Technical Design Memo

Client:	Ohio Department of Transportation, District 10
Project:	**MRG-37-8.09 (Task Order 10-AA)** **PID 117975**
HDR Project No:	10365632
Rev:	1
Calculation No:	1
Page:	1 of 116
Title:	Landslide Remediation Analyses and Design
Purpose:	Prepare slope stability analyses and wall calculations for the design of a landslide repair along the eastbound travel lane of State Route 37 (SR 37) in Morgan County, Ohio.
Originator:	AKB/DCM
Date:	4/12/2023 (Revised 5/19/2023)
Checked by:	DMV
Date:	4/19/2023 (5/22/2023)
QC Review by:	DMV
Date:	4/20/2023 (5/22/2023)

Summary

1. A landslide has occurred on the slope below SR 37 near mile marker 8.09 in Morgan County, Ohio. The project location is shown on the attached Site Vicinity and Topographic Map. Based on observations gathered during the site reconnaissance performed on March 7, 2023, coupled with the findings from the geotechnical explorations performed on March 21 and 22, 2023, a soldier pile and lagging retaining wall is recommended to stabilize the landslide and repair SR 37. Presented herein are the discussion and evaluation of a soldier pile and lagging wall for landslide mitigation. This design assumes that the topography and slope geometry as presented in the surveyed cross sections are representative of the current field conditions.

2. The geotechnical exploration program consisted of a series of 3 test borings (designated as Borings B-001-0-23, B-002-0-23, and B-003-0-23) and 2 dynamic cone penetrometer soundings (designated as D-001-1-23 and D-002-1-23) to characterize the subsurface profile in the vicinity of the existing landslide and develop a repair. The 3 test borings were drilled within the eastbound lane of SR 37 and the 2 DCPs were performed on the slope below the roadway at the locations shown on the attached Boring Location Plan. Typed boring logs and the DCP test logs are also

included. The soil profile, as encountered in the borings, generally consisted of an upper layer of soft to medium stiff colluvium, underlain by very stiff to hard cohesive residuum. The residual soils transition to severely weathered claystone bedrock over more competent (able to be cored) claystone, with an isolated layer of sandstone in Boring B-003-0-23. Free water was encountered in Boring B-002-0-23 at a depth of 13 feet (El 831.6) during drilling and wet seams encountered just above bedrock at a depth of 19.5 feet (El 829.0) in Boring B-001-0-23 and 24.5 feet (El 818.5) in Boring B-003-0-23. As the borings were backfilled upon completion given their locations within the roadway, delayed water level readings were not obtained.

The generalized soil profile developed for the design section is primarily based on the findings from Borings B-002-0-23 and DCP Location B-002-1-23, located near the design section at Sta. 427+25. The soil profile is assumed to be depicted as shown graphically on the attached Slope/W output plots based on the generalized soil conditions as encountered in the explorations, as well as field observations gathered during the course of our site reconnaissance.

3. Morgan County is located within the Marietta Plateau region within the Allegheny (Kanawha) Plateaus section of the unglaciated Appalachian Plateaus province of southeast Ohio. 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. The county predominantly consists of steep hill sides and narrow ridge tops; however, the topography of the central part of Morgan County is also influenced by the Muskingum River, resulting in very gently to strongly sloping terraces of varying width along narrow flood plains within the vicinity of the river and its tributaries. The project site is drained directly by Slemmons Creek running along the toe of the overall slope below SR 37, which drains into the Muskingum River approximately 1.7 miles east of the project site.

The surficial materials within Morgan County consist of colluvium and residuum derived from local bedrock, lacustrine and alluvial deposits near streams and on terraces, or wind-blown silts (loess). The bedrock below the project site is mapped as the Pennsylvanian-age Conemaugh Group. The Pennsylvanian-age Monongahela group is mapped further up the hillsides and ridgelines above the project site, near approximately El. 920 to El. 940. The Conemaugh Group consists of claystone, shale, siltstone, and sandstone, with minor amounts of limestone and coal. The coal seams within the Conemaugh Group are generally thin. The Monongahela Group consists of shale, siltstone, and mudstone, with minor amounts of limestone and economic coal beds.

4. The main coal seam of note within the Conemaugh Group is the Mahoning No. 7a coal, and notable seams within the Monongahela Group include the Pittsburgh No. 8, Pomeroy (Redstone) No. 8a, Meigs Creek (Sewickley) No. 9, Uniontown No. 10, and Waynesburg No. 11 coals. No significant mining activity is mapped at the project site according to information from the Ohio Department of Natural Resources. One mine portal with unknown extents is mapped 0.7 mile northwest of the project site, and one is mapped 1.9 miles southeast of the project site. The coal seams and elevations associated with these openings are not identified.

5. No base flood elevation has been established based on review of FEMA flood maps for the area in order to determine the high water elevation along the slope located below the roadway. The project site is mapped in an area designated as an area of minimal flood hazard (Zone X).

6. HDR is unaware of any prior geotechnical explorations at the MEG-37-8.09 project site. A search of the available records on ODOT's Transportation Information Mapping System (TIMS) reveals only the geographical locations of known landslide activity in the project area. The nearest boring from a prior study was performed approximately 0.1 mile southeast of the project site.

7. In accordance with ODOT Geotechnical Design Manual (GDM) recommendations, an initial set of soil strength parameters were selected based on the boring logs, laboratory tests, and published correlations of soil strength with SPT N_{60} values. A statistical basis for selecting the initial soil parameters was performed and is in the attached printed spreadsheets entitled "Soil Strength Parameter Determination". Following development of the soil strength parameters, cross-sections perpendicular to the roadway centerline were reviewed, and the section at Station 427+25 was selected for design.

The developed soil parameters and subsurface profile were then entered into the Slope/W slope stability modeling software to re-create the landslide observed in the field by simulating a series of trial searches to determine the critical mode of failure based on a Morgenstern-Price stability model. Recognizing that a landslide had already occurred, strength parameters within the existing soil layers were adjusted in order to generate a reasonable slip surface (FS < 1.0) that is consistent with the field observations and engineering judgment.

Based on the available information and on-site observations, groundwater was modeled based on groundwater encountered in B-002-0-23 and extending horizontally to the face of the embankment slope. The groundwater line continued along the surface to the creek at the toe of the embankment.

Bedrock depths along the slope below SR 37 were estimated based on exposed bedrock outcrops observed during the site reconnaissance along the bank of the creek and in the creek bed itself, along with the refusal depths of the DCP tests. Analyses were performed with a 2-foot thick "Weak Rock" layer within the highly weathered, augerable claystone overlying the more competent claystone which was rock cored. Once the soil parameters and failure surface were established, they were entered into the UA Slope Version 2.3 software program and a model was developed based on the current slope configuration (See attached UA Slope screen shot).

8. After the soil profile and parameters between Slope/W and UA Slope were confirmed and finalized, a preliminary wall location was plotted with the centerline of the proposed drilled shafts a distance of 25 feet from the centerline of the roadway. This recommended offset allows for continuity with the existing site features including the guardrail located to the east and west of the project site, the approximately 10-foot wide shoulder, and the 10-foot travel lane. This offset also allows for a 4-foot wide bench to be included in front of the wall and remain within the existing standard highway easement. Elevations along this preliminary wall profile were reviewed

to establish the tallest exposed wall height (considering the elevation at the centerline of SR 37 to the proposed bench elevation), which was about 8 feet at Station 427+45 (see attached). This is approximately 1.2 feet greater than that at the design section at Station 427+25. Downslope stability was analyzed in Slope/W based on the actual geometry at the section, but the elevation of the bench was lowered to match the maximum exposed wall height for the UA Slope, wall loading, and LPile analyses (see attached).

Once the wall location was established, the "Manually Determined Load Transfer Factor" was selected in the UA Slope program and the load transfer factor (η) was set to zero in order to determine the horizontal forces acting on the wall. The computed unfactored force per shaft is **Ps = 19,232** pounds based on 36-inch diameter drilled shafts spaced at approximate 6-foot centers. (See attached UA Slope computer screen shots of the post-construction condition of these calculations.) The numbering of soil layers for the UA Slope profile is listed as follows:

a. Layer 1 = Surcharge Load
b. Layer 2 = Item 203 Embankment Fill
c. Layer 3 = Medium Stiff to Stiff Cohesive Soils
d. Layer 4 = Stiff to Hard Cohesive Soils
e. Layer 5 = Weak Rock
f. Layer 6 = Bedrock

9. In accordance with ODOT design requirements, LPILE software was used to determine the pile response to the applied lateral loading from the failure wedge determined by the Slope/W and UA Slope analyses performed at the design section. At Sta. 427+45 for an 8-foot exposed wall height, the following were considered relative to LPILE analyses:

(a) Factored Distributed Load (per GDM Section 903.1, pgs. 9-12 and 9-13)

- Convert concentrated load from UA Slope to distributed load
  - ½(D_L)(H_T) = 19,232 lbs.
    D_L = distributed load
    H_T =11.1 feet (top/wall to slip surface, see attached)
  - D_L = [(19,232 lbs)(2)]/[(19.1')(12"/ft)] = Resolution of Triangular Area
    D_L = **168 lbs/in** (Service Load)
  - (168 lbs/in)(γ_{EH}) = (168 lbs/in)(1.5) = **252 lbs/in** (Strength Load for Moment/Shear Analysis).

Loading due to conventional earth pressures were performed for comparison purposes.

- Calculate conventional earth pressure wall loading.
  - Equivalent Fluid Weight (G_H) = (γ_m) * (K) = **47 pcf**
    Ym = soil moist unit weight (see attached calculations)
    Ka = active earth pressure (see attached calculations)
  - Lateral Thrust (P) = 1/2 * G_H * H^2 = P = **2843 lbs/ft**
    H = Wall Height

- Horizontal Force Per Shaft (P_{SH}) = P*(S_{cc}) = **17,060 lbs/shaft**
  S_{cc} = Center-to-Center Shaft Spacing = 6 ft
- Resolve Horizontal Earth Pressure to Distributed Triangular Load
  (2* P_{SH}/H) / (12 in/ft)
  = **259 lbs/in per shaft (Service Load)**
  (259 lbs/in) (γ_{EH}) = (259 lbs/in) (1.5)
  = **389 lbs/in per shaft (Strength Load)**

Based on a comparison of the two loading methods, conventional earth-pressure loading was applied to the proposed wall.

(b) Traffic Surcharge (per GDM Section 903.7, pg. 9-16)

As loading traffic may be present up to the front edge of the guardrail, traffic surcharge loading was included in the distributed load acting on the shaft (see attached calculations).

(c) Modification of p-y curves

Since the center-to-center spacing is < 3.5 shaft diameters, a reduction in soil resistance (p) should be applied from the ground surface to the bottom of shaft or bedrock (whichever is shallower).

- $\beta_a = 0.64(S/D)^{0.34} = \beta_a = 0.64(6/3)^{0.34}$
- $\beta_a =$ **0.81**

The downslope stability exhibited a Factor of Safety less than 1.3. (See the Slope/W output plot included in the attached calculations.) As such, the GDM recommendation of artificially lowering the ground surface in the LPILE analysis was included.

- Top of Wall El. 843.8 ft
  - Assumes approximately 3.5 feet of fill placement to re-establish grade.
- Maintenance Bench GS El. = 835.8 ft (Based on Sta. 427+45)
- Wall Height = 843.8 ft – 835.8 ft = 8.0 ft. (Based on Max. Wall Height at Sta. 427+45)
- Artificially lowered surface = 3.0 feet (See attached)
- GS for LPILE analysis = 835.8 ft – 3.0 ft = 832.8 ft
  - Wall Height for LPILE Analysis = 8.0 ft + 3.0 ft = **11.0 ft**

(d) Pile Head Deflection

As noted in the ODOT GDM (Section 903.8, pgs. 9-16 and 9-17), for the unfactored Service Limit State analysis, pile head deflection shall be limited 1% or less of the drilled shaft length above bedrock (or the total shaft length when bedrock is not encountered). If the drilled shafts are within 10 feet of the edge of pavement, the deflection must be limited to 2 inches. The centerline of the drilled shafts is not

anticipated to be located less than 10 feet from the edge of pavement. However, a limited pile head deflection of 2 inches or less was adopted for conservatism as traffic may be present at some point on the 10-foot wide shoulder.

Computed Pile Head Deflection (W 21 x 101) = **1.26 inches** < 2.00 inches OK
(See attached calculations)

(e) Pile Length (per GDM Section 903.4, pg. 9-14)

*Minimum 10 feet below slip plane
*Slip Plane = 11.1 ft below top of wall
+10.0 ft
21.1 ft minimum pile length

- **Bottom of Drilled Shaft = 33.4 ft ≥ 21.1 ft** **OK**

The ODOT GDM requires embedding a drilled shaft a minimum of 10 feet below the failure surface and into a solid stratum such that the calculated deflection at the top of the wall is constrained to the appropriate serviceability limits. (See Section 9(d) above.) The "Top Deflection Versus Length" plot produced by the LPILE software was reviewed to determine the recommended length. Based on the encountered weathered and claystone bedrock and our experience with such local bedrock types, **a minimum drilled shaft length of 25 feet** is recommended.

(f) Steel Reinforcement and Pile Cross Section Character

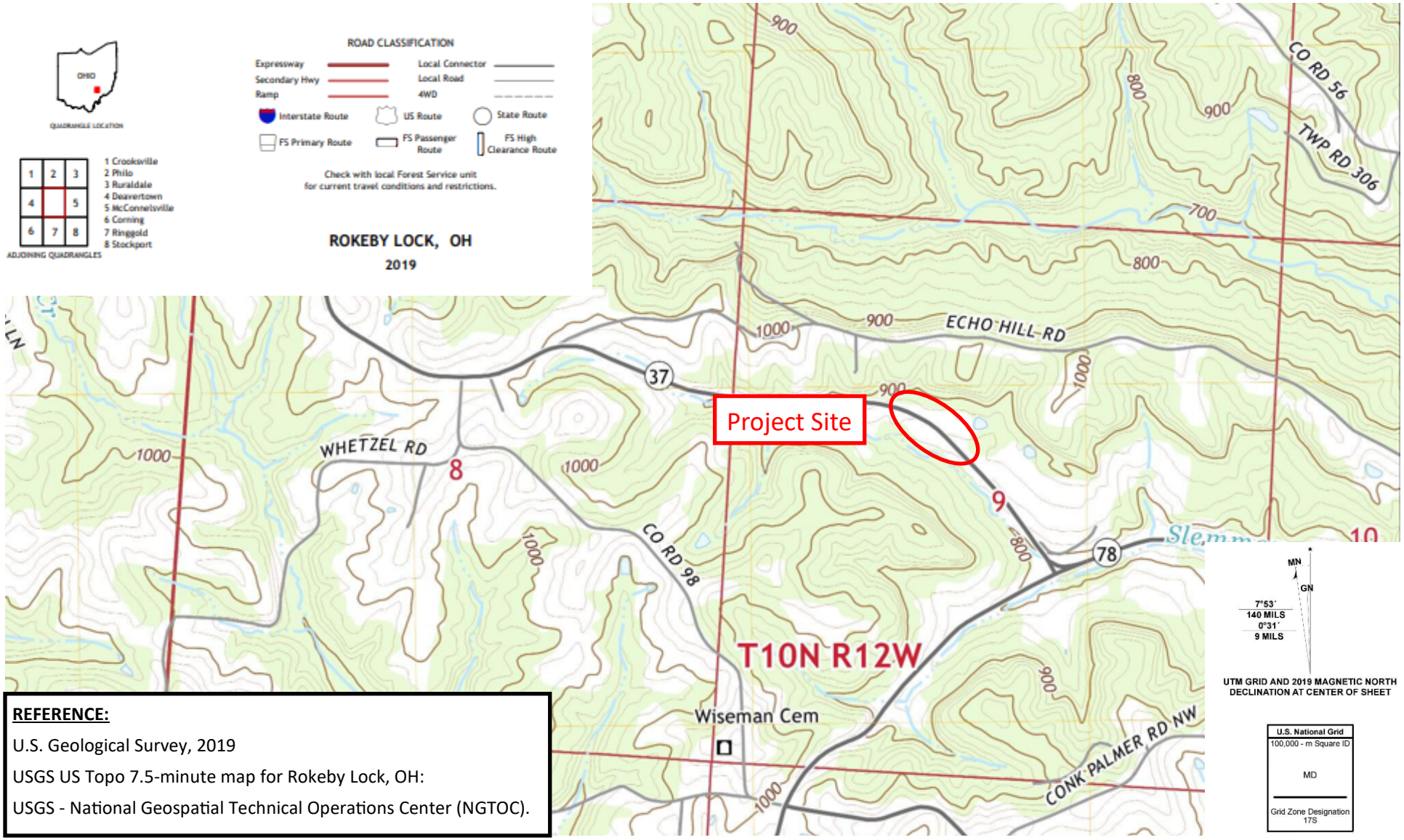
Use W 21 x 101 shaft reinforcement

A_s = Area of Steel = 29.8 in^2
I_x = Moment of Inertia around strong axis = 2420 in^4
T_w = web thickness = 0.5 in
E = Modulus of Elasticity of Steel = 29,000,000 psi
F_y = yield strength of steel = 50,000 psi
B_f = Flange Width = 12.3 in

8. It is recommended that plug piles be utilized to prevent loss of material and undermining of the concrete lagging. Please refer to the attached "Soldier Pile and Lagging Wall Details" sheet for details on the plug piles as well as further details on the wall itself.

Site Vicinity and Topographic Map

Site Vicinity and Topographic Map



REFERENCE:

U.S. Geological Survey, 2019

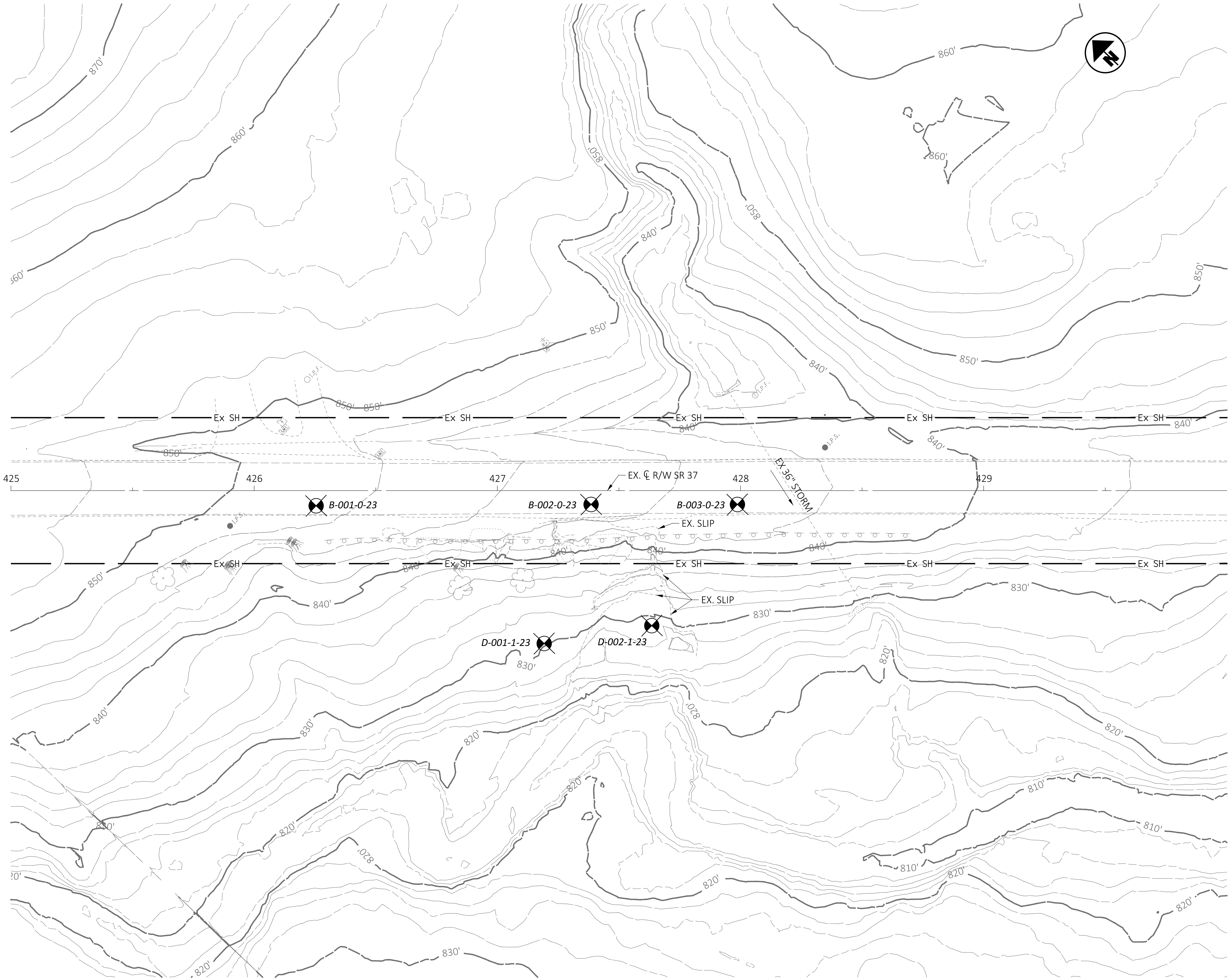
USGS US Topo 7.5-minute map for Rokeby Lock, OH:

USGS - National Geospatial Technical Operations Center (NGTOC).

Boring Location Plan

MRG-37-8.09

MODEL: CLX_37 - Plan 1 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 4/19/2023 TIME: 9:05:32 AM USER: CWAHLBRI
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Morgan\117975\401-Engineering_HDR\Geotechnical\Sheets\117975_IP901.dgn



HORIZONTAL SCALE IN FEET

0 10 20 40

BORING LOCATION PLAN
SR 37 - STA. 425+00 TO STA. 429+50

DESIGN AGENCY

HDR

DESIGNER
DCM

REVIEWER
DMV 04/19/23

PROJECT ID
117975

SHEET 1 TOTAL 1

Boring Logs
and
Rock Core Photos

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 426+25, 6' RT.	EXPLORATION ID B-001-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37	
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 848.5 (MSL) EOB: 52.5 ft.	PAGE 1 OF 2
START: 3/21/23 END: 3/21/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654621, -81.890326	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (20")	848.5																	
	846.8	1	9															
MEDIUM STIFF, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP (FILL)		2	3 2	7	44	SS-1	-	7	11	37	24	21	24	17	7	14	A-4a (2)	
	845.0	3																
MEDIUM STIFF TO STIFF, RED-BROWN AND BROWN, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP		4	3															
	842.5	5	2 3	7	56	SS-2	2.50	2	4	5	36	53	46	26	20	23	A-7-6 (13)	
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, SOME ROCK FRAGMENTS, SOME SAND, DAMP		6																
		7	2 3 4	10	78	SS-3	2.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
		8																
		9	3															
		10	5 6	16	78	SS-4	1.75	28	16	9	28	19	35	22	13	16	A-6a (3)	
	837.5	11																
MEDIUM DENSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, DAMP		12	7															
		13	6 10	23	67	SS-5	-	-	-	-	-	-	-	-	-	16	A-2-6 (V)	
@12.5' - 14.5': end of tube came back dented		14			67	ST-6	-	46	12	7	19	16	36	21	15	13	A-2-6 (1)	
	832.5	15																
VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE ROCK FRAGMENTS		16	4															
		17	7 8	22	72	SS-7	2.50	8	10	8	36	38	40	23	17	17	A-6b (11)	
	830.0	18																
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, DAMP		19	5															
@19.5': 1" wet gravel seam		20	6 9	22	89	SS-8	1.50	16	12	9	35	28	36	21	15	17	A-6a (8)	
	827.5	21																
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP		22	4															
		23	4 7	16	89	SS-9	1.75	8	7	9	38	38	36	22	14	18	A-6a (10)	
	825.0	TR																
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK.		24	24															
		25	38 50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	11	Rock (V)	
		26																
		27	34 50/5"	-	100	SS-11	-	-	-	-	-	-	-	-	-	11	Rock (V)	
		28																
		29	31 50/5"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	Rock (V)	

PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 426+25, 6' RT.	START: 3/21/23	END: 3/21/23	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK. *(continued)*	818.5	31	36 50/5"	-	100	SS-13	-	-	-	-	-	-	-	-	-	13	Rock (V)	
	816.0	32																
CLAYSTONE, RED-BROWN AND GRAY, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 85%, REC 100%.	814.3	33	85		100	NQ2-1											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SEVERELY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, VERY POOR TO POOR SURFACE; RQD 0%, REC 78%.	811.7	34 35 36 37	27		85	NQ2-2											CORE	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 57%, REC 98%. @43.3' - 44.6': contains 1" to 2" sandstone interbeds @43.3' - 45.6': highly fractured		38 39 40 41 42 43	58		95	NQ2-3											CORE	
		44 45 46 47 48 49 50 51	54		100	NQ2-4											CORE	
	796.0	EOB 52																

NOTES: NONE

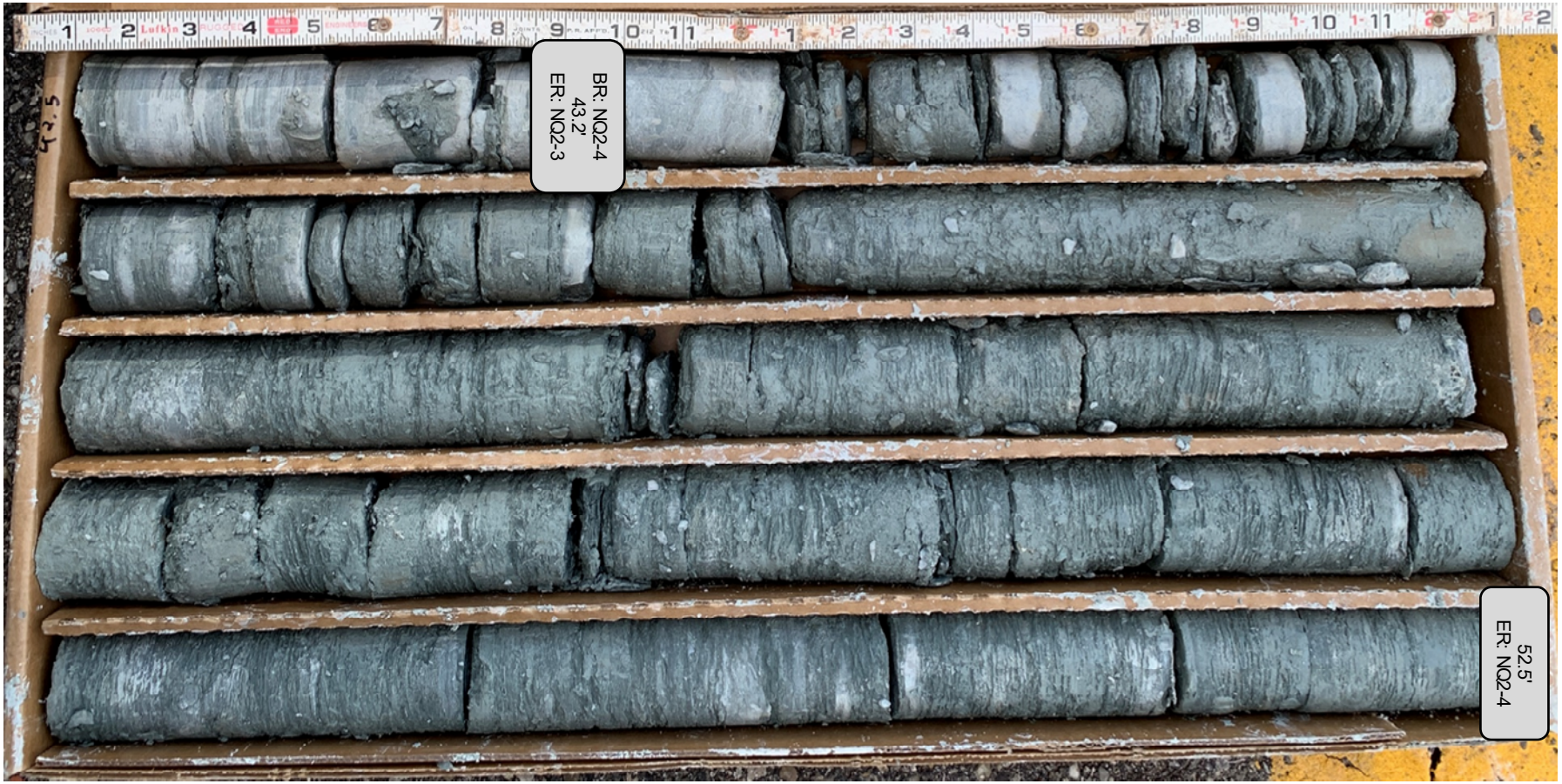
ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

B-001-0-23

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	32.5	34.2	20 in. / 20 in.	100%	17 in. / 20 in.	85%
NQ2-2	34.2	38.2	41 in. / 48 in.	85%	13 in. / 48 in.	27%
NQ2-3	38.2	43.2	57 in. / 60 in.	95%	35 in. / 60 in.	58%

