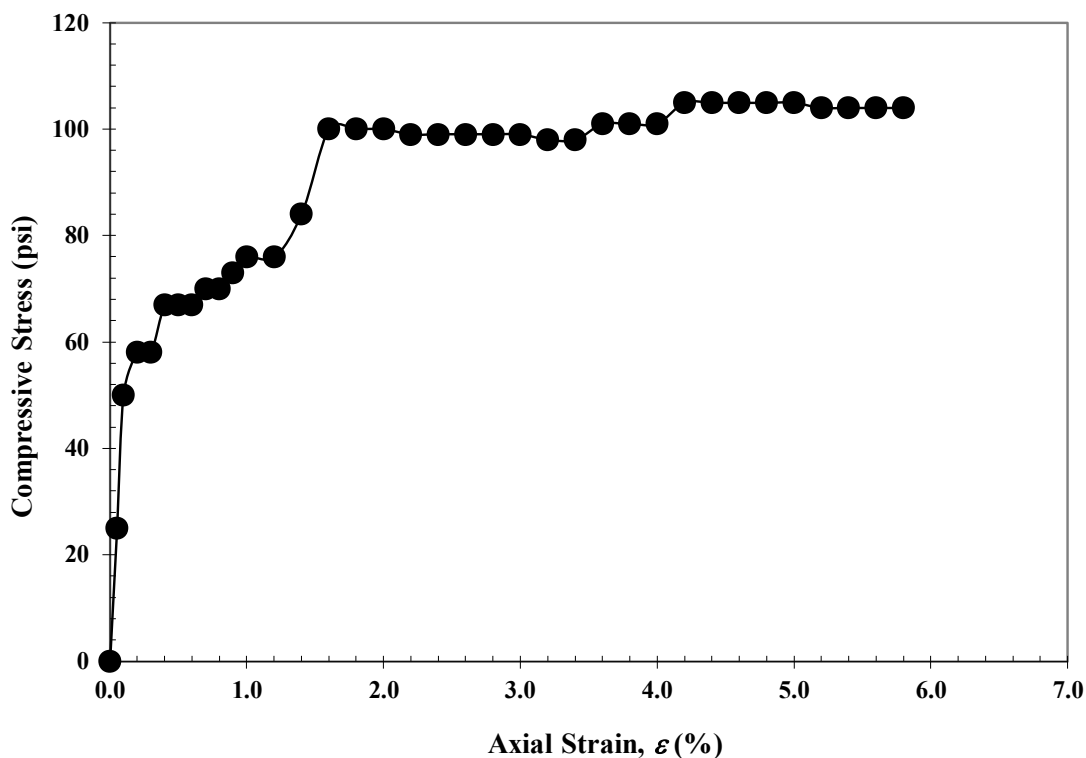
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	3.28
Length to Diameter Ratio:	1.65
Area, A (in ²):	3.10
Volume, V (in ³):	10.16
Wet Mass of Specimen (lb):	0.8
Moisture Content (%):	9.8
Dry Mass of Specimen (lb):	0.8
Wet Unit Weight, γ (lb/ft ³):	142.7
Dry Unit Weight, γ_d (lb/ft ³):	130.0

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	<u>105</u>	<u>0.7</u> (MPa)
Strain (%):	<u>4.2</u>	



Notes: Claystone, brown, severely weathered, extremely weak. Please note that this specimen does not meet the L/D ratio of D7012 and the results reported may differ from a specimen that does meet the L/D requirements of D7012.

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

(Project: LAW-243-11.28, Boring Location: B-003-0-25, NQ2-4, Depth: 30.7 - 31.1ft)

Tested Date: 5/6/2025

Specimen Properties

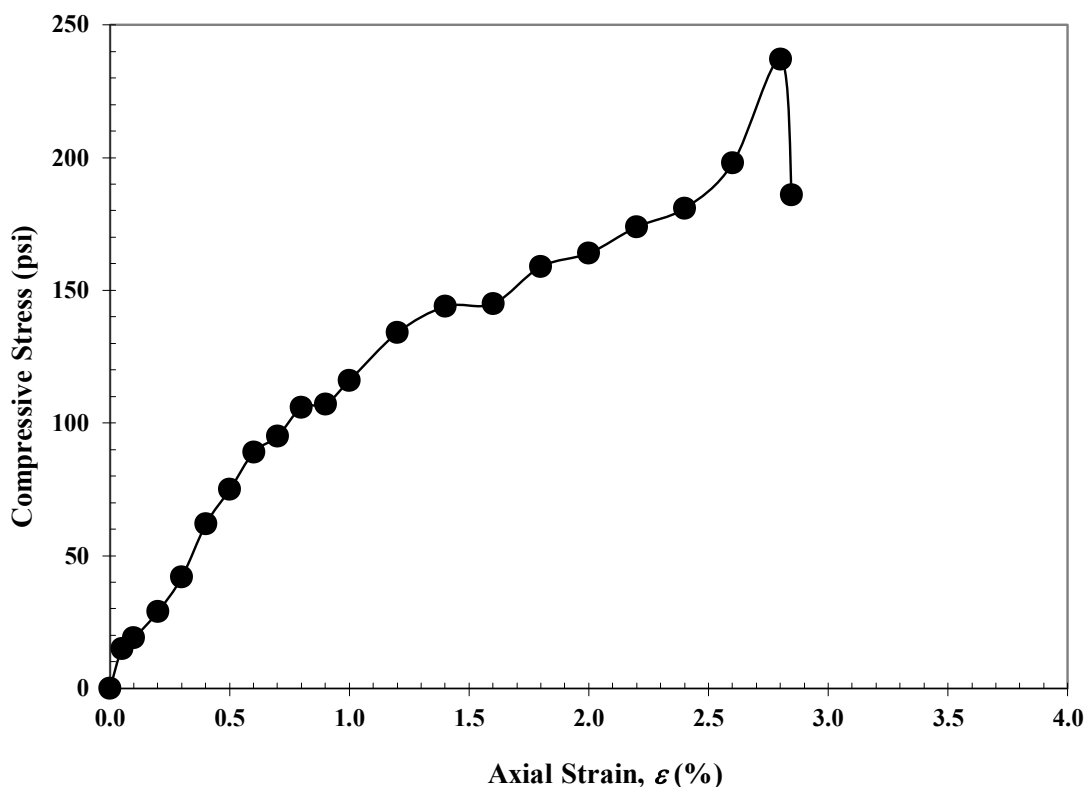
Average Dia., D_{avg} (in):	1.95
Average Height, H_{avg} (in):	4.39
Length to Diameter Ratio:	2.25
Area, A (in ²):	3.00
Volume, V (in ³):	13.17
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	10.7
Dry Mass of Specimen (lb):	1.0
Wet Unit Weight, γ (lb/ft ³):	146.4
Dry Unit Weight, γ_d (lb/ft ³):	132.2

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	<u>237</u>	<u>2</u>	(MPa)
Strain (%):	<u>2.8</u>		



← Claystone

Notes: Shale, dark gray, moderately weathered, very weak, fissile.

Rock Point Load Test (ASTM D5731)

POINT LOAD TEST DATA (ASTM D5731)

Project Name: <u>LAW-243-11.28</u>	Project Number: <u>25-0026</u>
Boring Number: <u>B-002-0-25</u>	Sample Number: <u>NQ2-3 (38.3'-39.3')</u>
Tested By: <u>LR</u>	Date: <u>5/5/2025</u>
Test Device: <u>Wille Geotechnik LP-4500</u>	Serial Number: <u>2510A971409</u>
Readout: <u>LEO 2 digital Manometer</u>	Calibrated Date: <u>1/9/2025</u>
Moisture Content %: <u>4.7% (as received - sealed)</u>	

Sample Details: Siltstone, gray, slightly weathered, weak, moderately fissile.

Specimen Number	Test Type	Width (w), mm	D (De), mm	Length (L), mm	Load (P), kN	De ² , mm ²	De, mm	Is, Mpa	F	Is ₍₅₀₎ , MPa
1	a	50.02	22.37		0.28	1425	37.74917	0.20	0.881	0.18
2	a	50.26	31.11		0.68	1991	44.62062	0.34	0.950	0.32
3	a	50.06	36.23		0.57	2309	48.05206	0.25	1.000	0.25
4	a	50.39	24.99		0.54	1603	40.03748	0.34	0.905	0.31
5	a	50.33	33.90		0.68	2172	46.60472	0.31	0.969	0.30
6	a	50.19	25.47		0.71	1628	40.34848	0.44	0.908	0.40
7	a	50.35	30.99		0.60	1987	44.57578	0.30	0.950	0.29
8	a	50.29	18.42		0.51	1179	34.33657	0.43	0.844	0.36
9	a	50.19	18.60		0.60	1189	34.48188	0.50	0.846	0.42
10	a	50.28	29.93		0.71	1916	43.77214	0.37	0.942	0.35

d = diametral

a = axial

b = block

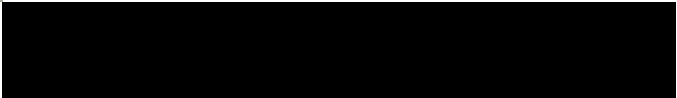
i = irregular lump

⊥ = perpendicular to plane of weakness

// = parallel to plane of weakness

Statistics	
Mean Is ₍₅₀₎ ⊥	0.318
Mean Is ₍₅₀₎ //	N/A
Ia ₍₅₀₎ //	N/A

Strength Conversion Factor, K: 23
Uniaxial compressive Stregnth, Sc: 7.314 Mpa = **1061 psi**

A large, solid red rectangular block positioned on the left side of the page, partially overlapping the section header.A large, solid grey rectangular block positioned at the top right of the page, partially overlapping the section header.A large, solid grey rectangular block positioned at the bottom left of the page, partially overlapping the section header.A solid black rectangular block positioned at the bottom right of the page, partially overlapping the section header.

Appendix D. Preliminary Analyses

Determination of Strength Parameters

Layer							Moist Unit Wt. (pcf)		Total Unit Wt. (pcf)		Adopted Short Term Parameters	Long-Term Strength Values						Adopted Long Term Strength Parameters	
	Undrained Shear Strength (Su) (psf)											Long-Term Strength Values							
	PPR	N-values				Tested	Correlation	Tested	Correlation	Tested		N ₆₀ Value	N ₁₆₀ Value	ODOT GDM Correlations		Tested			
		GDM	Sowers	T and P	Values	Cohesion (psf)								phi (deg)	Cohesion (psf)	phi (deg)	(Back-Calculated from SlopeW)		
Layer 1 SOFT TO MEDIUM STIFF COHESIVE	Max	1000	875	1225	931	402	108		118	128	S _u = 400 psf Φ = 0 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	Max	7	10	88	22		c' = 60 psf Φ' = 20 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	
	Min	0	500	700	532	402	102		112	128		Min	4	5	50	20			
	Average	389	563	863	599	402	103		113	128		Average	5	7	56	20			
	Std Dev	333	134	198	142		2		2			Std Dev	1	2	14	1			
	Avg + Std	722	696	1061	741		105		115		Avg + Std	6	9	70	21				
	Avg - Std	56	429	664	456		101		111		Avg - Std	3	5	43	20				
	Layer 2 MEDIUM STIFF TO STIFF COHESIVE	Max	2000	1375	2250	1463	995	110		120	124	S _u = 900 psf Φ = 0 deg Y _{moist} = 115 pcf Y _{total} = 125 pcf	Max	11	19	138	23		c' = 80 psf Φ' = 21 deg Y _{moist} = 115 pcf Y _{total} = 125 pcf
Min		250	625	875	665	707	105		115	124	Min		5	6	63	21			
Average		1161	990	1685	1053	851	108		118	124	Average		8	11	99	22			
Std Dev		609	223	495	237	204	1		1	0	Std Dev		2	3	22	1			
Avg + Std		1770	1212	2181	1290	1055	109		119	124	Avg + Std	10	14	122	22				
Avg - Std		551	767	1190	816	647	106		116	124	Avg - Std	6	8	77	21				
Layer 3 STIFF TO VERY STIFF COHESIVE		Max	3250	3750	4000	3990		118		128		S _u = 2600 psf Φ = 0 deg Y _{moist} = 115 pcf Y _{total} = 125 pcf	Max	30	36	297	26		c' = 160 psf Φ' = 23 deg Y _{moist} = 115 pcf Y _{total} = 125 pcf
	Min	2000	1625	3250	1729		110		120		Min		13	16	163	23			
	Average	2688	2469	3813	2627		114		124		Average		20	24	222	25			
	Std Dev	657	926	375	986		4		4		Std Dev		7	9	57	1			
	Avg + Std	3345	3395	4188	3612		117		127		Avg + Std	27	33	279	26				
	Avg - Std	2030	1542	3438	1641		110		120		Avg - Std	12	15	166	23				
	Layer 4 HARD COHESIVE (RESIDUAL CLAYSTONE)	Max	4500	13325	4000	4000		130		140		S _u = 4000 psf Φ = 0 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	116	128	709	28		c' = 350 psf Φ' = 27 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf
Min		2750	4000	4000	4000		118		128		Min		32	37	310	26			
Average		4250	7771	4000	4000		128		138		Average		69	77	481	28			
Std Dev		510	2666	0	0		4		4		Std Dev		26	27	115	0			
Avg + Std		4760	10437	4000	4000		132		142		Avg + Std	95	103	596	28				
Avg - Std		3740	5104	4000	4000		124		134		Avg - Std	43	50	366	27				

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 1																				Short-Term Cohesion (psf)			Correlated LT Cohesion (psf)		Midpoint Sample		Midpoint Sample		Correlated Dry Unit Wt.		Correlated Moist Unit Wt.		Correlated Total Unit Wt.		Assumed Specific Gravity (G _s)		Computed Void Ratio (e _u)		Laboratory Tested Values		Strength Testing	
	N ₆₀	Groundwater Depth (ft)	Effective Stress (ksf)	N ₁₀₀	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	WC	PPR	GDM	N-values Sowers	T & P	per GDM	phi (deg)	Depth (ft.)	Elevation (ft.)	89	108	118	Correlated C _c	2.72	1.043	Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Total Unit Wt	Qu/Qu Su (psf)	Correlated Eff. c (psf)								
Max	7	7	0.725	10	100	1.0	26	11	15	44	43	48	25	23	26	1000	875	1225	931	88	22	7.5	651.2	89	108	118	0.342	2.72	1.043	104	N/A	128	402	40								
Min	4	6	0.077	5	38	0.0	5	10	9	25	15	35	20	11	18	0	500	700	532	50	18	0.8	623.1	81	102	128	0.225	2.65	0.907	104	N/A	128	402	40								
Average	5	7	0.418	7	59	0.4	15	15	12	30	29	40	22	17	21	369	563	863	599	56	20	4.1	641.7	85	103	113	0.266	2.70	0.979	104	N/A	128	402	40								
Std Dev	1	1	0.218	2	21	0.3	8	4	2	7	10	5	2	4	3	333	134	198	142	14	1	2.2	8.6	8	2	2	0.045	0.03	0.050	N/A	N/A	N/A	N/A	N/A								
Avg + Std	6	7	0.637	9	80	0.7	22	19	14	37	39	44	24	21	24	722	696	1061	741	70	21	6.2	650.3	88	105	115	0.310	2.73	1.029	N/A	N/A	N/A	N/A	N/A								
Avg - Std	3	6	0.200	5	37	0.1	7	10	9	23	20	35	20	13	19	56	429	664	456	43	20	1.9	633.1	82	101	111	0.221	2.67	0.930	N/A	N/A	N/A	N/A	N/A								

Alignment	Surface Elevation	Exploration ID	From	To	Sample		N ₁₀₀	Groundwater Depth (ft)	Effective Stress (ksf)	Short-Term Cohesion (psf)															Correlated LT Cohesion (psf)	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf)	Correlated Total Unit Wt. (pcf)	Correlated C _c	Assumed Specific Gravity (G _s)	Computed Void Ratio (e _s)	Laboratory Test Values			Strength Testing										
					ID	N ₆₀				Rec	HP	Gr	CS	FS	Silt	Clay	LL	PL	PI	WC	Class.	Soil Type	Layer	PPR											N-values			Dry Unit Wt. (pcf)	Moist Unit Wt. (pcf)	Total Unit Wt. (pcf)	C _c	G _s	e _s	Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Total Unit Wt (pcf)	Qu/Qu Su (psf)	Correlated Eff. c (psf)
																																			GDM	Sowers	T & P											
SR 243	653.4	B-001-0-25	1.5	-	3	SS-2	4	6	0.234	7	67	0.75	17	13	13	27	30	42	22	20	A-7-6	Cohesive	1	750	500	1000	532	50	20	2.3	651.2	84	102	112	0.288	2.65	0.978											
SR 243	653.4	B-001-0-25	3	-	4.5	SS-3	4	6	0.387	6	39	0	26	18	13	28	15	36	25	11	19	A-6a	Cohesive	1	0	500	700	532	50	20	3.8	649.7	86	102	112	0.234	2.72	0.980										
SR 243	653.4	B-001-0-25	4.5	-	6	SS-4	4	6	0.540	6	50	0.25	-	-	-	-	-	-	-	-	-	A-6b	Cohesive	1	250	500	700	532	50	20	5.3	648.2	83	102	112			1.032										
SR 243	653.4	B-001-0-25	6.5	-	8.5	ST-5	4	7	0.725	9	58	0	16	12	12	27	33	40	21	19	22	A-6b	Cohesive	1	0	N/A	645.9	50	20	0	645.9	84	102	112	0.27	2.72	1.013											
SR 243	641.9	B-002-0-25	0	-	1.5	SS-1	4	7	0.077	8	44	1	-	-	-	-	-	-	-	-	-	A-6a	Cohesive	1	1000	500	700	532	50	20	0.8	641.2	84	102	112			1.013										
SR 243	641.9	B-002-0-25	1.5	-	3	SS-2	5	7	0.234	9	56	0.25	16	21	15	25	23	35	20	15	18	A-6a	Cohesive	1	250	625	875	665	63	21	2.3	639.7	89	105	115	0.225	2.72	0.907										
SR 243	641.9	B-002-0-25	3	-	4.5	SS-3	4	7	0.387	6	50	0.5	-	-	-	-	-	-	-	-	-	A-6a	Cohesive	1	500	500	700	532	50	20	3.8	638.2	86	102	112			0.964										
SR 243	642.7	B-002-1-25	3.5	-	5	SS-2	7	7	0.477	10	83	0.25	5	10	9	44	32	36	21	15	22	A-6a	Cohesive	1	250	875	1225	931	88	22	4.3	635.8	89	108	118	0.234	2.72	0.917										
SR 243	629.8	B-003-0-25	6	-	7.5	SS-5	4	6.5	0.705	5	100	0.5	7	13	9	28	43	48	25	23	26	A-7-6	Cohesive	1	500	500	1000	532	50	20	6.8	623.1	81	102	112	0.342	2.65	1.043										

Values for Soil Strength Correlation Reference	
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 2						Short-Term Cohesion (psf)										LT Cohesion (psf)		phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Dry Unit Wt. (pcf)	Moist Unit Wt. (pcf)	Total Unit Wt. (pcf)	Correlated C _c	Assumed Specific Gravity (G _s)	Computed Void Ratio (e _u)	Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Total Unit Wt (pcf)	Qu/Ui Su (psf)	Qu/Ui Correlated Eff. c (psf)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
N ₆₀	Groundwater Depth (ft)	Effective Stress (ksf)	N ₁₆₀	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	PPR	GDM	N-values Sowers	T & P	per GDM																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

																											Short-Term Cohesion (psf)			Correlated																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---------------------------	--	--	------------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 3																																	
		Groundwater	Effective		%		%	%	%	%	Short-Term Cohesion (psf)								LT Cohesion		Midpoint	Midpoint	Dry Unit Wt.	Moist Unit Wt.	Total Unit Wt.	Correlated	Assumed	Computed					
		N ₆₀	Depth (ft)	Stress (ksf)	N ₁₆₀	R _c	HP	G _r	CS	F _s	Silt	Clay	LL	PL	PI	I _p	WC		PPR	N-values			(pcf) per GDM	phi (deg)	Sample Depth (ft.)	Sample Elevation (ft.)	(pcf)	(pcf) per GDM	(pcf) per GDM	C _c	Specific Gravity (G _s)	Void Ratio (e _s)	
Max	30	7	1.063	36	89	3.3	5	15	8	34	69	53	26	27	23				Max	3250	3750	4000	3990	297	26	12.3	641.2	100	118	128	0.387	2.65	0.816
Min	13	6	0.987	16	72	2.0	0	0	1	30	38	46	26	20	18				Min	2000	1625	3250	1729	163	23	11.8	617.6	91	110	120	0.324	2.65	0.654
Average	20	7	1.034	24	78	2.7	3	8	5	32	54	50	26	24	20				Average	2688	2469	3813	2627	222	25	12.1	629.8	95	114	124	0.356	2.65	0.742
Std Dev	7	0	0.034	9	8	0.7	4	11	5	3	22	5	0	5	2				Std Dev	657	926	375	986	57	1	0.3	629.7	4	4	4	0.045	0.00	0.070
Avg + Std	27	7	1.068	33	86	3.3	6	18	9	35	75	54	26	28	22				Avg + Std	3345	3395	4188	3612	279	26	12.4	639.5	99	117	127	0.400	2.65	0.812
Avg - Std	12	6	1.000	15	70	2.0	-1	-3	0	29	32	45	26	19	17				Avg - Std	2030	1542	3438	1641	166	23	11.9	620.2	91	110	120	0.311	2.65	0.673

Layer 4																			Short-Term Cohesion (psf)				LT Cohesion (psf)	phi	Midpoint Sample	Midpoint Sample	Dry Unit Wt.	Moist Unit Wt.	Total Unit Wt.	Correlated	Assumed Specific	Computed	
																			N-values			per GDM	(deg)	Depth (ft.)	Elevation (ft.)	(pcf)	(pcf)	(pcf)	C _c	Gravity (G _s)	Void Ratio (e _s)		
																			GDM	Sowers	T & P												
Values for Soil Strength Correlation																			Max	4500	13325	4000	4000	709	28	25.8	639.7	120	130	140	0.369	2.70	0.640
Reference																			Min	2750	4000	4000	4000	310	26	13.8	614.6	101	118	128	0.261	2.65	0.374
HI PI (Sowers)																			Average	4250	7771	4000	4000	481	28	18.1	627.9	115	128	138	0.323	2.66	0.449
MD PI (Sowers)																			Std Dev	510	2666	0	0	115	0	3.6	6.8	6	4	4	0.037	0.02	0.074
LO PI (Sowers)																																	
T&P																																	
																			Avg + Std	4760	10437	4000	4000	596	28	21.7	634.7	120	132	142	0.360	2.67	0.524
																			Avg - Std	3740	5104	4000	4000	366	27	14.5	621.0	109	124	134	0.286	2.64	0.375

																			Short-Term Cohesion (psf)				Correlated LT Cohesion (psf)	phi	Midpoint Sample	Midpoint Sample	Correlated Dry Unit Wt.	Correlated Moist Unit Wt.	Correlated Total Unit Wt.	Correlated	Assumed Specific	Computed							
																			N-values			per GDM	(deg)	Depth (ft.)	Elevation (ft.)	(pcf)	(pcf)	(pcf)	C _c	Gravity (G _s)	Void Ratio (e _s)								
																			GDM	Sowers	T & P																		
Alignment	Surface Elevation	Exploration ID	From	To	Sample ID	N ₆₀	Groundwater Depth (ft)	Effective Stress (ksf)	N ₁₆₀	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	WC	Class.	Soil Type	Layer	PPR	GDM	Sowers	T & P	per GDM	(deg)	Depth (ft.)	Elevation (ft.)	per GDM	per GDM	C _c					
SR 243	653.4	B-001-0-25	13	-	14.5	SS-9	42	6	1.092	51	100	2.75	3	5	4	43	45	48	25	23	13	A-7-6	Cohesive	4	2750	5250	4000	4000	371	28	13.8	639.7	108	122	132	0.342	2.65	0.532	
SR 243	653.4	B-001-0-25	14.5	-	16	SS-10	47	6	1.201	55	83	-	-	-	-	-	-	-	-	-	13	A-7-6	Cohesive	4	N/A	5875	4000	4000	4000	401	28	15.3	638.2	111	125	135		2.65	0.495
SR 243	653.4	B-001-0-25	16	-	17.5	SS-11	71	6	1.317	81	100	4.25	-	-	-	-	-	-	-	-	11	A-7-6	Cohesive	4	4250	7514	4000	4000	474	28	16.8	636.7	117	130	140		2.65	0.412	
SR 243	653.4	B-001-0-25	17.5	-	19	SS-12	97	6	1.434	108	100	4.5	1	2	41	55	48	25	23	11	A-7-6	Cohesive	4	4500	10993	4000	4000	619	28	18.3	635.2	117	130	140	0.342	2.65	0.412		
SR 243	653.4	B-001-0-25	19	-	20.5	SS-13	107	6	1.550	116	100	4.5	-	-	-	-	-	-	-	-	11	A-7-6	Cohesive	4	4500	11323	4000	4000	632	28	19.8	633.7	117	130	140		2.65	0.412	
SR 243	653.4	B-001-0-25	20.5	-	22	SS-14	85	6	1.666	90	100	-	-	-	-	-	-	-	-	-	11	A-7-6	Cohesive	4	N/A	8995	4000	4000	538	28	21.3	632.2	117	130	140		2.65	0.412	
SR 243	653.4	B-001-0-25	22	-	23.5	SS-15	84	6	1.783	87	100	-	-	-	-	-	-	-	-	-	12	A-7-6	Cohesive	4	N/A	8889	4000	4000	533	28	22.8	630.7	116	130	140		2.65	0.425	
SR 243	653.4	B-001-0-25	23.5	-	25	SS-16	80	6	1.899	82	72	-	0	1	0	28	71	51	26	25	14	A-7-6	Cohesive	4	N/A	9005	4000	4000	538	28	24.3	629.2	114	130	140	0.369	2.65	0.450	
SR 243	653.4	B-001-0-25	25	-	26.42	SS-17	Refusal	6	2.016	Refusal	100	-	-	-	-	-	-	-	-	-	12	A-7-6	Cohesive	4	N/A	N/A	N/A	N/A	28	25.8	627.7	116	130	140		2.65	0.425		
SR 243	641.9	B-002-0-25	13	-	14.5	SS-9	34	7	1.155	40	78	3.75	0	0	1	36	63	49	25	24	17	A-7-6	Cohesive	4	3750	4250	4000	4000	322	27	13.8	628.2	101	118	128	0.351	2.65	0.640	
SR 243	641.9	B-002-0-25	14.5	-	16	SS-10	32	7	1.253	37	100	4	-	-	-	-	-	-	-	-	16	A-7-6	Cohesive	4	4000	4000	4000	4000	310	26	15.3	626.7	102	118	128		2.65	0.626	
SR 243	641.9	B-002-0-25	16	-	17.5	SS-11	69	7	1.369	78	78	-	-	-	-	-	-	-	-	-	10	A-7-6	Cohesive	4	N/A	7302	4000	4000	4000	465	28	16.8	625.2	118	130	140		2.65	0.399
SR 243	641.9	B-002-0-25	17.5	-	19	SS-12	116	7	1.486	128	100	4.5	3	3	5	50	39	41	22	19	9	A-7-6	Cohesive	4	4500	13325	4000	4000	709	28	18.3	623.7	119	130	140	0.279	2.65	0.386	
SR 243	641.9	B-002-0-25	19	-	20.33	SS-13	Refusal	7	1.602	Refusal	100	-	-	-	-	-	-	-	-	-	9	A-7-6	Cohesive	4	N/A	N/A	N/A	N/A	28	19.8	622.2	119	130	140		2.65	0.386		
SR 243	641.9	B-002-0-25	20.5	-	21.83	SS-14	Refusal	7	1.719	Refusal	100	4.5	-	-	-	-	-	-	-	-	8	A-7-6	Cohesive	4	4500	N/A	N/A	N/A	N/A	28	21.3	620.7	120	130	140		2.65	0.374	
SR 243	642.7	B-002-1-25	13.5	-	15	SS-6	53	7	1.257	61	83	4.5	0	0	2	51	47	45	26	19	15	A-7-6	Cohesive	4	4500	6088	4000	4000	410	28	14.3	628.5	113	130	140	0.315	2.65	0.463	
SR 243	642.7	B-002-1-25	16	-	17.5	SS-7	58	7	1.451	64	100	4.5	-	-	-	-	-	-	-	-	15	A-6b	Cohesive	4	4500	6629	4000	4000	435	28	16.8	626.0	113	130	140		2.70	0.490	
SR 243	642.7	B-002-1-25	18.5	-	19.83	SS-8	Refusal	7	1.645	Refusal	100	4.5	8	11	7	45	29	39	23	16	8	A-6b	Cohesive	4	4500	N/A	N/A	N/A	N/A	28	19.3	623.5	120	130	140	0.261	2.70	0.400	
SR 243	629.8	B-003-0-25	13	-	14.5	SS-9	62	6.5	1.148	74	100	4.5	6	7	6	41	40	46	27	19	13	A-7-6	Cohesive	4	4500	7122	4000	4000	457	28	13.8	616.1	115	130	140	0.324	2.65	0.437	
SR 243	629.8	B-003-0-25	14.5	-	15.83	SS-10	Refusal	6.5	1.264	Refusal	81	4.5	-	-	-	-	-	-	-	-	11	A-7-6	Cohesive	4	4500	N/A	N/A	N/A	N/A	28	15.3	614.6	117	130	140		2.65	0.412	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 9/10/25 12:56 - C:\P\WORKING\EAST01\10442335\LAW-243-11.28 BORING LOGS.GPJ

