Technical Design Memo

Client:	Ohio Department of Transportation, District 9		
Project:	**JAC-327-14.99 (Task Order 2)** **PID 123842**		
HDR Project No:	10432061	Rev:	0
Calculation No:	1	Page:	1 of 127
Title:	Landslide Remediation Analyses and Design		
Purpose:	Prepare slope stability analyses and wall calculations for the design of a landslide repair along the northbound travel lane of State Route 327 (SR 327) in Jackson County, Ohio.		
Originator:	DCM	Date:	8/13/2025
Checked by:	AKB	Date:	8/22/2025
QC Review by:	DMV	Date:	8/28/2025

Summary

1. A landslide has occurred on the slope below SR 327 near mile marker 14.99 in Jackson 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 April 11, 2025, coupled with the findings from the geotechnical explorations performed on June 11 and 12, 2025, a soldier pile and lagging retaining wall is recommended to stabilize the landslide and repair SR 327. 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 5 test borings (designated as Borings B-001-0-25, B-002-0-25, B-002-1-25, B-003-0-25, and B-004-0-25) to characterize the subsurface profile in the vicinity of the existing landslide and develop repair recommendations. Four test borings were drilled within the northbound lane and 1 boring was drilled in the southbound lane of SR 327 at the locations shown on the attached Boring Location Plan. Typed boring logs are also included in the attachments to this memorandum. The soil profile, as encountered in the borings, generally consists of a layer of soft to medium stiff colluvium

underlain by stiff to very stiff cohesive soils transitioning to very stiff to hard residuum with depth. These overburden soils are predominantly underlain by interbedded very weak claystone and weak to slightly strong sandstone with the occasional very weak to weak shale or slightly strong siltstone layer encountered. Free water was not recorded in any of the borings during drilling or at completion, with the boreholes noted to be dry prior to coring. 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-002-0-25 and B-002-1-25, located near the design section at Sta. 790+25 and supplemented with information from the remaining borings. These soil profiles are 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. Jackson County lies within the Ironton Plateau region of the Allegheny (Kanawha) Plateaus section of the Appalachian Plateaus province as shown on the attached Physiographic Map of Ohio. The Ironton Plateau region has moderately high relief, with elevations generally ranging from 515 to 1,060 feet above sea level. Soils in the Ironton Plateau generally consist of the Pleistocene-age Minford Clay within the remnants of the Teays drainage system, as well as silt-loam and channery colluvium over Pennsylvanian-age bedrock. According to the Quaternary Geology of Ohio map from the Ohio Department of Natural Resources (ODNR) Division of Geological Survey included in the attachments, surficial soils at the site primarily consist of Cenozoic aged colluvium (Cc) derived from the local bedrock with scattered areas of residuum, weathered material, and bedrock outcrops. The underlying Pennsylvanian-age bedrock is mapped as belonging to the Allegheny and Pottsville Groups, Undivided, which consists of primarily shale and siltstone with lesser amounts of sandstone, limestone, and claystone.

4. Based on review of available mapping from the ODNR, coal mining was not noted to occur within the limits of the project site. However, significant deep mining has occurred throughout the surrounding area as shown on the attached mine map. Areas of underground mining associated with the Sharon No. 1, Quakertown No. 2, and Lower Mercer No. 3 coal seams were mapped as near as 0.3 mile south of the project site, with several unassociated mine openings mapped approximately 0.8 mile to 2.0 miles north to northeast of the site.

During the site reconnaissance, a vertical metal pipe was observed sticking out of the ground approximately 125 feet left of the roadway. Based on correspondence with ODOT and review of ODNR mapping, this pipe way be an abandoned well associated with the Hamden Consolidated gas field., which overlies the project site. Discovered in 1916, this gas field shows an average producing depth of 2700 feet and spans approximately 300 acres with currently over 80 wells. The ODNR Oil and Gas Map, as well as the well summary of the nearest well (No. 60428, noted as “Inactive”) is attached for reference.

5. Based on review of FEMA flood maps for the area, the project site is located within an area of minimal flood hazard (Zone X).

6. HDR is unaware of any prior geotechnical explorations at the JAC-327-14.99 project site. A search of the available records on ODOT's Transportation Information Mapping System (TIMS) reveals only the geographical locations of known landslide and rock fall activity in the project area, with no geotechnical explorations performed within the project limits. The nearest borings from a prior study are located approximately 1.0 mile to the northwest along SR 327.

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 790+25 was selected for design.

The developed soil parameters and subsurface profiles were then entered into the Slope/W slope stability modeling software to re-create the landslide as 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. In addition, the Slope/W optimization feature was utilized, which generates a hybrid circular and translational failure shape. 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.

Limited groundwater information was available from the borings and published sources. However, elevated moisture contents were noted along the soil profile, near the interface of the overlying colluvial soils and underlying residual soils. This is not unexpected given the project's location near the top of the ridge, with these elevated moisture contents likely the result of run-off infiltration and/or perched water which percolates down through the soil until encountering a less permeable layer. Based on the available information and on-site observations, groundwater was modeled from the existing drainage ditch to the right of the existing roadway, traveling approximately 2 feet above the encountered surface of the residual soils to the approximate elevation of the noted elevated moisture contents, and then along the ground surface to the base of the slope.

The depth to bedrock along the slope above SR 327 was estimated based on the terrain and the residuum/severely weathered rock as observed in the existing cut above SR 327 near the south end of the site during the site reconnaissance. Bedrock depths below SR 327 were estimated based on the existing terrain and the overburden thicknesses as encountered in the soil borings.

Pavement deformation and cracking were observed within the shoulder and extending into the northbound lane of SR 327 during the site reconnaissance. The analyses were performed to

generate a similar failure surface. Once the soil parameters and failure surfaces 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. The design section at Sta. 790+25 is located near the observed cracking and deformations in the pavement surface. As Borings B-003-0-24 and B-004-0-25 were drilled should the wall need to be extended beyond the current limits of the observed slope movement, the analyses were limited from approximately Sta. 789+25 (near Boring B-003-0-25) to the area of currently observed deformation near Sta. 791+00. Extending the wall downstation from Sta. 789+25 may require additional review of the design to confirm the adequacy of the recommended pile size. A wall offset of 21 feet from the centerline of the roadway allows for an 11-foot travel lane and a 2-foot shoulder, 2 feet for the guardrail and posts, and a 5-foot distance from the back of the guardrail posts to the back of the proposed 2-foot diameter drilled shafts for the soldier pile and lagging wall. This offset is assuming the removal of the existing retaining structure (sign posts and lagging) observed during the site reconnaissance. Should the posts not be able to be pulled/removed, the proposed soldier pile and lagging wall may be offset further down slope provided it remains within the existing right of way.

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 to determine the horizontal forces acting on the wall. The computed unfactored force per shaft is **Ps = 17,736** pounds based on 24-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 (only applied to existing condition analysis, as traffic loading is calculated elsewhere for the post-construction condition)
b. Layer 2 = Item 203 - Embankment fill (Proposed Condition Only)
c. Layer 3 = Soft to Medium Stiff Cohesive Soil
d. Layer 4 = Stiff to Very Stiff Cohesive Soil
e. Layer 5 = Residuum
f. Layer 6 = Claystone Bedrock
g. Layer 7 = Sandstone 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. Based on current slope geometries, the height of the exposed wall will increase from 7 ft at the design section Sta. 790+25 to a height of approximately 9.0 feet near Sta. 789+25. This taller wall height was used in calculating the earth pressures. The following were considered relative to LPILE analyses:

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

- Convert concentrated load from <u>UA Slope</u> to distributed load
  - $½(D_L)(H_T)$ = 17,736 lbs.

D_L = distributed load
H_T = 9.2 feet (top/wall to slip surface, see attached)

- D_L = [(17,736 lbs)(2)]/[(9.2')(12"/ft)] = Resolution of Triangular Area
  D_L = **<u>321 lbs/in</u>** (Service Load)
- (321 lbs/in)(γ_{EH}) = (321 lbs/in)(1.5) = **<u>482 lbs/in</u>** (Strength Load for Moment/Shear Analysis).

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

- Calculate <u>conventional earth pressure wall loading</u>.
  - Equivalent Fluid Weight (G_H) = (γ_m) * (K) = **<u>48 pcf</u>**
    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 = **<u>1942 lbs/ft</u>**
    H = Wall Height = 7.0 feet
  - Horizontal Force Per Shaft (P_{SH}) = P*(S_{cc}) = **<u>11,652 lbs/shaft</u>**
    S_{cc} = Center-to-Center Shaft Spacing = 6 ft
  - Resolve Horizontal Earth Pressure to Distributed Triangular Load
    (2* P_{SH}/H) / (12 in/ft)
    = **<u>216 lbs/in per shaft (Service Load)</u>**
    (216 lbs/in) (γ_{EH}) = (216 lbs/in) (1.5)
    = **<u>324 lbs/in per shaft (Strength Load)</u>**

Based on a comparison of the two loading methods, landslide loading from UA Slope was applied to the proposed wall.

(b) <u>Traffic Surcharge (per GDM Section 903.7, pg. 9-16)</u>

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) <u>Modification of p-y curves</u>

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 the shaft or bedrock (whichever is shallower).

- $\beta_a = 0.64(S/D)^{0.34}$ = $\beta_a = 0.64(6/2)^{0.34}$
- β_a = **<u>0.93</u>**

Downslope stability analyses of the maintenance bench and slope below the wall indicated a factor of safety of greater than 1.3. As such, an artificially lowered ground surface due to downslope instability does not apply.

(d) <u>Pile Head Deflection</u>

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 the pavement, the deflection must be limited to 2 inches. The centerline of the drilled shafts is anticipated to be located less than 10 feet from the edge of pavement. As such, a limited pile head deflection of 2 inches or less was adopted.

Computed Pile Head Deflection (HP 12 x 53) = **1.14 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 = 9.2 ft below top of wall
+10.0 ft
19.2 ft minimum pile length

- **Bottom of Drilled Shaft = 30 ft ≥ 19.2 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 rock socket length. Based on the encountered overlying claystones and weathered sandstone, as well as our experience with such local bedrock types, **a minimum rock socket length of 10 feet** is recommended.

(f) Steel Reinforcement and Pile Cross Section Character

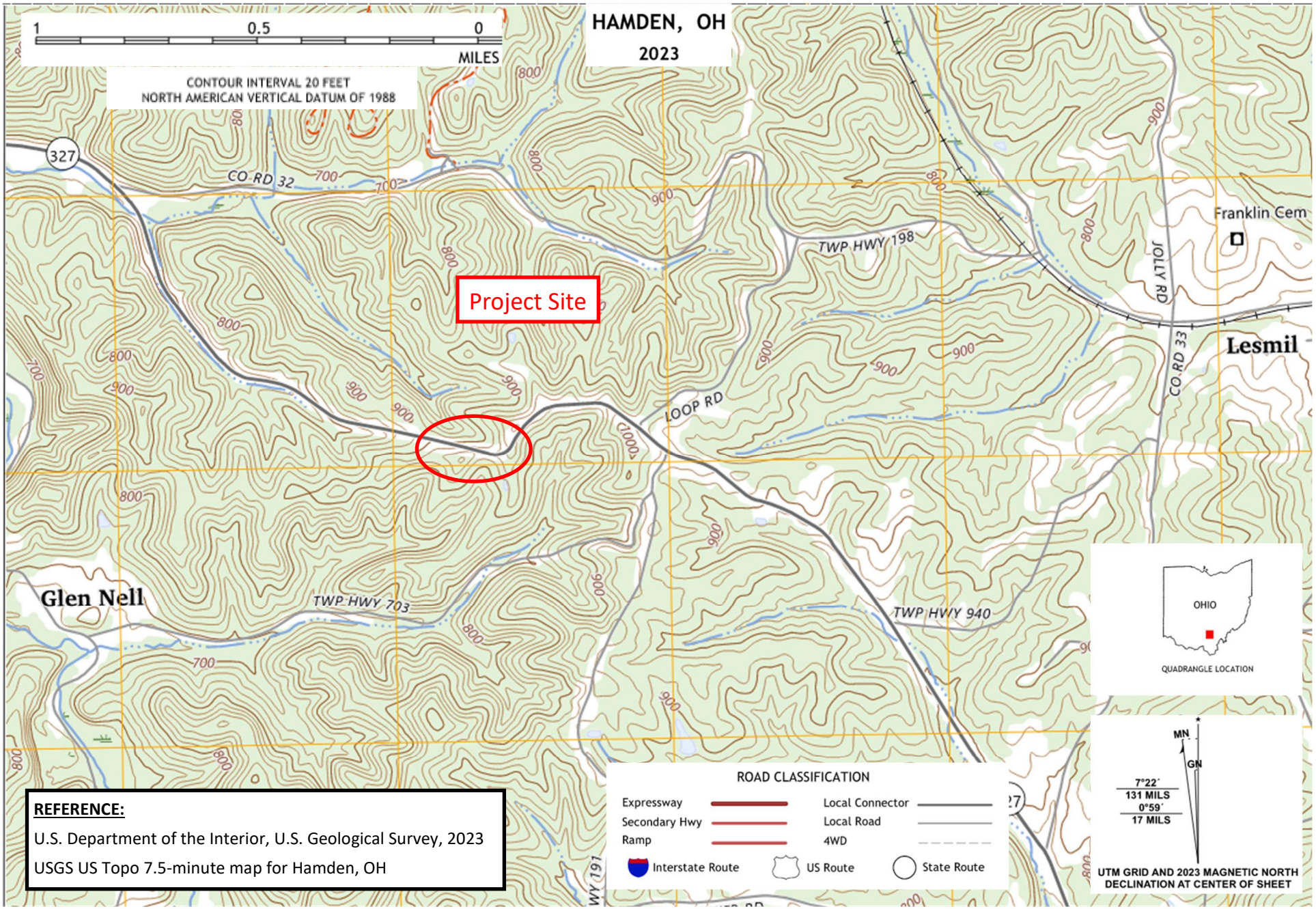
Use HP 12 x 53 shaft reinforcement

A_s = Area of Steel = 15.5 in^2
I_x = Moment of Inertia around strong axis = 393 in^4
T_w = web thickness = 0.435 in
E = Modulus of Elasticity of Steel = 29,000,000 psi
F_y = yield strength of steel = 50,000 psi
B_f = Flange Width = 12.0 in

10. Please refer to the attached "Soldier Pile and Lagging Wall Details" sheet for details on the soldier pile and lagging wall to assist with the plan development.

Site Vicinity and Topographic Map

Site Vicinity and Topographic Map



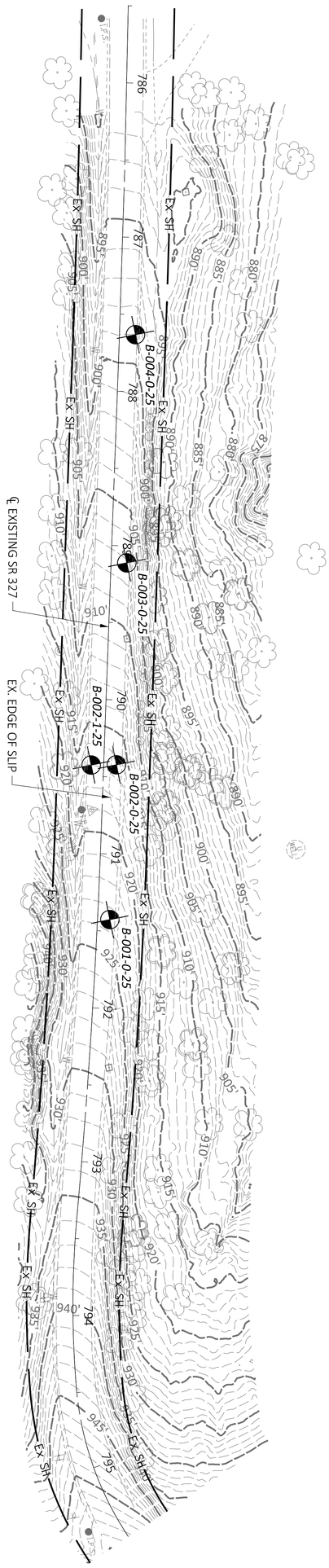
REFERENCE:

U.S. Department of the Interior, U.S. Geological Survey, 2023

USGS US Topo 7.5-minute map for Hamden, OH

Boring Location Plan

MODEL: Boring Location Plan [Sheet] PAPERSIZE: 34x22 (in.) DATE: 7/30/2025 TIME: 1:47:08 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Christopher.Wahlbrink@hdrinc.com WORKSPACE: OHDOTCEv02 WORKSET: 123842 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 09\Jackson\123842\401-Engineering_HDR\Geotechnical\Sheets\123842_IP901.dgn



BORING LOCATION PLAN
JAC-327-14.99

HORIZONTAL SCALE IN FEET
0 40
20 80

DESIGNER	REVIEWER	PROJECT ID	SHEET	TOTAL
DCM	DMV MM-DD-YY	123842	1	1

DESIGN AGENCY

Boring Logs
and
Rock Core Photos

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 791+42, 8' LT.	EXPLORATION ID B-001-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 923.5 (MSL) EOB: 35.8 ft.	PAGE 1 OF 2
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153744, -82.605456	

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 (14")	923.5																	
	922.3																	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, TRACE GRAVEL, MOIST		1	4 5 6	15	89	SS-1	-	5	7	61	16	11	NP	NP	NP	13	A-3a (0)	
	920.0	2																
STIFF TO VERY STIFF, BROWN, TRACE GRAY, **CLAY**, SOME SILT, TRACE GRAVEL, TRACE SAND, DAMP		3																
		4	5 5 5	13	78	SS-2	3.00	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
		5																
		6	6 6 7	18	100	SS-3	3.75	2	4	3	29	62	45	27	18	20	A-7-6 (12)	
	915.0	7																
HARD, GRAY, **SILT**, SOME CLAY, LITTLE SAND, DAMP (RESIDUUM)		8																
		9	7 10 13	31	100	SS-4	4.5+	-	-	-	-	-	-	-	-	15	A-4b (V)	
@11.0' - 12.5': brown		10																
		11	6 10 14	32	100	SS-5	4.5+	-	-	-	-	-	-	-	-	14	A-4b (V)	
		12																
		13	27 50/4"	-	100	SS-6	-	0	3	9	57	31	31	21	10	7	A-4b (8)	
		14																
		15	21 35 50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	10	A-4b (V)	
	905.0	16																
CLAYSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.		17 TR	48 50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	903.0	18																
CLAYSTONE, GRAY, TRACE BROWN, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 84%, REC 100%.		19																
@22.8': change to gray		20																
		21																
		22																
		23																
		24																
		25	80		100	NQ2-1											CORE	
@26.6' - 27.0': qu = 87 psi		26																
		27																
		28																
		29																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 8/28/25 12:25 - C:\PWWORKING\EAST01A\DMS03206\JAC-327-14.99.GPJ

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 791+42, 8' LT.	START: 6/12/25	END: 6/12/25	PG 2 OF 2	B-001-0-25

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 BROWN, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 84%, REC 100%. *(continued)*	893.5	31 32 33	90		100	NQ2-2											CORE	
CLAYSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 75%, REC 100%.	889.1	34 35 EOB																
	887.7																	

NOTES: NONE

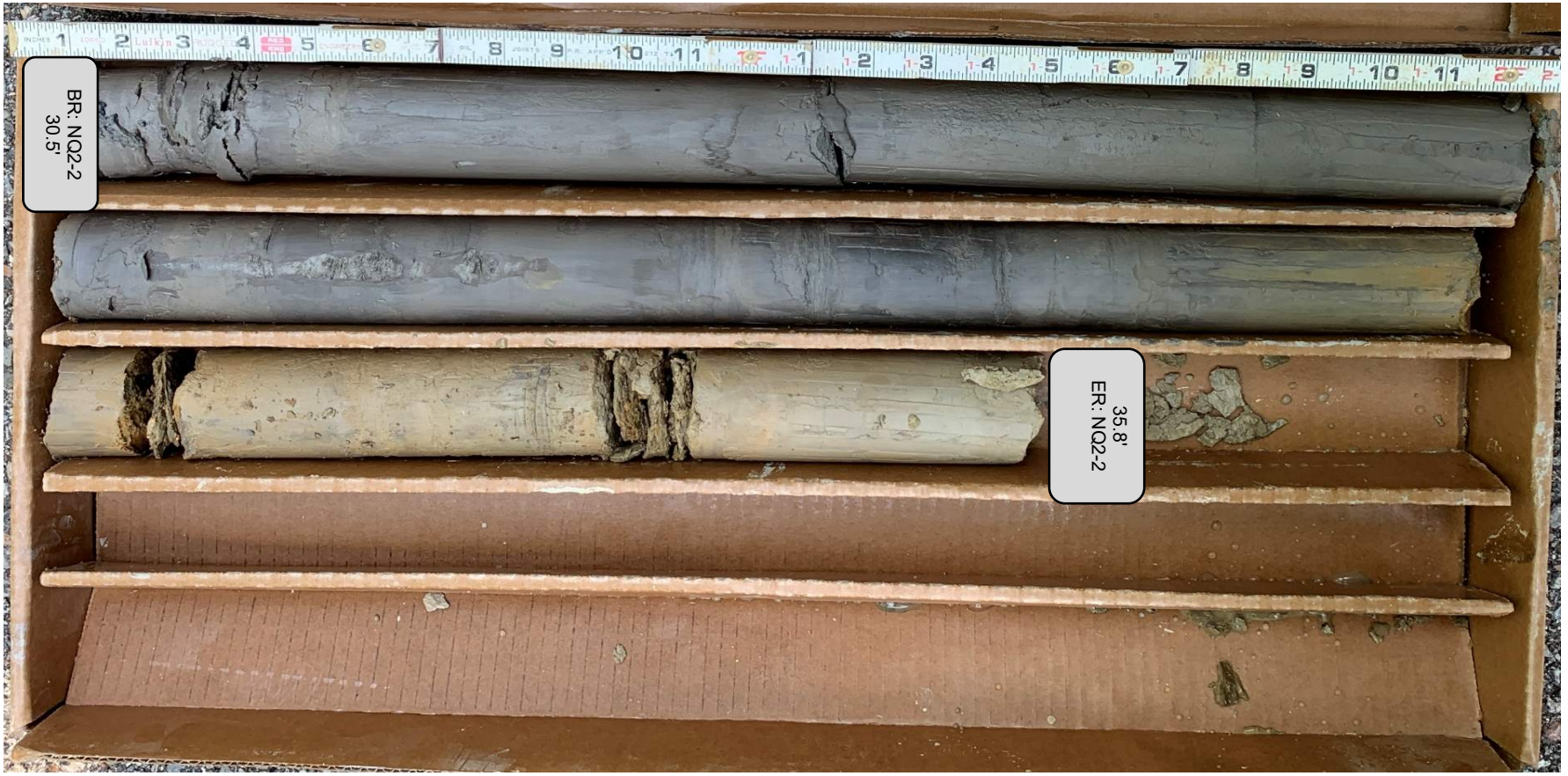
ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

B-001-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	20.5	30.5	120 in. / 120 in.	100%	96 in. / 120 in.	80%

JAC-327-14.99 PID 123842

B-001-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-2	30.5	35.8	63 in. / 63 in.	100%	57 in. / 63 in.	90%

JAC-327-14.99 PID 123842

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 790+42, 8' LT.	EXPLORATION ID B-002-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 916.4 (MSL) EOB: 40.4 ft.	PAGE 1 OF 2
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153810, -82.605800	

MATERIAL DESCRIPTION AND NOTES	ELEV. 916.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (21")	914.6	1																
MEDIUM STIFF, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, MOIST	912.9	2	2 1 3	5	50	SS-1	0.50	0	6	30	37	27	23	16	7	17	A-4a (6)	
MEDIUM STIFF, DARK BROWN, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP	911.4	3	5 2 2	5	11	SS-2	-	18	14	20	28	20	25	17	8	11	A-4a (3)	
SOFT, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	909.9	4	1 2 1	4	78	SS-3	0.00	7	6	32	36	19	23	17	6	19	A-4a (4)	
MEDIUM STIFF TO STIFF, MOTTLED BROWN AND GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, IRON STAINED, DAMP	907.9	5			83	ST-4	1.50	3	11	19	37	30	37	22	15	19	A-6a (8)	
@7.3' - 7.8': qu = 1661 psf		6																
STIFF TO VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, DAMP	906.4	7	3 3 4	9	100	SS-5	2.25	2	8	6	25	59	48	28	20	21	A-7-6 (14)	
VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, DAMP (RESIDUUM)	904.9	8	4 5 8	18	28	SS-6	3.75	1	7	5	25	62	50	29	21	20	A-7-6 (14)	
VERY STIFF TO HARD, GRAY TO BROWN, **SILT AND CLAY**, TRACE SAND, DAMP (RESIDUUM)		9	6 8 9	23	78	SS-7	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
		10	7 13 14	36	39	SS-8	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		11	13 16 19	47	89	SS-9	4.5+	0	0	4	60	36	35	22	13	10	A-6a (9)	
		12	15 23 31	73	78	SS-10	-	-	-	-	-	-	-	-	-	11	A-6a (V)	
		13	14 19 26	61	100	SS-11	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
		14	29 45 50/5"	-	82	SS-12	-	-	-	-	-	-	-	-	-	8	A-6a (V)	
	896.0	TR																
CLAYSTONE, BROWN, SLIGHTLY TO MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, ARENACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 75%, REC 100%.	892.0	15	75		100	NQ2-1											CORE	
@23.7' - 24.1': qu = 216 psi		16																
SANDSTONE, BROWN TO GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM TO COARSE GRAINED, MEDIUM TO THICK BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 53%, REC 100%.		17	53		100	NQ2-2											CORE	

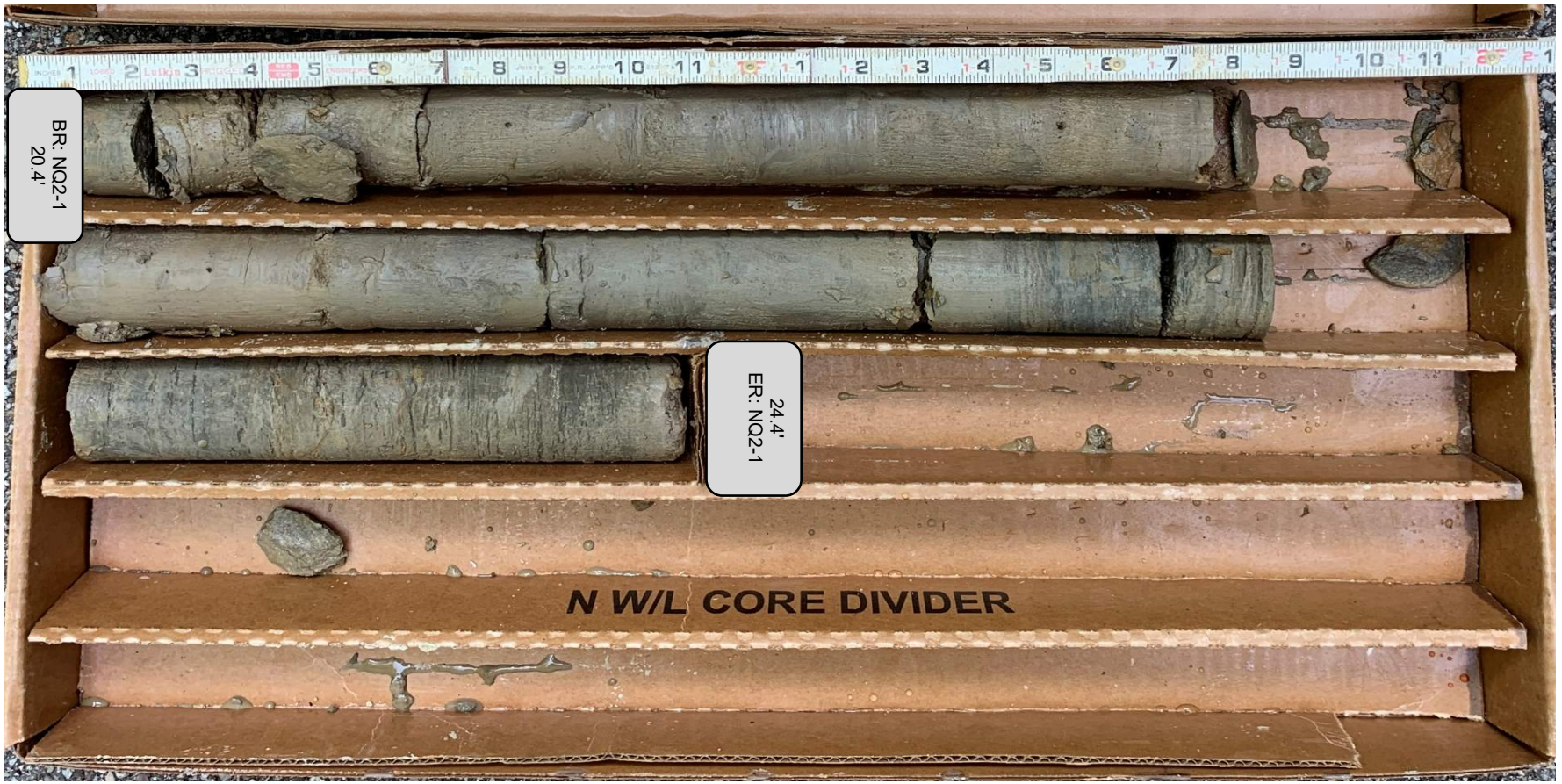
PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 790+42, 8' LT.	START: 6/12/25	END: 6/12/25	PG 2 OF 2	B-002-0-25

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
@29.3': becomes brown, contains black laminations **SANDSTONE**, BROWN TO GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM TO COARSE GRAINED, MEDIUM TO THICK BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 53%, REC 100%. *(continued)*	886.4	31 32 33 34																
	879.3	35 36 37	65		99	NQ2-3											CORE	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 73%, REC 98%. @37.1' - 37.5': 5" claystone layer, gray, very weak	876.0	38 39 40 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

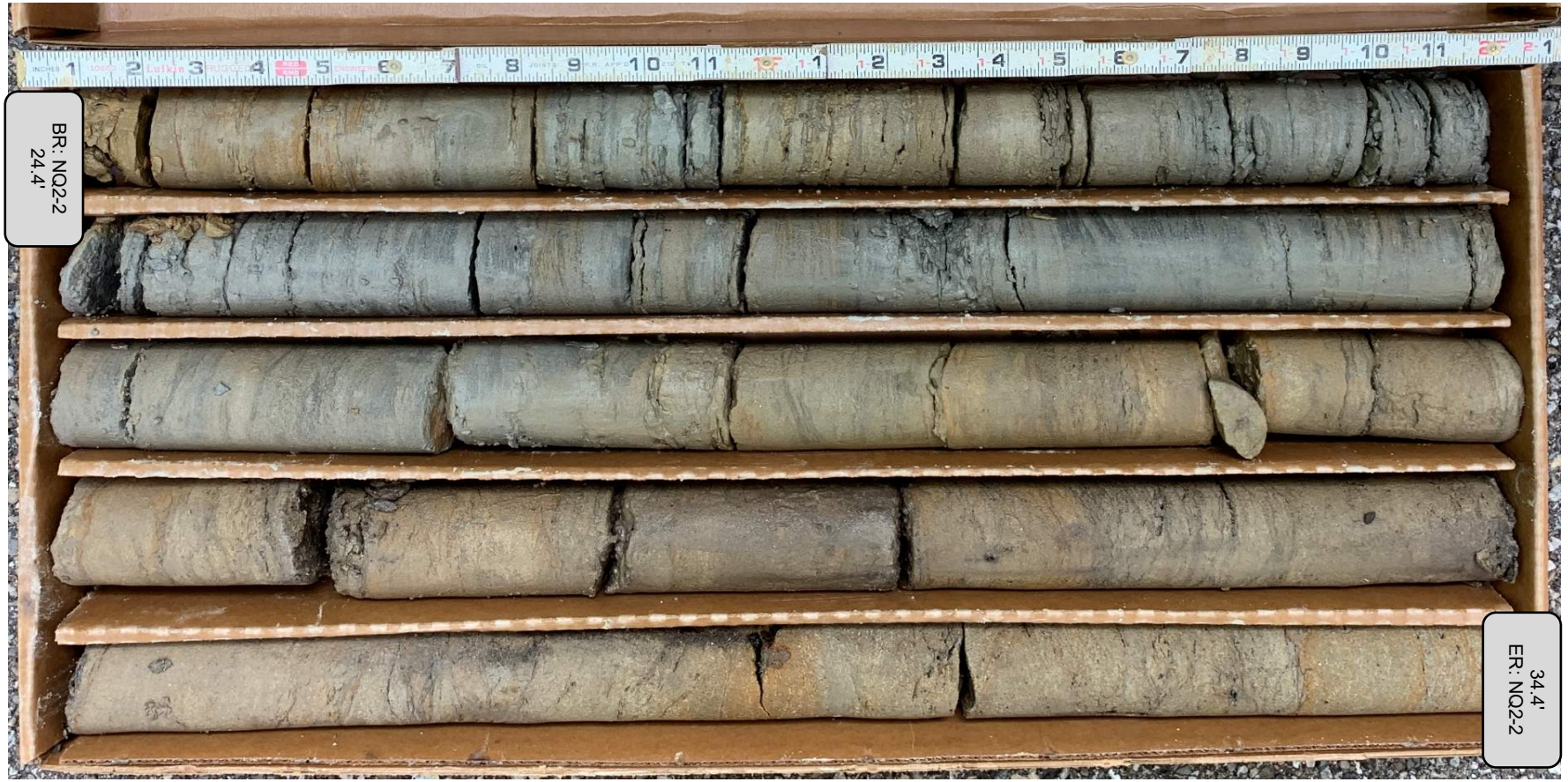
B-002-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	20.4	24.4	48 in. / 48 in.	100%	36 in. / 48 in.	75%