MRG-37-8.09 PID 117975

B-001-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	38.2	43.2	57 in. / 60 in.	95%	35 in. / 60 in.	58%
NQ2-4	43.2	52.5	112 in. / 112 in.	100%	60 in. / 112 in.	54%

MRG-37-8.09 PID 117975

PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 427+39, 6' RT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 844.6 (MSL) EOB: 50.5 ft.
START: 3/21/23 END: 3/22/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654396, -81.890049

EXPLORATION ID B-002-0-23

PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 844.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (48")		1																
	840.6	2	48 27 7	49	100	SS-1	-	-	-	-	-	-	-	-	-	-		
SOFT, BROWN, **SILTY CLAY**, SOME SAND, TRACE ROCK FRAGMENTS, MOIST	840.1	3 4	4 2 1	4	28	SS-2	0.25	8	12	22	26	32	36	18	18	24	A-6b (8)	
MEDIUM STIFF TO STIFF, BROWN AND GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST	838.6	5 6	1 2 3	7	78	SS-3	1.25	4	5	7	33	51	57	24	33	29	A-7-6 (19)	
MEDIUM STIFF TO STIFF, BROWN, **CLAY**, SOME SAND, SOME SILT, TRACE TO LITTLE GRAVEL, DAMP TO MOIST @7.9' - 8.4': qu = 1110 psf		7	WOH WOH 4	6	78	SS-4	-	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
		8 9			71	ST-5	1.50	8	14	8	33	37	51	26	25	24	A-7-6 (15)	
		10	2 1 3	6	61	SS-6	0.75	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
	832.1	11 12	2 2 2	6	94	SS-7	0.50	11	13	8	33	35	47	25	22	27	A-7-6 (13)	
SOFT TO MEDIUM STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, DAMP		W 831.6 13	2 4 8	17	67	SS-8	0.75	13	18	10	33	26	40	23	17	22	A-6b (8)	
	829.1	14 15	5 4 3	10	56	SS-9	0.25	-	-	-	-	-	-	-	-	22	A-6b (V)	
SOFT TO MEDIUM STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, MOIST	827.6	16	2 1 4	7	94	SS-10	0.25	18	16	9	30	27	40	24	16	26	A-6b (7)	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP	826.1	17 18	3 5 10	22	94	SS-11	1.75	3	3	6	40	48	40	24	16	23	A-6b (10)	
VERY STIFF TO HARD, RED-BROWN AND GRAY, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP (RELIC ROCK STRUCTURE)		19	8 12 15	39	50	SS-12	2.00	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
	823.1	20 21 TR	8 17 31	69	83	SS-13	4.5+	4	3	4	51	38	44	25	19	15	A-7-6 (12)	
CLAYSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.		22	16 31 50/5"	-	94	SS-14	-	-	-	-	-	-	-	-	-	12	Rock (V)	
		23 24	35 50/4"	-	100	SS-15	-	3	4	6	45	42	40	24	16	11	Rock (V)	
		25	31 43 50/4"	-	100	SS-16	-	-	-	-	-	-	-	-	-	11	Rock (V)	
@26' - 30.5': outside of samples wet due to water sitting overnight in hole		26 27	16 32 50/5"	-	76	SS-17	-	-	-	-	-	-	-	-	-	18	Rock (V)	
		28	26 42 50/4"	-	75	SS-18	-	-	-	-	-	-	-	-	-	18	Rock (V)	
@29': color change to red-brown and gray		29	30 50/4"	-	100	SS-19	-	-	-	-	-	-	-	-	-	18	Rock (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/17/23 21:23 - C:\PWWORKING\EAST01\D3186955\MRG-37-8.09 BORING LOGS.GPJ

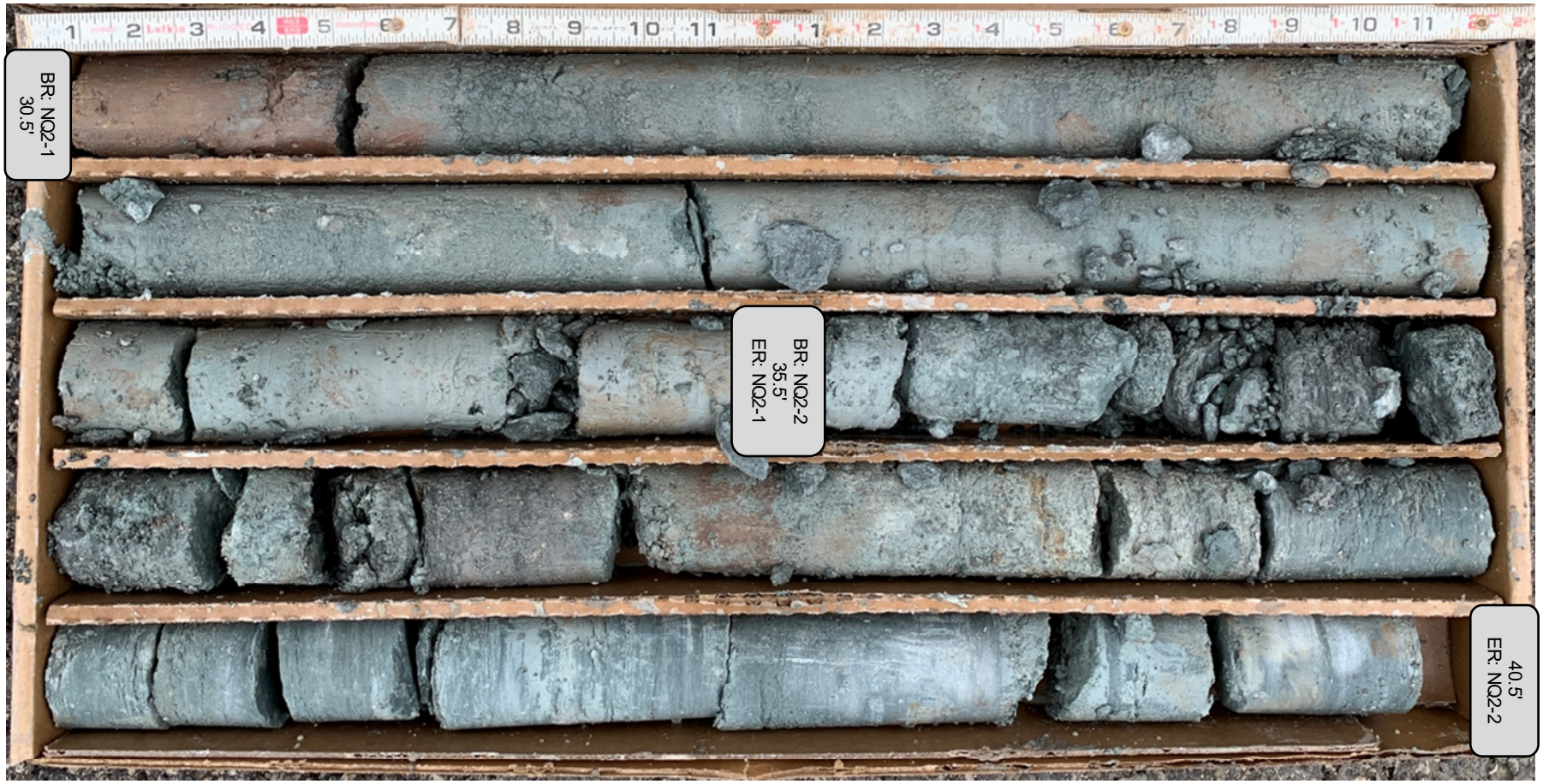
PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 427+39, 6' RT.	START: 3/21/23	END: 3/22/23	PG 2 OF 2	B-002-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	814.6																	
	814.1																	
CLAYSTONE, GRAY TRACE RED-BROWN, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 95%, REC 100%. @32.6' - 33.0': qu = 30 psi, γ = 140 pcf		31 32 33 34 35	95		100	NQ2-1											CORE	
	809.1																	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 27%, REC 98%.		36 37 38 39 40	30		95	NQ2-2											CORE	
@40.5' - 41.8': 1" to 2" interbedded sandstone layers @41' - 41.6': highly fractured @43' - 43.6': highly fractured		41 42 43 44 45 46	44		100	NQ2-3											CORE	
	798.1																	
CLAYSTONE, GRAY, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 75%, REC 100%.		47 48 49 50																
	794.1	EOB																

NOTES: BORING STOPPED AT 26' ON 3/21/23. WATER LEVEL MEASURED 3/22/23, 8:35 AM.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

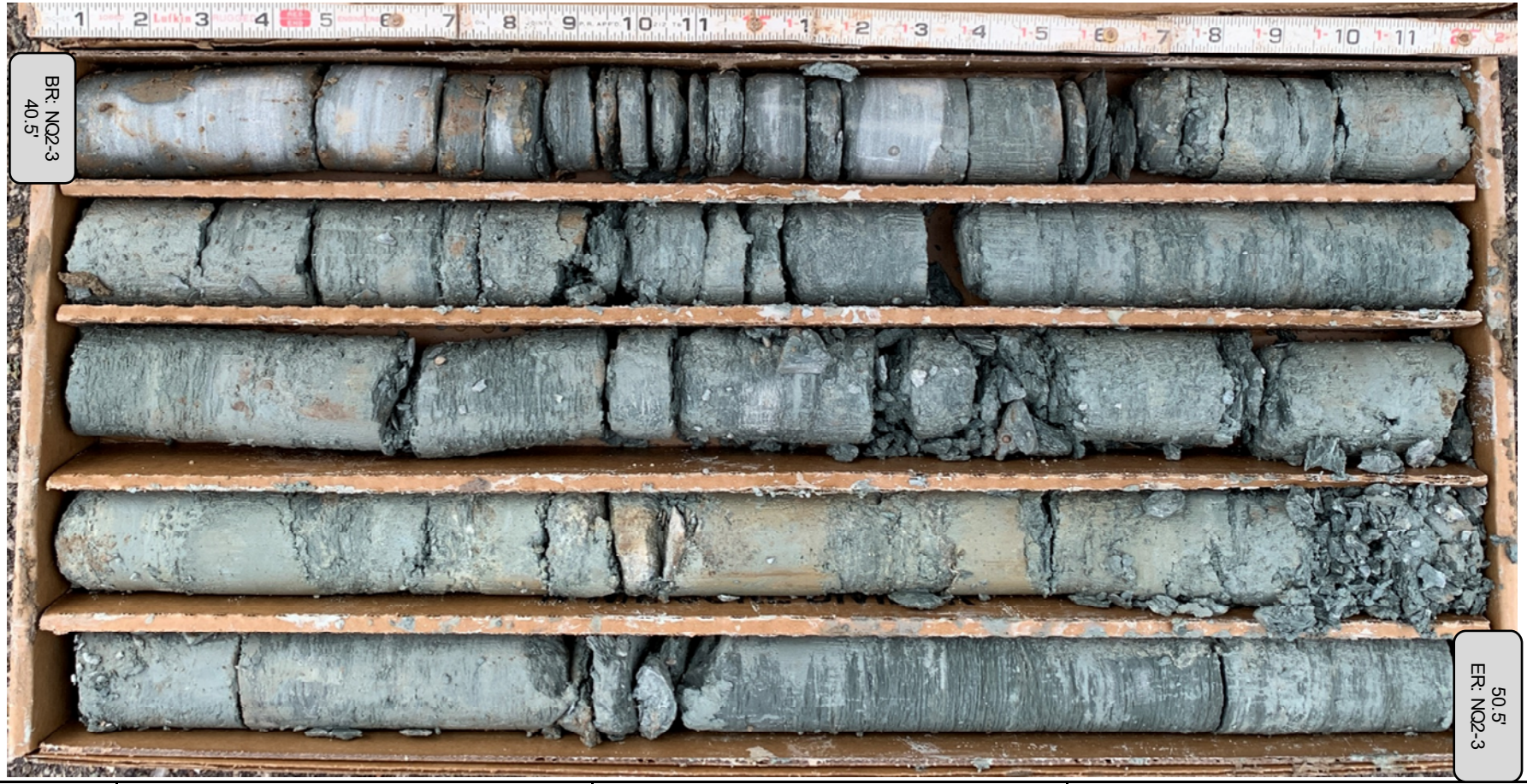
B-002-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	30.5	35.5	60 in. / 60 in.	100%	57 in. / 60 in.	95%
NQ2-2	35.5	40.5	57 in. / 60 in.	95%	18 in. / 60 in.	30%

MRG-37-8.09 PID 117975

B-002-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	40.5	50.5	120 in. / 120 in.	100%	53 in. / 120 in.	44%

MRG-37-8.09 PID 117975

PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 427+99, 6' RT.	EXPLORATION ID B-003-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37	
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 843.0 (MSL) EOB: 50.0 ft.	PAGE 1 OF 2
START: 3/22/23 END: 3/22/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654276, -81.889902	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (36")	843.0																	
	840.0		31 11 7	26	61	SS-1A	-	-	-	-	-	-	-	-	-	-		
MEDIUM DENSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP (FILL)	839.5					SS-1B	-	38	9	30	14	9	NP	NP	NP	8	A-2-4 (0)	
			3 3 4	10	44	SS-2	1.75	6	6	8	35	45	48	24	24	24	A-7-6 (15)	
STIFF, BROWN AND GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP (FILL)	837.0																	
MEDIUM STIFF TO STIFF, BROWN AND GRAY, **CLAY**, "AND" SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST			3 3 4	10	100	SS-3	0.75	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
			3 4 3	10	94	SS-4	1.00	1	3	9	42	45	45	23	22	28	A-7-6 (14)	
	831.5																	
STIFF TO VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP @12.2' - 12.7': qu = 2671 psf					71	ST-5	2.25	9	11	7	29	44	57	28	29	24	A-7-6 (18)	
			4 4 6	14	61	SS-6	2.50	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
	827.0																	
STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE ROCK FRAGMENTS, DAMP			5 6 6	17	78	SS-7	2.50	7	16	10	39	28	39	22	17	17	A-6b (9)	
			3 4 5	13	67	SS-8	2.00	-	-	-	-	-	-	-	-	24	A-6b (V)	
	822.0																	
STIFF TO VERY STIFF, RED-BROWN, **CLAY**, "AND" SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST			4 6 7	19	100	SS-9	1.75	1	3	12	38	46	47	24	23	25	A-7-6 (15)	
	819.5																	
VERY STIFF TO HARD, BROWN AND RED-BROWN, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP @24.5': wet seam			3 9 22	45	100	SS-10	3.00	1	1	8	50	40	44	27	17	17	A-7-6 (12)	
	817.0																	
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK.		TR	22 50/4"	-	100	SS-11	-	-	-	-	-	-	-	-	-	13	Rock (V)	
			30 42 50/3"	-	80	SS-12	-	3	2	6	56	33	32	20	12	10	Rock (V)	
	813.0																	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/17/23 21:23 - C:\PWWORKING\EAST01\D3186955\MRG-37-8.09 BORING LOGS.GPJ

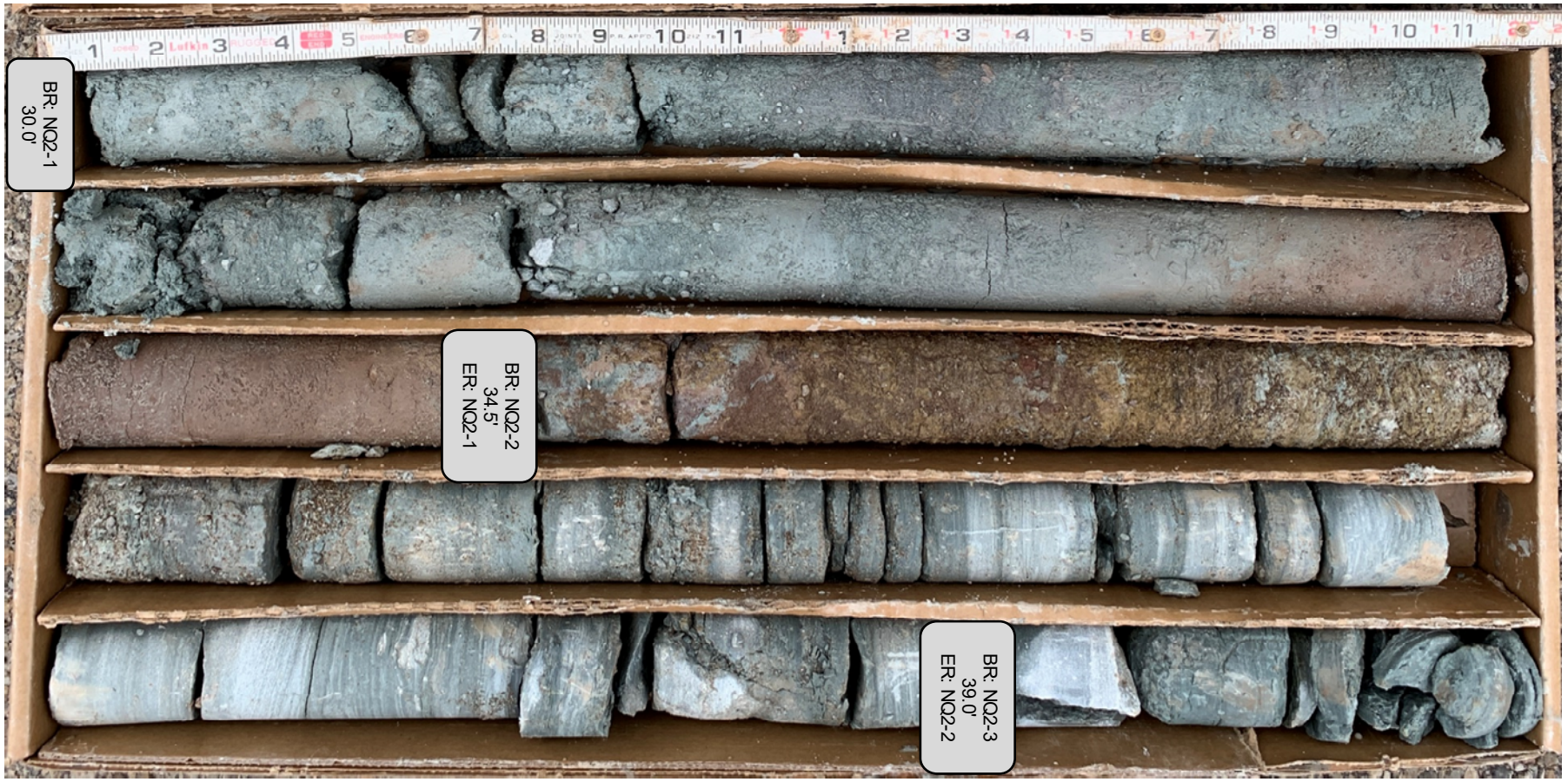
PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 427+99, 6' RT.	START: 3/22/23	END: 3/22/23	PG 2 OF 2	B-003-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, GRAY TRACE RED-BROWN, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 73%, REC 99%.	813.0	31	78		100	NQ2-1											CORE	
	806.6	35	35		98	NQ2-2											CORE	
SANDSTONE, GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, FINE GRAINED, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 15%, REC 100%.	803.8	39																
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 0%, REC 100%.	802.4	42	72		100	NQ2-3											CORE	
CLAYSTONE, GRAY, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 81%, REC 91%. @42.6' - 42.9': qu = 583 psi, γ = 159 pcf		47	67		84	NQ2-4											CORE	
@49.0' - 49.4': qu = 638 psi, γ = 158 pcf	793.0 EOB	50																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

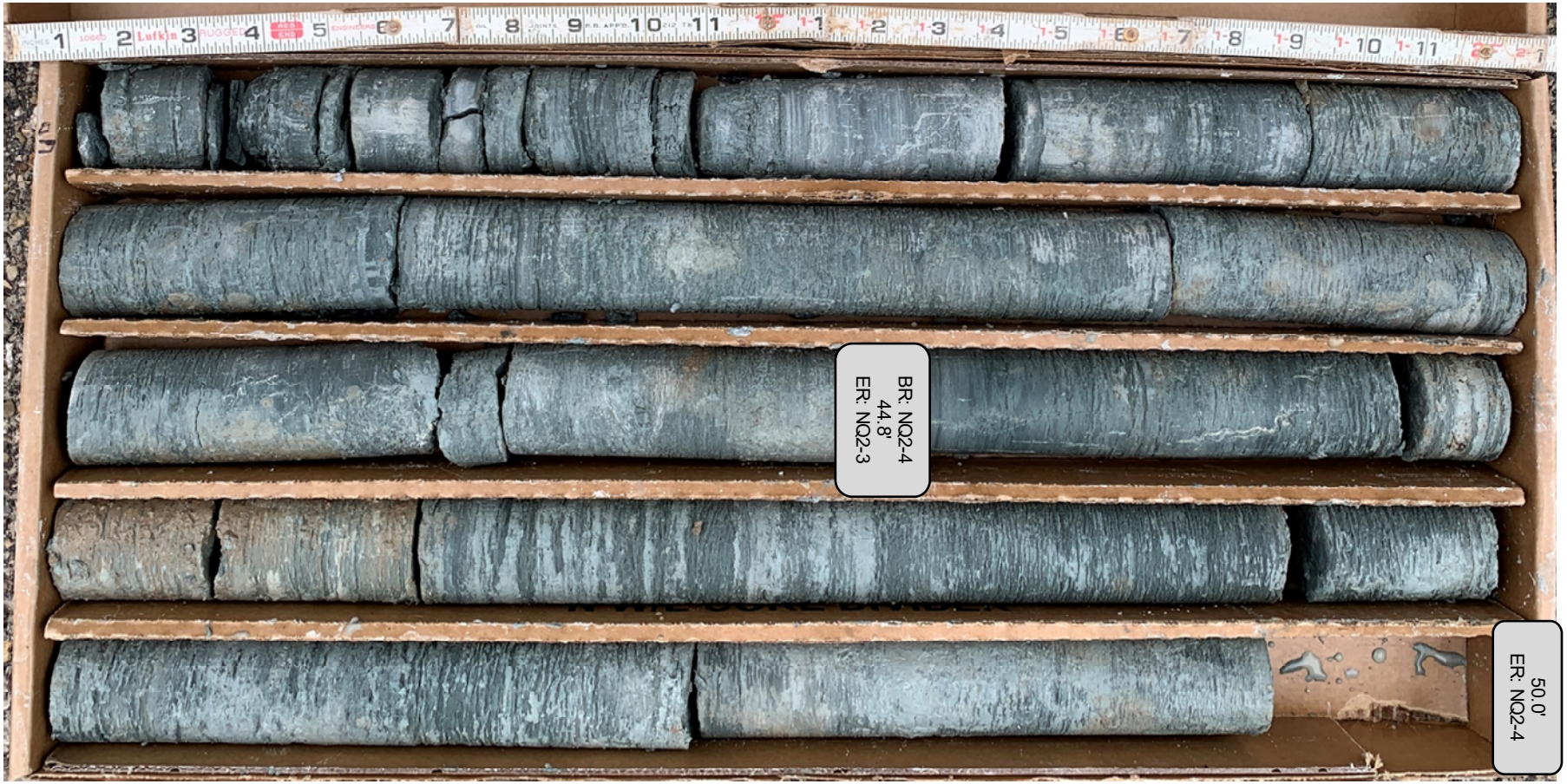
B-003-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	30.0	34.5	54 in. / 54 in.	100%	42 in. / 54 in.	78%
NQ2-2	34.5	39.0	53 in. / 54 in.	98%	19 in. / 54 in.	35%
NQ2-3	39.0	44.8	69 in. / 69 in.	100%	50 in. / 69 in.	72%

MRG-37-8.09 PID 117975

B-003-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	39.0	44.8	69 in. / 69 in.	100%	50 in. / 69 in.	72%
NQ2-4	44.8	50.0	53 in. / 63 in.	84%	42 in. / 63 in.	67%

MRG-37-8.09 PID 117975

DCP Logs

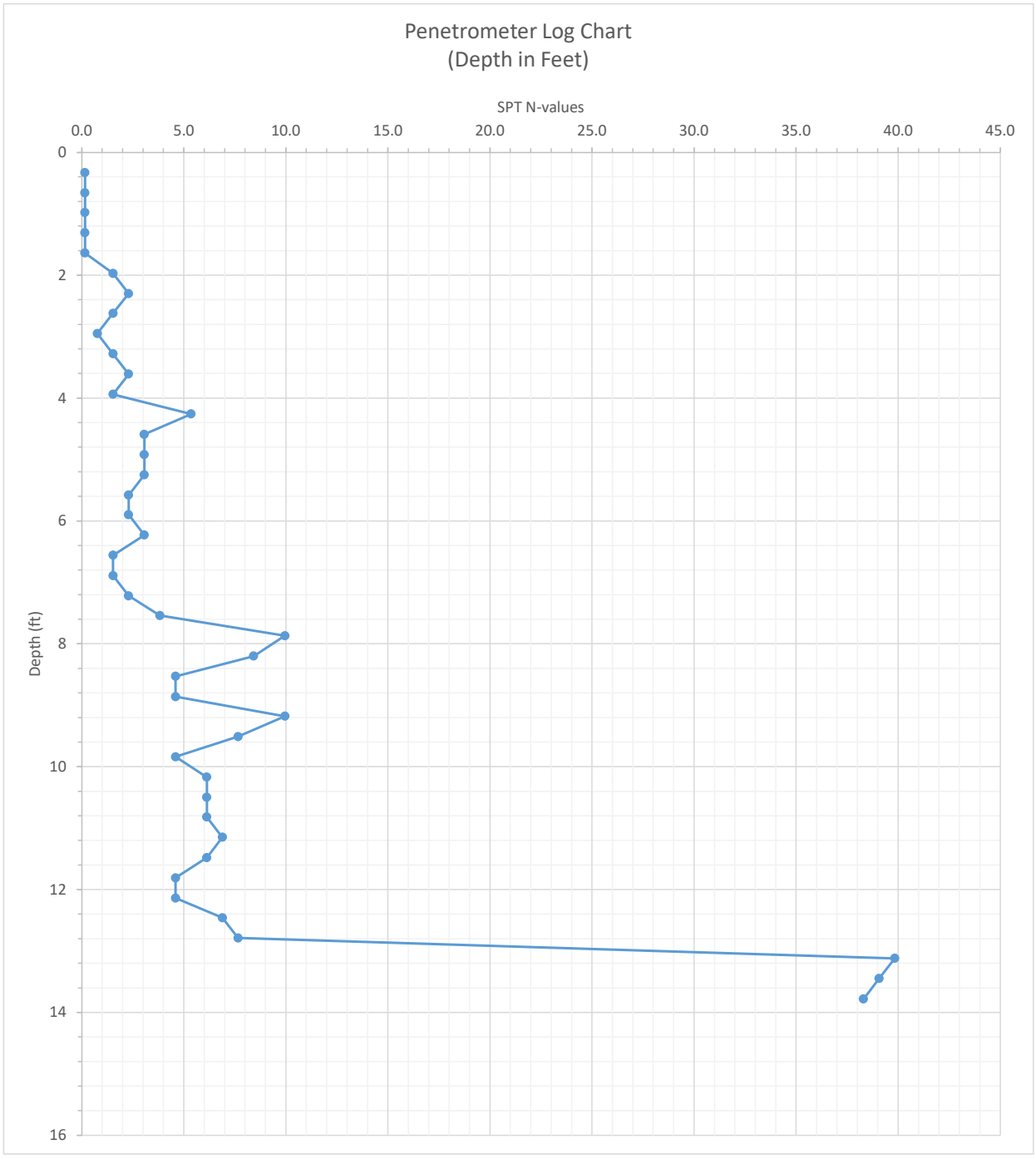
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65432694 -81.89024337
Location:	D-001-1-23	**North / East:**	603116.623 2140179.127
Station, Offset:	427+19, 63 RT	**Date:**	3/22/2023
Elevation:	829.4	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value	Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.2					
7.87	0.66	20	0.2	0.2					
11.81	0.98	30	0.2	0.2					
15.75	1.31	40	0.2	0.2					
19.69	1.64	50	0.2	0.2					
23.62	1.97	60	2	1.5					
27.56	2.3	70	3	2.3					
31.5	2.62	80	2	1.5					
35.43	2.95	90	1	0.8					
39.37	3.28	100	2	1.5					
43.31	3.61	110	3	2.3					
47.24	3.94	120	2	1.5					
51.18	4.26	130	7	5.4					
55.12	4.59	140	4	3.1					
59.06	4.92	150	4	3.1					
62.99	5.25	160	4	3.1					
66.93	5.58	170	3	2.3					
70.87	5.9	180	3	2.3					
74.8	6.23	190	4	3.1					
78.74	6.56	200	2	1.5					
82.68	6.89	210	2	1.5					
86.61	7.22	220	3	2.3					
90.55	7.54	230	5	3.8					
94.49	7.87	240	13	10.0					
98.43	8.2	250	11	8.4					
102.36	8.53	260	6	4.6					
106.3	8.86	270	6	4.6					
110.24	9.18	280	13	10.0					
114.17	9.51	290	10	7.7					
118.11	9.84	300	6	4.6					
122.05	10.17	310	8	6.1					
125.98	10.5	320	8	6.1					
129.92	10.82	330	8	6.1					
133.86	11.15	340	9	6.9					
137.8	11.48	350	8	6.1					
141.73	11.81	360	6	4.6					
145.67	12.14	370	6	4.6					
149.61	12.46	380	9	6.9					
153.54	12.79	390	10	7.7					
157.48	13.12	400	52	39.8					
161.42	13.45	410	51	39.1					
165.35	13.78	420	50	38.3					

