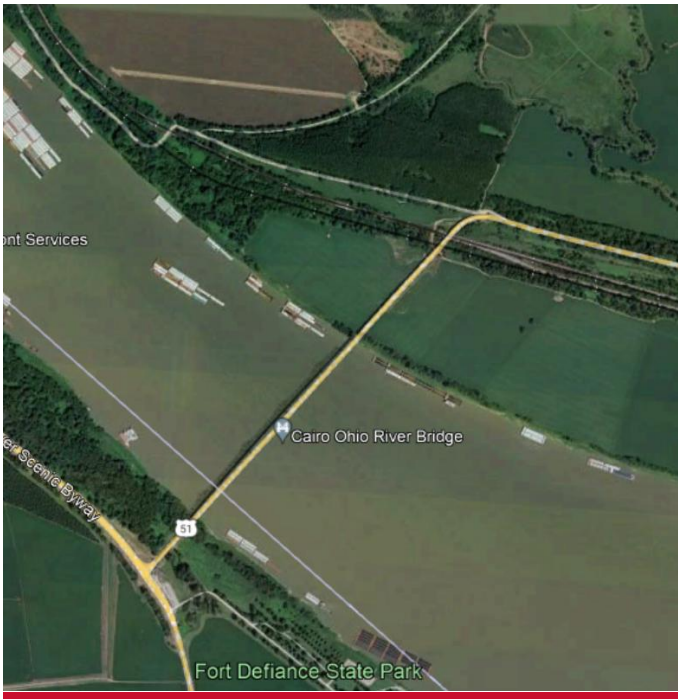


River Piers Foundation Geotechnical Report

US-51 Cairo Bridge Over Ohio River

Item No. 1-1140.00

Ballard County, Kentucky & Alexander County, Illinois

August 12, 2026

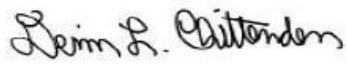
August 12, 2026

Mr. Erik Scott, P.E.
TEBM, Geotechnical Support & Review Branch
Division of Structural Design
1236 Wilkinson Boulevard
Frankfort, KY 40601-1200

Dear Mr. Scott,

We have completed the River Pier Bridge Foundation Geotechnical Report for the US-51 Bridge over the Ohio River improvements as part of the US-51 Ohio River Project. Please feel free to contact us at your convenience with any questions or comments regarding this report. HDR appreciates the opportunity to support this project and to provide geotechnical engineering services.

Sincerely,
HDR



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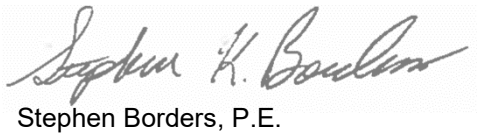

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Contents

Introduction 1

Subsurface Investigation and Lab testing 1

Geotechnical Investigation 1

Introduction 1

Summary of Subsurface Investigation Information 2

Geophysical Testing 6

Geotechnical Laboratory Testing 6

Geotechnical Site Characterization (Geology) 7

Generalized Site Stratigraphy 7

Geologic Hazards 8

Seismic Ground Motion Characterization and Site Response Analysis 8

Basis of Seismic Hazard and Design Parameters 8

Liquefaction Susceptibility and Seismic Deformations 9

Seismic Soil Profiles and Residual Strength Estimation 11

Summary of Scour Analysis 12

Foundation Analysis 12

Pipe Piles 13

Drilled Shafts 15

Group Resistance 15

Seismic Axial Resistance 16

Lateral Foundation Design Properties & Analysis Results 17

P-Y Method for Analysis and Required Soil Properties 17

Foundation Properties 18

Pile Cap Loads due to Lateral Displacements from Soil Liquefaction 18

Foundation Analysis for Load Test Program 19

Main Span Pier Foundation Analysis for Load Test Program 19

Global Stability Analysis 20

Summary and Conclusion 22

Limits to Report 23

References 24

Tables

Table 1. Summary of Boring and SCPTu Sounding Locations 2
Table 2. Summary of Soil Test Boring/Sounding Adversities 5
Table 3. Summary of Lab Test Quantities 6
Table 4. Summary of Seismic Parameters for Analysis 9
Table 5. Liquefaction Analysis Results 10
Table 6. Preliminary Scour Analysis Results 12
Table 7. Resistance Factors for Axial Resistance Analysis of Pipe Piles 14
Table 8. Seismic Downdrag Loads Per Pile 16
Table 9. Summary of Lateral Pile Cap Loads from Liquefaction Induced Lateral Displacements 19
Table 10. Revised Scour Analysis Results 20
Table 11. Ohio River Water Surface Elevations 20
Table 12. Global Stability Results at Service Limit State 21
Table 13. Global Stability Results at Rapid Drawdown (100-year Flood Water Level) 21
Table 14. 100YR PL Layer Elevations 22
Table 15. 1000YR PL Layer Elevations 22
Table 16. Global Stability Results at Extreme Limit State 22

Appendices

Appendix A – Site Vicinity Map, Coordinate Data Submission Form, Boring Plan, Subsurface Data Sheets, and Foundation Plan Sheets Excerpts

Appendix B – Sampling Method Definitions, Manufacturers Sampling Method Sheets, Drillers Boring Logs, & SCPTu Sounding Logs, P-S Suspension Logs

Appendix C – Laboratory Testing Results

Appendix D – Soil Parameters

Appendix E – Seismic & Liquefaction Analyses

Appendix F – Deep Foundation Analyses

Appendix G – Global Stability Analysis

Appendix H – Report Figures During Drilling Program

Introduction

The project is located in Ballard County, Kentucky (KY) and Alexander County, Illinois (IL) approximately four miles northwest of downtown Wickliffe, KY. This report presents the geotechnical design recommendations for the River Pier Foundations (Piers 3 through 8) for the proposed US-51 Bridge over the Ohio River. The foundation units outside of the River Piers will be evaluated and presented in a separate report. The purpose of this project is to meet the transportation needs of the region while improving the reliability of the connection between Kentucky and Illinois.

This report presents HDR's findings, conclusions, and recommendations regarding:

- Subsurface Conditions
- Geologic Setting and Hazards
- Evaluation of the engineering characteristics of the foundation soils; and
- Recommendations for deep foundations and the stability of the riverbanks.

As indicated in the US-51 Bridge Type Selection Report, the proposed structure over the Ohio River is a steel tied-arch, designated as having a main span length of 900-foot and 15-foot-deep foundation caps for the main span piers as well as the approach span river piers. The approach spans are proposed as welded steel plate girders with span lengths ranging from approximately 189 to 350 feet. The exploration plan for this phase of the project was developed by HDR with support from Terracon and was subsequently approved by Kentucky Transportation Cabinet (KYTC) in July 2023.

Recommendations presented herein are based on the applicable standards of the profession at the time of this report within this geographic area. HDR performed the work in accordance with the 9th Edition of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, the KYTC and Illinois Department of Transportation (IDOT) geotechnical design manuals, Federal Highway Administration (FHWA) geotechnical manuals, as well as the generally accepted state of the practice.

Subsurface Investigation and Lab testing

Geotechnical Investigation

Introduction

The geotechnical/geophysical fieldwork for this phase of the investigation (river borings) began on June 29, 2024, and was completed in its entirety on October 16, 2024. Of note, the Ohio River valley was hit with the remnants of three hurricanes during this period, with Hurricane Helene resulting in about a 1-to-2-week delay in fieldwork on the project due to high winds, rain, and increased flow/velocities of the river which limited the ability to set casing. The other tropical systems that impacted the project site, generally resulted in delays of less than 24-hrs. In addition to the delays associated with the tropical systems, periodic delays due to seasonal weather patterns were also encountered (typically under 6-hrs) and on July 25, 2024, a funnel cloud was observed near the work area, refer to Figure 2 in Appendix H.

Summary of Subsurface Investigation Information

Driller's Logs indicate Ohio River elevations during the subsurface investigation, shown on the right side of the log under the Remarks column. These elevations reference Gauge CIRI2 (NWSLI: CIRI2, Reach ID: 1841447) located in Cairo, Illinois at Lat/Long coordinates of 37.0000, -89.1625 and a Gauge Zero Elevation of 270.03 ft (NAVD88). The referenced gauge may be found at the following URL: https://water.noaa.gov/gauges/ciri2. Additionally, the surface elevations shown on the driller's logs and SCPTu sounding logs reference the mudline elevations, as shown in Table 1. The boring plan, coordinate data sheet, and subsurface data sheets are provided in Appendix A. Additionally, the individual driller's logs and SCPTu sounding logs are provided in Appendix B.

Initial boring locations were field verified with traditional survey means performed by Civil Design, Inc. (CDI). This typically occurred within one to two days of beginning drilling/advancing a boring and/or SCPTu. The Global Navigation Satellite Survey (GNSS) survey was performed and determined to be within allowable tolerances after comparisons with traditional surveys and discussions with HDR, Michael Baker, Int., and KYTC. After initial surveys confirmed accuracy of the GNSS GPS system, locations were periodically field verified by CDI. Additional field verifications of the GNSS GPS system occurred for borings in which P-S Logging (see subsequent sections) was performed or other locations that were deemed to be critical. A list of both GNSS and traditional surveyed boring/ SCPTu sounding locations and elevations are provided in Table 1.

Table 1. Summary of Boring and SCPTu Sounding Locations

Boring/ Sounding	Pier	Proposed Location		Surveyed Location				Elevation (feet)[1,2]	
				GNSS		CDI, Inc.			
		Lat. (deg)	Long. (deg)	Lat. (deg)	Long. (deg)	Lat. (deg)	Long. (deg)	Moonpool	Mudline
B1001	3	36.992375	-89.151871	36.992397	-89.151856	NA	NA	292.2	271.9
B1002	3	36.992410	-89.151924	36.992414	-89.151940	36.992396	-89.151967	306.5	273.5
B1002A	3	NA	NA	36.992381	-89.151911	36.992390	-89.151936	304.0	272.4
C1003	3	36.992393	-89.151898	36.992432	-89.151877	NA	NA	285.4	271.9
B1004	4	36.993119	-89.151112	36.993118	-89.151118	NA	NA	284.2	237.7
B1005	4	36.993153	-89.151165	36.993147	-89.151176	NA	NA	291.7	238.6
C1006	4	36.993136	-89.151138	36.993135	-89.151142	NA	NA	288.2	238.6
B1007	5	36.993882	-89.150518	36.993879	-89.150524	NA	NA	286.1	246.5
B1008	5	36.993826	-89.150433	36.993828	-89.150420	36.993809	-89.150443	292.4	243.7
B1009	5	36.993771	-89.150348	36.993772	-89.150359	36.993753	-89.150382	300.1	242.6
C1010	5	36.993758	-89.150503	36.993755	-89.150508	36.993736	-89.150532	284.8	244.6
C1011[3]	5	36.993894	-89.150364	NA	NA	NA	NA	NA	NA
B1012	6	36.995794	-89.148565	36.995798	-89.148573	NA	NA	285.2	258.5
B1013	6	36.995738	-89.148480	36.995737	-89.148486	36.995739	-89.148484	288.4	257.4
B1014	6	36.995683	-89.148395	36.995693	-89.148406	36.995675	-89.148404	301.8	257.1
C1015	6	36.995671	-89.148550	36.995668	-89.148547	36.995649	-89.148572	288.4	256.0
C1016	6	36.995806	-89.148411	36.995809	-89.148419	NA	NA	283.9	258.8
B1017	7	36.996411	-89.147747	36.996408	-89.147748	NA	NA	296.4	267.9
B1018	7	36.996445	-89.147800	36.996442	-89.147818	36.996417	-89.147833	306.3	262.1

Table 1. Summary of Boring and SCPTu Sounding Locations (Continued)

Boring/ Sounding	Pier	Proposed Location		Surveyed Location				Elevation (feet)[1,2]	
				GNSS		CDI, Inc.			
		Lat. (deg)	Long. (deg)	Lat. (deg)	Long. (deg)	Lat. (deg)	Long. (deg)	Moonpool	Mudline
C1019	7	36.996428	-89.147774	36.996428	-89.147777	NA	NA	281.2	267.7
B1020	8	36.997155	-89.146989	36.997169	-89.146989	NA	NA	295.8	270.8
B1021	8	36.997190	-89.147042	36.997195	-89.147042	36.997177	-89.147065	297.2	268.9
C1022	8	36.997172	-89.147015	36.997174	-89.147019	NA	NA	287.5	273.8
B1023	NA	36.997509	-89.146716	NA	NA	NA	NA	NA	272.7
B1024	NA	36.992800	-89.151437	36.992907	-89.151384	NA	NA	284.2	231.7
B1024A[4]	NA	NA	NA	NA	NA	NA	NA	NA	NA
C1025	NA	36.997474	-89.146663	36.997473	-89.146677	36.997454	-89.146701	296.9	277.0
C1026	NA	36.992835	-89.151490	36.992929	-89.151417	NA	NA	281.7	233.2

Notes:
1. Measured at Moonpool
2. Elevation at Mudline Calculated by Deck to Mudline Distance
3. SCPTu Sounding not Performed
4. Boring Location Not Attempted due to Obstruction near Surface

Geotechnical drilling and sampling consisted of Standard Penetration Testing (SPT) and thin-walled Shelby tubes. In addition to the thin-walled Shelby tubes, GUS sampling was also performed which is intended for very soft or weak soil deposits or where soil recovery is expected to be minimal using standard sampling techniques. The GUS soil sampler uses water or air pressure to extend the thin-walled sampler into the soil to retrieve an undisturbed sample. Additionally, GUS soil sampling was performed to collect relatively undisturbed samples of cohesionless soils in lieu of standard thin-walled soil sampling necessary for cyclic laboratory testing.

Soil samples within the upper 100-ft were generally collected at 5-ft intervals; from 100 to 200-ft, the sample interval was 10-ft, and from 200-ft to the boring termination depth, the sample interval was 20-ft. Borings were drilled using mud rotary drilling techniques except for Borings B1002A and B1024A which utilized casing to advance the boreholes. All borings achieved the proposed termination depths without encountering bedded material or refusal conditions. At five boring locations, soil coring techniques were attempted in both very dense cohesionless soils and hard cohesive soils. In general, recovery of granular material was of limited success whereas, the deeper clay was generally at or near full recovery. Of note, standard soil samples were still collected at prescribed intervals. Additional information regarding the subsurface investigation methods and noteworthy circumstances are provided in the sections below.

SOIL TEST BORINGS

Sixteen test borings were originally proposed to characterize subsurface conditions within the river pier foundations. Two additional borings/SCPTu soundings were later added (1002A and 1024) due to drilling difficulties and geophysical testing being performed within five of the borings. The following is a summary of the test borings:

- River Bents: Depths ranged from 193-ft to 403-ft below mudline
- Existing riverbank locations (B1023 and B1024): Depths of approximately 157-ft and 153-ft below mudline, respectively

- Two off-set borings were added:
    - B1002A – offset of B1002 in which a section of drill string was lost (and ultimately recovered). At the approved offset location, subsurface soils were sampled between depths of approximately 150-ft and 242-ft below the mudline, at which point, the boring was subsequently terminated.
    - B1024 – the original boring location, Boring 1024A, was terminated at mudline due to what appeared to be a concrete erosion control mat
- Drill casing was lost downhole at the three following locations and approximate depths after threads sheared:
    - B1023 – approximately 8-ft of drill casing lost around 150-ft below mudline
    - B1020 – approximately 10-ft of drill casing lost around 240-ft below mudline
    - B1007 – approximately 80-ft of drill casing lost around 120-ft below mudline

In addition to the challenges mentioned above, other obstructions were also identified on the river bottom by sonar, such as what appears to be a linear feature (refer to Figure 3 in Appendix H) or possible remnants of a barge that had sunk in the general vicinity. However, it is our understanding that this vessel was completely recovered based on discussions with personnel of Riverfront Services. In addition to the possible barge debris, organics (stumps) were visually identified by divers performing mussel surveys near the Illinois riverbank. Wood fragments were encountered at the B1002 boring location at a depth of about 205-ft below mudline (Figure 7 in Appendix H) and a large diameter aluminum cable (approximately one quarter inch in diameter) was also encountered within Boring B1002 at a depth of about 13-ft below mudline (Figure 8 in Appendix H). Lastly, apparent synthetic fibers were encountered about 13-ft below mudline in Boring B1013 (refer to Figure 9 in Appendix H). Communication with structures will be maintained to address constructability issues that may arise from existing debris or other deleterious materials.

SEISMIC PIEZOCONE PENETRATION TESTS (SCPTU)

Ten Seismic Piezocone Penetration Tests with pore pressure measurements (SCPTu) were proposed; however, one location was subsequently abandoned due to time and river constraints. Within all SCPTu soundings, if refusal occurred prior to the termination depth, the SCPTu sounding locations were to be drilled and temporarily cased to the refusal depth plus an additional 5 feet below the refusal depth. Subsequently, a second attempt of advancing the SCPTu sounding would take place and if refusal occurred after the second attempt, the SCPTu sounding could be terminated. This process will be abbreviated and designated as the CPT Refusal Mitigation (CRM) procedure herein. This procedure was implemented each time refusal occurred, even in the same test location. As the procedure mentions, the advancement of the cone was terminated once refusal occurred after the subsequent attempt. However, as discussed below, at several locations, multiple CRM's were attempted within individual SCPTu sounding. The following is a summary of the SCPTu soundings:

- River pier locations: One SCPTu sounding was proposed at each pier, except at the main span pier locations, where two SCPTu soundings were proposed.
- Existing Riverbank Locations: One SCPTu sounding near the toe of the Illinois and Kentucky riverbanks. Proposed depths ranged from 150-ft to 200-ft; however, actual hydraulically pushed depths ranged from 34-ft to 106-ft below mudline due to equipment encountering refusal conditions.

- Due to shallow refusal depths, CRM procedures were performed at several locations to extend SCPTu soundings to at least 100-ft below mudline. Additional CRM procedures (more than 2 CRMs) were performed in the following test locations:
    - C1010 (5 CRMs)
    - C1015 (3 CRMs)
    - C1016 (4 CRMs)
    - C1019 (3 CRMs)

- Refusal conditions were typically associated with high tip resistance, excessive sleeve friction, excessive rod tilt, and in one instance, excessive unsupported rod length as reported by the drill crew. Without the CRM procedure, the maximum depth of initial SCPTu advancement was about 30-ft to 35-ft except for C1025 which was pushed to depth of about 57-ft below mudline before a CRM procedure was required. Maximum penetration depth ranged from around 80-ft to 105-ft when implementing the CRM procedure. SCPTu data with increased depth was limited due to mechanical refusal conditions being encountered.

- Lastly, pore pressure dissipation tests were performed in fine-grained soils within the SCPTu soundings at several depths. Please refer to the drillers and SCPTu sounding logs, and dissipation test results in Appendix B.

- At the C1003 SCPTu sounding location, the CRM procedure was initiated; however, at a depth of about 34-ft below mudline, wood debris (Figure 4 in Appendix H) was encountered requiring additional tooling to remove the cone and allow the SCPTu testing to advance. Further, river levels dropped quickly which required the liftboat to move off the location without running aground on the river bottom (Figure 5 in Appendix H). At this location, one of the liftboat propellers was wrapped in steel cabling (assumed to be associated with erosion control matting – refer to Figure 6 in Appendix H) which required the liftboat crew to manually remove the cabling before the vessel could move to the next location. As such, SCPTu testing at this location was terminated before the CRM procedure was completed and subsequent SCPTu testing was attempted.

The table below summarizes the issues described above related to the advancement of soil test borings and SCPTu soundings. A brief description of the resulting action due to the difficulties encountered, if any action was taken, at each location is also provided.

Table 2. Summary of Soil Test Boring/Sounding Adversities

Boring/Sounding	Location	Described Adversity	Approx. Depth[1] (ft.)	Approx. Elevation (ft.)	Action Taken
B1002	Pier 3	Cable/Wire Encountered	13.0	EL. 260.5	N/A
B1002	Pier 3	Tooling Stuck	190.0	EL. 83.5	Hole abandoned; Offset to: Lat: 36.992411 Long: -89.151910
C1003	Pier 3	Wood Fragments Encountered	34.0	EL. 237.9	River levels lowered before CRM procedure could be performed. SCPTu sounding terminated at depth of 34.1’

Table 2. Summary of Soil Test Boring/Sounding Adversities (Continued)

Boring/Sounding	Location	Described Adversity	Approx. Depth[1] (ft.)	Approx. Elevation (ft.)	Action Taken
B1007	Pier 5	Lost Tooling (~85.5 ft of 6in SW Casing)	120.0	EL. 126.5	Abandoned Tooling
B1020	Pier 8	Lost Tooling (~10.0 ft of Casing and Drill Bit)	240.0	EL. 30.8	Abandoned Tooling
B1023	East Riverbank	Lost Tooling (~8.4 ft of Drill Stem)	150.0	EL. 122.7	Abandoned Tooling
B1024A	West Riverbank	Encountered Concrete Debris at Lat: 36.992800 Long: -89.151437	0.0	Unknown	Hole abandoned; Offset to: Lat: 36.992907 Long: -89.151384

Notes:
1. Depths are below mudline.

Geophysical Testing

P-S Logging, or an instrument used to obtain compressional (P) and shear (S) wave downhole velocities, were collected at target depths ranging from 250-ft to 400-ft within five of the soil borings using a Robertson Geo P-S Logger. The P-S Logging probe is comprised of a downhole hammer and two receivers separated by acoustic damping tubes. The probe is held stationary as each measurement depth with data measurements are collected.

In addition to the P-S logging, shear wave velocities were recorded at each pier or riverbank location within the SCPTu soundings. Shear wave velocities were recorded at nominal 3-ft depth intervals beginning at depths up to 6-ft below the mudline and extending to depths ranging from approximately 34-ft to approximately 106-ft below the mudline. At C1015, shear wave data was unable to be collected, and at C1016, shear wave data collection did not begin until a depth of 46-ft below the mudline. Results of the P-S Logging and SCPTu shear wave velocities are provided in Appendix B.

Geotechnical Laboratory Testing

During geotechnical drilling, soil samples from SPT and thin-walled samples (both standard Shelby tube and GUS samples) were delivered to HDR for laboratory testing. HDR's Paducah, Kentucky office performed conventional laboratory tests as summarized in Table 3.

Table 3. Summary of Lab Test Quantities

Test Type	Quantity
Natural Moisture Content	586
Atterberg Limits	206
Full Sieve Analysis with #200 Wash	380
Full Sieve Analysis with Hydrometer	206
Unconsolidated Undrained Triaxial Test	13

Further, nine of the GUS and Shelby tube samples, consisting of both cohesive and cohesionless soil samples, were shipped to GeoTesting Express in Atlanta, GA for Resonant Column (RC) and Cyclic Direct Simple Shear (CDSS) testing. These tests are necessary to determine soil properties for the ground response seismic analyses. Of the nine samples submitted for testing, only six specimens were suitable for testing and only four samples had sufficient material for the full suite of seismic tests (i.e., RC and CDSS). The cyclic testing performed on these samples is as follows:

- Resonant Column (RC)
- Cyclic Direct Simple Shear (CDSS)

Results of the soils lab testing including the RC and CDSS tests are presented in Appendix C.

Geotechnical Site Characterization (Geology)

The existing US Highway 60/62 bridge is situated southeast of the town of Cairo, Illinois, crossing the Ohio River, connecting Illinois to Kentucky. Physiographically, the surrounding area is located on the northern tip of the Mississippi Embayment, a wedge-shaped region of topographically low relief comprising 100,000 square miles within the Gulf Coastal Plain extending from the southern tip of Illinois, southward to the Gulf of Mexico. The Embayment is an artifact of a failed continental rift that originated from a subsurface system of predominantly northeast to southwest-trending normal faults known as the Reelfoot Rift. The rift is considered active to this day and is the primary cause of earthquake activity within the New Madrid Seismic Zone. Beginning during the Mesozoic, the rift was gradually infilled with marine and deltaic sediments, creating the Embayment feature as seen today.

The site is located near the confluence of the Mississippi and Ohio rivers, which today produces alluvial sediments of primarily clayey deposits with intermittent and discontinuous sand layers grading with depth to gravels. The most recent deposited alluvium is stratigraphically designated as Cahokian (Wisconsin-stage Glacial Period, Holocene) (Wright, 1964), the base of which – based on boring interpretations – is believed to lie between 180 to 200 feet elevation. Cahokian sediments are supported by Eocene deposits of the Claiborne and Wilcox formations, undivided. The Claiborne and Wilcox Formations consist of white to yellow, orange and reddish brown, fine to coarse-grained poorly sorted sand, silt, and clay. Based on borehole data, the base of the Claiborne and Wilcox Formations is interpreted at approximately -30 to -35 feet elevation where the top of the Porters Creek Formation (Paleocene) is encountered. The Porters Creek Formation is composed of a dark gray to dark olive-gray stiff and massive conchoidally-fractured clay with thin laminae of light gray micaceous fine-grained silt and sand. The base of the Porters Creek Formation was not encountered in advanced borings; however based on published geologic maps, these deposits are believed to extend to approximately -200-ft elevation, where undivided marine Cretaceous deposits of the Owl Creek, McNairy, and Post Creek Formations lie, composed of similar fine quartz-rich sands, micaceous and glauconitic silts and clays (Fisk, 1944). Cretaceous deposits are believed to extend to approximately -225-ft elevation, where the Devonian New Harmony Group is believed to lie, extending to an elevation of greater than -800-ft. The upper portion of the New Harmony Group is composed primarily of white to light gray chert cobbles to approximately -500-ft elevation, where a dark gray siliceous and argillaceous limestone was encountered in historic boreholes (greater than 800-ft depth) (Nelson, W.J. 2008).

Generalized Site Stratigraphy

In general, the soil profile at the boring locations consisted of up to 10 feet of silty clay to silty sand with intermittent lenses of sand and silt soils overlying cohesionless soils that generally consist of clean to silty sands and gravels that extended to deep clay layer generally encountered at elevations ranging from -10 to -30 ft. This deep clay layer (Porter's Creek Clay Formation) generally classifies as lean to fat clay. A picture of a sample collected near 385 feet below the mudline within B-1013 has been interpreted as originating from the Porter's Creek Formation, as portrayed on Figure 10 in Appendix H. Further, large

diameter cobbles classified as cherts were also observed in the base of the Claiborne-Wilcox formation in Boring B-1008, depicted in Figure 11 in Appendix H.

Geologic Hazards

Seismic Ground Motion Characterization and Site Response Analysis

Terracon performed the site response analyses and seismic ground motion characterization necessary for the liquefaction and seismic deformation at the river pier locations. Site response analysis was performed using equivalent linear and nonlinear total stress methods with SHAKE2000 and DEEPSOIL, and AASHTO limiting response spectra were developed using the USGS Uniform Hazard Tool. A ground motion study (GMS), which included a probabilistic seismic hazard analysis (PSHA), was performed to develop a uniform hazard spectrum using site-specific time histories. The PSHA characterizes the seismic hazard at the pier locations, incorporating regional seismicity, ground motion attenuation relationships, and site-specific conditions. Based on Terracon's ground motion study, acceleration histories for dynamic analysis of structures are typically generated by modifying recorded histories from past earthquakes. The goal is to select records that, after modification, possess the important engineering characteristics (i.e., amplitude, frequency content, and duration) of the design event. Selection criteria for this project included spectral shape, significant duration, Arias intensity, earthquake magnitude, site distance, and lowest usable frequency. The results of Terracon's ground motion study may be viewed in their Tech Memo dated November 3rd, 2025.

Basis of Seismic Hazard and Design Parameters

The liquefaction and seismic deformation analysis was conducted at each river pier and riverbank utilizing the results of the subsurface site investigation, Terracon's site response analysis and GMS. The GMS utilized the 2018 USGS National Seismic Hazard Model to develop Uniform Hazard Response Spectra (UHRS) at the base of the soil profile (Site Class C, V_{s30} =1500 ft/s). These spectra were generated for two primary hazard levels:

- 7% probability of exceedance in 75 years (approx. 1,033-year return period)
- 50% probability of exceedance in 75 years (approx. 109-year return period)

Deaggregation of the hazard indicated that the New Madrid Seismic Zone is the primary contributor of ground shaking at the site. The moment magnitudes for liquefaction triggering identified for use in the analyses were:

- M = 6.99 for the 1,033-year event (Also referred to herein as the "1,000-year event")
- M = 5.98 for the 109-year event (Also referred to herein as the "100-year event")

The site response analyses were performed by Terracon using both equivalent linear (SHAKE2000) and nonlinear total stress methods (DEEPSOIL). The final design response spectrum was compared to the AASHTO LRFD limiting spectra for Site Class D developed from the USGS Uniform Hazard Tool. The design spectra were adjusted, or increased, accordingly where site-specific spectral accelerations fell below 2/3 of the AASHTO values. Liquefaction susceptibility and resulting seismic settlement and lateral displacement analyses were conducted using the following return period accelerations, as modified and limited by AASHTO code values.

Table 4. Summary of Seismic Parameters for Analysis

Design Event	Earthquake Magnitude	Distance (km)	Ground Surface – Design PGA_m (g)					
			Pier 3	Pier 4[1]	Pier 5	Pier 6	Pier 7	Pier 8[2]
7% PE in 75 yrs (~1000-yr)	6.99	14.5	0.530	0.530	0.530	0.530	0.530	0.530
50% PE in 75 yrs (~100-yr)	5.98	127	0.081	0.079	0.063	0.086	0.121	0.075

Notes:
1. Seismic Parameters used in the west riverbank liquefaction analysis
2. Seismic Parameters used in the east riverbank liquefaction analysis

The provided response spectra do not account for kinematic interaction with respect to the response of the bridge structure and is intended to show the response at the groundline/mudline. If kinematic interaction is to be considered in design, it may be considered in an approximate manner by employing response spectra from a representative depth to be selected by the design team. These spectra can be developed at the request of the design team. At this time, the design response spectra will remain at the ground surface and have been incorporated into the analysis. Once the site-specific response analysis has been completed for the adjacent land piers, the kinematic loads due to the lateral displacements will be incorporated into the design.

Liquefaction Susceptibility and Seismic Deformations

Liquefaction susceptibility analyses and the resulting vertical settlements and lateral displacements were evaluated at each river pier location using data from each SPT boring, SCPTu sounding, and results from the suspension logging. The primary inputs for the liquefaction analysis included normalized SCPTu cone resistances, SPT N-values, shear wave velocity, and laboratory soil classification test results (plasticity and gradation), supplemented by site-specific ground motions and response spectra developed through the GMS. Cyclic Resistance Ratio (CRR) values were calculated and compared to Cyclic Stress Ratio (CSR) values to estimate the factor of safety against liquefaction, with a triggering threshold defined as a factor of safety of 1.1 per Section 6.3.4 of FHWA-NHI-11-032: Seismic Design – Geotechnical Features.

METHODOLOGY

Liquefaction screening, identification, and evaluation were performed using multiple established procedures. These included SCPTu-based methods developed by Youd et al. (2001) and Idriss and Boulanger (2008) and SPT-based methods developed by Idriss and Boulanger (2008). Additionally, V_s-based methods developed by Youd et al. (2001) and Kayen et al. (2013) were used in determining liquefaction susceptibility; however, the SCPTu-based and SPT-based methods took precedence over the Vs-based methods. SCPTu soundings collect data at greater intervals (essentially continuously), and the SPT-based methods are widely accepted by industry standards in part because soil properties are derived from tested, physical characteristics. Accordingly, the SCPTu and SPT methods offer a higher level of discernment for liquefaction susceptibility relative to the V_s-based methods.

As such, the SCPTu-based methods were preferred for identifying the base limits of liquefaction triggering and SPT- and V_s-based methods were used to further refine liquefaction boundaries, especially in areas where SCPTu data was limited due to shallow refusal. Liquefaction susceptibility using V_s-based results, the SPT data, and laboratory testing were also used to verify liquefiable zones identified in SCPTu profiles.

The following describes the general process of evaluating liquefiable zones and displacement profiles for this project:

- Perform the liquefaction analysis on each, SCPTu sounding, SPT boring, and collected V_s data at each pier location.

- Results from each method were plotted to holistically view data points so that liquefiable layers or zones could be established and trends from each method could be easily identified. Thus, using the three independent methods, potential liquefiable zones were identified where there was convergence in two or more of the three analysis results.

- The SCPTu results provide more data points which made it easier to view trends and better definition of liquefiable zones. The SCPTu results were graphically compared to the SPT and V_s data points for confirmation. If the SCPTu- and SPT-based results indicated certain intervals in the soil profile as non-liquefiable yet the Vs-based results did, the sleeve and cone tip resistances, SPT N-values, lab data results, etc., were reviewed and liquefiable zones were adjusted as necessary.

- Results for vertical settlement and lateral displacement from each method were also plotted together to view the range in predicted displacements. Average displacements may be determined and plotted over the results if desired by the design team; however, for the purposes of this analysis, each method's resulting vertical and lateral displacement were shown for completeness.

AGE-CORRECTION FACTORS

Additionally, age correction factors, or K_{DR} values, were reviewed for liquefaction screening; however, it was decided to withhold K_{DR} values greater than unity in the analysis. Age correction factors increase the resistance to liquefaction since it has been recognized that soil particle interlocking and rearrangement becomes greater with age. At this project site, a very dense sand layer was consistently encountered at each river pier and was near the approximate elevation of the Eocene formation, or older soil deposits. Thus, the liquefaction screening evaluation did not consider liquefaction below the approximate elevation of this very dense material. However, each SPT, CPT, and V_s-based analysis was reviewed on a case-by-case basis and engineering judgment was used to determine liquefaction potential of the materials. This methodology seemed appropriate, instead of applying an overarching age correction value to approximate elevations of the Eocene soil deposits, considering the location within the New Madrid seismic zone.

SUMMARY OF RESULTS

The results of the liquefaction analyses are summarized in Table 5 and presented graphically in Appendix E.

Table 5. Liquefaction Analysis Results

Location	Approximate Mudline Elevation (ft. AMSL)	Bottom of Liquefaction Elevation (ft. AMSL)	Bottom of Liquefaction Depth (ft. Below Mudline)	Approximate Thickness of Liquefiable Layers (ft.)	Estimated Range of Vertical Seismic Settlement (in.)	Estimated Range of Lateral Spread Displacement (ft.)
100-yr Return Period						
Pier 3	270.0	264.5	5.2	7.4	0.2 – 1.6	0.2 – 1.6
Pier 4	238.6	233.0	5.6	5.6	0.8 – 2.1	0.8 – 2.1
Pier 5	244.3	238.0	6.3	5.0	1.1 – 2.1	1.1 – 2.1
Pier 6	257.7	242.0	15.7	17.0	0.0 – 3.2	0.0 – 3.2
Pier 7	265.4	237.6	27.8	27.8	0.0 – 6.3	0.0 – 6.3
Pier 8	270.0	252.8	17.2	17.2	0.0 – 2.1	0.0 – 2.1

Table 5. Liquefaction Analysis Results (Continued)

Location	Approximate Mudline Elevation (ft. AMSL)	Bottom of Liquefaction Elevation (ft. AMSL)	Bottom of Liquefaction Depth (ft. Below Mudline)	Approximate Thickness of Liquefiable Layers (ft.)	Estimated Range of Vertical Seismic Settlement (in.)	Estimated Range of Lateral Spread Displacement (ft.)
East Riverbank	277.0	262.0	15.0	9.0	0.0 – 1.1	0.0 – 1.1
West Riverbank	233.2	226.6	5.1	6.6	0.9 – 2.6	0.9 – 2.6
1,000-yr Return Period						
Pier 3	270.0	199.0	73.7	40.4	4.2 – 9.3	2.3 – 6.3
Pier 4	238.6	195.0	43.6	11.6	1.1 – 6.5	1.5 – 4.1
Pier 5	244.3	224.0	20.3	15.0	0.0 – 2.4	1.5 – 2.3
Pier 6	257.7	200.0	57.7	45.0	0.9 – 6.7	0.4 – 5.8
Pier 7	265.4	173.2	92.2	68.3	3.1 – 9.4	4.6 – 10.3
Pier 8	270.0	179.0	91.0	46.2	3.8 – 7.9	6.2 – 7.9
East Riverbank	277.0	198.0	79.0	65.7	7.2 – 14.0	4.6 – 16.8
West Riverbank	233.2	192.4	40.8	23.8	3.9 – 4.3	2.2 – 3.3

The analysis indicates that at the 1,000-year return period event, there is significant potential for liquefaction of foundation soils across the river pier portion of the bridge. Additionally, foundation soils at river piers 6, 7, and 8, as well as soils at the eastern riverbank location, show notable liquefaction potential even at the 100-year event.

The estimated vertical settlements and lateral displacements shown in Table 5 are based on screening methods from Robertson (1998, 2009) for CPT data and Idriss and Boulanger (2008) for SPT data. The largest predicted displacements—both vertical and horizontal—are expected near Pier 7, Pier 8, and eastern riverbank location. The range in vertical settlements and lateral displacements due to liquefaction, as indicated above, are without mitigation measures and do not consider soil-structure interaction effects from the river piers. These estimates are derived from empirical correlations and should be considered approximate; lateral spreading predictions represent a rough order-of-magnitude, especially for larger calculated displacements.

Seismic Soil Profiles and Residual Strength Estimation

Residual shear strengths were estimated for discrete soil layers identified as potentially liquefiable, designated as “PL” layers. For the SPT-based analyses, these estimates were developed using methods from Idriss and Boulanger (2007), Olsen and Johnson (2008), and Kramer and Wang (2015), which rely primarily on corrected SPT blow counts and effective overburden stress. For SCPTu-based methods, the estimated residual shear strengths were developed using Youd et al. (2001), Olsen and Johnson (2008), and Idriss and Boulanger (2008) which rely primarily on the normalized cone resistance.

It should be noted that for the eastern riverbank location, the preliminary phase boring and CPT (B-3 and CPT-3, respectively) were used to further define the residual shear strengths of potentially liquefiable soils. The liquefaction analysis of the borings and CPTs indicates that potentially liquefiable soils occur at similar elevations across this riverbank; however, the vertical effective stress and the residual shear strength of

the liquefiable soils will increase as overburden increases along the bank. Therefore, the residual shear strength ratio, S_r/σ'_v, for each method is presented at the eastern riverbank liquefaction analysis and was implemented in global stability analysis. The same phenomenon occurs at the western riverbank; however, the distance between the recently obtained subsurface data within the river and the preliminary phase CPT and boring is relatively large. Thus, a reasonable estimation of the change in residual shear strength for liquefiable soils due to the increase in vertical effective stress was not evaluated at this location. Revised stability analyses will be required at the riverbanks as geotechnical data, including results of the Site-Specific Response Analyses (SSRA), at each land pier location are evaluated and the liquefaction analyses at these locations are refined. Once additional information is acquired, the lateral spread analysis at the riverbanks may be performed and the results will be provided under separate cover.

A graphical summary of the PL layers and their associated residual shear strengths for each river pier is provided in Appendix E. The results of these analyses were used to develop seismic soil profiles for each river pier location. These profiles, included in Appendix D, formed the basis for the seismic foundation analysis documented in this report.

Summary of Scour Analysis

A scour analysis was performed by Michael Baker International (MBI) at each river pier location as part of the hydraulic evaluation for the project. The analysis included estimates of contraction scour, local scour, and total scour for the 100-year and 500-year hydraulic events, designated as the Design Flood and Check Flood, respectively. These estimates were developed in accordance with HEC-18 guidance and based on subsurface data obtained from the available subsurface data.

The results of the preliminary scour analyses were considered in the static foundation analyses, as discussed later in this report, and the preliminary scour values for each pier and hydraulic event are summarized in Table 6. As the design progressed, the hydraulic analysis and scour values were revised after the foundation analysis design was performed and approved by KYTC. Thus, the foundation analyses will be revised during the final design phase; however, for the deep foundation load test program, the analyses were revised with the updated scour values at three pier locations which corresponded to the proposed locations for the load test areas. More information regarding these analyses is presented in the Foundation Analysis Load Test Program section in this report.

Table 6. Preliminary Scour Analysis Results

Pier	100-Year Event (Design Flood)			500-Year Event (Check Flood)		
	Contraction Scour (ft.)	Local Scour (ft.)	Total Scour (ft.)	Contraction Scour (ft.)	Local Scour (ft.)	Total Scour (ft.)
3	3.75	13.64	17.39	3.53	46.14	49.67
4	3.75	18.15	21.90	3.53	52.09	55.62
5	3.75	18.74	22.49	3.53	79.47	82.99
6	3.75	25.94	29.69	3.53	87.45	90.98
7	3.75	26.17	29.92	3.53	59.45	62.97
8	3.75	17.83	21.57	3.53	51.24	54.76

Foundation Analysis

Static and seismic analyses were performed for drilled shafts and pipe piles at each river pier location; however, following the results of these foundation analyses, the design team elected to move forward with

pipe piles as the preferred foundation type. Thus, some sections herein may not include results for the drilled shafts option as the decision had been made. However, the analysis performed and presentation of results for the drilled shafts option is included in this report for inclusion and transparency. Variations in subsurface conditions not identified during the current exploration program may influence the estimated resistances and required foundation lengths. The following sections present the analysis results and associated design recommendations. Axial resistance estimates will be refined once load test data from the planned preconstruction testing program become available during later design phases.

Pipe Piles

PROPOSED PIPE PILE SIZES AND CONDITIONS

Axial resistance calculations were performed for pipe piles with a 72-inch diameter and 1.5-inch wall thickness at river piers 3 through 8. The resistances were computed for two different conditions for the 72-inch pipe piles – (1) an open-ended pipe pile and (2) an open-ended pipe pile with a constrictor plate.

PLUGGING OF OPEN-ENDED PIPE PILES

The development of a soil plug for open-ended pipe piles in medium dense to dense sands generally begins at a pile penetration to pile diameter ratio of 20 but can be as high as 35. For pipe piles in soft to stiff clays, plugging can occur at penetration-to-pile diameter ratios of 10 to 20 (FHWA, 2016). Plugging during driving is significantly less likely for large diameter open-ended pipe piles, particularly for piles larger than 36 inches in diameter. Instead, the large diameter pipe piles will “core” through the soil resulting in less end bearing resistance.

Condition 1: Open-Ended Pipe Piles without a Constrictor Plate

The total resistance for this condition was determined by computing the exterior side resistance plus the end bearing resistance; however, the end bearing resistance was calculated using two separate methods (unplugged or plugged) and the minimum end bearing resistance from these two methods was used as the “design end bearing” value. This methodology was adopted from FHWA-HRT-20-011: Development of Guidelines for Bearing Resistance of Large Diameter Open-End Steel Piles.

The first method for computing end bearing resistance assumes an unplugged condition (i.e. Condition 1a) by computing the base resistance acting on the pipe pile annulus plus the interior side resistance developing along the interior of the pipe pile. The unit skin friction value for computing the interior side resistance was conservatively reduced by 50 percent to account for soil disturbance as the soil inside the pile progresses upwards relative to the pile. This 50 percent reduction represents the assumed residual shear strength of the soil. The second method for computing end bearing resistance assumes a plugged pile condition (i.e. Condition 1b) or base resistance acting on the entire cross-sectional area and not including the interior side resistance within the pipe pile. As previously mentioned, the minimum end bearing resistance from these two methods was used to determine the total pile resistance.

Condition 2: Open-Ended Pipe Piles with a Constrictor Plate

Considering the uncertainty of plugging in large-diameter pipe piles, resistance was also evaluated for piles equipped with an internal constrictor plate installed at a depth approximately matching the anticipated bearing stratum at the site. A constrictor plate attempts to prevent soil from moving further up inside the pipe pile so that a soil plug develops. This method for computing the total resistance combines the exterior side resistance and the end bearing resistance acting on the entire pipe pile cross-sectional area beginning at the installed constrictor plate depth. If constrictor plates are utilized, those described in KYTC Report SA-015-2010, which were used for the pipe piles at the US 68/KY 80 Bridge over Kentucky Lake, are recommended to reduce uncertainty and enhance axial resistance where required by design loads.

AXIAL RESISTANCE

Axial resistances for pipe piles were developed utilizing the following resistance factors for the static and seismic axial resistance calculations:

Table 7. Resistance Factors for Axial Resistance Analysis of Pipe Piles

Condition	Limit State	Event Description	Skin Friction φ	End Bearing φ	Uplift φ
Static	Strength I	100-YR Design Scour	0.8	0.8	0.5
	Extreme Event II	500-YR Check Scour	1.0	1.0	0.8
Seismic	Extreme Event I	100-YR Earthquake	1.0	1.0	0.8
		1,000-YR Earthquake	1.0	1.0	0.8

Notes:
1. Static, Strength I resistance factors based on AASHTO LRFD Table 10.5.5.2.3-1.
2. Both static and seismic, Extreme Event resistance factors based on AASHTO LRFD Article 10.5.5.3.

Axial resistances were calculated using soil parameters derived from the results of the subsurface investigation and laboratory testing program performed at each river pier. The static resistance factor of 0.80 for the Strength I limit state is based on establishing driving criteria by successful static load test of at least one pile per site condition and dynamic testing of at least two piles per site condition, but no less than 2% of the production piles.

Axial resistance for steel pipe piles was estimated using the P2A Method for mixed soil profiles, also commonly referred to as the American Petroleum Institute (API) design method, presented in FHWA-NHI-16-009. The Ensoft computer program APILE (v2025), employing the API design methodology, was used to validate the P2A Method for selected design conditions and river pier locations. For a pipe pile with a constrictor plate, the analysis assumed that the pile must penetrate a minimum of three pile diameters into the target bearing stratum to achieve a fully plugged condition. This assumption is consistent with the design approach implemented for the US 68/KY 80 Bridge over Kentucky Lake, as documented in KYTC Report SA-015-2010. Additionally, for cohesionless soils, the unit skin and toe resistance values were limited to those provided in Table 7-8 of FHWA-NHI-16-009.

Static axial resistance was estimated for two scour conditions, the design flood at the Strength I limit state and the check flood at the Extreme Event II limit state, in accordance with the recommendations of FHWA-NHI-16-009 and FHWA-NHI-18-024. All material in the scour prism above the total scour line was assumed to be removed and unavailable for axial support. Additionally, the effects of scour on vertical stress distribution along the pile length were considered when evaluating reductions in axial resistance, in accordance with Figure 10-18 of FHWA-NHI-18-024. This consideration is most applicable to cohesionless soils, where side resistance is directly influenced by the vertical effective stress.

Graphs showing the axial static resistance versus depth for a single pipe pile, with and without a constrictor plate, are provided for each river pier location in Appendix F. Uplift resistance graphs are also provided in these appendices. Discussion of the seismic neutral plane and the estimated seismic downdrag loads is provided later in this report. The very dense sand layer associated with the Claiborne and Wilcox formation, which starts between El. 155 and 200 ft, is anticipated to be the bearing layer for the piles. We anticipate piles will be driven into the very dense sand layer across the various foundations.

DRIVABILITY

HDR performed preliminary drivability analyses to estimate the ultimate driving resistance and potential damage that the pipe piles may experience during installation. HDR estimated the driving resistances under the assumption that resistances would be reduced to approximately 83% of the nominal resistance (Gain/Loss factor of 0.83) due to the increase in pore water pressure during the driving process.

Drivability analyses were conducted utilizing the GRLWEAP (version 2014) computer program that modeled the proposed 72-inch diameter steel pipe piles driven by pile hammers with average energy ratings ranging from approximately 500 ft-kips to 700 ft-kips. Detailed drivability analyses will be performed during final design to evaluate the driving resistance to the required depths.

Drilled Shafts

TYPE AND SIZE

Axial resistance calculations for drilled shafts were performed for a 96-inch diameter drilled shaft at each river pier location. Because bedrock depths exceed 200 feet at the river pier locations, the drilled shafts will depend on both skin and tip resistance within the soil to support the structural loads.

AXIAL RESISTANCE

Factored axial resistances were developed considering the following resistance factors (φ_{stat} / φ_{up} / φ_{load}) for skin friction, end bearing, and uplift resistance for drilled shafts in accordance with AASHTO LRFD Table 10.5.5.2.4-1:

Strength I Limit State:

- Side Resistance in Clay, φ_{stat} – 0.45
- Side Resistance in Sand, φ_{stat} – 0.55
- Uplift Resistance in Clay, φ_{up} – 0.35
- Tip Resistance in Clay, φ_{stat} – 0.40
- Tip Resistance in Sand, φ_{stat} – 0.50
- Uplift Resistance in Sand, φ_{up} – 0.45
- Tip and side resistance in all materials, φ_{load} – 0.70 (Static Load Test)

Extreme Event I/II Limit States:

- Tip and Side Resistance in All Materials, φ_{stat} – 1.00
- Tip and Side Resistance in All Materials, φ_{stat} – 1.00
- Uplift Resistance in All Materials, φ_{up} – 0.80

Axial resistances were calculated using soil parameters and idealized soil profiles derived from the results of the subsurface investigation and laboratory testing program performed at each river pier. In general, the static resistance estimates at the Strength I limit state assumes the completion of a successful static compression load test, and therefore, is based on a tip and side resistance factor of 0.70, while the seismic resistance curves at the Extreme Event I/II limit states are based on a tip and side resistance factor of 1.0. Axial resistance for drilled shafts at the limit states under consideration was estimated using the α-method for clay soils and the β-method for granular soils developed by Brown et al., (2010) and recommended in FHWA-NHI-18-024. Additionally, the Ensoft computer program SHAFT (v2023), employing this design methodology, was used to validate the axial resistance estimates for drilled shafts.

Similar to the pipe piles, static axial resistance was estimated for two scour conditions, the design flood at the Strength Limit I state and the check flood at the Extreme Event II limit state, in accordance with the recommendations of FHWA-NHI-16-009 and FHWA-NHI-18-024. For each limit state, all material in the scour prism above the total scour line was assumed to be removed and unavailable for axial support and the effects of scour on vertical stress distribution along the pile length were considered.

Graphs showing the axial static resistance versus depth for a single 96-inch diameter drilled shaft are provided for each river pier location in Appendix F. Uplift resistance graphs are also provided in these appendices.

Group Resistance

Preliminary evaluations of group resistance in axial compression have been performed; however, the results are not included in this report and will be updated once the structural loads and foundation layouts are finalized. Group effects and resistances for pile foundations will be evaluated in accordance with Sections 10.7.3.9 and 10.7.3.11 of the AASHTO LRFD Bridge Design Specifications, while those for drilled

shaft foundations will follow Sections 10.8.3.6 and 10.8.3.7 during subsequent design iterations. Because the final arrangement and loading conditions of the foundation groups have not yet been established, only individual pile and shaft resistances are presented herein.

Seismic Axial Resistance

Seismic axial resistance was estimated for two return periods, the 100-yr return period and the 1000-yr return period. Per AASHTO LRFD 9th Edition, Section 3.4.1 – Load Factors and Load Combinations, local pier scour and contraction scour depths should not be combined with earthquake loads; therefore, scour was not included in the seismic axial resistance calculations. Graphs showing the axial seismic resistance versus depth for a single pipe pile, with and without a constrictor plate, and for a single 96-inch diameter drilled shaft are provided for each river pier location in Appendix F. These resistance curves are provided for use by structures to help finalize the pier foundation design using FB-MuliPier.

SEISMIC DOWNDRAG

As part of the seismic foundation design, a liquefaction-induced downdrag analysis was performed in TZPile v2021 to assess the potential for negative skin friction acting on deep foundations at the river pier locations. The analysis employed the neutral plane method discussed in FHWA-NHI-16-009, which evaluates the balance between the dead load and accumulated drag load (negative skin friction) above the neutral plane, and the available skin friction and end bearing resistance below it. Theoretically, the neutral plane represents the depth at which the pile and surrounding soil transition between downward drag forces and upward resistance. Downdrag analyses using the neutral plane method require unfactored permanent (dead) structural loads; therefore, since final loads are not yet available, approximate order-of-magnitude loads ranging from 650 to 2,000 kips were assumed for the river piers. Load and resistance curves illustrating the location of the neutral plane, assumed structural loads, and the magnitude of the downdrag loads are provided in Appendix F for each river pier. Table 8 presents the seismic downdrag loads at the river piers; however, results may change based on the final design.

In relation to the downdrag analyses, ongoing pseudo-static slope stability analysis at both riverbanks indicate that the soil mass is susceptible to liquefaction-induced lateral flow, with a high potential for lateral spreading and significant ground displacements. As a result, mitigation measures are likely required to address these seismic hazards. Potential mitigation measures may include ground improvement techniques designed to reduce soil mobility and enhance stability such as vibro-stone columns, rigid inclusions, or deep soil mixing. Depending on the type and extent of the selected ground improvement technique, seismic downdrag loads may be reduced or eliminated at the river pier locations near the banks. A revised downdrag analysis will be performed once the need for ground modification is confirmed and a specific mitigation approach is defined.

Table 8. Seismic Downdrag Loads Per Pile

Foundation Type & Size	Downdrag Load (Kips) – 100-YR Return Period					
	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8
Pipe Piles – 72” x 1.5”	0	0	0	19	15	0
Pipe Piles – 72” x 1.5” with Constrictor Plate	0	0	0	14	37	0
Drilled Shafts – 96” Diameter	13	0	3	15	12	0
Foundation Type & Size	**Downdrag Load (Kips) – 1000-YR Return Period**					
	Pier 3	**Pier 4**	**Pier 5**	**Pier 6**	**Pier 7**	**Pier 8**
Pipe Piles – 72” x 1.5”	990	429	220	278	919	688
Pipe Piles – 72” x 1.5” with Constrictor Plate	1061	429	234	207	924	732
Drilled Shafts – 96” Diameter	1024	363	241	447	830	899

FOUNDATION LOAD-DEFORMATION ANALYSES

A preliminary load–deformation analysis was performed to support the downdrag evaluation using the neutral plane method. The analysis was based on the assumed pile loading conditions and compared against the estimated liquefaction-induced seismic settlement profile. The intersection of the pile settlement curve and the seismic soil settlement curve theoretically represents the location of the neutral plane, where the pile is expected to move with the soil. Inconsistency between the neutral plane estimated with the neutral plane method relative to the point where pile and soil settlement are equal is likely related to the assumptions that 100% of the skin is mobilized.

An updated load–deformation analysis will be performed once final design loads are available to further validate the neutral plane method and satisfy LRFD requirements at the service limit state. In general, the load-deformation analysis evaluates the side and base resistances that are mobilized at axial displacements induced by the design load. Axial displacements are then compared to tolerable deformations for the structure. As such, this will require a great deal of communication with the structural design team and multiple iterations; therefore, the information presented in the appendix should be taken as preliminary and for information purposes only.

Lateral Foundation Design Properties & Analysis Results

The following sections present the geomaterial properties, the selected method for analyzing lateral resistance from soils, and reductions in lateral resistance due to group effects. The design parameters will be refined once load test data from the planned preconstruction testing program become available during later design phases; therefore soil-structure interaction analyses may be updated with this new information. Additionally, the estimated lateral loads imparted on foundation caps due to free-field lateral displacements from soil liquefaction are provided in the following sections at the applicable piers. Soil properties required for the p-y analysis were provided to the structural design team so that they could perform the soil-structure interaction analysis; however, this type of analysis requires coordination between geotechnical and structural design teams to properly evaluate horizontal displacement and resistance from soils. This coordination is exhibited when evaluating lateral forces on pile caps due to lateral displacements from liquefied soils.

P-Y Method for Analysis and Required Soil Properties

At each of the foundation locations, HDR developed the subsurface layering (including top and bottom elevation of each stratigraphic unit) and corresponding strength properties for analysis based on an evaluation of the subsurface data. The unit weight and static (Mohr-Coulomb) strength parameters for each layer were estimated based on correlations with index properties (i.e. blow count, moisture content, Atterberg limits, etc) and corresponding laboratory testing where available. The seismic (Mohr-Coulomb) strength parameters were developed considering the effects of the shaking and potential liquefaction, which resulted in residual strengths within the loose sands and softer clays/silts. In addition, HDR also provided static and seismic soil properties in Appendix D, including the horizontal subgrade reaction (static and cyclic), the major principal strain for clay-like soils, Poisson's ratio, and the shear modulus for use in soil-structure interaction analysis. The layering and corresponding static and seismic soil parameters are presented in Appendix D.

The p-y method will be implemented in the soil-structure interaction analyses in FB-Multipier or an equivalent program and is a more rigorous semi-empirical method that incorporates theory and empirical data modeling the soil resistance per unit length of pile, "p", as a series of nonlinear springs versus the lateral soil or pile deflection, "y". The analyses will incorporate other modes of displacement in conjunction with lateral displacements; thus, additional soil properties and geotechnical resistance information, such as the unit side and unit end bearing resistance values for the t-z and q-z curve types, are required to model

the vertical soil or pile displacement similar to the p-y method. The soil parameters for the soil-structure interaction analysis, both static and seismic cases, are provided in Appendix D.

Foundation Properties

Physical properties of the foundation, such as the shape, material, and dimensions were provided by the structural design team. The spacing between each foundation influences the group action and the lateral capacity of individual piles will reduce for closer spacing due to overlapping stress zones; thus, group p-multipliers are used to modify soil resistance based on the position of an individual foundation element in the foundation group and the center-to-center spacing between foundation elements in accordance with Section 10.7.2.4 of the 9th Edition of AASHTO LRFD. See Figure 1 below which provides the p-multipliers for the current foundation layout (assumes piles are spaced 3D) at the two pier locations (Pier 3 and Pier 8) accentuated for discussion herein, which are subject to lateral flow forces. P-multipliers for the remaining piers will be calculated by Structures for use in FB-MultiPier and will not be provided herein. Excerpts of the foundation layout sheets are provided in Appendix A.

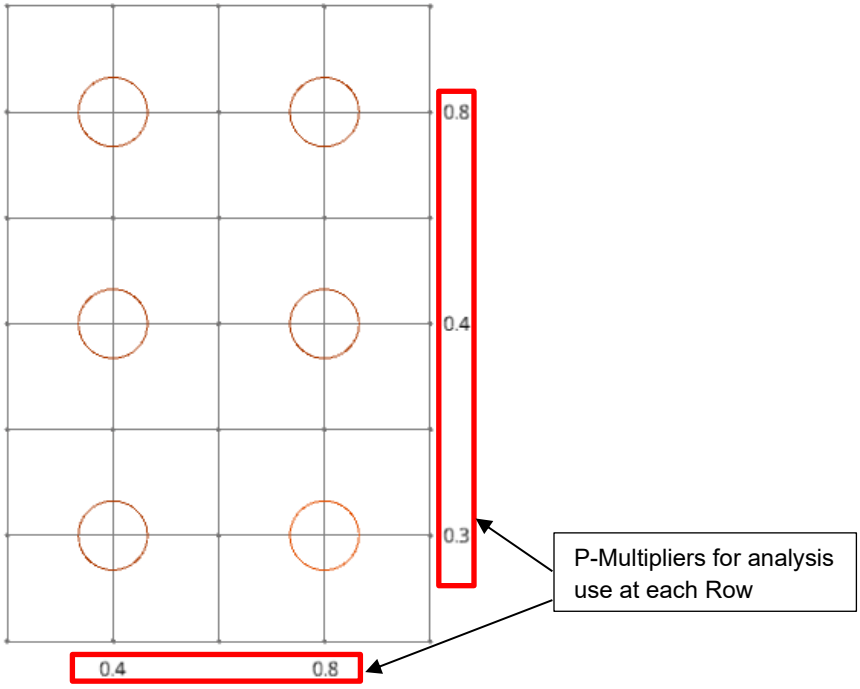

Figure 1. P-Multipliers for Pier 3 and Pier 8

Pile Cap Loads due to Lateral Displacements from Soil Liquefaction

As previously mentioned, the preferred foundation type for the river piers are large diameter steel pipe piles, and for two river piers (Pier 3 and Pier 8) near the riverbanks, a portion of each pile cap is estimated to be below the mudline elevation. This results in additional lateral loads to the cap as lateral displacements occur relative to the pile cap due to soil liquefaction. Preliminary calculations have been performed to determine the magnitude of lateral load applied to the pile cap due to these lateral displacements. For this analysis, soil liquefaction is expected to occur within the same elevation range of the top and bottom of each pile cap; thus, the p-y curve for liquefied soil (using residual shear strengths for liquefied soil) was used to evaluate the lateral load without a soil crust.

The total force due to flow liquefaction is estimated by using the lateral ground displacements determined from liquefaction analyses (refer to Table 5). For this analysis, the average lateral displacement values were used and the mobilized lateral soil resistance per unit length, p, is then computed based on the lateral

displacement using the liquefied p-y model specified in the seismic soil profiles. The mobilized soil reaction is then converted to soil pressure based on the cap dimensions and a resultant force, acting on the transverse face of the pile cap is computed. Additionally, the lateral forces from the liquefied soil displacement along the sides of the pile cap were determined by applying adhesion factors on the side faces as appropriate. Finally, the total force due to flow liquefaction is obtained by summing all resultant forces acting on the pile cap. The following table presents the approximate resultant lateral loads at each of the affected piers.

Table 9. Summary of Lateral Pile Cap Loads from Liquefaction Induced Lateral Displacements

Pier	Top of Cap Elevation (ft. AMSL)	Bottom of Cap Elevation (ft. AMSL)	Estimated Range of Lateral Displacement over Pile Cap (in.)	Total Force due to Flow Liquefaction[1,2] (kips)
100-YR Return Period				
Pier 3	282.0	270.0	0.6 – 8.0	123.0
Pier 8	282.0	270.0	1.0 – 15.0	155.0
1000-YR Return Period				
Pier 3	282.0	270.0	39.0 – 50.0	155.0
Pier 8	282.0	270.0	44.0 – 77.0	131.0

Notes:
1. Forces represent the resultant lateral load applied to the cap and will be appropriately distributed throughout the structural system.
2. Scour was not considered in the development of the lateral forces.

It should be noted that scour was not considered when performing these analyses. Section 3.4.1 – Load Factors and Load Combinations of AASHTO LRFD 9th Edition states that local pier scour and contraction scour depths should not be combined with earthquake loads; however, it also mentions that one-half of the total scour may be considered. Section 3.4.1 states that the joint probability of these events is extremely low and therefore, the events are specified to be applied separately.

Foundation Analysis for Load Test Program

A design-phase load test program is proposed for the US-51 Bridge Replacement Project stemming from the results from the preliminary phase of the project as well as the results of the river pier foundation analyses discussed within this report. Both phases of design for this project established sound reasoning for a design-phase load test program that will benefit final design. The predicted seismic loads transmitted to the foundations and superstructure are significant; thus, a thorough examination of the foundations to obtain soil characteristics for design use would be greatly beneficial in multiple aspects of this project. Also, by completing the load test program during the design phase, we can utilize higher resistance factors in the final design and evaluate opportunities for potentially shortening some of the required foundation lengths due to having site-specific foundation tests.

Main Span Pier Foundation Analysis for Load Test Program

As previously mentioned, scour depths were revised and foundation analyses were revisited to determine the order lengths for the load test program. The table below summarizes the scour information for the design flood (100-YR return period) and check flood (500-YR return period) used in this revised analysis.

Table 10. Revised Scour Analysis Results

Pier	100-Year Event (Design Flood)			500-Year Event (Check Flood)		
	Contraction Scour (ft.)	Local Scour (ft.)	Total Scour (ft.)	Contraction Scour (ft.)	Local Scour (ft.)	Total Scour (ft.)
6	3.10	23.32	26.42	3.01	24.06	27.07

Axial loads per foundation pier were estimated by the structural design team so that axial loads per pile could be used to determine pile lengths for the Strength-I, Extreme Event-I, and Extreme Event-II Limit States could be performed. Since the option to include a constrictor plate is available, the analyses were performed for both pile options (with and without a constrictor plate) and order lengths were obtained by comparing the pile lengths for each limit state to determine the minimum required pile length.

For the load test program, pile driving criteria are provided for initial pile driving operations and for pipe piles with constrictor plates, extended driving criteria is provided. The extended driving program is proposed to evaluate the effectiveness of the artificial plug in terms of resistance and pile mobilization with the increase in tip, or end bearing, resistance. Appendix F includes the minimum pile length evaluations as well as a modified version of the pile properties and testing assignments table used in the Special Note for Pile Load Test Program, focusing on the river pier foundation load tests.

Global Stability Analysis

Global stability analyses of potential deep-seated failure surfaces at both riverbanks were performed using the computer program SLOPE/W (GeoStudio, 2025.2) using the Spencer method. Circular failure surfaces for the existing slopes were evaluated at the Service Limit State for short-term (undrained) and long-term (drained) global stability and the Extreme Event Limit State for pseudo-static seismic (undrained) and rapid drawdown (undrained) global stability. Wedge failure surfaces were evaluated at the seismic Extreme Limit State using the residual shear strengths for liquefiable layers. Normal pool and maximum flood elevations, used in global stability analyses, are presented in Table 11 below. Results of the global stability analyses are presented in Appendix G.

Table 11. Ohio River Water Surface Elevations

Water Condition	Water Surface Elevation (ft. ASML)
Normal Pool	300.0
Maximum Flood Elevation	331.9

The adopted design strengths used in the global stability analyses were developed based on the results of laboratory strength testing, SPT blow counts, CPTs, as well as our general experience in the area. Target factors of safety for global stability at the limit states considered were obtained via the KYTC Transmittal Memorandum 19-02, Section GT-601-3, dated June 21st, 2019.

Tables of the design strengths and profiles are included in Appendix D. Table 12 below provides the results of the global stability analyses performed at the Service Limit State at the normal pool water condition for the existing riverbank slopes.

Table 12. Global Stability Results at Service Limit State

Location	Slope	Short-term Factor of Safety		Long-term Factor of Safety	
		Calculated	Minimum Required	Calculated	Minimum Required
IL, Riverbank	5H:1V[(1)]	1.7	1.3	1.7	1.4
KY, Riverbank	4H:1V[(1)]	1.9		1.4	

Notes:
1. Approximate existing slope; assumed undisturbed; no construction fill or slope grading.

The results of the analyses indicate that the global stability design requirements using normal pool water conditions for long-term and short-term stress states are satisfied for both undisturbed riverbanks.

Rapid drawdown analyses have been conducted using the maximum flood water level, which corresponds to an elevation of 331.9 feet, drawn down to normal pool conditions. The results of the global stability analysis performed for rapid drawdown are provided below in Table 13.

Table 13. Global Stability Results at Rapid Drawdown (100-year Flood Water Level)

Location	Slope	Rapid Drawdown Factor of Safety	
		Calculated	Minimum Required
IL, Riverbank	5H:1V[(1)]	1.6	1.1
KY, Riverbank	4H:1V[(1)]	1.4	

Notes:
1. Approximate existing slope; assumed undisturbed; no construction fill or slope grading.

The riverbank slopes were evaluated at the Extreme Event I Limit State for seismic global stability. For the Extreme Event I Limit State analysis, HDR considered pseudo-static (circular) and displacement based seismic wedge stability analyses. For the seismic wedge analyses, HDR considered Case I: liquefaction with no seismic loading. The riverbank slopes are capable of displacements of 1.0 to 2.0 inches; thus, the lateral acceleration coefficient, k_h, was reduced to 50 percent of the PGA when the factor of safety resulted in a value less than 1.0 for both the 100-year and 1,000-year seismic events. This reduction in the PGA value is based on guidance within FHWA-NHI-11-032.

Wedge analyses were performed for the Extreme Limit State at each “Post-Liquefied” (PL) layer identified in the seismic analysis using the normal pool water level. Table 14 and Table 15 below provide the elevations of the PL layers at each riverbank. Tables of the seismic design strengths are included in Appendix D. Table 16 provides the results of the global stability analyses performed at the Extreme Event-I Limit State for the existing riverbank embankments.

It should be noted that at the Illinois riverbank, liquefiable layers PL-1 through PL-3, are identified below as discrete layers; however, this is so the increase in residual strength (due to vertical effective stress) may be considered for design. Additionally, for analysis purposes, the liquefiable layers followed the riverbank slope geometry and the elevations shown in the tables below are the elevation ranges of each respective liquefiable layer. The liquefaction analysis indicates the soils are liquefiable within the elevation intervals shown below for PL-1 through PL-3.

Table 14. 100YR PL Layer Elevation Ranges

Location	100YR PL Elevations (ft. ASML)			
	PL1		PL2	
	Top	Bot.	Top	Bot.
IL, Riverbank	271.9	264.5	243.7	226.6
KY, Riverbank	271.0	262.0	-	-

Table 15. 1000YR PL Layer Elevation Ranges

Location	1000YR PL Elevations (ft. ASML)									
	PL1		PL2		PL3		PL4[1]		PL5	
	Top	Bot.	Top	Bot.	Top	Bot.	Top	Bot.	Top	Bot.
IL, Riverbank	295.1	264.5	289.0	258.0	284.0	242.5	243.7	221.0	212.7	192.4
KY, Riverbank	305.0	225.0	216.0	198.0	-	-	-	-	-	-

Notes:
1. PL Layer 4 (PL-4) is only present near the toe of the Illinois side riverbank and extends towards the channel.

Table 16. Global Stability Results at Extreme Limit State

Location	Pseudo-Static		Wedge Case I – 100YR		Wedge Case I – 1000YR					Minimum Required
	100YR	1000YR	PL1	PL2	PL1	PL2	PL3	PL4	PL5	
IL, Riverbank	1.1	0.6	0.8	1.4	0.6			--[1]	2.0	1.1 (ϕ=0.9)
KY, Riverbank	1.4	0.8	1.0	--	1.1	1.6	--	--	--	

Notes:
1. PL Layer 4 (PL-4) is only present near the toe of the Illinois side riverbank and extends towards the channel; thus, when analyzed, the stability analysis did not produce a critical factor of safety.

The results of the seismic analyses indicate that the global stability design requirements for Pseudo-Static (1000-YR event only) and Case I (for various PL layers) are not satisfied at both undisturbed riverbanks. Therefore, ground modification will be required to improve stability. Ground modification techniques are currently being investigated to evaluate feasibility, constructability, and cost. Further information will be presented at a later date.

Summary and Conclusion

At the time of this report, final foundation loads were not available and much of the results presented herein are on-going and will require updating. Particularly, results related to seismic downdrag, load-deformation, group resistance behavior, and pile drivability. Once the load test program has been concluded, structural loads are finalized, and a determination has been made for the appropriate technique for ground modification, a final report compiling all recommendations will be provided.

Axial resistances and soil parameters for lateral analyses have been developed for three deep foundation options at each river pier location: (1) open-ended steel pipe piles, (2) open-ended steel pipe piles with a constrictor plate, and (3) drilled shafts; however, as previously mentioned, the preferred foundation option for the river piers are steel pipe piles.

Revisions to the recommendations presented herein will be required as the design progresses. The unit side and unit tip resistance values presented in this report are based on soil parameters derived from lab testing results and published resources and the resistance factors are contingent upon successful completion of the planned design phase load testing program. Results from this program will be used to

refine the estimated resistances, establish appropriate driving criteria, and verify the viability of the very dense sand layer within the Wilcox/Claiborne formation as the target bearing stratum. Additionally, the load test program will include verification testing of the ground modification technique(s) to determine the appropriate method to mitigate liquefaction and provide required resistance to vertical and lateral displacements.

Limits to Report

This final geotechnical bridge report presents the geotechnical liquefaction, foundation, and global stability analysis findings, conclusions, and results for the river pier and riverbank locations for the proposed US-51 Bridge Replacement project. It has been prepared in accordance with generally accepted engineering practice and a manner consistent with the level of care and skill for this type of project within this geographic area. No warranty, expressed or implied, is made.

The conclusions and results presented herein are based on field reconnaissance, research, and available literature, the results of field exploration and laboratory materials testing, and the results of engineering analyses. The conclusions and recommendations do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to re-evaluate the conclusions and recommendations based upon on-site observations of the conditions. In the event that changes are made in the design or location of the proposed structure, the recommendations presented in the report shall not be considered valid unless the changes are reviewed by the geotechnical engineer of record and conclusions of this report modified and/or verified in writing. The opportunity should also be given to review the structural plan, grading plan, and project specifications when the design is finalized. This review is generally warranted to ensure that the recommendations and comments provided herein have been thoroughly understood and properly implemented.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, partly on our general experience, and on the state-of-the-practice at the time of this writing.

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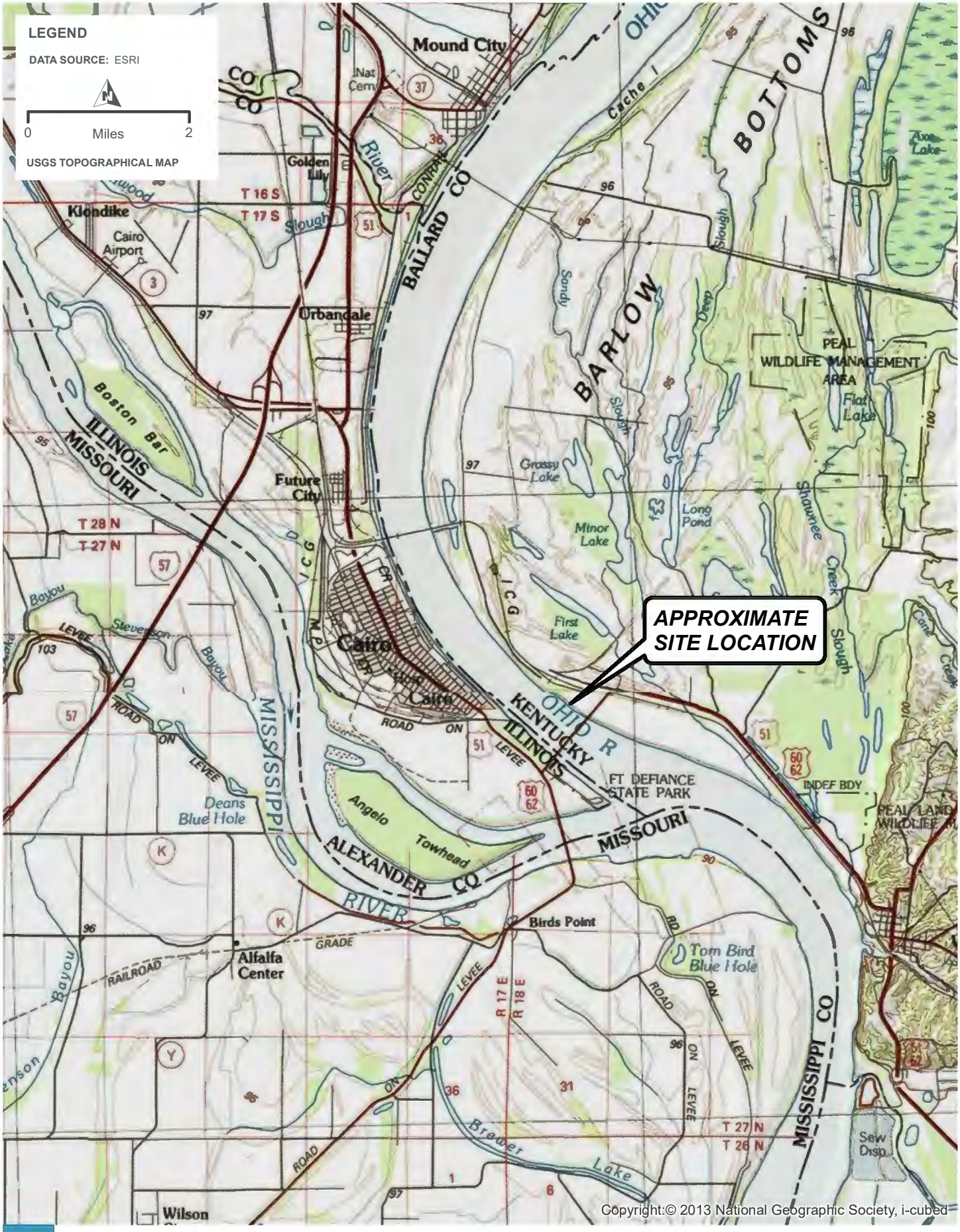
Appendix A – Site Vicinity Map, Coordinate Data Submission Form, Boring Plan, Subsurface Data Sheets, and Foundation Plan Sheets Excerpts



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US-51 CAIRO BRIDGE OVER OHIO RIVER

BALLARD COUNTY - KENTUCKY

SITE VICINITY MAP

SUBSURFACE INVESTIGATION

COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF STRUCTURAL DESIGN -- GEOTECHNICAL BRANCH

County Ballard **Date** 9/17/2025

Road Number US 51

Survey Crew / Consultant HDR, Inc.

Contact Person Devin Chittenden

Item # 01-1140.00

Mars #

Project #

Notes:

Elevation Datum (circle one) **Sea Level** **Assumed**

HOLE NUMBER	LATITUDE (Decimal Degrees)	LONGITUDE (Decimal Degrees)	HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)
B-1001	36.992397	-89.151856	B-1001	2038+75	10’ Rt.	271.9
B-1002	36.992396	-89.151967	B-1002	2038+73	15’ Lt.	273.5
B-1002-A	36.99239	-89.151936	B-1002-A	2038+78	7’ Lt.	272.4
C1003	36.992432	-89.151877	C1003	2038+90	4’ Lt.	271.9
B-1004	36.993118	-89.151118	B-1004	2042+24	9’ Rt.	237.7
B-1005	36.993147	-89.151176	B-1005	2042+21	11’ Lt.	238.6
C1006	36.993135	-89.151142	C1006	2042+24	CL	238.6
B-1007	36.993879	-89.150524	B-1007	2045+48	33’ Lt.	246.5
B-1008	36.993809	-89.150443	B-1008	2045+54	3’ Rt.	243.7
B-1009	36.993753	-89.150382	B-1009	2045+49	30’ Rt.	242.6
C1010	36.993736	-89.150532	C1010	2045+17	CL	244.6
B-1012	36.995798	-89.148573	B-1012	2054+50	35’ Lt.	258.5
B-1013	36.995739	89.148484	B-1013	2054+49	1’ Lt.	257.4
B-1014	36.995675	-89.148404	B-1014	2054+52	27’ Rt.	257.1
C1015	36.995649	-89.148572	C1015	2054+18	1’ Rt.	256.0
C1016	36.995809	-89.148419	C1016	2054+81	3’ Lt.	258.8
B-1017	36.996408	-89.147748	B-1017	2057+64	10’ Rt.	268.7
B-1018	36.996417	-89.147833	B-1018	2057+61	10’ Lt.	262.1
C1019	36.996428	-89.147777	C1019	2057+74	CL	267.7
B-1020	36.997169	-89.146989	B-1020	2061+25	10’ Rt.	270.8
B-1021	36.997177	-89.147065	B-1021	2061+17	12’ Lt.	268.9
C1022	36.997174	-89.147019	C1022	2061+25	1’ Lt.	273.8
B-1023	36.997509	-89.146716	B-1023	2062+75	10’ Lt.	272.7
B-1024	36.992907	-89.151384	B-1024	2041+15	3’ Rt.	231.7
B-1024-A	36.9928	89.151437	B-1024-A	2040+75	10' Rt.	NA
C1025	36.997454	-89.146701	C1025	2062+75	10’ Rt.	277.0
C1026	36.992929	-89.151417	C1026	2040+75	10’ Lt.	233.2

R = 1500.00'
E = 4.92'
e = ___%
Runoff =
Runout =

2029+00 2030+00 2031+00 2032+00 2033+00 2034+00 2035+00 2036+00 2037+00 2038+00 2039+00 2040+00 2041+00

1009+00
1010+00
1011+00
1012+00
1013+00
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1015+00
1016+00

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B–1
CPT–1
B–2004
C2006
B–2005
MASW–1
C2009
B–2007
B–2008
MASW–2
B–2
CPT–2B
B–1002
B–1002–A
C1003
B–1001

℄ ILLINOIS ABUTMENT
STA 2029+38.55

℄ PIER 1
STA 2032+25.00

℄ PIER 2
STA 2035+50.00

℄ PIER 3
STA 2038+75.00

PLAN

~SUPERSTRUCTURE NOT SHOWN~

LEGEND

- FINAL TEST LOCATIONS
- FINAL CPT LOCATIONS
- PRELIMINARY TEST LOCATIONS

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: W SHUECRAFT
CHECKED BY

BORING LAYOUT
CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	ALEXANDER
	SHEET NO. S012	DRAWING NUMBER

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B–1024
B–1005
C1006
B–1004
C1010
B–1007
B–1008
B–1009

℄ PIER 4
STA 2042+25.00

℄ PIER 5
STA 2045+50.00

℄ SURVEY US-51

N41°24'53"E

OHIO RIVER

PLAN

~SUPERSTRUCTURE NOT SHOWN~

LEGEND

- FINAL TEST LOCATIONS
- FINAL CPT LOCATIONS
- PRELIMINARY TEST LOCATIONS

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

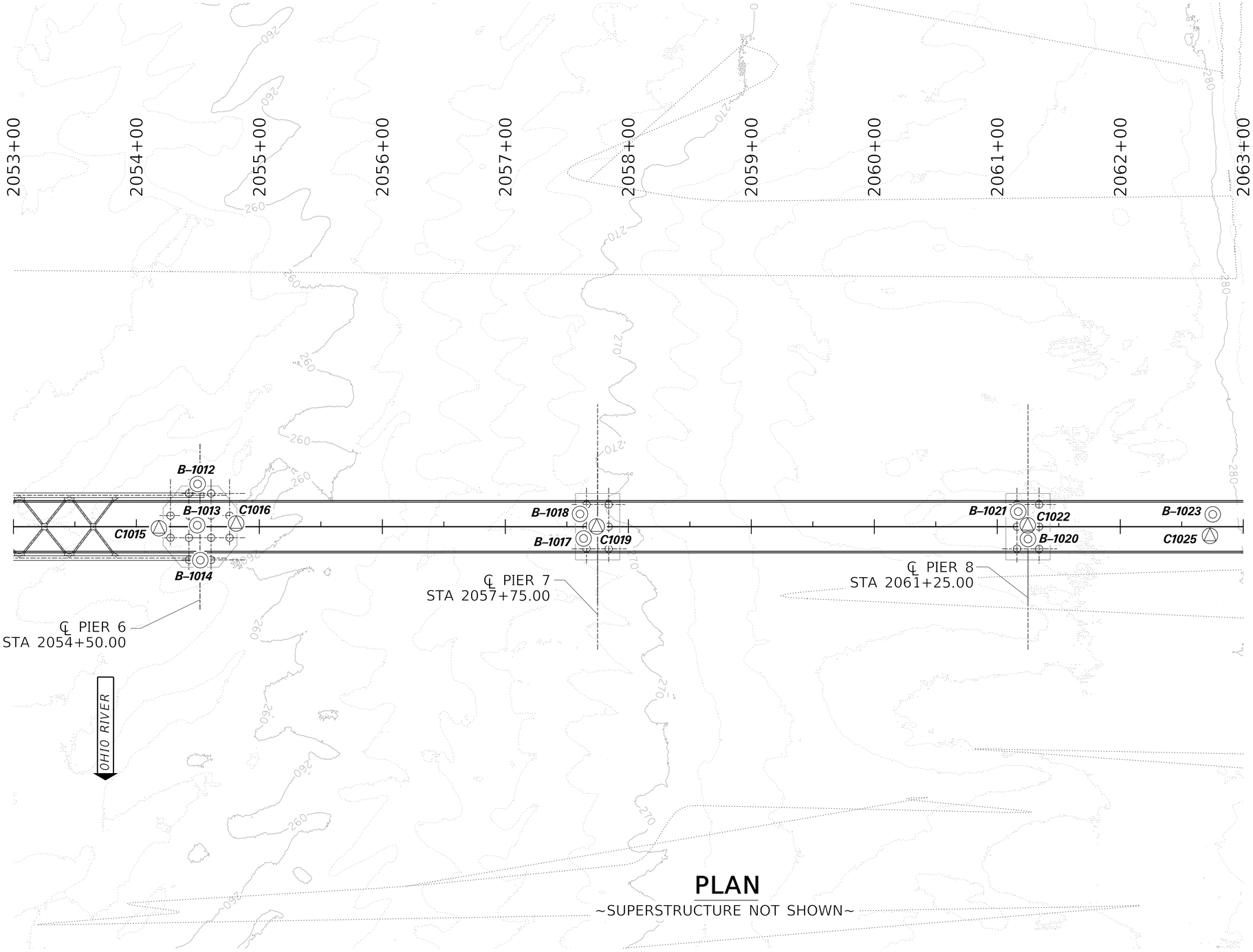
REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: W SHUECRAFT
CHECKED BY

BORING LAYOUT
CROSSING: OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S013	DRAWING NUMBER



PLAN

~SUPERSTRUCTURE NOT SHOWN~

LEGEND

- ***FINAL TEST LOCATIONS***
- ***FINAL CPT LOCATIONS***
- ***PRELIMINARY TEST LOCATIONS***

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026 | CHECKED BY:
DESIGNED BY: S BORDERS
DETAILED BY: W SHUECRAFT

BORING LAYOUT
CROSSING: OHIO RIVER

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US 51	01-1140.00	BALLARD
	SHEET NO. S014	DRAWING NUMBER

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150
140
130
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110

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2038+90
4' LT.
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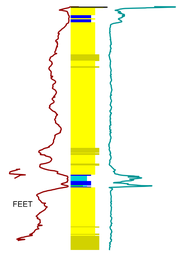

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ADJACENT BORINGS

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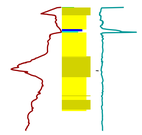

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SEE SHEET S020 FOR
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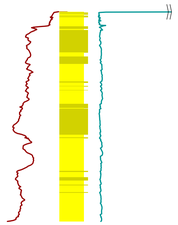

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SEE SHEET S021 FOR
ADJACENT BORINGS

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2045+17
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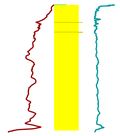
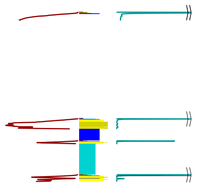




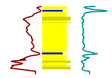


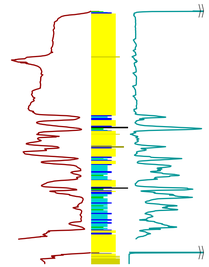
REFUSAL AT 105.8 FEET

SEE SHEET S021 FOR
ADJACENT BORINGS

C1015
2054+18
1' RT.
256.0

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)
400 300 200 100 2 4 6

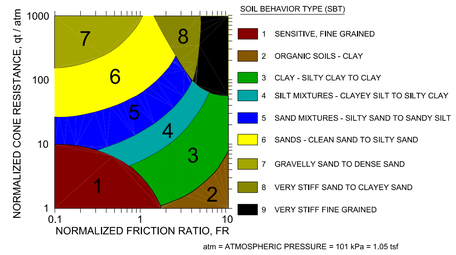




REFUSAL AT 76.9 FEET

SEE SHEET S022 FOR
ADJACENT BORINGS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=110

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

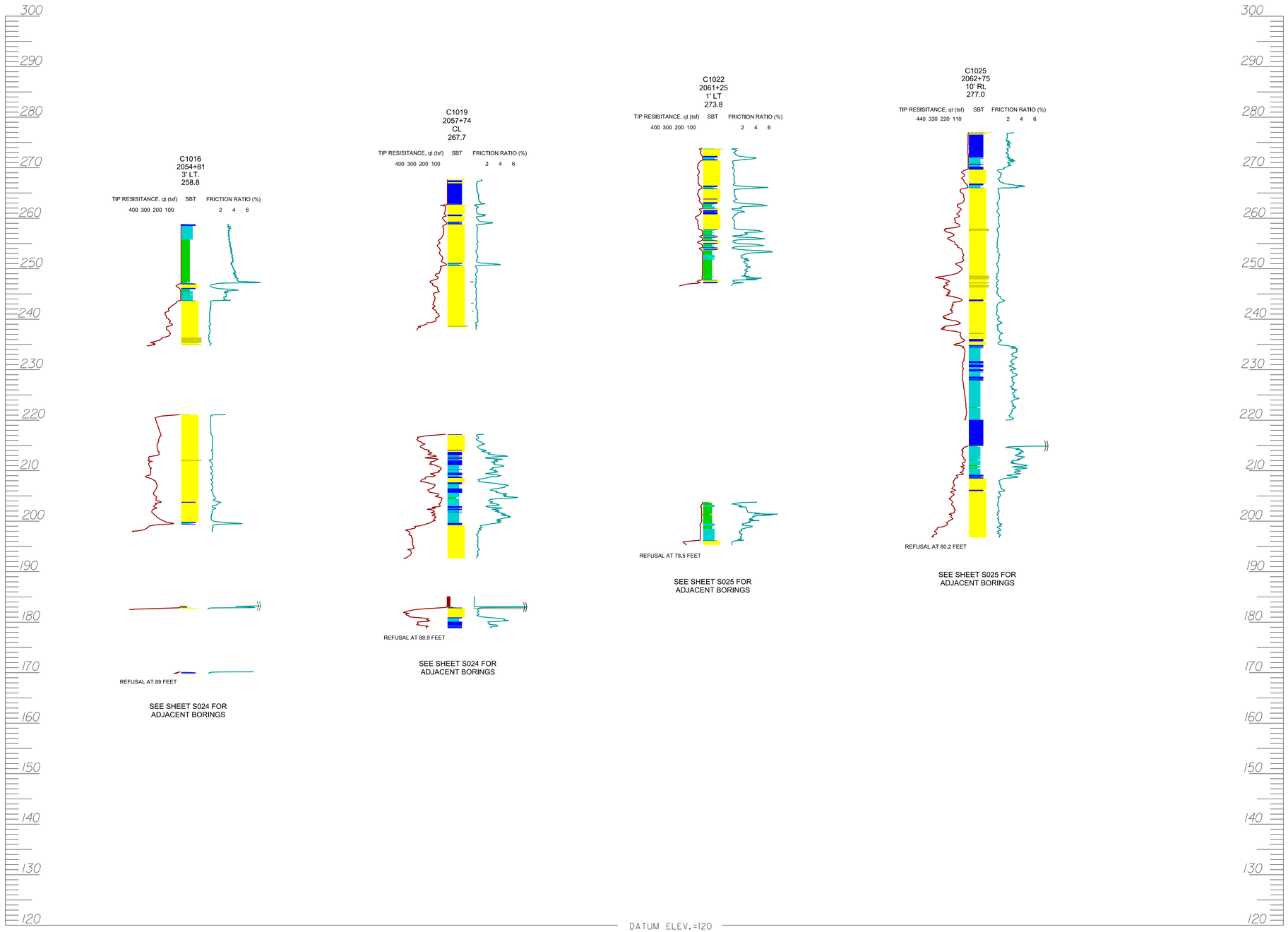
DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: T LYNN
CHECKED BY

BORING PROFILE

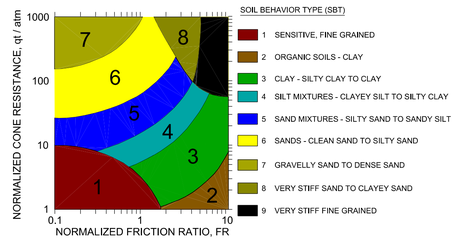
CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S037	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILE$



CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: T LYNN
CHECKED BY

BORING PROFILE

CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S038	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILEA$

PIER 3

B-1002
2038+73
15' LT.
273.5

D_{95} mm	D_{50} mm	w%	L.I.	
43.586	0.251	22		N=11, A-2-4(0), SM, S+C=26
23.613	0.258	20		N=11, A-2-4(0), SM, S+C=23
23.415	12.022	18		N=67, A-1-a(0), GP-GM, S+C=6 (ALLUMINUM CABLE/WIRE ENCOUNTERED AT 13.0 FT.)
4.624	0.867	19		N=4, A-1-b(0), SM, S+C=17
13.479	0.917	20		N=6, A-1-b(0), SM, S+C=21
1.235	0.188	26		N=13, A-3(0), SP-SM, S+C=8(7+1)
1.020	0.199	15		A-3(0), SP, S+C=0
21.517	0.224	17		N=52, A-2-4(0), SM, S+C=16
1.691	0.235	20		N=31, A-3(0), SP-SM, S+C=5
39.816	1.517	15		N=27, A-2-4(0), SM, S+C=26
16.627	0.857	16		N=34, A-1-b(0), SM, S+C=23
6.521	0.724	18		N=66, A-1-b(0), SM, S+C=12
1.996	0.417	22		N=58, A-1-b(0), SP-SM, S+C=10
0.413	0.111	26	3.133	N=16, A-4(0), SC-SM, S+C=37(24+13)
				No Specimen
1.174	0.169	26	2.504	N=21, A-2-4(0), SC-SM, S+C=18(14+4)
0.391	0.086	23	5.063	N=51, A-4(0), SM, S+C=46(28+18)
1.180	0.114	28	3.737	A-4(0), SC-SM, S+C=37(19+18)
1.192	0.184	21		N=58, A-2-4(0), SP-SM, S+C=12(10+2)
0.400	0.151	22		N=65, A-2-4(0), SM, S+C=18(15+3)
1.843	0.451	19		N=50/0.4', A-1-b(0), SP-SM, S+C=7
1.638	0.294	22		N=50/0.4', A-3(0), SP, S+C=4
1.662	0.293	19	3.306	N=52, A-2-4(0), SP-SM, S+C=11(8+3)
1.836	0.728	19		N=50, A-1-b(0), SW-SM, S+C=6
1.460	0.227	25		N=97/0.9', A-3(0), SP, S+C=4
1.079	0.189	53		N=0, A-3(0), SP-SM, S+C=7 (SOIL BELOW CASING EXPECTED TO BE WASHED OUT, BLOW COUNTS ARTIFICIALLY LOW)
1.740	0.432	29		N=24, A-1-b(0), SP, S+C=2
1.857	0.757	18		A-1-b(0), SP, S+C=1
1.538	0.240	31		N=0, A-3(0), SP-SM, S+C=6 (DRILL TOOLING FELL, BLOW COUNTS NOT REPRESENTATIVE)
1.105	0.193	24		N=50/0.1', A-3(0), SP-SM, S+C=6
1.614	0.279	23		N=R/0.4', A-3(0), SP-SM, S+C=7
1.810	0.727	20		N=50/0.4', A-1-b(0), SW, S+C=3
1.609	0.244	24		N=50/0.4', A-3(0), SP, S+C=5
1.814	0.361	17		N=21, A-3(0), SP-SM, S+C=5
				No Specimen
3.529	0.814	58		N=59, A-1-b(0), SP-SM, S+C=12
				N=48, No Specimen
1.906	0.183	68		N=79/1.0', A-3(0), SP-SM, S+C=7
0.501	0.178	45		N=35, A-3(0), SP-SM, S+C=6(5+1)