JAC-327-14.99 PID 123842

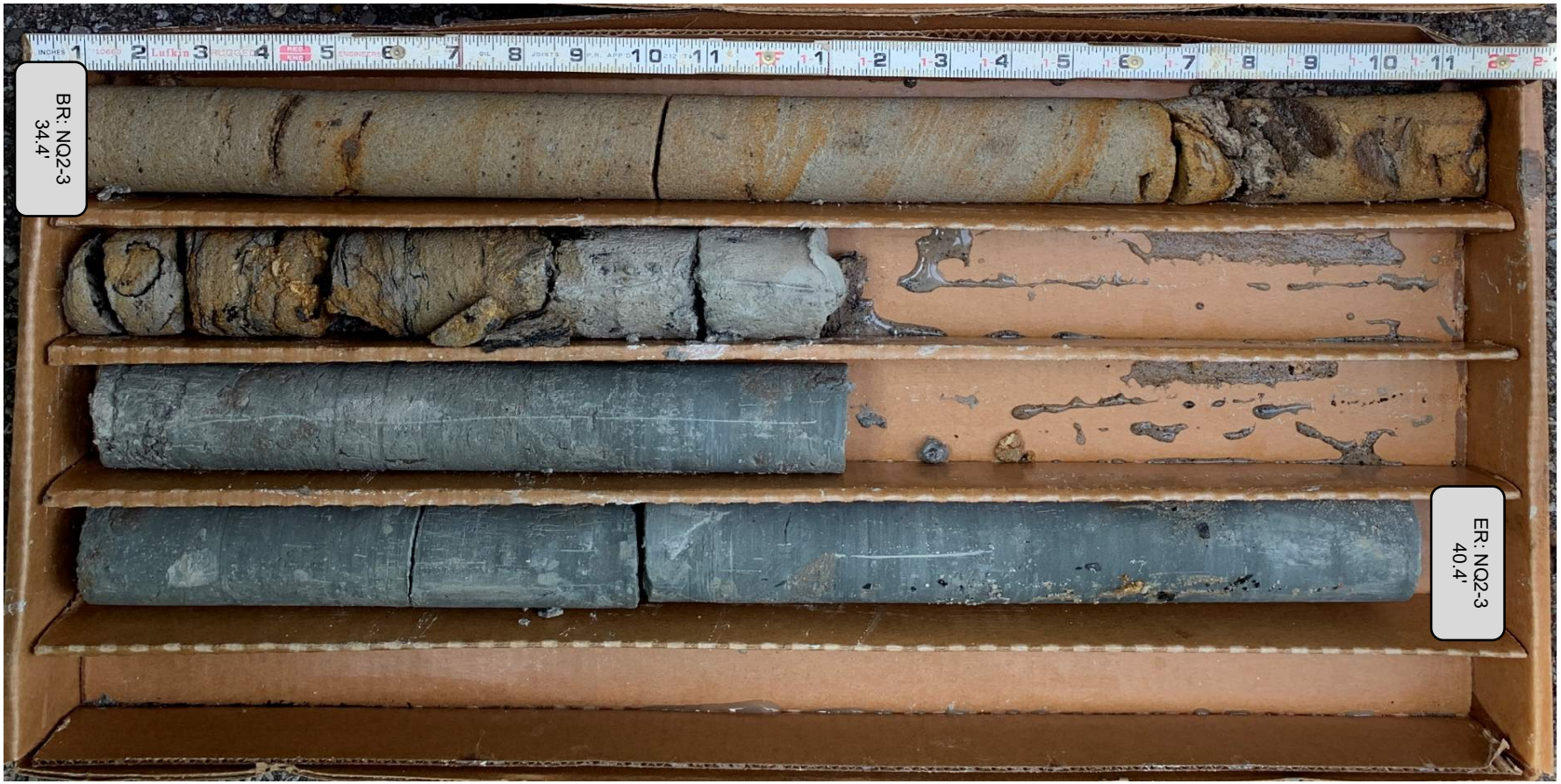
B-002-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-2	24.4	34.4	120 in. / 120 in.	100%	63 in. / 120 in.	53%

JAC-327-14.99 PID 123842

B-002-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	34.4	40.4	71 in. / 72 in.	99%	47 in. / 72 in.	65%

JAC-327-14.99 PID 123842

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 790+43, 8' RT.	EXPLORATION ID B-002-1-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 917.0 (MSL) EOB: 18.8 ft.	PAGE 1 OF 1
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153766, -82.605811	

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 (14")	917.0																	
	915.8	1																
MEDIUM STIFF TO STIFF, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, NOTED IRON STAINING, MOIST		2	3 4 3	9	83	SS-1	3.50	-	-	-	-	-	-	-	-	17	A-4a (V)	
		3																
		4	2 2 3	7	83	SS-2	1.00	2	6	25	40	27	28	18	10	22	A-4a (6)	
	911.0	5																
STIFF TO VERY STIFF, MOTTLED BROWN AND GRAY, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP		6	3 5 5	13	78	SS-3	2.25	6	7	4	36	47	45	29	16	18	A-7-6 (11)	
	908.5	7																
VERY STIFF TO HARD, BROWN, **SILT**, SOME CLAY, TRACE SAND, DAMP (RESIDUUM)		8																
		9	7 9 14	31	100	SS-4	2.75	-	-	-	-	-	-	-	-	13	A-4b (V)	
		10																
		11																
		12	12 21 27	65	100	SS-5	4.5+	-	-	-	-	-	-	-	-	11	A-4b (V)	
		13																
		14	20 31 50/4"	-	100	SS-6	-	0	2	8	61	29	31	22	9	6	A-4b (8)	
		15																
		16																
		17	30 36 42	105	100	SS-7	-	-	-	-	-	-	-	-	-	8	A-4b (V)	
	898.5	18																
CLAYSTONE, BROWN, SEVERELY WEATHERED, VERY WEAK.	898.2	TR. EOB	50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	6	Rock (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 8/28/25 12:25 - C:\PWWORKING\EAST01A\DMS03206\JAC-327-14.99.GPJ

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 789+11, 10' LT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 907.1 (MSL) EOB: 36.3 ft.
START: 6/11/25 END: 6/11/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153899, -82.606248

EXPLORATION ID B-003-0-25

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")	907.1																	
	904.1		7 3 1	5	28	SS-1	-	-	-	-	-	-	-	-	-	-		
MEDIUM STIFF TO STIFF, GRAY AND BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DRY	902.6		2 3 3	8	22	SS-2	1.50	3	5	9	44	39	35	23	12	1	A-6a (9)	
MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST			2 2 2	5	83	SS-3	2.25	-	-	-	-	-	-	-	-	21	A-6a (V)	
			2 2 3	7	39	SS-4	0.75	-	-	-	-	-	-	-	-	17	A-6a (V)	
	898.1		2 2 2	5	78	SS-5	0.75	2	7	25	44	22	36	24	12	27	A-6a (7)	
MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, DAMP @9.5' - 10.0': qu = 1884 psf	896.1				100	ST-6	4.5+	5	8	29	32	26	30	19	11	18	A-6a (5)	
HARD, BROWN, **SILT**, SOME SAND, SOME CLAY, DAMP (RESIDUUM)	893.1		8 16 26	57	72	SS-7	4.5+	-	-	-	-	-	-	-	-	7	A-4b (V)	
			18 35 47	111	72	SS-8	-	0	5	19	55	21	28	21	7	7	A-4b (8)	
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.	891.6	TR	25 50/5"	-	100	SS-9	-	-	-	-	-	-	-	-	-	6	Rock (V)	
			50/4"	-	100	SS-10	-	-	-	-	-	-	-	-	-	6	Rock (V)	
SANDSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 38%, REC 100%. @17.9' - 18.3': qu = 162 psi	885.9		50		100	NQ2-1											CORE	
SANDSTONE, BROWN TO GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG, COARSE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING AND BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 62%, REC 100%.	880.8																	
SHALE, BLACK, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, NOTED IRON STAINING, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, LAMINATED/SHEARED STRUCTURE, POOR SURFACE; RQD 0%, REC 100%.	880.2 877.5		25		87	NQ2-2											CORE	

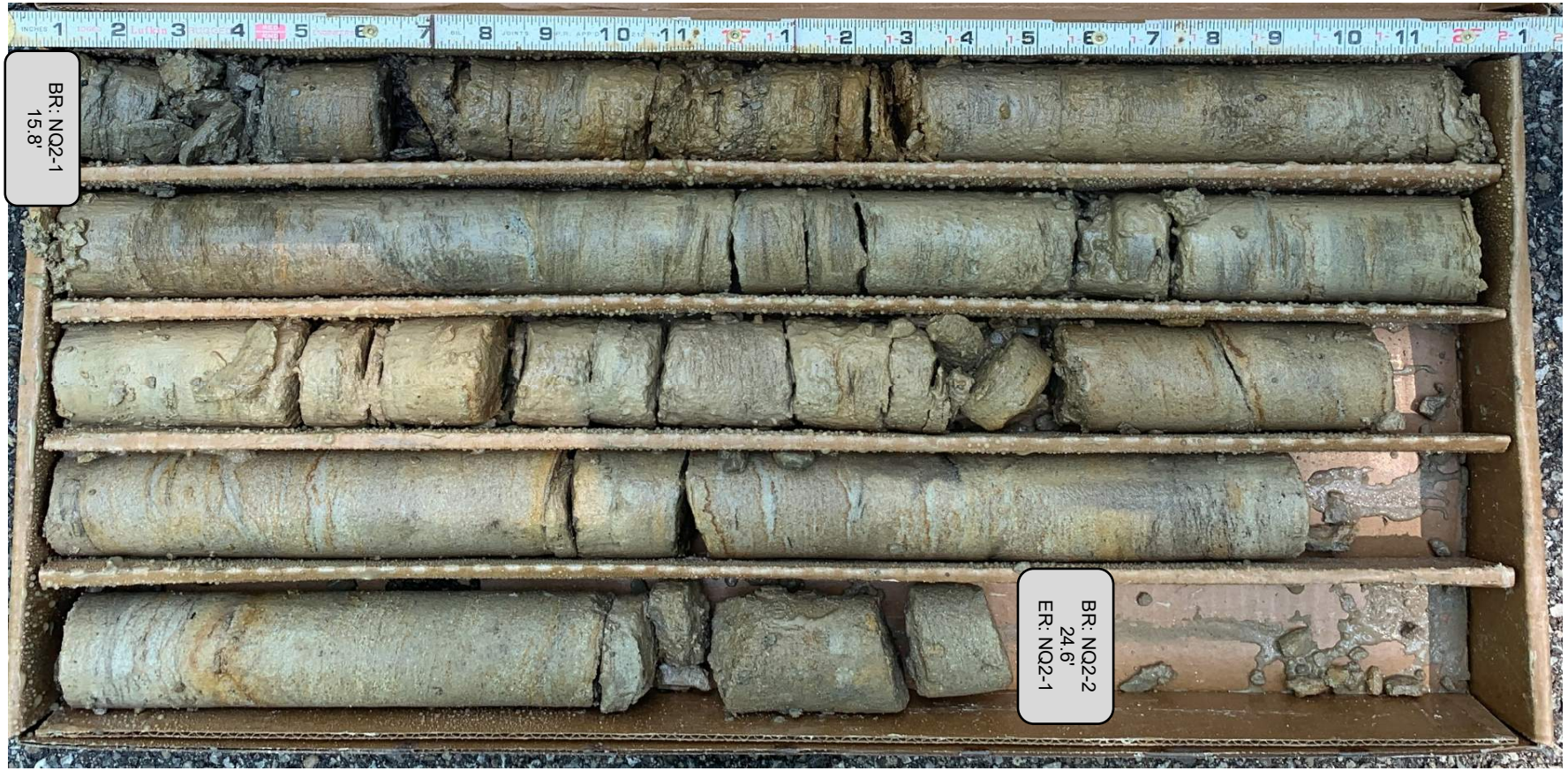
PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 789+11, 10' LT.	START: 6/11/25	END: 6/11/25	PG 2 OF 2	B-003-0-25

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
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, ARENACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, VERY BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 15%, REC 76%. @27.8': clay seam @28.2': 1" red-brown seam @29', 29.3' and 29.6': clay seams @29.6': 3" coal seam	877.1 876.0	31																
CLAYSTONE, DARK GRAY TO BLACK, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN BEDDED, CARBONACEOUS, JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 28%, REC 100%. *(continued)* @30.3': 3" coal seam	874.0	32 33	63		100	NQ2-3											CORE	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 38%, REC 100%.		34																
SANDSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, INTACT OR MASSIVE STRUCTURE, GOOD SURFACE; RQD 95%, REC 100%.	870.8	35 36 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

B-003-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	15.8	24.6	105 in. / 105 in.	100%	52 in. / 105 in.	50%

JAC-327-14.99 PID 123842

B-003-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-2	24.6	29.6	52 in. / 60 in.	87%	15 in. / 60 in.	25%

JAC-327-14.99 PID 123842

B-003-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-3	29.6	36.3	80 in. / 80 in.	100%	50 in. / 80 in.	63%

JAC-327-14.99 PID 123842

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 787+63, 10' LT.	EXPLORATION ID B-004-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 899.0 (MSL) EOB: 28.5 ft.	PAGE 1 OF 2
START: 6/11/25 END: 6/11/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153995, -82.606755	

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 (21") AGGREGATE BASE (3")	899.0 897.0																	
VERY STIFF, GRAY AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP (FILL)	895.5		6 10 9	26	94	SS-1	2.75	8	12	22	44	14	24	20	4	11	A-4a (5)	
STIFF TO VERY STIFF, BROWN MOTTLED GRAY, **SILT AND CLAY**, LITTLE SAND, NOTED IRON STAINING, DAMP	893.0		5 5 6	15	72	SS-2	2.00	0	1	17	51	31	33	21	12	16	A-6a (9)	
HARD, GRAY, **SILT**, SOME SAND, SOME CLAY, TRACE GRAVEL, DAMP (RESIDUUM)	888.0		9 16 22	51	100	SS-3	4.5+	-	-	-	-	-	-	-	-	8	A-4b (V)	
			18 35 50/4"	-	100	SS-4	4.5+	1	1	24	51	23	28	22	6	8	A-4b (8)	
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK, ARENACEOUS.	885.5	TR	32 50/1"	-	100	SS-5	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SANDSTONE, BROWN AND DARK GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG, FINE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING, CONTAINS BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, VERY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 59%, REC 100%. @15.8' - 16.2': qu = 2385 psi @16.8', 17.0', 17.4', 17.7': gray clay seams	881.6 879.6		50/0" 62	-	100	SS-6 NQ2-1	-	-	-	-	-	-	-	-	-	-	Rock (V) CORE	
SANDSTONE, GRAY TRACE BROWN, SLIGHTLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, COARSE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING, CONTAINS BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED, OPEN APERTURE WIDTH, VERY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 72%, REC 100%. @18.3' - 18.7': qu = 2596 psi	878.7 877.3 874.8		27		95	NQ2-2										CORE	
SHALE, BLACK, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, NOTED IRON STAINING, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, LAMINATED/SHEARED STRUCTURE, FAIR SURFACE; RQD 0%, REC 100%.			70		100	NQ2-3										CORE	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE,	870.5	EOB																

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 787+63, 10' LT.	START: 6/11/25	END: 6/11/25	PG 2 OF 2	B-004-0-25

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
BLOCKY STRUCTURE, GOOD SURFACE; RQD 41%, REC 100%.	869.0																	
CLAYSTONE, GRAY TO BLACK, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 17%, REC 90%. @22.7' - 23.0': carbonaceous shale layer																		
SANDSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, INTACT OR MASSIVE STRUCTURE, GOOD SURFACE; RQD 75%, REC 100%. @24.4', 24.8', 24.9': clay seams @25.4' - 25.8': qu = 1644 psi																		

NOTES: NONE

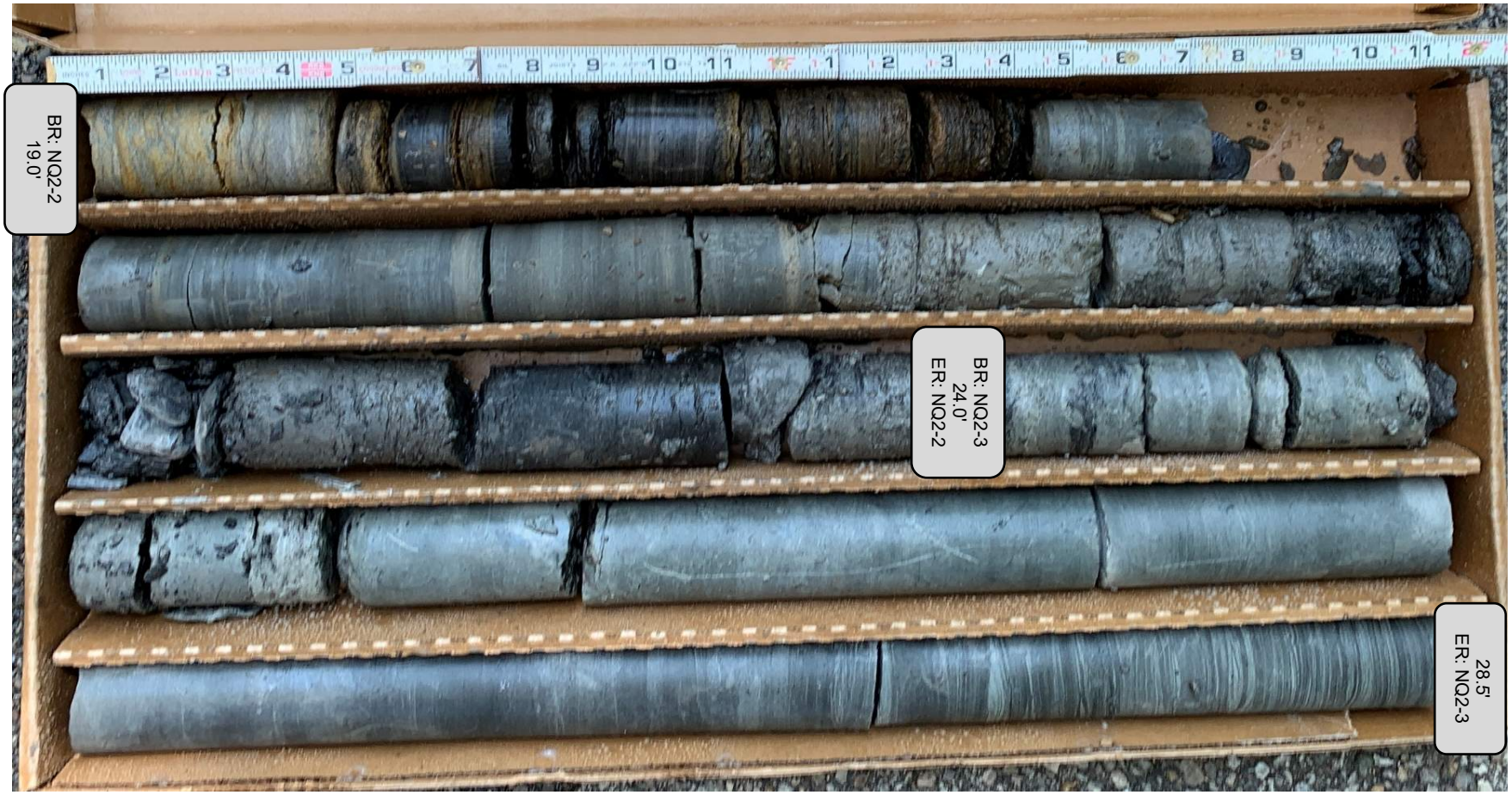
ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

B-004-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	15.0	19.0	48 in. / 48 in.	100%	41 in. / 48 in.	85%

JAC-327-14.99 PID 123842

B-004-0-25

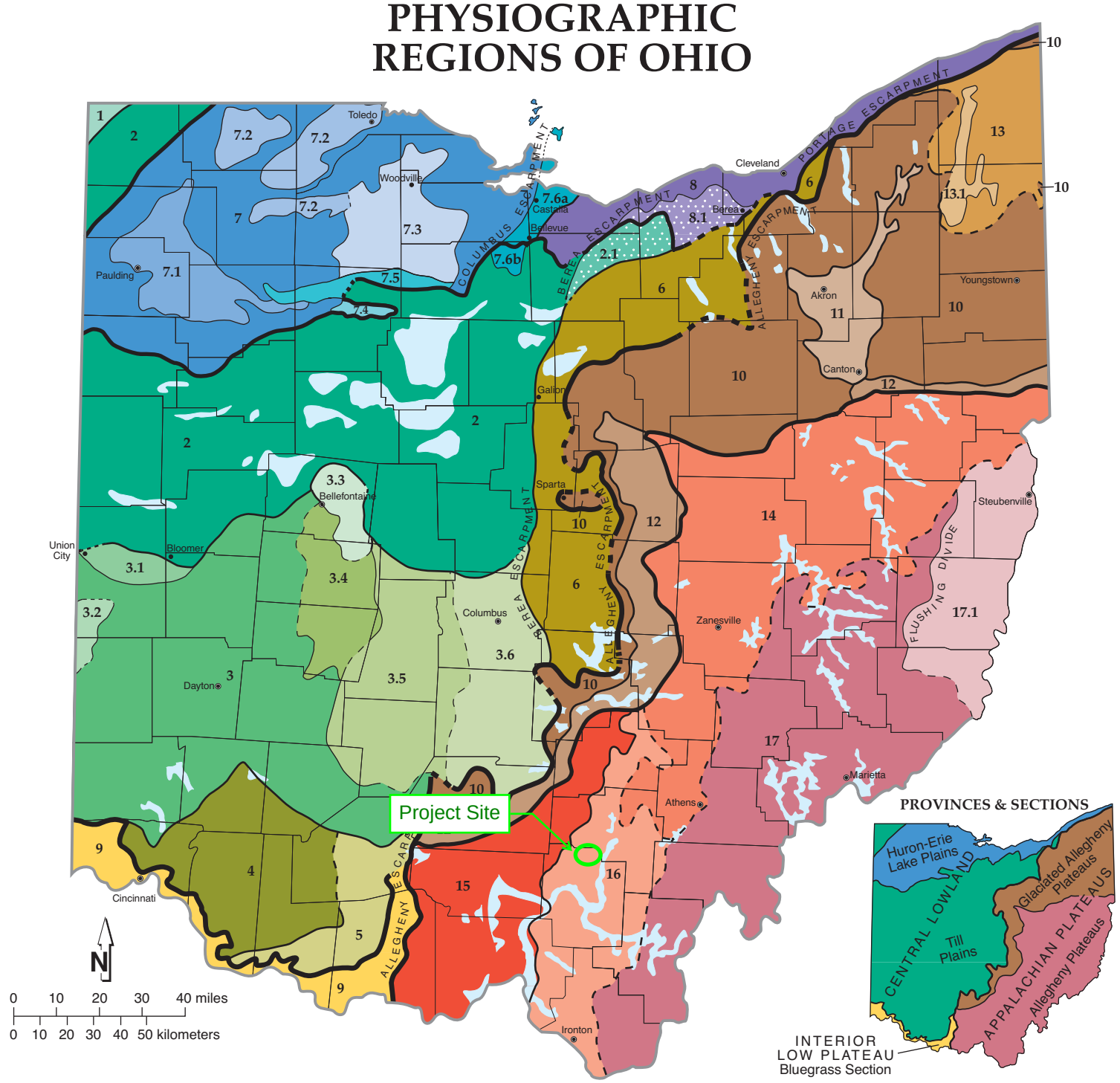


Run #	Depth (ft)		Recovery		RQD	
NQ2-2	19.0	24.0	57 in. / 60 in.	95%	16 in. / 60 in.	27%
NQ2-3	24.0	28.5	54 in. / 54 in.	100%	38 in. / 54 in.	70%

JAC-327-14.99 PID 123842

Physiographic Regions of Ohio Map

PHYSIOGRAPHIC REGIONS OF OHIO



Till Plains

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

Transitional boundary

Lake basin/deposits outside Huron-Erie Lake Plains

Huron-Erie Lake Plains

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

Bluegrass Section

- 9. Outer Bluegrass Region

Glaciated Allegheny Plateaus

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

Allegheny Plateaus

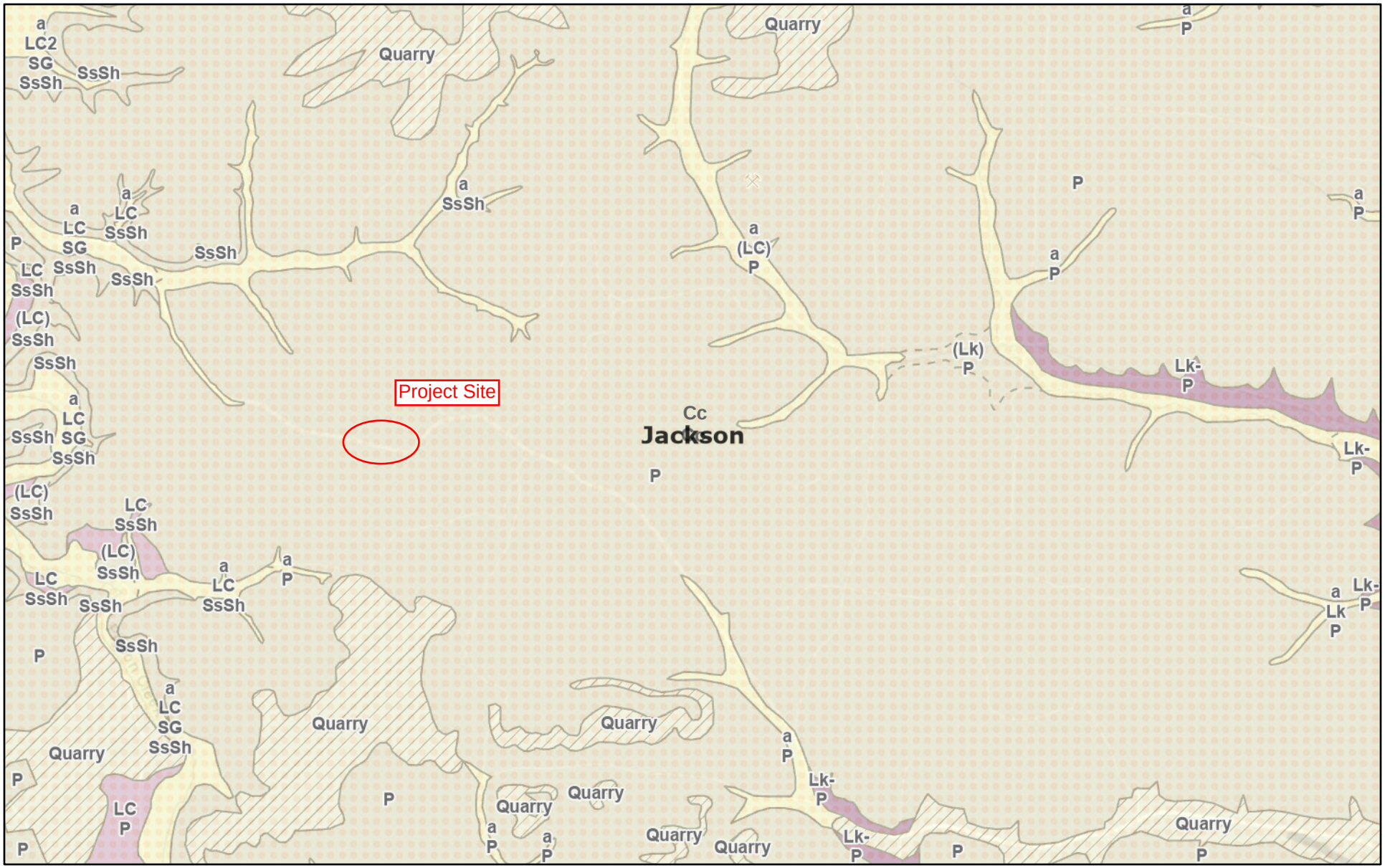
- 14. Muskingum-Pittsburgh Plateau
- 15. Shawnee-Mississippian Plateau
- 16. Ironton Plateau
- 17. Marietta Plateau
  - 17.1. Little Switzerland Plateau

4/98

Recommended citation: Ohio Division of Geological Survey, 1998, Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

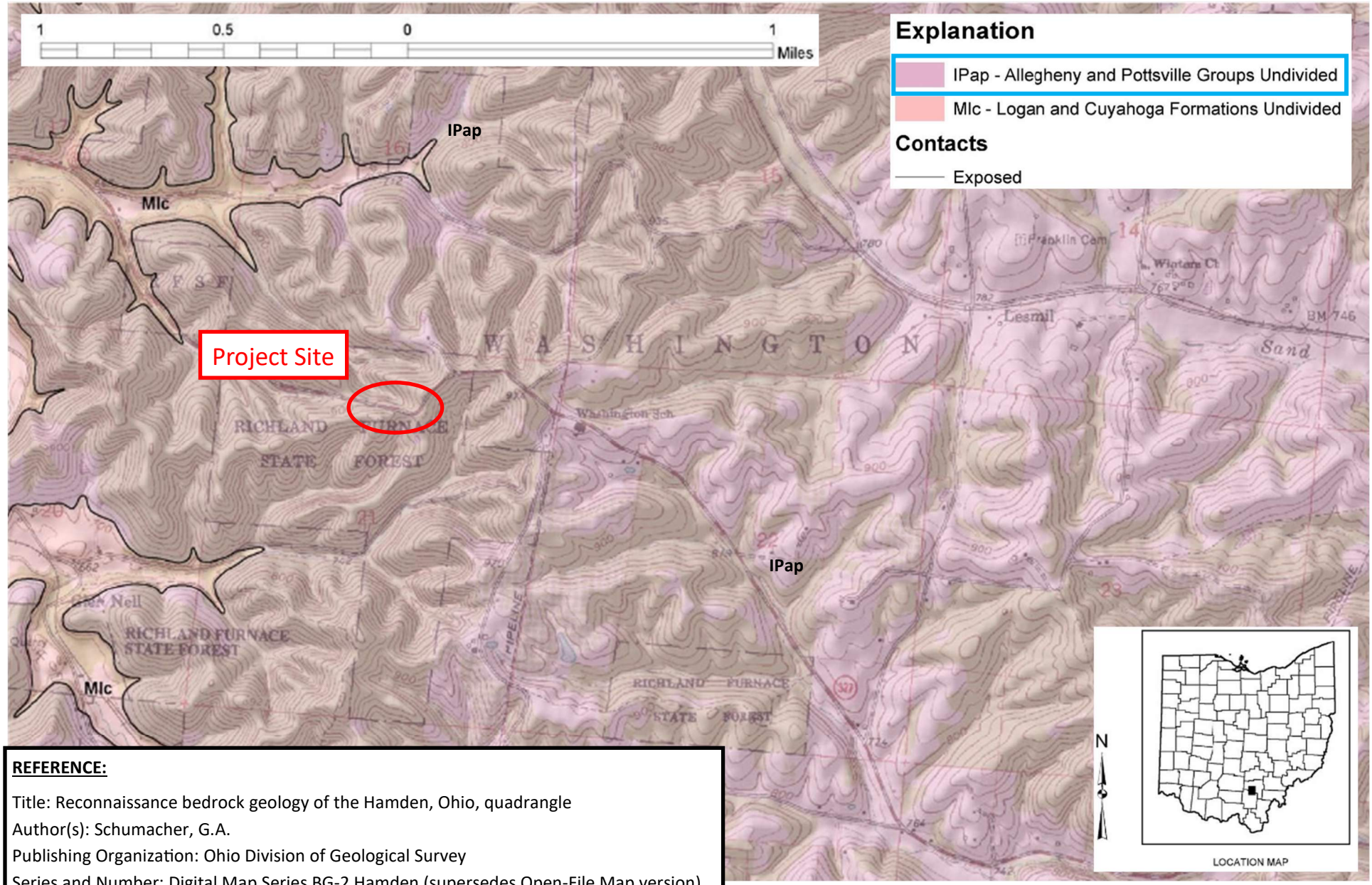
Surficial Geology Map

Surficial Geology Map



Bedrock Geology and Topography Maps

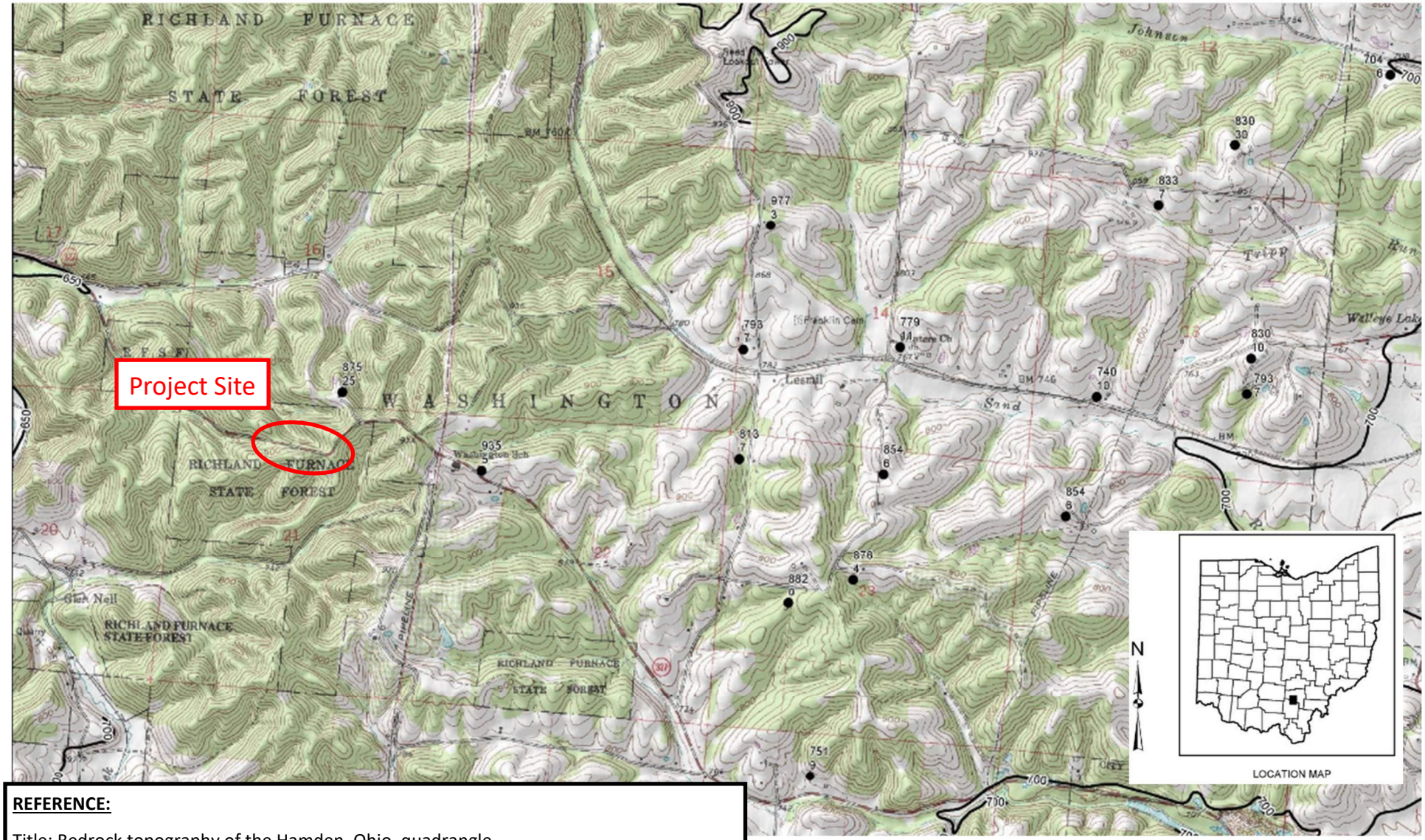
Bedrock Geology Map



REFERENCE:

Title: Reconnaissance bedrock geology of the Hamden, Ohio, quadrangle
Author(s): Schumacher, G.A.
Publishing Organization: Ohio Division of Geological Survey
Series and Number: Digital Map Series BG-2 Hamden (supersedes Open-File Map version)
Publication Date: 1995