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS		DRILL RIG: DIEDRICH D-50		STATION / OFFSET: 596+05, 16' RT.		EXPLORATION ID B-001-0-25												
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB		HAMMER: AUTOMATIC HAMMER		ALIGNMENT: SR 243														
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 6/24/24		ELEVATION: 653.4 (MSL) EOB: 54.5 ft.		PAGE 1 OF 2												
START: 4/18/25 END: 4/21/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.9		LAT / LONG: 38.494916, -82.483383														
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	INCL.	
									GR	CS	FS	SI	CL	LL	PL	PI				
TOPSOIL (2")		653.3	Omit	2	4	11	SS-1	-	41	21	15	17	6	NP	NP	NP	9	A-1-b (0)		
VERY LOOSE, DARK BROWN, GRAVEL WITH SAND, LITTLE SILT, TRACE CLAY, TRACE ORGANICS, DAMP		651.9		2	1	4	67	SS-2	0.75	17	13	13	27	30	42	22	20	22		A-7-6 (9)
SOFT TO MEDIUM STIFF, DARK BROWN, CLAY, SOME SAND, SOME SILT, LITTLE GRAVEL, DAMP		650.4		3	2					20	10	10	20	10	30	25	11	19		A-6a (2)
VERY SOFT TO SOFT, BROWN, SILT AND CLAY, SOME GRAVEL, SOME SAND, DAMP		648.9		4	2	4	39	SS-3	0.00	20	10	10	20	10	30	25	11	19		A-6a (2)
SOFT, BROWN, SILTY CLAY, SOME SAND, LITTLE GRAVEL, MOIST		Layer 1	5	1	4	50	SS-4	0.25	-	-	-	-	-	-	-	-	23	A-6b (V)		
@4.5' - 6.0': trace water at bottom of spoon			6	2																
@6.6' - 7.1': qu = 803 psf			7																	
			8			38	ST-5	0.00	16	12	12	27	33	40	21	19	22	A-6b (9)		
SOFT TO MEDIUM STIFF, BROWN, SILT AND CLAY, SOME SAND, TRACE LIMESTONE FRAGMENTS, DAMP		644.9	9	1	7	100	SS-6	0.25	5	14	15	38	28	34	21	13	21	A-6a (7)		
Layer 2		641.9	10	2	3															
			11	2	5	72	SS-7	0.25									17	A-6a (V)		
			12	2																
STIFF TO VERY STIFF, RED-BROWN, CLAY, SOME SAND, SOME SILT, TRACE STONE FRAGMENTS, DAMP		640.4	13	4	13	72	SS-8	3.25	5	15	8	34	38	46	26	20	18	A-7-6 (13)		
Layer 3		637.4	14	5	42	100	SS-9	2.75	3	5	4	43	45	48	25	23	13	A-7-6 (15)		
VERY STIFF TO HARD, RED-BROWN, CLAY, "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, DAMP			15	12	18	47	83	SS-10	-	-	-	-	-	-	-	-	13	A-7-6 (V)		
			16	12	21	71	100	SS-11	4.25	-	-	-	-	-	-	-	11	A-7-6 (V)		
			17	20	32															
HARD, RED-BROWN, CLAY, "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, DAMP		631.4	18	32	97	100	SS-12	4.5+	1	1	2	41	55	48	25	23	11	A-7-6 (15)		
Layer 4			19	22	40															
Residual claystone based on appearance and N-values			20	32	47	107	100	SS-13	4.5+	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
			21	27	35	85	100	SS-14	-	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
HARD, BROWN, TRACE GRAY AND PURPLE, CLAY, SOME SILT, TRACE SAND, DAMP		626.9	22	13	84	100	SS-15	-	-	-	-	-	-	-	-	-	12	A-7-6 (V)		
			23	27	35															
			24	20	30	80	72	SS-16	-	0	1	0	28	71	51	26	25	14	A-7-6 (16)	
			25	20	29															
		TR	26	40	-	100	SS-17	-	-	-	-	-	-	-	-	-	12	A-7-6 (V)		
			27	30	50/6"	-	100	SS-18	-	-	-	-	-	-	-	-	13	Rock (V)		
CLAYSTONE, BROWN TRACE GRAY, SEVERELY WEATHERED, VERY WEAK.			28	30	50/3"	-	100	SS-19	-	-	-	-	-	-	-	-	9	Rock (V)		
			29	40																

Omit

Elevated Moisture

Design water level at 6'

[illegible]

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/10/25 12:56 - C:\P\WORKING\EAST01\D442335\LAW-243-11.28 BORING LOGS.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS				DRILL RIG: DIEDRICH D-50				STATION / OFFSET: 597+06, 16' RT.				EXPLORATION ID B-002-0-25						
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB				HAMMER: AUTOMATIC HAMMER				ALIGNMENT: SR 243										
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2				CALIBRATION DATE: 6/24/24				ELEVATION: 641.9 (MSL) EOB: 46.5 ft.				PAGE 1 OF 2						
START: 4/17/25 END: 4/21/25		SAMPLING METHOD: SPT / ST / NQ2				ENERGY RATIO (%): 80.9				LAT / LONG: 38.494980, -82.483052										
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	INCL.
										GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (2")		641.9			2															
SOFT TO MEDIUM STIFF, DARK BROWN TO BROWN, SILT AND CLAY, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP Layer 1		641.7	1	1	4	44	SS-1	1.00	-	-	-	-	-	-	-	-	-	21	A-6a (V)	
			2	2	1	5	56	SS-2	0.25	16	21	15	25	23	35	20	15	18	A-6a (4)	
			3	2	3															
			4	2	2	4	50	SS-3	0.50	Elevated Moisture					-	-	18	A-6a (V)		
		636.9																		
MEDIUM STIFF TO STIFF, DARK BROWN TO BROWN, CLAY, "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP @5.4' - 5.9': qu = 1990 psf Layer 2		634.9				58	ST-4	1.25	1	8	8	36	47	50	26	24	26	A-7-6 (16)		
MEDIUM STIFF TO STIFF, BROWN, SILT AND CLAY, SOME SAND, LITTLE STONE FRAGMENTS, DAMP @7.0' - 8.5': trace water in sample		633.4			2	3	9	67	SS-5	0.50	14	12	12	34	28	31	20	11	19	A-6a (6)
MEDIUM STIFF TO STIFF, BROWN, SILTY CLAY, SOME SAND, LITTLE STONE FRAGMENTS, DAMP		631.9			2	3	8	61	SS-6	2.00	12	15	10	33	30	37	21	16	18	A-6b (8)
STIFF, RED-BROWN, CLAY, SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		630.4			3	2	9	67	SS-7	1.25	8	8	3	23	58	56	25	31	19	A-7-6 (19)
VERY STIFF TO HARD, GRAY TO PURPLE, CLAY, "AND" SILT, TRACE SAND, DAMP Layer 3					2	6	20	72	SS-8	2.00	Design water level at 7'							20	A-7-6 (V)	
					5	9														
		627.4			10	15	34	78	SS-9	3.75	0	0	1	36	63	49	25	24	17	A-7-6 (15)
HARD, BROWN, CLAY, "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, DAMP Layer 4					5	10	32	100	SS-10	4.00	-	-	-	-	-	-	-	-	16	A-7-6 (V)
					10	14														
					20	31	69	78	SS-11	-	-	-	-	-	-	-	-	-	10	A-7-6 (V)
					10	38	48	116	SS-12	4.50	3	3	5	50	39	41	22	19	9	A-7-6 (12)
Residual claystone based on appearance and N-values					30	45	50/4"	-	100	SS-13	-	-	-	-	-	-	-	-	9	A-7-6 (V)
					23	30	50/4"	-	100	SS-14	4.5+	-	-	-	-	-	-	-	8	A-7-6 (V)
CLAYSTONE, BROWN TO BROWN-GRAY, SEVERELY WEATHERED, VERY WEAK.		619.9	TR		50/5"	-	100	SS-15	-	-	-	-	-	-	-	-	-	-	10	Rock (V)
					36	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	7	Rock (V)
					50/5"	-	100	SS-17	-	-	-	-	-	-	-	-	-	-	6	Rock (V)
		615.4																		
CLAYSTONE, BROWN, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 26%, REC 100%.		612.6			20		100	NQ2-1												CORE
		611.9																		

MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	INCL.
									GR	CS	FS	SI	CL	LL	PL	PI			
@27.8' - 28.1': qu = 105 psi CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 0%, REC 100%. SILTSTONE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 54%, REC 98%. @32.2' - 32.3': 1" red brown claystone seam @36.7' - 38.1': highly fractured @38.3' - 39.3': qu = 1061 psi (point load test)																			

PROJECT: <u>LAW-243-11.28</u>	DRILLING FIRM / OPERATOR: <u>HDR / TS</u>	DRILL RIG: <u>DIEDRICH D-50</u>	STATION / OFFSET: <u>597+07, 7' LT.</u>	EXPLORATION ID <u>B-002-1-25</u>
TYPE: <u>LANDSLIDE</u>	SAMPLING FIRM / LOGGER: <u>CENTRAL STAR / AKB</u>	HAMMER: <u>AUTOMATIC HAMMER</u>	ALIGNMENT: <u>SR 243</u>	
PID: <u>123191</u> SFN: <u></u>	DRILLING METHOD: <u>2.25" HSA</u>	CALIBRATION DATE: <u>6/24/24</u>	ELEVATION: <u>642.7 (MSL)</u> EOB: <u>28.8 ft.</u>	PAGE 1 OF 1
START: <u>4/16/25</u> END: <u>4/16/25</u>	SAMPLING METHOD: <u>SPT</u>	ENERGY RATIO (%): <u>80.9</u>	LAT / LONG: <u>38.495043, -82.483058</u>	

[illegible]

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/10/25 12:56 - C:\PWORKING\EAST01\4422335\LAW-243-11.28 BORING LOGS.GPJ

NOTES: SURFACE PATCHED WITH QUIKCRETE

ABANDONMENT METHODS. MATERIALS, QUANTITIES: PLACED 10 LB. BENTONITE CHIPS: 35 GAL. WATER MIXED WITH 12.5 LB. BENTONITE POWDER: 48 LB. CEMENT

PROJECT: LAW-243-11.28		DRILLING FIRM / OPERATOR: HDR / TS		DRILL RIG: DIEDRICH D-50		STATION / OFFSET: 598+08, 15' RT.		EXPLORATION ID: B-003-0-25												
TYPE: LANDSLIDE		SAMPLING FIRM / LOGGER: CENTRAL STAR / AKB		HAMMER: AUTOMATIC HAMMER		ALIGNMENT: SR 243		PAGE 1 OF 2												
PID: 123191 SFN:		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 6/24/24		ELEVATION: 629.8 (MSL) EOB: 41.0 ft.														
START: 4/16/25 END: 4/17/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.9		LAT / LONG: 38.494985, -82.482704														
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT / RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
		629.8								GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (2")		629.6			3															
MEDIUM STIFF TO STIFF, RED-BROWN, BROWN, AND GRAY, SILTY CLAY , SOME STONE FRAGMENTS, SOME SAND, DAMP (FILL)		628.3	1		2	7	72	SS-1	1.75	27	16	10	22	25	38	22	16	18	A-6b (4)	
			2		3															
			3		2	11	83	SS-2	1.50	27	18	11	20	24	40	21	19	18	A-6b (4)	
STIFF, BROWN AND DARK BROWN, SILTY CLAY , SOME STONE FRAGMENTS, SOME SAND, NOTED ORGANIC ODOR, DAMP (FILL)		626.5	4		3															
Layer 2			5		2	7	83	SS-3	1.00	2	8	6	36	48	46	24	22	23	A-7-6 (14)	
MEDIUM STIFF TO STIFF, RED-BROWN AND GRAY, CLAY , "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		623.8	6		2	5	78	SS-4	0.25	Elevated Moisture								26	A-7-6 (V)	
			7		1															
SOFT TO MEDIUM STIFF, BROWN TO RED-BROWN, CLAY , SOME SAND, SOME SILT, TRACE STONE FRAGMENTS, MOIST		621.8	8		1	4	100	SS-5	0.50	7	13	9	28	43	48	25	23	26	A-7-6 (14)	
Layer 1			9		2															
@6.5': trace water in sand seams			10																	
MEDIUM STIFF TO STIFF, LIGHT BROWN TO RED-BROWN, CLAY , SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP			11		3	9	67	SS-7	1.75	Design water level at 6.5'								27	A-7-6 (V)	
Layer 2			12		3	16	78	SS-8	2.25									23	A-7-6 (V)	
Layer 3		616.8	13		5					-	-	-	-	-	-	-	-			
			14		7															
HARD, BROWN AND DARK BROWN, CLAY , "AND" SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP			15		13	62	100	SS-9	4.5+	6	7	6	41	40	46	27	19	13	A-7-6 (13)	
Layer 4			16		15															
			17		13															
			18		20		81	SS-10	4.5+	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
		613.8	19		50/6"	-	100	SS-11	-	-	-	-	-	-	-	-	-	6	Rock (V)	
CLAYSTONE, BROWN, SEVERELY WEATHERED, VERY WEAK, ARENACEOUS.			20		50/4"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	Rock (V)	
		610.8	21																	
			22																	
CLAYSTONE, BROWN, HIGHLY TO SEVERELY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 15%, REC 87%.			23		0	78		NQ2-1		Residual claystone based on appearance and N-values									CORE	
			24																	
			25																	
			26																	
			27																	
		601.8	28		18	82		NQ2-3												CORE
			29																	

[illegible]

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 9/10/25 12:56 - C:\PWORKING\EAST01\D4422335\LAW-243-11.28 BORING LOGS.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 47 LB. CEMENT; 50 GAL. WATER

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-001-0-25, ST-5, Depth: 6.6-7.1 ft)

Tested Date: 5/7/2025

Specimen Properties

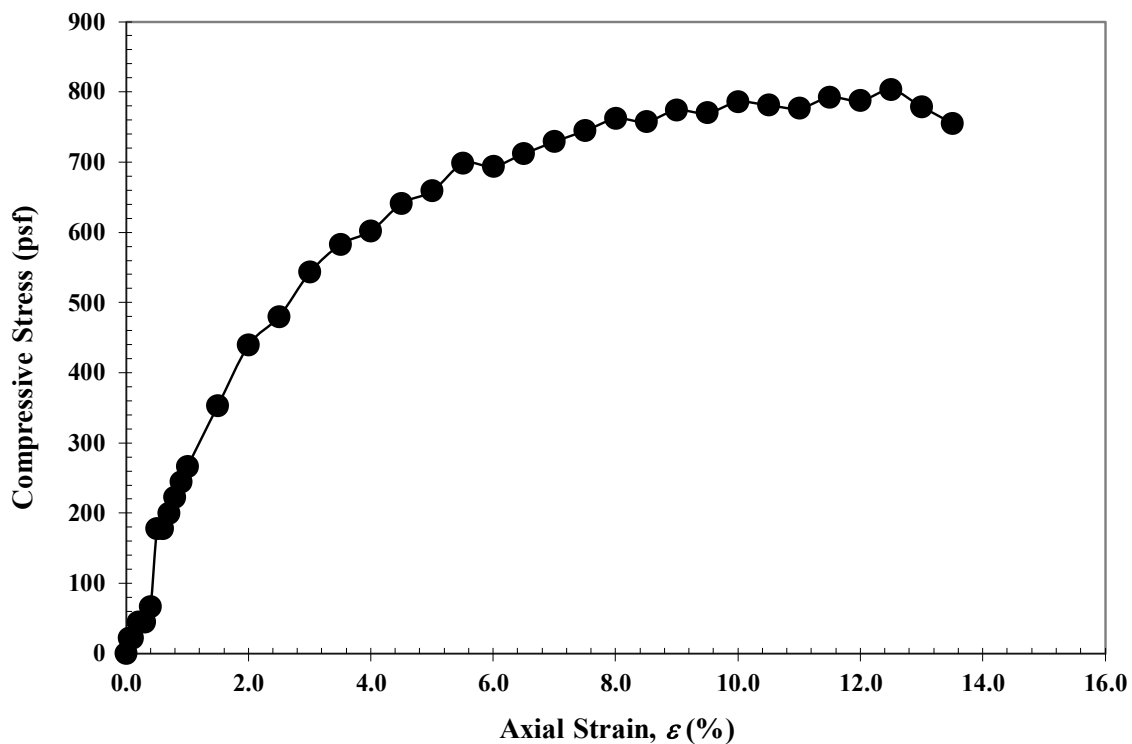
Average Dia., D_{avg} (in):	2.86
Average Height, H_{avg} (in):	5.71
Area, A (in ²):	6.43
Volume, V (in ³):	36.75
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	23.2
Dry Mass of Specimen (lb):	2.2
Wet Unit Weight, γ (lb/ft ³):	128.1
Dry Unit Weight, γ_d (lb/ft ³):	104.0

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	803
Strain (%):	12.5



Notes: Soft, brown, SILTY CLAY, some sand, little gravel, moist. Specimen contains gravel >1/6 specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-002-0-25, ST-4, Depth: 5.4-5.9 ft)

Tested Date: 5/8/2025

Specimen Properties

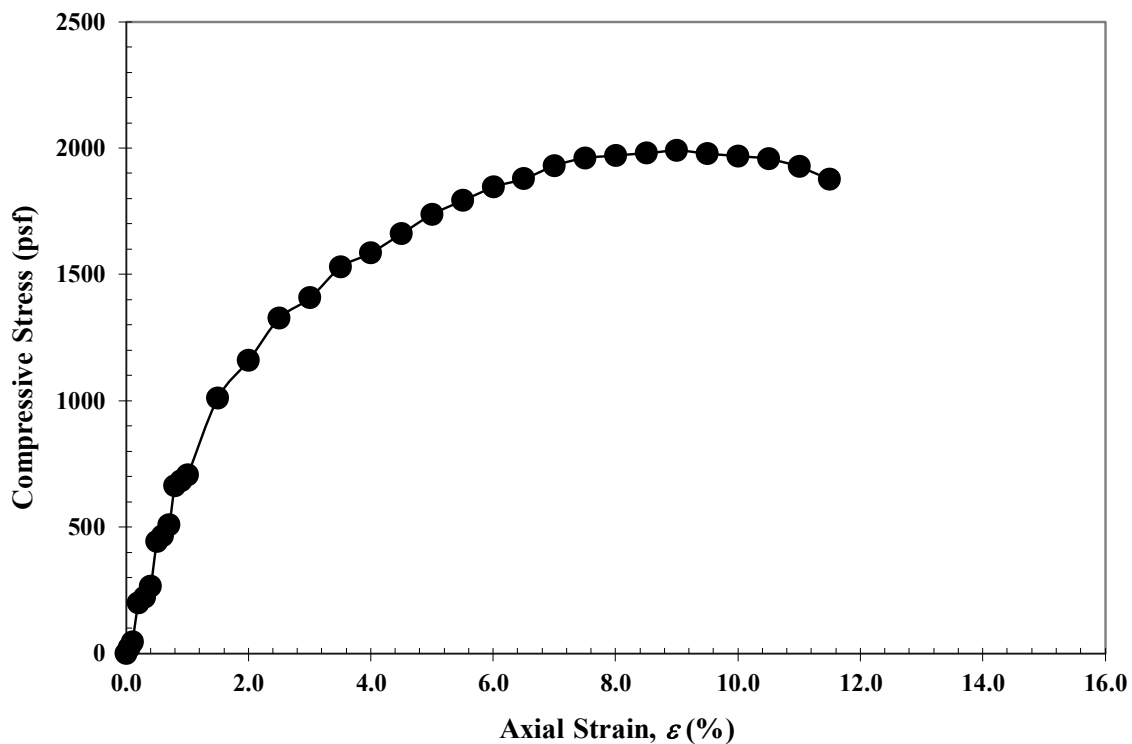
Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.75
Area, A (in ²):	6.45
Volume, V (in ³):	37.12
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	25.9
Dry Mass of Specimen (lb):	2.1
Wet Unit Weight, γ (lb/ft ³):	124.1
Dry Unit Weight, γ_d (lb/ft ³):	98.6

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	1990
Strain (%):	9.0



Notes: Medium stiff, brown, CLAY, "and" silt, little sand, trace gravel, moist.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: LAW-243-11.28, Boring Location: B-003-0-25, ST-6, Depth: 8.6-9.1 ft)

Tested Date: 5/8/2025

Specimen Properties

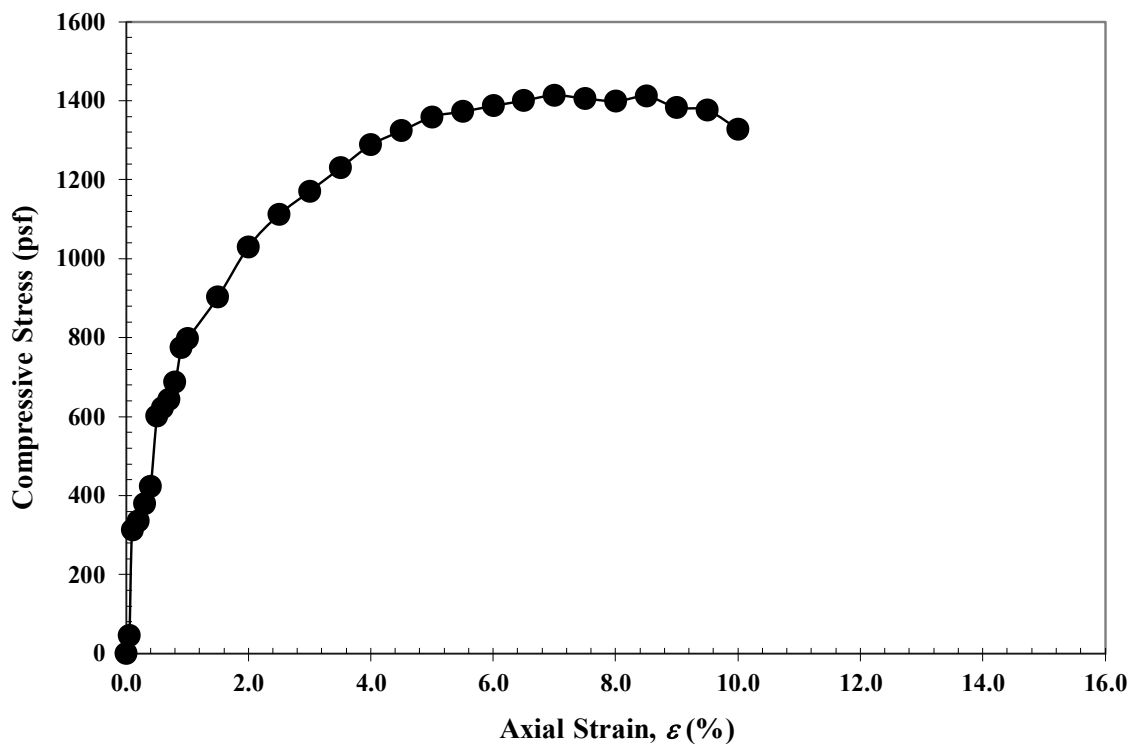
Average Dia., D_{avg} (in):	2.86
Average Height, H_{avg} (in):	5.74
Area, A (in ²):	6.44
Volume, V (in ³):	36.98
Wet Mass of Specimen (lb):	2.7
Moisture Content (%):	25.9
Dry Mass of Specimen (lb):	2.1
Wet Unit Weight, γ (lb/ft ³):	124.3
Dry Unit Weight, γ_d (lb/ft ³):	98.7

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	1414
Strain (%):	7.0



Notes: Medium stiff, brown, CLAY, some silt, little sand, trace gravel, moist. Specimen contains gravel $>1/6$ specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166.

WEATHERED BEDROCK WITH SPT

Hammer Efficiency 80.9 %

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)		No. Refusal Blows	Refusal Distance (in)	N	N90	Compressive Strength, Qu		
						GDM Range	USE					(ksf)	(psi)	(MPa)
LAW-243-11.28	B-001-0-25	26.5	SS-18	Claystone	Brown tr. Gray	130 - 165	145	50	6	100	90	8	57	0.4
LAW-243-11.28	B-001-0-25	28	SS-19	Claystone	Brown tr. Gray	130 - 165	145	50	3	200	180	17	115	0.8
LAW-243-11.28	B-001-0-25	29.5	SS-20	Claystone	Gray	130 - 165	145	50	4	150	135	12	86	0.6
LAW-243-11.28	B-001-0-25	31	SS-21	Claystone	Gray	130 - 165	145	50	5	120	108	10	69	0.5
LAW-243-11.28	B-001-0-25	32.5	SS-22	Claystone	Gray	130 - 165	145	50	5	120	108	10	69	0.5
LAW-243-11.28	B-001-0-25	34	SS-23	Claystone	Gray	130 - 165	145	50	4	150	135	12	86	0.6
LAW-243-11.28	B-002-0-25	22	SS-15	Claystone	Brown/Brown-Gray	130 - 165	145	50	5	120	108	10	69	0.5
LAW-243-11.28	B-002-0-25	23.5	SS-16	Claystone	Brown/Brown-Gray	130 - 165	145	50	5	120	108	10	69	0.5
LAW-243-11.28	B-002-0-25	25	SS-17	Claystone	Brown/Brown-Gray	130 - 165	145	50	5	120	108	10	69	0.5
LAW-243-11.28	B-002-1-25	23.5	SS-9	Claystone	Gray	130 - 165	145	50	4	150	135	12	86	0.6
LAW-243-11.28	B-002-1-25	28.5	SS-10	Claystone	Gray	130 - 165	145	50	4	150	135	12	86	0.6
LAW-243-11.28	B-003-0-25	16	SS-11	Claystone	Brown	130 - 165	145	50	6	100	90	8	57	0.4
LAW-243-11.28	B-003-0-25	17.5	SS-12	Claystone	Brown	130 - 165	145	50	4	150	135	12	86	0.6
				Claystone	Maximum		145					Maximum	17	115
					Minimum		145					Minimum	8	57
					Average		145					Average	11	77
					Std Dev		0					Std Dev	2	16
					Adopted Value		145					Adopted Value	11	75

$Q_u \text{ (ksf)} = 0.092 * N_{90} \text{ (ODOT GDM Section 404.3)}$

Table 400-5: Rock Properties of Typical Rock Types Found in Ohio (Masada and Han, 2013)

Rock Type	Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Slake Durability Index (%)
Claystone	130-165	15-1400	0-60
Shale	155-165 (unweathered) 150-160 (weathered)	2100-4600 (unweathered) 100-400 (weathered)	20-90
Siltstone	160-170	3600-8100	65-90
Sandstone	155-165	1800-7800	85-100
Friable Sandstone	125-140	<3600	<85
Limestone	155-170	3500-16400	95-100
Dolomite	165-175	4100-10300	95-100
Coal	80-85	1300-7000	NA
Underclay	125-135	200-400	0-20

CORED BEDROCK, NO TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Unit Weight (pcf)		Geologic Strength Descriptor	Compressive Strength, Qu				GSD Ei Modulus		GSI	Em (Hoek & Brown)		Lesser of Ei vs Em	
						Range	USE		Based on Rock Type (psi)	Based on GSD (psi)	(psi)	(MPa)	(psi)	(MPa)		Range	USE		(GPa)
LAW-243-11.28	B-003-0-25	31.3		Shale (Unweathered)	Black	155 - 165	145	Very Weak	2,100 - 4,600	200	200	1	18,000	124	50 - 70	60	2.1	302,869	18,000
				Shale (Unweathered)	Maximum	145			Shale (Unweathered)	Maximum	200					Shale (Unweathered)	Maximum	18,000	
					Minimum	145				Minimum	200						Minimum	18,000	
					Average	145				Average	200						Average	18,000	
					Std Dev	N/A				Std Dev	N/A						Std Dev	N/A	
					Adopted Value	155				Adopted Value	200						Adopted Value	18,000	

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Unit Weight (pcf)		Geologic Strength Descriptor	Compressive Strength, Qu				GSD Ei Modulus		Em (Hoek & Brown) Modulus		Lesser of Ei vs Em (psi)		
						Range	USE		Based on Rock Type (psi)	Based on GSD (psi)	(psi)	(MPa)	(psi)	(MPa)	Range	USE		(GPa)	(psi)
LAW-243-11.28	B-001-0-25	41		Limestone	Gray	155 - 170	160	Slightly Strong	3,500 - 16,400	1,500	1,500	10	140,000	965	60 - 75	65	7.6	1,106,079	140,000
LAW-243-11.28	B-002-0-25	42.5		Limestone	Gray	155 - 170	160	Moderately Strong	3,500 - 16,400	3,600	3,600	25	320,000	2,206	60 - 80	70	15.8	2,285,029	320,000
				Limestone					Limestone	Maximum	3,600					Limestone	Maximum	320,000	
										Minimum	1,500						Minimum	140,000	
										Average	2,550						Average	230,000	
										Std Dev	1,485						Std Dev	127,279	
						Adopted Value	160			Adopted Value	2550						Adopted Value	230,000	

BEDROCK CORE TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu			Er Modulus		GSI		Em (Hoek & Brown) Modulus		Lesser of Er vs Em (psi)	Em (Yang) Modulus	
								Based on Rock Type (psi)	(psi)	(MPa)	(psi)	(MPa)	Range	USE	(GPa)	(psi)		(psi)	(psi)
LAW-243-11.28	8-001-0-25	45.2	NQ2-2	Siltstone	Gray	161.8	Very Weak	3,600 - 8,100	661	4.6	75,114	518	50 - 60	55	2.8	412,897	75,114	65.3	9,470
LAW-243-11.28	8-002-0-25	38.3	NQ2-3	Siltstone	Gray		Weak	3,600 - 8,100	1,061	7.3			50 - 70	60	4.8	697,587	697,587		
				Siltstone				Siltstone	Maximum	1,061					Siltstone	Maximum	697,587		
									Minimum	661						Minimum	75,114		
									Average	861						Average	386,350		
									Std Dev	283						Std Dev	440,155		
					Adopted Value	160			Adopted Value	850						Adopted Value	386,300		

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu				Er		GSI	Em (Hoek & Brown)		Lesser of Er vs Em	Em (Yang)	
								Based on Rock Type (psi)	(psi)	(MPa)	(psi)	Modulus (MPa)	Range		USE	(GPa)		(psi)	(psi)
LAW-243-11.28	B-002-0-25	27.8	NQ2-1	Claystone	Brown	142.7	Very Weak	15 - 1,400	105	0.7		40 - 50	45	0.6	92,541	92,541			
LAW-243-11.28	B-003-0-25	30.7	NQ2-4	Claystone	Gray	146.4	Very Weak	15 - 1,400	237	1.6	10,376	72	45 - 60	50	1.3	185,402	10,376	7.2	1,039
				Claystone		146		Claystone	237				Claystone		Maximum	92,541			
					Maximum	143			105						Minimum	10,376			
					Average	145			171						Average	51,459			
					Std Dev	3			93						Std Dev	58,100			
					Adopted Value	145			Adopted Value	150					Adopted Value	51,400			

krm 0.0005

Table 400-5: Rock Properties of Typical Rock Types Found in Ohio (Masada and Han, 2013)

Rock Type	Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Sake Durability Index (%)
Claystone	130-165	15-1400	0-60
Shale	155-165 (unweathered) 150-160 (weathered)	2100-4600 (unweathered) 100-400 (weathered)	20-90
Siltstone	160-170	3600-8100	65-90
Sandstone	155-165	1800-7800	85-100
Friable Sandstone	125-140	<3600	<85
Limestone	155-170	3500-16400	95-100
Dolomite	165-175	4100-10300	95-100
Coal	80-85	1300-7000	NA
Underclay	125-135	200-400	0-20

Table 400-6: Estimated Bedrock Strength Characteristics from Visual Description

Geologic Strength Descriptor	Qu (psi)	Ei (psi)	Historic Hardness Descriptor (used prior to 2007)
Very Weak	200	18000	Very Soft
Very Weak to Weak	360	32000	Very Soft to Soft
Weak	750	68000	Soft
Weak to Slightly Strong	1125	100000	Soft to Medium
Slightly Strong	1500	140000	Medium / Medium-Firm
Slightly Strong to Moderately Strong	2250	200000	Medium to Moderately Hard
Moderately Strong	3600	320000	Moderately Hard
Moderately Strong to Strong	5000	450000	Moderately Hard to Hard
Strong	7500	680000	Hard
Strong to Very Strong	10000	900000	Hard to Very Hard
Very Strong	15000	1400000	Very Hard
Very Strong to Extremely Strong	20000	1800000	
Extremely Strong	30000	2700000	

Table 10.4.6.5-1—Estimation of E_m Based on GSI

Expression	Notes/Remarks	Reference
$E_m (GPa) = \sqrt[10]{\frac{GSI - 10}{100} \cdot 10^{40}} \quad \text{for } q_u \leq 100 \text{ MPa}$	Accounts for rocks with $q_u < 100$ MPa; notes q_u in MPa	Hoek and Brown (1997); Hoek et al. (2002)
$E_m (GPa) = 10^{\frac{GSI - 10}{40}} \quad \text{for } q_u \leq 100 \text{ MPa}$		
$E_m = \frac{E_R}{100} e^{GSI/21.7}$	Reduction factor on intact modulus, based on GSI	Yang (2006)
Notes: E_r = modulus of intact rock, E_m = equivalent rock mass modulus, GSI = geological strength index, q_u = uniaxial compressive strength, and 1 MPa = 2.09 ksf.		