B-1002A

B-1002A

NR (30.9)

B-1001
2038+75
10' RT.
271.9

D_{95} mm	D_{50} mm	w%	L.I.	
0.776	0.174	24		N=10, A-2-4(0), SP-SM, S+C=11
				No Specimen
1.474	0.220	24		N=5, A-3(0), SP, S+C=3
0.922	0.192	24		N=8, A-3(0), SP, S+C=2
43.708	1.313	16		N=9, A-1-b(0), SM, S+C=25
1.956	0.715	20		N=6, A-1-b(0), SW, S+C=5
0.793	0.184	15		A-3(0), SP, S+C=4
1.338	0.213	20		N=34, A-3(0), SP, S+C=3
1.710	0.285	19		N=37, A-3(0), SP, S+C=5
13.467	0.278	18		N=27, A-2-4(0), SM, S+C=17
4.529	0.830	16		N=31, A-1-b(0), SM, S+C=15
4.769	0.755	18		N=41, A-1-b(0), SP-SM, S+C=11
7.778	0.683	17		N=72, A-1-b(0), SM, S+C=15
0.399	0.150	21	7.764	N=14, A-2-4(0), SM, S+C=18(10+8)
0.105	0.014	21	2.777	No Specimen N=14, A-4(0), ML, S+C=94(93+1)
0.412	0.158	20	2.675	N=18, A-2-4(0), SM, S+C=15(3+12)
				No Specimen
0.403	0.141	21	2.011	N=36, A-2-4(0), SC-SM, S+C=23(12+11)
0.771	0.163	21	1.961	N=33, A-2-4(0), SM, S+C=16(11+5)
0.797	0.124	21		N=46, A-2-4(0), SM, S+C=33(21+12)
1.516	0.125	24	2.171	N=17, A-4(0), SC-SM, S+C=37(21+16)
1.511	0.237	13		A-3(0), SP, S+C=3
1.690	0.317	21		N=65, A-3(0), SP, S+C=4
1.827	0.342	19		N=37, A-3(0), SP-SM, S+C=7
1.830	0.801	20		N=47, A-1-b(0), SP, S+C=4
1.721	0.435	21		N=73/0.9', A-1-b(0), SP, S+C=2
0.386	0.143	27		N=90/0.7', A-2-4(0), SM, S+C=21(13+8)
1.830	0.823	23		N=8, A-1-b(0), SP, S+C=1
				No Specimen
1.832	0.460	16		N=69/0.8', A-1-b(0), SP, S+C=5
1.305	0.202	25		N=R-0.4, A-3(0), SP-SM, S+C=8
1.832	0.656	18		N=61, A-1-b(0), SW, S+C=3
1.478	0.154	26		N=R/0.4', A-2-4(0), SM, S+C=32
1.410	0.222	24		N=50/0.4', A-3(0), SP, S+C=4
0.481	0.172	27		N=50/0.3', A-3(0), SP-SM, S+C=9
1.281	0.212	29		N=38, A-3(0), SP, S+C=2
0.394	0.172	30		N=50/0.3', A-3(0), SP, S+C=5
0.978	0.189	27		N=50/0.3', A-3(0), SP, S+C=5

NR (22.0)

C1003
2038+90
4' LT.
271.9

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)

440 330 220 110 2 4 6

REFUSAL ON WOOD AT 34.1 FEET

C1026
2040+75
10' Lt.
233.2

440 330 220 110 2 4 6

REFUSAL AT 41.6 FEET

B-1024
2041+15
3' LT.
231.7

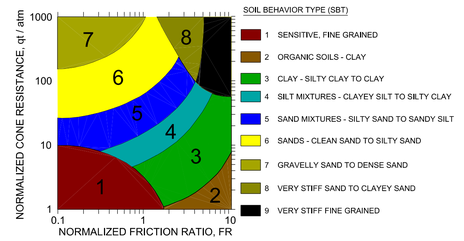
D_{95} mm	D_{50} mm	w%	L.I.	
41.047	10.322	19		N=13, A-1-a(0), GM, S+C=15
33.811	0.949	19		N=16, A-1-b(0), SP-SM, S+C=10
1.862	0.853	21		N=22, A-1-b(0), SP, S+C=2
1.849	0.832	19		N=38, A-1-b(0), SP, S+C=2
15.698	1.236	14		N=65, A-1-b(0), SM, S+C=25
0.412	0.153	27	2.539	N=9, A-2-4(0), SC-SM, S+C=18(10+8)
0.408	0.154	25	2.965	N=9, A-2-4(0), SC-SM, S+C=17(11+6)
0.403	0.151	22	2.598	A-2-4(0), SM, S+C=18(10+8)
0.394	0.147	25	4.025	N=10, A-2-4(0), SM, S+C=20(10+10)
0.388	0.128	21	2.507	N=27, A-2-4(0), SM, S+C=28(16+12)
1.304	0.132	22	2.564	N=37, A-2-4(0), SC-SM, S+C=33(21+12)
0.663	0.154	22	10.307	N=32, A-2-4(0), SM, S+C=19(10+9)
0.192	0.006	24	0.384	N=43 { A-6(13), CL, S+C=90(57+33)
1.656	0.321	24		A-3(0), SP, S+C=4
0.288	0.008	24	0.602	N=40 { A-6(8), CL, S+C=84(54+30)
1.501	0.188	22		A-2-4(0), SM, S+C=23
0.408	0.164	23		N=90/0.8', A-2-4(0), SP-SM, S+C=11
0.434	0.172	25		N=78, A-3(0), SP-SM, S+C=9
1.775	0.577	20		N=79/1.0', A-1-b(0), SW, S+C=2
1.835	0.826	20		N=66, A-1-b(0), SP, S+C=2
0.390	0.169	27		N=50/0.4', A-3(0), SP-SM, S+C=6(5+1)
0.392	0.165	26		N=50/0.3', A-3(0), SP-SM, S+C=9
0.408	0.172	23		N=80/0.9', A-3(0), SP-SM, S+C=7
1.837	0.808	19		N=57, A-1-b(0), SP, S+C=1
				No Specimen
1.847	0.889	20		N=50/0.4', A-1-b(0), SP, S+C=0
1.998	0.811	17		N=19, A-1-b(0), SW-SM, S+C=7
				No Specimen
1.803	0.679	19		N=92/0.9', A-1-b(0), SW, S+C=2
3.907	0.703	19		N=50/0.2', A-1-b(0), SM, S+C=19
1.238	0.208	22		N=84/0.9', A-3(0), SP, S+C=2

NR (78.9)

NOTE:

SEE SHEET NO. S037 FOR CPT DETAILS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=-20

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026 | CHECKED BY

DESIGNED BY: S BORDERS

DETAILED BY: T LYNN

BORING PROFILE

CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S020	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILEA$

PIER 4

B-1005
2042+21
11' LT.
238.6

D_{95} mm	D_{50} mm	w%	L.I.	
17.897	10.446	9		N=8, A-1-a(0), GP, S+C=2
0.417	0.177	23		N=28, A-3(0), SP, S+C=5
				N=68, No Specimen
0.409	0.174	25		N=34, A-3(0), SP-SM, S+C=5
7.611	0.350	18		N=17, A-2-4(0), SM, S+C=22
5.173	0.519	17		N=20, A-1-b(0), SM, S+C=22
				No Specimen
1.652	0.312	20		N=40, A-3(0), SP, S+C=4
0.418	0.176	22		N=56, A-3(0), SP-SM, S+C=6
0.402	0.150	21		N=7, A-2-4(0), SM, S+C=19(9+10)
				No Specimen
0.414	0.154	24		N=16, A-2-4(0), SM, S+C=17
0.882	0.180	23		N=48, A-3(0), SP-SM, S+C=9
0.656	0.165	22		N=45, A-2-4(0), SM, S+C=14(2+12)
0.419	0.148	22	7.102	N=29, A-2-4(0), SM, S+C=21(12+9)
				No Specimen
0.410	0.156	23		N=38, A-2-4(0), SM, S+C=16(7+9)
0.419	0.119	21	2.246	N=74, A-2-4(0), SC-SM, S+C=34(22+12)
0.737	0.184	23		N=50/0.4', A-3(0), SP, S+C=5
1.649	0.297	23		N=22, A-3(0), SP-SM, S+C=9
1.679	0.295	21		N=50/0.5', A-3(0), SP-SM, S+C=9
1.798	0.344	20		N=50/0.3', A-3(0), SP-SM, S+C=6
1.762	0.564	21		N=R/0.5', A-1-b(0), SP, S+C=2
0.397	0.166	25		N=50/0.4', A-3(0), SP-SM, S+C=9(2+7)
0.390	0.171	24		N=50/0.4', A-3(0), SP, S+C=5
1.787	0.620	20		N=77/1.0', A-1-b(0), SW, S+C=3
1.593	0.255	18		N=96/0.8', A-3(0), SP-SM, S+C=10
1.779	0.602	22		N=50/0.4', A-1-b(0), SW, S+C=3
1.931	0.720	19		N=44, A-1-b(0), SW, S+C=4
				No Specimen
2.389	0.802	16		N=41, A-1-b(0), SW-SM, S+C=7
1.384	0.216	24		N=50/0.3', A-3(0), SP, S+C=4
0.392	0.162	23		N=69, A-2-4(0), SP-SM, S+C=11
0.402	0.174	28		N=50/0.3', A-3(0), SP, S+C=5
1.719	0.423	24		N=50/0.4', A-1-b(0), SP, S+C=3
0.374	0.022	26	1.127	N=70, A-4(4), CL, S+C=69(57+12)
0.169	0.015	29		N=R/0.5', A-4(0), ML, S+C=91
0.379	0.037	22	0.970	N=50/0.3', A-4(2), CL, S+C=59(44+15)
1.567	0.260	24		N=50/0.4', A-3(0), SP, S+C=4

NR
(-11.4)

C1006
2042+24
CL
238.6

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)
440 330 220 110 2 4 6

REFUSAL AT 40.9 FEET

B-1004
2042+24
9' RT.
237.7

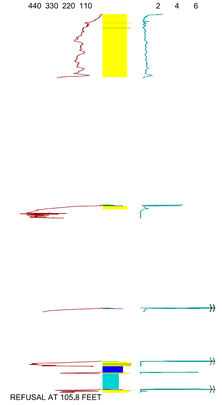
D_{95} mm	D_{50} mm	w%	L.I.	
16.631	6.124	23		N=4, A-1-a(0), GW, S+C=1
				No Specimen
1.890	0.870	20		N=18, A-1-b(0), SP, S+C=1
6.576	0.163	23		N=28, A-2-4(0), SM, S+C=21
1.642	0.271	21		N=29, A-3(0), SP, S+C=5
8.328	1.405	12		N=17, A-1-b(0), SM, S+C=25
				No Specimen
1.722	0.443	18		N=93/0.8', A-1-b(0), SP, S+C=5
46.626	24.885	7		N=96/0.9', A-1-a(0), GW-GM, S+C=6 (2" DIAMETER GRAVEL LODGED IN SAMPLE, BLOW COUNTS LIKELY ELEVATED)
2.202	0.175	18		N=58, A-2-4(0), SP-SM, S+C=11(5+6)
0.407	0.150	22		N=13, A-2-4(0), SM, S+C=19(12+7)
0.407	0.153	20		A-2-4(0), SM, S+C=17(9+8)
1.257	0.194	21		N=33, A-3(0), SP-SM, S+C=9(4+5)
0.947	0.170	23		N=21, A-2-4(0), SM, S+C=15(5+10)
1.459	0.178	20	6.978	N=52, A-2-4(0), SM, S+C=22(13+9)
0.794	0.161	21	1.745	N=57, A-2-4(0), SC-SM, S+C=17(11+6)
1.558	0.194	19	2.247	N=82/1.0', A-2-4(0), SM, S+C=21(14+7)
0.559	0.097	22	9.488	N=42, A-4(0), SM, S+C=42(24+18)
1.157	0.200	23		N=89/0.7', A-3(0), SP, S+C=3
1.810	0.703	21		N=50/0.4', A-1-b(0), SW, S+C=0
1.843	0.852	20		N=50/0.4', A-1-b(0), SP, S+C=0
1.805	0.694	17		N=97/0.8', A-1-b(0), SW, S+C=2
0.408	0.175	24		N=50/0.3', A-3(0), SP-SM, S+C=5(2+3)
0.390	0.159	26		N=50/0.3', A-2-4(0), SM, S+C=13
1.880	0.843	18		N=14, A-1-b(0), SP, S+C=4 (SAMPLE DISTURBED, BLOWCOUNTS LIKELY IMPACTED)
1.834	0.798	17		N=50/0.3', A-1-b(0), SW-SM, S+C=7
1.800	0.676	19		N=50/0.4', A-1-b(0), SW, S+C=2
1.863	0.898	21		N=R/0.4', A-1-b(0), SP, S+C=1
1.709	0.413	24		N=R/0.3', A-3(0), SP, S+C=3
1.428	0.221	24		N=R/0.3', A-3(0), SP-SM, S+C=5
1.779	0.611	23		N=51, A-1-b(0), SW, S+C=1
0.416	0.163	27		N=R/0.3', A-2-4(0), SM, S+C=13
0.420	0.174	25		N=R/0.3', A-3(0), SP-SM, S+C=7
1.821	0.782	22		N=R/0.4', A-1-b(0), SP, S+C=1
1.682	0.034	61	2.878	N=50/0.3' { A-6(6), CL, S+C=60(48+12)
1.077	0.128	41		A-2-4(0), SM, S+C=33
0.390	0.170	27		N=50/0.3', A-3(0), SP-SM, S+C=6
1.397	0.218	23		N=90/1.0', A-3(0), SP, S+C=5
1.617	0.286	23		N=50/0.2', A-3(0), SP, S+C=4

NR
(-13.5)

PIER 5

C1010
2045+17
CL
244.6

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)
440 330 220 110 2 4 6



REFUSAL AT 105.8 FEET

B-1007
2045+48
33' LT.
246.5

D_{95} mm	D_{50} mm	w%	L.I.	
8.460	3.328	44		N=0, A-1-b(0), SM, S+C=18
				No Specimen
46.111	16.721	18		N=11, A-1-a(0), GM, S+C=15
0.410	0.148	30		N=23, A-2-4(0), SM, S+C=20
1.069	0.159	27		N=19, A-2-4(0), SM, S+C=21
41.619	0.760	19		N=24, A-1-b(0), SM, S+C=23
1.462	0.235	3		A-3(0), SP, S+C=0
1.730	0.251	28		N=0, A-3(0), SP-SM, S+C=5
1.823	0.405	18		N=68, A-3(0), SP-SM, S+C=5
1.505	0.227	20		N=56, A-3(0), SP-SM, S+C=5
1.854	0.614	16		N=83/1.0', A-1-b(0), SW, S+C=5
3.683	0.374	20		N=27, A-3(0), SP-SM, S+C=10
				No Specimen
1.626	0.238	20		N=66, A-3(0), SP-SM, S+C=8
22.253	7.378	14		N=34, A-1-b(0), GM, S+C=16
22.959	8.444	13		N=32, A-1-a(0), GM, S+C=13
0.979	0.172	21		N=50, A-2-4(0), SM, S+C=14(7+7)
1.460	0.224	22		N=36, A-3(0), SP-SM, S+C=7
				No Specimen
1.429	0.216	20		N=40, A-3(0), SP-SM, S+C=8
1.328	0.142	19	1.444	N=77, A-2-4(0), SC-SM, S+C=31(19+12)
0.061	0.003	24	0.295	N=19, A-6(15), CL, S+C=86(52+46)
1.731	0.233	19	0.835	A-4(0), SC, S+C=39(29+10)
1.731	0.454	21		N=50/0.4', A-1-b(0), SP, S+C=1
1.780	0.614	22		N=50/0.4', A-1-b(0), SW, S+C=4
0.486	0.012	18	0.246	N=50/0.5', A-6(9), CL, S+C=77(55+23)
1.871	0.913	16		N=46, A-1-b(0), SP, S+C=1
1.835	0.826	19		N=96/0.8', A-1-b(0), SP, S+C=1
1.787	0.649	21		N=97/0.9', A-1-b(0), SW, S+C=1
1.783	0.627	24		N=50/0.3', A-1-b(0), SW, S+C=2
1.875	0.890	18		N=73, A-1-b(0), SP, S+C=3
1.345	0.213	27		N=R/0.3', A-3(0), SP, S+C=4
1.542	0.252	24		N=50/0.2', A-3(0), SP, S+C=3
1.821	0.779	23		N=50/0.3', A-1-b(0), SP, S+C=1
0.409	0.165	26		N=50/0.3', A-2-4(0), SP-SM, S+C=11
1.430	0.220	24		N=50/0.3', A-3(0), SP, S+C=5
0.690	0.012	21	0.169	N=84/0.7', A-6(9), CL, S+C=86(73+13)
0.462	0.169	30		N=R/0.3', A-2-4(0), SP-SM, S+C=11
1.853	0.874	22		N=50/0.5', A-1-b(0), SP, S+C=1
1.699	0.330	42	0.219	N=16, A-2-7(2), SM, S+C=35(30+5)
1.666	0.265	46	0.723	N=30, A-2-7(2), SM, S+C=30(21+9)

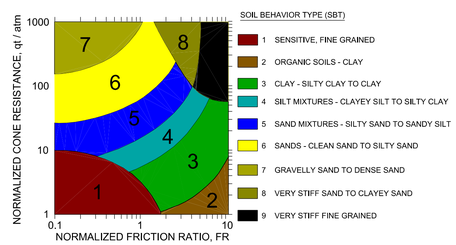
NR
(-53.7)

APPROXIMATELY 85.54 FT OF 6 IN SW CASING
LOST DOWNHOLE DRILLERS ESTIMATE
AT/NEAR A DEPTH OF 120 FT BELOW MUDLINE.

NOTE:

SEE SHEET NO. S037 FOR CPT DETAILS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=-80

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: T LYNN
CHECKED BY

BORING PROFILE

CROSSING
OHIO RIVER

ROUTE
US 51

ITEM NO.
01-1140.00

SHEET NO.
S021

COUNTY OF
BALLARD

DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILEA$

PIER 5

B-1009
2045+49
30' RT.
242.6

D_{95} mm	D_{50} mm	w%	L.I.	
8.598	3.280	24		N=4, A-1-b(0), SM, S+C=21
0.849	0.179	28		N=8, A-3(0), SP-SM, S+C=7
1.630	0.175	23		N=23, A-2-4(0), SM, S+C=14
1.226	0.198	21		No Specimen
1.227	0.191	22		N=47, A-3(0), SP, S+C=5
18.874	0.221	19		N=37, A-3(0), SP-SM, S+C=8
0.657	0.186	24		N=62, A-2-4(0), SM, S+C=15
1.701	0.332	18		N=21, A-3(0), SP, S+C=3
6.250	0.677	15		No Specimen
6.639	0.645	13		N=48, A-3(0), SP, S+C=4
3.637	0.257	19		N=28, A-1-b(0), SM, S+C=22
22.167	6.224	14		N=58, A-1-b(0), SM, S+C=24
1.018	0.178	40		N=43, A-2-4(0), SP-SM, S+C=12
0.424	0.178	16		N=60, A-1-b(0), GM, S+C=23
1.243	0.190	25		N=22, A-2-4(0), SP-SM, S+C=12(4+8)
1.223	0.190	8		A-3(0), SP-SM, S+C=6
1.372	0.199	22		N=10, A-2-4(0), SP-SM, S+C=11(5+6)
1.374	0.133	21	4.670	N=25, A-2-4(0), SP-SM, S+C=11(3+8)
0.427	0.178	24		N=23, A-2-4(0), SP-SM, S+C=12(6+6)
1.804	0.713	21		N=47, A-2-4(0), SM, S+C=33(20+13)
1.745	0.506	22		N=50/5.5', A-3(0), SP-SM, S+C=6
1.910	0.878	19		N=45, A-1-b(0), SW, S+C=2
1.670	0.324	24		N=50/0.4', A-1-b(0), SP, S+C=5
1.657	0.321	22		N=50/0.4', A-3(0), SP, S+C=3 (SPT SAMPLER OVERFILLED, BLOWCOUNTS POSSIBLY NOT REPRESENTATIVE)
1.724	0.453	22		N=50/0.4', A-3(0), SP, S+C=2
1.799	0.668	22		N=96/0.8', A-3(0), SP, S+C=4
0.416	0.170	26		N=50/0.5', A-1-b(0), SP-SM, S+C=6
0.457	0.172	26		N=97/0.8', A-1-b(0), SW-SM, S+C=5
1.548	0.250	24		N=74, A-3(0), SP-SM, S+C=9
0.394	0.168	29		N=50/0.3', A-3(0), SP-SM, S+C=9
1.396	0.221	26		N=50/0.3', A-3(0), SP, S+C=4
0.412	0.169	27		N=50/0.3', A-3(0), SP-SM, S+C=8
0.074	0.009	24	0.286	N=R/0.4', A-3(0), SP, S+C=3
0.193	0.009	31	0.694	N=50/0.4', A-3(0), SP-SM, S+C=9(6+3)
0.395	0.167	27		N=0, A-6(15), CL, S+C=95(73+19)
1.825	0.717	24		A-6(13), CL, S+C=100(80+20) (TUBE ADVANCED WITH WEIGHT OF ROD ONLY)
1.761	0.559	43	0.089	N=50/0.2', A-3(0), SP-SM, S+C=8
1.603	0.196	43	-1.079	N=50/0.4', A-1-b(0), SW, S+C=5
				N=40, A-2-7(0), SM, S+C=18(15+3)
				N=38, A-2-5(0), SM, S+C=32(29+3)

NR
(-58.3)

B-1008
2045+54
3' RT.
243.7

D_{95} mm	D_{50} mm	w%	L.I.	
6.675	1.087	26		N=2, A-1-b(0), SM, S+C=25
22.087	0.217	19		N=41, A-2-4(0), SM, S+C=25
0.407	0.164	25		N=21, A-2-4(0), SP-SM, S+C=11
1.219	0.182	25		No Specimen
1.586	0.201	22		N=20, A-2-4(0), SP-SM, S+C=12
0.632	0.181	23		N=24, A-3(0), SP-SM, S+C=6
1.713	0.269	17		N=70, A-3(0), SP-SM, S+C=6
1.820	0.282	17		N=41, A-3(0), SP-SM, S+C=6
3.461	0.459	13		N=24, A-3(0), SP-SM, S+C=6
1.400	0.217	22		N=64, A-1-b(0), SP-SM, S+C=12
3.616	0.282	18		N=60, A-3(0), SP, S+C=4
22.529	6.525	14		N=76, A-2-4(0), SM, S+C=13
33.194	7.757	15		N=47, A-1-a(0), GM, S+C=15
1.485	0.215	23		N=36, A-1-a(0), GM, S+C=14
1.466	0.219	20		N=30, A-3(0), SP-SM, S+C=7
1.367	0.147	21		N=83/1.0', A-3(0), SP-SM, S+C=8
1.855	0.531	19		N=74, A-2-4(0), SM, S+C=26(14+12)
1.765	0.558	20		N=88/0.90', A-1-b(0), SP-SM, S+C=8
1.832	0.694	17		N=85/0.9', A-1-b(0), SW-SM, S+C=6
1.770	0.572	20		N=50/0.5', A-1-b(0), SW, S+C=4
1.818	0.683	17		N=38, A-1-b(0), SW, S+C=1
1.643	0.303	21		A-1-b(0), SW, S+C=2
1.907	0.687	17		N=94/0.9', A-3(0), SP, S+C=4
1.757	0.506	19		N=76/0.8', A-1-b(0), SW-SM, S+C=6
1.760	0.542	18		N=54, A-1-b(0), SP, S+C=5
1.846	0.769	21		A-1-b(0), SP, S+C=1
0.407	0.176	29		N=0, A-1-b(0), SP, S+C=2 (CLEANING PLUGGED CASING, VALUES NOT REPRESENTATIVE)
0.409	0.175	27		N=70/1.0', A-3(0), SP, S+C=4
1.215	0.205	22		N=90/0.9', A-3(0), SP-SM, S+C=5
0.394	0.165	28		N=61/1.0', A-3(0), SP, S+C=2
1.542	0.209	25		N=R/0.3', A-3(0), SP-SM, S+C=9
1.287	0.198	22		N=R/0.2', A-3(0), SP-SM, S+C=9
1.843	0.401	19	0.711	N=55, A-3(0), SP-SM, S+C=7
0.392	0.174	30		N=92/0.8', A-2-4(0), SC-SM, S+C=12(10+2)
1.720	0.435	23		N=37, A-3(0), SP, S+C=3
1.775	0.608	40	-0.069	N=76/0.9', A-1-b(0), SP, S+C=5
1.774	0.531	43	-0.124	N=39, A-2-7(0), SM, S+C=14(12+2)
				N=42, A-2-7(0), SM, S+C=12(9+3)

MATCHLINE "A"

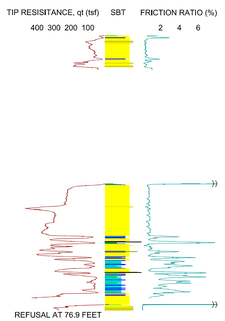
MATCHLINE "A"

1.661	0.302	42	1.533	N=34, A-2-4(0), SM, S+C=16(13+3)
1.506	0.198	50	-0.431	N=66, A-2-7(1), SM, S+C=21(19+2)
1.584	0.198	49	-0.018	N=82, A-2-7(3), SM, S+C=28(22+6)
1.535	0.166	51	-1.180	N=86/1.0', A-2-7(0), SM, S+C=32(27+5)
1.537	0.083	47	-0.581	N=59, A-7-5(7), SM, S+C=49(42+7)
1.435	0.072	53	-0.011	N=78, A-7-5(9), MH, S+C=50(43+7)

NR
(-159.0)

PIER 6

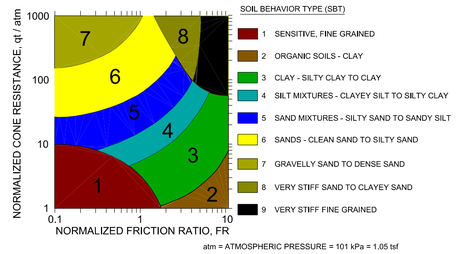
C1015
2054+18
1' RT.
256.0



NOTE:

SEE SHEET NO. S037 FOR CPT DETAILS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=-80

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: T LYNN
CHECKED BY

BORING PROFILE
CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S022	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILE$

B-1013
2054+49
1' LT.
257.4

UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
	2.463	0.600	28		N=8, A-1-b(0), SW-SM, S+C=10
	8.941	1.352	19		N=2, A-1-b(0), SM, S+C=25 No Specimen
	7.107	1.655	94		N=13, A-1-b(0), SP, S+C=2 (ROPE ENCOUNTERED IN SAMPLE)
	43.434	10.280	15		N=35, A-1-a(0), GP-GM, S+C=12
	3.421	0.320	16		N=32, A-2-4(0), SM, S+C=12
	2.325	0.709	13		N=44, A-1-b(0), SW-SM, S+C=8
	4.697	0.624	15		N=47, A-1-b(0), SM, S+C=15
					N=85/0.9', No Specimen
	5.837	0.499	15		N=55, A-1-b(0), SM, S+C=16
	0.415	0.156	21		N=11, A-2-4(0), SM, S+C=16(7+9)
	0.422	0.164	15	0.447	A-2-4(0), SC-SM, S+C=13(4+9)
	0.420	0.160	20		N=20, A-2-4(0), SM, S+C=15(6+9)
	0.416	0.158	22	4.054	N=21, A-2-4(0), SM, S+C=15(8+7)
	0.179	0.015	27	0.475	N=30 { A-6(12), CL, S+C=90
	0.400	0.087	26	6.899	N=30 { A-4(0), SM, S+C=46(29+17)
	0.268	0.018	22	0.908	N=42, A-4(5), CL, S+C=82
7196	0.261	0.009	20	0.432	A-4(5), CL, S+C=83(58+25)
					No Specimen
	0.789	0.162	19		N=83, A-2-4(0), SM, S+C=17
	0.961	0.174	20		N=99/0.9', A-2-4(0), SM, S+C=13
	0.669	0.153	22		N=18, A-2-4(0), SM, S+C=20(10+10)
					No Specimen (SAMPLE LOST DURING DISSASSEMBLY)
	1.691	0.347	20		N=11, A-3(0), SP, S+C=2
	1.805	0.508	19		N=57, A-1-b(0), SP, S+C=4
	1.705	0.359	4		A-3(0), SP, S+C=2
	1.855	0.819	17		N=79, A-1-b(0), SP, S+C=3
	0.803	0.022	19		N=57, A-4(0), ML, S+C=75
	1.815	0.730	13		A-1-b(0), SP, S+C=1
	1.814	0.672	20		N=67, A-1-b(0), SW, S+C=4
	1.956	0.824	17		N=75, A-1-b(0), SW-SM, S+C=6
	1.727	0.442	21		N=98/0.8', A-1-b(0), SP, S+C=4
	0.980	0.189	25		N=R/0.5', A-3(0), SP-SM, S+C=5
	1.855	0.734	19		N=50/0.4', A-1-b(0), SW-SM, S+C=6
	1.591	0.258	22		N=50/0.1', A-3(0), SP-SM, S+C=6
	1.224	0.199	24		N=68, A-3(0), SP-SM, S+C=6
	0.783	0.109	26		N=50/0.1', A-4(0), SM, S+C=39 (Decaying wood fibers in sample)
	0.926	0.183	25		N=50/0.2', A-3(0), SP-SM, S+C=8
	1.696	0.381	22		N=50/0.2', A-3(0), SP, S+C=5
	1.752	0.489	20		N=76/1.0', A-1-b(0), SP-SM, S+C=9
	1.767	0.579	40	0.572	N=38, A-2-5(0), SM, S+C=16(12+4)

MATCHLINE "A"

B-1012
2054+50
35' LT.
258.5

D_{95} mm	D_{50} mm	w%	L.I.	
1.778	0.598	31		N=1, A-1-b(0), SW, S+C=1
1.280	0.011	38	1.075	N=10, A-6(11), CL, S+C=77(52+25)
1.558	0.015	21		A-6(10), CL, S+C=72(50+22)
7.335	0.983	19		N=6, A-1-b(0), SM, S+C=23
37.291	0.528	15		N=39, A-2-4(0), SM, S+C=26
		1		N=31, No Specimen
3.757	0.638	16		N=32, A-1-b(0), SM, S+C=13
				No Specimen
44.835	1.767	14		N=22, A-2-4(0), GM, S+C=26
1.719	0.261	19		N=26, A-3(0), SP-SM, S+C=5
5.305	0.675	14		N=72, A-1-b(0), SM, S+C=13
0.890	0.148	23		N=23, A-2-4(0), SM, S+C=23(13+10)
				No Specimen
0.425	0.161	21		N=15, A-2-4(0), SM, S+C=15(7+8)
0.433	0.164	21		N=20, A-2-4(0), SM, S+C=13(6+7)
0.430	0.161	20	1.394	N=12, A-2-4(0), SC-SM, S+C=14(8+6)
0.418	0.162	21	2.611	A-2-4(0), SM, S+C=13(7+6)
0.228	0.016	25		N=0, A-4(0), ML, S+C=87
1.201	0.188	20		N=35, A-2-4(0), SP-SM, S+C=11(7+4)
1.087	0.179	20		N=68, A-2-4(0), SM, S+C=13(8+5)
1.108	0.178	18		N=67, A-2-4(0), SM, S+C=13(6+7)
1.187	0.183	20		N=19, A-2-4(0), SM, S+C=12(5+7)
0.936	0.177	23		N=16, A-2-4(0), SP-SM, S+C=11
				No Specimen
1.748	0.463	20		N=75/0.8', A-1-b(0), SP, S+C=3
1.681	0.317	21		N=98/0.8', A-3(0), SP, S+C=4
1.627	0.274	20		N=88/0.8', A-3(0), SP-SM, S+C=6
1.821	0.753	21		N=61, A-1-b(0), SP, S+C=2
1.998	0.643	17		N=80/0.8', A-1-b(0), SW-SM, S+C=8
1.829	0.817	19		N=99/0.8', A-1-b(0), SP, S+C=2
1.812	0.710	21		N=50/0.4', A-1-b(0), SW, S+C=3
1.726	0.435	20		N=50/0.4', A-1-b(0), SP, S+C=4
0.913	0.192	26		N=R/0.4', A-3(0), SP, S+C=3
1.153	0.199	25		N=R/0.4', A-3(0), SP, S+C=3
1.700	0.361	22		N=R/0.4', A-3(0), SP, S+C=2
1.309	0.192	23		N=50/0.5', A-3(0), SP-SM, S+C=9
				No Specimen
1.810	0.524	17		N=50/0.1', A-1-b(0), SP-SM, S+C=8
1.623	0.292	24		N=50/0.3', A-3(0), SP, S+C=2
1.266	0.207	24		N=50/0.3', A-3(0), SP, S+C=3
0.189	0.011	19	0.157	N=75 { A-6(14), CL, S+C=92(78+14)
1.754	0.517	18		N=75 { A-1-b(0), SP-SM, S+C=12
1.782	0.631	42	-0.112	N=44, A-2-7(0), SM, S+C=14(9+5)
1.629	0.284	47	0.143	N=49, A-2-7(0), SP-SC, S+C=9(7+2)

NR
(-77.4)

B-1014
2054+52
27' RT.
257.1

D_{95} mm	D_{50} mm	w%	L.I.	
7.312	0.572	35	2.297	N=2, A-2-4(0), SC, S+C=28(20+8)
14.479	2.578	29		N=9, A-1-a(0), SP, S+C=1
5.147	0.910	19		N=15, A-1-b(0), SM, S+C=14
				N=40, No Specimen
10.773	0.826	9		N=31, A-1-b(0), SM, S+C=16
47.593	30.529	9		N=97/1.0', A-1-b(0), GM, S+C=21 (LARGE GRAVEL LODGED IN SPOON)
2.772	0.763	17		N=62, A-1-b(0), SP-SM, S+C=10
1.357	0.183	22		N=53, A-2-4(0), SP-SM, S+C=12
4.077	0.278	17		N=30, A-2-4(0), SP-SM, S+C=11 (SAMPLER OVERFILLED, BLOWCOUNTS LIKELY NOT REPRESENTATIVE)
0.584	0.166	23		N=18, A-2-4(0), SM, S+C=13(7+6)
				No Specimen
0.411	0.159	22	5.020	N=21, A-2-4(0), SM, S+C=14(6+8)
0.679	0.135	22	3.406	N=31, A-2-4(0), SM, S+C=28(17+11)
0.741	0.167	22		N=33, A-2-4(0), SM, S+C=14(6+8)
0.236	0.007	19	0.328	N=27, A-4(7), CL, S+C=85(53+32)
0.208	0.006	22	0.346	A-6(11), CL, S+C=100(65+35)
0.208	0.008	23	0.635	N=90/0.8' { A-4(5), CL, S+C=88(62+26)
1.228	0.176	20	3.670	N=90/0.8' { A-2-4(0), SM, S+C=17(13+4)
1.243	0.182	21	4.499	N=64, A-2-4(0), SM, S+C=15(11+4)
1.275	0.186	20		N=68, A-2-4(0), SM, S+C=13(9+4)
0.821	0.016	22	2.044	N=67, A-4(0), CL-ML, S+C=71(50+21)
1.810	0.353	21		N=89, A-3(0), SP-SM, S+C=5(4+1)
1.754	0.500	22		N=50/0.4', A-1-b(0), SP, S+C=5
1.510	0.227	21		N=95/1.0', A-3(0), SP-SM, S+C=7
1.823	0.762	23		N=9, A-1-b(0), SP, S+C=1 (INTERVAL WASHED OUT, BLOWCOUNTS NOT REPRESENTATIVE)
1.743	0.424	20		N=83/1.0', A-1-b(0), SP, S+C=4
1.836	0.774	18		N=96/0.7', A-1-b(0), SW, S+C=4 (HAMMER MALFUNCTION 14 BLOWS INTO THE THIRD INCREMENT)
1.737	0.422	23		N=50/0.5', A-1-b(0), SP-SM, S+C=5
1.822	0.501	24		N=50/0.3', A-1-b(0), SP-SM, S+C=6
1.758	0.540	23		N=50/0.3', A-1-b(0), SP, S+C=2
40.890	0.519	21		N=50/0.3', A-1-b(0), SM, S+C=18
1.573	0.247	21		N=50/0.4', A-3(0), SP-SM, S+C=8
1.085	0.153	23		N=50/0.3', A-2-4(0), SM, S+C=23
1.652	0.294	33		N=50/0.3', A-2-4(0), SM, S+C=15(11+4)
0.826	0.186	27		N=R/0.4', A-3(0), SP, S+C=4
1.730	0.469	23		N=R/0.5', A-1-b(0), SP, S+C=4
1.599	0.256	24		N=R/0.4', A-3(0), SP, S+C=4
1.796	0.683	43	0.486	N=45, A-2-7(0), SM, S+C=13(11+2)
1.789	0.656	42	0.542	N=57, A-2-5(0), SM, S+C=12(11+1)

NR
(-47.9)

MATCHLINE "A"

D_{95} mm	D_{50} mm	w%	L.I.	
1.780	0.623	44	0.038	N=22, A-2-7(0), SW-SM, S+C=8(5+3)
1.576	0.236	45	0.069	N=36, A-2-7(0), SM, S+C=16
1.698	0.361	60	0.078	N=84/1.0', A-2-7(2), SM, S+C=23(20+4)
1.728	0.465	55	-0.157	N=50/0.5', A-2-7(1), SM, S+C=23(18+5)
1.672	0.270	53	-0.162	N=95/0.9', A-2-7(3), SM, S+C=31(27+4)
1.549	0.136	48	-0.210	N=92/0.8', A-7-5(5), SM, S+C=40(32+8)

NR
(-145.0)

DATUM ELEV.=-80

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY: HDR

DATE: 02/27/2026
DESIGNED BY: S BORDERS
DETAILED BY: T LYNN
CHECKED BY:

BORING PROFILE
CROSSING
OHIO RIVER

ROUTE: US 51
ITEM NO.: 01-1140.00
SHEET NO.: S023
COUNTY OF: BALLARD
DRAWING NUMBER:

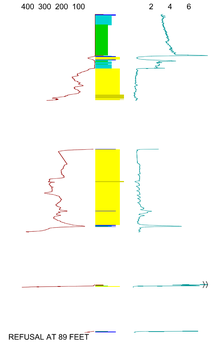
PIER 6

PIER 7

C1016
2054+81
3' LT.
258.8

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)

400 300 200 100 2 4 6



REFUSAL AT 89 FEET

B-1018
2057+61
10' LT.
262.1

UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
	1.746	0.043	24		N=9, A-4(0), ML, S+C=59
					N=10, No Specimen
					No Specimen
	24.175	14.464	6		N=11, A-1-a(0), GP, S+C=0
					No Specimen
	8.707	1.167	18		N=8, A-1-b(0), SM, S+C=25
	5.575	0.177	29		N=8, A-3(0), SP-SM, S+C=9
	46.143	12.621	19		N=14, A-1-a(0), GM, S+C=15
	15.606	1.428	13		N=15, A-2-4(0), SM, S+C=27
	21.229	1.685	24		N=61, A-2-4(0), SM, S+C=27
	4.109	0.688	17		N=34, A-1-b(0), SM, S+C=12
	3.468	0.736	15		N=38, A-1-b(0), SM, S+C=12
	7.873	1.156	15		N=49, A-1-b(0), SM, S+C=24
	0.399	0.147	25	3.892	N=18, A-2-4(0), SM, S+C=20(12+8)
					No Specimen
	0.242	0.008	22	0.718	N=15, A-4(6), CL, S+C=85(57+28)
2714	0.340	0.019	24	1.465	A-4(2), CL, S+C=63(35+28)
					No Specimen
	0.385	0.124	22	2.807	N=7, A-2-4(0), SM, S+C=30(21+9)
	0.415	0.163	23		N=20, A-2-4(0), SM, S+C=13(4+9)
					No Specimen
	0.422	0.156	20		N=29, A-2-4(0), SM, S+C=17(13+4)
	0.419	0.147	23	8.863	N=30, A-2-4(0), SM, S+C=21(15+6)
	1.102	0.156	22	2.297	N=17, A-2-4(0), SC-SM, S+C=22(10+12)
	33.641	0.216	18		A-2-4(0), SP-SM, S+C=12(6+6)
	1.619	0.131	21		N=67, A-4(0), SM, S+C=39(31+8)
	1.680	0.232	24		N=84/0.9', A-2-4(0), SM, S+C=29(22+7)
	1.652	0.300	21		N=92/0.8', A-3(0), SP, S+C=5
	1.406	0.139	19	7.492	N=88/0.9', A-2-4(0), SM, S+C=34(25+9)
	0.422	0.156	27	10.553	N=50/0.4', A-2-4(0), SM, S+C=17(13+4)
	1.734	0.475	22		N=50/0.5', A-1-b(0), SP, S+C=3
	2.292	0.811	15		N=77, A-1-b(0), SW-SM, S+C=8
	1.507	0.027	20	0.756	N=50/0.2', A-4(2), CL-ML, S+C=65(52+13)
					No Specimen
	0.405	0.180	30		N=R/0.5', A-3(0), SP, S+C=2
	0.387	0.159	29		N=88/1.0', A-2-4(0), SM, S+C=12
	1.862	0.237	22		N=50/0.3', A-2-4(0), SM, S+C=16
	1.683	0.358	21		N=50/0.2', A-3(0), SP, S+C=3
	1.917	0.475	19		N=78/0.9', A-1-b(0), SP-SM, S+C=7
	1.751	0.236	28		N=50/0.4', A-3(0), SP-SM, S+C=10
					N=R/0.3', No Specimen
					No Specimen
	1.808	0.702	23		N=23, A-1-b(0), SW, S+C=2
					No Specimen
	1.795	0.669	23		N=25, A-1-b(0), SW, S+C=1
		0.011	35	-0.196	N=18, A-7-5(30), MH, S+C=99(93+6)

NR
(-38.1)

B-1017
2057+64
10' RT.
268.7

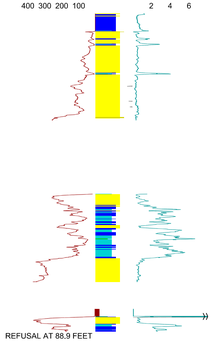
UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
	1.871	0.338	24		A-3(0), SP-SM, S+C=10
	5.831	0.565	29		N=9, A-1-b(0), SM, S+C=17
	6.143	0.735	22		N=8, A-1-b(0), SM, S+C=15
	6.988	0.848	20		N=16, A-1-b(0), SM, S+C=22
	5.260	0.172	27		N=77/1.0', A-2-4(0), SM, S+C=16
	15.879	0.990	15		N=43, A-2-4(0), SM, S+C=26
	8.084	0.602	19		N=37, A-1-b(0), SM, S+C=14
	9.588	0.813	18		N=37, A-1-b(0), SM, S+C=16
	3.650	0.767	14		N=59, A-1-b(0), SM, S+C=14
	8.087	1.051	6		N=59, A-1-b(0), SM, S+C=25
	0.386	0.129	26	4.327	N=12, A-2-4(0), SM, S+C=28(12+16)
					No Specimen
	0.374	0.070	24	1.874	N=31, A-4(0), CL-ML, S+C=51(33+18)
	0.365	0.014	25	1.503	N=21, A-4(2), CL, S+C=68(39+30)
8600	0.142	0.007	20	0.168	A-6(17), CL, S+C=100(74+26)
	0.294	0.010	23	0.539	N=16, A-6(7), CL, S+C=82(57+25)
	0.410	0.148	23	8.199	N=22, A-2-4(0), SM, S+C=20(12+8)
	0.424	0.164	25	5.691	N=9, A-2-4(0), SM, S+C=18(10+8)
	0.413	0.156	17		A-2-4(0), SM, S+C=16(11+5)
	0.423	0.143	21	2.439	N=41, A-2-4(0), SM, S+C=23(15+8)
	0.403	0.054	24	2.794	N=10, A-4(0), CL-ML, S+C=53(36+17)
	2.003	0.221	19	1.847	A-2-4(0), SC-SM, S+C=100(92+8)
	1.539	0.183	20		N=70/1.0', A-2-4(0), SM, S+C=18(11+7)
	1.774	0.234	22		N=58, A-3(0), SP, S+C=5
	1.808	0.462	17		N=90/0.8', A-1-b(0), SP-SM, S+C=6
					No Specimen
	0.402	0.021	16	0.228	N=20, A-4(4), CL, S+C=71(61+10)
	1.232	0.043	22	1.534	N=87/1.0', A-4(0), CL-ML, S+C=57(48+9)
	1.800	0.666	22		N=87/1.0', A-1-b(0), SW, S+C=3
	1.937	0.609	15		N=89/1.0', A-1-b(0), SW-SM, S+C=7
	1.880	0.021	25		N=R/0.4', A-4(0), ML, S+C=77
	0.414	0.177	28		N=50/0.3', A-3(0), SP, S+C=4
	0.418	0.119	22		N=50/0.3', A-2-4(0), SM, S+C=33(22+12)
	1.601	0.181	20		N=80, A-2-4(0), SM, S+C=24(16+8)
	1.713	0.418	22		N=50/0.3', A-1-b(0), SP, S+C=5
	0.399	0.169	30		N=50/0.2', A-3(0), SP-SM, S+C=8
	1.727	0.449	23		N=30, A-1-b(0), SP, S+C=5
					N=R/0.3', No Specimen
	1.611	0.266	24		N=R/0.4', A-3(0), SP-SM, S+C=6
	1.853	0.841	19		N=R/0.3', A-1-b(0), SP, S+C=3
	1.785	0.641	24		N=R/0.4', A-1-b(0), SW, S+C=1
	5.492	0.186	23		N=90/0.8', A-2-4(0), SM, S+C=15(9+6)

NR
(-33.4)

C1019
2057+74
CL
267.7

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)

400 300 200 100 2 4 6

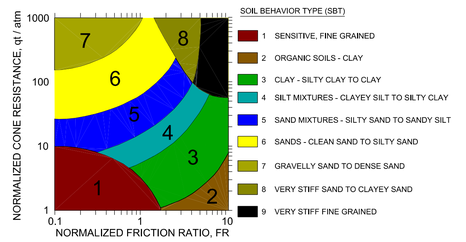


REFUSAL AT 88.9 FEET

NOTE:

SEE SHEET NO. S038 FOR CPT DETAILS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=-80

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026 CHECKED BY

DESIGNED BY: S BORDERS

DETAILED BY: T LYNN

BORING PROFILE

CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S024	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILEA$

PIER 8

B-1021
2061+17
12' LT.
268.9

UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
841					No Specimen
	4.617	0.210	28		A-3(0), SP-SM, S+C=6
	0.420	0.175	31		N=7, A-3(0), SP-SM, S+C=6
	0.423	0.139	42	2.091	N=4, A-2-6(0), SC, S+C=25(19+6)
	0.065	0.008	47	0.842	A-7-6(29), CH, S+C=100(78+22)
	5.677	0.265	17		N=30, A-2-4(0), SM, S+C=14
	9.121	0.563	17		N=19, A-1-b(0), SM, S+C=16
	10.627	0.829	15		N=24, A-1-b(0), SM, S+C=16
	0.414	0.153	23		N=53, A-2-4(0), SM, S+C=18
	3.265	0.012	81	3.474	N=22 { A-6(12), CL, S+C=75(49+26)
	1.830	0.466	19		A-1-b(0), SP-SM, S+C=10 }
	1.825	0.414	17		N=44, A-3(0), SP-SM, S+C=6
	36.064	19.597	15		N=39, A-1-a(0), GP-GM, S+C=5
	16.259	0.857	29		N=66/1.0', A-2-4(0), SM, S+C=29
	0.382	0.129	25	10.375	N=6, A-2-4(0), SM, S+C=28(17+11)
	0.260	0.005	23	0.572	N=12, A-6(10), CL, S+C=83(45+38)
	1.007	0.170	23	3.518	N=34, A-2-4(0), SM, S+C=16(10+6)
	0.353	0.037	23	1.391	N=20, A-4(1), CL-ML, S+C=57(38+19)
	0.373	0.097	22	1.350	N=6, A-4(0), SC-SM, S+C=42(27+15)
	0.414	0.031	25	1.934	N=41, A-4(1), CL-ML, S+C=59(37+22)
	1.798	0.279	21	2.301	N=66, A-2-4(0), SC-SM, S+C=27(16+11)
	1.668	0.177	22	2.295	N=29, A-4(0), SC-SM, S+C=37(25+12)
	0.392	0.132	26		N=50/0.4', A-2-4(0), SM, S+C=27(21+6)
	1.715	0.306	21		N=97/0.9', A-2-4(0), SM, S+C=25(19+6)
	1.796	0.671	20		N=50/0.5', A-1-b(0), SW-SM, S+C=9
	1.810	0.702	20		N=50/0.4', A-1-b(0), SW, S+C=4
	1.839	0.817	19		N=50/0.4', A-1-b(0), SP, S+C=3
	0.579	0.179	29		N=R/0.3', A-3(0), SP-SM, S+C=6
	1.503	0.173	24		N=R/0.4', A-2-4(0), SM, S+C=26
	1.857	0.273	22		N=R/0.5', A-3(0), SP-SM, S+C=8
	1.109	0.189	25		N=50/0.3', A-3(0), SP-SM, S+C=7
	1.800	0.684	21		N=21, A-1-b(0), SW, S+C=2
	1.508	0.213	26		N=50/0.5', A-3(0), SP-SM, S+C=6
	0.067	0.012	27	0.601	N=43, A-6(13), CL, S+C=98(95+3)
4683					
	1.338	0.146	35	-0.693	N=31, A-2-4(0), SM, S+C=31(30+1)
	1.661	0.230	34	-0.156	A-2-7(1), SM, S+C=100(99+1)
	1.526	0.093	28	-0.628	N=24, A-5(2), SM, S+C=47(43+4)
	0.061	0.006	27	-0.370	N=56, A-7-5(21), ML, S+C=99(72+27)

NR
(-31.2)

C1022
2061+25
1' LT
273.8

TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)
400 300 200 100 2 4 6

REFUSAL AT 78.5 FEET

B-1020
2061+25
10' RT.
270.8

UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
	0.572	0.184	28		N=4, A-3(0), SP, S+C=3
	0.357	0.024	47	2.207	N=4, A-6(7), CL, S+C=70(63+7)
					No Specimen
	0.392	0.177	26		N=6, A-3(0), SP, S+C=2
	0.284	0.015	51	2.726	N=2, A-6(8), CL, S+C=82(71+11)
1130	0.058	0.005	39	0.544	A-7-5(21), ML, S+C=100(66+34)
	13.020	0.238	21		No Specimen N=10, A-2-4(0), SM, S+C=13
	15.711	1.735	25		No Specimen N=11, A-1-b(0), SM, S+C=25
	7.804	0.224	24		N=11, A-3(0), SP-SM, S+C=9(7+2)
	11.940	0.817	14		N=27, A-1-b(0), SM, S+C=24
	4.530	0.710	17		No Specimen N=26, A-1-b(0), SM, S+C=13
	37.841	0.868	15		N=33, A-1-b(0), SM, S+C=21
	0.375	0.098	24	0.963	N=16, A-6(1), SC, S+C=41(24+17)
	0.391	0.120	20	2.627	No Specimen N=25, A-2-4(0), SM, S+C=32(15+17)
	1.157	0.109	27	0.676	N=17, A-6(2), SC, S+C=40(27+13)
4241	0.189	0.005	32	0.717	A-6(15), CL, S+C=90(52+38)
2294	1.491	0.101	24	0.995	A-4(1), SC, S+C=45(25+20)
	1.787	0.594	20	2.636	N=35, A-1-b(0), SM, S+C=13(9+4)
4373	0.351	0.044	24	1.733	A-4(0), CL-ML, S+C=56(39+17)
7474	0.385	0.046	21	0.778	A-4(2), CL, S+C=56(41+15)
	1.672	0.306	19	3.681	N=42, A-2-4(0), SP-SM, S+C=11(4+7)
	0.396	0.173	26		N=R/0.4', A-3(0), SP, S+C=5
	1.131	0.187	24		N=50/0.2', A-3(0), SP-SM, S+C=10(8+2)
	1.708	0.387	20		N=90/1.0', A-3(0), SP, S+C=4
	1.814	0.754	27		N=55, A-1-b(0), SW-SM, S+C=8
	1.819	0.728	19		N=50/0.2', A-1-b(0), SW, S+C=2
	1.805	0.718	25		N=13, A-1-b(0), SW, S+C=4
	1.163	0.131	25		N=50/0.3', A-2-4(0), SM, S+C=33(22+11)
	3.137	0.679	14		N=50/0.3', A-1-b(0), SM, S+C=15
	2.732	0.690	15	2.368	N=27, A-1-b(0), SM, S+C=13(8+5)
	1.598	0.281	26		N=39, A-3(0), SP, S+C=1
	1.668	0.317	22		N=88/1.0', A-3(0), SP-SM, S+C=6
	1.393	0.127	28	0.001	N=13, A-6(1), SM, S+C=37(34+3)
9895	1.710	0.392	25	-0.900	No Specimen A-7-5(1), SM, S+C=37(32+5)
9415	1.381	0.103	21	-1.703	A-5(1), SM, S+C=44(39+5)
	1.773	0.600	31	0.127	N=0, A-2-7(0), SM, S+C=24(21+3)
	1.563	0.215	33	0.001	N=19, A-2-7(0), SM, S+C=21(17+4)

NR
(-13.2)

APPROXIMATELY 3 (M) 10 FT OF DRILL CASING AND BIT REMAIN NEAR BOTTOM OF HOLE. DRILLERS ESTIMATE AT/NEAR A DEPTH OF 240 FT BELOW MUDLINE.

B-1023
2062+75
10' LT.
272.7

UU(psf)	D_{95} mm	D_{50} mm	w%	L.I.	
1884	0.287	0.013	31	1.334	A-4(6), CL, S+C=80(64+16)
	0.394	0.053	35	5.288	N=2, A-4(0), CL-ML, S+C=54(45+9)
	11.061	0.147	29		N=5, A-4(0), SM, S+C=40(32+9)
	13.758	0.935	20		N=9, A-1-b(0), SM, S+C=21
	7.643	0.708	21		N=9, A-1-b(0), SM, S+C=12
	21.678	3.571	19		N=9, A-1-b(0), GM, S+C=24
	12.745	2.478	21		N=13, A-1-b(0), SM, S+C=25
	8.713	3.966	35		N=26, A-1-a(0), SP, S+C=0
	1.721	0.230	19		N=30, A-3(0), SP-SM, S+C=10
	0.420	0.169	28		N=14 { A-3(0), SP-SM, S+C=10
	0.242	0.012	34	0.296	A-7-6(19), ML, S+C=90(60+10)
	0.139	0.011	21	-1.039*	A-7-5(9), ML, S+C=93(81+12)
					No Specimen
	0.385	0.140	26	8.881	A-2-4(0), SM, S+C=22(9+13)
	0.357	0.020	29	1.282	N=5, A-6(4), CL, S+C=62(32+30)
					No Specimen
	0.358	0.025	26	1.219	N=21, A-6(4) CL, S+C=60(34+26)
	1.041	0.023	24	0.860	N=11, A-6(4), CL, S+C=63(40+23)
	0.397	0.142	25	2.901	N=9, A-2-4(0), SC-SM, S+C=22(10+12)
	0.417	0.147	20	2.194	A-2-4(0), SM, S+C=21(13+8)
	0.392	0.142	24	1.672	N=24, A-2-4(0), SC-SM, S+C=22(11+11)
	0.386	0.137	25	10.522	N=31, A-2-4(0), SM, S+C=24(13+11)
	0.411	0.153	24	3.573	N=27, A-2-4(0), SM, S+C=18(9+9)
	1.111	0.161	16	0.970	No Specimen N=87/1.0', A-2-4(0), SM, S+C=21(10+11)
	1.598	0.210	20		N=56, A-2-4(0), SM, S+C=17(13+4)
	1.648	0.287	19	3.127	N=48, A-2-4(0), SM, S+C=16(7+9)
	1.568	0.203	23	5.672	N=R/0.3', A-2-4(0), SP-SM, S+C=8(3+6)
	1.789	0.633	21		N=88/0.7', A-1-b(0), SW, S+C=4
	1.828	0.783	20		N=50/0.3', A-1-b(0), SP, S+C=2
	1.959	0.763	19		N=59, A-1-b(0), SW-SM, S+C=7
	1.814	0.740	21		N=82/0.3', A-1-b(0), SP, S+C=1

NR
(115.2)

APPROXIMATELY 2.5 M (8.4 FT) OF GEOBORE DRILL STEM LOST DOWNHOLE. DRILLERS ESTIMATE AT/NEAR A DEPTH OF 150 FT BELOW MUDLINE.

C1025
2062+75
10' Rt.
277.0

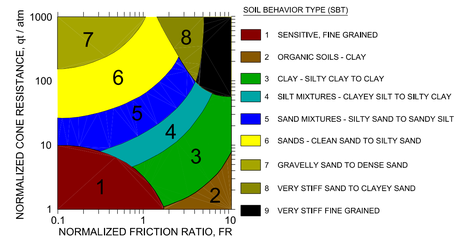
TIP RESISITANCE, qt (tsf) SBT FRICTION RATIO (%)
440 330 220 110 2 4 6

REFUSAL AT 80.2 FEET

NOTE:

SEE SHEET NO. S038 FOR CPT DETAILS

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

DATUM ELEV.=-60

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE: 02/27/2026
DESIGNED BY: S BORDER
DETAILED BY: T LYNN
CHECKED BY

BORING PROFILE

CROSSING
OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO. S025	DRAWING NUMBER

OpenRoads Designer v23.00.01.11 USER: $USER$ DATE PLOTTED: $DATE$ $TIME$ FILE NAME: $FILEA$

MicroStation v8.11.9.99
E-SHEET NAME:
USER: WSHUECRA
DATE PLOTTED: December 15, 2021
FILE NAME: G:_EBS_HDR PROJECTS\10174706 KY CAIRO BRIDGE\DWGS\CAIRO FENCE DIAGRAM.DGN

B-1
2030+15
1' LT
315.6

D_{95} mm	D_{50} mm	w%	L.I.	N
0.067	0.011	31	1.06	A-4(7), ML, S+C=98(90+8)
0.066	0.010	29	1.08	A-4(6), CL-ML, S+C=98(85+13)
		30		
0.187	0.014	30		A-4(0), ML, S+C=90(86+4)
0.378	0.086	47		A-4(0), SM, S+C=46(42+4)
0.381	0.140	31		N=14, A-2-4(0), SM, S+C=22(22+0)
0.344	0.035	20		A-4(0), ML, S+C=64
0.060	0.007	37	0.57	A-7-6(24), CL, S+C=100(77+23)
0.060	0.008	30	0.27	A-7-6(22), CL, S+C=100(80+20)
0.397	0.125	37		N=14, A-2-4(0), SM, S+C=30(30+0)
0.414	0.129	31		N=24, A-2-4(0), SM, S+C=29(28+2)
0.402	0.162	25		N=31, A-2-4(0), SP-SM, S+C=12(7+5)
		20		
0.392	0.165	23		N=69, A-3(0), SP-SM, S+C=9(9+0)
0.386	0.161	28		N=67, A-2-4(0), SP-SM, S+C=11(9+2)
21.857	1.319	13		N=25, A-1-b(0), SW, S+C=4(4+0)
13.077	1.004	16		N=94/0.92', A-1-b(0), SW-SM, S+C=7(5+1)
24.018	1.477	14	-5.10	N=52, A-1-b(0), SW-SM, S+C=6(6+0)
30.426	0.589	19		N=50/0.50', A-1-b(0), SP-SM, S+C=7(7+0)
21.772	0.109	28	2.34	N=15, A-4(0), SM, S+C=44(40+4)
				No Specimen
23.136	0.040	28	0.41	N=17, A-6(5), CL, S+C=57(40+17)
0.385	0.012	26	0.82	N=17, A-6(6), CL, S+C=69(39+30)
				No Specimen
20.090	0.021	27	0.84	N=37, A-6(6), CL, S+C=64(40+24)
0.410	0.039	24	2.24	N=76, A-4(0), CL-ML, S+C=56(34+22)
		9		
5.143	0.186	24	3.35	N=98/0.92', A-4(0), SM, S+C=36(24+12)
1.810	0.379	21		N=64, A-3(0), SP-SM, S+C=9(6+3)
0.498	0.154	26		N=59, A-2-4(0), SM, S+C=19(12+6)
1.626	0.278	29		No Specimen N=R/0.25', A-2-4(0), SP-SM, S+C=11(8+3)
1.555	0.250	22		N=50/0.25', A-3(0), SP-SM, S+C=6(5+2)
1.688	0.316	20		N=50/0.42', A-2-4(0), SM, S+C=14(11+2)

NR

CPT-1
PROJECTED AHEAD FROM 2030+14
29' RT
315.9

TIP RESISTANCE, qt (tsf) SBT FRICTION RATIO (%)
400 300 200 100 0 0 8 16 24 32 40

CPTT-29

B-2
2036+84
CL
307.0

D_{95} mm	D_{50} mm	w%	L.I.		N
0.354	0.022	25	0.76		A-4(3), CL-ML, S+C=71(63+8)
		35			N=6
0.066	0.011	34	1.42		A-4(7), ML, S+C=98(89+9)
0.245	0.015	35	2.33		N=3, A-6(5), CL-ML, S+C=86(79+7)
0.396	0.176	21			A-3(0), SP, S+C=3
0.393	0.042	29	6.18		N=23, A-4(0), ML, S+C=59(55+4)
0.388	0.167	26			N=20, A-3(0), SP-SM, S+C=7
1.351	0.176	21			A-2-4(0), SM, S+C=20
0.790	0.181	22			N=27, A-3(0), SP-SM, S+C=6
		23			N=65
		21			N=30
		20			
1.755	0.351	19			N=39, A-3(0), SP, S+C=5
		18			N=85/1.00'
0.414	0.173	25			N=54, A-3(0), SP-SM, S+C=7
1.657	0.223	20			N=53, A-3(0), SP-SM, S+C=8
		31			
4.749	0.760	15			N=66, A-1-b(0), SW, S+C=4
		17			N=72
20.003	1.187	16			N=50/0.50', A-1-b(0), SW, S+C=4
0.387	0.143	26			N=10, A-2-4(0), SM, S+C=21
19.246	0.153	14	-0.04		A-2-4(0), SM, S+C=20
		24			N=17
0.402	0.151	26			N=18, A-2-4(0), SM, S+C=18
		21			N=59
0.488	0.054	28			A-4(0), ML, S+C=55
1.654	0.227	17			N=65, A-2-4(0), SM, S+C=15
		24			N=50/0.33'
1.474	0.202	21			N=73/1.00', A-3(0), SP-SM, S+C=10
3.108	0.154	32	4.65		A-4(0), SC-SM, S+C=38(32+6)
1.200	0.177	20			N=85/0.80', A-2-4(0), SM, S+C=32
1.468	0.210	22			N=61, A-3(0), SP-SM, S+C=8
		28			N=R/0.25'
1.469	0.223	25			N=R/0.33', A-3(0), SP-SM, S+C=6
1.729	0.436	19			No Specimen N=95/0.80', A-1-b(0), SP, S+C=4
		21			N=50/0.50'
		25			N=50/0.30'
0.415	0.148	27			N=R/0.40', A-2-4(0), SM, S+C=20
0.715	0.185	26			A-3(0), SP, S+C=4(2+2)
		24			N=50/0.30'
0.395	0.173	25			N=50/0.20', A-3(0), SP, S+C=4
		28			N=R/0.40'
0.409	0.165	26			N=50/0.30', A-2-4(0), SP-SM, S+C=11
		23			No Specimen N=R/0.20'

NR

CPT-2B
PROJECTED AHEAD FROM 2036+87
15' LT
307.1

TIP RESISTANCE, qt (tsf) SBT FRICTION RATIO (%)
400 300 200 100 0 0 8 16 24 32 40

CPTT-40

OHIO RIVER

B-3
2065+00
CL
315.1

D_{95} mm	D_{50} mm	w%	L.I.		N
0.085	0.009	26	0.34		A-6(19), CL, S+C=98(83+15)
0.387	0.129	23			A-2-4(0), SM, S+C=28(27+1)
0.397	0.158	45			A-2-4(0), SM, S+C=14(13+1)
0.399	0.116	34			A-2-4(0), SM, S+C=34(31+3)
0.244	0.012	38	1.24		A-6(12), CL, S+C=85(69+16)
0.390	0.167	48			A-3(0), SP-SM, S+C=8(7+1)
0.418	0.159	41			N=8, A-2-4(0), SM, S+C=15(12+3)
1.485	0.206	57			A-2-4(0), SP-SM, S+C=12(10+2)
1.583	0.262	26			N=11, A-2-4(0), SP-SM, S+C=11(7+4)
1.344	0.176	35			N=12, A-2-4(0), SM, S+C=18(17+1)
1.922	0.258	25			N=16, A-3(0), SP, S+C=4(2+2)
1.835	0.692	25			N=12, A-1-b(0), SW, S+C=2(2+0)
		17			
10.255	1.124	21			N=14, A-1-b(0), SW, S+C=3(3+0)
12.326	1.046	18			N=25, A-1-b(0), SW, S+C=3(2+1)
5.892	0.909	17			N=18, A-1-b(0), SW-SM, S+C=7(7+0)
		21			
0.383	0.134	29	1.72		N=5, A-2-4(0), SC, S+C=25(25+0)
0.691	0.132	28	2.50		N=7, A-2-4(0), SM, S+C=29(29+0)
1.015	0.126	30	1.39		N=7, A-2-4(0), SC-SM, S+C=33(27+6)
1.706	0.312	39			A-2-4(0), SM, S+C=19
0.403	0.087	31	1.30		N=3, A-4(1), SC-SM, S+C=46(43+3)
0.355	0.049	29			N=3, A-4(0), ML, S+C=56(50+6)
0.624	0.121	28	10.95		A-2-4(0), SM, S+C=34(24+10)
0.374	0.100	26	1.36		A-4(0), SC, S+C=40(26+14)
38.399	0.188	30			A-2-4(0), SM, S+C=17(12+5)
0.420	0.115	29			A-2-4(0), SM, S+C=35
0.393	0.122	20	1.38		N=35, A-2-4(0), SC-SM, S+C=31(18+13)
0.395	0.085	20	0.91		N=52, A-4(1), SC, S+C=46(30+16)
		26			
1.661	0.290	20			N=50/0.42', A-3(0), SP-SM, S+C=10(8+2)
1.343	0.187	19	1.98		N=50/0.42', A-2-4(0), SM, S+C=16(11+5)
0.387	0.160	26			N=50/0.17', A-2-4(0), SP-SM, S+C=12(8+4)
0.400	0.117	19			A-2-4(0), SM, S+C=34(28+6)
0.395	0.168	25			N=R/0.42', A-3(0), SP-SM, S+C=8(7+0)
1.812	0.635	20			N=50/0.17', A-1-b(0), SW-SM, S+C=7(6+1)
1.803	0.640	22	1.77		N=50/0.17', A-1-b(0), SW-SM, S+C=5(5+0)
1.785	0.641	21			N=50/0.17', A-1-b(0), SW, S+C=4(4+0)
1.771	0.591	22			N=R/0.25', A-1-b(0), SW-SM, S+C=5(5+0)
1.834	0.750	22			N=50/0.33', A-1-b(0), SW, S+C=4(3+1)
1.809	0.637	20			N=96/1.00', A-1-b(0), SW-SM, S+C=6(5+1)
1.592	0.249	22			N=76/1.00', A-3(0), SP-SM, S+C=6(5+1)
1.412	0.055	19	1.06		A-4(1), CL, S+C=55

NR

CPT-3
PROJECTED AHEAD FROM 2065+00
15' RT
314.6

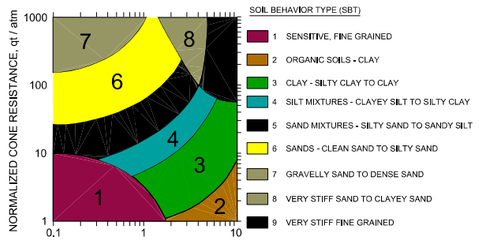
TIP RESISTANCE, qt (tsf) SBT FRICTION RATIO (%)
400 300 200 100 0 0 8 16 24 32 40

CPTT-69

MATCHLINE A - SEE SHEET 4

DATUM ELEV.=80

CPT SOIL CLASSIFICATION GRAPHIC SYMBOLS



atm = ATMOSPHERIC PRESSURE = 101 kPa = 1.05 tsf

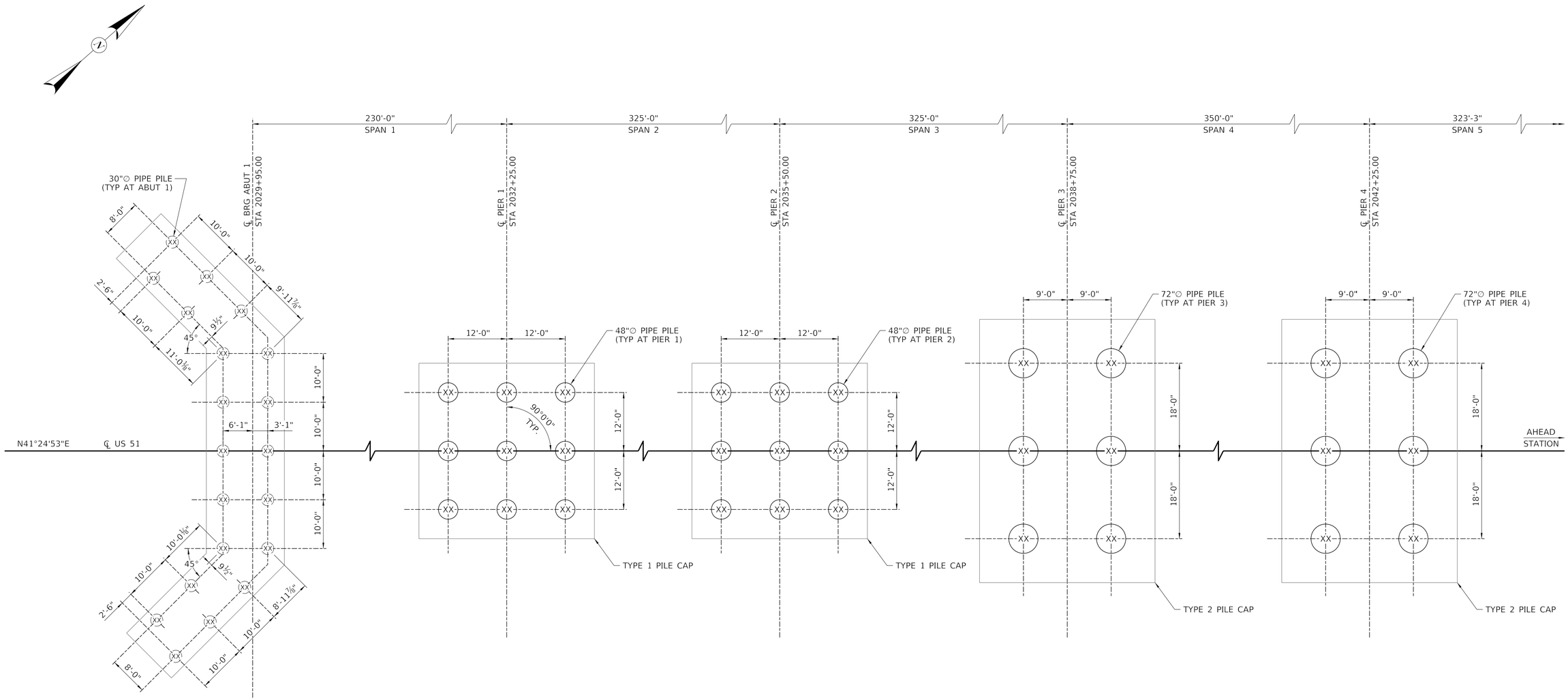
DATE: 10/14/2021	CHECKED BY
DESIGNED BY: TSL	DLC
DETAILED BY:	

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
BALLARD

ROUTE	CROSSING
US 51	OHIO RIVER

ITEM NUMBER	PREPARED BY	SHEET NO.
1-1140.00	HDR	3
		DRAWING NO.



NOTES:

1. FOR PILE RECORD SEE PILE RECORD SHEETS.
2. FOR ABUTMENT 1 DETAILS SEE ABUTMENT 1 PILE CAP SHEET.
3. FOR TYPE 1 PILE CAP DETAILS SEE TYPE 1 PILE CAP DETAILS SHEETS.
4. FOR TYPE 2 PILE CAP DETAILS SEE TYPE 2 PILE CAP DETAILS SHEETS.

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE:	CHECKED BY
DESIGNED BY: Nickolas Hatinger	
DETAILED BY: Josh Perry	Wes Hagerman

FOUNDATION LAYOUT (1 OF 7)

CROSSING: OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO.	DRAWING NUMBER

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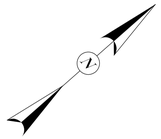

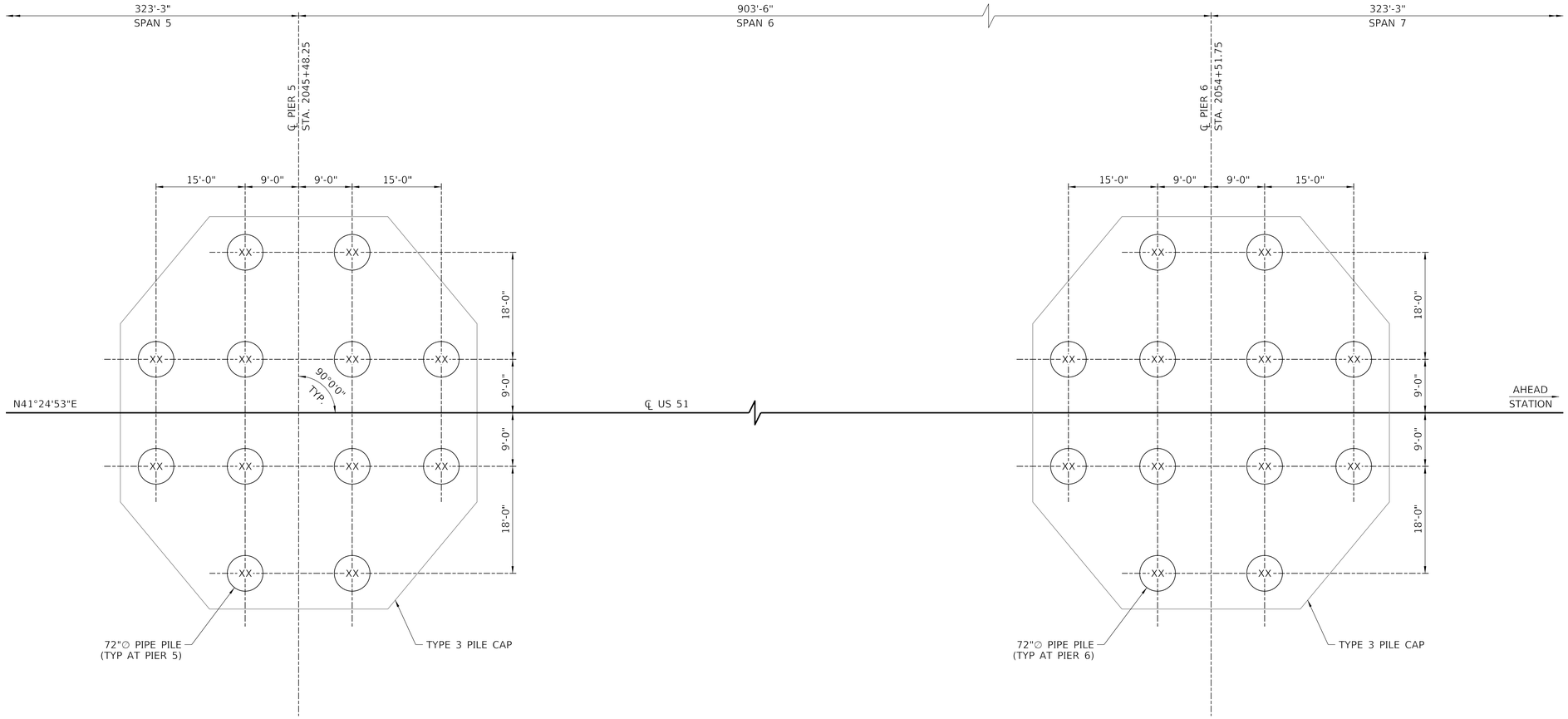

NOTES:

1. FOR PILE RECORD SEE PILE RECORD SHEETS.
2. FOR TYPE 3 PILE CAP DETAILS SEE TYPE 3 PILE CAP DETAILS SHEETS.

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
TEAM KENTUCKY TRANSPORTATION CABINET

REVISION	DATE

PREPARED BY HDR

DATE:	CHECKED BY
DESIGNED BY: Nickolas Hatinger	
DETAILED BY: Josh Perry	Wes Hagerman

FOUNDATION LAYOUT (2 OF 7)

CROSSING: OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
US 51	01-1140.00	BALLARD
	SHEET NO.	DRAWING NUMBER

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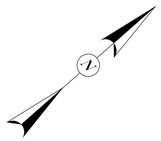

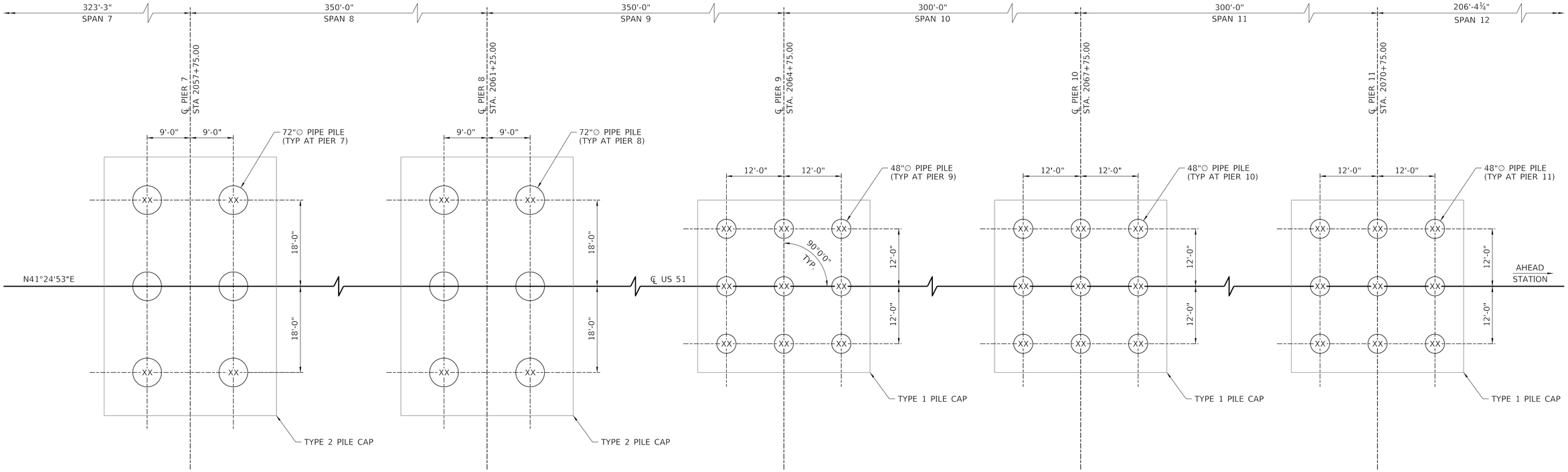

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3. FOR TYPE 2 PILE CAP DETAILS SEE TYPE 2 PILE CAP DETAILS SHEETS.

US 51 BRIDGE REPLACEMENT

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TEAM KENTUCKY TRANSPORTATION CABINET

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DETAILED BY: Josh Perry	Wes Hagerman

FOUNDATION LAYOUT (3 OF 7)

CROSSING
OHIO RIVER

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US 51	01-1140.00	BALLARD
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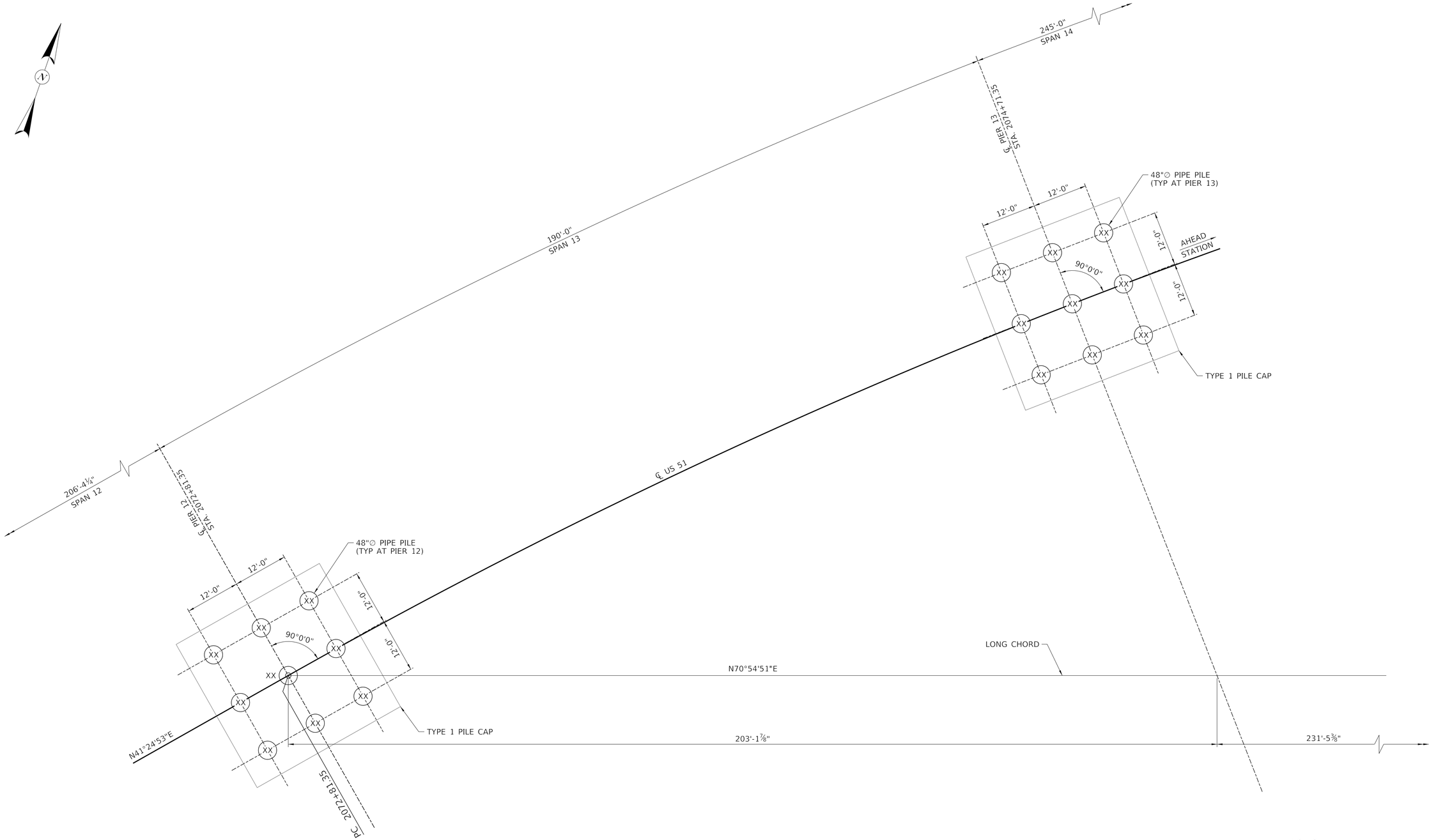

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US 51 BRIDGE REPLACEMENT

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DETAILED BY: Josh Perry		Wes Hagerman

FOUNDATION LAYOUT (4 OF 7)
CROSSING: OHIO RIVER

ROUTE	ITEM NO.	COUNTY OF
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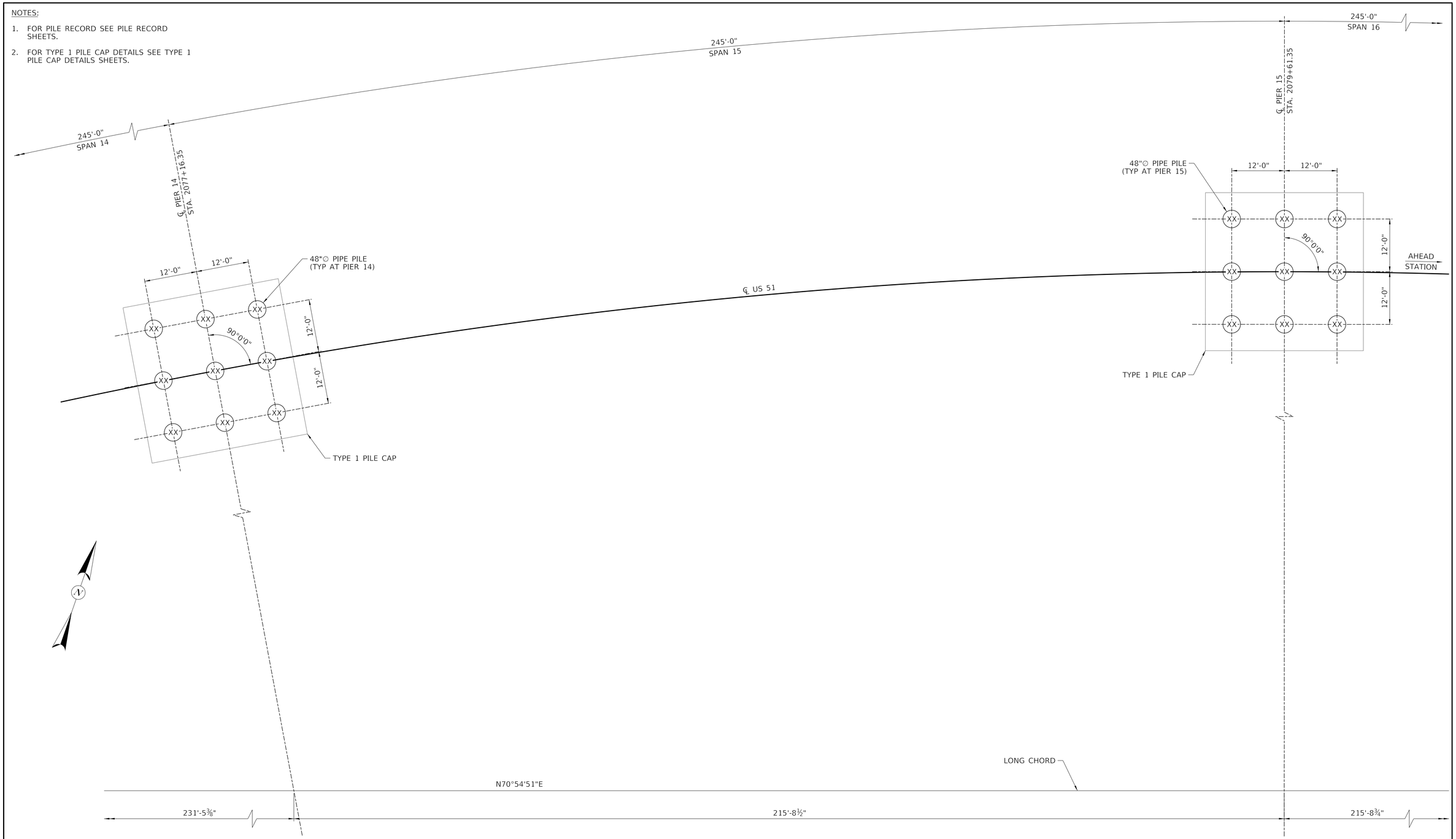

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				DETAILED BY: Josh Perry	Wes Hagerman	OHIO RIVER		SHEET NO.	DRAWING NUMBER

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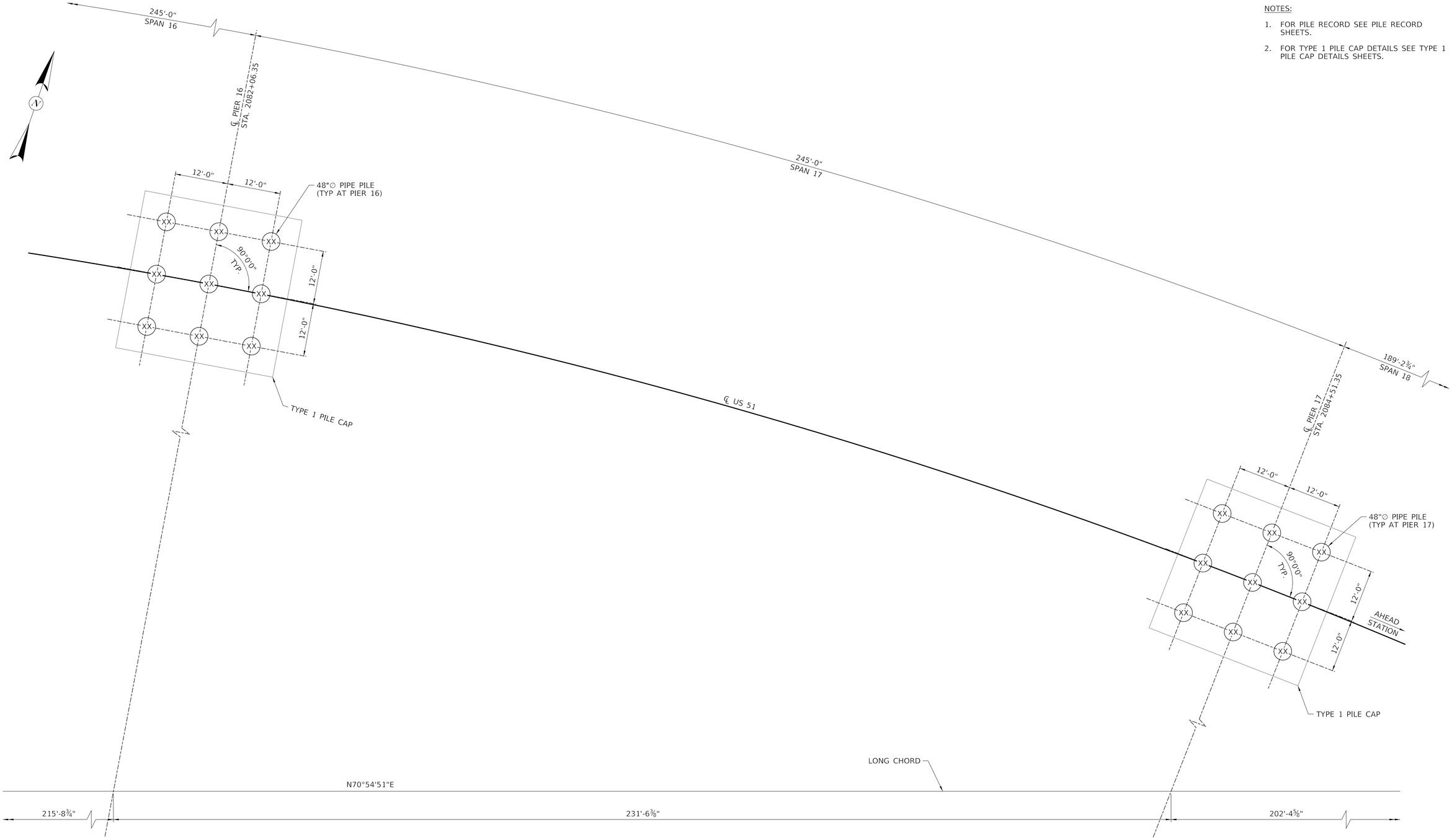

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FOUNDATION LAYOUT (6 OF 7)

CROSSING: OHIO RIVER

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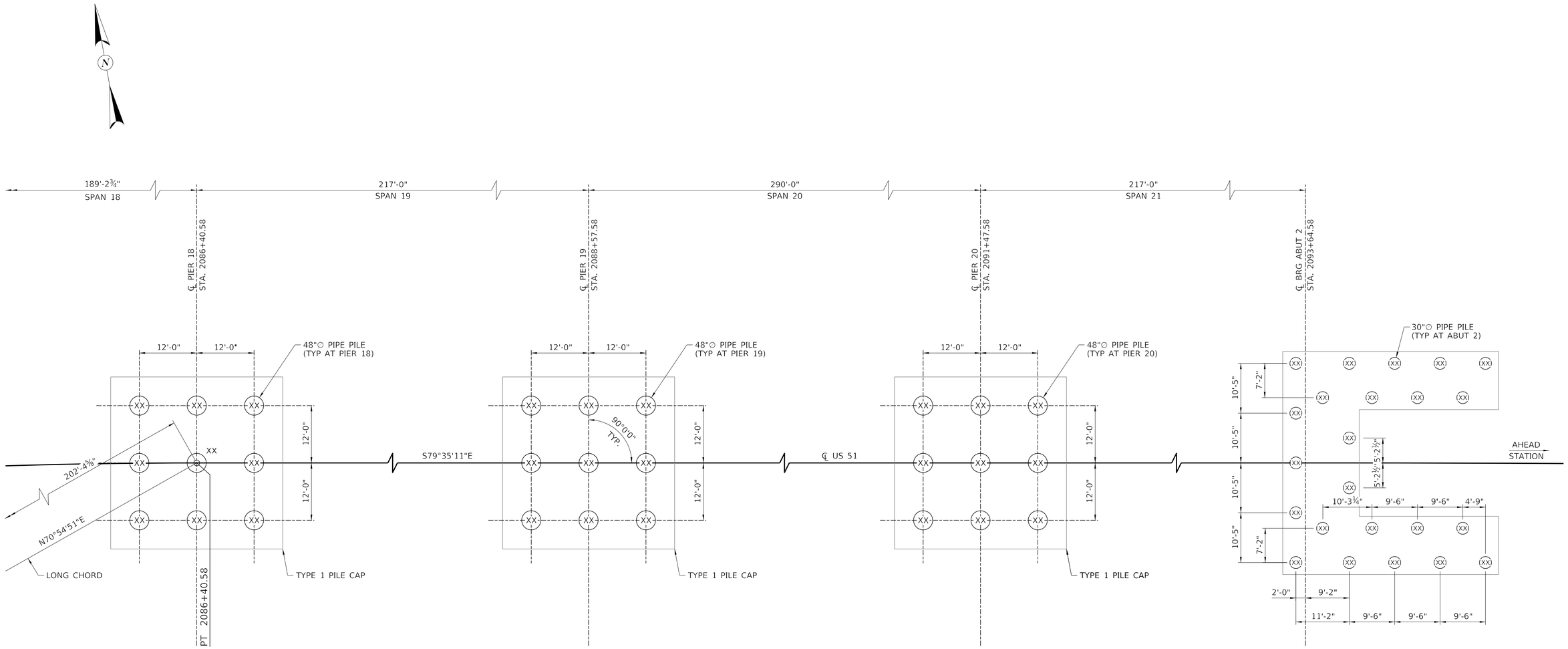

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3. FOR TYPE 1 PILE CAP DETAILS SEE TYPE 1 PILE CAP DETAILS SHEETS.