Bedrock Topography Map

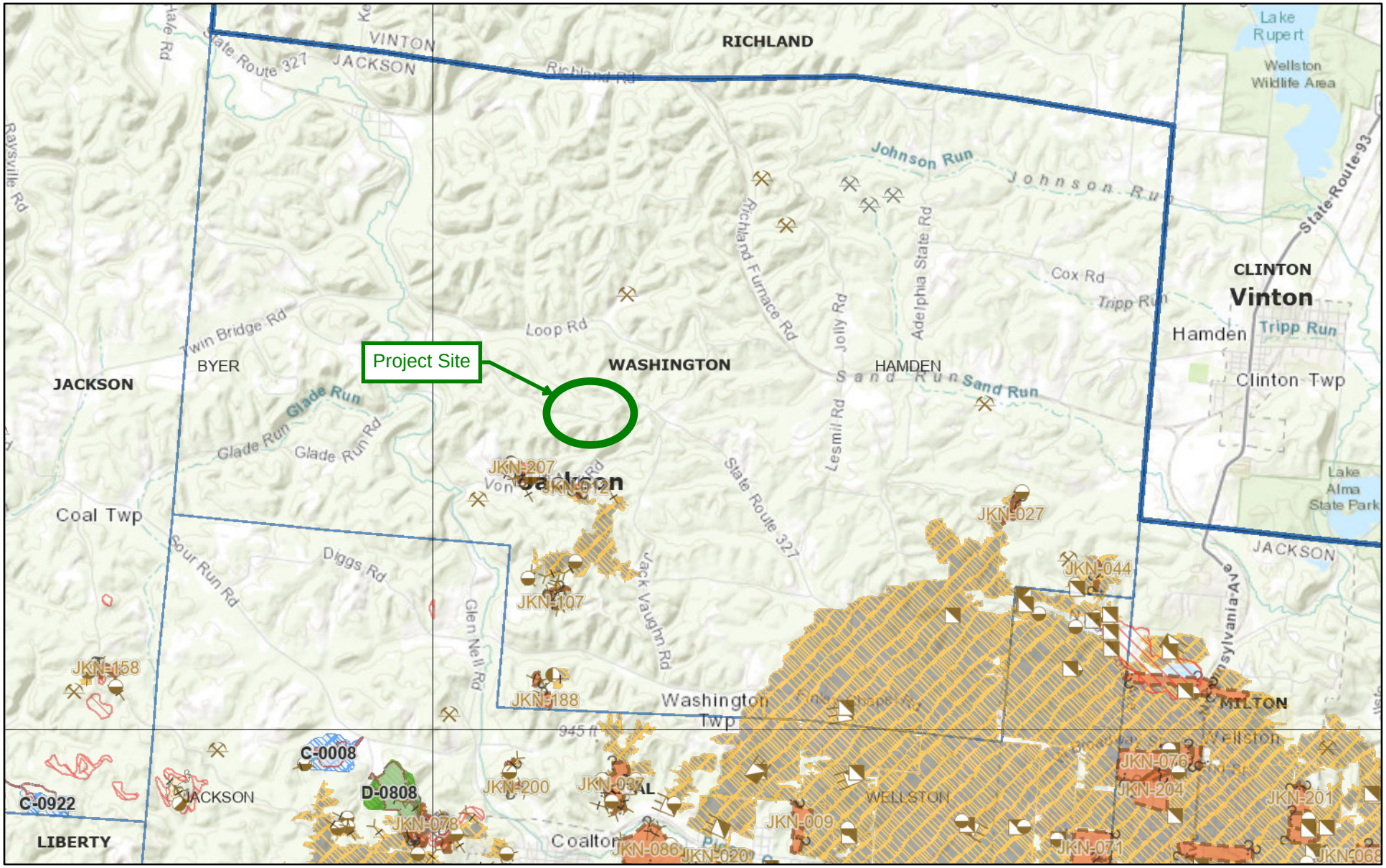


REFERENCE:

Title: Bedrock topography of the Hamden, Ohio, quadrangle
Author(s): Vorbau, K.E.
Publishing Organization: Ohio Division of Geological Survey
Series and Number: Digital Map Series BT-3B Hamden (supersedes Open-File Map version)
Publication Date: 1995

Mine Map

JAC-327-14.99: Mines of Ohio



July 17, 2025

1:72,224

0 0.5 1 2 mi

0 0.75 1.5 3 km

- Quadrangle 24K (7.5 min)
- Abandoned before 1977
- Known
- Partially Known
- Historic - From Topo Maps

Past

- C Law (1976 - 1981)
- D Law (1982 - Present)
- Surface Affected Area
- Locations

Past

- Locations
- Air Shaft
- Drift Entry
- Vertical Mine Shaft
- Slope Entry

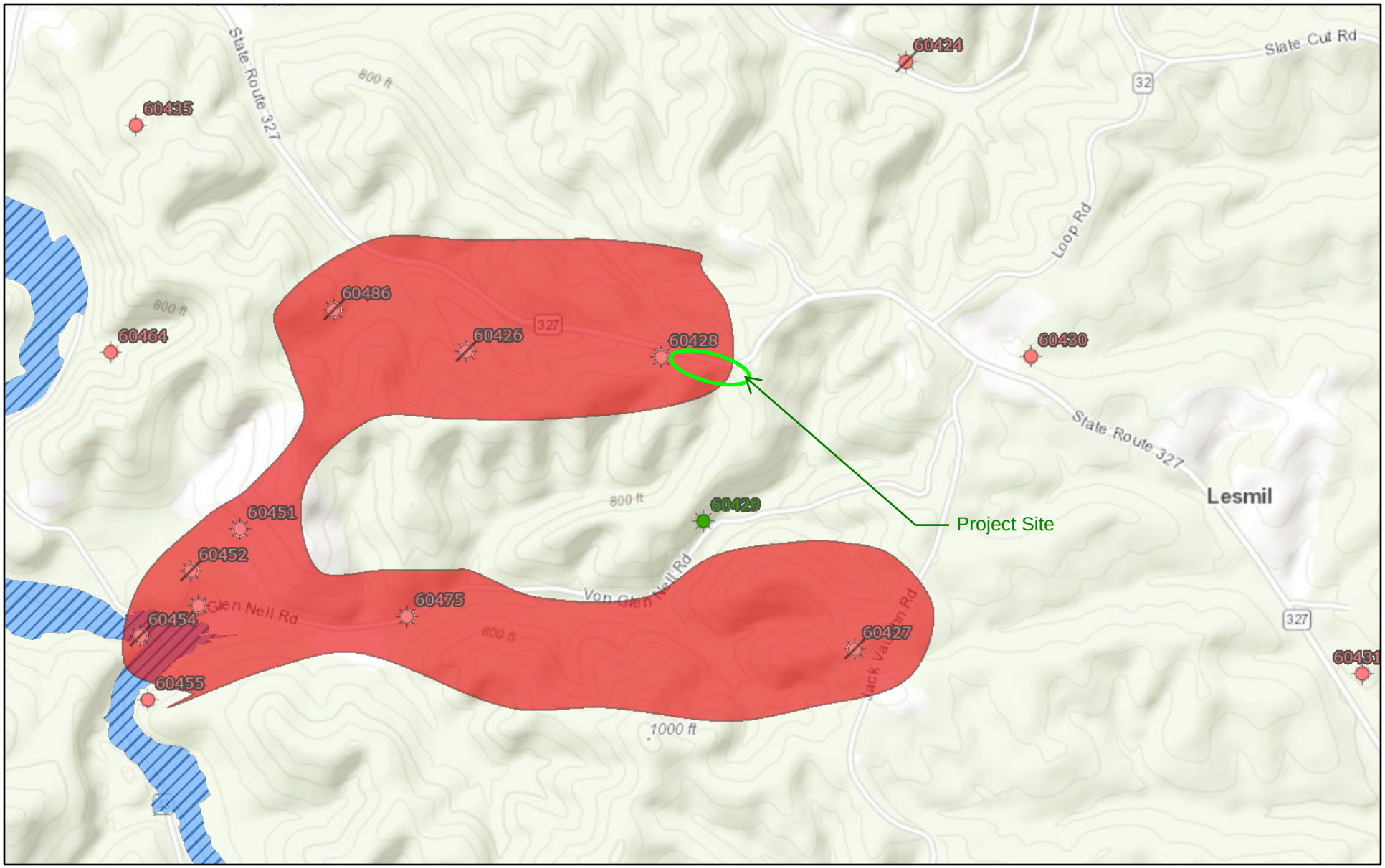
VITA, West Virginia GIS, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Ohio Dept. of Natural Resources

Oil and Gas Well Map
and
Well Summary

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

Ohio Oil & Gas Wells



August 21, 2025

1:18,056

0 0.1 0.2 0.4 mi

0 0.17 0.35 0.7 km

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

ODNR - Division of Oil and Gas Resources Management

C-0094-5-22

GEOLOGICAL SURVEY OF OHIO

60428 | 4614

OIL AND GAS WELL LOG

State Ohio

County Jackson Township Washington Quadrangle Jackson

Lot ____ Quarter ____ Tract ____ Section 21 NW ____ NE ____ SW ____

Measured 1248 Feet From E Line And 685 Feet From N Line Of ____

SI 591 2300 wl & 650 nl grant 1357 Acres

Land Owner Lawrence Polland Well No. 8 Date Started 2-7-30

Operator O F G Well No. 4759 Date Completed 3-11-30

Elevation Bar ____ S. L. P-887.0-g Total Depth 2513 Plugged Back ____

Formation Drilled To Clinton Producing Form. Clinton Init. Prod. Nat. 591 M.

Shot or Acid Record ____ Prod. A. S. or Acid ____

Init. Rock Press. 370 #'s Abandoned ____

Formation	Top	Bottom	Remarks
Berea sd.	853	879	dry
B. Ls.	1718	2303	w. 2106
2nd shell	2482	2489	
Clinton	2501	2511	591 M gas
		2513	T.D.

Formation	Top	Bottom	Remarks

Formation	Top	Bottom	Remarks	Formation	Top	Bottom	Remarks

Casing Record 8" 18 6" 889 5" 2328
2"-2531'.

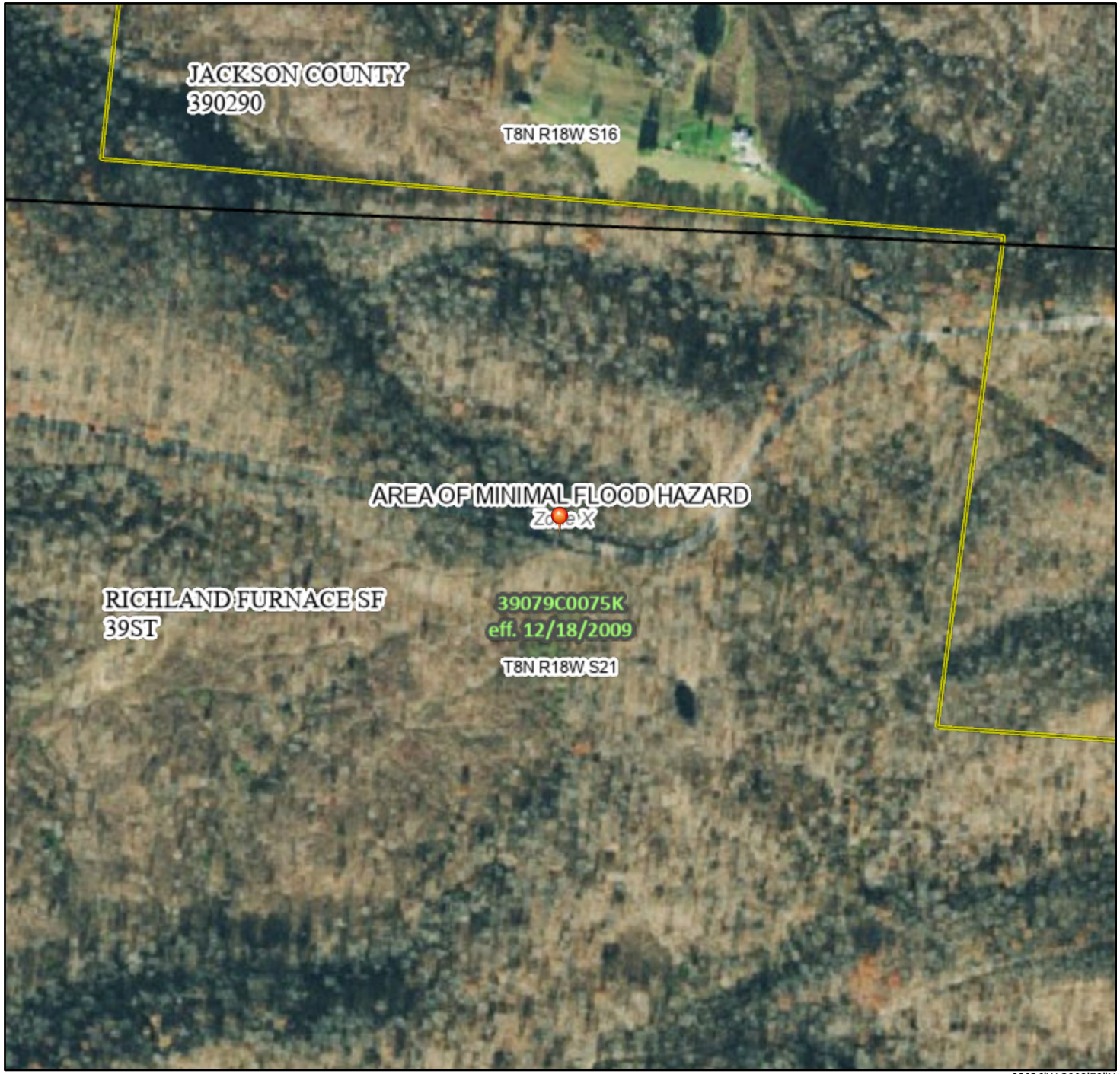
1	2	3	4	5	10
70	115	155	190	220	285

FEMA Flood Map

National Flood Hazard Layer FIRMette

FEMA

82°36'37"W 39°9'27"N



82°36'W 39°8'59"N

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

1:6,000

Basemap Imagery Source: USGS National Map 2023

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 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- 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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 7/17/2025 at 12:47 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Soil Strength Parameter Determination
and
Soil Laboratory Testing

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

ODOT District 9
JAC-327-14.99

Soil Strength Parameter Determination

Computed By = DCM
Checked By = AKB

Layer		Undrained Shear Strength (Su) (psf)					Moist Unit Wt. (pcf)		Total 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	$N1_{60}$ Value	ODOT GDM Correlations		Tested	
			GDM	Sowers	T and P	Values	Correlation	Tested	Correlation	Tested					Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)	
Layer 1 MEDIUM DENSE GRANULAR	Max	N/A	N/A	N/A	N/A		115		125		S_u= 0 psf	Max	15	27	N/A	36			c' = 0 psf
	Min	N/A	N/A	N/A	N/A		115		125		Φ = 36 deg	Min	15	27	N/A	36			Φ' = 36 deg
	Average	N/A	N/A	N/A	N/A		115		125			Average	15	27	N/A	36			
	Std Dev	N/A	N/A	N/A	N/A		N/A		N/A		Y_{moist} = 115 pcf	Std Dev	N/A	N/A	N/A	N/A			Y_{moist} = 115 pcf
	Avg + Std	N/A	N/A	N/A	N/A		N/A		N/A		Y_{total} = 125 pcf	Avg + Std	N/A	N/A	N/A	N/A			Y_{total} = 125 pcf
	Avg - Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg - Std	N/A	N/A	N/A	N/A			
Layer 2 STIFF TO VERY STIFF COHESIVE	Max	3750	3250	4000	3458		115		125		S_u= 1800 psf	Max	26	42	270	25			c' = 100 psf
	Min	1000	875	525	931		108		118		Φ = 0 deg	Min	7	10	88	22			Φ' = 23 deg
	Average	2694	1778	2503	1892		111		121			Average	14	20	170	23			
	Std Dev	917	736	1286	783		2		2		Y_{moist} = 110 pcf	Std Dev	6	9	59	1			Y_{moist} = 110 pcf
	Avg + Std	3611	2514	3789	2675		113		123		Y_{total} = 120 pcf	Avg + Std	20	30	229	24			Y_{total} = 120 pcf
	Avg - Std	1778	1042	1216	1108		108		118			Avg - Std	8	11	111	22			
Layer 3 SOFT TO MEDIUM STIFF COHESIVE	Max	4500	1000	1400	1064	942	108	131	118	141		Max	8	12	100	22			
	Min	0	500	300	532	831	102	129	112	139	S_u= 800 psf	Min	4	6	50	20			c' = 50 psf
	Average	1469	696	775	741	886	105	130	115	140	Φ = 0 deg	Average	6	8	70	21			Φ' = 20 deg
	Std Dev	1411	175	439	186	79	2	1	2	1		Std Dev	1	2	17	1			
											Y_{moist} = 130 pcf								Y_{moist} = 130 pcf
	Avg + Std	2879	871	1214	927	965	107	132	117	142	Y_{total} = 140 pcf	Avg + Std	7	10	87	22			Y_{total} = 140 pcf
	Avg - Std	58	522	336	555	807	103	129	113	139		Avg - Std	4	6	53	20			
Layer 4 HARD RESIDUUM	Max	4500	13186	4000	4000		130		140			Max	111	126	704	28			
	Min	2500	2875	2325	3059		115		125		S_u= 3600 psf	Min	23	26	250	25			c' = 300 psf
	Average	4159	6697	3606	3928		126		136		Φ = 0 deg	Average	56	64	431	27			Φ' = 26 deg
	Std Dev	761	3201	718	261		6		6			Std Dev	28	30	140	1			
											Y_{moist} = 125 pcf								Y_{moist} = 125 pcf
	Avg + Std	4920	9899	4323	4189		132		142		Y_{total} = 135 pcf	Avg + Std	83	94	571	28			Y_{total} = 135 pcf
	Avg - Std	3399	3496	2888	3667		120		130			Avg - Std	28	33	291	26			

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}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
Max	15	8	0.201	27	89	N/A	5	7	61	16	11	N/A	N/A	N/A	13	Max	N/A	N/A	N/A	N/A	N/A	36	1.8	921.8	102	115	125	N/A	2.65	0.625
Min	15	8	0.201	27	89	N/A	5	7	61	16	11	N/A	N/A	N/A	13	Min	N/A	N/A	N/A	N/A	N/A	36	1.8	921.8	102	115	125	N/A	2.65	0.625
Average	15	8	0.201	27	89	N/A	5	7	61	16	11	N/A	N/A	N/A	13	Average	N/A	N/A	N/A	N/A	N/A	36	1.8	921.8	102	115	125	N/A	2.65	0.625
Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
SR 327	923.5	B-001-0-25	1	-	2.5	SS-1	15	7.5	0.201	27	89	-	5	7	61	16	11	NP	NP	NP	13	A-3a	Granular	1	N/A					36	1.8	921.8	102	115	125	N/A	2.65	0.625

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}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
Max	26	12	1.186	42	100	3.8	8	12	25	51	62	50	29	21	22	Max	3750	3250	4000	3458	270	25	10.8	919.3	104	115	125	0.360	2.72	0.917
Min	7	8	0.243	10	28	1.0	0	1	3	25	14	24	18	4	11	Min	1000	875	525	931	88	22	2.3	894.8	89	108	118	0.126	2.65	0.638
Average	14	9	0.630	20	80	2.7	3	6	12	36	43	39	25	14	19	Average	2694	1778	2503	1892	170	23	5.7	908.6	93	111	121	0.261	2.68	0.795
Std Dev	6	2	0.318	9	22	0.9	3	3	9	10	19	10	5	6	4	Std Dev	917	736	1286	783	59	1	2.9	8.6	5	2	2	0.094	0.04	0.078
Avg + Std	20	11	0.948	30	101	3.6	6	10	21	46	62	49	29	21	22	Avg + Std	3611	2514	3789	2675	229	24	8.6	917.2	98	113	123	0.355	2.72	0.874
Avg - Std	8	7	0.312	11	58	1.8	0	3	2	26	24	29	20	8	15	Avg - Std	1778	1042	1216	1108	111	22	2.8	900.0	89	108	118	0.167	2.64	0.717

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
SR 327	923.5	B-001-0-25	3.5	-	5	SS-2	13	7.5	0.476	19	78	3	-	-	-	-	-	-	-	-	22	A-7-6	Cohesive	2	3000	1625	3250	1729	163	23	4.3	919.3	90	110	120		2.65	0.834
SR 327	923.5	B-001-0-25	6	-	7.5	SS-3	18	7.5	0.756	24	100	3.75	2	4	3	29	62	45	27	18	20	A-7-6	Cohesive	2	3750	2250	4000	2394	215	24	6.8	916.8	93	112	122	0.315	2.65	0.772
SR 327	916.4	B-002-0-25	8.5	-	10	SS-5	9	11.5	1.018	11	100	2.25	2	8	6	25	59	48	28	20	21	A-7-6	Cohesive	2	2250	1125	2250	1197	113	22	9.3	907.2	89	108	118	0.342	2.65	0.853
SR 327	916.4	B-002-0-25	10	-	11.5	SS-6	18	11.5	1.186	21	28	3.75	1	7	5	25	62	50	29	21	20	A-7-6	Cohesive	2	3750	2250	4000	2394	215	24	10.8	905.7	93	112	122	0.36	2.65	0.772
SR 327	917.0	B-002-1-25	1.5	-	3	SS-1	9	7.5	0.243	15	83	3.5	-	-	-	-	-	-	-	-	17	A-4a	Cohesive	2	3500	1125	675	1197	113	22	2.3	914.8	92	108	118		2.72	0.839
SR 327	917.0	B-002-1-25	3.5	-	5	SS-2	7	7.5	0.459	10	83	1	2	6	25	40	27	28	18	10	22	A-4a	Cohesive	2	1000	875	525	931	88	22	4.3	912.8	89	108	118	0.162	2.72	0.917
SR 327	917.0	B-002-1-25	6	-	7.5	SS-3	13	7.5	0.734	17	78	2.25	6	7	4	36	47	45	29	16	18	A-7-6	Cohesive	2	2250	1625	3250	1729	163	23	6.8	910.3	93	110	120	0.315	2.65	0.774
SR 327	899.0	B-004-0-25	2	-	3.5	SS-1	26	11	0.316	42	94	2.75	8	12	22	44	14	24	20	4	11	A-4a	Cohesive	2	2750	3250	1950	3458	270	25	2.8	896.3	104	115	125	0.126	2.72	0.638
SR 327	899.0	B-004-0-25	3.5	-	5	SS-2	15	11	0.484	22	72	2	0	1	17	51	31	33	21	12	16	A-6a	Cohesive	2	2000	1875	2625	1995	188	24	4.3	894.8	97	112	122	0.207	2.72	0.758

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}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC
Max	8	12	1.094	12	100	4.5	18	14	32	44	39	37	24	15	27
Min	4	9	0.289	6	11	0.0	0	5	9	28	19	23	16	6	1
Average	6	10	0.665	8	60	1.5	5	8	23	37	26	30	20	10	17
Std Dev	1	1	0.258	2	31	1.4	6	3	8	6	7	6	3	3	7
Avg + Std	7	11	0.923	10	91	2.9	11	11	31	43	33	36	23	13	24
Avg - Std	4	9	0.407	6	29	0.1	-1	5	15	31	19	24	16	7	9

	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)	Laboratory Tested Values: Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Total Unit Wt (pcf)	Strength Testing: Qu/UU Su (psf)	Qu/UU Correlated Eff. c (psf)
Max	4500	1000	1400	1064	100	22	10.0	913.7	107	108	118	0.243	2.72	1.053	112	131	141	942	94
Min	0	500	300	532	50	20	2.8	897.1	83	102	112	0.117	2.72	0.587	109	129	139	831	83
Average	1469	696	775	741	70	21	6.0	905.2	91	105	115	0.179	2.72	0.871	111	130	140	886	89
Std Dev	1411	175	439	186	17	1	2.3	6.2	8	2	2	0.056	0.00	0.153	2	1	1	79	8
Avg + Std	2879	871	1214	927	87	22	8.4	911.4	99	107	117	0.235	2.72	1.024	113	132	142	965	96
Avg - Std	58	522	336	555	53	20	3.7	899.0	83	103	113	0.123	2.72	0.719	108	129	139	807	81

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)	Laboratory Tested Values: Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Total Unit Wt (pcf)	Strength Testing: Qu/UU Su (psf)	Qu/UU Correlated Eff. c (psf)
SR 327	916.4	B-002-0-25	2	-	3.5	SS-1	5	11.5	0.289	8	50	0.5	0	6	30	37	27	23	16	7	17	A-4a	Cohesive	3	500	625	375	665	63	21	2.8	913.7	90	105	115	0.117	2.72	0.891					
SR 327	916.4	B-002-0-25	3.5	-	5	SS-2	5	11.5	0.446	8	11	-	18	14	20	28	20	25	17	8	11	A-4a	Cohesive	3	N/A	625	375	665	63	21	4.3	912.2	95	105	115	0.135	2.72	0.794					
SR 327	916.4	B-002-0-25	5	-	6.5	SS-3	4	11.5	0.599	6	78	0	7	6	32	36	19	23	17	6	19	A-4a	Cohesive	3	0	500	300	532	50	20	5.8	910.7	86	102	112	0.117	2.72	0.980					
SR 327	916.4	B-002-0-25	6.5	-	8.5	ST-4	ST	11.5	0.829	ST	83	1.5	3	11	19	37	30	37	22	15	19	A-6a	Cohesive	3	1500	N/A	N/A	N/A			7.5	908.9				0.243	2.72		112.4	131.3	141.3	830.5	83
SR 327	907.1	B-003-0-25	3	-	4.5	SS-2	8	9	0.444	12	22	1.5	3	5	9	44	39	35	23	12	1	A-6a	Cohesive	3	1500	1000	1400	1064	100	22	3.8	903.4	107	108	118	0.225	2.72	0.587					
SR 327	907.1	B-003-0-25	4.5	-	6	SS-3	5	9	0.601	7	83	2.25	-	-	-	-	-	-	-	-	21	A-6a	Cohesive	3	2250	625	875	665	63	21	5.3	901.9	87	105	115		2.72	0.956					
SR 327	907.1	B-003-0-25	6	-	7.5	SS-4	7	9	0.763	9	39	0.75	-	-	-	-	-	-	-	-	17	A-6a	Cohesive	3	750	875	1225	931	88	22	6.8	900.4	92	108	118		2.72	0.839					
SR 327	907.1	B-003-0-25	7.5	-	9	SS-5	5	9	0.921	6	78	0.75	2	7	25	44	22	36	24	12	27	A-6a	Cohesive	3	750	625	875	665	63	21	8.3	898.9	83	105	115	0.234	2.72	1.053					
SR 327	907.1	B-003-0-25	9	-	11	ST-6	ST	9	1.094	ST	100	4.5	5	8	29	32	26	30	19	11	18	A-6a	Cohesive	3	4500	N/A	N/A	N/A			10.0	897.1				0.18	2.72		108.9	129.3	139.3	942	94

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 4

	N_{60}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC
Max	111	12	1.879	126	100	4.5	1	5	24	61	36	35	22	13	16
Min	23	8	0.797	26	39	2.5	0	0	4	51	21	28	21	6	6
Average	56	9	1.325	64	89	4.2	0	2	13	57	28	31	22	9	11
Std Dev	28	2	0.289	30	17	0.8	0	2	8	4	6	3	1	3	3
Avg + Std	83	11	1.614	94	106	4.9	1	4	21	61	34	33	22	12	14
Avg - Std	28	7	1.037	33	73	3.4	0	0	4	53	22	28	21	6	7

	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
Max	4500	13186	4000	4000	704	28	19.8	914.3	123	130	140	0.225	2.72	0.697
Min	2500	2875	2325	3059	250	25	6.8	889.8	100	115	125	0.162	2.72	0.384
Average	4159	6697	3606	3928	431	27	13.4	901.8	114	126	136	0.185	2.72	0.492
Std Dev	761	3201	718	261	140	1	3.5	6.8	8	6	6	0.026	0.00	0.107
Avg + Std	4920	9899	4323	4189	571	28	16.9	908.5	122	132	142	0.211	2.72	0.599
Avg - Std	3399	3496	2888	3667	291	26	9.9	895.0	107	120	130	0.159	2.72	0.386

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	Groundwater Depth (ft)	Effective Stress (ksf)	$N1_{60}$	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	PPR	Short-Term Cohesion (psf) N-values GDM	Sowers	T & P	Correlated LT Cohesion (psf) per GDM	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf)	Correlated Moist Unit Wt. (pcf) per GDM	Correlated Total Unit Wt. (pcf) per GDM	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e_0)
SR 327	923.5	B-001-0-25	8.5	-	10	SS-4	31	7.5	0.960	39	100	4.5	-	-	-	-	-	-	-	-	15	A-4b	Cohesive	4	4500	3875	2325	4000	303	26	9.3	914.3	103	118	128		2.72	0.654
SR 327	923.5	B-001-0-25	11	-	12.5	SS-5	32	7.5	1.124	38	100	4.5	-	-	-	-	-	-	-	-	14	A-4b	Cohesive	4	4500	4000	2400	4000	310	26	11.8	911.8	104	118	128		2.72	0.640
SR 327	923.5	B-001-0-25	13.5	-	14.33	SS-6	Refusal	7.5	1.298	Refusal	100	-	0	3	9	57	31	31	21	10	7	A-4b	Cohesive	4	N/A	N/A	N/A	N/A		28	14.0	909.5	121	130	140	0.189	2.72	0.397
SR 327	923.5	B-001-0-25	16	-	17.25	SS-7	Refusal	7.5	1.512	Refusal	100	-	-	-	-	-	-	-	-	-	10	A-4b	Cohesive	4	N/A	N/A	N/A	N/A		28	16.8	906.8	118	130	140		2.72	0.436
SR 327	916.4	B-002-0-25	11.5	-	13	SS-7	23	11.5	1.319	26	78	4.5	-	-	-	-	-	-	-	-	15	A-6a	Cohesive	4	4500	2875	4000	3059	250	25	12.3	904.2	100	115	125		2.72	0.697
SR 327	916.4	B-002-0-25	13	-	14.5	SS-8	36	11.5	1.421	40	39	2.5	-	-	-	-	-	-	-	-	15	A-6a	Cohesive	4	2500	4500	4000	4000	335	27	13.8	902.7	104	120	130		2.72	0.627
SR 327	916.4	B-002-0-25	14.5	-	16	SS-9	47	11.5	1.530	51	89	4.5	0	0	4	60	36	35	22	13	10	A-6a	Cohesive	4	4500	5875	4000	4000	401	28	15.3	901.2	114	125	135	0.225	2.72	0.494
SR 327	916.4	B-002-0-25	16	-	17.5	SS-10	73	11.5	1.646	78	78	-	-	-	-	-	-	-	-	-	11	A-6a	Cohesive	4	N/A	8498	4000	4000	517	28	16.8	899.7	117	130	140		2.72	0.449
SR 327	916.4	B-002-0-25	17.5	-	19	SS-11	61	11.5	1.762	64	100	4.5	-	-	-	-	-	-	-	-	16	A-6a	Cohesive	4	4500	7101	4000	4000	456	28	18.3	898.2	112	130	140		2.72	0.514
SR 327	916.4	B-002-0-25	19	-	20.42	SS-12	Refusal	11.5	1.879	Refusal	82	-	-	-	-	-	-	-	-	-	8	A-6a	Cohesive	4	N/A	N/A	N/A	N/A		28	19.8	896.7	120	130	140		2.72	0.410
SR 327	917.0	B-002-1-25	8.5	-	10	SS-4	31	7.5	0.937	39	100	2.75	-	-	-	-	-	-	-	-	13	A-4b	Cohesive	4	2750	3875	2325	4000	303	26	9.3	907.8	104	118	128		2.72	0.625
SR 327	917.0	B-002-1-25	11	-	12.5	SS-5	65	7.5	1.131	78	100	4.5	-	-	-	-	-	-	-	-	11	A-4b	Cohesive	4	4500	7704	4000	4000	483	28	11.8	905.3	117	130	140		2.72	0.449
SR 327	917.0	B-002-1-25	13.5	-	14.83	SS-6	Refusal	7.5	1.325	Refusal	100	-	0	2	8	61	29	31	22	9	6	A-4b	Cohesive	4	N/A	N/A	N/A	N/A		28	14.3	902.8	123	130	140	0.189	2.72	0.384
SR 327	917.0	B-002-1-25	16	-	17.5	SS-7	105	7.5	1.519	115	100	-	-	-	-	-	-	-	-	-	8	A-4b	Cohesive	4	N/A	12445	4000	4000	676	28	16.8	900.3	120	130	140		2.72	0.410
SR 327	907.1	B-003-0-25	11	-	12.5	SS-7	57	9	1.230	66	72	4.5	-	-	-	-	-	-	-	-	7	A-4b	Cohesive	4	4500	6756	4000	4000	441	28	11.8	895.4	121	130	140		2.72	0.397
SR 327	907.1	B-003-0-25	12.5	-	14	SS-8	111	9	1.347	126	72	-	0	5	19	55	21	28	21	7	7	A-4b	Cohesive	4	N/A	13186	4000	4000	704	28	13.3	893.9	121	130	140	0.162	2.72	0.397
SR 327	899.0	B-004-0-25	6	-	7.5	SS-3	51	11	0.797	67	100	4.5	-	-	-	-	-	-	-	-	8	A-4b	Cohesive	4	4500	6375	3825	4000	423	28	6.8	892.3	116	125	135		2.72	0.466
SR 327	899.0	B-004-0-25	8.5	-	9.83	SS-4	Refusal	11	1.122	Refusal	100	4.5	1	1	24	51	23	28	22	6	8	A-4b	Cohesive	4	4500	N/A	N/A	N/A		28	9.3	889.8	120	130	140	0.162	2.72	0.410

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 791+42, 8' LT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 923.5 (MSL) EOB: 35.8 ft.
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153744, -82.605456

EXPLORATION ID B-001-0-25

PAGE 1 OF 2

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 (14")	923.5																	
	922.3																	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, TRACE GRAVEL, MOIST		1	4															
Layer 1 - Medium Dense Granular		2	5 6	15	89	SS-1	-	5	7	61	16	11	NP	NP	NP	13	A-3a (0)	
	920.0	3																
STIFF TO VERY STIFF, BROWN, TRACE GRAY, **CLAY**, SOME SILT, TRACE GRAVEL, TRACE SAND, DAMP		4	5															
		5	5 5	13	78	SS-2	3.00	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
Layer 2 - Stiff To V. Stiff Cohesive		6	6															
		7	6 7	18	100	SS-3	3.75	2	4	3	29	62	45	27	18	20	A-7-6 (12)	
	915.0	8																
HARD, GRAY, **SILT**, SOME CLAY, LITTLE SAND, DAMP (RESIDUUM)		9	7															
		10	10 13	31	100	SS-4	4.5+	-	-	-	-	-	-	-	-	15	A-4b (V)	
Groundwater 2 feet Above Residuum Adopted For Design		11																
@11.0' - 12.5': brown		12	6 10 14	32	100	SS-5	4.5+	-	-	-	-	-	-	-	-	14	A-4b (V)	
Elevated moisture - 1 foot above the residuum layer		13																
Layer 4 - Hard Residuum		14	27 50/4"	-	100	SS-6	-	0	3	9	57	31	31	21	10	7	A-4b (8)	
		15																
		16																
		17	21 35 50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	10	A-4b (V)	
	905.0	18																
CLAYSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.		19	48 50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	903.0	20																
CLAYSTONE, GRAY, TRACE BROWN, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 84%, REC 100%. @22.8': change to gray		21																
		22																
		23																
		24																
		25	80		100	NQ2-1											CORE	
		26																
@26.6' - 27.0': qu = 87 psi		27																
		28																
		29																

TR

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 791+42, 8' LT.	START: 6/12/25	END: 6/12/25	PG 2 OF 2	B-001-0-25