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65432694 -81.89024337
Location:	D-001-1-23	**North / East:**	603116.623 2140179.127
Station, Offset:	427+19, 63 RT	**Date:**	3/22/2023
Elevation:	829.4	**Sheet:**	2 of 2
Notes:	Staked Location		



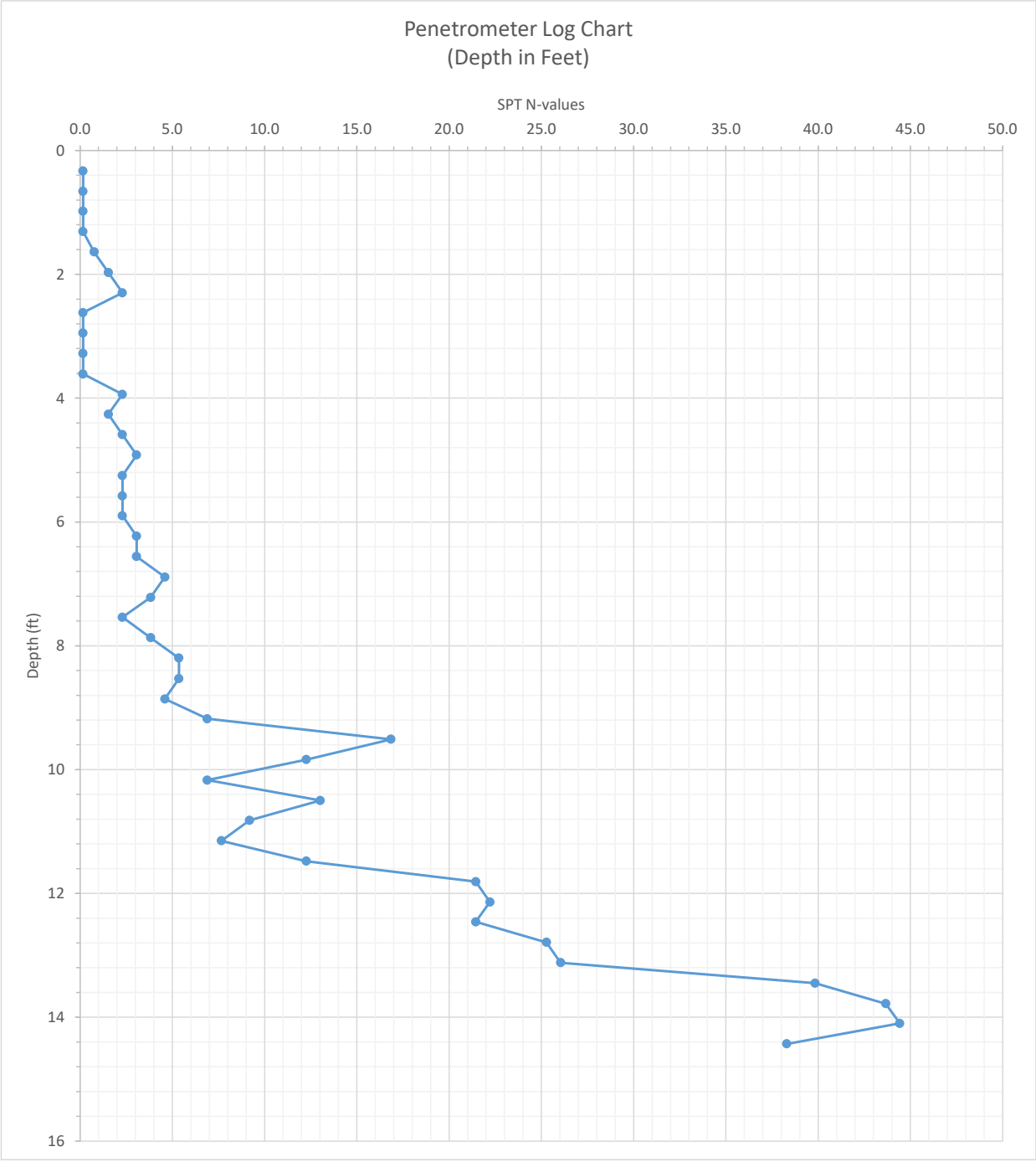
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.654252 -81.890117
Location:	D-002-1-23	**North / East:**	603089.723 2140215.020
Station, Offset:	427+64, 56 RT	**Date:**	3/22/2023
Elevation:	828.7	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value	Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.2					
7.87	0.66	20	0.2	0.2					
11.81	0.98	30	0.2	0.2					
15.75	1.31	40	0.2	0.2					
19.69	1.64	50	1	0.8					
23.62	1.97	60	2	1.5					
27.56	2.3	70	3	2.3					
31.5	2.62	80	0.2	0.2					
35.43	2.95	90	0.2	0.2					
39.37	3.28	100	0.2	0.2					
43.31	3.61	110	0.2	0.2					
47.24	3.94	120	3	2.3					
51.18	4.26	130	2	1.5					
55.12	4.59	140	3	2.3					
59.06	4.92	150	4	3.1					
62.99	5.25	160	3	2.3					
66.93	5.58	170	3	2.3					
70.87	5.9	180	3	2.3					
74.8	6.23	190	4	3.1					
78.74	6.56	200	4	3.1					
82.68	6.89	210	6	4.6					
86.61	7.22	220	5	3.8					
90.55	7.54	230	3	2.3					
94.49	7.87	240	5	3.8					
98.43	8.2	250	7	5.4					
102.36	8.53	260	7	5.4					
106.3	8.86	270	6	4.6					
110.24	9.18	280	9	6.9					
114.17	9.51	290	22	16.9					
118.11	9.84	300	16	12.3					
122.05	10.17	310	9	6.9					
125.98	10.5	320	17	13.0					
129.92	10.82	330	12	9.2					
133.86	11.15	340	10	7.7					
137.8	11.48	350	16	12.3					
141.73	11.81	360	28	21.4					
145.67	12.14	370	29	22.2					
149.61	12.46	380	28	21.4					
153.54	12.79	390	33	25.3					
157.48	13.12	400	34	26.0					
161.42	13.45	410	52	39.8					
165.35	13.78	420	57	43.7					
169.29	14.1	430	58	44.4					
173.23	14.43	440	50	38.3					

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65425242 -81.89011654
Location:	D-002-1-23	**North / East:**	603089.723 2140215.02
Station, Offset:	427+64, 56 RT	**Date:**	3/22/2023
Elevation:	828.7	**Sheet:**	2 of 2
Notes:	Staked Location		



Site Photos

Image provided by ODOT
(File Date 12/2022)

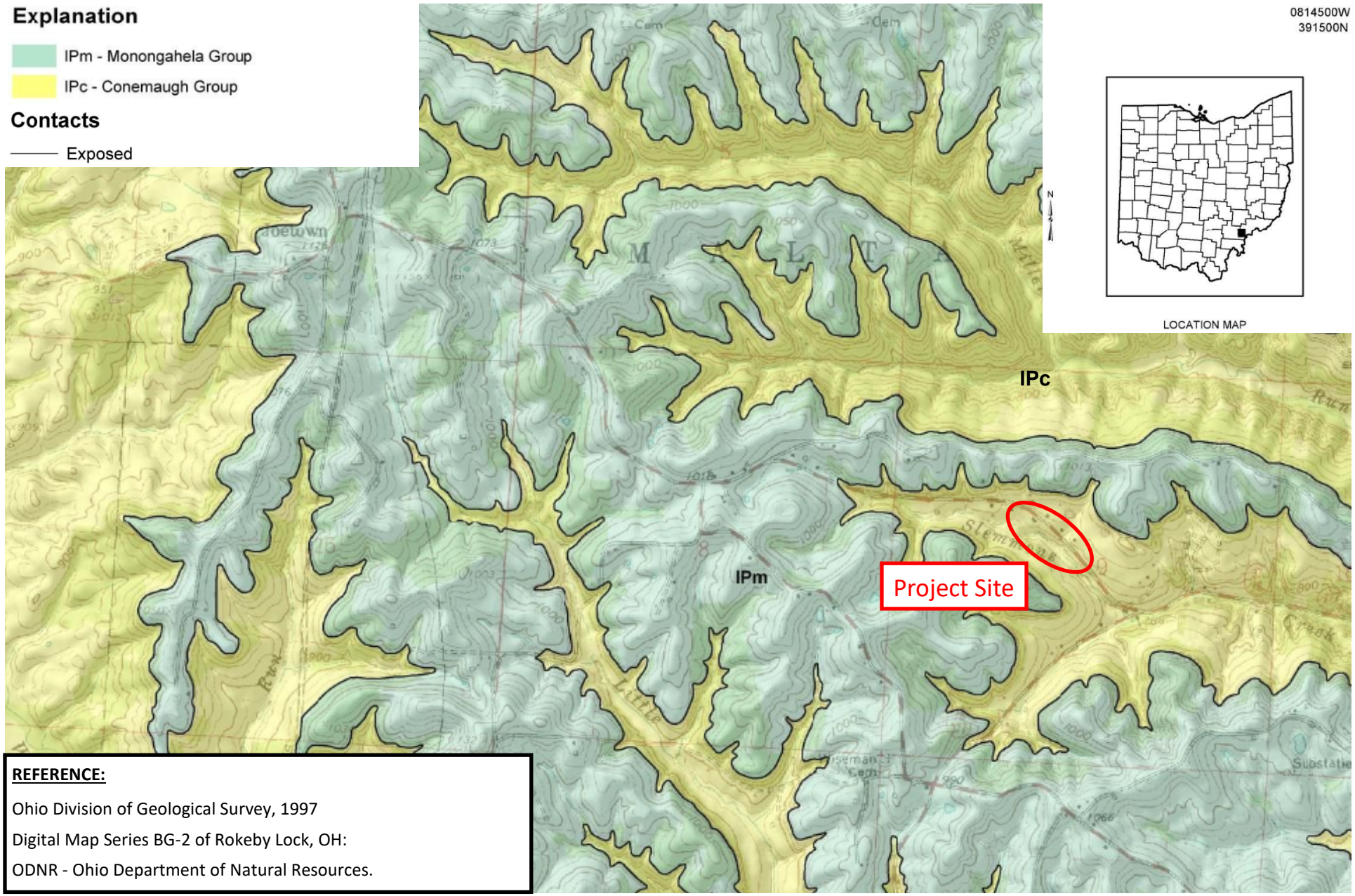

W
240
W
270
300
NW
330
N
0
30
313°NW (T) • 39.654441, -81.889742 ±31ft
07 Mar 2023, 12:19:32


E
E
SE
S
60
90
120
150
180
210
134°SE (T) • 39.654571, -81.890157 ±27ft
07 Mar 2023, 13:18:14

Bedrock Geology and Topography Maps

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

Bedrock Geology Map



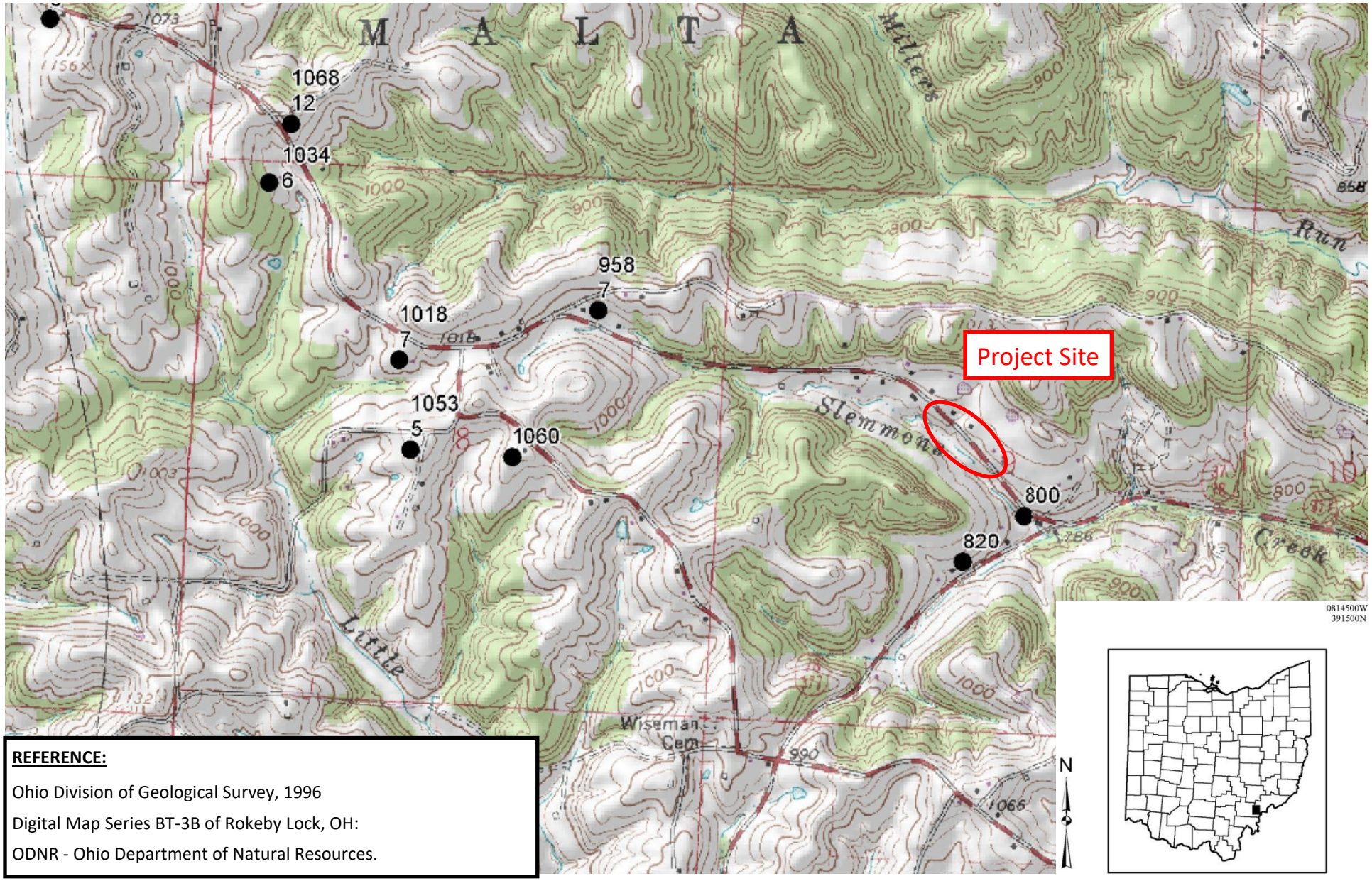
REFERENCE:

Ohio Division of Geological Survey, 1997

Digital Map Series BG-2 of Rokeby Lock, OH:

ODNR - Ohio Department of Natural Resources.

Bedrock Topography Map



REFERENCE:

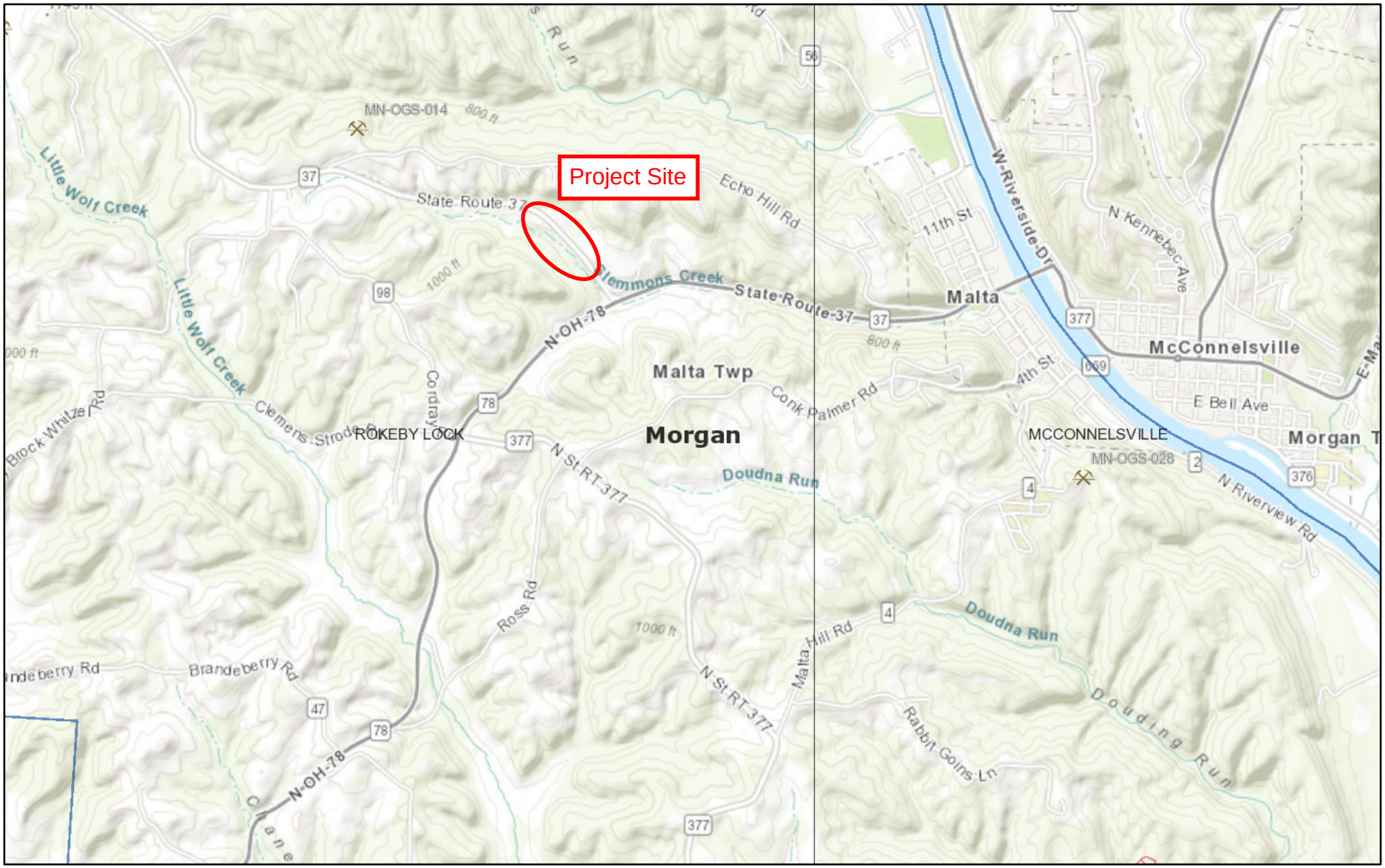
Ohio Division of Geological Survey, 1996

Digital Map Series BT-3B of Rokeby Lock, OH:

ODNR - Ohio Department of Natural Resources.

Mine Map

Mines of Ohio



April 3, 2023

Quadrangle 24K (7.5 min)

Abandoned before 1977

Past

Current

Proposed

Original Application

Adjacent Area Application

Historic - From Geology Maps

Past

Current

Proposed

Original Application

1:36,112

0 0.23 0.45 0.9 mi

0 0.38 0.75 1.5 km

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

Ohio Dept. of Natural Resources

FEMA Flood Map

National Flood Hazard Layer FIRMette

FEMA

81°53'44"W 39°39'30"N

81°53'6"W 39°39'3"N

Feet 1:6,000

0 250 500 1,000 1,500 2,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

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Soil Strength Parameter Determination

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

ODOT District 10
MRG-37-8.09 (10-AA)

Soil Strength Parameter Determination

Computed By = DCM
Checked By = DMV

Layer		Undrained Shear Strength (Su) (psf)				Dry Unit Weight (pcf)		Moist Unit Wt. (pcf)		Adopted Short Term Parameters		Long-Term Strength Values					Adopted Long Term Strength Parameters (Back-Calculated from SlopeW)	
		PPR	N-values		Tested								N_{60} Value	ODOT GB-7 Correlations		Tested		
			Sowers	T and P	Values	Correlation	Tested	Correlation	Tested					Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)	
Layer 1 MEDIUM STIFF TO STIFF COHESIVE	Max	2500	3500	2261	1336	115	101	130	127			Max	17	157	24			
	Min	250	525	532	555	90	100	105	125	S_u=	550 psf	Min	4	50	20			c' = 120 psf
	Average	1375	1999	1308	945	102	101	121	126	Φ =	0 deg	Average	10	108	22			Φ' = 23 deg
	Std Dev	837	807	538	552	8	1	7	1			Std Dev	4	32	1			
										Y_{dry} =	100 pcf							Y_{dry} = 100 pcf
	Avg + Std	2212	2806	1846	1497	110	101	128	127	Y_{moist} =	125 pcf	Avg + Std	14	140	24			Y_{moist} = 125 pcf
	Avg - Std	538	1191	770	393	94	100	113	125			Avg - Std	6	76	21			
Layer 2 VERY STIFF TO HARD COHESIVE	Max	4500	4000	4000		130		140				Max	69	250	28			
	Min	1500	2800	2128		115		130		S_u =	2500 psf	Min	16	153	24			c' = 190 psf
	Average	2344	3794	3179		121		134		Φ =	0 deg	Average	32	192	26			Φ' = 26 deg
	Std Dev	999	408	731		6		4				Std Dev	18	38	2			
										Y_{dry} =	100 pcf							Y_{dry} = 100 pcf
	Avg + Std	3343	4202	3910		128		139		Y_{moist} =	135 pcf	Avg + Std	50	230	28			Y_{moist} = 135 pcf
	Avg - Std	1344	3385	2448		115		130				Avg - Std	14	154	24			
Layer 3 WEATHERED ROCK	Max	N/A	N/A	N/A		N/A		N/A				Max	N/A	250	28			
	Min	N/A	N/A	N/A		N/A		N/A		S_u =	4000 psf	Min	N/A	250	28			c' = 250 psf
	Average	N/A	N/A	N/A		N/A		N/A		Φ =	0 deg	Average	N/A	250	28			Φ' = 28 deg
	Std Dev	N/A	N/A	N/A		N/A		N/A				Std Dev	N/A	0	0			
										Y_{dry} =	100 pcf							Y_{dry} = 100 pcf
	Avg + Std	N/A	N/A	N/A		N/A		N/A		Y_{moist} =	125 pcf	Avg + Std	N/A	250	28			Y_{moist} = 125 pcf
	Avg - Std	N/A	N/A	N/A		N/A		N/A				Avg - Std	N/A	250	28			

ODOT District 10
MRG-37-8.09 (10-AA)

Soil Strength Parameter Determination

Computed By = DCM
Checked By = DMV

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

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)	Strength Testing Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Qu/UU Su (psf)
Max	17	100	2.5	28	18	37	42	53	57	28	33	29	Max	2500	3500	2261	157	24	19.0	846.5	115	130	0.423	2.72	0.872	101	127	1336
Min	4	28	0.3	1	3	5	24	19	24	17	7	14	Min	250	525	532	50	20	2.0	824.0	90	105	0.126	2.65	0.465	100	125	555
Average	10	70	1.4	9	11	11	32	36	43	23	20	24	Average	1375	1999	1308	108	22	9.8	835.0	102	121	0.301	2.68	0.644	101	126	945
Std Dev	4	19	0.8	7	5	9	5	11	9	3	7	4	Std Dev	837	807	538	32	1	4.9	6.1	8	7	0.083	0.03	0.125	1	1	552
Avg + Std	14	89	2.2	17	16	20	37	47	53	26	27	28	Avg + Std	2212	2806	1846	140	24	14.7	841.1	110	128	0.384	2.71	0.769	101	127	1497
Avg - Std	6	51	0.5	2	6	3	27	24	34	20	13	19	Avg - Std	538	1191	770	76	21	4.9	828.9	94	113	0.218	2.65	0.519	100	125	393

B-003-0-23, SS-1b, (3.0 - 3.5)

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)	Strength Testing Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Qu/UU Su (psf)
SR 37	848.5	B-001-0-23	1	-	2.5	SS-1	7	44	-	7	11	37	24	21	24	17	7	14	A-4a	Cohesive	1	N/A	525	931	88	22	2.0	846.5	95	110	0.126	2.72	0.787			
SR 37	848.5	B-001-0-23	3.5	-	5	SS-2	7	56	2.5	2	4	5	36	53	46	26	20	23	A-7-6	Cohesive	1	2500	1750	931	88	22	4.0	844.5	95	110	0.324	2.65	0.741			
SR 37	848.5	B-001-0-23	6	-	7.5	SS-3	10	78	2.25	-	-	-	-	-	-	-	-	19	A-6a	Cohesive	1	2250	1750	1330	114	23	7.0	841.5	105	125		2.72	0.616			
SR 37	848.5	B-001-0-23	8.5	-	10	SS-4	16	78	1.75	28	16	9	28	19	35	22	13	16	A-6a	Cohesive	1	1750	2800	2128	153	24	9.0	839.5	110	125	0.225	2.72	0.543			
SR 37	844.6	B-002-0-23	3	-	4.5	SS-2	4	28	0.25	8	12	22	26	32	36	18	18	24	A-6b	Cohesive	1	250	700	532	50	20	4.0	840.6	90	105	0.234	2.70	0.872			
SR 37	844.6	B-002-0-23	4.5	-	6	SS-3	7	78	1.25	4	5	7	33	51	57	24	33	29	A-7-6	Cohesive	1	1250	1750	931	88	22	5.0	839.6	95	110	0.423	2.65	0.741			
SR 37	844.6	B-002-0-23	6	-	7.5	SS-4	6	78	-	-	-	-	-	-	-	-	-	29	A-7-6	Cohesive	1	N/A	1500	798	75	21	7.0	837.6	95	120		2.65	0.741			
SR 37	844.6	B-002-0-23	7.5	-	9.5	ST-5	ST	71	1.5	8	14	8	33	37	51	26	25	24	A-7-6	Cohesive	1	1500	N/A	N/A			9.0	835.6			0.369	2.65		101.1	126.7	555
SR 37	844.6	B-002-0-23	9.5	-	11	SS-6	6	61	0.75	-	-	-	-	-	-	-	-	29	A-7-6	Cohesive	1	750	1500	798	75	21	10.0	834.6	95	120		2.65	0.741			
SR 37	844.6	B-002-0-23	11	-	12.5	SS-7	6	94	0.5	11	13	8	33	35	47	25	22	27	A-7-6	Cohesive	1	500	1500	798	75	21	12.0	832.6	95	120	0.333	2.65	0.741			
SR 37	844.6	B-002-0-23	12.5	-	14	SS-8	17	67	0.75	13	18	10	33	26	40	23	17	22	A-6b	Cohesive	1	750	2975	2261	157	24	13.0	831.6	115	130	0.27	2.70	0.465			
SR 37	844.6	B-002-0-23	14	-	15.5	SS-9	10	56	0.25	-	-	-	-	-	-	-	-	22	A-6b	Cohesive	1	250	1750	1330	114	23	15.0	829.6	110	125		2.70	0.532			
SR 37	844.6	B-002-0-23	15.5	-	17	SS-10	7	94	0.25	18	16	9	30	27	40	24	16	26	A-6b	Cohesive	1	250	1225	931	88	22	16.0	828.6	95	120	0.27	2.70	0.773			
SR 37	843.0	B-003-0-23	3.5	-	5	SS-2	10	44	1.75	6	6	8	35	45	48	24	24	24	A-7-6	Cohesive	1	1750	2500	1330	114	23	4.0	839.0	100	120	0.342	2.65	0.654			
SR 37	843.0	B-003-0-23	6	-	7.5	SS-3	10	100	0.75	-	-	-	-	-	-	-	-	28	A-7-6	Cohesive	1	750	2500	1330	114	23	7.0	836.0	105	125		2.65	0.575			
SR 37	843.0	B-003-0-23	8.5	-	10	SS-4	10	94	1	1	3	9	42	45	45	23	22	28	A-7-6	Cohesive	1	1000	2500	1330	114	23	9.0	834.0	105	125	0.315	2.65	0.575			
SR 37	843.0	B-003-0-23	11.5	-	13.5	ST-5	ST	71	2.25	9	11	7	29	44	57	28	29	24	A-7-6	Cohesive	1	2250	N/A	N/A			13.0	830.0			0.423	2.65		100.1	125	1335.5
SR 37	843.0	B-003-0-23	13.5	-	15	SS-6	14	61	2.5	-	-	-	-	-	-	-	-	22	A-7-6	Cohesive	1	2500	3500	1862	143	24	14.0	829.0	110	125		2.65	0.503			
SR 37	843.0	B-003-0-23	16	-	17.5	SS-7	17	78	2.5	7	16	10	39	28	39	22	17	17	A-6b	Cohesive	1	2500	2975	2261	157	24	17.0	826.0	115	130	0.261	2.70	0.465			
SR 37	843.0	B-003-0-23	18.5	-	20	SS-8	13	67	2	-	-	-	-	-	-	-	-	24	A-6b	Cohesive	1	2000	2275	1729	136	23	19.0	824.0	110	125		2.70	0.532			

B-002-0-23, SS-1B from 3'-3.5' omitted as outlier.