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DETAILED BY: Josh Perry	Wes Hagerman

FOUNDATION LAYOUT (7 OF 7)

CROSSING: OHIO RIVER

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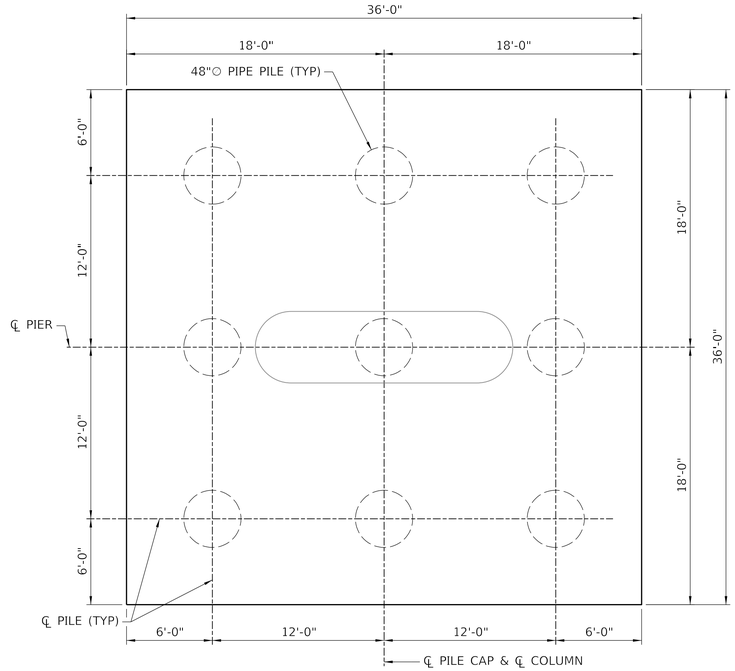

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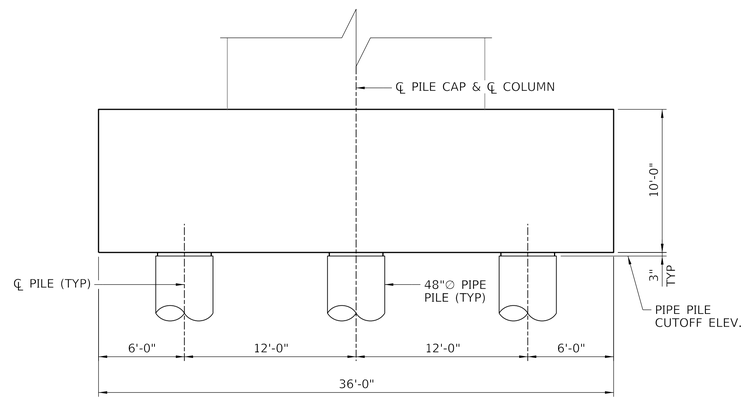

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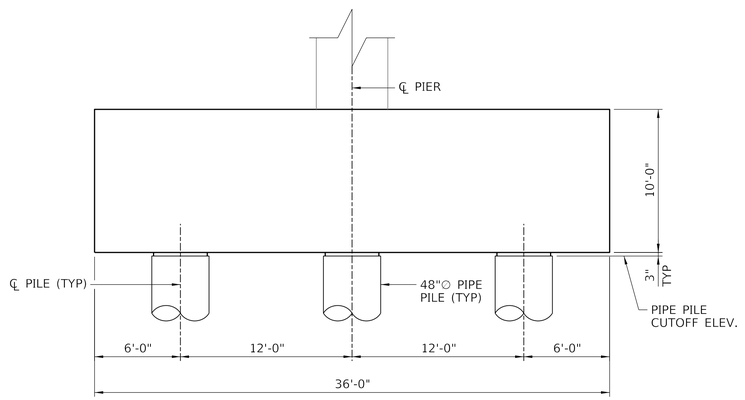

END ELEVATION

US 51 BRIDGE REPLACEMENT

COMMONWEALTH OF KENTUCKY
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TYPE 1 PILE CAP

CROSSING
OHIO RIVER

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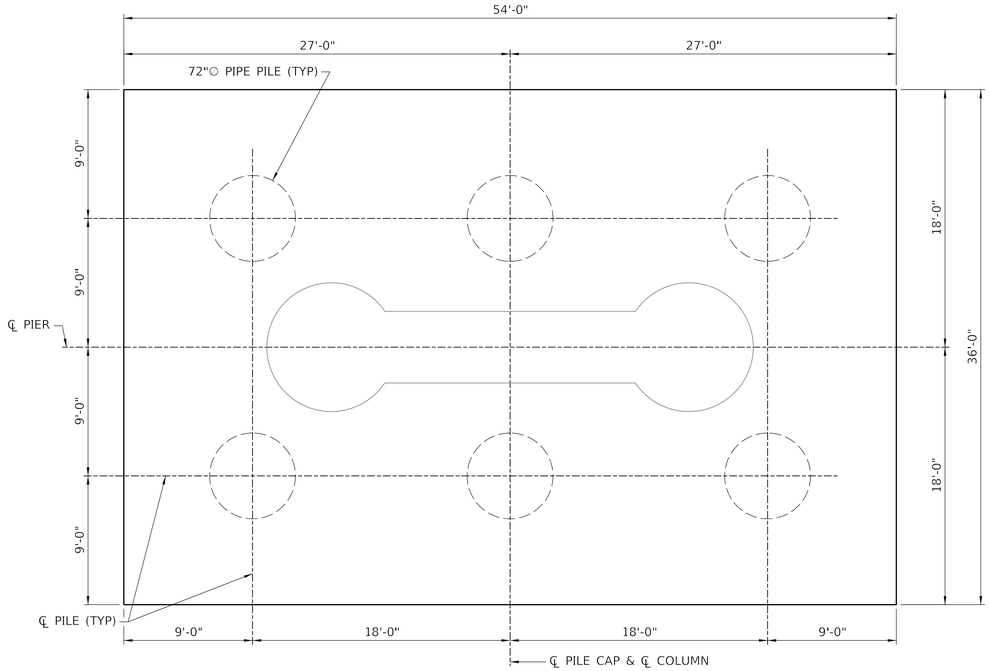

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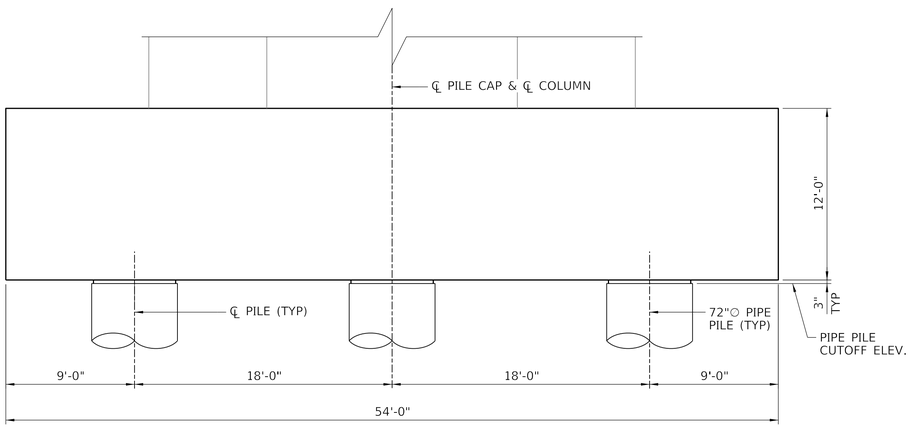

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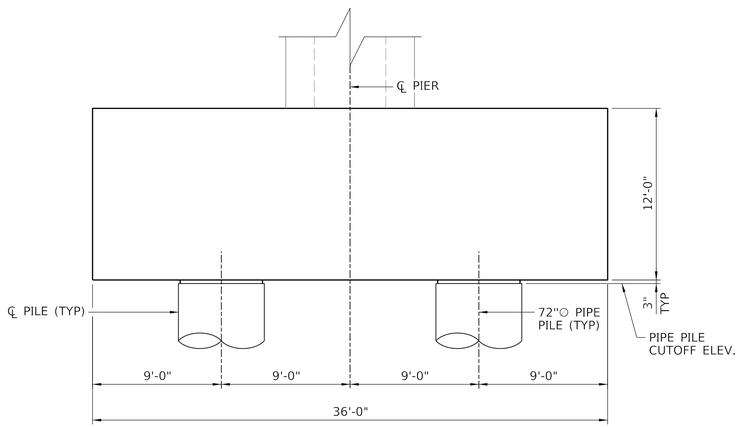

END ELEVATION

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TYPE 2 PILE CAP

CROSSING: OHIO RIVER

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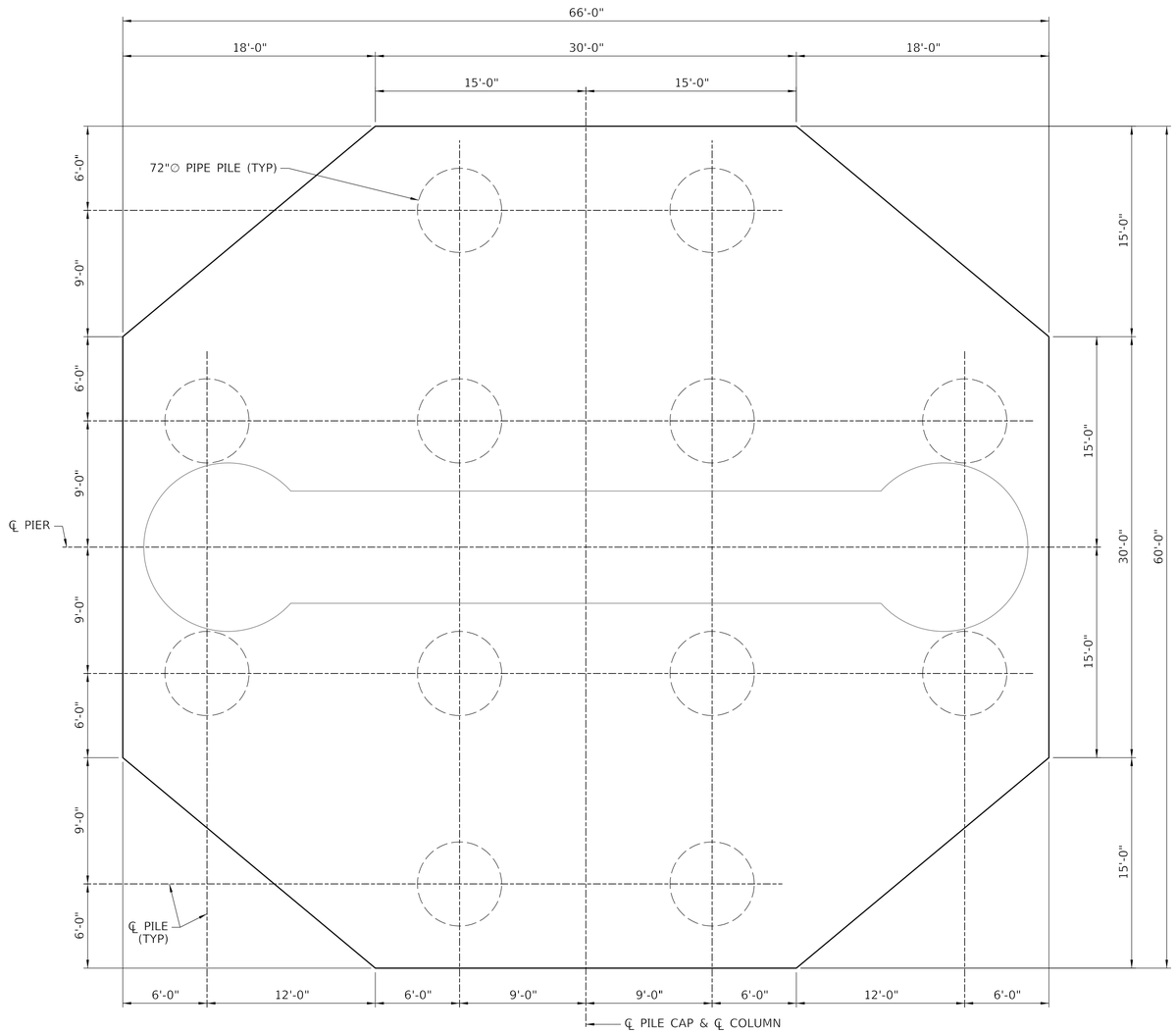

PLAN

US 51 BRIDGE REPLACEMENT

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TYPE 3 PILE CAP (1 OF 2)

CROSSING: OHIO RIVER

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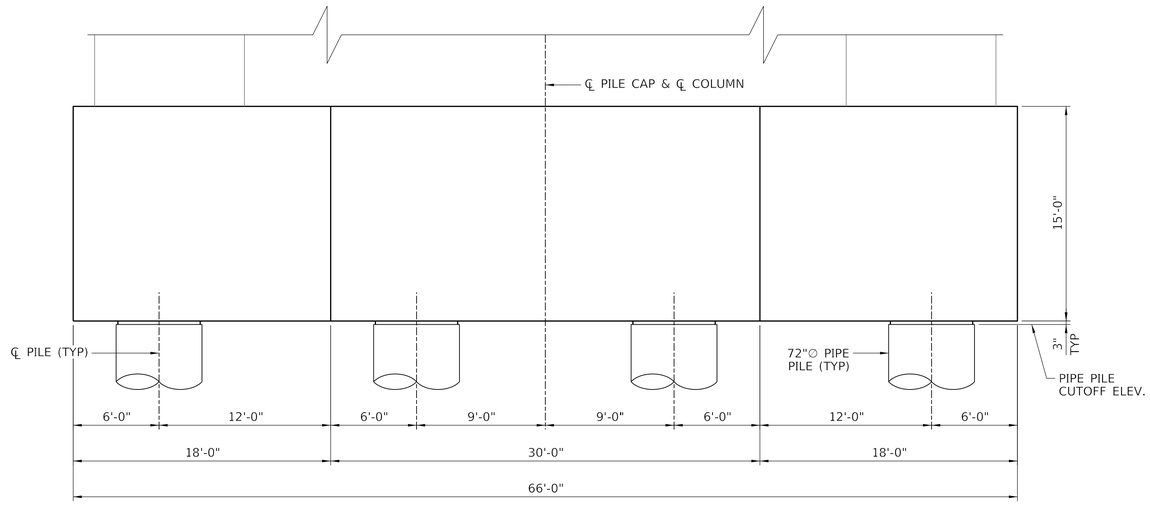

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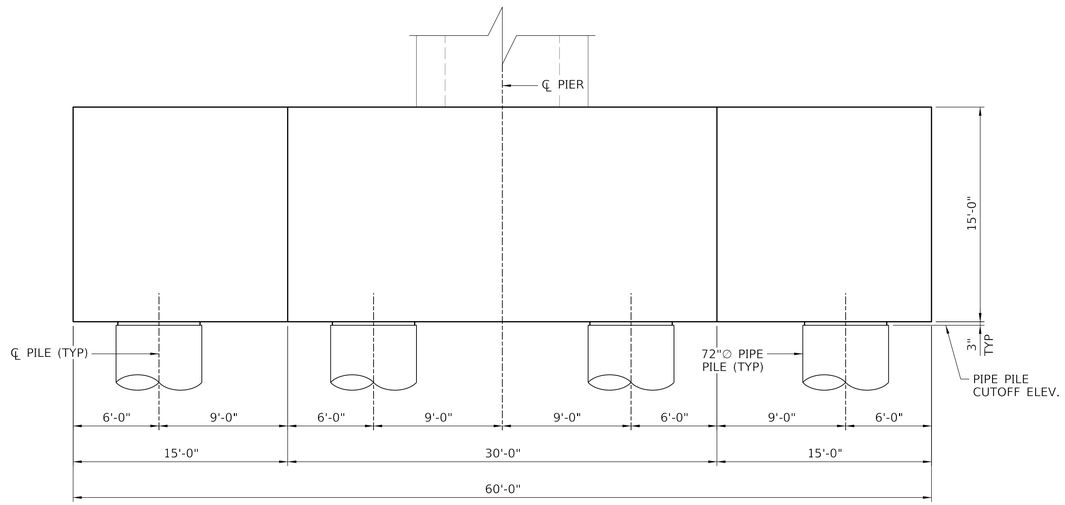

END ELEVATION

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TYPE 3 PILE CAP (2 OF 2)

CROSSING: OHIO RIVER

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Appendix B – Sampling Method Definitions, Manufacturers Sampling Method Sheets, Drillers Boring Logs, & SCPTu Sounding Logs

Subsurface investigation Methods Definitions

FIELD METHODS FOR EXPLORATION AND SAMPLING SOIL

A. Boring Procedures Between Samples

The boring is extended downward between samples, by a hollow stem auger (AASTHO Designation T251), continuous flight augers, driven and washed-out casing, or rotary boring with drilling mud.

B. Standard Penetration Test and Split-Barrel Sampling of Soils

AASHTO Designation: T206

This method consists of driving a 2-in. outside diameter split-barrel sampler using a 140-lb weight falling freely through a distance of 30 in. The sampler is first seated 6 in. in the material to be sampled and then driven an additional 12 in. The number of blows required to the drive sampler the final 12 in. is recorded on the Log of Test and know as the Standard Penetration Resistance or N-value. Recovered samples are first classified as to texture by field personnel. Later in the laboratory, the field classification is reviewed by the geotechnical engineer or a qualified person under their direction who observes each sample.

C. Thin-walled Tube Sampling of Soils

AASHTO Designation: T207

This method consists of hydraulically pushing a 2-in. or 3-in. outside diameter thin wall tube into the soil, usually cohesive soil types. Relatively undisturbed samples are recovered.

D. Gus Sampling of Soils

This method consists of pneumatically pressing a 2-in. or 3-in. outside diameter thin wall tube into the soil strata, usually soft cohesive soils, but has been used for cohesionless soils with some success. Water pressure (operating range of 100 to 600 psi) is used to actuate the piston in the head assembly which drives the tube into the soils. Relatively undisturbed samples are recovered.

E. Soil Core Drilling for Site Investigation

This method consists of advancing a hole in subsurface soil or hard/dense strata by rotating downward a single tube/barrel equipped with a cutting head. Diamond, tungsten carbide, or other cutting agents may be used for the bit. Wash water (or mud rotary) drilling techniques are used to remove the cuttings and advance the core barrel. Normally a 3-in. outside diameter by 2-in. inside diameter coring bit is used unless otherwise noted. A plexiglass sleeve is inserted into the barrel where softer/looser formations can be contained. The recovered material within the core barrel/plexiglass sleeve is examined in the field and/or laboratory. The soil cores are stored in the plexiglass sleeves until needed. For the river crossing, the S Geobore wireline system was utilized. Operational differences between standard coring operations and the S. Geobore are present, however, the core size collected is 102 mm (4.01 in.).

Manufacturer Schematics of Gus Sampler and Soil Core Barrel

Bulletin 9

acker DRILL COMPANY

GUS SAMPLER

(Gregory Undisturbed Sampler)

This unique, air or hydraulic piston sampler was designed and test proven in the drilling field for many years. The design allows the sampler to be classed as a truly undisturbed piston sampler producing high production sampling.

HOW IT WORKS

The GUS Samper is assembled on a drill rod and lowered to the bottom of a cleaned bore hole. The drill rod may be chucked by means of a chucking rod. A water swivel is attached with a hose line coupled to the swivel and the pressure pump.

As the water or air pressure is applied to the drill rods at approximately 100 to 600 PSI, the piston in the head of the assembly forces the thin wall sample tube in the soft underlying soil or clay materials to take the sample.

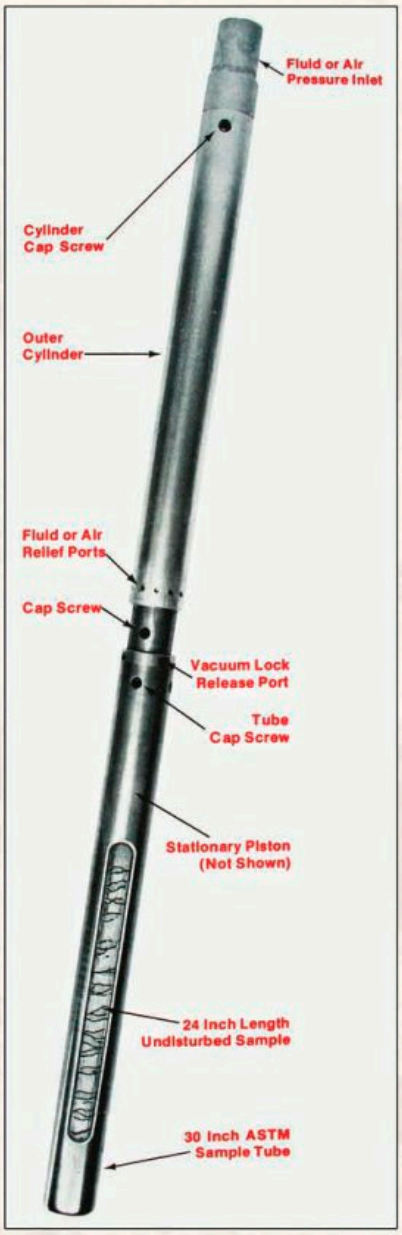
Once the sampler reaches the end of its maximum travel, the water or air used for pressing exhausts through a relief hole and returns immediately to the surface. This is a signal to the operator that the sample has been taken to its maximum depth.

Depending upon the materials being sampled, the sampling may take only a few seconds or as much as one minute to reach its maximum travel.

A compressed air bottle or tank may be used in lieu of a fluid pump for pressing the sample, however, one must be careful to limit tank pressure to prevent "over pressure" which may collapse the sample tube.

After the sample has been taken, the rods and sampler are pulled to the surface and the sampler is layed out on the work table for removing of the sample tube containing the sample.

The outer tube of the sampler containing the sample is rotated in a counter clockwise direction three turns which releases the "vacuum lock" created over the sample in the sample tube and allows for easy removal of the sample tube from the assembly. A new sample tube is then installed on the sampler head for additional tests and the procedure repeated.



IN OPERATION

(1) The hole is drilled by rotary means and prepared by using either casing or drilling mud to support the overburden.

(2) The drill rods extending the sampler to the bottom of the hole may be clamped to the casing to prevent upward movement from down thrust of fluid or air pressure used...or rods may be connected to the chucking rod in rotary drill head.

(3) A water swivel or adaptor is used to direct fluid or air into the drill string to operate the sampler.

(4) A positive displacement pump or compressed air is used to exert pressure on the stationary piston of the sampler. Pressure range normally required is 100 to 600 PSI for at least one minute.

FEATURES OF THE GUS SAMPLER

- Bore hole size need not be larger than sampler size in use.
- Available in 4 popular sizes - 2-1/2", 3", 3-1/2", 5" (63.5, 76.2, 88.9 & 127 mm)
- Fluid or air under pressure is required to operate sampler
- Simple to operate - there is no need for actuating rods or complicated procedures
- Uses standard ASTM thin wall steel sampler tubes with standard holes and cap screws
- Sampler adapts directly to standard AW or NW drill rods
- Used in holes cased with mud, steel casing or self supporting auger holes
- Piston closes off sampler until sample is taken
- Maximum length of sample recovered is 24" (609.6 mm)
- Maximum pressure required - 100 to 600 PSI
- Stainless steel actuating cylinder
- Drill rig is not necessary for sampling; however, hoist is required to lift tools and sampler from the drill hole
- Inexpensive when compared to other comparable types of samplers

acker DRILL COMPANY
P.O. Box 830, Scranton, PA 18501 USA
Toll Free: 800.752.2537 Fax: 570.586.2659
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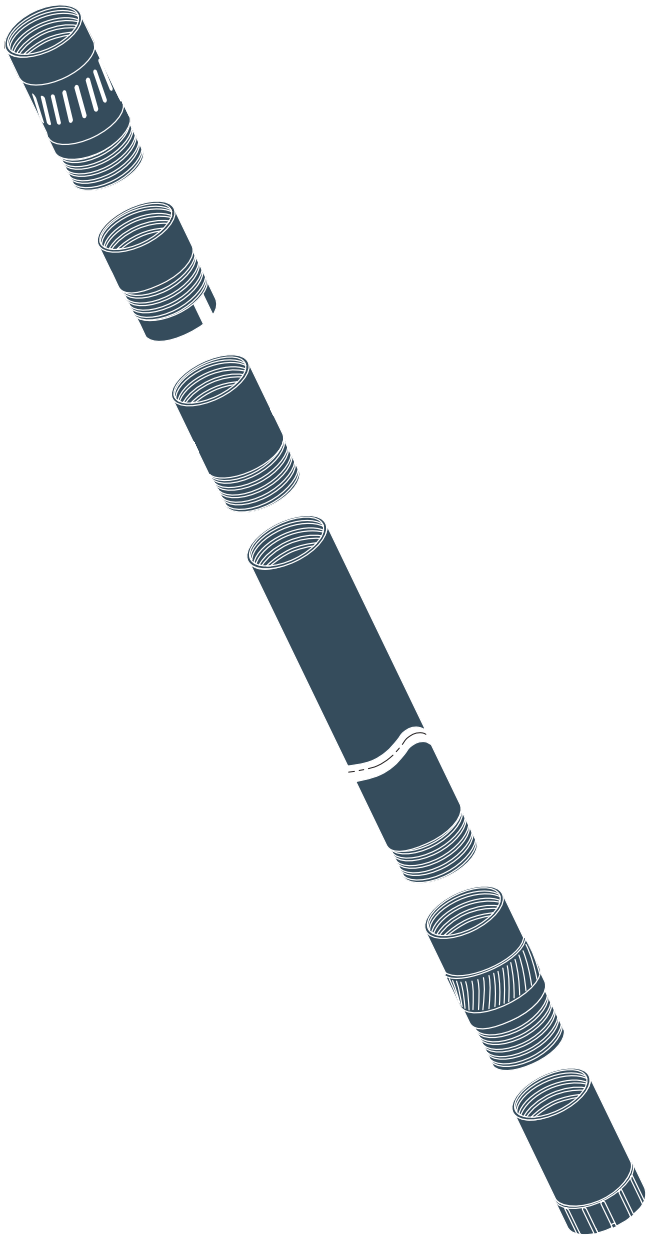
S Geobor
wireline core barrel



Contents

Introduction **2**

1. Product description ... 3

1.1. Description ... 3

1.2. Method 1-7 description ... 3

1.3. Technical data - wireline core barrel ... 5

1.4. Technical data - rods ... 5

1.5. Technical data - drill bits ... 6

2. Operating instructions **7**

2.1. Basic setting of the core barrel ... 7

2.2. Drilling ... 8

2.2.1. Recommended drilling parameters ... 8

2.3. Catching and lifting the inner core barrel ... 8

2.4. Installing inner core barrel (water filled hole) ... 8

2.5. Installing inner tube assembly (dry hole) ... 8

2.5.1. Using Dry-Hole device as overshot ... 9

2.6. Overload protections - optional safety device ... 9

2.7. Pilot coring 4" (101 mm) hole ... 10

Introduction

These instructions are intended for operators of the equipment. The aim of the instructions is to provide you with knowledge of how to use the equipment in an efficient and safe way. These instructions also give you advice and tell you how to perform regular maintenance on the equipment. It does not replace thorough training of operator, it is a complement. For further information concerning service measures, please contact your nearest representative.

Always read these instructions carefully and make sure that you understand all of them before starting for the first time.

1. Product description

1.1. Description

The S Geobor wireline core barrel with standard diameter 146 mm was designed for core sampling from hard, to extremely soft and clayey formations, using a wide range of drilling methods. It is available in usable lengths of 1.500 m and 3.000 m.

In general, the S Geobor system is extremely versatile. As a triple core barrel, i.e. a double core barrel with a plastic liner, it can cope with most coring tasks. Water, fluid mud or air can be used as the flushing medium.

S Geobor can be adapted to almost all soil and rock situations using different types and shapes of drill bit.

Coring is optimised by changing the core lifter (with- or without catch springs), core lifter cases, inner tube assemblies, bits with varying design, etc.

The plastic liner filled with the core sample, can be used for protection during transport or storage.

The S Geobor drilling system is an original design and offers a number of advantages such as:

- Stable core barrel head with reliable triple latching
- Full flexibility in core sampling method 1–5 standard coring, pilot coring, Shelby tube sampling or non coring.
- Safety installation and recovering of inner tube assembly. The optional "Dry hole device" guarantee the inner tube will be inserted and released only when latched, working in liquid filled – or dry hole.

1.2. Method 1–7 description

The S Geobor wire line core barrel can be used in many ways, e.g.:

Method 1: Coring in hard to medium-hard formations

Drill bit with surface set- or impregnated diamonds, PCD, Corborit or carbide inserts. The cutting diameter of 146 (150) mm gives a core diameter of 102 mm.
The drill bits normally have flushing holes through the bit front (face discharge FD), but can also have water channels over the bit front (channel flush CF, ECF).

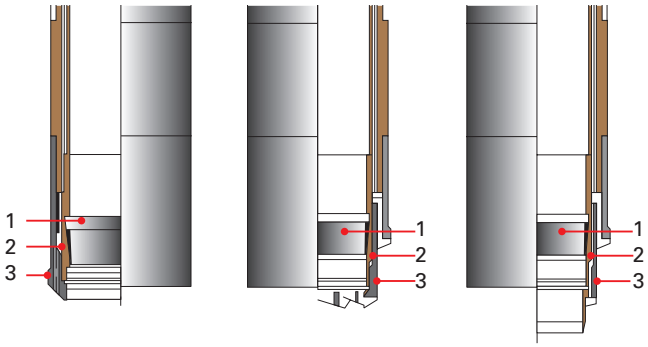
Method 2: Coring in soft to very soft formations

Here, the carbide bit is build divided in two steps,(reamer and pilot). The pilot step cuts the core and the reamer step keep the hole gauge. The flushing fluid comes out between the two steps, thus avoiding flushing out the core. The reamer keep the hole diameter of 150 mm. The pilot cuts a core diameter of 102 mm.

Method 3: Coring in very soft and loose formations, extremely sensitive to flushing.

This carbide bit is built in two steps. However the pilot ID allows the core lifter case to protrude about 25 mm in front of the bit, as a plunger sleeve, in order to keep the flushing fluid away from the core samples. The reamer cuts a hole of 150 mm, the pilot together with the special protruding core lifter case return a core sample with diameter 102 mm.

Fig 1.2.1. Method 1–3



Method 1 **Method 2** **Method 3**

1. Core lifter
2. Core lifter case
3. Core bit

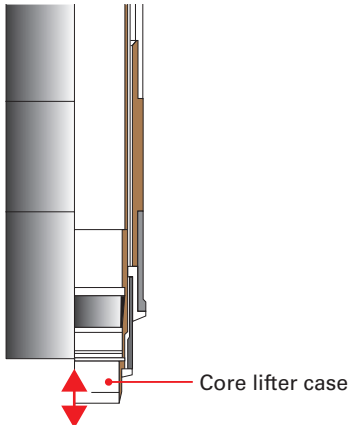
Method 4: Coring in soft varying formations.

(Mazier method). *(Available on request).*

For coring in very soft, loose formations with varying layers. The spring-loaded inner tube assembly is extended to run in front of the bit, but is retractable for optimized adaption to the hardness of the ground and to protect the core lifter case from destruction. For this method, a carbide bit OD/ID 146/109 is used. The core diameter is 102 mm.

The inner tube with the core lifter case protrude about 60 mm ahead of the bit. The assembly will retract at around 600 kg total pressure, to the bit front, which means that position of the core lifter case is constantly adjusted to the hardness of the rock. This will minimize the exposure of the sample to the flushing.

Fig 1.2.2. Method 4



Method 5: “Shelby tube” sampling.

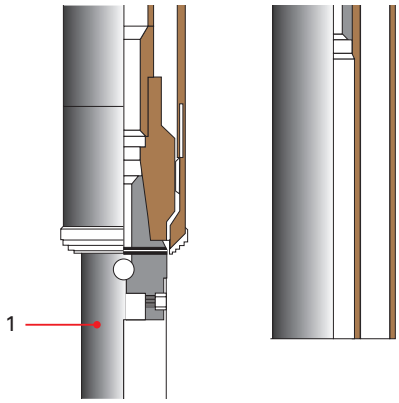
Used for taking samples from very soft and fine cohesion ground (clay etc.)

The inner tube assembly will be replaced with a non rotating Shelby tube assembly. Samples are collect in front of the bit by pressing the sampler down in the ground as far as the sample tube lebth allow (762/914 mm).

The Shelby tube tube return a core sample with diameter 95 mm:
– bit size OD/ID 146/102 mm.

Note! With this method, there is no rotation, only pressure.

Fig 1.2.3. Method 5: Non core drilling method



1. Sampler

Method 6: Non core drilling method

If core drilling will be alternated with non coring the inner tube assamble is replaced with a non coring inner tube assembly. The non coring assemble is designed for $3^{7}/_{8}$" (98,4 mm) non coring bit with $2^{3}/_{8}$" API REG pin connection.

The outer tube assemble should be equipped with standard S Geobor bit size (OD/ID 146/102 mm).

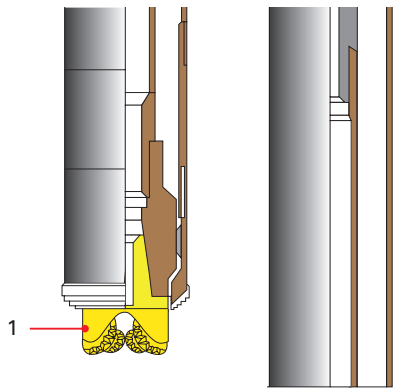
The S Geobor a strong and unique three latching system, allow 7 ton trust load.

“Pilot coring” optional alternative with method 6

Pilot coring is used for strain measurements in a 4" (102 mm) hole.

The non coring bit will be replaced with a core barrel (101T2, 101T6 or 101T6S) and a crossover adapter. Pilot coring will return a core sample with smaller diameter from the section where the 4" (102 mm) hole is required.

Fig 1.2.4. Method 6: Non coring method



1. Non coring bit

Method 7: Packer for water loss

(Lugeon) test and/or fluid collection. *(Available on request).*

Fig 1.2.5. Packer Method



1.3. Technical data – wireline core barrel

Diameter and core diameter		
Part	Diameter (mm)	
	OD	ID
Outer tube	139,7	128,0
Inner tube	117,0	111,0
PVC liner	110,0	105,6
Core	102	

Length and core length		
Part	Length (mm)	Core length (mm)
Core barrel x 1500 mm	2600	1500
Core barrel x 3000 mm	4100	3000

Weights	
Part	Weight (kg)
Core barrel x 1500 mm	101
Core barrel x 3000 mm	136
Inner tube unit x 1500 mm	46
Inner tube unit x 3000 mm	58
Outer tube unit x 1500 mm	55
Outer tube unit x 3000 mm	78
Core barrel head complete	25
Overshot (catcher)	11
Dry hole device	15
Overload protection complete	5

1.4. Technical data – rods

The following information applies for S Geobor Monobloc wire line core rods.

Technical data	
Material quality	P-105
Yield strength (min.)	740 N/mm²
Tensile strength (min.)	880 N/mm²
Expansion after A 5% (min)	13 %
Recommended make up torque	3 KNm
Maximum single torque	8,2 KNm
Maximum pull force	445 KN
Outer tube diameter	139,7 mm
Inner tube diameter	125,5 mm

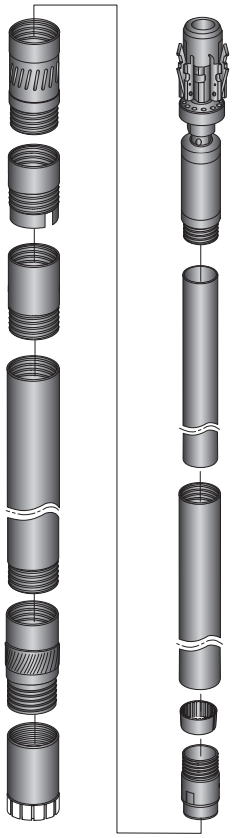
Rods are available in 3 lengths as standard:

Available rods		
Length (mm)	Part number	Weight per rod assembly (kg)
500	8393 0528 00	12
1500	8393 0528 20	35
3000	8393 0528-30	70

Rods described (Monobloc) are made in one piece.

They are cold-drawn and heat-treated.

Threads are conical with 3TPI. Surface treated by special coating.





1.5. Technical data – drill bits

Various types and designs of drill bit can be used for the S Geobor core barrel, depending on which method is used and in what formation drilling is to be carried out. The most common types and application are described here:

Method 1 (OD 146 mm, ID 102 mm)	
Type / Application	**Part number**
TCI – Tungsten Carbide Insert bit. Two step bit (pilot and reamer). Flushing holes (FD). For soft formation.	8372 0941 10
CRB – Tungsten Carbide Chip bit. Flushing holes (FD. For soft to medium soft formation.	8372 0925 05
DPX – Diapax bit with 12 x 13 mm. PCD inserts. Flushing holes (FD). For soft formation	3702 1901 17
DPX – Diapax bit with 8 x 13 mm. PCD inserts. Flushing channels (CF). For soft formation.	3702 6391 00
TRX – Tripax bits. with PCD inserts. For soft to medium hard formations.	
- 96 triangular inserts. With flushing holes (FD).	3702 5085 00
- 60 cubic inserts. With flushing channels (CF).	3702 6461 00
- 77 cubic inserts. Saw-tooth profile. With flushing holes (FD).	3702 5066 00
SS – Surface Set diamond bit. For soft to medium hard formations.	
- Tapered crown profile, 20/25 spc. With flushing holes (FD).	3702 1901 67
- Multi step profile, 20/25 spc. With flushing holes (FD).	3702 1901 62
IMP – Impregnated diamond bit. For hard to very hard formation. With flushing holes (FD).	
- #4, 6 mm impregnation. With flushing holes (9FD). For soft to medium soft, abrasive, highly fractured formation.	3740 4007 61
- #4, 6 mm impregnation. With flushing channels (12CF). For medium soft to hard, abrasive, fractured formation.	3740 4007 63
- #6–8, 6 mm impregnation. With flushing channels (12CF). For medium hard to hard, abrasive + mixed formation.	3702 6978 00
#9, 10 mm impregnation. With flushing holes (12FD). For hard to very hard, slightly abrasive formation.	8370 2300 38
Reaming Shell SS Surface diamond set	3761 0014 77

Look to Terracore catalogue for wider selections of bits.

Method 2 (OD 150 mm, ID 102 mm)	
Type / Application	**Part number**
TCI – Tungsten Carbide Insert bit. Two step bit (pilot and reamer). For very soft formation. With flushing holes (FD).	8372 0902 10
To be used with Core lifter case	3867 2876 00

Method 3 (OD 150 mm, ID 110 mm)	
Type / Application	**Part number**
TCI-Tungsten Carbide Insert bit. Two step bit (pilot and reamer).For very loose formation. With flushing holes (FD).	8372 0941 40
To be used with core lifter case (protruding 25 mm).	3867 2881 00



CBT TCI



CBT CRB CF



CBT TRX CF



CBT DPX FD



CBT SS CF



CBT IMP FD

2. Operating instructions

2.1. Basic setting of the core barrel

Check that the three latches on the inner core barrel are in the outer position and that they can be pressed in if pressed lightly by hand and that they spring back of their own accord into the initial position. Mount the core lifter into the core lifter case.

This must be done from the thread side.

Once the inner core barrel has been positioned in the outer core barrel and the reaming shell and the drill bit have been assembled, the distance between the landing shoulder (7, 3702 1294 00) and the sleeve (9, 3702 1295 00) must be 70,5 mm.

This ensures the right basic setting for the distance between the core lifter case and the drill bit.

If the distance is too less, the flushing fluid will flushing out and disturb the core sample.

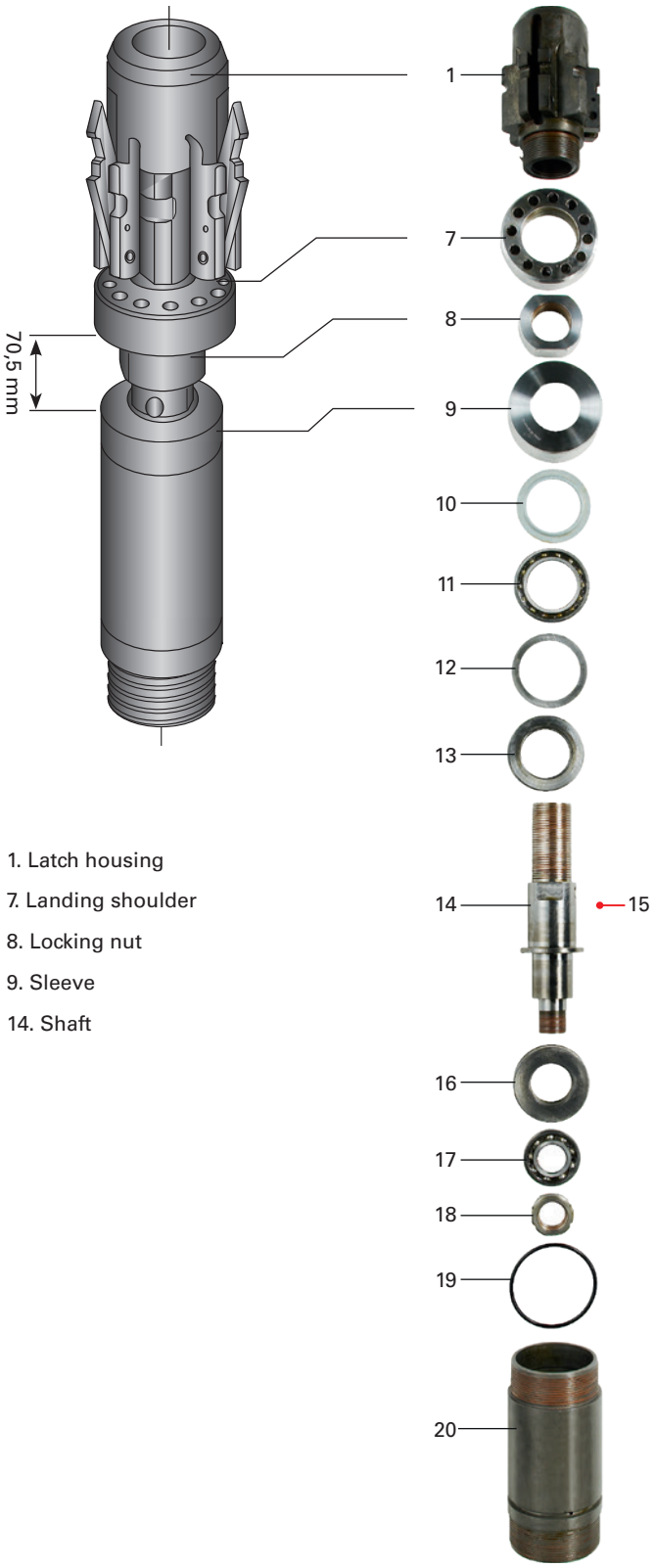
If the distance is too large, the inner core barrel might jam and turn with the outer core barrel. The inner tube core barrel might even not latch at all and be pushed upward during drilling. The core sample might be lost in the hole and destroyed.

Setting procedure

1. Place one wrench on the locking nut (8, 3702 1293 00).
2. Place the other wrench on the shaft (14, 3702 1292).
3. Loosen the locking nut by easy hitting it with a hammer.
4. Turn the core barrel head to the right = reducing the distance
5. Turn the core barrel head to the left = increasing the distance
6. After correctly setting the distance at 70,5 mm, tighten the locking nut with the wrenches and secure the setting.

Fig 2.1.1. Basic setting of the core barrel

(See also Product Catalogue 6991 1715 01).



1. Latch housing
7. Landing shoulder
8. Locking nut
9. Sleeve
14. Shaft

2.2. Drilling

When the core barrel and drilling equipment are installed, the drilling will be performed in the same way as a normal drilling process.

To achieve an optimum drilling result, the right bit for the formation to be drilled must be selected, and correct drilling parameters used.

2.2.1. Recommended drilling parameters

Bit type	RPM
TCI – Tungsten Carbide Insert bit	50–100
CRB – Tungsten Carbide Chip bit	80–150
DPX – Diapax (PCD) bit	50–100
TRX – Tripax sawtooth (PCD) bit	80–150
TRX – Tripax (PCD Geoset)	150–300
SS – Surface Set diamond bit	200–400
IMP – Impregnated diamond bit	300–500

Drilling parameter	Recommended value
Flushing volume	140–250 l/min (water/mud flushing, depending on formation and bit type)
Air flushing	10–17 m^3/min (air flushing depending on formation and bit type)
WOB (weight on bit)	Max 90 kN (depending on formation, bit type and method)
Core break force	With core diameter 102 mm in e.g. undisturbed, fault-free dolomite (laboratory data) 40–60 kN (experience has however shown that these values are lower in practice)

2.3. Catching and lifting the inner core barrel

If the core barrel is full, or core block occur, drilling is interrupted. Pull the drill rods up to break the core off. When the top rod joint visible above the rod holder this rod with water swivel (Kelly) have to be disconnected.

The rotation head is swung sideways (if rig design allow) to clear the box end of the drill rods.

Check that the wire line wire is securely fixed to the overshot and lower the overshot down into the drill string. When the overshot has come to a stop, grip the wire and pull, to check whether the overshot is locked to the inner core barrel head.

If the overshot is not locked, pull up the overshot approx. one metre and let it drop. When the overshot is locked to the inner core barrel, pull it up to the surface. Once the inner core barrel and the overshot is recovered from the hole, loosen the inner core barrel from the overshot by pressing the latches together. Remove the core sample from the inner tube. Sometimes it is necessary to use a rubber hammer to gently tap the inner tube to get the liner with core out. Never use a steel hammer. Dented inner tubes cause core blocks.

2.4. Installing inner core barrel – (water filled hole)

If the inner tube is empty or a second empty inner core barrel is used, check first the core lifter and the core lifter case are not damaged or worn. Check the correct distance between core lifter case and bit (see 2.1. Basic setting of the core barrel). Check that the latches are free. The latches must always be in the outer position and must not show any tendency to "grab".

Insert the complete inner tube into the drill string and let I sink by gravity down to the outer tube core barrel. Once the inner core barrel has latched into the outer tube core barrel, a vibration or unusual noise can be heard. This shows that the inner core barrel is secured in the working position. Do not confuse this noise with the noise that can be heard when the inner core barrel passes the joints in the drill string.

2.5. Installing inner tube assembly – (dry hole)

Check the core barrel as described in 2.4.

If the hole contains little or no water, the inner tube assembly cannot be installed in the same way as with a water filled hole. The wire line hoist and optional accessory "Dry hole device" have to be used.

Instruction to mount, load and install the Dry hole device.

1. Disassemble (catch sleeve 12, P/N 3702 1238 00) from the Overshot 3702 1249 80.
2. Attach the dry hole device (13, P/N 3702 1220 80 to the sleeve (11) in the overshot).
3. Loosen the nut (1) on the Dry hole device (P/N 3702 1221 00) by turning it to the left.
4. Place the complete assembly on to the loading tool (11, P/N 3702 1229 00).
5. Press Dry hole device as far down as possible, until the three latches come out at the side.
6. Lock the Dry hole device at this loaded position by turning the nut (1, P/N 3702 1221 00) to the right.
7. Install and fix the complete Dry hole device on to the head of the inner tube assembly.
8. Use the wire line hoist and insert the complete Dry hole device and inner tube assembly into the drill rod. Stop the installation just when the nut (1, P/N 3702 1221 00) still available and visible above the end of the top rod.
9. Loosen the nut by turning left until you hear a snap from the released latches in the Dry hole device. The inside of the rod will now prevent the Dry hole device releasing from the inner tube. WARNING, Risk for dropping the inner tube assembly if Dry Hole device is too far up.
10. Continue to install the complete assembly with the wire line hoist, until you reach the final position in the core barrel outer tube.
11. When the inner tube is established in correct position the dry hole device will automatically release from the inner tube assembly, only in this position.

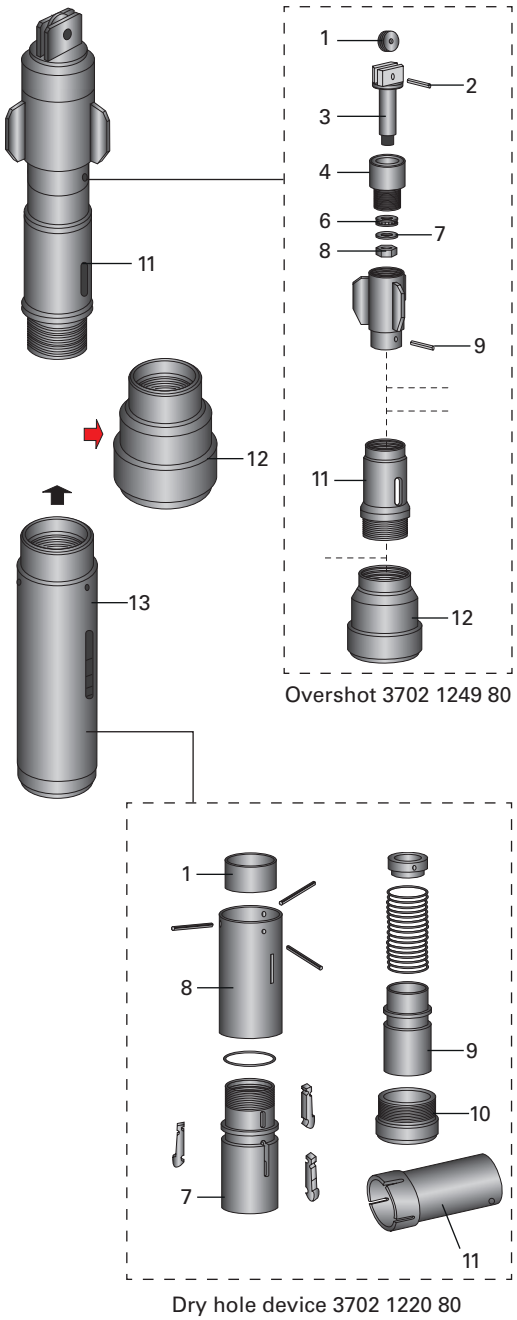
Installing the inner tube assembly with the Dry hole device will give you a guaranteed indication, that the inner tube is in correct position.

2.5.1. Using Dry hole device as overshot

After attaching the Dry hole installation device as described in 2.5., the Dry hole device does not need to be removed. The Dry hole device is recommended to be used as over shot to catch the inner tube once the inner tube assembly should be retrieved.

Fig 2.5.1. Installing inner tube assembly

(See also Product Catalogue 6991 1715 01).



1. Load the Dry hole device (repeat procedure 1–6 in section 2.5.).
2. The loaded Dry hole device will be utilized as overshot assembly.
3. On surface the Dry hole device can be released from inner tube assembly by pressing in three core barrel head latches. Recommended to use latch ompression wire – Part No. 3702 1438 00).

2.6. Overload protection – optional safety device

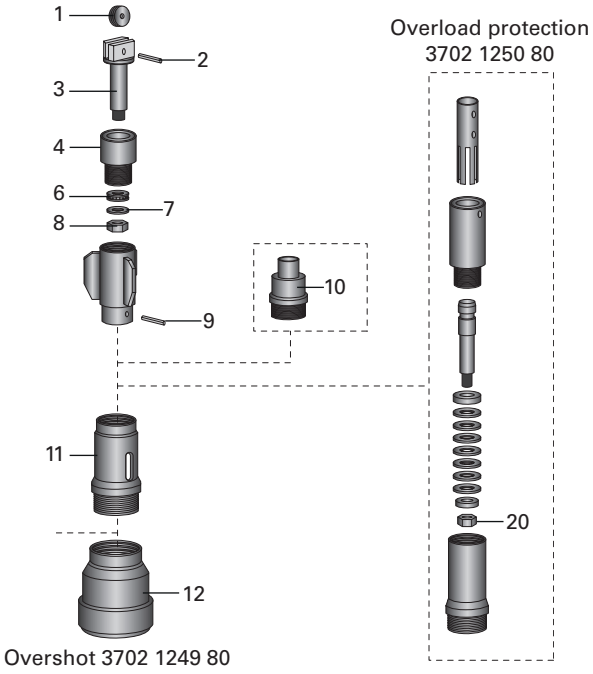
The overload protection prevents the wire to brake, if the inner tube assembly and overshot get stuck in the rods.

Instruction to assemble the Overload protection.

1. Replace the coupling (10, 3702 1247 00) in the overshot 3702 1249 80 with the complete overload protection 3702 1250 80.
2. If Dry hole device used, install overload protection as above (pos.1) and repeat installation procedure (1–6 in section 1.5).
3. Adjustment of release pressure: Tighten or losen the lock nut (20, 0291 1114 00) to get correct release pressure. Recommended to test the setting on surface.

Fig 2.6. Overload protection.

(See also Product Catalogue 6991 1715 01).



2.7. Pilot coring 4" (101 mm hole)

Brief description of procedure

With Method 6, either non coring bit or a core barrel equipment can be used. With pilot core equipment, a 101T6/T2 core barrel is used in to be installed through the 102 mm inner diameter in the S GEOBOR bit.

Application of a "measurement process" in a 4" (101 mm) hole can be as follow:

1. S Geobor-S Method I used to drill 146 mm diameter hole with 102 mm diameter core size.
2. A strain measurement (dilation) is to be carried out at desired depth.
3. The inner tube assembly is pulled out.
4. Rods with core barrel outer tube are lifted about 2–3,5 m from bottom.
5. Non coring assembly is completed with an adapter to 101 mm core barrel assembly.
6. Complete assembly in pos 5. installed with Dry hole device and wire line hoist into the rods.
7. Drilling is carried out by rotating S Geobor rods.
8. 101T6 core barrel is pulled out after 1,5 m (3 m) pilot coring distance.

Core recovered and measurement can be carried out.

Replace the 101 mm core barrel and adapter with a $3^{7}/_{8}$" non coring bit, to ream up the pilot cored length to S (146 mm) hole size.

S Geobor inner core barrel installed and further full size coring can be carried out.

Fig 2.7. Pilot coring.

(See also Product Catalogue 6991 1715 01).



Drillers Logs and SCPTU Sounding Logs

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			SS-1	3.2-4.7	1.0	7-5-5	SPT	**Ohio River Level on 08/12 at 11 p.m. was 16.83 ft @ 3**
			GT-1	8.1-10.1	0.0		ST	**No Recovery @ 8.1**
			SS-2	10.1-11.6	0.8	0-1-4	SPT	
			SS-3	13.0-14.5	1.2	3-2-6	SPT	
			SS-4	17.9-19.4	0.6	4-5-4	SPT	
			SS-5	22.8-24.3	0.8	2-3-3	SPT	**Ohio River Level on 08/13 at 12 a.m. was 16.86 ft @ 22**
			GT-2	27.8-29.8	1.5		ST	
			SS-6	32.7-34.2	1.1	9-15-19	SPT	
235.9	36.0	Loose to dense, dark gray to gray, wet, sand (with gravel between 17.9 and 19.4 ft).						
		Rock Core						
			SS-7	37.6-39.1	0.9	12-18-19	SPT	
			SS-8	42.5-44.0	1.3	6-10-17	SPT	
		Dense to very dense, gray, wet, sand with with gravel.						
			SS-9	47.4-48.9	0.9	12-10-21	SPT	

Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-10	52.4-53.9	1.1	13-19-22	SPT	
55		Dense to very dense, gray, wet, sand with with gravel.						55
			SS-11	57.3-58.8	1.2	19-34-38	SPT	
60 211.9	60.0							60
			SS-12	62.2-63.7	1.5	10-6-8	SPT	
65								65
			GT-3	67.1-69.1	0.0		ST	**No Recovery @ 67.1**
70			SS-13	69.1-70.6	1.5	0-7-7	SPT	70
			SS-14	72.0-73.5	1.5	2-7-11	SPT	
75		Medium dense to dense, white, wet, clayey sand (with clay lens below 86.8 ft).	GT-4	73.7-75.7	0.0		ST	**No Recovery @ 73.7** 75
			SS-15	77.0-78.5	1.5	7-15-21	SPT	
80								80
			SS-16	81.9-83.4	1.5	5-12-21	SPT	
85								85
			SS-17	86.8-88.3	1.5	8-23-23	SPT	
182.9	89.0							
90		Stiff, tan and white, wet, silty clay (varved with clayey fine sand lens).						90
178.7	93.2		SS-18	91.7-93.2	1.3	1-7-10	SPT	
			ST-5	93.4-94.1	0.7		ST	
95		Dense to very dense, light gray, wet, sand (fine grained).						95 **Ohio River Level on 08/13 at 12 p.m. was 15.88 ft @ 95**
			SS-19	96.6-98.1	1.1	8-25-40	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
				Std/Ky RQD				
			SS-20	101.6-103.1	1.0	5-18-19	SPT	
105								105
110								110
		Dense to very dense, light gray, wet, sand (fine grained).	SS-21	111.4-112.9	1.0	2-19-28	SPT	
115								115
120								120
			SS-22	121.2-122.6	1.2	2-23-50/0.40'	SPT	
125 146.9	125.0							125
130		Very dense, light gray, wet, clayey sand (fine grained).						130
			SS-23	131.1-132.3	0.8	11-40-50/0.20'	SPT	
135 136.9	135.0							135
140								140
		Loose, light gray, wet, sand (fine grained).	SS-24	140.9-142.4	1.0	1-2-6	SPT	
145								145
123.9	148.0		GT-6	145.8-147.8	0.0		ST	**No Recovery @ 145.8**
150		Dense to very dense, light gray, wet, sand with with silt.						150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-25	150.8-152.1	1.2	19-39-50/0.30	SPT	
155								155
160			SS-26	160.6-161.0	0.4	50/0.40'	SPT	160
165								165 **Ohio River Level on 08/14 at 12 a.m. was 16.59 ft @ 165**
170			SS-27	170.4-171.9	1.5	28-30-31	SPT	170
175		Dense to very dense, light gray, wet, sand with with silt.						175
180			SS-28	180.3-180.7	0.3	50/0.40'	SPT	180
185								185
190			SS-29	190.1-191.0	0.9	27-50/0.40'	SPT	190
195								195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-30	200.0-200.8	0.8	49-50/0.30'	SPT	
			SC1-A	200.9-202.9	0.0		ST	**No recovery @ 201**
			SC1-B	202.9-204.9	0.0		ST	
205			SC2-A	204.9-206.9	0.0		ST	**No recovery @ 205**
			SC2-B	206.9-208.9	0.0		ST	
210			SC2-C	208.9-209.8	0.0		ST	**30% recovery @ 209**
			SC3-A	209.8-211.8	1.5		ST	**Ohio River Level on 08/14 at 12 p.m. was 16.43 ft @ 210**
			SC3-B	211.8-213.8	0.0		ST	
215			SC3-C	213.8-214.7	0.0		ST	
			SC4-A	214.7-216.7	0.0		ST	**No recovery @ 214**
			SC4-B	216.7-218.7	0.0		ST	
220			SC4-C	218.7-219.6	0.0		ST	
			SS-31	219.6-221.1	1.1	0-10-28	SPT	
225		Dense to very dense, light gray, wet, sand with with silt.						
230								
235								
240			SS-32	239.3-240.1	0.5	21-50/0.30'	SPT	
245								
250	22.0	250.0	SS-33	249.2-250.0	0.8	24-50/0.30'	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1001***	Immediate Water Depth ***NA***	Start Date ***08/13/2024***	Hole Type ***sample***
Surface Elevation ***271.9'***	Static Water Depth ***NA***	End Date ***08/13/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992397***	
Location ***2038+75.00 10.0' Rt.***		Longitude(83) ***-89.151856***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255		(Bottom of Hole 250.0') (No Refusal)						255
260		Deck Elevation = 292.21 ft Deck to mudline = 20.3 ft Deck to water = 5.2 ft Water depth = 15.1 ft						260
265		6" Casing extended to 10 ft below mudline 5" Geobore-S casing extended to borehole termination depth						265
270		Boring location off-set due to near surface debris identified by mesotech sonar - possible remnants of tug or barge						270
275		P-S Logging on 08/14/2024						275
280								280
285								285
290								290
295								295
300								300

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002***	Immediate Water Depth ***NA***	Start Date ***07/13/2024***	Hole Type ***sample***
Surface Elevation ***273.5'***	Static Water Depth ***NA***	End Date ***07/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***192.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992396***	
Location ***2038+75.00 10.0' Lt.***		Longitude(83) ***-89.151967***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						**Ohio River Level on 07/13 at 4 p.m. was 31.47 ft @ 0**
			SS-1	3.0-4.5	0.5	13-7-4	SPT	
5		Medium dense, dark gray, wet, sand with rock fragments.						
			SS-2	7.9-9.4	0.3	10-5-6	SPT	
10								
262.5	11.0							
		Very dense, gray, wet, gravel.	SS-3	12.8-14.3	0.1	26-28-39	SPT	**Alluminum cable/wire encountered during drilling, blowcounts likely elevated. Casing extracted, several attempts were made to reset casing plumb. @ 13 Ohio River Level on 07/14 at 3 a.m. was 31.36 ft @ 20**
15								
257.5	16.0							
		Loose, gray, wet, sand with gravel (coarse grained).	SS-4	17.8-19.3	0.3	2-2-2	SPT	
20								
			SS-5	22.7-24.2	0.6	1-3-3	SPT	
25								
247.5	26.0							
		Medium dense, gray, wet, silty sand.	SS-6	27.6-29.1	0.8	8-6-7	SPT	
30								
			GT-1	32.5-34.5	1.4		ST	
35								
237.5	36.0							
		Dense, dark gray, wet, sand with trace gravel (coarse grained).	SS-7	37.4-38.9	1.0	13-20-32	SPT	
40								
			SS-8	42.4-43.9	0.8	9-13-18	SPT	
45								
228.0	45.5							
		Medium dense to dense, brown and gray, wet, gravelly sand.	SS-9	47.3-48.8	1.0	11-11-16	SPT	
50								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002***	Immediate Water Depth ***NA***	Start Date ***07/13/2024***	Hole Type ***sample***
Surface Elevation ***273.5'***	Static Water Depth ***NA***	End Date ***07/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***192.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992396***	
Location ***2038+75.00 10.0' Lt.***		Longitude(83) ***-89.151967***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
				Std/Ky RQD				
		Medium dense to dense, brown and gray, wet, gravelly sand.	SS-10	52.2-53.7	1.1	7-14-20	SPT	
55 218.0	55.5							
		Very dense, gray, wet, sand with with gravel (coarse grained).	SS-11	57.1-58.6	1.3	15-29-37	SPT	
60								
			SS-12	62.0-63.5	1.1	21-24-34	SPT	**Ohio River Level on 07/14 at 12 p.m. was 30.93 ft @ 62**
65 208.5	65.0							
		Medium dense to very dense, very light gray to light gray, wet, sand with silt.	SS-13	67.0-68.5	1.0	6-5-11	SPT	
70								
			GT-2	71.9-73.5	0.0		ST	
75			SS-14	73.5-75.0	1.5	4-7-14	SPT	
			SS-15	76.8-78.3	1.5	8-18-33	SPT	
80								
			ST-3	81.7-83.7	0.3		ST	
85			SS-16	83.7-85.2	1.5	9-18-40	SPT	
			SS-17	86.6-88.1	1.5	16-23-42	SPT	
90 183.5	90.0							
		Very dense, white, wet, silty sand (medium grained).	SS-18	91.6-92.5	0.8	3-50/0.40'	SPT	
95								
			SS-19	96.5-97.4	0.8	40-50/0.40'	SPT	
100								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002***	Immediate Water Depth ***NA***	Start Date ***07/13/2024***	Hole Type ***sample***
Surface Elevation ***273.5'***	Static Water Depth ***NA***	End Date ***07/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***192.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992396***	
Location ***2038+75.00 10.0' Lt.***		Longitude(83) ***-89.151967***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
								Ohio River Level on 07/15 at 12 a.m. was 31.03 ft @ 101
			SS-20	101.4-102.9	1.3	19-24-28	SPT	
105		Very dense, white, wet, silty sand (medium grained).						105
166.5	107.0							
110		Very dense, white, wet, sand with gravel (medium to fine grained).						110
			SS-21	111.2-112.7	1.1	10-17-33	SPT	
115								115
156.5	117.0							
120		Medium dense, white, wet, sand (fine to medium grained).						120
			SS-22	121.1-122.5	0.8	36-47-50/0.40'	SPT	
125								125
130								130
			SS-23	130.9-132.4	0.1	1-0-0	SPT	**Soil below casing expected to have been washed out, blow counts artificially low @ 131**
135								135
140								140
			SS-24	141.4-142.9	0.2	5-9-15	SPT	
145								145
			GT-4	146.8-148.8	1.6		ST	
150123.5	150.0							150

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002***	Immediate Water Depth ***NA***	Start Date ***07/13/2024***	Hole Type ***sample***
Surface Elevation ***273.5'***	Static Water Depth ***NA***	End Date ***07/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***192.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992396***	
Location ***2038+75.00 10.0' Lt.***		Longitude(83) ***-89.151967***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
								Drill tooling fell, blow counts not representative. Drilled an additional 5 ft to collect SPT sample. @ 151
		Light gray, wet, clayey sand (fine grained).	SS-25	151.2-152.7	1.0	0-0-0	SPT	
119.0	154.5							
155								155
			SS-26	156.1-156.7	0.6	45-50/0.10'	SPT	
160								160 **Ohio River Level on 07/15 at 12 p.m. was 30.26 ft @ 160**
			SS-27	161.0-161.4	0.4	50/0.40'	SPT	
165								165
170		Very dense, light gray, wet, sand (fine grained).						170
			SS-28	170.9-171.8	0.9	14-50/0.40'	SPT	
175								175
180								180
			SS-29	180.7-181.6	0.9	10-50/0.40'	SPT	
185								185
87.5	186.0							**Ohio River Level on 07/16 at 12 a.m. was 29.97 ft @ 185**
190		Medium dense, dark gray, wet, silty sand (fine grainded).						190 **Casing stuck around 4 a.m. 07/16/2024 @ 190**
81.5	192.0		SS-30	190.5-192.0	1.5	7-9-12	SPT	
195								195
		(Bottom of Hole 192.0') (No Refusal)						
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002***	Immediate Water Depth ***NA***	Start Date ***07/13/2024***	Hole Type ***sample***
Surface Elevation ***273.5'***	Static Water Depth ***NA***	End Date ***07/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***192.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992396***	
Location ***2038+75.00 10.0' Lt.***		Longitude(83) ***-89.151967***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	

Deck Elevation = 306.51 ft
Deck to mudline = 33.0 ft
Deck to water = 4.2 ft
Water depth = 28.8 ft

7" Casing extended to 10 ft below mudline
5" Geobore-S casing extended to borehole termination depth

Fishing operations for tooling began at around 3:30 pm on 07.16.2024, all tooling remaining in the hole was extracted by 5:20 pm. Hole abandoned, off-set location (B-1002a) will be drilled to collect soil information starting at a depth of about 195 ft below mudline.

205
210
215
220
225
230
235
240
245
250

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology		Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
Elevation	Depth	Overburden / Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
		(blank drilling without sampling).						

5 10 15 20 25 30 35 40 45 50

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology		Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
Elevation	Depth	Overburden / Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
		(blank drilling without sampling).						

55 60 65 70 75 80 85 90 95 100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology Elevation	Lithology Depth	Description	Sample No. / Std/Ky RQD	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden						
		Rock Core						
		(blank drilling without sampling).						

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
155								155
160								160
165								165
170								170
		(blank drilling without sampling).						
175								175
180								180
185								185
190								190
195								195
75.6	196.9							
		Very dense, white, sand (fine to coarse grained with wood).	GT-5	196.9-198.9	0.0		ST	
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
205								205
			SS-31	205.0-206.5	1.3	21-22-37	SPT	
210								210
215								215
220								220
		Very dense, white, sand (fine to coarse grained with wood).	SS-32	220.0-221.5	0.0	24-31-17	SPT	
225								225
			SS-33	225.0-226.5	0.8	16-29-50/0.50'	SPT	
230								230
235								235
240								240
30.9	241.5		SS-34	240.0-241.5	0.7	19-17-18	SPT	
245		(Bottom of Hole 241.5') (No Refusal)						245
250		Deck Elevation = 304.03 ft						250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1002-A***	Immediate Water Depth ***NA***	Start Date ***07/17/2024***	Hole Type ***sample***
Surface Elevation ***272.4'***	Static Water Depth ***NA***	End Date ***07/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***241.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.992390***	
Location ***+ ' Lt.***		Longitude(83) ***-89.151936***	

Lithology Elevation	Lithology Depth	Description	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
		Overburden						
		Rock Core						
255		Deck to mudline = 31.6 ft Deck to water = 5.3 ft Water depth = 26.5 ft 7" Casing extended to 32.2 ft below deck 5" Geobore-S casing extended to borehole termination depth						255
260								260
265								265
270								270
275								275
280								280
285								285
290								290
295								295
300								300

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
234.7	3.0	Very loose, gray, wet, gravel (fine, with wood fibers).	SS-1	1.6-3.1	0.6	1-2-2	SPT	
								Ohio River Level on 09/11 at 3 pm was 8.37 ft @ 5
			GT-1	6.5-8.1	0.0		ST	
			SS-2	8.1-9.6	0.7	1-6-12	SPT	
			SS-3	11.4-12.9	0.7	9-9-19	SPT	
		Medium dense, gray and brown, wet, sand with fine gravel.						
			SS-4	16.3-17.8	0.8	10-12-17	SPT	
			SS-5	21.3-22.8	0.5	6-7-10	SPT	
210.7	27.0		GT-2	26.2-27.8	0.0		ST	
			SS-6	27.8-29.1	0.6	30-43-50/0.33'	SPT	
			SS-7	31.1-32.5	0.1	25-46-50/0.42'	SPT	**2" diameter gravel lodged in sample, blowcounts likely elevated @ 31 Ohio River Level on 09/13 at 12 am was 10.21 ft @ 36**
		Very dense, gray, wet, sand with fine gravel.						
			SS-8	36.0-37.5	1.2	14-24-34	SPT	
199.7	38.0							
			SS-9	40.9-42.4		8-6-7	SPT	
			GT-3	42.6-44.6	1.3		ST	
		Medium dense to dense, light gray, wet, sand with with clay.						
			SS-10	45.9-47.4	1.3	7-13-20	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Std/Ky RQD	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
			SS-11		50.8-52.3	0.4	5-6-15	SPT	
55		Medium dense to dense, light gray, wet, sand with with clay.	SS-12		55.7-57.2	1.3	14-21-31	SPT	
60			SS-13		60.6-62.1	1.1	11-18-29	SPT	
173.7	64.0								
65		Very dense, light gray, wet, sand with with clay.	SS-14		65.5-67.0	1.2	20-39-43/0.50'	SPT	
168.7	69.0								
70		Dense, light gray to tan, wet, clayey sand.	SS-15		70.5-72.0	1.4	7-18-24	SPT	
163.7	74.0								
75		Dense to very dense, light gray, wet, sand (fine to medium grained).	SS-16		75.4-76.6	0.9	8-39-50/0.20'	SPT	
			SS-17		78.3-79.2	0.8	22-50/0.40'	SPT	**Ohio River Level on 09/13 at 12 pm was 10.03 ft @ 78**
80									
85									**SPT sample interval missed @ 83**
			SS-18		88.1-89.0	0.7	15-50/0.40'	SPT	
90									
			SS-19		93.1-94.4	1.1	17-47-50/0.30'	SPT	
95									
141.7	96.0								
		Very dense, light gray, wet, sand (fine grained).	SS-20		98.0-98.8	0.8	32-50/0.30'	SPT	
100									

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
105		Very dense, light gray, wet, sand (fine grained).	SS-21	102.9-103.7	0.8	15-50/0.30'	SPT	
131.7	106.0							
110								
115			SS-22	112.7-114.2	1.5	1-5-9	SPT	**Sample disturbed, blowcounts likely impacted @ 113**
			SS-23	117.7-118.4	0.8	47-50/0.25'	SPT	
120								
			SS-24	122.6-123.5	0.9	20-50/0.41'	SPT	**Ohio River Level on 09/14 at 12 am was 10.34 ft @ 122**
125		Very dense, light gray to white, wet, sand (fine grained).						
130								
			SS-25	132.4-132.8	0.4	50/0.41'	SPT	
135								
140								
			SS-26	142.3-142.5	0.3	50/0.25'	SPT	
145								
150								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
		Very dense, light gray to white, wet, sand (fine grained).	SS-27	152.1-152.3	0.3	50/0.25'	SPT	
155 82.7	155.0							155
160								160
			SS-28	161.9-163.4	1.5	6-9-42	SPT	
165		Very dense, light gray, wet, sand (fine to coarse grained).						165
170								170
			SS-29	171.8-172.0	0.3	50/0.25'	SPT	
175 62.7	175.0							175
180								180
			SS-30	181.6-181.9	0.3	50/0.25'	SPT	
185								185
		Very dense, light gray, wet, sand (fine).						
190								190
			SS-31	191.5-191.9	0.3	50/0.40'	SPT	**Ohio River Level on 09/15 at 12 am was 10.53 ft @ 191**
195								195
40.7	197.0							
200		Hard, dark gray, wet, lean clay with with lignite.						200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
36.7	201.0	Hard, dark gray, wet, lean clay with with lignite.						
			SS-32	201.3-202.1	0.8	28-50/0.33'	SPT	**Lignite encountered @ 201**
			SS-33	221.0-221.8	0.8	20-50/0.33'	SPT	
		Very dense, light gray, wet, sand.						
			SS-34	240.7-242.0	1.3	19-40-50/0.30	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1004***	Immediate Water Depth ***NA***	Start Date ***09/11/2024***	Hole Type ***sample***
Surface Elevation ***237.7'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***251.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993118***	
Location ***2042+25.00 10.0' Rt.***		Longitude(83) ***-89.151118***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
-13.5	251.2	Very dense, light gray, wet, sand.	SS-35	250.5-251.2	0.7	42-50/0.20'	SPT	
		(Bottom of Hole 251.2') (No Refusal) On 9/11/2024 Deck Elevation = 284.22 ft Deck to mudline = 46.5 ft Deck to water = 7.4 ft Water depth = 39.1 ft 6" Casing extended to 50.54 ft below deck on 09/11 6" Casing extended to 90.54 ft below deck on 09/12 6" Casing extended to 105.54 ft below deck on 09/13 6" Casing extended to 205.54 ft below deck on 09/14 5" Geobore-S casing extended to borehole termination depth At 4:00 pm on 09/12/2024, liftboat raised 2 ft, new deck to mudline is 48.5 ft due to remnants of Hurricane Francine						

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
5		Loose, brown, wet, gravel (fine grained).	SS-1	3.1-4.6	0.1	2-4-4	SPT	
232.1	6.5							**Ohio River Level on 08/23 at 9 a.m. was 15.28 ft @ 5**
			SS-2	8.1-9.6	1.1	10-13-15	SPT	
10								
			SS-3	13.0-14.5	0.0	25-32-36	SPT	
15			SS-4	14.6-16.1	1.2	11-17-17	SPT	
			SS-5	17.9-19.4	0.8	5-8-9	SPT	
20		Mediium dense to very dense, gray, wet, sand with with silt and fine gravel (fine grained).						
			SS-6	22.8-24.3	1.1	7-9-11	SPT	
25								
			GT-1	27.7-29.7	0.0		ST	**Ohio River Level on 08/23 at 12 p.m. was 15.68 ft @ 27**
30			SS-7	30.4-31.9	1.1	6-16-24	SPT	
			SS-8	32.7-34.2	1.3	11-26-30	SPT	
35								
202.6	36.0							
			SS-9	37.6-39.1	1.5	1-3-4	SPT	
40		Loose, white, wet, clayey sand (fine grained).	GT-2	39.1-41.1	0.0		ST	
196.6	42.0							
			SS-10	42.5-44.0	0.2	3-7-9	SPT	
45		Medium dense to dense, white, wet, clayey sand (fine grained).						
			SS-11	47.4-48.9	1.2	4-17-31	SPT	
50								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-12	52.3-53.8	1.4	5-22-23	SPT	
55		Medium dense to dense, white, wet, clayey sand (fine grained).						55
			SS-13	57.3-58.8	1.5	3-12-17	SPT	
60								60
176.4	62.2							
			GT-3	62.2-64.2	0.0		ST	
65			SS-14	64.2-65.7	1.5	11-15-23	SPT	65
			SS-15	67.1-68.6	1.5	15-25-49	SPT	
70		Dense to very dense, white, wet, sand with with little silt and clay seams (fine grained).						70
			SS-16	72.0-72.9	0.8	42-50/0.42'	SPT	
75	163.6	75.0						75
		Medium dense, light gray and white, wet, sand (medium grained).	SS-17	76.9-78.4	0.7	3-7-15	SPT	
80	158.6	80.0						80
			SS-18	81.9-82.9	0.7	27-50/0.50'	SPT	
85								85
			SS-19	86.8-87.6	0.5	41-50/0.30'	SPT	
90		Very dense, white, wet, sand with with little silt (fine grained).						90
			SS-20	91.7-92.2	0.4	50/0.50'	SPT	**Ohio River Level on 08/24 at 12 a.m. was 15.83 ft @ 91**
95								95
			SS-21	96.6-97.5	0.9	23-50/0.40'	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			SS-22	101.5-102.4	0.9	32-50/0.40'	SPT	
		Very dense, white, wet, sand with with little silt (fine grained).						
105								105
132.1	106.5							
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
110								110
			SS-23	111.4-112.9	1.1	11-27-50/0.50'	SPT	
115								115
120								120
			SS-24	121.2-122.5	1.3	35-46-50/0.30'	SPT	
125								125
		Dense to very dense, white to light gray, wet, sand (coarse grained).						
130								130
			SS-25	131.1-132.0	0.9	40-50/0.40'	SPT	
135								135
140								140
			SS-26	140.9-142.4	0.9	7-14-30	SPT	
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			GT-4	150.7-152.7	0.0		ST	
			SS-27	152.7-154.2	1.5	6-6-35	SPT	
155		Dense to very dense, white to light gray, wet, sand (coarse grained).						155
160			SS-28	160.6-161.4	0.7	34-50/0.30'	SPT	**Ohio River Level on 08/24 at 12 p.m. was 14.08 ft @ 160** 160
165								165
72.6	166.0							
170								170
			SS-29	170.4-171.9	1.3	19-23-46	SPT	
175		Very dense, light gray, wet, silty sand (fine grained).						175
180								180
			SS-30	180.3-181.1	0.7	37-50/0.30'	SPT	
185								185
52.6	186.0							
190								190
		Very dense, light gray, wet, sand (medium to coarse grained).	SS-31	190.1-191.0	0.8	26-50/0.40'	SPT	
195								195
42.6	196.0							
		Hard, brown and gray, moist, sandy clay.						
200								200

Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-32	199.9-201.4	1.5	16-29-41	SPT	
205		Hard, brown and gray, moist, sandy clay.						205
210 28.6	210.0							210
215								215
220		Very dense, light gray, wet, sand (fine grained).	SS-33	219.6-220.1	0.5	50/0.50'	SPT	220
225								225
230 8.6	230.0							230
235		Very hard, white and light gray, moist, sandy clay.						235
240			SS-34	239.3-240.1	0.7	26-50/0.30'	SPT	240
245 -6.4	245.0							245
		Very dense, light brown and white, wet, sand (medium to coarse grained).						
250 -11.4	250.0		SS-35	249.1-250.0	0.9	40-50/0.40'	SPT	250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1005***	Immediate Water Depth ***NA***	Start Date ***08/23/2024***	Hole Type ***sample***
Surface Elevation ***238.6'***	Static Water Depth ***NA***	End Date ***08/25/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***250.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993147***	
Location ***2042+25.00 10.0' Lt.***		Longitude(83) ***-89.151176***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
								Ohio River Level on 08/25 at 12 a.m. was 12.87 ft @ 250
255		(Bottom of Hole 250.0') (No Refusal)						
		On 8/23/2024						
260		Deck Elevation = 291.71 ft Deck to mudline = 53.1 ft Deck to water = 6.5 ft Water depth = 46.6 ft						
265		6" Casing extended to 7.9 ft below mudline 5" Geobore-S casing extned to borehole termination depth						
		P-S Logging on 08/25/2024						
270								
275								
280								
285								
290								
295								
300								

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
5		Very loose, brown, wet, sand (coarse grained).	SS-1	3.5-5.0	0.2	0-0-0	SPT	5
			GT-1	5.0-7.0	0.0		ST	
238.5	8.0							
10		Medium dense, brown, wet, gravelly sand with with shell fragments.	SS-2	8.4-9.9	0.8	4-6-5	SPT	10
234.5	12.0							
15			SS-3	13.4-14.9	1.0	5-10-13	SPT	15
20		Medium dense, gray, wet, sand with with trace gravel (fine grained).	SS-4	18.3-19.8	1.1	7-10-9	SPT	20
25			SS-5	23.2-24.7	0.7	7-10-14	SPT	25
			GT-2	24.7-26.7	1.9		ST	
219.0	27.5							
30		Very loose, gray, wet, sand (medium grained).	SS-6	28.1-29.6	0.7	0-0-0	SPT	30
214.5	32.0							
35		Dense, gray, wet, sand (medium grained).	SS-7	33.0-34.5	1.1	12-20-48	SPT	35
40			SS-8	38.0-39.5	1.1	10-18-38	SPT	40
204.5	42.0							
45		Medium dense, gray, wet, sand (fine to medium grained).	SS-9	42.9-44.4	1.2	16-33-50/0.50'	SPT	45
50			SS-10	47.8-49.3	0.9	0-6-21	SPT	50

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
			Std/Ky RQD					
194.5	52.0	Medium dense, gray, wet, sand (fine to medium grained).	GT-3 GT-3	49.4-51.4 49.4-51.4	0.0 0.0		ST ST	
			SS-11	52.7-54.2	1.3	13-29-37	SPT	
55		Very dense, dark gray, wet, sand with trace silt (fine grained).						55
189.5	57.0							
			SS-12	57.6-59.1	0.7	13-17-17	SPT	
60								60
		Dense, brown and gray, wet, gravelly sand with with silt.	SS-13	62.6-64.1	0.8	11-12-20	SPT	
65								65
179.5	67.0							
			SS-14	67.5-69.0	1.3	6-19-31	SPT	
70								70
			SS-15	72.4-73.9	1.4	6-15-21	SPT	
75			GT-4	74.0-76.0	0.0		ST	75
		Dense to very dense, white, wet, clayey sand (fine grained).						
			SS-16	77.3-78.8	1.4	6-18-22	SPT	
80								80
			SS-17	82.2-83.7	1.3	13-30-47	SPT	
85 161.5	85.0							85
		Stiff, white, moist, fat clay.	SS-18	87.2-88.7	1.5	4-7-12	SPT	
157.5	89.0							
90			ST-1	88.7-90.7	1.3		ST	90
			SS-19	92.1-93.0	0.9	24-50/0.40'	SPT	
95		Very dense, white, wet, sand with with clayey sand seams.						95
			SS-20	97.0-97.9	0.9	28-50/0.40'	SPT	
100 146.5	100.0							100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-21	101.9-102.9	1.0	11-50/0.50'	SPT	
105		Hard, white, moist, fat clay.						105
138.5	108.0							
110								110
			SS-22	111.8-113.3	1.0	11-17-29	SPT	
115								115
120								120
			SS-23	121.6-122.9	0.9	22-46-50/0.30'	SPT	
125								125
130		Dense to very dense, white, wet, sand (coarse to medium grained).						130
			SS-24	131.4-132.8	1.1	24-47-50/0.40'	SPT	
135								135
140								140
			SS-25	141.3-142.1	0.7	42-50/0.30'	SPT	
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-26	151.1-152.6	0.9	12-33-40	SPT	
155		Dense to very dense, white, wet, sand (coarse to medium grained).						155
160			SS-27	161.0-161.3	0.3	50/0.30'	SPT	**Intermittent drill chatter @ 160** 160
165 81.5	165.0							165
170		Very dense, light gray and brown, wet, sand (fine grained).	SS-28	170.8-171.5	0.7	23-50/0.20'	SPT	170
175								175
180			SS-29	180.6-181.4	0.8	17-50/0.30'	SPT	**Difficult drilling @ 180** 180
185								185
190			SS-30	190.5-191.3	0.4	30-50/0.30'	SPT	190
195								195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-31	200.3-201.1	0.7	18-50/0.30'	SPT	
205		Very dense, light gray and brown, wet, sand (fine grained).						205
210								210
215 31.5	215.0							215
220								220
			SS-32	220.0-221.2	1.2	5-34-50/0.20'	SPT	
225		Hard, brown, wet, sandy lean clay.						225
230 16.5	230.0							230
235								235
240		Very dense, light gray, wet, sand (fine grained).	SS-33	239.7-240.0	0.3	50/0.30'	SPT	240
245								245
250 -3.5	250.0							250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								255
260								260
			SS-34	260.7-261.7	1.0	10-50/0.50'	SPT	
		Very dense, brown to light brown, wet, sand (coarse grained).						
265								265
270								270
275 -29.0	275.5							275
		Very stiff, dark gray, wet, fat clay (with 45 degree slickenside at 279.44 ft).						
280			SS-35	279.0-280.5	0.8	0-6-10	SPT	280
			SC-1	280.5-282.5	2.0		ST	
-37.4	284.0		SC-1a	282.5-284.0	1.4		ST	
285			SC-2	284.0-286.0	2.0		ST	285
			SC-2a	286.0-288.0	2.0		ST	
			SC-2b	288.0-288.9	0.0		ST	
290			SC-3	288.9-290.9	2.0		ST	290
		Very stiff to hard, dark gray, moist to wet, lean clay (with few 45 degree slickenside).	SC-3a	290.9-292.9	2.0		ST	
			SC-3b	292.9-293.8	0.9		ST	
295			SC-4	293.8-295.8	2.0		ST	295
			SC-4a	295.8-297.8	2.0		ST	
			SC-4b	297.8-298.7	0.7		ST	
300			SS-36	298.7-300.2	1.5	4-11-19	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1007***	Immediate Water Depth ***NA***	Start Date ***09/01/2024***	Hole Type ***sample***
Surface Elevation ***246.5'***	Static Water Depth ***NA***	End Date ***09/04/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.993879***	
Location ***2045+50.00 32.0' Lt.***		Longitude(83) ***-89.150524***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
-53.7	300.2							
		(Bottom of Hole 300.2') (No Refusal)						
		On 9/01/2024						
		Deck Elevation = 286.12 ft Deck to mudline = 39.6 ft Deck to water = 4.8 ft						
		Water depth = 34.8 ft						
		6" Casing extended to 85.54 ft below deck 5" Geobore-S casing extended to borehole termination depth						
		Approximately 85.54 ft of 6 in SW casing lost downhole. Drillers estimate at/near a depth of 120 ft below mudline.						