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 BROWN, HIGHLY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 84%, REC 100%. *(continued)*	893.5	31 32 33	90		100	NQ2-2											CORE	
CLAYSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, FAIR SURFACE; RQD 75%, REC 100%.	889.1	34 35 EOB																
	887.7																	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 790+42, 8' LT.	EXPLORATION ID B-002-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 916.4 (MSL) EOB: 40.4 ft.	PAGE 1 OF 2
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153810, -82.605800	

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 (21")	916.4																	
MEDIUM STIFF, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, MOIST	914.6		2 1 3	5	50	SS-1	0.50	0	6	30	37	27	23	16	7	17	A-4a (6)	
MEDIUM STIFF, DARK BROWN, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP	912.9		5 2 2	5	11	SS-2	-	18	14	20	28	20	25	17	8	11	A-4a (3)	
SOFT, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	911.4		1 2 1	4	78	SS-3	0.00	7	6	32	36	19	23	17	6	19	A-4a (4)	
MEDIUM STIFF TO STIFF, MOTTLED BROWN AND GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, IRON STAINED, DAMP	909.9				83	ST-4	1.50	3	11	19	37	30	37	22	15	19	A-6a (8)	
@7.3' - 7.8': qu = 1661 psf	907.9		3 3 4	9	100	SS-5	2.25	2	8	6	25	59	48	28	20	21	A-7-6 (14)	
STIFF TO VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, DAMP	906.4		4 5 8	18	28	SS-6	3.75	1	7	5	25	62	50	29	21	20	A-7-6 (14)	
VERY STIFF, BROWN, **CLAY**, SO TRACE GRAVEL, DAMP (RESIDUUM)	904.9		6 8 9	23	78	SS-7	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY STIFF TO HARD, GRAY TO BROWN, **SILT AND CLAY**, TRACE SAND, DAMP (RESIDUUM)			7 13 14	36	39	SS-8	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
			13 16 19	47	89	SS-9	4.5+	0	0	4	60	36	35	22	13	10	A-6a (9)	
			15 23 31	73	78	SS-10	-	-	-	-	-	-	-	-	-	11	A-6a (V)	
			14 19 26	61	100	SS-11	4.5+									16	A-6a (V)	
	896.0	TR	29 45 50/5"	-	82	SS-12	-	-	-	-	-	-	-	-	-	8	A-6a (V)	
CLAYSTONE, BROWN, SLIGHTLY TO MODERATELY WEATHERED, VERY WEAK, MEDIUM TO THICK BEDDED, ARENACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 75%, REC 100%.	892.0		75		100	NQ2-1											CORE	
@23.7' - 24.1': qu = 216 psi																		
SANDSTONE, BROWN TO GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM TO COARSE GRAINED, MEDIUM TO THICK BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 53%, REC 100%.			53		100	NQ2-2											CORE	

Layer 3 - Soft to M. Stiff Cohesive

Layer 2 - Stiff To V. Stiff Cohesive

Layer 4 - Hard Residuum

Groundwater
2 feet Above Residuum
Adopted For Design

Elevated moisture - along the top of the residuum layer

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 8/28/25 12:25 - C:\PWWORKING\EA\ST01A\DMS-103206\JAC-327-14.99.GPJ

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 790+42, 8' LT.	START: 6/12/25	END: 6/12/25	PG 2 OF 2	B-002-0-25

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
@29.3': becomes brown, contains black laminations **SANDSTONE**, BROWN TO GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM TO COARSE GRAINED, MEDIUM TO THICK BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 53%, REC 100%. *(continued)*	886.4	31 32 33 34																
	879.3	35 36 37	65		99	NQ2-3											CORE	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, WEAK TO SLIGHTLY STRONG, MEDIUM BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, TIGHT TO NARROW APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 73%, REC 98%. @37.1' - 37.5': 5" claystone layer, gray, very weak	876.0	38 39 40 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 790+43, 8' RT.	EXPLORATION ID B-002-1-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 917.0 (MSL) EOB: 18.8 ft.	PAGE 1 OF 1
START: 6/12/25 END: 6/12/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153766, -82.605811	

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 (14")	917.0																	
MEDIUM STIFF TO STIFF, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, NOTED IRON STAINING, MOIST	915.8		3 4 3	9	83	SS-1	3.50	-	-	-	-	-	-	-	-	17	A-4a (V)	
Layer 2 - Stiff To V. Stiff Cohesive			2 2 3	7	83	SS-2	1.00	2	6	25	40	27	28	18	10	22	A-4a (6)	
STIFF TO VERY STIFF, MOTTLED BROWN AND GRAY, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP	911.0		3 5 5	13	78	SS-3	2.25	6	7	4	36	47	45	29	16	18	A-7-6 (11)	
VERY STIFF TO HARD, BROWN, **SILT**, SOME CLAY, TRACE SAND, DAMP (RESIDUUM)	908.5		7 9 14	31	100	SS-4	2.75	-	-	-	-	-	-	-	-	13	A-4b (V)	
Layer 4 - Hard Residuum			12 21 27	65	100	SS-5	4.5+	-								11	A-4b (V)	
Groundwater 2 feet Above Residuum Adopted For Design			20 31 50/4"	-	100	SS-6	-	0	2	8	61	29	31	22	9	6	A-4b (8)	
			30 36 42	105	100	SS-7	-	-	-	-	-	-	-	-	-	8	A-4b (V)	
CLAYSTONE, BROWN, SEVERELY WEATHERED, VERY WEAK.	898.5 / 898.2	EOB	50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	6	Rock (V)	

Elevated moisture - 1 feet above the residuum layer

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 8/28/25 12:25 - C:\PWWORKING\EAST01A\DMS03206\JAC-327-14.99.GPJ

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 789+11, 10' LT.	EXPLORATION ID B-003-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327	
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 907.1 (MSL) EOB: 36.3 ft.	PAGE 1 OF 2
START: 6/11/25 END: 6/11/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153899, -82.606248	

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")	907.1																	
Groundwater 2 feet Above Residuum Adopted For Design			7 3 1	5	28	SS-1	-	-	-	-	-	-	-	-	-	-		
MEDIUM STIFF TO STIFF, GRAY AND BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DRY	904.1		2 3 3	8	22	SS-2	1.50	3	5	9	44	39	35	23	12	1	A-6a (9)	
MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST	902.6		2 2 2	5	83	SS-3	2.25	-	-	-	-	-	-	-	-	21	A-6a (V)	
Layer 3 - Soft to M. Stiff Cohesive			2 2 3	7	39	SS-4	0.75	-	-	-	-	-	-	-	-	17	A-6a (V)	
			2 2 2	5	78	SS-5	0.75	2	7	25	44	22	36	24	12	27	A-6a (7)	
	898.1																	
MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, DAMP @9.5' - 10.0': qu = 1884 psf	896.1				100	ST-6	4.5+	5	8	29	32	26	30	19	11	18	A-6a (5)	
HARD, BROWN, **SILT**, SOME SAND, SOME CLAY, DAMP (RESIDUUM)			8 16 26	57	72	SS-7	4.5+	-	-	-	-	-	-	-	-	7	A-4b (V)	
Layer 4 - Hard Residuum	893.1	TR	18 35 47	111	72	SS-8	-	0	5	19	55	21	28	21	7	7	A-4b (8)	
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.	891.6		25 50/5"	-	100	SS-9	-	-	-	-	-	-	-	-	-	6	Rock (V)	
			50/4"	-	100	SS-10	-	-	-	-	-	-	-	-	-	6	Rock (V)	
SANDSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, ARGILLACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 38%, REC 100%. @17.9' - 18.3': qu = 162 psi	885.9		50		100	NQ2-1											CORE	
SANDSTONE, BROWN TO GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG, COARSE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING AND BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 62%, REC 100%.	880.8																	
SHALE, BLACK, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, NOTED IRON STAINING, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, LAMINATED/SHEARED STRUCTURE, POOR SURFACE; RQD 0%, REC 100%.	880.2		25		87	NQ2-2											CORE	
	877.5																	

Elevated moisture - 2 feet above the residuum layer

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 8/28/25 12:25 - C:\PW\WORKING\EAST\01A\DMS\83206\JAC-327-14.99.GPJ

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 789+11, 10' LT.	START: 6/11/25	END: 6/11/25	PG 2 OF 2	B-003-0-25

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
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, ARENACEOUS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, VERY BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 15%, REC 76%. @27.8': clay seam @28.2': 1" red-brown seam @29', 29.3' and 29.6': clay seams @29.6': 3" coal seam	877.1 876.0	31																
CLAYSTONE, DARK GRAY TO BLACK, MODERATELY TO HIGHLY WEATHERED, WEAK, THIN BEDDED, CARBONACEOUS, JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE; RQD 28%, REC 100%. *(continued)* @30.3': 3" coal seam	874.0	32 33	63		100	NQ2-3											CORE	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 38%, REC 100%.		34																
SANDSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, INTACT OR MASSIVE STRUCTURE, GOOD SURFACE; RQD 95%, REC 100%.	870.8	35 36 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

PROJECT: JAC-327-14.99	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 787+63, 10' LT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 327
PID: 123842 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 899.0 (MSL) EOB: 28.5 ft.
START: 6/11/25 END: 6/11/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.153995, -82.606755

EXPLORATION ID B-004-0-25

PAGE 1 OF 2

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
	899.0																	
ASPHALT (21") AGGREGATE BASE (3")	897.0																	
VERY STIFF, GRAY AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP (FILL)	895.5		6 10 9	26	94	SS-1	2.75	8	12	22	44	14	24	20	4	11	A-4a (5)	
STIFF TO VERY STIFF, BROWN MOTTLED GRAY, **SILT AND CLAY**, LITTLE SAND, NOTED IRON STAINING, DAMP Layer 2 - Stiff To V. Stiff Cohesive	893.0		5 5 6	15	72	SS-2	2.00	0	1	17	51	31	33	21	12	16	A-6a (9)	
HARD, GRAY, **SILT**, SOME SAND, SOME CLAY, TRACE GRAVEL, DAMP (RESIDUUM) Layer 4 - Hard Residuum	888.0		9 16 22	51	100	SS-3	4.5+	-	-	-	-	-	-	-	-	8	A-4b (V)	
			18 35 50/4"	-	100	SS-4	4.5+	1	1	24	51	23	28	22	6	8	A-4b (8)	
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK, ARENACEOUS.	885.5	TR	32 50/1"	-	100	SS-5	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SANDSTONE, BROWN AND DARK GRAY, MODERATELY WEATHERED, SLIGHTLY STRONG, FINE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING, CONTAINS BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, VERY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 59%, REC 100%. @15.8' - 16.2': qu = 2385 psi @16.8', 17.0', 17.4', 17.7': gray clay seams	881.6		50/0" 62	-	100	SS-6 NQ2-1	-	-	-	-	-	-	-	-	-	-	Rock (V) CORE	
SANDSTONE, GRAY TRACE BROWN, SLIGHTLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, COARSE GRAINED, MEDIUM BEDDED, NOTED IRON STAINING, CONTAINS BLACK LAMINATIONS, JOINT DISCONTINUITIES, MODERATELY FRACTURED, OPEN APERTURE WIDTH, VERY ROUGH SURFACE, BLOCKY STRUCTURE, FAIR TO GOOD SURFACE; RQD 72%, REC 100%. @18.3' - 18.7': qu = 2596 psi	879.6 878.7 877.3		27		95	NQ2-2										CORE	
SHALE, BLACK, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, NOTED IRON STAINING, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, LAMINATED/SHEARED STRUCTURE, FAIR SURFACE; RQD 0%, REC 100%.	874.8		70		100	NQ2-3										CORE	
SILTSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE,	870.5	EOB																

PID: 123842	SFN:	PROJECT: JAC-327-14.99	STATION / OFFSET: 787+63, 10' LT.	START: 6/11/25	END: 6/11/25	PG 2 OF 2	B-004-0-25

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
BLOCKY STRUCTURE, GOOD SURFACE; RQD 41%, REC 100%.	869.0																	
CLAYSTONE, GRAY TO BLACK, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, JOINT DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, BLOCKY STRUCTURE, POOR TO FAIR SURFACE; RQD 17%, REC 90%. @22.7' - 23.0': carbonaceous shale layer																		
SANDSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY STRONG, MEDIUM TO THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLIGHTLY ROUGH SURFACE, INTACT OR MASSIVE STRUCTURE, GOOD SURFACE; RQD 75%, REC 100%. @24.4', 24.8', 24.9': clay seams @25.4' - 25.8': qu = 1644 psi																		

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: 25 GAL. WATER MIXED WITH 25 LB. BENTONITE POWDER; 47 LB. CEMENT; SURFACE PATCHED WITH QUICKCRETE

NEAS
National Engineering & Architectural Services Inc.

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

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: JAC-327-14.99, Boring Location: B-002-0-25, ST-4, Depth: 7.3 - 7.8ft)

Tested Date: 7/2/2025

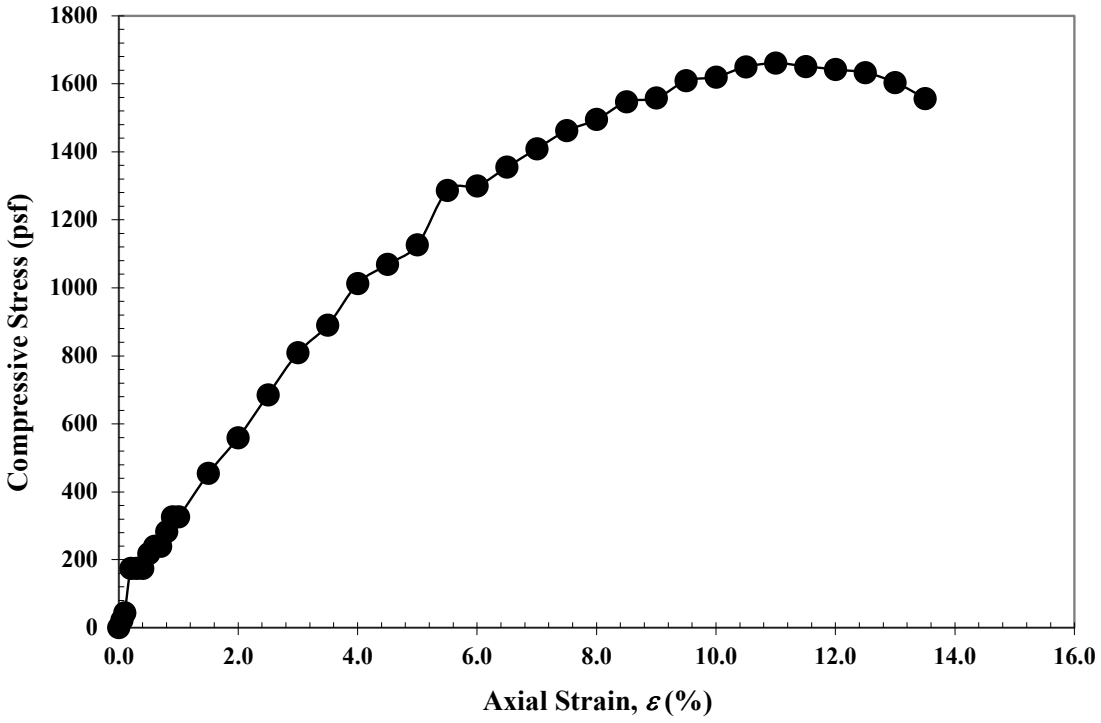
Specimen Properties

Average Dia., D_{avg} (in):	2.89
Average Height, H_{avg} (in):	5.74
Area, A (in^2):	6.56
Volume, V (in^3):	37.67
Wet Mass of Specimen (lb):	2.9
Moisture Content (%):	16.8
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft^3):	131.3
Dry Unit Weight, γ_d (lb/ft^3):	112.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psf):	**1661**
Strain (%):	**11.0**



Notes: Medium stiff, mottled brown and gray, SILT AND CLAY, some sand, trace gravel, damp. Specimen contains gravel >1/6 specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166.

NEAS
National Engineering & Architectural Services Inc.

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

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: JAC-327-14.99, Boring Location: B-003-0-25, ST-6, Depth: 9.5-10.0 ft)

Tested Date: 7/2/2025

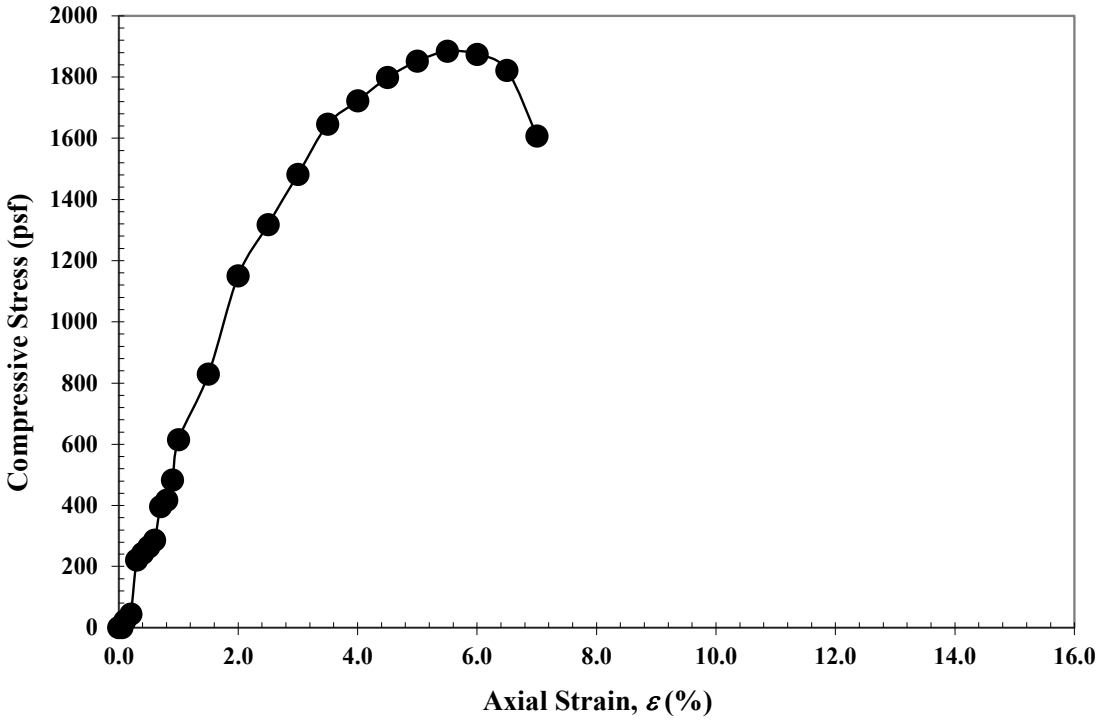
Specimen Properties

Average Dia., D_{avg} (in):	2.88
Average Height, H_{avg} (in):	5.75
Area, A (in^2):	6.50
Volume, V (in^3):	37.37
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	18.8
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft^3):	129.3
Dry Unit Weight, γ_d (lb/ft^3):	108.9

Final Specimen Figure

Results

Unconfined Compressive Strength (psf):	**1884**
Strain (%):	**5.5**



Notes: Medium stiff, brown, SILT AND CLAY, "and" sand, trace gravel, damp.

Rock Strength Parameter Determination
and
Rock Laboratory Testing

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

ODOT District 9
JAC-327-14.99

Weathered Rock Strength Parameter Determination

Computed By = DCM
Checked By = AKB

WEATHERED BEDROCK WITH SPT

Hammer Efficiency 80.9 %

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf) GDM Range	USE	No. Refusal Blows	Refusal Distance (in)	N	N90	Compressive Strength, Qu (ksf)	(psi)	(MPa)
JAC-327-14.99	B-001-0-25	18.5	SS-8	Claystone	Gray	130 - 165	145	50	3	200	180	17	115	0.8
JAC-327-14.99	B-002-1-25	18.5	SS-8	Claystone	Brown	130 - 165	145	50	3	200	180	17	115	0.8
JAC-327-14.99	B-003-0-25	14	SS-9	Shale (Weathered)	Brown	150 - 160	155	50	5	120	108	10	69	0.5
JAC-327-14.99	B-003-0-25	15	SS-10	Shale (Weathered)	Brown	150 - 160	155	50	4	150	135	12	86	0.6
JAC-327-14.99	B-004-0-25	11	SS-5	Shale (Weathered)	Brown	150 - 160	155	50	1	600	539	50	345	2.4
				Claystone	Maximum		155			Maximum		50	345	
					Minimum		145			Minimum		10	69	
					Average		151			Average		21	146	
					Std Dev		5			Std Dev		16	113	
					Adopted Value		150			Adopted Value		21	145	

*Qu (ksf) = 0.092*N90 (ODOT GDM Section 404.3)*

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

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

ODOT District 10
JAC-327-14.99

Rock Strength Parameter Determination

Computed By = DCM
Checked By = AKB

BEDROCK CORE TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu Based on Rock Type (psi)	USE (psi)	USE (MPa)	Er Modulus (psi)	Er Modulus (MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	Em (Hoek & Brown) Modulus (psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	Em (Yang) Modulus (psi)
JAC-327-14.99	B-003-0-25	17.9	NQ2-1	Sandstone (Friable)	Brown	149.3	Very Weak	<3600	162	1.1	5,500	38	20-40	30	0.3	48473	5500	1.5	219
				Sandstone (Friable)	Maximum	149		Sandstone (Friable)	Maximum	162						Sandstone (Friable)	Maximum	5500	
					Minimum	149			Minimum	162							Minimum	5500	
					Average	149			Average	162							Average	5500	
					Std Dev	N/A			Std Dev	N/A							Std Dev	N/A	
					Adopted Value	150			Adopted Value	160							Adopted Value	5,500	
					krm	0.0005													

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	Depth Range (ft.) To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
JAC-327-14.99	B-003-0-25	Sandstone	15.5	21.2	5.7	38	38.0
					0		0.0
					0		0.0
					0		0.0
					0		0.0
					0		0.0
					0		0.0
				Sandstone	5.7	RQD SUM	38
				Maximum	5.7	38	
				Minimum	0	38	
				Average	0.7	38.0	
				Adopted Value			40

BEDROCK CORE TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu Based on Rock Type (psi)	USE (psi)	USE (MPa)	Er Modulus (psi)	Er Modulus (MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	Em (Hoek & Brown) Modulus (psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	Em (Yang) Modulus (psi)
JAC-327-14.99	B-004-0-25	15.8	NQ2-1	Sandstone	Brown/Dk Gray	150.6	Slightly Strong	1800 - 7800	2385	16.4	209,000	1441	50-60	55	5.4	784304	209000	181.7	26350
JAC-327-14.99	B-004-0-25	18.3	NQ2-1	Sandstone	Gray/Org Brown	141.6	Slightly Strong	1800 - 7800	2596	17.9	564,000	3889	50-60	55	5.6	818263	564000	490.3	71107
JAC-327-14.99	B-004-0-25	25.4	NQ2-3	Sandstone	Gray	159.4	Slightly Strong	1800 - 7800	1644	11.3	103,000	710	70-85	80	18.9	2745942	103000	283.3	41092
				Sandstone	Maximum	159		Sandstone	Maximum	2596						Sandstone	Maximum	564000	
					Minimum	142			Minimum	1644							Minimum	103000	
					Average	151			Average	2208							Average	292000	
					Std Dev	9			Std Dev	500							Std Dev	241448	
					Adopted Value	150			Adopted Value	2,200							Adopted Value	292,000	
					krm	0.0005													

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	Depth Range (ft.) To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
JAC-327-14.99	B-002-0-25	Sandstone	24.4	37.1	12.7	53	16.2
JAC-327-14.99	B-002-0-25	Sandstone	37.1	40.4	3.3	73	5.8
JAC-327-14.99	B-003-0-25	Sandstone	15.5	21.2	5.7	38	5.2
JAC-327-14.99	B-003-0-25	Sandstone	21.2	26.3	5.1	62	7.6
JAC-327-14.99	B-003-0-25	Sandstone	33.1	36.3	3.2	95	7.3
JAC-327-14.99	B-004-0-25	Sandstone	13.5	17.4	3.9	59	5.5
JAC-327-14.99	B-004-0-25	Sandstone	17.4	19.4	2	72	3.5
JAC-327-14.99	B-004-0-25	Siltstone	20.3	21.7	1.4	41	1.4
JAC-327-14.99	B-004-0-25	Sandstone	24.2	28.5	4.3	75	7.8
				Sandstone	41.6	RQD SUM	60
				Maximum	12.7	95	
				Minimum	1.4	38	
				Average	4.6	63.1	
				Adopted Value			60

BEDROCK CORE TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu Based on Rock Type (psi)	USE (psi)	USE (MPa)	Er Modulus (psi)	Er Modulus (MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	Em (Hoek & Brown) Modulus (psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	Em (Yang) Modulus (psi)
JAC-327-14.99	B-001-0-25	26.6	NQ2-1	Claystone	Dark Gray	142.8	Very Weak	15 - 1400	87	0.6	2,900	20	40-60	50	0.8	112331	2900	2.0	290
JAC-327-14.99	B-002-0-25	23.7	NQ2-1	Claystone	Brown	149.8	Very Weak	15 - 1400	216	1.5	9,718	67	50-60	55	1.6	236030	9718	8.4	1225
				Claystone	Maximum	150		Claystone	Maximum	216						Claystone	Maximum	9718	
					Minimum	143			Minimum	87							Minimum	2900	
					Average	146			Average	152							Average	6309	
					Std Dev	5			Std Dev	91							Std Dev	4821	
					Adopted Value	145			Adopted Value	150							Adopted Value	6,300	
					krm	0.0005													

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	Depth Range (ft.) To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
JAC-327-14.99	B-001-0-25	Claystone	20.5	34.4	13.9	84	39.6
JAC-327-14.99	B-001-0-25	Claystone	34.4	35.8	1.4	75	3.6
JAC-327-14.99	B-002-0-25	Claystone	20.4	24.4	4	75	10.2
JAC-327-14.99	B-003-0-25	Shale	26.3	26.9	0.6	0	0.0
JAC-327-14.99	B-003-0-25	Shale	26.9	29.6	2.7	15	1.4
JAC-327-14.99	B-003-0-25	Claystone	29.6	31.1	1.5	28	1.4
JAC-327-14.99	B-003-0-25	Claystone	31.1	33.1	2	38	2.6
JAC-327-14.99	B-004-0-25	Shale	19.4	20.3	0.9	0	0.0
JAC-327-14.99	B-004-0-25	Claystone	21.7	24.2	2.5	17	1.4
					0		0.0
				Claystone	29.5	RQD SUM	60
				Maximum	13.9	84	
				Minimum	0	0	
				Average	3.0	36.9	
				Adopted Value			60

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

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

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

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

Table 10.4.6.5-1—Estimation of E_m Based on GSI

Expression	Notes/Remarks	Reference
$E_m(GPa) = \sqrt{\frac{q_u}{100}} 10^{\frac{GSI-10}{40}}$ for $q_u \le 100$ MPa $E_m(GPa) = 10^{\frac{GSI-10}{40}}$ 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.

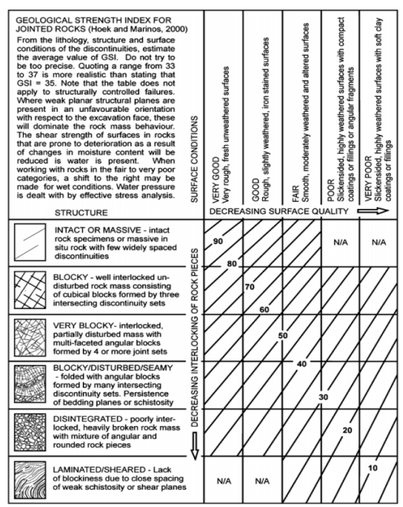


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

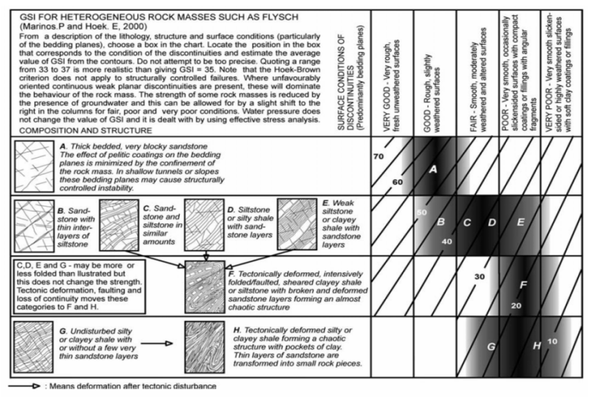


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

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Columbus, OH 43213
614-892-0162

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

(Project: JAC-327-14.99, Boring Location: B-001-0-25, NQ2-1, Depth: 26.6 - 27.0ft)

Tested Date: 7/11/2025

Specimen Properties

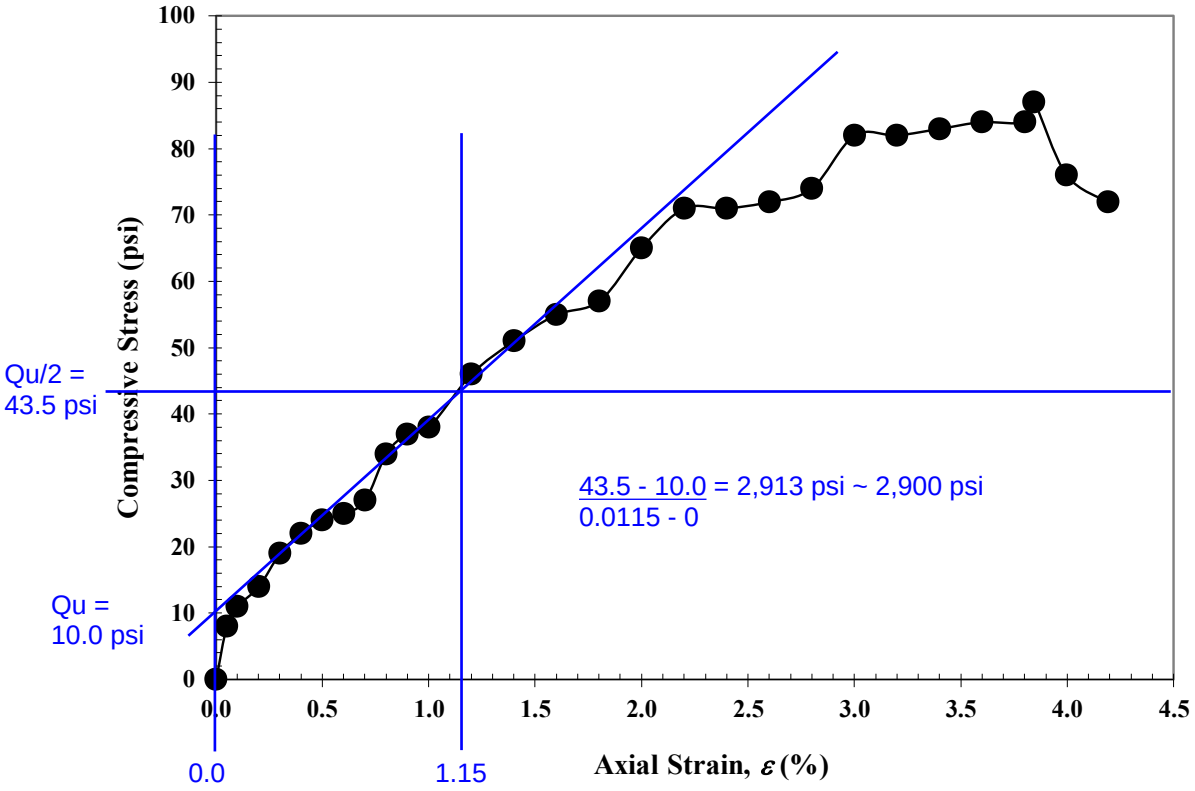
Average Dia., D_{avg} (in):	2.02
Average Height, H_{avg} (in):	4.55
Length to Diameter Ratio:	2.26
Area, A (in^2):	3.20
Volume, V (in^3):	14.58
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	8.0
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	142.8
Dry Unit Weight, γ_d (lb/ft^3):	132.2

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **87** **0.6** (MPa)

Strain (%): **3.8**



Notes: Claystone, dark gray, highly 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.

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: JAC-327-14.99, Boring Location: B-003-0-25, NQ2-1, Depth: 17.9 - 18.3ft)

Tested Date: 7/11/2025

Specimen Properties

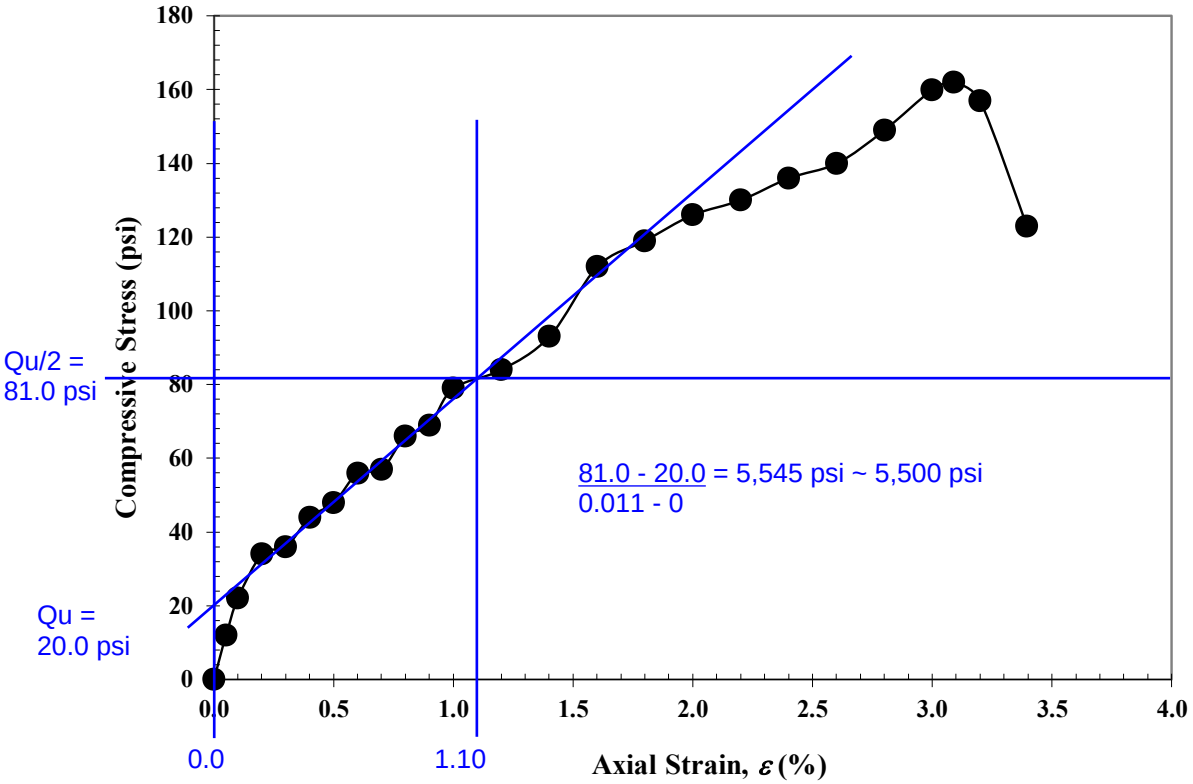
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.60
Length to Diameter Ratio:	2.33
Area, A (in^2):	3.07
Volume, V (in^3):	14.09
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	6.3
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	149.3
Dry Unit Weight, γ_d (lb/ft^3):	140.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **162** **1.1** (MPa)

Strain (%): **3.1**



Notes: Sandstone, brown, highly 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.

