Technical Design Memo

Client:	Ohio Department of Transportation, District 9
Project:	**ADA-41-31.38 (Task Order 2)** **PID 123193**
HDR Project No:	10429999
Rev:	0
Calculation No:	1
Page:	1 of 131
Title:	Landslide Remediation Analyses and Design
Purpose:	Prepare slope stability analyses and wall calculations for the design of a landslide repair along the southbound travel lane of State Route 41 (SR 41) in Adams County, Ohio.
Originator:	DCM
Date:	7/16/2025
Checked by:	AKB
Date:	7/22/2025
QC Review by:	DMV
Date:	7/24/2025

Summary

1. A landslide has occurred on the slope below SR 41 near mile marker 31.38 in Adams 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 February 12, 2025, coupled with the findings from the geotechnical explorations performed on April 14 and 15, 2025, a soldier pile and lagging retaining wall is recommended to stabilize the landslide and repair SR 41. 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 6 test borings (designated as Borings B-001-0-25, B-002-0-25, B-003-0-25, B-003-1-25, B-004-0-25, and B-004-1-25) to characterize the subsurface profile in the vicinity of the existing landslide and develop repair recommendations. Four test borings were drilled within the southbound lane and 2 borings were drilled in the northbound lane of SR 41 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 consisted of interbedded layers of granular and cohesive

soils, transitioning to very stiff to hard and dense residuum with depth. The overburden soils were predominantly underlain by moderately strong to strong sandstone bedrock, with the occasional weathered shale layer encountered at the bedrock surface in B-003-0-25 and B-004-0-25. 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 Boring B-002-0-25, located near the design section at Sta. 1657+00 and supplemented with information from the remaining borings. An alternate design section at Sta. 1659+00 was also developed given the varying slope geometries across the site. This profile was largely based on the encountered conditions at Borings B-004-0-25 and B-004-1-25. 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. North-central Adams County is located within the Outer Bluegrass region of the Bluegrass Section of the Interior Low Plateaus province. This region, which generally bisects the county from north to south, consists of a rolling to steep dissected plateau of carbonate rocks. Caves and other karst features are relatively common in the eastern portion of the region near the project area. Although no areas of karst are mapped within the project extents, Adams County contains areas dense with karst geology. As shown on the karst maps included in the attachments, multiple karst features are mapped within about 0.5 miles of the project site. The Cenozoic Era surficial materials within Adams County mainly consist of residuum and colluvium derived from the underlying sedimentary bedrock, with the soils in the Outer Bluegrass region generally comprised of thin pre-Wisconsinan drift on ridges in the western portion of the region, and silt-loam colluvium in the eastern portion of the region containing the project area.

The project site is located along the southeastern corner of the Serpent Mound Impact Structure, the site of an ancient asteroid impact. This impact created irregularities in the bedrock geology layering as shown in the attachments. The bedrock mapped below the project site is the Silurian-age Lilley and Bischer Formations, Undivided. This formation consists of primarily dolomite with minor amounts of shale, limestone, and chert.

Adams County is primarily drained by tributaries of Ohio Brush Creek, which enters the Ohio River along the southern border of the county. The site is directly drained by an unnamed tributary that runs along the toe of the slope to the northwest of the roadway and drains into Crooked Creek located approximately 275 feet south of the project site. Crooked Creek, in turn, meanders and drains into the Ohio Brush Creek approximately 2.5 miles west of the site.

4. Based on review of Ohio Department of Natural Resources (ODNR) mapping, surface mining and deep mining were not noted within the limits of the project site. The maps indicate surface mines located approximately 6.5 miles northeast and 3 miles southeast of the project site. Available information indicates limestone as the primary commodity.

5. Based on review of FEMA flood maps for the area, the site is not located within an established flood area. A special flood hazard area was noted along Crooked Creek to the south of the project limits, but base flood elevations had not been established (Zone A) and the mapped limits did not appear to encroach on the project limits.

6. A search of the available records on ODOT's Transportation Information Mapping System (TIMS) reveals two geotechnical explorations performed approximately 275 feet south of the current project limits as part of the ADA-41-31.31 culvert replacement project (ODOT, 2013). These two borings encountered Sandy Silt (A-4a), Silt and Clay (A-6a) and Clay (A-7-6) to depths of 1.0 feet to 13.5 feet below grade. Soils were underlain by weathered, moderately strong sandstone, strong dolomite, and very weak to weak shale bedrock. The ADA-41-31.31 Structural Foundation Exploration sheets have been attached to this memorandum for reference.

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 1657+00 was selected for design. Given the varying slope geometries across the project limits, additional slope stability analyses were performed at Sta. 1659+00 for comparative purposes.

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 soil and bedrock, which may be a result of run-off infiltration and/or perched water conditions. 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 along the bedrock surface to the elevation of noted elevated moisture contents (approx. El. 756), extending to the face of the existing hillside, and then along the rock slope/bluff to the unnamed stream located at the base of the slope.

The depth to bedrock along the slope above SR 41 was estimated based on the existing terrain and the rock outcrops observed along the sidehill cut during the site reconnaissance. Bedrock depths along the slope below SR 41 were estimated based on the terrain, the overburden soil

thicknesses as encountered in the soil borings, measurements along the rock bluff that forms the southern streambank of the unnamed tributary to Crooked Creek, and the exposed sandstone along the stream bed. Based on past experiences with the failure surface tending to be along the soil/bedrock interface, Section 704.5 of the ODOT Geotechnical Design Manual (GDM) recommends incorporating a "soft rock" layer near the bedrock surface. This layer is recommended to be +/- 2 feet in thickness with a friction angle between 12° to 18°. Given the relatively thin overburden at the site, the slope stability analyses were performed with a 1-foot thick "soft rock" layer along the interface of the residual soils and bedrock as a 2-foot layer would have incorporated a significant portion of the overall subsurface profile.

Pavement deformation and cracking were observed within the shoulder and extending into the southbound lane of SR 41 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. 1657+00 exhibits the most limiting geometries along the roadway alignment given the relatively steep hillside slope below the roadway. These conditions will likely require construction of the wall near the back of the guardrail around Sta. 1657+00. A wall offset of 16 feet from the centerline of the roadway allows for an 11-foot travel lane and a 2-foot shoulder, with the back of the steel guardrail posts (approximately 15 feet from the centerline of SR 41) generally in line with the back of the proposed 2-foot diameter drilled shafts for the proposed soldier pile and lagging wall. However, gentler and wider slopes up station from the design section may allow for an increase in the offset of the wall.

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 = 8,732** 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 (Existing Condition) or Item 203 Embankment fill (Proposed)
b. Layer 2 = Layer 1 Granular Soil
c. Layer 3 = Layer 2 Cohesive Soil
d. Layer 4 = Layer 1 Granular Soil
e. Layer 5 = Soft Rock
f. Layer 6 = Sandstone Bedrock

Additional analyses were also performed in UA Slope for the comparison section at Sta. 1659+00 to provide landslide loading at various potential offsets should the wall transition as the slope allows. The attachments include UA Slope analyses for Sta. 1659+00 at 16' LT, 20' LT, and 24' LT

offsets. However, none of these cases generated loading on the wall greater than the loading at Sta. 1657+00.

9. In accordance with ODOT design requirements, LPILE software was used to determine the pile response to the applied lateral loading from the failure wedge determined by the Slope/W and UA Slope analyses performed at the design section. At Sta. 1657+00 for a 6.9-foot exposed wall height, the following were considered relative to LPILE analyses:

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

- Convert concentrated load from UA Slope to distributed load
  - ½(D_L)(H_T) = 8,732 lbs.
    D_L = distributed load
    H_T = 6.9 feet (top/wall to slip surface, see attached)
  - D_L = [(8,732 lbs)(2)]/[(6.9')(12"/ft)] = Resolution of Triangular Area
    D_L = **211 lbs/in** (Service Load)
  - (211 lbs/in)(γ_{EH}) = (211 lbs/in)(1.5) = **316 lbs/in** (Strength Load for Moment/Shear Analysis).

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

- Calculate conventional earth pressure wall loading.
  - Equivalent Fluid Weight (G_H) = (γ_m) * (K) = **39 pcf**
    Ym = soil moist unit weight (see attached calculations)
    Ka = active earth pressure (see attached calculations)
  - Lateral Thrust (P) = 1/2 * G_H * H^2 = P = **925 lbs/ft**
    H = Wall Height = 6.9 feet
  - Horizontal Force Per Shaft (P_{SH}) = P*(S_{cc}) = **5,550 lbs/shaft**
    S_{cc} = Center-to-Center Shaft Spacing = 6 ft
  - Resolve Horizontal Earth Pressure to Distributed Triangular Load
    (2* P_{SH}/H) / (12 in/ft)
    = **134 lbs/in per shaft (Service Load)**
    (112 lbs/in) (γ_{EH}) = (112 lbs/in) (1.5)
    = **201 lbs/in per shaft (Strength Load)**

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

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

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

(c) Modification of p-y curves

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

- $\beta_a = 0.64(S/D)^{0.34} = \beta_a = 0.64(5/2)^{0.34}$
- $\beta_a =$ **0.93**

It is assumed that the soil overburden will be completely lost below the retaining wall at Sta. 1657+00 given the encountered subsurface conditions at the site. As such, downslope stability does not apply.

(d) Pile Head Deflection

As noted in the ODOT GDM (Section 903.8, pgs. 9-16 and 9-17), for the unfactored Service Limit State analysis, pile head deflection shall be limited 1% or less of the drilled shaft length above bedrock (or the total shaft length when bedrock is not encountered). If the drilled shafts are within 10 feet of the edge of 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) = **0.06 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 = 6.9 ft below top of wall
+10.0 ft
16.9 ft minimum pile length

- **Bottom of Drilled Shaft = 17.0 ft ≥ 16.9 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 shales and weathered sandstone and 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

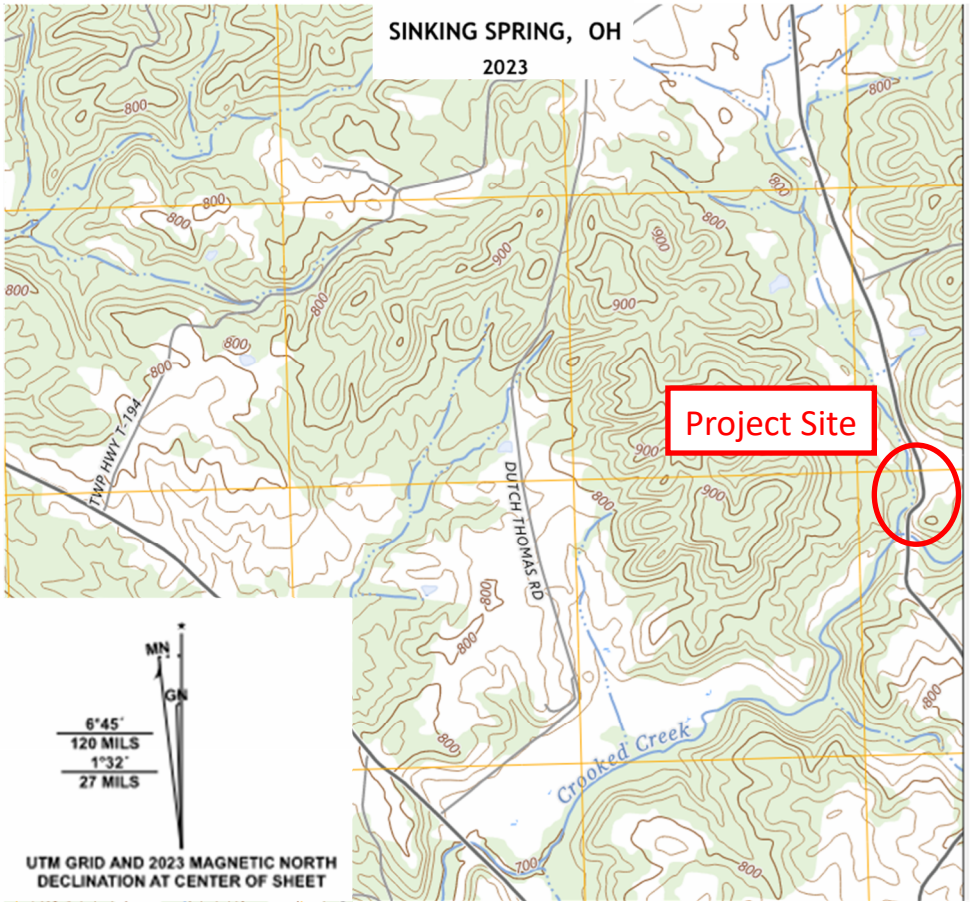
Use HP 12 x 53 shaft reinforcement

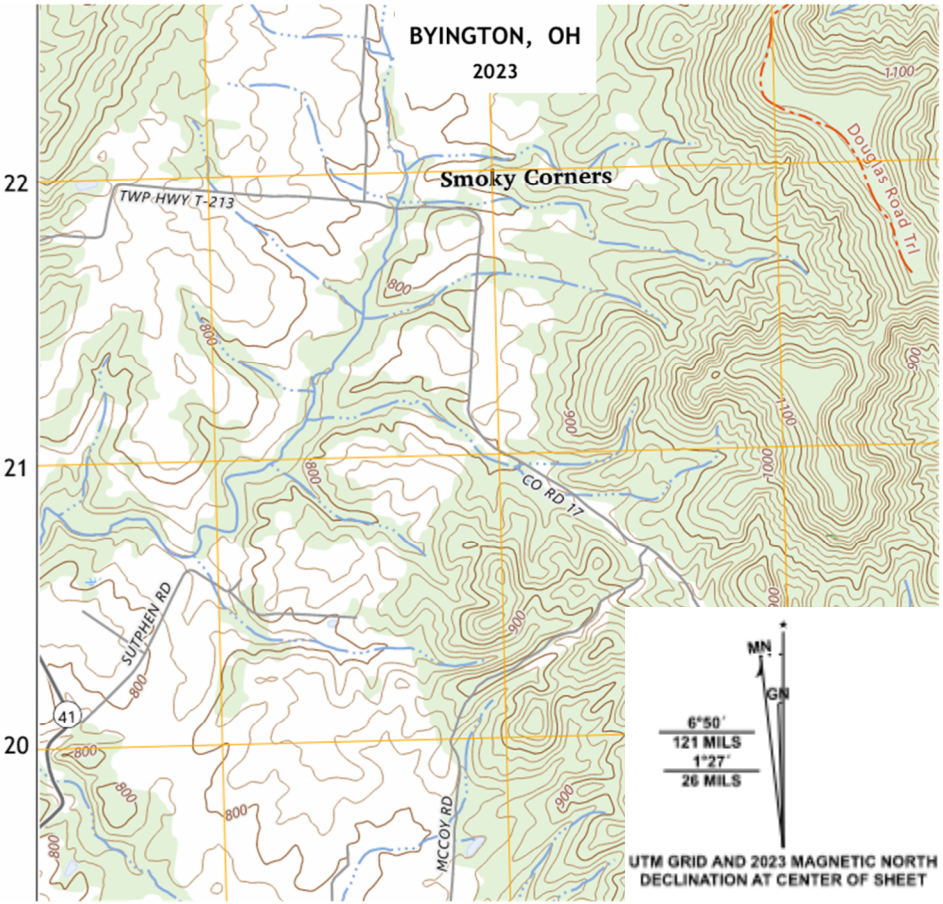
A_s = Area of Steel = 15.5 in^2
I_x = Moment of Inertia around strong axis = 393 in^4
T_w = web thickness = 0.435 in
E = Modulus of Elasticity of Steel = 29,000,000 psi
F_y = yield strength of steel = 50,000 psi
B_f = Flange Width = 12.0 in

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





1 0.5 0 MILES

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

ROAD CLASSIFICATION

Expressway	Local Connector
Secondary Hwy	Local Road
Ramp	4WD

Interstate Route | US Route | State Route

REFERENCE:

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

USGS US Topo 7.5-minute map for Sinking Spring, OH

USGS US Topo 7.5-minute map for Byington, OH

Boring Location Plan

The proposed wall is only shown for illustrative purposes.

Approximate locations of rock outcrops as observed in the field.

HORIZONTAL SCALE IN FEET
0 10 20 40

BORING LOCATION PLAN
ADA-41-31.38

DESIGN AGENCY

DESIGNER DCM
REVIEWER DMV 07/29/25
PROJECT ID 123193
SHEET 1 TOTAL 1

ADA-41-31.38

MODEL: 123193_YP002 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 7/23/2025 TIME: 9:33:13 AM USER: CWAHLBRI
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Boring Logs
and
Rock Core Photos

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1656+16, 11' LT.	EXPLORATION ID B-001-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 756.4 (MSL) EOB: 3.6 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012515, -83.377174	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (16")	756.4																	
AGGREGATE BASE (3")	755.1	1																
VERY DENSE, BROWN, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DAMP	754.8	2	35 46 26	97	100	SS-1	-	19	21	24	28	8	NP	NP	NP	8	A-4a (0)	
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG.	752.9	3																
	752.8	TR3	50/1"	-	100	SS-2	-	58	15	9	14	4	-	-	-	5	Rock (V)	

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 12.5 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D442339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1657+10, 7' LT.	EXPLORATION ID B-002-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 760.7 (MSL) EOB: 23.5 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012692, -83.376910	

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 (13")	760.7																	
	759.6																	
AGGREGATE BASE (4")	759.3																	
DENSE, BROWN TRACE BLACK, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY (FILL) @ 2.5' - 3.0' : Auger Grinding	757.7	1	8 5 19	32	28	SS-1	-	58	15	9	14	4	NP	NP	NP	5	A-1-b (0)	
MEDIUM STIFF TO STIFF, BROWN, **CLAY**, "AND" SILT, TRACE SAND, TRACE GRAVEL, MOIST	756.2	2																
		3	3 8 9	23	56	SS-2	0.75	3	1	2	39	55	68	26	42	29	A-7-6 (20)	
	755.6	4			100	ST-3A	-	41	8	22	19	10	NP	NP	NP	12	A-2-4 (0)	
MEDIUM DENSE, LIGHT BROWN, **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP	754.7	5				ST-3B	2.50	4	14	26	33	23	36	21	15	20	A-6a (6)	
VERY STIFF, LIGHT BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, DAMP @ 5.5' - 6.0' : Auger Grinding	753.2	6	44 50/3"	-	100	SS-4	-	36	22	23	16	3	NP	NP	NP	6	A-1-b (0)	
		7																
	752.2	TR 8	50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	14	Rock (V)	
VERY DENSE, BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP		9																
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG.		10																
SANDSTONE, BROWN AND GRAY, MODERATELY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 61%, REC 100%. @ 11.6' - 11.9' : Quartz Crystals	746.9	11	61		100	NQ2-1											CORE	
		12																
		13																
		14																
SANDSTONE, GRAY TRACE BROWN, SLIGHTLY WEATHERED, STRONG, MEDIUM GRAINED, JOINT DISCONTINUITIES, MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, INTACT/MASSIVE, GOOD TO VERY GOOD SURFACE CONDTIONS; RQD 78%, REC 100%.		15																
		16	93		100	NQ2-2											CORE	
		17																
		18																
@ 18.8' - 19.8' : Fractured		19																
		20																
@ 20.0' - 20.4' : Qu = 7638 psi		21	63		100	NQ2-3											CORE	
		22																
	737.2	EOB 23																

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 75 LB. BENTONITE CHIPS

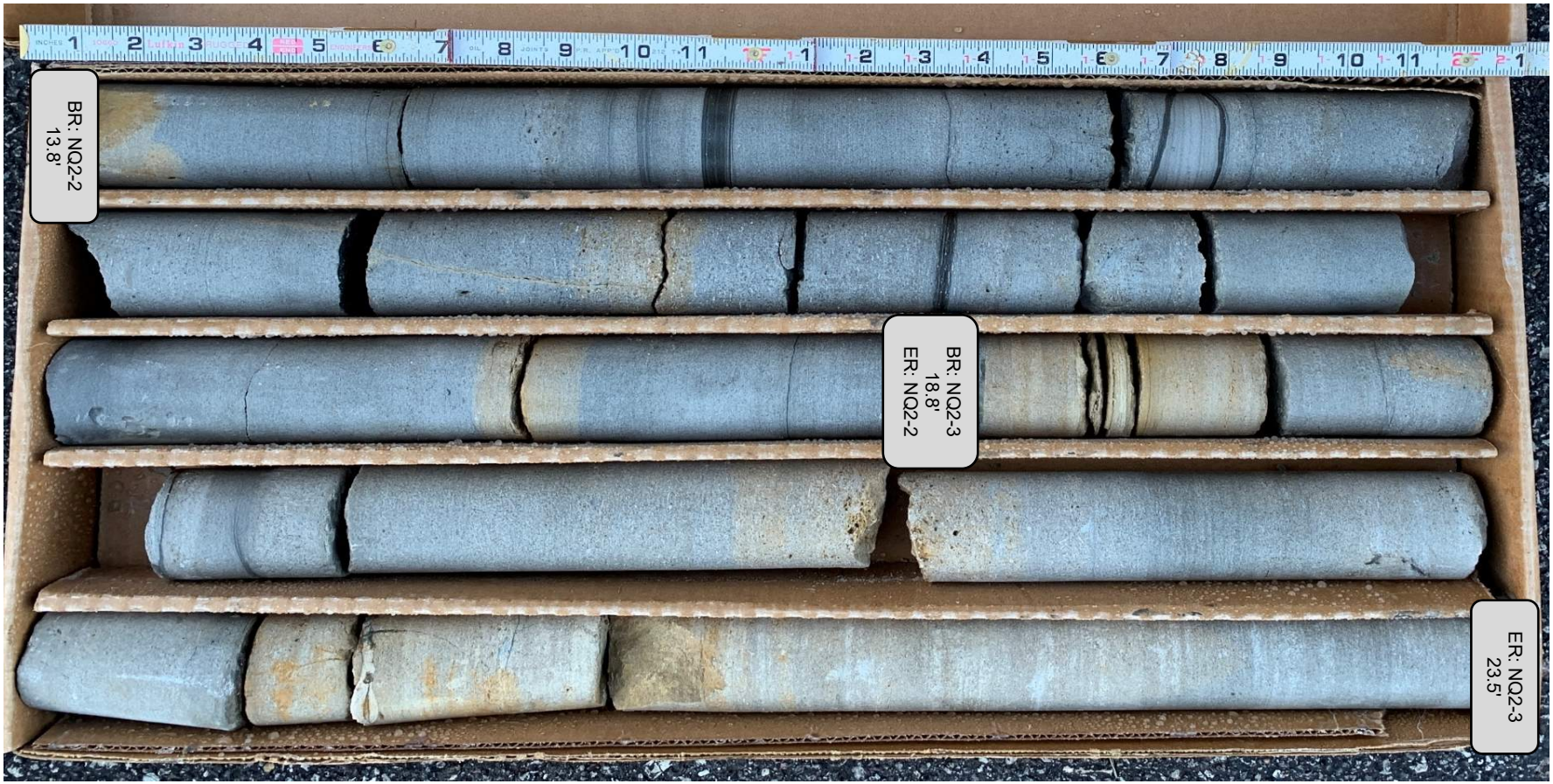
STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

B-002-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	8.5	13.8	64 in. / 64 in.	100%	39 in. / 64 in.	61%

ADA-41-31.38 PID 123193

B-002-0-25



Run #	Depth (ft)		Recovery		RQD	
NQ2-2	13.8	18.8	60 in. / 60 in.	100%	56 in. / 60 in.	93%
NQ2-3	18.8	23.5	56 in. / 56 in.	100%	35 in. / 56 in.	63%

ADA-41-31.38 PID 123193

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1658+14, 8' LT.	EXPLORATION ID B-003-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 764.0 (MSL) EOB: 26.2 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012904, -83.376684	

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
	764.0																	
ASPHALT (13")	762.9	1																
AGGREGATE BASE (3") @ 1.0' - 2.5' : Drove 2-inch Spoon Sample for Additional Sample Material (10" of Recovery)	762.7	2	7 10 6	22	6	SS-1	-	19	21	14	31	15	30	18	12	11	A-6a (3)	
VERY STIFF, DARK BROWN TO BROWN, **SILT AND CLAY**, SOME SAND, LITTLE STONE FRAGMENTS, DAMP	761.0	3																
STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, MOIST @ 3.8' - 4.3' : qu = 2296 psf	758.0	4			88	ST-2	3.00	0	1	10	57	32	40	21	19	22	A-6b (12)	
		5																
		TR 6	50/5"	-	100	SS-3	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SHALE, BROWN TRACE GRAY, SEVERELY WEATHERED, MODERATELY STRONG, ARENACEOUS.	755.5	7																
		8																
		9	50/5"	-	100	SS-4	-	-	-	-	-	-	-	-	-	12	Rock (V)	
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG, ARGILLACEOUS.	752.8	10																
		11																
SANDSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 57%, REC 100%. @ 12.8' - 13.2' : Qu = 8364 psi	748.9	12	49		100	NQ2-1											CORE	
		13																
		14																
SANDSTONE, BROWN AND GRAY, MODERATELY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR TO GOOD SURFACE CONDITIONS; RQD 67%, REC 100%.	744.6	15	72		100	NQ2-2											CORE	
		16																
		17																
		18																
		19																
SANDSTONE, GRAY, SLIGHTLY WEATHERED, STRONG, MEDIUM GRAINED, THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, INTACT OR MASSIVE TO BLOCKY, GOOD TO VERY GOOD SURFACE CONDITIONS; RQD 75%, REC 100%. @ 19.5' - 19.9' : Qu = 9125 psi @ 20.2' - 20.5' : Brown Staining		20																
		21																
		22																
		23	75		100	NQ2-3											CORE	
		24																
		25																
@ 25.9' - 26.2' : Possible Fossils	737.8	EOB 26																

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 175 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

B-003-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	11.2	14.4	39 in. / 39 in.	100%	19 in. / 39 in.	49%
NQ2-2	14.4	19.4	60 in. / 60 in.	100%	43 in. / 60 in.	72%

ADA-41-31.38 PID 123193

B-003-0-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-3	19.4	26.2	81 in. / 81 in.	100%	61 in. / 81 in.	75%

ADA-41-31.38 PID 123193

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1658+15, 11' RT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 765.9 (MSL) EOB: 9.3 ft.
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012900, -83.376622

EXPLORATION ID B-003-1-25

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
	765.9																	
ASPHALT (10.5")	765.0																	
AGGREGATE BASE (4")	764.7																	
VERY DENSE, DARK GRAY, **GRAVEL**, LITTLE SAND, LITTLE SILT, TRACE CLAY, DRY (FILL)	763.9	1	12 16 30	62	67	SS-1A	-	67	13	7	11	2	NP	NP	NP	4	A-1-a (0)	
	763.4	2				SS-1B	-	42	18	15	20	5	NP	NP	NP	5	A-1-b (0)	
VERY DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DRY		3	14 50/3"	-	67	SS-2	-	23	11	25	34	7	NP	NP	NP	9	A-4a (1)	
	761.4	4																
DENSE TO VERY DENSE, BROWN, **SANDY SILT**, SOME GRAVEL, TRACE CLAY, DAMP		5	12 13 15	38	100	SS-3	1.50	1	10	14	43	32	43	25	18	22	A-7-6 (12)	
	759.9	6																
VERY STIFF, BROWN, **CLAY**, "AND" SILT, SOME SAND, TRACE GRAVEL, DAMP			21 50/4"	-	90	SS-4	-	-	-	-	-	-	-	-	-	8	A-6b (V)	
HARD, BROWN, **SILTY CLAY**, DRY	758.4	7																
		TR	50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	6	Rock (V)	
SANDSTONE, GRAY AND BROWN, SEVERELY WEATHERED, MODERATELY STRONG.		8																
	756.6	9 EOB	50/3"	-	100	SS-6	-	-	-	-	-	-	-	-	-	3	Rock (V)	

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1659+18, 8' LT.	EXPLORATION ID B-004-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 764.6 (MSL) EOB: 11.1 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.013172, -83.376617	

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
	764.6																	
ASPHALT (12.5")	763.6																	
AGGREGATE BASE (2")	763.4																	
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP (FILL)	761.1	1 2 3	12 5 4	12	67	SS-1	0.50	2	2	10	55	31	39	21	18	21	A-6b (11)	
VERY STIFF, BROWN, **CLAY**, "AND"SILT, LITTLE SAND, TRACE GRAVEL, MOIST	758.6	4 5 6	4 8 5	18	56	SS-2	2.00	8	4	13	43	32	44	20	24	22	A-7-6 (14)	
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, DAMP	756.1	7 8	9 15 16	42	100	SS-3	4.5+	0	0	14	62	24	33	21	12	15	A-6a (9)	
SHALE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG, ARENACEOUS.	753.5	TR 9 10 EOB 11	50/2"	-	0	SS-4	-	-	-	-	-	-	-	-	-	-	Rock (V)	
			50/1"	-	100	SS-5	-	-	-	-	-	-	-	-	-	7	Rock (V)	

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 75 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1659+17, 8' RT.	EXPLORATION ID B-004-1-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 765.9 (MSL) EOB: 14.8 ft.	PAGE 1 OF 1
START: 4/15/25 END: 4/15/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.013170, -83.376565	

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 (12")	765.9 / 764.9																	
AGGREGATE BASE (6")	764.4																	
DENSE, GRAY TO BLACK, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DRY (FILL)	762.4		23 22 8	40	22	SS-1	-	46	19	10	20	5	23	19	4	5	A-1-b (0)	
VERY STIFF TO HARD, LIGHT BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	759.4		8 30 15	61	94	SS-2	2.50	4	1	12	63	20	33	22	11	16	A-6a (8)	
VERY DENSE, LIGHT BROWN, **SILT**, SOME SAND, LITTLE CLAY, DAMP	757.4		18 33 41	100	100	SS-3	-	0	1	21	62	16	NP	NP	NP	9	A-4b (8)	
SANDSTONE, LIGHT BROWN, SEVERELY WEATHERED, MODERATELY STRONG.	756.1	TR	50/2"	-	100	SS-4	-	-	-	-	-	-	-	-	-	8	Rock (V)	
SANDSTONE, BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, FINE TO MEDIUM GRAINED, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERATURE, SLIGHTLY ROUGH, BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 45%, REC 98%. @ 13.1' : 1 inch Gray Clay Seam @ 13.5' - 13.9' : Qu = 8651 psi	751.1	EOB	45		98	NQ2-1											CORE	

1 2 3 4 5 6 7 8 9 10 11 12 13 14

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 125 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

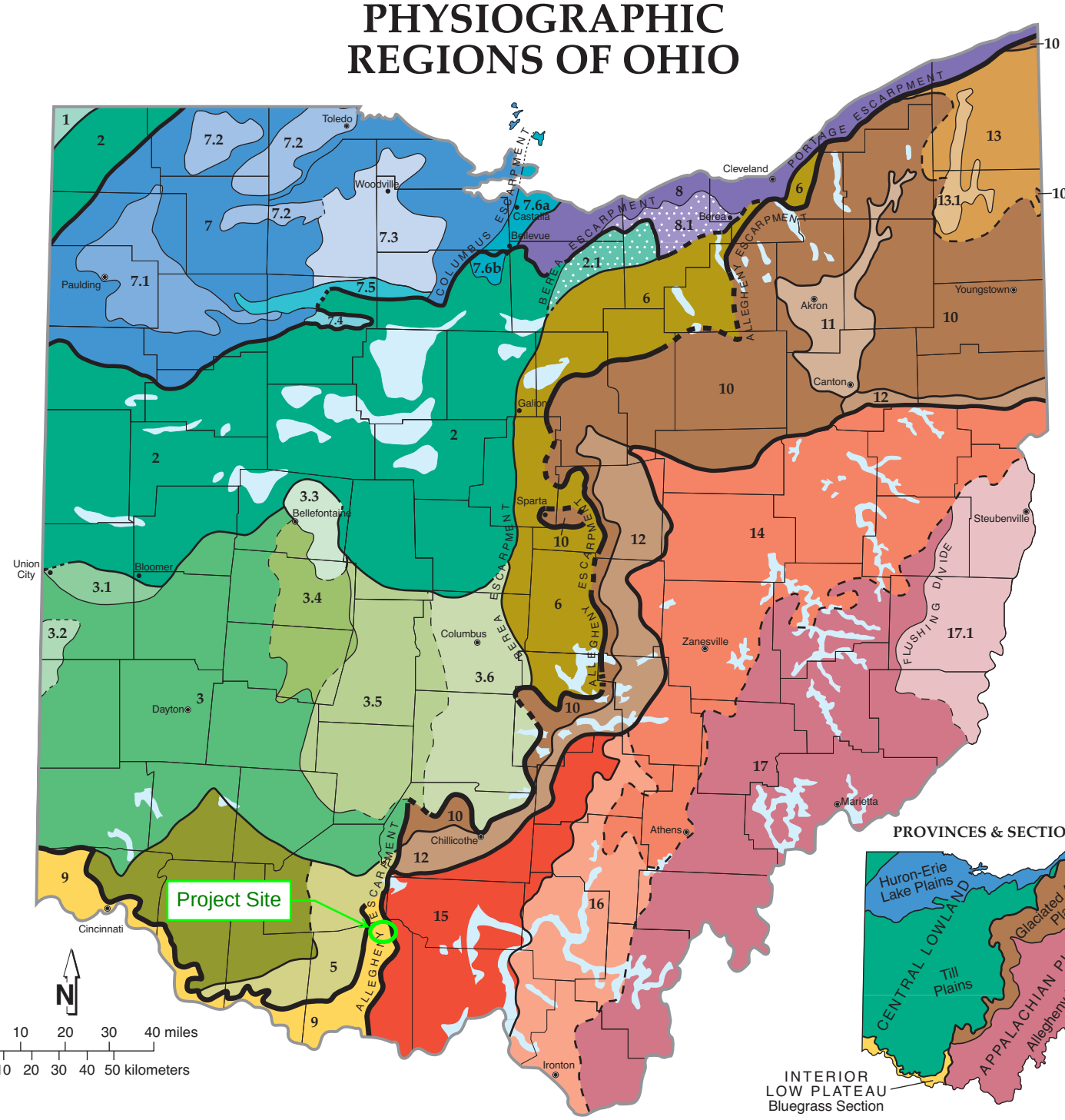
B-004-1-25

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	9.8	14.8	59 in. / 60 in.	98%	27 in. / 60 in.	45%

ADA-41-31.38 PID 123193

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

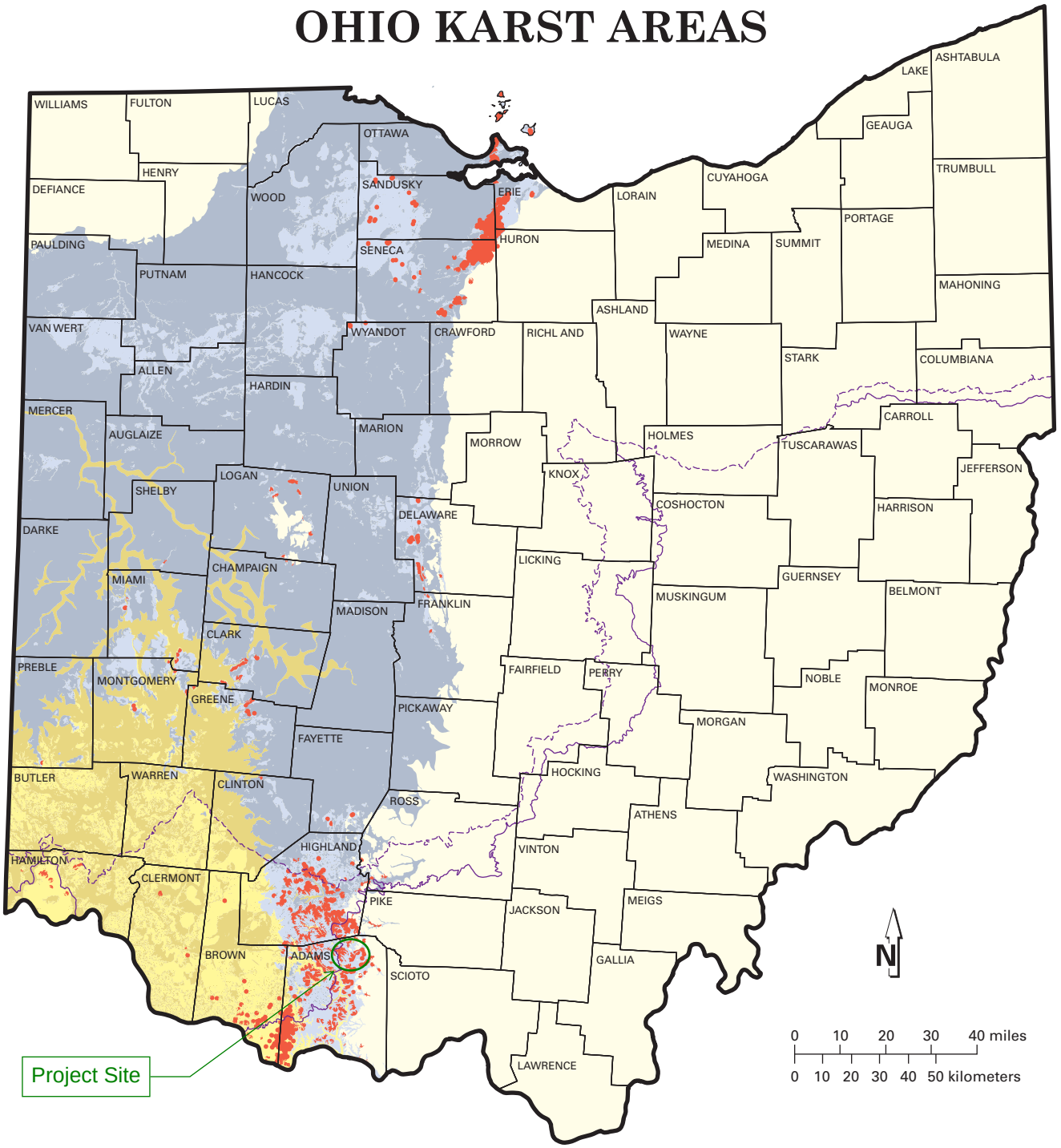
- 14. Muskingum-Pittsburgh Plateau
- 15. Shawnee-Mississippian Plateau
- 16. Ironton Plateau
- 17. Marietta Plateau
  - 17.1. Little Switzerland Plateau

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.