305 310 315 320 325 330 335 340 345 350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
		Very loose, brown, black and orange, wet, silty gravel (fine grained).	SS-1	2.6-4.1	1.2	1-1-1	SPT	**Ohio River Level on 08/15 at 2 p.m. was 15.68 ft @ 3**
237.7	6.0							
		Very dense, dark gray, wet, gravelly sand (fine grained).	SS-2	7.5-9.0	0.8	12-19-22	SPT	
232.7	11.0							
			SS-3	12.5-14.0	0.8	6-10-11	SPT	
			GT-1	17.4-18.2	0.0		ST	
		Medium dense to very dense, dark gray, wet, silty sand (fine grained).	SS-4	19.0-20.5	0.9	5-10-10	SPT	**with clay lense @ 19.62**
			SS-5	22.3-23.8	0.8	4-7-17	SPT	
			SS-6	27.2-28.7	1.5	10-30-40	SPT	
212.7	31.0							
			SS-7	32.1-33.6	1.5	15-18-23	SPT	
			SS-8	37.1-38.6	1.3	8-10-14	SPT	
		Medium dense to very dense, gray, wet, sand (with silt and gravel below 47 ft).	SS-9	42.0-43.5	1.1	23-26-38	SPT	
			SS-10	46.9-48.4	1.5	21-30-30	SPT	**Ohio River Level on 08/16 at 12 a.m. was 16.83 ft @ 45**

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-11	51.8-53.3	1.3	18-31-45	SPT	
55								55
		Medium dense to very dense, gray, wet, sand (with silt and gravel below 47 ft).	SS-12	56.7-58.2	1.0	13-25-22	SPT	
60								60
			SS-13	61.7-63.2	0.8	12-18-18	SPT	
65 178.7	65.0							65
70		Dense, white, wet, clayey sand (fine grained).						70
			SS-14	72.8-74.3	0.9	9-13-17	SPT	
75 168.7	75.0							75
		Very dense, white, wet, sand (fine grained).	SS-15	76.4-77.9	1.2	8-33-50/0.50'	SPT	
80 163.7	80.0							80
		Very dense, white, wet, clayey sand (fine grained).	SS-16	81.3-82.8	1.4	5-26-48	SPT	
85 158.7	85.0							85
			SS-17	86.3-87.7	0.9	3-38-50/0.40'	SPT	
90								90
		Very dense, white, wet, sand with trace clay.	SS-18	91.2-92.6	1.0	7-35-50/0.40'	SPT	
95								95
			SS-19	96.1-97.1	0.8	17-50/0.50'	SPT	
100								100

Sample interval washed out, advanced to next interval @ 68 Ohio River Level on 08/16 at 12 a.m. was 14.14 ft @ 72

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
105		Very dense, white, wet, sand with trace clay.	SS-20	104.0-105.5	1.4	4-14-24	SPT	105
			GT-2	105.9-107.9	1.4		ST	
134.7	109.0							
110								110
			SS-21	110.9-112.3	1.0	33-44-50/0.40'	SPT	
115								115
120								120
			SS-22	120.7-122.0	1.2	7-26-50/0.30'	SPT	
125								125
130		Very dense, light gray, wet, sand (fine grained).						130
			SS-23	130.5-132.0	0.8	18-21-33	SPT	**Ohio River Level on 08/17 at 12 a.m. was 15.58 ft @ 130**
135								135
140								140
			GT-3	140.4-142.4	1.5		ST	
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-24	150.2-151.7	1.5	0-0-0	SPT	**Sample depth likely impacted due to cleaning plugged casing. Values not representative. @ 150.2**
155								155
			SS-25	155.1-156.6	1.2	7-20-50/0.50'	SPT	
160								160
			SS-26	160.1-161.5	1.4	22-40-50/0.40'	SPT	
165								165
		Very dense, light gray, wet, sand (fine grained).						
170								170
			SS-27	169.9-171.4	1.5	3-11-50/0.50'	SPT	**Top of spoon (SS-27) appeared to have several inches of blowback, which was discarded @ 170 Ohio River Level on 08/17 at 12 P.m. was 14.18 ft @ 175**
175								175
			SS-28	179.7-180.0	0.3	50/0.30'	SPT	
180								180
185 58.7	185.0							185
		Dense to very dense, light gray to dark brown, wet, sand with trace silt (medium grained).						
190			SS-29	189.6-189.8	0.2	50/0.20'	SPT	190
195								195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
				SS-30	199.4-200.9	1.5	32-25-30	SPT	
				SS-30	199.4-200.9	1.5	32-25-30	SPT	
205									205
210									210
215									215
220				SS-31	219.1-220.4	1.2	35-42-50/0.30'	SPT	220
225		Dense to very dense, light gray to dark brown, wet, sand with trace silt (medium grained).							225
230									230 **Ohio River Level on 08/18 at 12 a.m. was 15.19 ft @ 230**
235									235
240				SS-32	238.8-240.3	1.3	11-18-19	SPT	240
245									245
250									250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
255								255
260		Dense to very dense, light gray to dark brown, wet, sand with trace silt (medium grained).	SS-33	258.5-259.9	1.0	13-26-50/0.40'	SPT	260
265								265
270-26.3	270.0							270
275								275
280			SS-34	278.1-279.6	1.5	7-10-29	SPT	280
			SC-1	279.6-281.6	2.0		ST	**Soil coring started at beginning of interval for SS-34, upper 1.5 ft not retained @ 280**
			SC-1a	281.6-283.1	1.4		ST	
285		Hard to very hard, gray, moist, lean clay.	SC-2	283.1-285.1	2.0		ST	285
			SC-2a	285.1-287.1	2.0		ST	
			SC-2b	287.1-288.0	0.7		ST	
290			SC-3	288.0-290.0	2.0		ST	290
			SC-3a	290.0-292.0	2.0		ST	
			SC-3b	292.0-292.9	0.9		ST	
295			SC-4	292.9-294.9	2.0		ST	295
			SC-4a	294.9-296.9	2.0		ST	
			SC-4b	296.9-297.8	0.4		ST	
300			SS-35	297.8-299.3	1.5	11-15-27	SPT	**Soil coring** 300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden	SC-5	299.3-301.3	2.0		ST	started at beginning of interval for SS-35, upper 1.5 ft not retained @ 299
			SC-5	299.3-301.3	2.0		ST	
			SC-5a	301.3-302.7	1.4		ST	
			SC-6	302.7-304.7	0.0		ST	
305			SC-6a	304.7-306.7	0.0		ST	305
			SC-6b	306.7-307.7	0.0		ST	
310								310
			SC-7	312.6-314.6	2.0		ST	with cobble @ 313
315			SC-7a	314.6-316.6	2.0		ST	315
			SC-7b	316.6-317.5	0.9		ST	
			SS-36	317.5-319.0	1.5	6-14-20	SPT	Soil coring started at beginning of interval for SS-36, upper 1.5 ft not retained @ 317.5
320			SC-8	319.0-321.0	2.0		ST	320
			SC-8a	321.0-322.4	1.4		ST	
			SC-9	322.4-324.4	2.0		ST	
325		Hard to very hard, gray, moist, lean clay.	SC-9a	324.4-326.4	2.0		ST	325
			SC-9b	326.4-327.3	0.4		ST	
			SC-10	327.3-329.3	2.0		ST	
330			SC-10a	329.3-331.3	2.0		ST	330
			SC-10b	331.3-332.3	0.9		ST	
			SC-11	332.3-334.3	2.0		ST	
335			SC-11a	334.3-336.3	2.0		ST	335
			SC-11b	336.3-337.2	0.8		ST	
			SS-37	337.2-338.7	1.5	10-27-39	SPT	Soil coring started at beginning of interval for SS-37, upper 1.5 ft not retained @ 337 with cobble @ 340
340			SC-12	338.7-340.7	2.0		ST	340
			SC-12a	340.7-342.1	1.4		ST	
			SC-13	342.1-344.1	2.0		ST	
345			SC-13a	344.1-346.1	1.7		ST	345
			SC-13B	346.1-347.0	0.0		ST	
			SC-14	347.0-349.0	2.0		ST	
350			SC-14a	349.0-351.0	2.0		ST	350

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden	SC-14a	349.0-351.0	2.0		ST	**Ohio River Level on 08/20 at 12 p.m. was 13.56 ft @ 350**
			SC-14b	351.0-351.9	0.9		ST	
			SC-15	351.9-353.9	2.0		ST	
355			SC-15a	353.9-355.9	1.9		ST	355
			SC-15b	355.9-356.9	0.0		ST	
			SS-38	356.9-358.4	1.5	13-34-48	SPT	**Soil coring started at beginning of interval for SS-38, upper 1.5 ft not retained @ 357**
360			SC-16	358.4-360.4	2.0		ST	360
			SC-16a	360.4-361.8	1.4		ST	
			SC-17	361.8-363.8	2.0		ST	
365			SC-17a	363.8-365.8	2.0		ST	365
			SC-17b	365.8-366.7	0.8		ST	
			SC-18	366.7-368.7	2.0		ST	
370			SC-18a	368.7-370.7	2.0		ST	370
			SC-18b	370.7-371.6	0.6		ST	
			SC-19	371.6-373.6	2.0		ST	
375		Hard to very hard, gray, moist, lean clay.	SC-19a	373.6-375.6	2.0		ST	375
			SC-19b	375.6-376.5	0.2		ST	
			SS-39	376.5-378.0	1.5	22-37-49/0.50'	SPT	**Ohio River Level on 08/21 at 12 a.m. was 15.48 ft @ 376**
380			SC-20	378.0-380.0	2.0		ST	380
			SC-20a	380.0-381.5	1.4		ST	**Soil coring started at beginning of interval for SS-39, upper 1.5 ft not retained @ 376.5**
			SC-21	381.5-383.5	2.0		ST	
385			SC-21a	383.5-385.5	2.0		ST	385
			SC-21b	385.5-386.4	0.9		ST	
			SC-22	386.4-388.4	2.0		ST	
390			SS-22a	388.4-390.4	2.0		ST	**Soil Core Run #21 recovered by day shift @ 384** 390
			SS-22b	390.4-391.3	0.9		ST	
			SS-23	391.3-393.3	2.0		ST	
395			SS-23a	393.3-395.3	2.0		ST	395
			SS-23B	395.3-396.2	0.7		ST	
			SS-40	396.2-397.7	1.5	10-27-32	SPT	
			SC-24	397.2-399.2	2.0		ST	
400			SS-24a	399.2-401.1	1.4		ST	400

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1008***	Immediate Water Depth ***NA***	Start Date ***08/15/2024***	Hole Type ***sample***
Surface Elevation ***243.7'***	Static Water Depth ***NA***	End Date ***08/21/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.6'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.993809***	
Location ***2045+50.00 CL***		Longitude(83) ***-89.150443***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-24a	399.2-401.1	1.4		ST	
-159.0	402.6	Hard to very hard, gray, moist, lean clay.	SS-41	401.1-402.6	1.5	11-32-46	SPT	

405

(Bottom of Hole 402.6')
(No Refusal)

410

On 08/15/2024
Deck Elevation = 292.37 ft
Deck to mudline = 48.7 ft
Deck to water = 6.0 ft
Water depth = 42.7 ft

415

5" Geobore-S casing extended from deck to borehole termination
6" casing 73.54 ft from deck on 08/15/2024
6" Casing 111.34 ft from deck on 08/18/2024

420

P-S Suspension Logging 08/21/2024 thru 08/22/2024

425

430

435

440

445

450

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Very loose, brown to black, wet, sandy gravel (fine grained).	SS-1	3.7-5.2	0.9	1-1-3	SPT	
235.6	7.0							
		Loose to medium dense, dark gray, wet, sand with trace fine gravel (fine grained).	SS-2	8.7-10.2	0.7	1-3-5	SPT	
			SS-3	13.6-15.1	1.3	2-8-15	SPT	
224.1	18.5							
		Dense, dark gray, wet, sand with trace silt (fine grained).	GT-1	18.5-20.5	0.0		ST	
			SS-4	20.5-22.0	1.1	14-23-24	SPT	
220.1	22.5							
		Medium dense to very dense, dark gray, wet, sand with trace fine gravel (fine grained).	SS-5	23.4-24.9	1.1	11-15-22	SPT	
			SS-6	28.3-29.8	1.0	12-28-34	SPT	**Ohio River Level on 7/30 at 12 am was 24.65 ft @ 30**
			SS-7	33.3-34.8	1.2	9-9-12	SPT	
			GT-2	38.2-40.2	0.1		ST	
			SS-8	40.2-41.7	1.1	18-22-26	SPT	
			SS-9	43.1-44.6	0.9	13-15-13	SPT	
			SS-10	48.0-49.5	1.3	11-29-29	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden / Rock Core	Std/Ky RQD					
191.6	51.0							
		Dense, gray, wet, sand (fine to medium grained).	SS-11	52.9-54.4	1.0	8-20-23	SPT	
55								55
186.6	56.0							
		Very dense, brown and gray, wet, sandy gravel.	SS-12	57.9-59.4	1.0	10-27-33	SPT	
60								60
181.6	61.0							**Ohio River Level on 7/30 at 12 pm was 23.7 ft @ 60**
			SS-13	62.8-64.3	1.3	7-9-13	SPT	
65								65
			GT-3	64.4-66.4	1.3		ST	
								Added 10 ft of 6 in casing @ 66
			SS-14	67.7-69.2	1.3	1-4-6	SPT	
70		Loose to medium dense, white, wet, clayey sand (fine grained).						70
			SS-15	72.6-74.1	1.5	4-10-15	SPT	
75								75
			SS-16	77.5-79.0	1.5	2-7-16	SPT	
80								80
161.6	81.0							
		Dense, white to brown, wet, clayey sand with with few clay seams (fine grained).	SS-17	82.5-84.0	1.4	9-21-26	SPT	
85								85
156.6	86.0							
			SS-18	87.4-88.4	0.8	14-50/0.50'	SPT	**Added 25 ft of 6 in casing @ 87**
90								90
		Dense to very dense, light gray, wet, sand (fine grained).	SS-19	92.3-93.8	1.0	11-17-28	SPT	**Ohio River Level on 7/31 at 12 am was 24.02 ft @ 90**
95								95
			SS-20	97.2-98.1	0.9	27-50/0.40'	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
105								105
			SS-21	107.1-108.0	0.9	20-50/0.40'	SPT	**SPT sampler overfilled, blowcounts possibly not representative @ 107**
110								110
			SS-22	112.0-112.9	0.9	31-50/0.40'	SPT	
115								115
120								120
			SS-23	121.8-123.1	0.9	30-46-50/0.30'	SPT	
125		Dense to very dense, light gray, wet, sand (fine grained).						125
130								130
			SS-24	131.7-132.7	0.6	33-50/0.50'	SPT	
135								135
140								140
			SS-25	141.5-142.8	0.8	11-47-50/0.30'	SPT	
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
								Ohio River Level on 7/31 at 12 pm was 22.98 ft @ 150
			SS-26	151.3-152.8	0.9	15-33-41	SPT	
155								155
160								160
			SS-27	161.2-162.0	0.5	24-50/0.30'	SPT	
165								165
		Dense to very dense, light gray, wet, sand (fine grained).						
170								170
			SS-28	171.0-171.8	0.7	15-50/0.30'	SPT	
175								175
180								180
			SS-29	180.9-181.7	0.6	21-50/0.30'	SPT	
185 57.6	185.0							185
190								190
			SS-30	190.7-191.1	0.4	50/0.40'	SPT	
		Very dense, light gray to brown, wet, sand with little clay below 200.5 ft (fine grained).						
195								195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-31	200.5-201.4	0.9	40-50/0.40'	SPT	**Ohio River Level on 8/01 at 12 am was 24.44 ft @ 200**
205		Very dense, light gray to brown, wet, sand with little clay below 200.5 ft (fine grained).						205
210 32.6	210.0							210
215								215
220								220
			SS-32	220.2-221.7	1.0	0-0-0	SPT	**Ohio River Level on 8/01 at 12 pm was 24.15 ft @ 220**
		Very soft to stiff, brown, moist to wet, clay.						
225								225
230			ST-4	228.8-230.8	0.8		ST	**Tube advanced with weight of rod only. @ 229** 230
235 7.6	235.0							235
240								240
			SS-33	239.9-240.6	0.5	18-50/0.20'	SPT	
		Very dense, light gray, wet, sand (fine grained).						
245								245
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								255
260		Very dense, light gray, wet, sand (fine grained).	SS-34	259.6-260.5	0.9	27-50/0.40'	SPT	260
265								265
270-27.5	270.0							270
275								275
280			SS-35	279.3-280.8	1.4	9-15-25	SPT	280
285		Hard, dark gray, wet, clay.						285
290								290
295								295
300								300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1009***	Immediate Water Depth ***NA***	Start Date ***07/29/2024***	Hole Type ***sample***
Surface Elevation ***242.6'***	Static Water Depth ***NA***	End Date ***08/02/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.9'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.993753***	
Location ***2045+50.00 32.0' Rt.***		Longitude(83) ***-89.150382***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
-58.3	300.9		SS-36	299.4-300.9	1.5	7-16-22	SPT	
305		(Bottom of Hole 300.9') (No Refusal) On 07/29/2024 Deck Elevation = 300.05 ft Deck to mudline = 57.5 ft Deck to water = 6.0 ft Water depth = 51.5 ft 5" Geobore-S casing extended from deck to borehole termination 6" casing 84.64 ft from deck on 07/29/2024 6" casing 149.34 ft from deck on 07/30/2024 6" casing 229.34 ft from deck 08/01/2024						305
310								310
315								315
320								320
325								325
330								330
335								335
340								340
345								345
350								350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
253.7	4.8	Very loose, brown, wet, sand (coarse).	SS-1	3.3-4.8	0.7	0-0-1	SPT	
			SS-2	8.2-9.7	1.5	0-3-7	SPT	
		Loose to medium dense, gray and brown, wet, sand with fine gravel (fine to coarse).	GT-1	9.9-11.9	1.7		ST	
			SS-3	13.1-14.6	0.8	3-3-3	SPT	
242.5	16.0							
			SS-4	18.1-19.6	1.0	8-14-25	SPT	
			SS-5	23.0-24.5	0.1	9-11-20	SPT	
		Medium dense to dense, wet.	SS-6	27.9-29.4	1.5	6-12-20	SPT	
			GT-2	29.5-31.3	0.0		ST	
226.5	32.0							
			SS-7	32.8-34.3	0.9	6-10-12	SPT	
		Medium dense, gray, wet, sand (fine to medium).						
221.5	37.0							
			SS-8	37.7-39.2	1.1	5-13-13	SPT	
		Medium dense to dense, gray, wet, sand with coarse sand to fine gravel (fine).	SS-9	42.7-44.2	0.9	15-32-40	SPT	
211.5	47.0							
		Medium dense, white, wet, clayey sand (fine).	SS-10	47.6-49.1	1.4	2-7-16	SPT	
			GT-3	49.2-51.2	0.0		ST	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
			GT-3	49.2-51.2	0.0		ST	
			SS-11	52.5-54.0	1.4	1-7-8	SPT	**Ohio River Level on 09/06 at 12 pm was 11.1 ft @ 52**
55								55
		Medium dense, white, wet, clayey sand (fine).	SS-12	57.4-58.9	1.5	5-10-10	SPT	
60								60
			SS-13	62.3-63.8	1.5	2-5-7	SPT	
65			GT-4	64.0-66.0	0.8		ST	65
192.0	66.5							
			SS-14	67.3-68.8	0.2	0-0-0	SPT	
70 188.5	70.0	Very soft, white, fat clay.						70
			SS-15	72.2-73.7	1.5	10-15-20	SPT	
75								75
			SS-16	77.1-78.6	1.1	13-31-37	SPT	
80								80
		Medium dense to very dense, white, wet, clayey sand.	SS-17	82.0-83.5	1.4	11-31-36	SPT	
85								85
			SS-18	86.9-88.4	1.5	4-8-11	SPT	
90								90
			SS-19	91.9-93.4	0.9	2-5-11	SPT	
95			GT-5	93.5-95.5	0.0		ST	95
162.5	96.0							
			SS-20	96.8-98.1	1.0	10-25-50/0.33'	SPT	
100		Very dense, white to brown, wet, sand (fine to coarse).						100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-21	101.7-103.0	1.0	13-48-50/0.25'	SPT	
105								105
110								110
			SS-22	111.5-112.9	0.8	24-38-50/0.33'	SPT	
115								115
120								120
			SS-23	121.4-122.9	0.8	17-24-37	SPT	
125		Very dense, white to brown, wet, sand (fine to coarse).						125
130								130
			SS-24	131.2-132.6	0.8	15-30-50/0.33'	SPT	**Ohio River Level on 09/07 at 12 am was 10.5 ft @ 131**
135								135
140								140
			SS-25	141.1-142.3	0.8	13-49-50/0.25'	SPT	
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-26	150.4-151.3	0.6	26-50/0.40'	SPT	
155								155
160			SS-27	160.7-161.6	0.5	24-50/0.40'	SPT	160
165								165
170			SS-28	170.6-171.0	0.3	50/0.40'	SPT	170
175		Very dense, white to brown, wet, sand (fine to coarse).						175
180			SS-29	180.4-180.8	0.3	50/0.40'	SPT	180
185								185
190			SS-30	190.3-190.7	0.3	50/0.40'	SPT	190
			SC-1	190.7-192.7	0.6		ST	
			SC-1a	192.7-194.7	0.0		ST	
195			SC-1b	194.7-195.2	0.0		ST	195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden	SS-31	200.1-201.1	0.9	21-50/0.50'	SPT	
			SC-2	201.1-203.1	1.1		ST	
205		Very dense, white to brown, wet, sand (fine to coarse).	SC-2a	203.1-205.0	0.0		ST	205
51.5	207.0							
210			ST-1	209.9-210.3	0.4		ST	210
			SC-3	210.3-212.3	2.0		ST	**wood fragments, Ohio River Level on 09/07 at 12 pm was 9.65 ft @ 210**
			SC-3a	212.3-214.3	0.5		ST	
215			SC-3b	214.3-214.9	0.0		ST	215
220			SS-32	219.8-220.4	0.6	44-50/0.10'	SPT	220
			SC-4	220.4-222.4	0.0		ST	
			SC-4a	222.4-224.4	0.0		ST	
225			SC-4b	224.4-224.7	0.0		ST	225
230		Very dense, white to brown, wet, sand (fine).						230
235								235
240			SS-33	239.5-240.3	0.8	38-50/0.30'	SPT	240
245								245
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								255
260		Very dense, white to brown, wet, sand (fine).	SS-34	259.1-259.9	0.8	10-50/0.30'	SPT	260
265								265
-9.5	268.0							
270								270 **Ohio River Level on 09/08 at 12 am was 9.76 ft @ 270**
275								275
280			SS-35	278.8-280.3	0.8	9-37-38	SPT	280 **gray clayey sand seam @ 279**
285		Hard, gray, wet, fat clay with trace fine sand.						285
290								290
295			SC-5	293.6-295.6	2.0		ST	295
			SC-5a	295.6-297.6	2.0		ST	
			SC-5b	297.6-298.5	0.0		ST	
300			SS-36	298.5-300.0	1.5	7-20-24	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SC-6	300.0-302.0	2.0		ST	**Ohio River Level on 09/08 at 12 pm was 8.78 ft @ 300**
			SC-6a	302.0-303.4	1.4		ST	
305			SC-7	303.4-305.4	2.0		ST	305
			SC-7a	305.4-306.3	0.9		ST	
			SC-8	306.3-308.3	2.0		ST	
310			SC-8a	308.3-310.3	2.0		ST	310
			SC-8b	310.3-311.3	0.9		ST	
			SC-9	311.3-313.3	2.0		ST	
		Hard, gray, wet, fat clay with trace fine sand.						
315			SC-9a	313.3-315.3	2.0		ST	315
			SC-9b	315.3-316.2	0.9		ST	
			SS-37	316.2-317.7	1.5	6-21-28	SPT	
			SC-10	317.7-319.7	2.0		ST	
320			SC-10a	319.7-321.1	1.4		ST	320
			SC-11	321.1-323.1	2.0		ST	
325			SC-11a	323.1-325.1	2.0		ST	325
-67.5	326.0		SC-11b	325.1-326.0	0.9		ST	
			SC-12	326.0-328.0	2.0		ST	
330			SC-12a	328.0-330.0	2.0		ST	330
			SC-12b	330.0-330.9	0.9		ST	
			SC-13	330.9-332.9	2.0		ST	
335			SC-13a	332.9-334.9	2.0		ST	335
			SC-13b	334.9-335.9	0.9		ST	
340		(Bottom of Hole 335.9') (No Refusal)						340
345		On 9/06/2024 Deck Elevation = 285.16 ft Deck to mudline = 26.7 ft Deck to water = 5.0 ft						345
350		Water depth = 26.7 ft						350

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1012***	Immediate Water Depth ***NA***	Start Date ***09/05/2024***	Hole Type ***sample***
Surface Elevation ***258.5'***	Static Water Depth ***NA***	End Date ***09/07/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***335.9'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995798***	
Location ***2054+50.00 32.0' Lt.***		Longitude(83) ***-89.148573***	

Lithology		Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
Elevation	Depth	Overburden / Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
355		6" Casing extended to 65.54 ft below deck 6" Casing extended to 190.54 ft below deck 5" Geobore-S casing extended to borehole termination depth At 12:00 pm on 09/08/2024, liftboat raised 2 ft, new deck to mudline is 28.7 ft						355
360								360
365								365
370								370
375								375
380								380
385								385
390								390
395								395
400								400

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager:

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
		Loose, gray, wet, sand (fine to medium grained).	SS-1	3.9-5.4	0.7	2-3-5	SPT	
250.4	7.0							
		Very dense, gray, wet, sand (medium to coarse grained).	SS-2	8.8-10.3	0.4	1-1-1	SPT	**Ohio River Level on 8/26 at 12 am was 13.87 ft @ 9**
247.1	10.3		ST-1	10.3-12.3	0.0		ST	
		Medium dense to dense, gray, wet, sand (medium to coarse grained).	SS-3	13.8-15.3	0.2	6-8-5	SPT	**Possible cobble or debris between 12.9 and 19.2 ft @ 12.9**
			SS-4	18.7-20.2	0.7	4-16-19	SPT	**white rope (consistent with old mop) observed in SS-3 @ 13.8**
235.4	22.0							
		Dense to very dense, gray, wet, sand (fine to medium grained).	SS-5	23.6-25.1	1.1	18-15-17	SPT	
			SS-6	28.5-30.0	1.0	14-20-24	SPT	
			SS-7	33.4-34.9	0.9	20-23-24	SPT	
			SS-8	38.4-39.8	0.0	16-35-50/0.40'	SPT	
215.4	42.0							
		Very dense, gray, wet, sand (coarse grained).	SS-9	43.3-44.8	0.9	16-32-23	SPT	
210.4	47.0							
		Medium dense, white, wet, clayey sand (fine grained).	SS-10	48.2-49.7	1.5	1-4-7	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
55		Medium dense, white, wet, clayey sand (fine grained).	GT-1	53.1-55.1	1.8		ST	
			SS-11	58.0-59.5	1.5	4-9-11	SPT	
60								
			SS-12	63.0-64.5	1.5	3-9-12	SPT	
65 192.4	65.0							
189.0	68.4	Medium stiff, white, wet, fat clay with with fine sand.						
70			SS-13	67.9-69.4	1.5	4-11-19	SPT	**Ohio River Level on 8/26 at 12 pm was 12.2 ft @ 67**
186.4	71.0	Medium dense, white, wet, clayey sand (fine grained).						
			SS-14	72.8-74.3	1.4	3-17-25	SPT	
75		Hard, light gray, wet, silty clay (varved with fine sand lens).	ST-2	74.4-76.4	2.0		ST	
178.4	79.0		ST-3	77.7-78.7	0.0		ST	
80			SS-15	79.4-80.9	1.0	5-34-49	SPT	
		Very dense, white, wet, clayey sand (fine grained).	SS-16	82.6-84.0	1.3	12-49-50/0.40'	SPT	
85								
171.4	86.0							
			SS-17	87.6-89.1	1.5	3-7-11	SPT	
90		Medium dense, white, wet, clayey sand (fine grained).						
162.9	94.5		GT-2	92.5-94.5	0.0		ST	**approximately 1/2 ft to 1 ft of material recovered, cap and sample fell out when dissassembly of sampler @**
95			SS-18	94.5-96.0	0.7	2-5-6	SPT	
100		Medium to very dense, light gray, wet, sand (fine grained).						100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
								92.5 Casing fell out of clamp, fell approximately 5.6 ft below deck, sampling advanced to 100.7 for SS-19 @ 96
		Medium to very dense, light gray, wet, sand (fine grained).	SS-19	100.7-102.2	1.1	16-22-35	SPT	
152.9	104.5		GT-3	102.3-104.3	1.9		ST	
105								105
110								110
			SS-20	112.2-113.7	1.4	16-31-48	SPT	
115								115
120								120
			SS-21	122.0-123.5	1.1	6-18-39	SPT	
125								125
130		Very dense, light gray to brown, wet, sand (fine to medium grained).						130
			GT-4	131.8-133.8	1.9		ST	**Ohio River Level on 8/27 at 12 am was 12.51 ft @ 131**
135								135
140								140
			SS-22	141.7-143.2	1.3	24-30-37	SPT	
145								145
150107.4	150.0							150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-23	151.5-153.0	1.3	16-27-48	SPT	
155								155
160			SS-24	161.4-162.7	1.3	27-48-50/0.30	SPT	160
165								165
170			SS-25	171.2-171.7	0.5	50/0.50'	SPT	170
		Very dense, white and light gray, wet, sand (medium grained).						
175								175
180			SS-26	181.0-181.9	0.8	26-50/0.40'	SPT	180
185								185
190			SS-27	190.9-191.5	0.6	19-50/0.10'	SPT	190
195 62.4	195.0							195
		Very dense, white, wet, sand with with clay (fine grained).						
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-28	200.7-202.2	1.5	6-29-39	SPT	
205								205
210								210 **Ohio River Level on 8/27 at 12 pm was 11.31 ft @ 210**
215		Very dense, white, wet, sand with with clay (fine grained).						215
220			SS-29	220.4-221.0	0.6	38-50/0.10'	SPT	220 **with decaying wood fibers @ 220**
225								225
230 27.4	230.0							230
235								235
240		Very dense, off white and tan, wet, sand (fine grained).	SS-30	240.1-240.8	0.6	27-50/0.20'	SPT	240
245								245
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								255
260			SS-31	259.8-260.5	0.7	24-50/0.20'	SPT	260
265								265
270		Very dense, off white and tan, wet, sand (fine grained).						270
275								275
280			SS-32	279.4-280.9	1.5	31-31-45/0.50'	SPT	280
285								285
-30.6	288.0							**Clay encountered @ 288**
290			SC-1	289.3-291.3	2.0		ST	290
			SC-1a	291.3-293.3	2.0		ST	
			SC-2b	293.3-294.2	0.0		ST	
295		Very stiff to hard, dark gray, moist, lean clay.	SC-2	294.2-296.2	2.0		ST	295 **Ohio River Level on 8/28 at 12 am was 11.94 ft @ 295**
			SC-2a	296.2-298.2	1.2		ST	
			SC-2B	298.2-299.1	0.0		ST	
300			SS-33	299.1-300.6	1.5	6-14-24	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SC-3	300.6-302.6	2.0		ST	
			SC-3a	302.6-304.0	0.3		ST	
305			SC-4	304.0-306.0	2.0		ST	305
			SC-4a	306.0-308.0	2.0		ST	
			SC-4b	308.0-309.0	0.9		ST	
310			SC-5	309.0-311.0	2.0		ST	310
			SC-5a	311.0-313.0	2.0		ST	
			SC-5b	313.0-313.9	0.8		ST	
315			SC-6	313.9-315.9	2.0		ST	315
			SC-6a	315.9-317.9	2.0		ST	
			SC-6b	317.9-318.8	0.8		ST	
320			SS-34	318.8-320.3	1.5	0-10-12	SPT	320
			SC-7	320.3-322.3	2.0		ST	
			SC-7a	322.3-323.7	1.4		ST	
325		Very stiff to hard, dark gray, moist, lean clay.	SC-8	323.7-325.7	2.0		ST	325
			SC-8a	325.7-327.7	2.0		ST	
			SC-8b	327.7-328.6	0.9		ST	
330			SC-9	328.6-330.6	2.0		ST	330
			SC-9a	330.6-332.6	1.9		ST	
			SC-9b	332.6-333.6	0.0		ST	
335			SC-10	333.6-335.6	2.0		ST	335
			SC-10a	335.6-337.6	2.0		ST	
			SC-10b	337.6-338.5	0.8		ST	
340			SS-35	338.5-340.0	1.5	6-17-19	SPT	340
			SC-11	340.0-342.0	2.0		ST	
			SC-11a	342.0-343.4	1.4		ST	
345			SC-12	343.4-345.4	2.0		ST	345
			SC-12a	345.4-347.4	2.0		ST	
			SC-12b	347.4-348.3	0.9		ST	
350			SC-13	348.3-350.3	2.0		ST	350

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
		Overburden / Rock Core	Std/Ky RQD					
			SC-13a	350.3-352.3	2.0		ST	
			SC-13b	352.3-353.2	0.8		ST	
355			SC-14	353.2-355.2	2.0		ST	355
			SC-14a	355.2-357.2	2.0		ST	
			SC-14b	357.2-358.2	0.8		ST	
		Very stiff to hard, dark gray, moist, lean clay.	SS-36	358.2-359.7	1.5	16-35-49/0.50'	SPT	
360			SC-15	359.7-361.7	2.0		ST	360
			SC-15a	361.7-363.1	1.4		ST	
365			SC-16	363.1-365.1	2.0		ST	365
			SC-16a	365.1-366.7	1.6		ST	
-110.6	368.0		SC-17	366.7-368.7	2.0		ST	**possibly Potters Creek Formation @ 368**
370			SC-17a	368.7-370.7	2.0		ST	370
			SC-17b	370.7-371.6	0.9		ST	
			SC-18	371.6-373.6	2.0		ST	
375			SC-18a	373.6-375.6	2.0		ST	375
			SC-18b	375.6-376.5	0.9		ST	
			SS-37	376.5-377.5	1.0	25-50/0.50'	SPT	
			SC-19	377.5-379.5	2.0		ST	
380			SC-19a	379.5-381.5	1.9		ST	380
			SC-20	381.5-383.5	2.0		ST	
385		Hard, grat, moist, lean clay with with mica.	SC-20a	383.5-385.5	2.0		ST	385
			SC-20b	385.5-386.4	0.9		ST	
			SC-21	386.4-388.4	2.0		ST	
390			SC-21a	388.4-390.4	2.0		ST	390
			SC-21b	390.4-391.3	0.9		ST	
			SC-22	391.3-393.3	2.0		ST	
395			SC-22a	393.3-395.3	2.0		ST	395
			SC-22b	395.3-396.2	0.9		ST	
			SS-38	396.2-397.6	1.4	23-45-50/0.40'	SPT	
			SC-23	397.6-399.6	2.0		ST	
400								400

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1013***	Immediate Water Depth ***NA***	Start Date ***08/25/2024***	Hole Type ***sample***
Surface Elevation ***257.4'***	Static Water Depth ***NA***	End Date ***08/31/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***402.4'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.995739***	
Location ***2054+50.00 CL***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SC-23a	399.6-401.1	1.2		ST	
-145.0	402.4	Hard, grat, moist, lean clay with with mica.	SC-23a	399.6-401.1	1.2	21-42-50/0.30	ST	
			SS-39	401.1-402.4	1.3		SPT	
405								405
		(Bottom of Hole 402.4') (No Refusal)						
410								410
		On 8/25/2024 Deck Elevation = 288.42 ft Deck to mudline = 31 ft Deck to water = 5.3 ft Water depth = 25.7 ft						
415								415
		On 08/30/2024 - Liftboat raised 1.3 ft Deck to mudline = 32.3 ft						
		6" Casing extended to 50.54 ft below deck 6" Casing extended to 65.54 ft below deck on 08/26/2024 6" Casing extended to 74.74 ft below mudline on 08/28/2024 5" Geobore-S casing extended to borehole termination depth						
420								420
		P-S Logging not performed due to equipment issues. Location B-1012 will be logged as an alternate.						
425								425
430								430
435								435
440								440
445								445
450								450

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
5		Very loose, brown and gray, wet, sand (with 6 in silty clay seam near 4 ft).	SS-1	3.6-5.1	1.3	1-1-1	SPT	**Ohio River Level on 7/25 at 12 am was 26.28 ft @ 3**
249.1	8.0							
10		Loose, dark gray and brown, wet, gravel with sand.						
			SS-2	13.2-14.7	0.3	3-4-5	SPT	
15								
240.6	16.5							
			SS-3	18.1-19.6	0.5	3-7-8	SPT	
20		Medium dense to dense, dark gray, wet, sand with trace fine gravel (fine to coarse).						**Ohio River Level on 7/25 at 12 pm was 25.61 ft @ 20**
			SS-4	23.0-24.5	0.0	15-21-19	SPT	
25			SS-5	24.7-26.2	0.9	3-14-17	SPT	
230.1	27.0							
			SS-6	28.0-29.5	0.2	18-48-49/0.50'	SPT	**Single large gravel piece logged in bottom of spoon. Blowcounts likely elevated in SS-6. @ 27.95**
30		Very dense, gray, wet, gravel with sand (coarse).						
226.1	31.0							
		Very dense, brown, wet, silty sand (fine to medium grained).	SS-7	32.9-34.4	1.1	20-30-32	SPT	
35								
221.1	36.0							
			SS-8	37.8-39.3	1.3	14-26-27	SPT	
40		Very dense, gray, wet, sand with with gravel.						
213.1	44.0		SS-9	42.7-44.2	1.5	6-13-17	SPT	**Sampler overfilled, blow counts not likely representative in SS-9 @ 42.7**
45		Medium dense to dense, light gray, wet, sand.						
			SS-10	47.6-49.1	1.5	6-8-10	SPT	
50								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			GT-1	50.8-52.8	0.0		ST	**Ohio River Level on 7/26 at 12 am was 26.50 ft @ 51**
			SS-11	52.8-54.3	1.3	7-10-11	SPT	
55								55
		Medium dense to dense, light gray, wet, sand.	SS-12	57.5-59.0	1.2	7-10-21	SPT	
60								60
			SS-13	62.4-63.9	1.3	9-15-18	SPT	
65 192.1	65.0							65
			SS-14	67.3-68.8	1.2	10-12-15	SPT	
70		Very stiff, light gray, wet, silty clay.						70
			ST-2	72.2-74.2	1.0		ST	
75								75
179.5	77.6		SPT-15	77.2-78.5	1.3	10-40-50/0.30'	SPT	
80								80
			SPT-16	82.1-83.6	1.5	10-25-39	SPT	
85		Very dense, white, wet, clayey sand (fine grained).						85
			SPT-17	87.0-88.5	1.5	24-34-34	SPT	**Ohio River Level on 7/26 at 12 pm was 25.40 ft @ 87**
90 167.1	90.0							90
		Very dense, white, wet, clayey sand with varved (with fat clay seams) (fine grained).	SPT-18	91.9-93.4	1.4	7-28-39	SPT	
95 162.1	95.0							95
		Very dense, white to light gray, wet, sand with trace clay (fine grained).	SPT-19	96.8-98.3	1.1	10-40-49	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SPT-20	101.8-102.7	0.9	21-50/0.40'	SPT	
105		Very dense, white to light gray, wet, sand with trace clay (fine grained).						105
110								110
			SPT-21	112.2-113.7	1.3	20-45-50/0.50'	SPT	
115								115
140.1	117.0							
120		Very dense, light gray to tan, wet, sand (fine to coarse grained).						120
			SPT-22	121.4-122.9	1.5	0-2-7	SPT	**Ohio River Level on 7/27 at 12 am was 25.66 ft @ 120**
125								125 **Sampling interval at SS-22 likely washed out during drilling, blowcounts not representative @ 121**
130.1	127.0							
130		Very dense, light gray to white, wet, sand (coarse grained).						130
			SPT-23	131.3-132.8	0.9	17-37-46/0.50'	SPT	
135								135
140								140
			SPT-24	141.1-142.3	1.0	20-46-50/0.17'	SPT	**Hydraulic hose on hammer ruptured at 14 blows on third increment after advancing 0.5",**
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SPT-25	150.9-151.9	0.9	20-50/0.50'	SPT	**assumed 50/2" for final increment @ 141**
155								155
								Ohio River Level on 7/27 at 12 pm was 25.33 ft @ 150
160								160
			SPT-26	160.8-161.6	0.8	27-50/0.30'	SPT	
		Very dense, light gray to white, wet, sand (coarse grained).						
165								165
170								170
			SPT-27	170.6-171.4	0.8	6-50/0.30'	SPT	
175								175
81.1	176.0							
180		Very dense, tan and gray, wet, sand with with rock fragments (coarse grained).						180
			SPT-28	180.5-181.3	0.8	32-50/0.30'	SPT	
185								185
71.1	186.0							
190								190
			SPT-29	190.3-191.2	0.8	45-50/0.40'	SPT	
		Very dense, tan and gray, wet, sand (fine to medium grained).						
195								195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SPT-30	200.2-201.0	0.8	30-50/0.30'	SPT	
205								205
210		Very dense, tan and gray, wet, sand (fine to medium grained).						**Ohio River Level on 7/28 at 12 am was 26.09 ft @ 210** 210
215								215
220 37.3	219.8							220
36.8	220.3	Hard, dark brown, wet, fat clay (laminated).	SPT-31	219.8-220.6	0.8	39-50/0.30'	SPT	
225		Very dense, tan and gray, wet, sand (medium grained).						225
28.1	229.0							
230								230
235								235
240		Very dense, light gray and tan, wet, sand (fine grained).	SPT-32	239.5-239.9	0.4	50/0.40'	SPT	240
245								245
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
255								255
260		Very dense, light gray and tan, wet, sand (fine grained).	SPT-33	259.2-259.7	0.5	50/0.50'	SPT	**Ohio River Level on 7/28 at 12 pm was 26.15 ft @ 260** 260
265								265
270								270
-16.0	273.0							
275		Hard, wet, fat clay.						**Based on drilling conditions encountered, not directly sampled @ 273** 275
-19.0	276.0							
280		Very dense, brown, wet, sand (coarse grained).	SPT-34	278.9-279.3	0.4	50/0.40'	SPT	280
285								285
290								290
295 -38.0	295.0							295
		Hard, dark gray, wet, fat clay.						
300			SPT-35	298.6-300.1	1.5	12-17-28	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1014***	Immediate Water Depth ***NA***	Start Date ***07/24/2024***	Hole Type ***sample***
Surface Elevation ***257.1'***	Static Water Depth ***NA***	End Date ***07/29/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***305.0'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.995675***	
Location ***2054+50.00 32.0' Rt.***		Longitude(83) ***-89.148484***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
		Hard, dark gray, wet, fat clay.						**Ohio River Level on 7/29 at 12 am was 25.42 ft @ 300**
305-48.0	305.0		SPT-36	303.5-305.0	1.5	22-26-31	SPT	
310		(Bottom of Hole 305.0') (No Refusal) On 07/25/2024 Deck Elevation = 301.75 ft Deck to mudline = 44.7 ft Deck to water = 5.6 ft Water depth = 39.1 ft 5" Geobore-S casing extended from deck to borehole termination 65.1 ft of 6" Casing						
315								
320								
325								
330								
335								
340								
345								
350								

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
5			GT-1	4.8-6.8	1.5		ST	**Ohio River Level on 8/07 at 10 pm was 20.72 ft @ 5**
10			SS-1	9.7-11.2	0.3	4-4-5	SPT	
		Loose to medium dense, brown, wet, sand.						
15			SS-2	14.6-16.1	0.4	3-4-4	SPT	
20			SS-3	19.6-21.1	0.6	4-8-8	SPT	
244.9	23.0							
25			SS-4	24.5-26.0	1.0	13-27-50/0.50'	SPT	**Ohio River Level on 8/08 at 12 am was 21.00 ft @ 25**
30			SS-5	29.4-30.9	0.4	20-27-16	SPT	
		Dene to very dense, brown, wet, sand with with little gravel and rock.						
35			SS-6	34.3-35.8	0.5	10-17-20	SPT	
40			SS-7	39.2-40.7	0.7	12-18-19	SPT	
224.9	43.0							
45			SS-8	44.2-45.7	0.6	15-25-34	SPT	
		Very dense, brown, wet, sand with with little gravel.						
50			SS-9	49.1-50.6	0.8	15-25-34	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
				Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)
214.9	53.0	Very dense, brown, wet, sand with with little gravel.						
55		Medium dense to dense, white, wet, sand.	SS-10	54.0-55.5	1.0	3-5-7	SPT	55
			GT-2	55.6-57.6	0.0		ST	
209.9	58.0							
60		Medium dense to dense, white, wet, clayey sand (with sandy fat clay).	SS-11	58.9-60.4	0.7	7-13-18	SPT	60
65			SS-12	63.8-65.3	1.5	2-8-13	SPT	65
201.9	66.0							
		Very stiff, off white, wet, silty clay (with fine sand lens).	ST-3	65.5-67.5	1.9		ST	
70			SS-13	68.8-70.3	1.2	0-6-10	SPT	70
195.9	72.0							
75		Medium dense to dense, white, wet, clayey sand.	SS-14	73.7-75.2	1.5	1-11-11	SPT	75
80			SS-15	78.6-80.1	1.5	0-3-6	SPT	80
			GT-4	80.2-82.2	0.7		ST	
85			SS-16	83.5-85.0	1.5	0-20-21	SPT	85
180.9	87.0							
90		Stiff, white, tan to brown, wet, silty clay (with varved clayey fine sand lens).	SS-17	88.4-89.9	1.5	1-3-7	SPT	90
			ST-5	90.1-92.1	1.7		ST	
174.9	93.0							
95		Very dense, white, wet, sand.	SS-18	93.4-94.9	1.0	10-20-50/0.50'	SPT	95
100			SS-19	98.3-99.8	0.7	4-18-40	SPT	100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
105		Very dense, white, wet, sand.	SS-20	103.2-104.5	0.6	29-40-50/0.33'	SPT	105
110								110 **Ohio River Level on 8/10 at 12 am was 19.86 ft @ 110**
115 152.4	115.5		GT-6	113.0-115.0	0.0		ST	115
		Stiff, white, wet, clay.	SS-21	116.3-117.8	0.2	7-9-11	SPT	
120 147.9	120.0							120
125			SS-22	122.9-124.4	0.4	21-38-49/0.50'	SPT	125
130		Dense to very dense, white, wet, sand (fine grained).						130
			SS-23	132.7-134.2	1.0	25-38-49/0.50'	SPT	
135								135
140								140
			SS-24	142.6-144.1	0.9	29-39-50/0.50'	SPT	
145 122.9	145.0							145
		Very dense, white to light gray, wet, sand.						
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			SS-25	152.4-152.8	0.3	50/0.40'	SPT	
155								155
		Very dense, white to light gray, wet, sand.						
160								160
			SS-26	162.2-163.1	0.6	43-50/0.33'	SPT	
165 102.9	165.0							165
170								170
			SS-27	172.1-172.9	0.8	21-50/0.30'	SPT	
175		Very dense, light gray, wet, clayey sand.						175
180								180
			SS-28	181.9-183.4	1.4	15-35-45	SPT	
185 82.9	185.0							185
190								190
		Very dense, light gray to brown and gray, wet, sand (fine grained).	SS-29	191.8-192.6	0.8	23-50/0.30'	SPT	
195								195
200								200

Rock Core

Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-30	201.6-202.3	0.7	49-50/0.20'	SPT	
205								205
210								210
215								215
220								220
		Very dense, light gray to brown and gray, wet, sand (fine grained).	SS-31	221.3-222.8	1.0	6-8-22	SPT	
225								225
230								230
235								235
240								240
			SS-32	241.0-241.2	0.0	50/0.25'	SPT	**No Recovery in SS-32 @ 240.95**
24.9	243.0							
245		Very dense, dark brown to light gray, wet, sand with with trace silt.						245
			SS-33	246.0-246.4	0.4	50/0.40'	SPT	
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								
260								**Borehole cave-in no sample collected. Advanced 5 ft for next interval @ 260.63 Ohio River Level on 8/11 at 12 am was 19.46 ft @ 265**
265			SS-34	265.6-265.9	0.3	50/0.30'	SPT	
270		Very dense, dark brown to light gray, wet, sand with with trace silt.						
275								
280			SS-35	280.3-280.7	0.4	50/0.40'	SPT	
285								
290 -22.1	290.0							
295		Very dense, dark gray, wet, silty sand.						
300								

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1017***	Immediate Water Depth ***NA***	Start Date ***08/07/2024***	Hole Type ***sample***
Surface Elevation ***267.9'***	Static Water Depth ***NA***	End Date ***08/11/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***301.3'***	Driller ***M. Holmes / J. Sandinra***	Latitude(83) ***36.996408***	
Location ***2057+75.00 10.0' Rt.***		Longitude(83) ***-89.147748***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
-33.4	301.3	Very dense, dark gray, wet, silty sand.	SS-36	300.0-301.3	1.3	40-40-50/0.30'	SPT	
		(Bottom of Hole 301.3') (No Refusal)						
		On 08/08/2024 Deck Elevation = 296.40 ft Deck to mudline = 28.5 ft Deck to water = 5.5 ft Water depth = 23.0 ft						
		5" Geobore-S casing extended from deck to borehole termination 6" casing 59.64 ft from deck on 08/09/2024						
		P-S Suspension Logging began on 08/11/2024						

305 310 315 320 325 330 335 340 345 350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
								Ohio River Level on 7/8 at 12 pm was 30.22 ft @ 1
			SS-1	2.6-4.1	0.5	3-4-5	SPT	
5		Loose, brown and gray, wet, sand.						5
			SS-2	8.4-9.9	0.0	3-5-5	SPT	
10 252.1	10.0							10
		Medium dense, dark gray, wet, gravel (fine to medium grained).	GT-1	13.3-13.3	0.0	3-5-6	ST	
15			SS-3	13.3-14.8	0.1		SPT	15
245.6	16.5							
		Loose, dark gray, wet, gravelly sand (fine to coarse grained).	ST-2	18.2-19.9	0.0		ST	
20			SS-4	19.9-21.4	1.5	4-4-4	SPT	20
240.1	22.0							
237.6	24.5	Loose, dark gray, wet, sand with silt (fine grained).	SS-5	23.2-24.7	0.7	0-2-6	SPT	
25			GT-3	24.8-24.8	0.0	9-7-7	ST	25
			SS-6	24.8-26.3	0.4		SPT	
		Medium dense, gray, wet, sandy gravel with silt.						
30			SS-7	28.5-30.0	1.0	11-10-5	SPT	30
230.6	31.5							
			SS-8	33.0-34.5	1.2	17-26-35	SPT	
35								35
			SS-9	37.9-39.4	1.1	13-14-20	SPT	
40		Dense, gray, wet, gravelly sand.						40
			SS-10	42.4-43.9	1.1	17-19-19	SPT	**Ohio River Level on 7/9 at 12 am was 30.6 ft @ 40**
45								45
			SS-11	47.8-49.3	1.2	14-22-27	SPT	
50								50

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
210.1	52.0	Dense, gray, wet, gravelly sand.						
			SS-12	52.7-54.2	1.5	7-8-10	SPT	
55		Medium dense, white, wet, sand with silt.	GT-4	54.2-56.2	0.0		ST	55
205.1	57.0							
			SS-13	57.6-59.1	1.5	3-5-10	SPT	
60		Stiff, white, wet, sandy clay with silt.						60
198.6	63.5		ST-5	62.5-64.5	2.0		ST	
65		Loose, white, wet, clayey sand (fine grained).						65
			ST-6	67.4-69.4	0.0		ST	
70			SS-14	69.5-71.0	1.5	0-1-6	SPT	70
190.6	71.5							
			SS-15	72.4-73.9	1.5	9-9-11	SPT	
75			ST-7	74.0-76.0	0.0		ST	75
			SS-16	77.3-78.8	1.5	9-14-15	SPT	
80		Medium dense, white, wet, clayey sand (fine grained).						80 **Ohio River Level on 7/9 at 12 pm was 31.03 ft @ 80**
			SS-17	82.2-83.7	1.5	9-10-20	SPT	
85								85
			SS-18	87.1-88.6	1.5	2-6-11	SPT	**with dark red, dark brown and tan seams below 88.4 ft @ 88.4**
90			ST-8	88.8-90.8	2.0		ST	90
170.6	91.5							
			SS-19	92.0-93.5	1.5	19-32-35	SPT	
95		Very dense, white, wet, clayey sand (fine grained).						95
			SS-20	97.0-98.4	1.3	7-34-50/0.40'	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-21	101.9-103.2	1.0	4-42-50/0.30'	SPT	
105								105
110								110
			SS-22	111.7-113.1	1.4	25-38-50/0.40'	SPT	
		Very dense, white, wet, clayey sand (fine grained).						
115								115
120								120
			SS-23	121.6-122.5	0.9	20-50/0.40'	SPT	
125								125
135.1	127.0							
130								130
			SS-24	131.5-132.5	1.0	20-50/0.50'	SPT	
135								135
		Very dense, white, wet, sand (medium to coarse grained).						
140								140
			SS-25	141.2-142.7	1.2	8-30-47	SPT	**Ohio River Level on 7/11 at 12 am was 31.22 ft @ 142**
145								145
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
110.6	151.5		SS-26	151.1-151.8	0.6	35-50/0.17'	SPT	**Lost drill mud circulation @ 152**
		Hard, white, moist, silty clay.	ST-9	152.6-154.6	0.0		ST	
104.6	157.5							
		Very dense, white, wet, sand (medium grained).	SS-27	160.9-161.4	0.5	50/0.50'	SPT	
96.1	166.0							
		Very dense, gray, wet, clayey sand (medium to coarse grained).	SS-28	170.3-171.8	1.3	24-40-48/0.50'	SPT	
			SS-29	180.6-181.4	0.8	22-50/0.30'	SPT	
76.1	186.0							**Drill bit chatter noticed on advacement @ 185**
		Very dense, light gray to brown, wet, sand (fine grained).	SS-30	190.4-191.1	0.7	45-50/0.20'	SPT	**Ohio River Level on 7/11 at 12 pm was 30.9 ft @ 190**

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden	SS-31	200.3-201.7	0.9	2-28-50/0.40'	SPT	
205		Very dense, light gray to brown, wet, sand (fine grained).						205
210 52.1	210.0							210
215								215
220			SS-32	220.0-220.9	0.6	0-50/0.40'	SPT	220
225								225
230		Very dense, gray to black, wet, sand with silt (fine grained).						230
235								235
240			SS-33	239.6-239.9	0.0	50/0.30'	SPT	240
245								245
250								250

Rock Core

Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager:

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255		Very dense, gray to black, wet, sand with silt (fine grained).						255
260			ST-10	259.3-261.3	0.0		ST	260
-0.7	262.8		SS-34	261.3-262.8	0.8	7-11-12	SPT	
265								265
270								270
275								275
280		Medium dense, light gray, wet, sand (fine grained).	ST-11	279.0-281.0	0.0		ST	280
			SS-35	282.4-283.9	1.5	6-9-16	SPT	
285								285
290								290
295								295
-33.9	296.0							
		Stiff, dark gray, wet, fat clay.						
300 -38.1	300.2		SS-36	298.7-300.2	1.5	0-7-11	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1018***	Immediate Water Depth ***NA***	Start Date ***07/08/2024***	Hole Type ***sample***
Surface Elevation ***262.1'***	Static Water Depth ***NA***	End Date ***07/12/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.2'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.996417***	
Location ***2057+75.00 10.0' Lt.***		Longitude(83) ***-89.147833***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
305		(Bottom of Hole 300.2') (No Refusal)						305
		On 07/09/2024 Deck Elevation = 306.27 ft						
310		On 07.08.2024 Deck to mudline = 40.2 ft Deck to water = 6.8 ft Water depth = 33.4 ft						310
315		7" Casing extended to 3.04 ft below mudline 5" Geobore-S extended to borehole termination depth						315
		On 07.09.2024 Additional 7" inch casing was advanced to 17.22 ft below mudline, total casing length of 62.92 ft (which includes 1.5 ft stickup above deck) Deck to mudline = 44.2 ft Deck to water = 9.7 ft Water depth = 34.5 ft						
320								320
325								325
330								330
335								335
340								340
345								345
350								350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
5		Very loose, brown, wet, sand.	SS-1	3.5-5.0	0.6	0-2-2	SPT	5
263.8	7.0							
10		Soft, dark gray, wet, silt with fine sand.	SS-2	8.5-10.0	0.5	0-1-3	SPT	10
259.3	11.5							
15		Loose, brown, wet, sand.	GT-1	13.5-15.5	0.0		ST	15
			SS-3	15.5-17.0	1.5	2-2-3	SPT	
252.8	18.0							
20			SS-4	18.5-20.0	1.5	3-1-1	SPT	20
		Very soft, dark gray, wet, clayey silt.						
25			GT-2	23.5-25.5	2.0		ST	25
244.8	26.0							
			GT-3	27.0-28.0	0.0		ST	**no recovery, tube bent @ 27**
			SS-5	28.0-29.5	0.9	2-2-8	SPT	
30								30
		Dark gray, wet, sand with gravel.						
			GT-4	33.5-34.5	0.0		ST	
35			SS-6	34.5-36.0	0.6	3-6-5	SPT	**with coarse gravel @ 34.5** 35
233.8	37.0							
40		Medium dense, dark gray, wet, sand (some silt).	SS-7	38.5-40.0	1.3	6-5-6	SPT	40
228.8	42.0							
45		Medium dense, gray, wet, sand.	SS-8	43.5-45.0	0.6	13-13-14	SPT	**with gravel @ 43.5** 45
222.3	48.5							
50		Medium dense, gray, wet, sand with some silt.	GT-5	48.5-50.0	0.0		ST	**tube crushed, 2** 50

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
218.3	52.5	Medium dense, gray, wet, sand with some silt.	SS-9	50.0-51.5	1.4	4-10-16	SPT	**golf ball sized cobbles in tube @ 48.5**
55		Medium dense, gray, wet, sand (coarse).	SS-10	53.5-55.0	1.0	15-17-16	SPT	55
214.3	56.5							
60		Stiff, light gray, wet, sandy silt.	SS-11	58.5-60.0	1.5	8-7-9	SPT	60
209.3	61.5							
65		Medium dense, wet, sand.	GT-6	63.0-65.0	0.0		ST	65
			SS-12	65.0-66.5	1.5	7-10-15	SPT	
203.3	67.5							
70		Stiff, gray, wet, fat clay.	SS-13	68.5-70.0	1.5	6-7-10	SPT	70
75			ST-7	73.5-75.5	2.0		ST	75
80			ST-8	78.5-80.5	1.3		ST	80
188.8	82.0							
85		Dense, gray, wet, clayey sand.	SS-14	83.5-85.0	1.5	13-15-20	SPT	85
183.8	87.0							
90		Wet, sandy clay.	ST-9	88.5-90.5	2.0		ST	90
95			ST-10	93.5-95.5	2.0		ST	**tube bent @ 93.5** 95
173.8	97.0							
100		Very dense, light gray, wet, sand (trace silt).	SS-15	98.5-100.0	1.5	23-17-25	SPT	100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
105								105
110		Very dense, light gray, wet, sand (trace silt).	SS-16	108.5-108.9	0.4	50/0.40'	SPT	110
115								115
120			SS-17	118.5-119.2	0.7	40-50/0.20'	SPT	120
146.8	124.0							
125								125
130			SS-18	128.5-130.0	1.3	17-42-48/0.50'	SPT	130
135		Very dense, gray, wet, sand (medium to coarse grained).						135
140			SS-19	138.5-140.0	0.7	14-25-30	SPT	140
126.8	144.0							
145		Very dense, tan and brown, wet, sand (coarse grained).						145
150			SS-20	148.5-149.2	0.7	22-50/0.20'	SPT	150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
155		Very dense, tan and brown, wet, sand (coarse grained).						155
160			SS-21	158.5-160.0	0.1	5-6-7	SPT	160
106.8	164.0							
165								165
170			SS-22	168.5-169.3	0.8	23-50/0.30'	SPT	170
175		Very dense, white and light gray, wet, sand with gravel.						175
180			SS-23	178.5-179.3	0.8	34-50/0.30'	SPT	180
86.8	184.0							
185								185
190		Medium dense, gray, wet, sand with clay (coarse grained).	SS-24	188.5-190.0	1.2	7-8-19	SPT	190
76.8	194.0							
195		Dense, light gray to white, wet, sand (medium grained).						195
200			SS-25	198.5-200.0	1.5	3-13-26	SPT	200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
205		Dense, light gray to white, wet, sand (medium grained).						205
210 60.8	210.0							210
215								215
220		Very dense, brown, wet, sand (fine grained).	SS-26	218.5-220.0	1.5	45-43-45/0.50'	SPT	220
225								225
230 40.8	230.0							230
235								235
240		Medium stiff, dark gray, wet, silty clay (trace organics).	SS-27	239.5-241.0	1.5	0-4-9	SPT	240
			GT-11	241.0-241.1	0.0		ST	**attempted Gus Sampler, no penetration @ 240 pushed Shelby tube @ 241**
			ST-12	241.1-243.1	2.0		ST	
245								245
250 20.8	250.0							250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255		Gray, sand.						
260 10.3	260.5		ST-13	259.5-261.5	2.0		ST	
265								
270		Soft to stiff, greenish gray, wet, silty clay.						
275								
280			SS-28	279.5-281.0	1.5	0-0-0	SPT	
-13.2	284.0		SS-29	282.5-284.0	0.0	0-8-11	SPT	**SPT attempted from 281.5 to 282.5, spoon appeared to be overcompacted during sampling, 27, 29, 26 results likely impacted @ 281**
285		(Bottom of Hole 284.0') (No Refusal)						
290		Deck Elevation = 295.8 ft Deck to mudline = 25.0 ft Deck to water = 6.3 ft Water depth = 18.7 ft						
295		5" Geobore-S casing extended from deck to borehole termination						
300		Approximately 3 (m) 10 ft of drill casing and bit remain near bottom of hole. Drillers estimate at/near a depth of 240 ft						

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1020***	Immediate Water Depth ***NA***	Start Date ***06/29/2024***	Hole Type ***sample***
Surface Elevation ***270.8'***	Static Water Depth ***NA***	End Date ***07/03/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***284.0'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997169***	
Location ***2061+25.00 10.0' Rt.***		Longitude(83) ***-89.146989***	

Lithology Elevation	Lithology Depth	Description	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
		Overburden						
		Rock Core						
305		below mudline.						305
310								310
315								315
320								320
325								325
330								330
335								335
340								340
345								345
350								350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024*** Item Number: ***01-1140.00***	***Ballard - US-51 MP 7.3-8.3*** ***Ohio River***	Project Type: ***Structure State Bridge*** Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
			GT-1	3.0-5.0	0.0		ST	**Ohio River Level on 8/03 at 5 am was 25.09 ft @ 3**
		Loose to very loose, dark gray, wet, sand.	GT-2	7.9-9.9	2.0		ST	
			SS-1	12.8-14.3	1.0	3-1-6	SPT	
252.9	16.0							
		Very soft, dark gray, wet, sandy silt.	SS-2	17.8-19.3	1.5	1-1-3	SPT	
247.9	21.0							
		Dark gray, wet, silty clay.	GT-3	22.7-24.7	2.0		ST	
242.9	26.0							
			SS-3	27.6-29.1	1.1	12-13-17	SPT	
								Ohio River Level on 8/03 at 12 pm was 24.79 ft @ 30
		Medium dense to dense, dark gray to gray, wet, sand (with gravel below 32.5 ft and silt sand seams below 37.4 ft).	SS-4	32.5-34.0	1.0	8-9-10	SPT	
			SS-5	37.4-38.9	1.0	11-11-13	SPT	
227.9	41.0							
		Very dense, dark gray, wet, silty sand.	SS-6	42.4-43.9	1.5	16-23-30	SPT	
222.9	46.0							
221.1	47.8	Medium stiff, dark gray, wet, sandy clay (with wood).						
		Dense to very dense, dark gray, wet, sand (coarse grained, with gravel below 52.2 ft).	SS-7	47.3-48.8	1.5	7-10-12	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
				Std/Ky RQD				
55 213.4	55.5	Dense to very dense, dark gray, wet, sand (coarse grained, with gravel below 52.2 ft).	SS-8	52.2-53.7	0.9	17-19-25	SPT	
60 208.4	60.5	Dense, gray, wet, gravelly sand.	SS-9	57.1-58.6	0.9	13-18-21	SPT	
65 203.4	65.5	Very dense, gray and brown, wet, sandy gravel.	SS-10	62.0-63.5	1.2	38-40-26/0.50'	SPT	
70 198.4	70.5	Loose, light gray, wet, sand.	SS-11	67.0-68.5	0.6	1-2-4	SPT	
75 193.4	75.5	Stiff, light gray, wet, clay.	SS-12	71.9-73.4	1.1	1-4-8	SPT	
80		Loose to very dense, light gray, wet, clayey sand.	SS-13	76.8-78.3	1.4	13-18-16	SPT	
85			SS-14	81.7-83.2	1.3	3-7-13	SPT	
90			SS-15	86.6-88.1	1.4	2-1-5	SPT	**Ohio River Level on 8/04 at 12 am was 24.56 ft @ 90**
95			SS-16	91.6-93.1	1.3	6-16-25	SPT	
100			SS-17	96.5-98.0	0.8	11-26-40	SPT	

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			SS-18	101.4-102.9	0.5	12-13-16	SPT	
105								105
110								110
			SS-19	111.2-112.2	0.9	45-50/0.42'	SPT	
		Loose to very dense, light gray, wet, clayey sand.						
115								115
120								120
			SS-20	121.1-122.5	0.9	26-47-50/0.42	SPT	
125								125
141.9	127.0							
130								130
			SS-21	130.9-131.9	0.9	17-50/0.50'	SPT	
135								135
		Very dense, light gray and tan, wet, sand with trace clay (coarse grained).						
140								140
			SS-22	140.8-141.7	0.7	42-50/0.40'	SPT	
145								145
150								150

Rock Core

Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-23	150.6-151.5	0.9	26-50/0.40'	SPT	
155		Very dense, light gray and tan, wet, sand with trace clay (coarse grained).						155
112.9	156.0							
160								160
			SS-24	160.4-160.7	0.3	50/0.30'	SPT	
165		Very dense, very light gray, wet, sand (fine grained).						165
								Ohio River Level on 8/04 at 12 pm was 23.52 ft @ 165
170								170
			SS-25	170.3-170.7	0.4	50/0.40'	SPT	
175								175
92.9	176.0							
180		Very dense, light gray, wet, sand with trace gravel (coarse grained).						180
			SS-26	180.1-180.6	0.5	50/0.50'	SPT	
185								185
82.9	186.0							
190								190
			SS-27	190.0-190.8	0.8	45-50/0.30'	SPT	
195		Medium dense to very dense, light gray, wet, sand with trace silt (medium grained).						195
200								200

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
			SS-28	199.8-201.3	0.4	6-8-13	SPT	
205		Medium dense to very dense, light gray, wet, sand with trace silt (medium grained).						205
210								210
57.9	211.0							
215								215
		Very dense, brown, wet, sand.						
220			SS-29	219.5-220.4	0.3	26-50/0.46'	SPT	220
225								225
42.9	226.0							**hard drilling @ 226**
230								230
235								235
		Hard, gray, wet, clay.						
240			SS-30	239.2-240.7	0.8	12-18-25	SPT	240
								Ohio River Level on 8/05 at 12 am was 23.47 ft @ 240
245								245
250								250

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
255								255
260		Hard, gray, wet, clay.	SS-31	258.8-260.3	0.6	11-9-22	SPT	260
265			ST-4	264.1-265.7	1.6		ST	265 **Ohio River Level on 8/05 at 12 pm was 23.45 ft @ 265**
270								270
-3.1	272.0							
275								275
280			SS-32	278.9-280.4	1.5	0-10-14	SPT	280
285		Very stiff to hard, brown and gray, wet, silty lean clay.						285
290								290
295								295
300-31.2	300.1		SS-33	298.6-300.1	1.5	6-21-35	SPT	300

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1021***	Immediate Water Depth ***NA***	Start Date ***08/02/2024***	Hole Type ***sample***
Surface Elevation ***268.9'***	Static Water Depth ***NA***	End Date ***08/05/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***300.1'***	Driller ***M. Holmes / J. Herrera***	Latitude(83) ***36.997177***	
Location ***2061+25.00 10.0' Lt.***		Longitude(83) ***-89.147065***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
								Ohio River Level on 8/06 at 12 am was 23.72 ft @ 300
305		(Bottom of Hole 300.1') (No Refusal)						305
		On 08/02/2024 Deck Elevation = 297.16 ft Deck to mudline = 28.3 ft Deck to water = 5.6 ft Water depth = 22.7 ft						
310		5" Geobore-S casing extended from deck to borehole termination 6" casing 53.3 ft from deck on 08/03/2024 6" Casing to 85 ft from deck on 08/03/2024 - second shift						310
315		P-S Suspension Logging 08/06/2024						315
320								320
325								325
330								330
335								335
340								340
345								345
350								350

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1023***	Immediate Water Depth ***NA***	Start Date ***07/04/2024***	Hole Type ***sample***
Surface Elevation ***272.7'***	Static Water Depth ***NA***	End Date ***07/06/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***157.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997509***	
Location ***2062+72.00 10.0' Lt.***		Longitude(83) ***-89.146716***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
				Std/Ky RQD				
		Gray, wet, clayey silt.						**Ohio River Level on 7/4 at 12 pm was 24.17 ft @ 1**
5			ST-1	3.8-5.8	2.0		ST	5
265.7	7.0							
		Soft, gray and brown, wet, sandy silt.	SS-1	8.4-9.9	0.7	0-1-1	SPT	
10								10
261.2	11.5							
		Loose, gray and brown, wet, sand with clay (fine to medium grained).	SS-2	12.4-13.9	1.1	2-2-3	SPT	
15								15
256.7	16.0							
		Loose, brown and gray, wet, sand with trace silt (medium to coarse grained).	SS-3	17.3-18.8	0.9	4-4-5	SPT	
20								20
252.2	20.5							
		Loose to medium dense, brownish gray, wet, sand with trace silt and gravel (fine to medium grained).	SS-4	22.3-23.8	1.0	4-4-5	SPT	
25								25
			SS-5	27.2-28.7	0.7	4-5-4	SPT	**Ohio River Leval on 7/4 at 9 pm was 24.55 ft @ 27**
30								30
			SS-6	32.9-34.4	1.1	2-4-9	SPT	
35								35
237.2	35.5							
		Medium dense, wet, gravel (medium grained).	SS-7	37.0-38.5	0.1	8-12-14	SPT	
40								40
232.2	40.5							
		Dense, wet, sand with gravel (fine grained).	SS-8	41.9-43.4	1.1	10-15-15	SPT	
45								45
225.2	47.6		SS-9	46.6-48.1	1.5	6-7-7	SPT	
		Gray, wet, clay.	ST-2	48.1-50.1	2.0		ST	
50								50

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1023***	Immediate Water Depth ***NA***	Start Date ***07/04/2024***	Hole Type ***sample***
Surface Elevation ***272.7'***	Static Water Depth ***NA***	End Date ***07/06/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***157.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997509***	
Location ***2062+72.00 10.0' Lt.***		Longitude(83) ***-89.146716***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No.	Depth (ft) Run (ft)	Rec. (ft) Rec (ft)	SPT Blows Rec (%)	Sample Type SDI (JS)	Remarks
			Std/Ky RQD					
								Ohio River Level on 7/5 at 3 am was 24.95 ft @ 51
		Gray, wet, clay.	ST-3	51.4-53.4	0.0		ST	
55			ST-4	53.7-55.7	0.7		ST	55
216.2	56.5							
			SS-10	57.8-59.3	1.5	2-2-3	SPT	
60								60
		Soft to stiff, light brown, wet, sandy silt with with some clay.	ST-5	62.7-64.7	0.0		ST	
65			SS-11	64.7-66.2	1.5	5-8-13	SPT	65
			SS-12	67.6-69.1	1.5	4-4-7	SPT	
70								70
201.7	71.0							
		Medium dense, light brown and white, wet, sand with some silt (fine grained).	SS-13	72.6-74.1	1.5	3-3-6	SPT	
75								75
196.7	76.0							
			ST-6	77.5-78.7	1.2		ST	
80			SS-14	78.7-80.2	1.5	11-10-14	SPT	80
		Medium dense, light gray, wet, silty sand.	SS-15	82.4-83.9	1.5	9-12-19	SPT	
85								85
			SS-16	87.3-88.8	1.5	6-11-16	SPT	
90								90
182.2	90.5							
			ST-7	92.2-92.3	0.0	18-47-40/0.50	ST	
			SS-17	92.3-93.8	1.5		SPT	
95		Very dense, light gray, wet, silty sand (coarse grained).						95
			SS-18	97.2-98.7	1.3	12-21-35	SPT	**Ohio River Level on 7/5 at 12 pm was 26.04 ft @ 97**
100								100

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1023***	Immediate Water Depth ***NA***	Start Date ***07/04/2024***	Hole Type ***sample***
Surface Elevation ***272.7'***	Static Water Depth ***NA***	End Date ***07/06/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***157.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997509***	
Location ***2062+72.00 10.0' Lt.***		Longitude(83) ***-89.146716***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
105		Very dense, light gray, wet, silty sand (coarse grained).						105
			SS-19	107.0-108.5	1.5	13-25-23	SPT	
110								110
160.2	112.5							
115								115
			SS-20	116.8-117.2	0.3	50/0.33'	SPT	
120								120
125								125
			SS-21	126.7-127.9	0.6	17-38-50/0.20'	SPT	
130		Very dense, tan and brown, wet, sand (coarse).						130
135								135
			SS-22	136.5-137.3	0.8	26-50/0.30'	SPT	
140								140
145								145
			SS-23	146.4-147.9	1.5	8-20-39	SPT	
150								150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1023***	Immediate Water Depth ***NA***	Start Date ***07/04/2024***	Hole Type ***sample***
Surface Elevation ***272.7'***	Static Water Depth ***NA***	End Date ***07/06/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***157.5'***	Driller ***J. Sandin / J. Herrera***	Latitude(83) ***36.997509***	
Location ***2062+72.00 10.0' Lt.***		Longitude(83) ***-89.146716***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
155		Very dense, tan and brown, wet, sand (coarse).						155
115.2	157.5		SS-24	156.2-157.5	1.3	21-32-50/0.33'	SPT	**Ohio River Level on 7/6 at 4 pm was 29.06 ft @ 156**
160		(Bottom of Hole 157.5') (No Refusal) On 7/4/2024 Deck Elevation = 295.32 ft Deck to mudline = 22.6 ft Deck to water = 5.3 ft 7" Casing extended to 3.5 ft below mudline 5" Geobore-S casing extned to borehole termination depth On 7/6/2024 New depth to mudline 33.8 ft New depth to water = 7.3 ft Approximately 2.5 m (8.4 ft) of Geobore drill stem lost downhole. Drillers estimate at/near a depth of 150 ft below mudline.						160
165								165
170								170
175								175
180								180
185								185
190								190
195								195
200								200

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sample***
Surface Elevation ***231.7'***	Static Water Depth ***NA***	End Date ***09/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***152.8'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992907***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151384***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
5		Medium dense, gray, wet, sand with with fine gravel (fined grained).	SS-1	3.8-5.3	0.5	4-6-7	SPT	5
10			SS-2	8.7-10.2	0.8	3-7-9	SPT	10
219.7	12.0							
		Medium dense, gray, wet, sand (fine to coarse grained).						
15			SS-3	13.6-15.1	1.0	4-7-15	SPT	15
214.7	17.0							
		Dense, gray, wet, sand (fine grained).						
20			SS-4	18.5-20.0	1.2	7-14-24	SPT	20
209.7	22.0							
		Dense, gray, wet, sand with with fine gravel.						
25			SS-5	23.5-25.0	0.9	27-48-17	SPT	25
204.7	27.0							
30			SS-6	28.4-29.9	1.4	3-4-5	SPT	30
35			SS-7	33.3-34.8	0.7	2-4-5	SPT	35
			GT-1	34.9-36.9	1.8		ST	
		Soft to stiff, white to light gray, wet, sandy silt.						
40			SS-8	38.2-39.7	1.5	3-4-6	SPT	40
45			SS-9	43.1-44.6	1.5	7-10-17	SPT	45
50			SS-10	48.1-49.6	1.4	12-12-25	SPT	50

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sample***
Surface Elevation ***231.7'***	Static Water Depth ***NA***	End Date ***09/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***152.8'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992907***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151384***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
179.7	52.0	Soft to stiff, white to light gray, wet, sandy silt.						
		Dense, light gray to light brown, wet, sand (fine grained).	SS-11	53.0-54.5	1.5	11-11-21	SPT	
55								55
174.7	57.0							
		Very stiff to hard, light gray, wet, interbedded fat clay and sand (fine grained).	SS-12	57.9-59.4	1.4	6-19-24	SPT	
60								60
			SS-13	62.8-64.3	1.4	4-12-28	SPT	
65								65
			SS-14	67.7-69.0	1.3	20-40-50/0.30'	SPT	
70								70
160.7	71.0							
		Very dense, white, wet, sand (fine grained).	SS-15	72.7-74.2	0.9	14-36-42	SPT	
75								75
155.7	76.0							
		Very dense, light gray, wet, sand (fine grained).	SS-16	77.6-79.1	1.1	5-29-50/0.50'	SPT	
80								80
			SS-17	82.5-84.0	0.8	8-27-39	SPT	
85								85
145.7	86.0							
		Very dense, light gray, wet, sand (fine grained).	SS-18	87.4-88.3	0.9	26-50/0.40'	SPT	
90								90
			SS-19	92.3-93.1	0.8	30-50/0.30'	SPT	
95								95
135.7	96.0							
		Very dense, light gray, wet, sand (fine grained).	SS-20	97.3-98.7	1.2	11-30-50/0.40'	SPT	
100								100

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sample***
Surface Elevation ***231.7'***	Static Water Depth ***NA***	End Date ***09/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***152.8'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992907***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151384***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			SS-21	102.2-103.7	0.8	8-27-30	SPT	
105		Very dense, light gray, wet, sand (fine grained).						105
			GT-2	107.1-109.1	0.0		ST	
110								110
120.7	111.0							
		Rock Core	Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
			SS-22	112.0-112.9	0.8	10-50/0.40'	SPT	
115								115
120								120
			SS-23	121.9-123.4	0.7	1-5-14	SPT	
125								125
		Very dense, light gray, wet, sand with trace silt (fine to coarse grained).	GT-3	126.8-128.8	0.0		ST	
130								130
			SS-24	131.7-133.1	1.0	12-42-50/0.40'	SPT	
135								135
140								140
			SS-25	141.5-142.2	0.7	24-50/0.20'	SPT	
145								145
85.7	146.0							
150		Very dense, light gray, wet, sand (fine grained).						150

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sample***
Surface Elevation ***231.7'***	Static Water Depth ***NA***	End Date ***09/16/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***152.8'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992907***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151384***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
78.9	152.8	Very dense, light gray, wet, sand (fine grained).	SS-26	151.4-152.8	1.0	6-34-50/0.40'	SPT	
155		(Bottom of Hole 152.8') (No Refusal) On 9/15/2024 Deck Elevation = 284.20 ft Deck to mudline = 52.5 ft Deck to water = 6.3 ft Water depth = 46.2 ft 6" Casing extended to 90.54 ft below deck 5" Geobore-S casing extended to borehole termination depth						155
160								160
165								165
170								170
175								175
180								180
185								185
190								190
195								195
200								200

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Printed: 9/1/25

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024-A***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sounding***
Surface Elevation ***'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***50.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992800***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151437***	

Lithology Elevation	Lithology Depth	Description	Sample No.	Depth (ft)	Rec. (ft)	SPT Blows	Sample Type	Remarks
		Overburden						
			Std/Ky RQD	Run (ft)	Rec (ft)	Rec (%)	SDI (JS)	
		Lift boat Deck.						
5	5.0							5
		Water.						
10								10
15								15
20								20
25								25
30								30
35								35
40								40
45								45
50	50.0							50

Drilling Firm: Terracon
For: Division of Structural Design
Geotechnical Branch

DRILLER'S SUBSURFACE LOG

Project ID: ***S-033-2024***	***Ballard - US-51 MP 7.3-8.3***	Project Type: ***Structure State Bridge***
Item Number: ***01-1140.00***	***Ohio River***	Project Manager: -

Hole Number ***B-1024-A***	Immediate Water Depth ***NA***	Start Date ***09/15/2024***	Hole Type ***sounding***
Surface Elevation ***'***	Static Water Depth ***NA***	End Date ***09/15/2024***	Rig_Number ***CME 75 / 205497***
Total Depth ***50.0'***	Driller ***J. Sandin / M. Holmes***	Latitude(83) ***36.992800***	
Location ***2040+75.00 10.0' Rt.***		Longitude(83) ***-89.151437***	

Lithology Elevation	Lithology Depth	Description (Overburden / Rock Core)	Sample No. / Std/Ky RQD	Depth (ft) / Run (ft)	Rec. (ft) / Rec (ft)	SPT Blows / Rec (%)	Sample Type / SDI (JS)	Remarks
55		(Bottom of Hole 50.0') (No Refusal) On 9/15/2024 Deck to mudline = 52.5 ft 6" Casing extended to mudline - Encountered concrete debris - Boring Off-set to new location						55
60								60
65								65
70								70
75								75
80								80
85								85
90								90
95								95
100								100

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

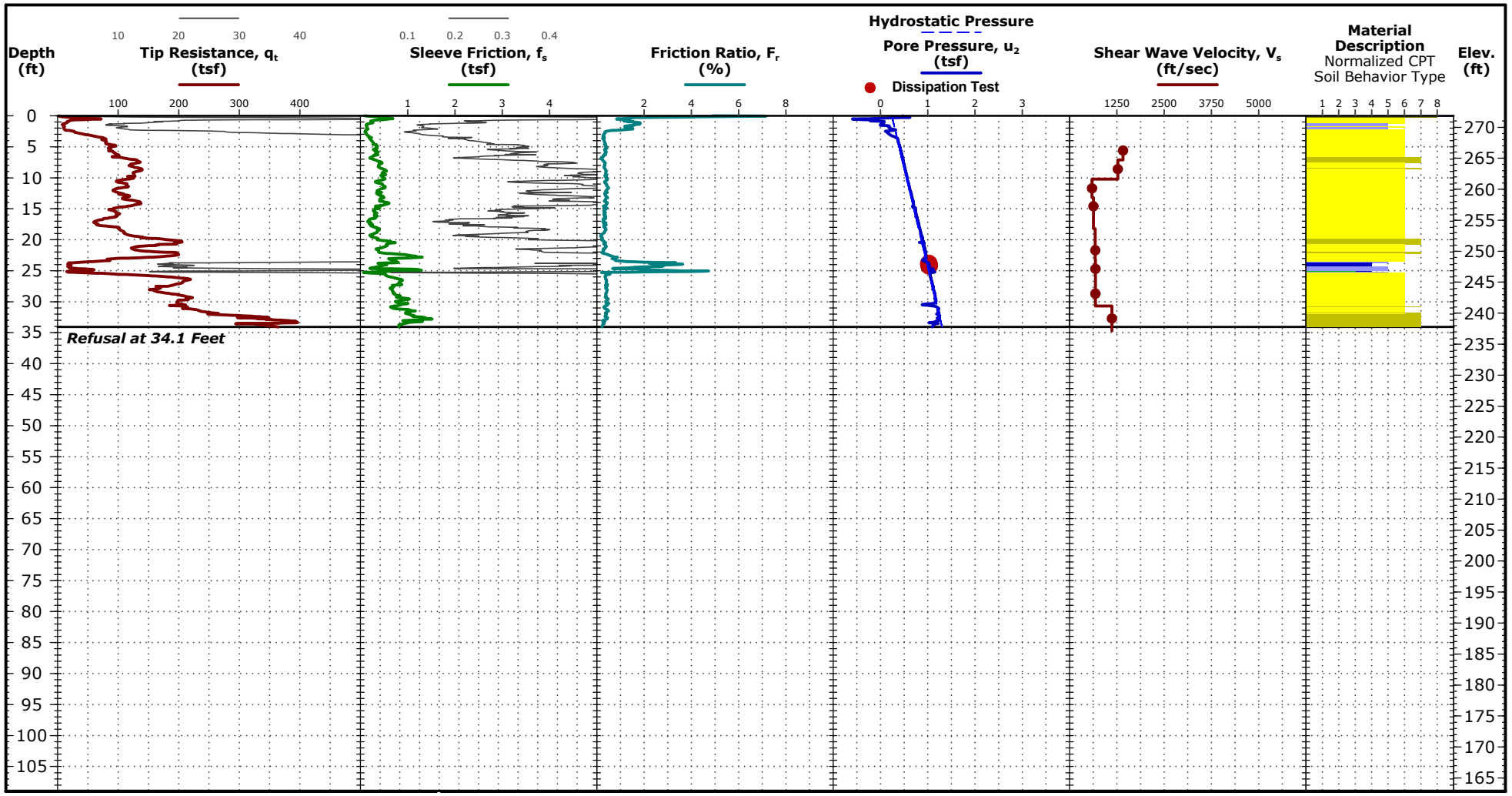
CPT Sounding ID C1003

Latitude: 36.992432° Longitude: -89.151877°
North: 3538936.38 East: 3927890.32
Station: 2038+90 Offset: 4 ft Lft

Elevation: 271.85 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 9/19/2024
CPT Completed: 9/19/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to mudline = 13.5 ft
Deck to Water = 5.83 ft
Tip refused on wood, switched to NWJ drilled out to 38 ft
Completed drillout with AOH Casing
Water level dropped below safe working conditions of liftboat. Moved off location, after remnant cable and rope wrapped around prop removed

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3620 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-7.67 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

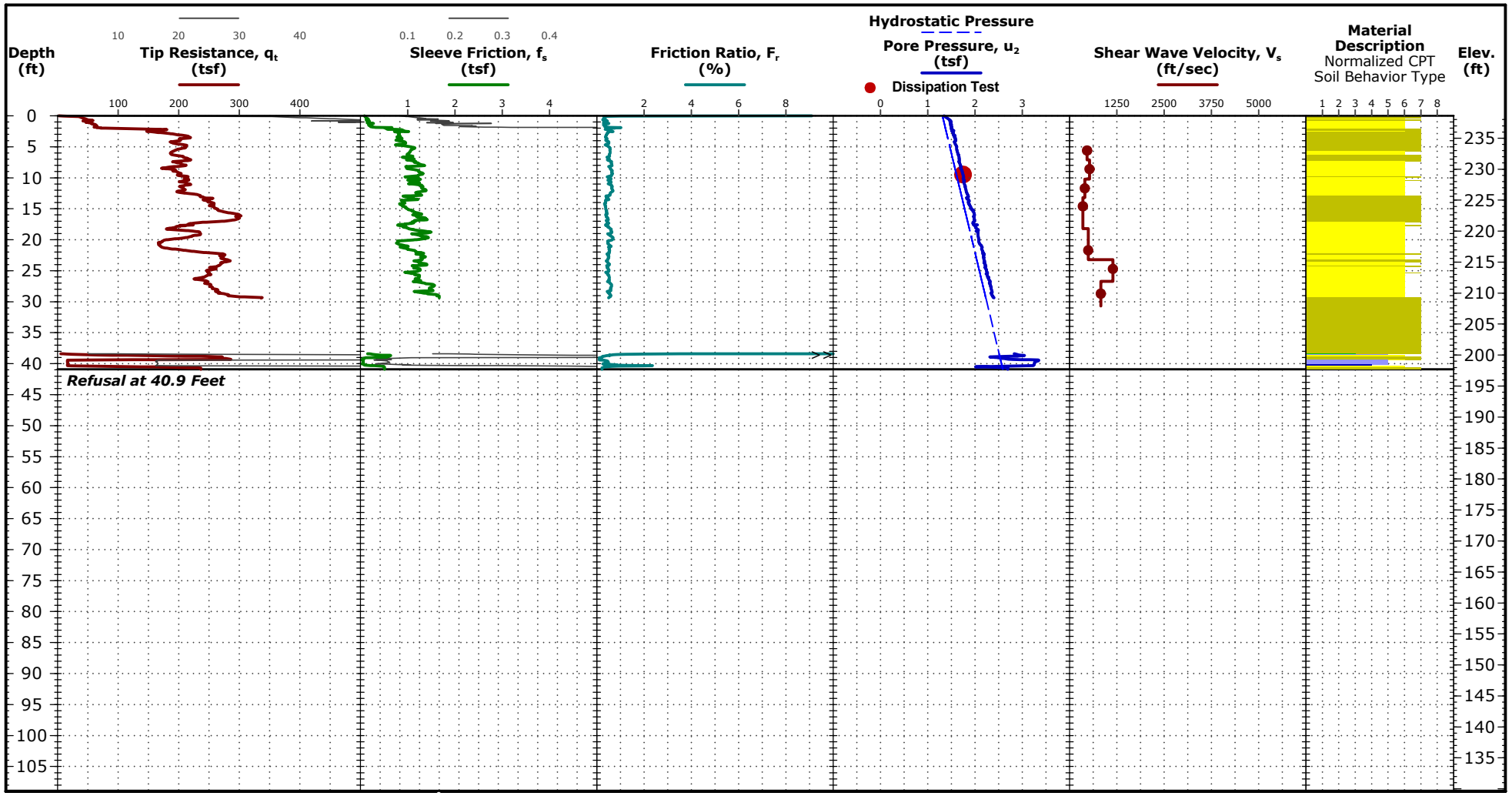
CPT Sounding ID C1006

Latitude: 36.993135° Longitude: -89.151142°
North: 3539184.35 East: 3928114.2
Station: 2042+24 Offset: CL

Elevation: 238.61 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 9/25/2024
CPT Completed: 9/25/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 49.6 ft
Deck to Water = 7.6 ft
Tip at 340 tsf drill
Tip refusal at 310 tsf with excessive rod inclination

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3619 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-42 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

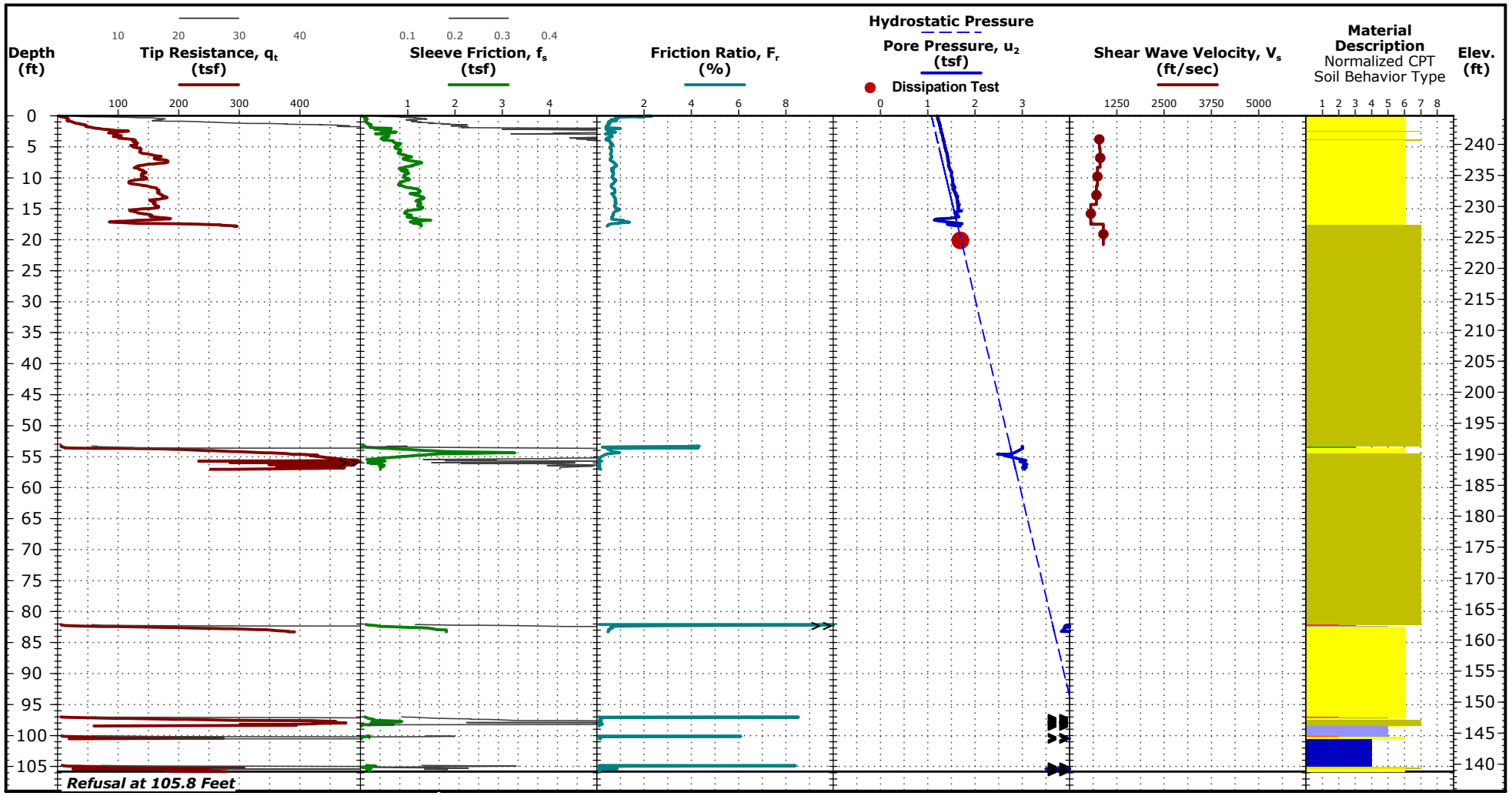
CPT Sounding ID C1010

Latitude: 36.993736° Longitude: -89.150532°
North: 3539403.53 East: 3928308.03
Station: 2045+17 Offset: CL

Elevation: 244.61 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 10/14/2024
CPT Completed: 10/14/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

Deck to Mudline = 40.2 ft

Deck to Water = 5.7 ft

Refusal at 325 tsf and sleeve at 2 tsf

Hydraulic push stopped (operator discretion) due to excessive bend in rods

CPT Equipment

CPT Rig:

Operator: Fugro

CPT sensor calibration reports available upon request

Probe No. 1701-3619 with net area ratio of 0.59

Manufactured by Fugro- Calibrated 4/15/2024

Tip and sleeve areas of 15 cm^2 and 225 cm^2

No friction reducer

Water Level Observation

-34.5 ft estimated water depth

(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

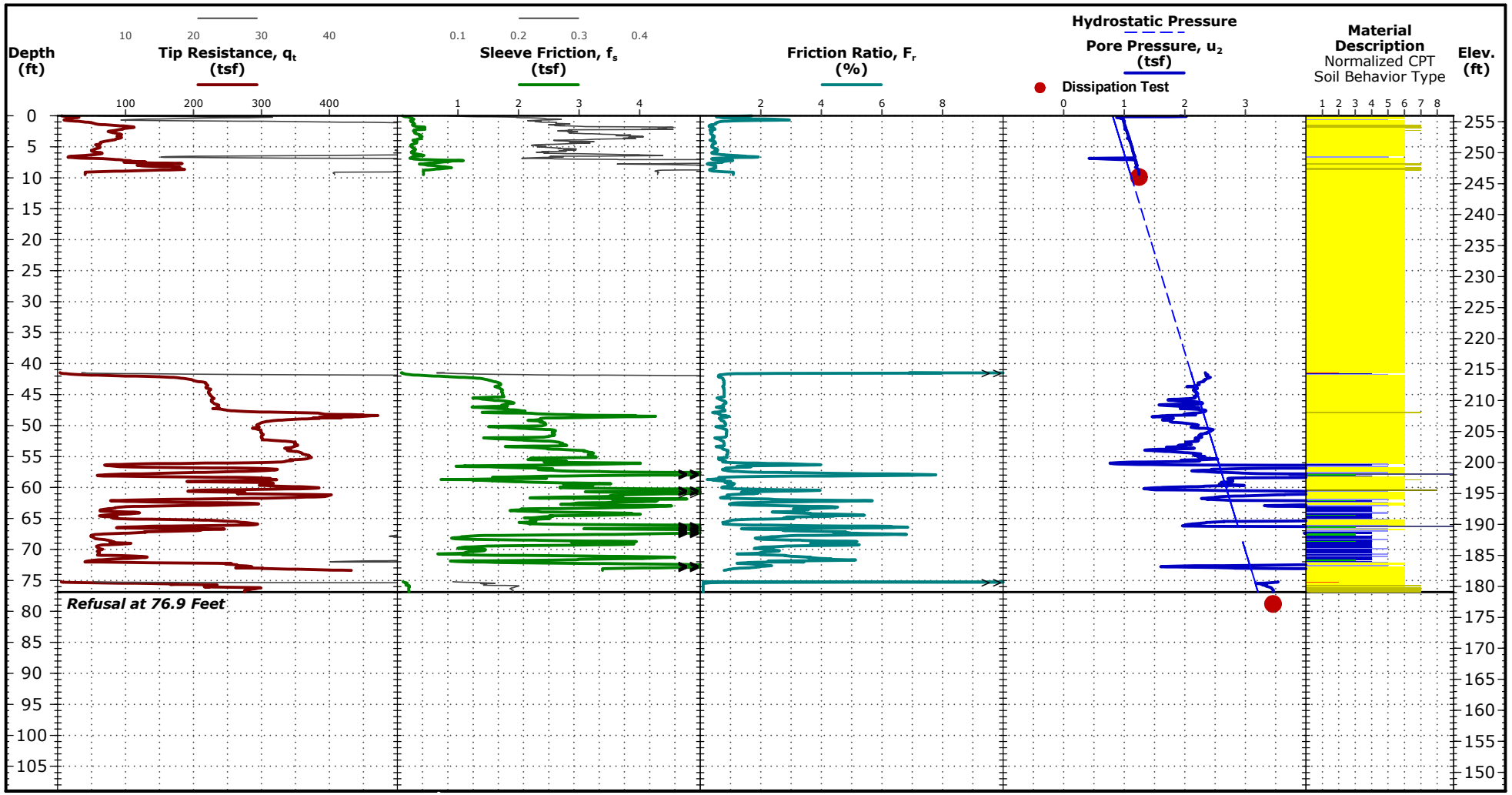
CPT Sounding ID C1015

Elevation: 255.96 (ft)

Latitude: 36.995649° Longitude: -89.148572°
North: 3540078.73 East: 3928905.53
Station: 2054+18 Offset: 1 ft Rt

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 10/10/2024
CPT Completed: 10/10/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 32.4 ft
Deck to Water = 6.5 ft
Refusal due to excessive tilt of 3.7 degrees
Refusal excessive tip at 440 tsf and inclination of 2.8 degrees

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3619 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-25.9 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

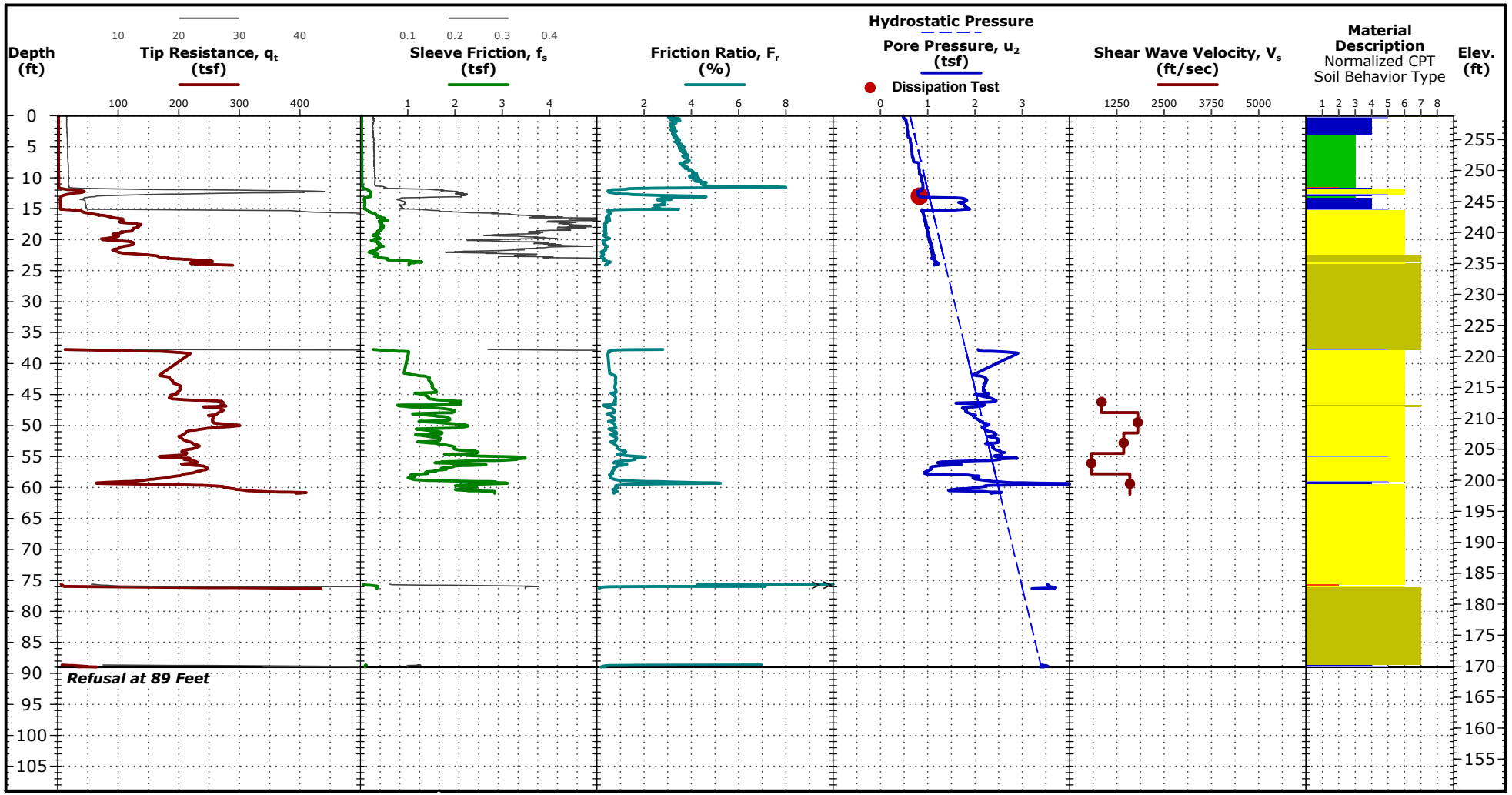
CPT Sounding ID C1016

Terracon
5111 Commerce Crossing Drive, Suite 120
Louisville, KY

Elevation: 258.84 (ft)

Latitude: 36.995809° Longitude: -89.148419°
North: 3540128.36 East: 3928944.3
Station: 2054+81 Offset: 3 ft Lft

CPT Started: 9/23/2024
CPT Completed: 9/23/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 25.1 ft
Deck to Water = 5.1 ft
Refusal due to sudden increase in rod inclination
Refusal at 371 tsf and with high increase in tip load
Refusal at 400 tsf and sleeve at 2 tsf

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3619 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-20 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

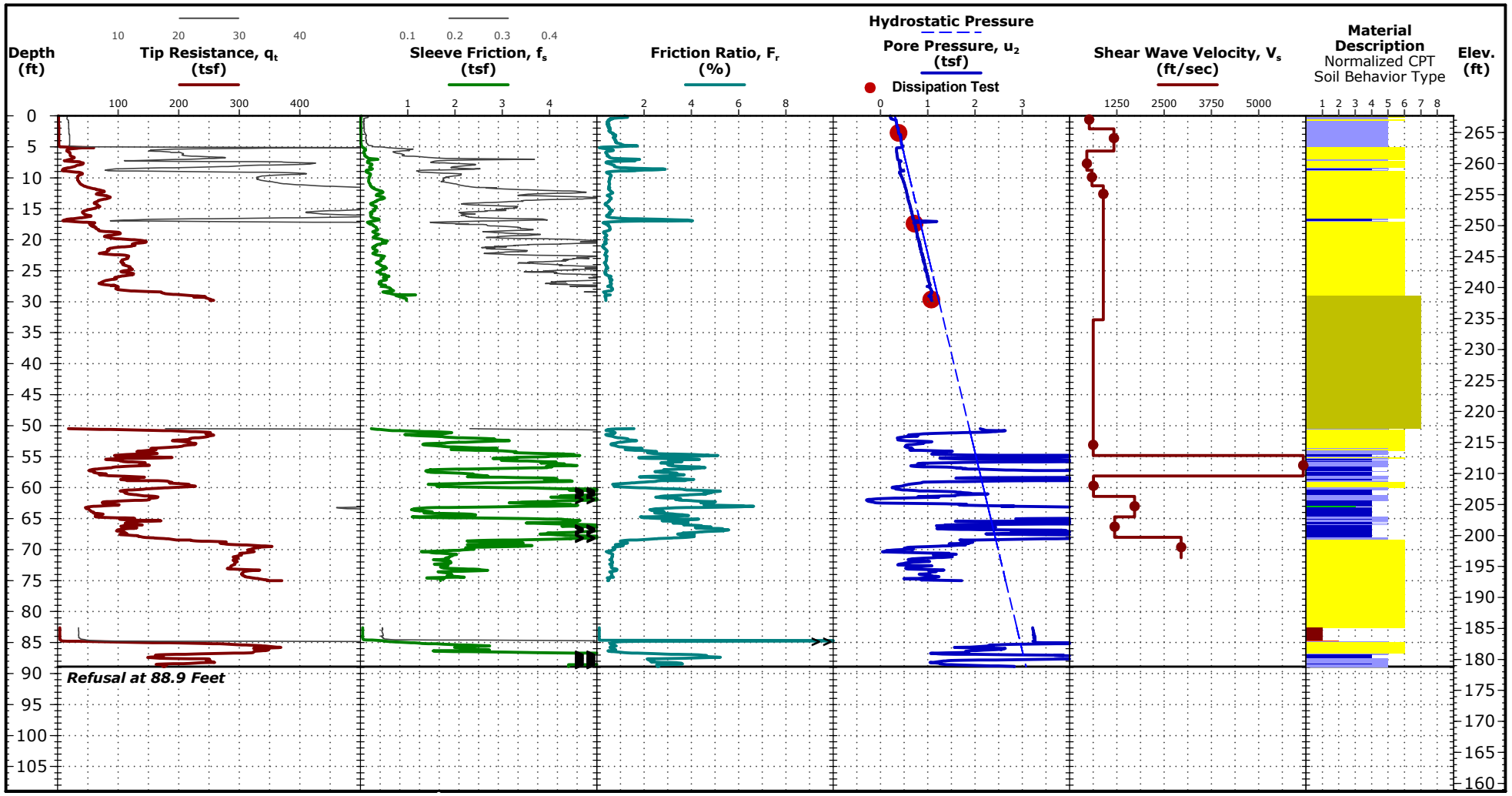
CPT Sounding ID C1019

Latitude: 36.996428° Longitude: -89.147777°
North: 3540346.67 East: 3929139.95
Station: 2057+74 Offset: CL

Elevation: 267.72 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 9/21/2024
CPT Completed: 9/21/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 13.5 ft
Deck to Water = 3.75 ft
Tip refusal at 381 tsf
Tip refusal at 400 tsf
Refusal due to excessive rod inclination.