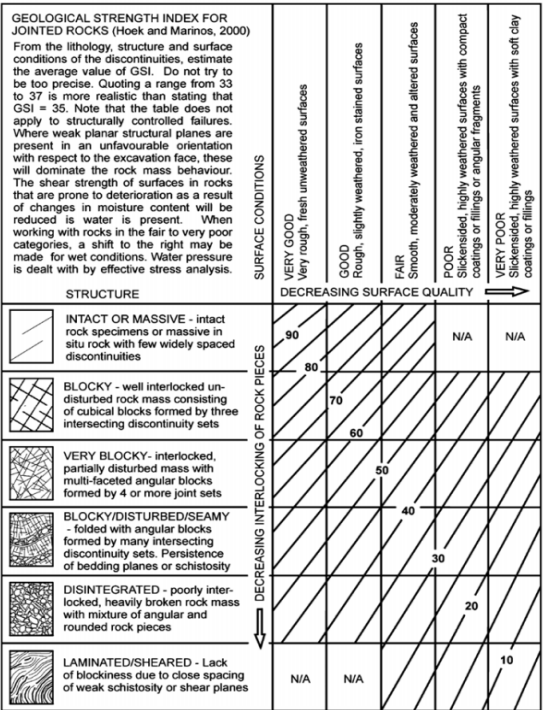


Figure 10.4.6.4-1—Determination of GSI for Jointed Rock Mass (Hoek and Marinos, 2000)

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.)		Thickness (ft)	Layer RQD (%)	Weighted RQD ¹ (length / total length)
			From	To			
LAW-243-11.28	B-003-0-25	Shale	31.3	37.1	5.8	48	48.0
				Shale	5.8	RQD SUM	48
				Maximum	5.8	48	
				Minimum	5.8	48	
				Average	5.8	48.0	
				Adopted Value			45

Project	Exploration ID	Rock Type	Depth Range (ft.)		Thickness (ft)	Layer RQD (%)	Weighted RQD ¹ (length / total length)
			From	To			
LAW-243-11.28	B-001-0-25	Limestone	41	42.4	1.4	53	30.9
LAW-243-11.28	B-002-0-25	Limestone	42.5	43.5	1	100	41.7
		Limestone			2.4	RQD SUM	73
		Maximum			1.4	100	
		Minimum			1	53	
		Average			1.2	76.5	
Adopted Value							70

Project	Exploration ID	Rock Type	Depth Range (ft.)		Thickness (ft)	Layer RQD (%)	Weighted RQD (%) $RQD \times \frac{thickness}{total\ length}$
			From	To			
LAW-243-11.28	B-001-0-25	Siltstone	42.4	49.5	7.1	74	30.2
LAW-243-11.28	B-002-0-25	Siltstone	30	40.3	10.3	54	32.0
		Siltstone			17.4	RQD SUM	62
		Maximum			10.3	74	
		Minimum			7.1	54	
		Average			8.7	64.0	
		Adopted Value					60

Project	Exploration ID	Rock Type	Depth Range (ft.)		Thickness (ft)	Layer RQD (%)	Weighted RQD ¹ (length / Total Length)
			From	To			
LAW-243-11.28	B-001-0-25	Claystone	34.5	38.1	3.6	48	5.1
LAW-243-11.28	B-001-0-25	Claystone	38.1	41	2.9	11	0.9
LAW-243-11.28	B-001-0-25	Claystone	49.5	54.5	5	10	1.5
LAW-243-11.28	B-002-0-25	Claystone	26.5	29.3	2.8	26	2.1
LAW-243-11.28	B-002-0-25	Claystone	29.3	30	0.7	0	0.0
LAW-243-11.28	B-002-0-25	Claystone	40.3	42.5	2.2	0	0.0
LAW-243-11.28	B-002-0-25	Claystone	43.5	46.5	3	22	1.9
LAW-243-11.28	B-003-0-25	Claystone	19	28	9	15	3.9
LAW-243-11.28	B-003-0-25	Claystone	28	31.3	3.3	58	5.6
LAW-243-11.28	B-003-0-25	Claystone	39.3	41	1.7	60	3.0
				Claystone	34.2	RQD SUM	24
				Maximum	9	60	
				Minimum	0.7	0	
				Average	3.4	25.0	
				Adopted Value			20

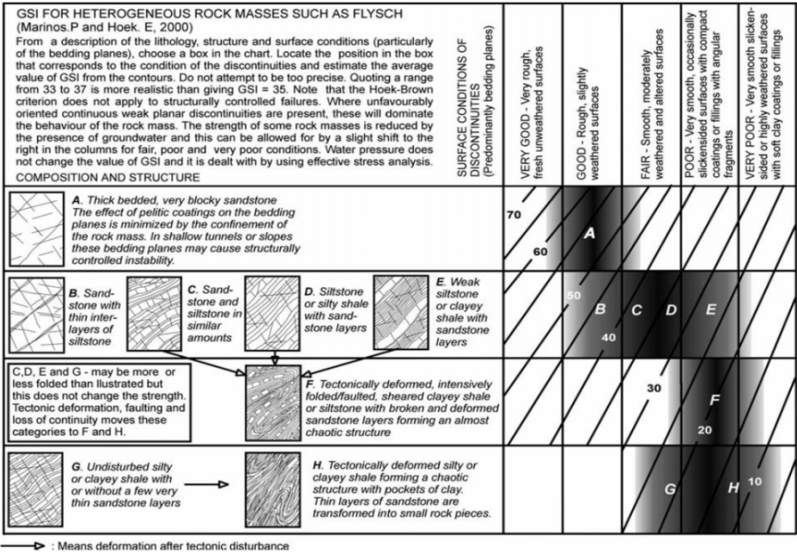


Figure 10.4.6.4-2—Determination of GSI for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

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

(Project: LAW-243-11.28, Boring Location: B-001-0-25, NQ2-2, Depth: 45.2 - 45.6ft)

Tested Date: 5/6/2025

Specimen Properties

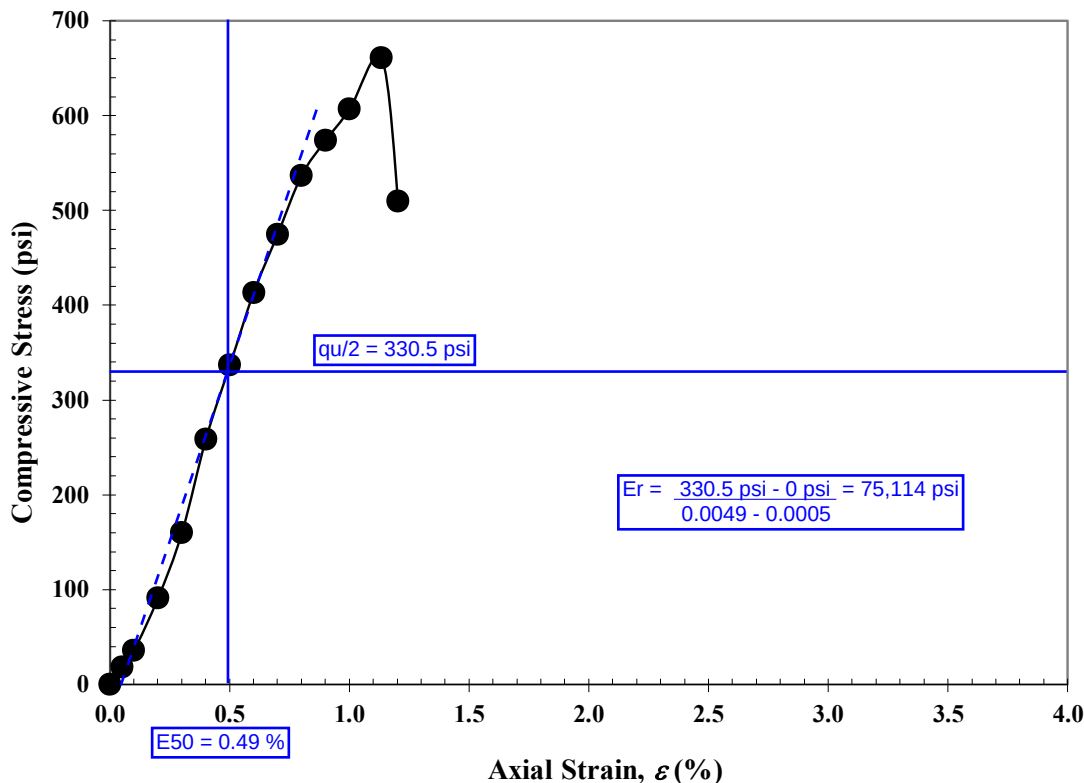
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.41
Length to Diameter Ratio:	2.23
Area, A (in ²):	3.08
Volume, V (in ³):	13.58
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	3.3
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft ³):	161.8
Dry Unit Weight, γ_d (lb/ft ³):	156.6

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	661	5	(MPa)
Strain (%):	1.1		



Notes: Siltstone, gray, slightly weathered, very weak.

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

(Project: LAW-243-11.28, Boring Location: B-002-0-25, NQ2-1, Depth: 27.8 - 28.1ft)

Tested Date: 5/6/2025

Specimen Properties

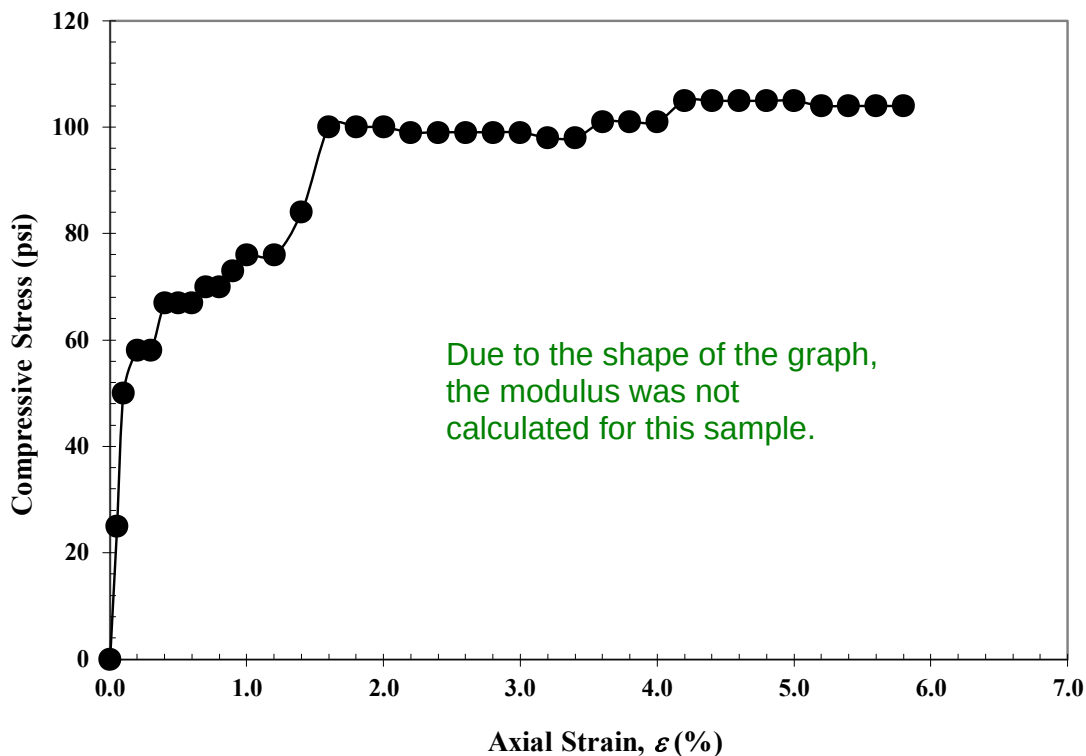
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	3.28
Length to Diameter Ratio:	1.65
Area, A (in ²):	3.10
Volume, V (in ³):	10.16
Wet Mass of Specimen (lb):	0.8
Moisture Content (%):	9.8
Dry Mass of Specimen (lb):	0.8
Wet Unit Weight, γ (lb/ft ³):	142.7
Dry Unit Weight, γ_d (lb/ft ³):	130.0

Final Specimen Figure



Results

Unconfined Compressive Strength (psi): 105 0.7 (MPa)
Strain (%): 4.2



Notes: Claystone, brown, severely weathered, extremely weak. Please note that this specimen does not meet the L/D ratio of D7012 and the results reported may differ from a specimen that does meet the L/D requirements of D7012.

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

(Project: LAW-243-11.28, Boring Location: B-003-0-25, NQ2-4, Depth: 30.7 - 31.1ft)

Tested Date: 5/6/2025

Specimen Properties

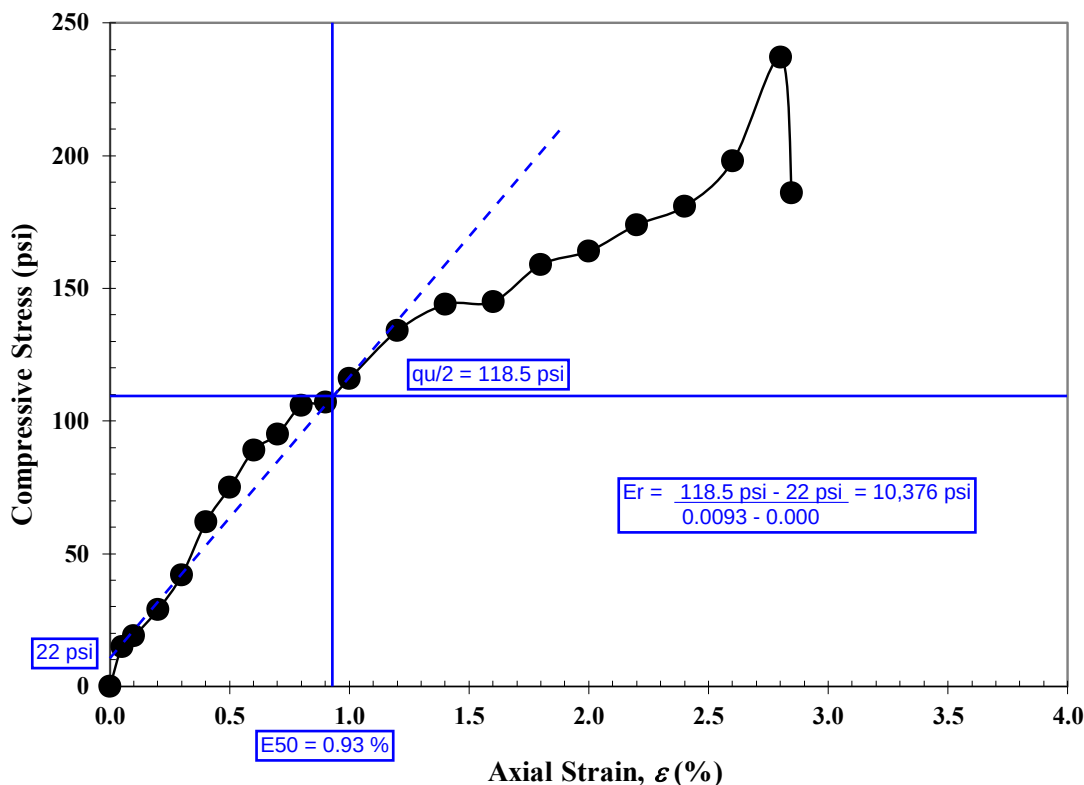
Average Dia., D_{avg} (in):	1.95
Average Height, H_{avg} (in):	4.39
Length to Diameter Ratio:	2.25
Area, A (in ²):	3.00
Volume, V (in ³):	13.17
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	10.7
Dry Mass of Specimen (lb):	1.0
Wet Unit Weight, γ (lb/ft ³):	146.4
Dry Unit Weight, γ_d (lb/ft ³):	132.2

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	237	
Strain (%):	2.8	2 (MPa)



Notes: Shale, dark gray, moderately weathered, very weak, fissile.

POINT LOAD TEST DATA (ASTM D5731)

Project Name: <u>LAW-243-11.28</u>	Project Number: <u>25-0026</u>
Boring Number: <u>B-002-0-25</u>	Sample Number: <u>NQ2-3 (38.3'-39.3')</u>
Tested By: <u>LR</u>	Date: <u>5/5/2025</u>
Test Device: <u>Wille Geotechnik LP-4500</u>	Serial Number: <u>2510A971409</u>
Readout: <u>LEO 2 digital Manometer</u>	Calibrated Date: <u>1/9/2025</u>
Moisture Content %: <u>4.7% (as received - sealed)</u>	

Sample Details: Siltstone, gray, slightly weathered, weak, moderately fissile.

Specimen Number	Test Type	Width (w), mm	D (De), mm	Length (L), mm	Load (P), kN	De ² , mm ²	De, mm	Is, Mpa	F	Is ₍₅₀₎ , MPa
1	a	50.02	22.37		0.28	1425	37.74917	0.20	0.881	0.18
2	a	50.26	31.11		0.68	1991	44.62062	0.34	0.950	0.32
3	a	50.06	36.23		0.57	2309	48.05206	0.25	1.000	0.25
4	a	50.39	24.99		0.54	1603	40.03748	0.34	0.905	0.31
5	a	50.33	33.90		0.68	2172	46.60472	0.31	0.969	0.30
6	a	50.19	25.47		0.71	1628	40.34848	0.44	0.908	0.40
7	a	50.35	30.99		0.60	1987	44.57578	0.30	0.950	0.29
8	a	50.29	18.42		0.51	1179	34.33657	0.43	0.844	0.36
9	a	50.19	18.60		0.60	1189	34.48188	0.50	0.846	0.42
10	a	50.28	29.93		0.71	1916	43.77214	0.37	0.942	0.35

d = diametral

a = axial

b = block

i = irregular lump

⊥ = perpendicular to plane of weakness

// = parallel to plane of weakness

Statistics	
Mean Is ₍₅₀₎ ⊥	0.318
Mean Is ₍₅₀₎ //	N/A
Ia ₍₅₀₎ //	N/A

Strength Conversion Factor, K: 23
Uniaxial compressive Strength, Sc: 7.314 Mpa = **1061 psi**

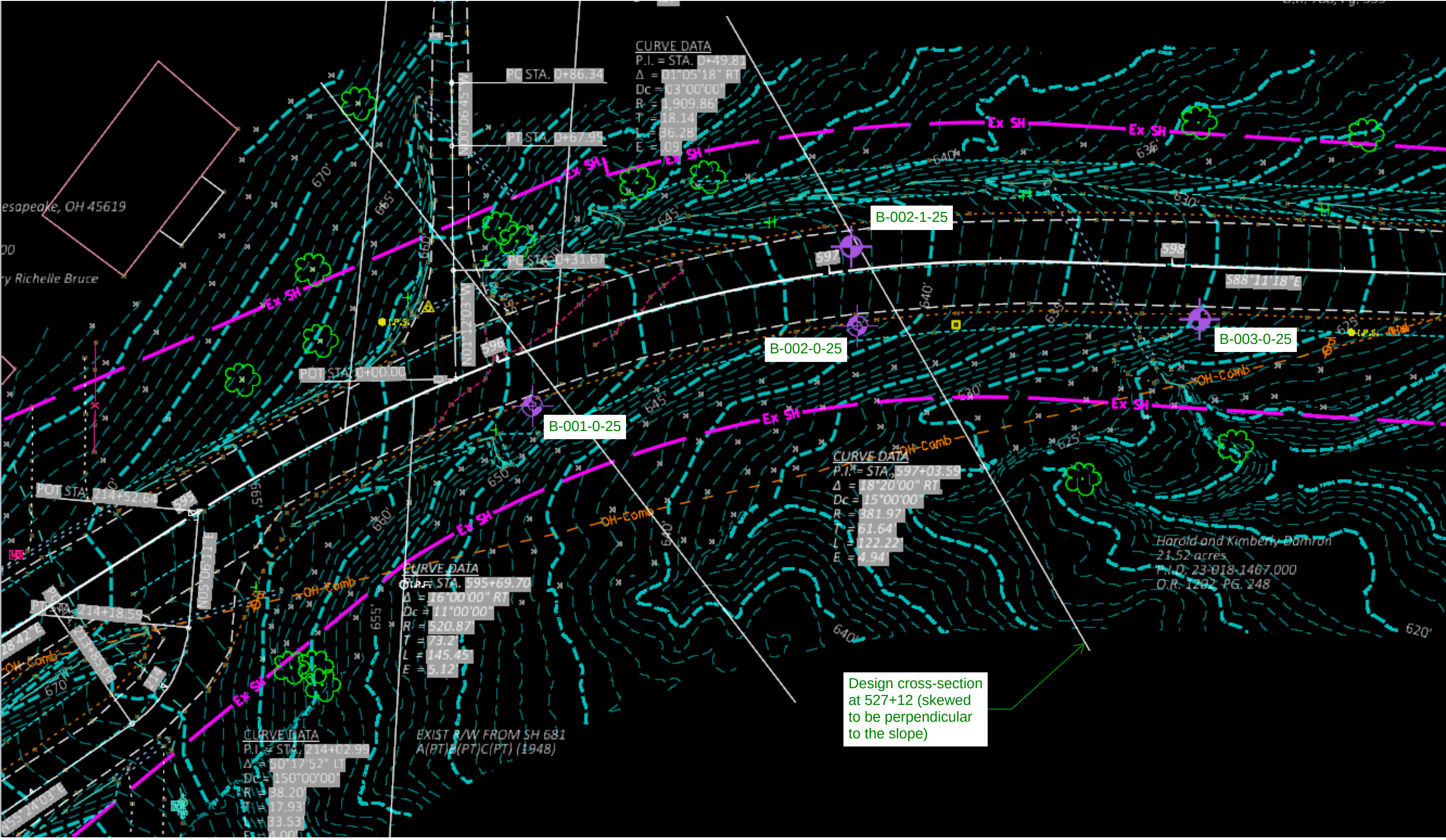
Slope Stability – Existing Condition



A horizontal scale bar labeled "HORIZONTAL SCALE IN FEET" at the top. The scale ranges from 0 to 40 feet. Major tick marks are at 0, 20, and 40. The bar is divided into alternating black and white segments: a black segment from 0 to 10, a white segment from 10 to 20, a black segment from 20 to 30, and a white segment from 30 to 40. A small black segment is also present between 10 and 20, and another between 20 and 30.