ODOT District 10
MRG-37-8.09 (10-AA)

Soil Strength Parameter Determination

Computed By = DCM
Checked By = DMV

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 2

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
Max	69	100	4.5	16	12	12	51	48	47	27	23	25	Max	4500	4000	4000	250	28	24.0	831.5	130	140	0.333	2.72	0.476
Min	16	50	1.5	1	1	4	35	28	36	21	14	15	Min	1500	2800	2128	153	24	17.0	819.0	115	130	0.234	2.65	0.272
Average	32	85	2.3	6	6	8	41	39	41	24	17	19	Average	2344	3794	3179	192	26	20.3	825.4	121	134	0.279	2.68	0.383
Std Dev	18	17	1.0	5	4	3	7	7	4	2	3	4	Std Dev	999	408	731	38	2	2.4	4.1	6	4	0.038	0.03	0.086
Avg + Std	50	101	3.3	11	10	11	48	46	45	26	20	23	Avg + Std	3343	4202	3910	230	28	22.6	829.6	128	139	0.317	2.71	0.469
Avg - Std	14	68	1.3	1	1	5	35	33	37	22	14	16	Avg - Std	1344	3385	2448	154	24	17.9	821.3	115	130	0.241	2.65	0.298

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
SR 37	848.5	B-001-0-23	16	-	17.5	SS-7	22	72	2.5	8	10	8	36	38	40	23	17	17	A-6b	Cohesive	2	2500	3850	2926	173	25	17.0	831.5	115	130	0.27	2.70	0.465
SR 37	848.5	B-001-0-23	18.5	-	20	SS-8	22	89	1.5	16	12	9	35	28	36	21	15	17	A-6a	Cohesive	2	1500	3850	2926	173	25	19.0	829.5	115	130	0.234	2.72	0.476
SR 37	848.5	B-001-0-23	21	-	22.5	SS-9	16	89	1.75	8	7	9	38	38	36	22	14	18	A-6a	Cohesive	2	1750	2800	2128	153	24	22.0	826.5	120	135	0.234	2.72	0.414
SR 37	844.6	B-002-0-23	17	-	18.5	SS-11	22	94	1.75	3	3	6	40	48	40	24	16	23	A-6b	Cohesive	2	1750	3850	2926	173	25	18.0	826.6	115	130	0.27	2.70	0.465
SR 37	844.6	B-002-0-23	18.5	-	20	SS-12	39	50	2	-	-	-	-	-	-	-	-	22	A-7-6	Cohesive	2	2000	4000	4000	200	28	19.0	825.6	125	135		2.65	0.323
SR 37	844.6	B-002-0-23	20	-	21.5	SS-13	69	83	4.5	4	3	4	51	38	44	25	19	15	A-7-6	Cohesive	2	4500	4000	4000	250	28	21.0	823.6	130	140	0.306	2.65	0.272
SR 37	843.0	B-003-0-23	21	-	22.5	SS-9	19	100	1.75	1	3	12	38	46	47	24	23	25	A-7-6	Cohesive	2	1750	4000	2527	163	25	22.0	821.0	120	135	0.333	2.65	0.378
SR 37	843.0	B-003-0-23	23.5	-	25	SS-10	45	100	3	1	1	8	50	40	44	27	17	17	A-7-6	Cohesive	2	3000	4000	4000	250	28	24.0	819.0	130	140	0.306	2.65	0.272

B-001-0-23, SS-5 from 11'-12.5' and B-001-0-23 12.5'-14.5' omitted as outliers.

ODOT District 10
MRG-37-8.09 (10-AA)

Soil Strength Parameter Determination

Computed By = DCM
Checked By = DMV

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

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
Max	N/A	120	N/A	3	4	6	56	42	40	24	16	18	Max	N/A	N/A	N/A	250	28	31.0	824.5	N/A	N/A	0.270	N/A	N/A
Min	N/A	75	N/A	3	2	6	45	33	32	20	12	10	Min	N/A	N/A	N/A	250	28	22.0	814.0	N/A	N/A	0.198	N/A	N/A
Average	N/A	96	N/A	3	3	6	51	38	36	22	14	13	Average	N/A	N/A	N/A	250	28	26.6	819.1	N/A	N/A	0.234	N/A	N/A
Std Dev	N/A	13	N/A	0	1	0	8	6	6	3	3	3	Std Dev	N/A	N/A	N/A	0	0	2.7	3.2	N/A	N/A	0.051	N/A	N/A
Avg + Std	N/A	110	N/A	3	4	6	58	44	42	25	17	16	Avg + Std	N/A	N/A	N/A	250	28	29.3	822.3	N/A	N/A	0.285	N/A	N/A
Avg - Std	N/A	83	N/A	3	2	6	43	31	30	19	11	10	Avg - Std	N/A	N/A	N/A	250	28	23.8	815.8	N/A	N/A	0.183	N/A	N/A

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
SR 37	848.5	B-001-0-23	23.5	-	24.92	SS-10	Refusal	100	-	-	-	-	-	-	-	-	-	11	Rock		3	N/A	N/A	N/A	250	28	24.0	824.5					
SR 37	848.5	B-001-0-23	26	-	26.92	SS-11	Refusal	100	-	-	-	-	-	-	-	-	-	11	Rock		3	N/A	N/A	N/A	250	28	26.0	822.5					
SR 37	848.5	B-001-0-23	28.5	-	29.42	SS-12	Refusal	100	-	-	-	-	-	-	-	-	-	11	Rock		3	N/A	N/A	N/A	250	28	29.0	819.5					
SR 37	848.5	B-001-0-23	31	-	31.92	SS-13	Refusal	100	-	-	-	-	-	-	-	-	-	13	Rock		3	N/A	N/A	N/A	250	28	31.0	817.5					
SR 37	844.6	B-002-0-23	21.5	-	22.92	SS-14	Refusal	94	-	-	-	-	-	-	-	-	-	12	Rock		3	N/A	N/A	N/A	250	28	22.0	822.6					
SR 37	844.6	B-002-0-23	23	-	23.75	SS-15	Refusal	111	-	3	4	6	45	42	40	24	16	11	Rock		3	N/A	N/A	N/A	250	28	23.0	821.6			0.27		
SR 37	844.6	B-002-0-23	24.5	-	25.83	SS-16	Refusal	100	-	-	-	-	-	-	-	-	-	11	Rock		3	N/A	N/A	N/A	250	28	25.0	819.6					
SR 37	844.6	B-002-0-23	26	-	27.42	SS-17	Refusal	76	-	-	-	-	-	-	-	-	-	18	Rock		3	N/A	N/A	N/A	250	28	27.0	817.6					
SR 37	844.6	B-002-0-23	27.5	-	28.83	SS-18	Refusal	75	-	-	-	-	-	-	-	-	-	18	Rock		3	N/A	N/A	N/A	250	28	28.0	816.6					
SR 37	844.6	B-002-0-23	29	-	29.83	SS-19	Refusal	120	-	-	-	-	-	-	-	-	-	18	Rock		3	N/A	N/A	N/A	250	28	29.0	815.6					
SR 37	843.0	B-003-0-23	26	-	26.83	SS-11	Refusal	100	-	-	-	-	-	-	-	-	-	13	Rock		3	N/A	N/A	N/A	250	28	26.0	817.0					
SR 37	843.0	B-003-0-23	28.5	-	29.75	SS-12	Refusal	80	-	3	2	6	56	33	32	20	12	10	Rock		3	N/A	N/A	N/A	250	28	29.0	814.0			0.198		

PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 426+25, 6' RT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 848.5 (MSL) EOB: 52.5 ft.
START: 3/21/23 END: 3/21/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654621, -81.890326

EXPLORATION ID B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (20")	848.5																	
MEDIUM STIFF, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP (FILL)	846.8		9 3 2	7	44	SS-1	-	7	11	37	24	21	24	17	7	14	A-4a (2)	
MEDIUM STIFF TO STIFF, RED-BROWN AND BROWN, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP	845.0		3 2 3	7	56	SS-2	2.50	2	4	5	36	53	46	26	20	23	A-7-6 (13)	
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, SOME ROCK FRAGMENTS, SOME SAND, DAMP	842.5		2 3 4	10	78	SS-3	2.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
Layer 1 : Medium Stiff to Stiff Cohesive			3 5 6	16	78	SS-4	1.75	28	16	9	28	19	35	22	13	16	A-6a (3)	
MEDIUM DENSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, DAMP	837.5		7 6 10	23	67	SS-5	-	-	-	-	-	-	-	-	-	16	A-2-6 (V)	
@12.5' - 14.5': end of tube came back dented					67	ST-6	-	46	12	7	19	16	36	21	15	13	A-2-6 (1)	
Layer 2: Very Stiff to Hard																		
VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE ROCK FRAGMENTS	832.5		4 7 8	22	72	SS-7	2.50	8	10	8	36	38	40	23	17	17	A-6b (11)	
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, DAMP @19.5': 1" wet gravel seam	830.0		5 6 9	22	89	SS-8	1.50	16	12	9	35	28	36	21	15	17	A-6a (8)	
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP	827.5		4 4 7	16	89	SS-9	1.75	8	7	9	38	38	36	22	14	18	A-6a (10)	
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK.	825.0	TR	24 38 50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	11	Rock (V)	
Layer 3: Weathered Rock			34 50/5"	-	100	SS-11	-	-	-	-	-	-	-	-	-	11	Rock (V)	
			31 50/5"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	Rock (V)	

PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 426+25, 6' RT.	START: 3/21/23	END: 3/21/23	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK. *(continued)*	818.5	31	36 50/5"	-	100	SS-13	-	-	-	-	-	-	-	-	-	13	Rock (V)	
	816.0	32																
CLAYSTONE, RED-BROWN AND GRAY, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 85%, REC 100%.	814.3	33	85		100	NQ2-1											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SEVERELY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, VERY POOR TO POOR SURFACE; RQD 0%, REC 78%.	811.7	34 35 36 37	27		85	NQ2-2											CORE	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 57%, REC 98%. @43.3' - 44.6': contains 1" to 2" sandstone interbeds @43.3' - 45.6': highly fractured		38 39 40 41 42 43	58		95	NQ2-3											CORE	
		44 45 46 47 48 49 50 51	54		100	NQ2-4											CORE	
	796.0	EOB 52																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

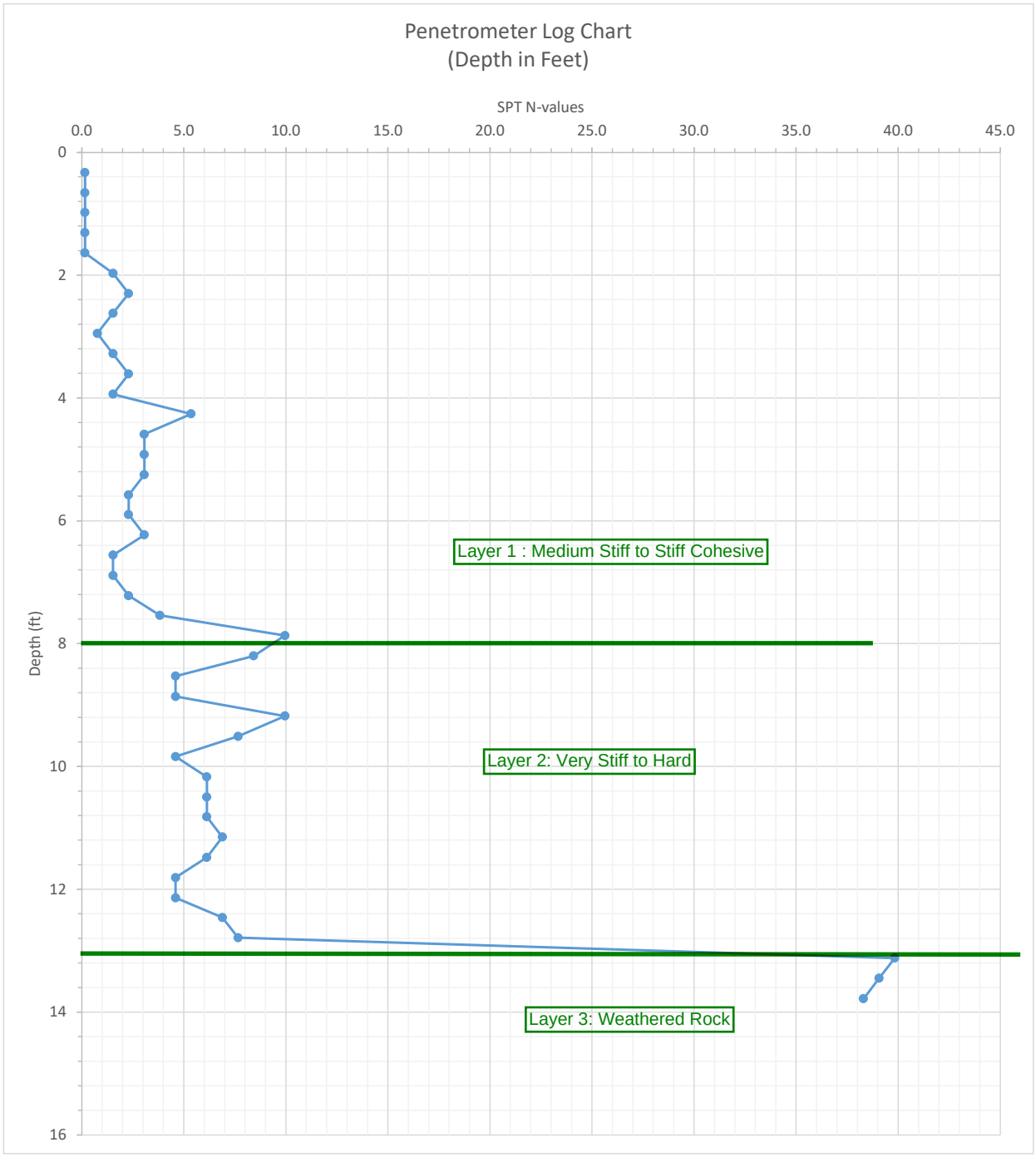
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65432694 -81.89024337
Location:	D-001-1-23	**North / East:**	603116.623 2140179.127
Station, Offset:	427+19, 63 RT	**Date:**	3/22/2023
Elevation:	829.4	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value	Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.2					
7.87	0.66	20	0.2	0.2					
11.81	0.98	30	0.2	0.2					
15.75	1.31	40	0.2	0.2					
19.69	1.64	50	0.2	0.2					
23.62	1.97	60	2	1.5					
27.56	2.3	70	3	2.3					
31.5	2.62	80	2	1.5					
35.43	2.95	90	1	0.8					
39.37	3.28	100	2	1.5					
43.31	3.61	110	3	2.3					
47.24	3.94	120	2	1.5	Layer 1 : Medium Stiff to Stiff Cohesive				
51.18	4.26	130	7	5.4					
55.12	4.59	140	4	3.1					
59.06	4.92	150	4	3.1					
62.99	5.25	160	4	3.1					
66.93	5.58	170	3	2.3					
70.87	5.9	180	3	2.3					
74.8	6.23	190	4	3.1					
78.74	6.56	200	2	1.5					
82.68	6.89	210	2	1.5					
86.61	7.22	220	3	2.3					
90.55	7.54	230	5	3.8					
94.49	7.87	240	13	10.0					
98.43	8.2	250	11	8.4					
102.36	8.53	260	6	4.6					
106.3	8.86	270	6	4.6					
110.24	9.18	280	13	10.0					
114.17	9.51	290	10	7.7					
118.11	9.84	300	6	4.6					
122.05	10.17	310	8	6.1	Layer 2: Very Stiff to Hard				
125.98	10.5	320	8	6.1					
129.92	10.82	330	8	6.1					
133.86	11.15	340	9	6.9					
137.8	11.48	350	8	6.1					
141.73	11.81	360	6	4.6					
145.67	12.14	370	6	4.6					
149.61	12.46	380	9	6.9					
153.54	12.79	390	10	7.7					
157.48	13.12	400	52	39.8					
161.42	13.45	410	51	39.1					
165.35	13.78	420	50	38.3	Layer 3: Weathered Rock				

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65432694 -81.89024337
Location:	D-001-1-23	**North / East:**	603116.623 2140179.127
Station, Offset:	427+19, 63 RT	**Date:**	3/22/2023
Elevation:	829.4	**Sheet:**	2 of 2
Notes:	Staked Location		



PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 427+39, 6' RT.	EXPLORATION ID B-002-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37	
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 844.6 (MSL) EOB: 50.5 ft.	PAGE 1 OF 2
START: 3/21/23 END: 3/22/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654396, -81.890049	

MATERIAL DESCRIPTION AND NOTES	ELEV. 844.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (48")		1																
		2	48 27 7	49	100	SS-1	-	-	-	-	-	-	-	-	-	-		
	840.6	3	4 2 1	4	28	SS-2	0.25	8	12	22	26	32	36	18	18	24	A-6b (8)	
SOFT, BROWN, **SILTY CLAY**, SOME SAND, TRACE ROCK FRAGMENTS, MOIST	840.1	4	1 2 3	7	78	SS-3	1.25	4	5	7	33	51	57	24	33	29	A-7-6 (19)	
MEDIUM STIFF TO STIFF, BROWN AND GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST	838.6	5	WOH WOH 4	6	78	SS-4	-	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
MEDIUM STIFF TO STIFF, BROWN, **CLAY**, SOME SAND, SOME SILT, TRACE TO LITTLE GRAVEL, DAMP TO MOIST @7.9' - 8.4': qu = 1110 psf		6			71	ST-5	1.50	8	14	8	33	37	51	26	25	24	A-7-6 (15)	
Layer 1 : Medium Stiff to Stiff Cohesive		7	2 1 3	6	61	SS-6	0.75	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
	832.1	8	2 2 2	6	94	SS-7	0.50	11	13	8	33	35	47	25	22	27	A-7-6 (13)	
SOFT TO MEDIUM STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, DAMP		9 W 831.6	2 4 8	17	67	SS-8	0.75	13	18	10	33	26	40	23	17	22	A-6b (8)	
	829.1	10	5 4 3	10	56	SS-9	0.25	-	-	-	-	-	-	-	-	22	A-6b (V)	
SOFT TO MEDIUM STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE ROCK FRAGMENTS, MOIST	827.6	11	2 1 4	7	94	SS-10	0.25	18	16	9	30	27	40	24	16	26	A-6b (7)	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP	826.1	12	3 5 10	22	94	SS-11	1.75	3	3	6	40	48	40	24	16	23	A-6b (10)	
VERY STIFF TO HARD, RED-BROWN AND GRAY, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP (RELIC ROCK STRUCTURE)		13	8 12 15	39	50	SS-12	2.00	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
Layer 2: Very Stiff to Hard		14	8 17 31	69	83	SS-13	4.5+	4	3	4	51	38	44	25	19	15	A-7-6 (12)	
	823.1	15 TR																
CLAYSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.		16	16 31 50/5"	-	94	SS-14	-	-	-	-	-	-	-	-	-	12	Rock (V)	
Layer 3: Weathered Rock		17	35 50/4"	-	100	SS-15	-	3	4	6	45	42	40	24	16	11	Rock (V)	
		18																
		19	31 43 50/4"	-	100	SS-16	-								-	11	Rock (V)	
@26' - 30.5': outside of samples wet due to water sitting overnight in hole		20	16 32 50/5"	-	76	SS-17	-								-	18	Rock (V)	
		21	26 42 50/4"	-	75	SS-18	-								-	18	Rock (V)	
@29': color change to red-brown and gray		22	30 50/4"	-	100	SS-19	-	-	-	-	-	-	-	-	-	18	Rock (V)	
		23																
		24																
		25																
		26																
		27																
		28																
		29																

Relatively sharp transition in moisture content from overlying soils and underlying bedrock.

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/17/23 21:23 - C:\PWWORKING\EAST01\D3186955\MRG-37-8.09 BORING LOGS.GPJ

PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 427+39, 6' RT.	START: 3/21/23	END: 3/22/23	PG 2 OF 2	B-002-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	814.6																	
	814.1																	
CLAYSTONE, GRAY TRACE RED-BROWN, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 95%, REC 100%. @32.6' - 33.0': qu = 30 psi, γ = 140 pcf		31 32 33 34 35	95		100	NQ2-1											CORE	
	809.1																	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 27%, REC 98%.		36 37 38 39 40	30		95	NQ2-2											CORE	
@40.5' - 41.8': 1" to 2" interbedded sandstone layers @41' - 41.6': highly fractured @43' - 43.6': highly fractured		41 42 43 44 45 46	44		100	NQ2-3											CORE	
	798.1																	
CLAYSTONE, GRAY, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 75%, REC 100%.		47 48 49 50																
	794.1	EOB																

NOTES: BORING STOPPED AT 26' ON 3/21/23. WATER LEVEL MEASURED 3/22/23, 8:35 AM.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

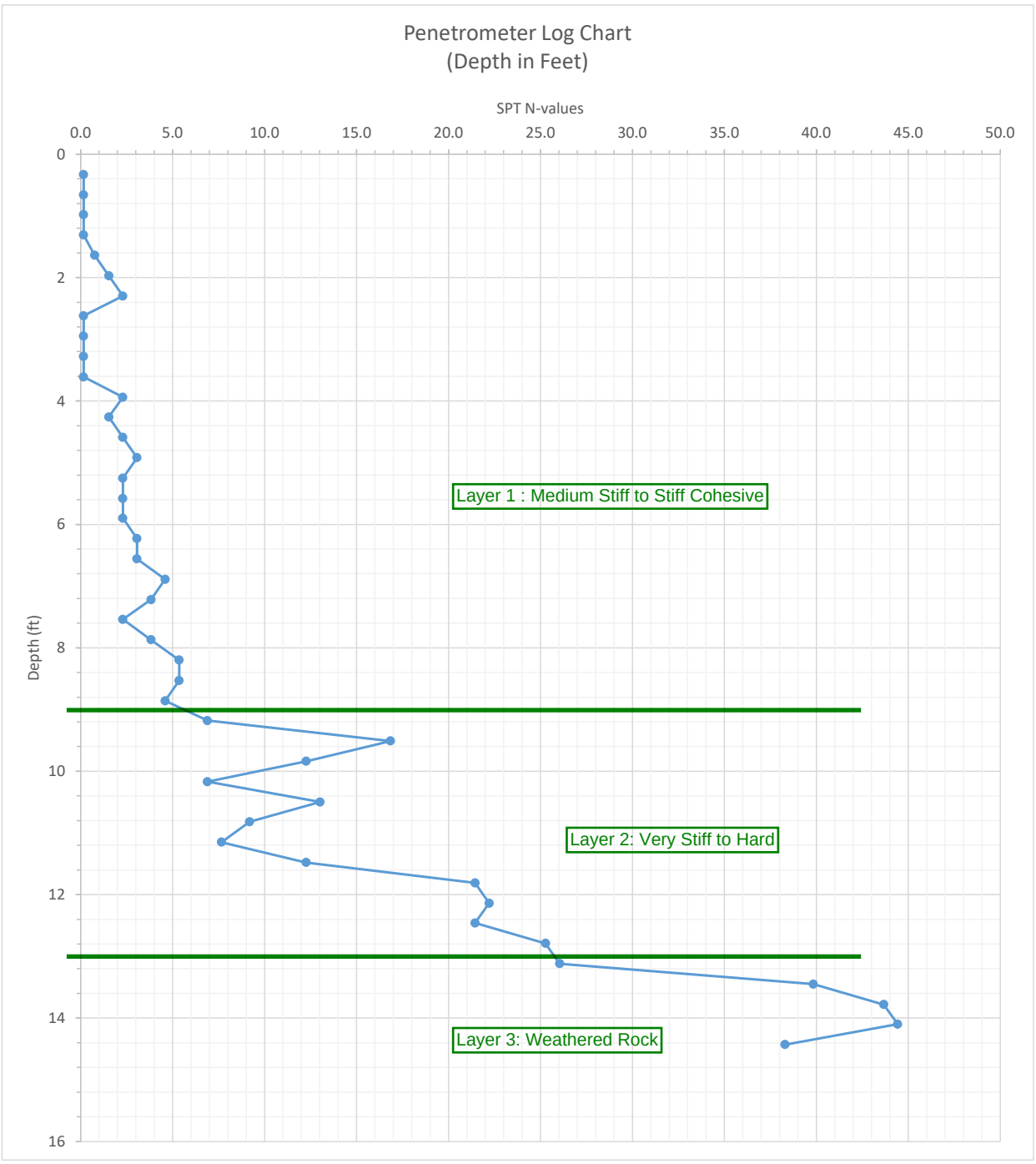
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.654252 -81.890117
Location:	D-002-1-23	**North / East:**	603089.723 2140215.020
Station, Offset:	427+64, 56 RT	**Date:**	3/22/2023
Elevation:	828.7	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value	
3.94	0.33	10	0.2	0.2	
7.87	0.66	20	0.2	0.2	
11.81	0.98	30	0.2	0.2	
15.75	1.31	40	0.2	0.2	
19.69	1.64	50	1	0.8	
23.62	1.97	60	2	1.5	
27.56	2.3	70	3	2.3	
31.5	2.62	80	0.2	0.2	
35.43	2.95	90	0.2	0.2	
39.37	3.28	100	0.2	0.2	
43.31	3.61	110	0.2	0.2	
47.24	3.94	120	3	2.3	
51.18	4.26	130	2	1.5	
55.12	4.59	140	3	2.3	
59.06	4.92	150	4	3.1	
62.99	5.25	160	3	2.3	
66.93	5.58	170	3	2.3	
70.87	5.9	180	3	2.3	
74.8	6.23	190	4	3.1	
78.74	6.56	200	4	3.1	
82.68	6.89	210	6	4.6	
86.61	7.22	220	5	3.8	
90.55	7.54	230	3	2.3	
94.49	7.87	240	5	3.8	Layer 1 : Medium Stiff to Stiff Cohesive
98.43	8.2	250	7	5.4	
102.36	8.53	260	7	5.4	
106.3	8.86	270	6	4.6	
110.24	9.18	280	9	6.9	
114.17	9.51	290	22	16.9	
118.11	9.84	300	16	12.3	
122.05	10.17	310	9	6.9	
125.98	10.5	320	17	13.0	
129.92	10.82	330	12	9.2	Layer 2: Very Stiff to Hard
133.86	11.15	340	10	7.7	
137.8	11.48	350	16	12.3	
141.73	11.81	360	28	21.4	
145.67	12.14	370	29	22.2	
149.61	12.46	380	28	21.4	
153.54	12.79	390	33	25.3	
157.48	13.12	400	34	26.0	
161.42	13.45	410	52	39.8	
165.35	13.78	420	57	43.7	
169.29	14.1	430	58	44.4	Layer 3: Weathered Rock
173.23	14.43	440	50	38.3	

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	MRG-37-8.09	**Lat / Long:**	39.65425242 -81.89011654
Location:	D-002-1-23	**North / East:**	603089.723 2140215.02
Station, Offset:	427+64, 56 RT	**Date:**	3/22/2023
Elevation:	828.7	**Sheet:**	2 of 2
Notes:	Staked Location		



PROJECT: MRG-37-08.09	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 427+99, 6' RT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: SR 37
PID: 117975 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 843.0 (MSL) EOB: 50.0 ft.
START: 3/22/23 END: 3/22/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 39.654276, -81.889902

EXPLORATION ID B-003-0-23

PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	843.0																	
ASPHALT (36")	840.0		31 11 7	26	61	SS-1A	-	-	-	-	-	-	-	-	-	-		
MEDIUM DENSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP (FILL)	839.5					SS-1B	-	38	9	30	14	9	NP	NP	NP	8	A-2-4 (0)	
			3 3 4	10	44	SS-2	1.75	6	6	8	35	45	48	24	24	24	A-7-6 (15)	
STIFF, BROWN AND GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP (FILL)	837.0																	
MEDIUM STIFF TO STIFF, BROWN AND GRAY, **CLAY**, "AND" SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST			3 3 4	10	100	SS-3	0.75	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
			3 4 3	10	94	SS-4	1.00	1	3	9	42	45	45	23	22	28	A-7-6 (14)	
	831.5																	
STIFF TO VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, DAMP @12.2' - 12.7': qu = 2671 psf					71	ST-5	2.25	9	11	7	29	44	57	28	29	24	A-7-6 (18)	
Layer 1 : Medium Stiff to Stiff Cohesive			4 4 6	14	61	SS-6	2.50	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
	827.0																	
STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE ROCK FRAGMENTS, DAMP			5 6 6	17	78	SS-7	2.50	7	16	10	39	28	39	22	17	17	A-6b (9)	
			3 4 5	13	67	SS-8	2.00	-	-	-	-	-	-	-	-	24	A-6b (V)	
	822.0																	
STIFF TO VERY STIFF, RED-BROWN, **CLAY**, "AND" SILT, LITTLE SAND, TRACE ROCK FRAGMENTS, MOIST			4 6 7	19	100	SS-9	1.75	1	3	12	38	46	47	24	23	25	A-7-6 (15)	
Layer 2: Very Stiff to Hard	819.5																	
VERY STIFF TO HARD, BROWN AND RED-BROWN, **CLAY**, "AND" SILT, TRACE ROCK FRAGMENTS, TRACE SAND, DAMP @24.5': wet seam			3 9 22	45	100	SS-10	3.00	1	1	8	50	40	44	27	17	17	A-7-6 (12)	
	817.0	TR																
CLAYSTONE, GRAY AND RED-BROWN, SEVERELY WEATHERED, VERY WEAK.			22 50/4"	-	100	SS-11	-	-	-	-	-	-	-	-	-	13	Rock (V)	
Layer 3: Weathered Rock																		
	813.0		30 42 50/3"	-	80	SS-12	-	3	2	6	56	33	32	20	12	10	Rock (V)	

Relatively sharp transition in moisture content from overlying soils and underlying bedrock.