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3620 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-9.75 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

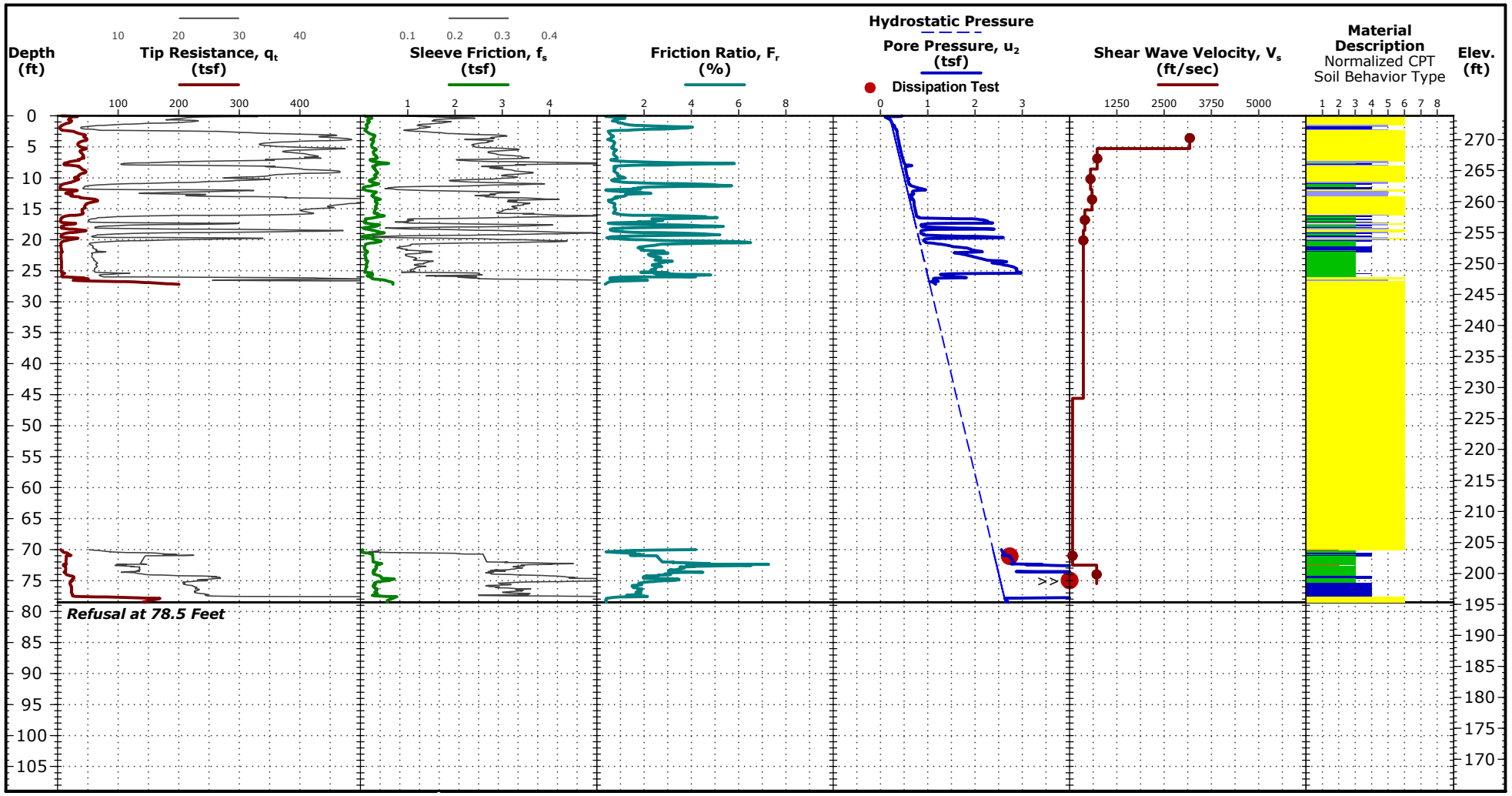
CPT Sounding ID C1022

Latitude: 36.997174° Longitude: -89.147019°
North: 3540610.06 East: 3929371.04
Station: 2061+25 Offset: 1 ft Lft

Elevation: 273.84 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 9/24/2024
CPT Completed: 9/24/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 13.7 ft
Deck to Water = 7.5 ft
Refusal due to 4 degree slope and 267 tsf
Push stopped due to loss of soft zones and loss of lateral support

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3619 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-6.2 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

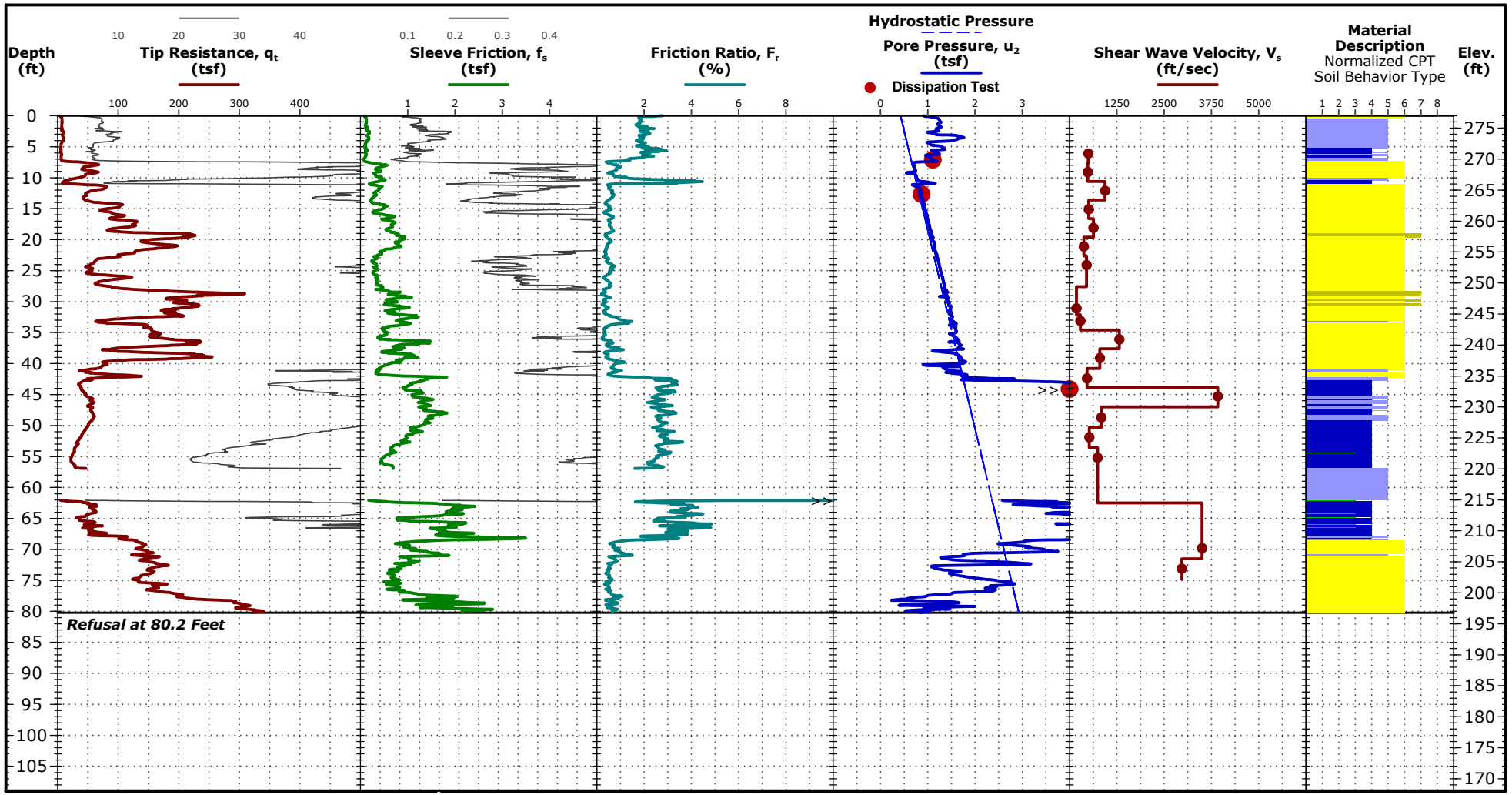
CPT Sounding ID C1025

Latitude: 36.997454° Longitude: -89.146701°
North: 3540715.59 East: 3929475.51
Station: 2062+75 Offset: 10 ft Rt

Elevation: 277.00 (ft)

Terracon
5111 Commerce Crossing
Drive, Suite 120
Louisville, KY

CPT Started: 9/29/2024
CPT Completed: 9/29/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

Deck to Mudline = 19.9 ft

Deck to Water = 6.3 ft

Refusal (operator discretion) bow in rod and excessive sleeve friction

Tip refusal at 325 tsf and sleeve friction of 2 tsf

CPT Equipment

CPT Rig:

Operator: Fugro

CPT sensor calibration reports available upon request

Probe No. 1701-3619 with net area ratio of 0.59

Manufactured by Fugro- Calibrated 4/15/2024

Tip and sleeve areas of 15 cm^2 and 225 cm^2

No friction reducer

Water Level Observation

-13.6 ft estimated water depth

(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

US-51 Bridge Replacement CM #3 / #4
US 51 | Wickliffe, KY
Terracon Project No. 57235039

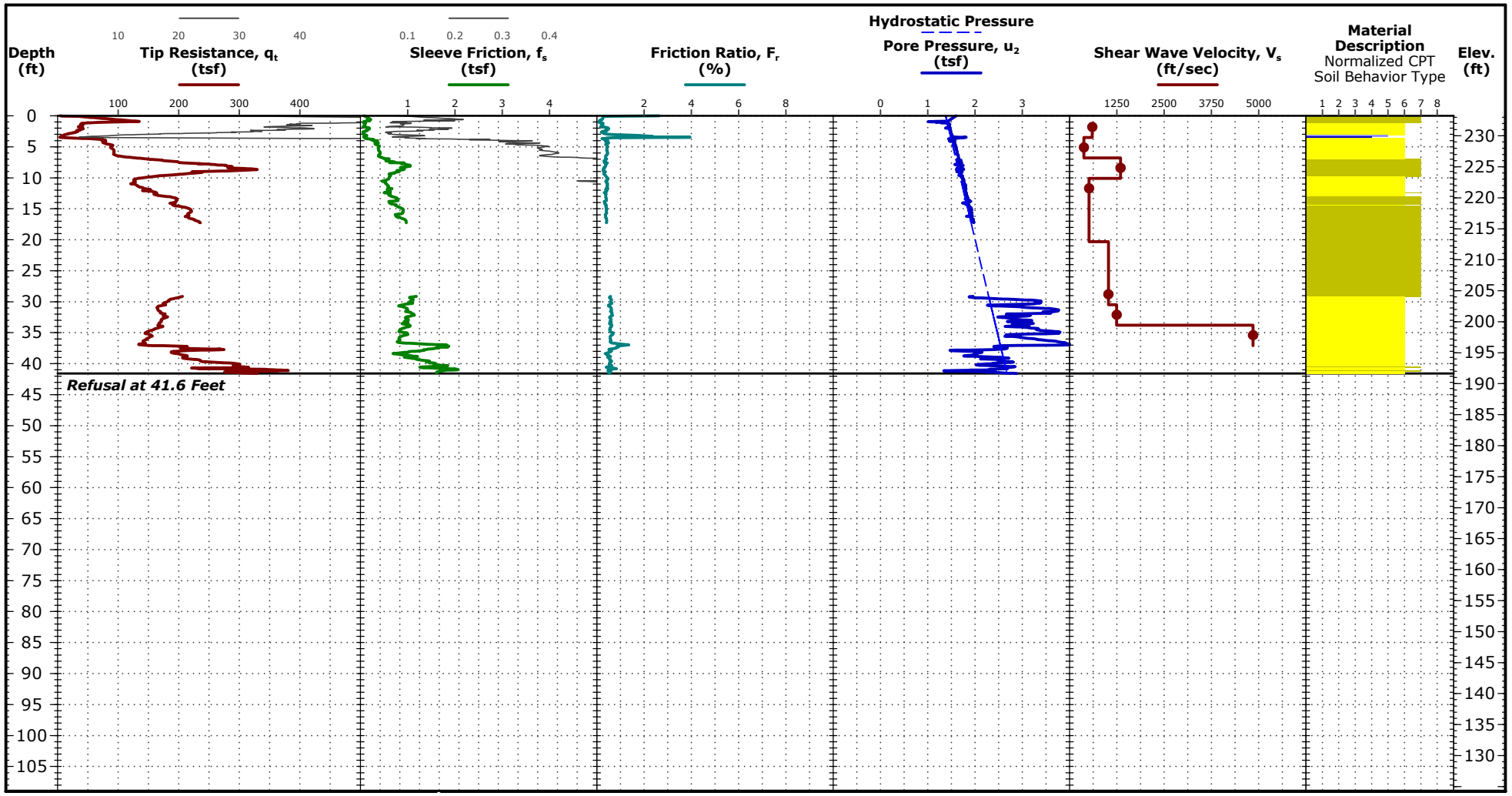
CPT Sounding ID C1026

Terracon
5111 Commerce Crossing Drive, Suite 120
Louisville, KY

Elevation: 233.23 (ft)

Latitude: 36.992929° Longitude: -89.151417°
North: 3539112.17 East: 3928030.98
Station: 2040+75 Offset: 10 ft Lft

CPT Started: 9/20/2024
CPT Completed: 9/20/2024



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan
Deck to Mudline = 48.5 ft
Deck to Water = 4.3 ft
Tip refusal at 400 tsf.
Tip refusal at 380 tsf.

CPT Equipment

CPT Rig:
Operator: Fugro
CPT sensor calibration reports available upon request
Probe No. 1701-3620 with net area ratio of 0.59
Manufactured by Fugro- Calibrated 4/15/2024
Tip and sleeve areas of 15 cm^2 and 225 cm^2
No friction reducer

Water Level Observation

-44.2 ft estimated water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

Appendix C – Laboratory Testing Results

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1001	SPT	3.15	0	0	0	0.174	11	A-2-4 (0)	SP-SM	23.5		
B-1001	ST											
B-1001	SPT	10.07	0	0	0	0.220	2	A-3 (0)	SP	23.6		
B-1001	SPT	12.99	0	0	0	0.192	2	A-3 (0)	SP	24.0		
B-1001	SPT	17.91	0	0	0	1.313	25	A-1-b (0)	SM	15.9		
B-1001	SPT	22.83	0	0	0	0.715	4	A-1-b (0)	SW	20.0		
B-1001	ST	27.75	0	0	0	0.184	4	A-3 (0)	SP	14.8		
B-1001	SPT	32.67	0	0	0	0.213	3	A-3 (0)	SP	19.8		
B-1001	SPT	37.59	0	0	0	0.285	5	A-3 (0)	SP	18.5		
B-1001	SPT	42.51	0	0	0	0.278	17	A-2-4 (0)	SM	18.0		
B-1001	SPT	47.43	0	0	0	0.830	15	A-1-b (0)	SM	16.0		
B-1001	SPT	52.35	0	0	0	0.755	11	A-1-b (0)	SP-SM	17.7		
B-1001	SPT	57.27	0	0	0	0.683	14	A-1-b (0)	SM	16.6		
B-1001	SPT	62.19	14	13	1	0.150	18	A-2-4 (0)	SM	20.8		
B-1001	ST											
B-1001	SPT	69.11	17	15	2	0.014	94	A-4 (0)	ML	20.6		
B-1001	SPT	72.03	17	15	2	0.158	15	A-2-4 (0)	SM	20.3		
B-1001	ST											
B-1001	SPT	76.95	17	13	4	0.141	23	A-2-4 (0)	SC-SM	21.0		
B-1001	SPT	81.87	18	15	3	0.163	16	A-2-4 (0)	SM	20.9		
B-1001	SPT	86.79	14	14	0	0.124	33	A-2-4 (0)	SM	21.1		
B-1001	SPT	91.71	17	11	6	0.125	37	A-4 (0)	SC-SM	24.0		
B-1001	ST	93.35	0	0	0	0.237	3	A-3 (0)	SP	12.5		
B-1001	SPT	96.63	0	0	0	0.317	4	A-3 (0)	SP	20.8		
B-1001	SPT	101.55	0	0	0	0.342	7	A-3 (0)	SP-SM	19.4		
B-1001	SPT	111.39	0	0	0	0.801	4	A-1-b (0)	SP	20.4		
B-1001	SPT	121.23	0	0	0	0.435	2	A-1-b (0)	SP	20.7		
B-1001	SPT	131.07	0	0	0	0.143	21	A-2-4 (0)	SM	27.1		
B-1001	SPT	140.91	0	0	0	0.823	1	A-1-b (0)	SP	23.4		
B-1001	ST											
B-1001	SPT	150.75	0	0	0	0.460	5	A-1-b (0)	SP	16.3		
B-1001	SPT	160.59	0	0	0	0.202	8	A-3 (0)	SP-SM	25.2		
B-1001	SPT	170.43	0	0	0	0.656	3	A-1-b (0)	SW	18.5		
B-1001	SPT	180.27	0	0	0	0.154	32	A-2-4 (0)	SM	25.9		
B-1001	SPT	190.11	0	0	0	0.222	4	A-3 (0)	SP	23.5		
B-1001	SPT	199.95	0	0	0	0.172	9	A-3 (0)	SP-SM	26.8		
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	ST											
B-1001	SPT	219.63	0	0	0	0.212	1	A-3 (0)	SP	29.3		
B-1001	SPT	239.31	0	0	0	0.172	5	A-3 (0)	SP	29.5		
B-1001	SPT	249.15	0	0	0	0.189	5	A-3 (0)	SP	27.0		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1002	SPT	3	0	0	0	0.251	26	A-2-4 (0)	SM	21.7		
B-1002	SPT	7.92	0	0	0	0.258	23	A-2-4 (0)	SM	19.6		
B-1002	SPT	12.84	0	0	0	12.022	6	A-1-a (0)	GP-GM	17.9		
B-1002	SPT	17.76	0	0	0	0.867	17	A-1-b (0)	SM	18.5		
B-1002	SPT	22.68	0	0	0	0.917	21	A-1-b (0)	SM	20.3		
B-1002	SPT	27.6	20	0	20	0.188	8	A-3 (0)	SP-SM	25.8		
B-1002	ST	32.52	0	0	0	0.199	0	A-3 (0)	SP	14.5		
B-1002	SPT	37.44	0	0	0	0.224	16	A-2-4 (0)	SM	16.6		
B-1002	SPT	42.36	0	0	0	0.235	5	A-3 (0)	SP-SM	19.6		
B-1002	SPT	47.28	0	0	0	1.517	26	A-2-4 (0)	SM	14.7		
B-1002	SPT	52.2	0	0	0	0.857	23	A-1-b (0)	SM	16.1		
B-1002	SPT	57.12	0	0	0	0.724	12	A-1-b (0)	SM	18.1		
B-1002	SPT	62.04	0	0	0	0.417	10	A-1-b (0)	SP-SM	22.4		
B-1002	SPT	66.96	17	13	4	0.111	37	A-4 (0)	SC-SM	25.5		
B-1002	ST											
B-1002	SPT	73.51	18	13	5	0.169	18	A-2-4 (0)	SC-SM	25.5		
B-1002	SPT	76.8	15	13	2	0.086	46	A-4 (0)	SM	23.1		
B-1002	ST	81.72	17	13	4	0.114	37	A-4 (0)	SC-SM	27.9		
B-1002	SPT	83.73	13	0	13	0.184	12	A-2-4 (0)	SP-SM	21.4		
B-1002	SPT	86.64	13	0	13	0.151	18	A-2-4 (0)	SM	21.9		
B-1002	SPT	91.56	0	0	0	0.451	7	A-1-b (0)	SP-SM	18.7		
B-1002	SPT	96.48	0	0	0	0.294	4	A-3 (0)	SP	21.6		
B-1002	SPT	101.4	14	13	2	0.293	11	A-2-4 (0)	SP-SM	18.6		
B-1002	SPT	111.24	0	0	0	0.728	6	A-1-b (0)	SW-SM	19.0		
B-1002	SPT	121.08	0	0	0	0.227	4	A-3 (0)	SP	25.1		
B-1002	SPT	130.92	0	0	0	0.189	7	A-3 (0)	SP-SM	52.9		
B-1002	SPT	141.35	0	0	0	0.432	2	A-1-b (0)	SP	28.9		
B-1002	ST	146.75	0	0	0	0.757	1	A-1-b (0)	SP	17.8		
B-1002	SPT	151.17	0	0	0	0.240	6	A-3 (0)	SP-SM	30.5		
B-1002	SPT	156.09	0	0	0	0.193	6	A-3 (0)	SP-SM	24.4		
B-1002	SPT	161.01	0	0	0	0.279	7	A-3 (0)	SP-SM	23.3		
B-1002	SPT	170.85	0	0	0	0.727	3	A-1-b (0)	SW	20.1		
B-1002	SPT	180.69	0	0	0	0.244	5	A-3 (0)	SP	24.5		
B-1002	SPT	190.53	0	0	0	0.361	5	A-3 (0)	SP-SM	16.8		
B-100~	ST											
B-100~	SPT	205	0	0	0	0.814	12	A-1-b (0)	SP-SM	57.6		
B-100~	SPT											
B-100~	SPT	225	0	0	0	0.183	7	A-3 (0)	SP-SM	68.4		
B-100~	SPT	240	19	0	19	0.178	6	A-3 (0)	SP-SM	45.0		
B-1004	SPT	1.57	0	0	0	6.124	1	A-1-a (0)	GW	22.7		
B-1004	ST											
B-1004	SPT	8.13	0	0	0	0.870	1	A-1-b (0)	SP	19.9		
B-1004	SPT	11.41	0	0	0	0.163	21	A-2-4 (0)	SM	22.6		
B-1004	SPT	16.33	0	0	0	0.271	5	A-3 (0)	SP	20.8		
B-1004	SPT	21.25	0	0	0	1.405	25	A-1-b (0)	SM	12.4		
B-1004	ST											
B-1004	SPT	27.81	0	0	0	0.443	5	A-1-b (0)	SP	17.7		
B-1004	SPT	31.09	0	0	0	24.885	6	A-1-a (0)	GW-GM	6.8		
B-1004	SPT	36.01	16	0	16	0.175	11	A-2-4 (0)	SP-SM	18.2		
B-1004	SPT	40.93	16	16	0	0.150	19	A-2-4 (0)	SM	21.5		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1004	ST	42.57	15	15	0	0.153	17	A-2-4 (0)	SM	20.1		
B-1004	SPT	45.85	0	0	0	0.194	9	A-3 (0)	SP-SM	21.3		
B-1004	SPT	50.77	15	15	0	0.170	15	A-2-4 (0)	SM	22.5		
B-1004	SPT	55.69	14	13	1	0.178	22	A-2-4 (0)	SM	20.0		
B-1004	SPT	60.61	16	9	7	0.161	17	A-2-4 (0)	SC-SM	21.2		
B-1004	SPT	65.53	15	12	3	0.194	21	A-2-4 (0)	SM	18.7		
B-1004	SPT	70.45	14	13	1	0.097	42	A-4 (0)	SM	22.5		
B-1004	SPT	75.37	0	0	0	0.200	3	A-3 (0)	SP	23.5		
B-1004	SPT	78.29	0	0	0	0.703	0	A-1-b (0)	SW	20.6		
B-1004	SPT	88.13	0	0	0	0.852	0	A-1-b (0)	SP	20.0		
B-1004	SPT	93.05	0	0	0	0.694	2	A-1-b (0)	SW	17.1		
B-1004	SPT	97.97	19	0	19	0.175	5	A-3 (0)	SP-SM	24.1		
B-1004	SPT	102.89	0	0	0	0.159	13	A-2-4 (0)	SM	25.9		
B-1004	SPT	112.73	0	0	0	0.843	4	A-1-b (0)	SP	17.7		
B-1004	SPT	117.65	0	0	0	0.798	7	A-1-b (0)	SW-SM	17.3		
B-1004	SPT	122.58	0	0	0	0.676	2	A-1-b (0)	SW	18.7		
B-1004	SPT	132.41	0	0	0	0.898	1	A-1-b (0)	SP	20.6		
B-1004	SPT	142.25	0	0	0	0.413	3	A-3 (0)	SP	23.6		
B-1004	SPT	152.09	0	0	0	0.221	5	A-3 (0)	SP-SM	24.5		
B-1004	SPT	161.93	0	0	0	0.611	1	A-1-b (0)	SW	22.9		
B-1004	SPT	171.77	0	0	0	0.163	13	A-2-4 (0)	SM	27.4		
B-1004	SPT	181.61	0	0	0	0.174	7	A-3 (0)	SP-SM	25.1		
B-1004	SPT	191.45	0	0	0	0.782	1	A-1-b (0)	SP	22.0		
B-1004	SPT	201.29	37	24	13	0.034	60	A-6 (6)	CL	61.4		
B-1004	SPT	201.79	0	0	0	0.128	33	A-2-4 (0)	SM	40.6		
B-1004	SPT	220.97	0	0	0	0.170	6	A-3 (0)	SP-SM	26.5		
B-1004	SPT	240.65	0	0	0	0.218	5	A-3 (0)	SP	23.3		
B-1004	SPT	250.49	0	0	0	0.286	4	A-3 (0)	SP	23.1		
B-1005	SPT	3.14	0	0	0	10.446	2	A-1-a (0)	GP	8.8		
B-1005	SPT	8.06	0	0	0	0.177	5	A-3 (0)	SP	23.1		
B-1005	SPT											
B-1005	SPT	14.62	0	0	0	0.174	5	A-3 (0)	SP-SM	25.2		
B-1005	SPT	17.9	0	0	0	0.350	22	A-2-4 (0)	SM	18.1		
B-1005	SPT	22.82	0	0	0	0.519	22	A-1-b (0)	SM	17.3		
B-1005	ST											
B-1005	SPT	30.42	0	0	0	0.312	4	A-3 (0)	SP	20.5		
B-1005	SPT	32.66	0	0	0	0.176	6	A-3 (0)	SP-SM	22.0		
B-1005	SPT	37.58	16	0	16	0.150	18	A-2-4 (0)	SM	21.0		
B-1005	ST											
B-1005	SPT	42.5	0	0	0	0.154	17	A-2-4 (0)	SM	23.9		
B-1005	SPT	47.42	0	0	0	0.180	9	A-3 (0)	SP-SM	22.5		
B-1005	SPT	52.34	15	0	15	0.165	14	A-2-4 (0)	SM	21.7		
B-1005	SPT	57.26	16	15	1	0.148	21	A-2-4 (0)	SM	22.1		
B-1005	ST											
B-1005	SPT	64.18	16	0	16	0.156	16	A-2-4 (0)	SM	22.8		
B-1005	SPT	67.1	16	12	4	0.119	34	A-2-4 (0)	SC-SM	21.0		
B-1005	SPT	72.02	0	0	0	0.184	5	A-3 (0)	SP	23.4		
B-1005	SPT	76.94	0	0	0	0.297	9	A-3 (0)	SP-SM	23.1		
B-1005	SPT	81.86	0	0	0	0.295	9	A-3 (0)	SP-SM	21.1		
B-1005	SPT	86.78	0	0	0	0.344	6	A-3 (0)	SP-SM	20.2		

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Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1005	SPT	91.7	0	0	0	0.564	2	A-1-b (0)	SP	21.1		
B-1005	SPT	96.62	19	0	19	0.166	9	A-3 (0)	SP-SM	25.0		
B-1005	SPT	101.54	0	0	0	0.171	5	A-3 (0)	SP	24.3		
B-1005	SPT	111.38	0	0	0	0.620	2	A-1-b (0)	SW	20.3		
B-1005	SPT	121.22	0	0	0	0.255	10	A-3 (0)	SP-SM	18.5		
B-1005	SPT	131.06	0	0	0	0.602	3	A-1-b (0)	SW	22.1		
B-1005	SPT	140.9	0	0	0	0.720	4	A-1-b (0)	SW	18.8		
B-1005	ST											
B-1005	SPT	152.74	0	0	0	0.802	7	A-1-b (0)	SW-SM	15.6		
B-1005	SPT	160.58	0	0	0	0.216	4	A-3 (0)	SP	24.2		
B-1005	SPT	170.42	0	0	0	0.162	11	A-2-4 (0)	SP-SM	22.7		
B-1005	SPT	180.26	0	0	0	0.174	5	A-3 (0)	SP	28.3		
B-1005	SPT	190.1	0	0	0	0.423	3	A-1-b (0)	SP	24.1		
B-1005	SPT	199.94	25	15	10	0.022	69	A-4 (4)	CL	26.3		
B-1005	SPT	219.62	0	0	0	0.015	91	A-4 (0)	ML	29.4		
B-1005	SPT	239.3	22	13	9	0.037	59	A-4 (2)	CL	21.7		
B-1005	SPT	249.14	0	0	0	0.260	4	A-3 (0)	SP	24.0		
B-1007	SPT	3.52	0	0	0	3.328	18	A-1-b (0)	SM	43.7		
B-1007	ST											
B-1007	SPT	8.44	0	0	0	16.721	15	A-1-a (0)	GM	17.5		
B-1007	SPT	13.36	0	0	0	0.148	20	A-2-4 (0)	SM	30.3		
B-1007	SPT	18.28	0	0	0	0.159	21	A-2-4 (0)	SM	27.1		
B-1007	SPT	23.2	0	0	0	0.760	22	A-1-b (0)	SM	18.7		
B-1007	ST	24.7	0	0	0	0.235	0	A-3 (0)	SP	3.1		
B-1007	SPT	28.12	0	0	0	0.251	5	A-3 (0)	SP-SM	27.8		
B-1007	SPT	33.04	0	0	0	0.405	5	A-3 (0)	SP-SM	17.7		
B-1007	SPT	37.96	0	0	0	0.227	5	A-3 (0)	SP-SM	19.6		
B-1007	SPT	42.88	0	0	0	0.614	5	A-1-b (0)	SW	15.6		
B-1007	SPT	47.8	0	0	0	0.374	9	A-3 (0)	SP-SM	20.2		
B-1007	ST											
B-1007	SPT	52.72	0	0	0	0.238	8	A-3 (0)	SP-SM	20.2		
B-1007	SPT	57.64	0	0	0	7.378	16	A-1-b (0)	GM	13.8		
B-1007	SPT	62.56	0	0	0	8.444	13	A-1-a (0)	GM	13.3		
B-1007	SPT	67.48	13	13	0	0.172	14	A-2-4 (0)	SM	21.4		
B-1007	SPT	72.4	0	0	0	0.224	7	A-3 (0)	SP-SM	21.6		
B-1007	ST											
B-1007	SPT	77.32	0	0	0	0.216	8	A-3 (0)	SP-SM	20.3		
B-1007	SPT	82.24	17	12	5	0.142	31	A-2-4 (0)	SC-SM	19.2		
B-1007	SPT	87.16	35	20	15	0.003	98	A-6 (15)	CL	24.4		
B-1007	ST	88.66	21	11	10	0.233	39	A-4 (0)	SC	19.4		
B-1007	SPT	92.08	0	0	0	0.454	1	A-1-b (0)	SP	21.4		
B-1007	SPT	97	0	0	0	0.614	4	A-1-b (0)	SW	22.2		
B-1007	SPT	101.92	29	15	14	0.012	77	A-6 (9)	CL	18.4		
B-1007	SPT	111.76	0	0	0	0.913	1	A-1-b (0)	SP	16.4		
B-1007	SPT	121.6	0	0	0	0.826	1	A-1-b (0)	SP	19.3		
B-1007	SPT	131.44	0	0	0	0.649	1	A-1-b (0)	SW	21.1		
B-1007	SPT	141.28	0	0	0	0.627	2	A-1-b (0)	SW	23.5		
B-1007	SPT	151.12	0	0	0	0.890	3	A-1-b (0)	SP	17.8		
B-1007	SPT	160.96	0	0	0	0.213	4	A-3 (0)	SP	27.3		
B-1007	SPT	170.8	0	0	0	0.252	3	A-3 (0)	SP	24.2		

Total Jars: 0
Total SPT: 0
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Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1007	SPT	180.64	0	0	0	0.779	1	A-1-b (0)	SP	23.3		
B-1007	SPT	190.48	0	0	0	0.165	11	A-2-4 (0)	SP-SM	26.3		
B-1007	SPT	200.32	0	0	0	0.220	5	A-3 (0)	SP	24.5		
B-1007	SPT	220	31	19	12	0.012	86	A-6 (9)	CL	21.0		
B-1007	SPT	239.68	0	0	0	0.169	11	A-2-4 (0)	SP-SM	30.2		
B-1007	SPT	260.66	0	0	0	0.874	1	A-1-b (0)	SP	22.1		
B-1007	SPT	279.04	59	37	22	0.330	35	A-2-7 (2)	SM	41.8		
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	ST											
B-1007	SPT	298.72	53	29	24	0.265	30	A-2-7 (2)	SM	46.4		
B-1008	SPT	2.62	0	0	0	1.087	25	A-1-b (0)	SM	25.5		
B-1008	SPT	7.54	0	0	0	0.217	25	A-2-4 (0)	SM	18.7		
B-1008	SPT	12.46	0	0	0	0.164	11	A-2-4 (0)	SP-SM	25.4		
B-1008	ST											
B-1008	SPT	19.02	0	0	0	0.182	12	A-2-4 (0)	SP-SM	25.5		
B-1008	SPT	22.3	0	0	0	0.201	6	A-3 (0)	SP-SM	22.1		
B-1008	SPT	27.22	0	0	0	0.181	6	A-3 (0)	SP-SM	23.1		
B-1008	SPT	32.14	0	0	0	0.269	6	A-3 (0)	SP-SM	16.5		
B-1008	SPT	37.06	0	0	0	0.282	6	A-3 (0)	SP-SM	17.4		
B-1008	SPT	41.98	0	0	0	0.459	12	A-1-b (0)	SP-SM	13.3		
B-1008	SPT	46.9	0	0	0	0.217	4	A-3 (0)	SP	22.3		
B-1008	SPT	51.82	0	0	0	0.282	13	A-2-4 (0)	SM	17.5		
B-1008	SPT	56.74	0	0	0	6.525	15	A-1-a (0)	GM	13.6		
B-1008	SPT	61.66	0	0	0	7.757	14	A-1-a (0)	GM	14.5		
B-1008	SPT	72.75	0	0	0	0.215	7	A-3 (0)	SP-SM	22.7		
B-1008	SPT	76.42	0	0	0	0.219	8	A-3 (0)	SP-SM	20.2		
B-1008	SPT	81.34	14	14	0	0.147	26	A-2-4 (0)	SM	20.5		
B-1008	SPT	86.26	0	0	0	0.531	8	A-1-b (0)	SP-SM	19.0		
B-1008	SPT	91.18	0	0	0	0.558	6	A-1-b (0)	SW-SM	19.8		
B-1008	SPT	96.1	0	0	0	0.694	3	A-1-b (0)	SW	16.7		
B-1008	SPT	103.95	0	0	0	0.572	1	A-1-b (0)	SW	20.3		
B-1008	ST	105.94	0	0	0	0.683	2	A-1-b (0)	SW	16.8		
B-1008	SPT	110.86	0	0	0	0.303	4	A-3 (0)	SP	20.8		
B-1008	SPT	120.7	0	0	0	0.687	6	A-1-b (0)	SW-SM	17.2		
B-1008	SPT	130.54	0	0	0	0.506	5	A-1-b (0)	SP	19.3		
B-1008	ST	140.38	0	0	0	0.542	1	A-1-b (0)	SP	17.5		
B-1008	SPT	150.22	0	0	0	0.769	2	A-1-b (0)	SP	20.6		
B-1008	SPT	155.14	0	0	0	0.176	4	A-3 (0)	SP	28.7		
B-1008	SPT	160.06	0	0	0	0.175	5	A-3 (0)	SP-SM	27.4		
B-1008	SPT	169.9	0	0	0	0.205	2	A-3 (0)	SP	22.0		
B-1008	SPT	179.74	0	0	0	0.165	9	A-3 (0)	SP-SM	28.3		

Total Jars: 0
Total SPT: 0
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Project ID: S-033-2024
Location: Ballard
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Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1008	SPT	189.58	0	0	0	0.209	9	A-3 (0)	SP-SM	24.9		
B-1008	SPT	199.42	0	0	0	0.198	7	A-3 (0)	SP-SM	22.2		
B-1008	SPT	219.1	20	16	4	0.401	12	A-2-4 (0)	SC-SM	18.8		
B-1008	SPT	238.78	0	0	0	0.174	3	A-3 (0)	SP	30.5		
B-1008	SPT	258.46	0	0	0	0.435	5	A-1-b (0)	SP	22.6		
B-1008	SPT	278.14	57	41	16	0.608	14	A-2-7 (0)	SM	39.9		
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	SPT	297.82	62	45	17	0.531	12	A-2-7 (0)	SM	42.9		
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	SPT	317.5	39	33	6	0.302	16	A-2-4 (0)	SM	42.2		
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	SPT	337.18	77	58	19	0.198	21	A-2-7 (1)	SM	49.8		
B-1008	ST											
B-1008	ST											
B-1008	ST											
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Project ID: S-033-2024
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Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1008	SPT	356.86	82	50	32	0.198	28	A-2-7 (3)	SM	49.4		
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	SPT	376.54	77	65	12	0.166	32	A-2-7 (0)	SM	50.8		
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	ST											
B-1008	SPT	396.22	71	56	15	0.083	49	A-7-5 (7)	SM	47.3		
B-1008	ST											
B-1008	ST											
B-1008	SPT	401.14	74	53	21	0.072	50	A-7-5 (9)	MH	52.8		
B-1009	SPT	3.73	0	0	0	3.280	21	A-1-b (0)	SM	23.5		
B-1009	SPT	8.65	0	0	0	0.179	7	A-3 (0)	SP-SM	28.4		
B-1009	SPT	13.57	0	0	0	0.175	14	A-2-4 (0)	SM	23.1		
B-1009	ST											
B-1009	SPT	20.5	0	0	0	0.198	5	A-3 (0)	SP	21.2		
B-1009	SPT	23.41	0	0	0	0.191	8	A-3 (0)	SP-SM	21.6		
B-1009	SPT	28.33	0	0	0	0.221	15	A-2-4 (0)	SM	18.9		
B-1009	SPT	33.25	0	0	0	0.186	3	A-3 (0)	SP	24.4		
B-1009	ST											
B-1009	SPT	40.2	0	0	0	0.332	4	A-3 (0)	SP	18.1		
B-1009	SPT	43.09	0	0	0	0.677	22	A-1-b (0)	SM	14.7		
B-1009	SPT	48.01	0	0	0	0.645	24	A-1-b (0)	SM	13.0		
B-1009	SPT	52.93	0	0	0	0.257	12	A-2-4 (0)	SP-SM	18.6		
B-1009	SPT	57.85	0	0	0	6.224	23	A-1-b (0)	GM	13.9		
B-1009	SPT	62.77	15	0	15	0.178	12	A-2-4 (0)	SP-SM	39.6		
B-1009	ST	64.41	0	0	0	0.178	6	A-3 (0)	SP-SM	15.5		
B-1009	SPT	67.69	0	0	0	0.190	11	A-2-4 (0)	SP-SM	25.5		
B-1009	SPT	72.61	16	0	16	0.190	11	A-2-4 (0)	SP-SM	8.4		
B-1009	SPT	77.53	12	0	12	0.199	12	A-2-4 (0)	SP-SM	21.5		
B-1009	SPT	82.45	14	12	2	0.133	33	A-2-4 (0)	SM	21.3		
B-1009	SPT	87.37	0	0	0	0.178	6	A-3 (0)	SP-SM	23.7		
B-1009	SPT	92.29	0	0	0	0.713	2	A-1-b (0)	SW	21.0		

Total Jars: 0
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Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1009	SPT	97.21	0	0	0	0.506	5	A-1-b (0)	SP	21.5		
B-1009	SPT	107.05	0	0	0	0.878	3	A-1-b (0)	SP	18.6		
B-1009	SPT	111.97	0	0	0	0.324	2	A-3 (0)	SP	24.4		
B-1009	SPT	121.81	0	0	0	0.321	4	A-3 (0)	SP	22.3		
B-1009	SPT	131.65	0	0	0	0.453	6	A-1-b (0)	SP-SM	22.3		
B-1009	SPT	141.49	0	0	0	0.668	5	A-1-b (0)	SW-SM	22.3		
B-1009	SPT	151.33	0	0	0	0.170	9	A-3 (0)	SP-SM	26.4		
B-1009	SPT	161.17	0	0	0	0.172	9	A-3 (0)	SP-SM	26.3		
B-1009	SPT	171.01	0	0	0	0.250	3	A-3 (0)	SP	24.4		
B-1009	SPT	180.85	0	0	0	0.168	8	A-3 (0)	SP-SM	29.1		
B-1009	SPT	190.69	0	0	0	0.221	3	A-3 (0)	SP	26.4		
B-1009	SPT	200.53	16	0	16	0.169	9	A-3 (0)	SP-SM	26.8		
B-1009	SPT	220.21	35	20	15	0.009	95	A-6 (15)	CL	24.3		
B-1009	ST	228.8	35	21	14	0.009	91	A-6 (13)	CL	30.7		
B-1009	SPT	239.89	0	0	0	0.167	8	A-3 (0)	SP-SM	27.1		
B-1009	SPT	259.57	0	0	0	0.717	5	A-1-b (0)	SW	23.8		
B-1009	SPT	279.25	54	42	12	0.559	18	A-2-7 (0)	SM	43.1		
B-1009	SPT	299.35	60	52	8	0.196	31	A-2-5 (0)	SM	43.4		
B-1012	SPT	3.3	0	0	0	0.598	1	A-1-b (0)	SW	31.2		
B-1012	SPT	8.22	37	21	16	0.011	77	A-6 (11)	CL	38.2		
B-1012	ST	9.86	36	21	15	0.015	72	A-6 (10)	CL	21.0		
B-1012	SPT	13.14	0	0	0	0.983	23	A-1-b (0)	SM	19.1		
B-1012	SPT	18.06	0	0	0	0.528	26	A-2-4 (0)	SM	14.8		
B-1012	SPT									0.5		
B-1012	SPT	27.9	0	0	0	0.638	13	A-1-b (0)	SM	16.2		
B-1012	ST											
B-1012	SPT	32.82	0	0	0	1.767	26	A-2-4 (0)	GM	13.9		
B-1012	SPT	37.74	0	0	0	0.261	5	A-3 (0)	SP-SM	19.4		
B-1012	SPT	42.66	0	0	0	0.675	13	A-1-b (0)	SM	13.9		
B-1012	SPT	47.58	18	0	18	0.148	22	A-2-4 (0)	SM	22.9		
B-1012	ST											
B-1012	SPT	52.5	14	0	14	0.161	15	A-2-4 (0)	SM	20.9		
B-1012	SPT	57.42	17	0	17	0.164	13	A-2-4 (0)	SM	20.8		
B-1012	SPT	62.34	18	13	5	0.161	14	A-2-4 (0)	SC-SM	20.0		
B-1012	ST	63.98	16	13	3	0.162	13	A-2-4 (0)	SM	20.8		
B-1012	SPT	67.26	0	0	0	0.016	87	A-4 (0)	ML	25.3		
B-1012	SPT	72.18	13	0	13	0.188	11	A-2-4 (0)	SP-SM	20.4		
B-1012	SPT	77.1	0	0	0	0.179	13	A-2-4 (0)	SM	20.1		
B-1012	SPT	82.02	15	0	15	0.178	13	A-2-4 (0)	SM	18.5		
B-1012	SPT	86.94	18	0	18	0.183	12	A-2-4 (0)	SM	20.1		
B-1012	SPT	91.86	0	0	0	0.177	11	A-2-4 (0)	SP-SM	22.5		
B-1012	ST											
B-1012	SPT	96.78	0	0	0	0.463	3	A-1-b (0)	SP	20.4		
B-1012	SPT	101.7	0	0	0	0.317	4	A-3 (0)	SP	21.0		
B-1012	SPT	111.54	0	0	0	0.274	6	A-3 (0)	SP-SM	19.7		
B-1012	SPT	121.38	0	0	0	0.753	2	A-1-b (0)	SP	20.6		
B-1012	SPT	131.22	0	0	0	0.643	8	A-1-b (0)	SW-SM	17.5		
B-1012	SPT	141.06	0	0	0	0.817	2	A-1-b (0)	SP	19.3		
B-1012	SPT	150.4	0	0	0	0.710	3	A-1-b (0)	SW	20.9		
B-1012	SPT	160.74	0	0	0	0.435	4	A-1-b (0)	SP	19.5		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1012	SPT	170.58	0	0	0	0.192	3	A-3 (0)	SP	25.8		
B-1012	SPT	180.42	0	0	0	0.199	3	A-3 (0)	SP	24.7		
B-1012	SPT	190.26	0	0	0	0.361	2	A-3 (0)	SP	22.1		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	SPT	200.1	0	0	0	0.192	9	A-3 (0)	SP-SM	22.7		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	SPT	219.78	0	0	0	0.524	8	A-1-b (0)	SP-SM	16.7		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	SPT	239.46	0	0	0	0.292	2	A-3 (0)	SP	23.6		
B-1012	SPT	259.14	0	0	0	0.207	3	A-3 (0)	SP	24.4		
B-1012	SPT	278.82	32	16	16	0.011	92	A-6 (14)	CL	18.5		
B-1012	SPT	281.12	0	0	0	0.517	11	A-1-b (0)	SP-SM	17.7		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	SPT	298.5	60	44	16	0.631	14	A-2-7 (0)	SM	42.2		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	SPT	316.18	101	38	63	0.284	9	A-2-7 (0)	SP-SC	47.0		
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1012	ST											
B-1013	SPT	3.92	0	0	0	0.600	10	A-1-b (0)	SW-SM	27.7		
B-1013	SPT	8.84	0	0	0	1.352	25	A-1-b (0)	SM	18.6		
B-1013	ST											

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1013	SPT	13.76	0	0	0	1.655	2	A-1-b (0)	SP	93.8		
B-1013	SPT	18.68	0	0	0	10.280	12	A-1-a (0)	GP-GM	14.7		
B-1013	SPT	23.6	0	0	0	0.320	12	A-2-4 (0)	SM	16.0		
B-1013	SPT	28.52	0	0	0	0.709	8	A-1-b (0)	SW-SM	13.2		
B-1013	SPT	33.44	0	0	0	0.624	15	A-1-b (0)	SM	15.0		
B-1013	SPT											
B-1013	SPT	43.28	0	0	0	0.499	16	A-1-b (0)	SM	14.5		
B-1013	SPT	48.2	15	0	15	0.156	16	A-2-4 (0)	SM	21.4		
B-1013	ST	53.12	17	13	4	0.164	13	A-2-4 (0)	SC-SM	14.8		
B-1013	SPT	58.04	17	0	17	0.160	15	A-2-4 (0)	SM	20.4		
B-1013	SPT	62.96	16	14	2	0.158	15	A-2-4 (0)	SM	22.1		
B-1013	SPT	67.88	0	0	0	0.015	90	A-4 (0)	ML	26.6		
B-1013	SPT	68.38	15	13	2	0.087	46	A-4 (0)	SM	26.4		
B-1013	SPT	72.8	0	0	0	0.018	82	A-4 (0)	ML	22.2		
B-1013	ST	74.44	25	16	9	0.009	83	A-4 (5)	CL	19.9		
B-1013	ST											
B-1013	SPT	79.36	0	0	0	0.162	17	A-2-4 (0)	SM	19.4		
B-1013	SPT	82.64	0	0	0	0.174	13	A-2-4 (0)	SM	19.6		
B-1013	SPT	87.56	13	0	13	0.153	20	A-2-4 (0)	SM	21.8		
B-1013	ST											
B-1013	SPT	94.48	0	0	0	0.347	2	A-3 (0)	SP	20.4		
B-1013	SPT	100.68	0	0	0	0.508	4	A-1-b (0)	SP	18.5		
B-1013	ST	102.32	0	0	0	0.359	2	A-3 (0)	SP	4.1		
B-1013	SPT	112.16	0	0	0	0.819	3	A-1-b (0)	SP	17.5		
B-1013	SPT	122	0	0	0	0.022	75	A-4 (0)	ML	19.0		
B-1013	ST	131.84	0	0	0	0.730	1	A-1-b (0)	SP	12.6		
B-1013	SPT	141.68	0	0	0	0.672	3	A-1-b (0)	SW	19.5		
B-1013	SPT	151.52	0	0	0	0.824	6	A-1-b (0)	SW-SM	17.0		
B-1013	SPT	161.36	0	0	0	0.442	4	A-1-b (0)	SP	20.6		
B-1013	SPT	171.2	0	0	0	0.189	5	A-3 (0)	SP-SM	25.1		
B-1013	SPT	181.04	0	0	0	0.734	6	A-1-b (0)	SW-SM	19.2		
B-1013	SPT	190.88	0	0	0	0.258	6	A-3 (0)	SP-SM	22.1		
B-1013	SPT	200.72	0	0	0	0.199	6	A-3 (0)	SP-SM	24.0		
B-1013	SPT	220.4	0	0	0	0.109	39	A-4 (0)	SM	25.6		
B-1013	SPT	240.08	0	0	0	0.183	7	A-3 (0)	SP-SM	25.0		
B-1013	SPT	259.76	0	0	0	0.381	5	A-3 (0)	SP	22.3		
B-1013	SPT	279.44	0	0	0	0.489	9	A-1-b (0)	SP-SM	20.1		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	SPT	299.12	44	34	10	0.579	16	A-2-5 (0)	SM	39.7		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	SPT	318.8	58	43	15	0.623	8	A-2-7 (0)	SW-SM	43.6		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	SPT	338.48	0	0	0	0.236	16	A-2-4 (0)	SM	45.2		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	SPT	358.16	89	58	31	0.361	23	A-2-7 (2)	SM	60.4		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	SPT	376.54	86	59	27	0.465	23	A-2-7 (1)	SM	54.8		
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											
B-1013	ST											

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1013	ST											
B-1013	ST											
B-1013	SPT	396.22	84	57	27	0.270	31	A-2-7 (3)	SM	52.6		
B-1013	ST											
B-1013	ST											
B-1013	SPT	401.14	76	53	23	0.136	40	A-7-5 (5)	SM	48.2		
B-1014	SPT	3.56	23	14	9	0.572	28	A-2-4 (0)	SC	34.7		
B-1014	SPT	13.19	0	0	0	2.578	1	A-1-a (0)	SP	28.6		
B-1014	SPT	18.11	0	0	0	0.910	14	A-1-b (0)	SM	19.0		
B-1014	SPT											
B-1014	SPT	24.67	0	0	0	0.826	16	A-1-b (0)	SM	17.1		
B-1014	SPT	27.95	0	0	0	30.529	21	A-1-b (0)	GM	8.5		
B-1014	SPT	32.87	0	0	0	0.763	10	A-1-b (0)	SP-SM	17.0		
B-1014	SPT	37.79	0	0	0	0.183	12	A-2-4 (0)	SP-SM	22.3		
B-1014	SPT	42.71	0	0	0	0.278	11	A-2-4 (0)	SP-SM	16.6		
B-1014	SPT	47.63	14	0	14	0.166	13	A-2-4 (0)	SM	23.2		
B-1014	ST											
B-1014	SPT	52.77	14	12	2	0.159	14	A-2-4 (0)	SM	22.0		
B-1014	SPT	57.47	15	12	3	0.135	28	A-2-4 (0)	SM	22.2		
B-1014	SPT	62.39	16	0	16	0.167	14	A-2-4 (0)	SM	21.8		
B-1014	SPT	67.31	26	16	10	0.007	85	A-4 (7)	CL	19.3		
B-1014	ST	72.23	31	17	14	0.006	88	A-6 (11)	CL	21.8		
B-1014	SPT	77.15	26	18	8	0.008	88	A-4 (5)	CL	23.1		
B-1014	SPT	77.55	15	13	2	0.176	17	A-2-4 (0)	SM	20.3		
B-1014	SPT	82.07	14	12	2	0.182	15	A-2-4 (0)	SM	21.0		
B-1014	SPT	86.99	14	0	14	0.186	13	A-2-4 (0)	SM	19.6		
B-1014	SPT	91.91	17	12	5	0.016	71	A-4 (0)	CL-ML	22.2		
B-1014	SPT	96.83	15	0	15	0.353	5	A-3 (0)	SP-SM	21.2		
B-1014	SPT	101.75	0	0	0	0.500	5	A-1-b (0)	SP	21.8		
B-1014	SPT	112.18	0	0	0	0.227	7	A-3 (0)	SP-SM	21.1		
B-1014	SPT	121.43	0	0	0	0.762	1	A-1-b (0)	SP	23.4		
B-1014	SPT	131.27	0	0	0	0.424	4	A-1-b (0)	SP	20.5		
B-1014	SPT	141.11	0	0	0	0.774	4	A-1-b (0)	SW	17.7		
B-1014	SPT	150.85	0	0	0	0.422	5	A-1-b (0)	SP-SM	22.7		
B-1014	SPT	160.79	0	0	0	0.501	5	A-1-b (0)	SP-SM	24.4		
B-1014	SPT	170.63	0	0	0	0.540	2	A-1-b (0)	SP	22.8		
B-1014	SPT	180.47	0	0	0	0.519	18	A-1-b (0)	SM	20.7		
B-1014	SPT	190.31	0	0	0	0.247	8	A-3 (0)	SP-SM	20.6		
B-1014	SPT	200.15	0	0	0	0.153	23	A-2-4 (0)	SM	22.7		
B-1014	SPT	219.83	0	0	0	0.294	15	A-2-4 (0)	SM	32.5		
B-1014	SPT	239.51	0	0	0	0.186	4	A-3 (0)	SP	27.1		
B-1014	SPT	259.19	0	0	0	0.469	4	A-1-b (0)	SP	23.1		
B-1014	SPT	278.87	0	0	0	0.256	4	A-3 (0)	SP	23.9		
B-1014	SPT	298.55	56	31	25	0.683	13	A-2-7 (0)	SM	43.1		
B-1014	SPT	303.47	47	37	10	0.656	12	A-2-5 (0)	SM	42.4		
B-1017	ST	4.79	0	0	0	0.338	10	A-3 (0)	SP-SM	23.7		
B-1017	SPT	9.71	0	0	0	0.565	17	A-1-b (0)	SM	29.5		
B-1017	SPT	14.63	0	0	0	0.735	15	A-1-b (0)	SM	22.4		
B-1017	SPT	19.55	0	0	0	0.848	22	A-1-b (0)	SM	19.7		
B-1017	SPT	24.47	0	0	0	0.172	16	A-2-4 (0)	SM	26.8		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1017	SPT	29.39	0	0	0	0.990	26	A-2-4 (0)	SM	15.3		
B-1017	SPT	34.31	0	0	0	0.602	14	A-1-b (0)	SM	18.7		
B-1017	SPT	39.23	0	0	0	0.813	16	A-1-b (0)	SM	18.1		
B-1017	SPT	44.15	0	0	0	0.767	14	A-1-b (0)	SM	14.0		
B-1017	SPT	49.07	0	0	0	1.051	25	A-1-b (0)	SM	6.3		
B-1017	SPT	53.99	16	13	3	0.129	28	A-2-4 (0)	SM	26.0		
B-1017	ST											
B-1017	SPT	58.91	19	13	6	0.070	51	A-4 (0)	CL-ML	24.2		
B-1017	SPT	63.83	21	13	8	0.014	68	A-4 (2)	CL	25.0		
B-1017	ST	65.47	36	17	19	0.007	92	A-6 (17)	CL	20.2		
B-1017	SPT	68.75	28	17	11	0.010	82	A-6 (7)	CL	22.9		
B-1017	SPT	73.67	16	15	1	0.148	20	A-2-4 (0)	SM	23.2		
B-1017	SPT	78.59	16	14	2	0.154	18	A-2-4 (0)	SM	25.4		
B-1017	ST	80.23	0	0	0	0.156	16	A-2-4 (0)	SM	16.7		
B-1017	SPT	83.51	17	14	3	0.143	23	A-2-4 (0)	SM	21.3		
B-1017	SPT	88.43	17	13	4	0.054	53	A-4 (0)	CL-ML	24.2		
B-1017	ST	90.07	16	12	4	0.221	17	A-2-4 (0)	SC-SM	19.4		
B-1017	SPT	93.35	13	0	13	0.183	18	A-2-4 (0)	SM	19.8		
B-1017	SPT	98.27	0	0	0	0.234	5	A-3 (0)	SP	21.6		
B-1017	SPT	103.19	0	0	0	0.462	6	A-1-b (0)	SP-SM	17.5		
B-1017	ST											
B-1017	SPT	116.29	23	14	9	0.021	71	A-4 (4)	CL	16.0		
B-1017	SPT	122.87	19	13	6	0.043	57	A-4 (0)	CL-ML	22.2		
B-1017	SPT	132.71	0	0	0	0.666	3	A-1-b (0)	SW	21.9		
B-1017	SPT	142.55	0	0	0	0.609	7	A-1-b (0)	SW-SM	15.2		
B-1017	SPT	152.39	0	0	0	0.021	77	A-4 (0)	ML	25.1		
B-1017	SPT	162.23	0	0	0	0.177	4	A-3 (0)	SP	27.7		
B-1017	SPT	172.07	16	16	0	0.119	33	A-2-4 (0)	SM	22.2		
B-1017	SPT	181.91	14	14	0	0.181	24	A-2-4 (0)	SM	20.5		
B-1017	SPT	191.75	0	0	0	0.418	5	A-1-b (0)	SP	22.0		
B-1017	SPT	201.59	0	0	0	0.169	8	A-3 (0)	SP-SM	30.0		
B-1017	SPT	221.27	0	0	0	0.449	5	A-1-b (0)	SP	23.3		
B-1017	SPT											
B-1017	SPT	245.97	0	0	0	0.266	6	A-3 (0)	SP-SM	23.5		
B-1017	SPT	265.55	0	0	0	0.841	3	A-1-b (0)	SP	19.4		
B-1017	SPT	280.31	0	0	0	0.641	1	A-1-b (0)	SW	24.1		
B-1017	SPT	299.99	16	0	16	0.186	15	A-2-4 (0)	SM	22.9		
B-1018	SPT	2.56	0	0	0	0.043	59	A-4 (0)	ML	23.8		
B-1018	SPT											
B-1018	ST											
B-1018	SPT	13.33	0	0	0	14.464	0	A-1-a (0)	GP	6.0		
B-1018	ST											
B-1018	SPT	19.88	0	0	0	1.167	25	A-1-b (0)	SM	17.6		
B-1018	SPT	23.16	0	0	0	0.177	9	A-3 (0)	SP-SM	29.3		
B-1018	ST											
B-1018	SPT	24.82	0	0	0	12.621	15	A-1-a (0)	GM	18.6		
B-1018	SPT	28.5	0	0	0	1.428	27	A-2-4 (0)	SM	12.5		
B-1018	SPT	33	0	0	0	1.685	27	A-2-4 (0)	SM	23.7		
B-1018	SPT	37.92	0	0	0	0.688	12	A-1-b (0)	SM	17.1		
B-1018	SPT	42.4	0	0	0	0.736	12	A-1-b (0)	SM	14.7		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1018	SPT	47.76	0	0	0	1.156	24	A-1-b (0)	SM	15.1		
B-1018	SPT	52.68	16	13	3	0.147	20	A-2-4 (0)	SM	24.7		
B-1018	ST											
B-1018	SPT	57.6	25	16	9	0.008	85	A-4 (6)	CL	22.5		
B-1018	ST	62.52	20	13	8	0.019	63	A-4 (2)	CL	23.7		
B-1018	ST											
B-1018	SPT	69.45	17	14	3	0.124	30	A-2-4 (0)	SM	22.4		
B-1018	SPT	72.36	13	13	0	0.163	13	A-2-4 (0)	SM	23.2		
B-1018	ST											
B-1018	SPT	77.28	12	12	0	0.156	17	A-2-4 (0)	SM	20.4		
B-1018	SPT	82.2	15	14	1	0.147	21	A-2-4 (0)	SM	22.9		
B-1018	SPT	87.12	17	13	4	0.156	22	A-2-4 (0)	SC-SM	22.2		
B-1018	ST	88.76	0	0	0	0.216	12	A-2-4 (0)	SP-SM	18.0		
B-1018	SPT	92.04	12	12	0	0.131	39	A-4 (0)	SM	21.4		
B-1018	SPT	96.96	14	0	14	0.232	29	A-2-4 (0)	SM	23.9		
B-1018	SPT	101.88	0	0	0	0.300	5	A-3 (0)	SP	21.2		
B-1018	SPT	111.72	13	12	1	0.139	34	A-2-4 (0)	SM	19.5		
B-1018	SPT	121.56	17	16	1	0.156	17	A-2-4 (0)	SM	26.6		
B-1018	SPT	131.46	0	0	0	0.475	3	A-1-b (0)	SP	21.6		
B-1018	SPT	141.24	0	0	0	0.811	8	A-1-b (0)	SW-SM	14.6		
B-1018	SPT	151.08	22	15	7	0.027	65	A-4 (2)	CL-ML	20.3		
B-1018	ST											
B-1018	SPT	160.92	0	0	0	0.180	2	A-3 (0)	SP	29.9		
B-1018	SPT	170.26	0	0	0	0.159	12	A-2-4 (0)	SM	28.8		
B-1018	SPT	180.6	0	0	0	0.237	16	A-2-4 (0)	SM	21.8		
B-1018	SPT	190.44	0	0	0	0.358	3	A-3 (0)	SP	21.2		
B-1018	SPT	200.28	0	0	0	0.475	7	A-1-b (0)	SP-SM	19.0		
B-1018	SPT	219.96	0	0	0	0.236	10	A-3 (0)	SP-SM	28.3		
B-1018	SPT											
B-1018	ST											
B-1018	SPT	261.33	0	0	0	0.702	2	A-1-b (0)	SW	22.8		
B-1018	ST											
B-1018	SPT	282.39	0	0	0	0.669	1	A-1-b (0)	SW	23.0		
B-1018	SPT	298.68	61	39	22	0.011	99	A-7-5 (30)	MH	34.7		
B-1020	SPT	3.5	0	0	0	0.184	3	A-3 (0)	SP	27.7		
B-1020	SPT	8.5	31	18	13	0.024	69	A-6 (7)	CL	46.7		
B-1020	ST											
B-1020	SPT	15.5	0	0	0	0.177	1	A-3 (0)	SP	26.1		
B-1020	SPT	18.5	30	18	12	0.015	82	A-6 (8)	CL	50.7		
B-1020	ST	23.5	47	30	17	0.005	100	A-7-5 (21)	ML	39.2		
B-1020	ST											
B-1020	SPT	28	0	0	0	0.238	13	A-2-4 (0)	SM	21.4		
B-1020	ST											
B-1020	SPT	34.5	0	0	0	1.735	25	A-1-b (0)	SM	16.4		
B-1020	SPT	38.5	24	0	24	0.224	9	A-3 (0)	SP-SM	24.0		
B-1020	SPT	43.5	0	0	0	0.817	24	A-1-b (0)	SM	14.1		
B-1020	ST											
B-1020	SPT	50	0	0	0	0.710	13	A-1-b (0)	SM	17.2		
B-1020	SPT	53.5	0	0	0	0.868	21	A-1-b (0)	SM	15.5		
B-1020	SPT	58.5	24	13	11	0.098	41	A-6 (1)	SC	23.6		

Total Jars: 0
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Project ID: S-033-2024
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Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1020	ST											
B-1020	SPT	65	15	12	3	0.120	32	A-2-4 (0)	SM	19.9		
B-1020	SPT	68.5	32	18	14	0.109	40	A-6 (2)	SC	27.5		
B-1020	ST	73.5	37	20	17	0.005	89	A-6 (15)	CL	32.2		
B-1020	ST	78.5	24	14	10	0.101	45	A-4 (1)	SC	23.9		
B-1020	SPT	83.5	17	15	2	0.594	13	A-1-b (0)	SM	20.3		
B-1020	ST	88.5	20	14	6	0.044	56	A-4 (0)	CL-ML	24.4		
B-1020	ST	93.5	23	13	10	0.046	55	A-4 (2)	CL	20.8		
B-1020	SPT	98.5	14	12	2	0.306	11	A-2-4 (0)	SP-SM	19.4		
B-1020	SPT	108.5	0	0	0	0.173	5	A-3 (0)	SP	26.0		
B-1020	SPT	118.5	22	0	22	0.187	10	A-3 (0)	SP-SM	23.5		
B-1020	SPT	128.5	0	0	0	0.387	4	A-3 (0)	SP	19.9		
B-1020	SPT	138.5	0	0	0	0.754	8	A-1-b (0)	SW-SM	27.3		
B-1020	SPT	148.5	0	0	0	0.728	2	A-1-b (0)	SW	19.1		
B-1020	SPT	158.5	0	0	0	0.718	4	A-1-b (0)	SW	25.2		
B-1020	SPT	168.5	14	0	14	0.131	33	A-2-4 (0)	SM	25.1		
B-1020	SPT	178.5	0	0	0	0.679	15	A-1-b (0)	SM	13.5		
B-1020	SPT	188.5	12	10	2	0.690	13	A-1-b (0)	SM	14.7		
B-1020	SPT	198.5	0	0	0	0.281	0	A-3 (0)	SP	26.0		
B-1020	SPT	218.5	0	0	0	0.317	6	A-3 (0)	SP-SM	21.8		
B-1020	SPT	239.5	39	28	11	0.127	37	A-6 (1)	SM	28.1		
B-1020	ST											
B-1020	ST	241.1	46	35	11	0.392	37	A-7-5 (1)	SM	25.1		
B-1020	ST	259.5	43	35	8	0.103	44	A-5 (1)	SM	21.4		
B-1020	SPT	279.5	41	29	12	0.600	24	A-2-7 (0)	SM	30.5		
B-1020	SPT	282.5	44	33	11	0.215	21	A-2-7 (0)	SM	33.1		
B-1021	ST											
B-1021	ST	7.92	0	0	0	0.210	6	A-3 (0)	SP-SM	28.0		
B-1021	SPT	12.84	0	0	0	0.175	6	A-3 (0)	SP-SM	30.8		
B-1021	SPT	17.76	28	15	13	0.139	25	A-2-6 (0)	SC	42.2		
B-1021	ST	22.68	51	26	25	0.008	98	A-7-6 (29)	CH	47.0		
B-1021	SPT	27.6	0	0	0	0.265	14	A-2-4 (0)	SM	17.2		
B-1021	SPT	32.52	0	0	0	0.563	16	A-1-b (0)	SM	17.1		
B-1021	SPT	37.44	0	0	0	0.829	16	A-1-b (0)	SM	15.3		
B-1021	SPT	42.36	0	0	0	0.153	18	A-2-4 (0)	SM	22.8		
B-1021	SPT	47.28	39	22	17	0.012	74	A-6 (12)	CL	81.1		
B-1021	SPT	47.78	0	0	0	0.466	10	A-1-b (0)	SP-SM	19.0		
B-1021	SPT	52.2	0	0	0	0.414	6	A-3 (0)	SP-SM	17.3		
B-1021	SPT	57.12	0	0	0	19.597	5	A-1-a (0)	GP-GM	14.8		
B-1021	SPT	62.04	0	0	0	0.857	29	A-2-4 (0)	SM	15.1		
B-1021	SPT	66.96	16	15	1	0.129	28	A-2-4 (0)	SM	25.4		
B-1021	SPT	71.88	29	15	14	0.005	83	A-6 (10)	CL	23.0		
B-1021	SPT	76.8	15	12	3	0.170	16	A-2-4 (0)	SM	22.6		
B-1021	SPT	81.72	20	13	7	0.037	57	A-4 (1)	CL-ML	22.7		
B-1021	SPT	86.64	20	13	7	0.097	42	A-4 (0)	SC-SM	22.5		
B-1021	SPT	91.56	18	11	7	0.031	59	A-4 (1)	CL-ML	24.5		
B-1021	SPT	96.48	16	12	4	0.279	27	A-2-4 (0)	SC-SM	21.2		
B-1021	SPT	101.4	16	11	5	0.177	37	A-4 (0)	SC-SM	22.5		
B-1021	SPT	111.24	14	0	14	0.132	26	A-2-4 (0)	SM	25.9		
B-1021	SPT	121.08	11	11	0	0.306	25	A-2-4 (0)	SM	21.1		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
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Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1021	SPT	130.92	0	0	0	0.671	9	A-1-b (0)	SW-SM	20.4		
B-1021	SPT	140.76	0	0	0	0.702	4	A-1-b (0)	SW	20.0		
B-1021	SPT	150.6	0	0	0	0.817	3	A-1-b (0)	SP	19.3		
B-1021	SPT	160.44	0	0	0	0.179	6	A-3 (0)	SP-SM	29.3		
B-1021	SPT	170.28	0	0	0	0.173	26	A-2-4 (0)	SM	24.1		
B-1021	SPT	180.12	0	0	0	0.273	8	A-3 (0)	SP-SM	22.3		
B-1021	SPT	189.96	0	0	0	0.189	7	A-3 (0)	SP-SM	25.4		
B-1021	SPT	199.8	0	0	0	0.684	2	A-1-b (0)	SW	21.2		
B-1021	SPT	219.48	0	0	0	0.213	6	A-3 (0)	SP-SM	26.4		
B-1021	SPT	239.16	32	19	13	0.012	98	A-6 (13)	CL	26.8		
B-1021	SPT	258.84	38	36	2	0.146	31	A-2-4 (0)	SM	34.6		
B-1021	ST	264.11	49	36	13	0.230	35	A-2-7 (1)	SM	34.0		
B-1021	SPT	278.87	43	34	9	0.093	47	A-5 (2)	SM	28.3		
B-1021	SPT	298.55	49	33	16	0.006	99	A-7-5 (21)	ML	27.1		
B-1023	ST	3.75	28	18	10	0.013	80	A-4 (6)	CL	31.3		
B-1023	SPT	8.4	18	14	4	0.053	54	A-4 (0)	CL-ML	35.2		
B-1023	SPT	12.42	15	0	15	0.147	40	A-4 (0)	SM	29.0		
B-1023	SPT	17.34	0	0	0	0.935	21	A-1-b (0)	SM	19.6		
B-1023	SPT	22.26	0	0	0	0.708	12	A-1-b (0)	SM	21.3		
B-1023	SPT	27.18	0	0	0	3.571	24	A-1-b (0)	GM	18.6		
B-1023	SPT	32.9	0	0	0	2.478	25	A-1-b (0)	SM	20.9		
B-1023	SPT	37.02	0	0	0	3.966	0	A-1-a (0)	SP	34.6		
B-1023	SPT	41.94	0	0	0	0.230	10	A-3 (0)	SP-SM	19.1		
B-1023	SPT	46.56	0	0	0	0.169	10	A-3 (0)	SP-SM	27.8		
B-1023	SPT	47.56	47	29	18	0.012	90	A-7-6 (19)	ML	34.3		
B-1023	ST	48.06	43	32	11	0.011	93	A-7-5 (13)	ML	20.6		
B-1023	ST											
B-1023	ST	53.66	18	17	1	0.140	22	A-2-4 (0)	SM	25.9		
B-1023	SPT	57.8	26	14	12	0.020	62	A-6 (4)	CL	29.4		
B-1023	ST											
B-1023	SPT	64.72	23	11	12	0.025	60	A-6 (4)	CL	25.6		
B-1023	SPT	67.64	26	15	11	0.023	63	A-6 (4)	CL	24.5		
B-1023	SPT	72.56	17	13	4	0.142	22	A-2-4 (0)	SC-SM	24.6		
B-1023	ST	77.48	18	16	2	0.147	21	A-2-4 (0)	SM	20.4		
B-1023	SPT	78.65	19	12	7	0.142	22	A-2-4 (0)	SC-SM	23.7		
B-1023	SPT	82.4	15	14	1	0.137	24	A-2-4 (0)	SM	24.5		
B-1023	SPT	87.32	16	13	3	0.153	18	A-2-4 (0)	SM	23.7		
B-1023	ST											
B-1023	SPT	92.25	16	13	3	0.161	21	A-2-4 (0)	SM	15.9		
B-1023	SPT	97.16	15	15	0	0.210	17	A-2-4 (0)	SM	19.6		
B-1023	SPT	107	15	13	2	0.287	16	A-2-4 (0)	SM	19.3		
B-1023	SPT	116.84	18	17	1	0.203	8	A-2-4 (0)	SP-SM	22.7		
B-1023	SPT	126.68	0	0	0	0.633	4	A-1-b (0)	SW	20.7		
B-1023	SPT	136.52	0	0	0	0.783	2	A-1-b (0)	SP	19.7		
B-1023	SPT	146.36	0	0	0	0.763	7	A-1-b (0)	SW-SM	19.2		
B-1023	SPT	156.2	0	0	0	0.740	1	A-1-b (0)	SP	21.0		
B-1024	SPT	3.77	0	0	0	10.322	15	A-1-a (0)	GM	19.0		
B-1024	SPT	8.69	0	0	0	0.949	10	A-1-b (0)	SP-SM	18.5		
B-1024	SPT	13.61	0	0	0	0.853	2	A-1-b (0)	SP	21.2		
B-1024	SPT	18.53	0	0	0	0.832	2	A-1-b (0)	SP	18.8		

Total Jars: 0
Total SPT: 0
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Project ID: S-033-2024
Location: Ballard
Item No: 01-1140.00

Hole	Sample Type	Depth	Liquid Limit	Plastic Limit	PI	D50	%<#200 Sieve	AASHTO	Classif-ication	Water Content (%)	Dry Density (pcf)	CBR
B-1024	SPT	23.45	0	0	0	1.236	25	A-1-b (0)	SM	14.1		
B-1024	SPT	28.37	19	14	5	0.153	18	A-2-4 (0)	SC-SM	26.7		
B-1024	SPT	33.29	17	13	4	0.154	17	A-2-4 (0)	SC-SM	24.9		
B-1024	ST	34.93	36	27	9	0.151	18	A-2-4 (0)	SM	21.6		
B-1024	SPT	38.21	16	13	3	0.147	19	A-2-4 (0)	SM	25.1		
B-1024	SPT	43.13	18	16	2	0.128	28	A-2-4 (0)	SM	21.0		
B-1024	SPT	48.05	16	12	4	0.132	33	A-2-4 (0)	SC-SM	22.3		
B-1024	SPT	52.97	13	12	1	0.154	19	A-2-4 (0)	SM	22.3		
B-1024	SPT	57.89	33	18	15	0.006	90	A-6 (13)	CL	23.8		
B-1024	SPT	58.69	0	0	0	0.321	3	A-3 (0)	SP	23.6		
B-1024	SPT	62.81	29	17	12	0.008	84	A-6 (8)	CL	24.2		
B-1024	SPT	63.51	0	0	0	0.188	23	A-2-4 (0)	SM	22.2		
B-1024	SPT	67.73	0	0	0	0.164	11	A-2-4 (0)	SP-SM	23.4		
B-1024	SPT	72.65	0	0	0	0.172	9	A-3 (0)	SP-SM	24.9		
B-1024	SPT	77.57	0	0	0	0.577	2	A-1-b (0)	SW	20.1		
B-1024	SPT	82.49	0	0	0	0.826	2	A-1-b (0)	SP	19.5		
B-1024	SPT	87.41	19	0	19	0.169	6	A-3 (0)	SP-SM	26.7		
B-1024	SPT	92.33	0	0	0	0.165	9	A-3 (0)	SP-SM	25.5		
B-1024	SPT	97.25	0	0	0	0.172	7	A-3 (0)	SP-SM	23.3		
B-1024	SPT	102.17	0	0	0	0.808	1	A-1-b (0)	SP	19.2		
B-1024	ST											
B-1024	SPT	112.01	0	0	0	0.889	0	A-1-b (0)	SP	20.5		
B-1024	SPT	121.85	0	0	0	0.811	7	A-1-b (0)	SW-SM	17.2		
B-1024	ST											
B-1024	SPT	131.69	0	0	0	0.679	2	A-1-b (0)	SW	18.7		
B-1024	SPT	141.53	0	0	0	0.703	19	A-1-b (0)	SM	19.3		
B-1024	SPT	151.37	0	0	0	0.208	2	A-3 (0)	SP	21.8		

Total Jars: 0
Total SPT: 0
Total ST: 0
Total Cut Bags: 0
Total Fill Bags: 0

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1013
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 74.4' to 76.4'
LABORATORY #	: 10174706	DATE TESTED	: 10/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/30/2024

SOIL TYPE : Brown Lean Clay with Sand

WET DENSITY	: 132.2 pcf	DELTA HEIGHT	: 0.31 cm	INITIAL HEIGHT	: 14.83 cm
DRY DENSITY	: 109.6 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.15 cm
MOISTURE	: 20.63 %	CHAMBER PRES.	: 87.74 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	87.74	87.74	1.00
2	0.09	87.74	90.76	1.03
3	0.18	87.74	92.05	1.05
4	0.26	87.74	93.34	1.06
5	0.35	87.74	94.19	1.07
6	0.44	87.74	95.05	1.08
7	0.53	87.74	95.68	1.09
8	1.05	87.74	99.65	1.14
9	1.58	87.74	102.85	1.17
10	2.10	87.74	106.02	1.21
11	2.63	87.74	109.65	1.25
12	3.15	87.74	113.8	1.3
13	3.50	87.74	115.65	1.32
14	4.38	87.74	120.05	1.37
15	5.25	87.74	122.03	1.39
16	6.13	87.74	126.31	1.44
17	7.00	87.74	130.25	1.48
18	7.88	87.74	132.74	1.51
19	8.75	87.74	135.01	1.54
20	9.63	87.74	136.86	1.56
21	10.50	87.74	137.71	1.57
22	11.38	87.74	137.6	1.57
23	12.25	87.74	136.92	1.56
24	13.13	87.74	135.51	1.54
25	14.00	87.74	134.84	1.54

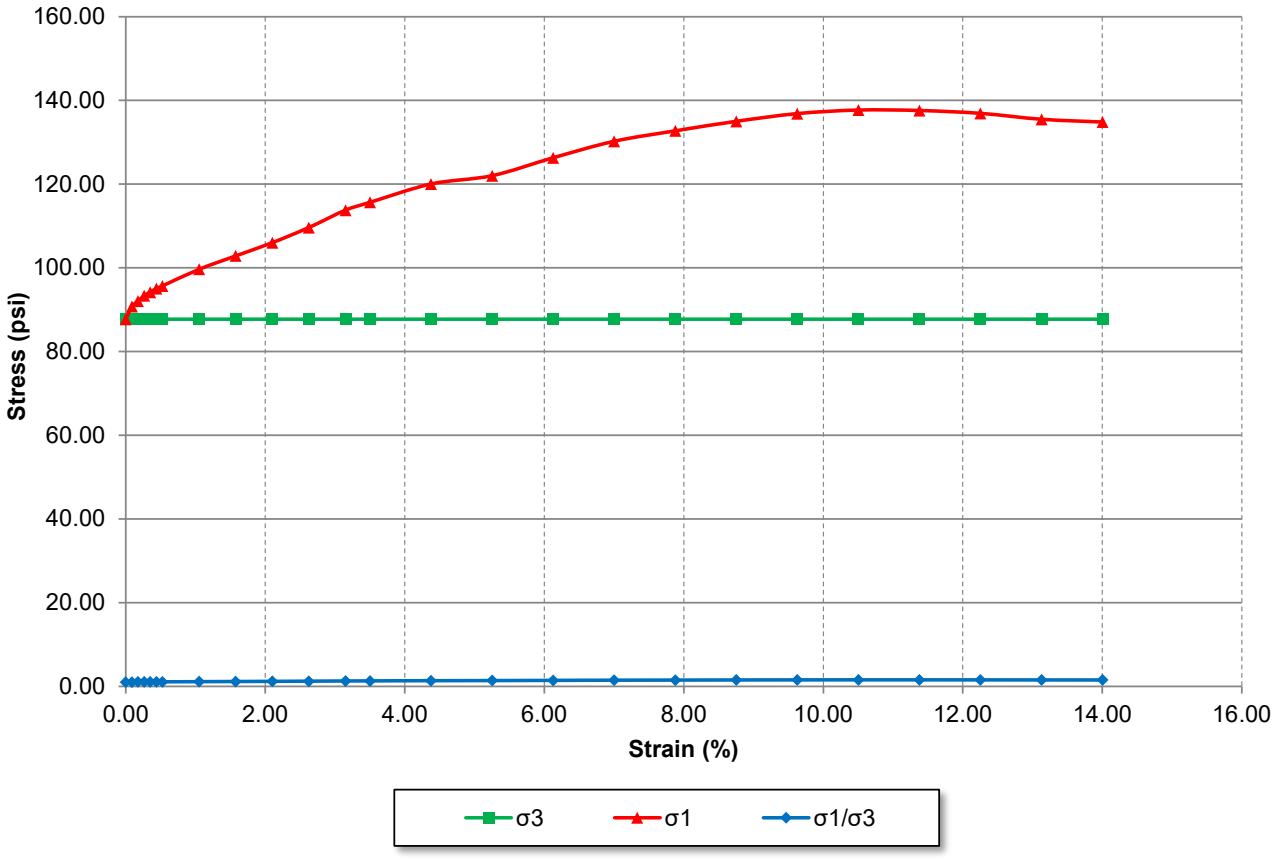
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1013
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 74.4' to 76.4'
LABORATORY #	: 10174706	DATE TESTED	: 10/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/30/2024

FINAL MOISTURE	: 20.63 %	EFF. CONS. STRESS	: 87.74 psi
FINAL HEIGHT	: 12.48 cm	SPECIFIC GRAVITY	: 2.63
FINAL DIAMETER	: 7.7 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1013
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 74.4' to 76.4'
LABORATORY #	: 10174706	DATE TESTED	: 10/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/30/2024

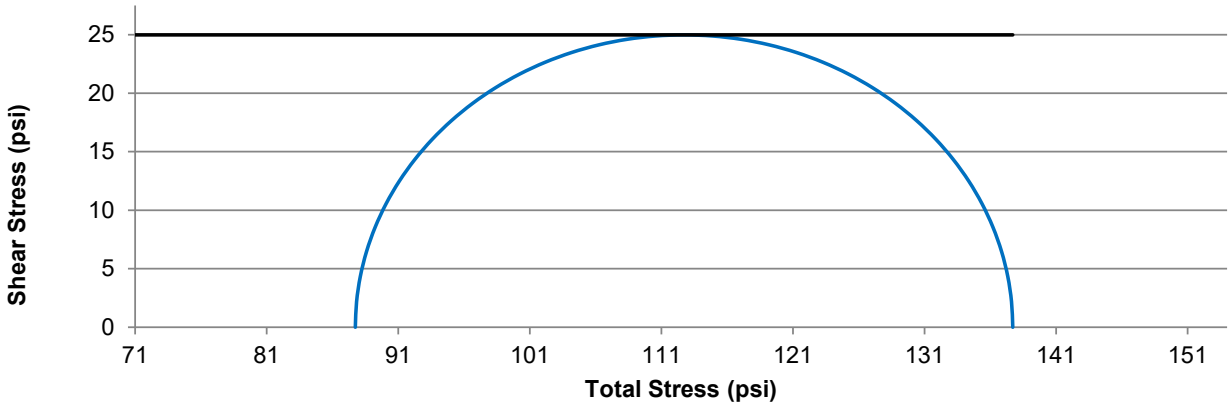
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	87.74 psi	137.71 psi

Compressive Strength =	7196	psf
Cohesion =	3598	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1017
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 65.5' to 66.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024
SOIL TYPE	: Off-White Lean Clay		
WET DENSITY	: 129.51 pcf	DELTA HEIGHT	: 0.43 cm
DRY DENSITY	: 108.4 pcf	DELTA VOLUME	: NA
MOISTURE	: 19.48 %	CHAMBER PRES.	: 74.79 psi
		INITIAL HEIGHT	: 14.65 cm
		INITIAL DIAMETER	: 7.34 cm
		COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	74.79	74.79	1.00
2	0.09	74.79	79.87	1.07
3	0.18	74.79	82.9	1.11
4	0.27	74.79	85.71	1.15
5	0.36	74.79	87.45	1.17
6	0.45	74.79	88.81	1.19
7	0.54	74.79	90.15	1.21
8	1.07	74.79	95.76	1.28
9	1.61	74.79	101.68	1.36
10	2.14	74.79	105.44	1.41
11	2.68	74.79	107.32	1.44
12	3.21	74.79	110.79	1.48
13	3.57	74.79	114.31	1.53
14	4.46	74.79	123.72	1.65
15	5.36	74.79	133.2	1.78
16	6.25	74.79	134.51	1.8
17	7.14	74.79	133.94	1.79
18	8.04	74.79	133.37	1.78
19	8.93	74.79	132.8	1.78
20	9.82	74.79	132.23	1.77
21	10.72	74.79	131.66	1.76
22	11.61	74.79	131.09	1.75
23	12.50	74.79	130.52	1.75
24	13.39	74.79	129.96	1.74
25	14.29	74.79	129.39	1.73
26	15.18	74.79	128.82	1.72
27	16.07	74.79	128.25	1.71
28	16.97	74.79	127.68	1.71
29	17.86	74.79	127.11	1.7
30	18.75	74.79	126.54	1.69
31	19.65	74.79	125.97	1.68