National Engineering & Architectural Services Inc.
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614-892-0162

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

(Project: JAC-327-14.99, Boring Location: B-004-0-25, NQ2-1, Depth: 15.8 - 16.2ft)

Tested Date: 7/11/2025

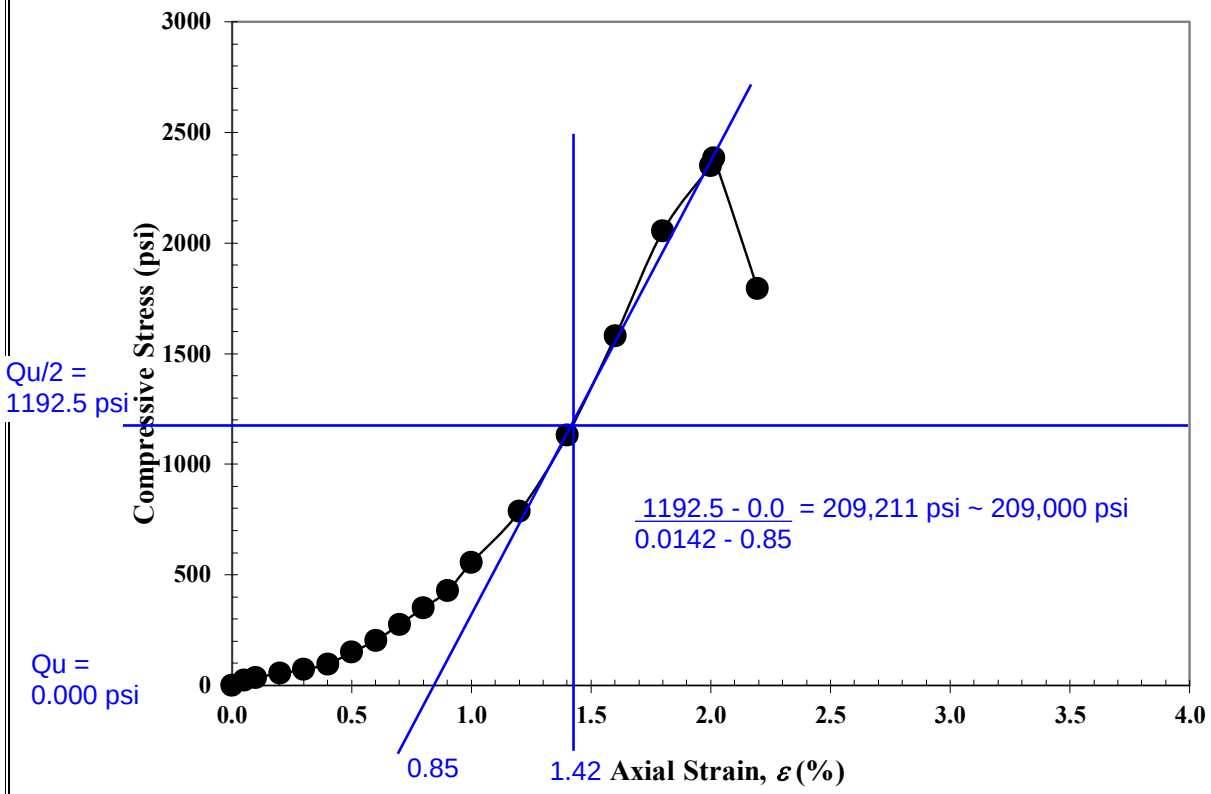
Specimen Properties

Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.37
Length to Diameter Ratio:	2.21
Area, A (in^2):	3.08
Volume, V (in^3):	13.47
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	4.3
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	150.6
Dry Unit Weight, γ_d (lb/ft^3):	144.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi):	**2385**	**16**	(MPa)
Strain (%):	**2.0**		



Notes: Sandstone, brown and dark gray, moderately weathered, slightly strong.

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.

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

(Project: JAC-327-14.99, Boring Location: B-004-0-25, NQ2-1, Depth: 18.3 - 18.7ft)

Tested Date: 7/11/2025

Specimen Properties

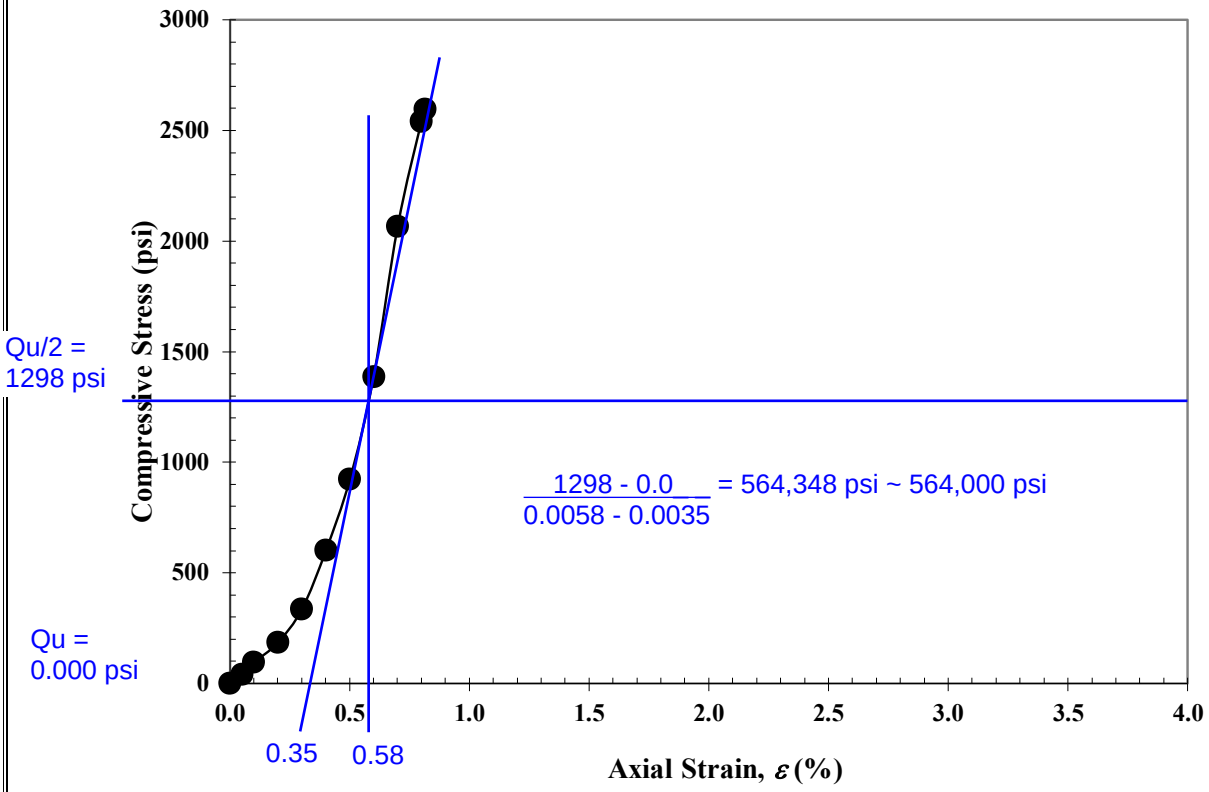
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.42
Length to Diameter Ratio:	2.23
Area, A (in^2):	3.07
Volume, V (in^3):	13.54
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	6.0
Dry Mass of Specimen (lb):	1.0
Wet Unit Weight, γ (lb/ft^3):	141.6
Dry Unit Weight, γ_d (lb/ft^3):	133.6

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **2596** **18** (MPa)

Strain (%): **0.8**



Notes: Sandstone, gray and orangish brown, moderately weathered, slightly strong.

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

(Project: JAC-327-14.99, Boring Location: B-004-0-25, NQ2-3, Depth: 25.4 - 25.8ft)

Tested Date: 7/11/2025

Specimen Properties

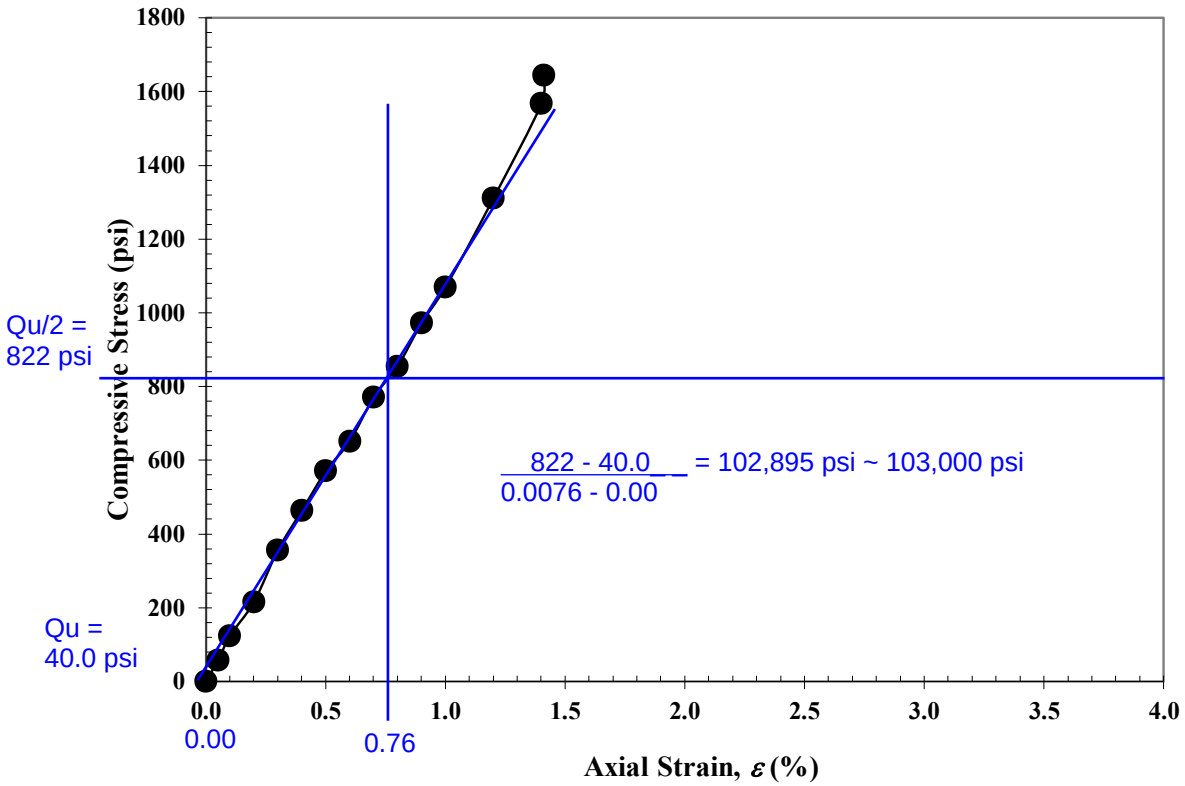
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.53
Length to Diameter Ratio:	2.30
Area, A (in^2):	3.06
Volume, V (in^3):	13.85
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	3.3
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	159.4
Dry Unit Weight, γ_d (lb/ft^3):	154.3

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **1644** **11** (MPa)

Strain (%): **1.4**



Notes: Sandstone, gray, slightly weathered, slightly strong.

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

(Project: JAC-327-14.99, Boring Location: B-002-0-25, NQ2-1, Depth: 23.7 - 24.1ft)

Tested Date: 7/11/2025

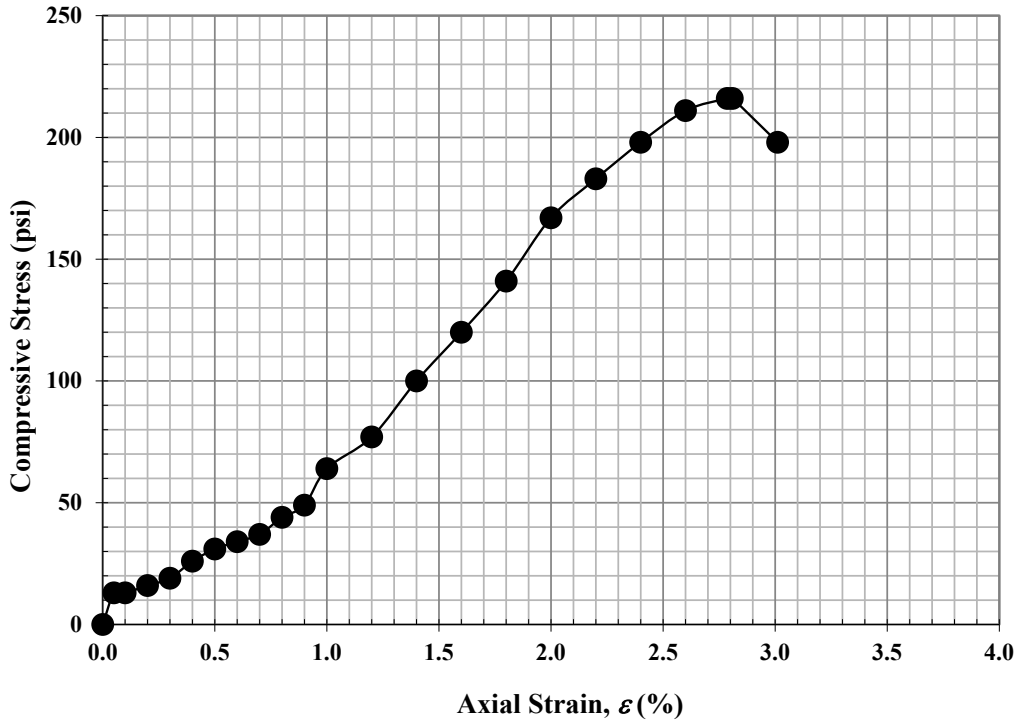
Specimen Properties

Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.45
Length to Diameter Ratio:	2.25
Area, A (in^2):	3.07
Volume, V (in^3):	13.65
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	5.5
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	149.8
Dry Unit Weight, γ_d (lb/ft^3):	141.9

Before Testing	After Testing
	

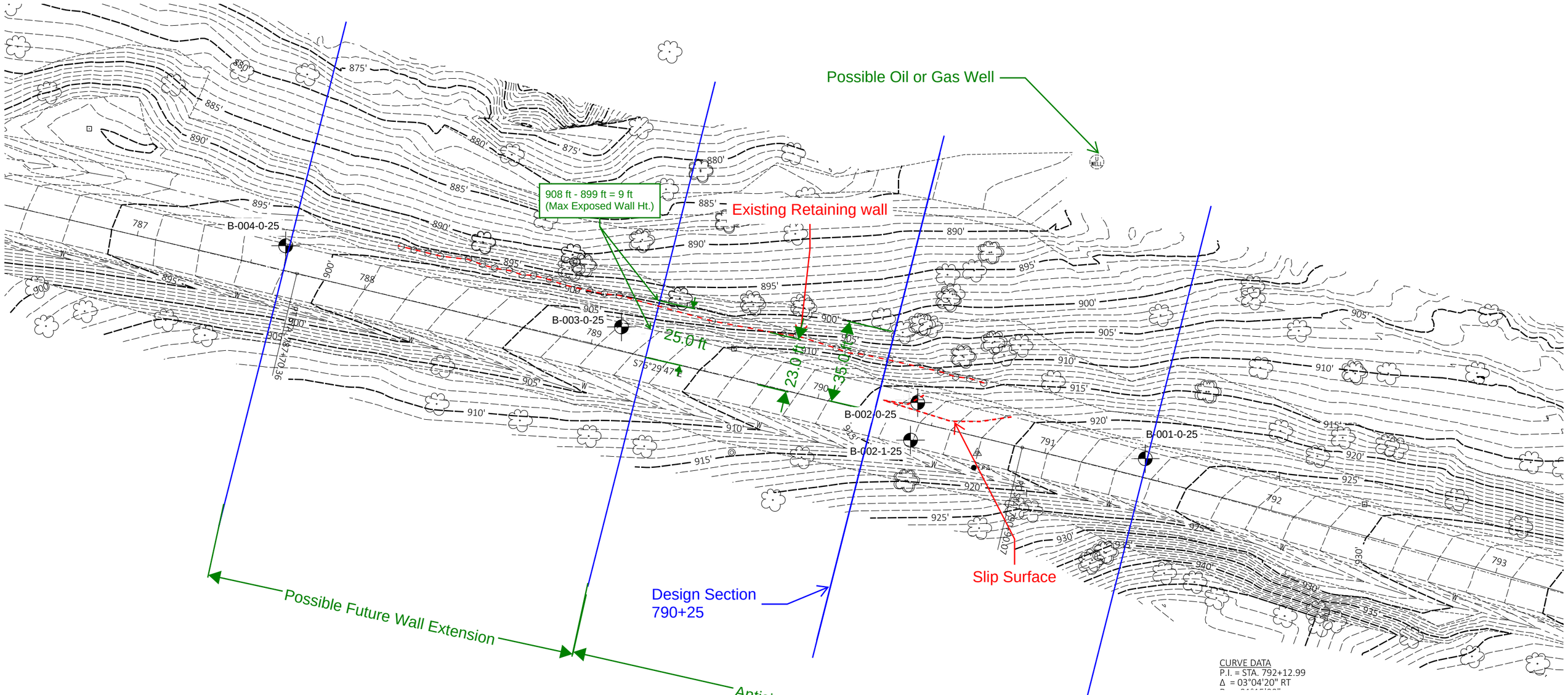
Results

Unconfined Compressive Strength (psi):	**216**	**1.5**	(MPa)
Strain (%):	**2.8**		
Elastic Modulus (Gpa):	**0.067**	= 9717.5 psi	



Notes: Claystone, brown, moderately weathered, very weak, arenaceous.

Slope Stability Analyses


Possible Oil or Gas Well
908 ft - 899 ft = 9 ft
(Max Exposed Wall Ht.)
Existing Retaining wall
B-004-0-25
B-003-0-25
B-002-0-25
B-002-1-25
B-001-0-25
25.0 ft
S75°29'47"E
23.0 ft
35.0 ft
Slip Surface
Design Section
790+25
Possible Future Wall Extension
Anticipated Extent of Wall
CURVE DATA
P.I. = STA. 792+12.99
Δ = 03°04'20" RT

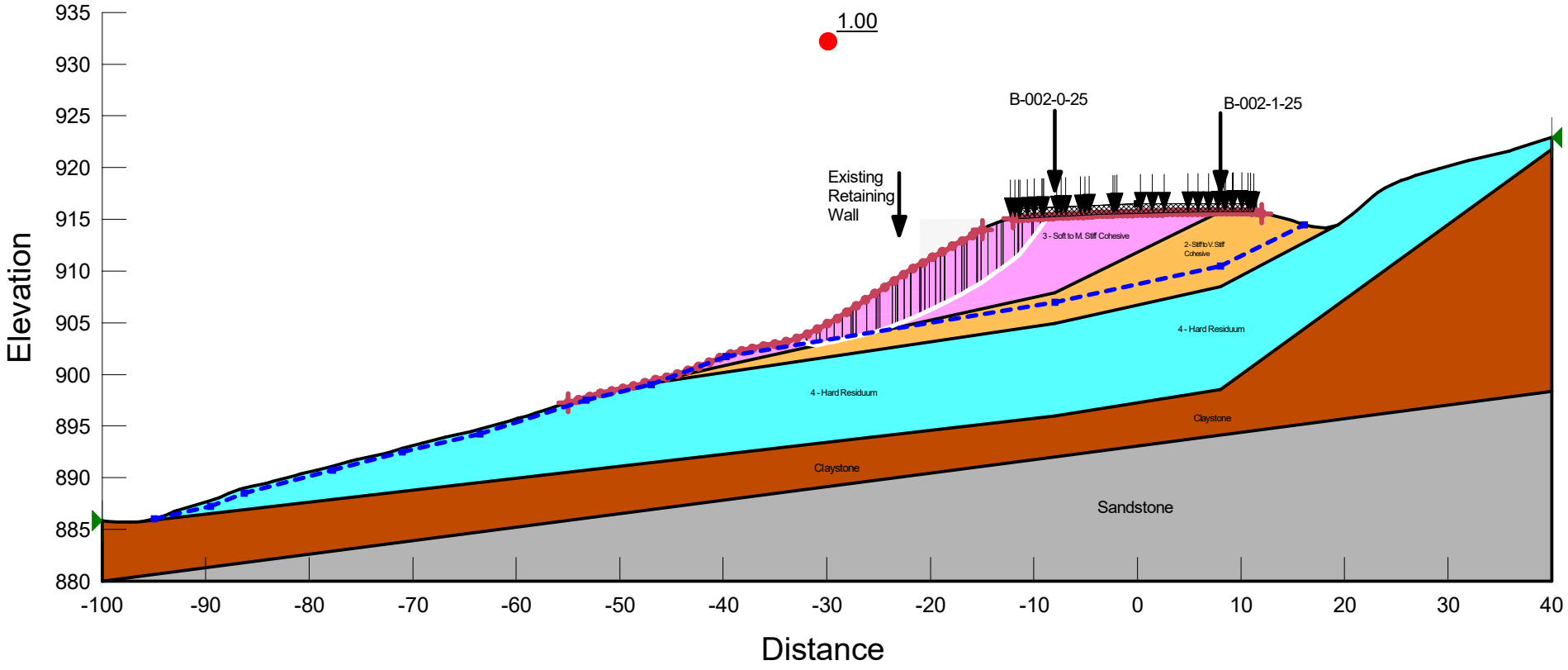
Station 790+25 (Design Section)
Existing Conditions

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

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock - Claystone	Bedrock (Impenetrable)				1
	Bedrock - Sandstone	Bedrock (Impenetrable)				1
	Layer 2 - Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	110	100	23	1
	Layer 3 - Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	130	50	20	1
	Layer 4 - Hard Residuum (LT)	Mohr-Coulomb	125	300	26	1

Title: JAC-327-14.99
Name: 790+25
Description: Existing Conditions

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Surcharge (Unit Weight): 250 pcf
Optimize Critical Slip Surface Location: Yes

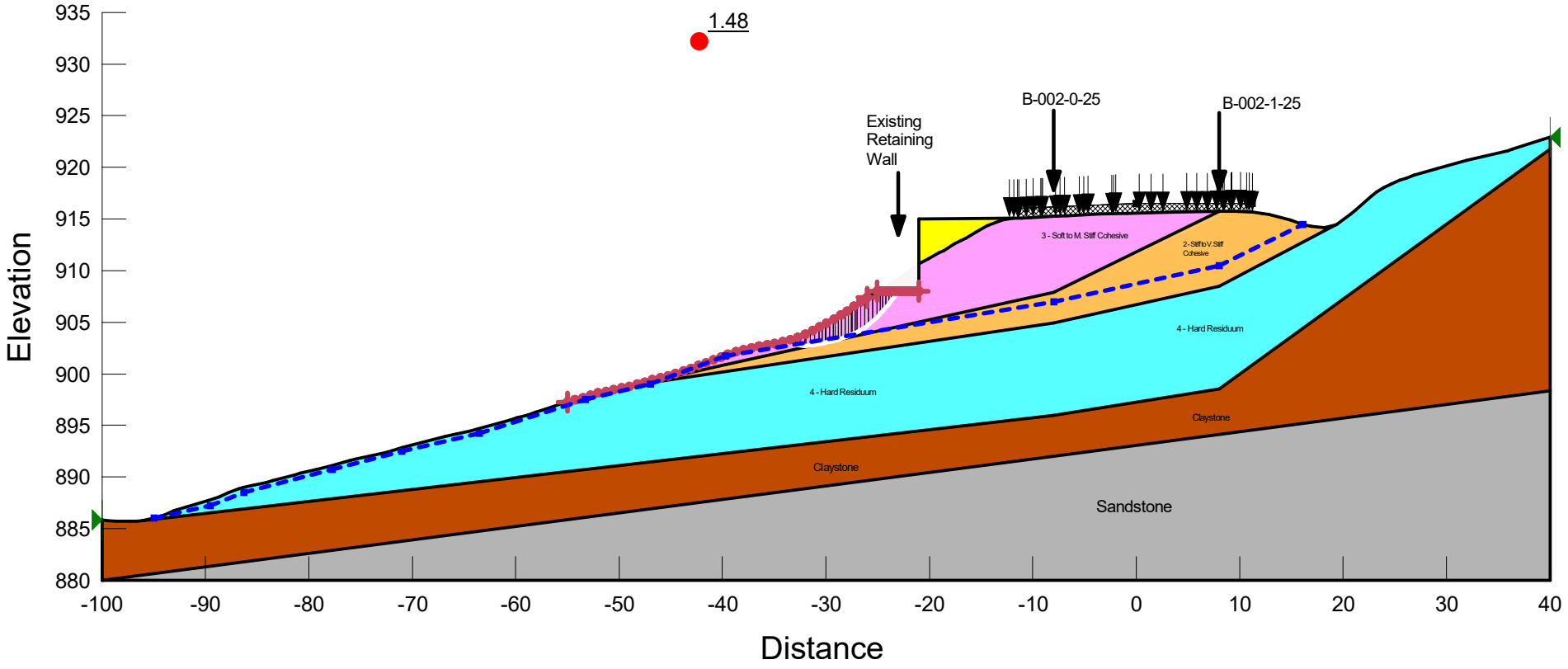


Station 790+25 (Design Section)
Downslope Stability

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

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock - Claystone	Bedrock (Impenetrable)				1
	Bedrock - Sandstone	Bedrock (Impenetrable)				1
	Item 203 - Embankment Material	Mohr-Coulomb	125	250	26	1
	Layer 2 - Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	110	100	23	1
	Layer 3 - Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	130	50	20	1
	Layer 4 - Hard Residuum (LT)	Mohr-Coulomb	125	300	26	1

Title: JAC-327-14.99
Name: 790+25 (2)
Description: Downslope Stability
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Surcharge (Unit Weight): 250 pcf
Optimize Critical Slip Surface Location: Yes

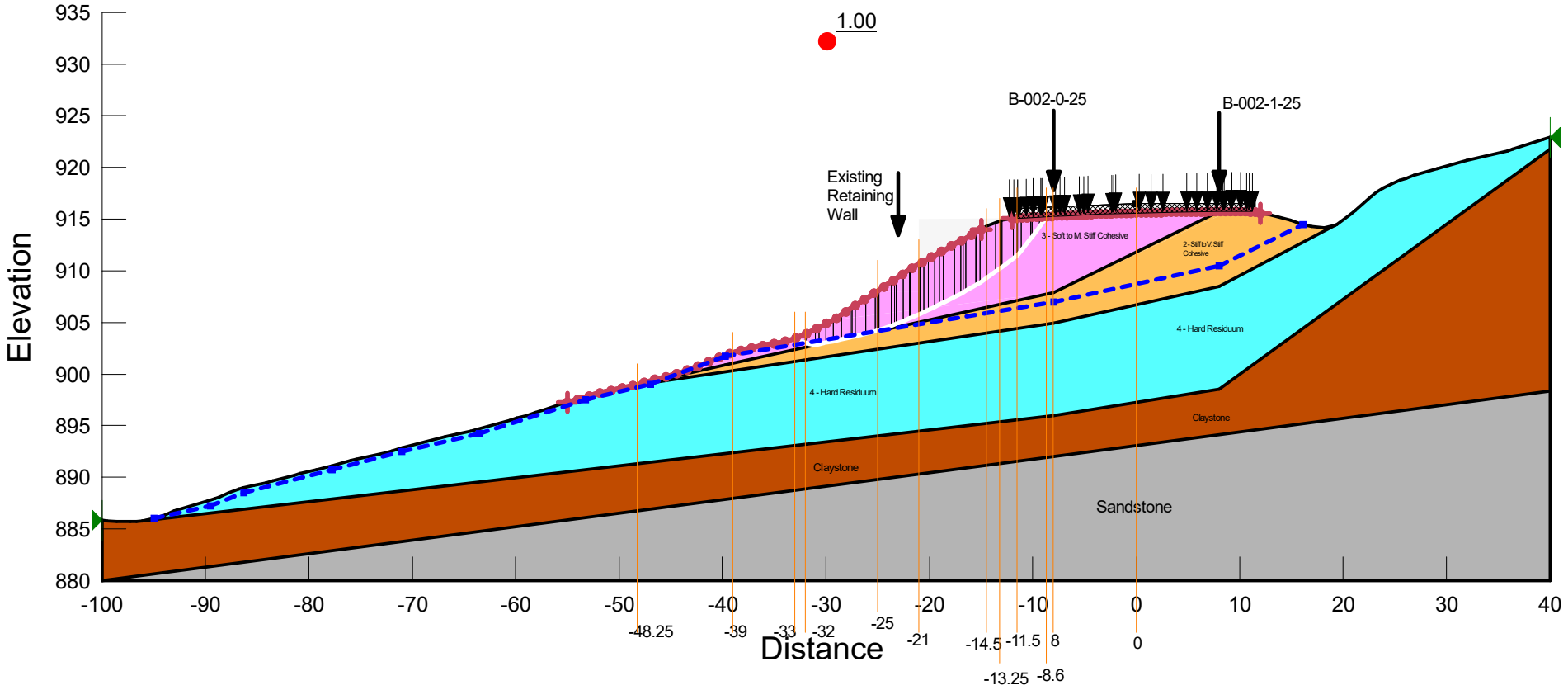


UA Slope Analyses

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock - Claystone	Bedrock (Impenetrable)				1
	Bedrock - Sandstone	Bedrock (Impenetrable)				1
	Layer 2 - Stiff to Very Stiff Cohesive (LT)	Mohr-Coulomb	110	100	23	1
	Layer 3 - Soft to Medium Stiff Cohesive (LT)	Mohr-Coulomb	130	50	20	1
	Layer 4 - Hard Residuum (LT)	Mohr-Coulomb	125	300	26	1

Title: JAC-327-14.99
Name: 790+25 (3)
Description: Existing Conditions (UA Slope Coordinates)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Surcharge (Unit Weight): 250 pcf
Optimize Critical Slip Surface Location: Yes



Station 790+25 (Design Section)
Existing Conditions

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

UA Slope Program Version 2.3 - J:\ODOT-D9 GES\Task 3_JAC-327-14.99\Report\20250811_JAC-327-14.99_UA Slope_Existing.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.00

Force per Shaft: 0.000 lb

Acting Point X: 0.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 13 Soil Layer Num: 7

Analysis Method

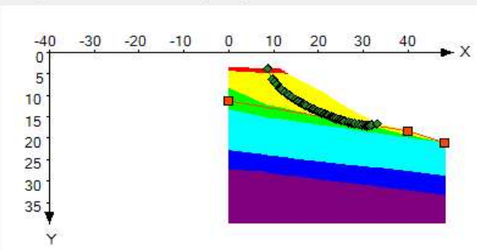
( ) Total Stress (•) Effective Stress

Soil Properties

	Cohesion (psf)	Material Description	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	Traffic Surcharge Load	0.0	250.0
Layer2	250.0	Item 203 Embankment Fill	26.0	125.0
Layer3	42.0	3 - Soft to Med. Stiff Cohesive	20.0	130.0
Layer4	100.0	2 - Stiff to V. Stiff Cohesive	23.0	110.0
Layer5	300.0	4 - Residdum	26.0	125.0
Layer6	4000.0	Claystone	40.0	145.0
Layer7	4000.0	Sandstone	40.0	150.0

Parameter Modified to better correspond the Factor of Safety value determined by UA Slope with the value determined by SlopeW

Chart (Double-Click for More Options)



Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13
X (ft)	0.00	8.00	8.60	11.50	13.25	14.50	21.00	21.00	25.00	32.00	33.00	39.00	48.25
Y1 (ft)	3.25	3.75	3.75	3.75	5.00	5.75	9.25	9.25	12.00	16.00	16.50	18.00	21.00
Y2 (ft)	4.25	4.75	4.75	4.75	5.00	5.75	9.25	9.25	12.00	16.00	16.50	18.00	21.00
Y3 (ft)	4.25	4.75	4.75	4.75	5.00	5.75	9.25	9.25	12.00	16.00	16.50	18.00	21.00
Y4 (ft)	8.25	12.00	12.25	12.75	13.25	13.50	15.00	15.00	15.75	17.50	17.50	19.00	21.00
Y5 (ft)	13.25	15.00	15.25	15.50	15.75	16.00	17.00	17.00	17.50	18.75	18.75	19.75	21.00
Y6 (ft)	22.75	23.75	24.00	24.25	24.50	24.75	25.50	25.50	26.00	26.75	26.75	27.50	28.75
Y7 (ft)	27.25	27.75	28.00	28.50	28.75	28.75	29.75	29.75	30.25	31.00	31.25	32.00	33.25
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

Coordinates of Crest X: -13.30 ft Y: 5.00 ft Coordinates of Toe X: -33.00 ft Y: 16.50 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: 0.30 ft

Xmax 0.00 CTC Spacing: 0.00 ft

XDelta 0.00 X Coordinate: 0.00 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
X (ft)	0.00	39.80	48.00
Y (ft)	11.30	18.30	21.00

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)	8.60	9.72	10.15	10.67	11.32	11.51	11.70	12.44	13.07	13.39	14.04	14.78	15.27	15.47	15.98	16.61	16.84	17.2
Y (ft)	3.75	6.27	6.83	7.47	8.28	8.51	8.67	9.21	9.69	9.92	10.39	10.92	11.25	11.38	11.68	12.04	12.17	12.1

Station 790+25 (Design Section)
Post-Construction Conditions

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

Roadway surcharge is not included in the UA Slope analyses as it is accounted for in the wall loading caluclations.