PID: 117975	SFN:	PROJECT: MRG-37-08.09	STATION / OFFSET: 427+99, 6' RT.	START: 3/22/23	END: 3/22/23	PG 2 OF 2	B-003-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, GRAY TRACE RED-BROWN, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 73%, REC 99%.	813.0	31	78		100	NQ2-1											CORE	
	806.6	35	35		98	NQ2-2											CORE	
SANDSTONE, GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, FINE GRAINED, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 15%, REC 100%.	803.8	39																
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 0%, REC 100%.	802.4	42	72		100	NQ2-3											CORE	
CLAYSTONE, GRAY, MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, GOOD SURFACE; RQD 81%, REC 91%. @42.6' - 42.9': qu = 583 psi, γ = 159 pcf		47	67		84	NQ2-4											CORE	
@49.0' - 49.4': qu = 638 psi, γ = 158 pcf	793.0 EOB	50																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 25 LB. BENTONITE POWDER; 94 LB. CEMENT MIXED WITH 50 GAL. WATER; SURFACE PATCHED WITH QUICKCRETE

Rock Strength Parameter Determination
and
Laboratory Testing

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

ODOT District 10
MRG-37-8.09 (10-AA)

Rock Strength Parameter Determination

Computed By = DCM
Checked By = DMV

BEDROCK TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
MRG-37-8.09	B-002-0-23	32.6	NQ2-1	Claystone	gray	140.2	30	0.2	1,143	8	20-30	25	0.1	15642	1143	0.2	36
MRG-37-8.09	B-003-0-23	42.6	NQ2-3	Claystone	gray	158.5	583	4.0	34,294	236	20-30	30	0.6	91955	34294	9.4	1366
MRG-37-8.09	B-003-0-23	49	NQ2-4	Claystone	gray	157.8	638	4.4	294	2	20-30	30	0.7	96195	294	0.1	12
				Claystone	Maximum	158.5	638							Claystone	Maximum	34294	
					Minimum	140.2	30								Minimum	294	
					Average	152	417								Average	11910	
					Std Dev	10	336								Std Dev	19389	
					Adopted Value	155	600								Adopted Value	12000	

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
								0.0		0			0.0	0	0	0.0	0
					Maximum	0	0								Maximum	0	
					Minimum	0	0								Minimum	0	
					Average	N/A	N/A								Average	0	
					Std Dev	N/A	N/A								Std Dev	N/A	
					Adopted Value										Adopted Value		

krm

BEDROCK QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(length / Total Length)
MRG-37-8.09	B-001-0-23	Claystone	32.5	34.2	1.7	85	2.5
MRG-37-8.09	B-001-0-23	Claystone	34.2	36.8	2.6	0	0.0
MRG-37-8.09	B-001-0-23	Claystone	36.8	52.5	15.7	57	15.6
MRG-37-8.09	B-002-0-23	Claystone	30.5	35.5	5	95	8.3
MRG-37-8.09	B-002-0-23	Claystone	35.5	46.5	11	27	5.2
MRG-37-8.09	B-002-0-23	Claystone	46.5	50.5	4	75	5.2
MRG-37-8.09	B-003-0-23	Claystone	30	36.4	6.4	73	8.2
MRG-37-8.09	B-003-0-23	Claystone	39.2	40.6	1.4	0	0.0
MRG-37-8.09	B-003-0-23	Claystone	40.6	50	9.4	81	13.3
				Claystone	57.2	RQD SUM	58
				Maximum	15.7	95	
				Minimum	1.4	0	
				Average	6.4	54.8	
				Adopted Value			60

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(length / Total Length)
MRG-37-8.09	B-003-0-23	Sandstone	36.4	39.2	2.8	15	15.0
					0		0.0
					0		0.0
					0		0.0
					0		0.0
					0		0.0
				Sandstone	2.8	RQD SUM	15
				Maximum	2.8	15	
				Minimum	0	15	
				Average	0.5	15.0	
				Adopted Value			15

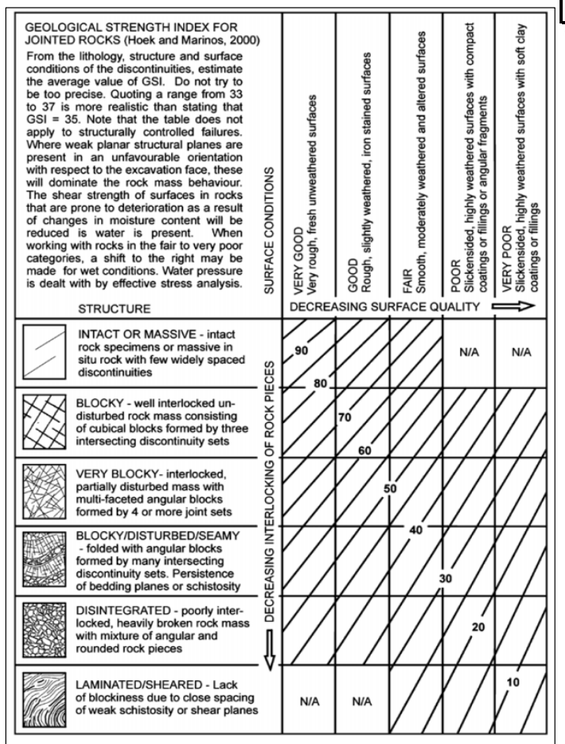


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

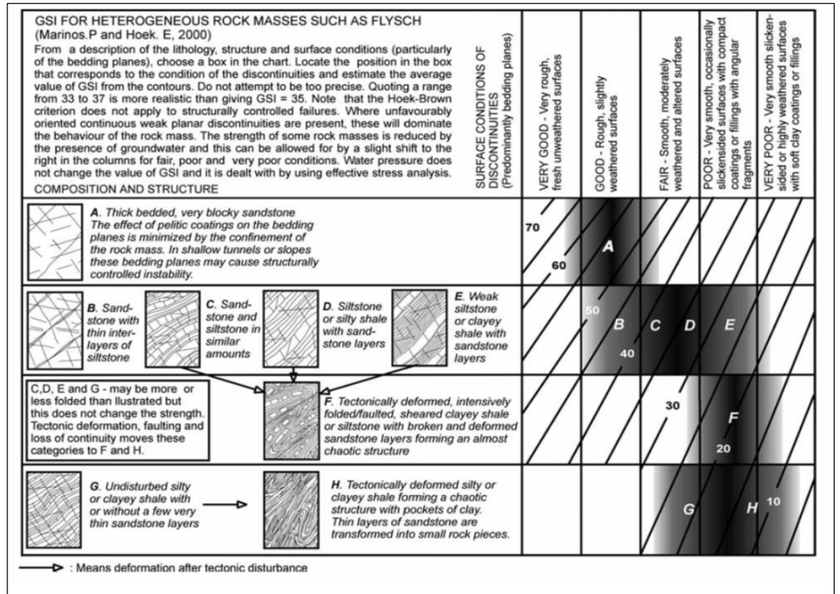


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

Table 10.4.6.5-1—Estimation of E_m Based on GSI

Expression	Notes/Remarks	Reference
$E_m\left(GPa\right)=\sqrt{\frac{q_u}{100}}10^{\frac{GSI-10}{40}}$ for $q_u \le 100$ MPa $E_m\left(GPa\right)=10^{\frac{GSI-10}{40}}$ for $q_u \le 100$ MPa	Accounts for rocks with $q_u < 100$ MPa; notes q_u in MPa	Hoek and Brown (1997); Hoek et al. (2002)
$E_m=\frac{E_R}{100}e^{GSI/21.7}$	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.		

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Columbus, OH 43213
614-892-0162

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

(Project: MRG-37-8.09, Boring Location: B-002-0-23, NQ2-1, Depth: 32.6 - 33.0ft)

Tested Date: 4/4/2023

Specimen Properties

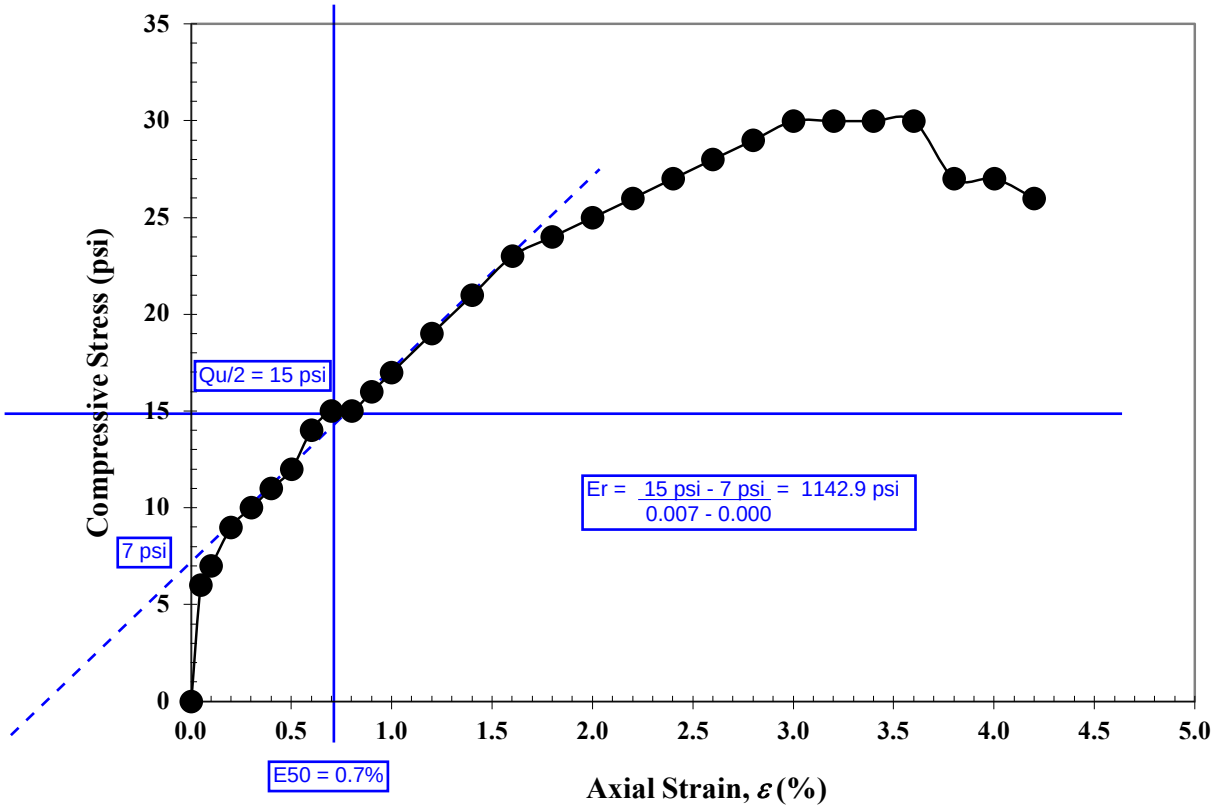
Average Dia., D_{avg} (in):	2.00
Average Height, H_{avg} (in):	4.50
Length to Diameter Ratio:	2.25
Area, A (in^2):	3.15
Volume, V (in^3):	14.18
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	8.5
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	140.2
Dry Unit Weight, γ_d (lb/ft^3):	129.3

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **30** **0.2** (MPa)

Strain (%): **3.0**



Notes: CLAYSTONE, gray, highly weathered, extremely weak.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

National Engineering & Architectural Services Inc.
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Columbus, OH 43213
614-892-0162

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

(Project: MRG-37-8.09, Boring Location: B-003-0-23, NQ2-3, Depth: 42.6 - 42.9ft)

Tested Date: 4/4/2023

Specimen Properties

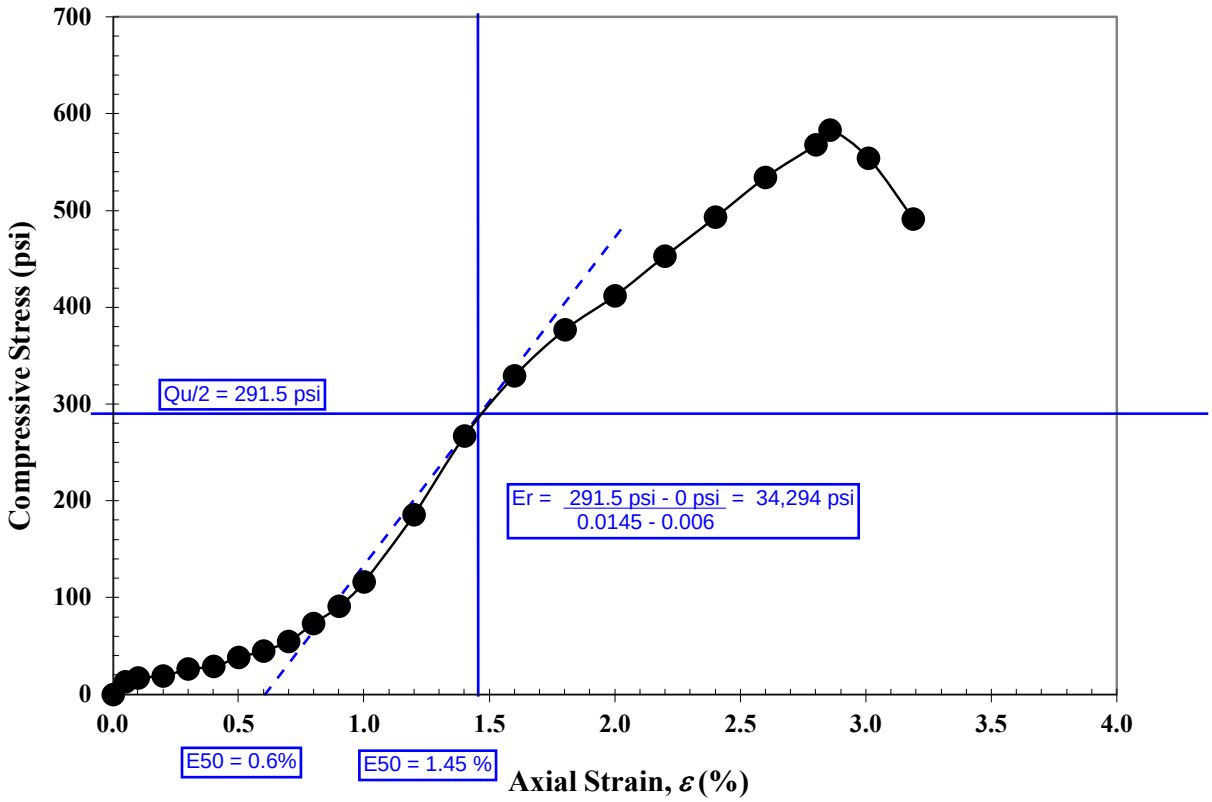
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	3.92
Length to Diameter Ratio:	1.98
Area, A (in^2):	3.08
Volume, V (in^3):	12.08
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	4.5
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	158.5
Dry Unit Weight, γ_d (lb/ft^3):	151.6

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **583** **4** (MPa)

Strain (%): **2.9**



Notes: CLAYSTONE, gray, moderately weathered, very weak.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

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Columbus, OH 43213
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Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: MRG-37-8.09, Boring Location: B-003-0-23, NQ2-4, Depth: 49.0 - 49.4ft)

Tested Date: 4/4/2023

Specimen Properties

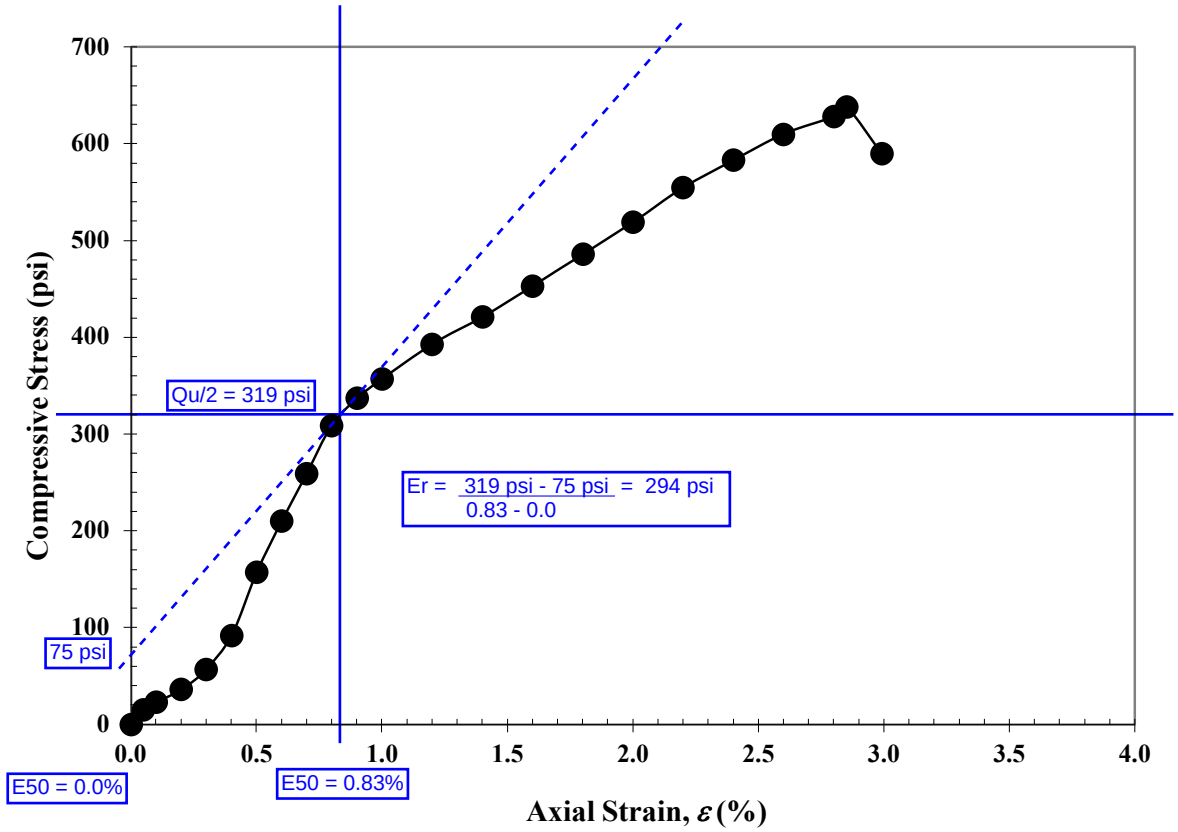
Average Dia., D_{avg} (in):	1.96
Average Height, H_{avg} (in):	4.31
Length to Diameter Ratio:	2.20
Area, A (in^2):	3.02
Volume, V (in^3):	13.03
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	5.3
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	157.8
Dry Unit Weight, γ_d (lb/ft^3):	149.8

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **638** **4** (MPa)

Strain (%): **2.9**



Notes: CLAYSTONE, gray, moderately weathered, very weak.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

Slope Stability Analyses

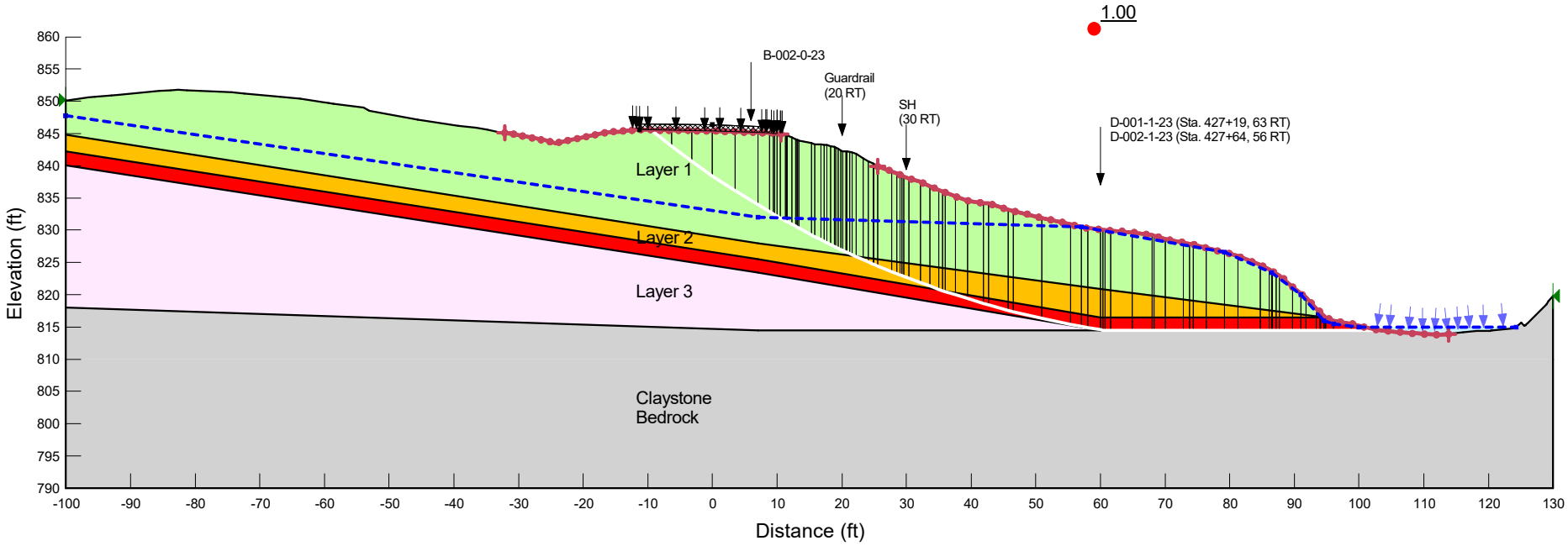
Station 427+25
Existing Conditions

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

Title: MRG-37-8.09 (10-AA)
Name: Existing Conditions
Description: Existing Conditions
Kind: SLOPE/W
Analysis Type: Morgenstern-Price

Optimize Critical Slip Surface Location: No
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Medium Stiff to Stiff Cohesive	Mohr-Coulomb	125	120	23
	2. Very Stiff to Hard Cohesive	Mohr-Coulomb	135	190	26
	3. Weathered Bedrock	Mohr-Coulomb	125	250	28
	Claystone Bedrock	Bedrock (Impenetrable)			
	Weak Rock (per GDM)	Mohr-Coulomb	125	0	13



Station 427+25
Downslope Stability

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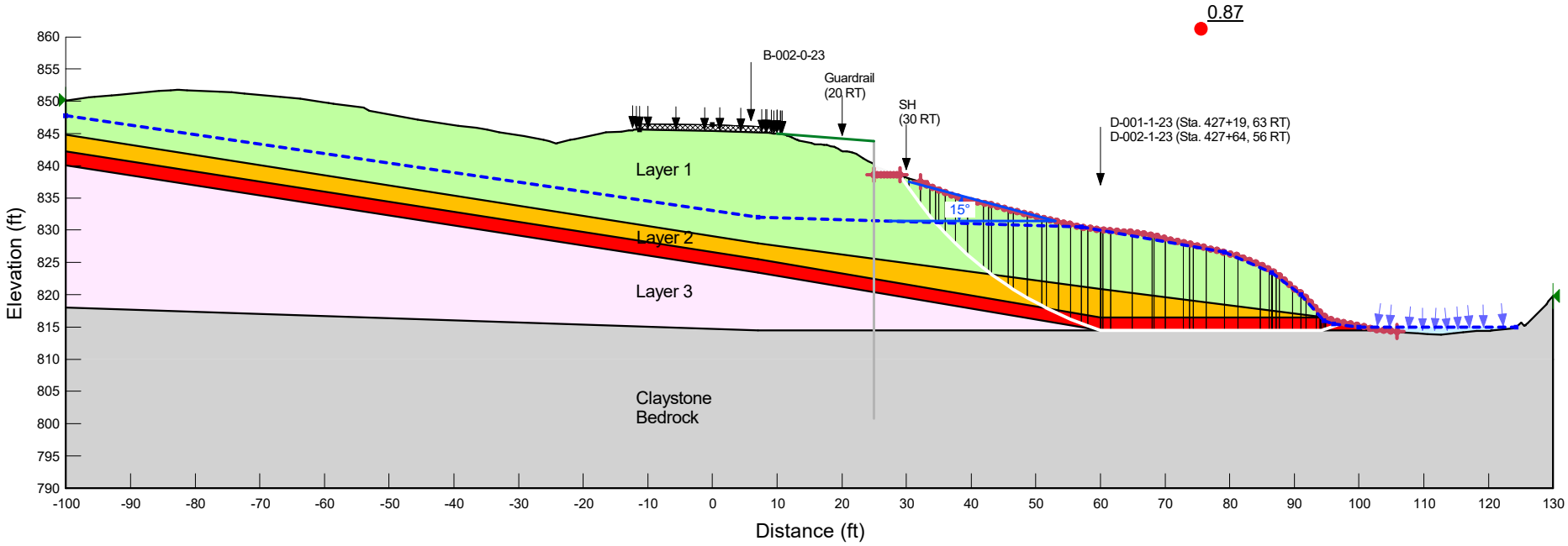
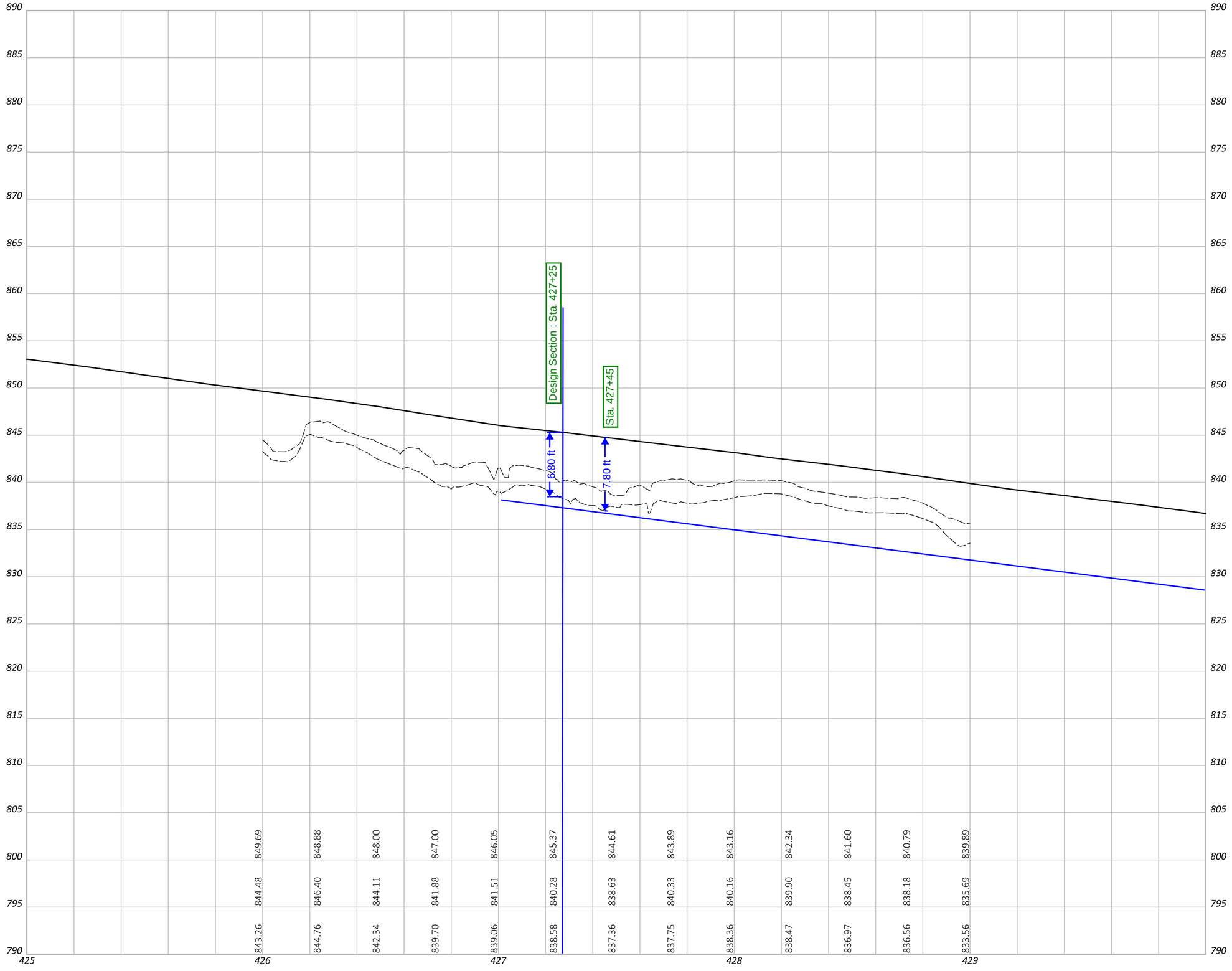
Title: MRG-37-8.09 (10-AA)
Name: Downslope Stability
Description: Downslope Stability
Kind: SLOPE/W
Analysis Type: Morgenstern-Price