תכר

EET	TOTAL
1	1



CURVE DATA
P.I. = STA. D+49.81
Δ = 01°05'18" RT
Dc = 03°00'00"
R = 1,909.86
T = 18.14
L = 36.28
E = 1.09

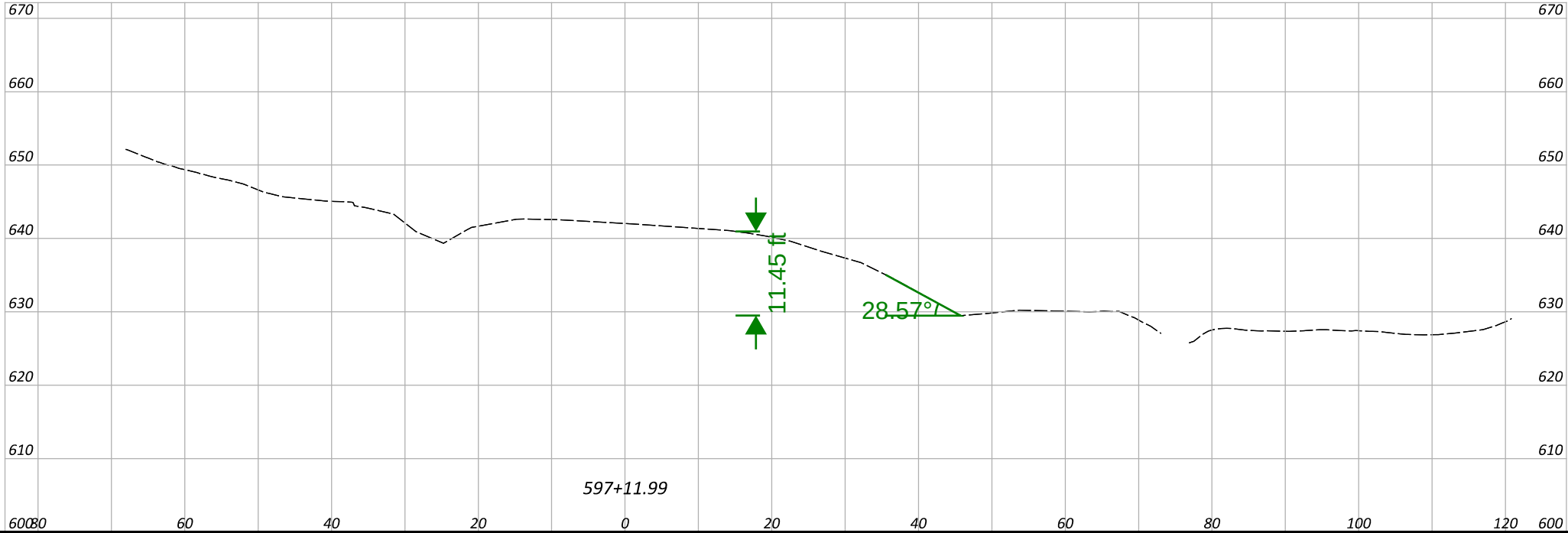
CURVE DATA
P.I. = STA. 597+03.59
Δ = 18°20'00" RT
Dc = 15°00'00"
R = 381.97
T = 61.64
L = 122.22
E = 4.94

CURVE DATA
P.I. = STA. 595+69.70
Δ = 16°00'00" RT
Dc = 11°00'00"
R = 520.87
T = 73.2
L = 145.45
E = 5.12

CURVE DATA
P.I. = STA. 214+02.99
Δ = 50°17'52" LT
Dc = 150°00'00"
R = 38.20
T = 17.93
L = 33.53
E = 4.00

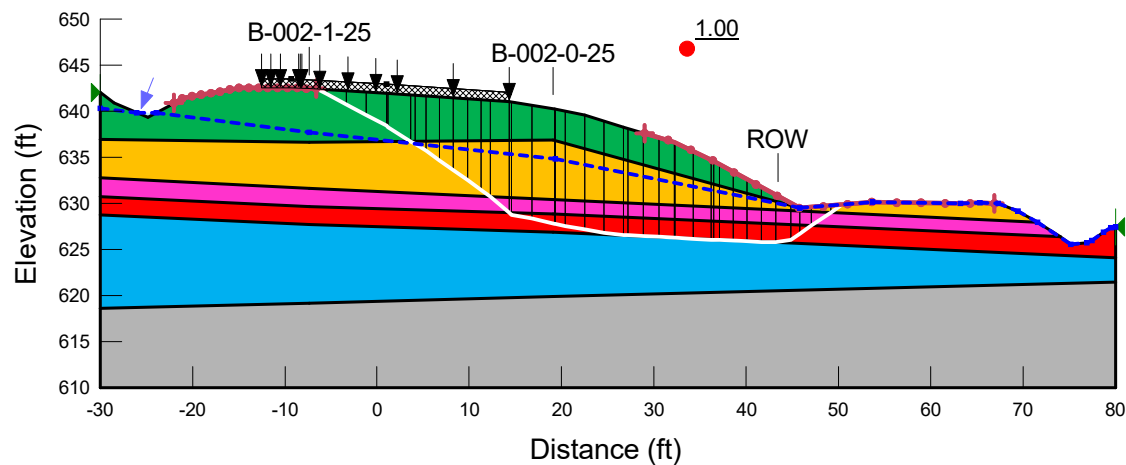
EXIST R/W FROM SH 681
A(PT)B(PT)C(PT) (1948)

Design cross-section
at 527+12 (skewed
to be perpendicular
to the slope)



Optimized failure surface
for determination of soil
parameters.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
■	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
■	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
■	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
■	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
■	Bedrock	Bedrock (Impenetrable)				
■	Soft Rock	Mohr-Coulomb	130	0	12	0



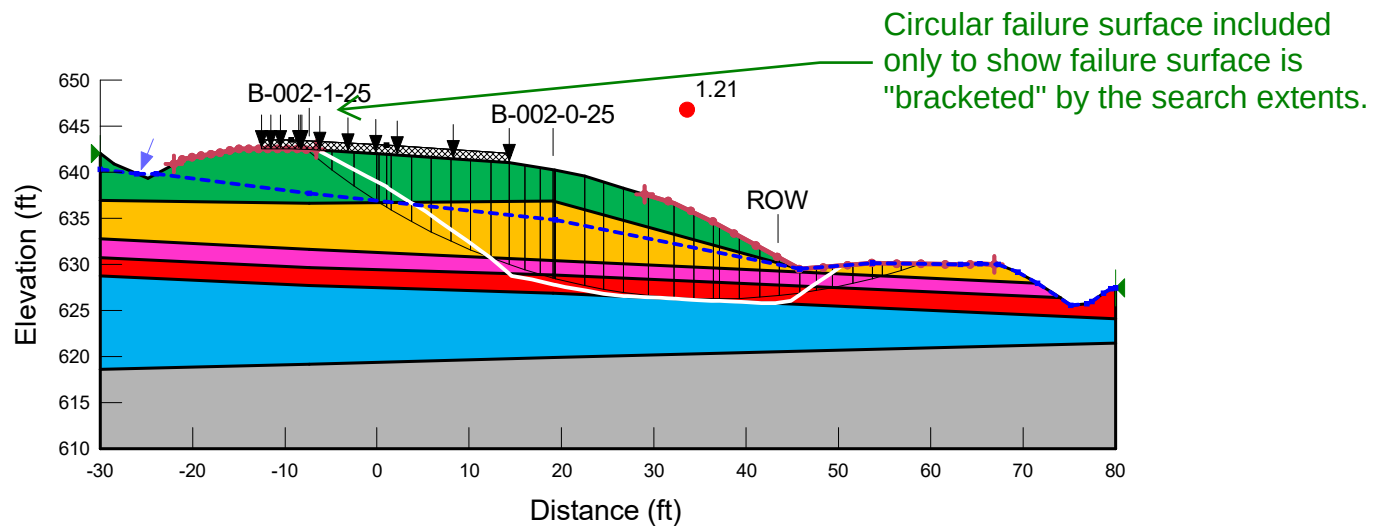
1. Existing Condition 579+11.99 (Skew)

LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
■	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
■	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
■	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
■	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
■	Bedrock	Bedrock (Impenetrable)				
■	Soft Rock	Mohr-Coulomb	130	0	12	0



1. Existing Condition 579+11.99 (Skew)

LAW-243-11.28.gsz

09/15/2025

1:250

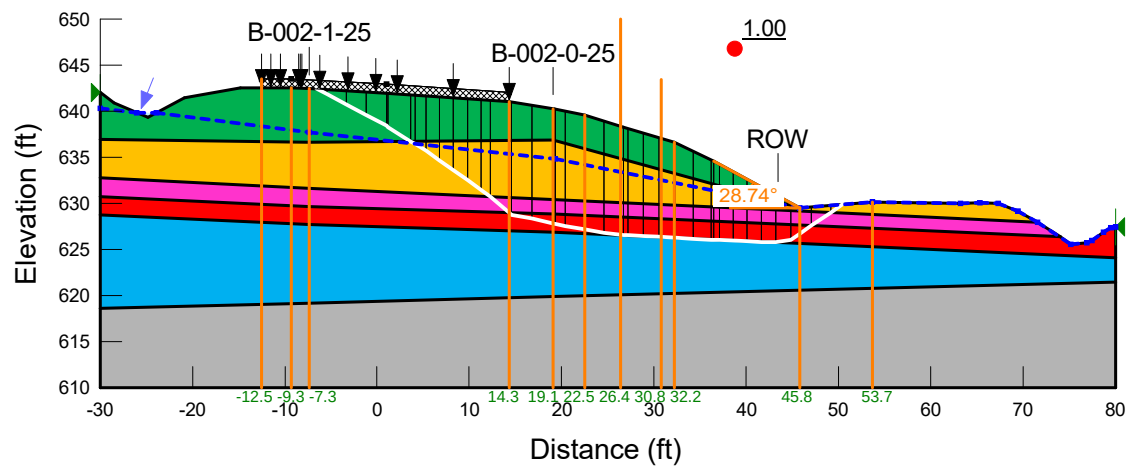


Option 1: Buried Drilled Shaft Wall



Slope Stability

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
■	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
■	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
■	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
■	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
■	Bedrock	Bedrock (Impenetrable)				
■	Soft Rock	Mohr-Coulomb	130	0	12	0



2. UA Slope 579+11.99 (Skew)

LAW-243-11.28.gsz

09/15/2025

1:250

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\Sta. 597+11.99 (Skew) Existing Condition.ua3

FileRunOptionsHelp

Calculated Results

Factor of Safety:1.00

Force per Shaft:0.000lb

Acting Point X: 26.400ftY: 0.000ft

Analysis Unit System

☒ English

☐ Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num:13

Soil Layer Num:8

Analysis Method

☐ Total Stress

☒ Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Surcharge Layer1	0.1	0.0	250.0
New Fill Layer2	200.0	26.0	115.0
Soft to M.S. Cohesive Layer3	60.0	20.0	120.0
M.S. to S. Cohesive Layer4	80.0	21.0	115.0
S. to V.S. Cohesive Layer5	160.0	23.0	115.0
Soft Rock Layer6	25.0	12.0	130.0
Hard Cohesive Layer7	350.0	27.0	130.0
Bedrock Layer8	4000.0	45.0	140.0

Drilled Shaft Information

☒ Calculate without Drilled Shaft

☐ Automatic Load Transfer Factor

☐ Manually Defined Load Transfer Factor

☐ Anchor (On/Off)

Anchor force:50000.0lb

Anchor angle:30.00

Anchor spacing:8.00ft

Auto☐ On☒ Off

0.000(n)

Xmin10.00

Diameter:3.00ft

Xmax20.00

CTC Spacing:6.00ft

XDelta2.00

X Coordinate:26.40ft

☐ Auto Save Data

Run

Chart (Double-Click for More Options)

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
► X (ft)	-12.50	-9.30	-7.30	14.30	14.30	19.10	22.50	26.40	26.40	30.80	32.20	45.80	53.70
Y1 (ft)	6.40	6.40	6.50	7.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y2 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y3 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y4 (ft)	13.20	13.30	13.30	13.10	13.10	13.10	14.00	15.10	15.10	16.30	16.70	20.50	19.80
Y5 (ft)	18.00	18.20	18.30	19.40	19.40	19.60	19.80	19.90	19.90	20.10	20.20	20.80	21.20
Y6 (ft)	20.00	20.20	20.30	21.00	21.00	21.10	21.30	21.40	21.40	21.60	21.70	22.30	22.70
Y7 (ft)	23.00	23.20	23.30	24.00	24.00	24.10	24.30	24.40	24.40	24.60	24.70	25.30	25.70
Y8 (ft)	30.90	30.90	30.80	30.20	30.20	30.10	30.00	29.90	29.90	29.80	29.80	29.40	29.20
Y9 (ft)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

Coordinates of CrestX:14.30ftY:8.90ft

Coordinates of ToeX:45.80ftY:20.50ft

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)	-12.50	-7.30	19.30	45.80	53.70
Y (ft)	11.60	12.30	15.10	20.50	19.80

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Point 18
► X (ft)	-8.68	-6.05	-4.41	-2.24	-0.08	1.10	2.45	3.92	4.72	6.04	7.53	9.03	10.54	11.77	13.27	14.42	15.68	18.00
Y (ft)	6.41	7.81	8.66	9.82	10.98	11.61	12.44	13.36	13.86	14.75	15.81	16.87	17.94	18.87	20.12	21.07	21.41	21.90

Surcharge
New Fill
Soft to M.S. Cohesive
M.S. to S. Cohesive
S. to V.S. Cohesive
Soft Rock
Hard Cohesive
Bedrock

Parameter adjusted to match FS of existing condition in Slope/W.

Traffic surcharge omitted as it is accounted for in the wall loading calculations.

Surcharge
New Fill
Soft to M.S. Cohesive
M.S. to S. Cohesive
S. to V.S. Cohesive
Soft Rock
Hard Cohesive
Bedrock

UA Slope Program Version 2.3 - C:\Users\abarat\Deskto\Sta. 597+11.99 (Skew) Wall.ua3

FileRunOptionsHelp

Calculated Results

Factor of Safety: 55.84

Force per Shaft: 63167.990 lb

Acting Point X: 26.400 ft Y: 19.475 ft

Analysis Unit System

English

Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 13

Soil Layer Num: 8

Analysis Method

Total Stress

Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	26.0	115.0
Layer3	60.0	20.0	120.0
Layer4	80.0	21.0	115.0
Layer5	160.0	23.0	115.0
Layer6	25.0	12.0	130.0
Layer7	350.0	27.0	130.0
Layer8	4000.0	45.0	140.0

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 (ft)

Xmin 0.00 Diameter: 3.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 26.40 ft

Run

Chart (Double-Click for More Options)

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
X (ft)	-12.50	-9.30	-7.30	14.30	14.30	19.10	22.50	26.40	26.40	30.80	32.20	45.80	53.70
Y1 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y2 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y3 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y4 (ft)	13.20	13.30	13.30	13.10	13.10	13.10	14.00	15.10	15.10	16.30	16.70	20.50	19.80
Y5 (ft)	18.00	18.20	18.30	19.40	19.40	19.60	19.80	19.90	19.90	20.10	20.20	20.80	21.20
Y6 (ft)	20.00	20.20	20.30	21.00	21.00	21.10	21.30	21.40	21.40	21.60	21.70	22.30	22.70
Y7 (ft)	23.00	23.20	23.30	24.00	24.00	24.10	24.30	24.40	24.40	24.60	24.70	25.30	25.70
Y8 (ft)	30.90	30.90	30.80	30.20	30.20	30.10	30.00	29.90	29.90	29.80	29.80	29.40	29.20
Y9 (ft)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

Coordinates of Crest X: 14.30 ft Y: 8.90 ft

Coordinates of Toe X: 45.80 ft Y: 20.50 ft

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)	-12.50	-7.30	19.30	45.80	53.70
Y (ft)	11.60	12.30	15.10	20.50	19.80

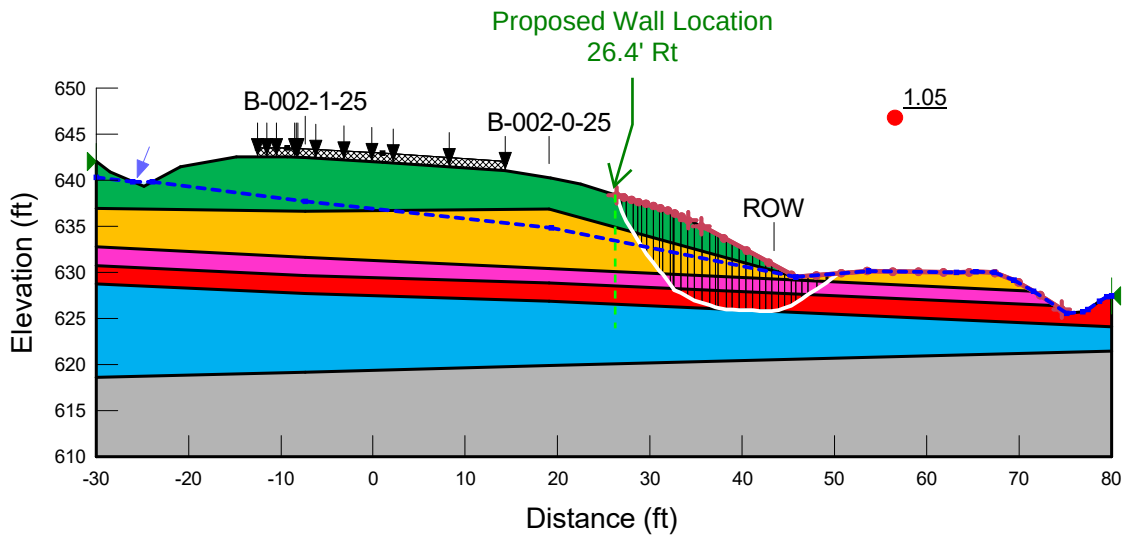
Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Point 18
X (ft)	-6.73	-6.05	-4.41	-2.24	-0.08	1.10	2.45	3.92	4.72	6.04	7.53	9.03	10.54	11.77	13.27	14.42	15.68	18.00
Y (ft)	7.47	7.81	8.66	9.82	10.98	11.61	12.44	13.36	13.86	14.75	15.81	16.87	17.94	18.87	20.12	21.07	21.41	21.90

Corresponds to 24' offset perpendicular to the roadway centerline.

Stability downslope of the wall location.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



3. Downslope Stability 579+11.99 (Skew)

LAW-243-11.28.gsz

09/15/2025

1:250



LPile

Geometry

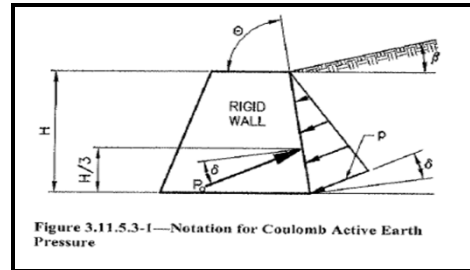
	Elevation (ft)		Horiz. Distance from C/L (ft)		
Top of Slope =	641.1	at Outside Edge of Shoulder	Start of Wall Backfill =	14.3	at Outside Edge of Shoulder
Top of Wall =	638.4	at C/L of Wall	Wall =	26.4	at C/L of Wall
Existing Ground Surface =	638.4	at C/L of Wall			
Slip Plane =	626.6	at C/L of Wall	Backfill Slope Angle =	4.4	H:1V

Wall Loading Profile

	Top Elev.		Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Soft to Medium Stiff Cohesive	638.4	3.5	60	20	120
Medium Stiff to Stiff Cohesive	634.9	3.0	80	21	115
Lowered Ground Surface	631.9				
Weighted Value		6.5	70	20	120

Earth Pressure Coefficients

Shear Resistance, Φ =	Deg	21
Wall Friction, δ^A =		0.0
Wall Slope, θ =		90
Backfill Slope, β =		12.80
Revised Backfill Slope, β =		12.80
Backfill Condition		INFINITE
Horz. Backslope Dist.	12.1	feet (C/L of Wall - Edge of Shoulder)
Wall Height (H)	0.0	feet (Top of Wall - Maintenance Bench)
Slope Height (h)	2.7	feet (Top of Backfill - Top of Wall)
I =		degrees



Active Earth Coefficient

$$K_a = \frac{\sin^2(\theta + \Phi)}{(\sin^2(\theta) \sin(\theta - \delta) * [1 + \nu(\sin(\Phi + \delta) \sin(\Phi - \beta)) / (\sin(\theta - \delta) \sin(\theta + \beta))])^2}$$

$$K_a = 0.566$$

At-Rest Earth Coefficient

$$K_o = (1 - \sin(\phi)) * (1 + \sin(\beta))$$

$$K_o = 0.775$$

Notes:

- Wall friction neglected
- Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- The wall is designed to be completely buried. The soil parameters as determined by backcalculation in SlopeW ($c' = 70$ psf and $\phi' = 20^\circ$, per backcalculated UA Slope Values), were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 21^\circ$ for computing earth pressures based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

As claystone layer is weathered, adopted value for very weak rock as provided in Table 400-6 in the GDM.

Soil Lateral Design Profile							
	Top Elev.	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ϵ_{50}	k
Medium Stiff to Stiff Cohesive	631.9	6.5	900	0	52.6	0.01	N/A
Stiff to Very Stiff Cohesive	630.1	8.3	2600	0	52.6	0.005	N/A
Hard Cohesive (Residual Claystone)	628.1	10.3	4000	0	67.6	0.005	N/A
Bedrock	620.1	18.3	N/A	N/A	N/A	N/A	N/A
Bedrock Lateral Design Profile							
	Top Elev.	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	k _{rm}
Weathered Claystone (SPT Refusal)	620.1	18.3	75	18,000	145	20	0.0005
Claystone	612.6	25.8	150	51,400	145	20	0.0005
Siltstone	611.9	26.5	850	386,300	160	60	0.0005
Claystone	601.6	36.8	150	51,400	145	20	0.0005

Depths referenced below the top of wall, starting at the lowered ground surface. ϵ_{50} and k values per LPILE Technical Manual.

Wall Loading Computations

Earth Pressure Model = **CONVENTIONAL** (Conventional or UA SLOPE)

UA SLOPE

1) Soil Unit Weight = **120** pcf Unit Weight Behind the Wall in the Lowered Ground Surface Zone

2) Determine Coefficient of Earth Pressure (K)

Restraint Condition = **ACTIVE** (Active or At-Rest)

Ka = **0.566**

3) Determine Equivalent Fluid Weight (G_H)

$G_H = (\gamma_m) * (K_a)$

$G_H =$ **68** For application to CONVENTIONAL Earth Pressure Model

4) Artificially Lowered Ground Surface (ODOT GDM Section 903.3.2, pg. 9-14) for $FS_{dh} < 1.30$

Consider Lowered G. S.? **YES**

Lowered Ground Surface (ft) = **6.5** = $dt (\tan(\beta_{dh}))$

$\beta_{dh} =$ **28.74** = steepness of the slope downhill of the drilled shaft

$FS_{dh} =$ **1.05** = Factor of Safety down slope of the proposed wall

$d_t =$ **11.8** = depth below top of wall to the shear surface at the location of the drilled shaft

5) Modification of p-y curves (ODOT GDM Section 903.2, pg. 9-13)

$P_m = 0.64 * (S/D)^{0.34}$ (Ref: Reese, Isenhowe, & Wang - 2006)

D = **3** feet (shaft diameter or pile flange width)

Assumed Shaft Spacing = **6** feet (center-to-center pile spacing)

$P_m =$ **0.81** For retaining wall, applies from top of wall to top of rock/bottom of drilled shafts

For a row of drilled shafts, applies below shear plane to top of rock/bottom of drilled shafts

Reduce p-multiplier? **YES** For application above shear plane if using a row of spaced drilled shafts instead of a retaining wall

$FS_{UAS} =$ **2.72** = Factor of Safety from UASlope including shafts

p-multiplier = **0.51** = $(P_m - P_m/FS_{UAS})$ From top of wall to bottom of shear plane

6) Determine Lateral Thrust

Conventional Earth Pressure Theory

Exposed Wall Height (H) = **0.0** feet

Wall Height (H) + $GS_{AL} =$ **6.5**

$P = 1/2 * G_H * H^2$

P = **1421** lbs/foot

$P_{SH} = P * (\text{Shaft Spacing})$ (earth loading)

$P_{SH} =$ **8525** lbs/shaft

UA SLOPE

Depth from T/Wall to Slip Plane = **11.8** feet

Force Per Shaft = **63168** lbs/shaft

7) Resolve horizontal earth force to distributed triangular load (for LPILE)

$w = 2 * P_{SH} / H$

$w =$ **2635** lbs/foot per shaft (Earth - Service Limit)

10706 lbs/foot per shaft

$w =$ **220** lbs/inch per shaft (Earth - Service Limit)

892 lbs/inch per shaft

$\gamma_E =$ **1.5** Earth Load Factor

$w = (2 * P_{SH} / H) * \gamma_E$

$w =$ **329** lbs/inch per shaft (Earth - Strength Limit)

1338 lbs/inch per shaft

8) Determine live-load traffic surcharge force (P_s)

Include traffic surcharge? **YES**

Surcharge Pressure (q_s) = **250** psf

$P_s = K_a * q_s * H$

$P_s =$ **915** lbs/foot

(surcharge resolved to distributed load)

1668 lbs/foot

$P_s =$ **5489** lbs/shaft

10009 lbs/shaft

9) Resolve surcharge to distributed rectangular load (for LPILE)

$w = P_s / H$

$w =$ **848** lbs/foot per shaft (surcharge - unfactored)

848 lbs/foot per shaft

$w =$ **71** lbs/inch per shaft (surcharge - unfactored)

71 lbs/inch per shaft

$\gamma_s =$ **1.75** Surcharge Load Factor - Strength I

$w = (P_s / L) * \gamma_s$

$w =$ **124** lbs/inch per shaft (Surcharge - Strength I)

124 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL		
Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	71	124
6.5	290	453

Distributed Lateral Loads for LPILE

UA SLOPE		
Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	71	124
11.8	963	1462

Shear, Moment, and Deflection Results

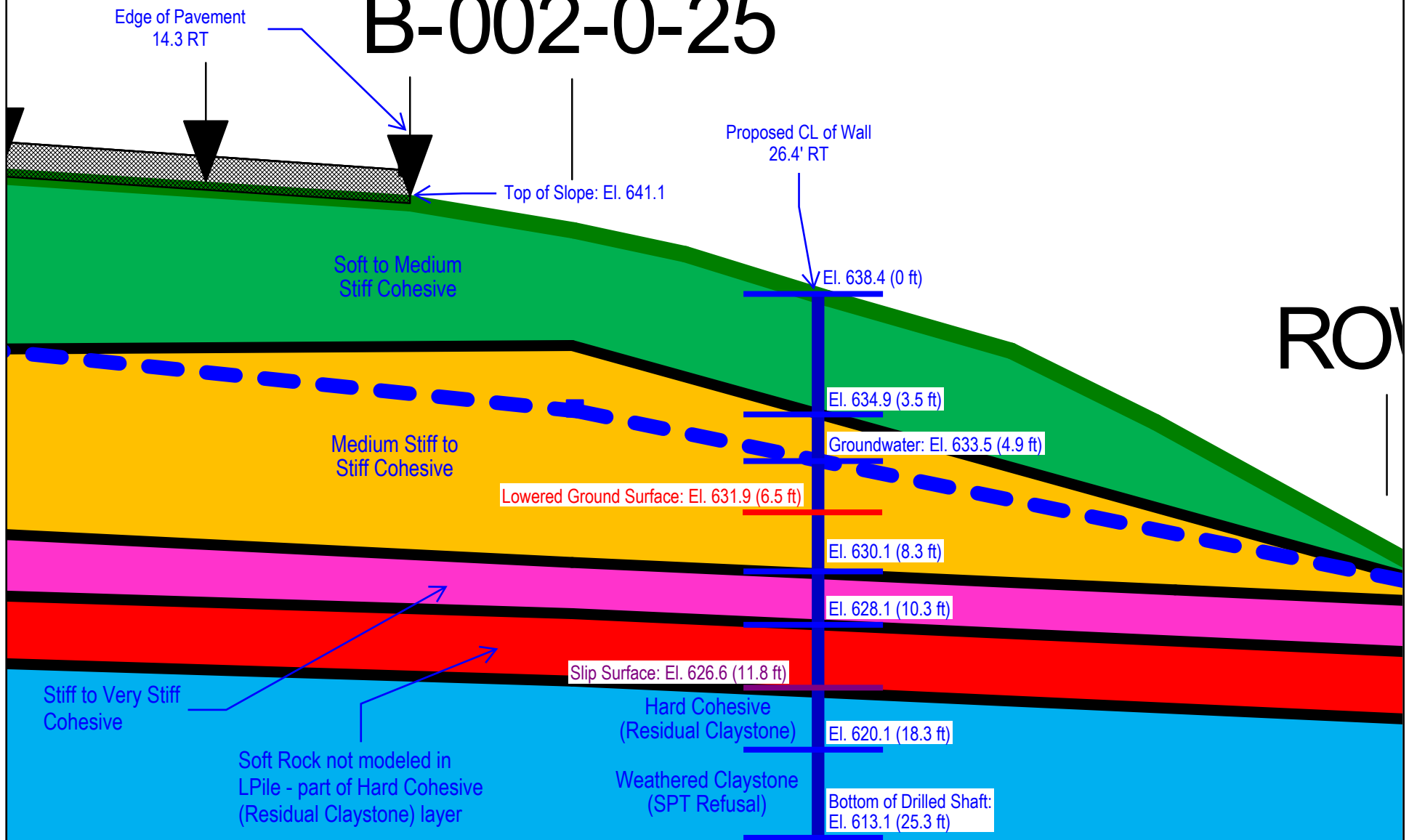
Shear and Moment capacity will need to be confirmed in the final analyses.