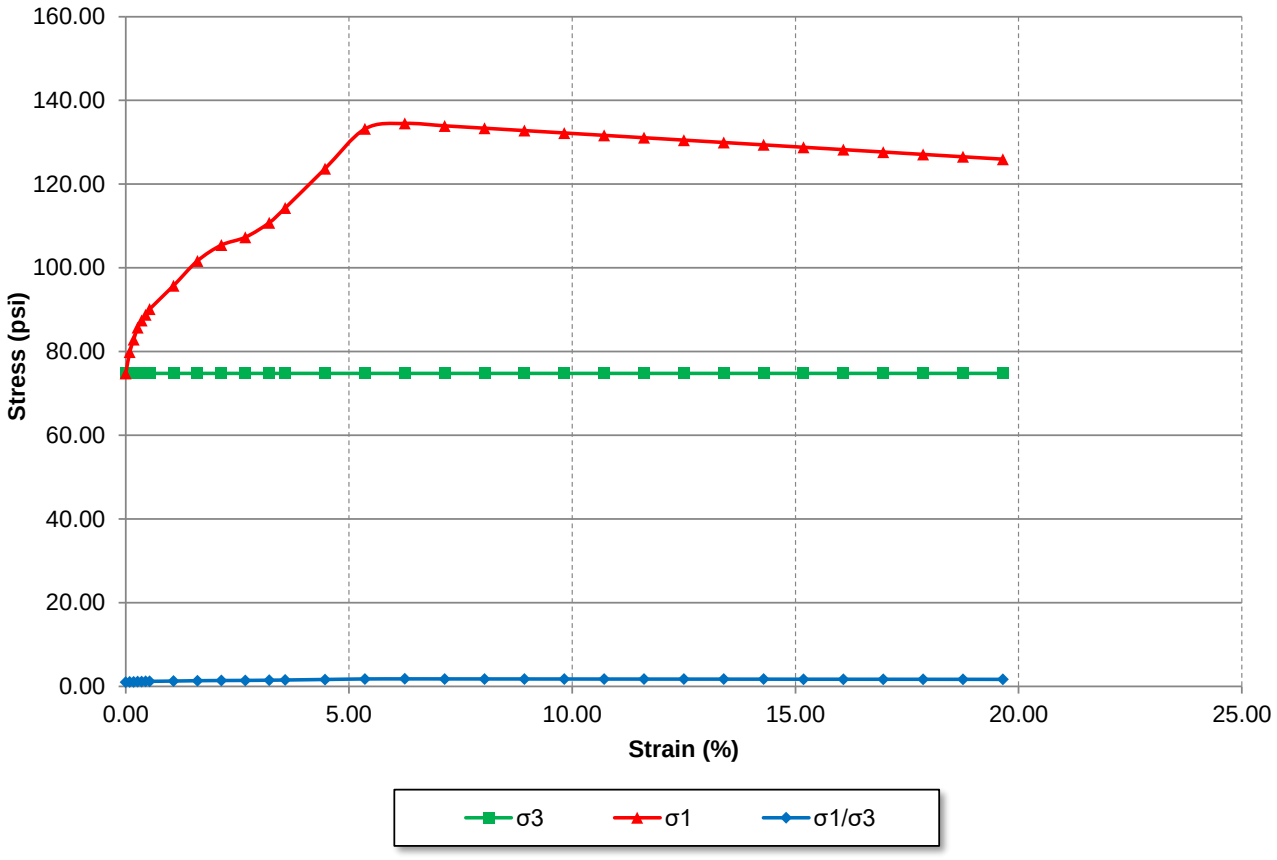
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1017
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 65.5' to 66.0'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/29/2024
LABORATORY #	: 10174706	DATE REPORTED	: 10/2/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 19.48 %	EFF. CONS. STRESS	: 74.79 psi
FINAL HEIGHT	: 11.43 cm	SPECIFIC GRAVITY	: 2.63
FINAL DIAMETER	: 8.16 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1017
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 65.5' to 66.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024

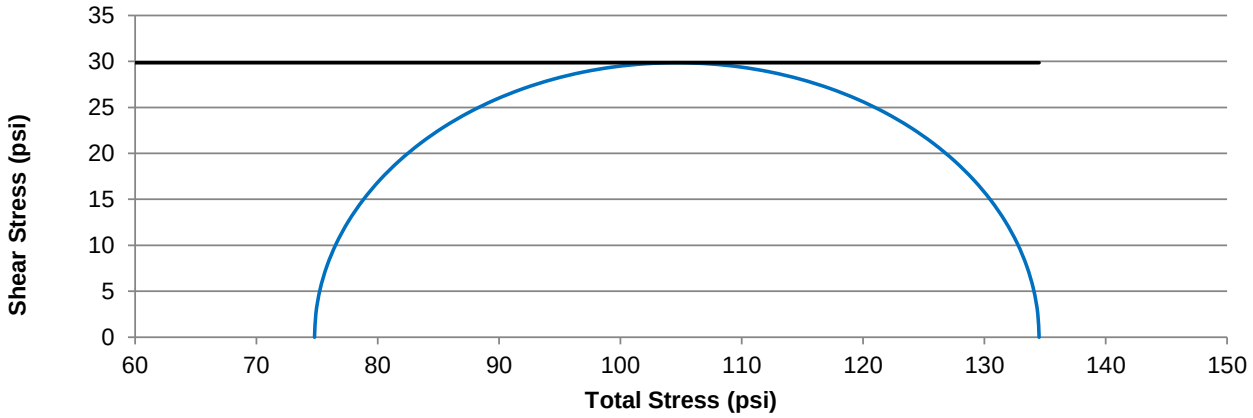
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	74.79 psi	134.51 psi

Compressive Strength =	8600	psf
Cohesion =	4300	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1018
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 63.0' to 63.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024
SOIL TYPE	: Gray & Brown Sandy Lean Clay		
WET DENSITY	: 134.65 pcf	DELTA HEIGHT	: 0.45 cm
DRY DENSITY	: 109.3 pcf	DELTA VOLUME	: NA
MOISTURE	: 23.19 %	CHAMBER PRES.	: 75.78 psi

	INITIAL HEIGHT	: 14.77 cm
	INITIAL DIAMETER	: 6.99 cm
	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	75.78	75.78	1.00
2	0.09	75.78	76.68	1.01
3	0.18	75.78	77.12	1.02
4	0.27	75.78	77.35	1.02
5	0.35	75.78	77.57	1.02
6	0.44	75.78	77.57	1.02
7	0.53	75.78	77.79	1.03
8	1.06	75.78	79.33	1.05
9	1.60	75.78	81.07	1.07
10	2.13	75.78	82.35	1.09
11	2.66	75.78	83.84	1.11
12	3.19	75.78	84.67	1.12
13	3.55	75.78	85.07	1.12
14	4.44	75.78	86.26	1.14
15	5.32	75.78	87.6	1.16
16	6.21	75.78	88.9	1.17
17	7.10	75.78	89.58	1.18
18	7.99	75.78	90.43	1.19
19	8.87	75.78	91.27	1.2
20	9.76	75.78	92.09	1.22
21	10.65	75.78	92.7	1.22
22	11.54	75.78	93.1	1.23
23	12.42	75.78	93.68	1.24
24	13.31	75.78	94.25	1.24
25	14.20	75.78	94.43	1.25
26	15.08	75.78	94.65	1.25
27	15.97	75.78	94.69	1.25
28	16.86	75.78	94.72	1.25
29	17.75	75.78	94.63	1.25
30	18.63	75.78	94.54	1.25
31	19.52	75.78	94.56	1.25
32	20.41	75.78	94.57	1.25

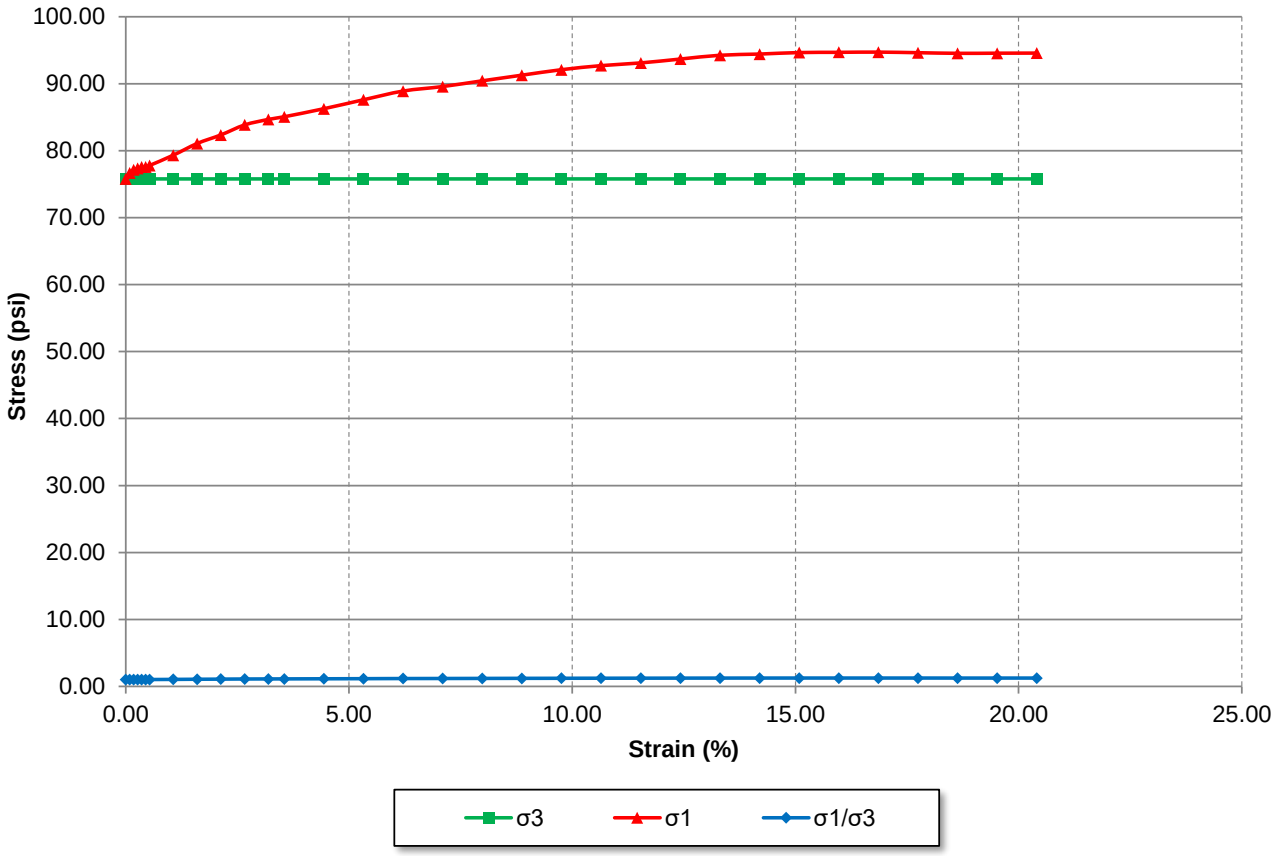
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1018
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 63.0' to 63.5'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/28/2024
LABORATORY #	: 10174706	DATE REPORTED	: 9/4/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 23.19 %	EFF. CONS. STRESS	: 75.78 psi
FINAL HEIGHT	: 11.39 cm	SPECIFIC GRAVITY	: 2.64
FINAL DIAMETER	: 7.81 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1018
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 63.0' to 63.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

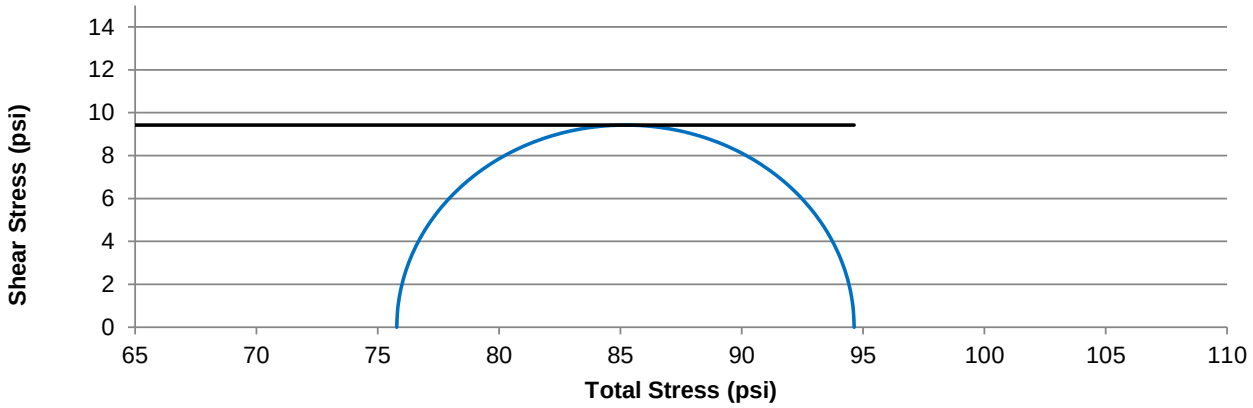
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	75.78 psi	94.63 psi

Compressive Strength =	2714	psf
Cohesion =	1357	psf
Phi =	0	deg
Tan (Phi) =	0	

At Maximum Deviator Stress 15%

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 24.5' to 25.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/26/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 8/28/2024
SOIL TYPE	: Dark Gray Silt		

WET DENSITY	: 114.13 pcf	DELTA HEIGHT	: 0.45 cm	INITIAL HEIGHT	: 15.03 cm
DRY DENSITY	: 78.25 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.07 cm
MOISTURE	: 45.85 %	CHAMBER PRES.	: 35.93 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	35.93	35.93	1.00
2	0.09	35.93	36.81	1.02
3	0.17	35.93	37.03	1.03
4	0.26	35.93	37.25	1.04
5	0.35	35.93	37.46	1.04
6	0.44	35.93	37.68	1.05
7	0.52	35.93	37.68	1.05
8	1.05	35.93	38.75	1.08
9	1.57	35.93	39.39	1.1
10	2.09	35.93	40.23	1.12
11	2.61	35.93	40.84	1.14
12	3.14	35.93	41.67	1.16
13	3.48	35.93	42.49	1.18
14	4.36	35.93	42.64	1.19
15	5.23	35.93	43	1.2
16	6.10	35.93	43.55	1.21
17	6.97	35.93	43.68	1.22
18	7.84	35.93	43.61	1.21
19	8.71	35.93	43.74	1.22
20	9.58	35.93	43.66	1.22
21	10.45	35.93	43.78	1.22
22	11.32	35.93	43.7	1.22
23	12.20	35.93	43.63	1.21
24	13.07	35.93	43.55	1.21
25	13.94	35.93	43.47	1.21
26	14.81	35.93	43.4	1.21
27	15.68	35.93	43.32	1.21
28	16.55	35.93	43.24	1.2
29	17.42	35.93	43.17	1.2
30	18.29	35.93	43.09	1.2
31	19.16	35.93	43.01	1.2
32	20.04	35.93	42.94	1.19

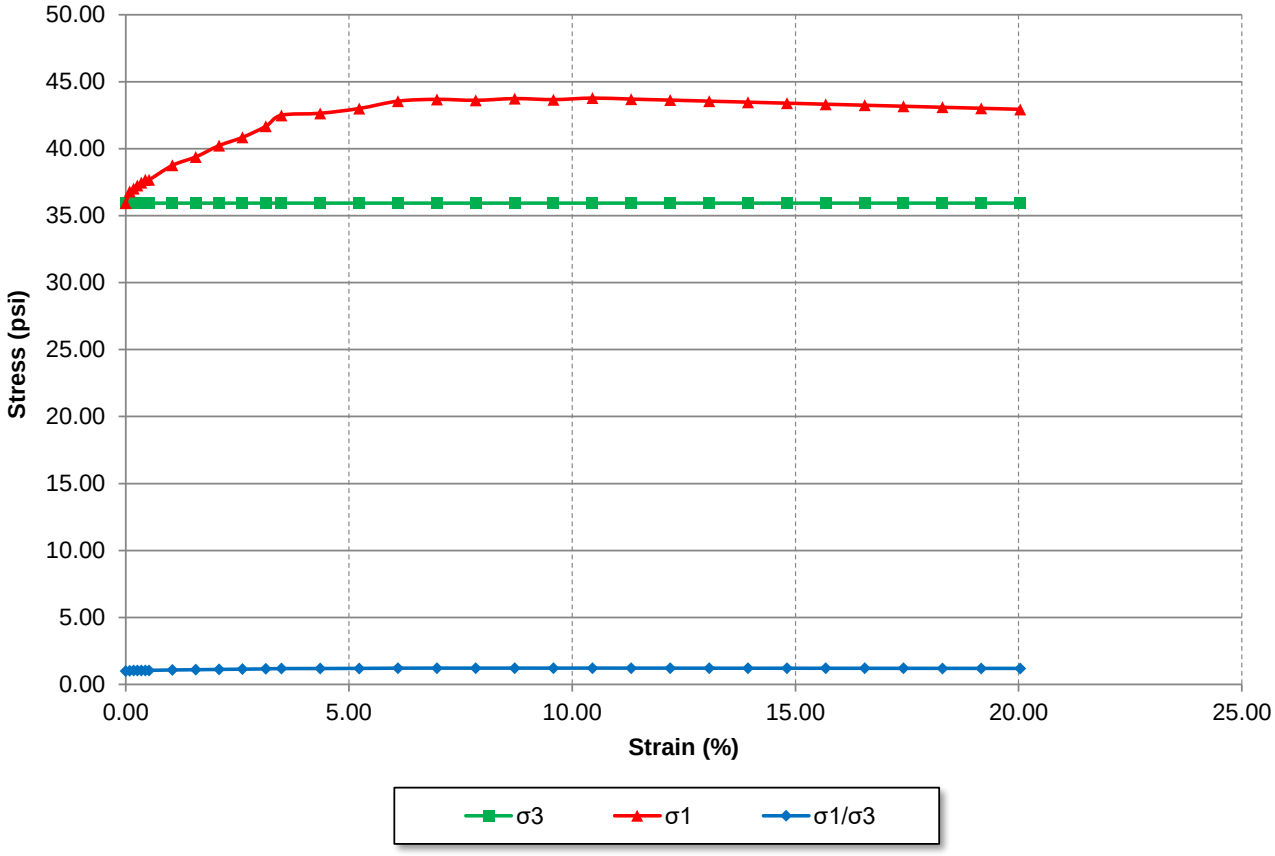
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 24.5' to 25.0'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/26/2024
LABORATORY #	: 10174706	DATE REPORTED	: 8/28/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 45.85 %	EFF. CONS. STRESS	: 35.93 psi
FINAL HEIGHT	: 11.66 cm	SPECIFIC GRAVITY	: 2.7
FINAL DIAMETER	: 7.87 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 24.5' to 25.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/26/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 8/28/2024

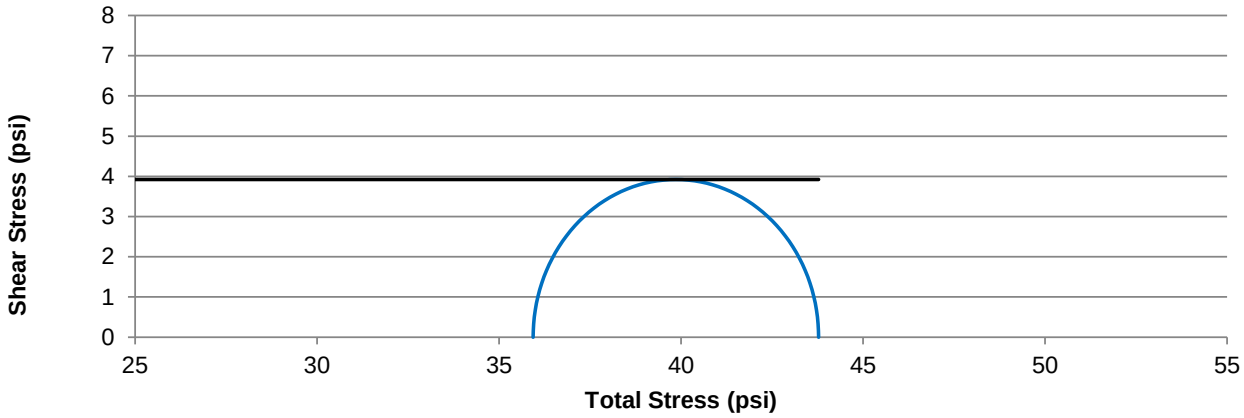
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	35.93 psi	43.78 psi

Compressive Strength =	1130	psf
Cohesion =	565	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

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Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 74.5' to 75.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024
SOIL TYPE	: Gray Lean Clay		
WET DENSITY	: 119.8 pcf	DELTA HEIGHT	: 0.45 cm
DRY DENSITY	: 93.74 pcf	DELTA VOLUME	: NA
MOISTURE	: 27.8 %	CHAMBER PRES.	: 75.78 psi
RESULTS:			

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	75.78	75.78	1.00
2	0.09	75.78	79.26	1.05
3	0.18	75.78	81.09	1.07
4	0.27	75.78	82.31	1.09
5	0.36	75.78	83.53	1.1
6	0.45	75.78	84.13	1.11
7	0.54	75.78	85.35	1.13
8	1.07	75.78	89.6	1.18
9	1.61	75.78	94.94	1.25
10	2.14	75.78	99.5	1.31
11	2.68	75.78	102.61	1.35
12	3.21	75.78	103.83	1.37
13	3.57	75.78	104.18	1.37
14	4.46	75.78	104.67	1.38
15	5.36	75.78	105.04	1.39
16	6.25	75.78	105.24	1.39
17	7.14	75.78	105.11	1.39
18	8.03	75.78	104.75	1.38
19	8.93	75.78	104.32	1.38
20	9.82	75.78	104.11	1.37
21	10.71	75.78	104.14	1.37
22	11.60	75.78	103.85	1.37
23	12.50	75.78	103.57	1.37
24	13.39	75.78	103.58	1.37
25	14.28	75.78	103.58	1.37
26	15.18	75.78	103.22	1.36
27	16.07	75.78	103	1.36
28	16.96	75.78	102.64	1.35
29	17.85	75.78	102.49	1.35
30	18.75	75.78	102.07	1.35
31	19.64	75.78	101.71	1.34
32	20.53	75.78	101.42	1.34

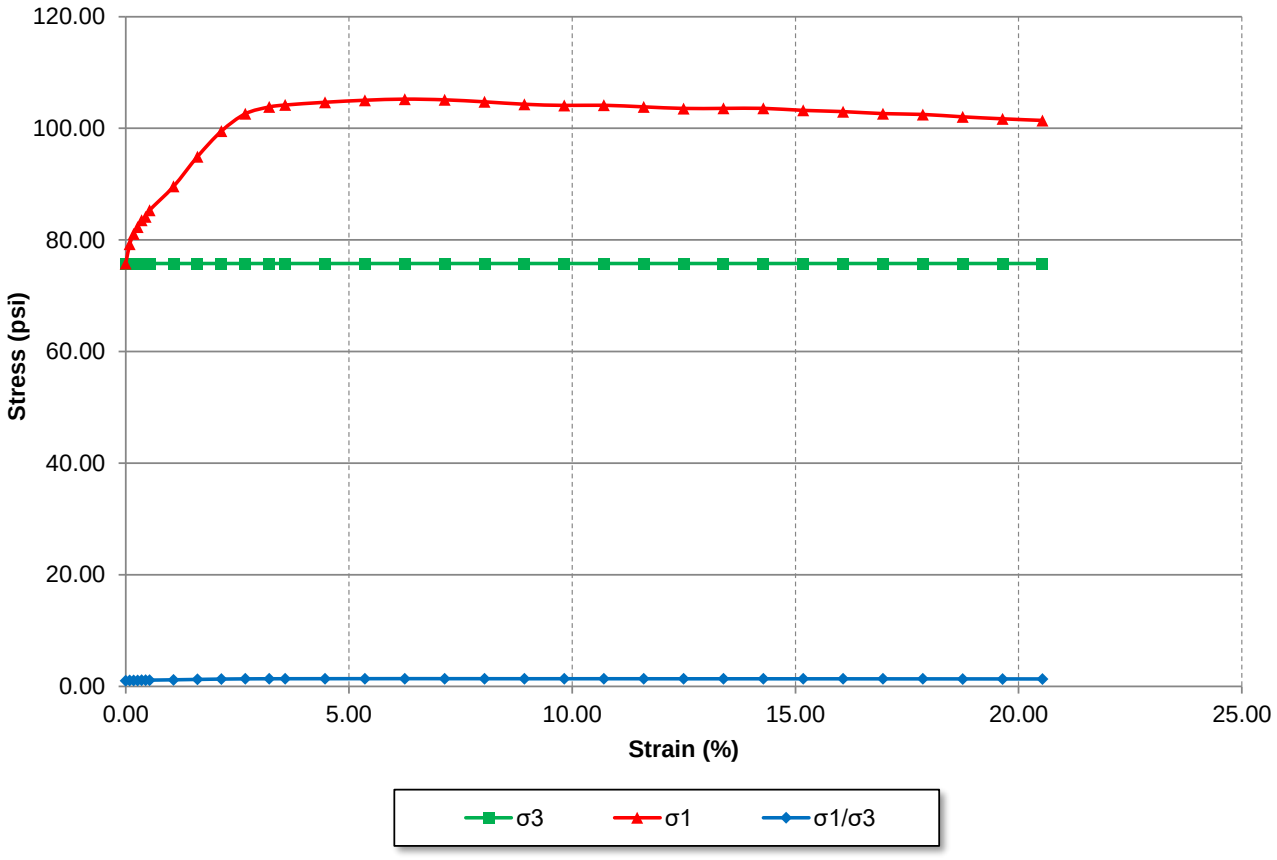
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 74.5' to 75.0'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/28/2024
LABORATORY #	: 10174706	DATE REPORTED	: 9/4/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 27.8 %	EFF. CONS. STRESS	: 75.78 psi
FINAL HEIGHT	: 11.31 cm	SPECIFIC GRAVITY	: 2.77
FINAL DIAMETER	: 8.17 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 74.5' to 75.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

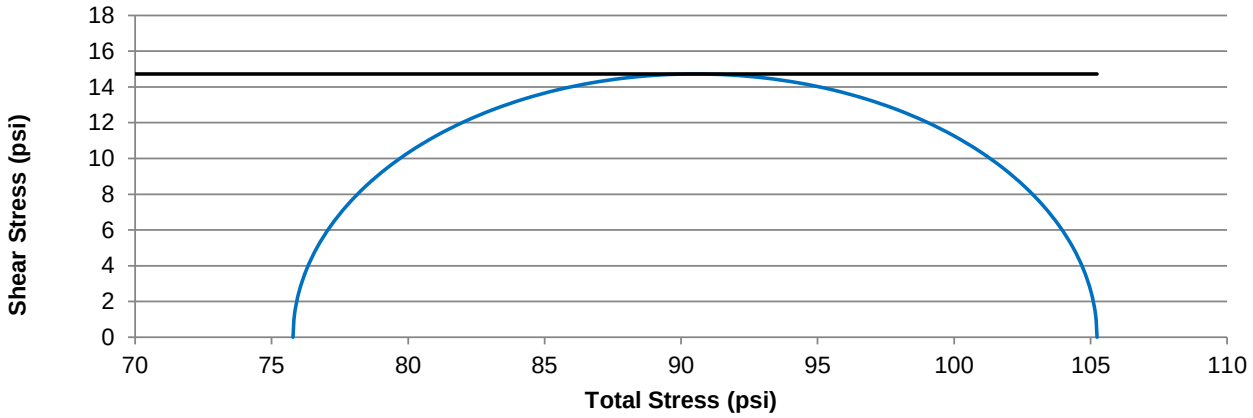
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	75.78 psi	105.24 psi

Compressive Strength =	4241	psf
Cohesion =	2121	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 78.5' to 79.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024
SOIL TYPE	: Gray Clayey Sand		
WET DENSITY	: 128.36 pcf	DELTA HEIGHT	: 0.45 cm
DRY DENSITY	: 102.53 pcf	DELTA VOLUME	: NA
MOISTURE	: 25.2 %	CHAMBER PRES.	: 80.76 psi
		INITIAL HEIGHT	: 14.77 cm
		INITIAL DIAMETER	: 7.18 cm
		COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	80.76	80.76	1.00
2	0.09	80.76	80.98	1
3	0.18	80.76	80.98	1
4	0.27	80.76	81.19	1.01
5	0.35	80.76	81.4	1.01
6	0.44	80.76	81.82	1.01
7	0.53	80.76	82.03	1.02
8	1.06	80.76	82.86	1.03
9	1.60	80.76	83.69	1.04
10	2.13	80.76	84.5	1.05
11	2.66	80.76	85.72	1.06
12	3.19	80.76	86.92	1.08
13	3.55	80.76	87.52	1.08
14	4.44	80.76	89.08	1.1
15	5.32	80.76	90.41	1.12
16	6.21	80.76	91.86	1.14
17	7.10	80.76	93.46	1.16
18	7.98	80.76	94.28	1.17
19	8.87	80.76	94.33	1.17
20	9.76	80.76	94.57	1.17
21	10.64	80.76	95.71	1.19
22	11.53	80.76	95.74	1.19
23	12.42	80.76	95.77	1.19
24	13.31	80.76	96.15	1.19
25	14.19	80.76	96.69	1.2
26	15.08	80.76	96.7	1.2
27	15.97	80.76	96.7	1.2
28	16.85	80.76	96.7	1.2
29	17.74	80.76	97.04	1.2
30	18.63	80.76	97.03	1.2
31	19.51	80.76	97.01	1.2
32	20.40	80.76	97	1.2

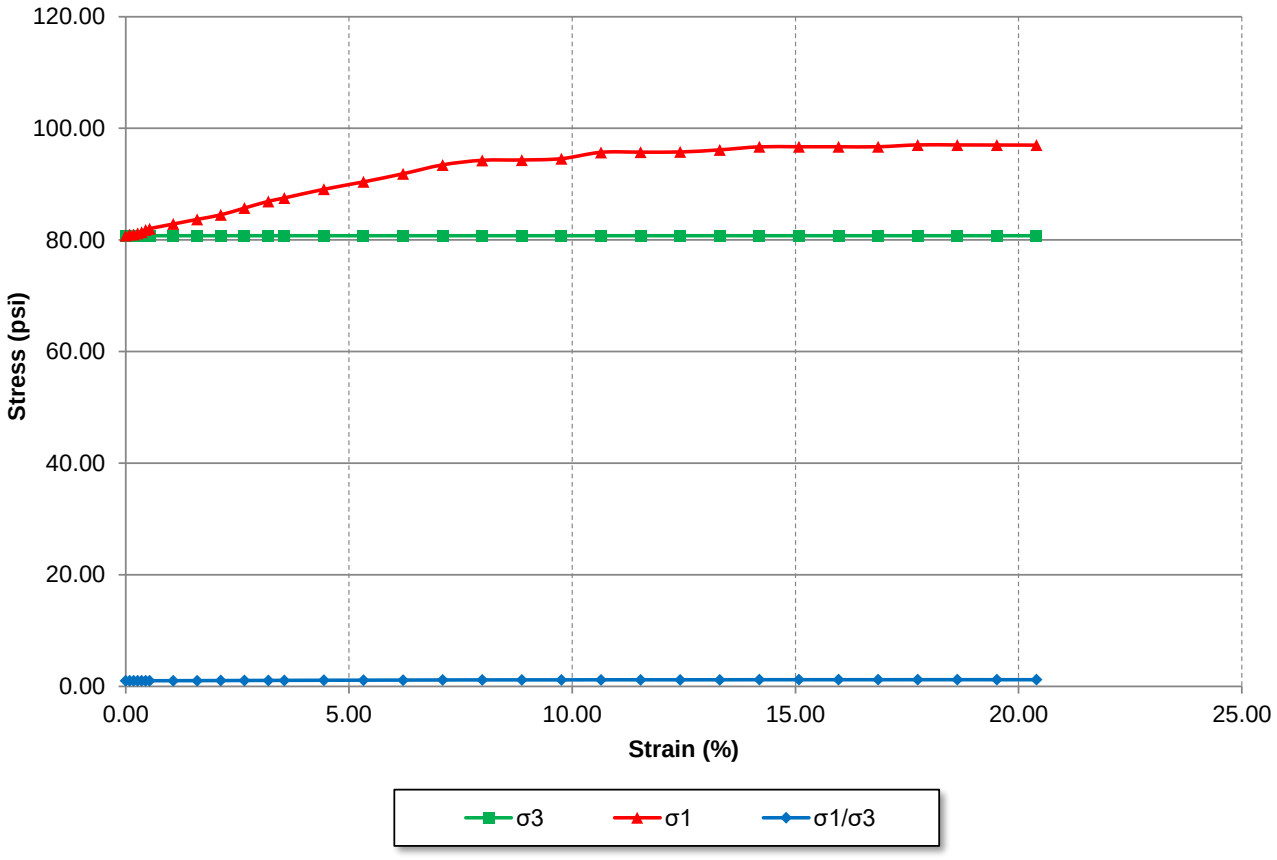
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 78.5' to 79.0'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/28/2024
LABORATORY #	: 10174706	DATE REPORTED	: 9/4/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 25.2 %	EFF. CONS. STRESS	: 80.76 psi
FINAL HEIGHT	: 11.4 cm	SPECIFIC GRAVITY	: 2.63
FINAL DIAMETER	: 8.02 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 78.5' to 79.0'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

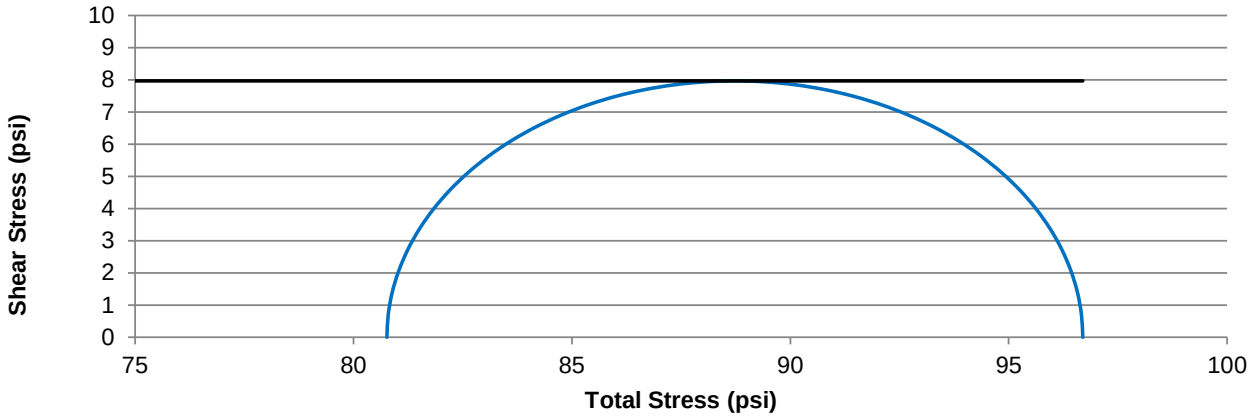
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	80.76 psi	96.7 psi

Compressive Strength =	2294	psf
Cohesion =	1147	psf
Phi =	0	deg
Tan (Phi) =	0	

At Maximum Deviator Stress 15%

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 89.0' to 89.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

SOIL TYPE	: Gray Sandy, Silty Clay				
WET DENSITY	: 132.22 pcf	DELTA HEIGHT	: 0.45 cm	INITIAL HEIGHT	: 14.56 cm
DRY DENSITY	: 108.99 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.17 cm
MOISTURE	: 21.31 %	CHAMBER PRES.	: 88.73 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	88.73	88.73	1.00
2	0.09	88.73	90.85	1.02
3	0.18	88.73	91.92	1.04
4	0.27	88.73	92.98	1.05
5	0.36	88.73	93.6	1.05
6	0.45	88.73	93.81	1.06
7	0.54	88.73	94.44	1.06
8	1.08	88.73	96.93	1.09
9	1.62	88.73	98.98	1.12
10	2.16	88.73	101.33	1.14
11	2.70	88.73	103.44	1.17
12	3.24	88.73	105.54	1.19
13	3.60	88.73	106.65	1.2
14	4.50	88.73	109.51	1.23
15	5.40	88.73	112.67	1.27
16	6.30	88.73	114.95	1.3
17	7.20	88.73	116.52	1.31
18	8.10	88.73	117.68	1.33
19	9.00	88.73	118.35	1.33
20	9.90	88.73	118.93	1.34
21	10.80	88.73	119.1	1.34
22	11.70	88.73	119.02	1.34
23	12.60	88.73	119.1	1.34
24	13.51	88.73	118.94	1.34
25	14.41	88.73	118.92	1.34
26	15.31	88.73	118.9	1.34
27	16.21	88.73	118.66	1.34
28	17.11	88.73	118.48	1.34
29	18.01	88.73	118.48	1.34
30	18.91	88.73	118.48	1.34
31	19.81	88.73	118.15	1.33
32	20.71	88.73	117.97	1.33

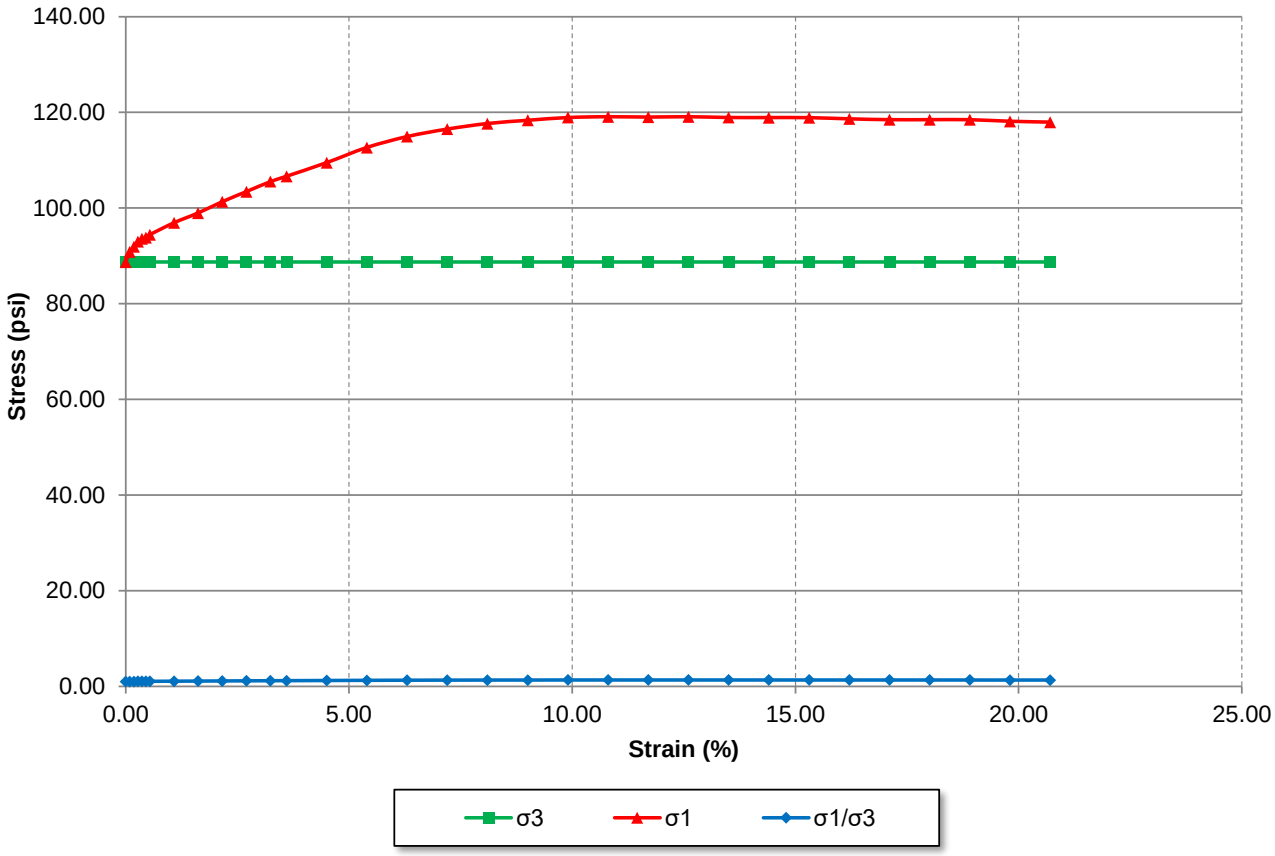
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 89.0' to 89.5'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/28/2024
LABORATORY #	: 10174706	DATE REPORTED	: 9/4/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 21.31 %	EFF. CONS. STRESS	: 88.73 psi
FINAL HEIGHT	: 11.18 cm	SPECIFIC GRAVITY	: 2.66
FINAL DIAMETER	: 8.02 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 89.0' to 89.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

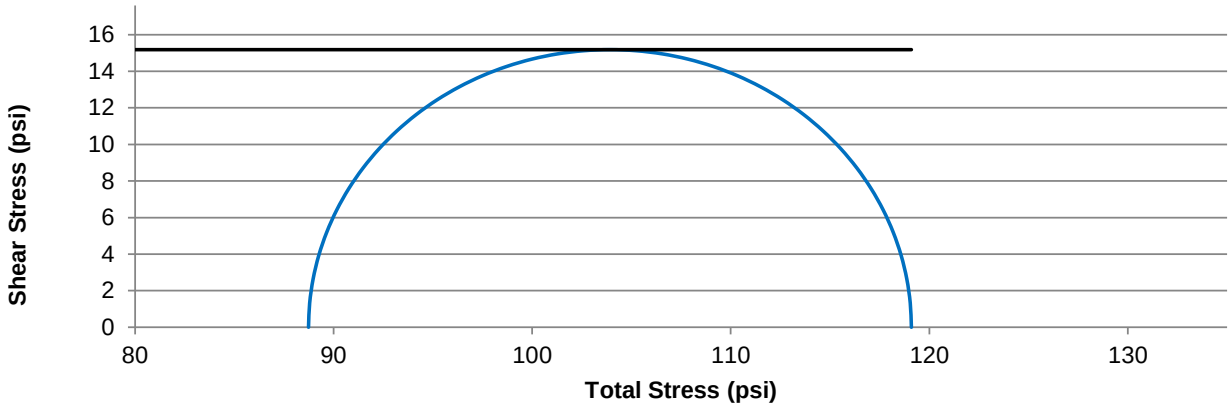
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	88.73 psi	119.1 psi

Compressive Strength =	4373	psf
Cohesion =	2186	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 94.0' to 94.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024
SOIL TYPE	: Gray Sandy Lean Clay		
WET DENSITY	: 129.29 pcf	DELTA HEIGHT	: 0.45 cm
DRY DENSITY	: 108.43 pcf	DELTA VOLUME	: NA
MOISTURE	: 19.24 %	CHAMBER PRES.	: 92.72 psi
		INITIAL HEIGHT	: 14.8 cm
		INITIAL DIAMETER	: 7.22 cm
		COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	92.72	92.72	1.00
2	0.09	92.72	93.97	1.01
3	0.18	92.72	93.97	1.01
4	0.27	92.72	94.18	1.02
5	0.35	92.72	94.39	1.02
6	0.44	92.72	94.8	1.02
7	0.53	92.72	95.01	1.02
8	1.06	92.72	95	1.02
9	1.59	92.72	101.38	1.09
10	2.12	92.72	107.12	1.16
11	2.66	92.72	111.55	1.2
12	3.19	92.72	114.12	1.23
13	3.54	92.72	116.92	1.26
14	4.43	92.72	121.71	1.31
15	5.31	92.72	124.35	1.34
16	6.20	92.72	126.1	1.36
17	7.08	92.72	129.24	1.39
18	7.97	92.72	132.48	1.43
19	8.85	92.72	134.82	1.45
20	9.74	92.72	137.01	1.48
21	10.62	92.72	138.59	1.49
22	11.51	92.72	140.51	1.52
23	12.39	92.72	141.83	1.53
24	13.28	92.72	142.92	1.54
25	14.16	92.72	143.8	1.55
26	15.05	92.72	144.67	1.56
27	15.93	92.72	145.32	1.57
28	16.82	92.72	145.79	1.57
29	17.70	92.72	146.23	1.58
30	18.59	92.72	146.15	1.58
31	19.47	92.72	145.57	1.57
32	20.36	92.72	144.99	1.56

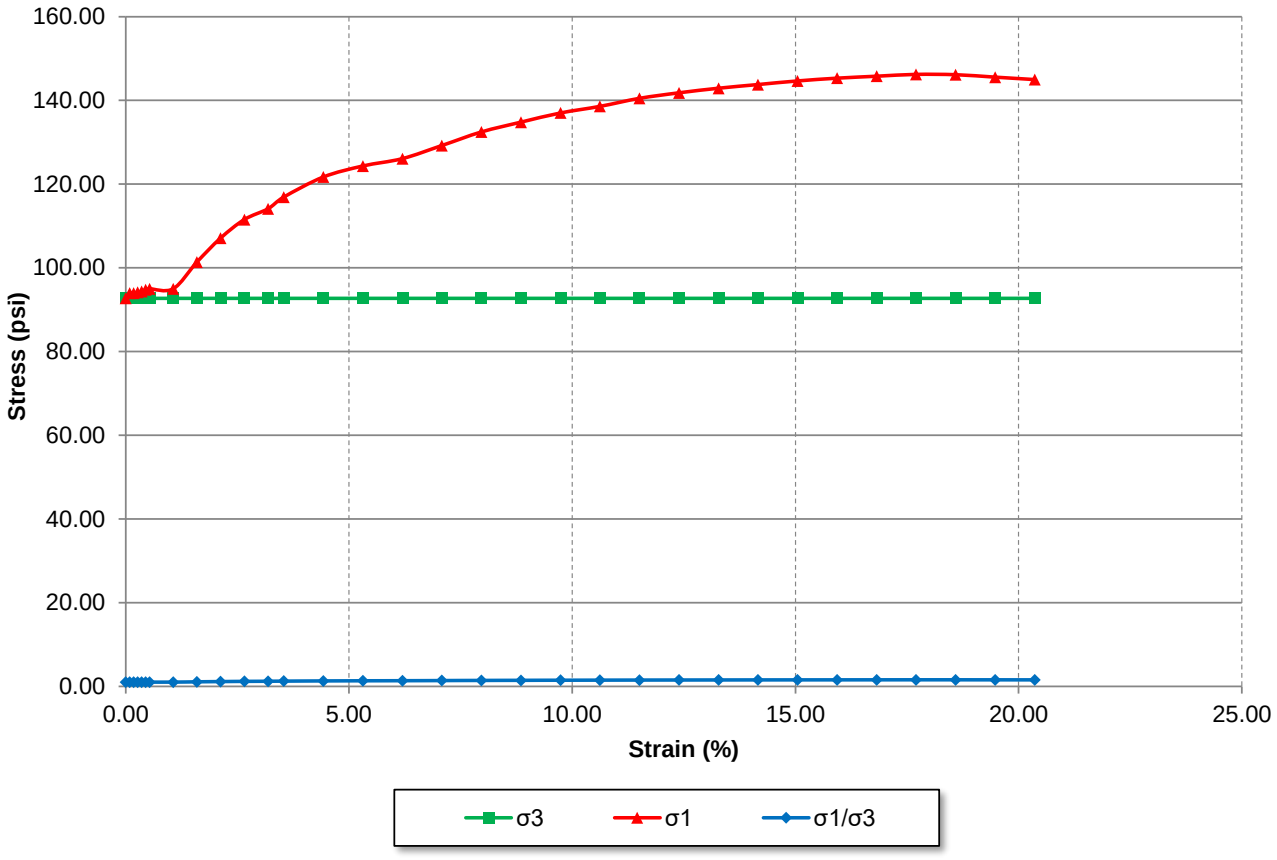
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 94.0' to 94.5'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/28/2024
LABORATORY #	: 10174706	DATE REPORTED	: 9/4/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 19.24 %	EFF. CONS. STRESS	: 92.72 psi
FINAL HEIGHT	: 11.43 cm	SPECIFIC GRAVITY	: 2.66
FINAL DIAMETER	: 8.06 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 94.0' to 94.5'
LABORATORY #	: 10174706	DATE TESTED	: 8/28/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 9/4/2024

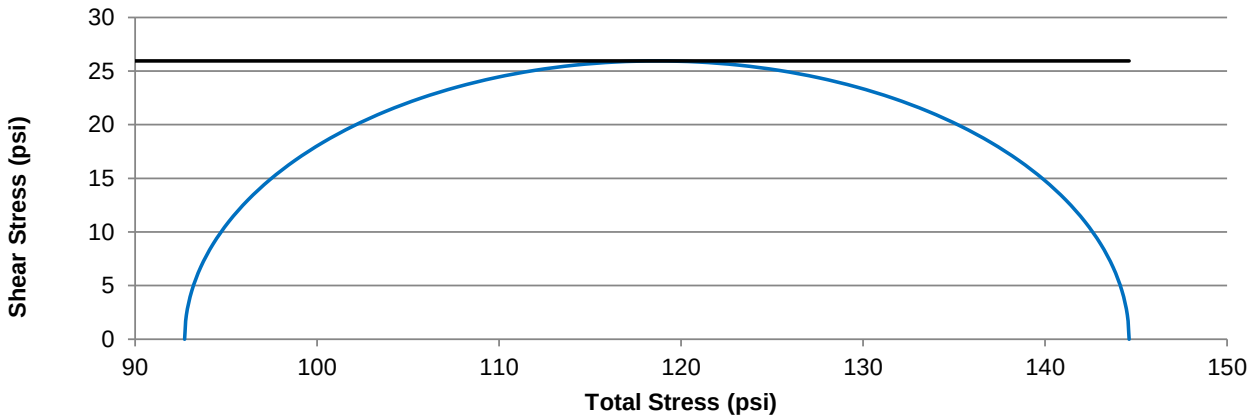
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	92.72 psi	144.62 psi

Compressive Strength =	7474	psf
Cohesion =	3737	psf
Phi =	0	deg
Tan (Phi) =	0	

At Maximum Deviator Stress 15%

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 241.5' to 242.0'
LABORATORY #	: 10174706	DATE TESTED	: 9/18/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 12/12/2016

SOIL TYPE : Dark Gray Silty Sand

WET DENSITY	: 129.36 pcf	DELTA HEIGHT	: 0.14 cm	INITIAL HEIGHT	: 14.72 cm
DRY DENSITY	: 102.48 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.08 cm
MOISTURE	: 26.23 %	CHAMBER PRES.	: 214.26 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	214.26	214.26	1.00
2	0.09	214.26	224.28	1.05
3	0.17	214.26	232.01	1.08
4	0.26	214.26	238.26	1.11
5	0.35	214.26	242.91	1.13
6	0.44	214.26	245.61	1.15
7	0.52	214.26	247.58	1.16
8	1.04	214.26	267.85	1.25
9	1.57	214.26	282.97	1.32
10	2.09	214.26	282.61	1.32
11	2.61	214.26	282.24	1.32
12	3.13	214.26	281.88	1.32
13	3.48	214.26	281.63	1.31
14	4.35	214.26	281.02	1.31
15	5.22	214.26	280.42	1.31
16	6.10	214.26	279.81	1.31

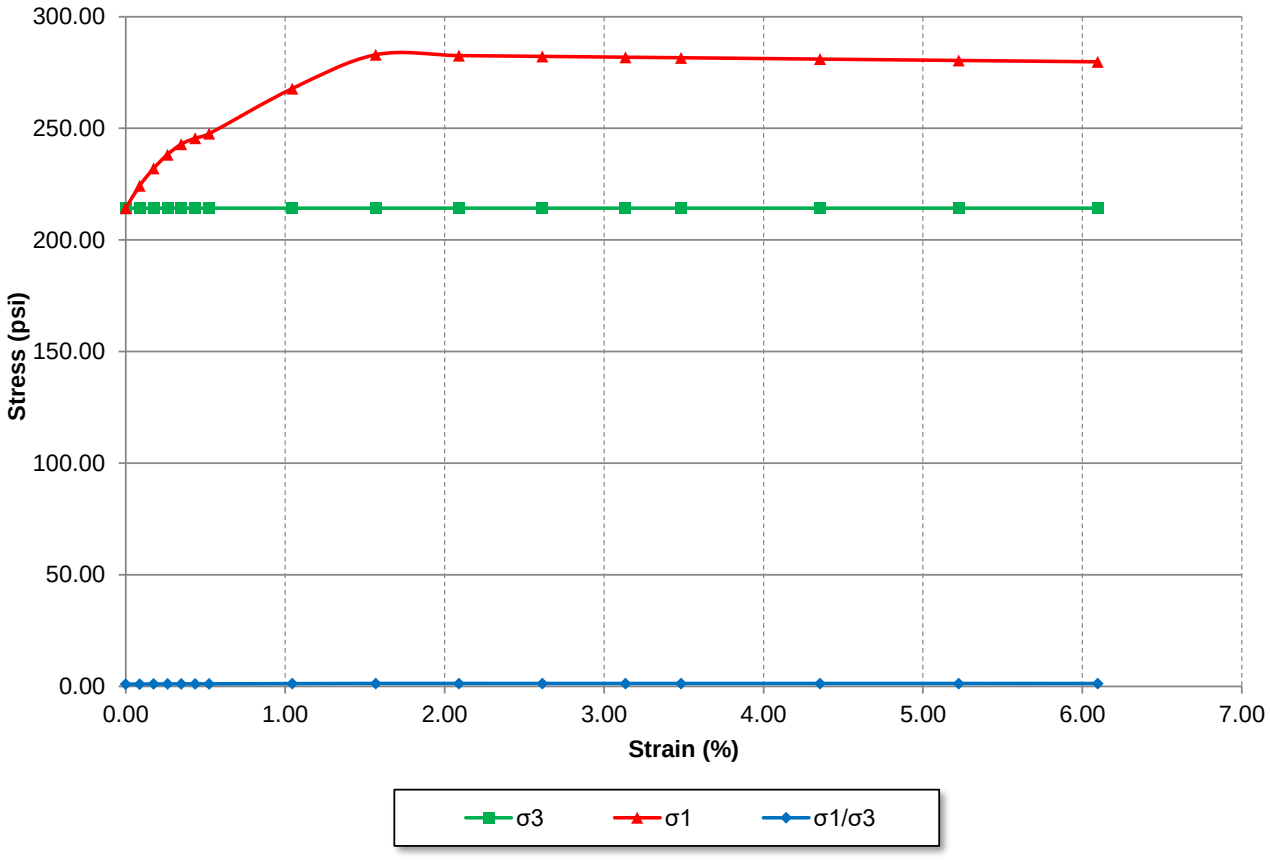
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 241.5' to 242.0'
PROJECT STATE	: Kentucky	DATE TESTED	: 9/18/2024
LABORATORY #	: 10174706	DATE REPORTED	: 12/12/2016
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 26.23 %	EFF. CONS. STRESS	: 214.26 psi
FINAL HEIGHT	: 13.7 cm	SPECIFIC GRAVITY	: 2.65
FINAL DIAMETER	: 7.31 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 241.5' to 242.0'
LABORATORY #	: 10174706	DATE TESTED	: 9/18/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 12/12/2016

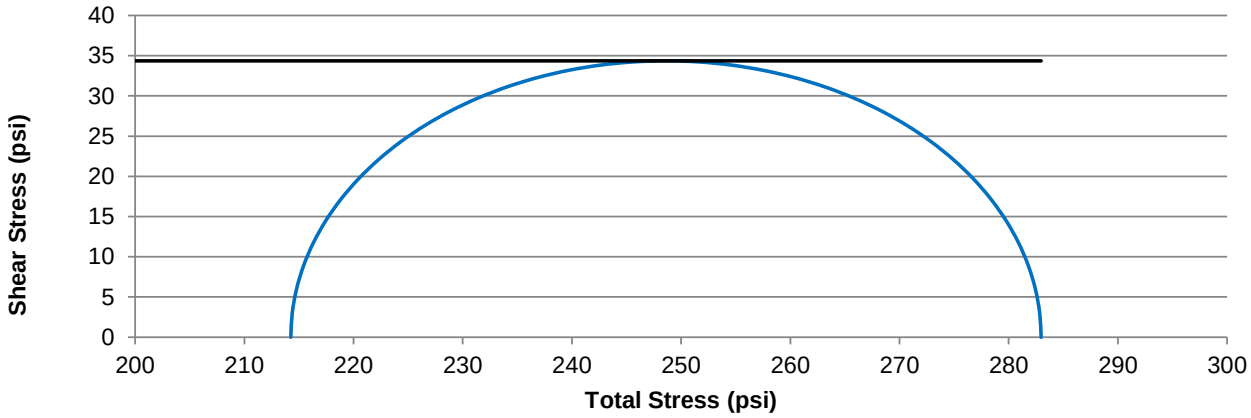
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	214.26 psi	282.97 psi

Compressive Strength =	9895	psf
Cohesion =	4947	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 260.4' to 260.9'
LABORATORY #	: 10174706	DATE TESTED	: 9/18/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 12/12/2016
SOIL TYPE	: Gray Silty Sand		
WET DENSITY	: 124.72 pcf	DELTA HEIGHT	: 0.18 cm
DRY DENSITY	: 97.44 pcf	DELTA VOLUME	: NA
MOISTURE	: 27.99 %	CHAMBER PRES.	: 231.19 psi
		INITIAL HEIGHT	: 14.99 cm
		INITIAL DIAMETER	: 7.21 cm
		COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	231.19	231.19	1.00
2	0.09	231.19	241.9	1.05
3	0.17	231.19	245.59	1.06
4	0.26	231.19	250.92	1.09
5	0.34	231.19	255.57	1.11
6	0.43	231.19	259.37	1.12
7	0.51	231.19	261.48	1.13
8	1.03	231.19	271.16	1.17
9	1.54	231.19	284.31	1.23
10	2.06	231.19	295.49	1.28
11	2.57	231.19	296.57	1.28
12	3.09	231.19	296.23	1.28
13	3.43	231.19	296	1.28
14	4.29	231.19	295.42	1.28
15	5.15	231.19	294.85	1.28
16	6.00	231.19	294.27	1.27
17	6.86	231.19	293.7	1.27
18	7.72	231.19	293.12	1.27

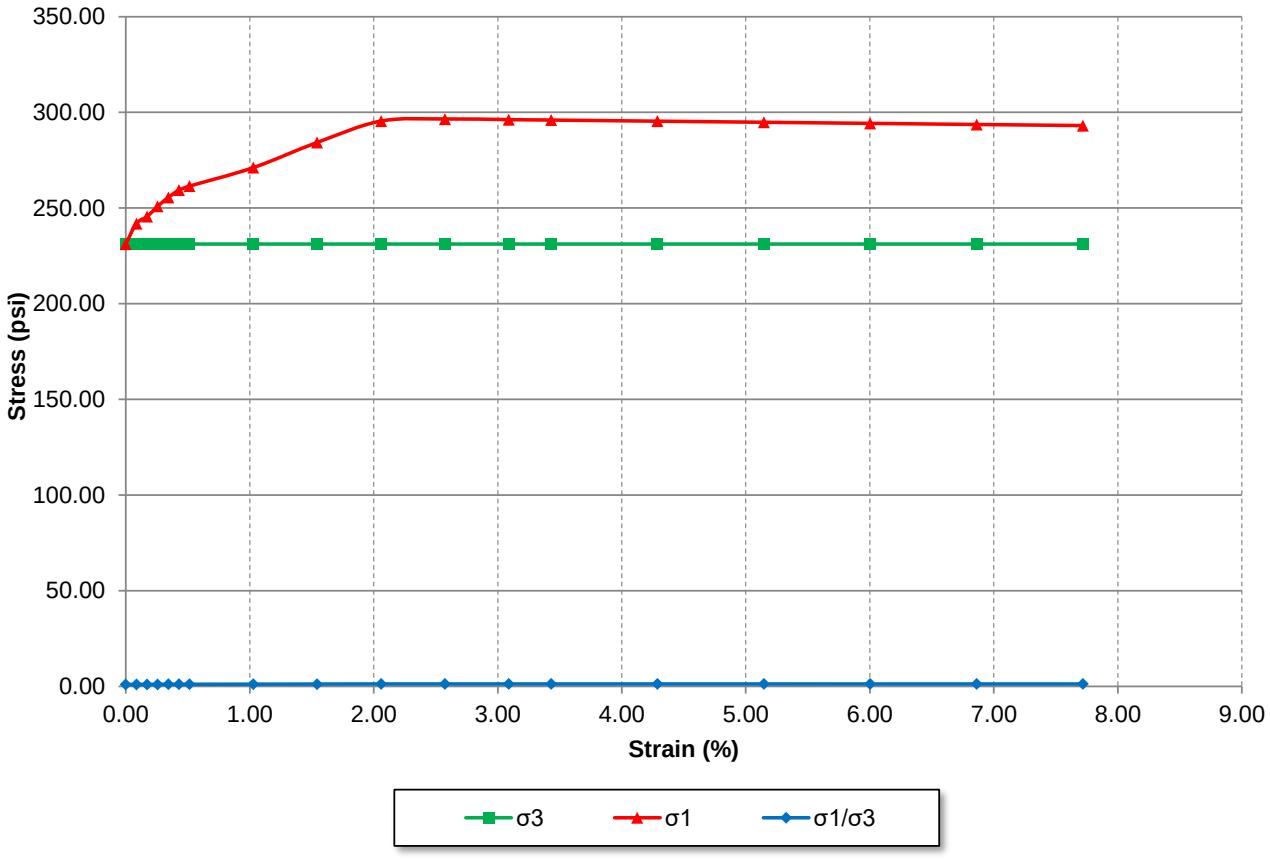
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1020
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 260.4' to 260.9'
PROJECT STATE	: Kentucky	DATE TESTED	: 9/18/2024
LABORATORY #	: 10174706	DATE REPORTED	: 12/12/2016
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 27.99 %	EFF. CONS. STRESS	: 231.19 psi
FINAL HEIGHT	: 13.67 cm	SPECIFIC GRAVITY	: 2.68
FINAL DIAMETER	: 7.51 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1020
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 260.4' to 260.9'
LABORATORY #	: 10174706	DATE TESTED	: 9/18/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 12/12/2016

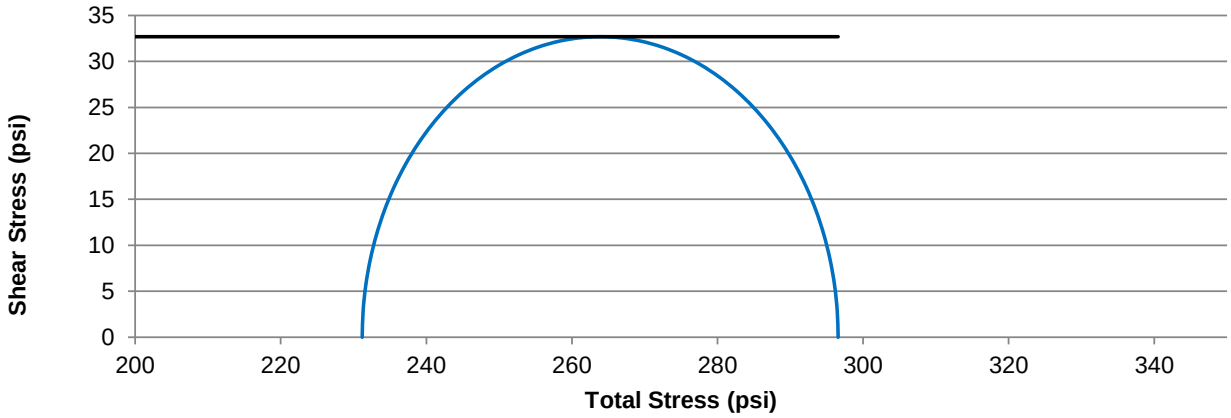
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	231.19 psi	296.57 psi

Compressive Strength =	9415	psf
Cohesion =	4708	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1021
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 22.6' to 23.1'
LABORATORY #	: 10174706	DATE TESTED	: 8/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024

SOIL TYPE : Dark Gray Fat Clay

WET DENSITY	: 113.79 pcf	DELTA HEIGHT	: 0.45 cm	INITIAL HEIGHT	: 14.65 cm
DRY DENSITY	: 78.98 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.05 cm
MOISTURE	: 44.07 %	CHAMBER PRES.	: 35.93 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	35.93	35.93	1.00
2	0.09	35.93	36.15	1.01
3	0.18	35.93	36.37	1.01
4	0.27	35.93	36.59	1.02
5	0.36	35.93	36.59	1.02
6	0.45	35.93	36.59	1.02
7	0.54	35.93	36.59	1.02
8	1.07	35.93	37.24	1.04
9	1.61	35.93	37.88	1.05
10	2.15	35.93	38.52	1.07
11	2.68	35.93	38.72	1.08
12	3.22	35.93	39.13	1.09
13	3.58	35.93	39.33	1.09
14	4.47	35.93	39.93	1.11
15	5.37	35.93	40.1	1.12
16	6.26	35.93	40.26	1.12
17	7.16	35.93	40.63	1.13
18	8.05	35.93	40.79	1.14
19	8.95	35.93	40.74	1.13
20	9.84	35.93	41.09	1.14
21	10.74	35.93	41.43	1.15
22	11.63	35.93	41.57	1.16
23	12.53	35.93	41.51	1.16
24	13.42	35.93	41.46	1.15
25	14.31	35.93	41.78	1.16
26	15.21	35.93	41.72	1.16
27	16.10	35.93	41.65	1.16
28	17.00	35.93	41.78	1.16
29	17.89	35.93	41.71	1.16
30	18.79	35.93	41.65	1.16
31	19.68	35.93	41.59	1.16
32	20.58	35.93	41.52	1.16

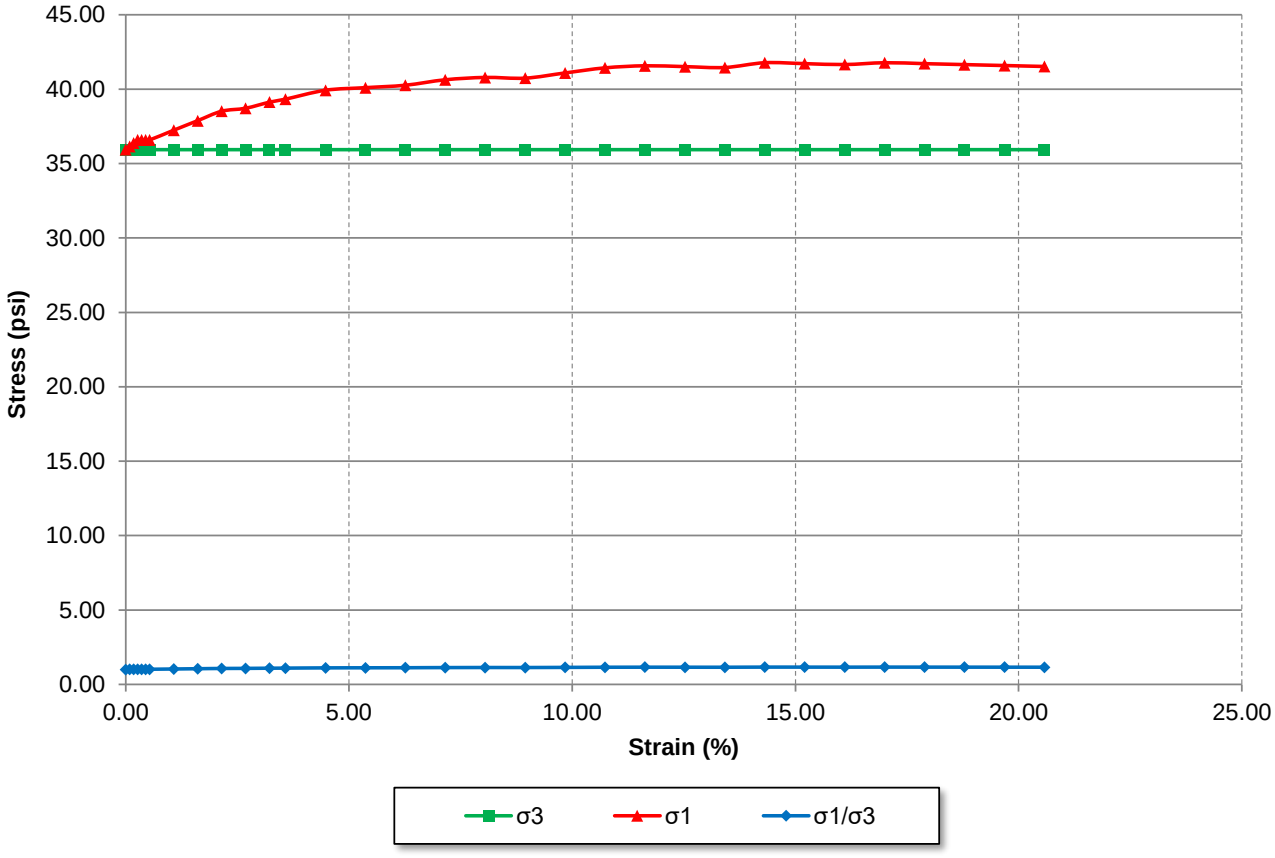
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1021
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 22.6' to 23.1'
LABORATORY #	: 10174706	DATE TESTED	: 8/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024

FINAL MOISTURE	: 44.07 %	EFF. CONS. STRESS	: 35.93 psi
FINAL HEIGHT	: 11.27 cm	SPECIFIC GRAVITY	: 2.67
FINAL DIAMETER	: 7.88 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1021
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 22.6' to 23.1'
LABORATORY #	: 10174706	DATE TESTED	: 8/29/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024

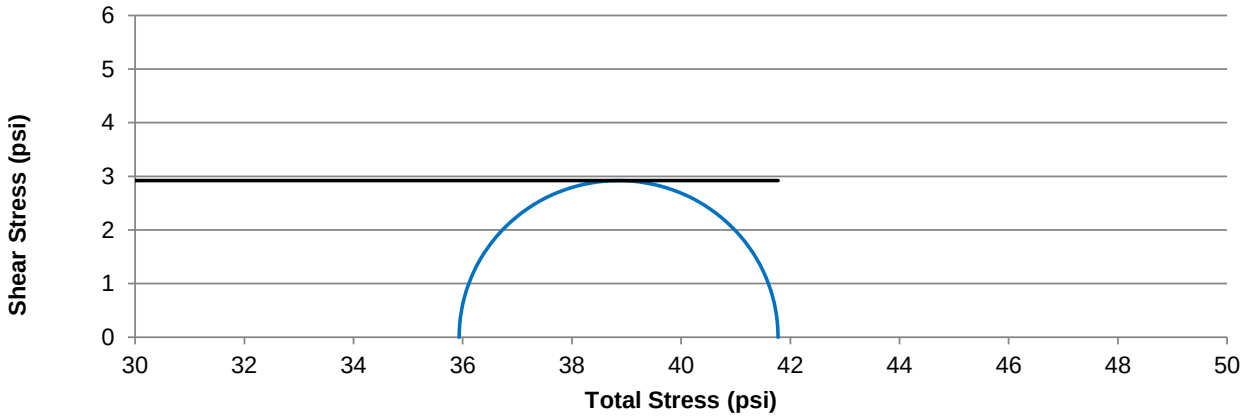
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	35.93 psi	41.78 psi

Compressive Strength =	841	psf
Cohesion =	421	psf
Phi =	0	deg
Tan (Phi) =	0	

Maximum Deviator Stress

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1021
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 264.1' to 264.6'
LABORATORY #	: 10174706	DATE TESTED	: 9/17/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024
SOIL TYPE	: Gray Silty Sand		
WET DENSITY	: 122.4 pcf	DELTA HEIGHT	: 0.47 cm
DRY DENSITY	: 93.49 pcf	DELTA VOLUME	: NA
MOISTURE	: 30.92 %	CHAMBER PRES.	: 245.14 psi
		INITIAL HEIGHT	: 14.97 cm
		INITIAL DIAMETER	: 7.25 cm
		COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	245.14	245.14	1.00
2	0.09	245.14	247.21	1.01
3	0.18	245.14	247.21	1.01
4	0.26	245.14	247.2	1.01
5	0.35	245.14	247.2	1.01
6	0.44	245.14	247.2	1.01
7	0.53	245.14	247.2	1.01
8	1.05	245.14	247.19	1.01
9	1.58	245.14	247.18	1.01
10	2.10	245.14	249	1.02
11	2.63	245.14	255.05	1.04
12	3.15	245.14	257.32	1.05
13	3.50	245.14	258.82	1.06
14	4.38	245.14	261.56	1.07
15	5.26	245.14	266.01	1.09
16	6.13	245.14	269.44	1.1
17	7.01	245.14	271.61	1.11
18	7.89	245.14	273.05	1.11
19	8.76	245.14	273.92	1.12
20	9.64	245.14	274.42	1.12
21	10.51	245.14	274.83	1.12
22	11.39	245.14	275.23	1.12
23	12.27	245.14	275.61	1.12
24	13.14	245.14	276.1	1.13
25	14.02	245.14	276.96	1.13
26	14.89	245.14	277.62	1.13
27	15.77	245.14	277.94	1.13
28	16.65	245.14	278.56	1.14
29	17.52	245.14	278.85	1.14
30	18.40	245.14	279.13	1.14
31	19.27	245.14	279.39	1.14
32	20.15	245.14	279.48	1.14
33	21.03	245.14	278.95	1.14

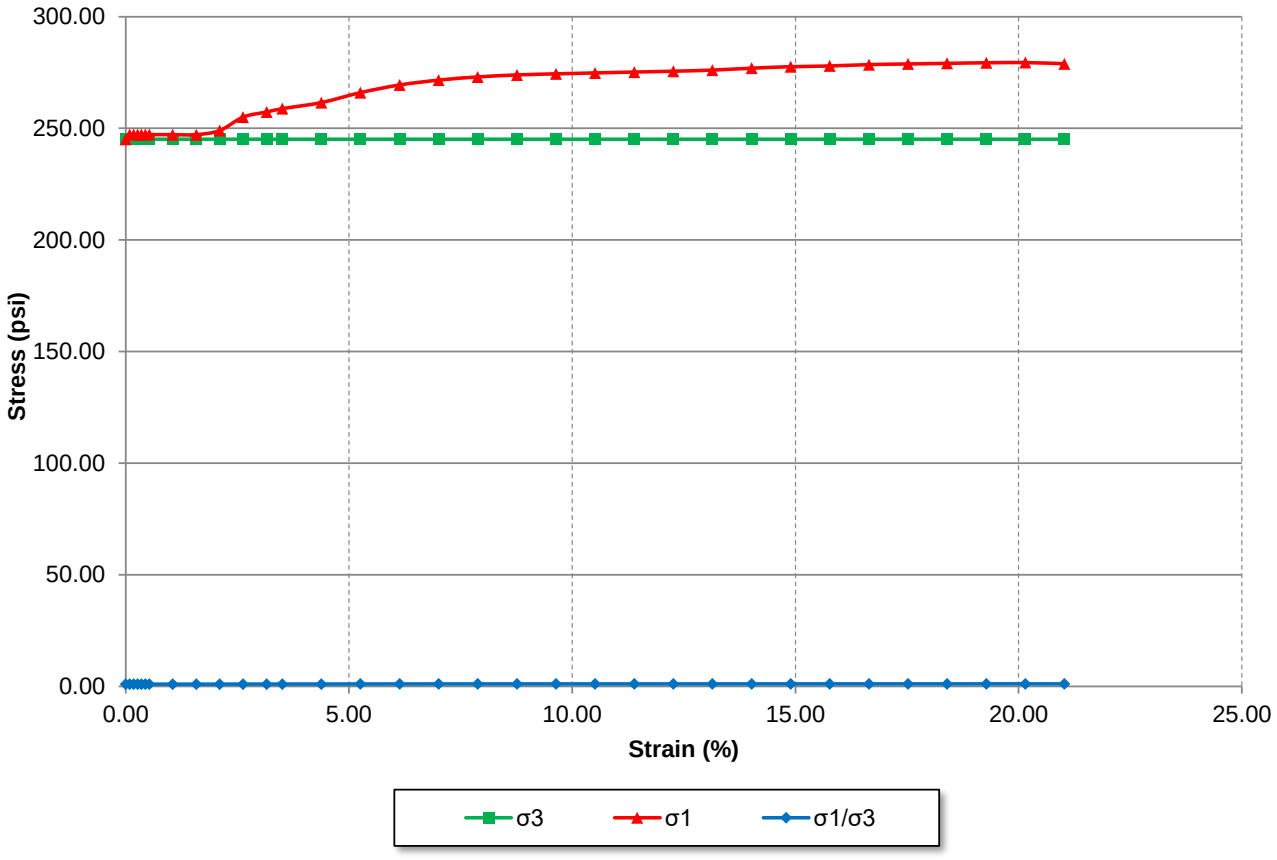
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1021
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 264.1' to 264.6'
PROJECT STATE	: Kentucky	DATE TESTED	: 9/17/2024
LABORATORY #	: 10174706	DATE REPORTED	: 10/2/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 30.92 %	EFF. CONS. STRESS	: 245.14 psi
FINAL HEIGHT	: 11.45 cm	SPECIFIC GRAVITY	: 2.72
FINAL DIAMETER	: 8.13 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1021
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 264.1' to 264.6'
LABORATORY #	: 10174706	DATE TESTED	: 9/17/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 10/2/2024

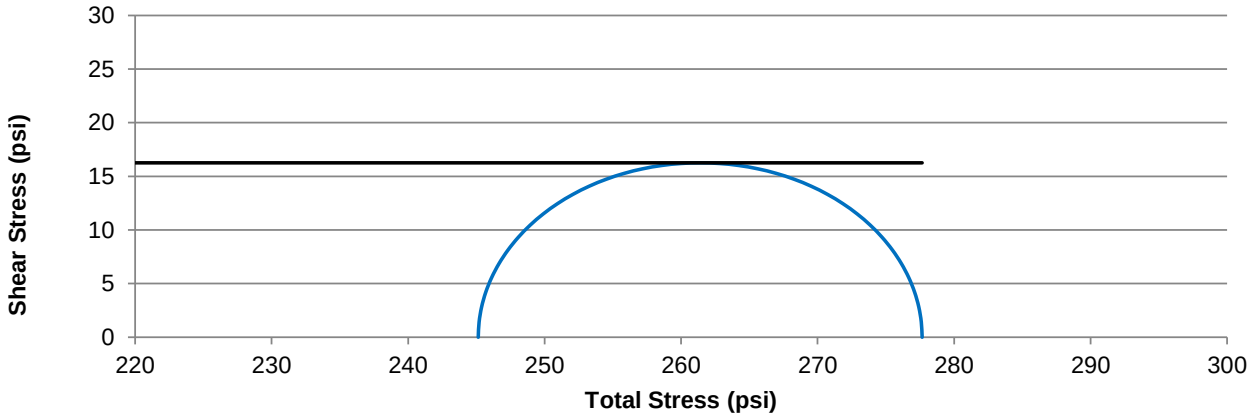
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	245.14 psi	277.66 psi

Compressive Strength =	4683	psf
Cohesion =	2342	psf
Phi =	0	deg
Tan (Phi) =	0	

At Maximum Deviator Stress 15%

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	POINT #	: 1
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1023
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 4.2' to 4.7'
LABORATORY #	: 10174706	DATE TESTED	: 8/26/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 8/28/2024

SOIL TYPE : Gray Lean Clay with Sand

WET DENSITY	: 115.81 pcf	DELTA HEIGHT	: 0.45 cm	INITIAL HEIGHT	: 15.03 cm
DRY DENSITY	: 83.53 pcf	DELTA VOLUME	: NA	INITIAL DIAMETER	: 7.12 cm
MOISTURE	: 38.64 %	CHAMBER PRES.	: 19.99 psi	COMMENTS	: AASHTO T-296

RESULTS:

	ε a	σ 3 (psi)	σ 1 (psi)	σ1/σ3
1	0.00	19.99	19.99	1.00
2	0.09	19.99	20.86	1.04
3	0.17	19.99	21.29	1.06
4	0.26	19.99	21.5	1.08
5	0.35	19.99	21.71	1.09
6	0.44	19.99	21.93	1.1
7	0.52	19.99	22.13	1.11
8	1.05	19.99	23.62	1.18
9	1.57	19.99	24.88	1.24
10	2.09	19.99	25.7	1.29
11	2.61	19.99	26.93	1.35
12	3.14	19.99	27.73	1.39
13	3.48	19.99	28.31	1.42
14	4.36	19.99	29.49	1.47
15	5.23	19.99	30.61	1.53
16	6.10	19.99	30.9	1.55
17	6.97	19.99	31.19	1.56
18	7.84	19.99	31.66	1.58
19	8.71	19.99	32.11	1.61
20	9.58	19.99	32.37	1.62
21	10.45	19.99	32.44	1.62
22	11.33	19.99	32.87	1.64
23	12.20	19.99	32.92	1.65
24	13.07	19.99	33.16	1.66
25	13.94	19.99	33.2	1.66
26	14.81	19.99	33.07	1.65
27	15.68	19.99	33.11	1.66
28	16.55	19.99	33.15	1.66
29	17.42	19.99	33.35	1.67
30	18.30	19.99	33.21	1.66
31	19.17	19.99	32.9	1.65
32	20.04	19.99	32.76	1.64

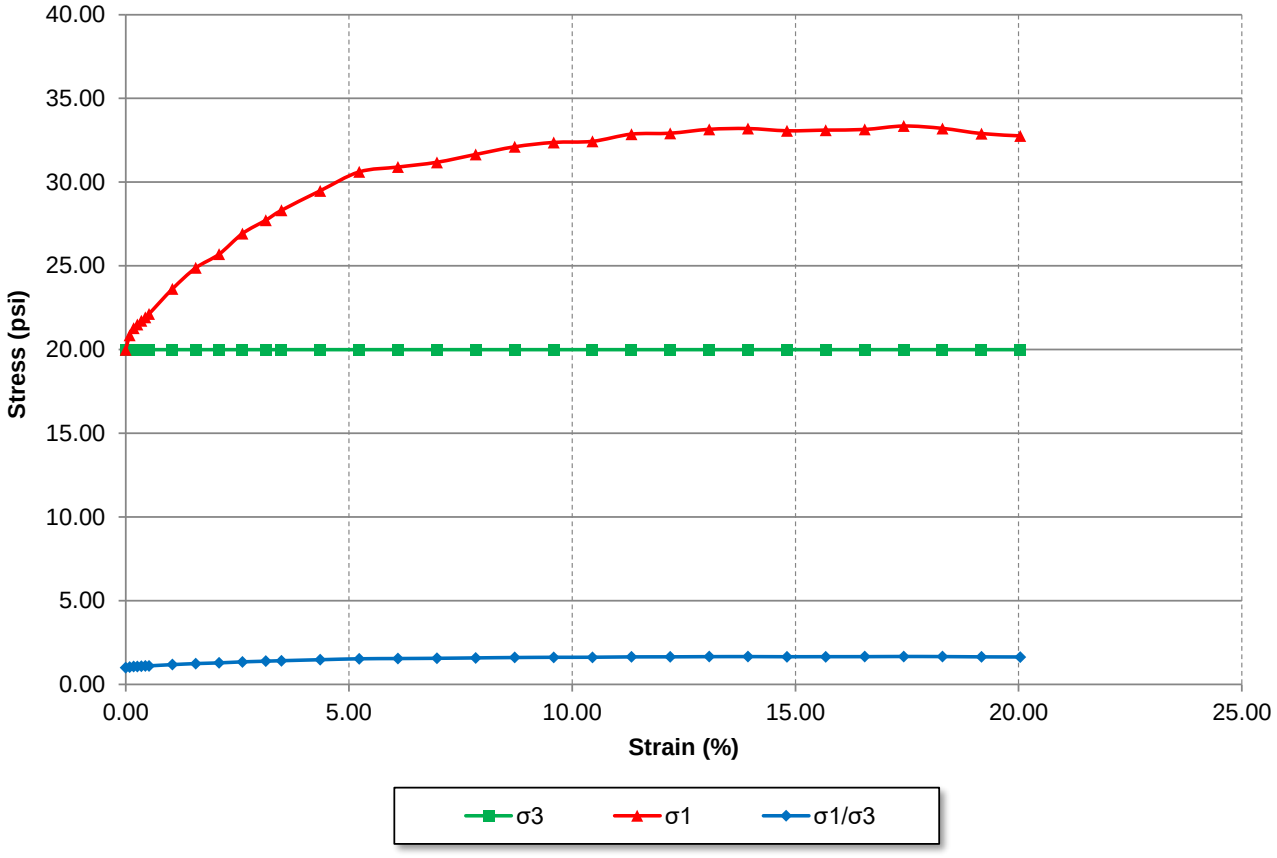
Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge	POINT #	: 1
PROJECT #	: 10174706	SAMPLE LOC.	: B-1023
PROJECT COUNTY	: Ballard	SAMPLE DEPTH	: 4.2' to 4.7'
PROJECT STATE	: Kentucky	DATE TESTED	: 8/26/2024
LABORATORY #	: 10174706	DATE REPORTED	: 8/28/2024
SUBMITTED BY	: HDR		

FINAL MOISTURE	: 38.64 %	EFF. CONS. STRESS	: 19.99 psi
FINAL HEIGHT	: 11.66 cm	SPECIFIC GRAVITY	: 2.65
FINAL DIAMETER	: 7.94 cm	COMMENTS	: AASHTO T-296

RESULTS:



Unconsolidated Undrained

TRIAXIAL COMPRESSION TEST

PROJECT NAME	: KY Cairo Bridge		
PROJECT #	: 10174706	COMMENTS	: AASHTO T-296
PROJECT COUNTY	: Ballard	SAMPLE LOC.	: B-1023
PROJECT STATE	: Kentucky	SAMPLE DEPTH	: 4.2' to 4.7'
LABORATORY #	: 10174706	DATE TESTED	: 8/26/2024
SUBMITTED BY	: HDR	DATE REPORTED	: 8/28/2024

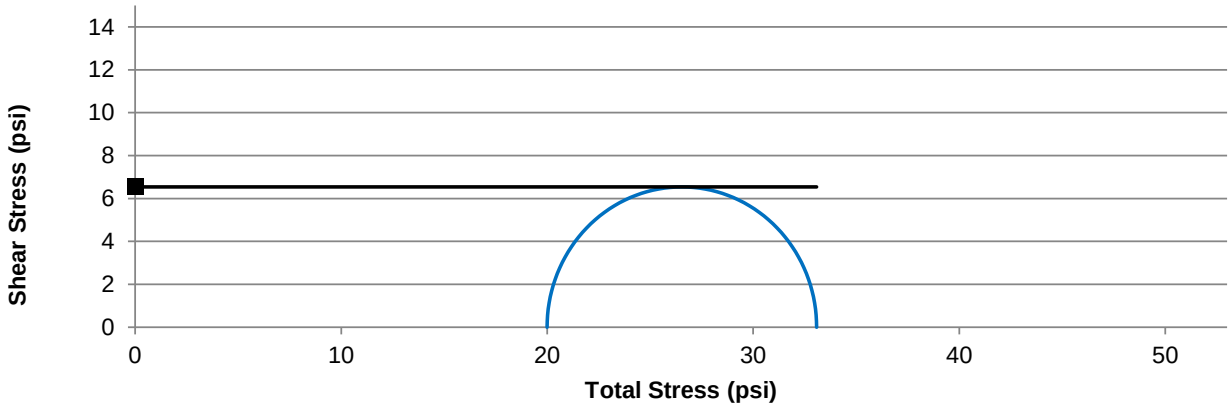
COEFFICIENT OF INTERNAL FRICTION AND COHESION BY THE METHOD OF LEAST SQUARES

Test	Lateral	Total
1	19.99 psi	33.08 psi

Compressive Strength =	1884	psf
Cohesion =	942	psf
Phi =	0	deg
Tan (Phi) =	0	

At Maximum Deviator Stress 15%

Triaxial Mohr's Circles
Unconsolidated Undrained Triaxial Test



Approved By: Kevin E. Walker

GeoTesting Express Lab Report and Results

GeoTesting EXPRESS
A Sercel Business

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Houston
www.geotesting.com

January 22, 2025

Zachary Bruce
HDR Engineering, Inc.
8404 Indian Hills Drive
Omaha, NE 68114

RE: US-51 Over Ohio River Updated (GTX-319809)

Dear Zachary:

Enclosed are the test results you requested for the above referenced project. GeoTesting Express, LLC (GTX) received 10 samples from you between 9/16/2024 and 10/25/2024. This sample was labeled as follows:

Boring Number	Sample Number	Depth
B-1007	ST-1	88.7-90.7
B-1008	GT-3	140.4-142.4
B-1009	GT-3	64.4-66.4
B-1012	ST-1	209.9-210.3
B-1013	GT-4	131.8-133.8
B-1017	GT-1	4.8-6.8
B-1017	GT-4	80.2-82.2
B-1018	ST-8	88.8-90.8
B-1021	GT-2	7.9-9.9
B-1023	ST-2	48.1-50.1

GTX performed the following tests on these samples:

23 ASTM D4015 - Modulus and Damping of Soil by Resonant Column
7 GTX-S1062 - Cyclic Direct Simple Shear (<=2.62 inch diameter, 1 normal stress)
17 GTX-S1084 - Additional Cyclic Stress Ratio (CSR)
2 ASTM D5311P - Post-Cyclic Monotonic Test
10 ASTM D4452 - X-Ray of Shelby Tubes - Digital Imaging
8 ASTM D854 - Specific Gravity

The results presented in this report apply only to the items tested. This report shall not be reproduced except in full, without written approval from GeoTesting Express. The remainder of these samples will be retained for a period of sixty (60) days and will then be discarded unless otherwise notified by you. Please call me if you have any questions or require additional information. Thank you for allowing GeoTesting Express the opportunity of providing you with testing services. We look forward to working with you again in the future.

Boston
New York
Atlanta
Chicago
Los Angeles
Houston
www.geotesting.com

Respectfully yours,



Dave Norton
Assistant Laboratory Manager

Boston
New York
Atlanta
Chicago
Los Angeles
Houston
www.geotesting.com

Geotechnical Test Report **1/22/2025**

GTX-319809
US-51 Over Ohio River Updated

Prepared for:

HDR Engineering, Inc.

Client:	HDR Engineering, Inc.				
Project:	US-51 Over Ohio River Updated				
Location:				Project No:	GTX-319809
Boring ID:	---	Sample Type:	---	Tested By:	jlw
Sample ID:	---	Test Date:	10/04/24	Checked By:	ank
Depth :	---	Test Id:	786051		

Specific Gravity of Soils by ASTM D854

Boring ID	Sample ID	Depth	Visual Description	Specific Gravity	Comment
B-1008	GT- 3	140.4-142.4	Moist, light gray sand	2.65	
B-1009	GT- 3	64.4-66.4	Moist, light gray sand	2.66	
B-1013	GT- 4	131.8-133.8	Moist, very pale brown sand	2.70	
B-1017	GT- 1	4.8-6.8	Moist, dark yellowish brown sand with clay	2.68	
B-1017	GT- 4	80.2-82.2	Moist, light gray sand	2.67	
B-1018	ST- 8	88.8-90.8	Moist, light gray sand	2.68	
B-1021	GT- 2	7.9-9.9	Moist, grayish brown sand with clay	2.68	
B-1023	ST- 2	48.1-50.1	Moist, light brownish gray clay	2.70	

Notes: Specific Gravity performed by using method B (oven dried specimens) of ASTM D854
Moisture Content determined by ASTM D2216.