UA Slope Program Version 2.3 - J:\ODOT-D9 GES\Task 3_JAC-327-14.99\Report\20250811_JAC-327-14.99_UA Slope_Proposed.ua3

File Run Options Help

Calculated Results

Factor of Safety: 2.24

Force per Shaft: 17735.649 lb

Acting Point X: 21.000 ft Y: 11.168 ft

Analysis Unit System

(•) English ( ) Metric

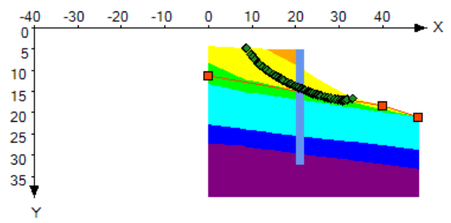
Number of Vertical Sections and Soil Layers

Vertical Section Num: 13 Soil Layer Num: 7

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Material Description	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	Traffic Surcharge Load	0.0	250.0
Layer2	250.0	Item 203 Embankment Fill	26.0	125.0
Layer3	42.0	3 - Soft to Med. Stiff Cohesive	20.0	130.0
Layer4	100.0	2 - Stiff to V. Stiff Cohesive	23.0	110.0
Layer5	300.0	4 - Residdum	26.0	125.0
Layer6	4000.0	Claystone	40.0	145.0
Layer7	4000.0	Sandstone	40.0	150.0

Parameter Modified to better correspond the Factor of Safety value determined by UA Slope with the value determined by SlopeW for the existing condition

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13
X (ft)	0.00	8.00	8.60	11.50	13.25	14.50	21.00	21.00	25.00	32.00	33.00	39.00	48.25
Y1 (ft)	4.25	4.75	4.75	4.75	5.00	5.00	5.00	12.00	12.00	16.00	16.50	18.00	21.00
Y2 (ft)	4.25	4.75	4.75	4.75	5.00	5.00	5.00	12.00	12.00	16.00	16.50	18.00	21.00
Y3 (ft)	4.25	4.75	4.75	4.75	5.00	5.75	9.25	9.25	12.00	16.00	16.50	18.00	21.00
Y4 (ft)	8.25	12.00	12.25	12.75	13.25	13.50	15.00	15.00	15.75	17.50	17.50	19.00	21.00
Y5 (ft)	13.25	15.00	15.25	15.50	15.75	16.00	17.00	17.00	17.50	18.75	18.75	19.75	21.00
Y6 (ft)	22.75	23.75	24.00	24.25	24.50	24.75	25.50	25.50	26.00	26.75	26.75	27.50	28.75
Y7 (ft)	27.25	27.75	28.00	28.50	28.75	28.75	29.75	29.75	30.25	31.00	31.25	32.00	33.25
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

Coordinates of Crest X: -13.30 ft Y: 5.00 ft Coordinates of Toe X: -33.00 ft Y: 16.50 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: 2.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 21.00 ft

[ ] Auto Save Data

Run

Proposed Wall CL Offset 21 LT

Pore Water Pressure

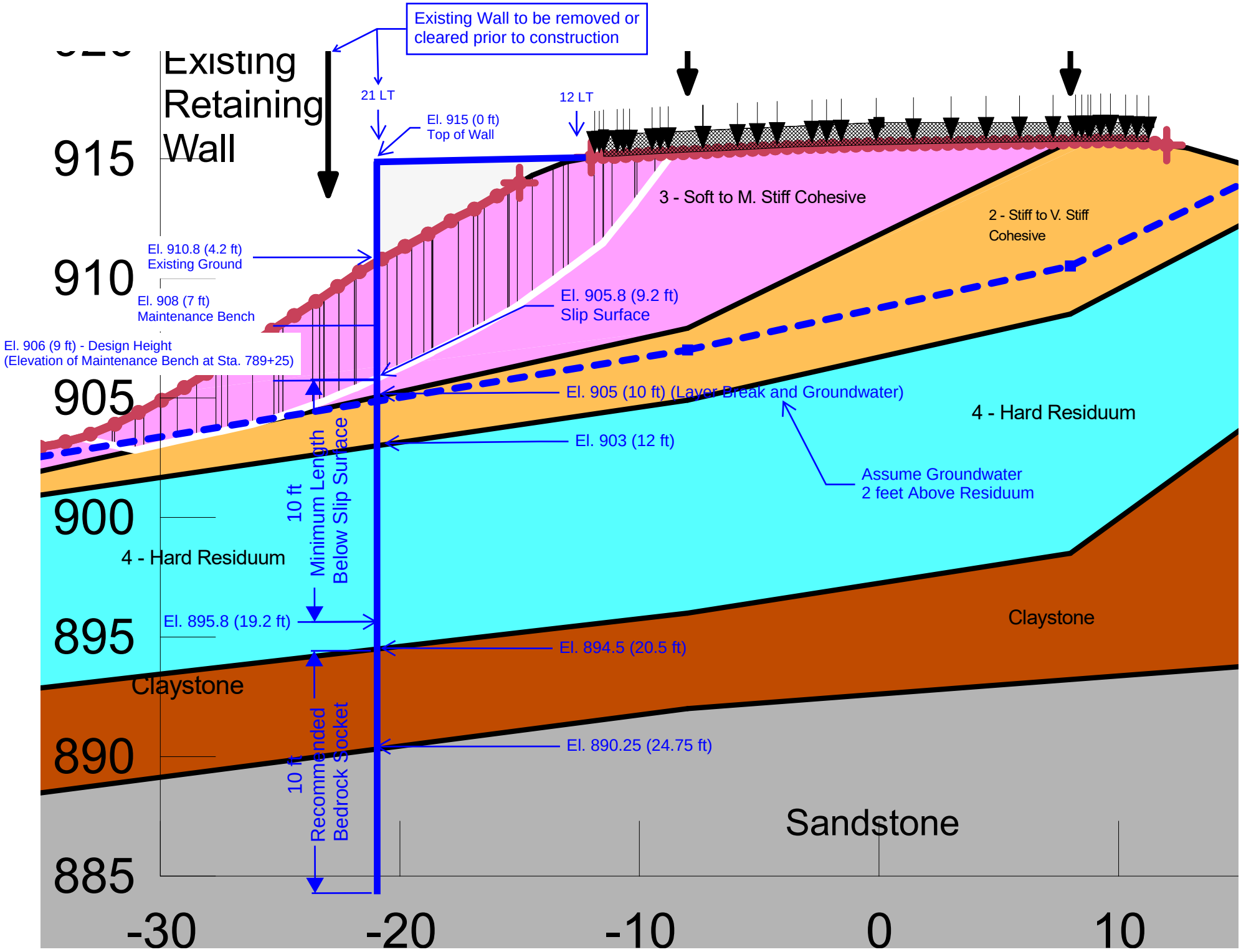
Pore Pressure Options: ( ) No Pore Pressure ( ) Constant Ratio (•) Specified phreatic surface

	Point 1	Point 2	Point 3
X (ft)	0.00	39.80	48.00
Y (ft)	11.30	18.30	21.00

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)	8.60	9.72	10.15	10.67	11.32	11.51	11.70	12.44	13.07	13.39	14.04	14.78	15.27	15.47	15.98	16.61	16.84	17.2
Y (ft)	4.75	6.27	6.83	7.47	8.28	8.51	8.67	9.21	9.69	9.92	10.39	10.92	11.25	11.38	11.68	12.04	12.17	12.1

Wall Calculations


Existing Wall to be removed or cleared prior to construction
Existing Retaining Wall
21 LT
12 LT
El. 915 (0 ft)
Top of Wall
915
910
905
900
895
890
885
3 - Soft to M. Stiff Cohesive
2 - Stiff to V. Stiff Cohesive
El. 910.8 (4.2 ft)
Existing Ground
El. 908 (7 ft)
Maintenance Bench
El. 906 (9 ft) - Design Height
(Elevation of Maintenance Bench at Sta. 789+25)
El. 905.8 (9.2 ft)
Slip Surface
El. 905 (10 ft) (Layer Break and Groundwater)
4 - Hard Residuum
El. 903 (12 ft)
Assume Groundwater
2 feet Above Residuum
10 ft
Minimum Length
Below Slip Surface
4 - Hard Residuum
El. 895.8 (19.2 ft)
Claystone
El. 894.5 (20.5 ft)
Claystone
10 ft
Recommended
Bedrock Socket
El. 890.25 (24.75 ft)
Sandstone
-30
-20
-10
0
10

LPILE Analyses
(HP 12 x 53)

ODOT District 9
JAC-327-14.99

Calculated: DCM Date: 8/13/2025
Calculated: AKB Date: 8/22/2025

Geometry

	Elevation (ft)	
Top of Backfill =	915.0	*at Outside Edge of Shoulder*
Top of Wall =	915.0	*at C/L of Wall*
Existing Ground Surface =	910.8	*at C/L of Wall*
Maintenance Bench =	906.0	*at C/L of Wall*
Slip Plane =	905.8	*at C/L of Wall*

	Horiz. Distance from C/L (ft)	
Start of Wall Backfill =	12.0	*at Outside Edge of Shoulder*
Wall =	21.0	*at C/L of Wall*
Backfill Slope Angle =	12.0	H:1V

Maintenance bench Elevation based on maximum potential wall height (~9 ft) at 789+25

Wall Loading Profile

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Item 203	915.0	4.2	200	28	120
3 - Soft to M. Stiff Cohesive	910.8	4.8	90	22	120
Bottom of Wall/Maintenance Bench	906.0				
Weighted Value		9.0	140	25	120

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	27		
Wall Friction , δ^{Δ} =	0.0		
Wall Slope, θ =	90		
Backfill Slope, β =	4.76		
Revised Backfill Slope, β =	4.76		
Backfill Condition	INFINITE		
Horz. Backslope Dist.	9.0	feet	*(C/L of Wall - Edge of Shoulder)*
Wall Height (H)	9.0	feet	*(Top of Wall - Maintenance Bench)*
Slope Height (h)	0.0	feet	*(Top of Backfill - Top of Wall)*
I =	0.00	degrees	

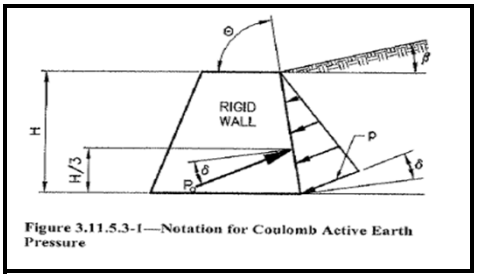


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

Active Earth Coefficient

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

K_a = 0.400

At-Rest Earth Coefficient

$K_o = (1- \mathrm{Sin}(\phi))*(1+\mathrm{Sin}(\beta))$

K_o = 0.595

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' = 140 psf and φ' = 25°, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters c' = 0 psf and φ'= 27° 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
3 - Soft to Medium Stiff Cohesive	906.0	9.0	800	0	130	0.01	N/A
2 - Stiff to V. Stiff Cohesive (Below GW)	905	10.0	1800	0	57.6	0.007	N/A
4 - Hard Residuum (Below GW)	903	12.0	3600	0	72.6	0.005	N/A
Claystone	894.5	20.5	N/A	N/A	N/A	N/A	N/A
Sandstone	890.3	24.8	N/A	N/A	N/A	N/A	N/A

Bedrock Lateral Design Profile

	Top Elev	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	krm
Claystone	894.5	20.5	150	6,300	145	60	0.0005
Sandstone	890.3	24.8	2200	292,000	150	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 = 120 pcf *Weighted Average Along Cantilevered Wall Height*

2) Determine Coefficient of Earth Pressure (K)

Restraint Condition = ACTIVE *(Active or At-Rest)*
Ka = 0.400

3) Determine Equivalent Fluid Weight (G_H)

G_H = $(\gamma_m) * (K_a)$
G_H = 48 *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) = 0.0 = dt (tan(β_{dh})
β_{dh} = 32 = steepness of the slope downhill of the drilled shaft
FS_{dh} = 1.48 = Factor of Safety down slope of the proposed wall
d_t = 0.2 = 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 = 2 feet *(shaft diameter or pile flange width)*
Assumed Shaft Spacing = 6 feet *(center-to-center pile spacing)*
P_m = 0.93 *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 = 0.93 = (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) = 9 feet Depth from T/Wall to Slip Plane = 9.2 feet
Wall Height (H) + GS_{AL} = 9.0
P = $1/2 * G_H * H^2$
P = 1942 lbs/foot
P_{SH} = P*(Shaft Spacing) *(earth loading)*
P_{SH} = 11652 lbs/shaft Force Per Shaft = 17736 lbs/shaft

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

w = $2*P_{SH}/H$
w = 2589 lbs/foot per shaft (Earth - Service Limit) 3856 lbs/foot per shaft
w = 216 lbs/inch per shaft (Earth - Service Limit) 321 lbs/inch per shaft
γ_E = 1.5 *Earth Load Factor*
w = $(2*P_{SH}/H)*\gamma_E$
w = 324 lbs/inch per shaft (Earth - Strength Limit) 482 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 = 899 lbs/foot *(surcharge resolved to distributed load)* 919 lbs/foot
P_s = 5395 lbs/shaft 5514 lbs/shaft

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

w = P_S/H
w = 599 lbs/foot per shaft (surcharge - unfactored) 599 lbs/foot per shaft
w = 50 lbs/inch per shaft (surcharge - unfactored) 50 lbs/inch per shaft
γ_S = 1.75 *Surcharge Load Factor - Strength I*
w = $(P_S/L)*\gamma_S$
w = 87 lbs/inch per shaft (Surcharge - Strength I) 87 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	50	87
9.0	266	411

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	50	87
9.2	371	569

ODOT District 9
JAC-327-14.99

Calculated: DCM Date: 8/13/2025
Calculated: AKB Date: 8/22/2025

Steel Beam and Cross-Section Properties

Assumed Pile Shape HP 12x53

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	24	in
Longest Beam Dimension	16.829736	in
Clear Distance	3.5851322	in

Steel Beam Geometry

Beam Depth (D)	11.8	in
Web Thickness (t_w)	0.435	in
Flange Width (B_f)	12.0	in
Flange Thickness (t_f)	0.435	in
Area of Steel (A_s)	15.5	in^2

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I_{xx}) of Steel	393	in^4
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	1.14E+10	$lb*in^2$
Section Modulus (S_x)	66.7	in^3
Section Modulus (Z_x)	74	in^3
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t_w	27.126437	
$1.12\sqrt{Ek/F_{yw}}$	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 * 11.8 * 0.435

$V_p =$ 148.9 kips

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

$\phi V_{cr} =$ 1 * 1 * 148.9

$\phi V_{cr =}$ 148.9 kips

$V_u =$ 45.0 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 * 66.7

$\phi M_n =$ 3335 in*kips

$M_u =$ 2775.9 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 =	9.2	ft	
Minimum Pile Length Below Slip Plane =	10	ft	*ODOT Minimum Required Length*
Minimum Required Pile Length =	19.2	ft	

Deflection Criteria

Pile Length Above Rock = 20.5 ft = 246 in

Exposed Wall Height = 9 ft = 108 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	$\delta =$	1.14 in	*(from LPILE)*
1.5% Wall Height - PYWALL		in	$\delta =$	in	*(from PYWALL)*

Service Limit Analysis

Service Limit State
HP 12x53

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

                    LPile for Windows, Version 2022-12.009

                 Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
                          © 1985-2022 by Ensoft, Inc.
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================================================================================

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

Path to file locations:
\ODOT-D9 GES\Task 3_JAC-327-14.99\LPILE\

Name of input data file:
20250812_JAC-327-14.99_LPILE_Service Limit.lp12d

Name of output report file:
20250812_JAC-327-14.99_LPILE_Service Limit.lp12o

Name of plot output file:
20250812_JAC-327-14.99_LPILE_Service Limit.lp12p

Name of runtime message file:
20250812_JAC-327-14.99_LPILE_Service Limit.lp12r



--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  August 26, 2025            Time:  15:25:16
```

Problem Title

Project Name: JAC-327-14.99

PID: 123842

Client: ODOT

Engineer: HDR

Description: Sta 790+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                      =            2
Total length of pile                                 =       30.000 ft
Depth of ground surface below top of pile            =       9.0000 ft

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

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

            Depth Below           Pile
Point        Pile Head          Diameter
 No.            feet             inches
-----      -------------     -------------
  1             0.000           12.0000
  2             9.000           12.0000
  3             9.000           24.0000
  4            30.000           24.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is an elastic pile
   Cross-sectional Shape                             = Strong H-Pile
   Length of section                                 =     9.000000 ft
   Flange Width                                      =    12.000000 in
   Section Depth                                     =    11.800000 in
   Flange Thickness                                  =     0.435000 in
   Web Thickness                                     =     0.435000 in
   Section Area                                      =    15.194550 sq. in
   Moment of Inertia                                 =   384.614130 in^4
   Elastic Modulus                                   =    29000000. psi

Pile Section No. 2:

   Section 2 is a drilled shaft with casing and AISC section core/insert
   Length of section                                 =    21.000000 ft
   Section Diameter                                  =    24.000000 in
   Core/Insert AISC Section Type                     = HP

   Core/Insert AISC Section Name                     = HP12X53




--------------------------------------------------------------------------------
                      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	=	9.000000 ft
Distance from top of pile to bottom of layer	=	10.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	800.000000 psf
Undrained cohesion at bottom of layer	=	800.000000 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	=	10.000000 ft
Distance from top of pile to bottom of layer	=	12.000000 ft
Effective unit weight at top of layer	=	57.600000 pcf
Effective unit weight at bottom of layer	=	57.600000 pcf
Undrained cohesion at top of layer	=	1800. psf
Undrained cohesion at bottom of layer	=	1800. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	12.000000 ft
Distance from top of pile to bottom of layer	=	20.500000 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	=	3600. psf
Undrained cohesion at bottom of layer	=	3600. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

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

Distance from top of pile to top of layer	=	20.500000 ft
Distance from top of pile to bottom of layer	=	24.800000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	150.000000 psi
Uniaxial compressive strength at bottom of layer	=	150.000000 psi
Initial modulus of rock at top of layer	=	6300. psi
Initial modulus of rock at bottom of layer	=	6300. psi
RQD of rock at top of layer	=	60.000000 %
RQD of rock at bottom of layer	=	60.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

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

```
   Distance from top of pile to top of layer           =    24.800000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =   150.000000 pcf
   Effective unit weight at bottom of layer            =   150.000000 pcf
   Uniaxial compressive strength at top of layer       =        2200. psi
   Uniaxial compressive strength at bottom of layer    =        2200. psi
   Initial modulus of rock at top of layer             =      292000. psi
   Initial modulus of rock at bottom of layer          =      292000. 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 20.000 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 = 150.00 pcf

This data may be erroneous. Please check your data.
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay w/o Free Water	9.0000 10.0000	130.0000 130.0000	800.0000 800.0000	-- --	-- --	0.01000 0.01000	-- --
2	Stiff Clay w/o Free Water	10.0000 12.0000	57.6000 57.6000	1800. 1800.	-- --	-- --	0.00700 0.00700	-- --
3	Stiff Clay w/o Free Water	12.0000 20.5000	72.6000 72.6000	3600. 3600.	-- --	-- --	0.00500 0.00500	-- --
4	Weak Rock	20.5000 24.8000	145.0000 145.0000	-- --	150.0000 150.0000	60.0000 60.0000	5.00E-04 5.00E-04	6300. 6300.
5	Weak Rock	24.8000 50.0000	150.0000 150.0000	-- --	2200. 2200.	60.0000 60.0000	5.00E-04 5.00E-04	292000. 292000.

Modification Factors for p-y Curves

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

Point	Depth X	p-mult	y-mult

No.	ft		
1	9.000	0.9300	1.0000
2	20.500	0.9300	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 ft	Dist. Load lb/in
1	0.000	50.000
2	9.200	371.000

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 = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	21.000000	ft
Outside Diameter of Casing	=	24.000000	in
Casing Wall Thickness	=	0.0000	in
Moment of Inertia of Steel Casing	=	0.0000	in^4
Width Flange of Core/Insert	=	12.000000	in
Depth of Core/Insert	=	11.800000	in
Flange Thickness of Core/Insert	=	0.435000	in
Web Thickness of Core/Insert	=	0.435000	in
Moment of Inertia of Steel Core/Insert	=	393.000000	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Yield Stress of Core/Insert	=	50000.	psi
Elastic Modulus of Core/Insert	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Gross Area of Pile	=	452.389342	sq. in.
Area of Concrete	=	437.194792	sq. in.
Cross-sectional Area of Steel Casing	=	0.0000	sq. in.
Cross-sectional Area of Steel Core/Insert	=	15.500000	sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	15.194550	sq. in.
Area Ratio of All Steel to Gross Area	=	3.36	percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	2260.424	kips
Tensile Load for Cracking of Concrete	=	-233.565	kips
Nominal Axial Tensile Capacity	=	-775.000	kips

Concrete Properties:

Compressive Strength of Concrete	=	4000.	psi
Modulus of Elasticity of Concrete	=	3604997.	psi
Modulus of Rupture of Concrete	=	-474.34165	psi
Compression Strain at Peak Stress	=	0.001886	
Tensile Strain at Fracture of Concrete	=	-0.0001154	

Maximum Coarse Aggregate Size = 0.750000 in

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

Number	Axial Thrust Force kips
1	0.000

Definitions of Run Messages and Notes:

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

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

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000125	98.0433232	78434659.	12.0000000	0.00001500	-0.00001500	0.0627335	0.00000	0.00000	0.2131500	
0.00000250	195.6277501	78251100.	12.0000000	0.00003000	-0.00003000	0.1249712	0.00000	0.00000	0.4263000	
0.00000375	292.7532804	78067541.	12.0000000	0.00004500	-0.00004500	0.1867130	0.00000	0.00000	0.6394500	
0.00000500	389.4199144	77883983.	12.0000000	0.00006000	-0.00006000	0.2479590	0.00000	0.00000	0.8526000	
0.00000625	485.6276518	77700424.	12.0000000	0.00007500	-0.00007500	0.3087091	0.00000	0.00000	1.0657500	
0.00000750	581.3764929	77516866.	12.0000000	0.00009000	-0.00009000	0.3689635	0.00000	0.00000	1.2789000	
0.00000875	676.6664375	77333307.	12.0000000	0.0001050	-0.000105	0.4287220	0.00000	0.00000	1.4920500	
0.00001000	266.7489824	26674898.	7.9679830	0.00007968	-0.000160	0.3259223	0.00000	0.00000	-2.874485	C
0.00001125	299.9213296	26659674.	7.9709110	0.00008967	-0.000180	0.3658220	0.00000	0.00000	-3.232840	C
0.00001250	333.0552008	26644416.	7.9738464	0.00009967	-0.000200	0.4055337	0.00000	0.00000	-3.590981	C
0.00001375	366.1504694	26629125.	7.9767891	0.0001097	-0.000220	0.4450570	0.00000	0.00000	-3.948906	C
0.00001500	399.2070082	26613801.	7.9797393	0.0001197	-0.000240	0.4843915	0.00000	0.00000	-4.306614	C
0.00001625	432.2246887	26598442.	7.9826969	0.0001297	-0.000260	0.5235368	0.00000	0.00000	-4.664104	C
0.00001750	465.2033822	26583050.	7.9856619	0.0001397	-0.000280	0.5624925	0.00000	0.00000	-5.021377	C
0.00001875	498.1429587	26567624.	7.9886346	0.0001498	-0.000300	0.6012583	0.00000	0.00000	-5.378430	C
0.00002000	531.0433642	26552168.	7.9916147	0.0001598	-0.000320	0.6398338	0.00000	0.00000	-5.735263	C
0.00002125	563.9043216	26536674.	7.9946025	0.0001699	-0.000340	0.6782184	0.00000	0.00000	-6.091876	C
0.00002250	596.7257677	26521145.	7.9975979	0.0001799	-0.000360	0.7164120	0.00000	0.00000	-6.448267	C
0.00002375	629.5075691	26505582.	8.0006010	0.0001900	-0.000380	0.7544140	0.00000	0.00000	-6.804436	C
0.00002500	662.2495918	26489984.	8.0036119	0.0002001	-0.000400	0.7922240	0.00000	0.00000	-7.160381	C
0.00002625	694.9517009	26474351.	8.0066305	0.0002102	-0.000420	0.8298417	0.00000	0.00000	-7.516102	C
0.00002750	727.6137603	26458682.	8.0096568	0.0002203	-0.000440	0.8672667	0.00000	0.00000	-7.871599	C

0.00002875	760.2356336	26442979.	8.0126911	0.0002304	-0.000460	0.9044985	0.00000	0.00000	-8.226869 C
0.00003000	792.8171829	26427239.	8.0157332	0.0002405	-0.000480	0.9415368	0.00000	0.00000	-8.581912 C
0.00003125	825.3582697	26411465.	8.0187832	0.0002506	-0.000499	0.9783811	0.00000	0.00000	-8.936728 C
0.00003250	857.8587547	26395654.	8.0218412	0.0002607	-0.000519	1.0150310	0.00000	0.00000	-9.291315 C
0.00003375	890.3184973	26379807.	8.0249073	0.0002708	-0.000539	1.0514860	0.00000	0.00000	-9.645672 C
0.00003500	922.7373565	26363924.	8.0279813	0.0002810	-0.000559	1.0877459	0.00000	0.00000	-9.999799 C
0.00003625	955.1151898	26348005.	8.0310635	0.0002911	-0.000579	1.1238101	0.00000	0.00000	-10.353694 C
0.00003750	987.4518541	26332049.	8.0341538	0.0003013	-0.000599	1.1596783	0.00000	0.00000	-10.707358 C
0.00003875	1020.	26316057.	8.0372523	0.0003114	-0.000619	1.1953500	0.00000	0.00000	-11.060788 C
0.00004000	1052.	26300028.	8.0403504	0.0003216	-0.000638	1.2308235	0.00000	0.00000	-11.413993 C
0.00004125	1084.	26283969.	8.0433913	0.0003318	-0.000658	1.2660901	0.00000	0.00000	-11.767043 C
0.00004250	1116.	26267873.	8.0464401	0.0003420	-0.000678	1.3011584	0.00000	0.00000	-12.119862 C
0.00004375	1149.	26251741.	8.0494968	0.0003522	-0.000698	1.3360279	0.00000	0.00000	-12.472451 C
0.00004500	1181.	26235572.	8.0525616	0.0003624	-0.000718	1.3706982	0.00000	0.00000	-12.824807 C
0.00004625	1213.	26219367.	8.0556344	0.0003726	-0.000737	1.4051689	0.00000	0.00000	-13.176930 C
0.00004750	1245.	26203124.	8.0587153	0.0003828	-0.000757	1.4394395	0.00000	0.00000	-13.528820 C
0.00004875	1277.	26186844.	8.0618043	0.0003930	-0.000777	1.4735095	0.00000	0.00000	-13.880474 C
0.00005125	1340.	26154171.	8.0680070	0.0004135	-0.000817	1.5410463	0.00000	0.00000	-14.583075 C
0.00005375	1404.	26121346.	8.0742427	0.0004340	-0.000856	1.6077757	0.00000	0.00000	-15.284724 C
0.00005625	1467.	26088369.	8.0805119	0.0004545	-0.000895	1.6736941	0.00000	0.00000	-15.985415 C
0.00005875	1531.	26055237.	8.0868149	0.0004751	-0.000935	1.7387979	0.00000	0.00000	-16.685139 C
0.00006125	1594.	26021949.	8.0931522	0.0004957	-0.000974	1.8030833	0.00000	0.00000	-17.383888 C
0.00006375	1657.	25988504.	8.0995240	0.0005163	-0.001014	1.8665467	0.00000	0.00000	-18.081655 C
0.00006625	1720.	25954899.	8.1059307	0.0005370	-0.001053	1.9291842	0.00000	0.00000	-18.778430 C
0.00006875	1782.	25921133.	8.1123728	0.0005577	-0.001092	1.9909921	0.00000	0.00000	-19.474207 C
0.00007125	1844.	25887204.	8.1188507	0.0005785	-0.001132	2.0519664	0.00000	0.00000	-20.168975 C
0.00007375	1907.	25853111.	8.1253647	0.0005992	-0.001171	2.1121032	0.00000	0.00000	-20.862726 C
0.00007625	1969.	25818852.	8.1319153	0.0006201	-0.001210	2.1713986	0.00000	0.00000	-21.555452 C
0.00007875	2031.	25784425.	8.1385029	0.0006409	-0.001249	2.2298486	0.00000	0.00000	-22.247144 C
0.00008125	2092.	25749828.	8.1451279	0.0006618	-0.001288	2.2874489	0.00000	0.00000	-22.937792 C
0.00008375	2154.	25715060.	8.1517907	0.0006827	-0.001327	2.3441957	0.00000	0.00000	-23.627388 C
0.00008625	2215.	25680118.	8.1584919	0.0007037	-0.001366	2.4000845	0.00000	0.00000	-24.315922 C
0.00008875	2276.	25645001.	8.1652318	0.0007247	-0.001405	2.4551113	0.00000	0.00000	-25.003384 C
0.00009125	2337.	25609707.	8.1720110	0.0007457	-0.001444	2.5092716	0.00000	0.00000	-25.689766 C
0.00009375	2398.	25574233.	8.1788298	0.0007668	-0.001483	2.5625612	0.00000	0.00000	-26.375056 C
0.00009625	2458.	25538579.	8.1856888	0.0007879	-0.001522	2.6149757	0.00000	0.00000	-27.059246 C
0.00009875	2518.	25502741.	8.1925884	0.0008090	-0.001561	2.6665105	0.00000	0.00000	-27.742325 C
0.0001013	2579.	25466714.	8.1995291	0.0008302	-0.001600	2.7171609	0.00000	0.00000	-28.424285 C
0.0001038	2638.	25430503.	8.2065115	0.0008514	-0.001639	2.7669228	0.00000	0.00000	-29.105111 C
0.0001063	2698.	25394103.	8.2135361	0.0008727	-0.001677	2.8157913	0.00000	0.00000	-29.784794 C
0.0001088	2758.	25357511.	8.2206033	0.0008940	-0.001716	2.8637616	0.00000	0.00000	-30.463325 C
0.0001113	2817.	25320725.	8.2277137	0.0009153	-0.001755	2.9108290	0.00000	0.00000	-31.140691 C
0.0001138	2876.	25283743.	8.2348678	0.0009367	-0.001793	2.9569885	0.00000	0.00000	-31.816882 C
0.0001163	2935.	25246562.	8.2420663	0.0009581	-0.001832	3.0022353	0.00000	0.00000	-32.491886 C
0.0001188	2994.	25209180.	8.2493096	0.0009796	-0.001870	3.0465644	0.00000	0.00000	-33.165692 C
0.0001213	3052.	25171594.	8.2565984	0.0010011	-0.001909	3.0899706	0.00000	0.00000	-33.838288 C
0.0001238	3110.	25133803.	8.2639332	0.0010227	-0.001947	3.1324489	0.00000	0.00000	-34.509661 C
0.0001263	3168.	25095804.	8.2713145	0.0010443	-0.001986	3.1739939	0.00000	0.00000	-35.179801 C
0.0001288	3226.	25057595.	8.2787431	0.0010659	-0.002024	3.2146006	0.00000	0.00000	-35.848692 C
0.0001313	3284.	25019225.	8.2860579	0.0010875	-0.002062	3.2542242	0.00000	0.00000	-36.516943 C
0.0001338	3341.	24980657.	8.2933862	0.0011092	-0.002101	3.2928909	0.00000	0.00000	-37.184080 C
0.0001363	3398.	24941877.	8.3007610	0.0011310	-0.002139	3.3306029	0.00000	0.00000	-37.849969 C
0.0001388	3455.	24902882.	8.3081831	0.0011528	-0.002177	3.3673547	0.00000	0.00000	-38.514599 C
0.0001413	3512.	24863669.	8.3156530	0.0011746	-0.002215	3.4031409	0.00000	0.00000	-39.177957 C
0.0001438	3568.	24824236.	8.3231715	0.0011965	-0.002254	3.4379557	0.00000	0.00000	-39.840030 C
0.0001463	3625.	24784579.	8.3307391	0.0012184	-0.002292	3.4717934	0.00000	0.00000	-40.500804 C

0.0001488	3681.	24744697.	8.3383565	0.0012403	-0.002330	3.5046482	0.00000	0.00000	-41.160265 C
0.0001588	3903.	24582851.	8.3693382	0.0013286	-0.002481	3.6261181	0.00000	0.00000	-43.784710 C
0.0001688	4120.	24417150.	8.4011741	0.0014177	-0.002632	3.7313699	0.00000	0.00000	-46.387005 C
0.0001788	4334.	24247384.	8.4339139	0.0015076	-0.002782	3.8199818	0.00000	0.00000	-48.966148 C
0.0001888	4511.	23899357.	8.4428390	0.0015936	-0.002936	3.8882117	0.00000	0.00000	-50.000000 CY
0.0001988	4585.	23069680.	8.3809626	0.0016657	-0.003104	3.9328462	0.00000	0.00000	-50.000000 CY
0.0002088	4645.	22252263.	8.3181181	0.0017364	-0.003274	3.9656046	0.00000	0.00000	-50.000000 CY
0.0002188	4698.	21478750.	8.2584462	0.0018065	-0.003443	3.9873716	0.00000	0.00000	-50.000000 CY
0.0002288	4746.	20746685.	8.2012668	0.0018760	-0.003614	3.9984038	0.00000	0.00000	-50.000000 CY
0.0002388	4788.	20053590.	8.1477072	0.0019453	-0.003785	3.9991831	0.00000	0.00000	-50.000000 CY
0.0002488	4825.	19398662.	8.0980811	0.0020144	-0.003956	3.9994984	0.00000	0.00000	-50.000000 CY
0.0002588	4859.	18778084.	8.0518737	0.0020834	-0.004127	3.9995413	0.00000	0.00000	-50.000000 CY
0.0002688	4888.	18189376.	8.0075700	0.0021520	-0.004298	3.9993259	0.00000	0.00000	-50.000000 CY
0.0002788	4915.	17631516.	7.9659040	0.0022205	-0.004470	3.9987213	0.00000	0.00000	-50.000000 CY
0.0002888	4938.	17102759.	7.9270822	0.0022889	-0.004641	3.9974339	0.00000	0.00000	-50.000000 CY
0.0002988	4960.	16601266.	7.8908376	0.0023574	-0.004813	3.9984115	0.00000	0.00000	-50.000000 CY
0.0003088	4979.	16125127.	7.8570408	0.0024259	-0.004984	3.9997064	0.00000	0.00000	-50.000000 CY
0.0003188	4996.	15672912.	7.8254703	0.0024944	-0.005156	3.9980025	0.00000	0.00000	-50.000000 CY
0.0003288	5011.	15243244.	7.7957082	0.0025628	-0.005327	3.9981445	0.00000	0.00000	-50.000000 CY
0.0003388	5025.	14833712.	7.7666657	0.0026310	-0.005499	3.9991397	0.00000	0.00000	-50.000000 CY
0.0003488	5037.	14443376.	7.7391306	0.0026990	-0.005671	3.9950882	0.00000	0.00000	-50.000000 CY
0.0003588	5048.	14071730.	7.7133646	0.0027672	-0.005843	3.9993974	0.00000	0.00000	-50.000000 CY
0.0003688	5058.	13717682.	7.6892643	0.0028354	-0.006015	3.9947087	0.00000	0.00000	-50.000000 CY
0.0003788	5067.	13378885.	7.6661859	0.0029036	-0.006186	3.9991153	0.00000	0.00000	-50.000000 CY
0.0003888	5075.	13055908.	7.6446398	0.0029719	-0.006358	3.9960393	0.00000	0.00000	-50.000000 CY
0.0003988	5083.	12746684.	7.6242008	0.0030402	-0.006530	3.9979817	0.00000	0.00000	-50.000000 CY
0.0004088	5089.	12451147.	7.6048279	0.0031085	-0.006702	3.9999816	0.00000	0.00000	-50.000000 CY
0.0004188	5095.	12167842.	7.5865942	0.0031769	-0.006873	3.9950829	0.00000	0.00000	-50.000000 CY
0.0004288	5101.	11896551.	7.5692725	0.0032453	-0.007045	3.9989818	0.00000	0.00000	-50.000000 CY
0.0004388	5105.	11636131.	7.5522701	0.0033136	-0.007216	3.9982011	0.00000	0.00000	-50.000000 CY
0.0004488	5110.	11386218.	7.5358992	0.0033817	-0.007388	3.9950752	0.00000	0.00000	-50.000000 CY
0.0004588	5113.	11145800.	7.5199211	0.0034498	-0.007560	3.9987789	0.00000	0.00000	-50.000000 CY
0.0004688	5117.	10915333.	7.5049637	0.0035180	-0.007732	3.9998649	0.00000	0.00000	-50.000000 CY
0.0004788	5119.	10693043.	7.4905981	0.0035861	-0.007904	3.9926063	0.00000	0.00000	-50.000000 CY
0.0004888	5122.	10479334.	7.4768997	0.0036543	-0.008076	3.9971798	0.00000	0.00000	-50.000000 CY
0.0004988	5124.	10273973.	7.4640213	0.0037227	-0.008247	3.9995967	0.00000	0.00000	-50.000000 CY
0.0005088	5126.	10075389.	7.4512988	0.0037908	-0.008419	3.9962291	0.00000	0.00000	-50.000000 CY
0.0005188	5110.	9850418.	7.4544058	0.0038670	-0.008583	3.9939188	0.00000	0.00000	-50.000000 CY

Summary of Results for Nominal Moment Capacity for Section 2

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	0.000	5078.475	0.00300000	-0.00642891

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

In ACI 318, the value of the strength reduction factor depends on whether

the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

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

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

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	0.0000	5078.	0.0000	3301.	25007642.
1	0.75	0.0000	5078.	0.0000	3809.	24651217.
1	0.90	0.0000	5078.	0.0000	4571.	23231726.