Karst Map

OHIO KARST AREAS

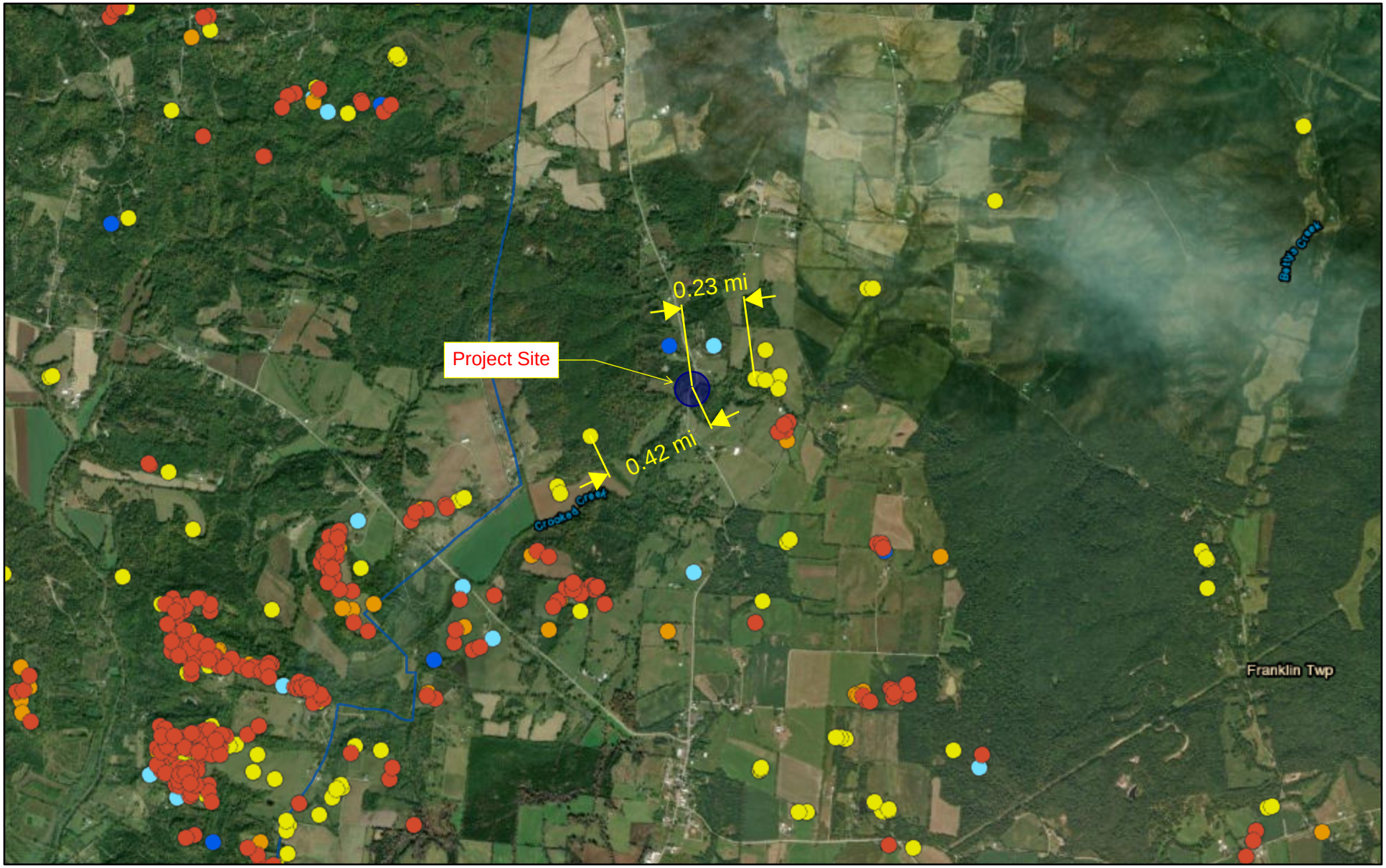


EXPLANATION

- Silurian- and Devonian-age carbonate bedrock overlain by less than 20 feet of glacial drift and/or alluvium
- Silurian- and Devonian-age carbonate bedrock overlain by more than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by less than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by more than 20 feet of glacial drift and/or alluvium
- Probable karst areas
- Area not known to contain karst features
- Wisconsinan Glacial Margin
- Illinoian Glacial Margin

Recommended citation: Ohio Division of Geological Survey, 1999 (rev. 2002, 2006), Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

ADA-41-31.38 Karst Map



7/24/2025, 1:56:01 PM

World_Boundaries_and_Places

Current Township

Counties

Karst - Field Verified

Karst - Suspect - Field Visited

Karst - Suspect - Not Visited

Spring - Field Verified Carbonate

Spring - Field Verified Non-Carbonate

Spring - Suspect Carbonate

Spring - Suspect Non-Carbonate

1:45,553

0 0.3 0.6 1.2 mi

0 0.5 1 2 km

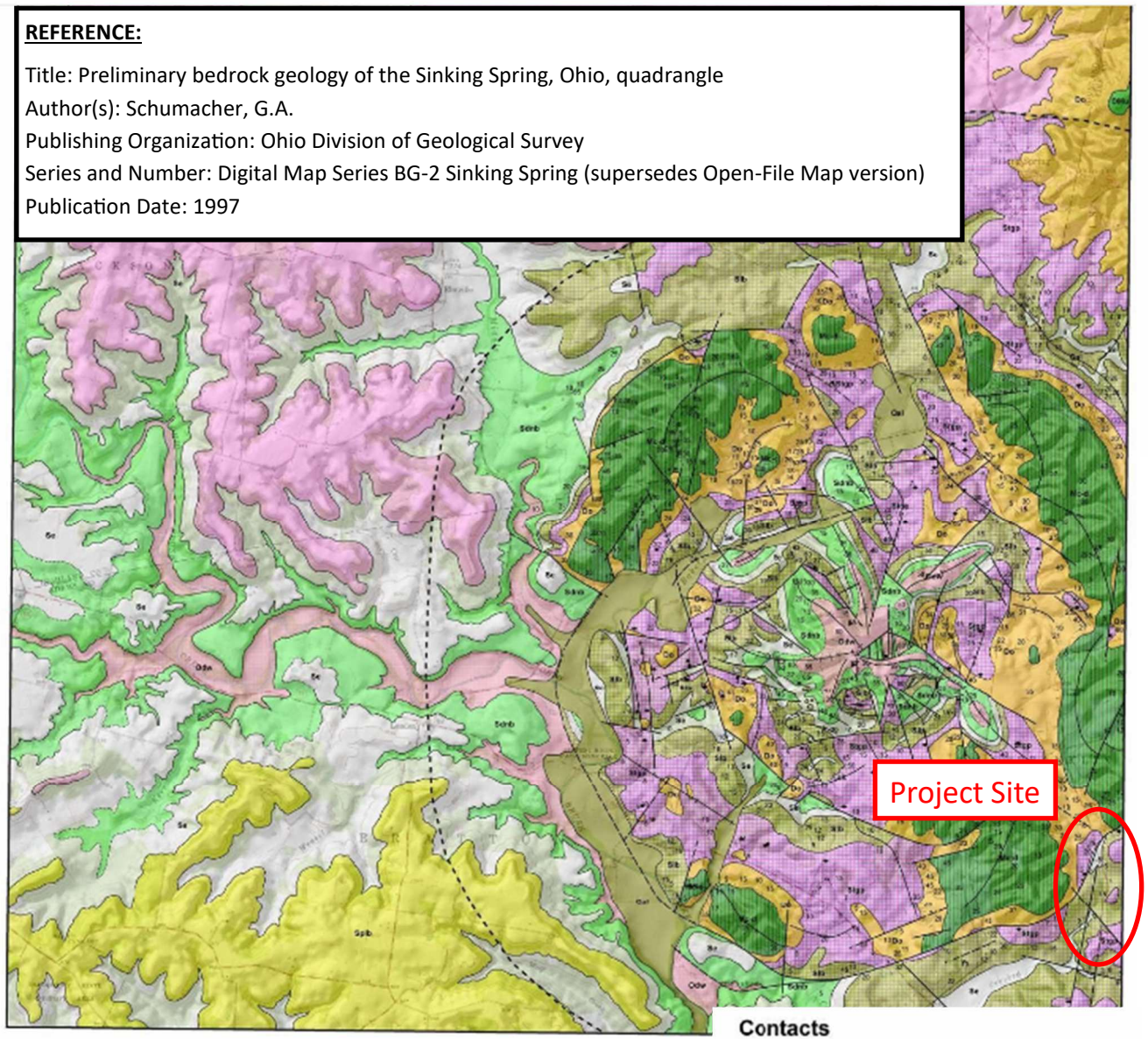
VITA, Esri, HERE, Garmin, Maxar

Bedrock Geology and Topography Maps

Bedrock Geology Map

REFERENCE:

Title: Preliminary bedrock geology of the Sinking Spring, Ohio, quadrangle
Author(s): Schumacher, G.A.
Publishing Organization: Ohio Division of Geological Survey
Series and Number: Digital Map Series BG-2 Sinking Spring (supersedes Open-File Map version)
Publication Date: 1997



1 0.5 0 1
MILES

Contacts

Exposed
Concealed

Facies Changes and Mappable Limits

Mapping limit of Serpent Mound structure

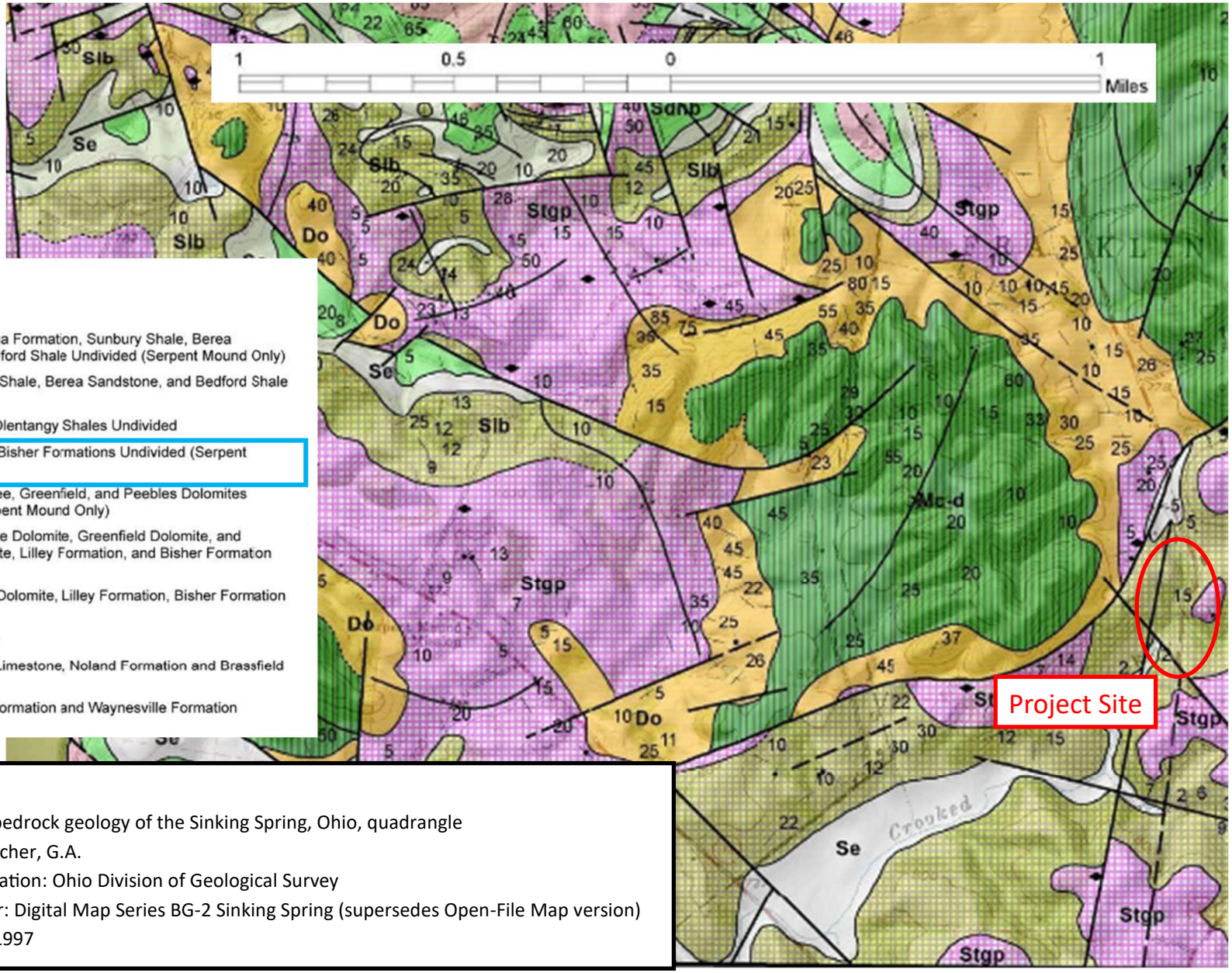
Explanation

Qal - Alluvium
Mc-d - Cuyahoga Formation, Sunbury Shale, Berea Sandstone, Bedford Shale Undivided (Serpent Mound Only)
DMu - Sunbury Shale, Berea Sandstone, and Bedford Shale Undivided
Do - Ohio and Olentangy Shales Undivided
Slb - Lilley and Bisher Formations Undivided (Serpent Mound Only)
Stgp - Tymochtee, Greenfield, and Peebles Dolomites Undivided (Serpent Mound Only)
St-b - Tymochtee Dolomite, Greenfield Dolomite, and Peebles Dolomite, Lilley Formation, and Bisher Formation Undivided
Splb - Peebles Dolomite, Lilley Formation, Bisher Formation Undivided
Se - Estill Shale
Sdnb - Dayton Limestone, Noland Formation and Brassfield Undivided
Odw - Drakes Formation and Waynesville Formation Undivided

Structures

Anticline, known
Anticline, approximate
Syncline, known
Syncline, approximate
Fault - certain
Fault - approximate
Anticline
Syncline
Brecca
Horizontal Beds
Minor Anticline
Overturned Anticline
Plunging Anticline
Strike and Dip of Beds
Strike and Dip of Joints
Strike and Dip of Overturned Beds
Shatter Cone Location
Strike of Vertical Beds
Strike of Vertical Joints
Zinc Mineral Location

Bedrock Geology Map



Explanation

- Qal - Alluvium
- Mc-d - Cuyahoga Formation, Sunbury Shale, Berea Sandstone, Bedford Shale Undivided (Serpent Mound Only)
- DMu - Sunbury Shale, Berea Sandstone, and Bedford Shale Undivided
- Do - Ohio and Olentangy Shales Undivided
- Slb - Lilley and Bisher Formations Undivided (Serpent Mound Only)
- Stgp - Tymochtee, Greenfield, and Peebles Dolomites Undivided (Serpent Mound Only)
- St-b - Tymochtee Dolomite, Greenfield Dolomite, and Peebles Dolomite, Lilley Formation, and Bisher Formaton Undivided
- Splb - Peebles Dolomite, Lilley Formation, Bisher Formation Undivided
- Se - Estill Shale
- Sdnb - Dayton Limestone, Noland Formation and Brassfield Undivided
- Odw - Drakes Formation and Waynesville Formation Undivided

REFERENCE:

Title: Preliminary bedrock geology of the Sinking Spring, Ohio, quadrangle
Author(s): Schumacher, G.A.
Publishing Organization: Ohio Division of Geological Survey
Series and Number: Digital Map Series BG-2 Sinking Spring (supersedes Open-File Map version)
Publication Date: 1997

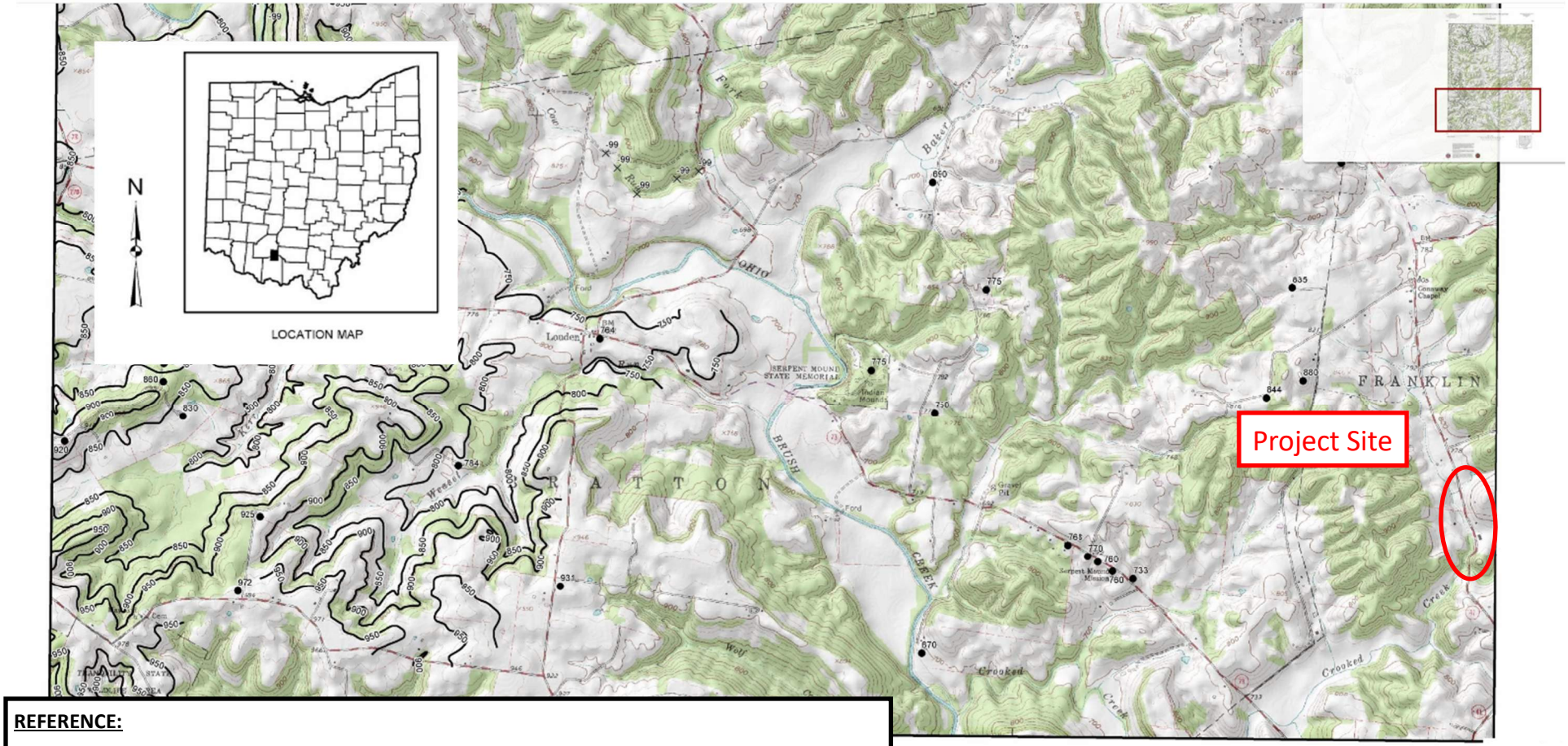
Bedrock Topography Map

National Geologic Map Database

Preview

Schumacher, G.A., 1994, Bedrock topography of the Sinking Spring, Ohio, quadrangle: Ohio Division of Geological Survey, Digital Map Series BT-3B Sinking Spring (supersedes Open-File Map version), scale 1:24,000

Image provided by Ohio Division of Geological Survey

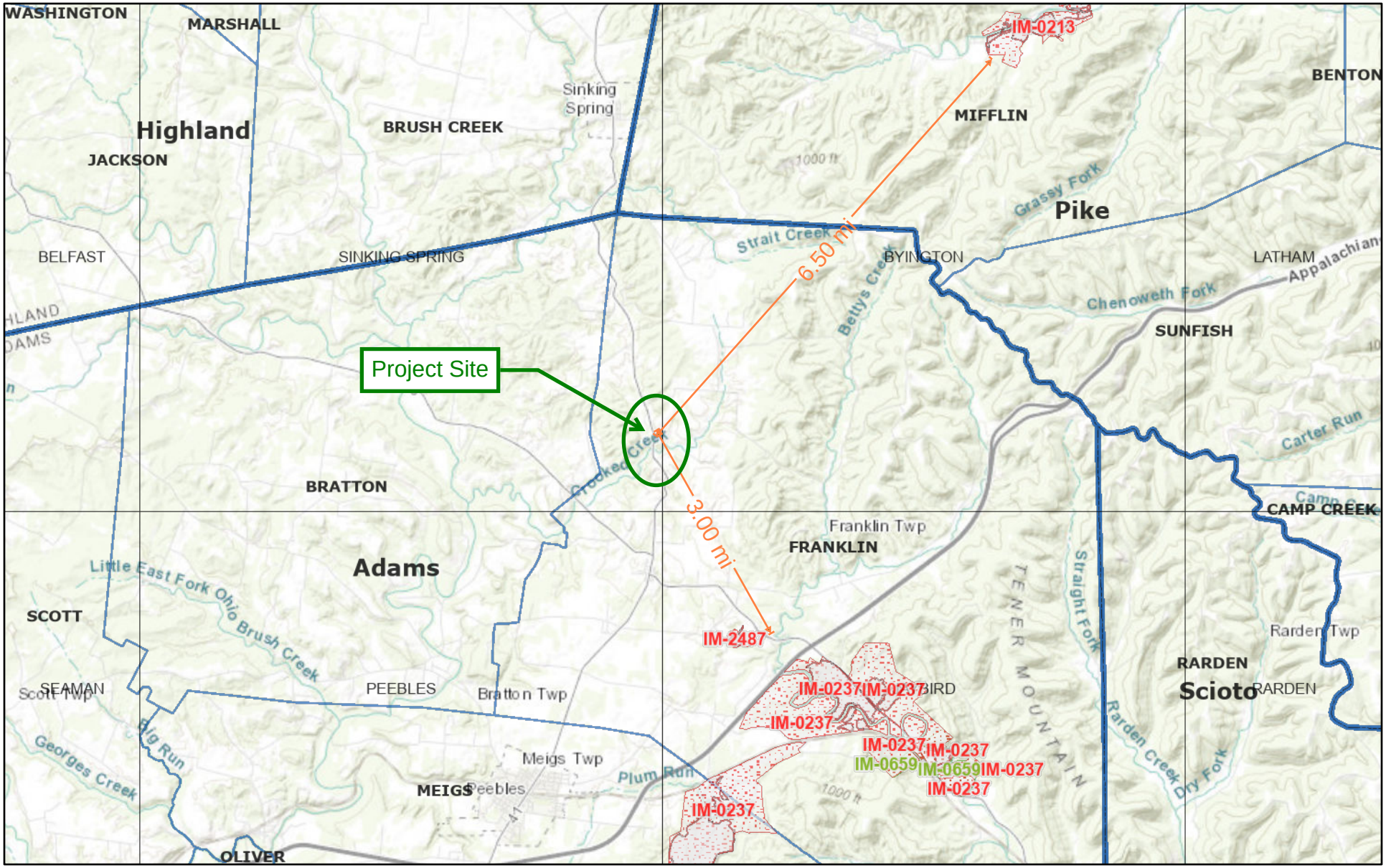


REFERENCE:

Title: Bedrock topography of the Sinking Spring, Ohio, quadrangle
Author(s): Schumacher, G.A.
Publishing Organization: Ohio Division of Geological Survey
Series and Number: Digital Map Series BT-3B Sinking Spring (supersedes Open-File Map version)
Publication Date: 1994

Mine Map

ADA-41-31.38: Mines of Ohio



July 3, 2025

Quadrangle 24K (7.5 min)

Past

Current

Surface Affected Area

1:144,448

0 0.75 1.5 3 mi

0 1.5 3 6 km

VITA, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Ohio Dept. of Natural Resources

FEMA Flood Map

National Flood Hazard Layer FIRMette

FEMA

83°22'55"W 39°1'N

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

1:6,000

83°22'18"W 39°0'32"N

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 7/16/2025 at 1:02 AM 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.

TIMS Historic Records

ADA-41-31.31 Geotechnical Profile Sheets (2013)

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

PROJECT DESCRIPTION

THE PROJECT INVOLVES THE REPLACEMENT OF AN EXISTING CULVERT ALONG STATE ROUTE 41 IN ADAMS COUNTY, OHIO.

HISTORIC RECORDS

NO HISTORIC RECORDS WERE FOUND FOR THIS PROJECT.

GEOLOGY

ACCORDING TO THE OHIO DEPARTMENT OF NATURAL RESOURCES, PHYSIOGRAPHIC REGIONS OF OHIO, THE SITE LIES ON OUTER BLUEGRASS REGION OF OHIO. ACCORDING TO BEDROCK GEOLOGY MAP OF OHIO (2006), BEDROCK BELOW THE SITE CONSISTS OF DOLOMITE, SHALE, LIMESTONE OR SANDSTONE OF THE SILURIAN AGE.

RECONNAISSANCE

A SITE VISIT WAS PERFORMED BY PERSONNEL FROM CTL ENGINEERING ON NOVEMBER 14, 2013. EVIDENCE OF SHALLOW ROCK WAS NOTED IN THE CREEK BED AT THE INLET AND OUTLET, AS WELL AS IN THE CUT SLOPE NORTH OF THE STRUCTURE ON THE EAST SIDE OF THE ROADWAY. SOME EROSION WAS NOTED ON THE EAST BANK OF THE CREEK IN THE VICINITY OF THE STRUCTURE.

NO MAJOR SIGNS OF SLOPE INSTABILITY WERE NOTED IN THE ALONG THE EXISTING ROADWAY.

SUBSURFACE EXPLORATION

TWO (2) TEST BORINGS WERE PERFORMED FOR THIS PROJECT.
THE BORINGS WERE PERFORMED WITH A TRACK MOUNTED DRILL RIG UTILIZING HOLLOW STEM AUGERS (HSA) ON MARCH 19 AND 20, 2014. STANDARD PENETRATION TESTS WERE CONDUCTED USING A 140-POUND HAMMER FALLING 30 INCHES TO DRIVE A 2-INCH O.D. SPLIT BARREL SAMPLER. THE ENERGY TRANSFER RATIO ASSOCIATED WITH THE AUTOMATIC SPT HAMMER WAS 81.2 PERCENT. THE HAMMER WAS CALIBRATED IN OCTOBER 2013.

EXPLORATION FINDINGS

IN GENERAL, THE BORINGS EXHIBITED SANDY SILT (A-4a), SILT AND CLAY (A-6a) OR CLAY (A-7-6) EXTENDING TO DEPTHS RANGING FROM 1.0 TO 13.5 FEET.

BELOW THE SOIL OVERBURDEN, THE BORINGS EXHIBITED HIGHLY WEATHERED, MODERATELY STRONG SANDSTONE. THE UPPER FEW INCHES OF BEDROCK WAS AUGERED AND SAMPLED USING SOIL SAMPLING TECHNIQUES. THE LOWER 7.5 TO 10 FEET OF BEDROCK WAS SAMPLED USING ROCK CORING TECHNIQUES AND WAS DESCRIBED AS STRONG TO VERY STRONG DOLOMITE OR VERY WEAK SHALE.

NO GROUNDWATER WAS ENCOUNTERED IN THE BORINGS DURING THE DRILLING OPERATIONS.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JULY 2013.

AVAILABLE INFORMATION

ALL AVAILABLE INFORMATION AND BEDROCK INFORMATION THAT CAN BE CONVINIENTLY SHOWN ON THE SOIL PROFILE SHEETS HAS BEEN REPORTED. ADDITIONAL SUBSURFACE EXPLORATIONS MAY HAVE BEEN MADE TO STUDY SOME SPECIAL ASPECT OF THE PROJECT. COPIES OF THIS DATA, IF ANY, MAY BE INSPECTED IN THE DISTRICT DEPUTY DIRECTOR'S OFFICE, THE OFFICE OF GEOTECHNICAL ENGINEERING AT 1980 WEST BROAD STREET, OR THE OFFICE OF THE STRUCTURAL ENGINEERING AT 1980 WEST BROAD STREET.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
SANDY SILT	*A-4a*	-	*3*
SILT AND CLAY	*A-6a*	-	*1*
CLAY	*A-7-6*	*1*	*1*
	TOTAL	*1*	*5*
DOLOMITE	*VISUAL*		
SHALE	*VISUAL*		
WEATHERED SANDSTONE	*VISUAL*		

EXPLORATION LOCATION - PLAN VIEW

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

WC INDICATES WATER CONTENT IN PERCENT.

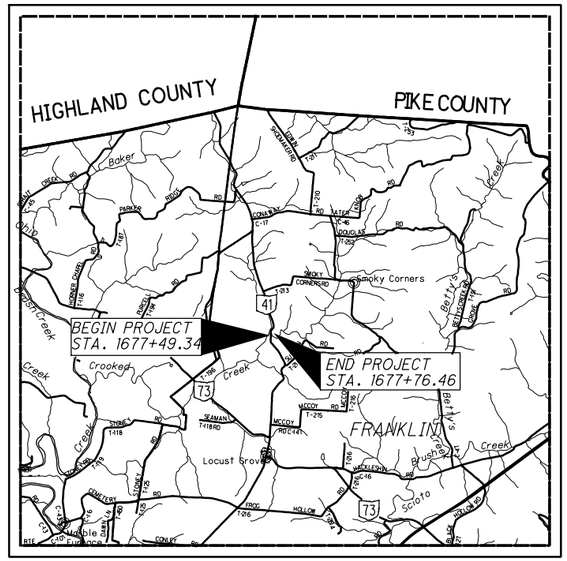
N_{60} INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

SS INDICATES A SPLIT-SPOON SAMPLE.

TR INDICATES THE TOP OF ROCK.