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	12/13/24
Project Location:	Kentucky		

Boring ID: B-1008
Sample ID: GT-3
Depth, ft: 140.4-142.4

Visual Description: Moist, light gray sand

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 59 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-6				
Initial Moisture Content, %	19.00				
Initial Dry Density, pcf	99.71				
Vertical Consolidation Stress, psi	59				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	8	---	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				21.3	
Delay before shearing, sec				---	
Nominal Rate of Shear Strain, %/hr				---	
Measured Post-Cyclic Peak Shear Stress, psi				---	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				---	
Membrane Correction, psi				---	
Corrected Post-Cyclic Peak Shear Stress, psi				---	
S_r/σ'_{vc}				---	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Specimen reached an R value approaching 1 and liquified the sample at about 8 cycles into Step 3 of the test. Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

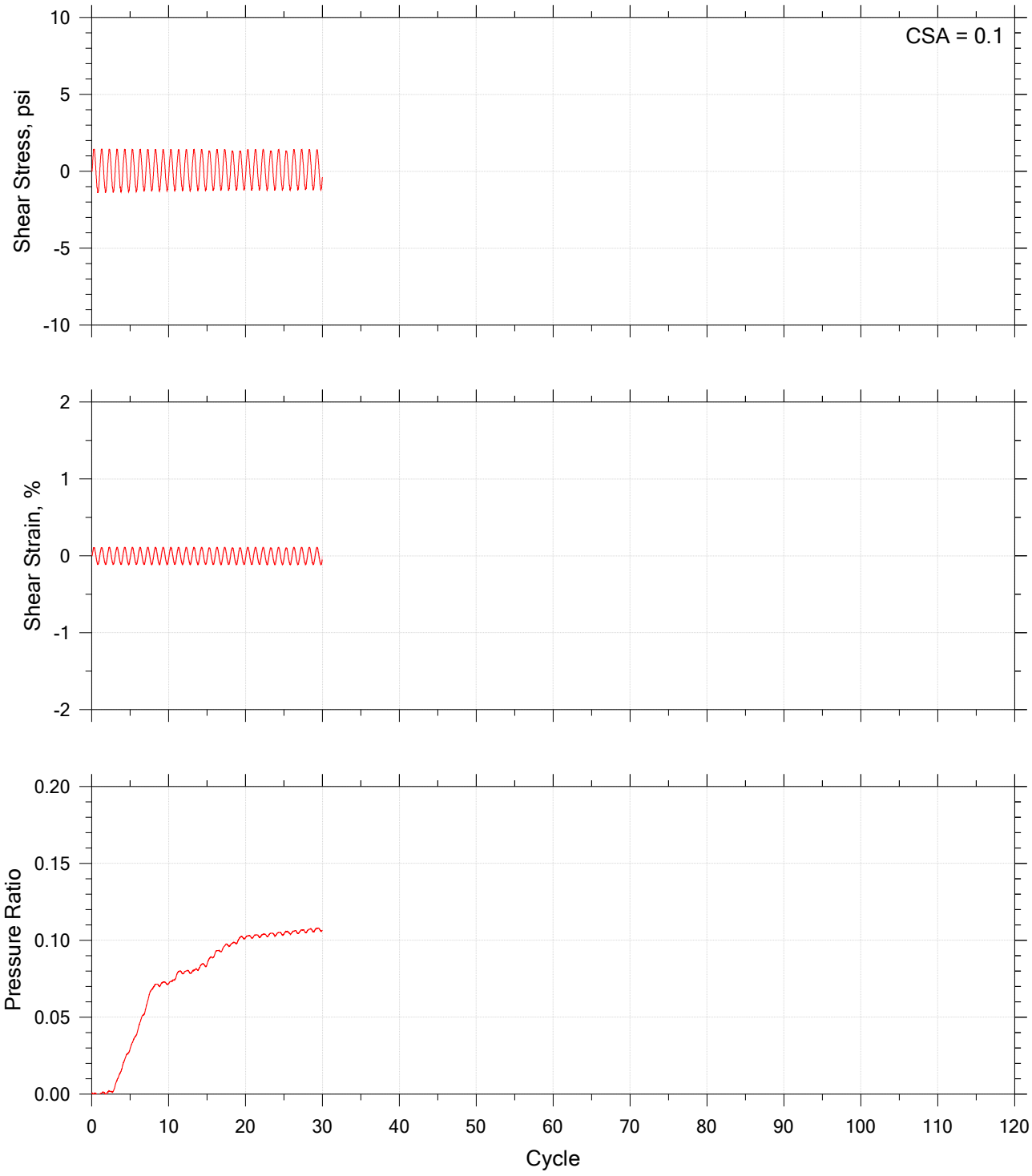
Tested By: jlw Checked By: njh

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4

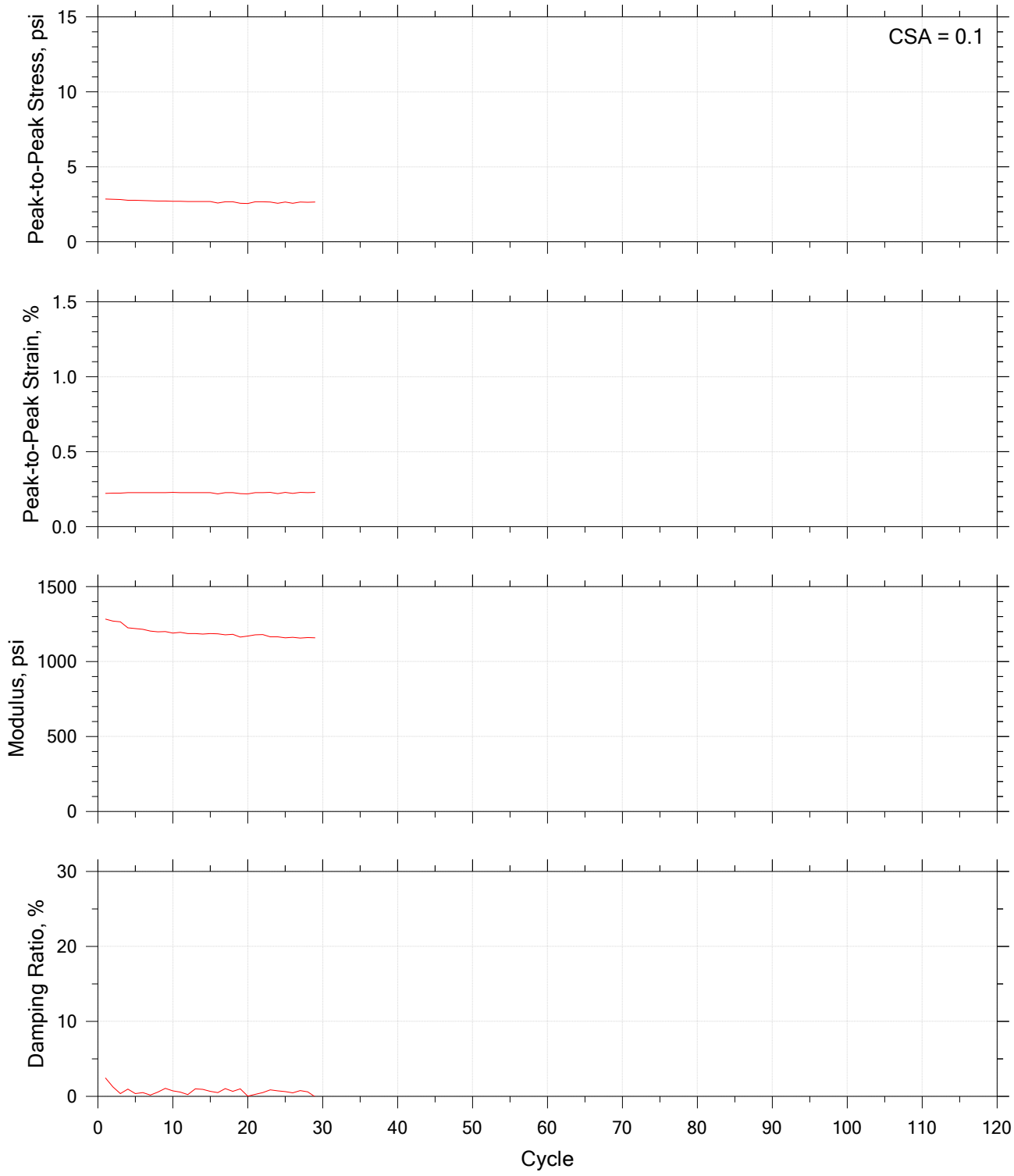


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4



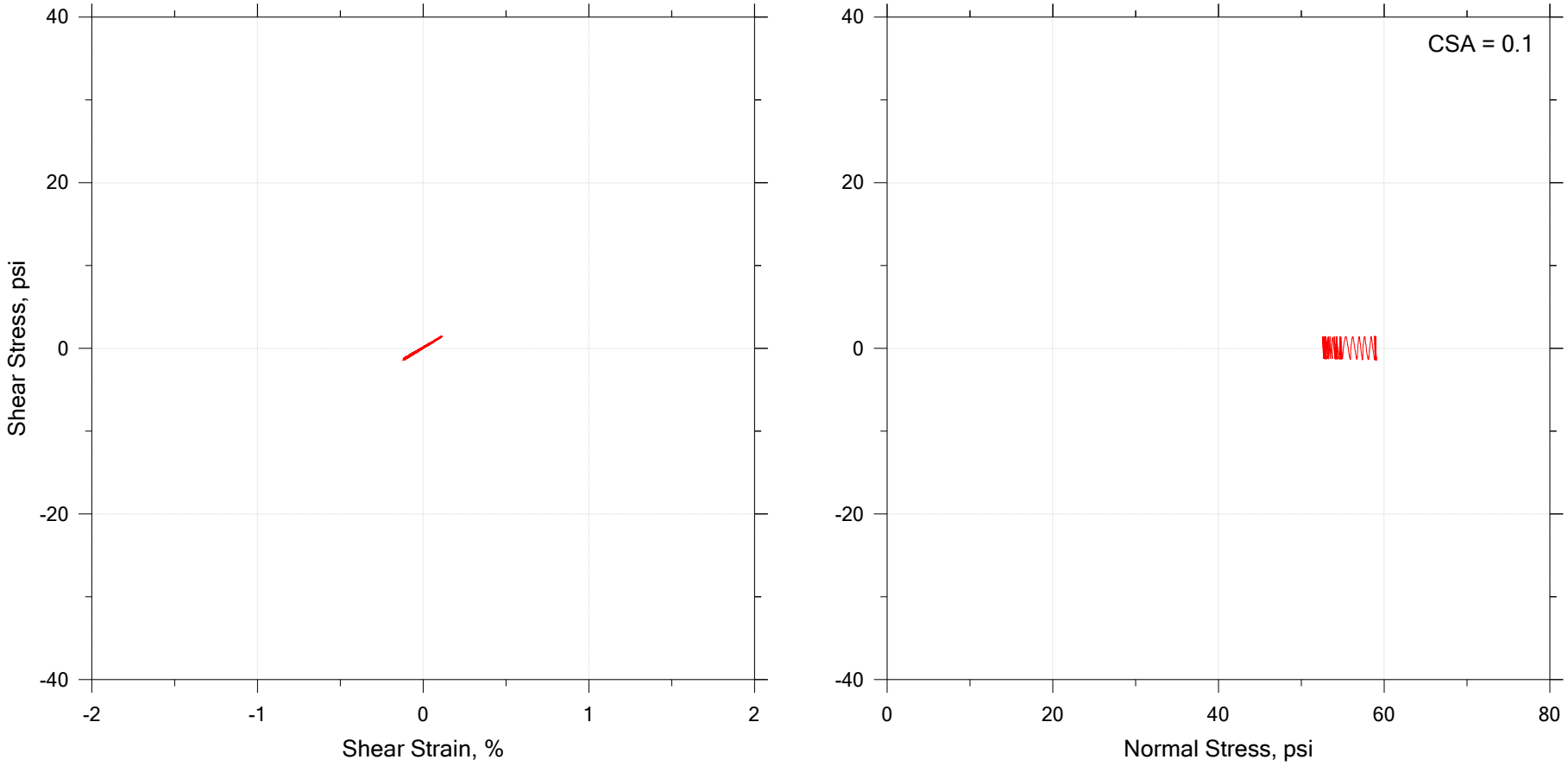
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0

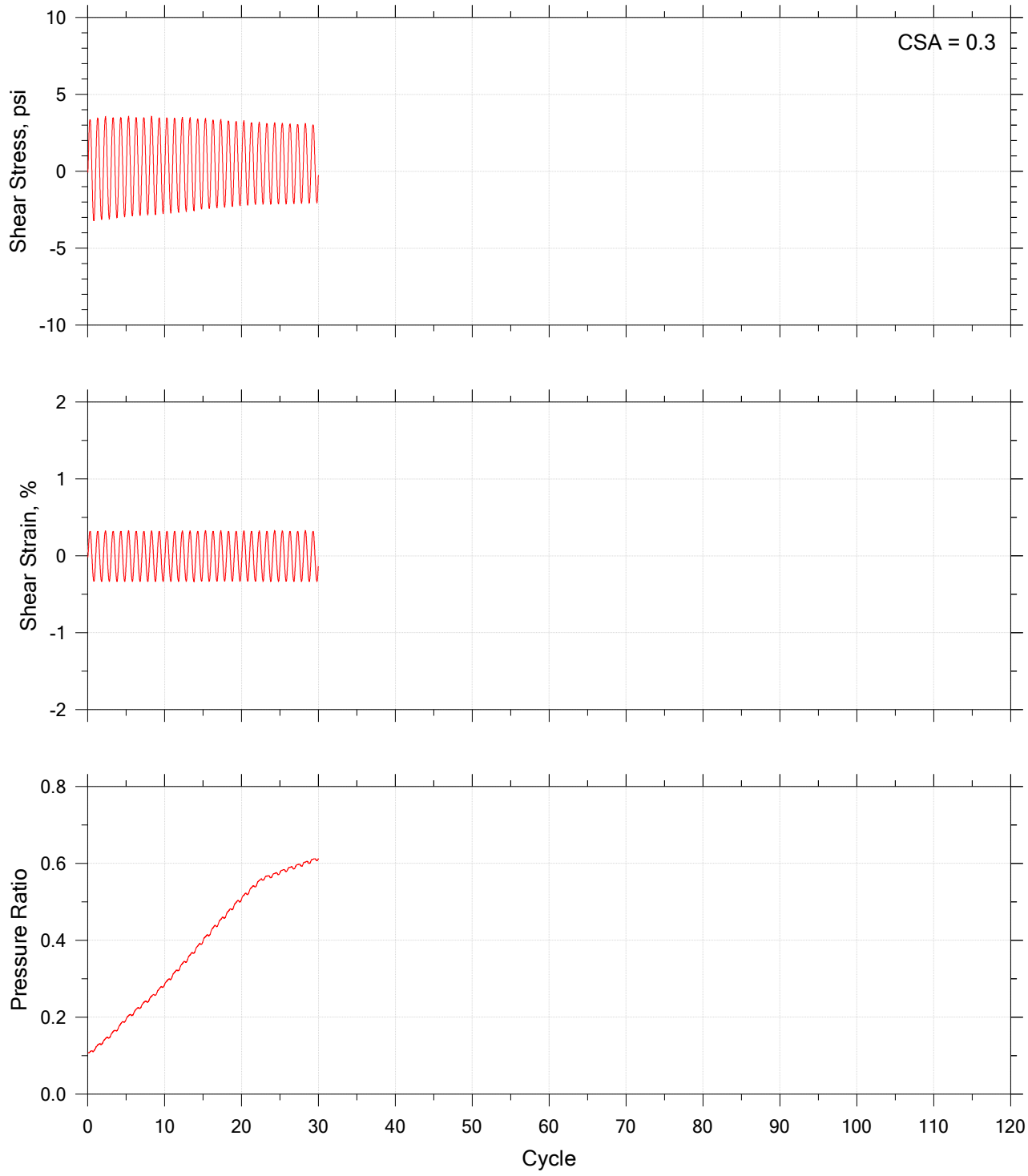


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4

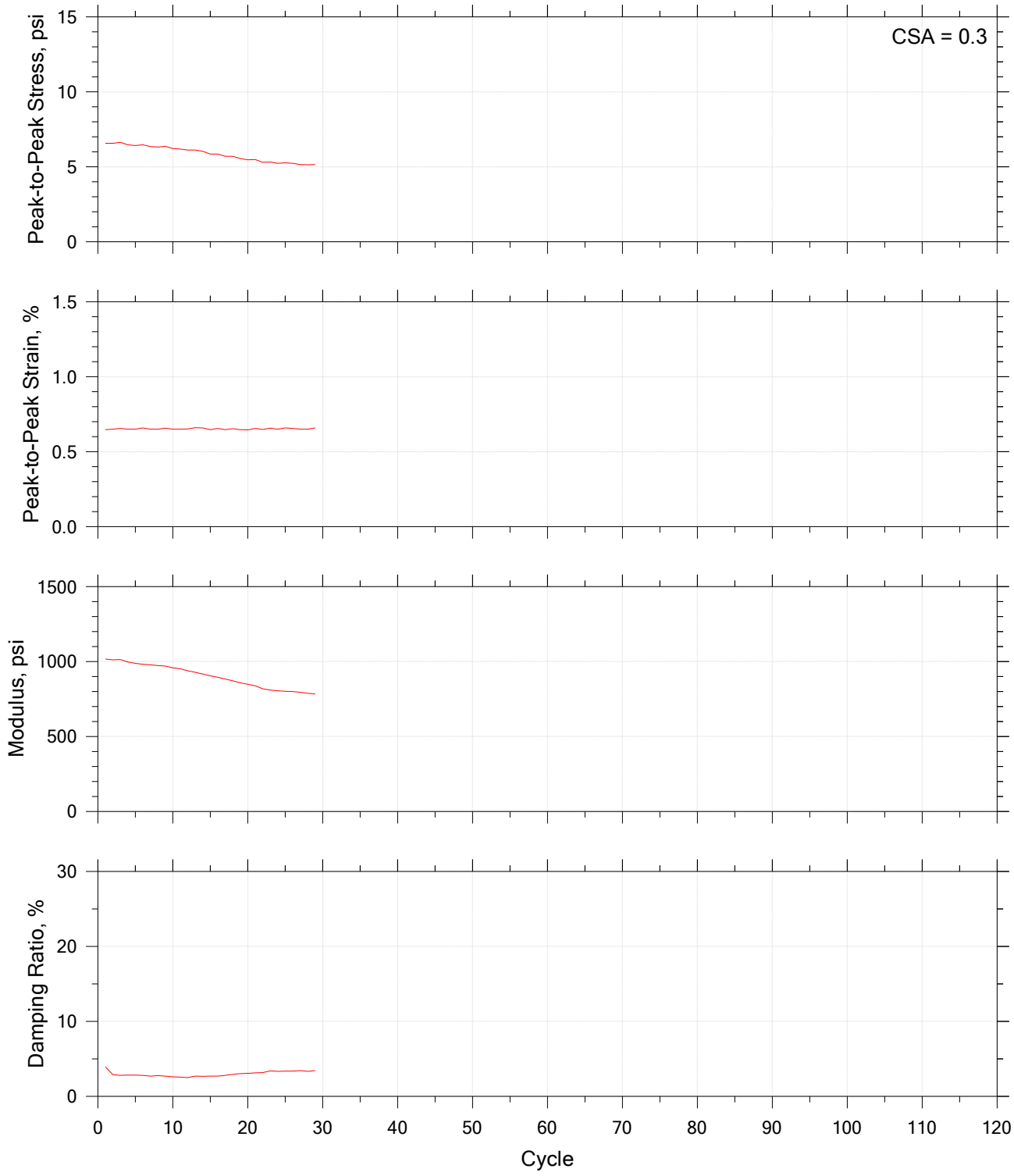


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4



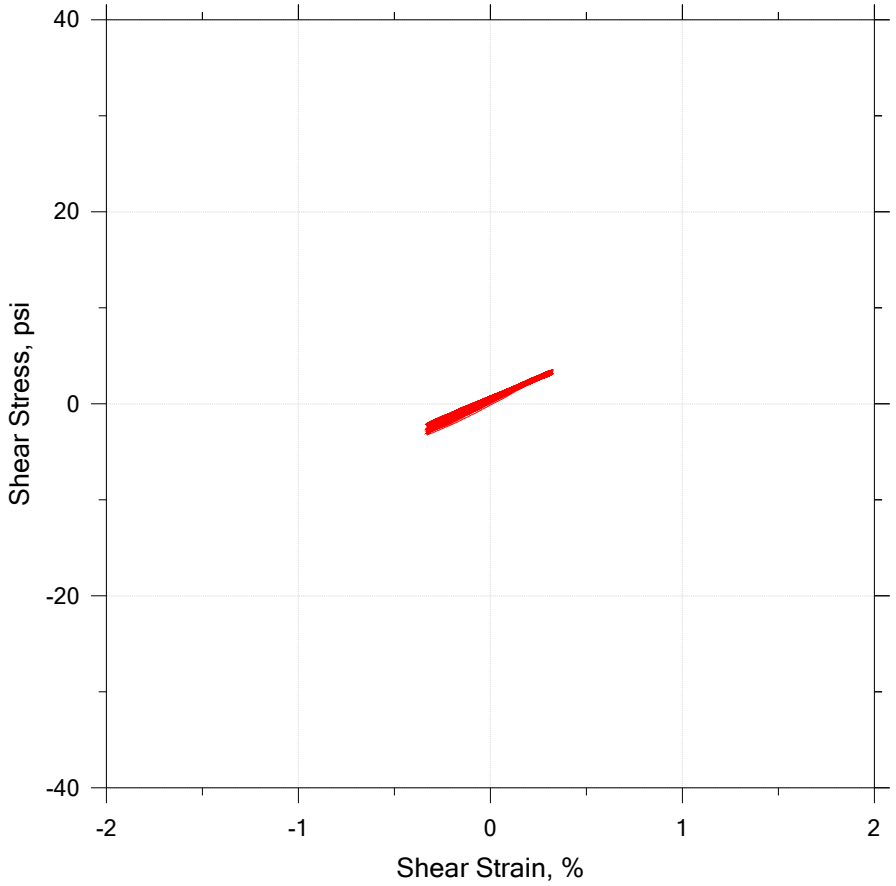
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

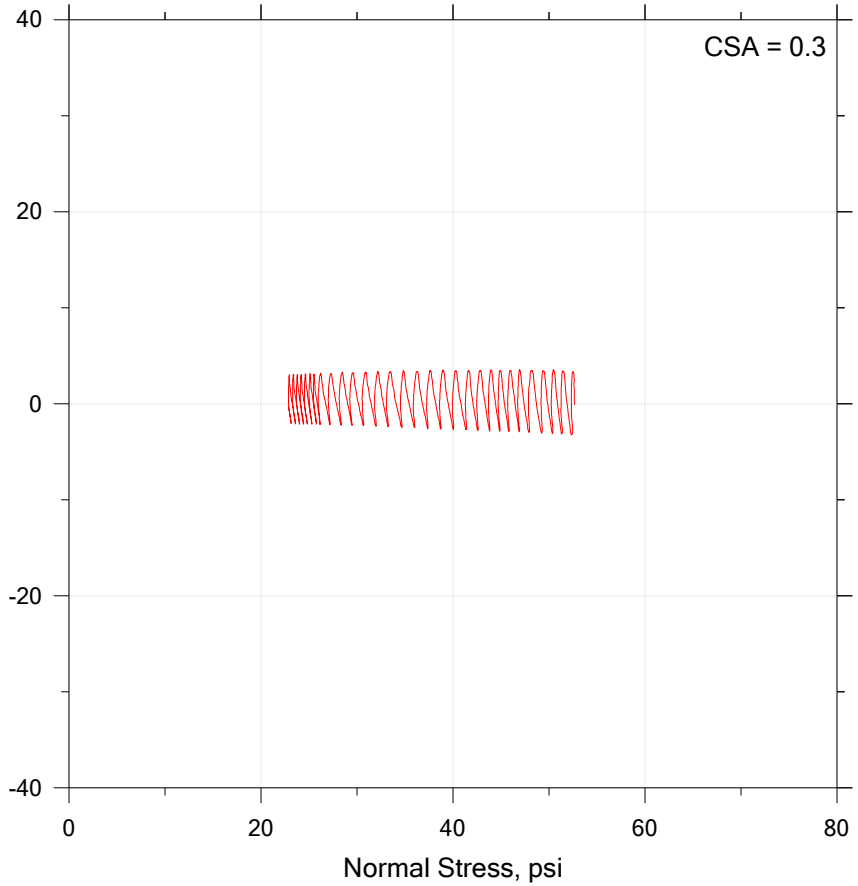
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



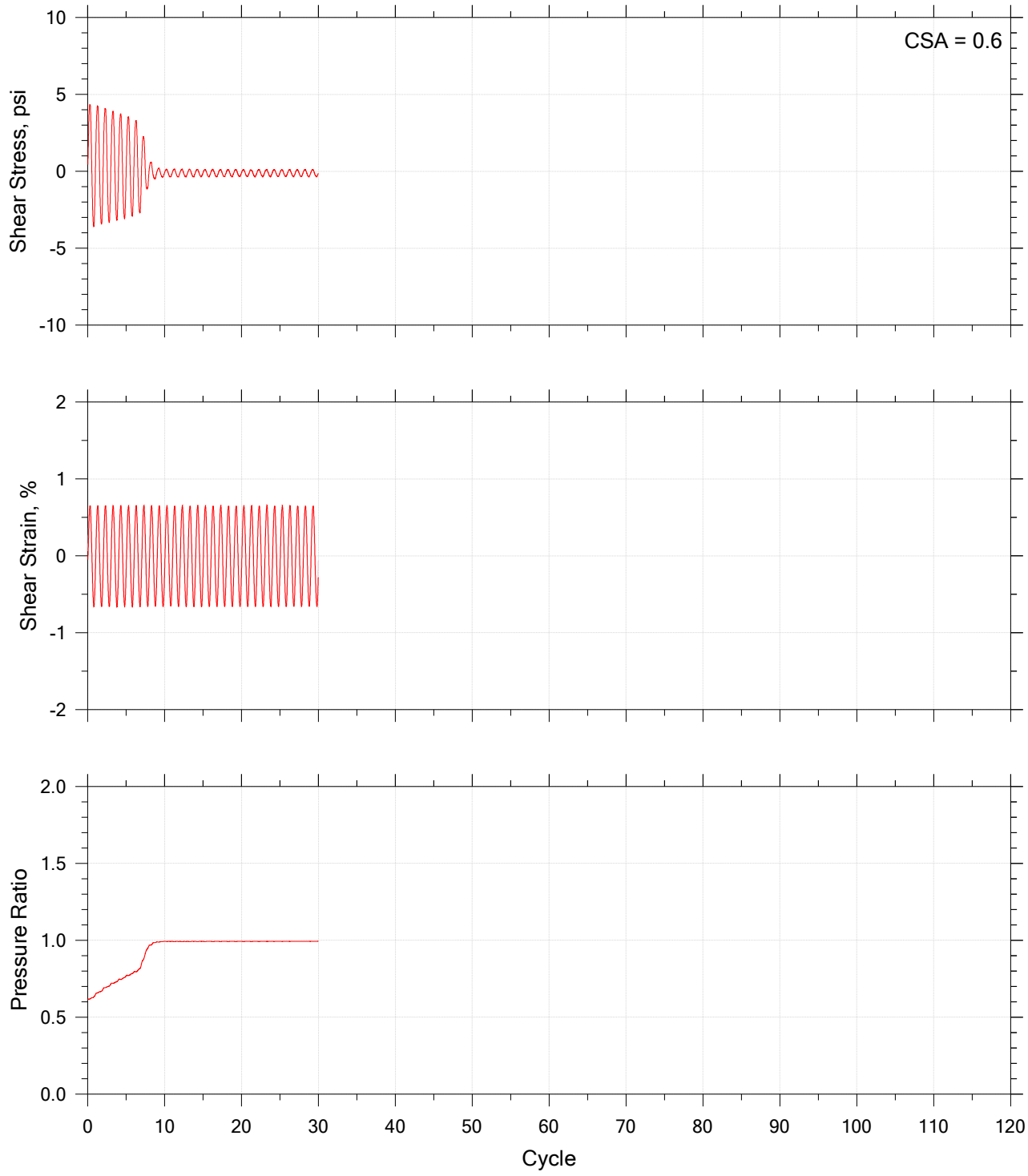


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



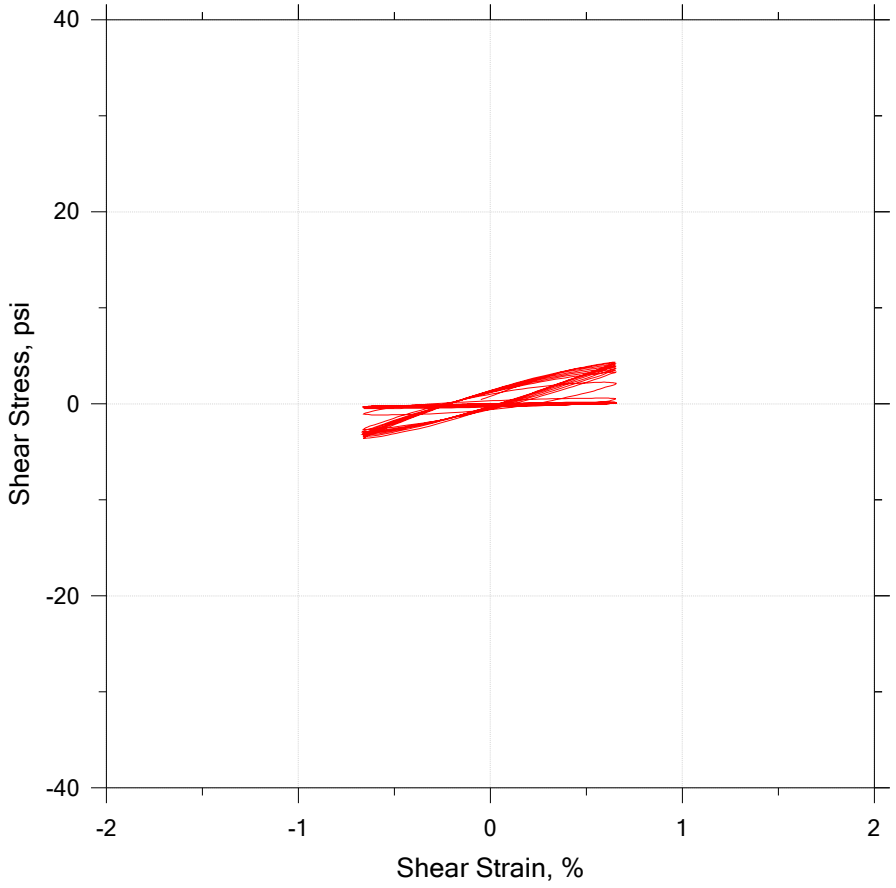
Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
Boring Number: B-1008	Tester: sjt	Checker: njh
Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
Test Number: CDSS-6	Preparation: intact	Elevation:
Description: Moist, light gray sand		
Remarks: CST-005		

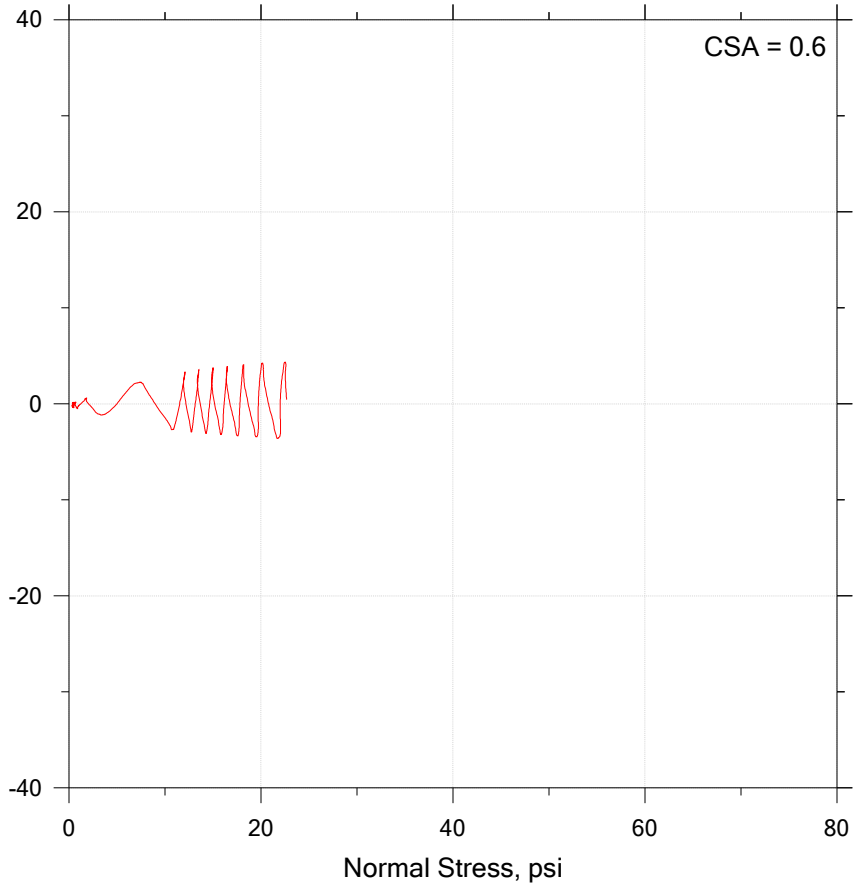
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0



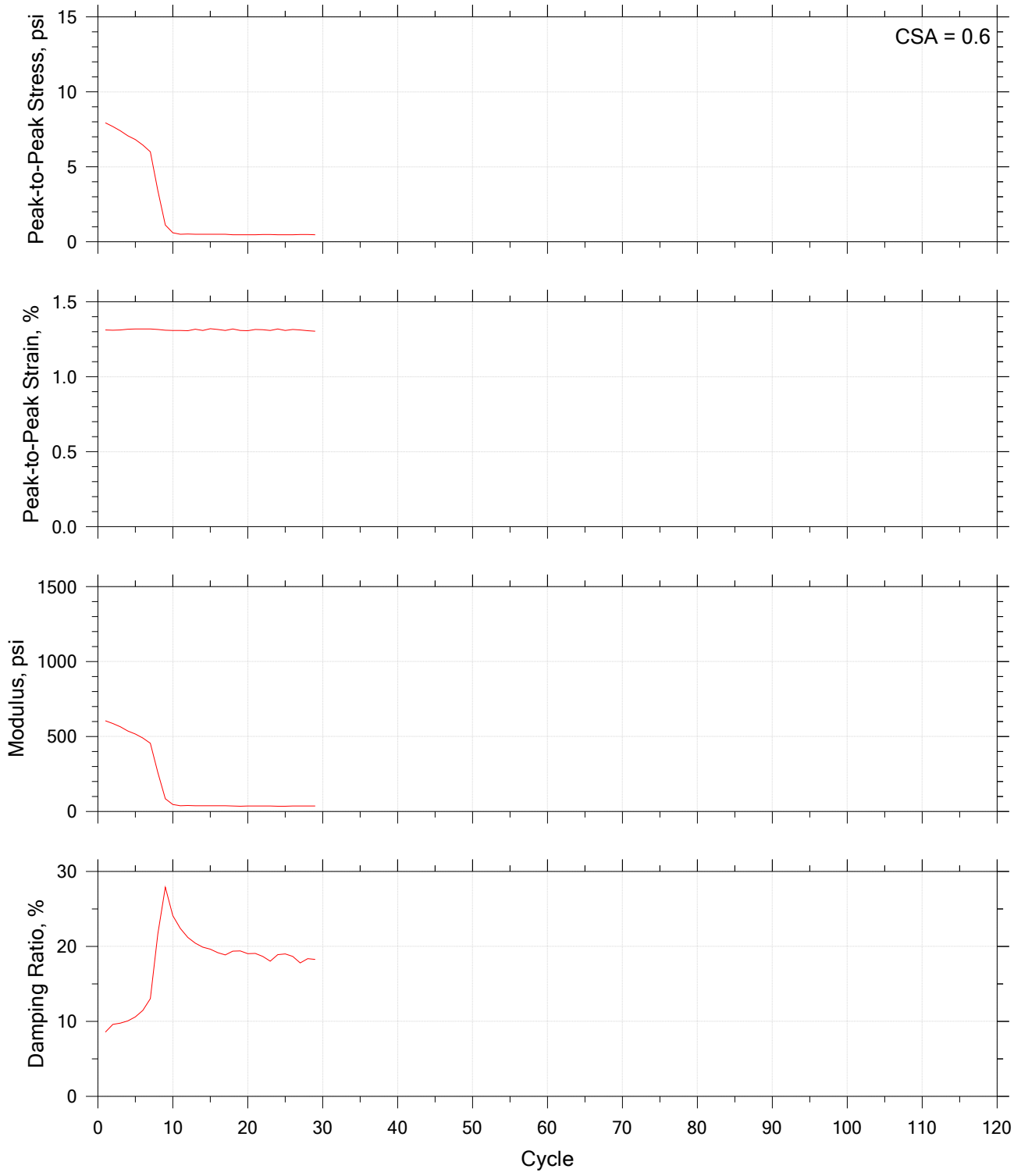


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

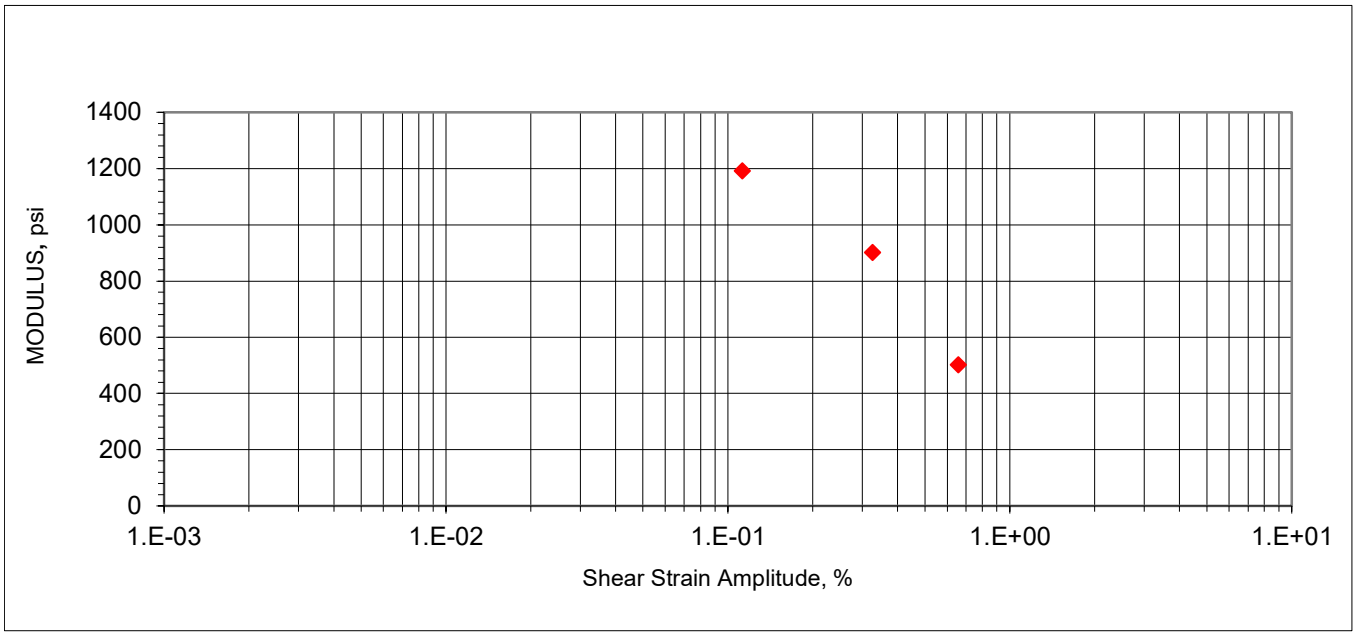


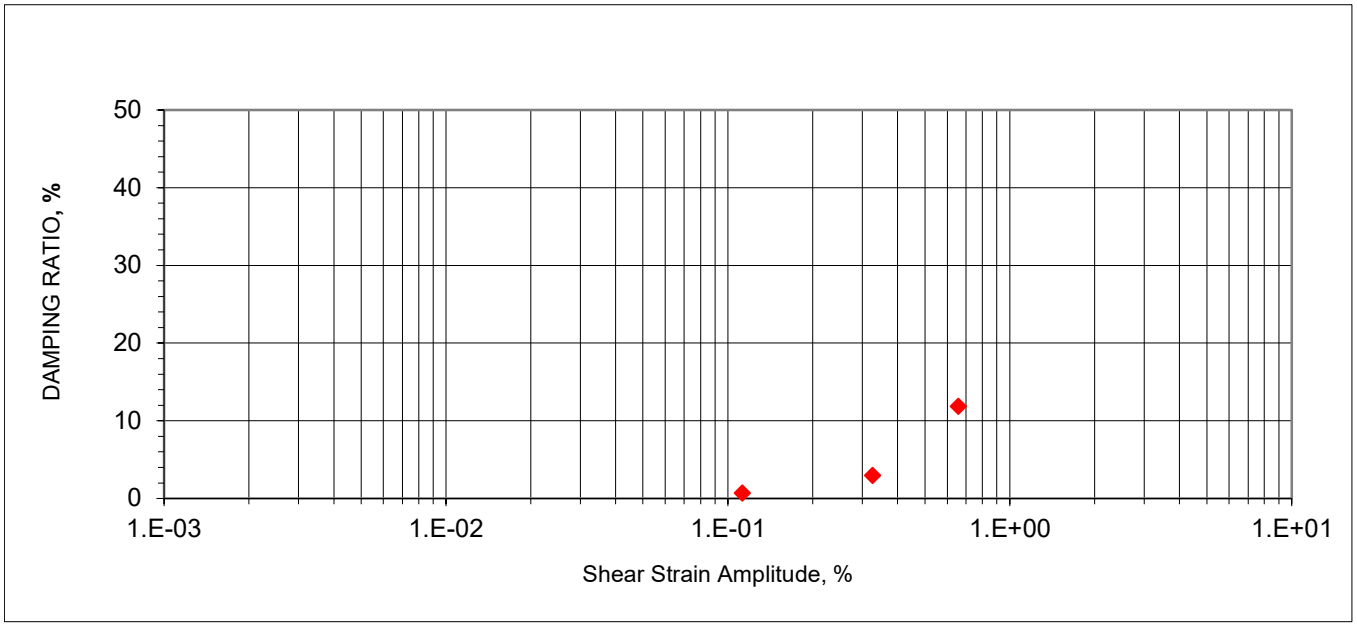
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1008	Tester: sjt	Checker: njh
	Sample Number: GT-3	Test Date: 12/13/24	Depth: 140.4-142.4
	Test Number: CDSS-6	Preparation: intact	Elevation:
	Description: Moist, light gray sand		
	Remarks: CST-005		

GeoTesting EXPRESS
A Sercel Business

Modulus and Damping Properties of Soils

Using the Cyclic Direct Simple Shear Apparatus





Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1008	Tested By: jlw	Checked By:	njh
Sample No.: GT-3	Test Date: 12/13/24	Test No.:	CDSS-6
Depth: 140.4-142.4	Sample Type: intact	Elevation:	---
Description: Moist, light gray sand			
Remarks: Average values of G and D from 30 cycles in Step 1 and Step 2 and 8 cycles in Step 3.			

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	12/10/24
Project Location:	Kentucky		

Boring ID: B-1009
Sample ID: GT-3
Depth, ft: 64.4-66.4

Visual Description: Moist, light gray sand

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 26 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-1				
Initial Moisture Content, %	18.7				
Initial Dry Density, pcf	106.7				
Vertical Consolidation Stress, psi	26				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	30	3	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				18.9	
Delay before shearing, sec				---	
Nominal Rate of Shear Strain, %/hr				---	
Measured Post-Cyclic Peak Shear Stress, psi				---	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				---	
Membrane Correction, psi				---	
Corrected Post-Cyclic Peak Shear Stress, psi				---	
S_r/σ'_{vc}				---	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Specimen reached an R value approaching 1 and liquified the sample at about 3 cycles into Step 4 of the test. Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

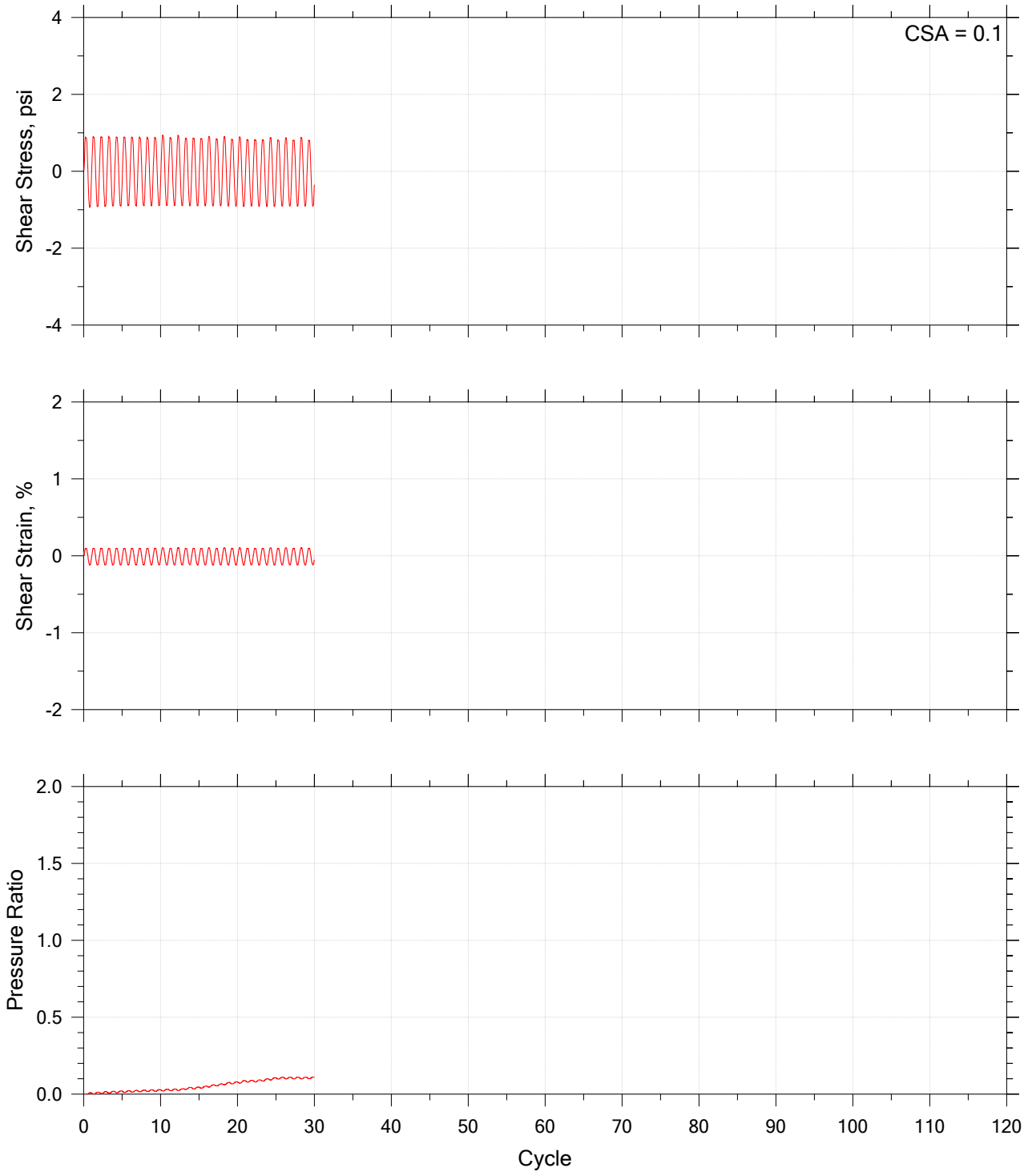
Tested By: sjt Checked By: dgz

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



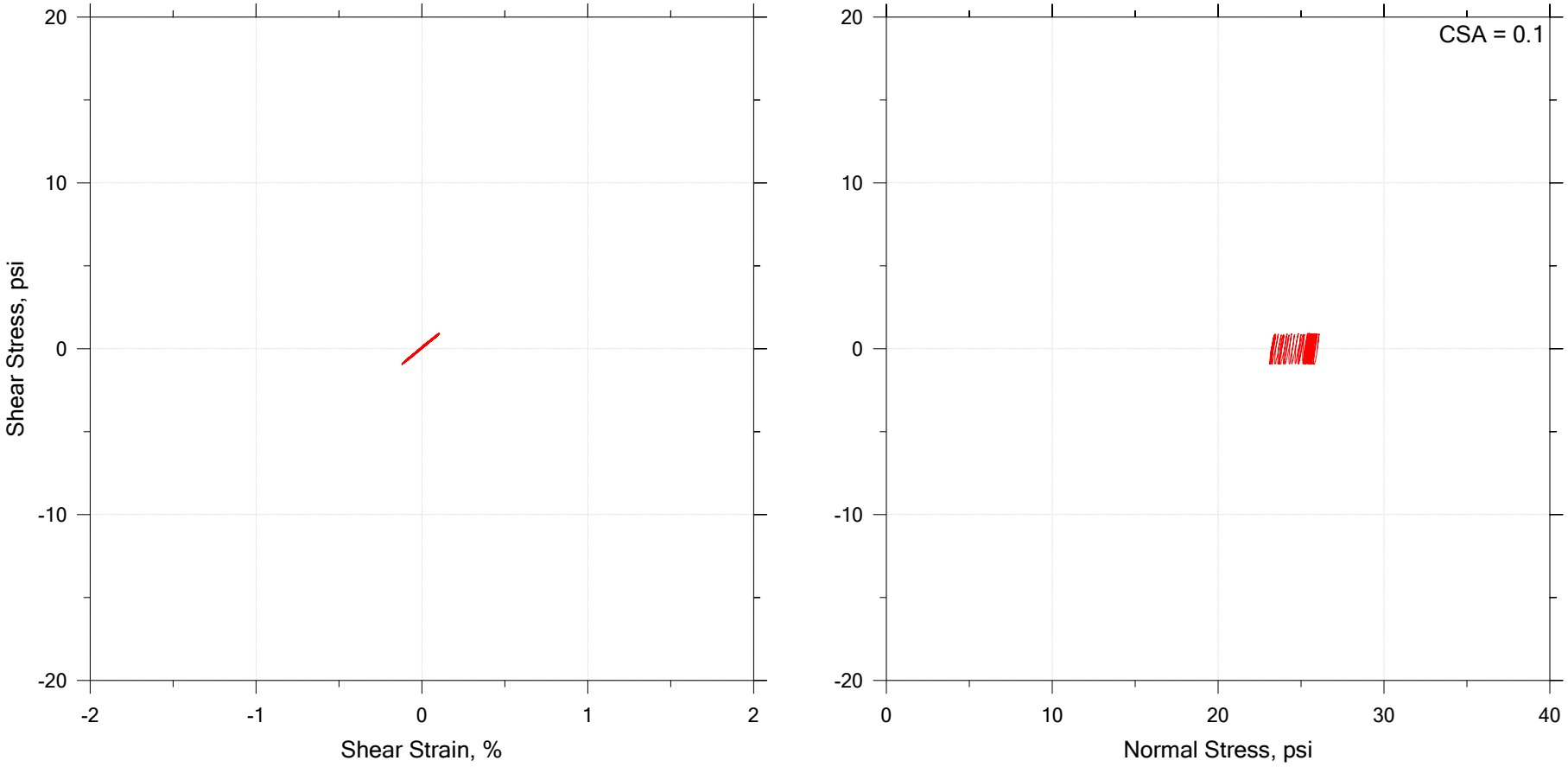
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0

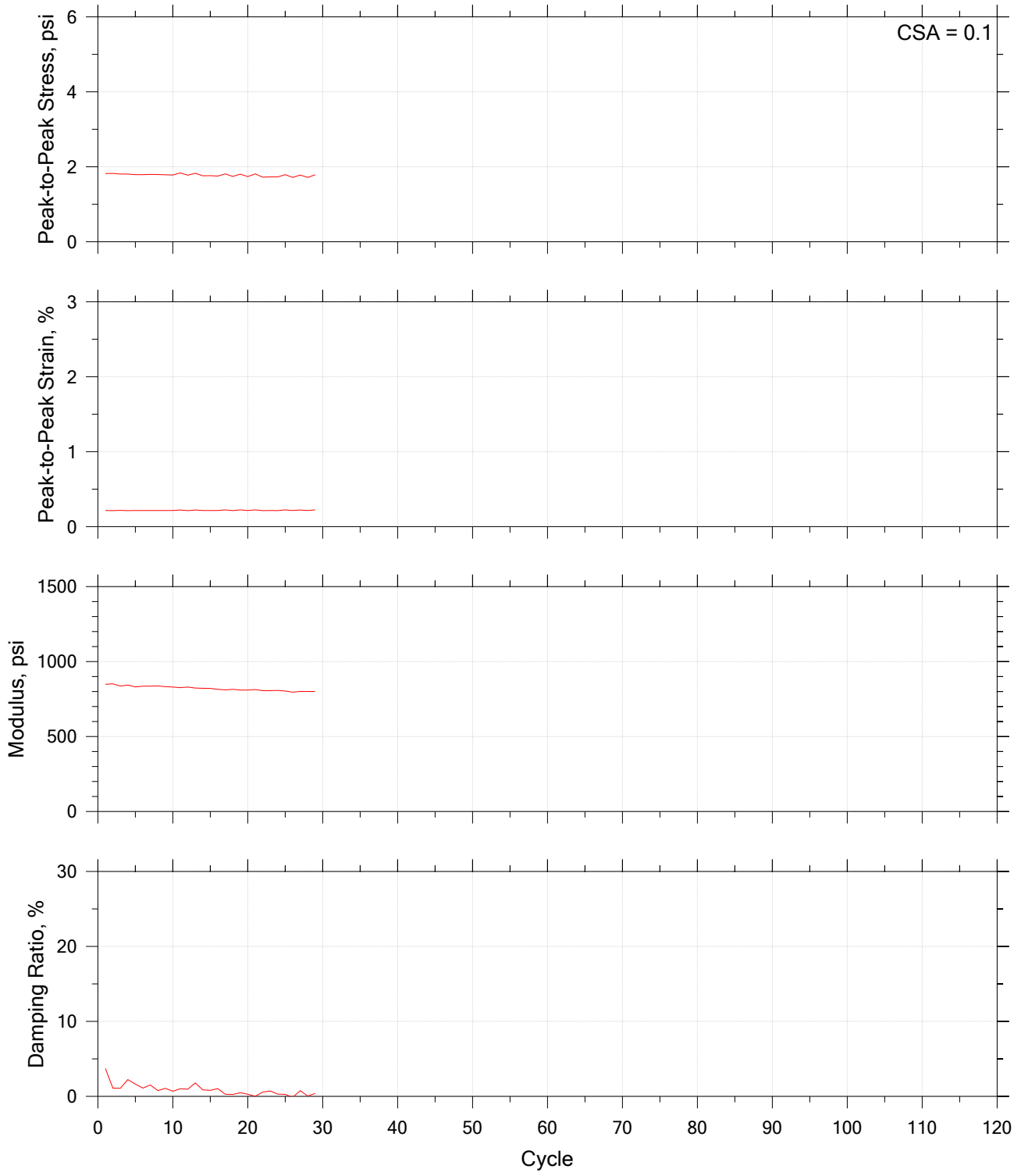


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

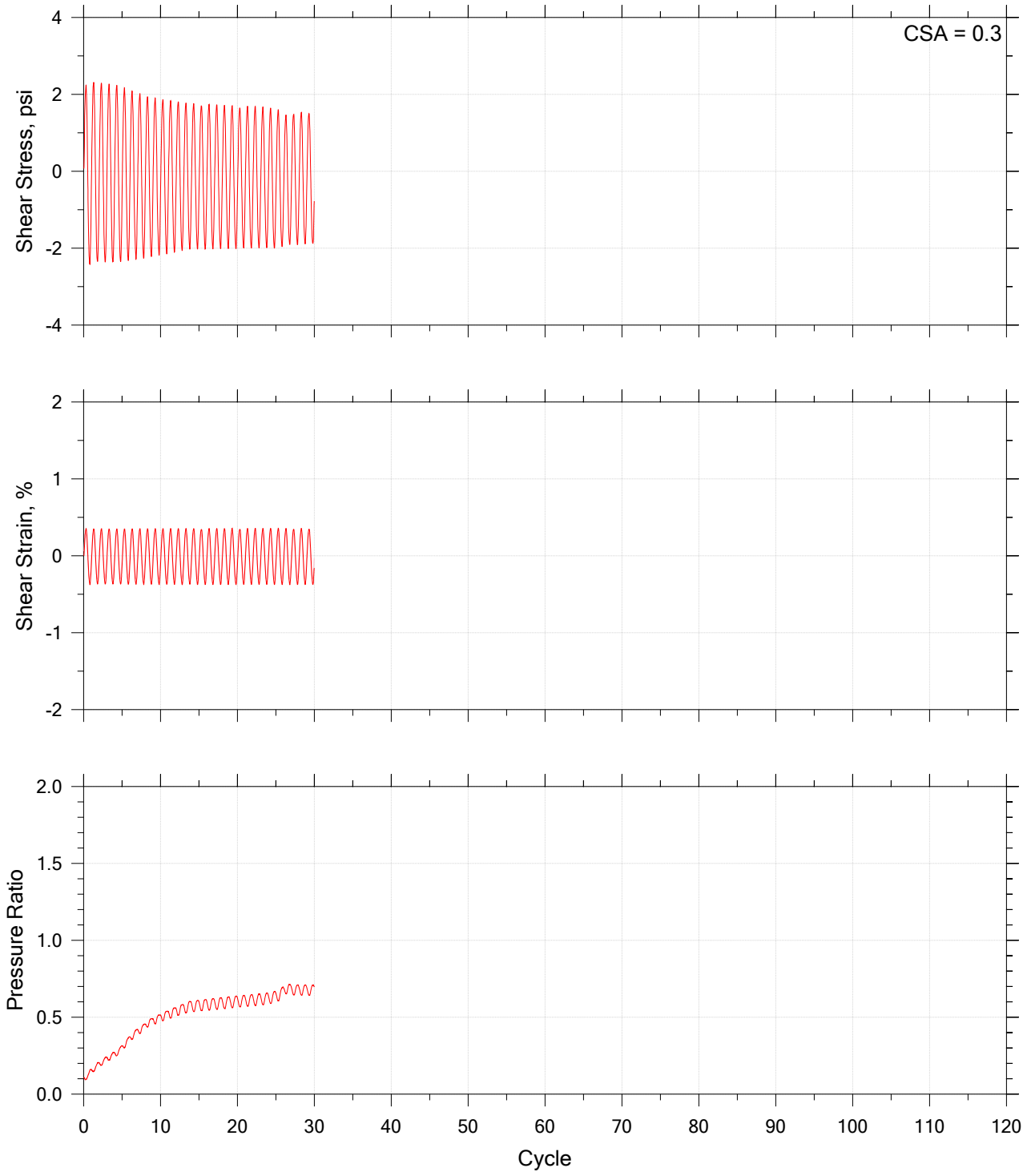


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



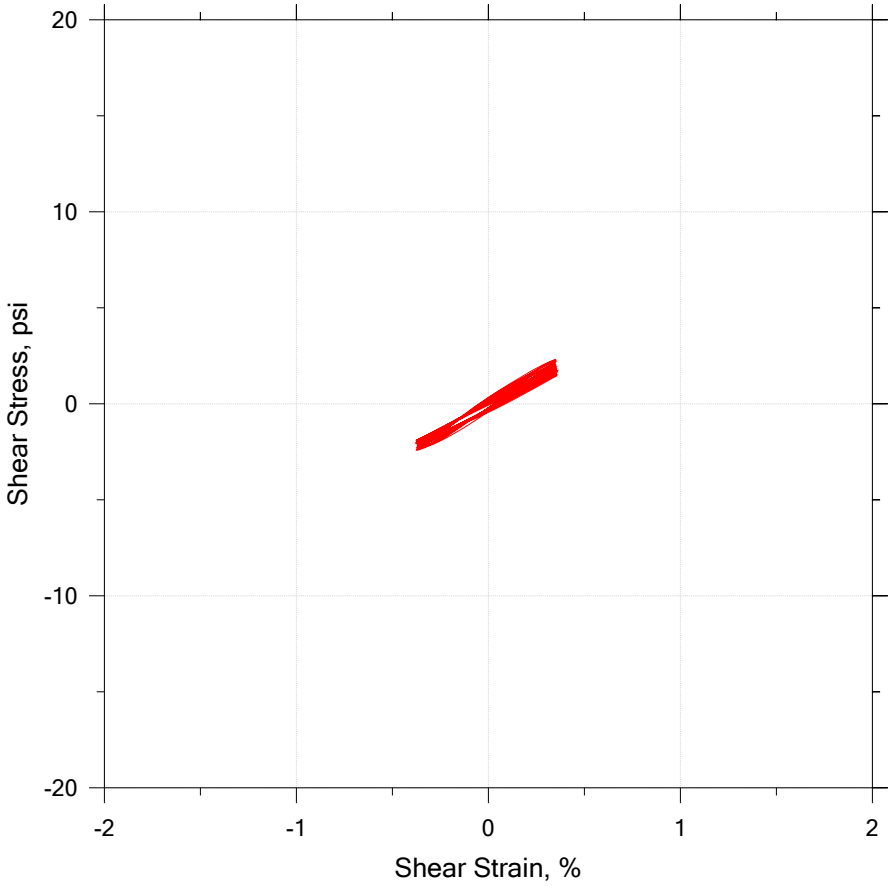
Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
Boring Number: B-1009	Tester: sjt	Checker: dgz
Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
Test Number: CDSS-4	Preparation: intact	Elevation: ---
Description: Moist, light gray sand		
Remarks: CST-005		

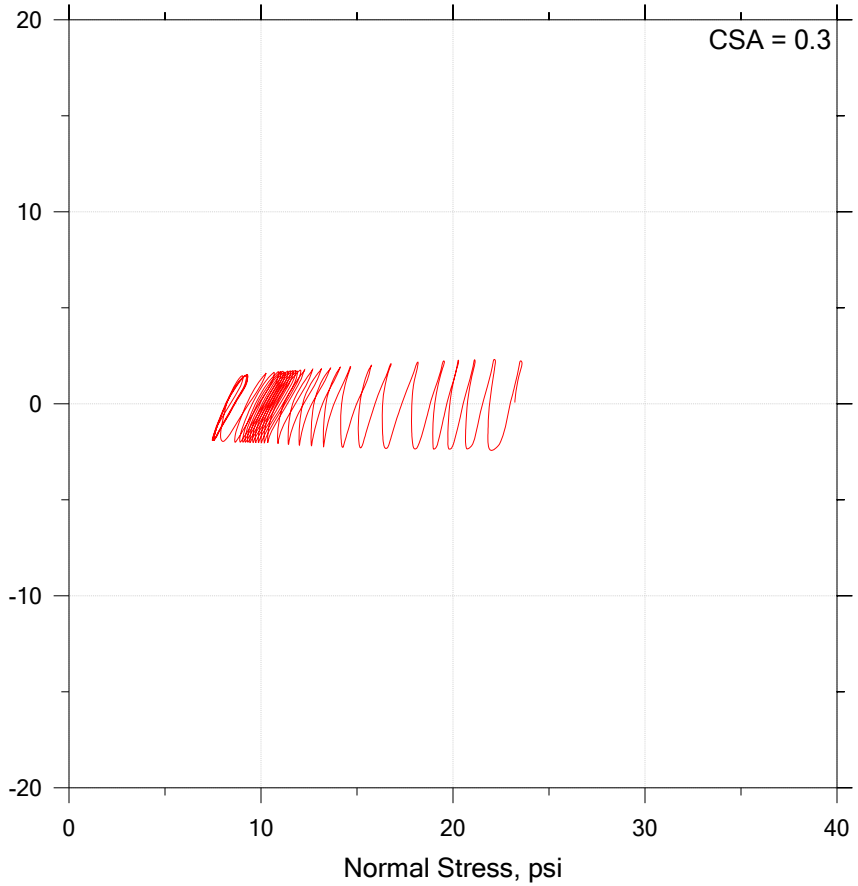
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



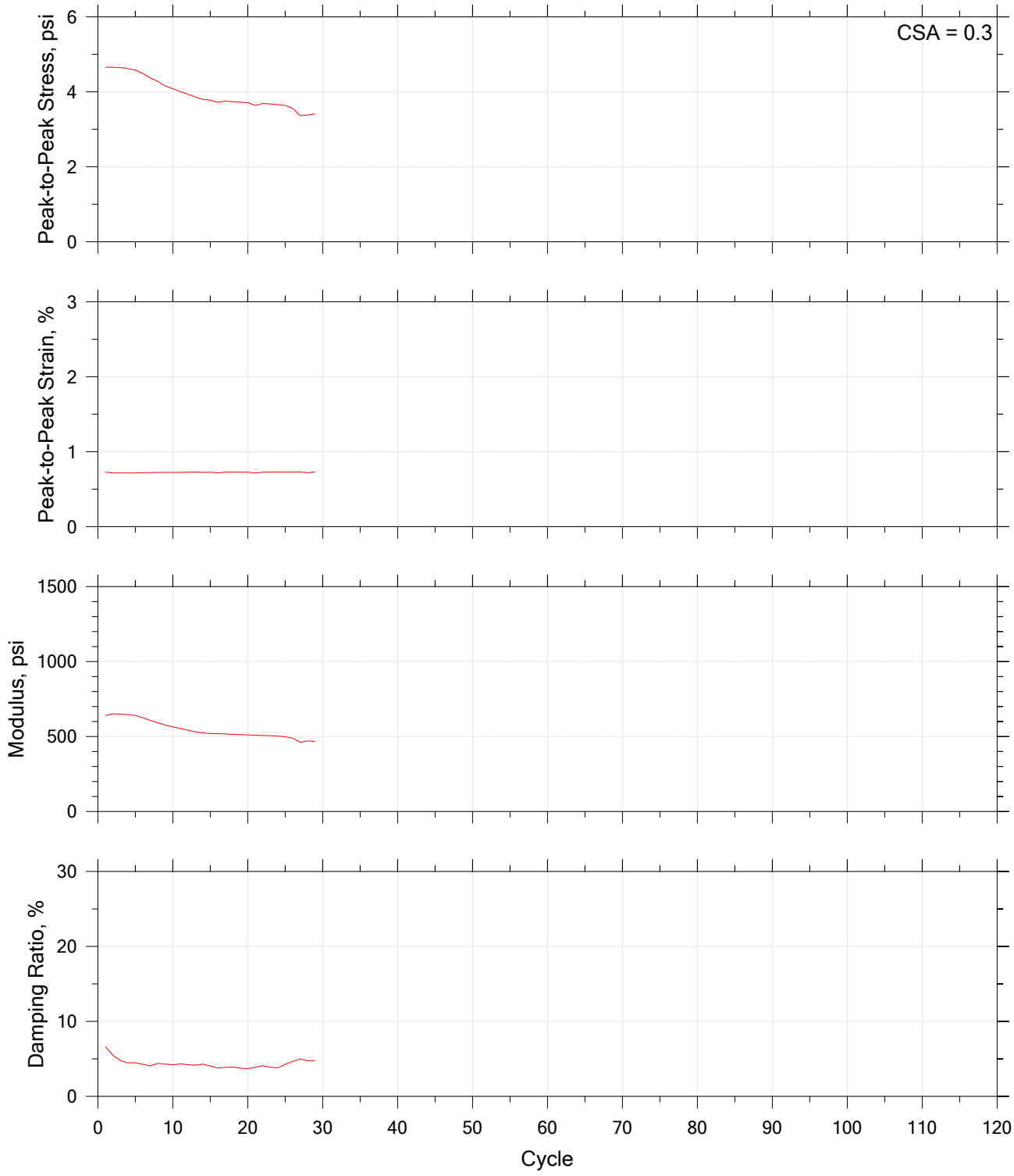


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

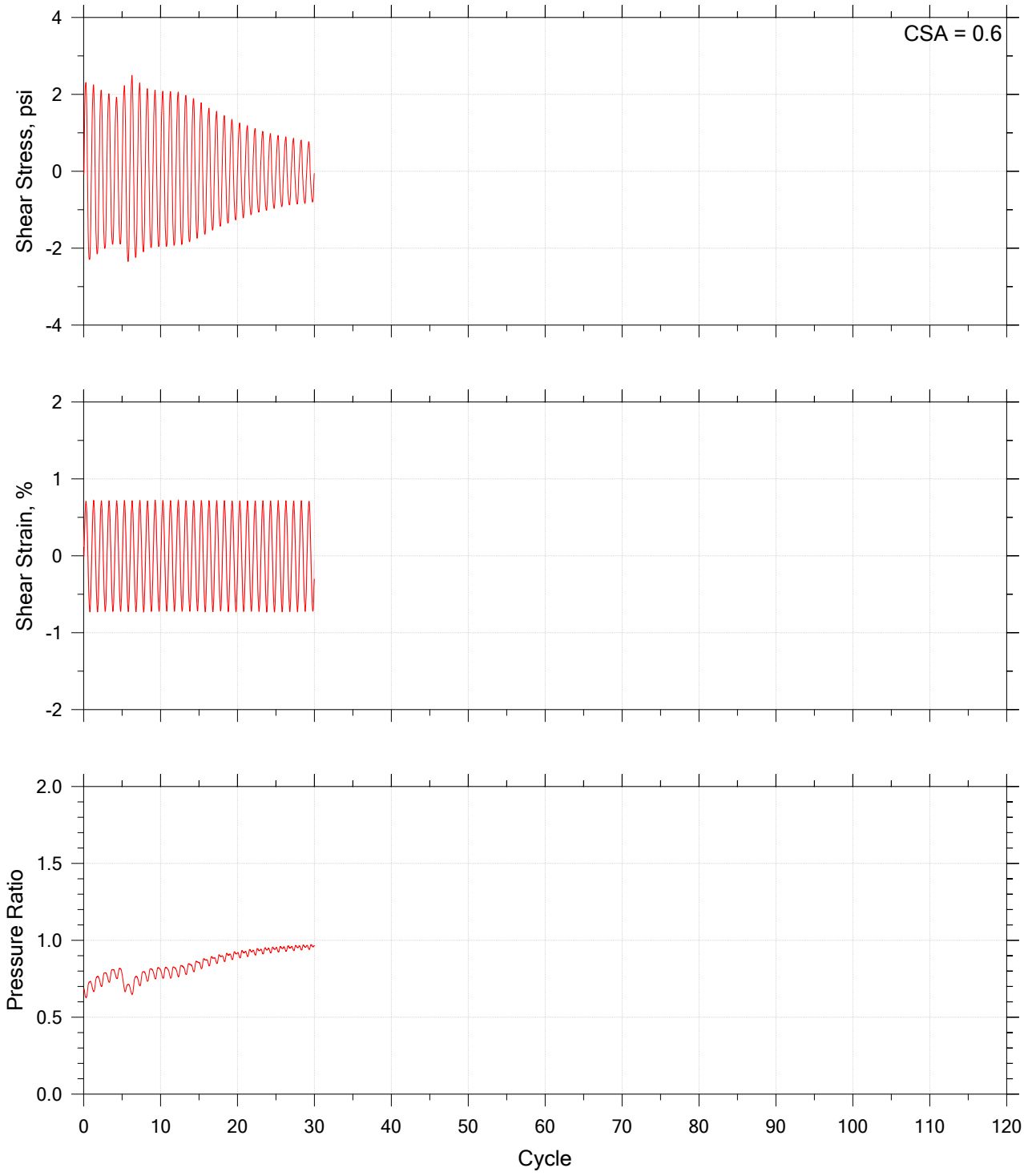


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



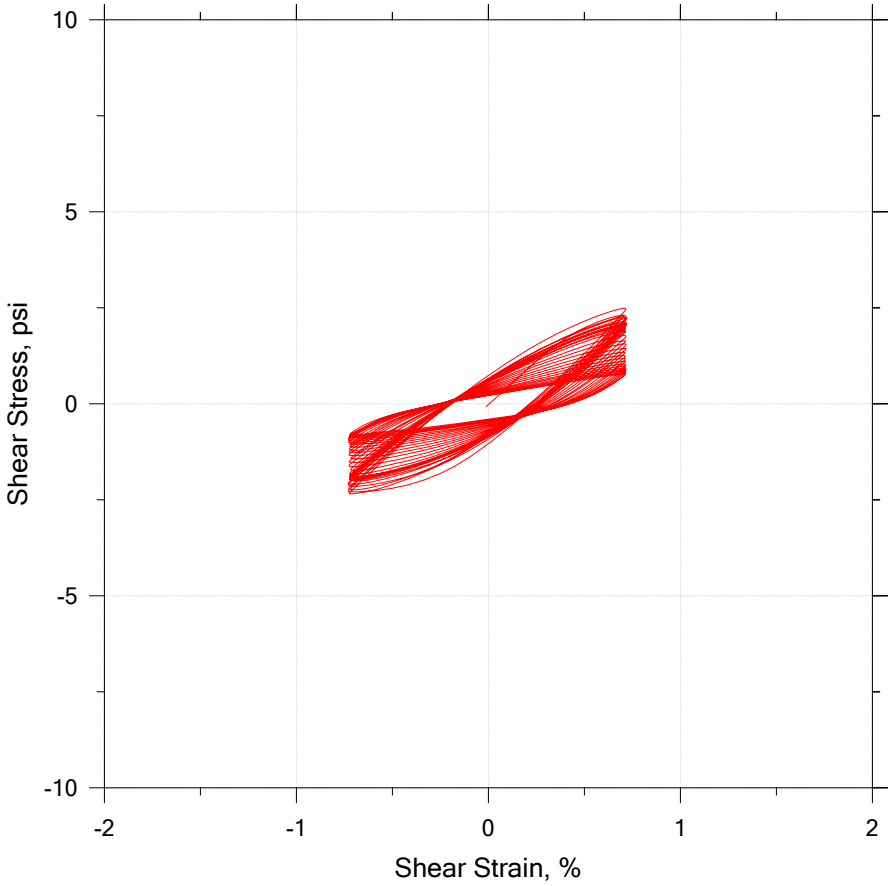
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

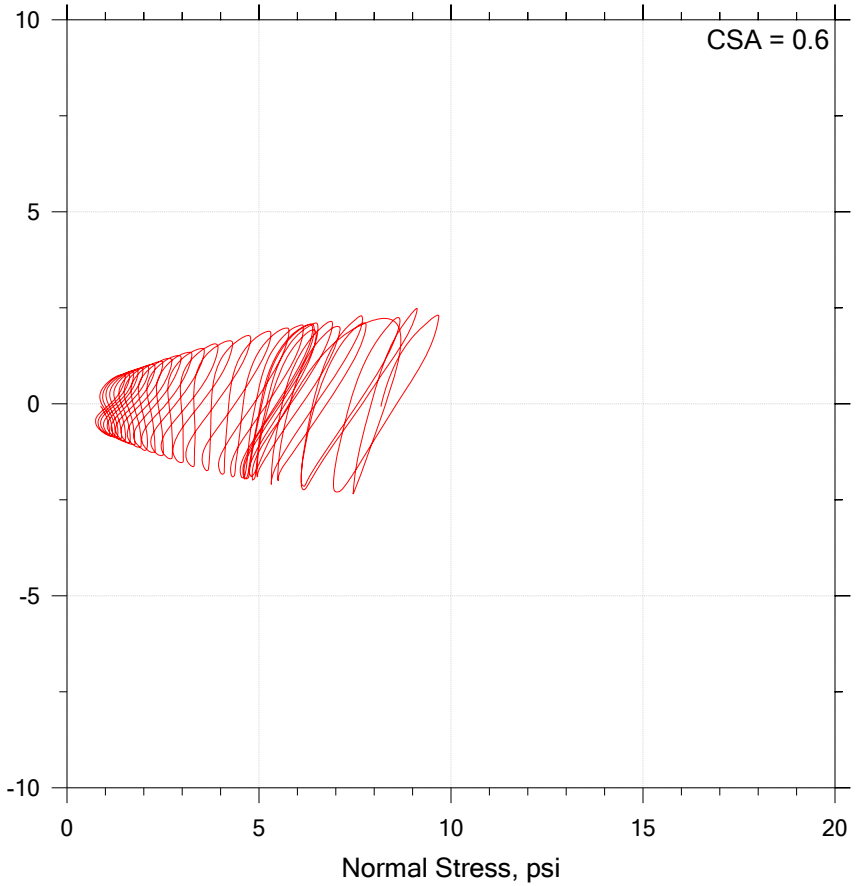
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0



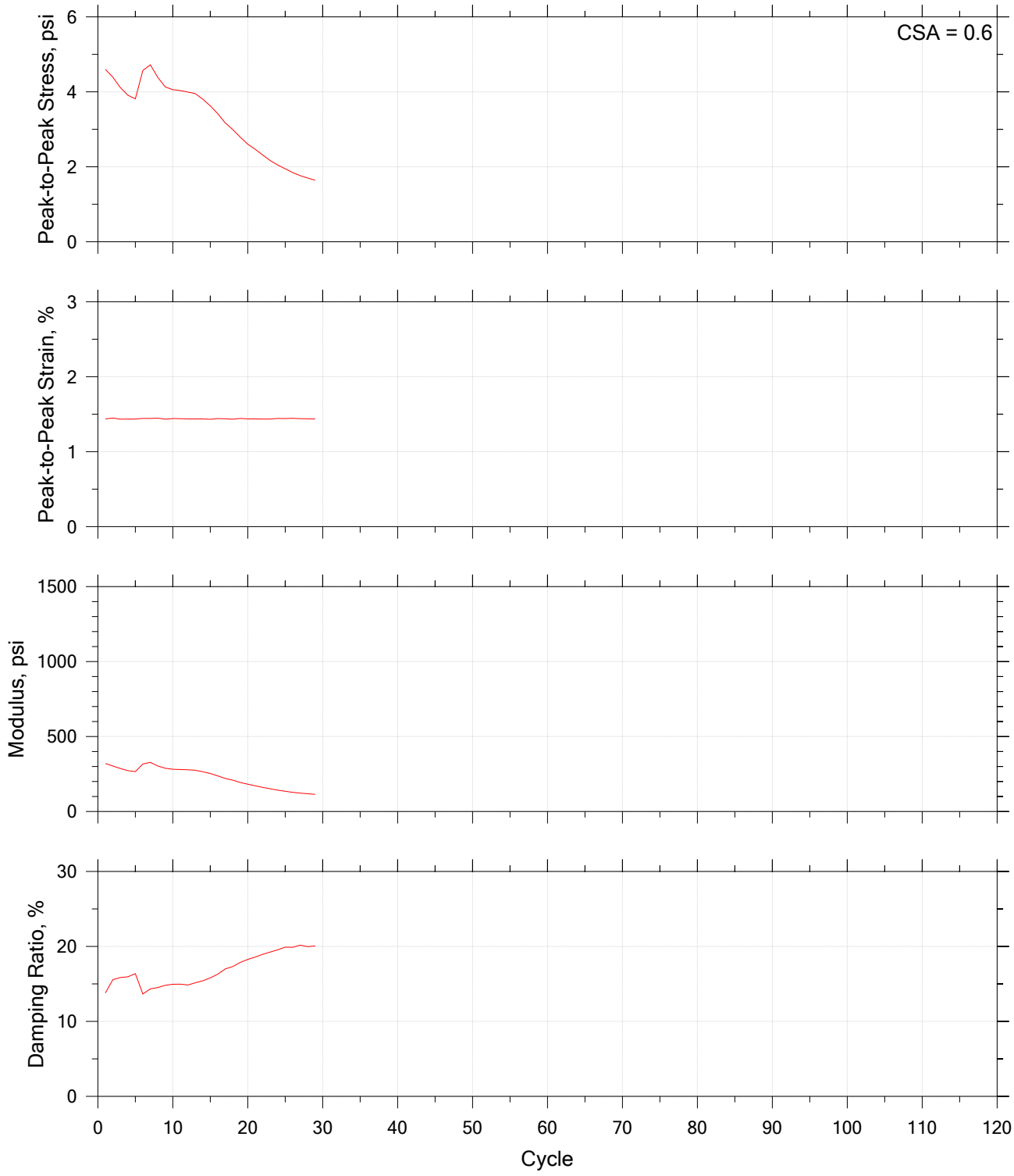


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

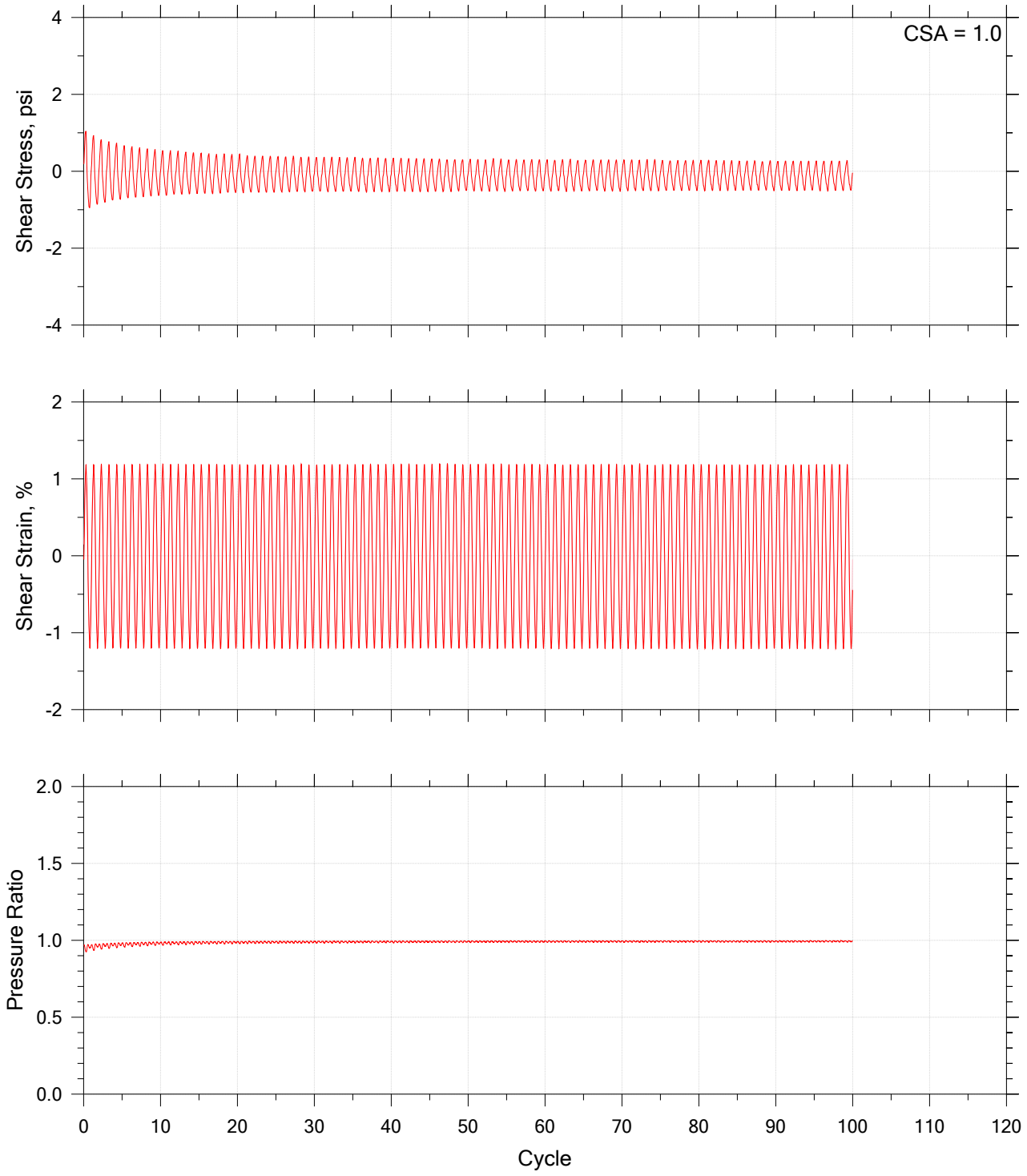


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 4 of 4



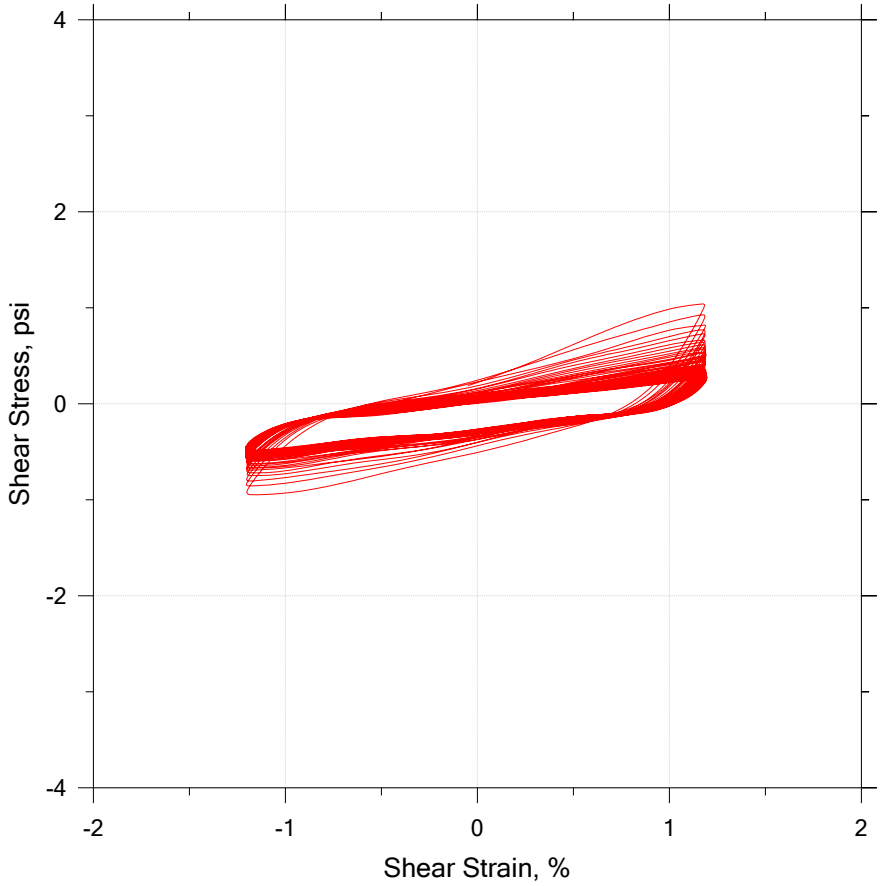
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

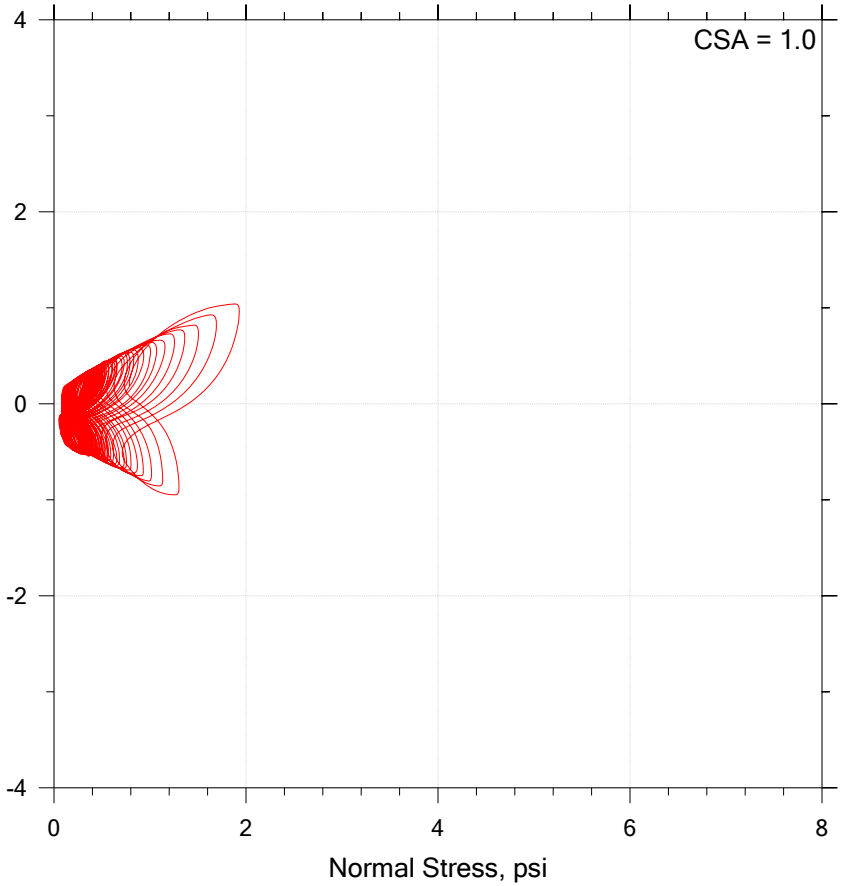
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 4 of 4

Cycle 0.0 to 100.0



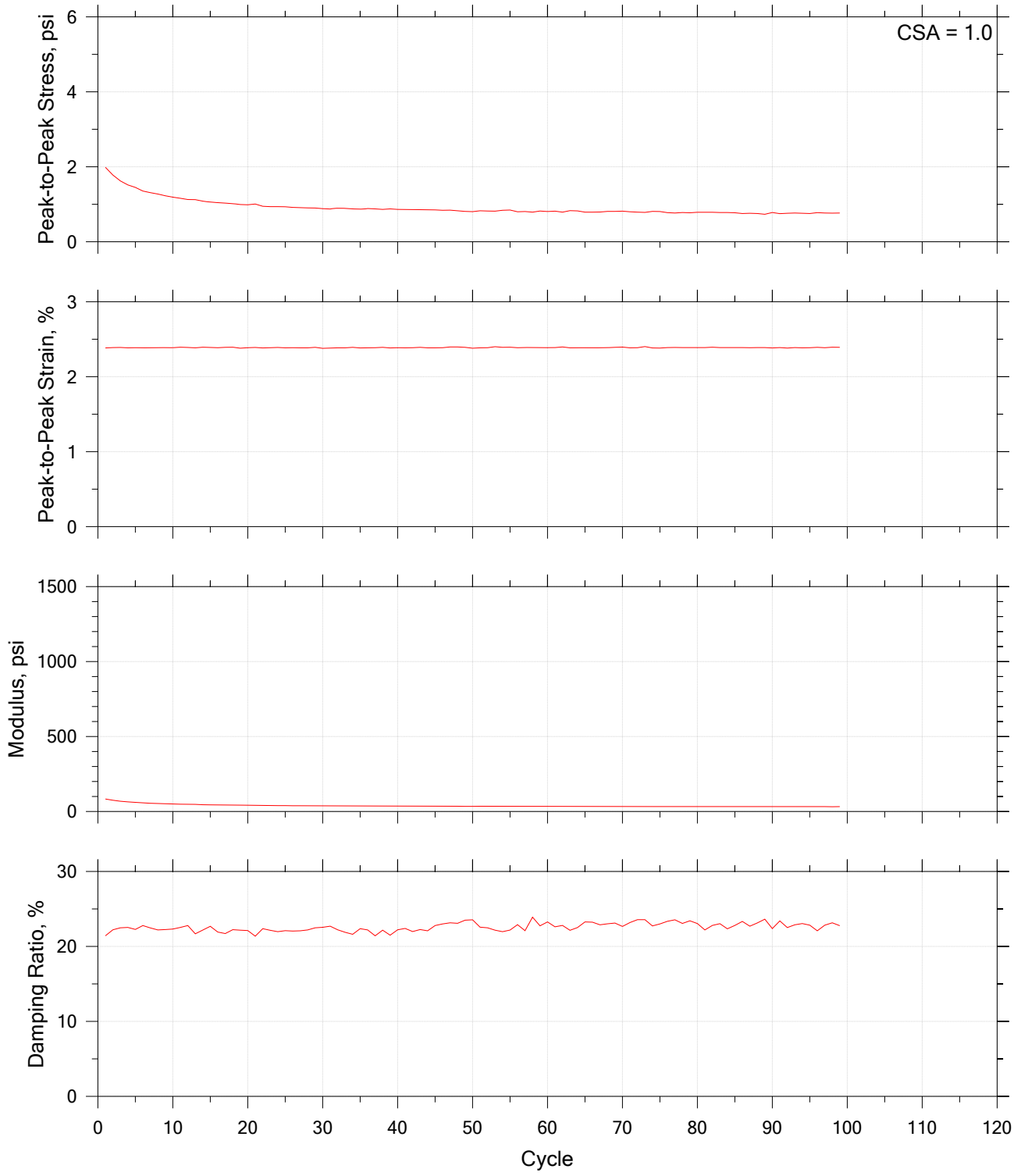


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

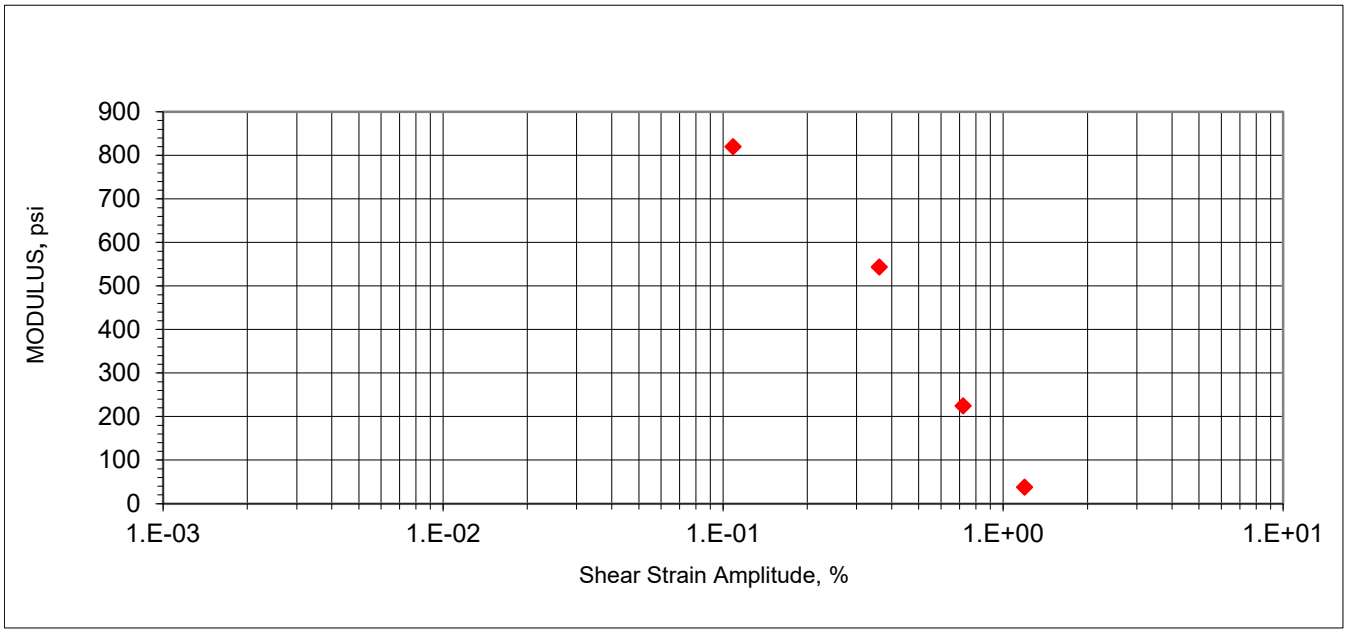
Step 4 of 4

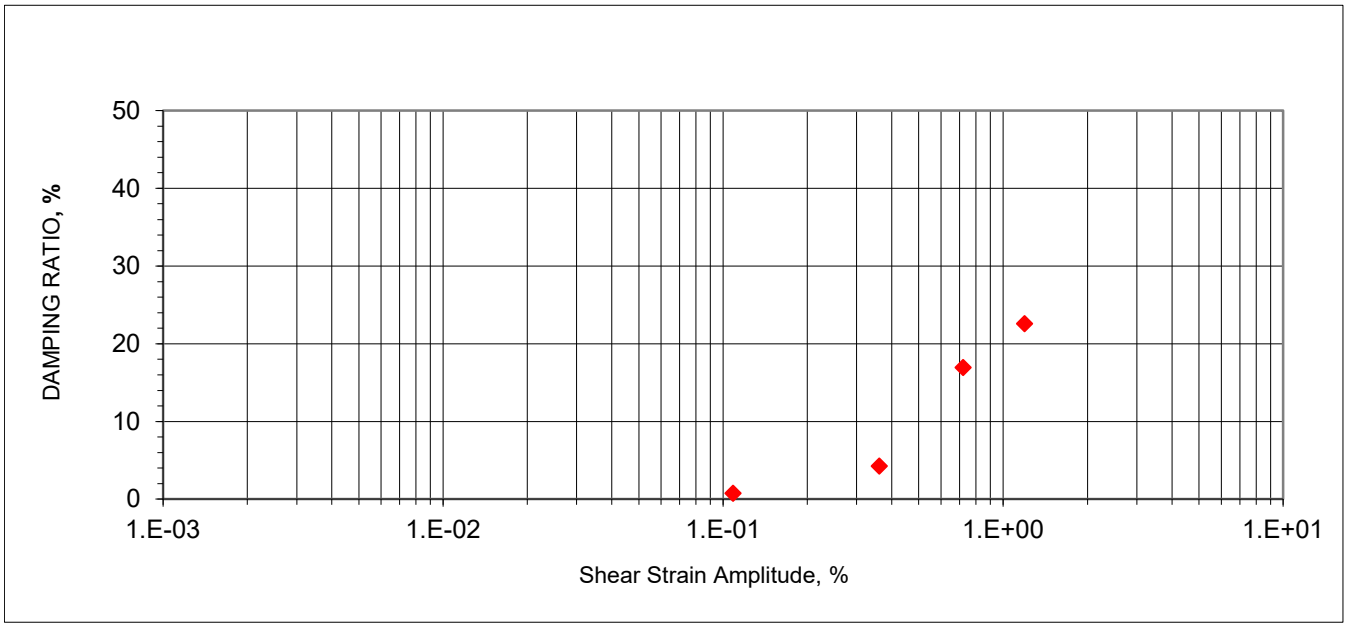


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1009	Tester: sjt	Checker: dgz
	Sample Number: GT-3	Test Date: 12/10/24	Depth: 64.4-66.4
	Test Number: CDSS-4	Preparation: intact	Elevation: ---
	Description: Moist, light gray sand		
	Remarks: CST-005		

Modulus and Damping Properties of Soils

Using the Cyclic Direct Simple Shear Apparatus





Project: US-51 Over Ohio River	Location: ---		Project No.:	GTX-319809
Boring No.: B-1009	Tested By: sjt		Checked By:	dgz
Sample No.: GT-3	Test Date: 12/10/24		Test No.:	CDSS-4
Depth: 64.4-66.4	Sample Type: intact		Elevation:	---
Description: Moist, light gray sand				
Remarks: Average values of G and D from 30 cycles in Step 1, 2 & 3 and 100 cycles in Step 4.				