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	9.0000	0.00	N.A.	No	0.00	5133.
2	10.0000	0.4637	Yes	No	5133.	24799.
3	12.0000	1.3080	Yes	No	29932.	279005.
4	20.5000	11.5000	No	Yes	N.A.	N.A.
5	24.8000	15.8000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs

Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.1369	-1.53E-06	-2.65E-08	-0.00821	2.38E-08	1.12E+10	0.00	0.00	52.6168
0.3000	1.1073	340.9572	203.5516	-0.00821	5.3189	1.12E+10	0.00	0.00	60.4674
0.6000	1.0777	1466.	440.0755	-0.00821	22.8630	1.12E+10	0.00	0.00	70.9348
0.9000	1.0482	3510.	714.2821	-0.00821	54.7484	1.12E+10	0.00	0.00	81.4022
1.2000	1.0186	6608.	1026.	-0.00821	103.0914	1.12E+10	0.00	0.00	91.8696
1.5000	0.9891	10898.	1376.	-0.00821	170.0083	1.12E+10	0.00	0.00	102.3370
1.8000	0.9595	16514.	1763.	-0.00820	257.6154	1.12E+10	0.00	0.00	112.8043
2.1000	0.9300	23592.	2188.	-0.00820	368.0288	1.12E+10	0.00	0.00	123.2717
2.4000	0.9005	32267.	2651.	-0.00819	503.3649	1.12E+10	0.00	0.00	133.7391
2.7000	0.8711	42676.	3151.	-0.00818	665.7400	1.12E+10	0.00	0.00	144.2065
3.0000	0.8416	54953.	3689.	-0.00816	857.2702	1.12E+10	0.00	0.00	154.6739
3.3000	0.8123	69235.	4265.	-0.00814	1080.	1.12E+10	0.00	0.00	165.1413
3.6000	0.7830	85657.	4878.	-0.00811	1336.	1.12E+10	0.00	0.00	175.6087
3.9000	0.7539	104356.	5529.	-0.00808	1628.	1.12E+10	0.00	0.00	186.0761
4.2000	0.7248	125466.	6218.	-0.00805	1957.	1.12E+10	0.00	0.00	196.5435
4.5000	0.6959	149122.	6944.	-0.00800	2326.	1.12E+10	0.00	0.00	207.0109
4.8000	0.6672	175462.	7708.	-0.00795	2737.	1.12E+10	0.00	0.00	217.4783
5.1000	0.6387	204621.	8510.	-0.00789	3192.	1.12E+10	0.00	0.00	227.9457
5.4000	0.6104	236733.	9349.	-0.00782	3693.	1.12E+10	0.00	0.00	238.4130
5.7000	0.5824	271936.	10226.	-0.00774	4242.	1.12E+10	0.00	0.00	248.8804
6.0000	0.5547	310363.	11141.	-0.00764	4842.	1.12E+10	0.00	0.00	259.3478
6.3000	0.5274	352152.	12094.	-0.00753	5494.	1.12E+10	0.00	0.00	269.8152
6.6000	0.5005	397438.	13084.	-0.00741	6200.	1.12E+10	0.00	0.00	280.2826
6.9000	0.4740	446357.	14112.	-0.00728	6963.	1.12E+10	0.00	0.00	290.7500
7.2000	0.4481	499043.	15177.	-0.00712	7785.	1.12E+10	0.00	0.00	301.2174
7.5000	0.4227	555633.	16281.	-0.00695	8668.	1.12E+10	0.00	0.00	311.6848
7.8000	0.3980	616263.	17421.	-0.00677	9614.	1.12E+10	0.00	0.00	322.1522
8.1000	0.3740	681067.	18600.	-0.00656	10625.	1.12E+10	0.00	0.00	332.6196
8.4000	0.3508	750183.	19816.	-0.00633	11703.	1.12E+10	0.00	0.00	343.0870
8.7000	0.3285	823745.	21070.	-0.00607	12850.	1.12E+10	0.00	0.00	353.5543
9.0000	0.3071	901889.	22194.	-0.00579	14070.	1.12E+10	-93.546	1097.	364.0217
9.3000	0.2868	983538.	22502.	-0.00558	0.00	2.63E+10	-161.033	2022.	61.6880
9.6000	0.2669	1063900.	22027.	-0.00544	0.00	2.63E+10	-164.438	2218.	0.00
9.9000	0.2476	1142130.	21429.	-0.00529	0.00	2.63E+10	-167.527	2436.	0.00
10.2000	0.2288	1218190.	20435.	-0.00513	0.00	2.62E+10	-384.657	6051.	0.00
10.5000	0.2107	1289264.	19046.	-0.00495	0.00	2.62E+10	-387.144	6615.	0.00
10.8000	0.1932	1355321.	17649.	-0.00477	0.00	2.61E+10	-388.828	7247.	0.00
11.1000	0.1763	1416339.	16248.	-0.00458	0.00	2.61E+10	-389.751	7958.	0.00
11.4000	0.1602	1472306.	14844.	-0.00438	0.00	2.61E+10	-389.922	8763.	0.00
11.7000	0.1448	1523219.	13442.	-0.00418	0.00	2.61E+10	-389.334	9682.	0.00
12.0000	0.1301	1569086.	11758.	-0.00396	0.00	2.60E+10	-546.218	15113.	0.00
12.3000	0.1162	1607875.	9412.	-0.00374	0.00	2.60E+10	-756.820	23439.	0.00
12.6000	0.1032	1636855.	6696.	-0.00352	0.00	2.60E+10	-751.970	26239.	0.00
12.9000	0.09091	1656089.	4001.	-0.00329	0.00	2.60E+10	-745.405	29516.	0.00
13.2000	0.07949	1665663.	1333.	-0.00306	0.00	2.60E+10	-737.056	33382.	0.00
13.5000	0.06889	1665685.	-1302.	-0.00283	0.00	2.60E+10	-726.847	37985.	0.00
13.8000	0.05912	1656287.	-3897.	-0.00260	0.00	2.60E+10	-714.686	43521.	0.00
14.1000	0.05018	1637627.	-6444.	-0.00237	0.00	2.60E+10	-700.468	50256.	0.00
14.4000	0.04205	1609888.	-8936.	-0.00215	0.00	2.60E+10	-684.067	58563.	0.00
14.7000	0.03473	1573284.	-11365.	-0.00193	0.00	2.60E+10	-665.326	68971.	0.00

15.0000	0.02819	1528057.	-13722.	-0.00171	0.00	2.61E+10	-644.049	82256.	0.00
15.3000	0.02241	1474484.	-15997.	-0.00150	0.00	2.61E+10	-619.977	99609.	0.00
15.6000	0.01736	1412876.	-18180.	-0.00130	0.00	2.61E+10	-592.760	122928.	0.00
15.9000	0.01301	1343585.	-20259.	-0.00111	0.00	2.62E+10	-561.891	155449.	0.00
16.2000	0.00933	1267012.	-22218.	-9.35E-04	0.00	2.62E+10	-526.589	203143.	0.00
16.5000	0.00628	1183615.	-24040.	-7.67E-04	0.00	2.62E+10	-485.531	278412.	0.00
16.8000	0.00381	1093925.	-25699.	-6.11E-04	0.00	2.63E+10	-436.132	412194.	0.00
17.1000	0.00188	998583.	-27153.	-4.68E-04	0.00	2.63E+10	-371.943	712424.	0.00
17.4000	4.41E-04	898421.	-28268.	-3.38E-04	0.00	2.64E+10	-247.293	2016478.	0.00
17.7000	-5.55E-04	795053.	-28203.	-2.23E-04	0.00	2.64E+10	283.2954	1837395.	0.00
18.0000	-0.00116	695358.	-27070.	-1.21E-04	0.00	2.65E+10	346.5280	1073861.	0.00
18.3000	-0.00143	600153.	-25778.	-6.00E-05	0.00	7.75E+10	370.8453	934949.	0.00
18.6000	-0.00159	509754.	-24414.	-3.43E-05	0.00	7.76E+10	387.2979	874824.	0.00
18.9000	-0.00167	424375.	-23000.	-1.26E-05	0.00	7.78E+10	398.3078	856301.	0.00
19.2000	-0.00168	344158.	-21553.	5.15E-06	0.00	7.80E+10	405.1055	865707.	0.00
19.5000	-0.00164	269191.	-20089.	1.93E-05	0.00	7.81E+10	408.3954	897861.	0.00
19.8000	-0.00155	199516.	-18618.	3.01E-05	0.00	7.82E+10	408.6110	951694.	0.00
20.1000	-0.00142	135138.	-17152.	3.78E-05	0.00	7.83E+10	406.0340	1028798.	0.00
20.4000	-0.00127	76021.	-15700.	4.26E-05	0.00	7.84E+10	400.8575	1133085.	0.00
20.7000	-0.00111	22100.	-13755.	4.49E-05	0.00	7.84E+10	679.5122	2196277.	0.00
21.0000	-9.50E-04	-23015.	-11140.	4.49E-05	0.00	7.84E+10	773.3934	2929565.	0.00
21.3000	-7.91E-04	-58107.	-8373.	4.30E-05	0.00	7.84E+10	763.8741	3477600.	0.00
21.6000	-6.41E-04	-83298.	-5738.	3.98E-05	0.00	7.84E+10	699.6831	3931200.	0.00
21.9000	-5.04E-04	-99422.	-3373.	3.56E-05	0.00	7.84E+10	614.4501	4384800.	0.00
22.2000	-3.85E-04	-107583.	-1336.	3.08E-05	0.00	7.84E+10	516.9599	4838400.	0.00
22.5000	-2.83E-04	-109044.	341.9403	2.58E-05	0.00	7.84E+10	415.4141	5292000.	0.00
22.8000	-1.99E-04	-105121.	1660.	2.09E-05	0.00	7.84E+10	316.9220	5745600.	0.00
23.1000	-1.32E-04	-97091.	2640.	1.63E-05	0.00	7.84E+10	227.1762	6199200.	0.00
23.4000	-8.13E-05	-86117.	3319.	1.21E-05	0.00	7.84E+10	150.2822	6652800.	0.00
23.7000	-4.49E-05	-73195.	3749.	8.42E-06	0.00	7.84E+10	88.7245	7106400.	0.00
24.0000	-2.07E-05	-59123.	3987.	5.39E-06	0.00	7.84E+10	43.3981	7560000.	0.00
24.3000	-6.15E-06	-44488.	4090.	3.01E-06	0.00	7.84E+10	13.6988	8013600.	0.00
24.6000	1.01E-06	-29676.	4110.	1.31E-06	0.00	7.84E+10	-2.368	8467200.	0.00
24.9000	3.26E-06	-14895.	3431.	2.85E-07	0.00	7.84E+10	-374.899	4.13E+08	0.00
25.2000	3.06E-06	-4973.	2091.	-1.71E-07	0.00	7.84E+10	-369.355	4.34E+08	0.00
25.5000	2.03E-06	162.9468	963.1375	-2.81E-07	0.00	7.84E+10	-257.464	4.56E+08	0.00
25.8000	1.04E-06	1962.	252.8171	-2.32E-07	0.00	7.84E+10	-137.158	4.77E+08	0.00
26.1000	3.62E-07	1983.	-84.056	-1.42E-07	0.00	7.84E+10	-49.993	4.98E+08	0.00
26.4000	1.50E-08	1357.	-177.925	-6.52E-08	0.00	7.84E+10	-2.156	5.19E+08	0.00
26.7000	-1.08E-07	702.1665	-153.528	-1.79E-08	0.00	7.84E+10	15.7105	5.26E+08	0.00
27.0000	-1.14E-07	251.2691	-95.248	3.95E-09	0.00	7.84E+10	16.6673	5.26E+08	0.00
27.3000	-7.92E-08	16.3801	-44.434	1.01E-08	0.00	7.84E+10	11.5626	5.26E+08	0.00
27.6000	-4.15E-08	-68.658	-12.709	8.89E-09	0.00	7.84E+10	6.0627	5.26E+08	0.00
27.9000	-1.52E-08	-75.124	2.1982	5.59E-09	0.00	7.84E+10	2.2191	5.26E+08	0.00
28.2000	-1.29E-09	-52.831	6.5305	2.65E-09	0.00	7.84E+10	0.1878	5.26E+08	0.00
28.5000	3.90E-09	-28.105	5.8442	7.95E-10	0.00	7.84E+10	-0.569	5.26E+08	0.00
28.8000	4.44E-09	-10.753	3.6538	-9.68E-11	0.00	7.84E+10	-0.648	5.26E+08	0.00
29.1000	3.20E-09	-1.798	1.6465	-3.85E-10	0.00	7.84E+10	-0.467	5.26E+08	0.00
29.4000	1.67E-09	1.1021	0.3675	-4.01E-10	0.00	7.84E+10	-0.243	5.26E+08	0.00
29.7000	3.15E-10	0.8487	-0.153	-3.56E-10	0.00	7.84E+10	-0.04593	5.26E+08	0.00
30.0000	-8.97E-10	0.00	0.00	-3.37E-10	0.00	7.84E+10	0.1310	2.63E+08	0.00

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

polated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.13687658 inches
Computed slope at pile head      =     -0.0082129 radians
Maximum bending moment           =       1665685. inch-lbs
Maximum shear force              =        -28268. lbs
Depth of maximum bending moment  =    13.50000000 feet below pile head
Depth of maximum shear force     =    17.40000000 feet below pile head
Number of iterations             =             25
Number of zero deflection points =              5
Pile deflection at ground        =     0.30709235 inches
```

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
30.00000	1.13687658	1665685.	-28268.
28.50000	1.13715216	1679137.	-28418.
27.00000	1.14178236	1678487.	-28641.
25.50000	1.14634420	1680013.	-28658.
24.00000	1.12227224	1660496.	-28079.
22.50000	1.13285086	1664954.	-27619.
21.00000	1.16603570	1647832.	-30274.
19.50000	1.83806016	1588987.	-35523.
18.00000	4.56440369	1478612.	-38858.
16.50000	20.44284604	1355496.	-43470.

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	1.1369	-0.00821	-28268.	1665685.

Maximum pile-head deflection = 1.1368765771 inches
Maximum pile-head rotation = -0.0082129442 radians = -0.470567 deg.

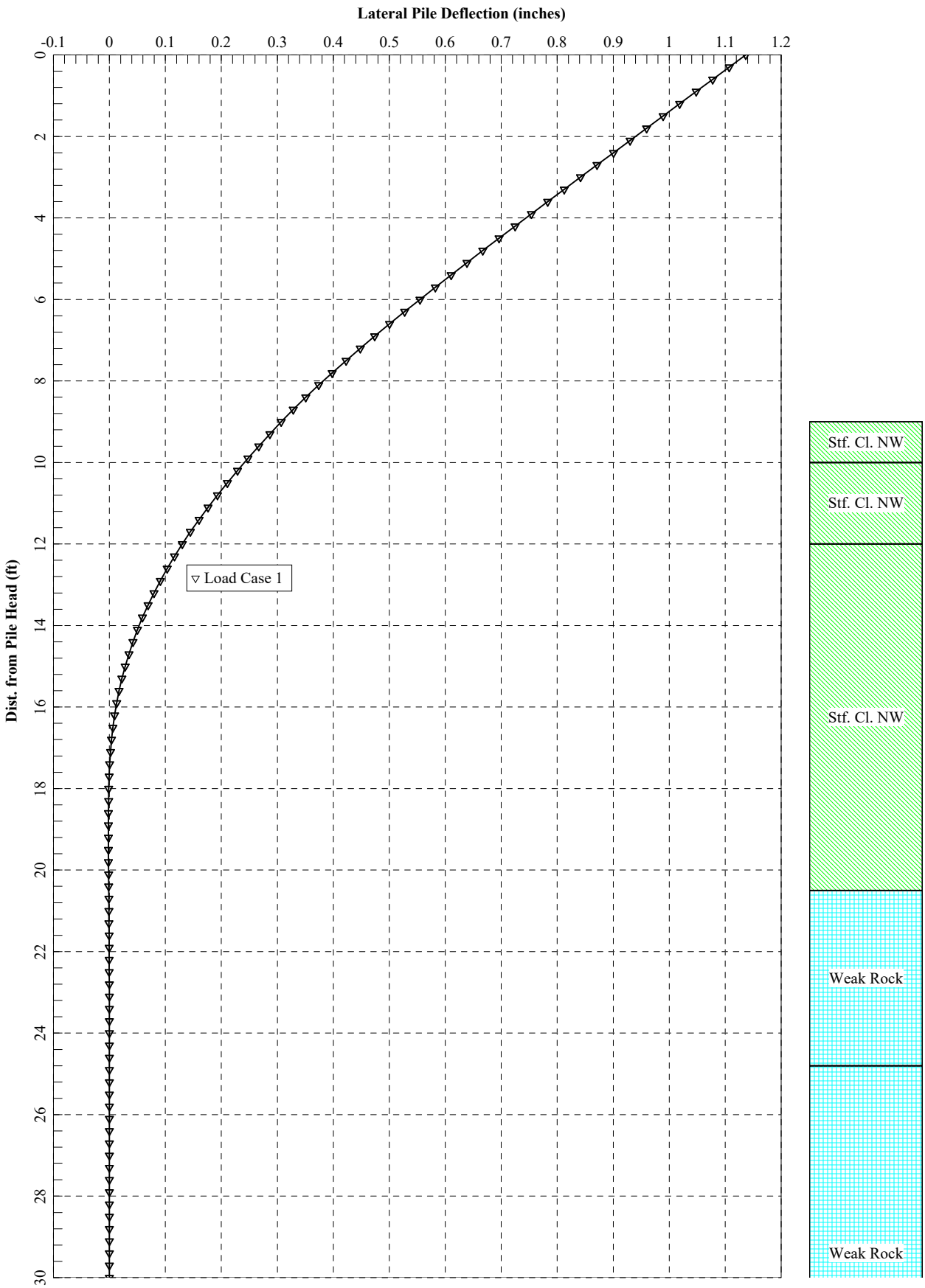
Summary of Warning Messages

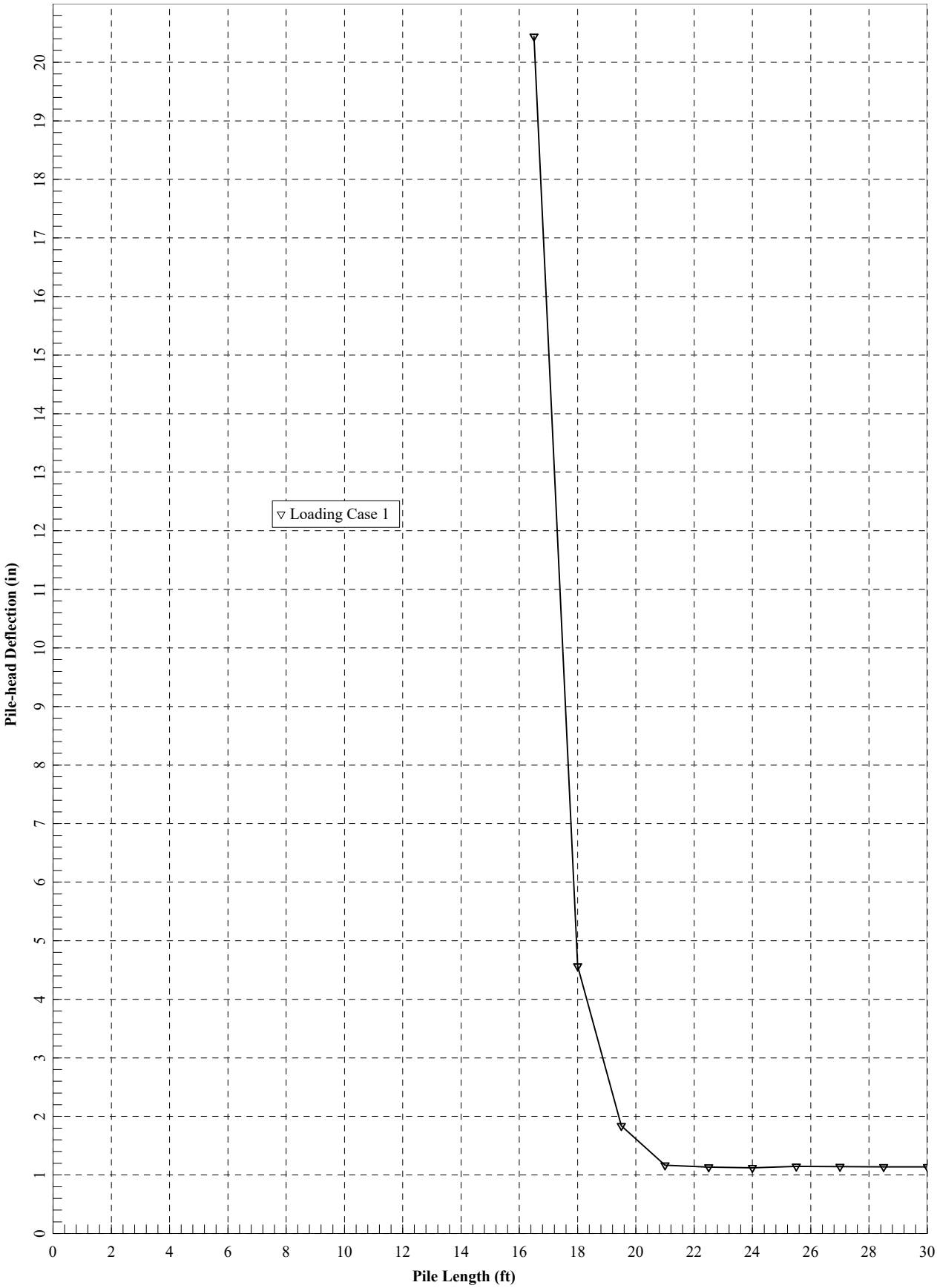
The following warning was reported 1555 times

**** 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)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock


Pile-head Deflection (in)
Pile Length (ft)
Loading Case 1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Strength Limit Analysis

Strength Limit State
HP 12x53

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

                    LPile for Windows, Version 2022-12.009

                 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:
\ODOT-D9 GES\Task 3_JAC-327-14.99\LPILE\

Name of input data file:
20250812_JAC-327-14.99_LPILE_Strength Limit.lp12d

Name of output report file:
20250812_JAC-327-14.99_LPILE_Strength Limit.lp12o

Name of plot output file:
20250812_JAC-327-14.99_LPILE_Strength Limit.lp12p

Name of runtime message file:
20250812_JAC-327-14.99_LPILE_Strength Limit.lp12r



--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  August 26, 2025            Time:  15:37:12
```

Problem Title

Project Name: JAC-327-14.99

PID: 123842

Client: ODOT

Engineer: HDR

Description: Sta 790+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                      =            2
Total length of pile                                 =       30.000 ft
Depth of ground surface below top of pile            =       9.0000 ft

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

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

            Depth Below           Pile
Point        Pile Head          Diameter
 No.            feet             inches
-----      -------------     -------------
  1             0.000           12.0000
  2             9.000           12.0000
  3             9.000           24.0000
  4            30.000           24.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is an elastic pile
   Cross-sectional Shape                             = Strong H-Pile
   Length of section                                 =     9.000000 ft
   Flange Width                                      =    12.000000 in
   Section Depth                                     =    11.800000 in
   Flange Thickness                                  =     0.435000 in
   Web Thickness                                     =     0.435000 in
   Section Area                                      =    15.194550 sq. in
   Moment of Inertia                                 =   384.614130 in^4
   Elastic Modulus                                   =    29000000. psi

Pile Section No. 2:

   Section 2 is a drilled shaft with casing and AISC section core/insert
   Length of section                                 =    21.000000 ft
   Section Diameter                                  =    24.000000 in
   Core/Insert AISC Section Type                     = HP

   Core/Insert AISC Section Name                     = HP12X53



--------------------------------------------------------------------------------
                      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	=	9.000000 ft
Distance from top of pile to bottom of layer	=	10.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	800.000000 psf
Undrained cohesion at bottom of layer	=	800.000000 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	=	10.000000 ft
Distance from top of pile to bottom of layer	=	12.000000 ft
Effective unit weight at top of layer	=	57.600000 pcf
Effective unit weight at bottom of layer	=	57.600000 pcf
Undrained cohesion at top of layer	=	1800. psf
Undrained cohesion at bottom of layer	=	1800. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	12.000000 ft
Distance from top of pile to bottom of layer	=	20.500000 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	=	3600. psf
Undrained cohesion at bottom of layer	=	3600. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

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

Distance from top of pile to top of layer	=	20.500000 ft
Distance from top of pile to bottom of layer	=	24.800000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	150.000000 psi
Uniaxial compressive strength at bottom of layer	=	150.000000 psi
Initial modulus of rock at top of layer	=	6300. psi
Initial modulus of rock at bottom of layer	=	6300. psi
RQD of rock at top of layer	=	60.000000 %
RQD of rock at bottom of layer	=	60.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