Optimize Critical Slip Surface Location: No
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Medium Stiff to Stiff Cohesive	Mohr-Coulomb	125	120	23
	2. Very Stiff to Hard Cohesive	Mohr-Coulomb	135	190	26
	3. Weathered Bedrock	Mohr-Coulomb	125	250	28
	Claystone Bedrock	Bedrock (Impenetrable)			
	Weak Rock (per GDM)	Mohr-Coulomb	125	0	13



Wall Profile



CTY-RTE-SECTION

MODEL: CLP_Bench2 - Profile 2 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 4/12/2023 TIME: 1:15:45 PM USER: CWAHLBRI
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Morgan\117975\401-Engineering_HDR\Geotechnical\Basemaps\117975_BI002.dgn

SHEET TITLE
SHEET SUB-TITLE

DESIGN AGENCY

DESIGNER
XXX

REVIEWER
XXX MM-DD-YY

PROJECT ID
0

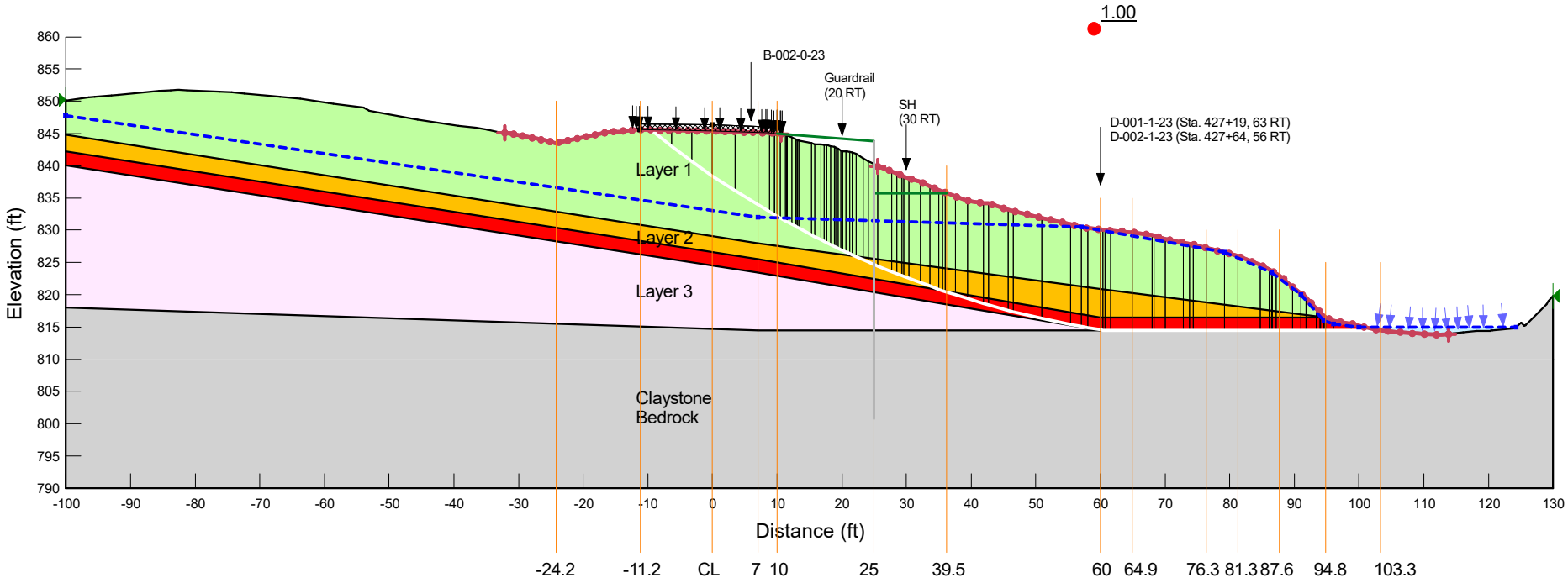
SHEET P.0 | TOTAL 0

UA Slope Analyses

Title: MRG-37-8.09 (10-AA)
Name: UA Slope Coordinates
Description: Coordinates for UA Slope Analysis
Kind: SLOPE/W
Analysis Type: Morgenstern-Price

Optimize Critical Slip Surface Location: No
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Medium Stiff to Stiff Cohesive	Mohr-Coulomb	125	120	23
	2. Very Stiff to Hard Cohesive	Mohr-Coulomb	135	190	26
	3. Weathered Bedrock	Mohr-Coulomb	125	250	28
	Claystone Bedrock	Bedrock (Impenetrable)			
	Weak Rock (per GDM)	Mohr-Coulomb	125	0	13



Station 427+25
Existing Conditions

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UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20230519_MRG-37-8.09_10-AA_Existing Condition.xlsx

File Run Options Help

Calculated Results

Factor of Safety: 1.00

Force per Shaft: 0.000 lb

Acting Point X: 20.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 17 Soil Layer Num: 7

Analysis Method

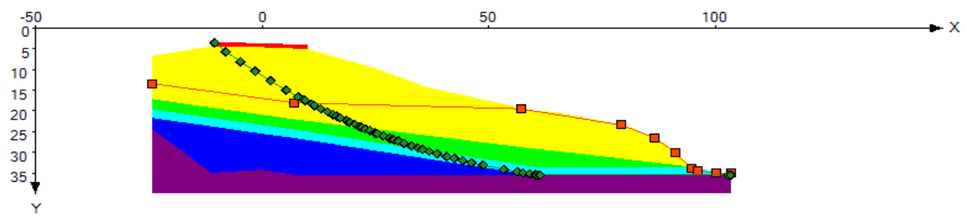
( ) Total Stress (•) Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	28.0	125.0
Layer3	120.0	23.0	125.0
Layer4	190.0	26.0	135.0
Layer5	5.0	13.0	125.0
Layer6	250.0	28.0	125.0
Layer7	4000.0	40.0	125.0

Adjusted parameter to match Slope/W results.

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	Section 14
X (ft)	-24.20	-11.20	-11.20	0.00	7.00	10.00	10.00	25.00	25.00	36.20	60.00	64.90	76.30	81.30
Y1 (ft)	6.60	4.40	3.40	3.60	3.90	4.00	5.00	9.70	9.70	14.20	19.90	20.30	22.70	24.00
Y2 (ft)	6.60	4.40	4.40	4.60	4.90	5.00	5.00	9.70	9.70	14.20	19.90	20.30	22.70	24.00
Y3 (ft)	6.60	4.40	4.40	4.60	4.90	5.00	5.00	9.70	9.70	14.20	19.90	20.30	22.70	24.00
Y4 (ft)	17.10	19.20	19.20	20.90	22.00	22.40	22.40	24.40	24.40	25.90	29.10	29.70	31.10	31.80
Y5 (ft)	19.60	21.70	21.70	23.40	24.50	25.00	25.00	27.60	27.60	29.50	33.50	33.50	33.50	33.50
Y6 (ft)	21.70	23.70	23.70	25.50	26.50	27.00	27.00	29.60	29.60	31.50	35.50	35.50	35.50	35.50
Y7 (ft)	24.50	34.90	34.90	34.20	35.40	35.50	35.50	35.50	35.50	35.50	35.50	35.50	35.50	35.50
Y8 (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	40.00

Coordinates of Crest X: -9.00 ft Y: 12.00 ft Coordinates of Toe X: 27.00 ft Y: 13.60 ft

Drilled Shaft Information

(•) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

( ) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 50000.0 lb

Anchor angle: 30.00

Anchor spacing: 8.00 ft

Auto ( ) On (•) Off 0.000 (n)

Xmin 10.00 Diameter: 3.00 ft

Xmax 20.00 CTC Spacing: 6.00 ft

XDelta 2.00 X Coordinate: 20.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
X (ft)	-24.20	7.00	57.00	79.20	86.50	91.00	94.50	96.00	100.00	103.30
Y (ft)	13.40	18.00	19.50	23.40	26.50	30.00	34.00	34.50	35.00	35.00

Slip Surface

	34	Point 35	Point 36	Point 37	Point 38	Point 39	Point 40	Point 41	Point 42	Point 43	Point 44	Point 45	Point 46	Point 47	Point 48	Point 49	Point 50
X (ft)		36.80	38.50	40.70	42.30	44.20	46.10	48.70	53.20	56.20	57.50	59.00	60.20	60.60	61.20	102.70	103.30
Y (ft)		29.80	30.30	31.00	31.40	32.00	32.50	33.10	34.10	34.70	35.00	35.20	35.40	35.50	35.50	35.50	35.50

Station 427+50
Post-Construction Conditions

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UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20230519_MRG-37-8.09_10-AA_New Wall.ua3

File Run Options Help

Calculated Results

Factor of Safety: 1.10

Force per Shaft: 19232.238 lb

Acting Point X: 25.000 ft Y: 19.014 ft

Analysis Unit System

(•) English ( ) Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 17 Soil Layer Num: 7

Analysis Method

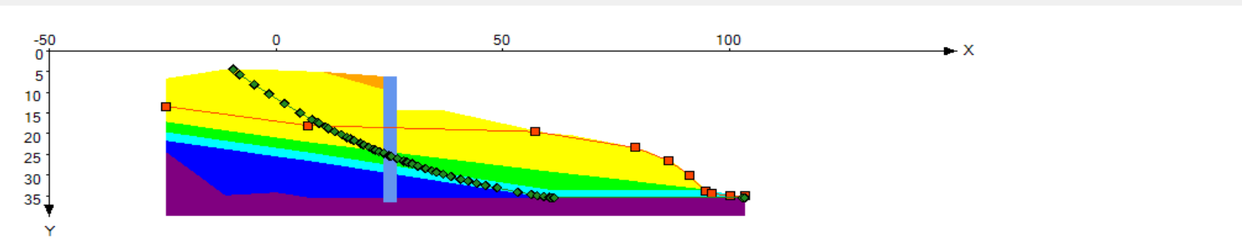
( ) Total Stress (•) Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	28.0	125.0
Layer3	120.0	23.0	125.0
Layer4	190.0	26.0	135.0
Layer5	5.0	13.0	125.0
Layer6	250.0	28.0	125.0
Layer7	4000.0	40.0	125.0

Adjusted parameter to match Slope/W results.

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	Section 14
X (ft)	-24.20	-11.20	-11.20	0.00	7.00	10.00	10.00	25.00	25.00	36.20	60.00	64.90	76.30	81.30
Y1 (ft)	6.60	4.40	4.40	4.60	4.90	5.00	5.00	6.20	14.20	14.20	19.90	20.30	22.70	24.00
Y2 (ft)	6.60	4.40	4.40	4.60	4.90	5.00	5.00	6.20	14.20	14.20	19.90	20.30	22.70	24.00
Y3 (ft)	6.60	4.40	4.40	4.60	4.90	5.00	5.00	9.70	14.20	14.20	19.90	20.30	22.70	24.00
Y4 (ft)	17.10	19.20	19.20	20.90	22.00	22.40	22.40	24.40	24.40	25.90	29.10	29.70	31.10	31.80
Y5 (ft)	19.60	21.70	21.70	23.40	24.50	25.00	25.00	27.60	27.60	29.50	33.50	33.50	33.50	33.50
Y6 (ft)	21.70	23.70	23.70	25.50	26.50	27.00	27.00	29.60	29.60	31.50	35.50	35.50	35.50	35.50
Y7 (ft)	24.50	34.90	34.90	34.20	35.40	35.50	35.50	35.50	35.50	35.50	35.50	35.50	35.50	35.50
Y8 (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	40.00

Coordinates of Crest X: -9.00 ft Y: 12.00 ft Coordinates of Toe X: 27.00 ft Y: 13.60 ft

Drilled Shaft Information

( ) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

(•) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto ( ) On (•) Off 0.000 (n)

Xmin 0.00 Diameter: 3.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 25.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
X (ft)	-24.20	7.00	57.00	79.20	86.50	91.00	94.50	96.00	100.00	103.30
Y (ft)	13.40	18.00	19.50	23.40	26.50	30.00	34.00	34.50	35.00	35.00

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	Po
X (ft)	-9.50	-8.00	-4.80	-1.60	1.80	5.30	7.90	9.10	9.50	10.90	11.50	12.90	14.40	15.60	16.30	17.10	18.60	19.1
Y (ft)	4.40	5.70	8.10	10.40	12.70	15.00	16.60	17.30	17.50	18.30	18.70	19.50	20.20	20.90	21.20	21.60	22.30	22.7

Wall Calculations

Geometry

	Elevation (ft)	
Top of Backfill =	845.0	*at Outside Edge of Shoulder*
Top of Wall =	843.8	*at C/L of Wall*
Existing Ground Surface =	840.3	*at C/L of Wall*
Maintenance Bench** =	835.8	*at C/L of Wall*
Slip Plane =	824.7	*at C/L of Wall*

***Sta. 427+45 Bench Elevation*

	Horiz. Distance from C/L (ft)	
Start of Wall Backfill =	10.0	*at Outside Edge of Shoulder*
Wall =	25.0	*at C/L of Wall*
Backfill Slope Angle =	12.0	H:1V

Wall Loading Profile

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Item 203	843.8	3.5	200	28	125
1. Medium Stiff to Stiff Cohesive	840.3	4.5	120	23	125
Bottom of Wall/Maintenance Bench	835.8				
Weighted Value		8.0	155	25	125

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	28		
Wall Friction , δ^A =	0.0		
Wall Slope, θ =	90		
Backfill Slope, β =	4.76		
Revised Backfill Slope, β =	4.76		
Backfill Condition	INFINITE		
Horz. Backslope Dist.	15.0	feet	*(C/L of Wall - Edge of Shoulder)*
Wall Height (H)	8.0	feet	*(Top of Wall - Maintenance Bench)*
Slope Height (h)	1.2	feet	*(Top of Backfill - Top of Wall)*
I =	4.29	degrees	

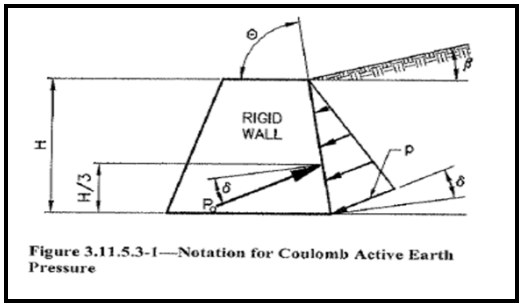


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

Active Earth Coefficient

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

K_a = 0.378

At-Rest Earth Coefficient

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

K_o = 0.571

Notes:

A. *Wall friction neglected*

B. *Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).*

C. *The wall backfill will consist of proposed fill and cohesive overburden. Using the soil layer thicknesses and respective soil parameters as determined by backcalculation in SlopeW, a weighted average was determined and assumed for the entire backfill (c' = 155 psf and φ' = 25°, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters c' = 0 psf and φ'= 28° 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).*

Soil Lateral Design Profile

	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ε50	k
1. Medium Stiff to Stiff Cohesive (Above GW)	832.8	11.0	550	0	125	0.01	N/A
1. Medium Stiff to Stiff Cohesive (Below GW)	831.5	12.3	550	0	62.6	0.01	N/A
2. Very Stiff to Hard Cohesive	825.6	18.2	2500	0	72.6	0.005	N/A
3. Weathered Bedrock	820.4	23.4	4000	0	62.6	0.005	N/A

Bedrock Lateral Design Profile

	Top Elev	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	krm
Claystone	814.5	29.3	600	12000	155	60	0.0005

Depths referenced below the top of wall, starting at the lowered ground surface. ε50 and k values per LPile Technical Manual.

Wall Loading Computations

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

1) Soil Unit Weight = 125 pcf *Weighted Average Along Cantilevered Wall Height*

2) Determine Coefficient of Earth Pressure (K)

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

Ka = 0.378

3) Determine Equivalent Fluid Weight (G_H)

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

G_H = 47 *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) = 3.0 = dt (tan(β_{dh})

β_{dh} = 15 = steepness of the slope downhill of the drilled shaft

FS_{dh} = 0.87 = Factor of Safety down slope of the proposed wall

d_t = 11.1 = depth below bench 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, Isenhower, & 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? NO *For application above shear plane if using a row of spaced drilled shafts instead of a retaining wal*

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

p-multipler = 0.81 = (P_m - P_m/FS_{UAS}) *From top of wall to bottom of shear plane*

6) Determine Lateral Thrust

Conventional Earth Pressure Theory *UA SLOPE*

Exposed Wall Height (H) = 8 feet Depth from T/Wall to Slip Plane = 19.1 feet

Wall Height (H) + GS_{AL} = 11.0

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

P = 2843 lbs/foot

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

P_{SH} = 17060 lbs/shaft Force Per Shaft = 19232 lbs/shaft

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

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

w = 3109 lbs/foot per shaft (Earth - Service Limit) 2014 lbs/foot per shaft

w = 259 lbs/inch per shaft (Earth - Service Limit) 168 lbs/inch per shaft

γ_E = 1.5 *Earth Load Factor*

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

w = 389 lbs/inch per shaft (Earth - Strength Limit) 252 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 = Ka * qs * H

P_s = 1036 lbs/foot *(surcharge resolved to distributed load)* 1804 lbs/foot

P_s = 6218 lbs/shaft 10823 lbs/shaft

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

w = P_S/H

w = 567 lbs/foot per shaft (surcharge - unfactored) 567 lbs/foot per shaft

w = 47 lbs/inch per shaft (surcharge - unfactored) 47 lbs/inch per shaft

γ_S = 1.75 *Surcharge Load Factor - Strength I*

w = $(P_S/L)*\gamma_S$

w = 83 lbs/inch per shaft (Surcharge - Strength I) 83 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	47	83
11.0	306	471

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	47	83
19.1	215	334

Steel Beam and Cross-Section Properties

Assumed Pile Shape W 21x101

Pile Availability

AISC Member Producers	2
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	36	in
Longest Beam Dimension	24.68299	in
Clear Distance	5.658505	in

Steel Beam Geometry

Beam Depth (D)	21.4	in
Web Thickness (t_w)	0.5	in
Flange Width (B_f)	12.3	in
Flange Thickness (t_f)	0.8	in
Area of Steel (A_s)	29.8	in^2

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I_{xx}) of Steel	2420	in^4
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	7.018E+10	$lb*in^2$
Section Modulus (S_x)	227	in^3
Section Modulus (Z_x)	253	in^3
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t_w	42.8	
$1.12\sqrt{Ek/F_{yw}}$	60.313846	
$1.40\sqrt{Ek/F_{yw}}$	75.392307	

Determined by AASHTO LRFD Bridge Specifications Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$V_u \le \phi V_{cr}$

$\phi_v =$ 1 *AASHTO LRFD Bridge Design Spec's 6.5.4.2*

$V_u =$ *shear in web due to factored permanent and construction loads applied to noncompact section (kips)*

$V_{cr} =$ *shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)*

$V_n = V_{cr} = CV_p$

$V_p = 0.58F_{yw}Dt_w$

$V_p =$ *plastic shear force (kips)*

$C =$ *ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6*

$V_p =$ 0.58 * 50 * 21.4 * 0.5

$V_p =$ 310.3 kips

$\phi V_{cr} = \phi * C * V_p$

$\phi V_{cr} =$ 1 * 1 * 310.3

$\phi V_{cr =}$ 310.3 kips

$V_u =$ 58.474 kips *(from LPILE)*

kips *(from PYWALL)*

$V_u < \phi V_{cr}$ **OK**

Flexure Capacity Calculation

$M_u \le \phi M_n$

$\phi_b =$ 1 *AASHTO LRFD Bridge Design Spec's 6.5.4.2*

$M_u =$ *Moment due to the factored loads*

$M_n =$ *Nominal flexural resistance of a section*

$S_x =$ *Elastic section modulus about the x-axis*

$\phi M_n = \phi * F_y * S_x$

$\phi M_n =$ 1 * 50 * 227

$\phi M_n =$ 11350 in*kips

$M_u =$ 4143.3 in*kips *(from LPILE)*

$M_u =$ in*kips *(from PYWALL)*

$M_u < \phi M_n$ **OK**

Minimum Pile Length

Top of Wall to Slip Plane =	19.1	ft	
Minimum Pile Length Below Slip Plane =	10	ft	*ODOT Minimum Required Length*
Minimum Required Pile Length =	29.1	ft	

Deflection Criteria

Pile Length Above Rock =	29.3	ft	Exposed Wall Height = 8 ft
Pile Length Above Rock =	351.6	in	Exposed Wall Height = 96 in

1.) *Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.*

2.) *Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.*

ODOT Landslide Criteria Governs YES

Drilled Shafts Located Within 10 feet of Edge of Pavement YES

1% Wall Height **OR** 2 inches- LPILE	2	in	$\delta =$	1.26 in	*(from LPILE)*
1.5% Wall Height - PYWALL		in	$\delta =$	in	*(from PYWALL)*

LPILE Analyses
(HP 21 x 101)

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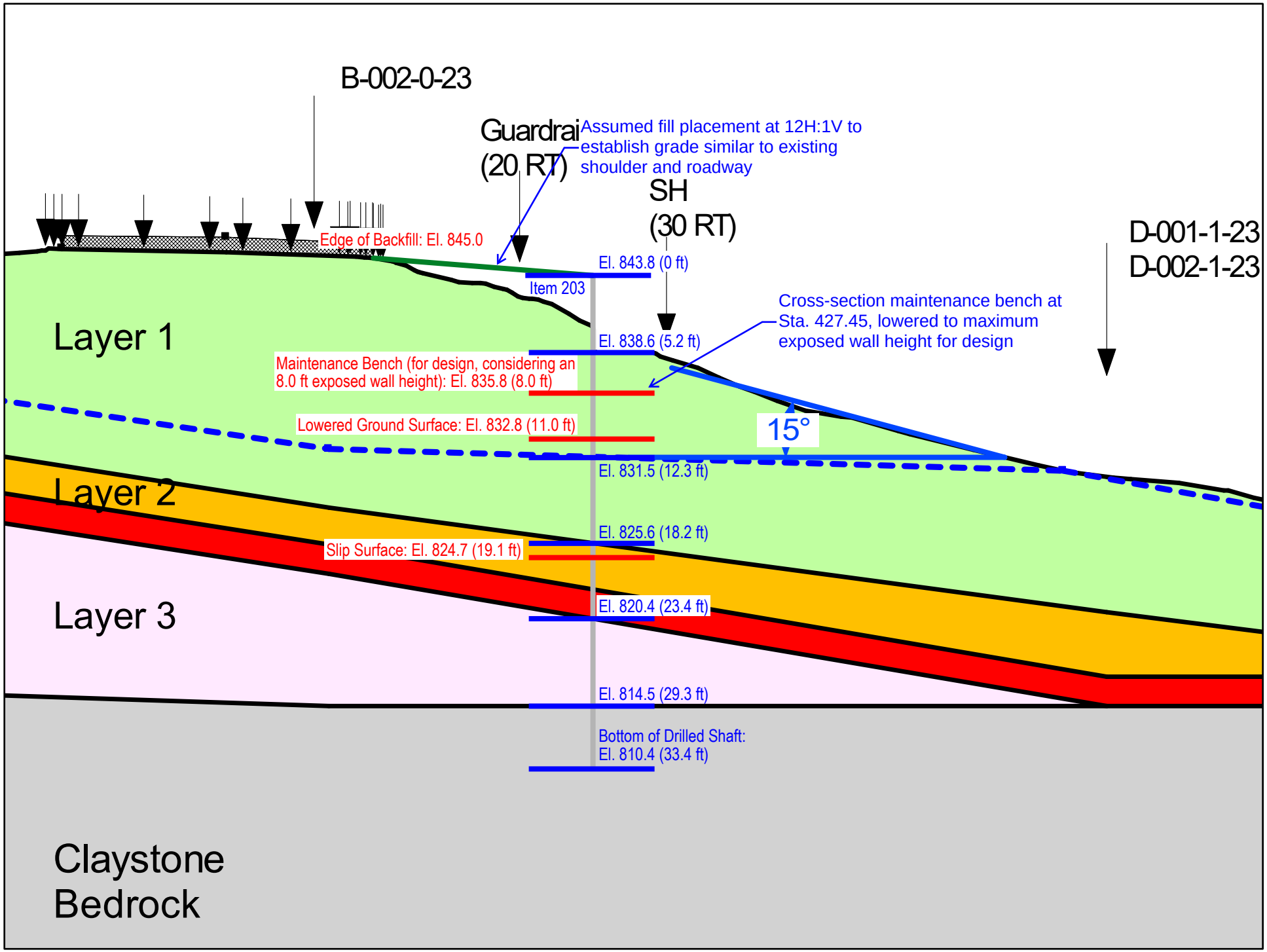
B-002-0-23
Guardrai
(20 RT)
Assumed fill placement at 12H:1V to establish grade similar to existing shoulder and roadway
SH
(30 RT)
D-001-1-23
D-002-1-23
Edge of Backfill: El. 845.0
El. 843.8 (0 ft)
Item 203
Cross-section maintenance bench at Sta. 427.45, lowered to maximum exposed wall height for design
Layer 1
El. 838.6 (5.2 ft)
Maintenance Bench (for design, considering an 8.0 ft exposed wall height): El. 835.8 (8.0 ft)
Lowered Ground Surface: El. 832.8 (11.0 ft)
15°
El. 831.5 (12.3 ft)
Layer 2
El. 825.6 (18.2 ft)
Slip Surface: El. 824.7 (19.1 ft)
Layer 3
El. 820.4 (23.4 ft)
El. 814.5 (29.3 ft)
Bottom of Drilled Shaft:
El. 810.4 (33.4 ft)
Claystone
Bedrock

Service Limit Analysis

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

                     LPile for Windows, Version 2019-11.002

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

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--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\pwworking\east01\d3227020\

Name of input data file:
20230519_MRG-37-8.09_10-AA_Service Limit.lp11

Name of output report file:
20230519_MRG-37-8.09_10-AA_Service Limit.lp11

Name of plot output file:
20230519_MRG-37-8.09_10-AA_Service Limit.lp11

Name of runtime message file:
```

20230519_MRG-37-8.09_10-AA_Service Limit.lp11

Date and Time of Analysis

Date: May 19, 2023 Time: 14:13:10

Problem Title

Project Name: MRG-37-8.09 (10-AA)

Job Number: 117975

Client: ODOT

Engineer: HDR

Description: Sta. 427+25_Service Limit State

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 one distributed lateral load 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 = 33.400 ft
Depth of ground surface below top of pile = 11.0000 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	33.400	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile

Cross-sectional Shape	=	Circular Pile
Length of section	=	33.400000 ft
Width of top of section	=	36.000000 in
Width of bottom of section	=	36.000000 in
Top Area	=	29.800000 sq. in
Bottom Area	=	29.800000 sq. in
Moment of Inertia at Top	=	2420. in^4
Moment of Inertia at Bottom	=	2420. in^4
Elastic Modulus	=	29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	11.000000 ft
Distance from top of pile to bottom of layer	=	12.300000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Undrained cohesion at top of layer	=	550.000000 psf
Undrained cohesion at bottom of layer	=	550.000000 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	=	12.300000 ft
Distance from top of pile to bottom of layer	=	18.200000 ft
Effective unit weight at top of layer	=	62.600000 pcf
Effective unit weight at bottom of layer	=	62.600000 pcf
Undrained cohesion at top of layer	=	550.000000 psf
Undrained cohesion at bottom of layer	=	550.000000 psf
Epsilon-50 at top of layer	=	0.010000
Epsilon-50 at bottom of layer	=	0.010000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	18.200000 ft
Distance from top of pile to bottom of layer	=	23.400000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Undrained cohesion at top of layer	=	2500. psf
Undrained cohesion at bottom of layer	=	2500. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 4 is stiff clay without free water

```
   Distance from top of pile to top of layer          =    23.400000 ft
   Distance from top of pile to bottom of layer       =    29.300000 ft
   Effective unit weight at top of layer              =    62.600000 pcf
   Effective unit weight at bottom of layer           =    62.600000 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 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    29.300000 ft
   Distance from top of pile to bottom of layer       =    53.000000 ft
   Effective unit weight at top of layer              =   155.000000 pcf
   Effective unit weight at bottom of layer           =   155.000000 pcf
   Uniaxial compressive strength at top of layer      =   600.000000 psi
   Uniaxial compressive strength at bottom of layer   =   600.000000 psi
   Initial modulus of rock at top of layer            =       12000. psi
   Initial modulus of rock at bottom of layer         =       12000. 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


 (Depth of the lowest soil layer extends 19.600 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   1, for effective unit weight = 155.00 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	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	11.0000	125.0000	550.0000	--	--	0.01000	--
	w/o Free Water	12.3000	125.0000	550.0000	--	--	0.01000	--
2	Stiff Clay	12.3000	62.6000	550.0000	--	--	0.01000	--
	w/o Free Water	18.2000	62.6000	550.0000	--	--	0.01000	--
3	Stiff Clay	18.2000	72.6000	2500.	--	--	0.00500	--
	w/o Free Water	23.4000	72.6000	2500.	--	--	0.00500	--
4	Stiff Clay	23.4000	62.6000	4000.	--	--	0.00500	--
	w/o Free Water	29.3000	62.6000	4000.	--	--	0.00500	--
5	Weak	29.3000	155.0000	--	600.0000	60.0000	5.00E-04	12000.
	Rock	53.0000	155.0000	--	600.0000	60.0000	5.00E-04	12000.