BEDROCK TEST SUMMAY

BORING NO.	SAMPLE NO.	DEPTH	Qu (psi)
B-001-0-13	NQ-1	2.0′ - 2.5′	21,737
B-002-0-13	NQ-2	25.0′ - 25.5′	12,559



LOCATION MAP

SCALE IN MILES
0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

12″	3″	2.0 mm	0.42 mm	0.074 mm	0.005 mm
BOULDERS |	COBBLES |	GRAVEL |	COARSE SAND |	FINE SAND |	SILT | CLAY
		No. 10 SIEVE	No. 40 SIEVE	No. 200 SIEVE	

RECON. - JG 11/14/2013
DRILLING - CTL ENGINEERING INC 03/19-03/20/14
DRAWN - SM 4/06/2015
REVIEWED - JG 4/16/2015

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

PID NO. 91408

STRUCTURE FOUNDATION EXPLORATION
STRUCTURE NO. ADA-41-3131

ADA-41-31.31

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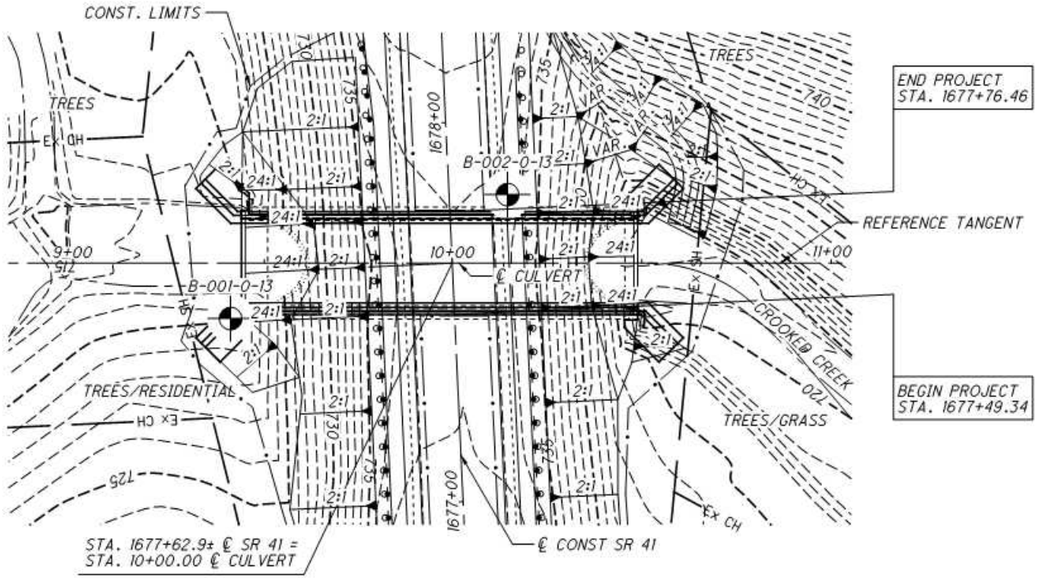

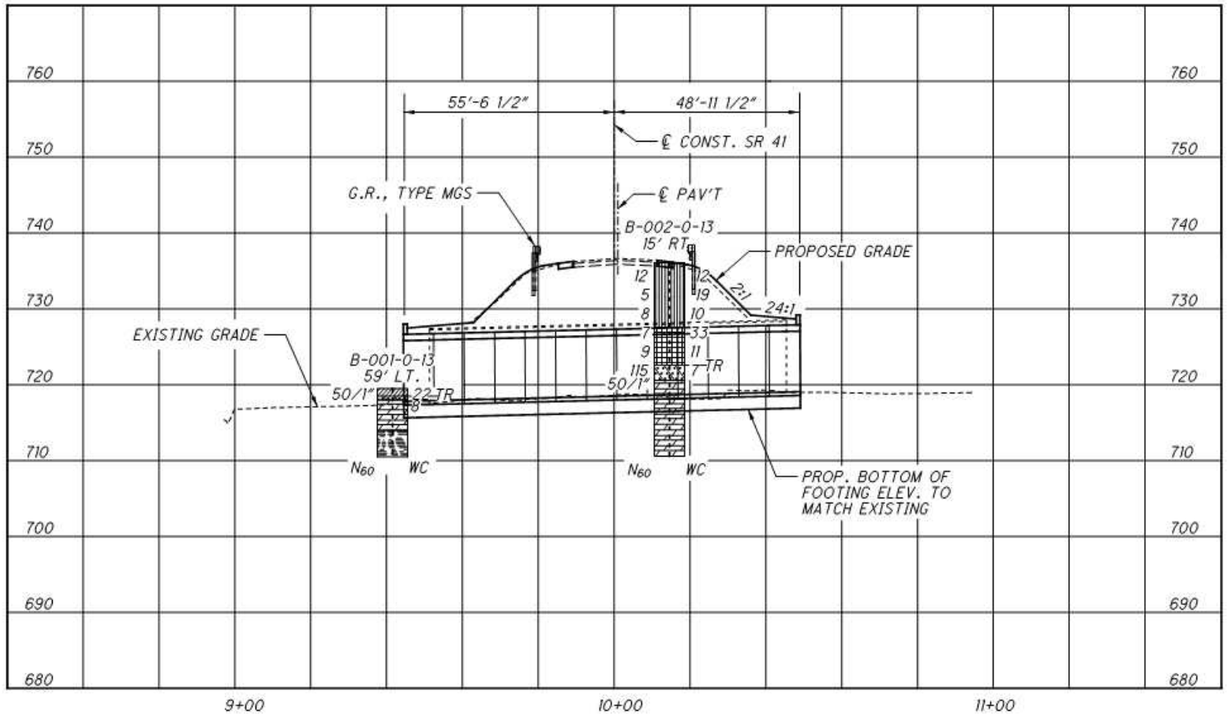

PROFILE SHOWN ALONG CENTERLINE OF CULVERT

HORIZONTAL SCALE IN FEET
0 10 20 40

DRAWN BRU
CHECKED SM

STRUCTURE FOUNDATION EXPLORATION
STRUCTURE NO. ADA-41-3131

ADA-41-31.31

2 / 3

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PROJECT: ADA-41-31.77
TYPE: STRUCTURE
PID: 91408 SFN:
START: 3/19/14 END: 3/19/14

DRILLING FIRM / OPERATOR: CTL / MF
SAMPLING FIRM / LOGGER: CTL / MF
DRILLING METHOD: 3.25" HSA / NQ
SAMPLING METHOD: SPT

DRILL RIG: 03050TKR349-13
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/29/13
ENERGY RATIO (%): 81.2

STATION / OFFSET: 1677+51, 59' LT.
ALIGNMENT: C.L. SR 41
ELEVATION: 719.5 (MSL) EOB: 9.0 ft.
COORD: 369684.0700 N, 1719178.2100 E

EXPLORATION ID B-001-0-13
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 719.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	ABAN-DONED
STIFF, BROWN, **SILT AND CLAY**, TRACE SAND WITH ORGANICS AND ROOTS, MOIST	718.5	TR 1	1 2 50/1"	-	0	SS-1	1.00	-	-	-	-	-	-	-	-	22	A-6a (V)	
SANDSTONE, BROWN, HIGHLY WEATHERED, MODERATELY STRONG.	718.0						-	-	-	-	-	-	-	-	-	8	Rock (V)	
DOLOMITE, LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, UNIT RQD = 88%. @2.0'; COMPRESSIVE STRENGTH = 21,737 PSI		2 3 4 5 6	77		98	NQ-1											CORE	
SHALE, GRAY, MODERATELY WEATHERED, VERY WEAK TO WEAK, UNIT RQD = 33%.	714.0	7 8	67		100	NQ-2											CORE	
	710.5	EOB 9																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

PROJECT: ADA-41-31.77
TYPE: STRUCTURE
PID: 91408 SFN:
START: 3/20/14 END: 3/20/14

DRILLING FIRM / OPERATOR: CTL / MF
SAMPLING FIRM / LOGGER: CTL / MF
DRILLING METHOD: 3.25" HSA / NQ
SAMPLING METHOD: SPT

DRILL RIG: 03050TKR349-13
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 10/29/13
ENERGY RATIO (%): 81.2

STATION / OFFSET: 1677+80, 15' RT.
ALIGNMENT: C.L. SR 41
ELEVATION: 736.1 (MSL) EOB: 25.5 ft.
COORD: 369712.6400 N, 1719252.9300 E

EXPLORATION ID B-002-0-13
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 736.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	ABAN-DONED
VERY STIFF, BROWN, **SANDY SILT**, SOME CLAY, DAMP		1 2	3 5 4	12	17	SS-1	-	-	-	-	-	-	-	-	-	12	A-4a (V)	
@3.5'; STIFF, SANDSTONE FRAGMENTS		3 4 5	3 2 2	5	44	SS-2	1.50	-	-	-	-	-	-	-	-	19	A-4a (V)	
		6 7	5 4 2	8	22	SS-3	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
	727.6	8																
STIFF, BROWN, **CLAY**, AND SILT, LITTLE SAND, TRACE GRAVEL WITH SANDSTONE FRAGMENTS, MOIST		9 10	1 2 3	7	39	SS-4	1.00	5	6	14	47	28	41	23	18	33	A-7-6 (11)	
@11.0'; DAMP		11 12	3 4 3	9	17	SS-5	1.00	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
	722.6	TR 13																
SANDSTONE, BROWN, HIGHLY WEATHERED, MODERATELY STRONG.		14	23 40 45	115	78	SS-6	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	720.6	15	50/1"	-	0	SS-7	-	-	-	-	-	-	-	-	-	-	Rock (V)	
DOLOMITE, GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, VERTICALLY FRACTURED, ROUGH, OPEN WITH IRON STAINING WITH FEW THIN CLAY SEAMS; UNIT RQD = 50%.	718.1	16 17 18 19 20	32		87	NQ-1											CORE	
DOLOMITE, GRAY, SLIGHTLY WEATHERED, STRONG, MODERATELY TO HIGHLY FRACTURED, ROUGH, OPEN; UNIT RQD = 61%.		21 22 23 24	85		98	NQ-2											CORE	
@25.0'; COMPRESSIVE STRENGTH = 12,559 PSI	710.6	EOB 25																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/19/15 16:13 - J:\DEPT5\13 PROJECTS\13050189COL-PALMER ENG-ADA-41-31.76\REPORTS\LOGS\13050189COL.GPJ

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
ADA-41-31.38

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
		PPR	N-values			Tested							N_{60} Value	$N1_{60}$ Value	ODOT GDM Correlations		Tested		(Back-Calculated from SlopeW)
			GDM	Sowers	T and P	Values	Correlation	Tested	Correlation	Tested					Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)	
Layer 1 GRANULAR MATERIAL	Max	N/A	N/A	N/A	N/A		130		140			Max	100	160	N/A	42			
	Min	N/A	N/A	N/A	N/A		118		128		S_u= 0 psf	Min	32	56	N/A	38			c' = 0 psf
	Average	N/A	N/A	N/A	N/A		126		136		Φ = 38 deg	Average	66	102	N/A	40			Φ' = 38 deg
	Std Dev	N/A	N/A	N/A	N/A		5		5			Std Dev	31	43	N/A	2			
											Y_{moist} = 125 pcf								Y_{moist} = 125 pcf
	Avg + Std	N/A	N/A	N/A	N/A		131		141		Y_{total} = 135 pcf	Avg + Std	98	145	N/A	42			Y_{total} = 135 pcf
	Avg - Std	N/A	N/A	N/A	N/A		121		131			Avg - Std	35	60	N/A	38			
Layer 2 COHESIVE MATERIAL	Max	4500	7175	4000	4000	1148	130	129	140			Max	61	88	459	28			
	Min	500	1500	2100	1596	1148	110	129	120		S_u= 1200 psf	Min	12	20	150	23			c' = 170 psf
	Average	2156	3793	3707	3139	1148	119	129	129		Φ = 0 deg	Average	31	45	291	26			Φ' = 24 deg
	Std Dev	1288	2002	711	932		8		8			Std Dev	17	23	106	2			
											Y_{moist} = 120 pcf								Y_{moist} = 120 pcf
	Avg + Std	3445	5795	4418	4071		127		137		Y_{total} = 130 pcf	Avg + Std	48	68	397	28			Y_{total} = 130 pcf
	Avg - Std	868	1791	2996	2207		112		122			Avg - Std	14	22	185	24			

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	100	9	0.920	160	100	N/A	58	22	25	62	16	23	19	4	9	**Max**	N/A	N/A	N/A	N/A	N/A	42	7.3	763.7	123	130	140	0.117	2.72	0.505
Min	32	4	0.207	56	22	N/A	0	1	9	14	3	23	19	4	5	**Min**	N/A	N/A	N/A	N/A	N/A	38	1.8	754.2	112	118	128	0.117	2.71	0.379
Average	66	7	0.446	102	70	N/A	32	15	18	28	7	23	19	4	7	**Average**	N/A	N/A	N/A	N/A	N/A	40	3.6	759.5	118	126	136	0.117	2.71	0.434
Std Dev	31	2	0.281	43	37	N/A	19	7	7	17	4	N/A	N/A	N/A	2	**Std Dev**	N/A	N/A	N/A	N/A	N/A	2	2.3	4.2	4	5	5	N/A	0.01	0.043
Avg + Std	98	9	0.727	145	106	N/A	51	23	25	44	11	N/A	N/A	N/A	9	**Avg + Std**	N/A	N/A	N/A	N/A	N/A	42	5.9	763.6	122	131	141	N/A	2.72	0.477
Avg - Std	35	6	0.165	60	33	N/A	13	8	11	11	2	N/A	N/A	N/A	5	**Avg - Std**	N/A	N/A	N/A	N/A	N/A	38	1.3	755.3	115	121	131	N/A	2.71	0.391

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-41	756.4	B-001-0-25	1.5	-	3	SS-1	97	3.5	0.293	160	100	-	19	21	24	28	8	NP	NP	NP	8	A-4a	NP SILT	1	N/A					38	2.3	754.2	120	130	140	N/A	2.72	0.410
SR-41	760.7	B-002-0-25	1	-	2.5	SS-1	32	7.5	0.207	56	28	-	58	15	9	14	4	NP	NP	NP	5	A-1-b	Granular	1	N/A					42	1.8	759.0	112	118	128	N/A	2.71	0.505
SR-41	760.7	B-002-0-25	6	-	6.75	SS-4	Refusal	7.5	0.772	Refusal	100	-	36	22	23	16	3	NP	NP	NP	6	A-1-b	Granular	1	N/A					42	6.5	754.2	123	130	140	N/A	2.71	0.379
SR-41	765.9	B-003-1-25	2	-	2.5	SS-1B	62	7.5	0.281	103	-	-	42	18	15	20	5	NP	NP	NP	5	A-1-b	Granular	1	N/A					42	2.3	763.7	119	125	135	N/A	2.71	0.420
SR-41	765.9	B-003-1-25	2.5	-	3.25	SS-2	Refusal	7.5	0.379	Refusal	67	-	23	11	25	34	7	NP	NP	NP	9	A-4a	NP SILT	1	N/A					38	3.0	762.9	119	130	140	N/A	2.72	0.423
SR-41	765.9	B-004-1-25	1.5	-	3	SS-1	40	8.5	0.270	67	22	-	46	19	10	20	5	23	19	4	5	A-1-b	Granular	1	N/A					42	2.3	763.7	114	120	130	0.117	2.71	0.480
SR-41	765.9	B-004-1-25	6.5	-	8	SS-3	100	8.5	0.920	126	100	-	0	1	21	62	16	NP	NP	NP	9	A-4b	NP SILT	1	N/A					38	7.3	758.7	119	130	140	N/A	2.72	0.423

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) GDM	Short-Term Cohesion (psf) N-values Sowers	Short-Term Cohesion (psf) N-values 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)	Laboratory Tested Values: Moist Unit Wt (pcf)	Laboratory Tested Values: Total Unit Wt (pcf)	Strength Testing: Qu/UU Su (psf)	Strength Testing: Qu/UU Correlated Eff. c (psf)	Strength Testing: CU Eff. c (psf)	Strength Testing: CU Eff. phi (deg)	Strength Testing: CU Total c (psf)	Strength Testing: CU Total phi (deg)
Max	61	9	0.811	88	100	4.5	19	21	26	63	55	68	26	42	29	**Max**	4500	7175	4000	4000	459	28	6.8	762.4	120	130	140	0.522	2.72	0.855	104	129	N/A	1148	115	N/A	N/A	N/A	N/A
Min	12	6	0.201	20	6	0.5	0	0	2	31	15	30	18	11	8	**Min**	500	1500	2100	1596	150	23	1.8	755.5	89	110	120	0.180	2.65	0.400	104	129	N/A	1148	115	N/A	N/A	N/A	N/A
Average	31	8	0.522	45	73	2.2	5	6	13	47	29	41	22	19	19	**Average**	2156	3793	3707	3139	291	26	4.4	759.7	102	119	129	0.276	2.69	0.668	104	129	N/A	1148	115	N/A	N/A	N/A	N/A
Std Dev	17	1	0.200	23	31	1.3	6	7	6	12	11	11	2	10	6	**Std Dev**	1288	2002	711	932	106	2	1.6	2.3	11	8	8	0.102	0.03	0.164	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg + Std	48	9	0.723	68	104	3.4	11	13	19	60	41	52	24	29	25	**Avg + Std**	3445	5795	4418	4071	397	28	6.0	762.0	113	127	137	0.378	2.72	0.832	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - Std	14	7	0.322	22	42	0.9	-1	-1	7	35	18	29	19	9	12	**Avg - Std**	868	1791	2996	2207	185	24	2.8	757.4	90	112	122	0.174	2.66	0.504	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) GDM	Short-Term Cohesion (psf) N-values Sowers	Short-Term Cohesion (psf) N-values 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)	Laboratory Tested Values: Moist Unit Wt (pcf)	Laboratory Tested Values: Total Unit Wt (pcf)	Strength Testing: Qu/UU Su (psf)	Strength Testing: Qu/UU Correlated Eff. c (psf)	Strength Testing: CU Eff. c (psf)	Strength Testing: CU Eff. phi (deg)	Strength Testing: CU Total c (psf)	Strength Testing: CU Total phi (deg)
SR-41	760.7	B-002-0-25	3	-	4.5	SS-2	23	7.5	0.437	35	56	0.75	3	1	2	39	55	68	26	42	29	A-7-6	Cohesive	2	750	2875	4000	3059	250	25	3.8	757.0	89	115	125	0.522	2.65	0.855										
SR-41	760.7	B-002-0-25	5.1	-	5.5	ST-3B	ST	7.5	0.609	ST	-	2.5	4	14	26	33	23	36	21	15	20	A-6a	Cohesive	2	2500	N/A	N/A	N/A			5.3	755.5				0.234	2.72											
SR-41	764.0	B-003-0-25	1	-	2.5	SS-1	22	6	0.201	39	6	-	19	21	14	31	15	30	18	12	11	A-6a	Cohesive	2	N/A	2750	3850	2926	243	25	1.8	762.3	104	115	125	0.18	2.72	0.638										
SR-41	764.0	B-003-0-25	3	-	5	ST-2	ST	6	0.491	ST	88	3	0	1	10	57	32	40	21	19	22	A-6b	Cohesive	2	3000	N/A	N/A	N/A			4.0	760.0				0.27	2.70		103.8	128.8		1148	115					
SR-41	765.9	B-003-1-25	4.5	-	6	SS-3	38	7.5	0.649	52	100	1.5	1	10	14	43	32	43	25	18	22	A-7-6	Cohesive	2	1500	4750	4000	4000	347	28	5.3	760.7	98	120	130	0.297	2.65	0.681										
SR-41	765.9	B-003-1-25	6	-	6.83	SS-4	Refusal	7.5	0.811	Refusal	90	-	-	-	-	-	-	-	-	-	8	A-6b	Cohesive	2	N/A	N/A	N/A	N/A		28	6.5	759.4	120	130	140		2.70	0.400										
SR-41	764.6	B-004-0-25	1.5	-	3	SS-1	12	8.5	0.248	20	67	0.5	2	2	10	55	31	39	21	18	21	A-6b	Cohesive	2	500	1500	2100	1596	150	23	2.3	762.4	91	110	120	0.261	2.70	0.853										
SR-41	764.6	B-004-0-25	3.5	-	5	SS-2	18	8.5	0.472	27	56	2	8	4	13	43	32	44	20	24	22	A-7-6	Cohesive	2	2000	2250	4000	2394	215	24	4.3	760.4	92	112	122	0.306	2.65	0.801										
SR-41	764.6	B-004-0-25	6	-	7.5	SS-3	42	8.5	0.777	55	100	4.5	0	0	14	62	24	33	21	12	15	A-6a	Cohesive	2	4500	5250	4000	4000	371	28	6.8	757.9	106	122	132	0.207	2.72	0.600										
SR-41	765.9	B-004-1-25	3.5	-	5	SS-2	61	8.5	0.530	88	94	2.5	4	1	12	63	20	33	22	11	16	A-6a	Cohesive	2	2500	7175	4000	4000	459	28	4.3	761.7	112	130	140	0.207	2.72	0.514										

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1656+16, 11' LT.	EXPLORATION ID B-001-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 756.4 (MSL) EOB: 3.6 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012515, -83.377174	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (16")	756.4																	
AGGREGATE BASE (3")	755.1	Layer 1																
VERY DENSE, BROWN, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DAMP	754.8		35 46 26	97	100	SS-1	-	19	21	24	28	8	NP	NP	NP	8	A-4a (0)	
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG.	752.9	t^{TR_3}	50/1"	-	100	SS-2	-	58	15	9	14	4	-	-	-	5	Rock (V)	
	752.8																	

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 12.5 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1657+10, 7' LT.	EXPLORATION ID B-002-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 760.7 (MSL) EOB: 23.5 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012692, -83.376910	

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 (13")	760.7																	
AGGREGATE BASE (4")	759.6																	
DENSE, BROWN TRACE BLACK, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY (FILL) @ 2.5' - 3.0' : Auger Grinding	759.3	Layer 1	8 5 19	32	28	SS-1	-	58	15	9	14	4	NP	NP	NP	5	A-1-b (0)	
MEDIUM STIFF TO STIFF, BROWN, **CLAY**, "AND" SILT, TRACE SAND, TRACE GRAVEL, MOIST	757.7		3 8 9	23	56	SS-2	0.75	3	1	2	39	55	68	26	42	29	A-7-6 (20)	
MEDIUM DENSE, LIGHT BROWN, **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP	756.2 / 755.6	2			100	ST-3A	-	41	8	22	19	10	NP	NP	NP	12	A-2-4 (0)	
	754.7					ST-3B	2.50	4	14	26	33	23	36	21	15	20	A-6a (6)	
VERY STIFF, LIGHT BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, DAMP @ 5.5' - 6.0' : Auger Grinding	753.2	1 TR	44 50/3"	-	100	SS-4	-	36	22	23	16	3	NP	NP	NP	6	A-1-b (0)	
VERY DENSE, BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	752.2		50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	14	Rock (V)	
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG.																		
SANDSTONE, BROWN AND GRAY, MODERATELY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 61%, REC 100%. @ 11.6' - 11.9' : Quartz Crystals	746.9		61		100	NQ2-1											CORE	
SANDSTONE, GRAY TRACE BROWN, SLIGHTLY WEATHERED, STRONG, MEDIUM GRAINED, JOINT DISCONTINUITIES, MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, INTACT/MASSIVE, GOOD TO VERY GOOD SURFACE CONDTIONS; RQD 78%, REC 100%. @ 18.8' - 19.8' : Fractured @ 20.0' - 20.4' : Qu = 7638 psi	737.2	EOB	63		100	NQ2-3											CORE	

Omitted

Interbedded Granular layer neglected in model

Elevated moisture contents considered to be potential perched water or groundwater conditions.

3.0 ft Above Top of Bedrock

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 75 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PW\WORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1658+14, 8' LT.	EXPLORATION ID B-003-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 764.0 (MSL) EOB: 26.2 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012904, -83.376684	

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 (13")	764.0	Layer 1																
AGGREGATE BASE (3") @ 1.0' - 2.5' : Drove 2-inch Spoon Sample for Additional Sample Material (10" of Recovery)	762.9 / 762.7		7 10 6	22	6	SS-1	-	19	21	14	31	15	30	18	12	11	A-6a (3)	
VERY STIFF, DARK BROWN TO BROWN, **SILT AND CLAY**, SOME SAND, LITTLE STONE FRAGMENTS, DAMP	761.0	Layer 2			88	ST-2	3.00	0	1	10	57	32	40	21	19	22	A-6b (12)	
STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, MOIST @ 3.8' - 4.3' : qu = 2296 psf	758.0	TR																
SHALE, BROWN TRACE GRAY, SEVERELY WEATHERED, MODERATELY STRONG, ARENACEOUS.	755.5		50/5"	-	100	SS-3	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SANDSTONE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG, ARGILLACEOUS.	752.8		50/5"	-	100	SS-4	-	-	-	-	-	-	-	-	-	12	Rock (V)	
SANDSTONE, BROWN, MODERATELY TO HIGHLY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 57%, REC 100%. @ 12.8' - 13.2' : Qu = 8364 psi	748.9		49		100	NQ2-1											CORE	
SANDSTONE, BROWN AND GRAY, MODERATELY WEATHERED, STRONG, MEDIUM GRAINED, MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR TO GOOD SURFACE CONDITIONS; RQD 67%, REC 100%.	744.6		72		100	NQ2-2											CORE	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, STRONG, MEDIUM GRAINED, THICK BEDDED, JOINT DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, INTACT OR MASSIVE TO BLOCKY, GOOD TO VERY GOOD SURFACE CONDITIONS; RQD 75%, REC 100%. @ 19.5' - 19.9' : Qu = 9125 psi @ 20.2' - 20.5' : Brown Staining			75		100	NQ2-3											CORE	
@ 25.9' - 26.2' : Possible Fossils	737.8	EOB																

1.0 ft Above Top of Bedrock

Elevated moisture contents considered to be potential perched water or groundwater conditions.

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 175 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1658+15, 11' RT.	EXPLORATION ID B-003-1-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 765.9 (MSL) EOB: 9.3 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.012900, -83.376622	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
	765.9																	
ASPHALT (10.5")	765.0	Layer 1																
AGGREGATE BASE (4")	764.7																	
VERY DENSE, DARK GRAY, **GRAVEL**, LITTLE SAND, LITTLE SILT, TRACE CLAY, DRY (FILL)	763.9	1	12 16 30	62	67	SS-1A	-	67	13	7	11	2	NP	NP	NP	4	A-1-a (0)	
	763.4	2				SS-1B	-	42	18	15	20	5	NP	NP	NP	5	A-1-b (0)	
VERY DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DRY		3	14 50/3"	-	67	SS-2	-	23	11	25	34	7	NP	NP	NP	9	A-4a (1)	
	761.4	4																
DENSE TO VERY DENSE, BROWN, **SANDY SILT**, SOME GRAVEL, TRACE CLAY, DAMP		5	12 13 15	38	100	SS-3	1.50	1	10	14	43	32	43	25	18	22	A-7-6 (12)	
VERY STIFF, BROWN, **CLAY**, "AND" SILT, SOME SAND, TRACE GRAVEL, DAMP	759.9	6	21 50/4"	-	90	SS-4	-	-	-	-	-	-	-	-	-	18	A-6b (V)	1.5 ft Above Top of Bedrock
HARD, BROWN, **SILTY CLAY**, DRY	758.4	TR																
SANDSTONE, GRAY AND BROWN, SEVERELY WEATHERED, MODERATELY STRONG.		7	50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	6	Rock (V)	
	756.6	8																
		EOB 9	50/3"	-	100	SS-6	-	-	-	-	-	-	-	-	-	3	Rock (V)	

Omitted to avoid double counting N-Values

Elevated moisture contents considered to be potential perched water or groundwater conditions.

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1659+18, 8' LT.	EXPLORATION ID B-004-0-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA	CALIBRATION DATE: 6/24/24	ELEVATION: 764.6 (MSL) EOB: 11.1 ft.	PAGE 1 OF 1
START: 4/14/25 END: 4/14/25	SAMPLING METHOD: SPT	ENERGY RATIO (%): 80.9	LAT / LONG: 39.013172, -83.376617	

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
	764.6																	
ASPHALT (12.5")	763.6	Layer 1																
AGGREGATE BASE (2")	763.4																	
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP (FILL)	761.1	2	12 5 4	12	67	SS-1	0.50	2	2	10	55	31	39	21	18	21	A-6b (11)	
VERY STIFF, BROWN, **CLAY**, "AND"SILT, LITTLE SAND, TRACE GRAVEL, MOIST	758.6		4 8 5	18	56	SS-2	2.00	8	4	13	43	32	44	20	24	22	A-7-6 (14)	
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, DAMP	756.1		9 15 16	42	100	SS-3	4.5+	0	0	14	62	24	33	21	12	15	A-6a (9)	
SHALE, BROWN, SEVERELY WEATHERED, MODERATELY STRONG, ARENACEOUS.	753.5	TR	50/2"	-	0	SS-4	-	-	-	-	-	-	-	-	-	-	Rock (V)	
		EOB 11	50/1"	-	100	SS-5	-	-	-	-	-	-	-	-	-	7	Rock (V)	

3.5 ft Above Top of Bedrock

Elevated moisture contents considered to be potential perched water or groundwater conditions.

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 75 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:08 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

PROJECT: ADA-41-31.38	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50	STATION / OFFSET: 1659+17, 8' RT.	EXPLORATION ID B-004-1-25
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / AKB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 41	
PID: 123193 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 6/24/24	ELEVATION: 765.9 (MSL) EOB: 14.8 ft.	PAGE 1 OF 1
START: 4/15/25 END: 4/15/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 80.9	LAT / LONG: 39.013170, -83.376565	

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
	765.9																	
ASPHALT (12")	764.9	Layer																
AGGREGATE BASE (6")	764.4																	
DENSE, GRAY TO BLACK, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DRY (FILL)	762.4	1	23 22 8	40	22	SS-1	-	46	19	10	20	5	23	19	4	5	A-1-b (0)	
VERY STIFF TO HARD, LIGHT BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	759.4	2	8 30 15	61	94	SS-2	2.50	4	1	12	63	20	33	22	11	16	A-6a (8)	
VERY DENSE, LIGHT BROWN, **SILT**, SOME SAND, LITTLE CLAY, DAMP	757.4	1	18 33 41	100	100	SS-3	-	0	1	21	62	16	NP	NP	NP	9	A-4b (8)	
SANDSTONE, LIGHT BROWN, SEVERELY WEATHERED, MODERATELY STRONG.	756.1	TR	50/2"	-	100	SS-4	-	-	-	-	-	-	-	-	-	8	Rock (V)	
SANDSTONE, BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, FINE TO MEDIUM GRAINED, THIN TO MEDIUM BEDDED, JOINT DISCONTINUITIES, MODERATELY FRACTURED TO FRACTURED, NARROW TO OPEN APERATURE, SLIGHTLY ROUGH, BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 45%, REC 98%. @ 13.1' : 1 inch Gray Clay Seam @ 13.5' - 13.9' : Qu = 8651 psi	751.1	EOB	45		98	NQ2-1											CORE	

3.5 ft Above Top of Bedrock

Elevated moisture contents considered to be potential perched water or groundwater conditions.

NOTES: SURFACE PATCHED WITH QUICKCRETE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 125 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/17/25 16:06 - C:\PWWORKING\EAST01\D4422339\ADA-41-31.38 BORING LOGS.GPJ

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: ADA-41-31.38, Boring Location: B-003-0-25, ST-2, Depth: 3.8-4.3 ft)

Tested Date: 4/23/2025

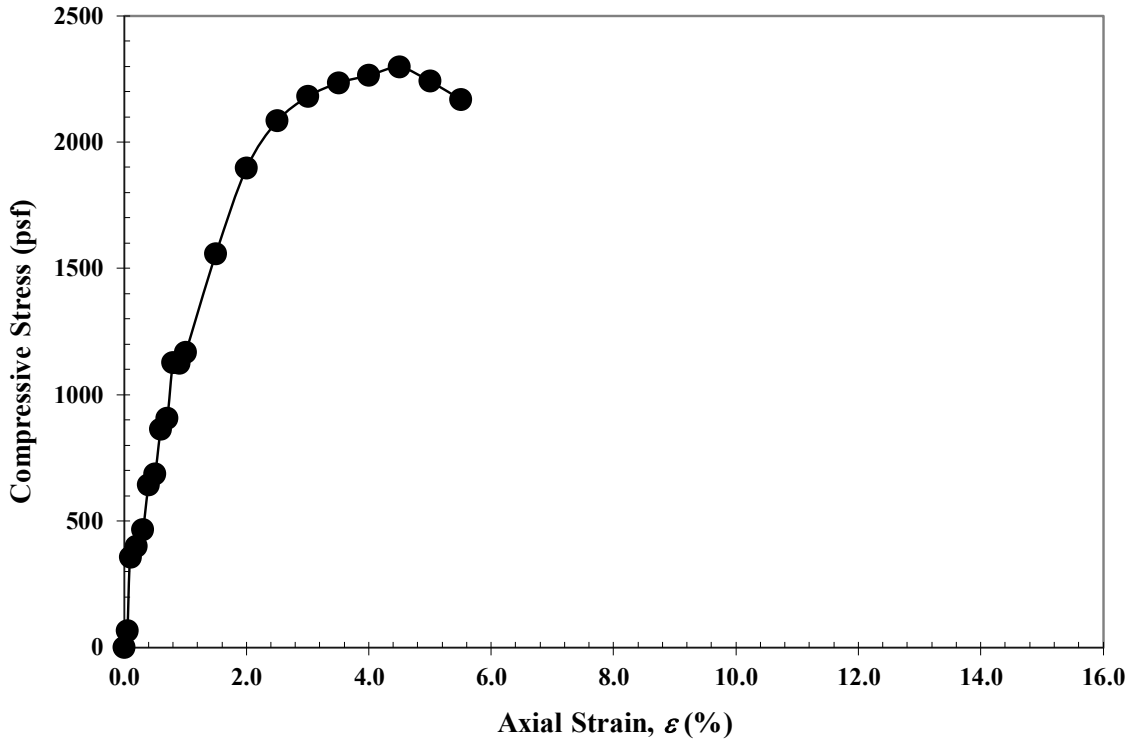
Specimen Properties

Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.74
Area, A (in^2):	6.47
Volume, V (in^3):	37.13
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	24.1
Dry Mass of Specimen (lb):	2.2
Wet Unit Weight, γ (lb/ft^3):	128.8
Dry Unit Weight, γ_d (lb/ft^3):	103.8

Final Specimen Figure

Results

Unconfined Compressive Strength (psf):	**2296**
Strain (%):	**4.5**



Notes: Stiff, yellowish brown, SILTY CLAY, little sand, trace gravel, moist.

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
ADA-41-31.38

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	Moist Unit Weight (pcf) USE	No. Refusal Blows	Refusal Distance (in)	N	N90	Compressive Strength, Qu (ksf)	Compressive Strength, Qu (psi)	Compressive Strength, Qu (MPa)
ADA-41-31.38	B-003-0-25	6	SS-3	Shale (Weathered)	Brown tr Gray	150 - 160	155	50	5	120	107.8667	10	69	0.5
ADA-41-31.38	B-004-0-25	8.5	SS-4	Shale (Weathered)	Brown	150 - 160	155	50	2	300	269.6667	25	172	1.2
ADA-41-31.38	B-004-0-25	11	SS-5	Shale (Weathered)	Brown	150 - 160	155	50	1	600	539.3333	50	345	2.4
				Shale (Weathered)	Maximum		155			Maximum		50	345	
					Minimum		155			Minimum		10	69	
					Average		155			Average		28	195	
					Std Dev		0			Std Dev		20	139	
					Adopted Value		155			Adopted Value		27	190	

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

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf) GDM Range	Moist Unit Weight (pcf) USE	No. Refusal Blows	Refusal Distance (in)	N	N90	Compressive Strength, Qu (ksf)	Compressive Strength, Qu (psi)	Compressive Strength, Qu (MPa)
ADA-41-31.38	B-001-0-25	3.5	SS-2	Sandstone	Brown	155 - 165	160	50	1	600	539.3333	50	345	2.4
ADA-41-31.38	B-002-0-25	7.5	SS-5	Sandstone	Brown	155 - 165	160	50	3	200	179.7778	17	115	0.8
ADA-41-31.38	B-003-0-25	8.5	SS-4	Sandstone	Brown	155 - 165	160	50	5	120	107.8667	10	69	0.5
ADA-41-31.38	B-003-1-25	7.5	SS-5	Sandstone	Gray & Brown	155 - 165	160	50	3	200	179.7778	17	115	0.8
ADA-41-31.38	B-003-1-25	9	SS-6	Sandstone	Gray & Brown	155 - 165	160	50	3	200	179.7778	17	115	0.8
ADA-41-31.38	B-004-1-25	8.5	SS-4	Sandstone	Lt Brown	155 - 165	160	50	2	300	269.6667	25	172	1.2
				Sandstone	Maximum		160			Maximum		50	345	
					Minimum		160			Minimum		10	69	
					Average		160			Average		22	155	
					Std Dev		0			Std Dev		14	98	
					Adopted Value		160			Adopted Value		22	150	

*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

Table C10.4.6.5-1—Summary of Elastic Moduli for Intact Rock (modified after Kulhawy, 1978)

Rock Type	No. of Values	No. of Rock Types	Elastic Modulus, E_R (ksi × 10^3) Maximum	Minimum	Mean	Standard Deviation (ksi × 10^3)
Granite	26	26	14.5	0.93	7.64	3.55
Diorite	3	3	16.2	2.48	7.45	6.19
Gabbro	3	3	12.2	9.8	11.0	0.97
Diabase	7	7	15.1	10.0	12.8	1.78
Basalt	12	12	12.2	4.20	8.14	2.60
Quartzite	7	7	12.8	5.29	9.59	2.32
Marble	14	13	10.7	0.58	6.18	2.49
Gneiss	13	13	11.9	4.13	8.86	2.31
Slate	11	2	3.79	0.35	1.39	0.96
Schist	13	12	10.0	0.86	4.97	3.18
Phyllite	3	3	2.51	1.25	1.71	0.57
Sandstone	27	19	5.68	0.09	2.13	1.19
Siltstone	5	5	4.76	0.38	2.39	1.65
Shale	30	14	5.60	0.001	1.42	1.45
Limestone	30	30	13.0	0.65	5.7	3.73
Dolostone	17	16	11.4	0.83	4.22	3.44

ODOT District 9
ADA-41-31.38

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)
ADA-41-31.38	B-002-0-25	20	NQ2-3	Sandstone	Gray	156.7	Strong	1800 - 7800	7638	52.7	1,909,500	13166	55-65	60	12.9	1,871,675	1,871,675	2,090	303,116
ADA-41-31.38	B-003-0-25	12.8	NQ2-1	Sandstone	Gray	161.9	Strong	1800 - 7800	8364	57.7	2,460,000	16961	55-65	60	13.5	1,958,608	1,958,608	2,692	390,503
ADA-41-31.38	B-003-0-25	19.5	NQ2-3	Sandstone	Yellow-Brown	157.5	Strong	1800 - 7800	9125	62.9	2,535,000	17478	60-70	65	18.8	2,728,079	2,535,000	3,493	506,670
ADA-41-31.38	B-004-1-25	13.5	NQ2-1	Sandstone	Gray	164.6	Strong	1800 - 7800	8651	59.6	2,703,750	18642	60-70	65	18.3	2,656,279	2,656,279	3,726	540,398
				Sandstone	Maximum	165		Sandstone	Maximum	9125				Sandstone	Maximum	2656279			
					Minimum	157			Minimum	7638					Minimum	1871675			
					Average	160			Average	8445					Average	2255390			
					Std Dev	4			Std Dev	623					Std Dev	397580			
					Adopted Value	160			Adopted Value	8,400					Adopted Value	2,255,000			
					krm	0.0005													

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	Depth Range (ft.) To	Thickness (ft)	Layer RQD (%)	Weighted $RQD*(\frac{Length}{Total\ Length})$
ADA-41-31.38	B-002-0-25	Sandstone	8.5	13.8	5.3	61	9.2
ADA-41-31.38	B-002-0-25	Sandstone	13.8	23.5	9.7	78	21.6
ADA-41-31.38	B-003-0-25	Sandstone	11.2	15.1	3.9	57	6.4
ADA-41-31.38	B-003-0-25	Sandstone	15.1	19.4	4.3	67	8.2
ADA-41-31.38	B-003-0-25	Sandstone	19.4	26.2	6.8	75	14.6
ADA-41-31.38	B-004-1-25	Sandstone	9.8	14.8	5	45	6.4
		Sandstone			35	RQD SUM	66
		Maximum			9.7	78	
		Minimum			3.9	45	
		Average			5.8	63.8	
		Adopted Value					65

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.		