Shaft Geometry	
Shaft Diameter	36 in
Rebar Cover	3 in
Steel Reinforcing	
Assumed Bar No.	8
No. of Bars	13
Percent Steel	1.01%
Yield Strength of Steel	60 ksi
Modulus of Elasticity of Steel (E _s)	29000000 psi
Concrete Properties	
Concrete Compressive Strength (f' _c)	4000 psi
Modulus of Elasticity of Concrete (E _c)	3604997 psi

Maximum Shear and Moment (from LPile)	
V_u =	112.9 kips
M_u =	6600.2 in*kips

Deflection Criteria			
Pile Length Above Rock =	18.3 ft	Exposed Wall Height =	0 ft
Pile Length Above Rock =	219.6 in	Exposed Wall Height =	in

B-002-0-25



Case 1 = Service Case
Case 2 = Strength Case

=====

LPIle for Version 2022-12.012

License ID : 202613844
License Type : (Network License)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
© 1985-2024 by Ensoft, Inc.
All Rights Reserved

This software is licensed for exclusive use by:
HDR
LPILE Global, Global License

=====

This model was prepared by:
abaratia

Files Used for Analysis

Path to file locations:
\pwworking\east01\d4575312\

Name of input data file:
LAW-243-11.28 Wall Design.lp12d

Name of output report file:
LAW-243-11.28 Wall Design.lp12o

Name of plot output file:
LAW-243-11.28 Wall Design.lp12p

Name of runtime message file:
LAW-243-11.28 Wall Design.lp12r

Date and Time of Analysis

Date: September 19, 2025 Time: 16:23:35

Problem Title

Project Name: LAW-243-11.28

Job Number:

Client: ODOT

Engineer: HDR

Description: Buried Drilled Shaft Wall

Program Options and Settings

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
- Analysis uses p-y modification factors for p-y curves
- 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	=	1
Total length of pile	=	25.300 ft
Depth of ground surface below top of pile	=	6.5000 ft

Pile diameters used for p-y curve computations are defined using 2 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	36.0000
2	25.300	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile
Length of section = 25.300000 ft
Shaft Diameter = 36.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 7 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer = 6.500000 ft
Distance from top of pile to bottom of layer = 8.300000 ft
Effective unit weight at top of layer = 52.600000 pcf
Effective unit weight at bottom of layer = 52.600000 pcf
Undrained cohesion at top of layer = 900.000000 psf
Undrained cohesion at bottom of layer = 900.000000 psf
Epsilon-50 at top of layer = 0.010000
Epsilon-50 at bottom of layer = 0.010000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer = 8.300000 ft
Distance from top of pile to bottom of layer = 10.300000 ft
Effective unit weight at top of layer = 52.600000 pcf
Effective unit weight at bottom of layer = 52.600000 pcf
Undrained cohesion at top of layer = 2600. psf
Undrained cohesion at bottom of layer = 2600. psf
Epsilon-50 at top of layer = 0.005000
Epsilon-50 at bottom of layer = 0.005000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer = 10.300000 ft
Distance from top of pile to bottom of layer = 18.300000 ft
Effective unit weight at top of layer = 67.600000 pcf

Effective unit weight at bottom of layer	=	67.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	18.300000 ft
Distance from top of pile to bottom of layer	=	25.800000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	75.000000 psi
Uniaxial compressive strength at bottom of layer	=	75.000000 psi
Initial modulus of rock at top of layer	=	18000. psi
Initial modulus of rock at bottom of layer	=	18000. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	25.800000 ft
Distance from top of pile to bottom of layer	=	26.500000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	150.000000 psi
Uniaxial compressive strength at bottom of layer	=	150.000000 psi
Initial modulus of rock at top of layer	=	51400. psi
Initial modulus of rock at bottom of layer	=	51400. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 6 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	26.500000 ft
Distance from top of pile to bottom of layer	=	36.800000 ft
Effective unit weight at top of layer	=	160.000000 pcf
Effective unit weight at bottom of layer	=	160.000000 pcf
Uniaxial compressive strength at top of layer	=	850.000000 psi
Uniaxial compressive strength at bottom of layer	=	850.000000 psi
Initial modulus of rock at top of layer	=	386300. psi
Initial modulus of rock at bottom of layer	=	386300. psi
RQD of rock at top of layer	=	60.000000 %
RQD of rock at bottom of layer	=	60.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	36.800000 ft
Distance from top of pile to bottom of layer	=	39.000000 ft

Effective unit weight at top of layer = 145.000000 pcf
 Effective unit weight at bottom of layer = 145.000000 pcf
 Uniaxial compressive strength at top of layer = 150.000000 psi
 Uniaxial compressive strength at bottom of layer = 150.000000 psi
 Initial modulus of rock at top of layer = 51400. psi
 Initial modulus of rock at bottom of layer = 51400. psi
 RQD of rock at top of layer = 20.000000 %
 RQD of rock at bottom of layer = 20.000000 %
 k rm of rock at top of layer = 0.0005000
 k rm of rock at bottom of layer = 0.0005000

(Depth of the lowest soil layer extends 13.700 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 7, for effective unit weight = 160.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	6.5000	52.6000	900.0000	--	--	0.01000	--
	w/o Free Water	8.3000	52.6000	900.0000	--	--	0.01000	--
2	Stiff Clay	8.3000	52.6000	2600.	--	--	0.00500	--
	w/o Free Water	10.3000	52.6000	2600.	--	--	0.00500	--
3	Stiff Clay	10.3000	67.6000	4000.	--	--	0.00500	--
	w/o Free Water	18.3000	67.6000	4000.	--	--	0.00500	--
4	Weak	18.3000	145.0000	--	75.0000	20.0000	5.00E-04	18000.
	Rock	25.8000	145.0000	--	75.0000	20.0000	5.00E-04	18000.
5	Weak	25.8000	145.0000	--	150.0000	20.0000	5.00E-04	51400.
	Rock	26.5000	145.0000	--	150.0000	20.0000	5.00E-04	51400.
6	Weak	26.5000	160.0000	--	850.0000	60.0000	5.00E-04	386300.
	Rock	36.8000	160.0000	--	850.0000	60.0000	5.00E-04	386300.
7	Weak	36.8000	145.0000	--	150.0000	20.0000	5.00E-04	51400.
	Rock	39.0000	145.0000	--	150.0000	20.0000	5.00E-04	51400.

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 4 points

Point No.	Depth X ft	p-mult	y-mult
-----	-----	-----	-----

1	6.500	0.5100	1.0000
2	11.800	0.5100	1.0000
3	11.800	0.8100	1.0000
4	18.300	0.8100	1.0000

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	71.000
2	11.800	963.000

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

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	124.000
2	11.800	1462.000

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	Yes	Yes
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	Yes	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 = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	25.300000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.000000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.940154 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.92
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	1.000000	0.790000	14.500000	0.000000
2	1.000000	0.790000	12.839112	6.738486
3	1.000000	0.790000	8.236939	11.933266
4	1.000000	0.790000	1.747782	14.394279
5	1.000000	0.790000	-5.14177	13.557736
6	1.000000	0.790000	-10.85341	9.615279
7	1.000000	0.790000	-14.07866	3.470077
8	1.000000	0.790000	-14.07866	-3.47008
9	1.000000	0.790000	-10.85341	-9.61528
10	1.000000	0.790000	-5.14177	-13.55774
11	1.000000	0.790000	1.747782	-14.39428
12	1.000000	0.790000	8.236939	-11.93327
13	1.000000	0.790000	12.839112	-6.73849

NOTE: The positions of the above rebars were computed by LPILE

Minimum spacing between any two bars not equal to zero = 5.940 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.92

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

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

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
6.25000E-07	234.8458740	375753398.	18.0000836	0.00001125	-0.00001125	0.0470968	0.2707890	
0.00000125	468.8181144	375054491.	18.0000839	0.00002250	-0.00002250	0.0939147	0.5415780	
0.00000188	701.9167212	374355585.	18.0000841	0.00003375	-0.00003375	0.1404538	0.8123671	
0.00000250	934.1416945	373656678.	18.0000843	0.00004500	-0.00004500	0.1867139	1.0831561	
0.00000313	1165.	372957771.	18.0000846	0.00005625	-0.00005625	0.2326951	1.3539452	
0.00000375	1396.	372258864.	18.0000848	0.00006750	-0.00006750	0.2783973	1.6247342	
0.00000438	1626.	371559957.	18.0000851	0.00007875	-0.00007875	0.3238207	1.8955233	

0.00000500	1854.	370861050.	18.0000853	0.00009000	-0.00009000	0.3689652	2.1663124
0.00000563	2082.	370162144.	18.0000856	0.0001013	-0.000101	0.4138308	2.4371015
0.00000625	2309.	369463237.	18.0000858	0.0001125	-0.000112	0.4584174	2.7078906
0.00000688	2309.	335875670.	8.6711586	0.00005961	-0.000188	0.2437545	-4.838600 C
0.00000750	2309.	307886031.	8.6733423	0.00006505	-0.000205	0.2656012	-5.277998 C
0.00000813	2309.	284202490.	8.6755298	0.00007049	-0.000222	0.2873954	-5.717316 C
0.00000875	2309.	263902312.	8.6777212	0.00007593	-0.000239	0.3091372	-6.156553 C
0.00000938	2309.	246308824.	8.6799163	0.00008137	-0.000256	0.3308263	-6.595710 C
0.00001000	2309.	230914523.	8.6821154	0.00008682	-0.000273	0.3524628	-7.034787 C
0.00001063	2309.	217331316.	8.6843182	0.00009227	-0.000290	0.3740466	-7.473782 C
0.00001125	2309.	205257354.	8.6865250	0.00009772	-0.000307	0.3955776	-7.912696 C
0.00001188	2309.	194454335.	8.6887357	0.0001032	-0.000324	0.4170558	-8.351529 C
0.00001250	2309.	184731618.	8.6909503	0.0001086	-0.000341	0.4384810	-8.790281 C
0.00001313	2309.	175934875.	8.6931687	0.0001141	-0.000358	0.4598532	-9.228950 C
0.00001375	2309.	167937835.	8.6953912	0.0001196	-0.000375	0.4811723	-9.667538 C
0.00001438	2309.	160636190.	8.6976175	0.0001250	-0.000392	0.5024383	-10.106043 C
0.00001500	2309.	153943015.	8.6998479	0.0001305	-0.000410	0.5236511	-10.544466 C
0.00001563	2309.	147785295.	8.7020822	0.0001360	-0.000427	0.5448106	-10.982806 C
0.00001625	2309.	142101245.	8.7043205	0.0001414	-0.000444	0.5659167	-11.421064 C
0.00001688	2309.	136838236.	8.7065628	0.0001469	-0.000461	0.5869694	-11.859238 C
0.00001750	2309.	131951156.	8.7088091	0.0001524	-0.000478	0.6079686	-12.297329 C
0.00001813	2309.	127401116.	8.7110595	0.0001579	-0.000495	0.6289142	-12.735337 C
0.00001875	2309.	123154412.	8.7133139	0.0001634	-0.000512	0.6498061	-13.173261 C
0.00001938	2309.	119181689.	8.7155724	0.0001689	-0.000529	0.6706443	-13.611100 C
0.00002000	2309.	115457261.	8.7178350	0.0001744	-0.000546	0.6914287	-14.048856 C
0.00002063	2309.	111958557.	8.7201016	0.0001799	-0.000563	0.7121592	-14.486527 C
0.00002125	2309.	108665658.	8.7223724	0.0001854	-0.000580	0.7328358	-14.924113 C
0.00002188	2309.	105560925.	8.7246473	0.0001909	-0.000597	0.7534584	-15.361614 C
0.00002250	2309.	102628677.	8.7269263	0.0001964	-0.000614	0.7740268	-15.799031 C
0.00002313	2309.	99854929.	8.7292095	0.0002019	-0.000631	0.7945410	-16.236361 C
0.00002375	2309.	97227168.	8.7314969	0.0002074	-0.000648	0.8150010	-16.673606 C
0.00002438	2309.	94734163.	8.7337884	0.0002129	-0.000665	0.8354067	-17.110766 C
0.00002563	2309.	90112985.	8.7383842	0.0002239	-0.000699	0.8760547	-17.984826 C
0.00002688	2309.	85921683.	8.7429968	0.0002350	-0.000733	0.9164845	-18.858539 C
0.00002813	2309.	82102941.	8.7476265	0.0002460	-0.000766	0.9566953	-19.731905 C
0.00002938	2309.	78609199.	8.7522734	0.0002571	-0.000800	0.9966866	-20.604920 C
0.00003063	2309.	75400661.	8.7569376	0.0002682	-0.000834	1.0364578	-21.477582 C
0.00003188	2309.	72443772.	8.7616193	0.0002793	-0.000868	1.0760082	-22.349891 C
0.00003313	2339.	70607879.	8.7663186	0.0002904	-0.000902	1.1153372	-23.221843 C
0.00003438	2426.	70578531.	8.7710355	0.0003015	-0.000936	1.1544440	-24.093436 C
0.00003563	2513.	70549088.	8.7757704	0.0003126	-0.000970	1.1933281	-24.964670 C
0.00003688	2600.	70519549.	8.7805232	0.0003238	-0.001004	1.2319889	-25.835540 C
0.00003813	2687.	70489912.	8.7852942	0.0003349	-0.001038	1.2704255	-26.706047 C
0.00003938	2774.	70460179.	8.7900834	0.0003461	-0.001071	1.3086375	-27.576186 C
0.00004063	2861.	70430347.	8.7948910	0.0003573	-0.001105	1.3466240	-28.445956 C
0.00004188	2948.	70400416.	8.7997172	0.0003685	-0.001139	1.3843844	-29.315356 C
0.00004313	3035.	70370385.	8.8045621	0.0003797	-0.001173	1.4219180	-30.184382 C
0.00004438	3121.	70340253.	8.8093847	0.0003909	-0.001207	1.4592241	-31.053032 C
0.00004563	3208.	70310021.	8.8141546	0.0004021	-0.001240	1.4963021	-31.921305 C
0.00004688	3294.	70279686.	8.8189430	0.0004134	-0.001274	1.5331512	-32.789198 C
0.00004813	3381.	70249285.	8.8236584	0.0004246	-0.001308	1.5697415	-33.656964 C
0.00004938	3467.	70218791.	8.8283743	0.0004359	-0.001342	1.6060946	-34.524410 C
0.00005063	3553.	70188198.	8.8331081	0.0004472	-0.001375	1.6422151	-35.391488 C
0.00005188	3639.	70157505.	8.8378601	0.0004585	-0.001409	1.6781024	-36.258195 C
0.00005313	3725.	70126711.	8.8426302	0.0004698	-0.001443	1.7137557	-37.124530 C
0.00005438	3811.	70095816.	8.8475917	0.0004811	-0.001476	1.7491742	-37.990489 C
0.00005563	3897.	70064818.	8.8524023	0.0004924	-0.001510	1.7843574	-38.856071 C
0.00005688	3983.	70033717.	8.8572316	0.0005038	-0.001544	1.8193044	-39.721273 C
0.00005813	4069.	70002512.	8.8620797	0.0005151	-0.001577	1.8540145	-40.586093 C

0.00005938	4155.	69971203.	8.8669467	0.0005265	-0.001611	1.8884870	-41.450529 C
0.00006063	4240.	69939789.	8.8718328	0.0005379	-0.001645	1.9227211	-42.314578 C
0.00006188	4326.	69908268.	8.8767382	0.0005492	-0.001678	1.9567160	-43.178239 C
0.00006313	4411.	69876641.	8.8816630	0.0005607	-0.001712	1.9904710	-44.041508 C
0.00006438	4496.	69844905.	8.8866073	0.0005721	-0.001745	2.0239854	-44.904384 C
0.00006563	4581.	69813062.	8.8915714	0.0005835	-0.001779	2.0572583	-45.766863 C
0.00006688	4667.	69781108.	8.8965553	0.0005950	-0.001813	2.0902890	-46.628944 C
0.00006813	4752.	69749045.	8.9015593	0.0006064	-0.001846	2.1230766	-47.490624 C
0.00006938	4837.	69716871.	8.9065834	0.0006179	-0.001880	2.1556204	-48.351900 C
0.00007063	4921.	69684584.	8.9116280	0.0006294	-0.001913	2.1879196	-49.212771 C
0.00007188	5006.	69652185.	8.9166930	0.0006409	-0.001947	2.2199733	-50.073232 C
0.00007313	5091.	69619673.	8.9217788	0.0006524	-0.001980	2.2517808	-50.933282 C
0.00007438	5176.	69587046.	8.9268854	0.0006639	-0.002014	2.2833411	-51.792919 C
0.00007938	5513.	69455373.	8.9475243	0.0007102	-0.002147	2.4070948	-55.227271 C
0.00008438	5849.	69321795.	8.9685114	0.0007567	-0.002281	2.5268266	-58.654782 C
0.00008938	6170.	69033079.	8.9833522	0.0008029	-0.002415	2.6409994	-60.000000 CY
0.00009438	6409.	67910374.	8.9604369	0.0008456	-0.002552	2.7425252	-60.000000 CY
0.00009938	6607.	66487052.	8.9226755	0.0008867	-0.002691	2.8361866	-60.000000 CY
0.0001044	6763.	64793237.	8.8699113	0.0009258	-0.002832	2.9219654	-60.000000 CY
0.0001094	6913.	63203100.	8.8209583	0.0009648	-0.002973	3.0042086	-60.000000 CY
0.0001144	7029.	61453725.	8.7579087	0.0010017	-0.003116	3.0788833	-60.000000 CY
0.0001194	7135.	59765488.	8.6960750	0.0010381	-0.003259	3.1497332	-60.000000 CY
0.0001244	7240.	58208315.	8.6401241	0.0010746	-0.003403	3.2179797	-60.000000 CY
0.0001294	7334.	56684611.	8.5838017	0.0011105	-0.003547	3.2822437	-60.000000 CY
0.0001344	7405.	55105827.	8.5203605	0.0011449	-0.003693	3.3412103	-60.000000 CY
0.0001394	7473.	53618595.	8.4610242	0.0011793	-0.003838	3.3975129	-60.000000 CY
0.0001444	7540.	52227726.	8.4035607	0.0012133	-0.003984	3.4507257	-60.000000 CY
0.0001494	7607.	50927402.	8.3504533	0.0012473	-0.004130	3.5016330	-60.000000 CY
0.0001544	7672.	49699623.	8.3005973	0.0012814	-0.004276	3.5500407	-60.000000 CY
0.0001594	7725.	48472163.	8.2475048	0.0013144	-0.004423	3.5946131	-60.000000 CY
0.0001644	7768.	47256861.	8.1925403	0.0013466	-0.004571	3.6357552	-60.000000 CY
0.0001694	7808.	46100044.	8.1401697	0.0013787	-0.004719	3.6745836	-60.000000 CY
0.0001744	7848.	45007261.	8.0908087	0.0014108	-0.004867	3.7112211	-60.000000 CY
0.0001794	7887.	43970883.	8.0421005	0.0014426	-0.005015	3.7452725	-60.000000 CY
0.0001844	7926.	42989243.	7.9965987	0.0014744	-0.005163	3.7772930	-60.000000 CY
0.0001894	7965.	42057984.	7.9540616	0.0015063	-0.005311	3.8072622	-60.000000 CY
0.0001944	8003.	41173194.	7.9142621	0.0015383	-0.005459	3.8351594	-60.000000 CY
0.0001994	8040.	40324416.	7.8749293	0.0015701	-0.005607	3.8608174	-60.000000 CY
0.0002044	8071.	39490836.	7.8369008	0.0016017	-0.005756	3.8838761	-60.000000 CY
0.0002094	8097.	38672432.	7.7967268	0.0016324	-0.005905	3.9044611	-60.000000 CY
0.0002144	8119.	37875124.	7.7565950	0.0016628	-0.006055	3.9228073	-60.000000 CY
0.0002194	8140.	37106762.	7.7149016	0.0016925	-0.006205	3.9389617	-60.000000 CY
0.0002244	8161.	36370452.	7.6750165	0.0017221	-0.006355	3.9531313	-60.000000 CY
0.0002294	8181.	35665365.	7.6382423	0.0017520	-0.006505	3.9654712	-60.000000 CY
0.0002344	8201.	34989484.	7.6042015	0.0017822	-0.006655	3.9759626	-60.000000 CY
0.0002394	8220.	34340962.	7.5708104	0.0018123	-0.006805	3.9845861	-60.000000 CY
0.0002444	8240.	33718102.	7.5392336	0.0018424	-0.006955	3.9913220	-60.000000 CY
0.0002494	8259.	33119365.	7.5092410	0.0018726	-0.007105	3.9961502	-60.000000 CY
0.0002544	8278.	32543297.	7.4810255	0.0019030	-0.007255	3.9990498	-60.000000 CY
0.0002594	8297.	31988573.	7.4542160	0.0019334	-0.007404	3.9998484	-60.000000 CY
0.0002644	8316.	31453657.	7.4286612	0.0019640	-0.007554	3.9952503	-60.000000 CY
0.0002694	8334.	30937816.	7.4049752	0.0019947	-0.007703	3.9984609	-60.000000 CY
0.0002744	8352.	30439234.	7.3816595	0.0020253	-0.007852	3.9999101	-60.000000 CY
0.0003044	8423.	27674597.	7.2338201	0.0022018	-0.008756	3.9948036	-60.000000 CY
0.0003344	8469.	25327089.	7.1052717	0.0023758	-0.009662	3.9969623	-60.000000 CY
0.0003644	8510.	23353711.	7.0058284	0.0025527	-0.010565	3.9966011	-60.000000 CY
0.0003944	8545.	21668453.	6.9199595	0.0027291	-0.011468	3.9927976	-60.000000 CY
0.0004244	8579.	20215343.	6.8522385	0.0029079	-0.012370	3.9910213	-60.000000 CY
0.0004544	8606.	18940608.	6.7941459	0.0030871	-0.013270	3.9992404	-60.000000 CYT

0.0004844	8623.	17801649.	6.7361829	0.0032628	-0.014175	3.9875287	-60.000000 CYT
0.0005144	8632.	16781743.	6.6813287	0.0034367	-0.015081	3.9993765	-60.000000 CYT
0.0005444	8639.	15869978.	6.6295482	0.0036090	-0.015989	3.9821596	-60.000000 CYT
0.0005744	8645.	15051624.	6.5816295	0.0037803	-0.016897	3.9944591	-60.000000 CYT
0.0006044	8645.	14304491.	6.5822074	0.0039781	-0.017779	3.9921260	60.000000 CYT

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	0.000	8592.892	0.00300000	-0.01283254

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	0.0000	8593.	0.0000	5585.	69426607.
1	0.75	0.0000	8593.	0.0000	6445.	67654407.
1	0.90	0.0000	8593.	0.0000	7734.	48233876.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	6.5000	0.00	N.A.	No	0.00	15615.
2	8.3000	0.6540	Yes	No	15615.	51618.
3	10.3000	1.7733	Yes	No	67233.	390580.
4	18.3000	11.8000	No	Yes	N.A.	N.A.

5	25.8000	19.3000	No	Yes	N.A.	N.A.
6	26.5000	20.0000	No	Yes	N.A.	N.A.
7	36.8000	30.3000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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	0.9650	-1.77E-04	-7.45E-07	-0.00541	0.00	3.76E+11	0.00	0.00	75.7813
0.2530	0.9486	349.2490	251.8458	-0.00541	0.00	3.76E+11	0.00	0.00	90.1251
0.5060	0.9322	1529.	554.4975	-0.00541	0.00	3.76E+11	0.00	0.00	109.2502
0.7590	0.9157	3716.	915.2129	-0.00541	0.00	3.76E+11	0.00	0.00	128.3753
1.0120	0.8993	7086.	1334.	-0.00541	0.00	3.76E+11	0.00	0.00	147.5003
1.2650	0.8829	11816.	1811.	-0.00541	0.00	3.76E+11	0.00	0.00	166.6254
1.5180	0.8664	18082.	2346.	-0.00541	0.00	3.76E+11	0.00	0.00	185.7505
1.7710	0.8500	26060.	2939.	-0.00541	0.00	3.76E+11	0.00	0.00	204.8756
2.0240	0.8336	35926.	3590.	-0.00541	0.00	3.76E+11	0.00	0.00	224.0007
2.2770	0.8171	47856.	4299.	-0.00541	0.00	3.76E+11	0.00	0.00	243.1258
2.5300	0.8007	62028.	5066.	-0.00541	0.00	3.76E+11	0.00	0.00	262.2508
2.7830	0.7843	78617.	5891.	-0.00541	0.00	3.76E+11	0.00	0.00	281.3759
3.0360	0.7678	97800.	6775.	-0.00541	0.00	3.76E+11	0.00	0.00	300.5010
3.2890	0.7514	119752.	7716.	-0.00541	0.00	3.76E+11	0.00	0.00	319.6261
3.5420	0.7350	144651.	8715.	-0.00541	0.00	3.76E+11	0.00	0.00	338.7512
3.7950	0.7186	172671.	9773.	-0.00541	0.00	3.76E+11	0.00	0.00	357.8763
4.0480	0.7022	203991.	10888.	-0.00541	0.00	3.76E+11	0.00	0.00	377.0014
4.3010	0.6857	238785.	12062.	-0.00540	0.00	3.76E+11	0.00	0.00	396.1264
4.5540	0.6693	277231.	13294.	-0.00540	0.00	3.76E+11	0.00	0.00	415.2515
4.8070	0.6529	319504.	14583.	-0.00540	0.00	3.75E+11	0.00	0.00	434.3766
5.0600	0.6366	365781.	15931.	-0.00540	0.00	3.75E+11	0.00	0.00	453.5017
5.3130	0.6202	416238.	17337.	-0.00539	0.00	3.75E+11	0.00	0.00	472.6268
5.5660	0.6038	471051.	18801.	-0.00539	0.00	3.75E+11	0.00	0.00	491.7519
5.8190	0.5874	530397.	20323.	-0.00539	0.00	3.75E+11	0.00	0.00	510.8769
6.0720	0.5711	594452.	21903.	-0.00538	0.00	3.75E+11	0.00	0.00	530.0020
6.3250	0.5548	663392.	23541.	-0.00538	0.00	3.74E+11	0.00	0.00	549.1271
6.5780	0.5385	737393.	25006.	-0.00537	0.00	3.74E+11	-152.268	858.5453	568.2522
6.8310	0.5222	815229.	26296.	-0.00536	0.00	3.74E+11	-153.954	895.1464	587.3773
7.0840	0.5059	897060.	27638.	-0.00536	0.00	3.74E+11	-155.570	933.6421	606.5024
7.3370	0.4896	983047.	29034.	-0.00535	0.00	3.73E+11	-157.111	974.1946	625.6275
7.5900	0.4734	1073352.	30483.	-0.00534	0.00	3.73E+11	-158.575	1017.	644.7525

7.8430	0.4572	1168139.	31986.	-0.00533	0.00	3.73E+11	-159.959	1062.	663.8776
8.0960	0.4410	1267571.	33543.	-0.00532	0.00	3.73E+11	-161.259	1110.	683.0027
8.3490	0.4249	1371811.	34624.	-0.00531	0.00	3.72E+11	-511.629	3656.	702.1278
8.6020	0.4088	1477808.	35227.	-0.00530	0.00	3.72E+11	-514.360	3820.	721.2529
8.8550	0.3927	1585711.	35881.	-0.00529	0.00	3.72E+11	-516.803	3996.	740.3780
9.1080	0.3767	1695675.	36585.	-0.00527	0.00	3.71E+11	-518.942	4183.	759.5031
9.3610	0.3607	1807857.	37342.	-0.00526	0.00	3.71E+11	-520.760	4384.	778.6281
9.6140	0.3447	1922415.	38152.	-0.00524	0.00	3.71E+11	-522.238	4599.	797.7532
9.8670	0.3288	2039513.	39015.	-0.00523	0.00	3.70E+11	-523.356	4832.	816.8783
10.1200	0.3130	2159317.	39934.	-0.00521	0.00	3.70E+11	-524.090	5084.	836.0034
10.3730	0.2972	2281995.	40543.	-0.00519	0.00	3.70E+11	-765.980	7825.	855.1285
10.6260	0.2814	2405495.	40843.	-0.00513	0.00	7.06E+10	-766.060	8264.	874.2536
10.8790	0.2660	2529992.	41201.	-0.00503	0.00	7.05E+10	-765.637	8738.	893.3786
11.1320	0.2509	2655667.	41619.	-0.00491	0.00	7.05E+10	-764.693	9252.	912.5037
11.3850	0.2362	2782704.	42099.	-0.00480	0.00	7.05E+10	-763.213	9811.	931.6288
11.6380	0.2218	2911294.	42643.	-0.00467	0.00	7.04E+10	-761.180	10419.	950.7539
11.8910	0.2078	3041631.	41306.	-0.00455	0.00	7.04E+10	-1205.	17603.	134.9362
12.1440	0.1942	3162106.	37861.	-0.00441	0.00	7.03E+10	-1200.	18756.	0.00
12.3970	0.1810	3271524.	34228.	-0.00427	0.00	7.03E+10	-1194.	20022.	0.00
12.6500	0.1683	3369937.	30614.	-0.00413	0.00	7.03E+10	-1187.	21415.	0.00
12.9030	0.1559	3457412.	27023.	-0.00398	0.00	7.02E+10	-1179.	22951.	0.00
13.1560	0.1441	3534022.	23458.	-0.00383	0.00	7.02E+10	-1170.	24651.	0.00
13.4090	0.1327	3599849.	19922.	-0.00368	0.00	7.02E+10	-1160.	26539.	0.00
13.6620	0.1217	3654986.	16417.	-0.00352	0.00	7.02E+10	-1149.	28643.	0.00
13.9150	0.1113	3699535.	12949.	-0.00336	0.00	7.01E+10	-1136.	30997.	0.00
14.1680	0.1013	3733609.	9519.	-0.00320	0.00	7.01E+10	-1123.	33642.	0.00
14.4210	0.09188	3757333.	6131.	-0.00304	0.00	7.01E+10	-1108.	36627.	0.00
14.6740	0.08290	3770840.	2790.	-0.00287	0.00	7.01E+10	-1093.	40012.	0.00
14.9270	0.07442	3774276.	-500.830	-0.00271	0.00	7.01E+10	-1075.	43872.	0.00
15.1800	0.06644	3767799.	-3738.	-0.00255	0.00	7.01E+10	-1057.	48300.	0.00
15.4330	0.05896	3751579.	-6917.	-0.00238	0.00	7.01E+10	-1037.	53413.	0.00
15.6860	0.05196	3725798.	-10034.	-0.00222	0.00	7.01E+10	-1016.	59358.	0.00
15.9390	0.04546	3690653.	-13084.	-0.00206	0.00	7.01E+10	-993.117	66327.	0.00
16.1920	0.03944	3646355.	-16062.	-0.00190	0.00	7.02E+10	-968.690	74570.	0.00
16.4450	0.03390	3593127.	-18963.	-0.00175	0.00	7.02E+10	-942.557	84416.	0.00
16.6980	0.02883	3531212.	-21782.	-0.00159	0.00	7.02E+10	-914.611	96312.	0.00
16.9510	0.02423	3460867.	-24513.	-0.00144	0.00	7.02E+10	-884.728	110872.	0.00
17.2040	0.02008	3382366.	-27151.	-0.00129	0.00	7.02E+10	-852.763	128957.	0.00
17.4570	0.01637	3296006.	-29688.	-0.00115	0.00	7.03E+10	-818.551	151808.	0.00
17.7100	0.01310	3202101.	-32117.	-0.00101	0.00	7.03E+10	-781.900	181264.	0.00
17.9630	0.01024	3100989.	-34432.	-8.73E-04	0.00	7.03E+10	-742.594	220127.	0.00
18.2160	0.00779	2993032.	-36622.	-7.42E-04	0.00	7.04E+10	-700.398	272827.	0.00
18.4690	0.00574	2878619.	-39125.	-6.15E-04	0.00	7.04E+10	-948.526	501868.	0.00
18.7220	0.00406	2755464.	-42030.	-4.94E-04	0.00	7.05E+10	-965.079	721882.	0.00
18.9750	0.00274	2623413.	-44954.	-3.78E-04	0.00	7.05E+10	-961.079	1064891.	0.00
19.2280	0.00176	2482503.	-47837.	-2.68E-04	0.00	7.06E+10	-938.199	1614548.	0.00
19.4810	0.00111	2332946.	-50635.	-1.65E-04	0.00	7.10E+10	-904.937	2469242.	0.00
19.7340	7.64E-04	2175048.	-53354.	-1.06E-04	0.00	3.70E+11	-886.457	3522856.	0.00
19.9870	4.69E-04	2008979.	-55976.	-8.88E-05	0.00	3.70E+11	-840.385	5434781.	0.00
20.2400	2.25E-04	1835164.	-58383.	-7.30E-05	0.00	3.71E+11	-745.429	1.01E+07	0.00
20.4930	2.61E-05	1654478.	-59655.	-5.87E-05	0.00	3.71E+11	-92.689	1.08E+07	0.00
20.7460	-1.32E-04	1472938.	-59044.	-4.60E-05	0.00	3.72E+11	494.9883	1.14E+07	0.00
20.9990	-2.53E-04	1295960.	-56911.	-3.47E-05	0.00	3.73E+11	910.3111	1.09E+07	0.00
21.2520	-3.42E-04	1127373.	-53961.	-2.48E-05	0.00	3.73E+11	1033.	9160612.	0.00
21.5050	-4.04E-04	968307.	-50678.	-1.63E-05	0.00	3.74E+11	1130.	8496341.	0.00
21.7580	-4.41E-04	819658.	-47125.	-9.03E-06	0.00	3.74E+11	1210.	8324611.	0.00
22.0110	-4.59E-04	682162.	-43350.	-2.94E-06	0.00	3.74E+11	1277.	8453038.	0.00
22.2640	-4.59E-04	556436.	-39389.	2.08E-06	0.00	3.75E+11	1333.	8810793.	0.00
22.5170	-4.46E-04	442993.	-35275.	6.13E-06	0.00	3.75E+11	1378.	9378139.	0.00