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	11.000	0.8100	1.0000

2	29.300	0.8100	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	47.000
2	132.000	306.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

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

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:

Moment-curvature properties were derived from elastic section properties

---

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	11.0000	0.00	N.A.	No	0.00	6984.
2	12.3000	1.3000	Yes	No	6984.	42487.
3	18.2000	2.0600	Yes	No	49471.	152628.
4	23.4000	4.8797	Yes	No	202099.	326710.
5	29.3000	18.3000	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 in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	1.2561	2.72E-05	-1.21E-07	-0.00593	2.02E-07	7.02E+10	0.00	0.00	48.9660
0.3340	1.2324	393.2968	208.0758	-0.00593	2.9253	7.02E+10	0.00	0.00	54.8642
0.6680	1.2086	1668.	443.7312	-0.00593	12.4061	7.02E+10	0.00	0.00	62.7284
1.0020	1.1848	3950.	710.9063	-0.00593	29.3820	7.02E+10	0.00	0.00	70.5925
1.3360	1.1610	7367.	1010.	-0.00593	54.7926	7.02E+10	0.00	0.00	78.4567
1.6700	1.1373	12043.	1340.	-0.00593	89.5776	7.02E+10	0.00	0.00	86.3209
2.0040	1.1135	18107.	1702.	-0.00593	134.6766	7.02E+10	0.00	0.00	94.1851
2.3380	1.0897	25683.	2095.	-0.00593	191.0293	7.02E+10	0.00	0.00	102.0493
2.6720	1.0660	34898.	2520.	-0.00593	259.5753	7.02E+10	0.00	0.00	109.9135
3.0060	1.0422	45880.	2976.	-0.00593	341.2544	7.02E+10	0.00	0.00	117.7776
3.3400	1.0185	58753.	3464.	-0.00592	437.0060	7.02E+10	0.00	0.00	125.6418
3.6740	0.9947	73645.	3983.	-0.00592	547.7700	7.02E+10	0.00	0.00	133.5060
4.0080	0.9710	90681.	4534.	-0.00591	674.4858	7.02E+10	0.00	0.00	141.3702
4.3420	0.9473	109988.	5116.	-0.00591	818.0933	7.02E+10	0.00	0.00	149.2344
4.6760	0.9237	131693.	5730.	-0.00590	979.5320	7.02E+10	0.00	0.00	157.0985
5.0100	0.9000	155921.	6376.	-0.00589	1160.	7.02E+10	0.00	0.00	164.9627
5.3440	0.8764	182799.	7052.	-0.00588	1360.	7.02E+10	0.00	0.00	172.8269
5.6780	0.8529	212453.	7761.	-0.00587	1580.	7.02E+10	0.00	0.00	180.6911
6.0120	0.8294	245010.	8501.	-0.00586	1822.	7.02E+10	0.00	0.00	188.5553
6.3460	0.8059	280597.	9272.	-0.00584	2087.	7.02E+10	0.00	0.00	196.4195
6.6800	0.7825	319338.	10075.	-0.00583	2375.	7.02E+10	0.00	0.00	204.2836
7.0140	0.7592	361361.	10910.	-0.00581	2688.	7.02E+10	0.00	0.00	212.1478

7.3480	0.7360	406792.	11776.	-0.00579	3026.	7.02E+10	0.00	0.00	220.0120
7.6820	0.7128	455757.	12674.	-0.00576	3390.	7.02E+10	0.00	0.00	227.8762
8.0160	0.6898	508383.	13603.	-0.00573	3781.	7.02E+10	0.00	0.00	235.7404
8.3500	0.6669	564796.	14563.	-0.00570	4201.	7.02E+10	0.00	0.00	243.6045
8.6840	0.6441	625122.	15555.	-0.00567	4650.	7.02E+10	0.00	0.00	251.4687
9.0180	0.6214	689487.	16579.	-0.00563	5128.	7.02E+10	0.00	0.00	259.3329
9.3520	0.5989	758019.	17634.	-0.00559	5638.	7.02E+10	0.00	0.00	267.1971
9.6860	0.5766	830843.	18721.	-0.00554	6180.	7.02E+10	0.00	0.00	275.0613
10.0200	0.5545	908085.	19839.	-0.00549	6754.	7.02E+10	0.00	0.00	282.9255
10.3540	0.5326	989873.	20989.	-0.00544	7363.	7.02E+10	0.00	0.00	290.7896
10.6880	0.5109	1076331.	22170.	-0.00538	8006.	7.02E+10	0.00	0.00	298.6538
11.0220	0.4894	1167588.	22745.	-0.00532	8685.	7.02E+10	-143.8793	1178.	132.1032
11.3560	0.4683	1258655.	22424.	-0.00525	9362.	7.02E+10	-148.5199	1271.	0.00
11.6900	0.4474	1347336.	21819.	-0.00517	10022.	7.02E+10	-152.9874	1371.	0.00
12.0240	0.4268	1433560.	21198.	-0.00509	10663.	7.02E+10	-157.2770	1477.	0.00
12.3580	0.4065	1517257.	20560.	-0.00501	11285.	7.02E+10	-161.0832	1588.	0.00
12.6920	0.3866	1598366.	19910.	-0.00492	11889.	7.02E+10	-163.2977	1693.	0.00
13.0260	0.3671	1676853.	19251.	-0.00483	12472.	7.02E+10	-165.3634	1805.	0.00
13.3600	0.3479	1752682.	18584.	-0.00473	13036.	7.02E+10	-167.2762	1927.	0.00
13.6940	0.3292	1825825.	17910.	-0.00463	13581.	7.02E+10	-169.0320	2058.	0.00
14.0280	0.3108	1896253.	17230.	-0.00452	14104.	7.02E+10	-170.6266	2200.	0.00
14.3620	0.2929	1963939.	16543.	-0.00441	14608.	7.02E+10	-172.0553	2354.	0.00
14.6960	0.2755	2028862.	15851.	-0.00430	15091.	7.02E+10	-173.3136	2522.	0.00
15.0300	0.2585	2091000.	15154.	-0.00418	15553.	7.02E+10	-174.3967	2704.	0.00
15.3640	0.2420	2150337.	14453.	-0.00406	15994.	7.02E+10	-175.2993	2903.	0.00
15.6980	0.2260	2206858.	13749.	-0.00393	16415.	7.02E+10	-176.0163	3122.	0.00
16.0320	0.2105	2260551.	13043.	-0.00381	16814.	7.02E+10	-176.5421	3362.	0.00
16.3660	0.1955	2311408.	12335.	-0.00368	17192.	7.02E+10	-176.8710	3627.	0.00
16.7000	0.1810	2359425.	11625.	-0.00354	17549.	7.02E+10	-176.9969	3920.	0.00
17.0340	0.1671	2404597.	10916.	-0.00341	17885.	7.02E+10	-176.9136	4244.	0.00
17.3680	0.1537	2446928.	10208.	-0.00327	18200.	7.02E+10	-176.6145	4606.	0.00
17.7020	0.1409	2486422.	9501.	-0.00313	18494.	7.02E+10	-176.0929	5010.	0.00
18.0360	0.1286	2523087.	8797.	-0.00298	18767.	7.02E+10	-175.3419	5464.	0.00
18.3700	0.1170	2556935.	7200.	-0.00284	19019.	7.02E+10	-621.2792	21291.	0.00
18.7040	0.1059	2580803.	4718.	-0.00269	19196.	7.02E+10	-617.5482	23379.	0.00
19.0380	0.09538	2594751.	2252.	-0.00254	19300.	7.02E+10	-612.8864	25755.	0.00
19.3720	0.08548	2598853.	-193.4580	-0.00240	19330.	7.02E+10	-607.2629	28474.	0.00
19.7060	0.07617	2593200.	-2614.	-0.00225	19288.	7.02E+10	-600.6436	31604.	0.00
20.0400	0.06746	2577898.	-5006.	-0.00210	19174.	7.02E+10	-592.9904	35230.	0.00
20.3740	0.05934	2553071.	-7365.	-0.00195	18990.	7.02E+10	-584.2599	39462.	0.00
20.7080	0.05180	2518857.	-9687.	-0.00181	18735.	7.02E+10	-574.4023	44440.	0.00
21.0420	0.04484	2475417.	-11967.	-0.00167	18412.	7.02E+10	-563.3596	50351.	0.00

21.3760	0.03845	2422927.	-14201.	-0.00153	18022.	7.02E+10	-551.0624	57441.	0.00
21.7100	0.03261	2361584.	-16382.	-0.00139	17566.	7.02E+10	-537.4267	66049.	0.00
22.0440	0.02731	2291609.	-18506.	-0.00126	17045.	7.02E+10	-522.3473	76649.	0.00
22.3780	0.02254	2213242.	-20566.	-0.00113	16462.	7.02E+10	-505.6899	89920.	0.00
22.7120	0.01827	2126752.	-22556.	-0.00100	15819.	7.02E+10	-487.2760	106879.	0.00
23.0460	0.01449	2032434.	-24468.	-8.85E-04	15117.	7.02E+10	-466.8596	129111.	0.00
23.3800	0.01118	1930616.	-26294.	-7.72E-04	14360.	7.02E+10	-444.0839	159237.	0.00
23.7140	0.00830	1821665.	-28368.	-6.65E-04	13550.	7.02E+10	-591.2210	285343.	0.00
24.0480	0.00585	1703216.	-30655.	-5.64E-04	12669.	7.02E+10	-550.0033	376935.	0.00
24.3820	0.00378	1575932.	-32761.	-4.71E-04	11722.	7.02E+10	-500.7532	530688.	0.00
24.7160	0.00208	1440604.	-34641.	-3.84E-04	10715.	7.02E+10	-437.5395	844601.	0.00
25.0500	7.00E-04	1298247.	-36182.	-3.06E-04	9656.	7.02E+10	-331.4372	1896456.	0.00
25.3840	-3.78E-04	1150566.	-36483.	-2.36E-04	8558.	7.02E+10	181.5707	1924100.	0.00
25.7180	-0.00119	1005802.	-35322.	-1.75E-04	7481.	7.02E+10	397.7753	1335755.	0.00
26.0520	-0.00178	867427.	-33631.	-1.21E-04	6452.	7.02E+10	445.7410	1004435.	0.00
26.3860	-0.00217	736213.	-31787.	-7.54E-05	5476.	7.02E+10	474.7487	878812.	0.00
26.7200	-0.00238	612626.	-29847.	-3.69E-05	4557.	7.02E+10	492.9710	829060.	0.00
27.0540	-0.00246	496957.	-27850.	-5.22E-06	3696.	7.02E+10	503.6932	820314.	0.00
27.3880	-0.00243	389380.	-25821.	2.01E-05	2896.	7.02E+10	508.5632	840525.	0.00
27.7220	-0.00230	289973.	-23783.	3.95E-05	2157.	7.02E+10	508.5040	886133.	0.00
28.0560	-0.00211	198734.	-21754.	5.34E-05	1478.	7.02E+10	504.0594	958147.	0.00
28.3900	-0.00187	115592.	-19751.	6.24E-05	859.7771	7.02E+10	495.5525	1061233.	0.00
28.7240	-0.00161	40411.	-17789.	6.69E-05	300.5793	7.02E+10	483.1705	1204196.	0.00
29.0580	-0.00134	-27008.	-15885.	6.73E-05	200.8870	7.02E+10	467.0248	1401587.	0.00
29.3920	-0.00107	-86925.	-12273.	6.40E-05	646.5510	7.02E+10	1335.	5006259.	0.00
29.7260	-8.22E-04	-125392.	-7245.	5.79E-05	932.6670	7.02E+10	1174.	5720218.	0.00
30.0600	-6.05E-04	-145002.	-2948.	5.02E-05	1079.	7.02E+10	970.5632	6434176.	0.00
30.3940	-4.20E-04	-149022.	497.9532	4.18E-05	1108.	7.02E+10	748.8831	7148134.	0.00
30.7280	-2.69E-04	-141011.	3057.	3.35E-05	1049.	7.02E+10	528.3179	7862093.	0.00
31.0620	-1.51E-04	-124513.	4764.	2.60E-05	926.1295	7.02E+10	323.1729	8576051.	0.00
31.3960	-6.12E-05	-102824.	5696.	1.95E-05	764.8045	7.02E+10	141.9441	9290010.	0.00
31.7300	5.02E-06	-78854.	5955.	1.43E-05	586.5193	7.02E+10	-12.5295	1.00E+07	0.00
32.0640	5.32E-05	-55086.	5645.	1.05E-05	409.7313	7.02E+10	-142.3420	1.07E+07	0.00
32.3980	8.88E-05	-33605.	4852.	7.92E-06	249.9509	7.02E+10	-253.3653	1.14E+07	0.00
32.7320	1.17E-04	-16193.	3635.	6.50E-06	120.4438	7.02E+10	-353.7620	1.21E+07	0.00
33.0660	1.41E-04	-4464.	2020.	5.91E-06	33.2058	7.02E+10	-452.2089	1.29E+07	0.00
33.4000	1.64E-04	0.00	0.00	5.78E-06	0.00	7.02E+10	-555.8173	6786880.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.25612878 inches
Computed slope at pile head      =    -0.00593231 radians
Maximum bending moment           =       2598853. inch-lbs
Maximum shear force              =        -36483. lbs
Depth of maximum bending moment  =    19.37200000 feet below pile head
Depth of maximum shear force     =    25.38400000 feet below pile head
Number of iterations             =             24
Number of zero deflection points =              2
```

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
33.40000	1.25612878	2598853.	-36483.
31.73000	1.26787509	2615051.	-36383.
30.06000	1.26553633	2615511.	-35830.
28.39000	1.57091093	2535282.	-41610.
26.72000	2.77854166	2402866.	-44616.
25.05000	6.43591840	2155962.	-44947.
23.38000	29.35186331	1914856.	-46354.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs

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

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.2561	-0.00593	-36483.	2598853.

Maximum pile-head deflection = 1.2561287844 inches
Maximum pile-head rotation = -0.0059323100 radians = -0.339896 deg.

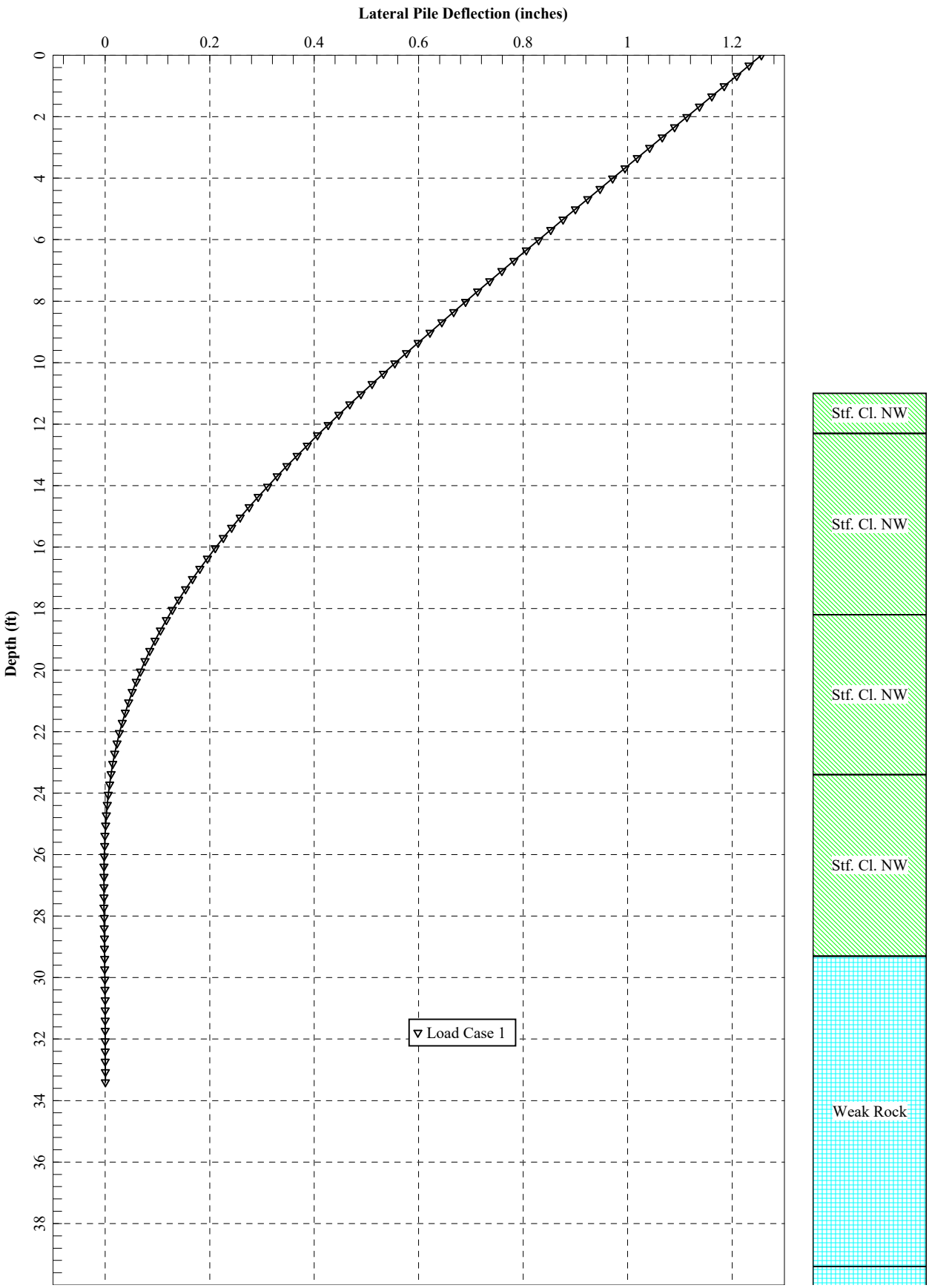
Summary of Warning Messages

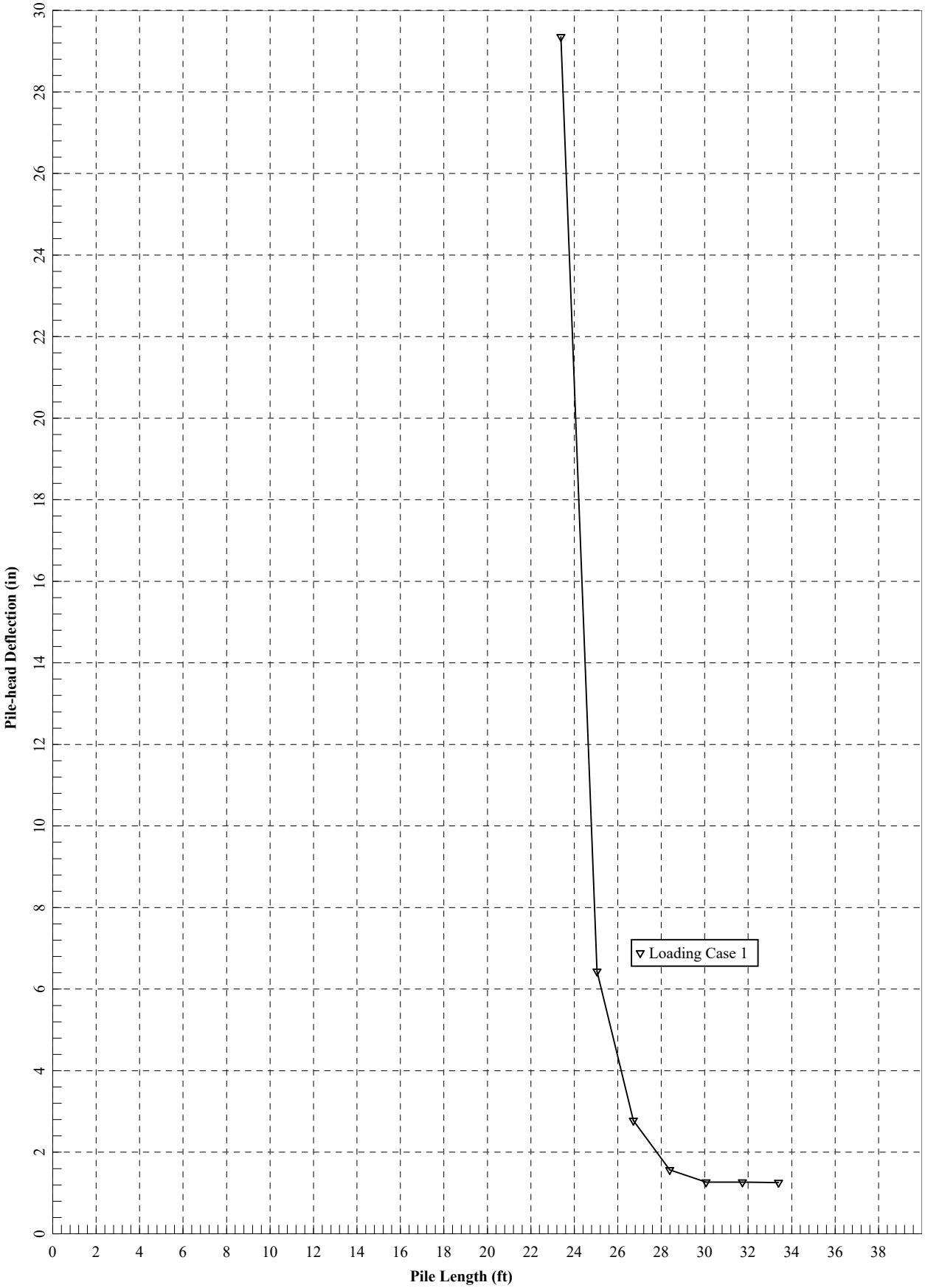
The following warning was reported 888 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.


Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock


Pile-head Deflection (in)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Pile Length (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Loading Case 1

Strength Limit Analysis

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

                     LPile for Windows, Version 2019-11.002

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

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--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\pwworking\east01\d3227020\

Name of input data file:
20230519_MRG-37-8.09_10-AA_Strength Limit.lp11

Name of output report file:
20230519_MRG-37-8.09_10-AA_Strength Limit.lp11

Name of plot output file:
```

20230519_MRG-37-8.09_10-AA_Strength Limit.lp11

Name of runtime message file:
20230519_MRG-37-8.09_10-AA_Strength Limit.lp11

Date and Time of Analysis

Date: May 22, 2023 Time: 10:18:03

Problem Title

Project Name: MRG-37-8.09 (10-AA)

Job Number: 117975

Client: ODOT

Engineer: HDR

Description: Sta. 427+25_Strength Limit State

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 one distributed lateral load 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 = 33.400 ft
Depth of ground surface below top of pile = 11.0000 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	33.400	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 33.400000 ft
Width of top of section = 36.000000 in
Width of bottom of section = 36.000000 in
Top Area = 21.400000 sq. in
Bottom Area = 21.400000 sq. in
Moment of Inertia at Top = 729.000000 in^4
Moment of Inertia at Bottom = 729.000000 in^4
Elastic Modulus = 29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000	degrees
	=	0.000	radians
Pile Batter Angle	=	0.000	degrees
	=	0.000	radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	11.000000	ft
Distance from top of pile to bottom of layer	=	12.300000	ft
Effective unit weight at top of layer	=	125.000000	pcf
Effective unit weight at bottom of layer	=	125.000000	pcf
Undrained cohesion at top of layer	=	550.000000	psf
Undrained cohesion at bottom of layer	=	550.000000	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	=	12.300000	ft
Distance from top of pile to bottom of layer	=	18.200000	ft
Effective unit weight at top of layer	=	62.600000	pcf
Effective unit weight at bottom of layer	=	62.600000	pcf
Undrained cohesion at top of layer	=	550.000000	psf
Undrained cohesion at bottom of layer	=	550.000000	psf
Epsilon-50 at top of layer	=	0.010000	
Epsilon-50 at bottom of layer	=	0.010000	

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	18.200000	ft
Distance from top of pile to bottom of layer	=	23.400000	ft
Effective unit weight at top of layer	=	72.600000	pcf
Effective unit weight at bottom of layer	=	72.600000	pcf
Undrained cohesion at top of layer	=	2500.	psf
Undrained cohesion at bottom of layer	=	2500.	psf
Epsilon-50 at top of layer	=	0.005000	
Epsilon-50 at bottom of layer	=	0.005000	

Layer 4 is stiff clay without free water

Distance from top of pile to top of layer	=	23.400000	ft
Distance from top of pile to bottom of layer	=	29.300000	ft
Effective unit weight at top of layer	=	62.600000	pcf
Effective unit weight at bottom of layer	=	62.600000	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 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	29.300000	ft
Distance from top of pile to bottom of layer	=	53.000000	ft
Effective unit weight at top of layer	=	155.000000	pcf
Effective unit weight at bottom of layer	=	155.000000	pcf
Uniaxial compressive strength at top of layer	=	600.000000	psi
Uniaxial compressive strength at bottom of layer	=	600.000000	psi
Initial modulus of rock at top of layer	=	12000.	psi
Initial modulus of rock at bottom of layer	=	12000.	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	

(Depth of the lowest soil layer extends 19.600 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 1, for effective unit weight = 155.00 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	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	11.0000	125.0000	550.0000	--	--	0.01000	--
	w/o Free Water	12.3000	125.0000	550.0000	--	--	0.01000	--
2	Stiff Clay	12.3000	62.6000	550.0000	--	--	0.01000	--
	w/o Free Water	18.2000	62.6000	550.0000	--	--	0.01000	--
3	Stiff Clay	18.2000	72.6000	2500.	--	--	0.00500	--
	w/o Free Water	23.4000	72.6000	2500.	--	--	0.00500	--

4	Stiff Clay	23.4000	62.6000	4000.	--	--	0.00500	--
	w/o Free Water	29.3000	62.6000	4000.	--	--	0.00500	--
5	Weak	29.3000	155.0000	--	600.0000	60.0000	5.00E-04	12000.
	Rock	53.0000	155.0000	--	600.0000	60.0000	5.00E-04	12000.