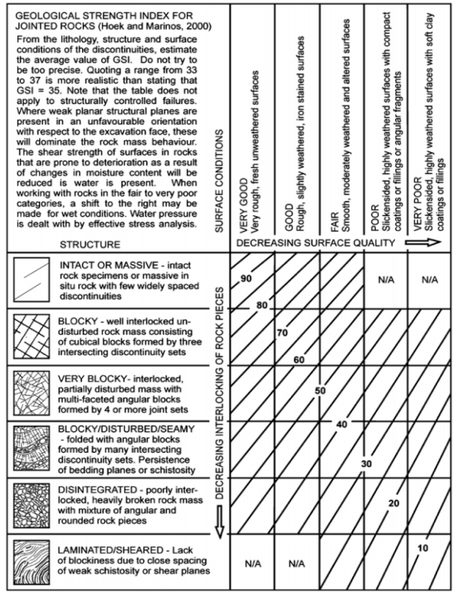


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

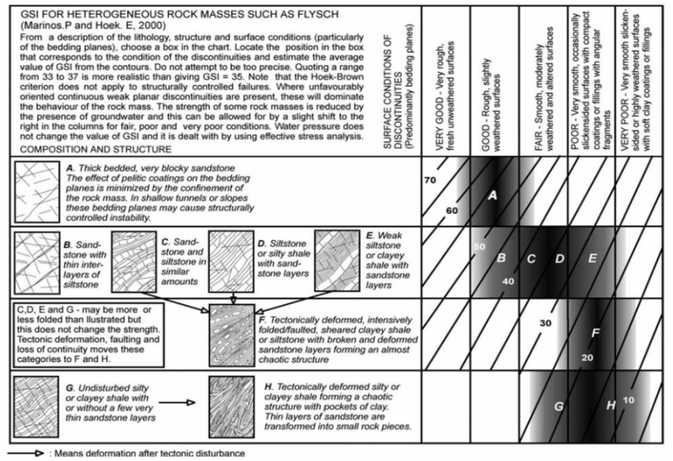


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

NEAS
National Engineering & Architectural Services Inc.

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

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

(Project: ADA-41-31.38, Boring Location: B-002-0-25, NQ2-3, Depth: 20.0-20.4ft)

Tested Date: 4/28/2025

Specimen Properties

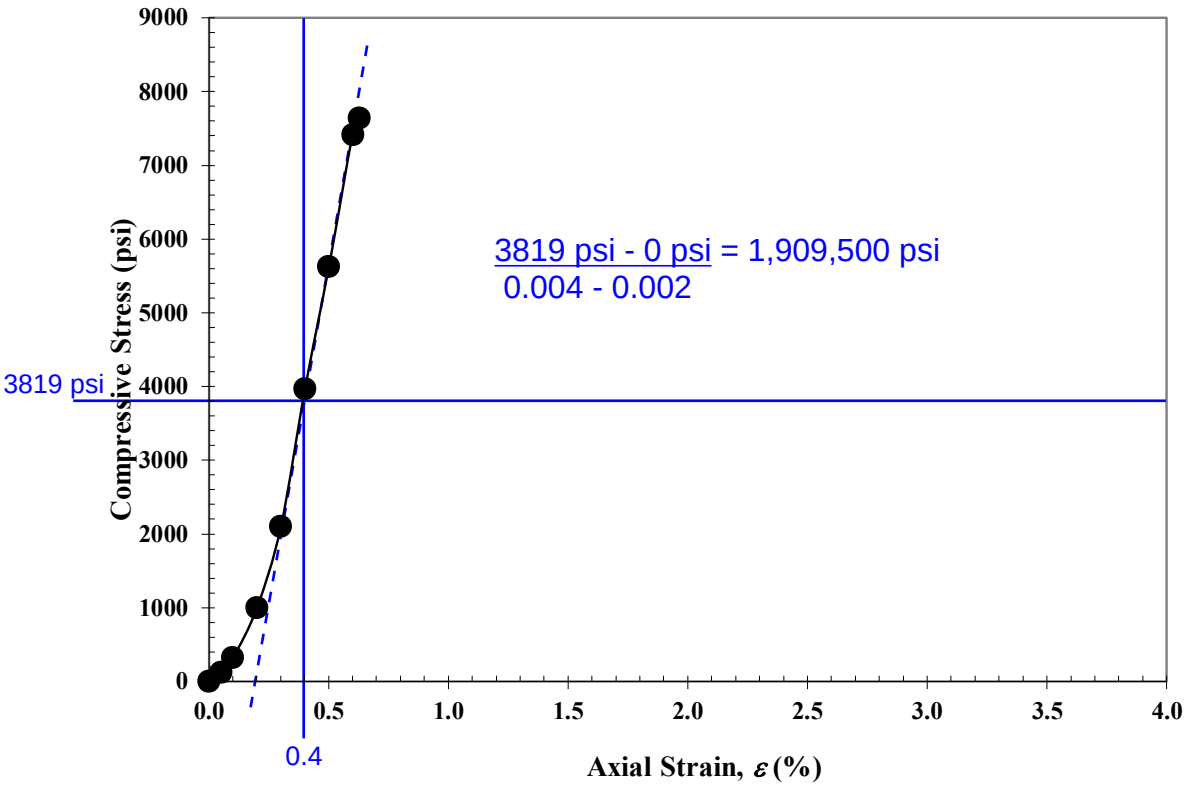
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.45
Length to Diameter Ratio:	2.25
Area, A (in^2):	3.08
Volume, V (in^3):	13.73
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	5.7
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	156.7
Dry Unit Weight, γ_d (lb/ft^3):	148.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **7638** **53** (MPa)

Strain (%): **0.6**



Notes: Sandstone, gray, slightly weathered, fine to medium grained, 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.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

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

(Project: ADA-41-31.38, Boring Location: B-003-0-25, NQ2-1, Depth: 12.8-13.2ft)

Tested Date: 4/28/2025

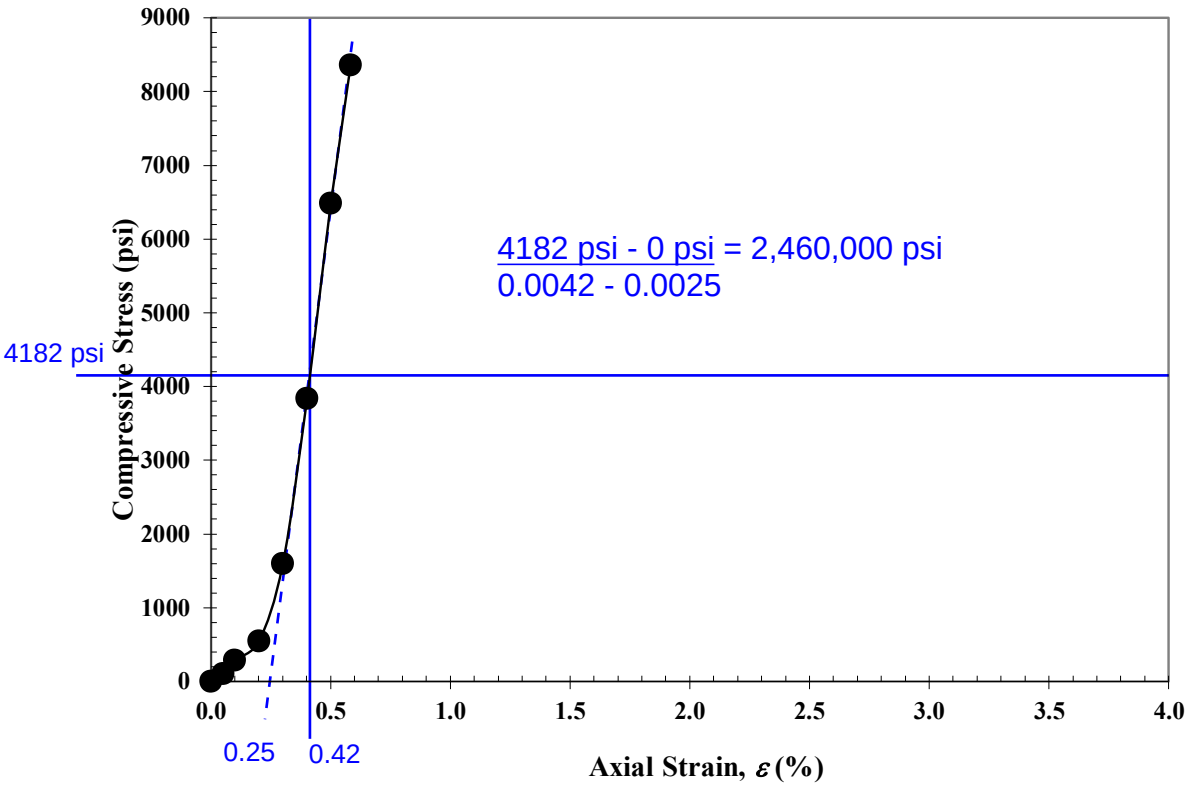
Specimen Properties

Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.28
Length to Diameter Ratio:	2.16
Area, A (in^2):	3.08
Volume, V (in^3):	13.22
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	2.8
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	161.9
Dry Unit Weight, γ_d (lb/ft^3):	157.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi):	**8364**	**58**	(MPa)
Strain (%):	**0.6**		



Notes: Sandstone, yellowish brown, moderately weathered, fine grained, 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
National Engineering & Architectural Services Inc.

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

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

(Project: ADA-41-31.38, Boring Location: B-003-0-25, NQ2-3, Depth: 19.5-19.9ft)

Tested Date: 4/28/2025

Specimen Properties

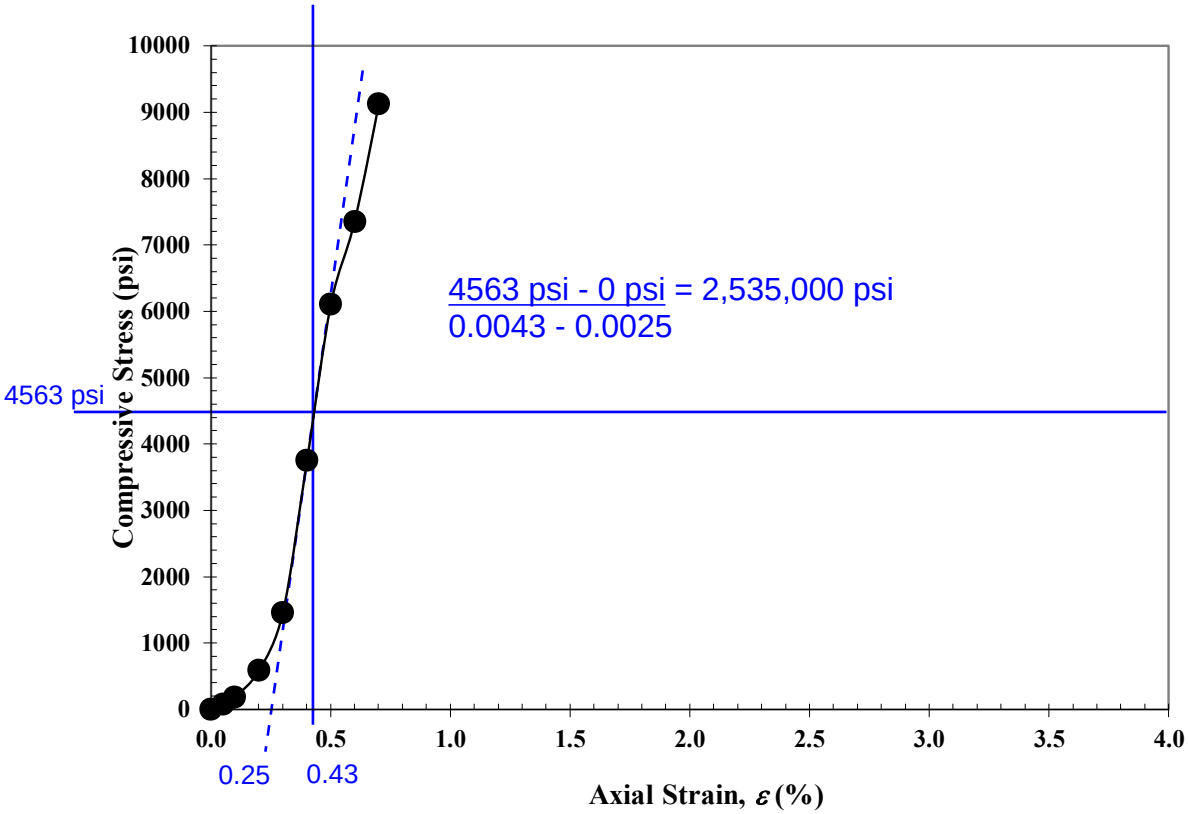
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.39
Length to Diameter Ratio:	2.22
Area, A (in^2):	3.08
Volume, V (in^3):	13.54
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	4.9
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	157.5
Dry Unit Weight, γ_d (lb/ft^3):	150.2

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **9125** **63** (MPa)

Strain (%): **0.7**



Notes: Sandstone, gray, slightly weathered, fine to medium grained, 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
National Engineering & Architectural Services Inc.

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

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

(Project: ADA-41-31.38, Boring Location: B-004-1-25, NQ2-1, Depth: 13.5-13.9ft)

Tested Date: 4/28/2025

Specimen Properties

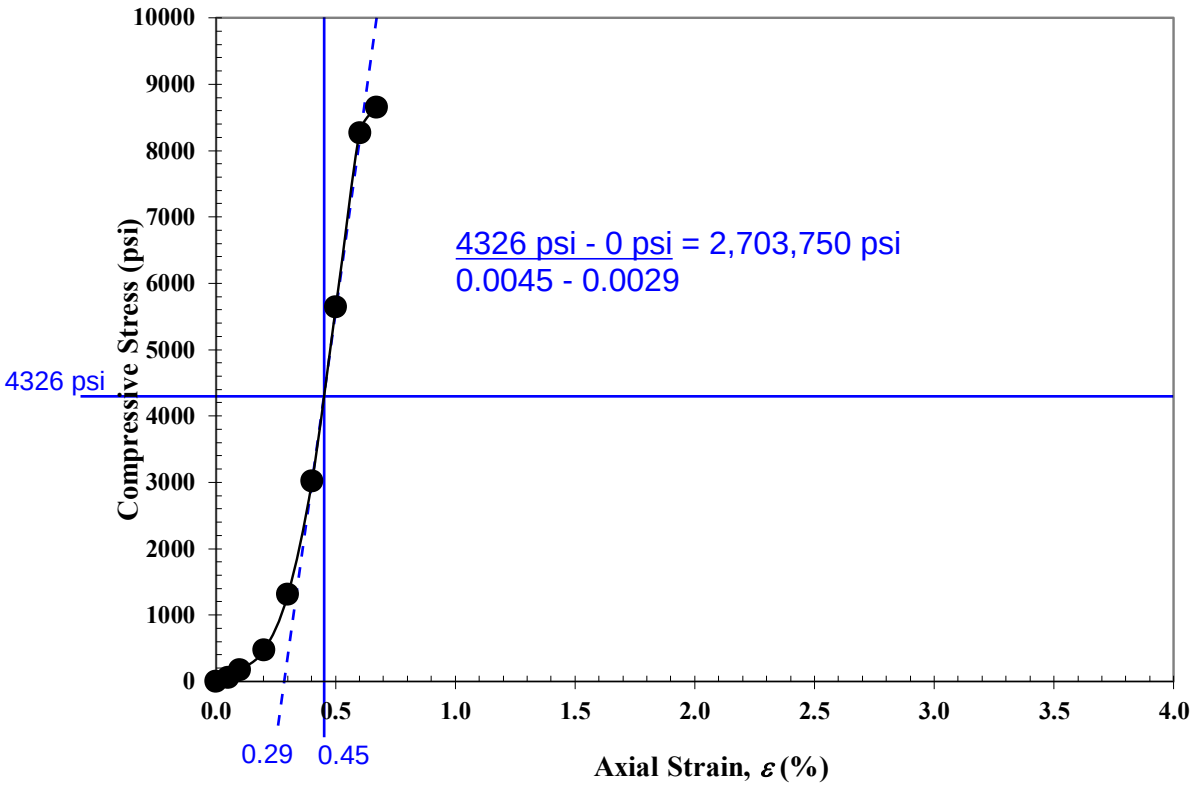
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.18
Length to Diameter Ratio:	2.11
Area, A (in^2):	3.08
Volume, V (in^3):	12.89
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	2.6
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	164.6
Dry Unit Weight, γ_d (lb/ft^3):	160.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **8651** **60** (MPa)

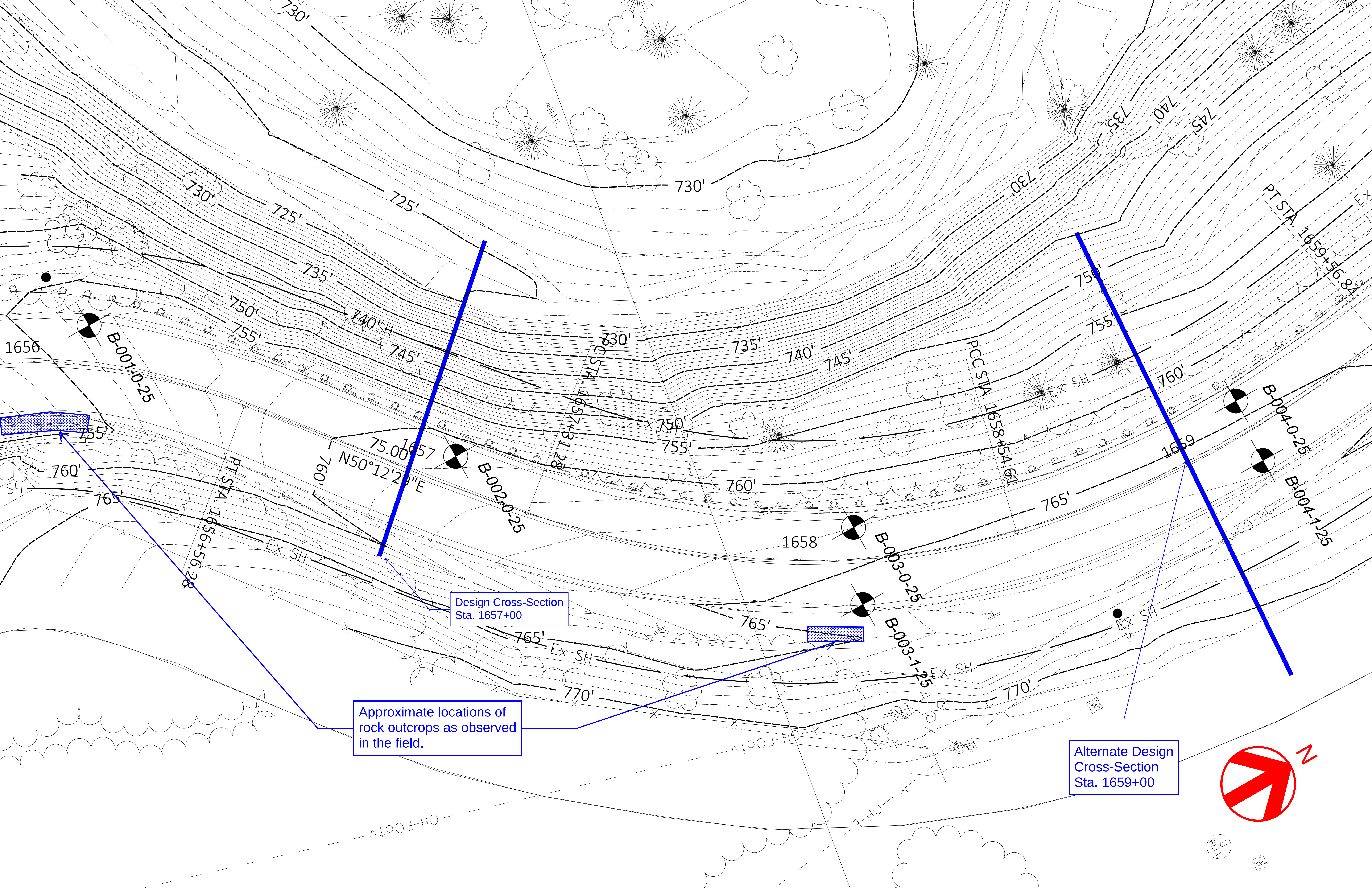
Strain (%): **0.7**



Notes: Sandstone, gray, slightly weathered, fine grained, 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.

Slope Stability Analyses



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Approximate locations of rock outcrops as observed in the field.
Alternate Design Cross-Section
Sta. 1659+00
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B-002-0-25
B-003-0-25
B-003-1-25
B-004-0-25
B-004-1-25
PT STA. 1656+56.28
PC STA. 1657+31.28
PCC STA. 1658+54.61
PT STA. 1659+56.84
N50°12'29"E
75.00'
1656
1657
1658
1659
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730'
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740'
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755'
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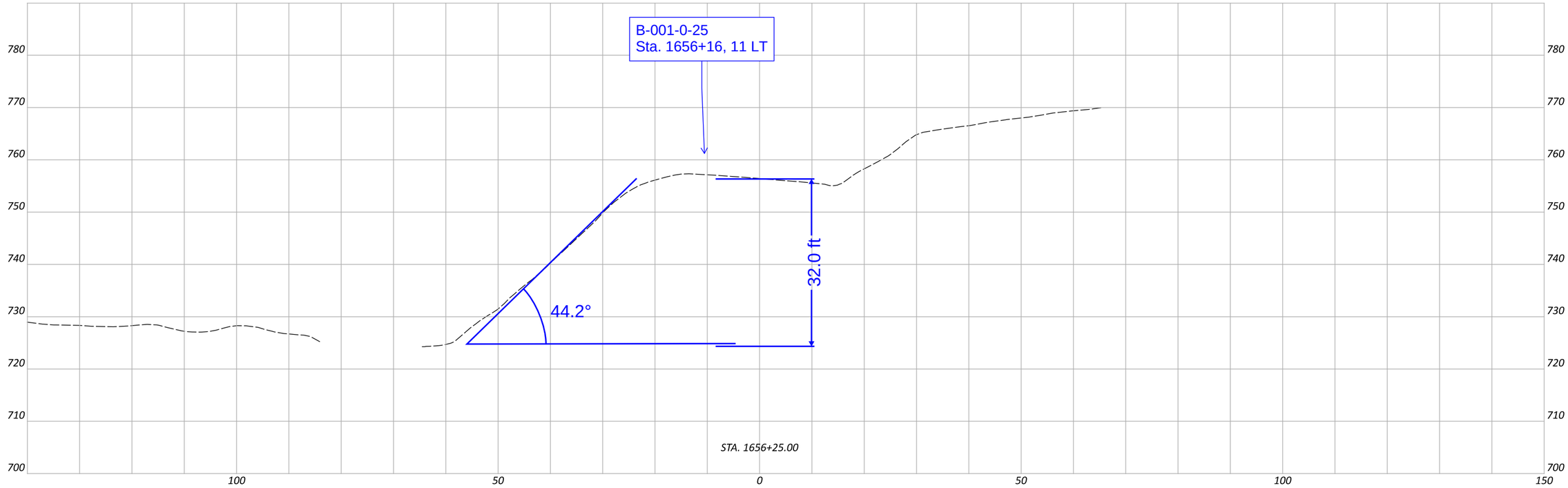
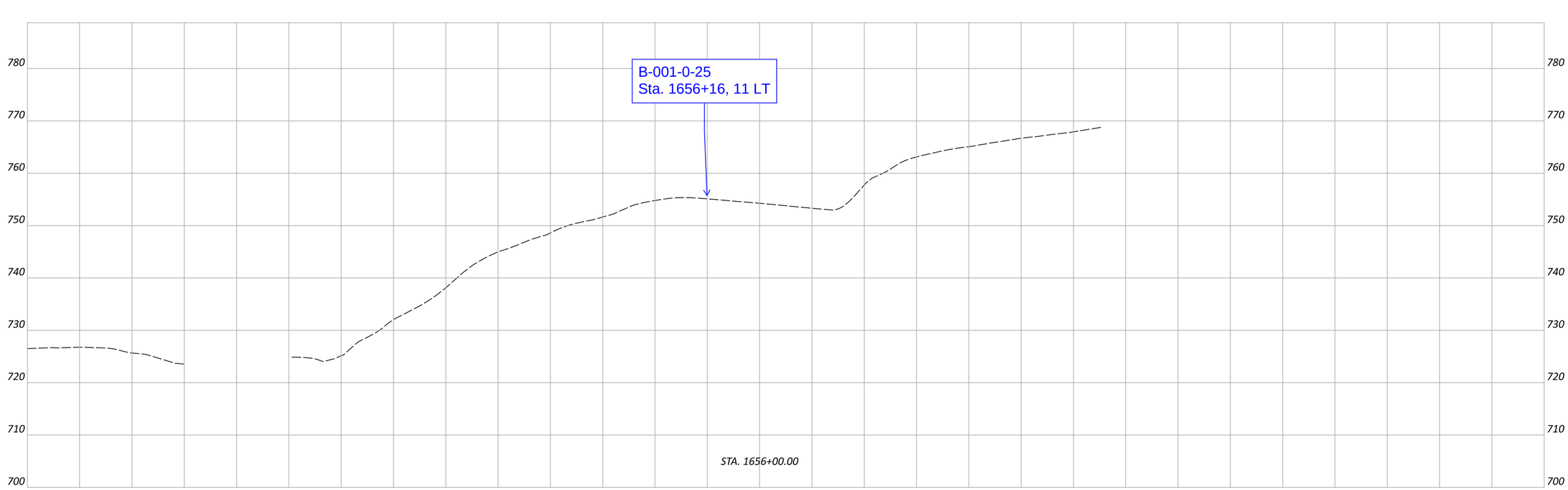
770'
Ex SH

FOR REFERENCE





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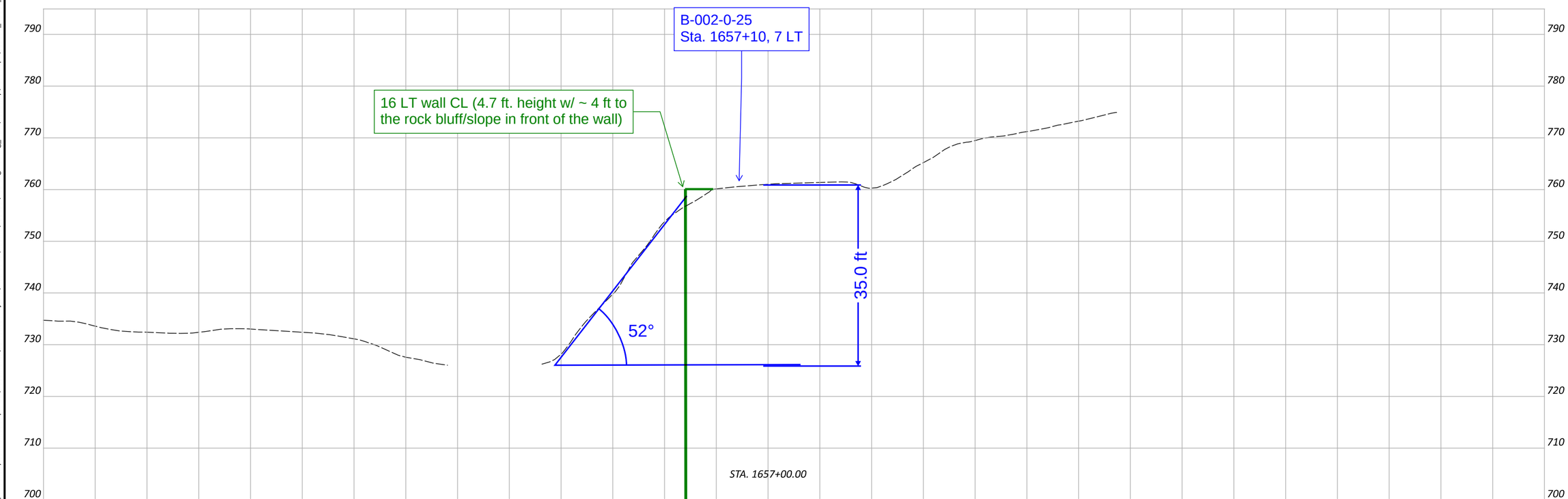

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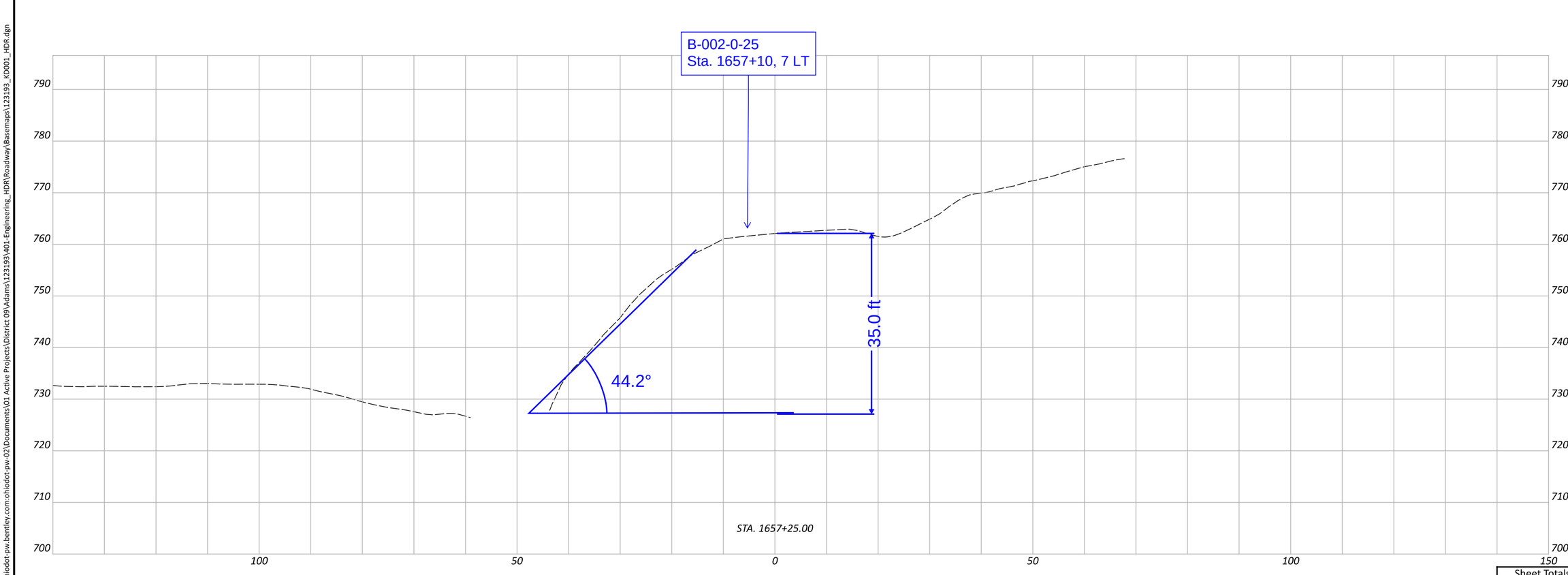

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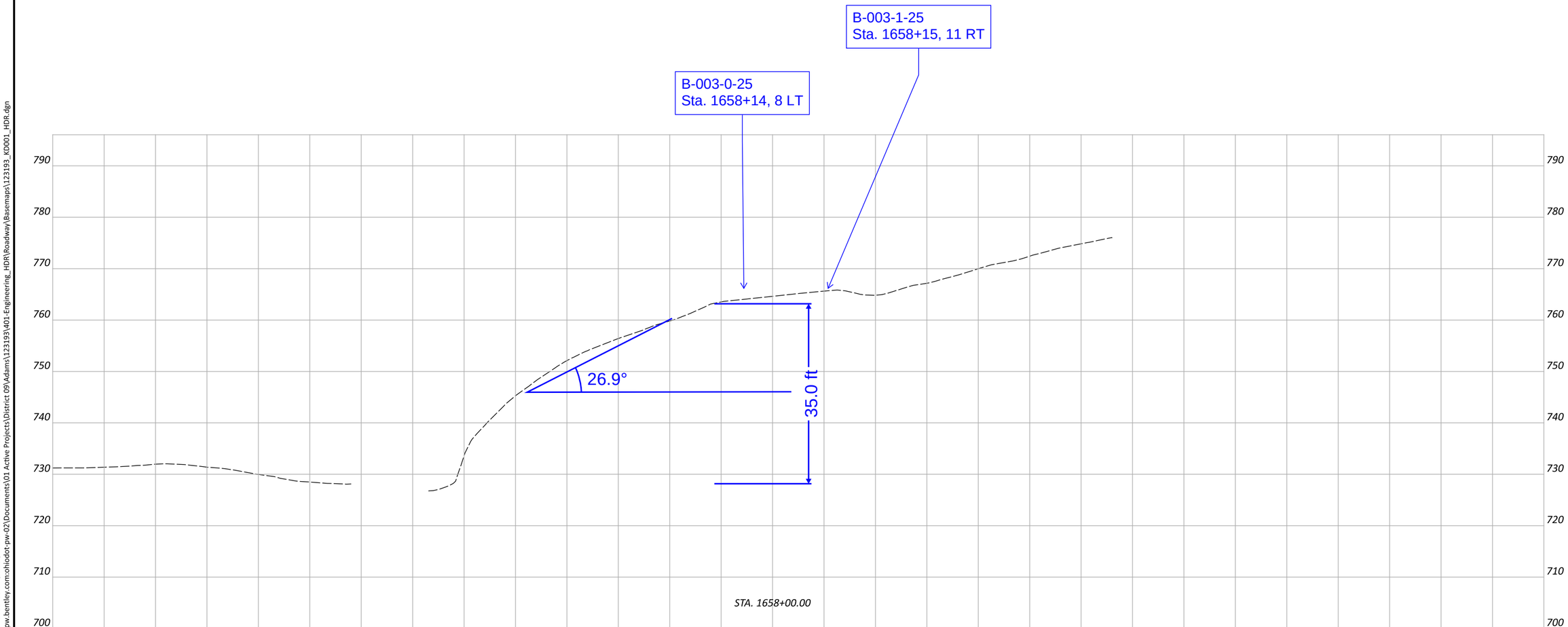

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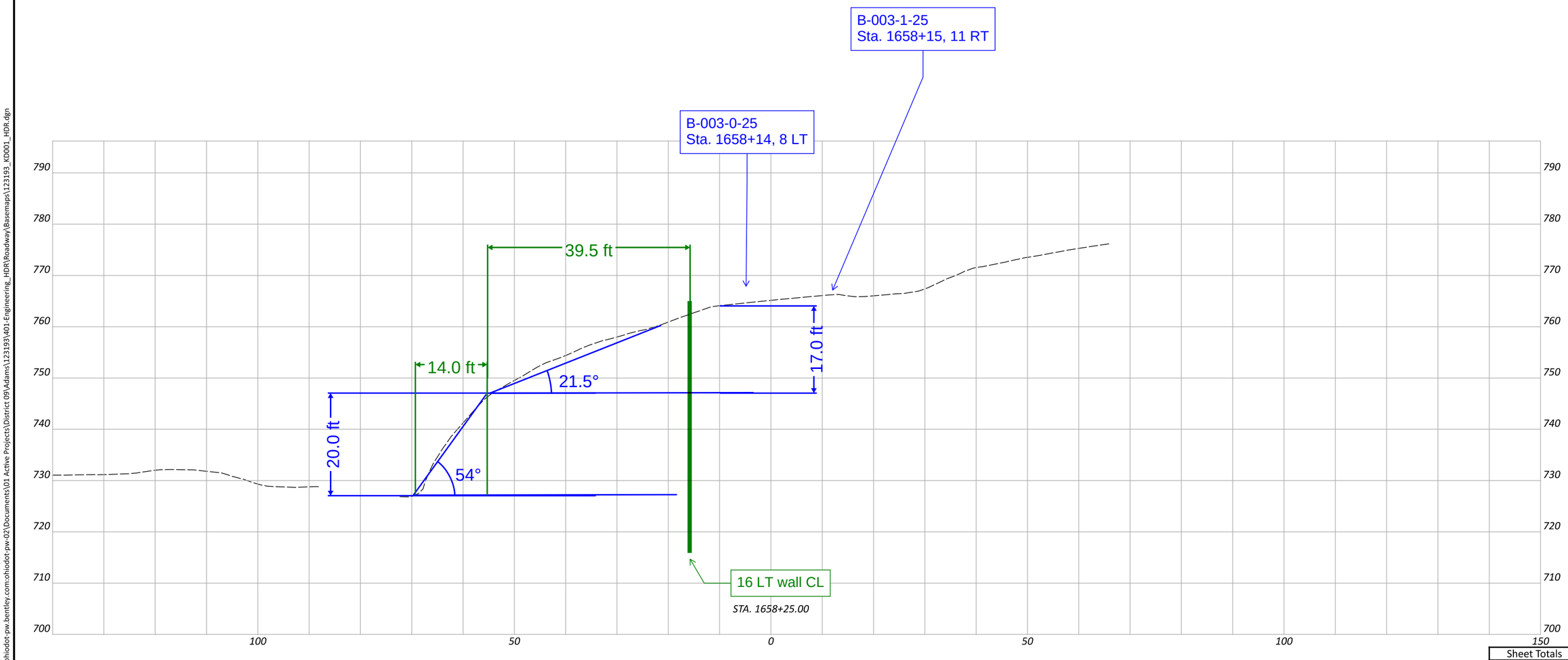