22.7700	-4.22E-04	342249.	-31039.	9.30E-06	0.00	3.75E+11	1413.	1.02E+07	0.00
23.0230	-3.90E-04	254526.	-26711.	1.17E-05	0.00	3.76E+11	1438.	1.12E+07	0.00
23.2760	-3.51E-04	180057.	-22324.	1.35E-05	0.00	3.76E+11	1452.	1.26E+07	0.00
23.5290	-3.08E-04	118974.	-17910.	1.47E-05	0.00	3.76E+11	1455.	1.44E+07	0.00
23.7820	-2.62E-04	71306.	-13507.	1.54E-05	0.00	3.76E+11	1446.	1.68E+07	0.00
24.0350	-2.14E-04	36962.	-9238.	1.59E-05	0.00	3.76E+11	1366.	1.94E+07	0.00
24.2880	-1.65E-04	15212.	-5511.	1.61E-05	0.00	3.76E+11	1089.	2.00E+07	0.00
24.5410	-1.16E-04	3499.	-2661.	1.62E-05	0.00	3.76E+11	788.9687	2.06E+07	0.00
24.7940	-6.70E-05	-943.019	-751.526	1.62E-05	0.00	3.76E+11	468.6942	2.12E+07	0.00
25.0470	-1.79E-05	-1065.	155.3061	1.62E-05	0.00	3.76E+11	128.6920	2.19E+07	0.00
25.3000	3.12E-05	0.00	0.00	1.62E-05	0.00	3.76E+11	-231.002	1.12E+07	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. 1:

Pile-head deflection	=	0.96503735 inches
Computed slope at pile head	=	-0.0054135 radians
Maximum bending moment	=	3774276. inch-lbs
Maximum shear force	=	-59655. lbs
Depth of maximum bending moment	=	14.92700000 feet below pile head
Depth of maximum shear force	=	20.49300000 feet below pile head
Number of iterations	=	85
Number of zero deflection points	=	2
Pile deflection at ground	=	0.54348093 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear	=	0. lbs
Moment	=	0. in-lbs
Axial Load	=	0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
25.30000	0.96503735	3774276.	-59655.
24.03500	0.98935177	3826266.	-64237.
22.77000	1.04364871	3733374.	-73307.
21.50500	1.32409742	3501900.	-72791.
20.24000	2.35095241	3223834.	-70153.
18.97500	6.26830154	2744488.	-65770.
17.71000	13.90603252	2391187.	-65773.
16.44500	68.87032890	2216076.	-74425.

 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	2.2939	5.61E-04	2.98E-06	-0.01233	0.00	3.76E+11	0.00	0.00	131.1719
0.2530	2.2565	604.5256	430.8988	-0.01233	0.00	3.76E+11	0.00	0.00	152.6876
0.5060	2.2191	2616.	938.0062	-0.01233	0.00	3.76E+11	0.00	0.00	181.3753
0.7590	2.1816	6300.	1532.	-0.01233	0.00	3.76E+11	0.00	0.00	210.0629
1.0120	2.1442	11920.	2214.	-0.01233	0.00	3.76E+11	0.00	0.00	238.7505
1.2650	2.1068	19741.	2982.	-0.01233	0.00	3.76E+11	0.00	0.00	267.4381
1.5180	2.0694	30026.	3837.	-0.01233	0.00	3.76E+11	0.00	0.00	296.1258
1.7710	2.0319	43041.	4780.	-0.01233	0.00	3.76E+11	0.00	0.00	324.8134
2.0240	1.9945	59050.	5810.	-0.01233	0.00	3.76E+11	0.00	0.00	353.5010
2.2770	1.9571	78317.	6926.	-0.01233	0.00	3.76E+11	0.00	0.00	382.1886
2.5300	1.9197	101107.	8130.	-0.01232	0.00	3.76E+11	0.00	0.00	410.8763
2.7830	1.8823	127685.	9421.	-0.01232	0.00	3.76E+11	0.00	0.00	439.5639
3.0360	1.8448	158313.	10799.	-0.01232	0.00	3.76E+11	0.00	0.00	468.2515
3.2890	1.8074	193258.	12265.	-0.01232	0.00	3.76E+11	0.00	0.00	496.9392
3.5420	1.7700	232783.	13817.	-0.01232	0.00	3.76E+11	0.00	0.00	525.6268
3.7950	1.7326	277154.	15456.	-0.01232	0.00	3.76E+11	0.00	0.00	554.3144
4.0480	1.6952	326633.	17183.	-0.01231	0.00	3.75E+11	0.00	0.00	583.0020
4.3010	1.6579	381486.	18996.	-0.01231	0.00	3.75E+11	0.00	0.00	611.6897
4.5540	1.6205	441977.	20897.	-0.01231	0.00	3.75E+11	0.00	0.00	640.3773
4.8070	1.5831	508371.	22884.	-0.01230	0.00	3.75E+11	0.00	0.00	669.0649
5.0600	1.5458	580932.	24959.	-0.01230	0.00	3.75E+11	0.00	0.00	697.7525
5.3130	1.5084	659924.	27121.	-0.01230	0.00	3.74E+11	0.00	0.00	726.4402
5.5660	1.4711	745612.	29370.	-0.01229	0.00	3.74E+11	0.00	0.00	755.1278
5.8190	1.4338	838260.	31706.	-0.01228	0.00	3.74E+11	0.00	0.00	783.8154
6.0720	1.3965	938133.	34130.	-0.01228	0.00	3.74E+11	0.00	0.00	812.5031
6.3250	1.3593	1045495.	36640.	-0.01227	0.00	3.73E+11	0.00	0.00	841.1907
6.5780	1.3220	1160610.	38948.	-0.01226	0.00	3.73E+11	-190.603	437.7105	869.8783
6.8310	1.2848	1281987.	41050.	-0.01225	0.00	3.73E+11	-192.819	455.6223	898.5659
7.0840	1.2477	1409868.	43233.	-0.01224	0.00	3.72E+11	-194.955	474.3936	927.2536
7.3370	1.2105	1544499.	45497.	-0.01223	0.00	3.72E+11	-197.007	494.0931	955.9412
7.5900	1.1734	1686126.	47842.	-0.01221	0.00	3.71E+11	-198.971	514.7974	984.6288
7.8430	1.1364	1834995.	50268.	-0.01220	0.00	3.71E+11	-200.845	536.5915	1013.
8.0960	1.0994	1991352.	52775.	-0.01218	0.00	3.70E+11	-202.625	559.5709	1042.
8.3490	1.0624	2155446.	54698.	-0.01217	0.00	3.70E+11	-643.367	1839.	1071.
8.6020	1.0255	2323478.	56033.	-0.01211	0.00	7.17E+10	-647.335	1916.	1099.
8.8550	0.9889	2495678.	57443.	-0.01200	0.00	7.06E+10	-651.021	1999.	1128.
9.1080	0.9526	2672274.	58930.	-0.01189	0.00	7.05E+10	-654.419	2086.	1157.
9.3610	0.9167	2853501.	60494.	-0.01177	0.00	7.04E+10	-657.521	2178.	1185.
9.6140	0.8811	3039593.	62136.	-0.01165	0.00	7.04E+10	-660.321	2275.	1214.
9.8670	0.8459	3230790.	63857.	-0.01151	0.00	7.03E+10	-662.809	2379.	1243.
10.1200	0.8112	3427334.	65658.	-0.01137	0.00	7.02E+10	-664.979	2489.	1272.
10.3730	0.7769	3629468.	67074.	-0.01122	0.00	7.02E+10	-973.985	3806.	1300.
10.6260	0.7431	3834608.	68104.	-0.01105	0.00	7.01E+10	-976.503	3990.	1329.
10.8790	0.7098	4042997.	69215.	-0.01088	0.00	7.00E+10	-978.528	4185.	1358.

11.1320	0.6770	4254879.	70407.	-0.01070	0.00	6.99E+10	-980.045	4395.	1386.
11.3850	0.6448	4470505.	71682.	-0.01051	0.00	6.99E+10	-981.040	4619.	1415.
11.6380	0.6132	4690131.	73042.	-0.01031	0.00	6.98E+10	-981.498	4860.	1444.
11.8910	0.5822	4914017.	71688.	-0.01011	0.00	6.97E+10	-1559.	8129.	204.8599
12.1440	0.5518	5125423.	67269.	-0.00989	0.00	6.96E+10	-1558.	8570.	0.00
12.3970	0.5221	5322473.	62543.	-0.00966	0.00	6.95E+10	-1556.	9046.	0.00
12.6500	0.4932	5505182.	57824.	-0.00942	0.00	6.95E+10	-1553.	9559.	0.00
12.9030	0.4649	5673579.	53115.	-0.00918	0.00	6.94E+10	-1549.	10115.	0.00
13.1560	0.4374	5827698.	48420.	-0.00893	0.00	6.93E+10	-1544.	10717.	0.00
13.4090	0.4107	5967584.	43740.	-0.00867	0.00	6.92E+10	-1538.	11371.	0.00
13.6620	0.3848	6093290.	39080.	-0.00840	0.00	6.91E+10	-1532.	12083.	0.00
13.9150	0.3597	6204880.	34443.	-0.00813	0.00	6.89E+10	-1524.	12860.	0.00
14.1680	0.3354	6302425.	29830.	-0.00786	0.00	6.84E+10	-1515.	13709.	0.00
14.4210	0.3120	6386009.	25247.	-0.00757	0.00	6.80E+10	-1505.	14641.	0.00
14.6740	0.2895	6455725.	20696.	-0.00729	0.00	6.76E+10	-1493.	15665.	0.00
14.9270	0.2678	6511674.	16180.	-0.00699	0.00	6.72E+10	-1481.	16794.	0.00
15.1800	0.2470	6553970.	11704.	-0.00670	0.00	6.69E+10	-1468.	18041.	0.00
15.4330	0.2271	6582738.	7270.	-0.00640	0.00	6.67E+10	-1453.	19425.	0.00
15.6860	0.2081	6598113.	2882.	-0.00610	0.00	6.65E+10	-1437.	20964.	0.00
15.9390	0.1901	6600240.	-1455.	-0.00580	0.00	6.65E+10	-1420.	22682.	0.00
16.1920	0.1729	6589278.	-5739.	-0.00550	0.00	6.66E+10	-1402.	24608.	0.00
16.4450	0.1567	6565396.	-9964.	-0.00520	0.00	6.68E+10	-1382.	26775.	0.00
16.6980	0.1414	6528775.	-14128.	-0.00490	0.00	6.70E+10	-1361.	29226.	0.00
16.9510	0.1270	6479609.	-18226.	-0.00461	0.00	6.74E+10	-1339.	32010.	0.00
17.2040	0.1134	6418105.	-22254.	-0.00432	0.00	6.78E+10	-1315.	35191.	0.00
17.4570	0.1007	6344484.	-26206.	-0.00403	0.00	6.82E+10	-1289.	38850.	0.00
17.7100	0.08894	6258979.	-30079.	-0.00375	0.00	6.86E+10	-1262.	43086.	0.00
17.9630	0.07797	6161841.	-33868.	-0.00348	0.00	6.90E+10	-1233.	48029.	0.00
18.2160	0.06782	6053334.	-37566.	-0.00321	0.00	6.91E+10	-1203.	53848.	0.00
18.4690	0.05848	5933740.	-41965.	-0.00295	0.00	6.92E+10	-1695.	87980.	0.00
18.7220	0.04993	5798525.	-47281.	-0.00269	0.00	6.93E+10	-1807.	109894.	0.00
18.9750	0.04215	5646652.	-52913.	-0.00244	0.00	6.94E+10	-1903.	137088.	0.00
19.2280	0.03512	5477236.	-58810.	-0.00220	0.00	6.95E+10	-1982.	171305.	0.00
19.4810	0.02882	5289555.	-64917.	-0.00196	0.00	6.95E+10	-2041.	215071.	0.00
19.7340	0.02322	5083058.	-71176.	-0.00173	0.00	6.96E+10	-2081.	272174.	0.00
19.9870	0.01829	4857378.	-77522.	-0.00152	0.00	6.97E+10	-2099.	348547.	0.00
20.2400	0.01400	4612347.	-83886.	-0.00131	0.00	6.98E+10	-2093.	453991.	0.00
20.4930	0.01032	4348019.	-90192.	-0.00112	0.00	6.99E+10	-2060.	605922.	0.00
20.7460	0.00722	4064703.	-96345.	-9.34E-04	0.00	7.00E+10	-1994.	838608.	0.00
20.9990	0.00465	3763009.	-102233.	-7.65E-04	0.00	7.01E+10	-1885.	1230701.	0.00
21.2520	0.00257	3443944.	-107691.	-6.09E-04	0.00	7.02E+10	-1711.	2017117.	0.00
21.5050	9.53E-04	3109110.	-112414.	-4.67E-04	0.00	7.03E+10	-1401.	4463129.	0.00
21.7580	-2.62E-04	2761367.	-112927.	-3.41E-04	0.00	7.05E+10	1062.	1.23E+07	0.00
22.0110	-0.00112	2423416.	-108894.	-2.29E-04	0.00	7.06E+10	1595.	4339309.	0.00
22.2640	-0.00165	2100165.	-103686.	-1.68E-04	0.00	3.70E+11	1836.	3371235.	0.00
22.5170	-0.00214	1793833.	-97806.	-1.52E-04	0.00	3.71E+11	2039.	2894926.	0.00
22.7700	-0.00258	1506290.	-91339.	-1.39E-04	0.00	3.72E+11	2221.	2615657.	0.00
23.0230	-0.00298	1239221.	-84337.	-1.28E-04	0.00	3.73E+11	2391.	2435471.	0.00
23.2760	-0.00335	994195.	-76830.	-1.19E-04	0.00	3.73E+11	2554.	2311878.	0.00
23.5290	-0.00370	772706.	-68840.	-1.11E-04	0.00	3.74E+11	2710.	2223261.	0.00
23.7820	-0.00403	576201.	-60378.	-1.06E-04	0.00	3.75E+11	2864.	2157386.	0.00
24.0350	-0.00434	406091.	-51454.	-1.02E-04	0.00	3.75E+11	3015.	2106797.	0.00
24.2880	-0.00465	263770.	-42073.	-9.93E-05	0.00	3.76E+11	3165.	2066711.	0.00
24.5410	-0.00495	150621.	-32238.	-9.76E-05	0.00	3.76E+11	3314.	2033964.	0.00
24.7940	-0.00524	68022.	-21948.	-9.67E-05	0.00	3.76E+11	3464.	2006436.	0.00
25.0470	-0.00553	17354.	-11203.	-9.64E-05	0.00	3.76E+11	3614.	1982724.	0.00
25.3000	-0.00583	0.00	0.00	-9.63E-05	0.00	3.76E+11	3765.	980965.	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 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 = 2.29390189 inches
 Computed slope at pile head = -0.0123269 radians
 Maximum bending moment = 6600240. inch-lbs
 Maximum shear force = -112927. lbs
 Depth of maximum bending moment = 15.93900000 feet below pile head
 Depth of maximum shear force = 21.75800000 feet below pile head
 Number of iterations = 274
 Number of zero deflection points = 1
 Pile deflection at ground = 1.33351762 inches

Pile-head Deflection vs. Pile Length for Load Case 2

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
 Moment = 0. in-lbs
 Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
25.30000	2.29390189	6600240.	-112927.
24.03500	2.56904003	6496466.	-127940.
22.77000	3.42216725	6050322.	-125950.
21.50500	5.83295057	5480573.	-115312.
20.24000	16.31596040	4816931.	-102365.

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	Pile-head Load	Load Type	Pile-head Load	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1		Load 1	2	Load 2					

1	V, lb	0.00	M, in-lb	0.00	0.00	0.9650	-0.00541	-59655.	3774276.
2	V, lb	0.00	M, in-lb	0.00	0.00	2.2939	-0.01233	-112927.	6600240.

Maximum pile-head deflection = 2.2939018857 inches

Maximum pile-head rotation = -0.0123269241 radians = -0.706281 deg.

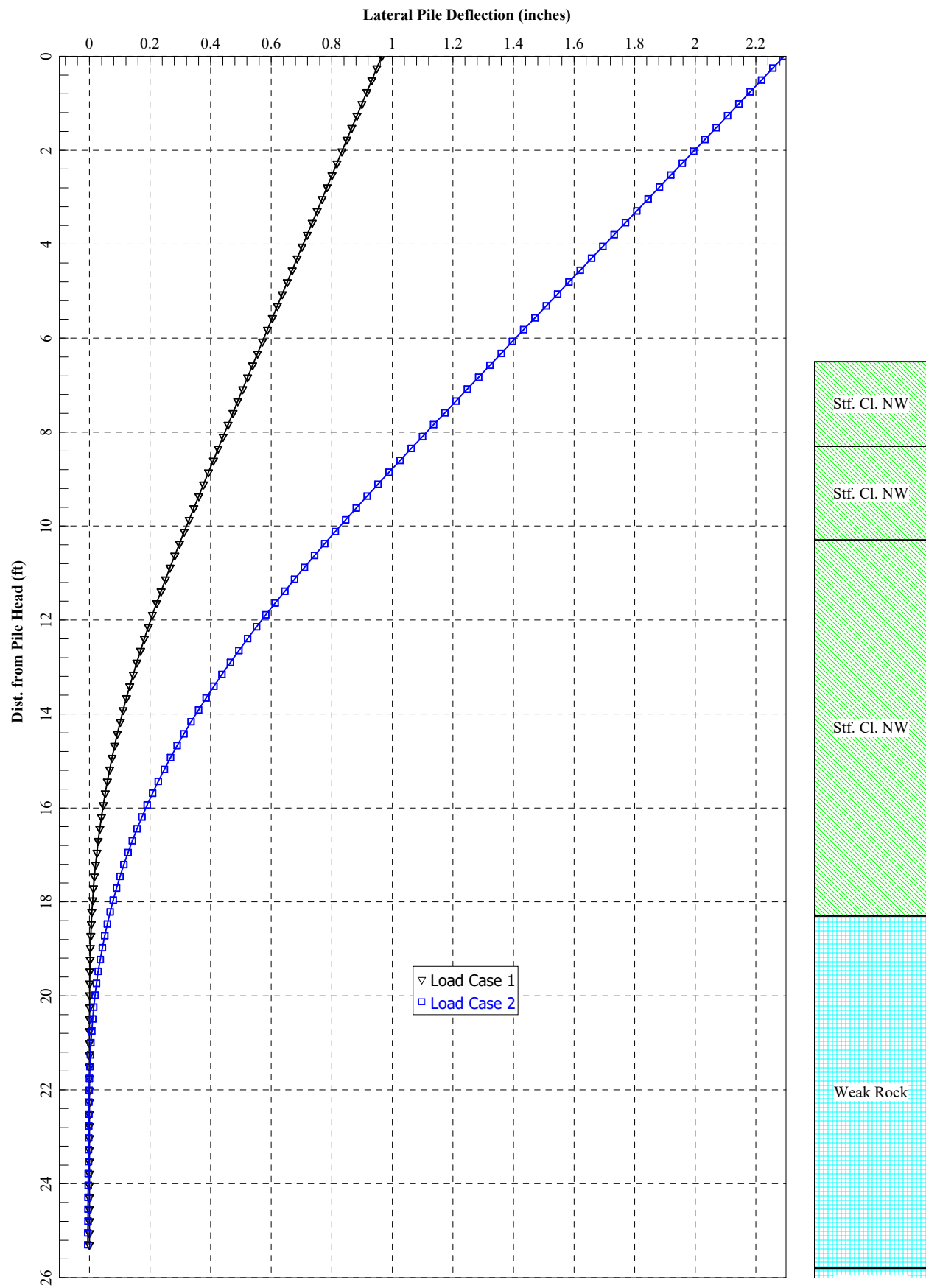
Summary of Warning Messages

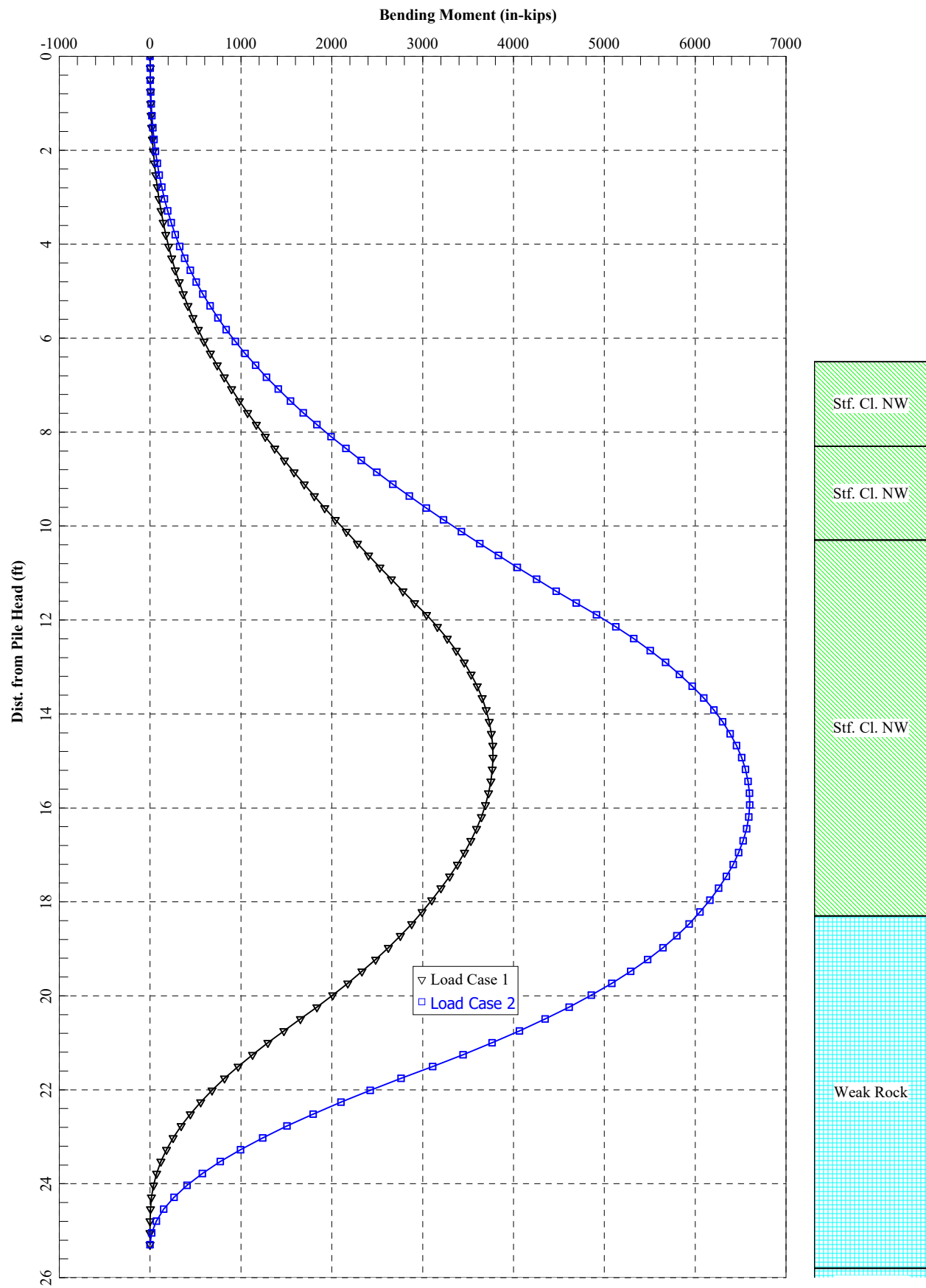
The following warning was reported 10000 times