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

```
   Distance from top of pile to top of layer           =    24.800000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =   150.000000 pcf
   Effective unit weight at bottom of layer            =   150.000000 pcf
   Uniaxial compressive strength at top of layer       =        2200. psi
   Uniaxial compressive strength at bottom of layer    =        2200. psi
   Initial modulus of rock at top of layer             =      292000. psi
   Initial modulus of rock at bottom of layer          =      292000. 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 20.000 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 = 150.00 pcf

This data may be erroneous. Please check your data.
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay w/o Free Water	9.0000 10.0000	130.0000 130.0000	800.0000 800.0000	-- --	-- --	0.01000 0.01000	-- --
2	Stiff Clay w/o Free Water	10.0000 12.0000	57.6000 57.6000	1800. 1800.	-- --	-- --	0.00700 0.00700	-- --
3	Stiff Clay w/o Free Water	12.0000 20.5000	72.6000 72.6000	3600. 3600.	-- --	-- --	0.00500 0.00500	-- --
4	Weak Rock	20.5000 24.8000	145.0000 145.0000	-- --	150.0000 150.0000	60.0000 60.0000	5.00E-04 5.00E-04	6300. 6300.
5	Weak Rock	24.8000 50.0000	150.0000 150.0000	-- --	2200. 2200.	60.0000 60.0000	5.00E-04 5.00E-04	292000. 292000.

Modification Factors for p-y Curves

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

Point	Depth X	p-mult	y-mult

No.	ft		
1	9.000	0.9300	1.0000
2	20.500	0.9300	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 ft	Dist. Load lb/in
1	0.000	87.000
2	9.200	569.000

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 = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	21.000000	ft
Outside Diameter of Casing	=	24.000000	in
Casing Wall Thickness	=	0.0000	in
Moment of Inertia of Steel Casing	=	0.0000	in^4
Width Flange of Core/Insert	=	12.000000	in
Depth of Core/Insert	=	11.800000	in
Flange Thickness of Core/Insert	=	0.435000	in
Web Thickness of Core/Insert	=	0.435000	in
Moment of Inertia of Steel Core/Insert	=	393.000000	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Yield Stress of Core/Insert	=	50000.	psi
Elastic Modulus of Core/Insert	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Gross Area of Pile	=	452.389342	sq. in.
Area of Concrete	=	437.194792	sq. in.
Cross-sectional Area of Steel Casing	=	0.0000	sq. in.
Cross-sectional Area of Steel Core/Insert	=	15.500000	sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	15.194550	sq. in.
Area Ratio of All Steel to Gross Area	=	3.36	percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	2260.424	kips
Tensile Load for Cracking of Concrete	=	-233.565	kips
Nominal Axial Tensile Capacity	=	-775.000	kips

Concrete Properties:

Compressive Strength of Concrete	=	4000.	psi
Modulus of Elasticity of Concrete	=	3604997.	psi
Modulus of Rupture of Concrete	=	-474.34165	psi
Compression Strain at Peak Stress	=	0.001886	
Tensile Strain at Fracture of Concrete	=	-0.0001154	

Maximum Coarse Aggregate Size = 0.750000 in

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

Number	Axial Thrust Force kips
1	0.000

Definitions of Run Messages and Notes:

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

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

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000125	98.0433232	78434659.	12.0000000	0.00001500	-0.00001500	0.0627335	0.00000	0.00000	0.2131500	
0.00000250	195.6277501	78251100.	12.0000000	0.00003000	-0.00003000	0.1249712	0.00000	0.00000	0.4263000	
0.00000375	292.7532804	78067541.	12.0000000	0.00004500	-0.00004500	0.1867130	0.00000	0.00000	0.6394500	
0.00000500	389.4199144	77883983.	12.0000000	0.00006000	-0.00006000	0.2479590	0.00000	0.00000	0.8526000	
0.00000625	485.6276518	77700424.	12.0000000	0.00007500	-0.00007500	0.3087091	0.00000	0.00000	1.0657500	
0.00000750	581.3764929	77516866.	12.0000000	0.00009000	-0.00009000	0.3689635	0.00000	0.00000	1.2789000	
0.00000875	676.6664375	77333307.	12.0000000	0.0001050	-0.000105	0.4287220	0.00000	0.00000	1.4920500	
0.00001000	266.7489824	26674898.	7.9679830	0.00007968	-0.000160	0.3259223	0.00000	0.00000	-2.874485	C
0.00001125	299.9213296	26659674.	7.9709110	0.00008967	-0.000180	0.3658220	0.00000	0.00000	-3.232840	C
0.00001250	333.0552008	26644416.	7.9738464	0.00009967	-0.000200	0.4055337	0.00000	0.00000	-3.590981	C
0.00001375	366.1504694	26629125.	7.9767891	0.0001097	-0.000220	0.4450570	0.00000	0.00000	-3.948906	C
0.00001500	399.2070082	26613801.	7.9797393	0.0001197	-0.000240	0.4843915	0.00000	0.00000	-4.306614	C
0.00001625	432.2246887	26598442.	7.9826969	0.0001297	-0.000260	0.5235368	0.00000	0.00000	-4.664104	C
0.00001750	465.2033822	26583050.	7.9856619	0.0001397	-0.000280	0.5624925	0.00000	0.00000	-5.021377	C
0.00001875	498.1429587	26567624.	7.9886346	0.0001498	-0.000300	0.6012583	0.00000	0.00000	-5.378430	C
0.00002000	531.0433642	26552168.	7.9916147	0.0001598	-0.000320	0.6398338	0.00000	0.00000	-5.735263	C
0.00002125	563.9043216	26536674.	7.9946025	0.0001699	-0.000340	0.6782184	0.00000	0.00000	-6.091876	C
0.00002250	596.7257677	26521145.	7.9975979	0.0001799	-0.000360	0.7164120	0.00000	0.00000	-6.448267	C
0.00002375	629.5075691	26505582.	8.0006010	0.0001900	-0.000380	0.7544140	0.00000	0.00000	-6.804436	C
0.00002500	662.2495918	26489984.	8.0036119	0.0002001	-0.000400	0.7922240	0.00000	0.00000	-7.160381	C
0.00002625	694.9517009	26474351.	8.0066305	0.0002102	-0.000420	0.8298417	0.00000	0.00000	-7.516102	C
0.00002750	727.6137603	26458682.	8.0096568	0.0002203	-0.000440	0.8672667	0.00000	0.00000	-7.871599	C

0.00002875	760.2356336	26442979.	8.0126911	0.0002304	-0.000460	0.9044985	0.00000	0.00000	-8.226869 C
0.00003000	792.8171829	26427239.	8.0157332	0.0002405	-0.000480	0.9415368	0.00000	0.00000	-8.581912 C
0.00003125	825.3582697	26411465.	8.0187832	0.0002506	-0.000499	0.9783811	0.00000	0.00000	-8.936728 C
0.00003250	857.8587547	26395654.	8.0218412	0.0002607	-0.000519	1.0150310	0.00000	0.00000	-9.291315 C
0.00003375	890.3184973	26379807.	8.0249073	0.0002708	-0.000539	1.0514860	0.00000	0.00000	-9.645672 C
0.00003500	922.7373565	26363924.	8.0279813	0.0002810	-0.000559	1.0877459	0.00000	0.00000	-9.999799 C
0.00003625	955.1151898	26348005.	8.0310635	0.0002911	-0.000579	1.1238101	0.00000	0.00000	-10.353694 C
0.00003750	987.4518541	26332049.	8.0341538	0.0003013	-0.000599	1.1596783	0.00000	0.00000	-10.707358 C
0.00003875	1020.	26316057.	8.0372523	0.0003114	-0.000619	1.1953500	0.00000	0.00000	-11.060788 C
0.00004000	1052.	26300028.	8.0403504	0.0003216	-0.000638	1.2308235	0.00000	0.00000	-11.413993 C
0.00004125	1084.	26283969.	8.0433913	0.0003318	-0.000658	1.2660901	0.00000	0.00000	-11.767043 C
0.00004250	1116.	26267873.	8.0464401	0.0003420	-0.000678	1.3011584	0.00000	0.00000	-12.119862 C
0.00004375	1149.	26251741.	8.0494968	0.0003522	-0.000698	1.3360279	0.00000	0.00000	-12.472451 C
0.00004500	1181.	26235572.	8.0525616	0.0003624	-0.000718	1.3706982	0.00000	0.00000	-12.824807 C
0.00004625	1213.	26219367.	8.0556344	0.0003726	-0.000737	1.4051689	0.00000	0.00000	-13.176930 C
0.00004750	1245.	26203124.	8.0587153	0.0003828	-0.000757	1.4394395	0.00000	0.00000	-13.528820 C
0.00004875	1277.	26186844.	8.0618043	0.0003930	-0.000777	1.4735095	0.00000	0.00000	-13.880474 C
0.00005125	1340.	26154171.	8.0680070	0.0004135	-0.000817	1.5410463	0.00000	0.00000	-14.583075 C
0.00005375	1404.	26121346.	8.0742427	0.0004340	-0.000856	1.6077757	0.00000	0.00000	-15.284724 C
0.00005625	1467.	26088369.	8.0805119	0.0004545	-0.000895	1.6736941	0.00000	0.00000	-15.985415 C
0.00005875	1531.	26055237.	8.0868149	0.0004751	-0.000935	1.7387979	0.00000	0.00000	-16.685139 C
0.00006125	1594.	26021949.	8.0931522	0.0004957	-0.000974	1.8030833	0.00000	0.00000	-17.383888 C
0.00006375	1657.	25988504.	8.0995240	0.0005163	-0.001014	1.8665467	0.00000	0.00000	-18.081655 C
0.00006625	1720.	25954899.	8.1059307	0.0005370	-0.001053	1.9291842	0.00000	0.00000	-18.778430 C
0.00006875	1782.	25921133.	8.1123728	0.0005577	-0.001092	1.9909921	0.00000	0.00000	-19.474207 C
0.00007125	1844.	25887204.	8.1188507	0.0005785	-0.001132	2.0519664	0.00000	0.00000	-20.168975 C
0.00007375	1907.	25853111.	8.1253647	0.0005992	-0.001171	2.1121032	0.00000	0.00000	-20.862726 C
0.00007625	1969.	25818852.	8.1319153	0.0006201	-0.001210	2.1713986	0.00000	0.00000	-21.555452 C
0.00007875	2031.	25784425.	8.1385029	0.0006409	-0.001249	2.2298486	0.00000	0.00000	-22.247144 C
0.00008125	2092.	25749828.	8.1451279	0.0006618	-0.001288	2.2874489	0.00000	0.00000	-22.937792 C
0.00008375	2154.	25715060.	8.1517907	0.0006827	-0.001327	2.3441957	0.00000	0.00000	-23.627388 C
0.00008625	2215.	25680118.	8.1584919	0.0007037	-0.001366	2.4000845	0.00000	0.00000	-24.315922 C
0.00008875	2276.	25645001.	8.1652318	0.0007247	-0.001405	2.4551113	0.00000	0.00000	-25.003384 C
0.00009125	2337.	25609707.	8.1720110	0.0007457	-0.001444	2.5092716	0.00000	0.00000	-25.689766 C
0.00009375	2398.	25574233.	8.1788298	0.0007668	-0.001483	2.5625612	0.00000	0.00000	-26.375056 C
0.00009625	2458.	25538579.	8.1856888	0.0007879	-0.001522	2.6149757	0.00000	0.00000	-27.059246 C
0.00009875	2518.	25502741.	8.1925884	0.0008090	-0.001561	2.6665105	0.00000	0.00000	-27.742325 C
0.0001013	2579.	25466714.	8.1995291	0.0008302	-0.001600	2.7171609	0.00000	0.00000	-28.424285 C
0.0001038	2638.	25430503.	8.2065115	0.0008514	-0.001639	2.7669228	0.00000	0.00000	-29.105111 C
0.0001063	2698.	25394103.	8.2135361	0.0008727	-0.001677	2.8157913	0.00000	0.00000	-29.784794 C
0.0001088	2758.	25357511.	8.2206033	0.0008940	-0.001716	2.8637616	0.00000	0.00000	-30.463325 C
0.0001113	2817.	25320725.	8.2277137	0.0009153	-0.001755	2.9108290	0.00000	0.00000	-31.140691 C
0.0001138	2876.	25283743.	8.2348678	0.0009367	-0.001793	2.9569885	0.00000	0.00000	-31.816882 C
0.0001163	2935.	25246562.	8.2420663	0.0009581	-0.001832	3.0022353	0.00000	0.00000	-32.491886 C
0.0001188	2994.	25209180.	8.2493096	0.0009796	-0.001870	3.0465644	0.00000	0.00000	-33.165692 C
0.0001213	3052.	25171594.	8.2565984	0.0010011	-0.001909	3.0899706	0.00000	0.00000	-33.838288 C
0.0001238	3110.	25133803.	8.2639332	0.0010227	-0.001947	3.1324489	0.00000	0.00000	-34.509661 C
0.0001263	3168.	25095804.	8.2713145	0.0010443	-0.001986	3.1739939	0.00000	0.00000	-35.179801 C
0.0001288	3226.	25057595.	8.2787431	0.0010659	-0.002024	3.2146006	0.00000	0.00000	-35.848692 C
0.0001313	3284.	25019225.	8.2860579	0.0010875	-0.002062	3.2542242	0.00000	0.00000	-36.516943 C
0.0001338	3341.	24980657.	8.2933862	0.0011092	-0.002101	3.2928909	0.00000	0.00000	-37.184080 C
0.0001363	3398.	24941877.	8.3007610	0.0011310	-0.002139	3.3306029	0.00000	0.00000	-37.849969 C
0.0001388	3455.	24902882.	8.3081831	0.0011528	-0.002177	3.3673547	0.00000	0.00000	-38.514599 C
0.0001413	3512.	24863669.	8.3156530	0.0011746	-0.002215	3.4031409	0.00000	0.00000	-39.177957 C
0.0001438	3568.	24824236.	8.3231715	0.0011965	-0.002254	3.4379557	0.00000	0.00000	-39.840030 C
0.0001463	3625.	24784579.	8.3307391	0.0012184	-0.002292	3.4717934	0.00000	0.00000	-40.500804 C

0.0001488	3681.	24744697.	8.3383565	0.0012403	-0.002330	3.5046482	0.00000	0.00000	-41.160265 C
0.0001588	3903.	24582851.	8.3693382	0.0013286	-0.002481	3.6261181	0.00000	0.00000	-43.784710 C
0.0001688	4120.	24417150.	8.4011741	0.0014177	-0.002632	3.7313699	0.00000	0.00000	-46.387005 C
0.0001788	4334.	24247384.	8.4339139	0.0015076	-0.002782	3.8199818	0.00000	0.00000	-48.966148 C
0.0001888	4511.	23899357.	8.4428390	0.0015936	-0.002936	3.8882117	0.00000	0.00000	-50.000000 CY
0.0001988	4585.	23069680.	8.3809626	0.0016657	-0.003104	3.9328462	0.00000	0.00000	-50.000000 CY
0.0002088	4645.	22252263.	8.3181181	0.0017364	-0.003274	3.9656046	0.00000	0.00000	-50.000000 CY
0.0002188	4698.	21478750.	8.2584462	0.0018065	-0.003443	3.9873716	0.00000	0.00000	-50.000000 CY
0.0002288	4746.	20746685.	8.2012668	0.0018760	-0.003614	3.9984038	0.00000	0.00000	-50.000000 CY
0.0002388	4788.	20053590.	8.1477072	0.0019453	-0.003785	3.9991831	0.00000	0.00000	-50.000000 CY
0.0002488	4825.	19398662.	8.0980811	0.0020144	-0.003956	3.9994984	0.00000	0.00000	-50.000000 CY
0.0002588	4859.	18778084.	8.0518737	0.0020834	-0.004127	3.9995413	0.00000	0.00000	-50.000000 CY
0.0002688	4888.	18189376.	8.0075700	0.0021520	-0.004298	3.9993259	0.00000	0.00000	-50.000000 CY
0.0002788	4915.	17631516.	7.9659040	0.0022205	-0.004470	3.9987213	0.00000	0.00000	-50.000000 CY
0.0002888	4938.	17102759.	7.9270822	0.0022889	-0.004641	3.9974339	0.00000	0.00000	-50.000000 CY
0.0002988	4960.	16601266.	7.8908376	0.0023574	-0.004813	3.9984115	0.00000	0.00000	-50.000000 CY
0.0003088	4979.	16125127.	7.8570408	0.0024259	-0.004984	3.9997064	0.00000	0.00000	-50.000000 CY
0.0003188	4996.	15672912.	7.8254703	0.0024944	-0.005156	3.9980025	0.00000	0.00000	-50.000000 CY
0.0003288	5011.	15243244.	7.7957082	0.0025628	-0.005327	3.9981445	0.00000	0.00000	-50.000000 CY
0.0003388	5025.	14833712.	7.7666657	0.0026310	-0.005499	3.9991397	0.00000	0.00000	-50.000000 CY
0.0003488	5037.	14443376.	7.7391306	0.0026990	-0.005671	3.9950882	0.00000	0.00000	-50.000000 CY
0.0003588	5048.	14071730.	7.7133646	0.0027672	-0.005843	3.9993974	0.00000	0.00000	-50.000000 CY
0.0003688	5058.	13717682.	7.6892643	0.0028354	-0.006015	3.9947087	0.00000	0.00000	-50.000000 CY
0.0003788	5067.	13378885.	7.6661859	0.0029036	-0.006186	3.9991153	0.00000	0.00000	-50.000000 CY
0.0003888	5075.	13055908.	7.6446398	0.0029719	-0.006358	3.9960393	0.00000	0.00000	-50.000000 CY
0.0003988	5083.	12746684.	7.6242008	0.0030402	-0.006530	3.9979817	0.00000	0.00000	-50.000000 CY
0.0004088	5089.	12451147.	7.6048279	0.0031085	-0.006702	3.9999816	0.00000	0.00000	-50.000000 CY
0.0004188	5095.	12167842.	7.5865942	0.0031769	-0.006873	3.9950829	0.00000	0.00000	-50.000000 CY
0.0004288	5101.	11896551.	7.5692725	0.0032453	-0.007045	3.9989818	0.00000	0.00000	-50.000000 CY
0.0004388	5105.	11636131.	7.5522701	0.0033136	-0.007216	3.9982011	0.00000	0.00000	-50.000000 CY
0.0004488	5110.	11386218.	7.5358992	0.0033817	-0.007388	3.9950752	0.00000	0.00000	-50.000000 CY
0.0004588	5113.	11145800.	7.5199211	0.0034498	-0.007560	3.9987789	0.00000	0.00000	-50.000000 CY
0.0004688	5117.	10915333.	7.5049637	0.0035180	-0.007732	3.9998649	0.00000	0.00000	-50.000000 CY
0.0004788	5119.	10693043.	7.4905981	0.0035861	-0.007904	3.9926063	0.00000	0.00000	-50.000000 CY
0.0004888	5122.	10479334.	7.4768997	0.0036543	-0.008076	3.9971798	0.00000	0.00000	-50.000000 CY
0.0004988	5124.	10273973.	7.4640213	0.0037227	-0.008247	3.9995967	0.00000	0.00000	-50.000000 CY
0.0005088	5126.	10075389.	7.4512988	0.0037908	-0.008419	3.9962291	0.00000	0.00000	-50.000000 CY
0.0005188	5110.	9850418.	7.4544058	0.0038670	-0.008583	3.9939188	0.00000	0.00000	-50.000000 CY

Summary of Results for Nominal Moment Capacity for Section 2

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	0.000	5078.475	0.00300000	-0.00642891

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

In ACI 318, the value of the strength reduction factor depends on whether

the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

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

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

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	0.0000	5078.	0.0000	3301.	25007642.
1	0.75	0.0000	5078.	0.0000	3809.	24651217.
1	0.90	0.0000	5078.	0.0000	4571.	23231726.

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	9.0000	0.00	N.A.	No	0.00	5133.
2	10.0000	0.4637	Yes	No	5133.	24799.
3	12.0000	1.3080	Yes	No	29932.	279005.
4	20.5000	11.5000	No	Yes	N.A.	N.A.
5	24.8000	15.8000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs

Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.2274	3.82E-07	5.31E-08	-0.01508	5.96E-09	1.12E+10	0.00	0.00	90.9293
0.3000	2.1731	589.2222	348.5641	-0.01508	9.1919	1.12E+10	0.00	0.00	102.7174
0.6000	2.1188	2510.	746.6380	-0.01508	39.1509	1.12E+10	0.00	0.00	118.4348
0.9000	2.0645	5965.	1201.	-0.01508	93.0546	1.12E+10	0.00	0.00	134.1522
1.2000	2.0103	11159.	1713.	-0.01508	174.0807	1.12E+10	0.00	0.00	149.8696
1.5000	1.9560	18295.	2280.	-0.01507	285.4070	1.12E+10	0.00	0.00	165.5870
1.8000	1.9017	27578.	2905.	-0.01507	430.2111	1.12E+10	0.00	0.00	181.3043
2.1000	1.8475	39210.	3586.	-0.01506	611.6707	1.12E+10	0.00	0.00	197.0217
2.4000	1.7933	53395.	4323.	-0.01504	832.9634	1.12E+10	0.00	0.00	212.7391
2.7000	1.7392	70337.	5117.	-0.01502	1097.	1.12E+10	0.00	0.00	228.4565
3.0000	1.6852	90241.	5968.	-0.01499	1408.	1.12E+10	0.00	0.00	244.1739
3.3000	1.6312	113308.	6876.	-0.01496	1768.	1.12E+10	0.00	0.00	259.8913
3.6000	1.5774	139744.	7839.	-0.01492	2180.	1.12E+10	0.00	0.00	275.6087
3.9000	1.5238	169752.	8860.	-0.01487	2648.	1.12E+10	0.00	0.00	291.3261
4.2000	1.4704	203536.	9937.	-0.01481	3175.	1.12E+10	0.00	0.00	307.0435
4.5000	1.4172	241298.	11071.	-0.01474	3764.	1.12E+10	0.00	0.00	322.7609
4.8000	1.3643	283244.	12261.	-0.01465	4419.	1.12E+10	0.00	0.00	338.4783
5.1000	1.3117	329577.	13508.	-0.01456	5141.	1.12E+10	0.00	0.00	354.1957
5.4000	1.2594	380499.	14811.	-0.01444	5936.	1.12E+10	0.00	0.00	369.9130
5.7000	1.2077	436216.	16171.	-0.01431	6805.	1.12E+10	0.00	0.00	385.6304
6.0000	1.1564	496931.	17588.	-0.01416	7752.	1.12E+10	0.00	0.00	401.3478
6.3000	1.1057	562847.	19061.	-0.01399	8780.	1.12E+10	0.00	0.00	417.0652
6.6000	1.0557	634168.	20590.	-0.01379	9893.	1.12E+10	0.00	0.00	432.7826
6.9000	1.0064	711098.	22177.	-0.01358	11093.	1.12E+10	0.00	0.00	448.5000
7.2000	0.9580	793841.	23820.	-0.01333	12384.	1.12E+10	0.00	0.00	464.2174
7.5000	0.9104	882600.	25519.	-0.01306	13769.	1.12E+10	0.00	0.00	479.9348
7.8000	0.8639	977579.	27275.	-0.01276	15250.	1.12E+10	0.00	0.00	495.6522
8.1000	0.8185	1078981.	29088.	-0.01243	16832.	1.12E+10	0.00	0.00	511.3696
8.4000	0.7744	1187011.	30957.	-0.01207	18517.	1.12E+10	0.00	0.00	527.0870
8.7000	0.7316	1301872.	32883.	-0.01166	20309.	1.12E+10	0.00	0.00	542.8043
9.0000	0.6904	1423768.	34659.	-0.01122	22211.	1.12E+10	-114.546	597.2880	558.5217
9.3000	0.6508	1551417.	35273.	-0.01089	0.00	2.60E+10	-197.650	1093.	94.6150
9.6000	0.6120	1677732.	34723.	-0.01066	0.00	2.60E+10	-202.345	1190.	0.00
9.9000	0.5740	1801423.	33987.	-0.01042	0.00	2.59E+10	-206.719	1296.	0.00
10.2000	0.5370	1922436.	32758.	-0.01016	0.00	2.58E+10	-476.074	3192.	0.00
10.5000	0.5009	2037279.	31036.	-0.00989	0.00	2.58E+10	-480.718	3455.	0.00
10.8000	0.4658	2145892.	29298.	-0.00960	0.00	2.57E+10	-484.523	3745.	0.00
11.1000	0.4318	2248225.	27548.	-0.00929	0.00	2.57E+10	-487.551	4065.	0.00
11.4000	0.3989	2344240.	25789.	-0.00896	0.00	2.56E+10	-489.823	4421.	0.00
11.7000	0.3672	2433906.	24023.	-0.00863	0.00	2.56E+10	-491.341	4817.	0.00
12.0000	0.3368	2517205.	21891.	-0.00828	0.00	2.55E+10	-692.813	7406.	0.00
12.3000	0.3076	2591525.	18907.	-0.00792	0.00	2.55E+10	-965.266	11297.	0.00
12.6000	0.2798	2653335.	15433.	-0.00755	0.00	2.54E+10	-964.947	12417.	0.00
12.9000	0.2533	2702640.	11962.	-0.00717	0.00	2.54E+10	-962.991	13688.	0.00
13.2000	0.2281	2739464.	8502.	-0.00678	0.00	2.54E+10	-959.352	15138.	0.00
13.5000	0.2044	2763854.	5058.	-0.00639	0.00	2.54E+10	-953.984	16800.	0.00
13.8000	0.1821	2775882.	1637.	-0.00600	0.00	2.53E+10	-946.832	18715.	0.00
14.1000	0.1612	2775638.	-1756.	-0.00560	0.00	2.53E+10	-937.838	20939.	0.00
14.4000	0.1418	2763240.	-5112.	-0.00521	0.00	2.54E+10	-926.938	23536.	0.00
14.7000	0.1237	2738828.	-8426.	-0.00482	0.00	2.54E+10	-914.060	26596.	0.00

15.0000	0.1071	2702571.	-11690.	-0.00443	0.00	2.54E+10	-899.121	30230.	0.00
15.3000	0.09180	2654661.	-14896.	-0.00405	0.00	2.54E+10	-882.025	34589.	0.00
15.6000	0.07788	2595320.	-18036.	-0.00368	0.00	2.55E+10	-862.661	39876.	0.00
15.9000	0.06528	2524799.	-21103.	-0.00332	0.00	2.55E+10	-840.895	46371.	0.00
16.2000	0.05397	2443379.	-24086.	-0.00297	0.00	2.55E+10	-816.559	54471.	0.00
16.5000	0.04389	2351378.	-26977.	-0.00263	0.00	2.56E+10	-789.443	64752.	0.00
16.8000	0.03501	2249145.	-29765.	-0.00231	0.00	2.57E+10	-759.268	78085.	0.00
17.1000	0.02726	2137071.	-32438.	-0.00200	0.00	2.57E+10	-725.652	95847.	0.00
17.4000	0.02058	2015594.	-34982.	-0.00171	0.00	2.58E+10	-688.043	120344.	0.00
17.7000	0.01492	1885199.	-37383.	-0.00144	0.00	2.59E+10	-645.586	155749.	0.00
18.0000	0.01021	1746438.	-39619.	-0.00119	0.00	2.59E+10	-596.836	210513.	0.00
18.3000	0.00636	1599942.	-41664.	-9.57E-04	0.00	2.60E+10	-539.002	304928.	0.00
18.6000	0.00332	1446460.	-43472.	-7.46E-04	0.00	2.61E+10	-465.378	505024.	0.00
18.9000	9.90E-04	1286947.	-44938.	-5.58E-04	0.00	2.62E+10	-349.497	1271479.	0.00
19.2000	-7.01E-04	1122904.	-44982.	-3.93E-04	0.00	2.63E+10	325.1801	1669388.	0.00
19.5000	-0.00184	963076.	-43640.	-2.50E-04	0.00	2.63E+10	420.2958	823236.	0.00
19.8000	-0.00250	808694.	-42054.	-1.29E-04	0.00	2.64E+10	460.8126	663341.	0.00
20.1000	-0.00277	660285.	-40361.	-2.91E-05	0.00	2.65E+10	479.6407	624018.	0.00
20.4000	-0.00271	518092.	-38627.	2.78E-05	0.00	7.76E+10	484.1391	643075.	0.00
20.7000	-0.00257	382174.	-36248.	4.86E-05	0.00	7.79E+10	837.2108	1174140.	0.00
21.0000	-0.00236	257105.	-32994.	6.34E-05	0.00	7.81E+10	970.8294	1480891.	0.00
21.3000	-0.00211	144619.	-29283.	7.26E-05	0.00	7.83E+10	1091.	1860877.	0.00
21.6000	-0.00184	46271.	-25167.	7.70E-05	0.00	7.84E+10	1196.	2342995.	0.00
21.9000	-0.00156	-36581.	-20705.	7.73E-05	0.00	7.84E+10	1283.	2968690.	0.00
22.2000	-0.00128	-102806.	-15963.	7.41E-05	0.00	7.84E+10	1352.	3799403.	0.00
22.5000	-0.00102	-151511.	-11009.	6.82E-05	0.00	7.83E+10	1400.	4929231.	0.00
22.8000	-7.90E-04	-182069.	-6219.	6.05E-05	0.00	7.83E+10	1260.	5745600.	0.00
23.1000	-5.87E-04	-196291.	-2132.	5.18E-05	0.00	7.82E+10	1011.	6199200.	0.00
23.4000	-4.16E-04	-197417.	1073.	4.28E-05	0.00	7.82E+10	769.6775	6652800.	0.00
23.7000	-2.79E-04	-188568.	3449.	3.39E-05	0.00	7.83E+10	550.4212	7106400.	0.00
24.0000	-1.72E-04	-172585.	5091.	2.56E-05	0.00	7.83E+10	362.0541	7560000.	0.00
24.3000	-9.46E-05	-151910.	6122.	1.81E-05	0.00	7.83E+10	210.4741	8013600.	0.00
24.6000	-4.18E-05	-128507.	6678.	1.17E-05	0.00	7.83E+10	98.4098	8467200.	0.00
24.9000	-1.04E-05	-103829.	9002.	6.35E-06	0.00	7.84E+10	1193.	4.13E+08	0.00
25.2000	3.91E-06	-63691.	10301.	2.51E-06	0.00	7.84E+10	-471.591	4.34E+08	0.00
25.5000	7.68E-06	-29664.	7703.	3.66E-07	0.00	7.84E+10	-971.451	4.56E+08	0.00
25.8000	6.55E-06	-8227.	4395.	-5.03E-07	0.00	7.84E+10	-866.520	4.77E+08	0.00
26.1000	4.06E-06	1979.	1826.	-6.46E-07	0.00	7.84E+10	-560.479	4.98E+08	0.00
26.4000	1.89E-06	4922.	327.0002	-4.88E-07	0.00	7.84E+10	-272.451	5.19E+08	0.00
26.7000	5.41E-07	4333.	-305.508	-2.76E-07	0.00	7.84E+10	-78.942	5.26E+08	0.00
27.0000	-9.39E-08	2722.	-422.926	-1.14E-07	0.00	7.84E+10	13.7093	5.26E+08	0.00
27.3000	-2.79E-07	1288.	-325.001	-2.18E-08	0.00	7.84E+10	40.6936	5.26E+08	0.00
27.6000	-2.51E-07	382.0493	-185.877	1.66E-08	0.00	7.84E+10	36.5975	5.26E+08	0.00
27.9000	-1.59E-07	-49.957	-78.089	2.42E-08	0.00	7.84E+10	23.2848	5.26E+08	0.00
28.2000	-7.66E-08	-180.192	-16.057	1.89E-08	0.00	7.84E+10	11.1773	5.26E+08	0.00
28.5000	-2.34E-08	-165.570	10.2118	1.10E-08	0.00	7.84E+10	3.4167	5.26E+08	0.00
28.8000	2.39E-09	-106.667	15.7325	4.72E-09	0.00	7.84E+10	-0.350	5.26E+08	0.00
29.1000	1.06E-08	-52.295	12.3261	1.07E-09	0.00	7.84E+10	-1.543	5.26E+08	0.00
29.4000	1.01E-08	-17.919	6.8952	-5.41E-10	0.00	7.84E+10	-1.474	5.26E+08	0.00
29.7000	6.67E-09	-2.650	2.4887	-1.01E-09	0.00	7.84E+10	-0.974	5.26E+08	0.00
30.0000	2.80E-09	0.00	0.00	-1.07E-09	0.00	7.84E+10	-0.409	2.63E+08	0.00

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

polated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     2.22744519 inches
Computed slope at pile head      =     -0.0150834 radians
Maximum bending moment           =       2775882. inch-lbs
Maximum shear force              =        -44982. lbs
Depth of maximum bending moment  =    13.80000000 feet below pile head
Depth of maximum shear force     =    19.20000000 feet below pile head
Number of iterations             =             34
Number of zero deflection points =              5
Pile deflection at ground        =     0.69039519 inches
```

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
30.00000	2.22744519	2775882.	-44982.
28.50000	2.23218973	2797036.	-45198.
27.00000	2.23287990	2795225.	-45174.
25.50000	2.24530559	2799186.	-45502.
24.00000	2.19994616	2769534.	-43630.
22.50000	2.23223219	2772866.	-44533.
21.00000	3.11266506	2655263.	-50780.
19.50000	7.75596967	2507211.	-56358.
18.00000	25.63932876	2333295.	-61543.

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	2.2274	-0.01508	-44982.	2775882.

Maximum pile-head deflection = 2.2274451947 inches
Maximum pile-head rotation = -0.0150834463 radians = -0.864218 deg.

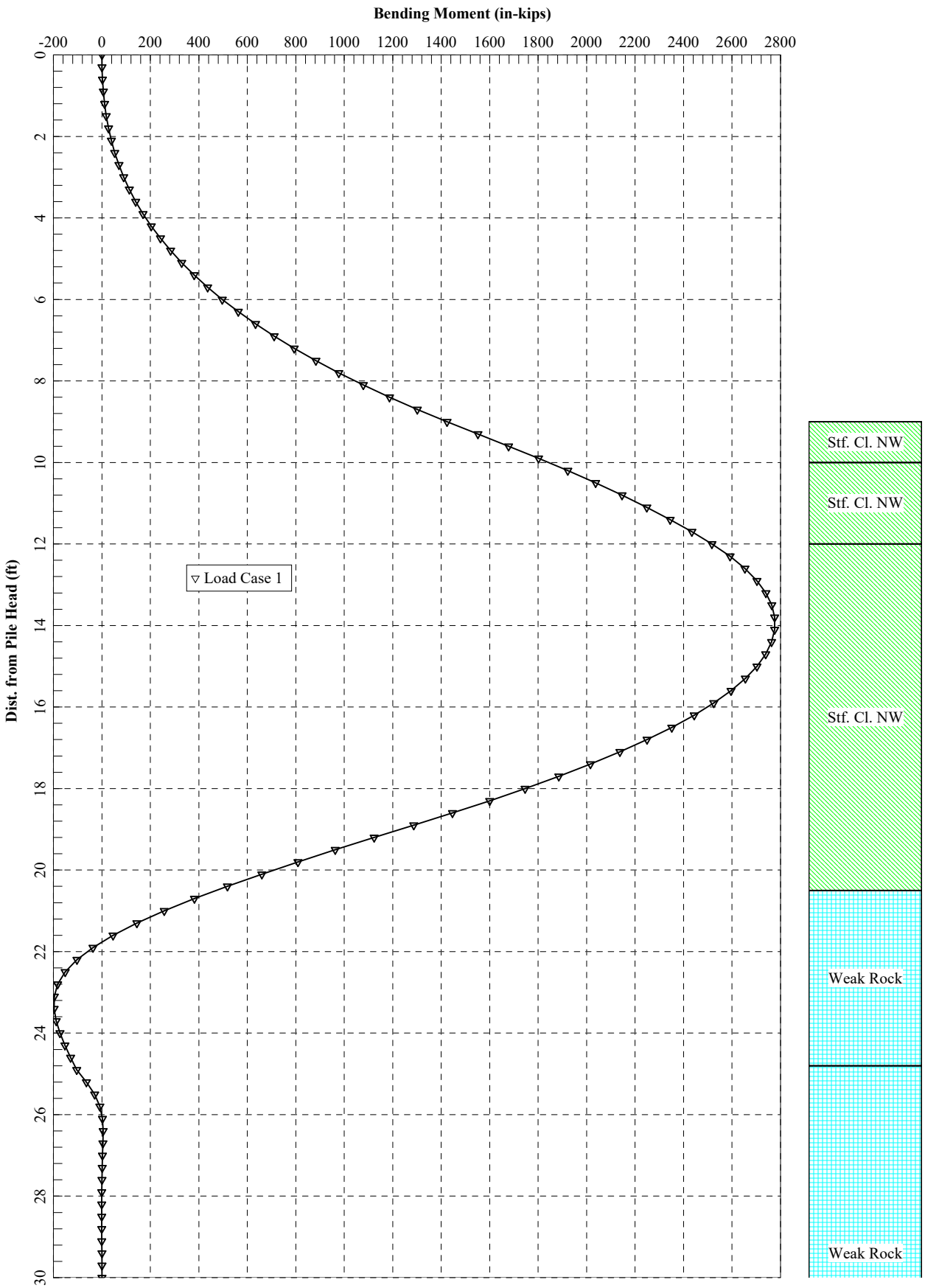
Summary of Warning Messages

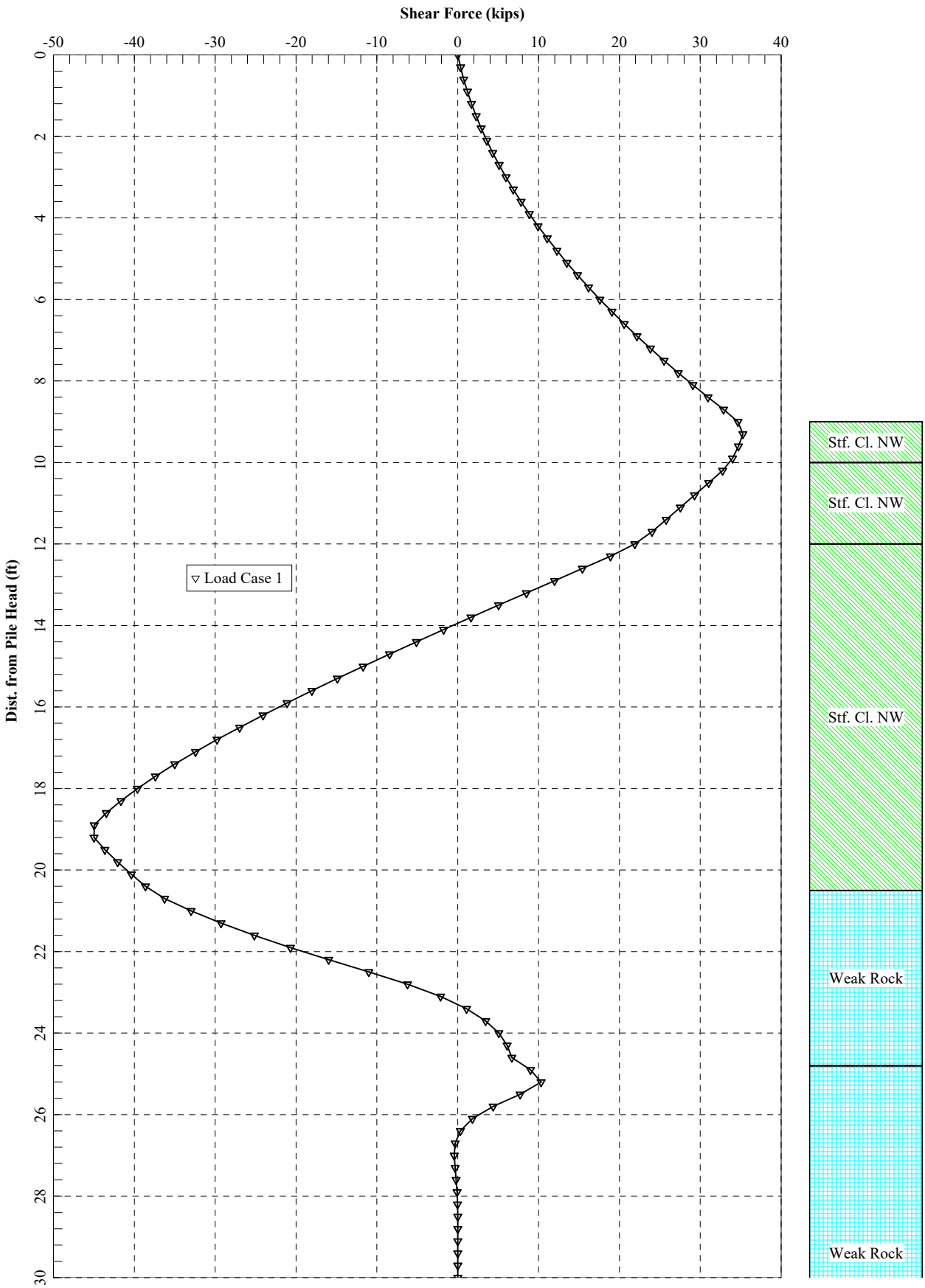
The following warning was reported 1935 times

**** 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.

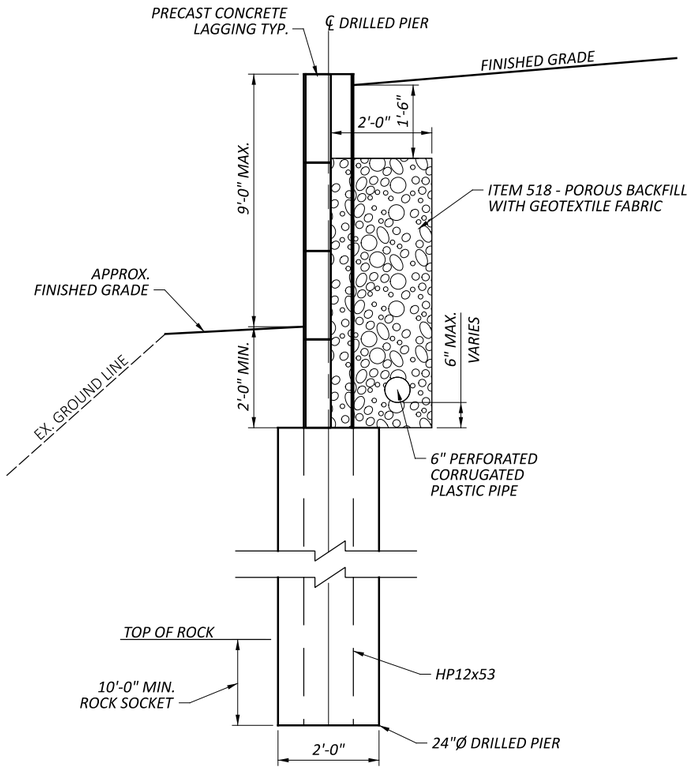
The analysis ended normally.


Bending Moment (in-kips)
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock

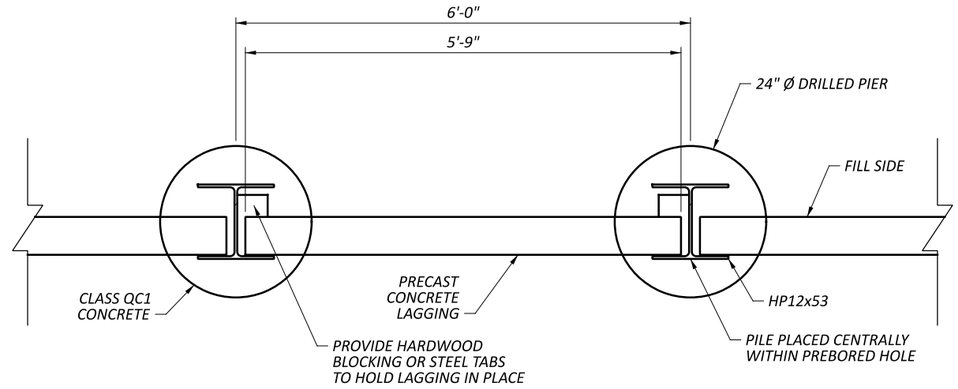

Shear Force (kips)
-50
-40
-30
-20
-10
0
10
20
30
40
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock

Soldier Pile and 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-001-0-25	791+42	8' LT.	923.5	905.0
B-002-0-25	790+42	8' LT	916.4	896.0
B-002-1-25	790+43	8' RT.	917.0	898.5
B-003-0-25	789+11	10' LT.	907.1	893.1
B-004-0-25	787+63	10' LT.	899.0	888.0

HORIZONTAL SCALE IN FEET
0 5 10 20

SOLDIER PILE AND LAGGING WALL DETAIL
CRITICAL SECTION STA. 790+25.00

DESIGN AGENCY
HDR

DESIGNER DCM
REVIEWER DMV 08/28/25
PROJECT ID 123193
SHEET 1 TOTAL 1

JAC-327-14.99