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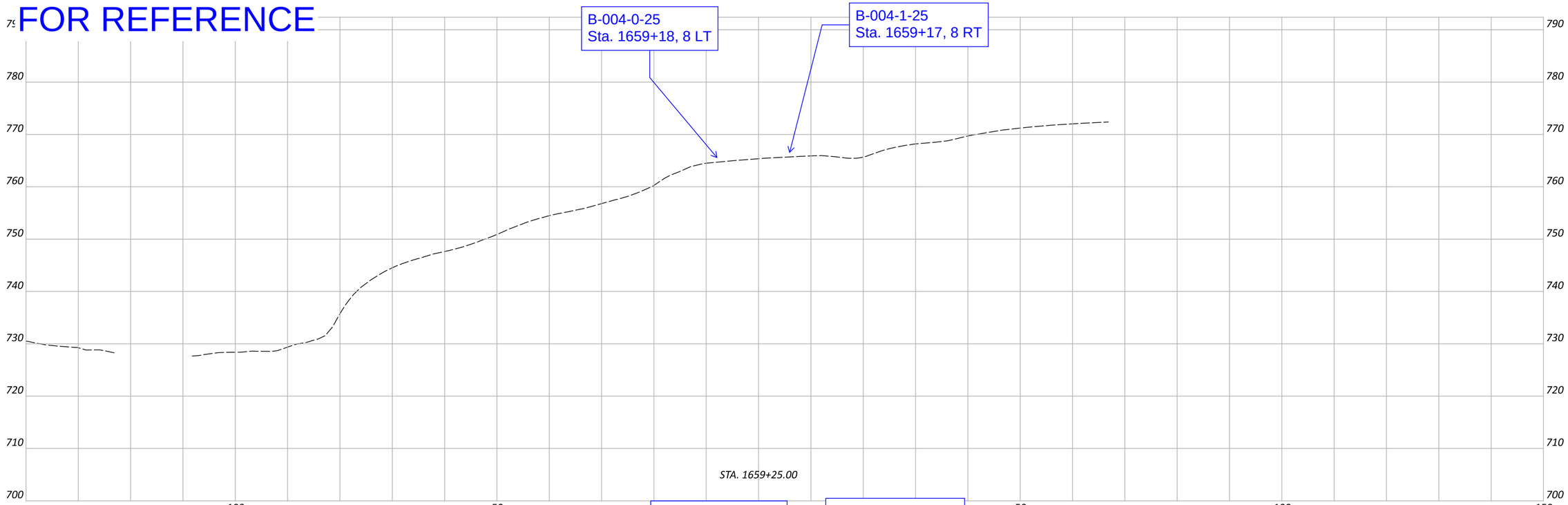

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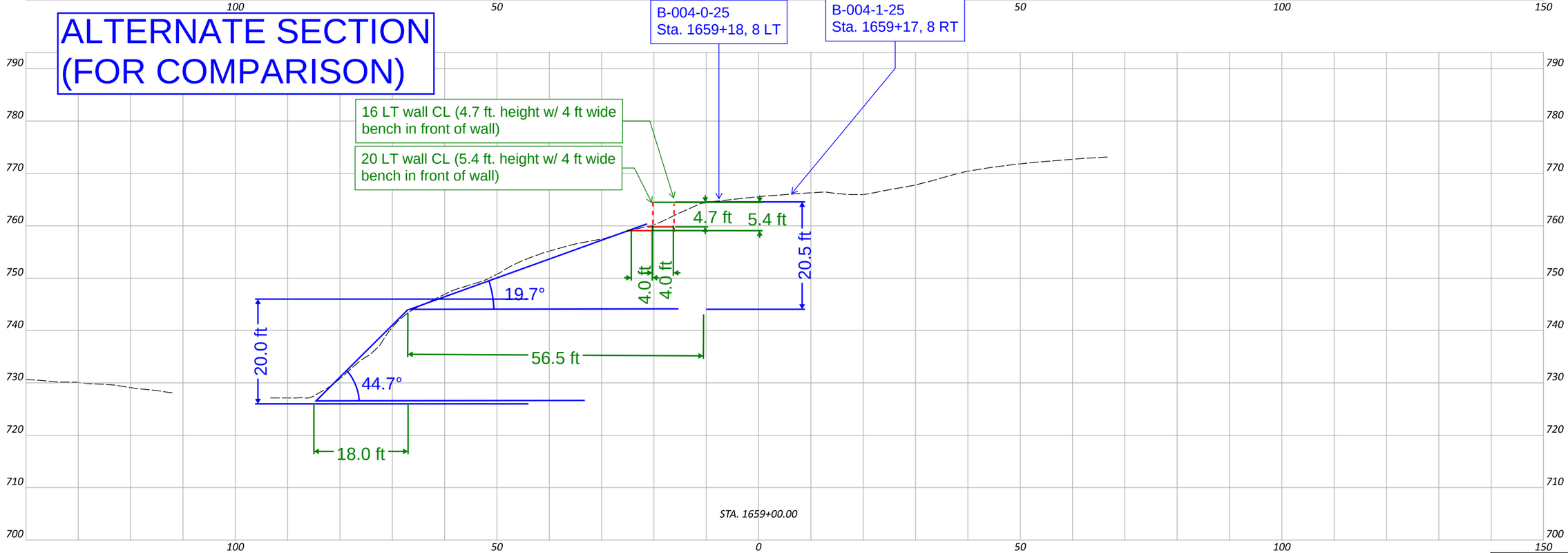

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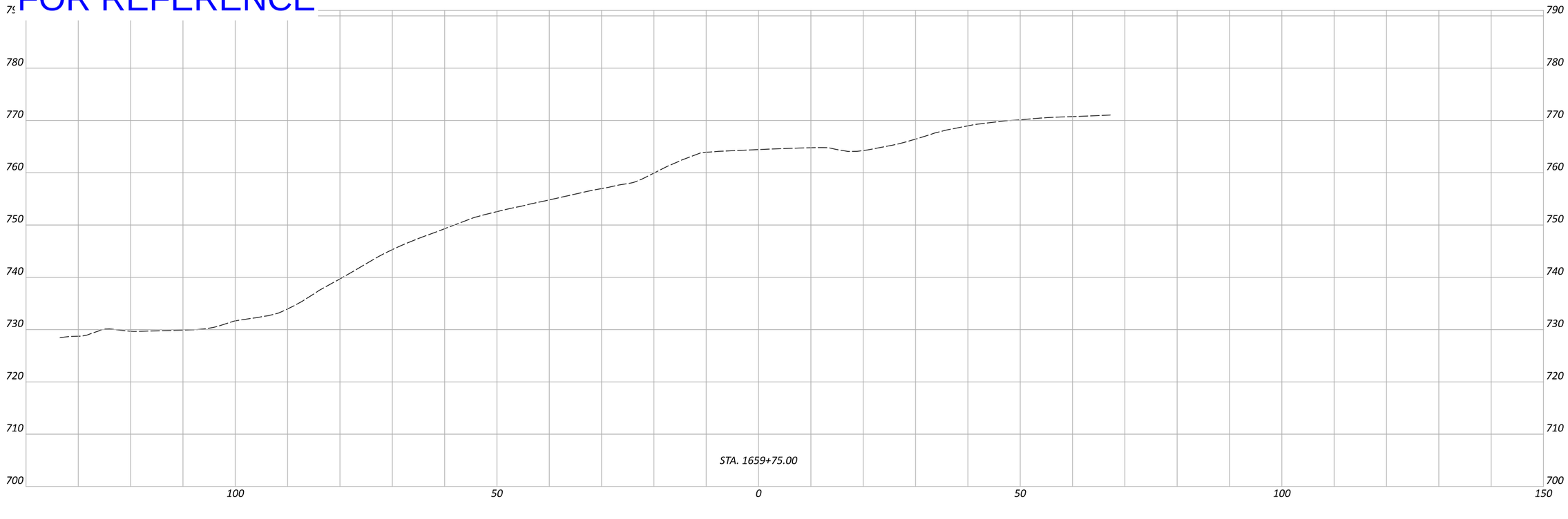

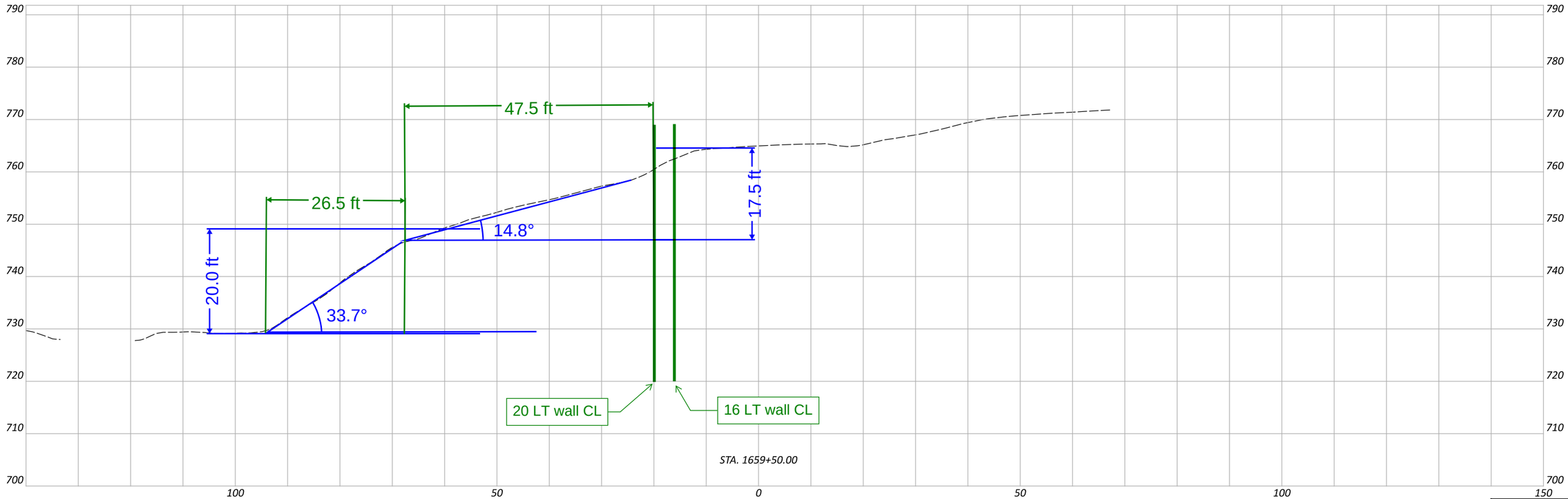

ADA-41-31.38

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pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 09\Adams\123193\401-Engineering_HDR\Roadway\Basemaps\123193_KD001_HDR.dgn

ADA-41-31.38
CROSS SECTIONS

Sheet Totals		
Seeding	Cut	Fill

DESIGN AGENCY

DESIGNER XXX

REVIEWER XXX MM-DD-YY

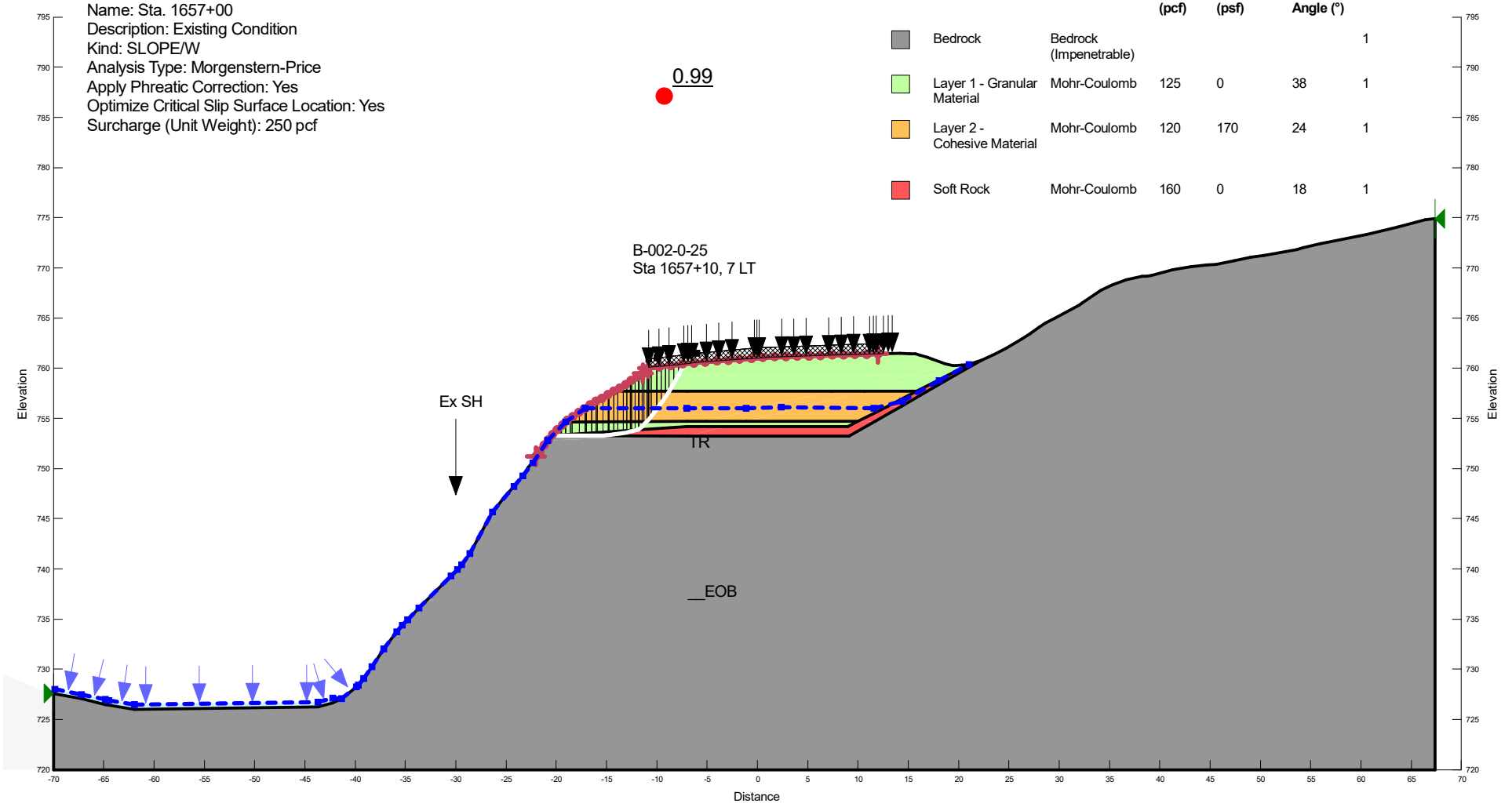
PROJECT ID 0

SHEET P.0 | TOTAL 0

Station 1657+00 (Design Section)
Existing Conditions

Title: ADA-41-31.38
Name: Sta. 1657+00
Description: Existing Condition
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock	Mohr-Coulomb	160	0	18	1

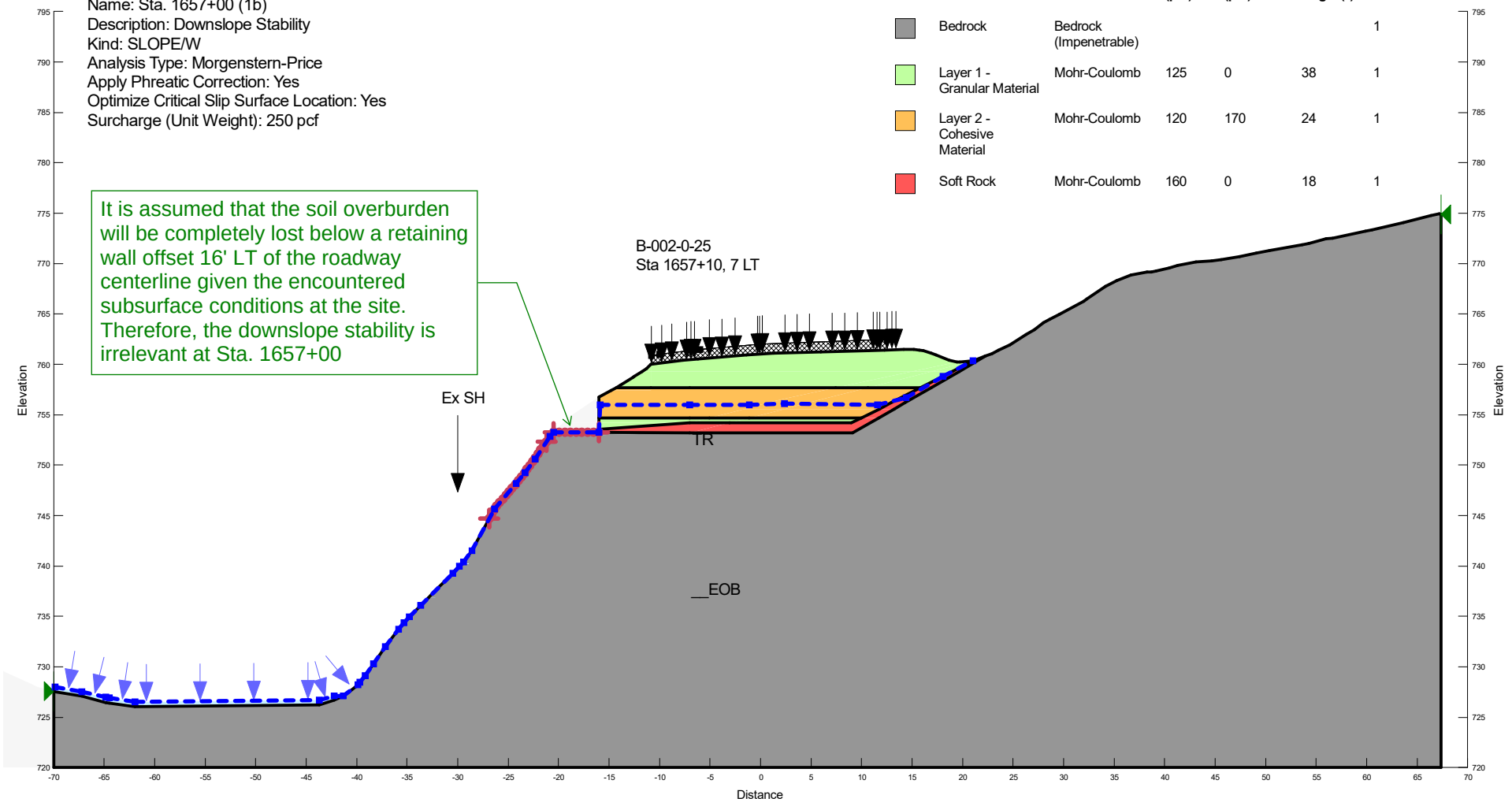


Station 1657+00 (Design Section)
Downslope Stability

Title: ADA-41-31.38
Name: Sta. 1657+00 (1b)
Description: Downslope Stability
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock	Mohr-Coulomb	160	0	18	1

It is assumed that the soil overburden will be completely lost below a retaining wall offset 16' LT of the roadway centerline given the encountered subsurface conditions at the site. Therefore, the downslope stability is irrelevant at Sta. 1657+00

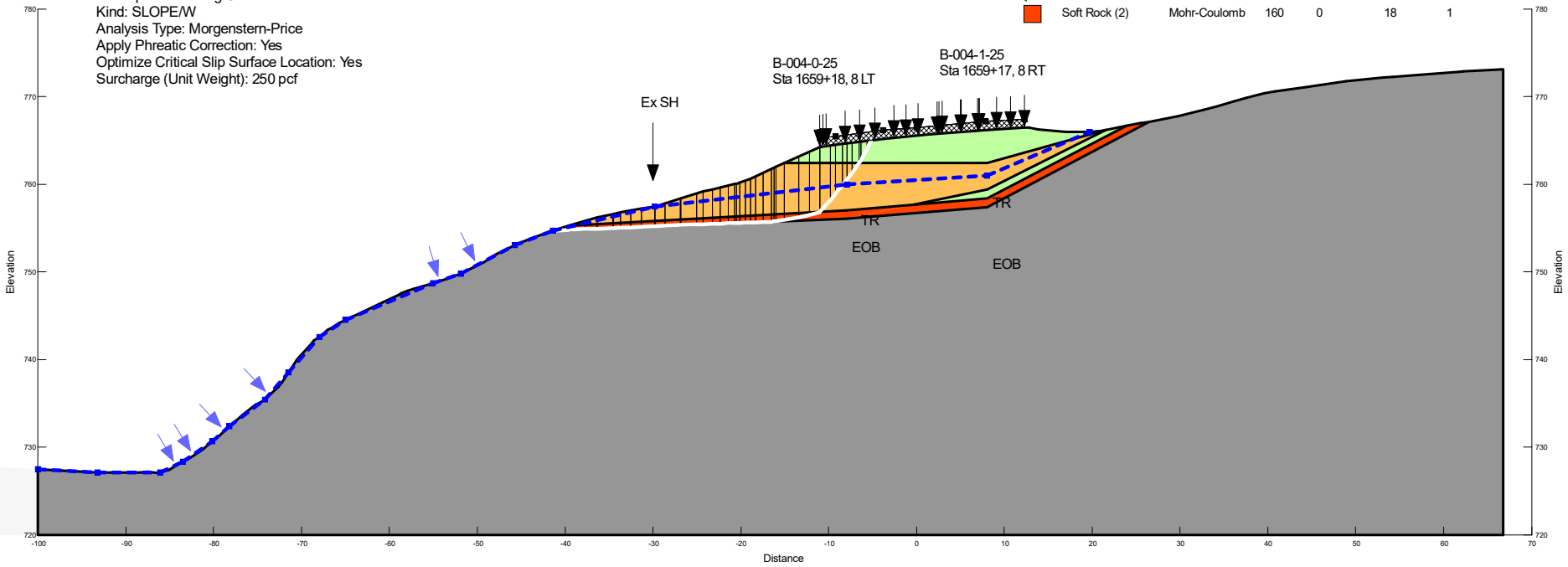


Station 1659+00 (Alternate Section)
Existing Conditions

Assume similar soil parameters for the soft rock as at Sta 1657+00 (Design Section)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock (2)	Mohr-Coulomb	160	0	18	1

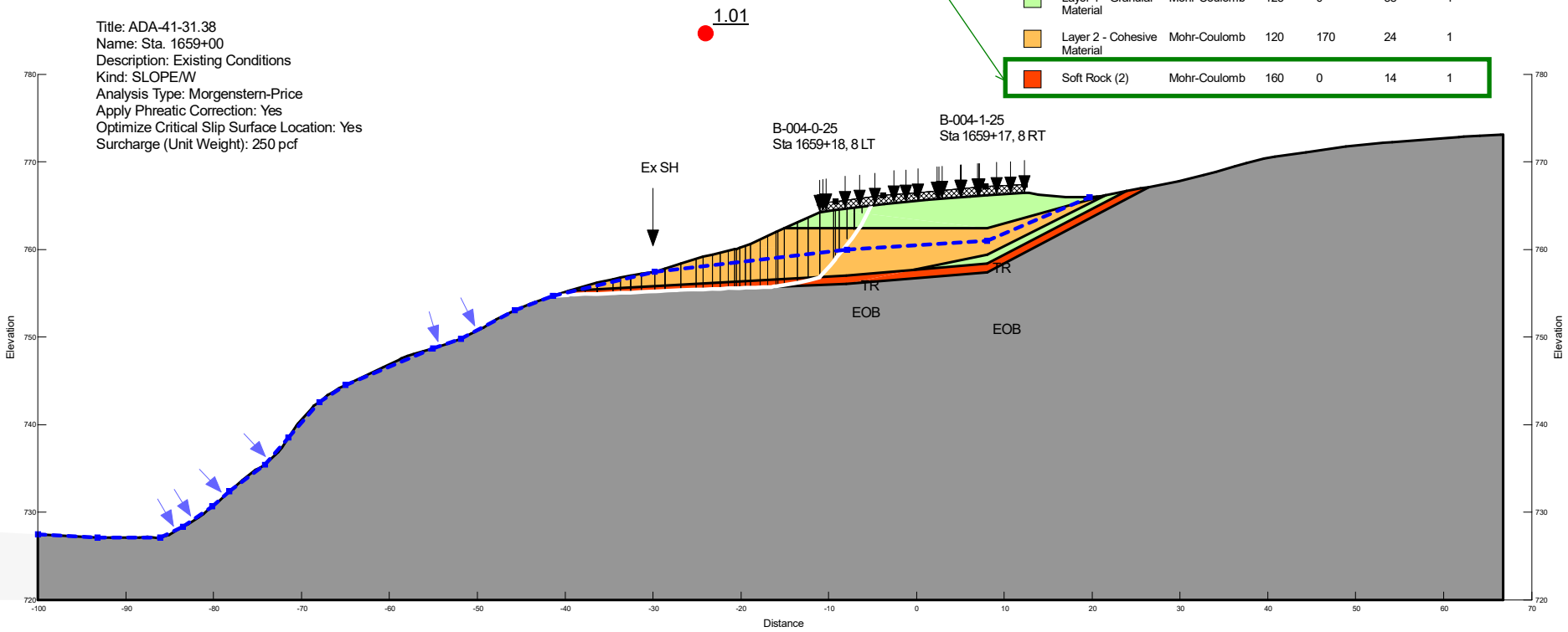
Title: ADA-41-31.38
Name: Sta. 1659+00
Description: Existing Conditions
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf



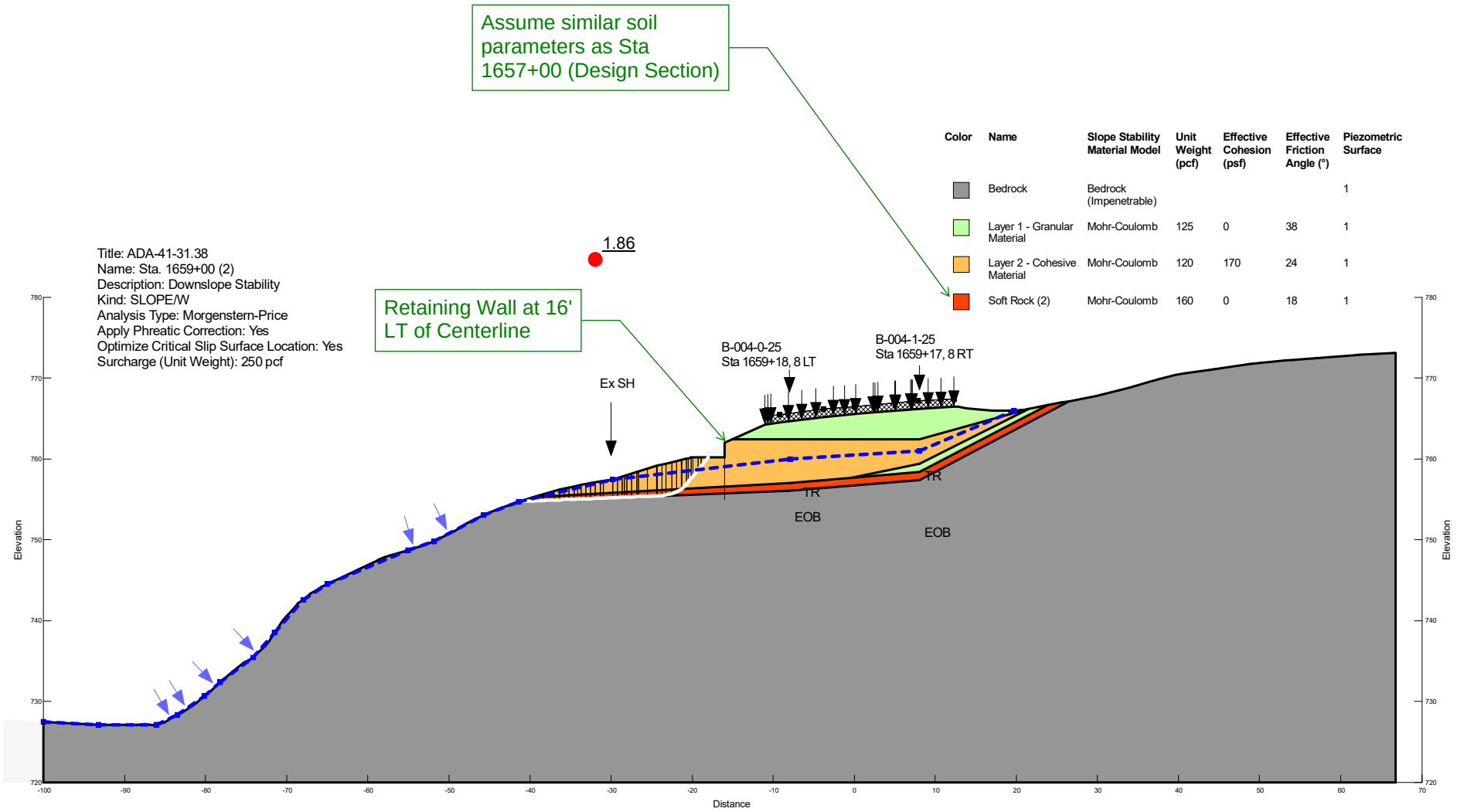
Reduced "Soft Rock" to create failure surface near FS of 1.0. for the existing condition.

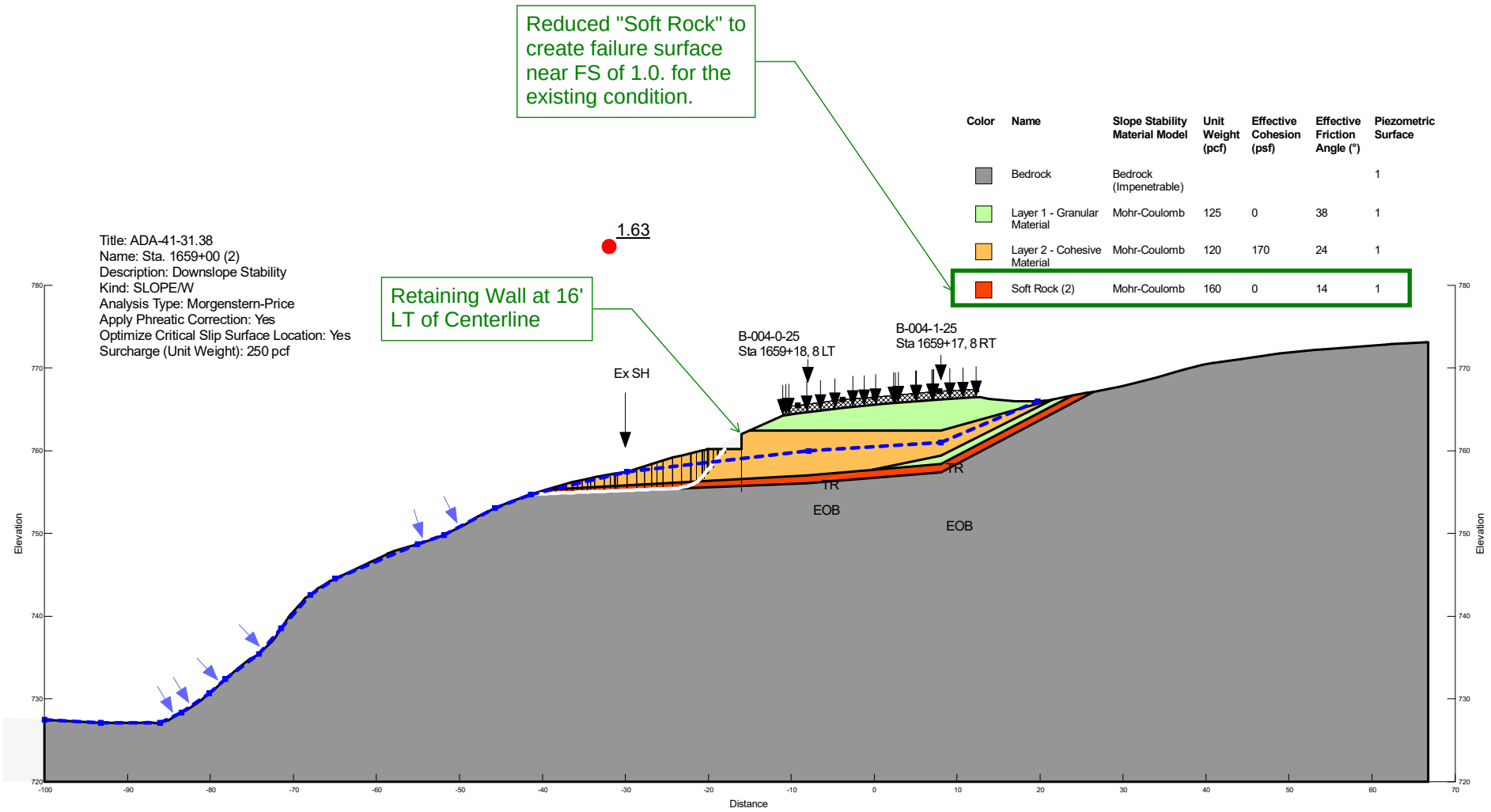
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock (2)	Mohr-Coulomb	160	0	14	1

Title: ADA-41-31.38
Name: Sta. 1659+00
Description: Existing Conditions
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf



Station 1659+00 (Alternate Section)
Downslope Stability


Assume similar soil parameters as Sta 1657+00 (Design Section)
Color
Name
Slope Stability Material Model
Unit Weight (pcf)
Effective Cohesion (psf)
Effective Friction Angle (°)
Piezometric Surface
Bedrock
Bedrock (Impenetrable)
1
Layer 1 - Granular Material
Mohr-Coulomb
125
0
38
1
Layer 2 - Cohesive Material
Mohr-Coulomb
120
170
24
1
Soft Rock (2)
Mohr-Coulomb
160
0
18
1
1.86
Title: ADA-41-31.38
Name: Sta. 1659+00 (2)
Description: Downslope Stability
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf
Retaining Wall at 16' LT of Centerline
Ex SH
B-004-0-25
Sta 1659+18, 8 LT
B-004-1-25
Sta 1659+17, 8 RT
TR
EOB
TR
EOB
Elevation
Distance