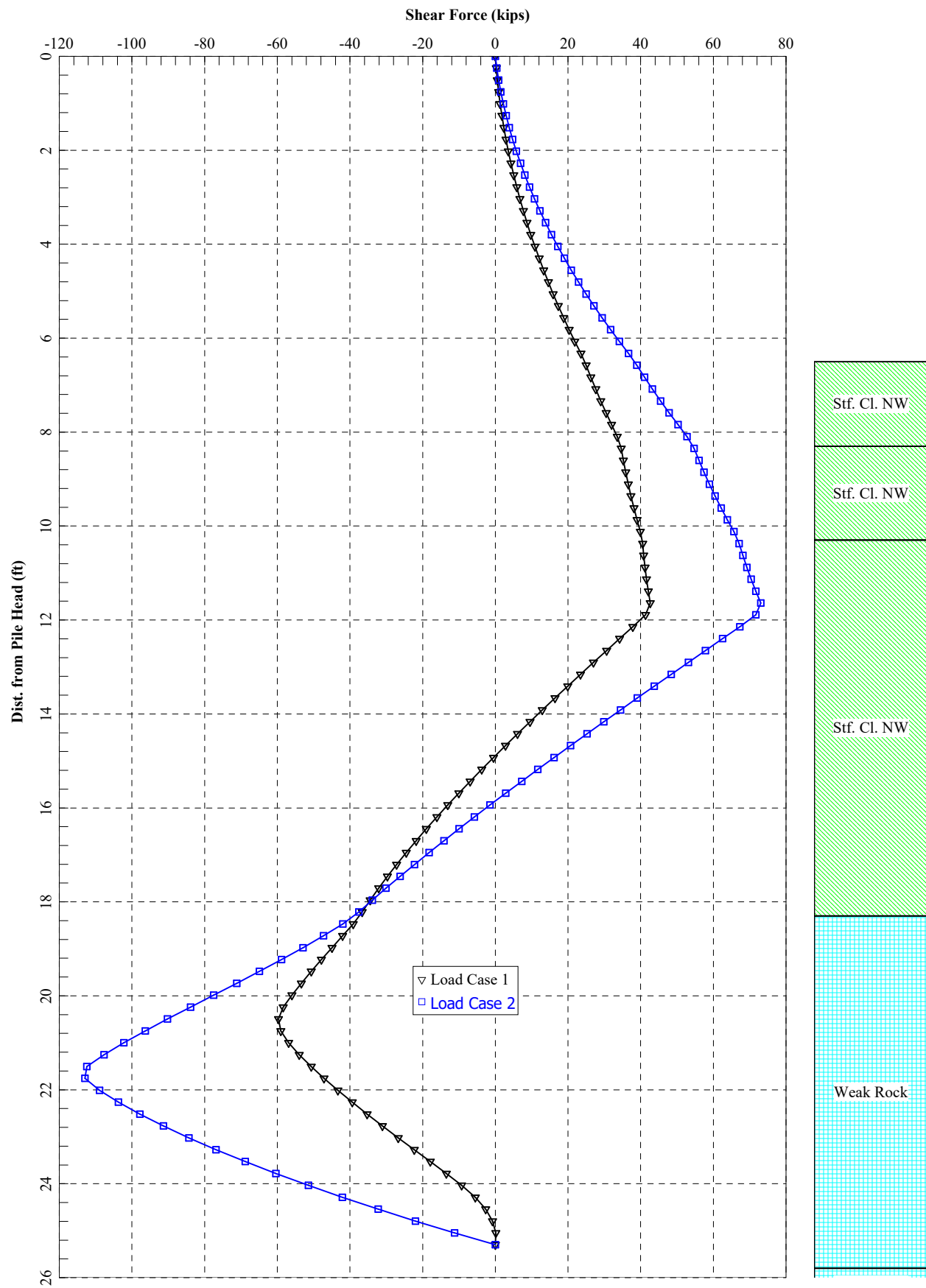
**** Warning ****

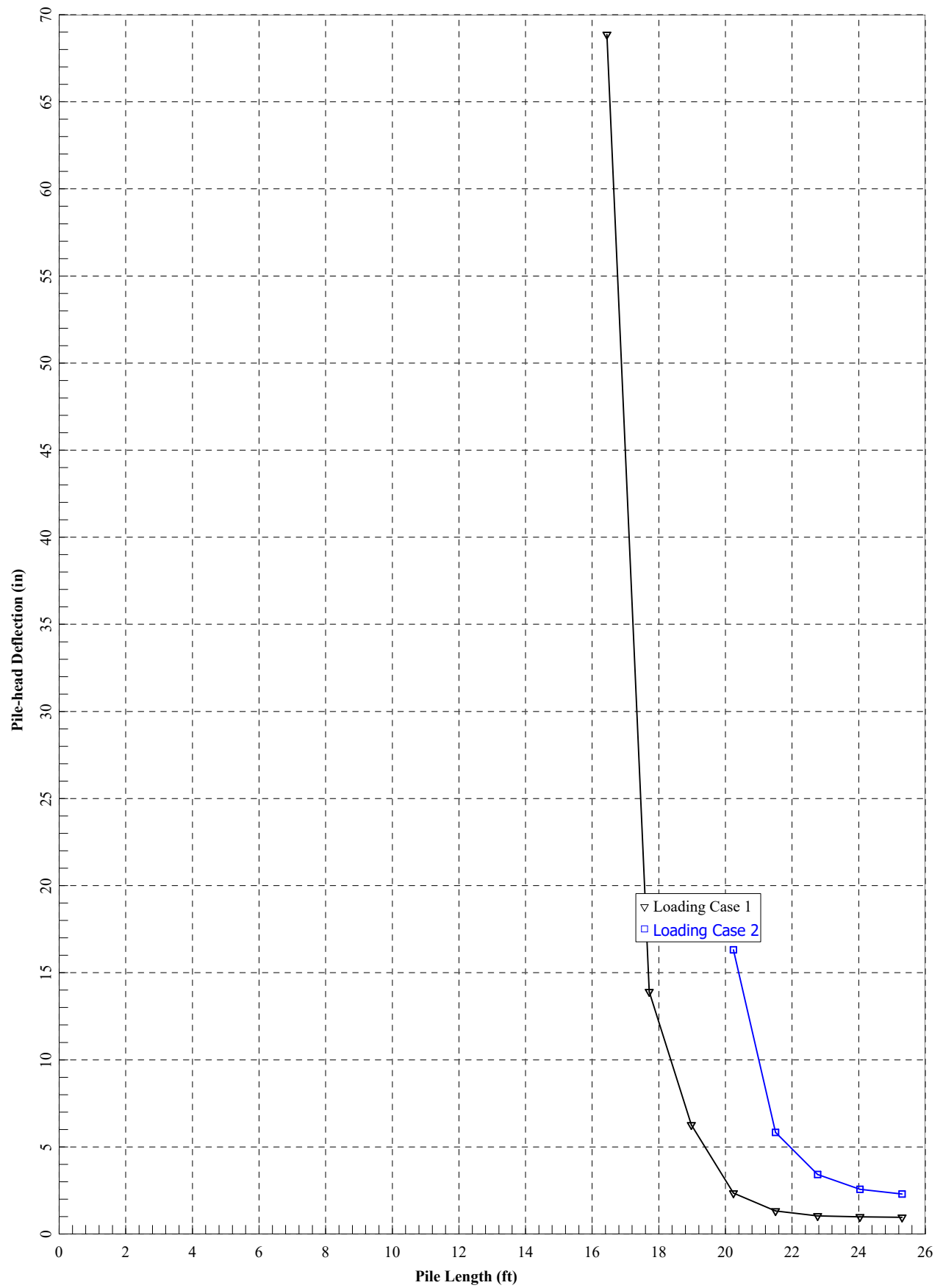
An unreasonable input value for compressive strength has been specified for a soil defined using the weak rock criteria. The input value is less than 100 psi. Please check your input data for correctness.

The analysis ended normally.









Use a minimum drilled shaft length of 15 feet into the weathered claystone.

Option 3: Earthwork

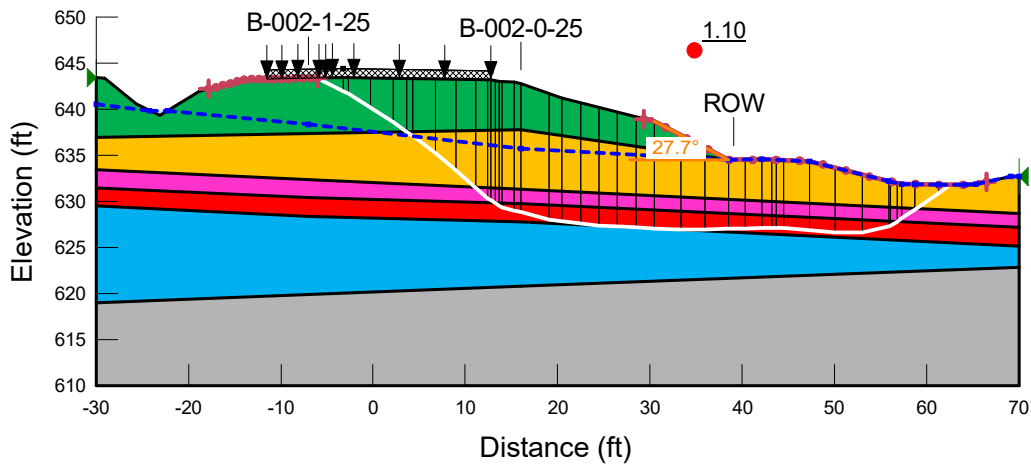
Preliminary analyses were run for the perpendicular cross-sections at Sta. 597+00 and Sta. 597+25 only for consideration of geometric constraints.



Sta. 597+00

Sta. 597+00
perpendicular to
roadway. FS ~ 0.1
higher than skew
section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



1. Existing Condition 597+00

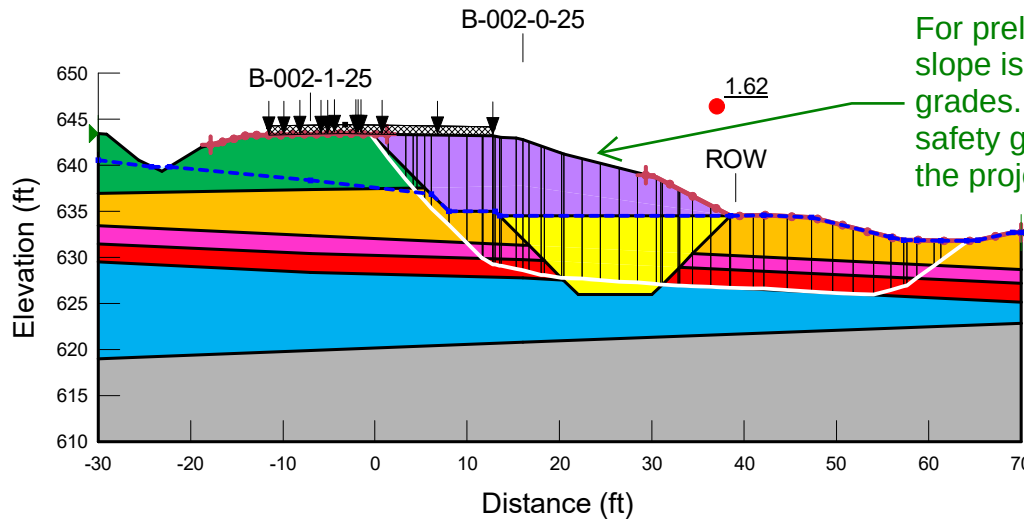
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (LT)	Mohr-Coulomb	115	200	26	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled in the shear key (no drainage).



For preliminary analyses, assumed slope is reconstructed to existing grades. Final grading is dependent on safety grading, grade changes through the project extents, etc.

2a. Post-Construction (LT) 597+00

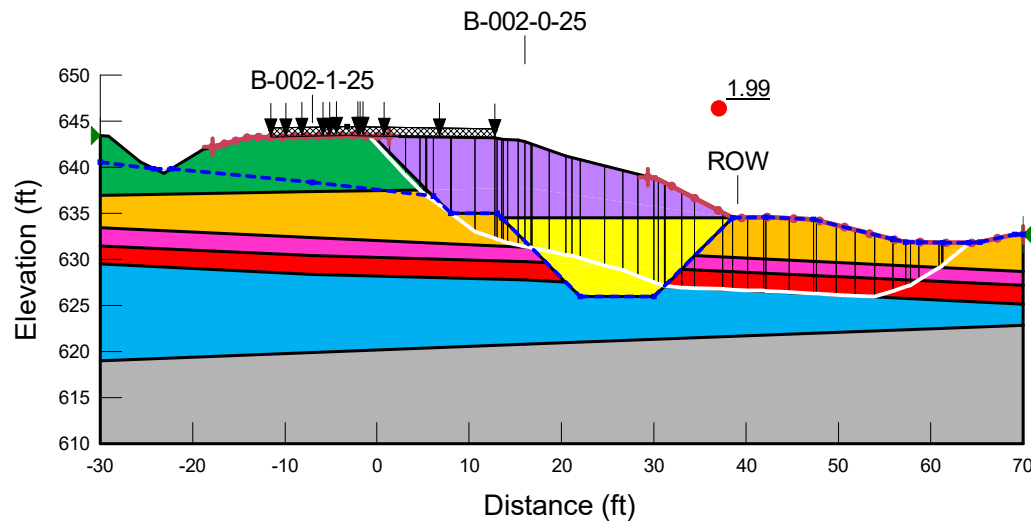
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (LT)	Mohr-Coulomb	115	200	26	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled at the bottom of the shear key (drainage).



2b. Post-Construction (LT) 597+00

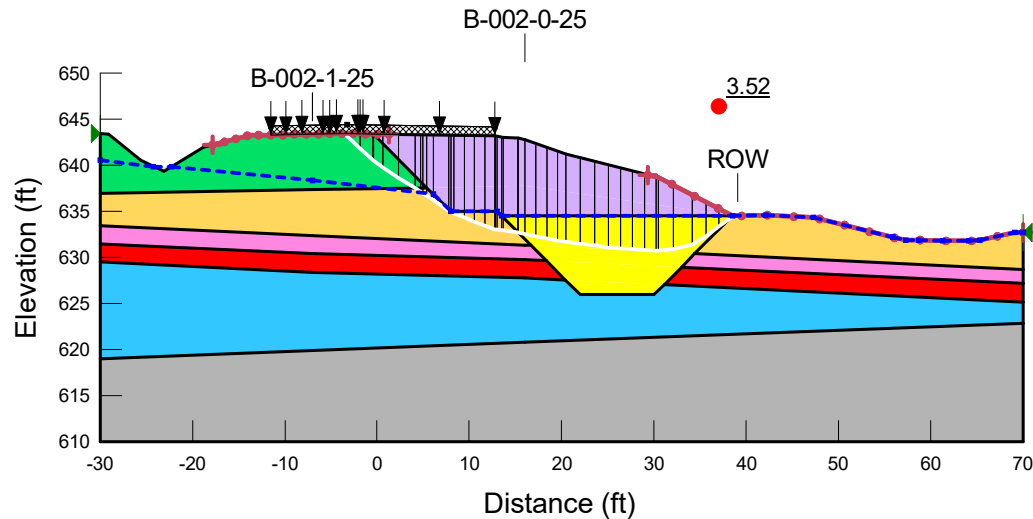
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (ST)	Mohr-Coulomb	115	2,000	0	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled in the shear key (no drainage).



3a. Post-Construction (ST) 597+00

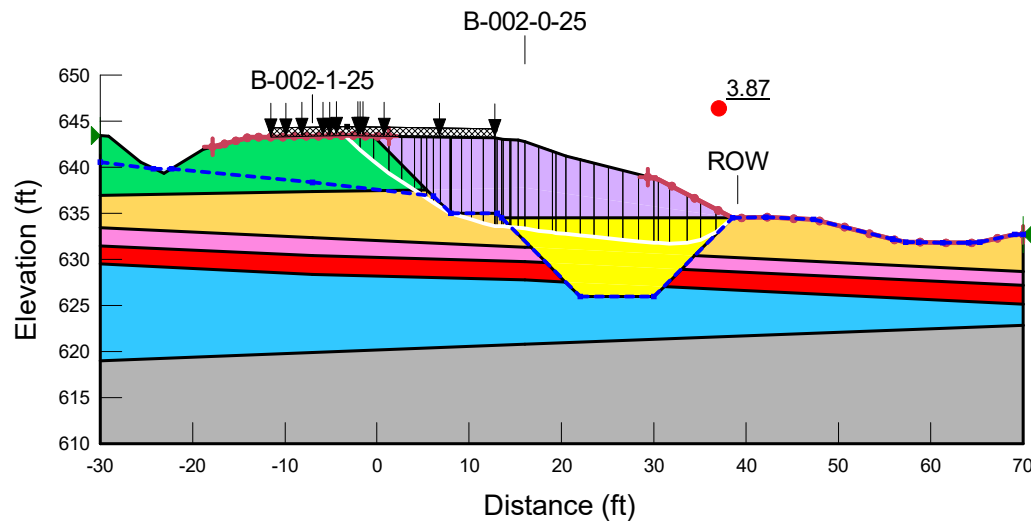
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
■	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
■	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
■	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
■	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
■	Bedrock	Bedrock (Impenetrable)				
■	New Fill (ST)	Mohr-Coulomb	115	2,000	0	0
■	Rock Fill	Mohr-Coulomb	135	0	38	0
■	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled at the bottom of the shear key (drainage).



3b. Post-Construction (ST) 597+00

LAW-243-11.28.gsz

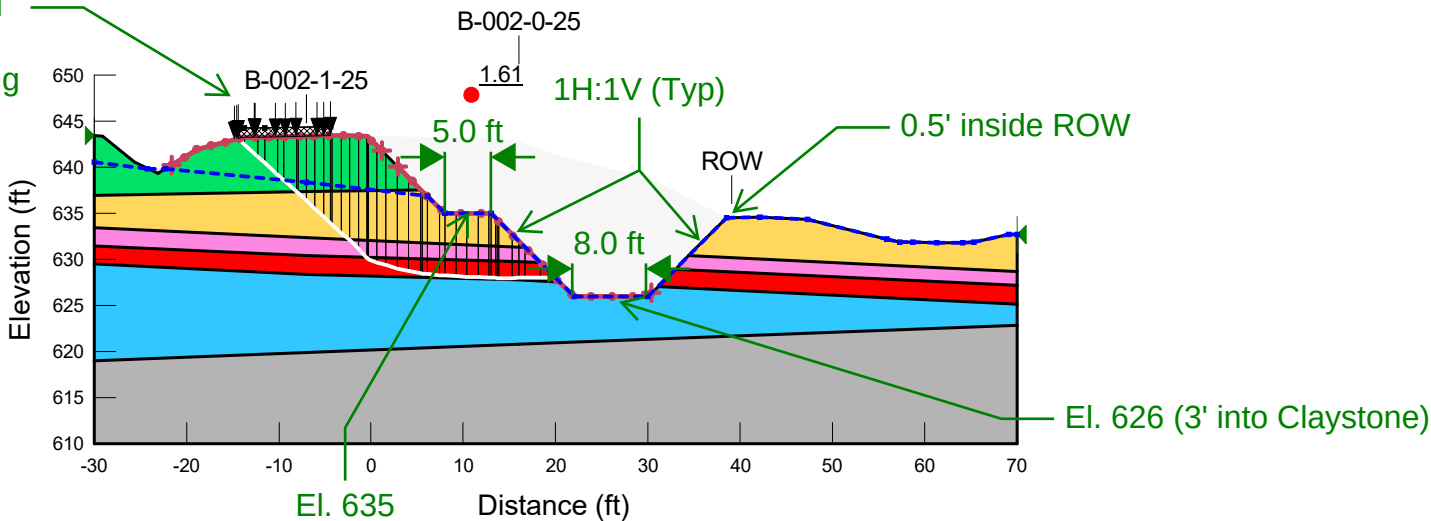
09/15/2025

1:250

FS > 1.2 and should be above 1.2 on the skew section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0

0.4' left of C/L
Assume 4' clearance for barrier, 12' travel lane (temporary pavement/grading not modeled)



4. Construction (Upper) 597+00

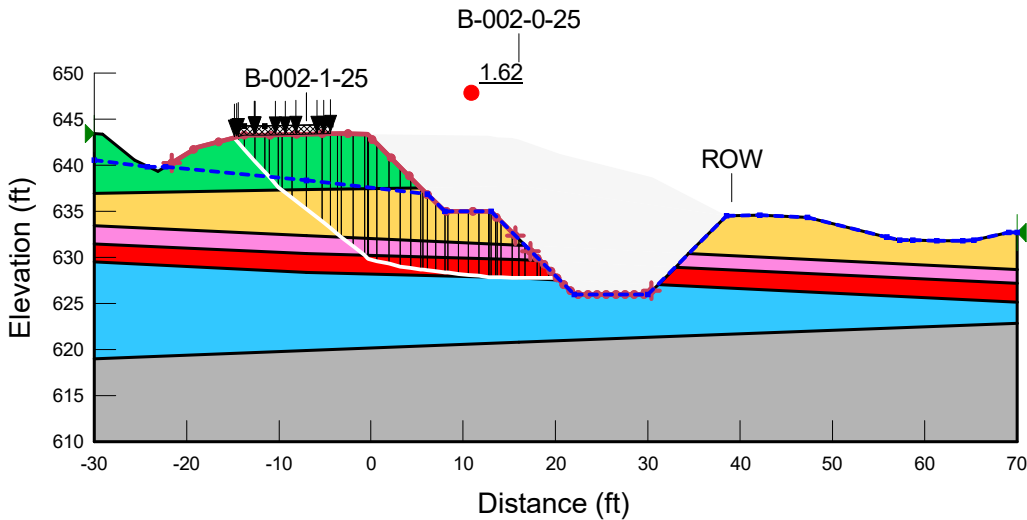
LAW-243-11.28.gsz

09/15/2025

1:250

FS > 1.2 and should be
above 1.2 on the skew
section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



5. Construction (Lower) 597+00

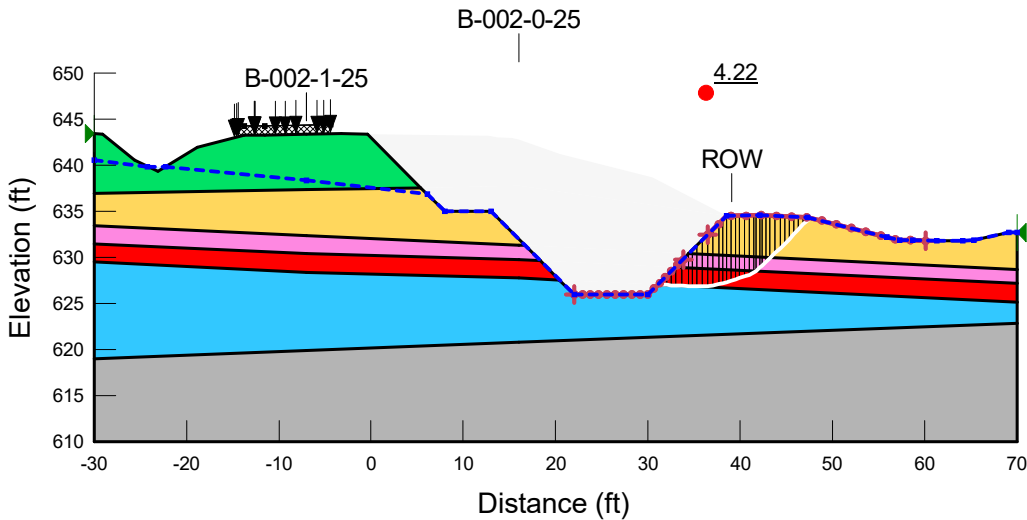
LAW-243-11.28.gsz

09/15/2025

1:250

FS > 1.2 and should be above 1.2 on the skew section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



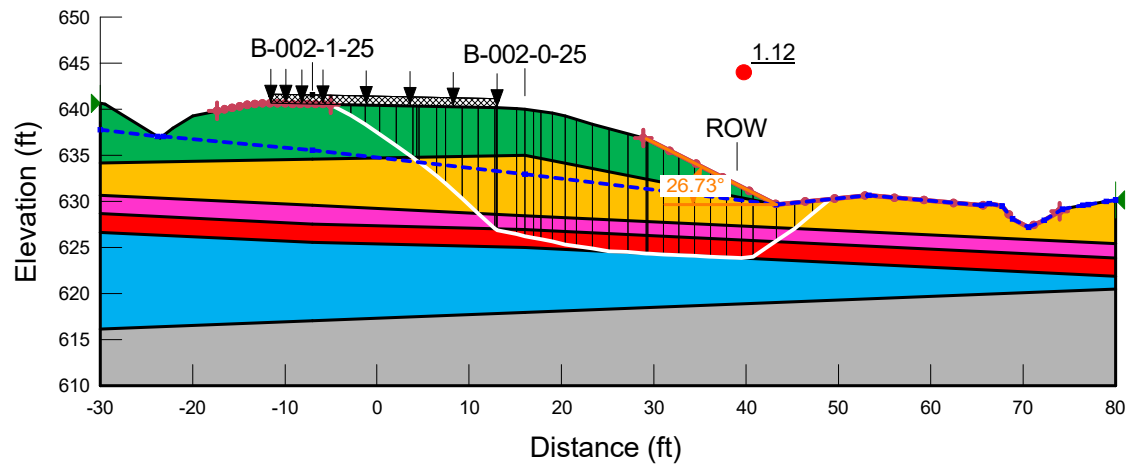
6. Construction (Shear Key) 597+00	
LAW-243-11.28.gsz	
09/15/2025	1:250



Sta. 597+25

Sta. 597+00
perpendicular to
roadway. FS ~ 0.1
higher than skew
section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
■	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
■	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
■	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
■	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
■	Bedrock	Bedrock (Impenetrable)				
■	Soft Rock	Mohr-Coulomb	130	0	12	0



1. Existing Condition 597+25

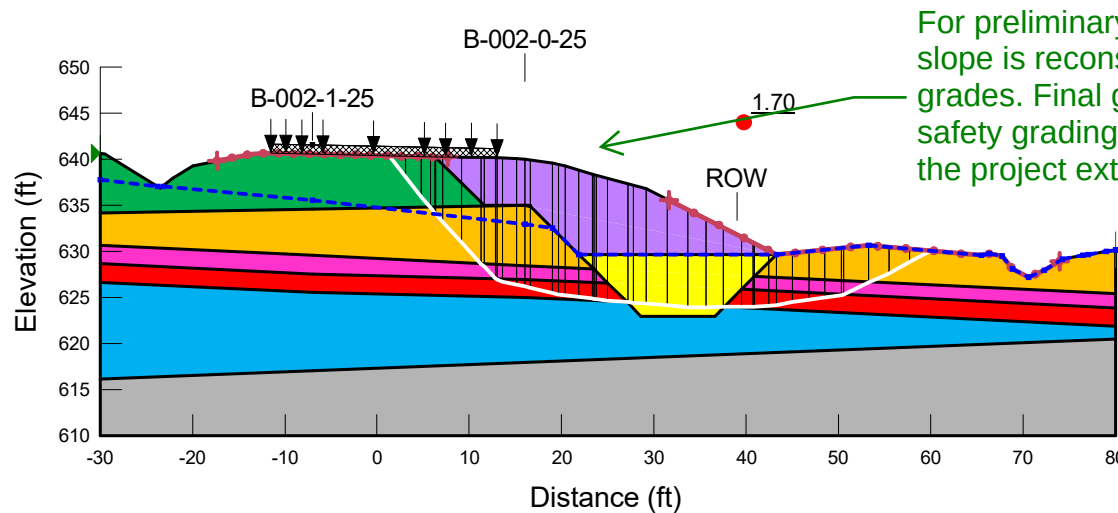
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (LT)	Mohr-Coulomb	115	200	26	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled in the shear key (no drainage).



2a. Post-Construction (LT) 597+25

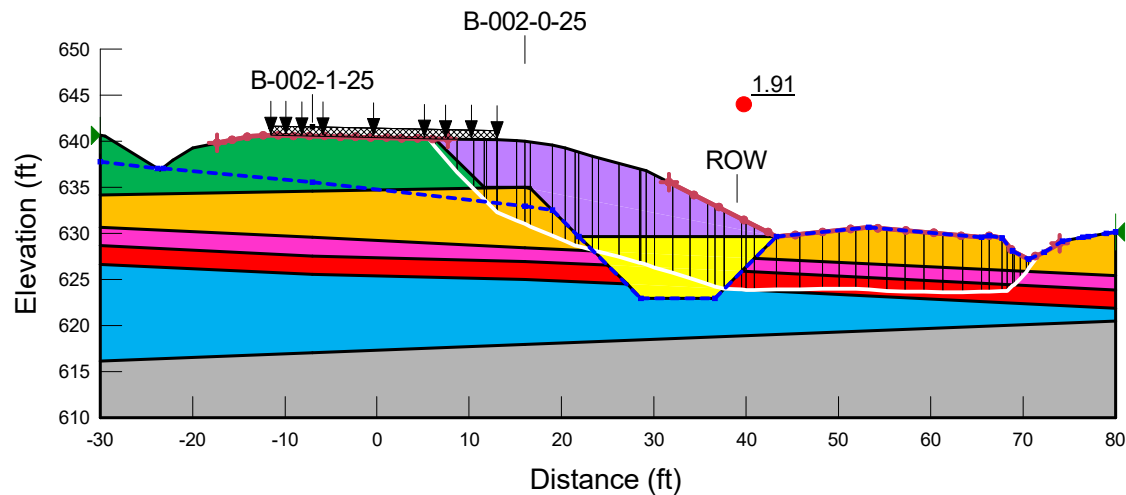
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	120	60	20	0
	2. Medium Stiff to Stiff Cohesive (LT)	Mohr-Coulomb	115	80	21	0
	3. Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	115	160	23	0
	4. Hard Cohesive (LT)	Mohr-Coulomb	130	350	27	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (LT)	Mohr-Coulomb	115	200	26	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled at the bottom of the shear key (drainage).



2b. Post-Construction (LT) 597+25

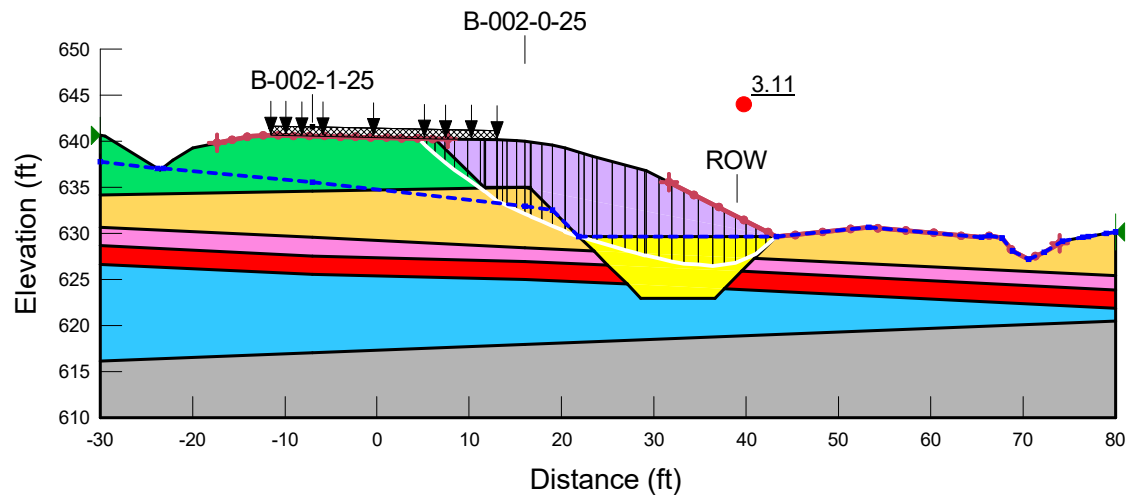
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (ST)	Mohr-Coulomb	115	2,000	0	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled in the shear key (no drainage).