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p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	11.000	0.8100	1.0000
2	29.300	0.8100	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	83.000
2	132.000	471.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

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

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

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

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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	11.0000	0.00	N.A.	No	0.00	6984.
2	12.3000	1.3000	Yes	No	6984.	42487.
3	18.2000	2.0600	Yes	No	49471.	152628.
4	23.4000	4.8797	Yes	No	202099.	326710.
5	29.3000	18.3000	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 in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	6.7420	-2.34E-06	0.00	-0.03171	5.77E-08	2.11E+10	0.00	0.00	85.9453
0.3340	6.6149	690.3152	362.1756	-0.03171	17.0448	2.11E+10	0.00	0.00	94.7811
0.6680	6.4878	2903.	765.6676	-0.03170	71.6839	2.11E+10	0.00	0.00	106.5622
1.0020	6.3608	6828.	1216.	-0.03170	168.5903	2.11E+10	0.00	0.00	118.3433
1.3360	6.2337	12654.	1714.	-0.03170	312.4367	2.11E+10	0.00	0.00	130.1244
1.6700	6.1066	20570.	2259.	-0.03170	507.8961	2.11E+10	0.00	0.00	141.9055
2.0040	5.9796	30765.	2852.	-0.03169	759.6414	2.11E+10	0.00	0.00	153.6865
2.3380	5.8526	43430.	3491.	-0.03169	1072.	2.11E+10	0.00	0.00	165.4676
2.6720	5.7256	58753.	4178.	-0.03168	1451.	2.11E+10	0.00	0.00	177.2487
3.0060	5.5987	76923.	4912.	-0.03166	1899.	2.11E+10	0.00	0.00	189.0298
3.3400	5.4718	98129.	5693.	-0.03165	2423.	2.11E+10	0.00	0.00	200.8109
3.6740	5.3450	122561.	6522.	-0.03163	3026.	2.11E+10	0.00	0.00	212.5920
4.0080	5.2183	150409.	7398.	-0.03160	3714.	2.11E+10	0.00	0.00	224.3731
4.3420	5.0917	181861.	8321.	-0.03157	4490.	2.11E+10	0.00	0.00	236.1542
4.6760	4.9652	217106.	9291.	-0.03153	5361.	2.11E+10	0.00	0.00	247.9353
5.0100	4.8389	256334.	10308.	-0.03149	6329.	2.11E+10	0.00	0.00	259.7164
5.3440	4.7128	299735.	11373.	-0.03143	7401.	2.11E+10	0.00	0.00	271.4975
5.6780	4.5869	347496.	12484.	-0.03137	8580.	2.11E+10	0.00	0.00	283.2785
6.0120	4.4613	399809.	13643.	-0.03130	9872.	2.11E+10	0.00	0.00	295.0596
6.3460	4.3360	456861.	14849.	-0.03122	11281.	2.11E+10	0.00	0.00	306.8407
6.6800	4.2111	518842.	16103.	-0.03113	12811.	2.11E+10	0.00	0.00	318.6218
7.0140	4.0865	585942.	17404.	-0.03102	14468.	2.11E+10	0.00	0.00	330.4029
7.3480	3.9624	658349.	18751.	-0.03091	16256.	2.11E+10	0.00	0.00	342.1840
7.6820	3.8387	736253.	20146.	-0.03077	18179.	2.11E+10	0.00	0.00	353.9651
8.0160	3.7157	819843.	21589.	-0.03063	20243.	2.11E+10	0.00	0.00	365.7462
8.3500	3.5932	909309.	23078.	-0.03046	22452.	2.11E+10	0.00	0.00	377.5273
8.6840	3.4715	1004839.	24615.	-0.03028	24811.	2.11E+10	0.00	0.00	389.3084
9.0180	3.3505	1106623.	26199.	-0.03008	27324.	2.11E+10	0.00	0.00	401.0895
9.3520	3.2304	1214850.	27830.	-0.02986	29996.	2.11E+10	0.00	0.00	412.8705
9.6860	3.1112	1329710.	29509.	-0.02962	32832.	2.11E+10	0.00	0.00	424.6516
10.0200	2.9930	1451391.	31234.	-0.02936	35837.	2.11E+10	0.00	0.00	436.4327

10.3540	2.8758	1580083.	33007.	-0.02907	39014.	2.11E+10	0.00	0.00	448.2138
10.6880	2.7599	1715975.	34827.	-0.02876	42370.	2.11E+10	0.00	0.00	459.9949
11.0220	2.6453	1859257.	35717.	-0.02842	45908.	2.11E+10	-219.3776	332.3828	203.3659
11.3560	2.5322	2002282.	35231.	-0.02805	49439.	2.11E+10	-226.4819	358.4854	0.00
11.6900	2.4205	2141668.	34309.	-0.02766	52881.	2.11E+10	-233.3257	386.3563	0.00
12.0240	2.3104	2277306.	33361.	-0.02724	56230.	2.11E+10	-239.9021	416.1655	0.00
12.3580	2.2021	2409090.	32388.	-0.02679	59484.	2.11E+10	-245.7451	447.2685	0.00
12.6920	2.0957	2536927.	31396.	-0.02633	62640.	2.11E+10	-249.1635	476.5316	0.00
13.0260	1.9911	2660761.	30391.	-0.02583	65698.	2.11E+10	-252.3585	507.9851	0.00
13.3600	1.8886	2780541.	29374.	-0.02532	68655.	2.11E+10	-255.3241	541.8568	0.00
13.6940	1.7882	2896219.	28345.	-0.02478	71512.	2.11E+10	-258.0541	578.4044	0.00
14.0280	1.6899	3007752.	27306.	-0.02422	74265.	2.11E+10	-260.5422	617.9208	0.00
14.3620	1.5940	3115100.	26257.	-0.02364	76916.	2.11E+10	-262.7817	660.7391	0.00
14.6960	1.5005	3218227.	25200.	-0.02304	79462.	2.11E+10	-264.7658	707.2403	0.00
15.0300	1.4093	3317100.	24135.	-0.02242	81904.	2.11E+10	-266.4872	757.8609	0.00
15.3640	1.3207	3411692.	23064.	-0.02178	84239.	2.11E+10	-267.9385	813.1035	0.00
15.6980	1.2347	3501980.	21988.	-0.02113	86469.	2.11E+10	-269.1119	873.5487	0.00
16.0320	1.1514	3587945.	20907.	-0.02045	88591.	2.11E+10	-269.9994	939.8699	0.00
16.3660	1.0708	3669573.	19824.	-0.01977	90607.	2.11E+10	-270.5923	1013.	0.00
16.7000	0.9929	3746854.	18739.	-0.01906	92515.	2.11E+10	-270.8821	1093.	0.00
17.0340	0.9180	3819784.	17653.	-0.01835	94316.	2.11E+10	-270.8594	1183.	0.00
17.3680	0.8459	3888362.	16568.	-0.01762	96009.	2.11E+10	-270.5149	1282.	0.00
17.7020	0.7768	3952595.	15485.	-0.01687	97595.	2.11E+10	-269.8389	1392.	0.00
18.0360	0.7106	4012494.	14406.	-0.01612	99074.	2.11E+10	-268.8212	1516.	0.00
18.3700	0.6476	4068073.	11957.	-0.01535	100446.	2.11E+10	-953.0145	5899.	0.00
18.7040	0.5876	4108344.	8148.	-0.01458	101441.	2.11E+10	-947.8522	6465.	0.00
19.0380	0.5307	4133388.	4362.	-0.01379	102059.	2.11E+10	-941.3086	7109.	0.00
19.3720	0.4770	4143311.	605.3724	-0.01301	102304.	2.11E+10	-933.3405	7842.	0.00
19.7060	0.4264	4138241.	-3117.	-0.01223	102179.	2.11E+10	-923.9004	8684.	0.00
20.0400	0.3790	4118329.	-6798.	-0.01144	101687.	2.11E+10	-912.9359	9654.	0.00
20.3740	0.3347	4083752.	-10431.	-0.01067	100833.	2.11E+10	-900.3885	10782.	0.00
20.7080	0.2935	4034710.	-14012.	-0.00990	99622.	2.11E+10	-886.1917	12101.	0.00
21.0420	0.2554	3971433.	-17532.	-0.00914	98060.	2.11E+10	-870.2695	13658.	0.00
21.3760	0.2203	3894176.	-20984.	-0.00839	96152.	2.11E+10	-852.5331	15512.	0.00
21.7100	0.1881	3803224.	-24362.	-0.00766	93907.	2.11E+10	-832.8773	17744.	0.00
22.0440	0.1589	3698892.	-27656.	-0.00695	91331.	2.11E+10	-811.1745	20465.	0.00
22.3780	0.1324	3581530.	-30860.	-0.00626	88433.	2.11E+10	-787.2665	23830.	0.00
22.7120	0.1087	3451521.	-33962.	-0.00559	85223.	2.11E+10	-760.9514	28062.	0.00
23.0460	0.08758	3309287.	-36954.	-0.00495	81711.	2.11E+10	-731.9627	33498.	0.00

23.3800	0.06899	3155296.	-39824.	-0.00434	77909.	2.11E+10	-699.9350	40665.	0.00
23.7140	0.05279	2990061.	-43108.	-0.00376	73829.	2.11E+10	-938.7517	71272.	0.00
24.0480	0.03887	2809745.	-46759.	-0.00321	69376.	2.11E+10	-883.0671	91059.	0.00
24.3820	0.02708	2615244.	-50170.	-0.00269	64574.	2.11E+10	-819.1083	121228.	0.00
24.7160	0.01728	2407585.	-53300.	-0.00222	59447.	2.11E+10	-743.1026	172352.	0.00
25.0500	0.00931	2187989.	-56084.	-0.00178	54024.	2.11E+10	-646.0823	278151.	0.00
25.3840	0.00300	1958013.	-58369.	-0.00139	48346.	2.11E+10	-494.0113	659722.	0.00
25.7180	-0.00182	1720102.	-58474.	-0.00104	42472.	2.11E+10	441.8818	973457.	0.00
26.0520	-0.00533	1489290.	-56413.	-7.35E-04	36773.	2.11E+10	586.5273	440808.	0.00
26.3860	-0.00771	1267899.	-53930.	-4.74E-04	31306.	2.11E+10	652.2541	338856.	0.00
26.7200	-0.00913	1056987.	-51241.	-2.54E-04	26098.	2.11E+10	689.7399	302677.	0.00
27.0540	-0.00975	857154.	-48434.	-7.23E-05	21164.	2.11E+10	710.5951	292146.	0.00
27.3880	-0.00971	668736.	-45569.	7.24E-05	16512.	2.11E+10	719.4458	296879.	0.00
27.7220	-0.00917	491876.	-42687.	1.82E-04	12145.	2.11E+10	718.5189	314090.	0.00
28.0560	-0.00825	326558.	-39826.	2.60E-04	8063.	2.11E+10	708.9407	344377.	0.00
28.3900	-0.00708	172628.	-37020.	3.07E-04	4262.	2.11E+10	691.2244	391029.	0.00
28.7240	-0.00579	29802.	-34302.	3.26E-04	735.8558	2.11E+10	665.4920	460845.	0.00
29.0580	-0.00447	-102333.	-31702.	3.20E-04	2527.	2.11E+10	631.6165	566583.	0.00
29.3920	-0.00323	-224322.	-22361.	2.89E-04	5539.	2.11E+10	4030.	5006259.	0.00
29.7260	-0.00215	-281581.	-8124.	2.41E-04	6953.	2.11E+10	3075.	5720218.	0.00
30.0600	-0.00130	-289445.	2210.	1.87E-04	7147.	2.11E+10	2082.	6434176.	0.00
30.3940	-6.59E-04	-263867.	8738.	1.34E-04	6515.	2.11E+10	1176.	7148134.	0.00
30.7280	-2.22E-04	-219404.	11966.	8.83E-05	5417.	2.11E+10	435.4100	7862093.	0.00
31.0620	4.85E-05	-167947.	12631.	5.16E-05	4147.	2.11E+10	-103.7721	8576051.	0.00
31.3960	1.91E-04	-118157.	11534.	2.44E-05	2917.	2.11E+10	-443.5164	9290010.	0.00
31.7300	2.44E-04	-75492.	9423.	6.08E-06	1864.	2.11E+10	-610.0571	1.00E+07	0.00
32.0640	2.40E-04	-42626.	6913.	-5.11E-06	1053.	2.11E+10	-642.1084	1.07E+07	0.00
32.3980	2.03E-04	-20076.	4464.	-1.11E-05	495.6980	2.11E+10	-580.2451	1.14E+07	0.00
32.7320	1.51E-04	-6846.	2381.	-1.36E-05	169.0451	2.11E+10	-459.0844	1.21E+07	0.00
33.0660	9.44E-05	-991.6452	854.0828	-1.44E-05	24.4851	2.11E+10	-302.7277	1.29E+07	0.00
33.4000	3.65E-05	0.00	0.00	-1.44E-05	0.00	2.11E+10	-123.4613	6786880.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 6.74199370 inches
Computed slope at pile head = -0.03170523 radians

```
Maximum bending moment           =       4143311. inch-lbs
Maximum shear force              =        -58474. lbs
Depth of maximum bending moment  =    19.37200000 feet below pile head
Depth of maximum shear force     =    25.71800000 feet below pile head
Number of iterations             =             34
Number of zero deflection points =              3
```

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
33.40000	6.74199370	4143311.	-58474.
31.73000	6.79857776	4168402.	-58791.
30.06000	6.78600609	4169986.	-56926.
28.39000	8.89109805	4017118.	-66205.
26.72000	16.46058166	3798350.	-70548.
25.05000	40.72533546	3432587.	-71602.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians

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

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	6.7420	-0.03171	-58474.	4143311.

Maximum pile-head deflection = 6.7419936985 inches
Maximum pile-head rotation = -0.0317052337 radians = -1.816576 deg.

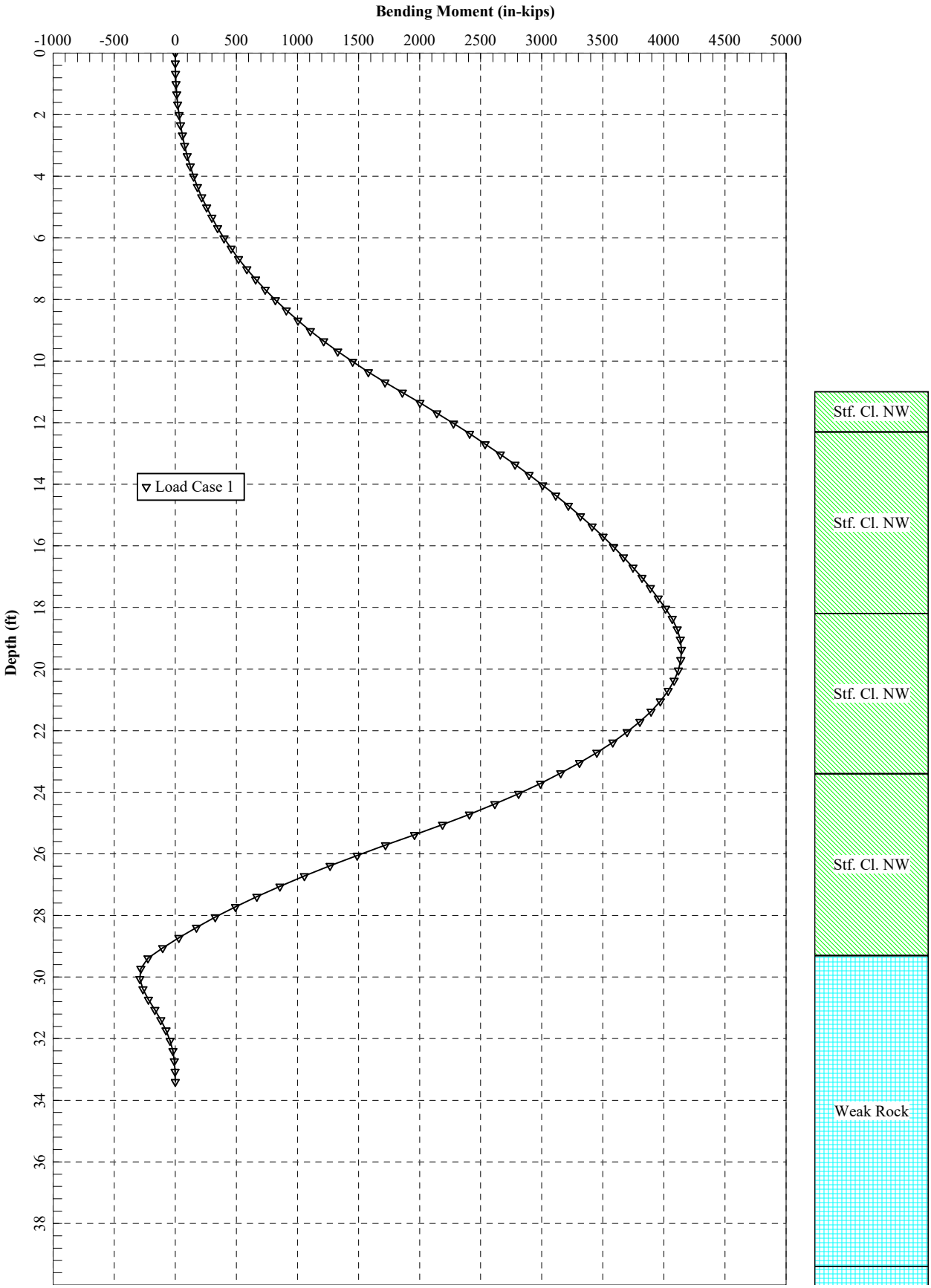
Summary of Warning Messages

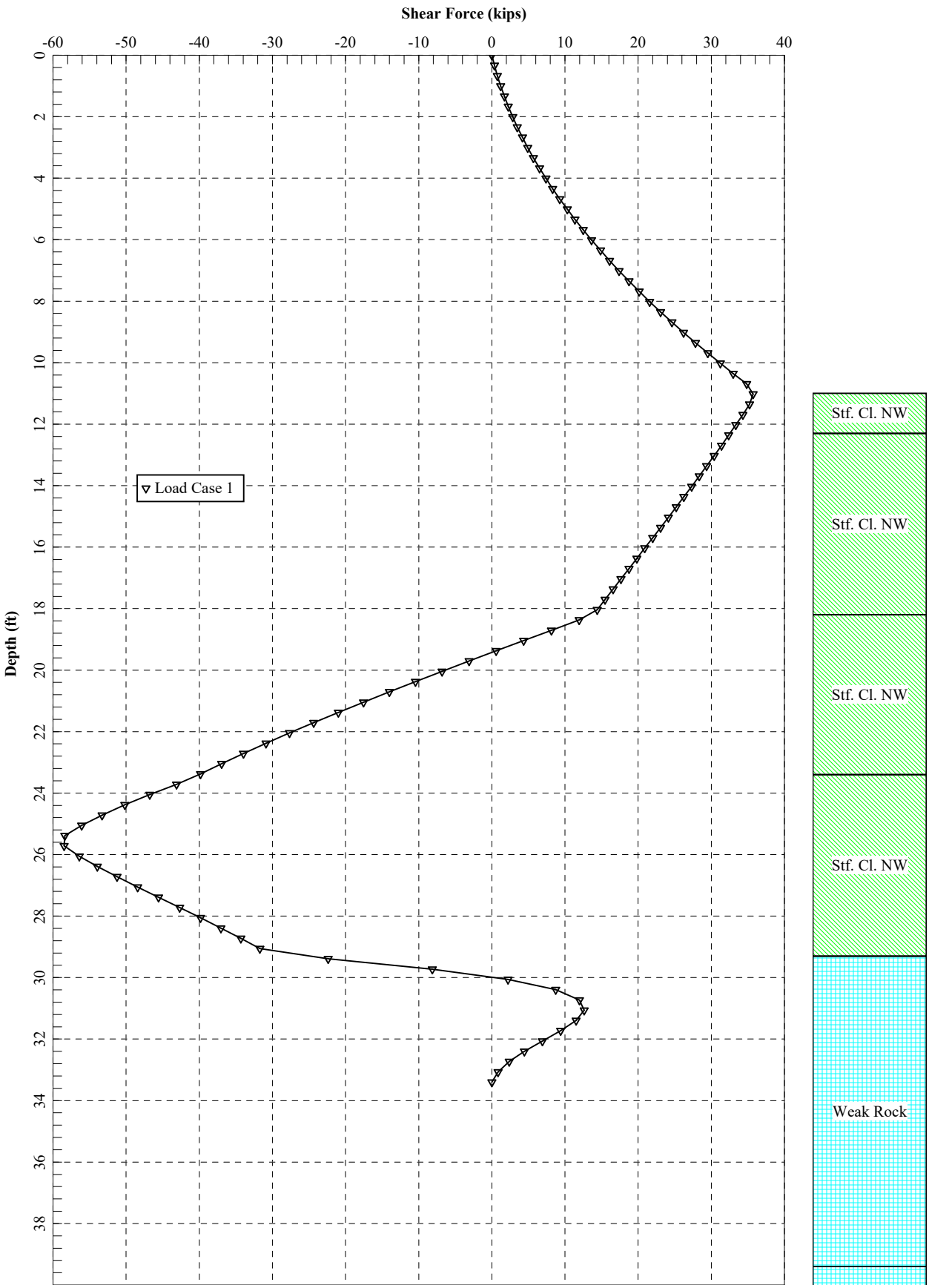
The following warning was reported 1240 times

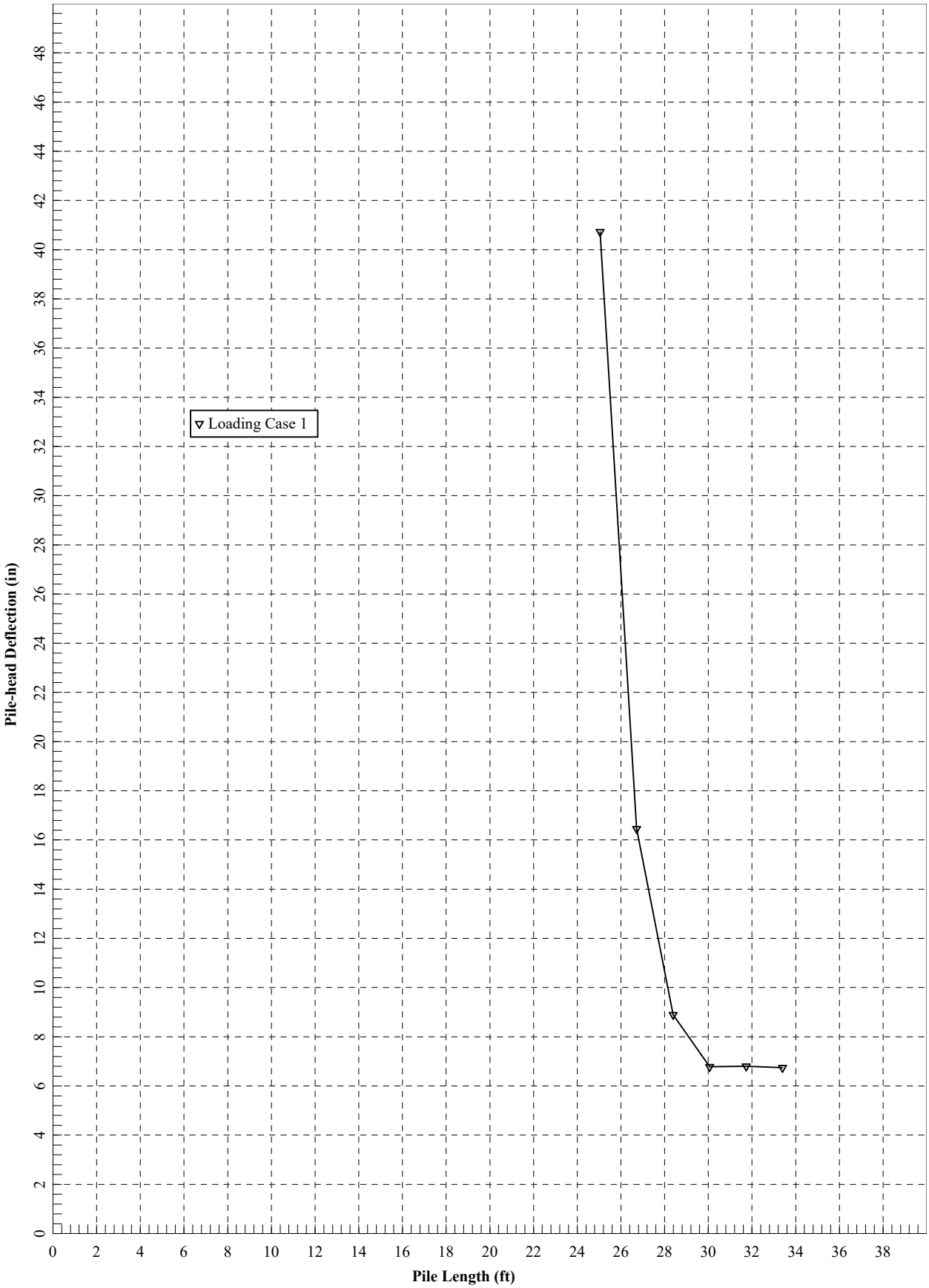
**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.

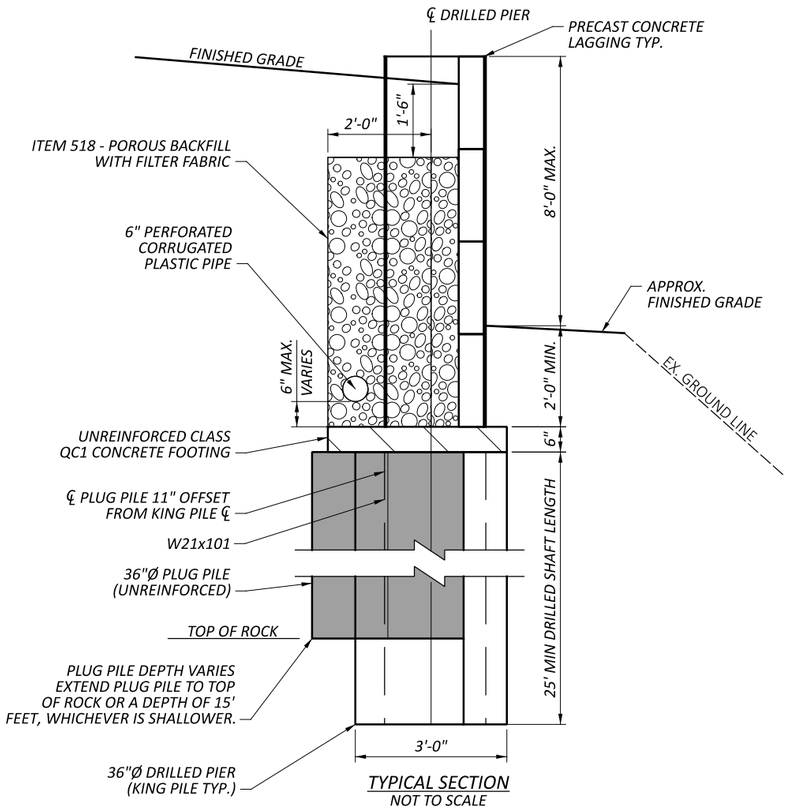

Bending Moment (in-kips)
-1000
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock


Shear Force (kips)
-60
-50
-40
-30
-20
-10
0
10
20
30
40
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock

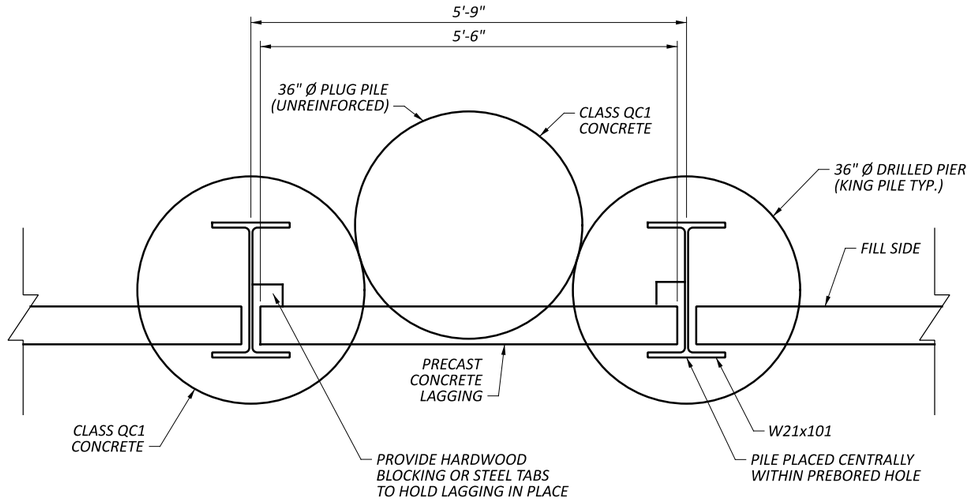

Loading Case 1
Pile-head Deflection (in)
Pile Length (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48

Soldier Pile Lagging Wall Detail

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

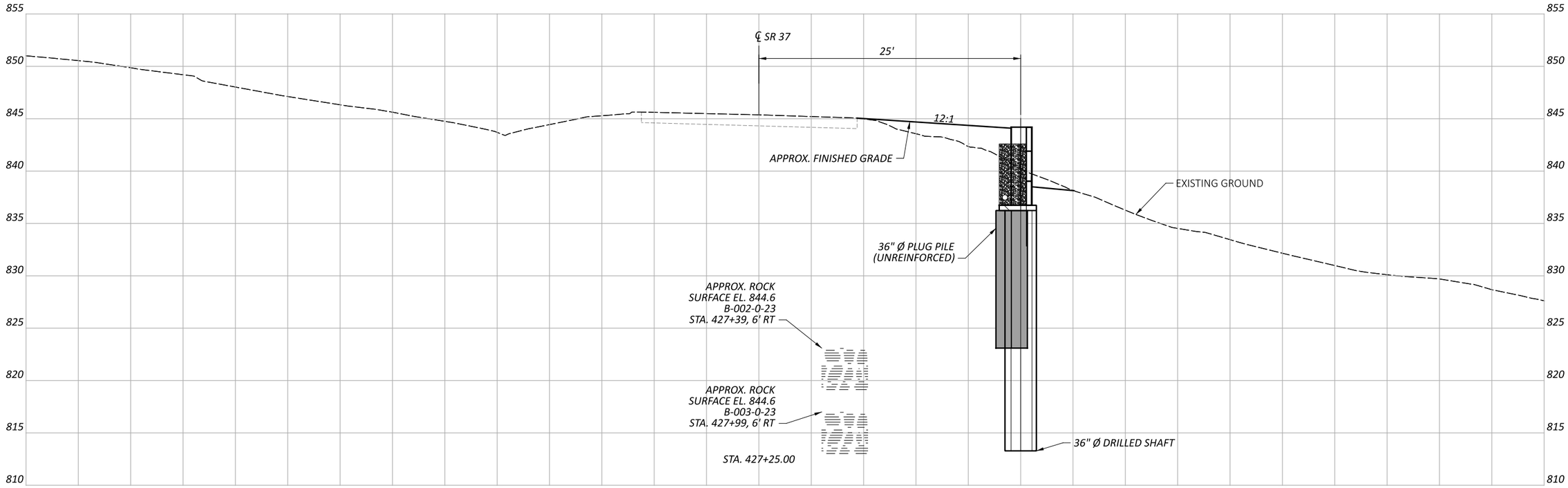


TYPICAL SECTION
NOT TO SCALE



PLAN - RETAINING WALL
NOT TO SCALE

BORING	STATION	OFFSET	APPROX. SURFACE ELEVATION	APPROX. ROCK SURFACE ELEVATION
B-001-0-23	426+25	6' RT	848.5	825.0
B-002-0-23	427+39	6' RT	844.6	823.1
B-003-0-23	427+99	6' RT	843.0	817.0



HORIZONTAL SCALE IN FEET
0 5 10 20

SOLDIER PILE AND LAGGING WALL DETAIL
CRITICAL SECTION STA. 427+25

DESIGN AGENCY
HDR

DESIGNER DCM
REVIEWER DMV 02/24/23
PROJECT ID 116165
SHEET 1 TOTAL 1

ATH-144-6.04