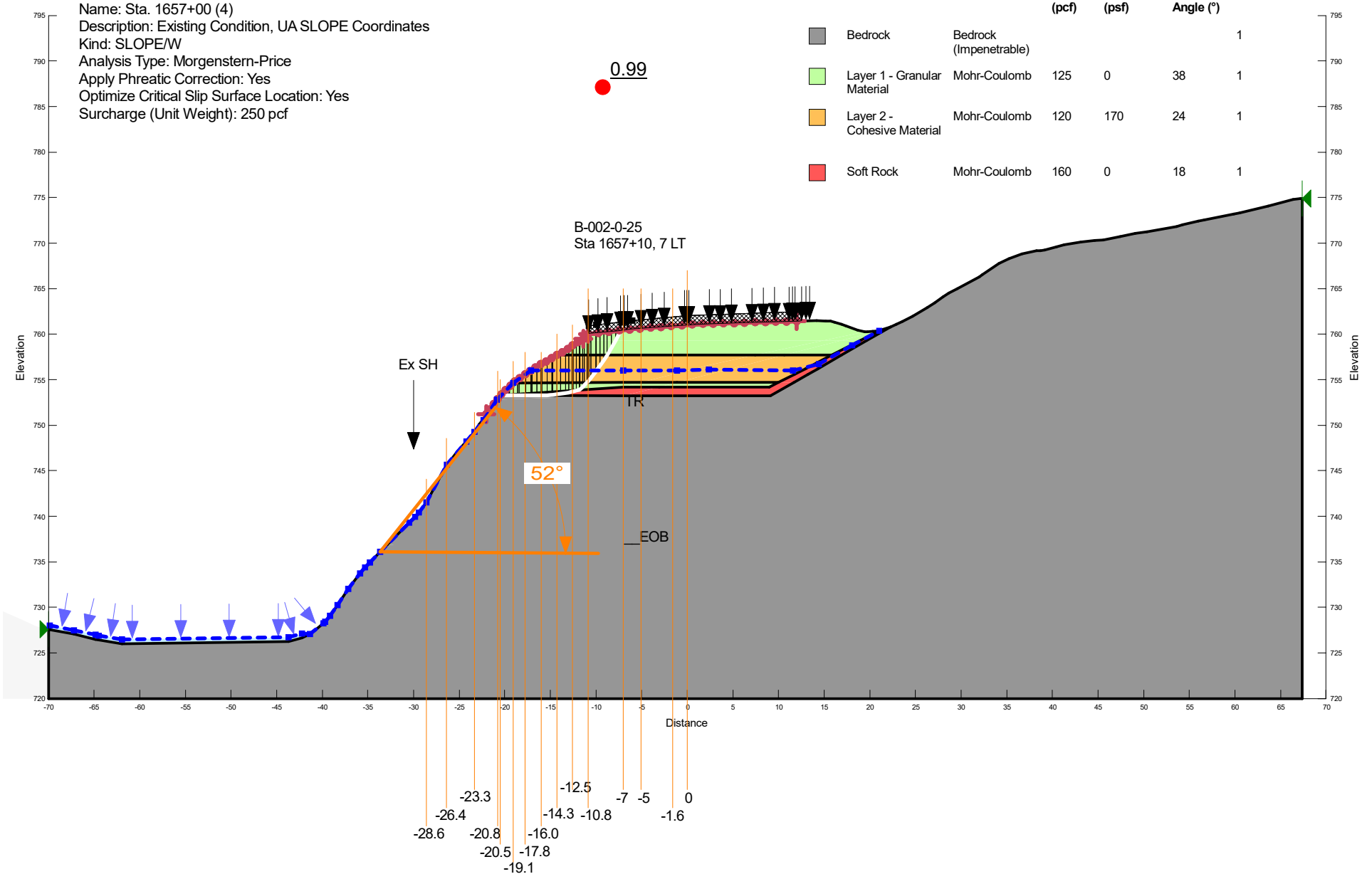

Reduced "Soft Rock" to create failure surface near FS of 1.0. for the existing condition.
Color | Name | Slope Stability Material Model | Unit Weight (pcf) | Effective Cohesion (psf) | Effective Friction Angle (°) | Piezometric Surface
Bedrock | Bedrock (Impenetrable) | | | | 1
Layer 1 - Granular Material | Mohr-Coulomb | 125 | 0 | 38 | 1
Layer 2 - Cohesive Material | Mohr-Coulomb | 120 | 170 | 24 | 1
Soft Rock (2) | Mohr-Coulomb | 160 | 0 | 14 | 1
1.63
Title: ADA-41-31.38
Name: Sta. 1659+00 (2)
Description: Downslope Stability
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf
Retaining Wall at 16' LT of Centerline
Ex SH
B-004-0-25
Sta 1659+18, 8 LT
B-004-1-25
Sta 1659+17, 8 RT
TR
EOB
TR
EOB
Elevation
Distance

UA Slope Analyses

Station 1657+00 (Design Section)
Existing Conditions

Title: ADA-41-31.38
Name: Sta. 1657+00 (4)
Description: Existing Condition, UA SLOPE Coordinates
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock	Mohr-Coulomb	160	0	18	1



UA Slope Program Version 2.3 - J:\ODOT-D9 GES\Task 2_ADA-41-31.38\20250715_ADA-41-31.38_UA Slope Analysis.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 0.99

Force per Shaft: 0.000 lb

Acting Point X: 16.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

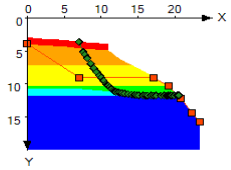
Number of Vertical Sections and Soil Layers

Vertical Section Num: 15 Soil Layer Num: 6

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

		Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Traffic Surcharge	Layer1	0.1	0.0	250.0
Layer 1 - Granular	Layer2	0.0	38.0	125.0
Layer 2 - Cohesive	Layer3	170.0	24.0	120.0
Layer 1 - Granular	Layer4	0.0	38.0	125.0
"Soft Rock"	Layer5	0.0	16.0	160.0
Sandstone	Layer6	4000.0	45.0	160.0

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

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14
X (ft)	0.00	1.60	5.00	7.00	11.00	11.00	12.50	14.30	16.00	16.00	17.80	19.10	20.50	20.80
Y1 (ft)	2.90	3.10	3.30	3.60	3.90	4.90	6.20	7.20	8.20	8.20	9.40	10.30	11.70	12.10
Y2 (ft)	3.90	4.10	4.30	4.60	4.90	4.90	6.20	7.20	8.20	8.20	9.40	10.30	11.70	12.10
Y3 (ft)	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	8.20	8.20	9.40	10.30	11.70	12.10
Y4 (ft)	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	11.70	12.10
Y5 (ft)	10.70	10.70	10.70	10.70	11.10	11.10	11.20	11.30	11.40	11.40	11.50	11.60	11.70	12.10
Y6 (ft)	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	12.10
Y7 (ft)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Coordinates of Crest X: 11.00 ft Y: 4.10 ft Coordinates of Toe X: 23.30 ft Y: 16.00 ft

Drilled Shaft Information

(•) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

( ) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 50000.0 lb

Anchor angle: 30.00

Anchor spacing: 8.00 ft

Auto ( ) On (•) Off 0.936 (η)

[ ] Auto Save Data

Xmin -40.00 Diameter: 2.00 ft

Xmax 20.00 CTC Spacing: 5.00 ft

XDelta 5.00 X Coordinate: 16.00 ft

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7
X (ft)	0.00	7.00	17.10	19.10	20.80	22.30	23.30
Y (ft)	3.90	9.00	9.00	10.30	12.20	14.40	15.70

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)	7.00	7.55	7.76	8.09	8.55	8.98	9.38	9.77	9.97	9.98	10.29	10.69	10.80	10.82	10.92	11.14	11.38	11.6
Y (ft)	3.60	5.15	5.52	6.10	6.91	7.60	8.16	8.72	9.00	9.02	9.44	9.97	10.11	10.13	10.23	10.45	10.70	10.9

Station 1657+00 (Design Section)
Post-Construction Conditions

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

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20250715_ADA-41-31.38_UA Slope Analysis_Proposed Wall.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 49.33

Force per Shaft: 8732.037 lb

Acting Point X: 16.000 ft Y: 9.483 ft

Analysis Unit System

(•) English ( ) Metric

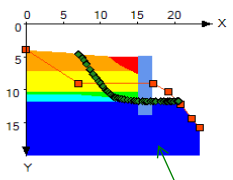
Number of Vertical Sections and Soil Layers

Vertical Section Num: 15 Soil Layer Num: 6

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

		Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Item 203 Fill	Layer1	200.0	26.0	120.0
Layer 1 - Granular	Layer2	0.0	38.0	125.0
Layer 2 - Cohesive	Layer3	170.0	24.0	120.0
Layer 1 - Granular	Layer4	0.0	38.0	125.0
"Soft Rock"	Layer5	0.0	16.0	160.0
Sandstone	Layer6	4000.0	45.0	160.0

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	Section 14
X (ft)	0.00	1.60	5.00	7.00	11.00	11.00	12.50	14.30	16.00	16.00	17.80	19.10	20.50	20.80
Y1 (ft)	3.90	4.10	4.30	4.60	4.90	4.90	4.90	4.90	4.90	11.70	11.70	11.70	11.70	12.10
Y2 (ft)	3.90	4.10	4.30	4.60	4.90	4.90	6.20	7.20	8.20	11.70	11.70	11.70	11.70	12.10
Y3 (ft)	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	8.20	11.70	11.70	11.70	11.70	12.10
Y4 (ft)	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	10.30	11.70	11.70	11.70	11.70	12.10
Y5 (ft)	10.70	10.70	10.70	10.70	11.10	11.10	11.20	11.30	11.40	11.70	11.70	11.70	11.70	12.10
Y6 (ft)	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.70	11.70	11.70	11.70	12.10
Y7 (ft)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Coordinates of Crest X: 11.00 ft Y: 4.10 ft Coordinates of Toe X: 23.30 ft Y: 16.00 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 0.186 (η)

[ ] Auto Save Data

Xmin 0.00 Diameter: 2.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 16.00 ft

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7
X (ft)	0.00	7.00	17.10	19.10	20.80	22.30	23.30
Y (ft)	3.90	9.00	9.00	10.30	12.20	14.40	15.70

Slip Surface

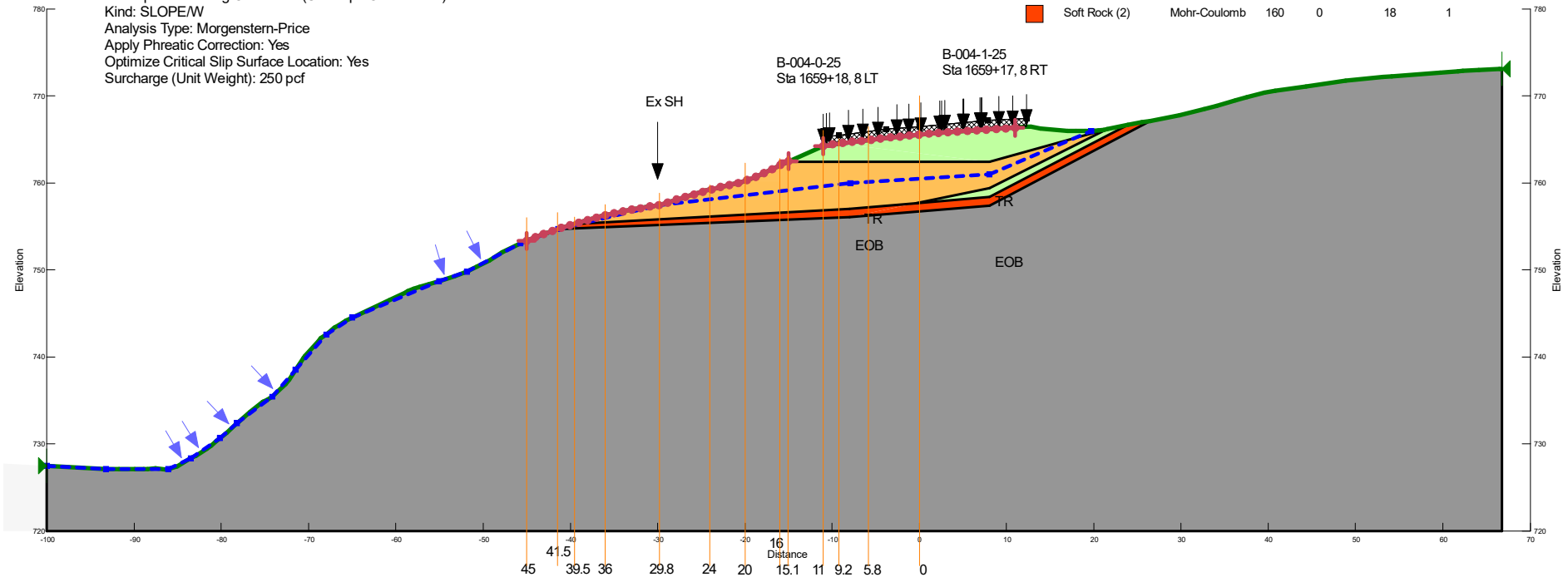
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Po
X (ft)	7.00	7.55	7.76	8.09	8.55	8.98	9.38	9.77	9.97	9.98	10.29	10.69	10.80	10.82	10.92	11.14	11.38	11.6
Y (ft)	4.60	5.15	5.52	6.10	6.91	7.60	8.16	8.72	9.00	9.02	9.44	9.97	10.11	10.13	10.23	10.45	10.70	10.9

Wall CL placed at 16 LT of CL

Station 1659+00 (Alternate Section)
Existing Conditions

Title: ADA-41-31.38
Name: Sta. 1659+00 (3)
Description: Existing Conditions (UA Slope Coordinates)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Apply Phreatic Correction: Yes
Optimize Critical Slip Surface Location: Yes
Surcharge (Unit Weight): 250 pcf

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	Layer 1 - Granular Material	Mohr-Coulomb	125	0	38	1
	Layer 2 - Cohesive Material	Mohr-Coulomb	120	170	24	1
	Soft Rock (2)	Mohr-Coulomb	160	0	18	1



Existing Condition

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20250721_ADA-41-31.38_UA Slope Analysis_Sta 1659_Existing Conditions.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.01

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: 17 Soil Layer Num: 5

Analysis Method

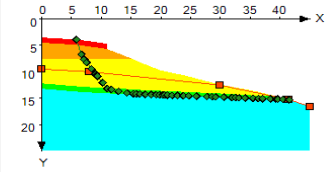
( ) Total Stress (•) Effective Stress

Soil Properties

		Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Traffic Surcharge	Layer1	0.1	0.0	250.0
Layer 1 - Granular	Layer2	0.0	38.0	125.0
Layer 2 - Cohesive	Layer3	170.0	21.0	120.0
"Soft Rock"	Layer4	0.0	14.0	160.0
Sandstone	Layer5	4000.0	45.0	160.0

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 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14	Section 1
X (ft)	5.80	9.20	11.00	11.00	15.10	16.00	16.00	20.00	20.00	24.00	24.00	29.80	36.00	39.50
Y1 (ft)	3.90	4.40	4.70	5.70	7.50	8.00	8.00	9.75	9.75	10.70	10.70	12.40	13.70	14.70
Y2 (ft)	4.90	5.40	5.70	5.70	7.50	8.00	8.00	9.75	9.75	10.70	10.70	12.40	13.70	14.70
Y3 (ft)	7.50	7.50	7.50	7.50	7.50	8.00	8.00	9.75	9.75	10.70	10.70	12.40	13.70	14.70
Y4 (ft)	12.75	13.00	13.10	13.10	13.30	13.40	13.40	13.60	13.60	13.80	13.80	14.10	14.50	14.70
Y5 (ft)	13.75	14.00	14.10	14.10	14.20	14.30	14.30	14.50	14.50	14.60	14.60	14.90	15.10	15.30
Y6 (ft)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Coordinates of Crest X: 5.70 ft Y: 5.70 ft Coordinates of Toe X: 41.00 ft Y: 15.20 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)

[ ] Auto Save Data

Xmin 0.00 Diameter: 0.30 ft

Xmax 0.00 CTC Spacing: 0.00 ft

XDelta 0.00 X Coordinate: 0.00 ft

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	0.00	7.90	29.79	41.44	45.00
Y (ft)	9.50	10.00	12.52	15.25	16.60

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)	5.80	6.64	7.11	7.52	8.36	9.01	9.22	9.35	10.23	11.00	11.01	11.03	11.66	12.92	14.32	15.42	15.88	16.4
Y (ft)	3.90	6.70	7.63	8.24	9.45	10.38	10.69	10.87	12.09	13.16	13.17	13.18	13.35	13.70	13.99	14.16	14.22	14.2

Station 1659+00 (Alternate Section)
Post-Construction Conditions

As the slope geometries transition to gentler and wider slopes upstation of the design section, the wall alignments also may transition accordingly. As such, multiple wall offsets (16' LT, 20' LT, 24' LT) were analyzed at Sta. 1659+00 to compare the wall loading at this location to that generated at the design section (Sta. 1657+00).

The loading generated at these locations were all less that that generated at the design section (8732 lb/shaft).

The calculated force per shaft is lower than that at Sta. 1657+00 (8732 lbs/shaft)

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

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20250721_ADA-41-31.38_UA Slope Analysis_Sta 1659_Proposed Conditions.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.65

Force per Shaft: 5523.141 lb

Acting Point X: 16.000 ft Y: 11.411 ft

Analysis Unit System

(•) English ( ) Metric

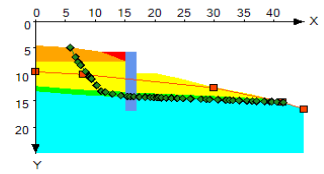
Number of Vertical Sections and Soil Layers

Vertical Section Num: 16 Soil Layer Num: 5

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Item 203 Fill — Layer1	200.0	26.0	120.0
Layer 1 - Granular — Layer2	0.0	38.0	125.0
Layer 2 - Cohesive — Layer3	170.0	21.0	120.0
"Soft Rock" — Layer4	0.0	14.0	160.0
Sandstone — Layer5	4000.0	45.0	160.0

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

	ction 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14	Section 15	Section 16
X (ft)	0	11.00	15.10	16.00	16.00	20.00	20.00	24.00	24.00	29.80	36.00	39.50	41.50	45.00
Y1 (ft)	0	5.70	5.70	5.70	9.75	9.75	9.75	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y2 (ft)	0	5.70	7.50	8.00	9.75	9.75	9.75	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y3 (ft)	0	7.50	7.50	8.00	9.75	9.75	9.75	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y4 (ft)	00	13.10	13.30	13.40	13.40	13.60	13.60	13.80	13.80	14.10	14.50	14.70	15.30	16.60
Y5 (ft)	00	14.10	14.20	14.30	14.30	14.50	14.50	14.60	14.60	14.90	15.10	15.30	15.30	16.60
Y6 (ft)	00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Coordinates of Crest X: 5.70 ft Y: 5.70 ft Coordinates of Toe X: 41.00 ft Y: 15.20 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 0.338 (n)

[ ] Auto Save Data

Xmin 0.00 Diameter: 2.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 16.00 ft

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	0.00	7.90	29.79	41.44	45.00
Y (ft)	9.50	10.00	12.52	15.25	16.60

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)	5.80	6.64	7.11	7.52	8.36	9.01	9.22	9.35	10.23	11.00	11.01	11.03	11.66	12.92	14.32	15.42	15.88	16.4
Y (ft)	4.90	6.70	7.63	8.24	9.45	10.38	10.69	10.87	12.09	13.16	13.17	13.18	13.35	13.70	13.99	14.16	14.22	14.2

Proposed Wall CL offset. 16 LT

The calculated force per shaft is lower than that at Sta. 1657+00 (8732 lbs/shaft)

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

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20250721_ADA-41-31.38_UA Slope Analysis_Sta 1659_Proposed Conditions.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.69

Force per Shaft: 4661.542 lb

Acting Point X: 20.000 ft Y: 11.521 ft

Analysis Unit System

(•) English ( ) Metric

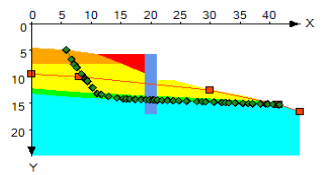
Number of Vertical Sections and Soil Layers

Vertical Section Num: 16 Soil Layer Num: 5

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Item 203 Fill / Layer1	200.0	26.0	120.0
Layer 1 - Granular / Layer2	0.0	38.0	125.0
Layer 2 - Cohesive / Layer3	170.0	21.0	120.0
"Soft Rock" / Layer4	0.0	14.0	160.0
Sandstone / Layer5	4000.0	45.0	160.0

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 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14	Section 15	Section 16
X (ft)	0	11.00	15.10	16.00	16.00	20.00	20.00	24.00	24.00	29.80	36.00	39.50	41.50	45.00
Y1 (ft)	0	5.70	5.70	5.70	5.70	5.70	10.70	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y2 (ft)	0	5.70	7.50	8.00	8.00	9.75	10.70	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y3 (ft)	0	7.50	7.50	8.00	8.00	9.75	10.70	10.70	10.70	12.40	13.70	14.70	15.30	16.60
Y4 (ft)	00	13.10	13.30	13.40	13.40	13.60	13.60	13.80	13.80	14.10	14.50	14.70	15.30	16.60
Y5 (ft)	00	14.10	14.20	14.30	14.30	14.50	14.50	14.60	14.60	14.90	15.10	15.30	15.30	16.60
Y6 (ft)	00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Coordinates of Crest X: 5.70 ft Y: 5.70 ft Coordinates of Toe X: 41.00 ft Y: 15.20 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 0.287 (η)

Xmin 0.00 Diameter: 2.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 20.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	0.00	7.90	29.79	41.44	45.00
Y (ft)	9.50	10.00	12.52	15.25	16.60

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)	5.80	6.64	7.11	7.52	8.36	9.01	9.22	9.35	10.23	11.00	11.01	11.03	11.66	12.92	14.32	15.42	15.88	16.4
Y (ft)	4.90	6.70	7.63	8.24	9.45	10.38	10.69	10.87	12.09	13.16	13.17	13.18	13.35	13.70	13.99	14.16	14.22	14.2

Proposed Wall CL offset. 20 LT

The calculated force per shaft is lower than that at Sta. 1657+00 (8732 lbs/shaft)

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

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\20250721_ADA-41-31.38_UA Slope Analysis_Sta 1659_Proposed Conditions 24' Offset.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.57

Force per Shaft: 2796.955 lb

Acting Point X: 24.000 ft Y: 11.630 ft

Analysis Unit System

(•) English ( ) Metric

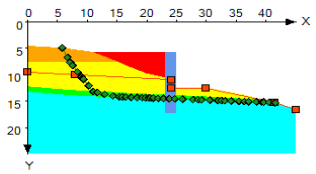
Number of Vertical Sections and Soil Layers

Vertical Section Num: 16 Soil Layer Num: 5

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Item 203 Fill ▸ Layer1	200.0	26.0	120.0
Layer 1 - Granular Layer2	0.0	38.0	125.0
Layer 2 - Cohesive Layer3	170.0	21.0	120.0
"Soft Rock" Layer4	0.0	14.0	160.0
Sandstone Layer5	4000.0	45.0	160.0

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	Section 14
X (ft)	0.00	5.80	9.20	11.00	15.10	16.00	16.00	20.00	20.00	24.00	24.00	29.80	36.00	39.50
Y1 (ft)	4.50	4.90	5.40	5.70	5.70	5.70	5.70	5.70	5.70	5.70	12.40	12.40	13.70	14.70
▸ Y2 (ft)	4.50	4.90	5.40	5.70	7.50	8.00	8.00	9.75	9.75	10.70	12.40	12.40	13.70	14.70
Y3 (ft)	7.50	7.50	7.50	7.50	7.50	8.00	8.00	9.75	9.75	10.70	12.40	12.40	13.70	14.70
Y4 (ft)	12.20	12.75	13.00	13.10	13.30	13.40	13.40	13.60	13.60	13.80	13.80	14.10	14.50	14.70
Y5 (ft)	13.20	13.75	14.00	14.10	14.20	14.30	14.30	14.50	14.50	14.60	14.60	14.90	15.10	15.30
Y6 (ft)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Coordinates of Crest X: 5.70 ft Y: 5.70 ft Coordinates of Toe X: 41.00 ft Y: 15.20 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 0.285 (η)

[ ] Auto Save Data

Xmin 0.00 Diameter: 2.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 24.00 ft

Run

Pore Water Pressure

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

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7
X (ft)	0.00	7.90	24.00	24.00	29.79	41.44	45.00
▸ Y (ft)	9.50	10.00	10.90	12.52	12.52	15.25	16.60

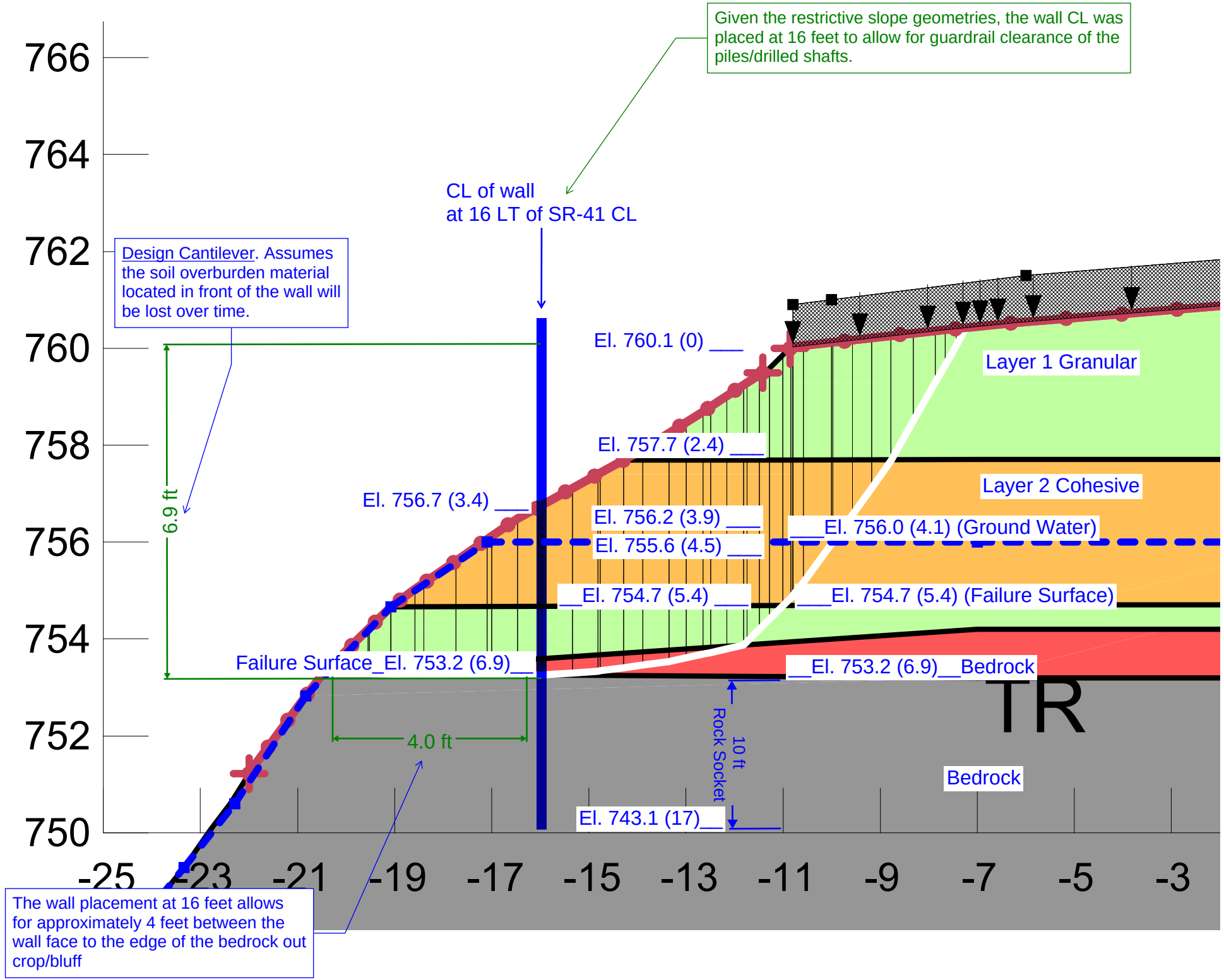
Slip Surface

	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)	5.80	6.64	7.11	7.52	8.36	9.01	9.22	9.35	10.23	11.00	11.01	11.03	11.66	12.92	14.32	15.42	15.88	16.4
Y (ft)	4.90	6.70	7.63	8.24	9.45	10.38	10.69	10.87	12.09	13.16	13.17	13.18	13.35	13.70	13.99	14.16	14.22	14.2

Proposed Wall CL offset. 24 LT

Wall Calculations

LPILE Analyses
(HP 12 x 53)


Given the restrictive slope geometries, the wall CL was placed at 16 feet to allow for guardrail clearance of the piles/drilled shafts.
CL of wall
at 16 LT of SR-41 CL
Design Cantilever. Assumes the soil overburden material located in front of the wall will be lost over time.
El. 760.1 (0)
Layer 1 Granular
El. 757.7 (2.4)
Layer 2 Cohesive
El. 756.7 (3.4)
El. 756.2 (3.9)
El. 756.0 (4.1) (Ground Water)
El. 755.6 (4.5)
El. 754.7 (5.4)
El. 754.7 (5.4) (Failure Surface)
Failure Surface_El. 753.2 (6.9)
El. 753.2 (6.9)__Bedrock
6.9 ft
4.0 ft
10 ft
Rock Socket
Bedrock
El. 743.1 (17)
766
764
762
760
758
756
754
752
750
-25
-23
-21
-19
-17
-15
-13
-11
-9
-7
-5
-3
The wall placement at 16 feet allows for approximately 4 feet between the wall face to the edge of the bedrock out crop/bluff

Geometry

	Elevation (ft)	
Top of Backfill =	760.1	*at Outside Edge of Shoulder*
Top of Wall =	760.1	*at C/L of Wall*
Existing Ground Surface =	756.7	*at C/L of Wall*
Maintenance Bench =	753.2	*at C/L of Wall*
Slip Plane =	753.2	*at C/L of Wall*

	Horiz. Distance from C/L (ft)	
Start of Wall Backfill =	11.0	*at Outside Edge of Shoulder*
Wall =	16.0	*at C/L of Wall*
Backfill Slope Angle =	11.0	H:1V

Wall Loading Profile

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Item 203	760.1	3.4	200	28	120
Layer 2 - Cohesive Material	756.7	2.0	170	24	120
Layer 1 - Granular Material	754.7	1.5	0	38	125
Bottom of Wall/Maintenance Bench	753.2				
Weighted Value		6.9	150	29	120

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	32		
Wall Friction , δ^A =	0.0		
Wall Slope, θ =	90		
Backfill Slope, β =	5.19		
Revised Backfill Slope, β =	5.19		
Backfill Condition	INFINITE		
Horz. Backslope Dist.	5.0	feet	*(C/L of Wall - Edge of Shoulder)*
Wall Height (H)	6.9	feet	*(Top of Wall - Maintenance Bench)*
Slope Height (h)	0.0	feet	*(Top of Backfill - Top of Wall)*
I =	0.00	degrees	

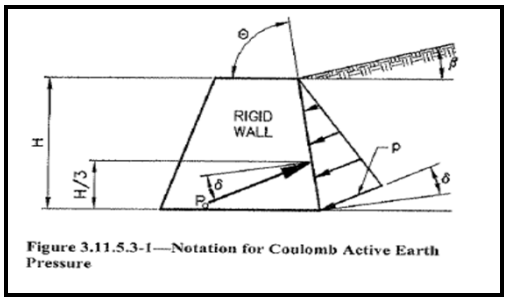


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

Active Earth Coefficient

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

K_a = 0.324

At-Rest Earth Coefficient

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

K_o = 0.512

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' = 150 psf and φ' = 29°, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters c' = 0 psf and φ'= 32° 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
Bedrock	753.2	6.9	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
Weathered Sandstone	753.2	6.9	150	90,000	155	65	0.0005
Sandstone	752.2	7.9	8,400	2,255,000	160	65	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 = 0.324

3) Determine Equivalent Fluid Weight (G_H)

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

G_H = 39 *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.? NO

Lowered Ground Surface (ft) = 0.0 = dt (tan(β_{dh})

β_{dh} = 52 = steepness of the slope downhill of the drilled shaft

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

d_t = 0.0 = 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

Exposed Wall Height (H) = 6.9 feet

Wall Height (H) + GS_{AL} = 6.9

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

P = 925 lbs/foot

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

P_{SH} = 5550 lbs/shaft

UA SLOPE

Depth from T/Wall to Slip Plane = 6.9 feet

Force Per Shaft = 8732 lbs/shaft

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

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

w = 1609 lbs/foot per shaft (Earth - Service Limit) 2531 lbs/foot per shaft

w = 134 lbs/inch per shaft (Earth - Service Limit) 211 lbs/inch per shaft

γ_E = 1.5 *Earth Load Factor*

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

w = 201 lbs/inch per shaft (Earth - Strength Limit) 316 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 = 559 lbs/foot *(surcharge resolved to distributed load)* 559 lbs/foot

P_s = 3351 lbs/shaft 3351 lbs/shaft

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

w = P_S/H

w = 486 lbs/foot per shaft (surcharge - unfactored) 486 lbs/foot per shaft

w = 40 lbs/inch per shaft (surcharge - unfactored) 40 lbs/inch per shaft

γ_S = 1.75 *Surcharge Load Factor - Strength I*

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

w = 71 lbs/inch per shaft (Surcharge - Strength I) 71 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	40	71
6.9	175	272

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	40	71
6.9	251	387

Adopted Wall Loads

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

$V_u =$ 92.651 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

$M_u =$ 784.95 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 =	6.9	ft
Minimum Pile Length Below Slip Plane =	10	ft *ODOT Minimum Required Length*
Minimum Required Pile Length =	16.9	ft

Deflection Criteria

Pile Length Above Rock =	6.9 ft	Exposed Wall Height =	6.9 ft
Pile Length Above Rock =	82.8 in	Exposed Wall Height =	82.8 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

1% Wall Height **OR** 2 inches- LPILE 2 in $\delta =$ 0.059 in *(from LPILE)*

1.5% Wall Height - PYWALL in $\delta =$ in *(from PYWALL)*

Drilled Shafts Located Within 10 feet of Edge of Pavement YES

Service Limit Analysis

Service Limit State - HP 12x53

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

                          LPile for Version 2022-12.012

                            License ID : 202613844
                        License Type : (Network License)

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

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

================================================================================


This model was prepared by:
abaratta




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

Path to file locations:
\pwworking\east01\d4504752\

Name of input data file:
20250715_ADA-41-31.38_Sta1657_ServiceLimit_UAS_Rock Bench.lp12d

Name of output report file:
20250715_ADA-41-31.38_Sta1657_ServiceLimit_UAS_Rock Bench.lp12o

Name of plot output file:
20250715_ADA-41-31.38_Sta1657_ServiceLimit_UAS_Rock Bench.lp12p

Name of runtime message file:
20250715_ADA-41-31.38_Sta1657_ServiceLimit_UAS_Rock Bench.lp12r



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

               Date:  July 24, 2025              Time:  13:34:23



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: ADA-41-31.38
```

PID Number: 123193

Client: ODOT

Engineer: HDR

Description: Sta. 1657+00 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 = 17.000 ft
Depth of ground surface below top of pile = 6.9000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	6.900	12.0000
3	6.900	24.0000
4	17.000	24.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong AISC Section Pile
Length of section = 6.900000 ft
AISC Section Type = HP

AISC Section Name = HP12X53

Flange Width = 12.000000 in
Section Depth = 11.800000 in
Flange Thickness = 0.435000 in
Web Thickness = 0.435000 in
Section Area = 15.500000 sq. in
Moment of Inertia = 393.000000 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 = 10.100000 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 2 layers

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

Distance from top of pile to top of layer = 6.900000 ft
Distance from top of pile to bottom of layer = 7.900000 ft
Effective unit weight at top of layer = 160.000000 pcf
Effective unit weight at bottom of layer = 160.000000 pcf

```
   Uniaxial compressive strength at top of layer       =   150.000000 psi
   Uniaxial compressive strength at bottom of layer    =   150.000000 psi
   Initial modulus of rock at top of layer             =       90000. psi
   Initial modulus of rock at bottom of layer          =       90000. psi
   RQD of rock at top of layer                         =    65.000000 %
   RQD of rock at bottom of layer                      =    65.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =     7.900000 ft
   Distance from top of pile to bottom of layer        =    30.000000 ft
   Effective unit weight at top of layer               =   160.000000 pcf
   Effective unit weight at bottom of layer            =   160.000000 pcf
   Uniaxial compressive strength at top of layer       =        8400. psi
   Uniaxial compressive strength at bottom of layer    =        8400. psi
   Initial modulus of rock at top of layer             =     2255000. psi
   Initial modulus of rock at bottom of layer          =     2255000. psi
   RQD of rock at top of layer                         =    65.000000 %
   RQD of rock at bottom of layer                      =    65.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 13.000 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   0, for effective unit weight = 160.00 pcf

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

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Weak	6.9000	160.0000	150.0000	65.0000	5.00E-04	90000.
	Rock	7.9000	160.0000	150.0000	65.0000	5.00E-04	90000.
2	Weak	7.9000	160.0000	8400.	65.0000	5.00E-04	2255000.
	Rock	30.0000	160.0000	8400.	65.0000	5.00E-04	2255000.