3a. Post-Construction (ST) 597+25

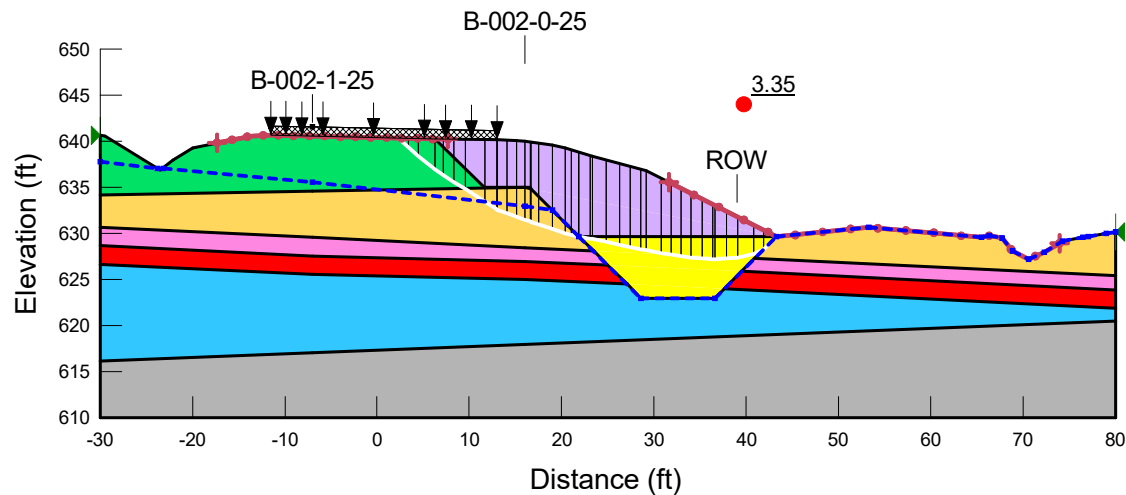
LAW-243-11.28.gsz

09/15/2025

1:250

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	New Fill (ST)	Mohr-Coulomb	115	2,000	0	0
	Rock Fill	Mohr-Coulomb	135	0	38	0
	Soft Rock	Mohr-Coulomb	130	0	12	0

FS > 1.3 and should be above 1.3 on the skew section. Groundwater modeled at the bottom of the shear key (drainage).



3b. Post-Construction (ST) 597+25

LAW-243-11.28.gsz

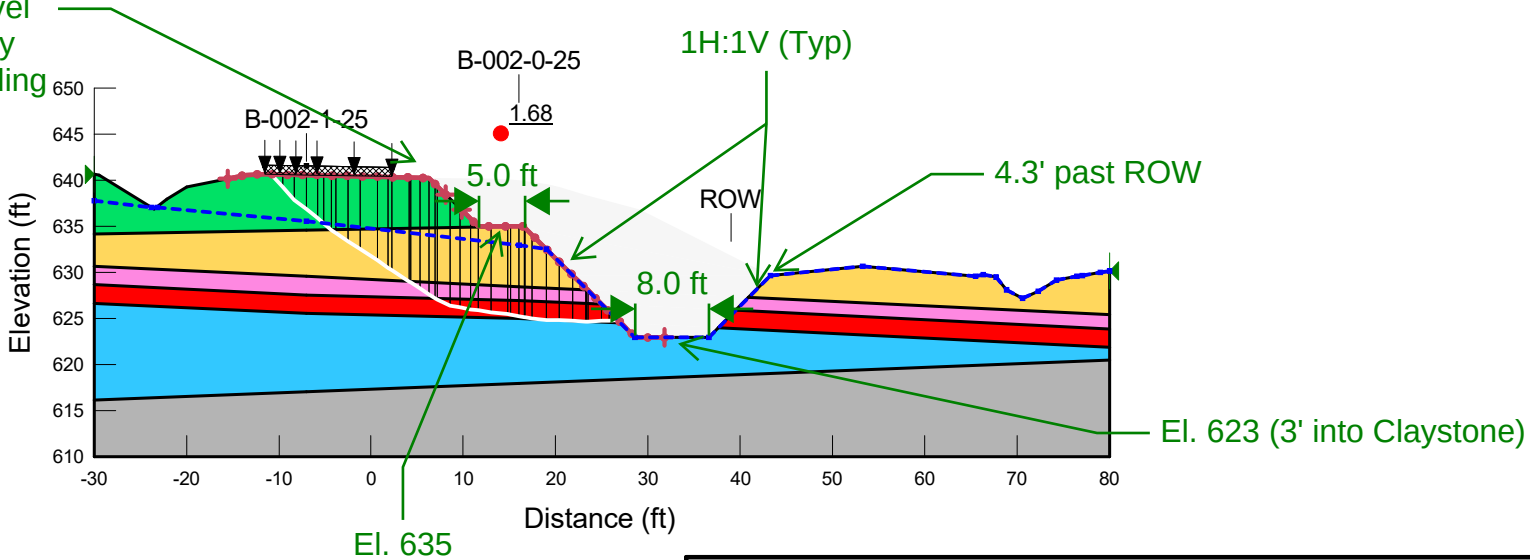
09/15/2025

1:250

FS > 1.2 and should be above 1.2 on the skew section.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0

6.3' right of C/L
Assume 4' clearance for barrier, 12' travel lane (temporary pavement/grading not modeled)



4. Construction (Upper) 597+25

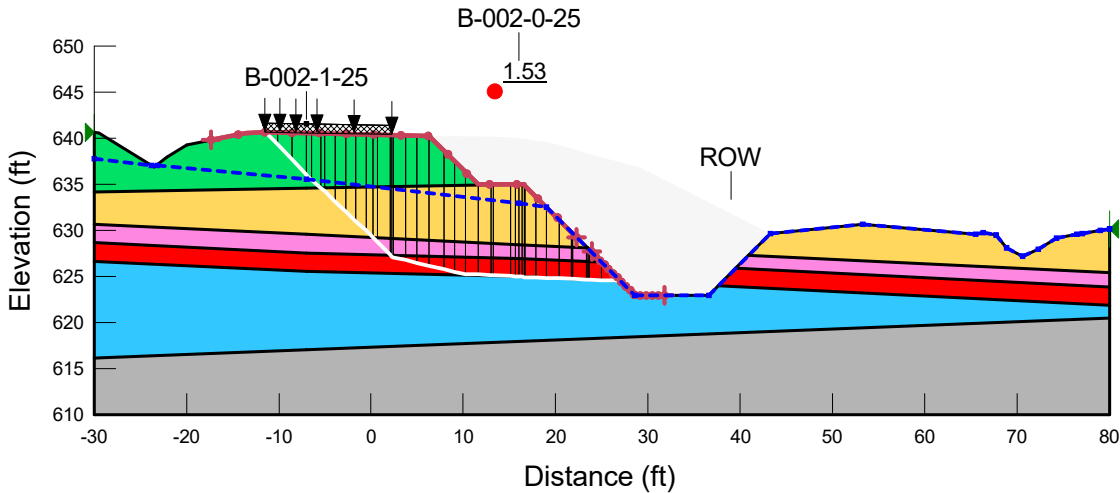
LAW-243-11.28.gsz

09/15/2025

1:250

FS > 1.2 and should be above 1.2 on the skew section.

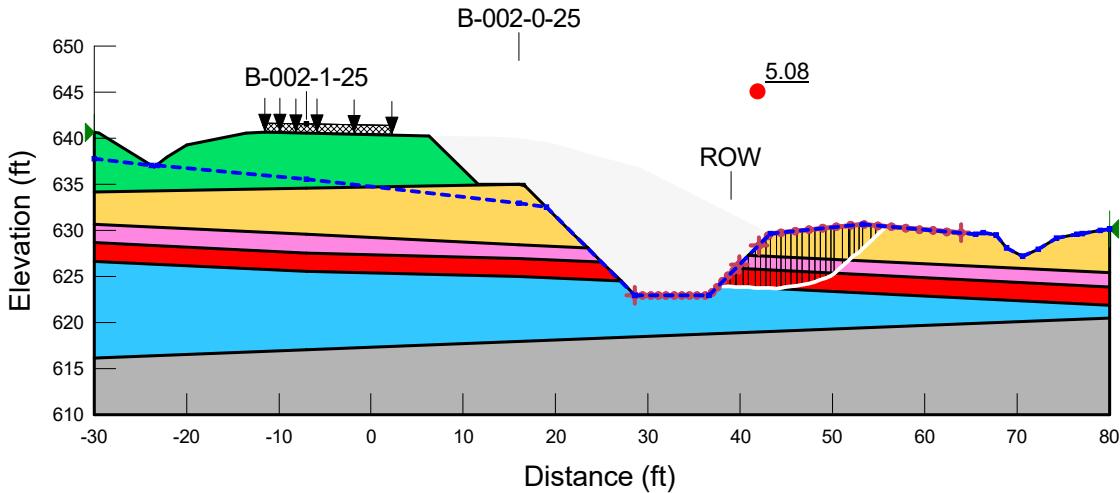
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



5. Construction (Lower) 597+25
LAW-243-11.28.gsz
09/15/20251:250

FS > 1.2 and should be above 1.2 on the skew section.

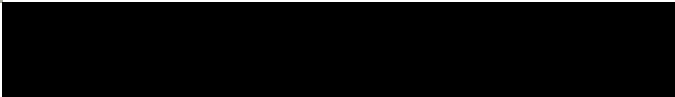
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	1. Soft to Medium Stiff Cohesive (ST)	Mohr-Coulomb	120	400	0	0
	2. Medium Stiff to Stiff Cohesive (ST)	Mohr-Coulomb	115	900	0	0
	3. Stiff to Very Stiff Cohesive (ST)	Mohr-Coulomb	115	2,600	0	0
	4. Hard Cohesive (ST)	Mohr-Coulomb	130	4,000	0	0
	Bedrock	Bedrock (Impenetrable)				
	Soft Rock	Mohr-Coulomb	130	0	12	0



6. Construction (Shear Key) 597+25	
LAW-243-11.28.gsz	
09/15/2025	1:250



Appendix E. Final Analyses



Structural Capacity Check and Reinforcing Design



Project: ODOT LAW-243-11.28
Subject: Drilled Shaft Analysis
Task: Drilled Shaft Analysis Overview

Computed: MAW
Checked: BJH

Date: 10/2/2025
Date: 10/2/2025

ODOT Drilled Shaft Analysis Overview

Drilled Shaft Analysis and Background Information

Background Information

- Analyze the drilled shafts for a drilled shaft wall for remediation of a landslide for ODOT. Use max moment and shear from provided LPile run to check the longitudinal and transverse shear reinforcement required. Use provided drilled shaft dimensions and assumed reinforcement.
- $f'_c = 4.0$ ksi for concrete strength
- $F_y = 60$ ksi steel strength
- Drilled Shaft diameter = 3'-0"
- Assumed longitudinal reinforcement = 13 - #8 bars (Provides 1.01% steel)
- Assumed transverse spiral reinforcement = #5 bars at 5" pitch (See ODOT BDM Section 305.4.4.3 Table 305-3)
- Clear cover to #5 transverse bar = 3" (See ODOT BDM Section 305.4.4.3 Table 305-3)

Loads from LPile

- Min Axial Load = 0 kips (See email reference provided - loads start below the top of drilled shaft)
- Max Factored Moment = 550.02 k-ft
- Max Factored Shear = 112.9 k

Analysis Results

- Based on analysis results, for the 3'-0" diameter drilled shaft and provided loading: Use 13 - #8 longitudinal bars and #5 at 5" pitch transverse spiral bars with a 3" clear cover to the transverse bars.

ODOT DRILLED SHAFT FLEXURAL ANALYSIS

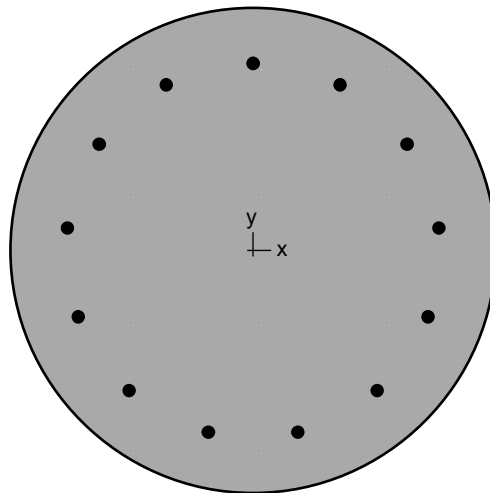
LAW-243-11.28

BY: MAW DATE: 10/2/2025

CHK: BJH DATE: 10/2/2025



spColumn v10.00 (TM)
Computer program for the Strength Design of Reinforced Concrete Sections
Copyright - 1988-2021, STRUCTUREPOINT, LLC.
All rights reserved



StructurePoint

Licensee stated below acknowledges that STRUCTUREPOINT (SP) is not and cannot be responsible for either the accuracy or adequacy of the material supplied as input for processing by the spColumn computer program. Furthermore, STRUCTUREPOINT neither makes any warranty expressed nor implied with respect to the correctness of the output prepared by the spColumn program. Although STRUCTUREPOINT has endeavored to produce spColumn error free the program is not and cannot be certified infallible. The final and only responsibility for analysis, design and engineering documents is the licensee's. Accordingly, STRUCTUREPOINT disclaims all responsibility in contract, negligence or other tort for any analysis, design or engineering documents prepared in connection with the use of the spColumn program. Licensed to: HDR - USA. License ID: 79849-1092335-4-283DC-2DF00

Contents

1. General Information	3
2. Material Properties	3
2.1. Concrete	3
2.2. Steel	3
3. Section	3
3.1. Shape and Properties	3
3.2. Section Figure	4
4. Reinforcement	4
4.1. Bar Set: ASTM A615	4
4.2. Confinement and Factors	4
4.3. Arrangement	4
5. Control Points	5
6. Factored Loads and Moments with Corresponding Capacity Ratios	5
7. Diagrams	6
7.1. PM at $\theta=0$ [deg]	6

List of Figures

Figure 1: Column section	4
--------------------------------	---

1. General Information

File Name	...\ODOT Drilled Shaft Design - 3.0' Drilled S...
Project	---
Column	---
Engineer	---
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

2. Material Properties

2.1. Concrete

Type	Standard
f'_c	4 ksi
E_c	3605 ksi
f_c	3.4 ksi
ϵ_u	0.003 in/in
β_1	0.85

2.2. Steel

Type	Standard
f_y	60 ksi
E_s	29000 ksi
ϵ_{ty}	0.00206897 in/in

3. Section

3.1. Shape and Properties

Type	Circular
Diameter	36 in
A_g	1017.88 in ²
I_x	82448 in ⁴
I_y	82448 in ⁴
r_x	9 in
r_y	9 in
X_o	0 in
Y_o	0 in

3.2. Section Figure

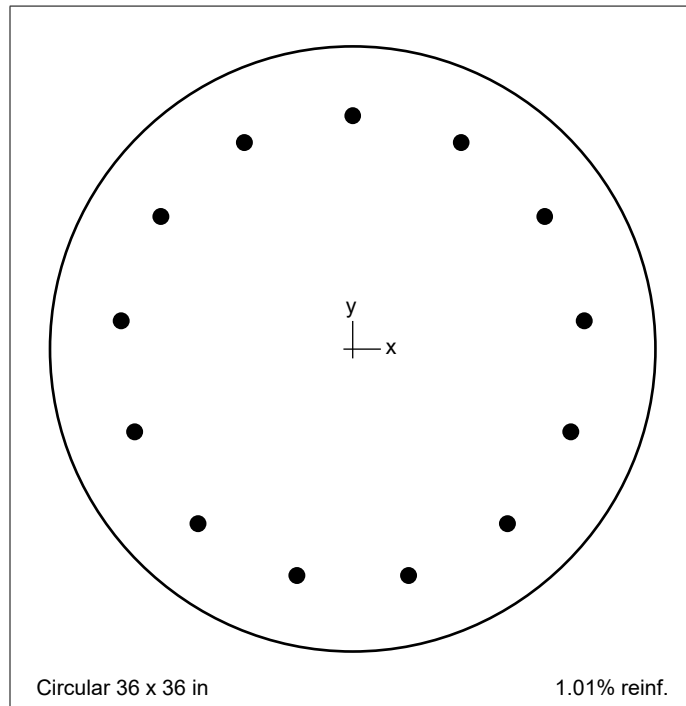


Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²
#3	0.38	0.11	#4	0.50	0.20	#5	0.63	0.31
#6	0.75	0.44	#7	0.88	0.60	#8	1.00	0.79
#9	1.13	1.00	#10	1.27	1.27	#11	1.41	1.56
#14	1.69	2.25	#18	2.26	4.00			

4.2. Confinement and Factors

Confinement type	Other
For #8 bars or less	#5 ties
For larger bars	#5 ties
Capacity Reduction Factors	
Axial compression, (a)	0.8
Tension controlled ϕ , (b)	0.9
Compression controlled ϕ , (c)	0.75

4.3. Arrangement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	13 #8

Total steel area, A_s	10.27 in ²
Rho	1.01 %
Minimum clear spacing	5.64 in

5. Control Points

About Point	P kip	X-Moment k-ft	Y-Moment k-ft	NA Depth in	d _t Depth in	ϵ_t	ϕ
X @ Max compression	3031.5	0.00	0.00	102.71	31.88	-0.00207	0.75000
X @ Allowable comp.	2425.2	603.52	0.00	32.96	31.88	-0.00010	0.75000
X @ $f_s = 0.0$	2342.4	667.35	0.00	31.88	31.88	0.00000	0.75000
X @ $f_s = 0.5 f_y$	1627.2	1012.52	0.00	23.70	31.88	0.00103	0.75000
X @ Balanced point	1129.2	1078.62	0.00	18.86	31.88	0.00207	0.75000
X @ Tension control	529.1	1037.76	0.00	11.95	31.88	0.00500	0.90000
X @ Pure bending	0.0	628.86	0.00	7.19	31.88	0.01030	0.90000
X @ Max tension	-554.6	0.00	0.00	0.00	31.88	9.99999	0.90000
-X @ Max compression	3031.5	0.00	0.00	101.41	31.47	-0.00207	0.75000
-X @ Allowable comp.	2425.2	-606.60	0.00	32.91	31.47	-0.00013	0.75000
-X @ $f_s = 0.0$	2314.5	-689.85	0.00	31.47	31.47	0.00000	0.75000
-X @ $f_s = 0.5 f_y$	1598.0	-1017.61	0.00	23.40	31.47	0.00103	0.75000
-X @ Balanced point	1106.8	-1082.11	0.00	18.63	31.47	0.00207	0.75000
-X @ Tension control	520.2	-1028.48	0.00	11.80	31.47	0.00500	0.90000
-X @ Pure bending	0.0	-625.02	0.00	7.16	31.47	0.01018	0.90000
-X @ Max tension	-554.6	0.00	0.00	0.00	31.47	9.99999	0.90000

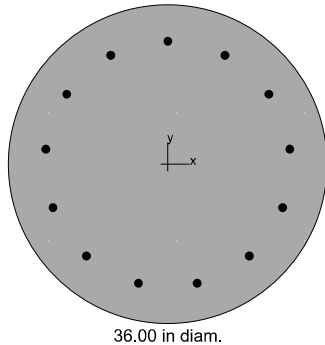
6. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Critical Capacity" Method.

No.	Demand		Capacity		Parameters at Capacity			Capacity Ratio
	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	NA Depth in	ϵ_t	ϕ	
1	0.00	550.02	0.00	628.86	7.19	0.01030	0.900	0.93

7. Diagrams

7.1. PM at $\theta=0$ [deg]



General Information

Project	---
Column	---
Engineer	---
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

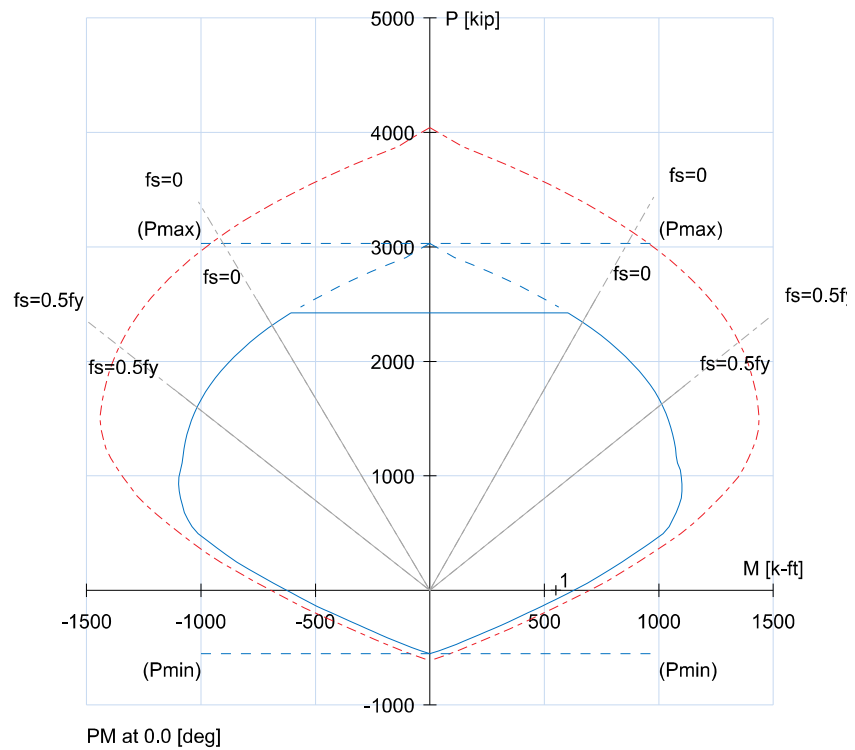
f'_c	4 ksi
E_c	3605 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	36 in
A_g	1017.88 in ²
I_x	82448 in ⁴
I_y	82448 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	13 #8
Confinement type	Other
Total steel area, A_s	10.27 in ²
Rho	1.01 %
Min. clear spacing	5.64 in



No.	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	Capacity Ratio
1	0.0	550.0	0.00	628.86	0.93

Max. Capacity Ratio: 0.93



Project:	ODOT LAW-243-11.28	Computed:	MAW	Date:	10-2-25
Subject:	Drilled Shaft Check	Checked:	BJH	Date:	10/2/2025
Task:	Drilled Caisson Shear Design	Page:		of:	
Job #:		No:			

DRILLED CAISSON SHEAR CHECK - DRILLED SHAFT

Determine Shear Capacity of Section

- Use Simplified Procedure as drilled shaft contains minimum transverse reinforcement and is not in axial tension (A5.7.3.4.1)

Drilled Caisson section:

Drilled Caisson Diameter =	36.0	in
Cover to shear reinforcing =	3.0	in
Shear Reinforcing bar size =	5	bar
Longitudinal Reinforcing bar size =	8	bar
Shear Reinforcing spacing =	5.0	in
Concrete Strength, f'_c =	4.0	ksi
Reinforcing Steel, f_y =	60	ksi

Nominal Shear Resistance is the lesser of:

$$V_n = V_c + V_s \quad (\text{A5.7.3.3-1})$$

$$V_n = 0.25 f'_c b_v d_v \quad (\text{A5.7.3.3-2})$$

$$V_c = 0.0316 \beta \lambda (f'_c)^{0.5} b_v d_v \quad (\text{A5.7.3.3-3})$$

β =	2.0	(A5.7.3.4.1)
λ =	1.0	(A5.4.2.8 - normal weight concrete)
b_v =	36.0	in (C5.7.2.8)
D_r =	27.8	in (Figure C5.7.8-2)
d_e =	26.8	in (C5.7.2.8-2)
d_v =	24.1	in (C5.7.2.8)
V_c =	109.9	k

$$V_s = A_v f_y d_v (\cot \theta) / s \quad (\text{C5.7.3.3-1})$$

θ =	45	degrees (A5.7.3.4.1)
V_s =	179.7	k

$$\phi = 0.9 \quad (\text{A5.5.4.2})$$
$$\phi V_n = \phi (V_c + V_s) = 260.6 \text{ k} \quad (\text{A5.7.2.1-1})$$
$$\phi V_{n \max} = \phi (0.25 f'_c b_v d_v) = 782.5 \text{ k} \quad (\text{A5.7.2.1-1})$$

$$\phi V_n = \min \text{ of } \phi (V_c + V_s) \text{ and } \phi V_{n \max} = 260.6 \text{ k}$$

For circular members, such as reinforced concrete columns or prestressed concrete piles, d_v can be determined from Eq. C5.7.2.8-1 provided that M_n is calculated ignoring the effects of axial load and that the reinforcement areas, A_s and A_{ps} , are taken as the reinforcement in one-half of the section. Alternatively, d_v can be taken as $0.9d_e$, where:

$$d_e = \frac{D}{2} + \frac{D_r}{\pi} \quad (\text{C5.7.2.8-2})$$

where:

D = external diameter of the circular member (in.)
 D_r = diameter of the circle passing through the centers of the longitudinal reinforcement (in.)

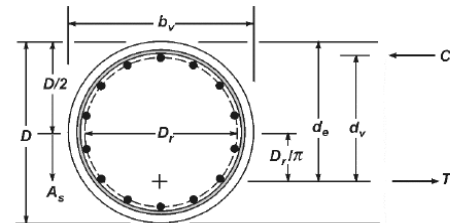


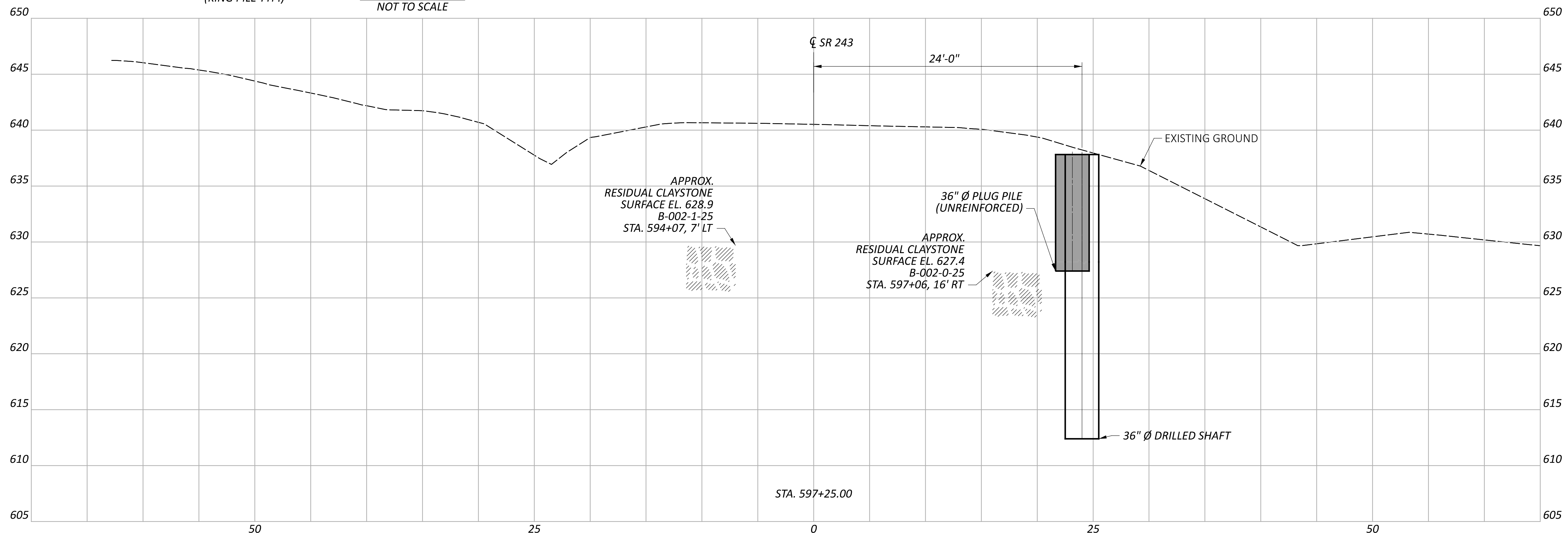
Figure C5.7.2.8-2—Illustration of Terms b_v , d_e , and d_v for Circular Sections

Circular members usually have the longitudinal reinforcement uniformly distributed around the perimeter of the section. When the member cracks, the highest shear stresses typically occur near the middepth of the section. This is also true when the section is not cracked. It is for this reason that the effective web width can be taken as the diameter of the section.

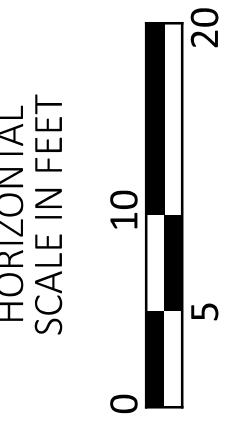
Shear Capacity Checks			
Shear Load Case	Resultant Shear (kips)	D/C	Section okay for Shear?
Max STR	112.9	0.43	YES

Max D/C =	0.43	<1.0 : Okay for Shear
-----------	------	-----------------------

Buried Drilled Shaft Wall Detail



<i>BORING</i>	<i>STATION</i>	<i>OFFSET</i>	<i>APPROX. SURFACE ELEVATION</i>	<i>APPROX. RESIDUAL CLAYSTONE ELEVATION</i>
<i>B-001-0-25</i>	<i>596+05</i>	<i>16' RT</i>	<i>653.4</i>	<i>640.4</i>
<i>B-002-0-25</i>	<i>597+06</i>	<i>16' RT</i>	<i>641.9</i>	<i>627.4</i>
<i>B-002-1-25</i>	<i>597+07</i>	<i>7' LT</i>	<i>642.7</i>	<i>629.7</i>
<i>B-003-0-25</i>	<i>598+08</i>	<i>15' RT</i>	<i>629.8</i>	<i>616.8</i>



BURIED DRILLED SHAFT WALL DETAIL
CRITICAL SECTION STA. 597+25

DESIGN AGENCY



DESIGNER

AKB

REVIEWER

REVIEWER
MAY 10/03/25

MIV 10/03/2004

PROJECT ID
118137

116165

TOTAL