Modification Factors for p-y Curves

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

Point No.	Depth X ft	p-mult	y-mult
1	6.900	1.0000	1.0000
2	6.900	1.0000	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	40.000
2	6.900	251.000

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	=	10.100000	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	676.6664375	67666644.	7.9679830	0.00007968	-0.000160	0.3259223	0.00000	0.00000	-2.874485	C
0.00001125	676.6664375	60148128.	7.9709110	0.00008967	-0.000180	0.3658220	0.00000	0.00000	-3.232840	C
0.00001250	676.6664375	54133315.	7.9738464	0.00009967	-0.000200	0.4055337	0.00000	0.00000	-3.590981	C
0.00001375	676.6664375	49212105.	7.9767891	0.0001097	-0.000220	0.4450570	0.00000	0.00000	-3.948906	C
0.00001500	676.6664375	45111096.	7.9797393	0.0001197	-0.000240	0.4843915	0.00000	0.00000	-4.306614	C
0.00001625	676.6664375	41641012.	7.9826969	0.0001297	-0.000260	0.5235368	0.00000	0.00000	-4.664104	C
0.00001750	676.6664375	38666654.	7.9856619	0.0001397	-0.000280	0.5624925	0.00000	0.00000	-5.021377	C
0.00001875	676.6664375	36088877.	7.9886346	0.0001498	-0.000300	0.6012583	0.00000	0.00000	-5.378430	C
0.00002000	676.6664375	33833322.	7.9916142	0.0001598	-0.000320	0.6398338	0.00000	0.00000	-5.735263	C
0.00002125	676.6664375	31843126.	7.9946020	0.0001699	-0.000340	0.6782184	0.00000	0.00000	-6.091876	C
0.00002250	676.6664375	30074064.	7.9975974	0.0001799	-0.000360	0.7164120	0.00000	0.00000	-6.448267	C
0.00002375	676.6664375	28491218.	8.0006010	0.0001900	-0.000380	0.7544140	0.00000	0.00000	-6.804436	C
0.00002500	676.6664375	27066658.	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.	8.0126905	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.	8.0218406	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.	8.0433906	0.0003318	-0.000658	1.2660901	0.00000	0.00000	-11.767043 C
0.00004250	1116.	26267873.	8.0464394	0.0003420	-0.000678	1.3011584	0.00000	0.00000	-12.119862 C
0.00004375	1149.	26251741.	8.0494961	0.0003522	-0.000698	1.3360279	0.00000	0.00000	-12.472451 C
0.00004500	1181.	26235572.	8.0525608	0.0003624	-0.000718	1.3706982	0.00000	0.00000	-12.824807 C
0.00004625	1213.	26219367.	8.0556336	0.0003726	-0.000737	1.4051689	0.00000	0.00000	-13.176930 C
0.00004750	1245.	26203124.	8.0587145	0.0003828	-0.000757	1.4394395	0.00000	0.00000	-13.528820 C
0.00004875	1277.	26186844.	8.0618035	0.0003930	-0.000777	1.4735095	0.00000	0.00000	-13.880474 C
0.00005125	1340.	26154171.	8.0680062	0.0004135	-0.000817	1.5410463	0.00000	0.00000	-14.583075 C
0.00005375	1404.	26121346.	8.0742420	0.0004340	-0.000856	1.6077757	0.00000	0.00000	-15.284724 C
0.00005625	1467.	26088369.	8.0805112	0.0004545	-0.000895	1.6736941	0.00000	0.00000	-15.985415 C
0.00005875	1531.	26055237.	8.0868142	0.0004751	-0.000935	1.7387979	0.00000	0.00000	-16.685139 C
0.00006125	1594.	26021949.	8.0931514	0.0004957	-0.000974	1.8030833	0.00000	0.00000	-17.383888 C
0.00006375	1657.	25988504.	8.0995232	0.0005163	-0.001014	1.8665467	0.00000	0.00000	-18.081655 C
0.00006625	1720.	25954899.	8.1059300	0.0005370	-0.001053	1.9291842	0.00000	0.00000	-18.778430 C
0.00006875	1782.	25921133.	8.1123721	0.0005577	-0.001092	1.9909921	0.00000	0.00000	-19.474207 C
0.00007125	1844.	25887204.	8.1188499	0.0005785	-0.001132	2.0519664	0.00000	0.00000	-20.168975 C
0.00007375	1907.	25853111.	8.1253640	0.0005992	-0.001171	2.1121032	0.00000	0.00000	-20.862726 C
0.00007625	1969.	25818852.	8.1319146	0.0006201	-0.001210	2.1713986	0.00000	0.00000	-21.555452 C
0.00007875	2031.	25784425.	8.1385022	0.0006409	-0.001249	2.2298486	0.00000	0.00000	-22.247144 C
0.00008125	2092.	25749828.	8.1451272	0.0006618	-0.001288	2.2874489	0.00000	0.00000	-22.937792 C
0.00008375	2154.	25715060.	8.1517901	0.0006827	-0.001327	2.3441957	0.00000	0.00000	-23.627388 C
0.00008625	2215.	25680118.	8.1584913	0.0007037	-0.001366	2.4000845	0.00000	0.00000	-24.315922 C
0.00008875	2276.	25645001.	8.1652312	0.0007247	-0.001405	2.4551113	0.00000	0.00000	-25.003384 C
0.00009125	2337.	25609707.	8.1720104	0.0007457	-0.001444	2.5092716	0.00000	0.00000	-25.689766 C
0.00009375	2398.	25574233.	8.1788292	0.0007668	-0.001483	2.5625612	0.00000	0.00000	-26.375056 C
0.00009625	2458.	25538579.	8.1856882	0.0007879	-0.001522	2.6149757	0.00000	0.00000	-27.059246 C
0.00009875	2518.	25502741.	8.1925879	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.	8.4428376	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.	8.2012661	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.	8.0977982	0.0020143	-0.003956	3.9994984	0.00000	0.00000	-50.000000 CY
0.0002588	4859.	18778084.	8.0518524	0.0020834	-0.004127	3.9995413	0.00000	0.00000	-50.000000 CY
0.0002688	4888.	18189376.	8.0075495	0.0021520	-0.004298	3.9993259	0.00000	0.00000	-50.000000 CY
0.0002788	4915.	17631516.	7.9658810	0.0022205	-0.004470	3.9987213	0.00000	0.00000	-50.000000 CY
0.0002888	4938.	17102759.	7.9270652	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.	7.8570367	0.0024259	-0.004984	3.9997064	0.00000	0.00000	-50.000000 CY
0.0003188	4996.	15672912.	7.8254667	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.	7.7666434	0.0026310	-0.005499	3.9991397	0.00000	0.00000	-50.000000 CY
0.0003488	5037.	14443376.	7.7391190	0.0026990	-0.005671	3.9950882	0.00000	0.00000	-50.000000 CY
0.0003588	5048.	14071730.	7.7133575	0.0027672	-0.005843	3.9993974	0.00000	0.00000	-50.000000 CY
0.0003688	5058.	13717682.	7.6892545	0.0028354	-0.006015	3.9947087	0.00000	0.00000	-50.000000 CY
0.0003788	5067.	13378885.	7.6661519	0.0029036	-0.006186	3.9991153	0.00000	0.00000	-50.000000 CY
0.0003888	5075.	13055908.	7.6446149	0.0029718	-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.	7.6048236	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.	7.4768811	0.0036543	-0.008076	3.9971798	0.00000	0.00000	-50.000000 CY
0.0004988	5124.	10273973.	7.4639868	0.0037227	-0.008247	3.9995967	0.00000	0.00000	-50.000000 CY
0.0005088	5126.	10075389.	7.4512145	0.0037908	-0.008419	3.9962291	0.00000	0.00000	-50.000000 CY
0.0005188	5126.	9881165.	7.4542065	0.0038669	-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	-0.00642893

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.	24651216.
1	0.90	0.0000	5078.	0.0000	4571.	23231719.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	6.9000	0.00	N.A.	Yes	N.A.	N.A.
2	7.9000	1.0000	No	Yes	N.A.	N.A.

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

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

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

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

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.05859	2.85E-07	4.66E-09	-8.67E-04	4.35E-09	1.14E+10	0.00	0.00	41.2996
0.1700	0.05682	85.9363	88.2282	-8.67E-04	1.3120	1.14E+10	0.00	0.00	45.1986
0.3400	0.05506	359.9709	185.7357	-8.67E-04	5.4957	1.14E+10	0.00	0.00	50.3971
0.5100	0.05329	843.7380	293.8483	-8.67E-04	12.8815	1.14E+10	0.00	0.00	55.5957
0.6800	0.05152	1559.	412.5660	-8.67E-04	23.7996	1.14E+10	0.00	0.00	60.7942
0.8500	0.04975	2527.	541.8887	-8.66E-04	38.5803	1.14E+10	0.00	0.00	65.9928
1.0200	0.04799	3770.	681.8164	-8.66E-04	57.5539	1.14E+10	0.00	0.00	71.1913
1.1900	0.04622	5309.	832.3492	-8.65E-04	81.0507	1.14E+10	0.00	0.00	76.3899
1.3600	0.04446	7166.	993.4870	-8.64E-04	109.4010	1.14E+10	0.00	0.00	81.5884
1.5300	0.04270	9362.	1165.	-8.62E-04	142.9350	1.14E+10	0.00	0.00	86.7870
1.7000	0.04094	11920.	1348.	-8.60E-04	181.9832	1.14E+10	0.00	0.00	91.9855
1.8700	0.03919	14860.	1541.	-8.58E-04	226.8758	1.14E+10	0.00	0.00	97.1841
2.0400	0.03744	18205.	1744.	-8.55E-04	277.9430	1.14E+10	0.00	0.00	102.3826

2.2100	0.03570	21976.	1958.	-8.51E-04	335.5152	1.14E+10	0.00	0.00	107.5812
2.3800	0.03397	26195.	2183.	-8.47E-04	399.9226	1.14E+10	0.00	0.00	112.7797
2.5500	0.03224	30883.	2418.	-8.42E-04	471.4957	1.14E+10	0.00	0.00	117.9783
2.7200	0.03053	36062.	2664.	-8.36E-04	550.5645	1.14E+10	0.00	0.00	123.1768
2.8900	0.02883	41754.	2921.	-8.29E-04	637.4595	1.14E+10	0.00	0.00	128.3754
3.0600	0.02715	47979.	3188.	-8.21E-04	732.5110	1.14E+10	0.00	0.00	133.5739
3.2300	0.02548	54761.	3466.	-8.12E-04	836.0492	1.14E+10	0.00	0.00	138.7725
3.4000	0.02384	62120.	3754.	-8.01E-04	948.4044	1.14E+10	0.00	0.00	143.9710
3.5700	0.02221	70079.	4053.	-7.89E-04	1070.	1.14E+10	0.00	0.00	149.1696
3.7400	0.02062	78658.	4363.	-7.76E-04	1201.	1.14E+10	0.00	0.00	154.3681
3.9100	0.01905	87880.	4683.	-7.61E-04	1342.	1.14E+10	0.00	0.00	159.5667
4.0800	0.01751	97765.	5014.	-7.45E-04	1493.	1.14E+10	0.00	0.00	164.7652
4.2500	0.01601	108337.	5355.	-7.26E-04	1654.	1.14E+10	0.00	0.00	169.9638
4.4200	0.01455	119615.	5707.	-7.06E-04	1826.	1.14E+10	0.00	0.00	175.1623
4.5900	0.01313	131623.	6070.	-6.83E-04	2010.	1.14E+10	0.00	0.00	180.3609
4.7600	0.01176	144381.	6443.	-6.59E-04	2204.	1.14E+10	0.00	0.00	185.5594
4.9300	0.01044	157912.	6827.	-6.32E-04	2411.	1.14E+10	0.00	0.00	190.7580
5.1000	0.00918	172236.	7222.	-6.02E-04	2630.	1.14E+10	0.00	0.00	195.9565
5.2700	0.00799	187376.	7627.	-5.70E-04	2861.	1.14E+10	0.00	0.00	201.1551
5.4400	0.00686	203353.	8042.	-5.35E-04	3105.	1.14E+10	0.00	0.00	206.3536
5.6100	0.00580	220188.	8469.	-4.97E-04	3362.	1.14E+10	0.00	0.00	211.5522
5.7800	0.00483	237905.	8905.	-4.56E-04	3632.	1.14E+10	0.00	0.00	216.7507
5.9500	0.00394	256523.	9353.	-4.12E-04	3916.	1.14E+10	0.00	0.00	221.9493
6.1200	0.00315	276064.	9811.	-3.64E-04	4215.	1.14E+10	0.00	0.00	227.1478
6.2900	0.00246	296552.	10280.	-3.13E-04	4528.	1.14E+10	0.00	0.00	232.3464
6.4600	0.00187	318006.	10759.	-2.58E-04	4855.	1.14E+10	0.00	0.00	237.5449
6.6300	0.00141	340448.	11249.	-1.99E-04	5198.	1.14E+10	0.00	0.00	242.7435
6.8000	0.00106	363901.	11749.	-1.36E-04	5556.	1.14E+10	0.00	0.00	247.9420
6.9700	8.53E-04	388386.	11461.	-9.81E-05	0.00	7.79E+10	-552.501	1321268.	22.1268
7.1400	6.63E-04	410663.	10331.	-8.77E-05	0.00	7.78E+10	-577.657	1776855.	0.00
7.3100	4.95E-04	430536.	9138.	-7.67E-05	0.00	7.78E+10	-591.720	2437018.	0.00
7.4800	3.50E-04	447947.	7930.	-6.51E-05	0.00	7.78E+10	-592.878	3450993.	0.00
7.6500	2.30E-04	462891.	6735.	-5.32E-05	0.00	7.77E+10	-578.531	5140464.	0.00
7.8200	1.33E-04	475427.	5590.	-4.09E-05	0.00	7.77E+10	-544.609	8322631.	0.00
7.9900	6.29E-05	485696.	-19927.	-2.83E-05	0.00	7.77E+10	-24472.	7.94E+08	0.00
8.1600	1.82E-05	394124.	-52601.	-1.67E-05	0.00	7.79E+10	-7562.	8.46E+08	0.00
8.3300	-5.34E-06	271082.	-57915.	-8.01E-06	0.00	7.81E+10	2352.	8.99E+08	0.00
8.5000	-1.45E-05	157830.	-48642.	-2.41E-06	0.00	7.83E+10	6739.	9.51E+08	0.00
8.6700	-1.52E-05	72621.	-34153.	5.87E-07	0.00	7.84E+10	7467.	1.00E+09	0.00
8.8400	-1.21E-05	18487.	-20171.	1.77E-06	0.00	7.84E+10	6240.	1.05E+09	0.00
9.0100	-7.96E-06	-9678.	-9399.	1.89E-06	0.00	7.84E+10	4321.	1.11E+09	0.00
9.1800	-4.37E-06	-19860.	-2457.	1.50E-06	0.00	7.84E+10	2485.	1.16E+09	0.00
9.3500	-1.84E-06	-19702.	1189.	9.87E-07	0.00	7.84E+10	1090.	1.21E+09	0.00
9.5200	-3.44E-07	-15009.	2518.	5.36E-07	0.00	7.84E+10	213.1157	1.26E+09	0.00
9.6900	3.51E-07	-9428.	2505.	2.18E-07	0.00	7.84E+10	-226.326	1.32E+09	0.00
9.8600	5.46E-07	-4790.	1901.	3.32E-08	0.00	7.84E+10	-365.890	1.37E+09	0.00
10.0300	4.86E-07	-1674.	1182.	-5.09E-08	0.00	7.84E+10	-338.528	1.42E+09	0.00
10.2000	3.38E-07	33.4230	587.8626	-7.22E-08	0.00	7.84E+10	-244.054	1.47E+09	0.00
10.3700	1.92E-07	724.8353	192.7281	-6.23E-08	0.00	7.84E+10	-143.333	1.52E+09	0.00
10.5400	8.39E-08	819.7537	-19.616	-4.22E-08	0.00	7.84E+10	-64.847	1.58E+09	0.00
10.7100	1.95E-08	644.8032	-101.638	-2.32E-08	0.00	7.84E+10	-15.566	1.63E+09	0.00
10.8800	-1.07E-08	405.0714	-108.517	-9.54E-09	0.00	7.84E+10	8.8224	1.68E+09	0.00
11.0500	-1.94E-08	202.0549	-82.688	-1.65E-09	0.00	7.84E+10	16.5002	1.73E+09	0.00
11.2200	-1.74E-08	67.7055	-50.309	1.86E-09	0.00	7.84E+10	15.2435	1.78E+09	0.00
11.3900	-1.18E-08	-3.206	-23.898	2.70E-09	0.00	7.84E+10	10.6496	1.84E+09	0.00
11.5600	-6.40E-09	-29.799	-6.990	2.27E-09	0.00	7.84E+10	5.9272	1.89E+09	0.00
11.7300	-2.56E-09	-31.725	1.5364	1.47E-09	0.00	7.84E+10	2.4320	1.94E+09	0.00
11.9000	-3.94E-10	-23.531	4.4099	7.54E-10	0.00	7.84E+10	0.3851	1.99E+09	0.00
12.0700	5.19E-10	-13.733	4.2720	2.69E-10	0.00	7.84E+10	-0.520	2.05E+09	0.00

12.2400	7.03E-10	-6.101	3.0037	1.10E-11	0.00	7.84E+10	-0.723	2.10E+09	0.00
12.4100	5.64E-10	-1.478	1.6599	-8.75E-11	0.00	7.84E+10	-0.594	2.15E+09	0.00
12.5800	3.46E-10	0.6715	0.6727	-9.80E-11	0.00	7.84E+10	-0.374	2.20E+09	0.00
12.7500	1.64E-10	1.2663	0.1067	-7.28E-11	0.00	7.84E+10	-0.181	2.25E+09	0.00
12.9200	4.90E-11	1.1070	-0.135	-4.20E-11	0.00	7.84E+10	-0.05530	2.30E+09	0.00
13.0900	-7.18E-12	0.7175	-0.183	-1.82E-11	0.00	7.84E+10	0.00809	2.30E+09	0.00
13.2600	-2.53E-11	0.3617	-0.145	-4.19E-12	0.00	7.84E+10	0.02856	2.30E+09	0.00
13.4300	-2.43E-11	0.1248	-0.08822	2.13E-12	0.00	7.84E+10	0.02739	2.30E+09	0.00
13.6000	-1.66E-11	0.00177	-0.04116	3.78E-12	0.00	7.84E+10	0.01875	2.30E+09	0.00
13.7700	-8.88E-12	-0.04317	-0.01182	3.24E-12	0.00	7.84E+10	0.01001	2.30E+09	0.00
13.9400	-3.42E-12	-0.04646	0.00232	2.07E-12	0.00	7.84E+10	0.00385	2.30E+09	0.00
14.1100	0.00	-0.03371	0.00673	1.03E-12	0.00	7.84E+10	4.73E-04	2.30E+09	0.00
14.2800	0.00	-0.01900	0.00630	0.00	0.00	7.84E+10	-8.89E-04	2.30E+09	0.00
14.4500	0.00	-0.00799	0.00426	0.00	0.00	7.84E+10	-0.00111	2.30E+09	0.00
14.6200	0.00	-0.00162	0.00225	0.00	0.00	7.84E+10	-8.62E-04	2.30E+09	0.00
14.7900	0.00	0.00117	8.44E-04	0.00	0.00	7.84E+10	-5.12E-04	2.30E+09	0.00
14.9600	0.00	0.00182	8.49E-05	0.00	0.00	7.84E+10	-2.32E-04	2.30E+09	0.00
15.1300	0.00	0.00151	-2.15E-04	0.00	0.00	7.84E+10	-6.15E-05	2.30E+09	0.00
15.3000	0.00	9.48E-04	-2.59E-04	0.00	0.00	7.84E+10	1.86E-05	2.30E+09	0.00
15.4700	0.00	4.60E-04	-1.97E-04	0.00	0.00	7.84E+10	4.19E-05	2.30E+09	0.00
15.6400	0.00	1.45E-04	-1.16E-04	0.00	0.00	7.84E+10	3.78E-05	2.30E+09	0.00
15.8100	0.00	-1.18E-05	-5.15E-05	0.00	0.00	7.84E+10	2.50E-05	2.30E+09	0.00
15.9800	0.00	-6.49E-05	-1.29E-05	0.00	0.00	7.84E+10	1.29E-05	2.30E+09	0.00
16.1500	0.00	-6.45E-05	4.91E-06	0.00	0.00	7.84E+10	4.62E-06	2.30E+09	0.00
16.3200	0.00	-4.48E-05	9.88E-06	0.00	0.00	7.84E+10	2.47E-07	2.30E+09	0.00
16.4900	0.00	-2.42E-05	8.65E-06	0.00	0.00	7.84E+10	-1.45E-06	2.30E+09	0.00
16.6600	0.00	-9.54E-06	5.46E-06	0.00	0.00	7.84E+10	-1.69E-06	2.30E+09	0.00
16.8300	0.00	-1.93E-06	2.34E-06	0.00	0.00	7.84E+10	-1.37E-06	2.30E+09	0.00
17.0000	0.00	0.00	0.00	0.00	0.00	7.84E+10	-9.26E-07	1.15E+09	0.00

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.05859345 inches
Computed slope at pile head = -0.0008669 radians
Maximum bending moment = 485696. inch-lbs
Maximum shear force = -57915. lbs
Depth of maximum bending moment = 7.99000000 feet below pile head
Depth of maximum shear force = 8.33000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 8
Pile deflection at ground = 0.00093976 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
17.00000	0.05859345	485696.	-57915.
16.15000	0.05745352	481121.	-57498.
15.30000	0.06065483	490307.	-59046.
14.45000	0.05773782	482236.	-58090.
13.60000	0.05842709	484735.	-58691.
12.75000	0.05997001	486735.	-57668.
11.90000	0.05737699	481028.	-58145.
11.05000	0.05912986	485601.	-59158.
10.20000	0.05853838	483770.	-58969.
9.35000	0.05814929	482299.	-57960.
8.50000	0.06301862	478403.	-99777.

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	0.05859	-8.67E-04	-57915.	485696.

Maximum pile-head deflection = 0.0585934485 inches
Maximum pile-head rotation   = -0.0008669114 radians = -0.049670 deg.

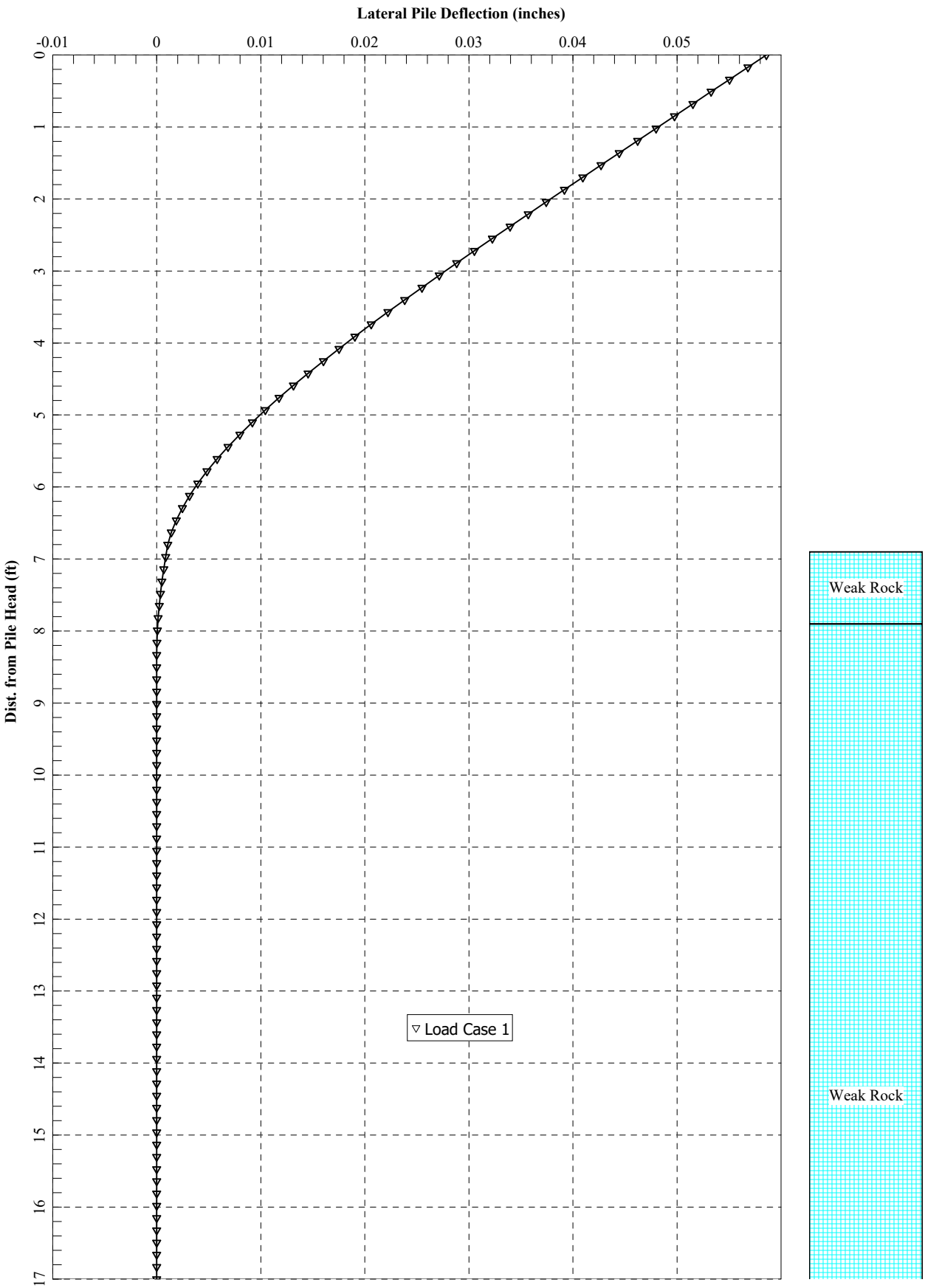
Summary of Warning Messages

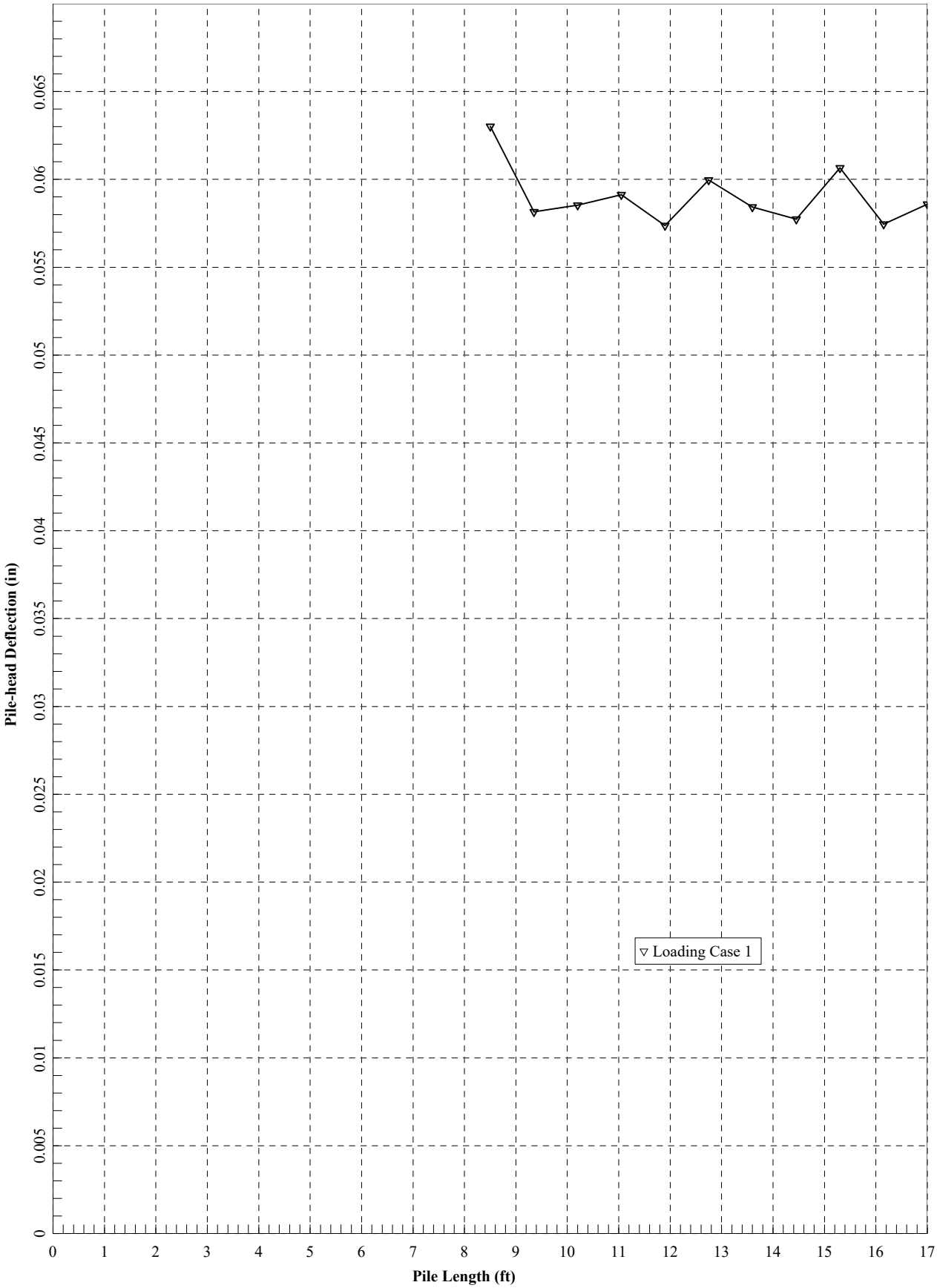
The following warning was reported 2810 times

**** 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)
-0.01
0
0.01
0.02
0.03
0.04
0.05
Dist. from Pile Head (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Load Case 1
Weak Rock
Weak Rock


Pile-head Deflection (in)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05
0.055
0.06
0.065
Pile Length (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
▽ Loading Case 1

Strength Limit Analysis

Strength Limit State - HP 12x53

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

                          LPile for Version 2022-12.012

                              License ID : 202613844
                          License Type : (Network License)

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

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

================================================================================


This model was prepared by:
abaratta




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

Path to file locations:
\pwworking\east01\d4504752\

Name of input data file:
20250715_ADA-41-31.38_Sta1657_StrengthLimit_UAS_Rock Bench.lp12d

Name of output report file:
20250715_ADA-41-31.38_Sta1657_StrengthLimit_UAS_Rock Bench.lp12o

Name of plot output file:
20250715_ADA-41-31.38_Sta1657_StrengthLimit_UAS_Rock Bench.lp12p

Name of runtime message file:
20250715_ADA-41-31.38_Sta1657_StrengthLimit_UAS_Rock Bench.lp12r



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

               Date:  July 24, 2025              Time:  13:41:47



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: ADA-41-31.38
```

PID Number: 123193

Client: ODOT

Engineer: HDR

Description: Sta. 1657+00 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 = 17.000 ft
Depth of ground surface below top of pile = 6.9000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	6.900	12.0000
3	6.900	24.0000
4	17.000	24.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong AISC Section Pile
Length of section = 6.900000 ft
AISC Section Type = HP

AISC Section Name = HP12X53

Flange Width = 12.000000 in
Section Depth = 11.800000 in
Flange Thickness = 0.435000 in
Web Thickness = 0.435000 in
Section Area = 15.500000 sq. in
Moment of Inertia = 393.000000 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 = 10.100000 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 2 layers

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

Distance from top of pile to top of layer = 6.900000 ft
Distance from top of pile to bottom of layer = 7.900000 ft
Effective unit weight at top of layer = 160.000000 pcf
Effective unit weight at bottom of layer = 160.000000 pcf

```
   Uniaxial compressive strength at top of layer       =   150.000000 psi
   Uniaxial compressive strength at bottom of layer    =   150.000000 psi
   Initial modulus of rock at top of layer             =       90000. psi
   Initial modulus of rock at bottom of layer          =       90000. psi
   RQD of rock at top of layer                         =    65.000000 %
   RQD of rock at bottom of layer                      =    65.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =     7.900000 ft
   Distance from top of pile to bottom of layer        =    30.000000 ft
   Effective unit weight at top of layer               =   160.000000 pcf
   Effective unit weight at bottom of layer            =   160.000000 pcf
   Uniaxial compressive strength at top of layer       =        8400. psi
   Uniaxial compressive strength at bottom of layer    =        8400. psi
   Initial modulus of rock at top of layer             =     2255000. psi
   Initial modulus of rock at bottom of layer          =     2255000. psi
   RQD of rock at top of layer                         =    65.000000 %
   RQD of rock at bottom of layer                      =    65.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 13.000 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   0, for effective unit weight = 160.00 pcf

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

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Weak	6.9000	160.0000	150.0000	65.0000	5.00E-04	90000.
	Rock	7.9000	160.0000	150.0000	65.0000	5.00E-04	90000.
2	Weak	7.9000	160.0000	8400.	65.0000	5.00E-04	2255000.
	Rock	30.0000	160.0000	8400.	65.0000	5.00E-04	2255000.

Modification Factors for p-y Curves

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

Point No.	Depth X ft	p-mult	y-mult
1	6.900	1.0000	1.0000
2	6.900	1.0000	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	71.000
2	6.900	387.000

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	=	10.100000	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	676.6664375	67666644.	7.9679830	0.00007968	-0.000160	0.3259223	0.00000	0.00000	-2.874485	C
0.00001125	676.6664375	60148128.	7.9709110	0.00008967	-0.000180	0.3658220	0.00000	0.00000	-3.232840	C
0.00001250	676.6664375	54133315.	7.9738464	0.00009967	-0.000200	0.4055337	0.00000	0.00000	-3.590981	C
0.00001375	676.6664375	49212105.	7.9767891	0.0001097	-0.000220	0.4450570	0.00000	0.00000	-3.948906	C
0.00001500	676.6664375	45111096.	7.9797393	0.0001197	-0.000240	0.4843915	0.00000	0.00000	-4.306614	C
0.00001625	676.6664375	41641012.	7.9826969	0.0001297	-0.000260	0.5235368	0.00000	0.00000	-4.664104	C
0.00001750	676.6664375	38666654.	7.9856619	0.0001397	-0.000280	0.5624925	0.00000	0.00000	-5.021377	C
0.00001875	676.6664375	36088877.	7.9886346	0.0001498	-0.000300	0.6012583	0.00000	0.00000	-5.378430	C
0.00002000	676.6664375	33833322.	7.9916142	0.0001598	-0.000320	0.6398338	0.00000	0.00000	-5.735263	C
0.00002125	676.6664375	31843126.	7.9946020	0.0001699	-0.000340	0.6782184	0.00000	0.00000	-6.091876	C
0.00002250	676.6664375	30074064.	7.9975974	0.0001799	-0.000360	0.7164120	0.00000	0.00000	-6.448267	C
0.00002375	676.6664375	28491218.	8.0006010	0.0001900	-0.000380	0.7544140	0.00000	0.00000	-6.804436	C
0.00002500	676.6664375	27066658.	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.	8.0126905	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.	8.0218406	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.	8.0433906	0.0003318	-0.000658	1.2660901	0.00000	0.00000	-11.767043 C
0.00004250	1116.	26267873.	8.0464394	0.0003420	-0.000678	1.3011584	0.00000	0.00000	-12.119862 C
0.00004375	1149.	26251741.	8.0494961	0.0003522	-0.000698	1.3360279	0.00000	0.00000	-12.472451 C
0.00004500	1181.	26235572.	8.0525608	0.0003624	-0.000718	1.3706982	0.00000	0.00000	-12.824807 C
0.00004625	1213.	26219367.	8.0556336	0.0003726	-0.000737	1.4051689	0.00000	0.00000	-13.176930 C
0.00004750	1245.	26203124.	8.0587145	0.0003828	-0.000757	1.4394395	0.00000	0.00000	-13.528820 C
0.00004875	1277.	26186844.	8.0618035	0.0003930	-0.000777	1.4735095	0.00000	0.00000	-13.880474 C
0.00005125	1340.	26154171.	8.0680062	0.0004135	-0.000817	1.5410463	0.00000	0.00000	-14.583075 C
0.00005375	1404.	26121346.	8.0742420	0.0004340	-0.000856	1.6077757	0.00000	0.00000	-15.284724 C
0.00005625	1467.	26088369.	8.0805112	0.0004545	-0.000895	1.6736941	0.00000	0.00000	-15.985415 C
0.00005875	1531.	26055237.	8.0868142	0.0004751	-0.000935	1.7387979	0.00000	0.00000	-16.685139 C
0.00006125	1594.	26021949.	8.0931514	0.0004957	-0.000974	1.8030833	0.00000	0.00000	-17.383888 C
0.00006375	1657.	25988504.	8.0995232	0.0005163	-0.001014	1.8665467	0.00000	0.00000	-18.081655 C
0.00006625	1720.	25954899.	8.1059300	0.0005370	-0.001053	1.9291842	0.00000	0.00000	-18.778430 C
0.00006875	1782.	25921133.	8.1123721	0.0005577	-0.001092	1.9909921	0.00000	0.00000	-19.474207 C
0.00007125	1844.	25887204.	8.1188499	0.0005785	-0.001132	2.0519664	0.00000	0.00000	-20.168975 C
0.00007375	1907.	25853111.	8.1253640	0.0005992	-0.001171	2.1121032	0.00000	0.00000	-20.862726 C
0.00007625	1969.	25818852.	8.1319146	0.0006201	-0.001210	2.1713986	0.00000	0.00000	-21.555452 C
0.00007875	2031.	25784425.	8.1385022	0.0006409	-0.001249	2.2298486	0.00000	0.00000	-22.247144 C
0.00008125	2092.	25749828.	8.1451272	0.0006618	-0.001288	2.2874489	0.00000	0.00000	-22.937792 C
0.00008375	2154.	25715060.	8.1517901	0.0006827	-0.001327	2.3441957	0.00000	0.00000	-23.627388 C
0.00008625	2215.	25680118.	8.1584913	0.0007037	-0.001366	2.4000845	0.00000	0.00000	-24.315922 C
0.00008875	2276.	25645001.	8.1652312	0.0007247	-0.001405	2.4551113	0.00000	0.00000	-25.003384 C
0.00009125	2337.	25609707.	8.1720104	0.0007457	-0.001444	2.5092716	0.00000	0.00000	-25.689766 C
0.00009375	2398.	25574233.	8.1788292	0.0007668	-0.001483	2.5625612	0.00000	0.00000	-26.375056 C
0.00009625	2458.	25538579.	8.1856882	0.0007879	-0.001522	2.6149757	0.00000	0.00000	-27.059246 C
0.00009875	2518.	25502741.	8.1925879	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.	8.4428376	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.	8.2012661	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.	8.0977982	0.0020143	-0.003956	3.9994984	0.00000	0.00000	-50.000000 CY
0.0002588	4859.	18778084.	8.0518524	0.0020834	-0.004127	3.9995413	0.00000	0.00000	-50.000000 CY
0.0002688	4888.	18189376.	8.0075495	0.0021520	-0.004298	3.9993259	0.00000	0.00000	-50.000000 CY
0.0002788	4915.	17631516.	7.9658810	0.0022205	-0.004470	3.9987213	0.00000	0.00000	-50.000000 CY
0.0002888	4938.	17102759.	7.9270652	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.	7.8570367	0.0024259	-0.004984	3.9997064	0.00000	0.00000	-50.000000 CY
0.0003188	4996.	15672912.	7.8254667	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.	7.7666434	0.0026310	-0.005499	3.9991397	0.00000	0.00000	-50.000000 CY
0.0003488	5037.	14443376.	7.7391190	0.0026990	-0.005671	3.9950882	0.00000	0.00000	-50.000000 CY
0.0003588	5048.	14071730.	7.7133575	0.0027672	-0.005843	3.9993974	0.00000	0.00000	-50.000000 CY
0.0003688	5058.	13717682.	7.6892545	0.0028354	-0.006015	3.9947087	0.00000	0.00000	-50.000000 CY
0.0003788	5067.	13378885.	7.6661519	0.0029036	-0.006186	3.9991153	0.00000	0.00000	-50.000000 CY
0.0003888	5075.	13055908.	7.6446149	0.0029718	-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.	7.6048236	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.	7.4768811	0.0036543	-0.008076	3.9971798	0.00000	0.00000	-50.000000 CY
0.0004988	5124.	10273973.	7.4639868	0.0037227	-0.008247	3.9995967	0.00000	0.00000	-50.000000 CY
0.0005088	5126.	10075389.	7.4512145	0.0037908	-0.008419	3.9962291	0.00000	0.00000	-50.000000 CY
0.0005188	5126.	9881165.	7.4542065	0.0038669	-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	-0.00642893

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.	24651216.
1	0.90	0.0000	5078.	0.0000	4571.	23231719.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	6.9000	0.00	N.A.	Yes	N.A.	N.A.
2	7.9000	1.0000	No	Yes	N.A.	N.A.

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

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

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

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

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1122	4.18E-07	-9.32E-09	-0.00159	6.38E-09	1.14E+10	0.00	0.00	72.9464
0.1700	0.1089	151.7868	154.7665	-0.00159	2.3174	1.14E+10	0.00	0.00	78.7855
0.3400	0.1057	631.4474	323.4302	-0.00159	9.6404	1.14E+10	0.00	0.00	86.5710
0.5100	0.1024	1471.	507.9763	-0.00159	22.4638	1.14E+10	0.00	0.00	94.3565
0.6800	0.09918	2704.	708.4048	-0.00159	41.2823	1.14E+10	0.00	0.00	102.1420
0.8500	0.09593	4362.	924.7157	-0.00159	66.5904	1.14E+10	0.00	0.00	109.9275
1.0200	0.09269	6477.	1157.	-0.00159	98.8829	1.14E+10	0.00	0.00	117.7130
1.1900	0.08944	9082.	1405.	-0.00159	138.6544	1.14E+10	0.00	0.00	125.4986
1.3600	0.08620	12209.	1669.	-0.00159	186.3995	1.14E+10	0.00	0.00	133.2841
1.5300	0.08296	15891.	1949.	-0.00159	242.6130	1.14E+10	0.00	0.00	141.0696
1.7000	0.07973	20160.	2245.	-0.00158	307.7894	1.14E+10	0.00	0.00	148.8551
1.8700	0.07651	25049.	2556.	-0.00158	382.4235	1.14E+10	0.00	0.00	156.6406
2.0400	0.07329	30589.	2884.	-0.00157	467.0099	1.14E+10	0.00	0.00	164.4261

2.2100	0.07009	36814.	3227.	-0.00157	562.0432	1.14E+10	0.00	0.00	172.2116
2.3800	0.06690	43755.	3586.	-0.00156	668.0182	1.14E+10	0.00	0.00	179.9971
2.5500	0.06373	51446.	3961.	-0.00155	785.4294	1.14E+10	0.00	0.00	187.7826
2.7200	0.06057	59918.	4352.	-0.00154	914.7715	1.14E+10	0.00	0.00	195.5681
2.8900	0.05744	69203.	4759.	-0.00153	1057.	1.14E+10	0.00	0.00	203.3536
3.0600	0.05433	79335.	5182.	-0.00152	1211.	1.14E+10	0.00	0.00	211.1391
3.2300	0.05125	90346.	5621.	-0.00150	1379.	1.14E+10	0.00	0.00	218.9246
3.4000	0.04820	102268.	6075.	-0.00148	1561.	1.14E+10	0.00	0.00	226.7101
3.5700	0.04519	115133.	6546.	-0.00146	1758.	1.14E+10	0.00	0.00	234.4957
3.7400	0.04223	128974.	7032.	-0.00144	1969.	1.14E+10	0.00	0.00	242.2812
3.9100	0.03931	143824.	7534.	-0.00142	2196.	1.14E+10	0.00	0.00	250.0667
4.0800	0.03644	159714.	8052.	-0.00139	2438.	1.14E+10	0.00	0.00	257.8522
4.2500	0.03363	176677.	8586.	-0.00136	2697.	1.14E+10	0.00	0.00	265.6377
4.4200	0.03089	194746.	9136.	-0.00133	2973.	1.14E+10	0.00	0.00	273.4232
4.5900	0.02821	213952.	9702.	-0.00129	3266.	1.14E+10	0.00	0.00	281.2087
4.7600	0.02562	234329.	10283.	-0.00125	3578.	1.14E+10	0.00	0.00	288.9942
4.9300	0.02311	255909.	10881.	-0.00121	3907.	1.14E+10	0.00	0.00	296.7797
5.1000	0.02069	278723.	11494.	-0.00116	4255.	1.14E+10	0.00	0.00	304.5652
5.2700	0.01838	302805.	12124.	-0.00111	4623.	1.14E+10	0.00	0.00	312.3507
5.4400	0.01618	328187.	12769.	-0.00105	5010.	1.14E+10	0.00	0.00	320.1362
5.6100	0.01409	354902.	13430.	-9.90E-04	5418.	1.14E+10	0.00	0.00	327.9217
5.7800	0.01214	382981.	14107.	-9.24E-04	5847.	1.14E+10	0.00	0.00	335.7072
5.9500	0.01032	412457.	14799.	-8.53E-04	6297.	1.14E+10	0.00	0.00	343.4928
6.1200	0.00866	443362.	15508.	-7.76E-04	6769.	1.14E+10	0.00	0.00	351.2783
6.2900	0.00716	475729.	16233.	-6.94E-04	7263.	1.14E+10	0.00	0.00	359.0638
6.4600	0.00583	509591.	16973.	-6.06E-04	7780.	1.14E+10	0.00	0.00	366.8493
6.6300	0.00469	544979.	17729.	-5.11E-04	8320.	1.14E+10	0.00	0.00	374.6348
6.8000	0.00374	581927.	18502.	-4.10E-04	8884.	1.14E+10	0.00	0.00	382.4203
6.9700	0.00301	620466.	18154.	-3.50E-04	0.00	7.74E+10	-757.388	513010.	34.1168
7.1400	0.00231	655994.	16611.	-3.33E-04	0.00	7.74E+10	-789.546	695944.	0.00
7.3100	0.00165	688238.	14990.	-2.98E-04	0.00	2.67E+10	-799.657	987317.	0.00
7.4800	0.00110	717153.	13370.	-2.44E-04	0.00	2.65E+10	-788.638	1466097.	0.00
7.6500	6.55E-04	742786.	11798.	-1.88E-04	0.00	2.65E+10	-751.923	2341072.	0.00
7.8200	3.30E-04	765290.	10335.	-1.30E-04	0.00	2.64E+10	-682.846	4221773.	0.00
7.9900	1.25E-04	784953.	-23186.	-7.01E-05	0.00	2.64E+10	-32181.	5.25E+08	0.00
8.1600	4.39E-05	670690.	-74602.	-3.10E-05	0.00	7.73E+10	-18226.	8.46E+08	0.00
8.3300	-1.20E-06	480577.	-92651.	-1.58E-05	0.00	7.77E+10	530.5800	8.99E+08	0.00
8.5000	-2.06E-05	292672.	-82318.	-5.68E-06	0.00	7.81E+10	9600.	9.51E+08	0.00
8.6700	-2.44E-05	144719.	-60296.	2.56E-08	0.00	7.83E+10	11991.	1.00E+09	0.00
8.8400	-2.05E-05	46666.	-37254.	2.52E-06	0.00	7.84E+10	10599.	1.05E+09	0.00
9.0100	-1.41E-05	-7279.	-18627.	3.03E-06	0.00	7.84E+10	7664.	1.11E+09	0.00
9.1800	-8.13E-06	-29331.	-6095.	2.55E-06	0.00	7.84E+10	4622.	1.16E+09	0.00
9.3500	-3.70E-06	-32146.	863.0868	1.75E-06	0.00	7.84E+10	2199.	1.21E+09	0.00
9.5200	-9.78E-07	-25810.	3724.	1.00E-06	0.00	7.84E+10	605.8690	1.26E+09	0.00
9.6900	3.78E-07	-16951.	4094.	4.44E-07	0.00	7.84E+10	-243.538	1.32E+09	0.00
9.8600	8.34E-07	-9107.	3275.	1.05E-07	0.00	7.84E+10	-559.202	1.37E+09	0.00
10.0300	8.07E-07	-3589.	2131.	-5.98E-08	0.00	7.84E+10	-561.870	1.42E+09	0.00
10.2000	5.90E-07	-410.364	1124.	-1.12E-07	0.00	7.84E+10	-425.740	1.47E+09	0.00
10.3700	3.51E-07	996.9905	422.3978	-1.04E-07	0.00	7.84E+10	-262.237	1.52E+09	0.00
10.5400	1.65E-07	1313.	24.9748	-7.42E-08	0.00	7.84E+10	-127.393	1.58E+09	0.00
10.7100	4.84E-08	1099.	-144.388	-4.28E-08	0.00	7.84E+10	-38.649	1.63E+09	0.00
10.8800	-9.73E-09	723.9149	-175.636	-1.91E-08	0.00	7.84E+10	8.0143	1.68E+09	0.00
11.0500	-2.95E-08	382.2943	-141.936	-4.70E-09	0.00	7.84E+10	25.0249	1.73E+09	0.00
11.2200	-2.89E-08	144.8173	-90.607	2.15E-09	0.00	7.84E+10	25.2971	1.78E+09	0.00
11.3900	-2.07E-08	12.6169	-45.810	4.20E-09	0.00	7.84E+10	18.6221	1.84E+09	0.00
11.5600	-1.18E-08	-42.086	-15.691	3.82E-09	0.00	7.84E+10	10.9062	1.89E+09	0.00
11.7300	-5.11E-09	-51.401	0.3912	2.60E-09	0.00	7.84E+10	4.8603	1.94E+09	0.00
11.9000	-1.17E-09	-40.490	6.5100	1.41E-09	0.00	7.84E+10	1.1385	1.99E+09	0.00
12.0700	6.29E-10	-24.841	7.0280	5.56E-10	0.00	7.84E+10	-0.631	2.05E+09	0.00

12.2400	1.11E-09	-11.816	5.2257	7.97E-11	0.00	7.84E+10	-1.136	2.10E+09	0.00
12.4100	9.54E-10	-3.520	3.0411	-1.20E-10	0.00	7.84E+10	-1.006	2.15E+09	0.00
12.5800	6.17E-10	0.5917	1.3367	-1.58E-10	0.00	7.84E+10	-0.665	2.20E+09	0.00
12.7500	3.10E-10	1.9338	0.3082	-1.25E-10	0.00	7.84E+10	-0.343	2.25E+09	0.00
12.9200	1.07E-10	1.8492	-0.164	-7.58E-11	0.00	7.84E+10	-0.120	2.30E+09	0.00
13.0900	1.13E-12	1.2641	-0.288	-3.53E-11	0.00	7.84E+10	-0.00127	2.30E+09	0.00
13.2600	-3.73E-11	0.6738	-0.246	-1.01E-11	0.00	7.84E+10	0.04208	2.30E+09	0.00
13.4300	-4.00E-11	0.2586	-0.158	2.04E-12	0.00	7.84E+10	0.04511	2.30E+09	0.00
13.6000	-2.90E-11	0.03108	-0.07818	5.81E-12	0.00	7.84E+10	0.03268	2.30E+09	0.00
13.7700	-1.63E-11	-0.06040	-0.02608	5.43E-12	0.00	7.84E+10	0.01839	2.30E+09	0.00
13.9400	-6.85E-12	-0.07532	5.56E-04	3.66E-12	0.00	7.84E+10	0.00772	2.30E+09	0.00
14.1100	-1.37E-12	-0.05813	0.01001	1.93E-12	0.00	7.84E+10	0.00155	2.30E+09	0.00
14.2800	1.01E-12	-0.03449	0.01042	0.00	0.00	7.84E+10	-0.00114	2.30E+09	0.00
14.4500	1.57E-12	-0.01561	0.00745	0.00	0.00	7.84E+10	-0.00177	2.30E+09	0.00
14.6200	1.30E-12	-0.00411	0.00414	0.00	0.00	7.84E+10	-0.00147	2.30E+09	0.00
14.7900	0.00	0.00127	0.00170	0.00	0.00	7.84E+10	-9.19E-04	2.30E+09	0.00
14.9600	0.00	0.00284	3.13E-04	0.00	0.00	7.84E+10	-4.44E-04	2.30E+09	0.00
15.1300	0.00	0.00255	-2.83E-04	0.00	0.00	7.84E+10	-1.40E-04	2.30E+09	0.00
15.3000	0.00	0.00168	-4.13E-04	0.00	0.00	7.84E+10	1.21E-05	2.30E+09	0.00
15.4700	0.00	8.64E-04	-3.36E-04	0.00	0.00	7.84E+10	6.33E-05	2.30E+09	0.00
15.6400	0.00	3.10E-04	-2.08E-04	0.00	0.00	7.84E+10	6.28E-05	2.30E+09	0.00
15.8100	0.00	1.66E-05	-9.90E-05	0.00	0.00	7.84E+10	4.38E-05	2.30E+09	0.00
15.9800	0.00	-9.41E-05	-3.00E-05	0.00	0.00	7.84E+10	2.38E-05	2.30E+09	0.00
16.1500	0.00	-1.06E-04	4.02E-06	0.00	0.00	7.84E+10	9.48E-06	2.30E+09	0.00
16.3200	0.00	-7.77E-05	1.51E-05	0.00	0.00	7.84E+10	1.43E-06	2.30E+09	0.00
16.4900	0.00	-4.38E-05	1.46E-05	0.00	0.00	7.84E+10	-1.97E-06	2.30E+09	0.00
16.6600	0.00	-1.82E-05	9.76E-06	0.00	0.00	7.84E+10	-2.76E-06	2.30E+09	0.00
16.8300	0.00	-3.97E-06	4.45E-06	0.00	0.00	7.84E+10	-2.45E-06	2.30E+09	0.00
17.0000	0.00	0.00	0.00	0.00	0.00	7.84E+10	-1.91E-06	1.15E+09	0.00

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.11218349 inches
Computed slope at pile head = -0.0015934 radians
Maximum bending moment = 784953. inch-lbs
Maximum shear force = -92651. lbs
Depth of maximum bending moment = 7.99000000 feet below pile head
Depth of maximum shear force = 8.33000000 feet below pile head
Number of iterations = 67
Number of zero deflection points = 8
Pile deflection at ground = 0.00331267 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
17.00000	0.11218349	784953.	-92651.
16.15000	0.10951299	776239.	-91163.
15.30000	0.11677510	788210.	-93242.
14.45000	0.11098731	776969.	-91400.
13.60000	0.11402303	782433.	-92285.
12.75000	0.11494265	782585.	-93419.
11.90000	0.10995568	776738.	-93963.
11.05000	0.11365707	782815.	-94280.
10.20000	0.11149571	780633.	-93473.
9.35000	0.11120921	778614.	-93565.
8.50000	0.13864020	764899.	-165035.

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	0.1122	-0.00159	-92651.	784953.

Maximum pile-head deflection = 0.1121834907 inches
Maximum pile-head rotation = -0.0015934087 radians = -0.091296 deg.

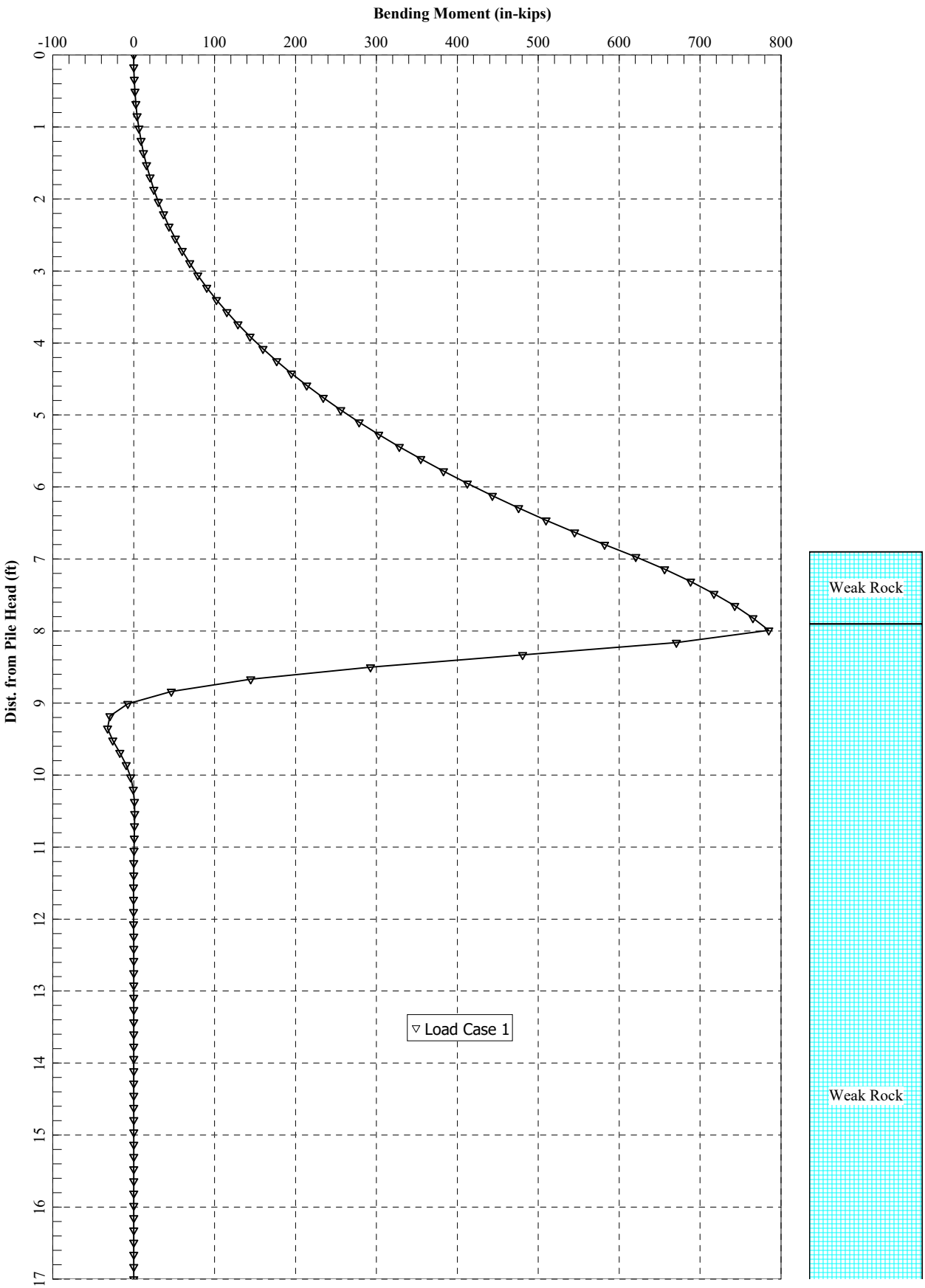
Summary of Warning Messages

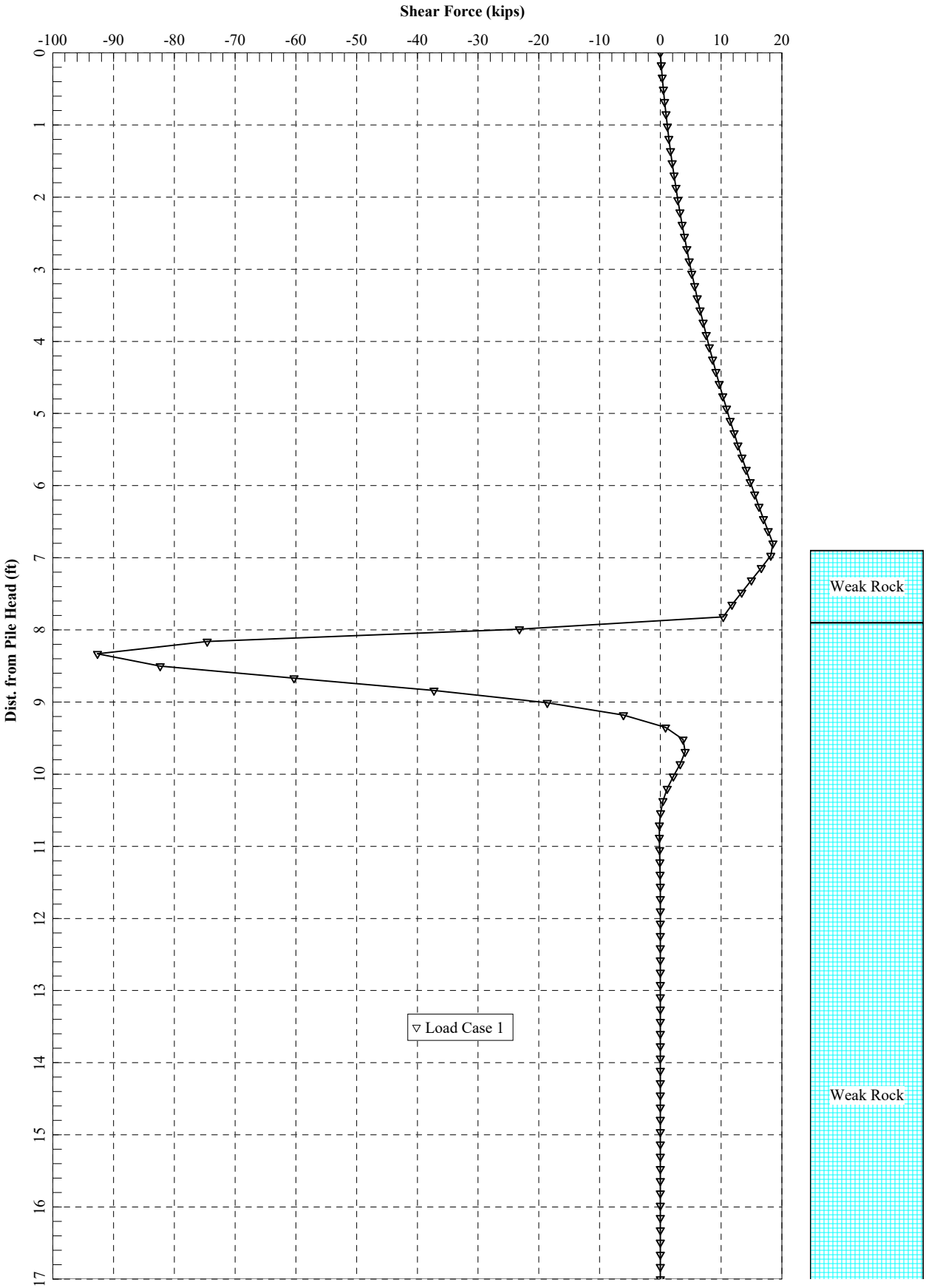
The following warning was reported 10000 times

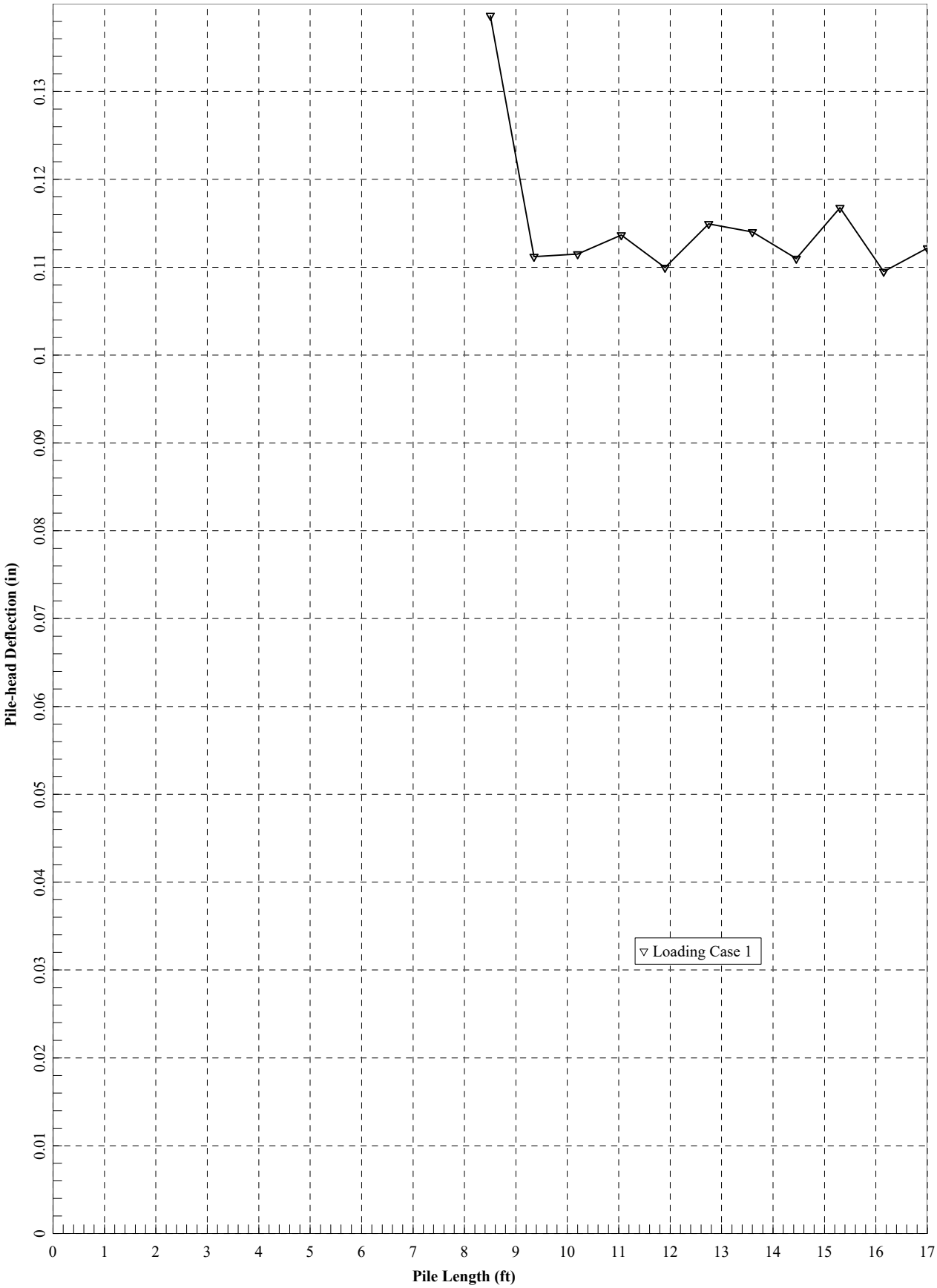
**** Warning ****

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.

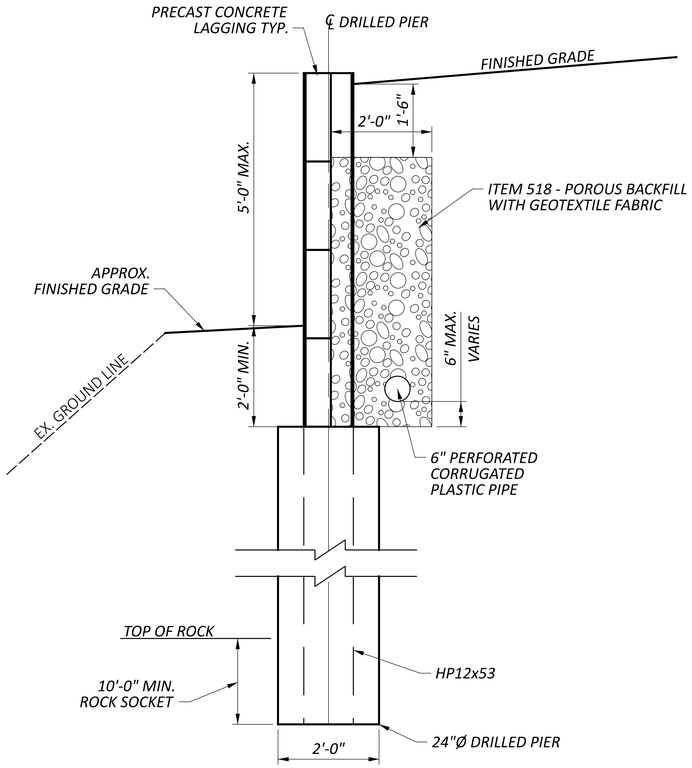
The analysis ended normally.


Bending Moment (in-kips)
-100
0
100
200
300
400
500
600
700
800
Dist. from Pile Head (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Load Case 1
Weak Rock
Weak Rock

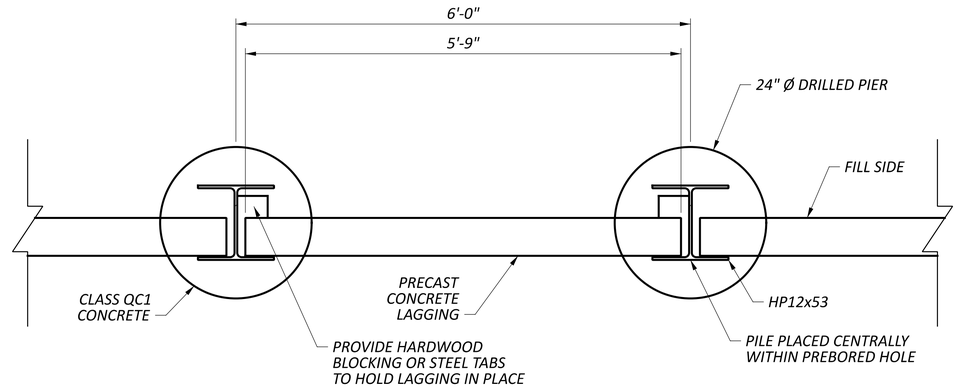

Shear Force (kips)
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
Dist. from Pile Head (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Load Case 1
Weak Rock
Weak Rock


Pile-head Deflection (in)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.13
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Pile Length (ft)
Loading Case 1

Soldier Pile and Lagging Wall Detail

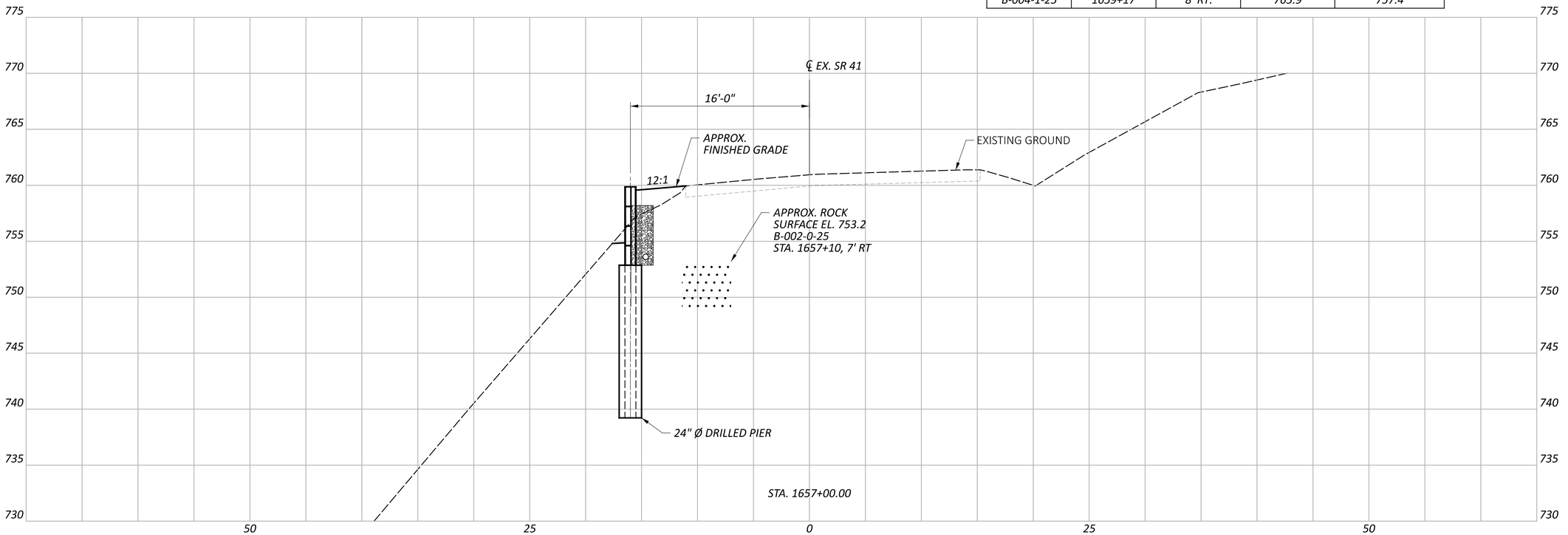


TYPICAL SECTION
NOT TO SCALE



PLAN - RETAINING WALL
NOT TO SCALE

BORING	STATION	OFFSET	APPROX. SURFACE ELEVATION	APPROX. ROCK SURFACE ELEVATION
B-001-0-25	1656+16	11 LT.	756.4	752.9
B-002-0-25	1657+10	7' LT.	760.7	753.2
B-003-0-25	1658+14	8' LT.	764.0	758.0
B-003-1-25	1658+15	11' RT.	765.9	758.4
B-004-0-25	1659+18	8' LT.	764.6	756.1
B-004-1-25	1659+17	8' RT.	765.9	757.4



HORIZONTAL SCALE IN FEET
0 5 10 20

SOLDIER PILE AND LAGGING WALL DETAIL
CRITICAL SECTION STA. 1657+00

DESIGN AGENCY
HDR

DESIGNER DCM
REVIEWER DMV 07/25/25
PROJECT ID 123193
SHEET 1 TOTAL 1

ADA-41-31.38

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 7/25/2025 TIME: 5:20:51 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Christopher.Wahlbrink@hdrinc.com WORKSPACE: OHDOTCEv02 WORKSET: 123193 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 09\Adams\123193\401-Engineering_HDR\Geotechnical\Sheets\123193_WD001.dgn