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	12/11/24
Project Location:	Kentucky		

Boring ID: B-1012
Sample ID: ST-1
Depth, ft: 209.9-210.3

Visual Description: Moist, light gray silt

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 90 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-5				
Initial Moisture Content, %	18.7				
Initial Dry Density, pcf	110.5				
Vertical Consolidation Stress, psi	90				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	30	100	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				15.1	
Delay before shearing, sec				60	
Nominal Rate of Shear Strain, %/hr				5.0	
Measured Post-Cyclic Peak Shear Stress, psi				21.59	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				19.73	
Membrane Correction, psi				0.33	
Corrected Post-Cyclic Peak Shear Stress, psi				21.26	
S_r/σ'_{vc}				0.24	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

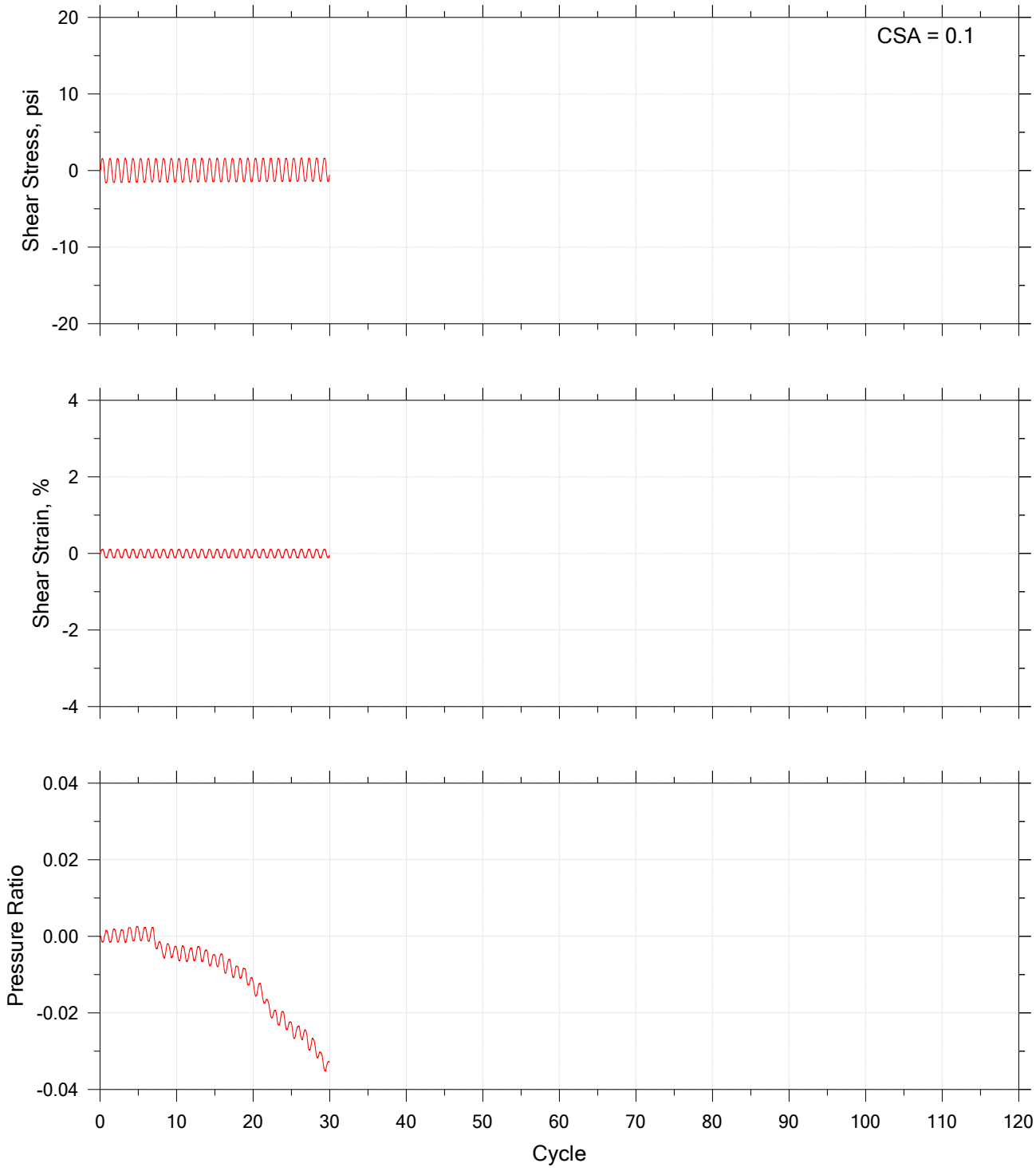
Tested By: sjt Checked By: njh

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



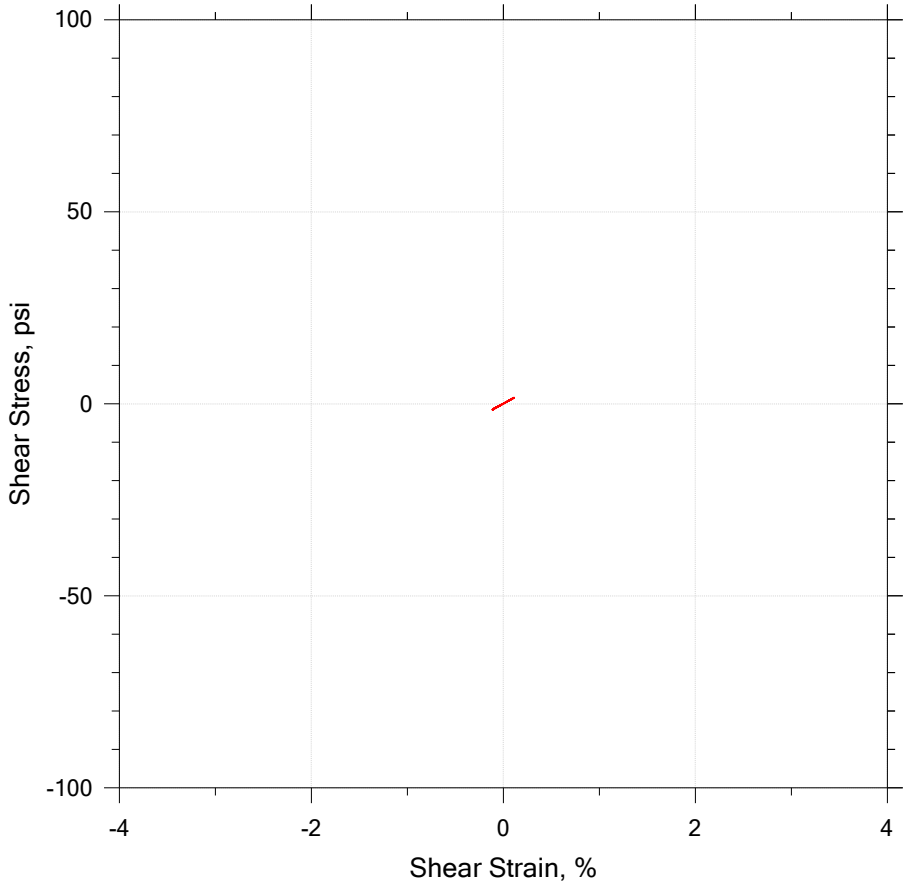
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

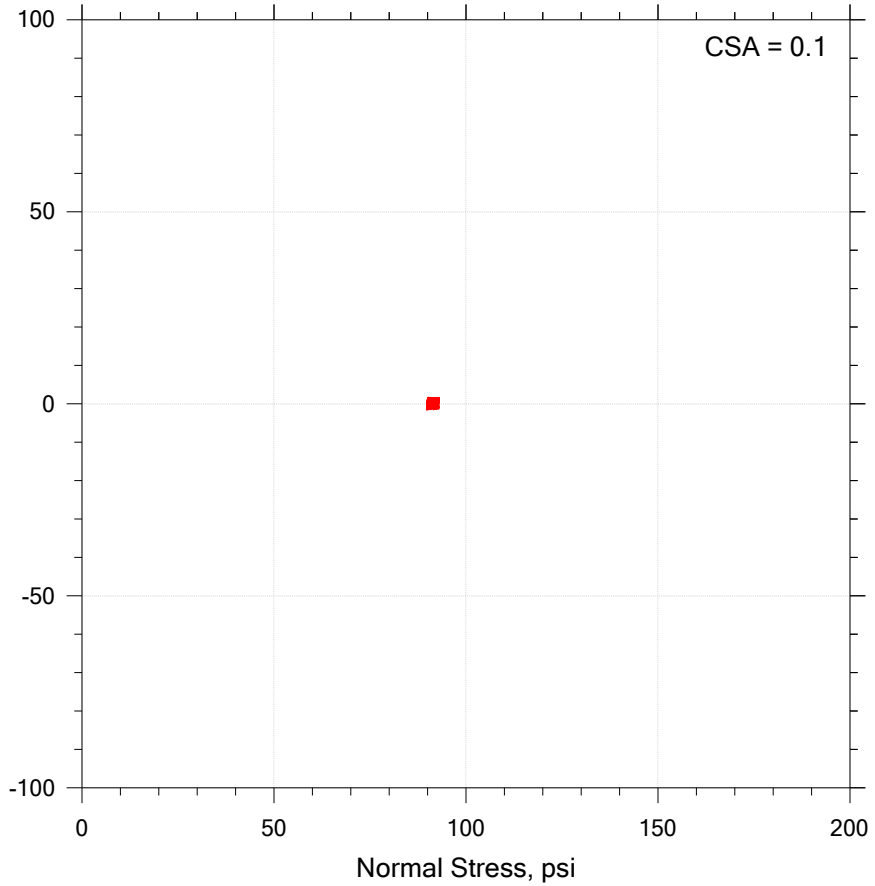
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0



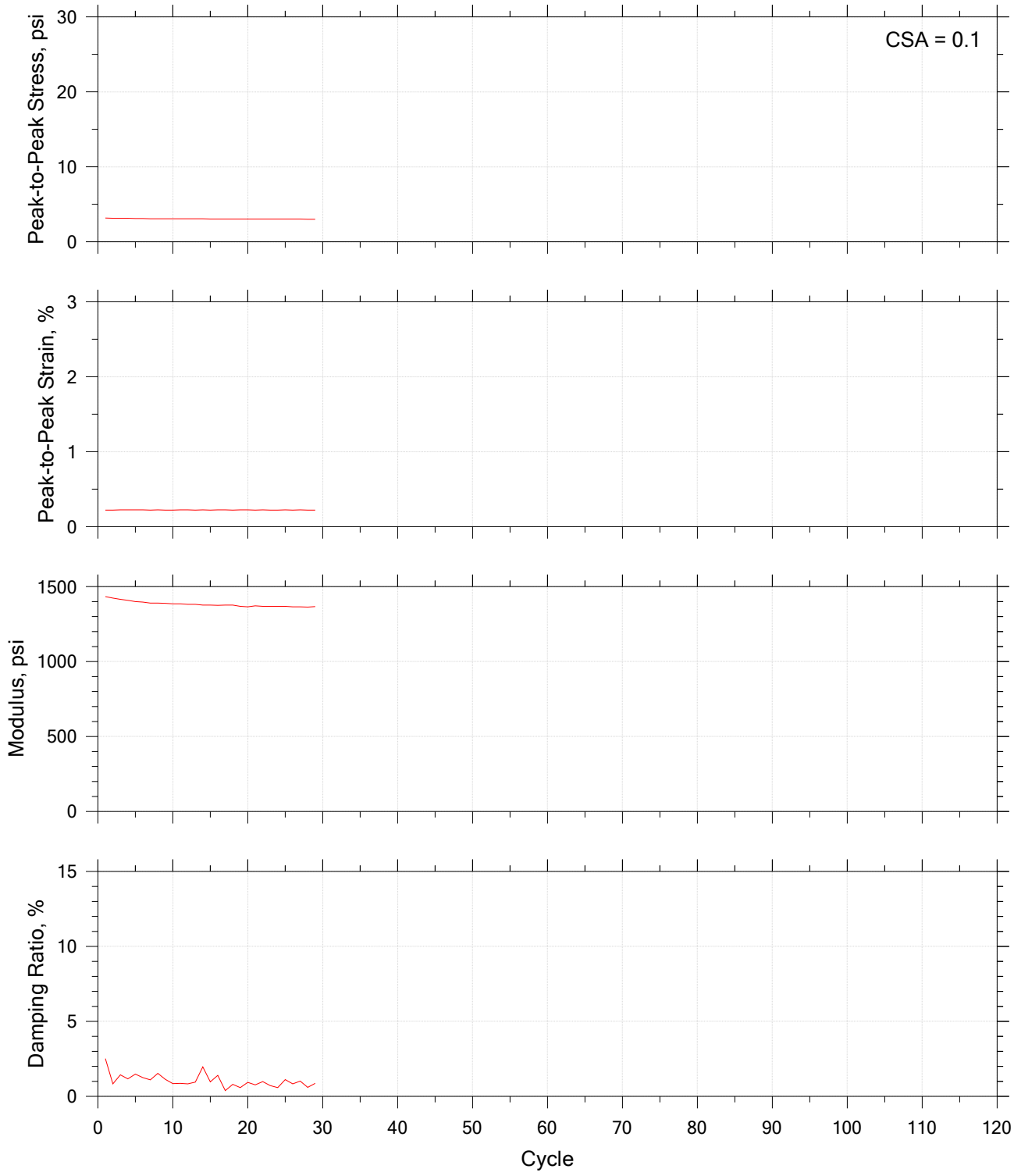


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

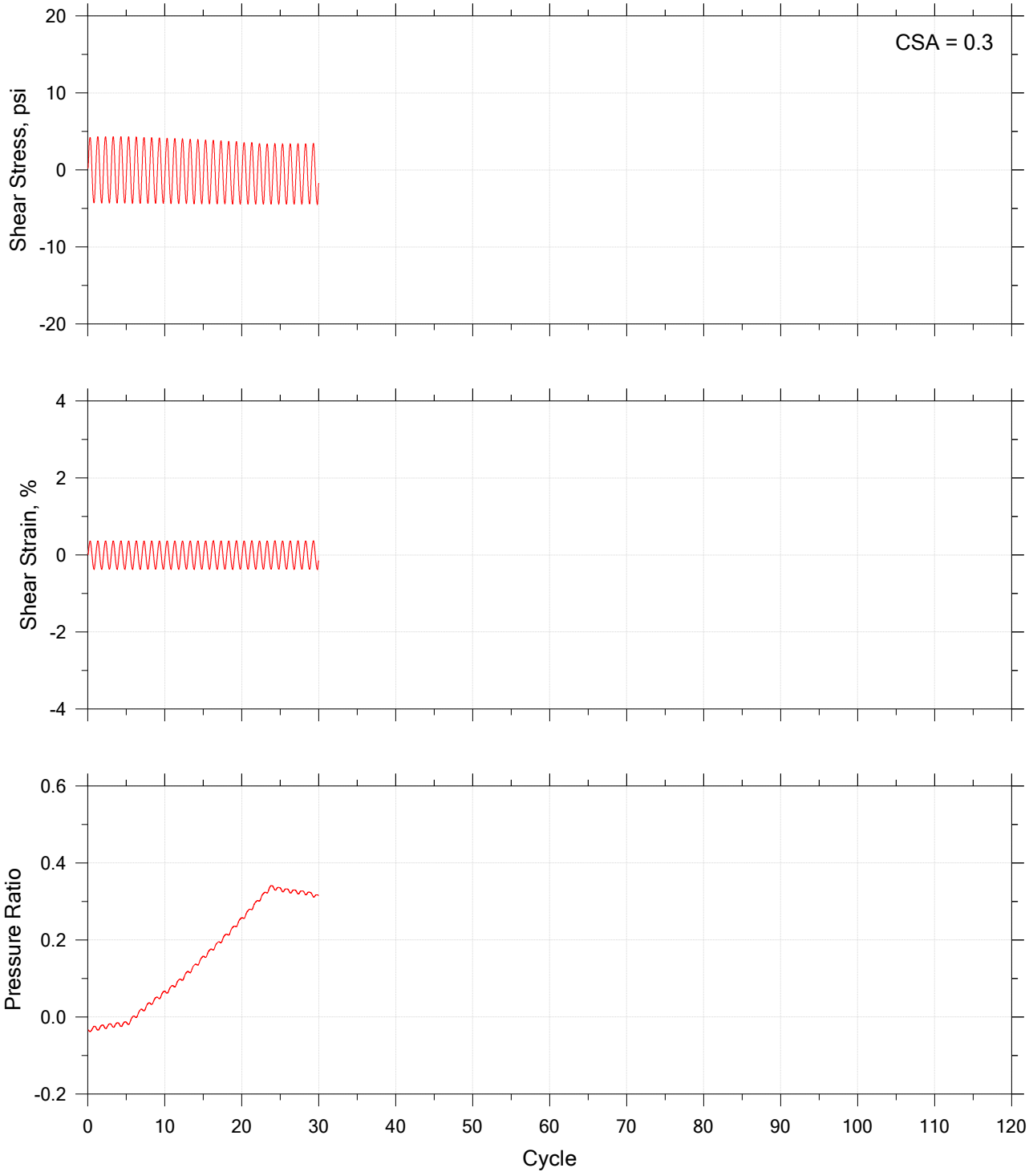


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



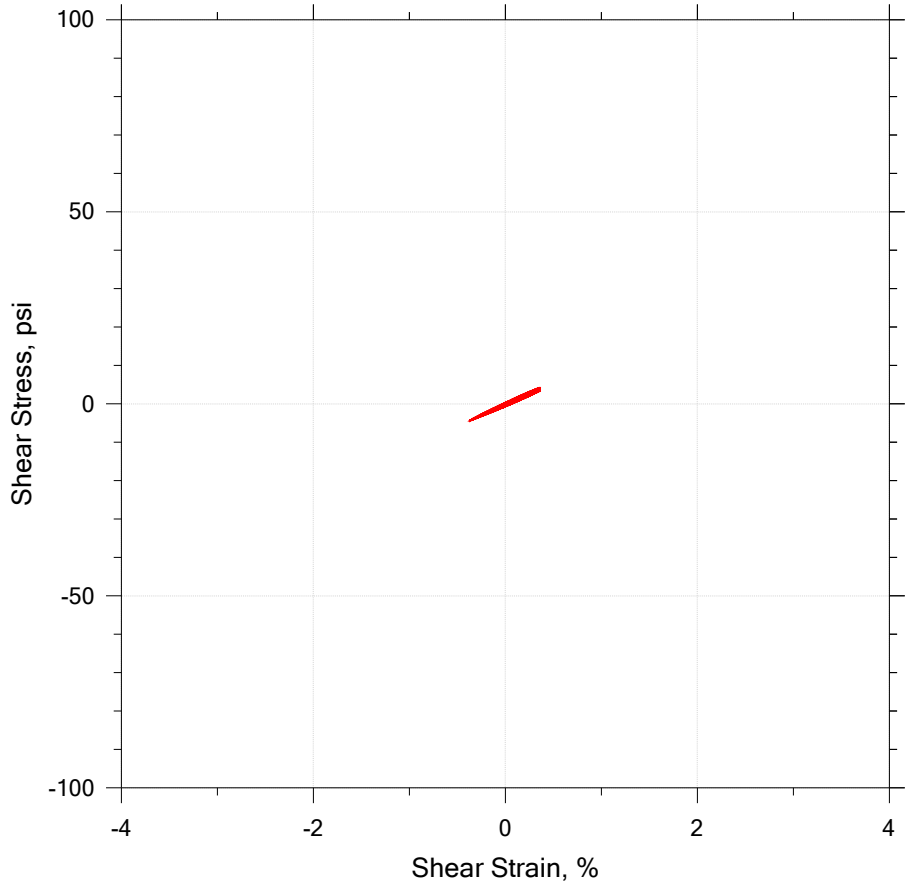
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

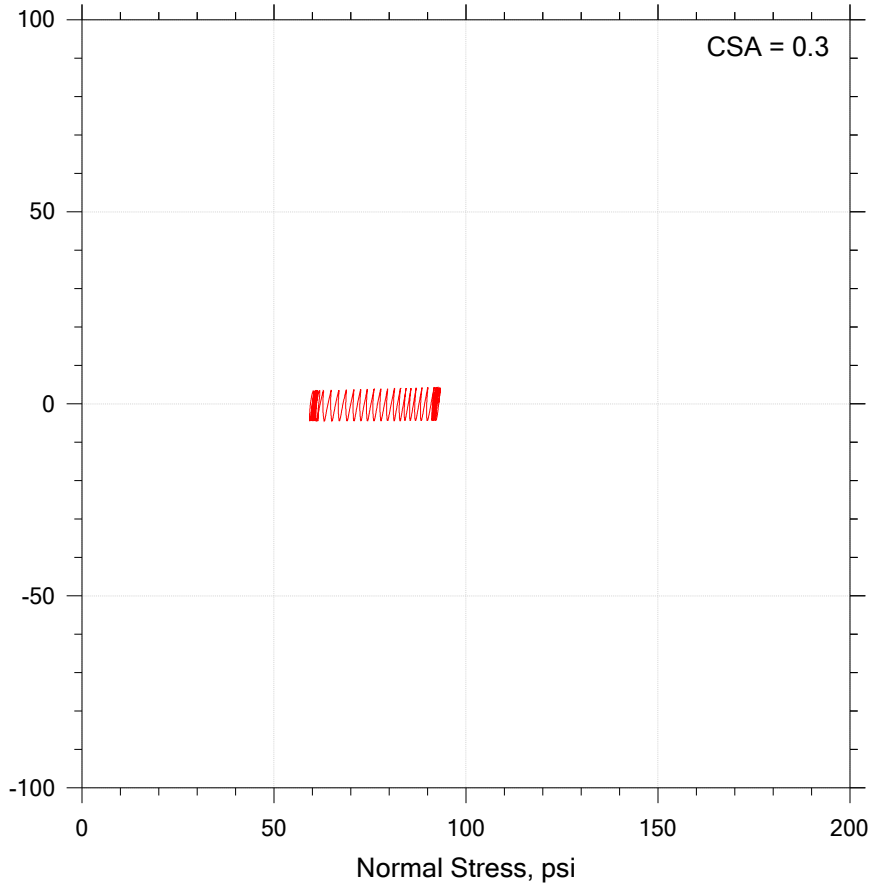
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



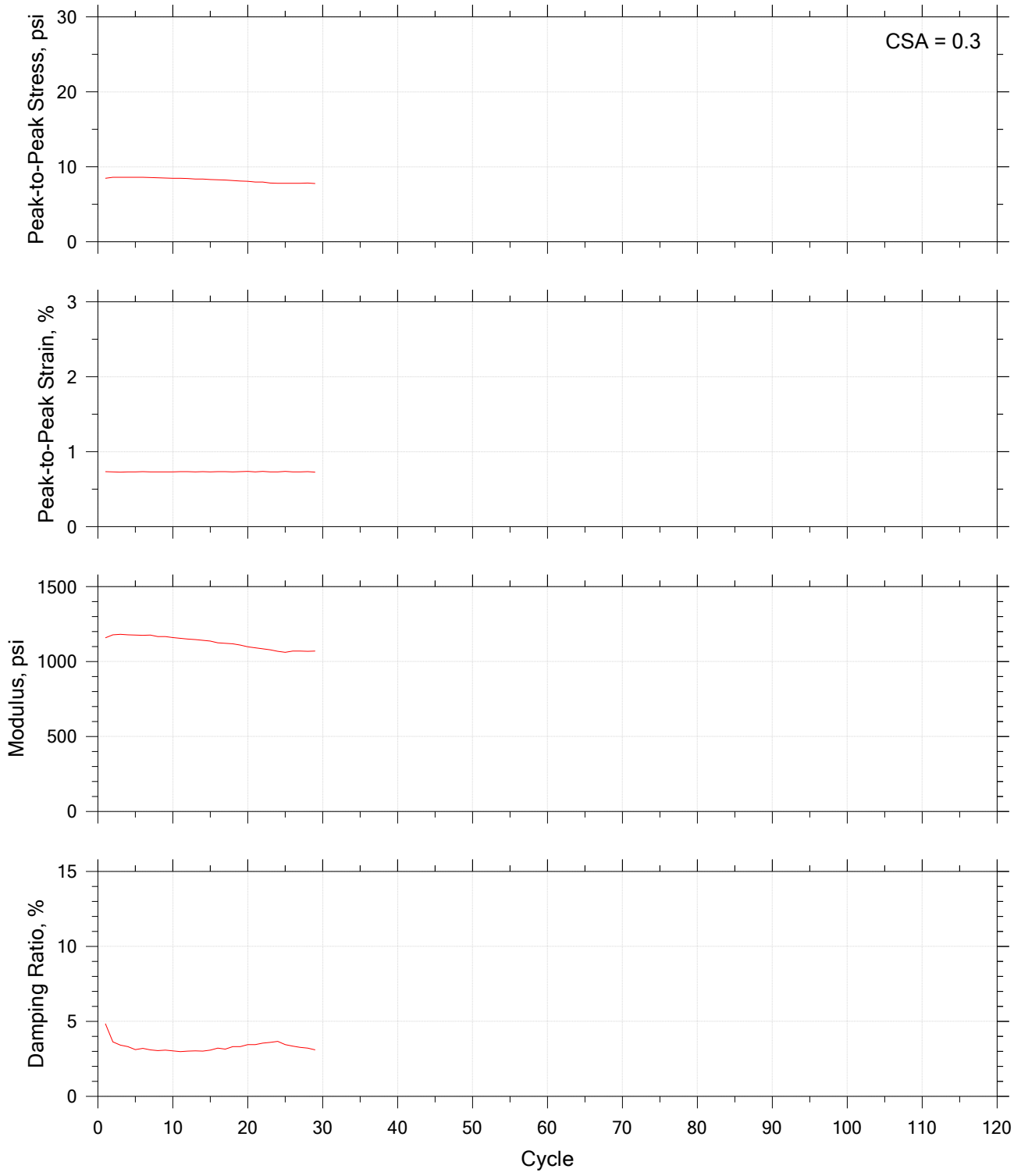


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

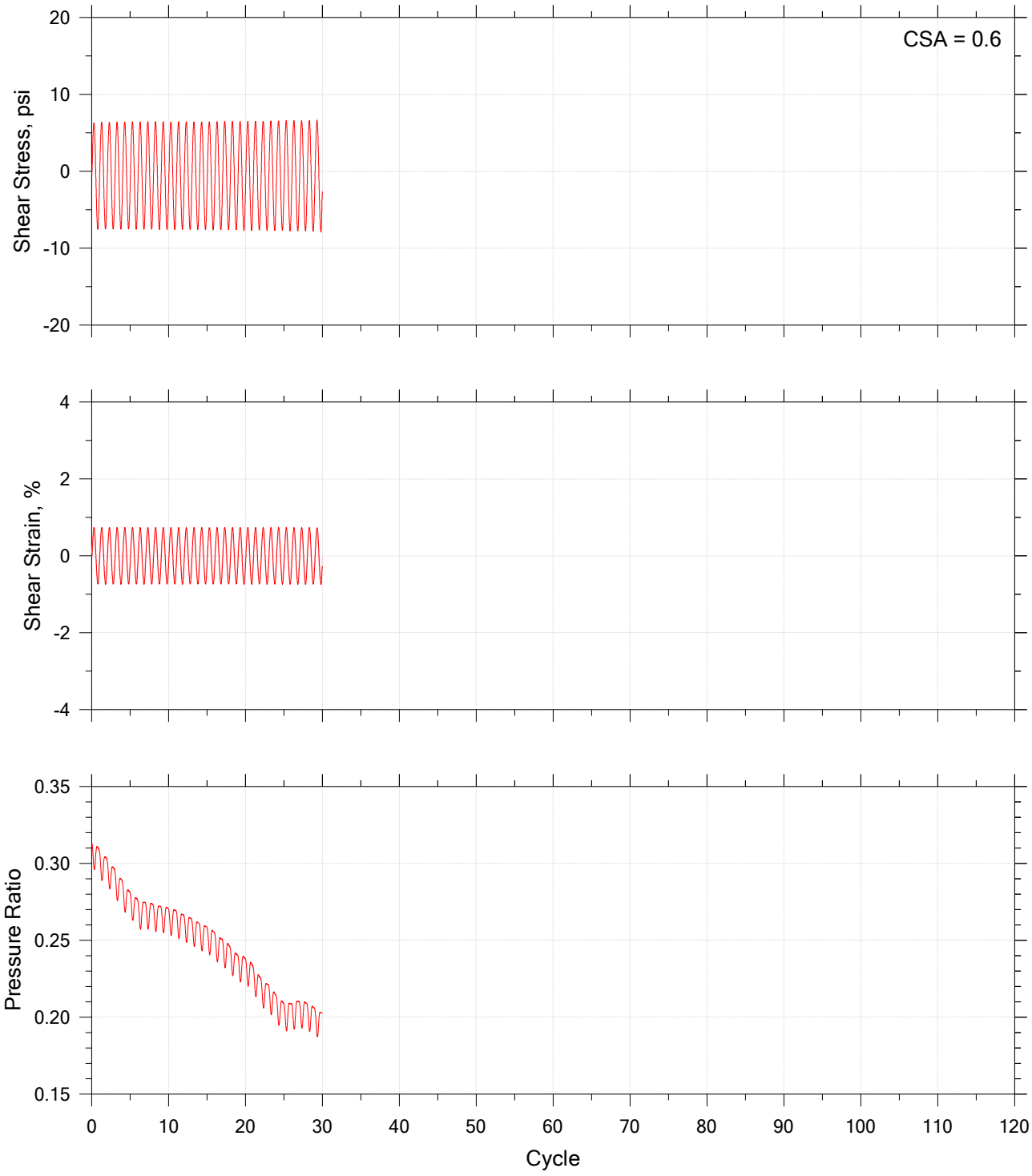


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



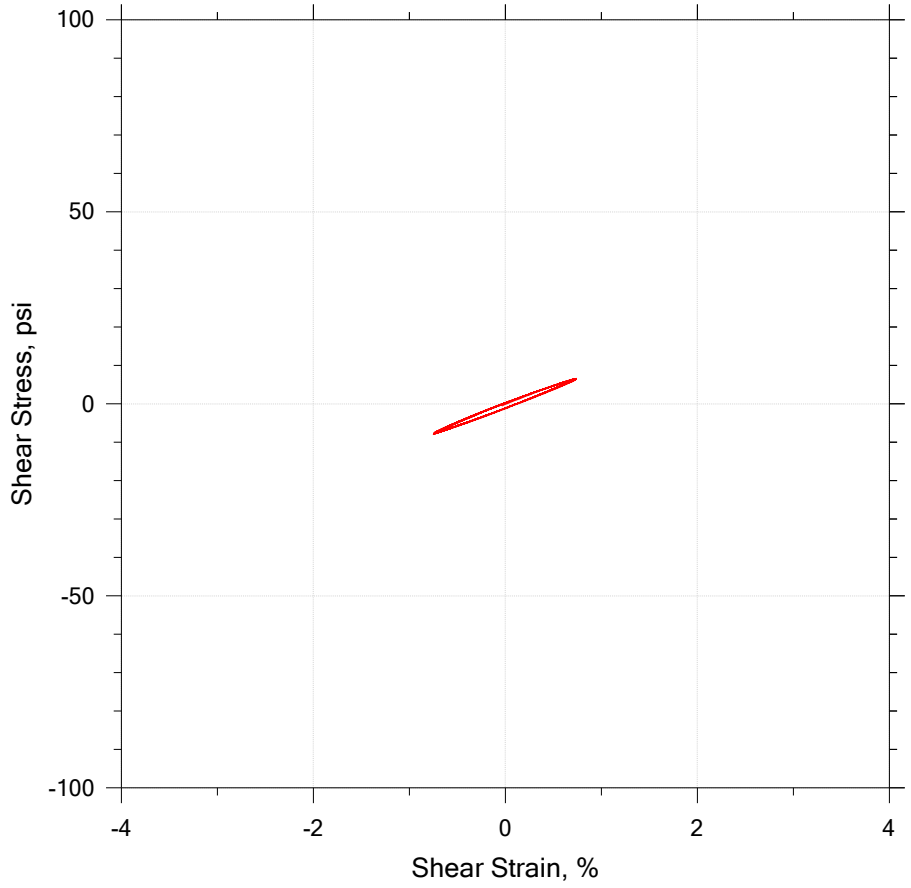
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

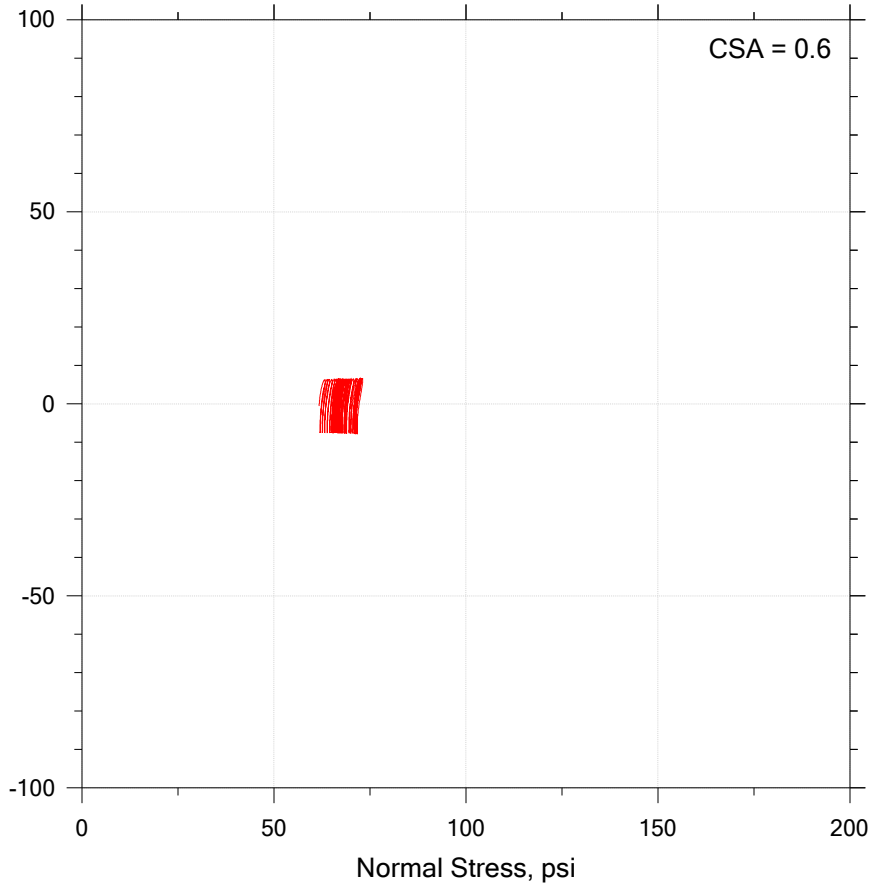
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0



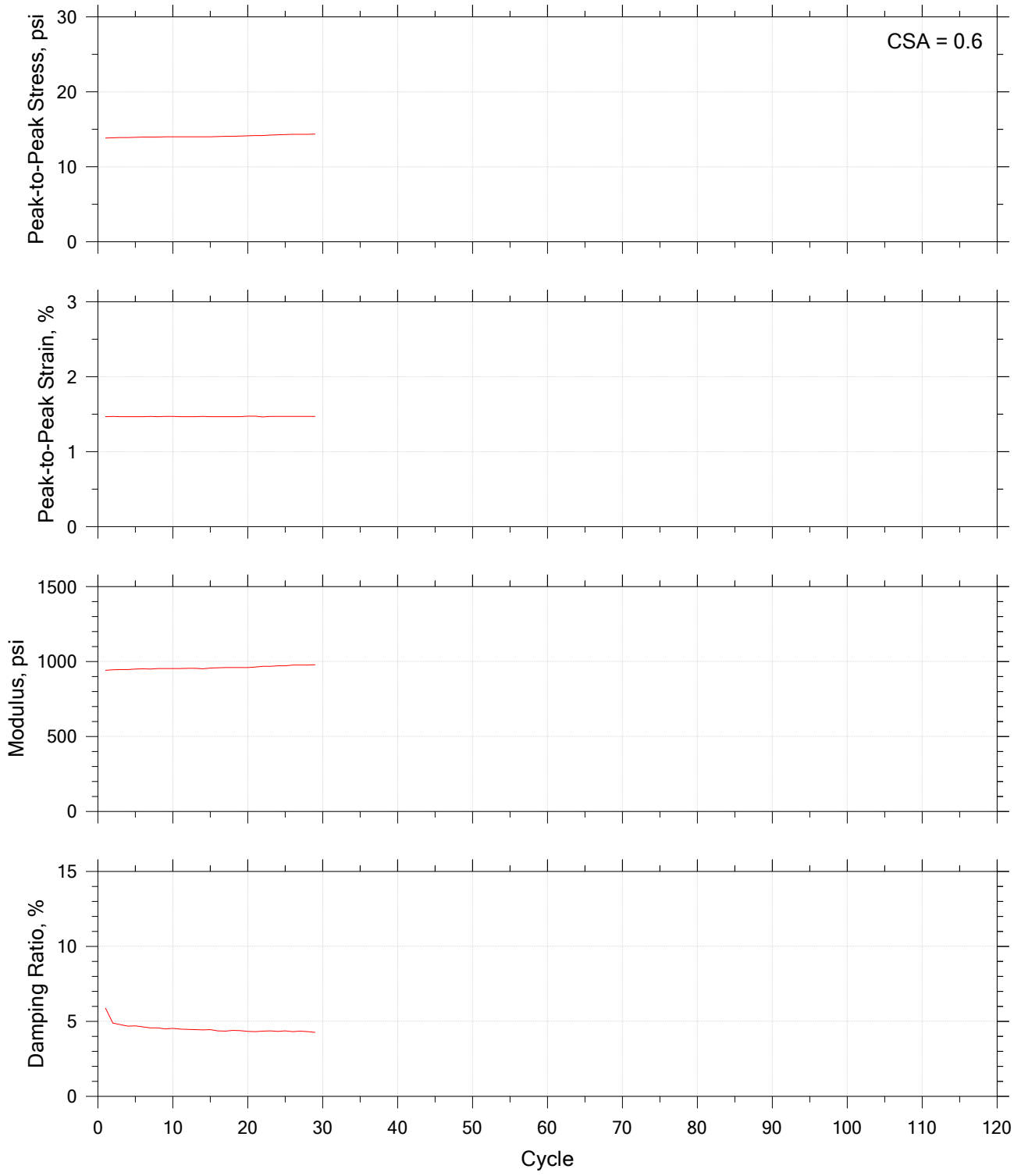


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

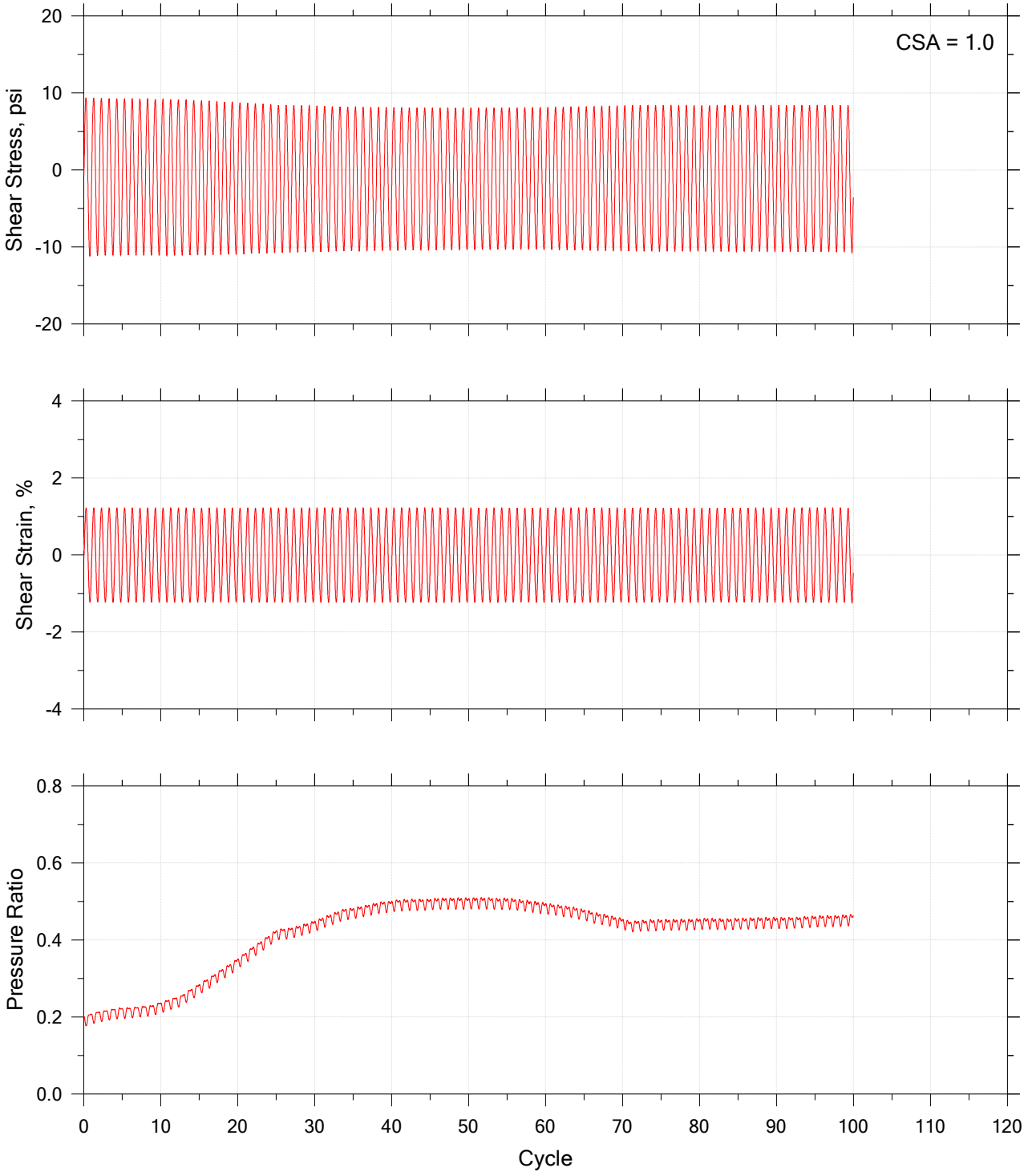


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 4 of 4



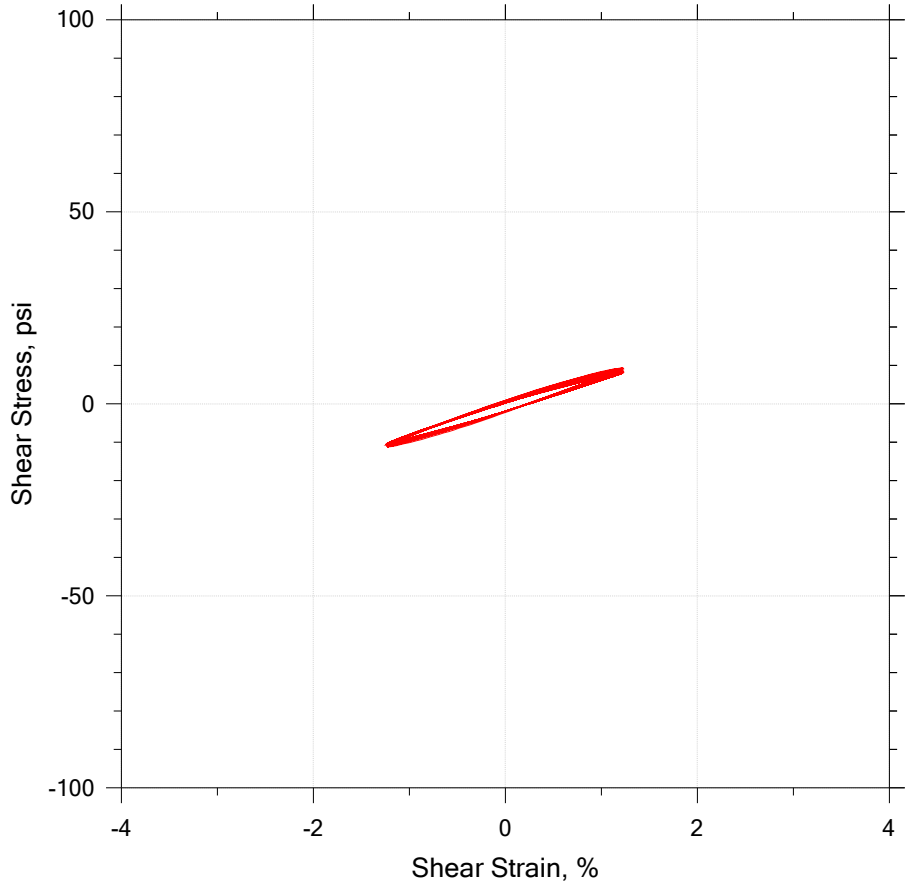
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

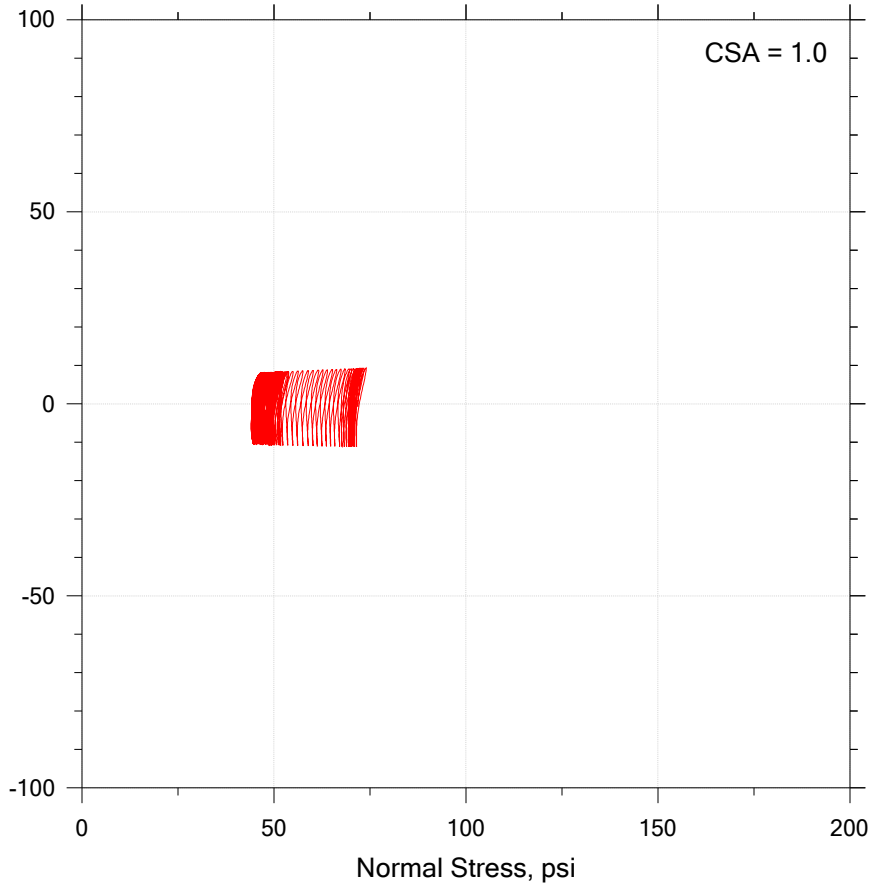
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 4 of 4

Cycle 0.0 to 100.0



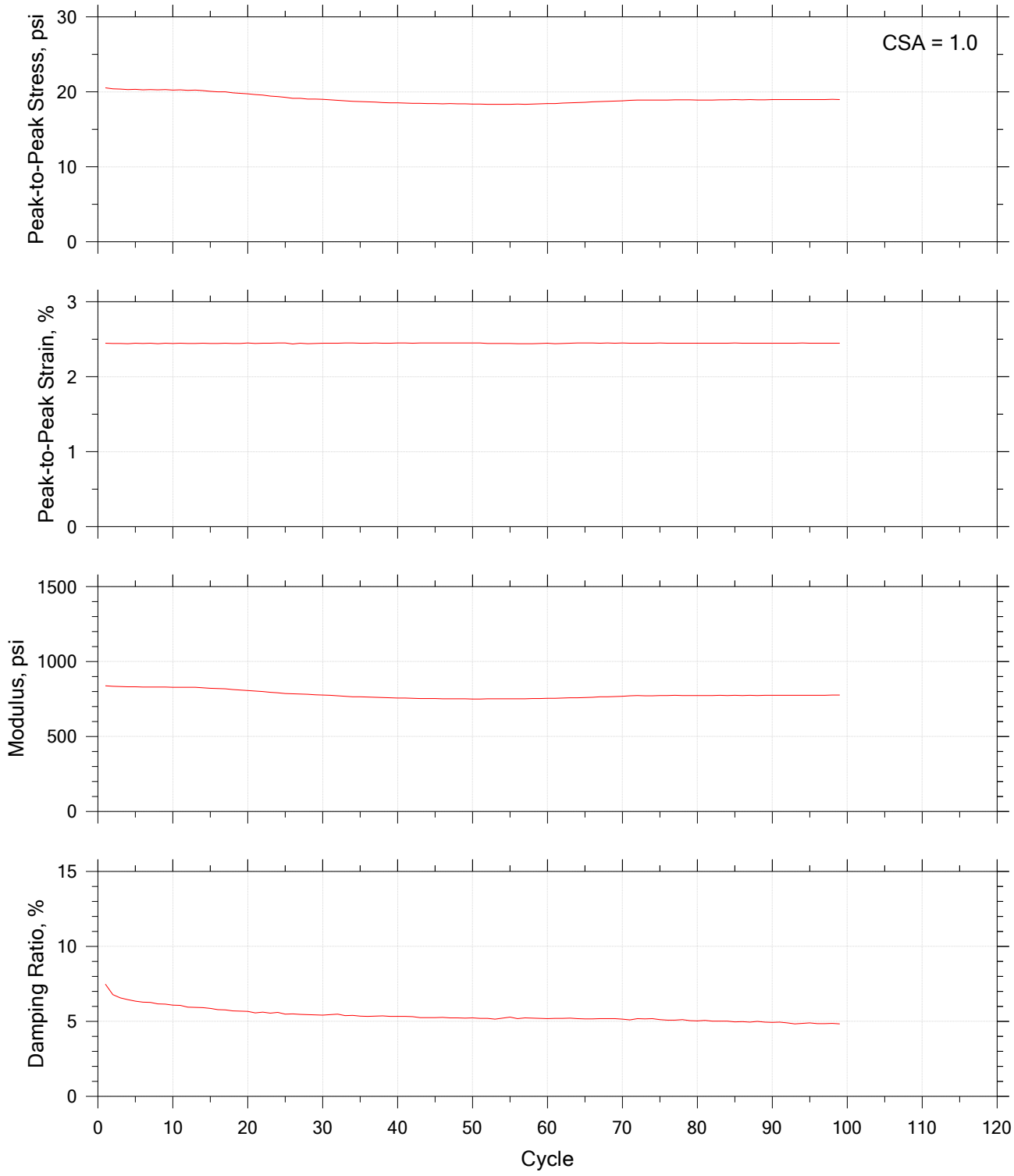


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 4 of 4

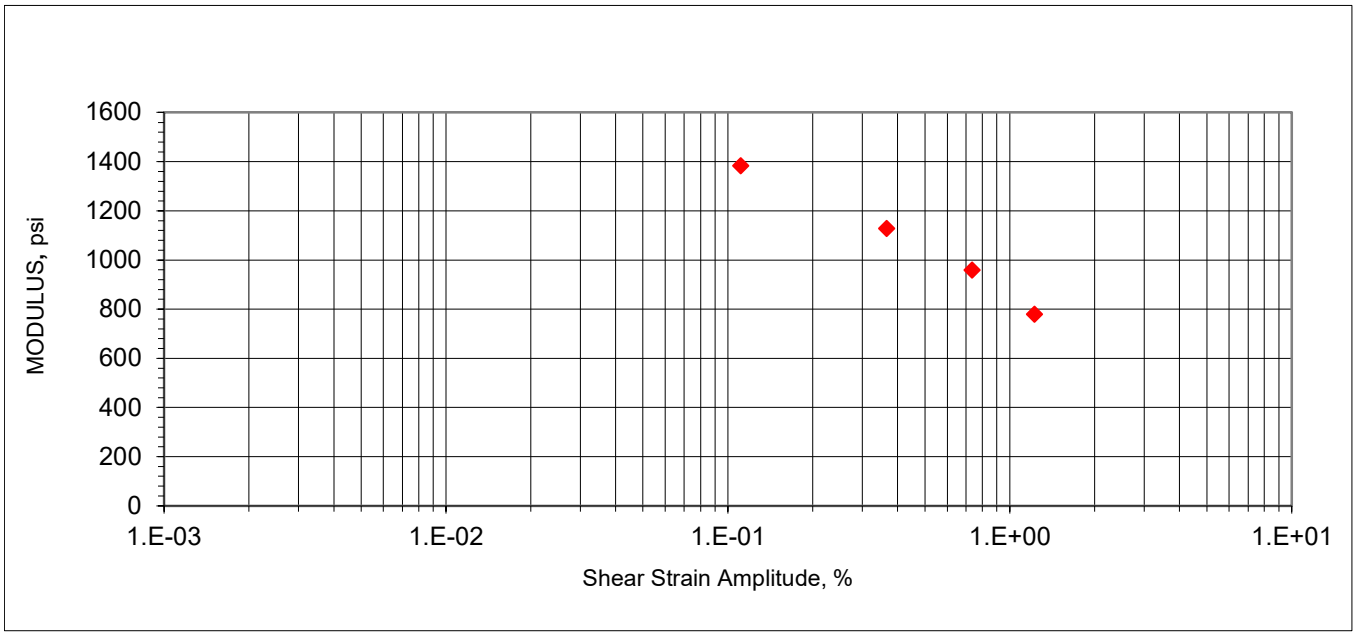


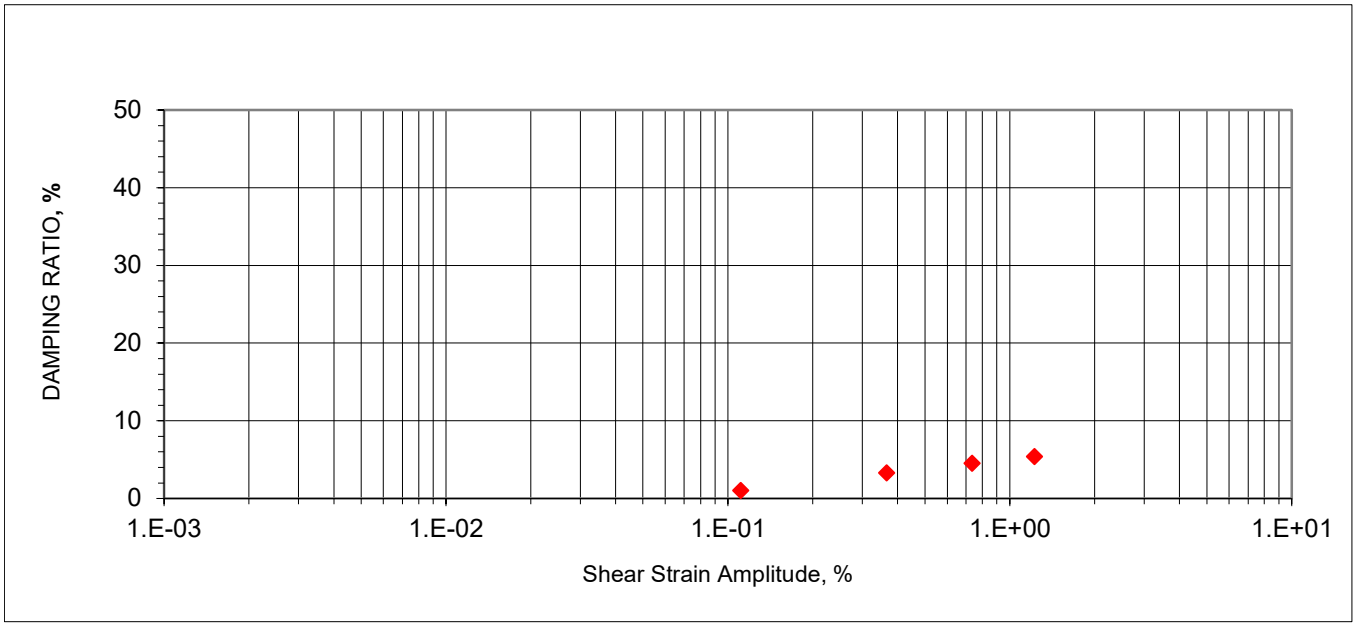
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

GeoTesting EXPRESS
A Sercel Business

Modulus and Damping Properties of Soils

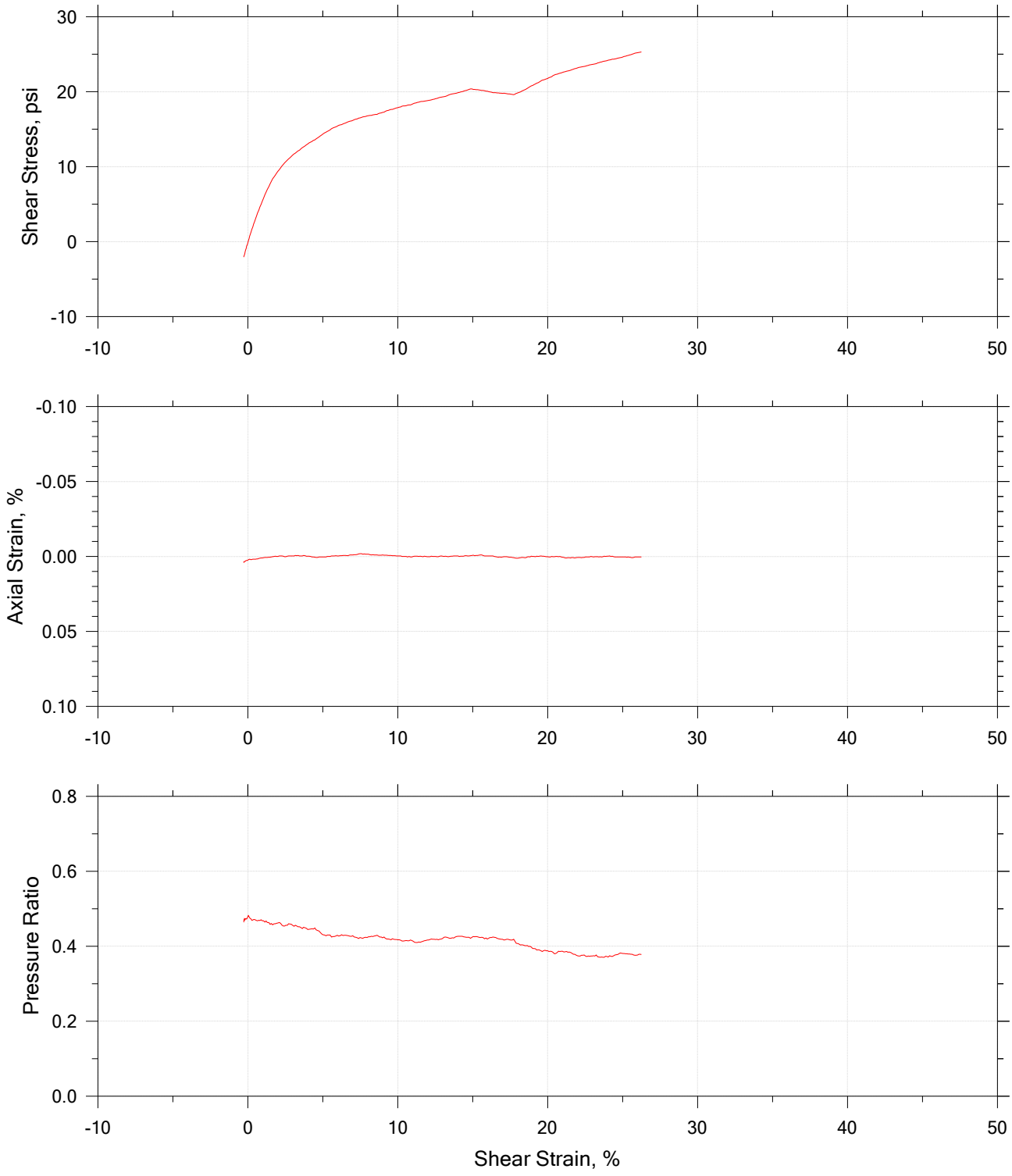
Using the Cyclic Direct Simple Shear Apparatus





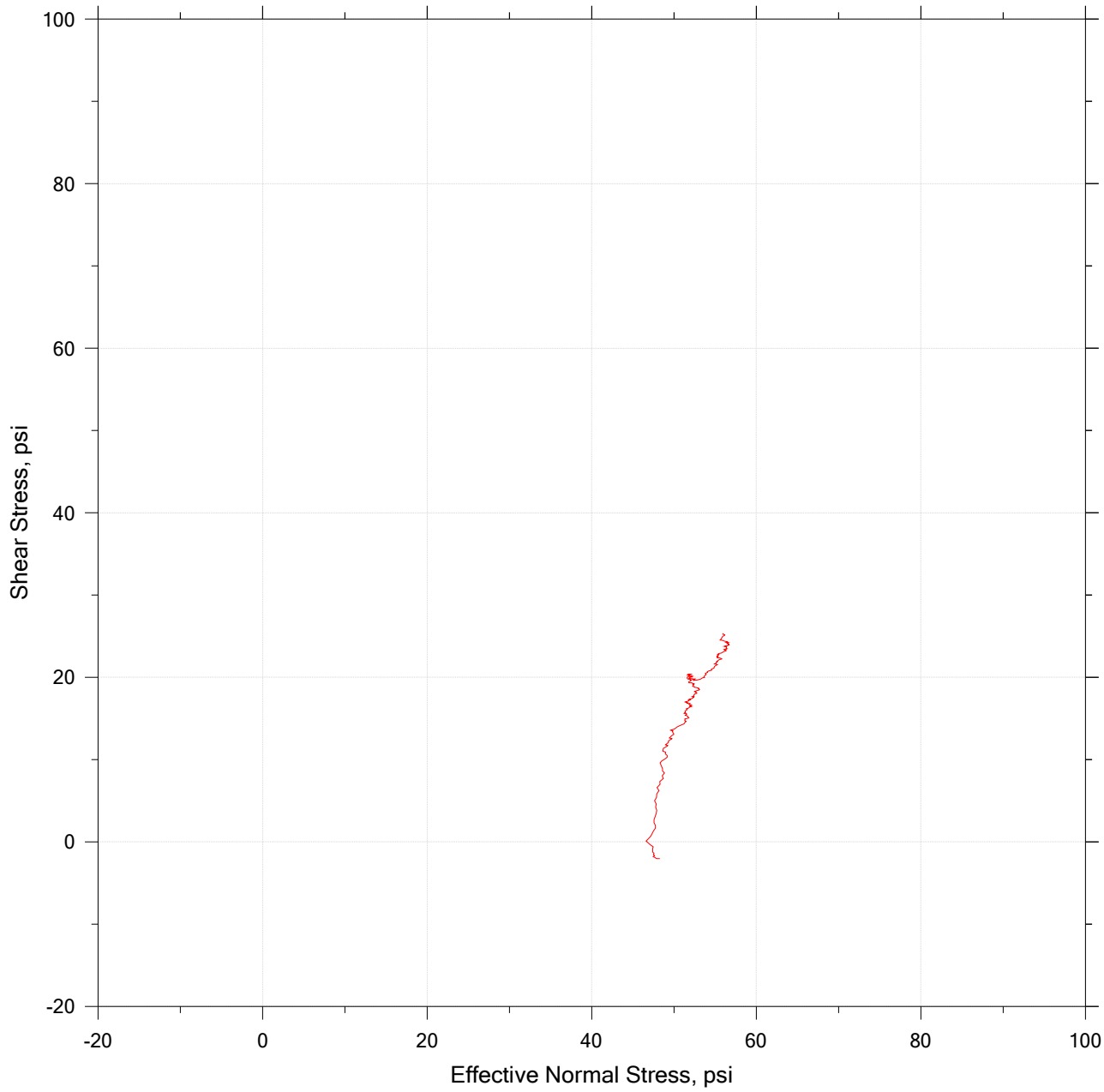
Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1012	Tested By: jlw	Checked By:	njh
Sample No.: ST-1	Test Date: 12/11/24	Test No.:	CDSS-5
Depth: 209.9-210.3	Sample Type: intact	Elevation:	---
Description: Moist, light gray silt			
Remarks: Average values of G and D from 30 cycles in Step 1, 2, 3 and 100 cycles in Step 4.			

Post Cyclic Simple Shear Test



Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
Boring Number: B-1012	Tester: sjt	Checker: njh
Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
Test Number: CDSS-5	Preparation: intact	Elevation:
Description: Moist, light gray silt		
Remarks: CST-005		

Post Cyclic Simple Shear Test



GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1012	Tester: sjt	Checker: njh
	Sample Number: ST-1	Test Date: 12/11/24	Depth: 209.9-210.3
	Test Number: CDSS-5	Preparation: intact	Elevation:
	Description: Moist, light gray silt		
	Remarks: CST-005		

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	1/13/25
Project Location:	Kentucky		

Boring ID: B-1013
Sample ID: GT-4
Depth, ft: 131.8-133.8

Visual Description: Moist, very pale brown sand

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 54 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-7R				
Initial Moisture Content, %	3.63				
Initial Dry Density, pcf	86.1				
Vertical Consolidation Stress, psi	54				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	6	---	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				2.99	
Delay before shearing, sec				---	
Nominal Rate of Shear Strain, %/hr				---	
Measured Post-Cyclic Peak Shear Stress, psi				---	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				---	
Membrane Correction, psi				---	
Corrected Post-Cyclic Peak Shear Stress, psi				---	
S_r/σ'_{vc}				---	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Specimen reached an R value approaching 1 in step 3 cycle 6.
Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

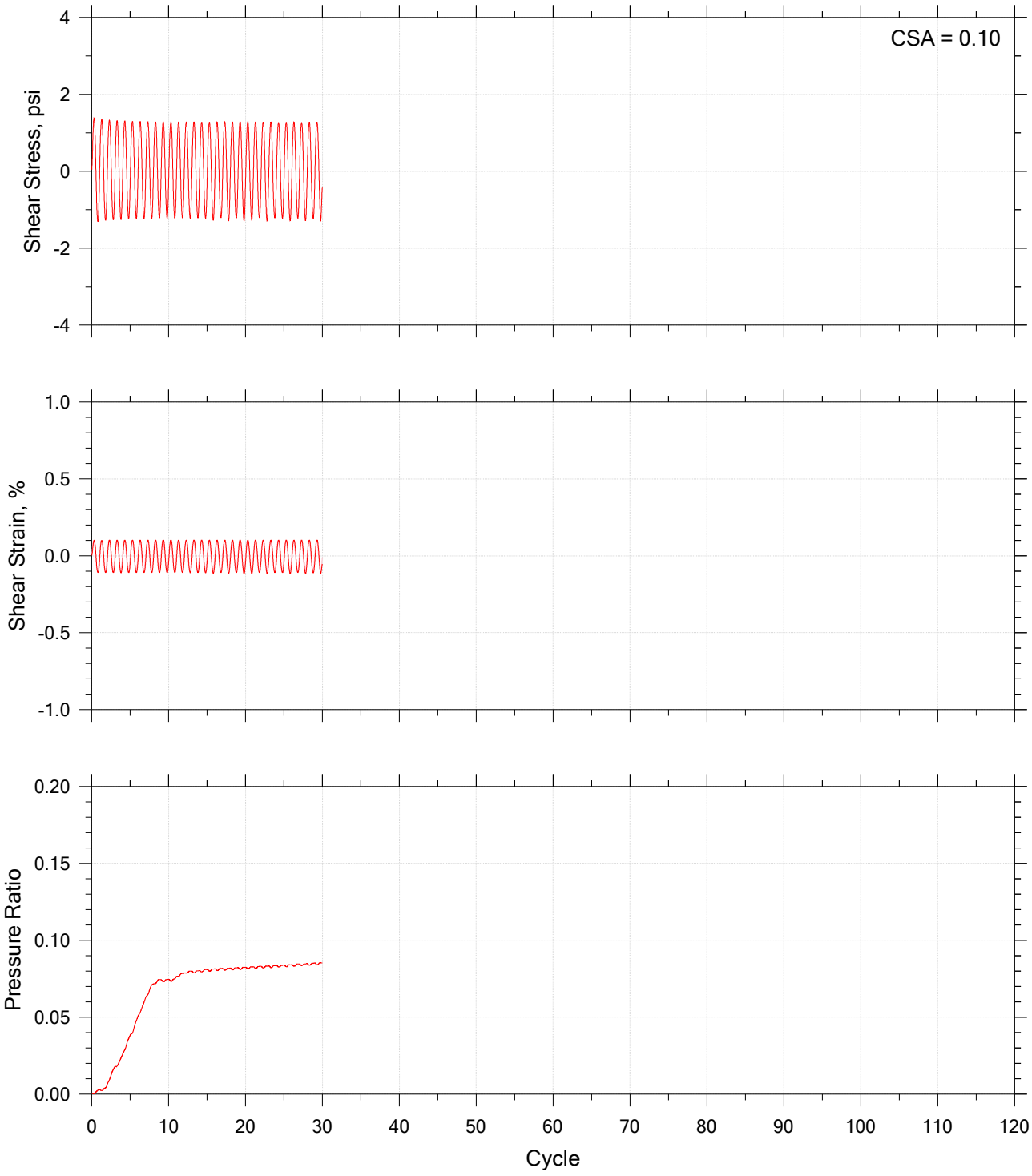
Tested By: sjt Checked By: njh

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



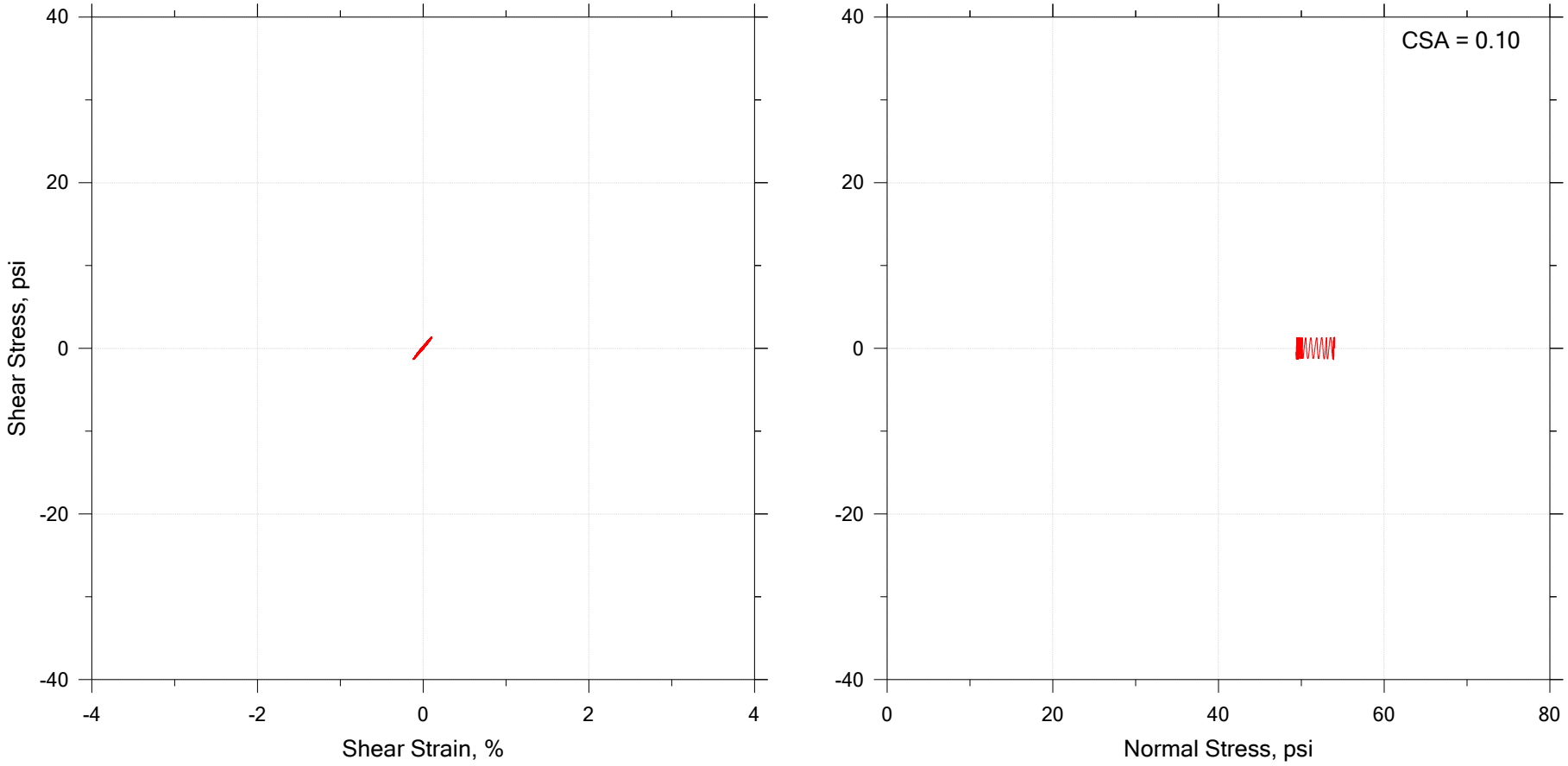
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0

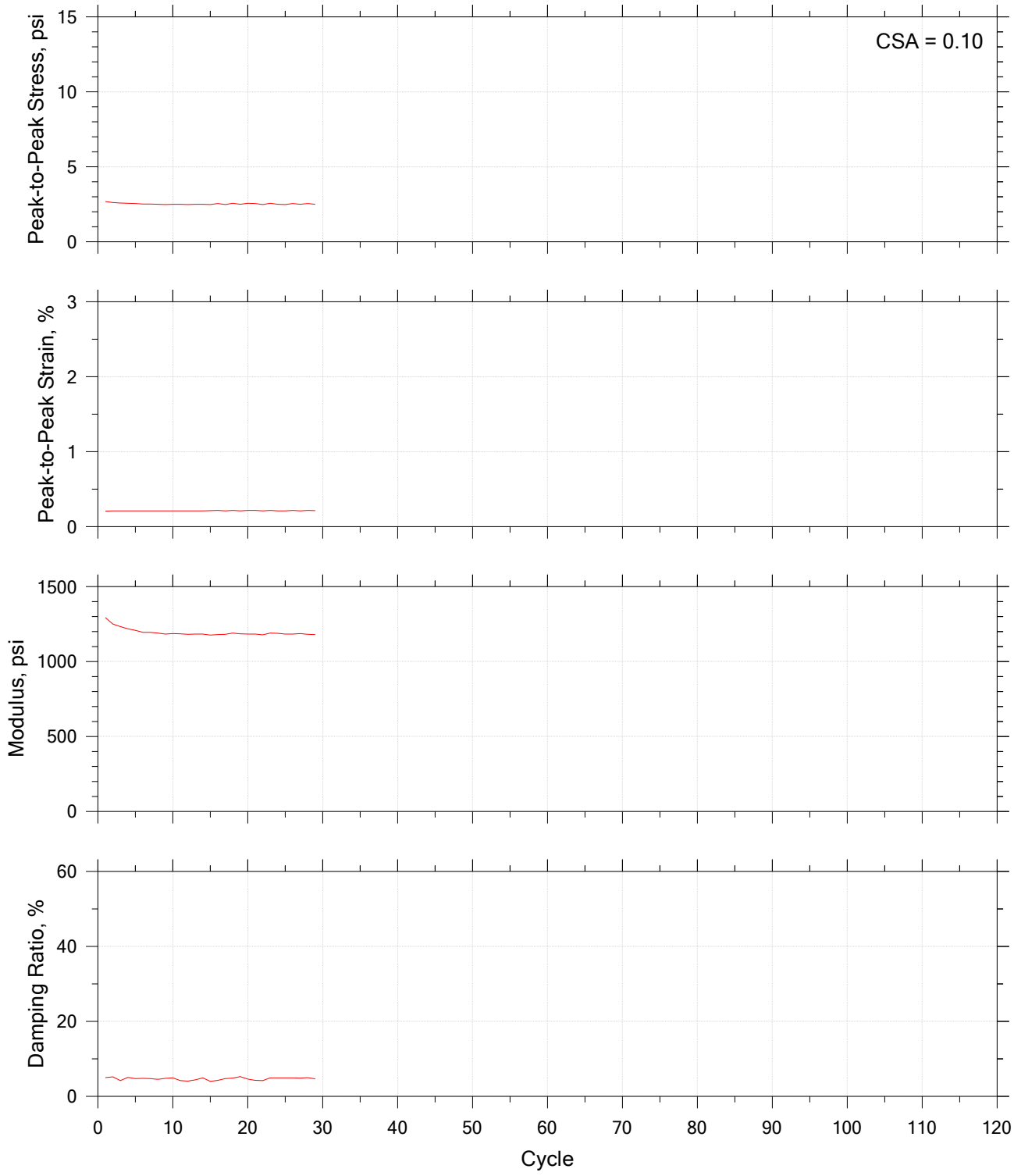


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

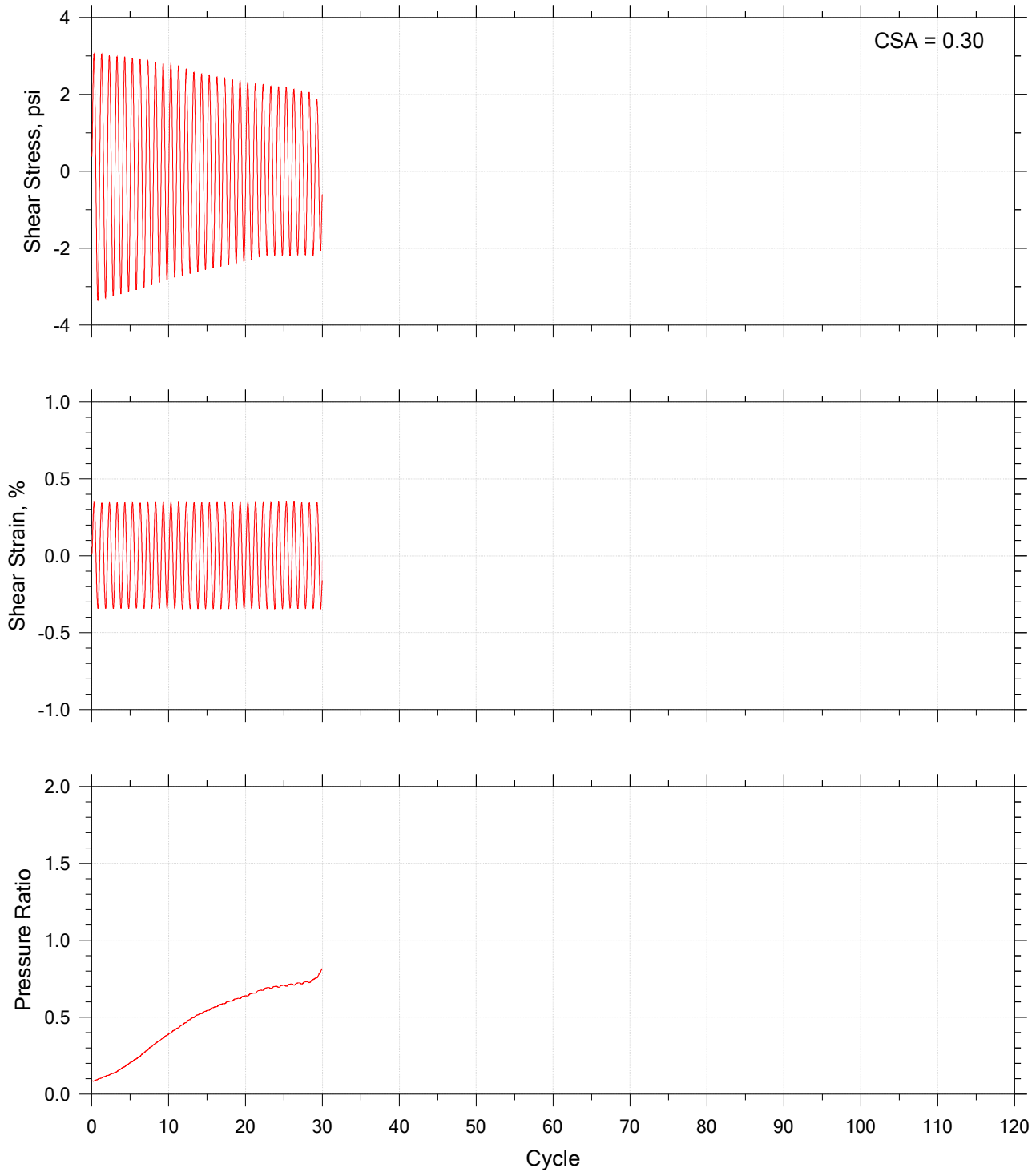


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



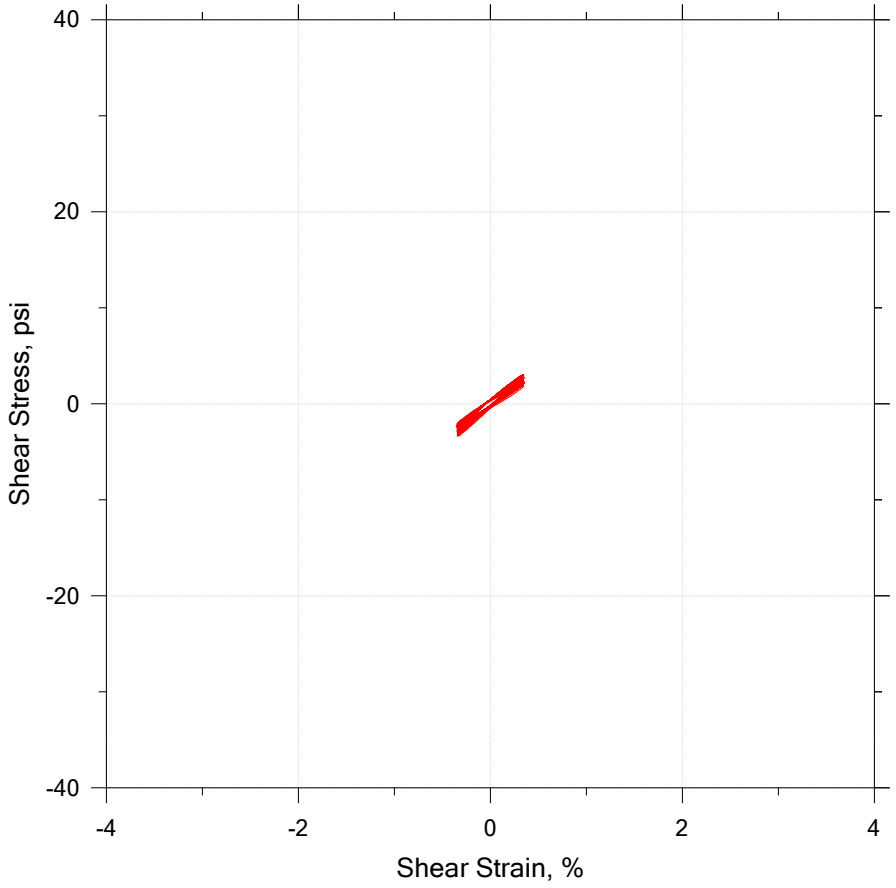
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

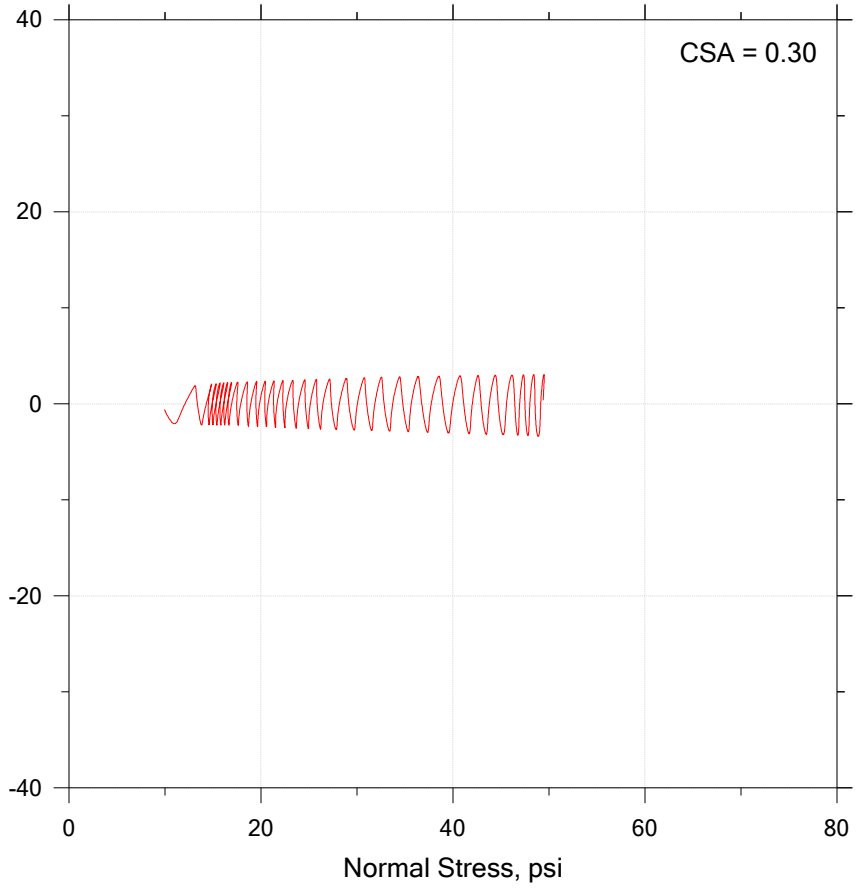
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



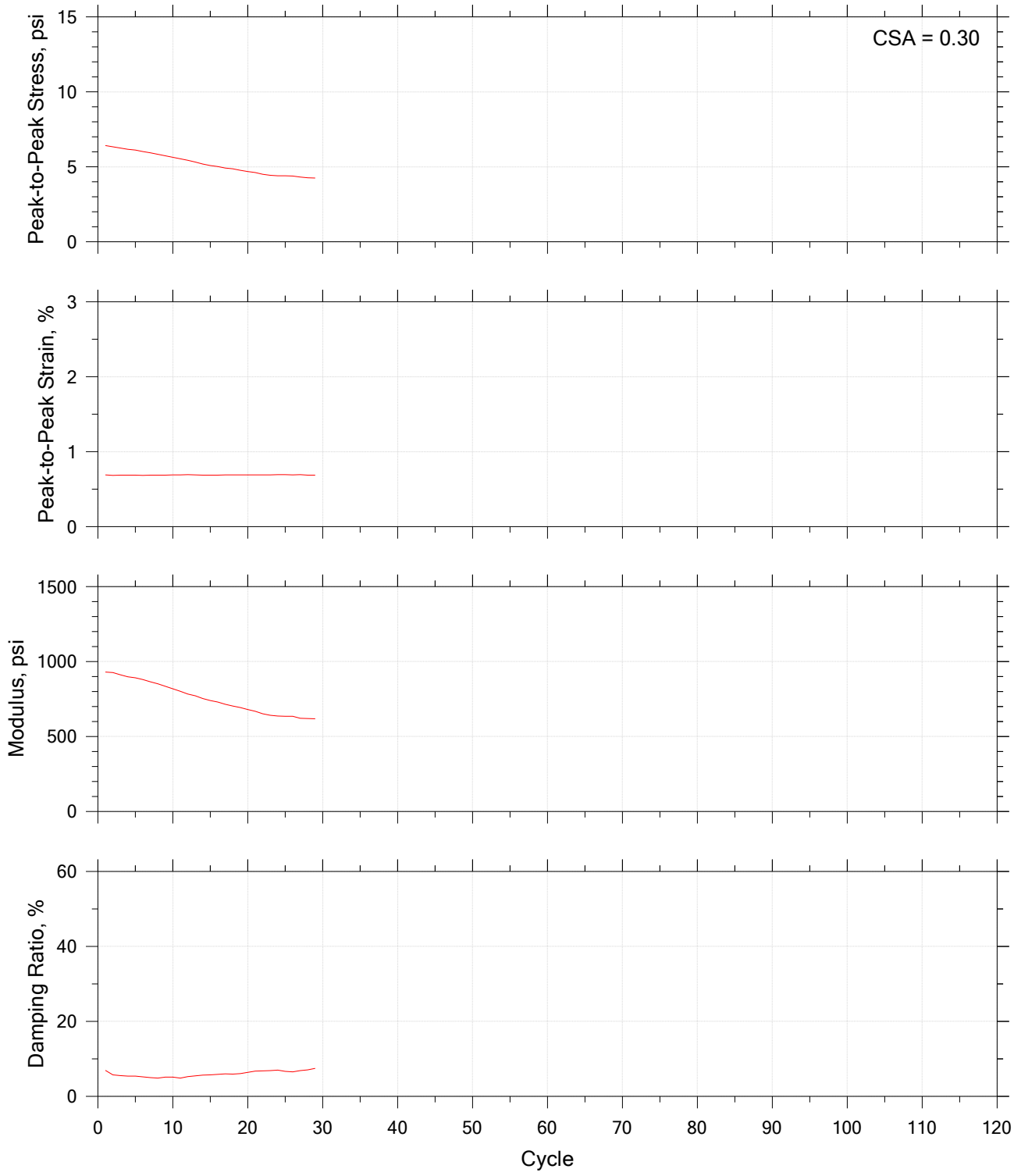


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

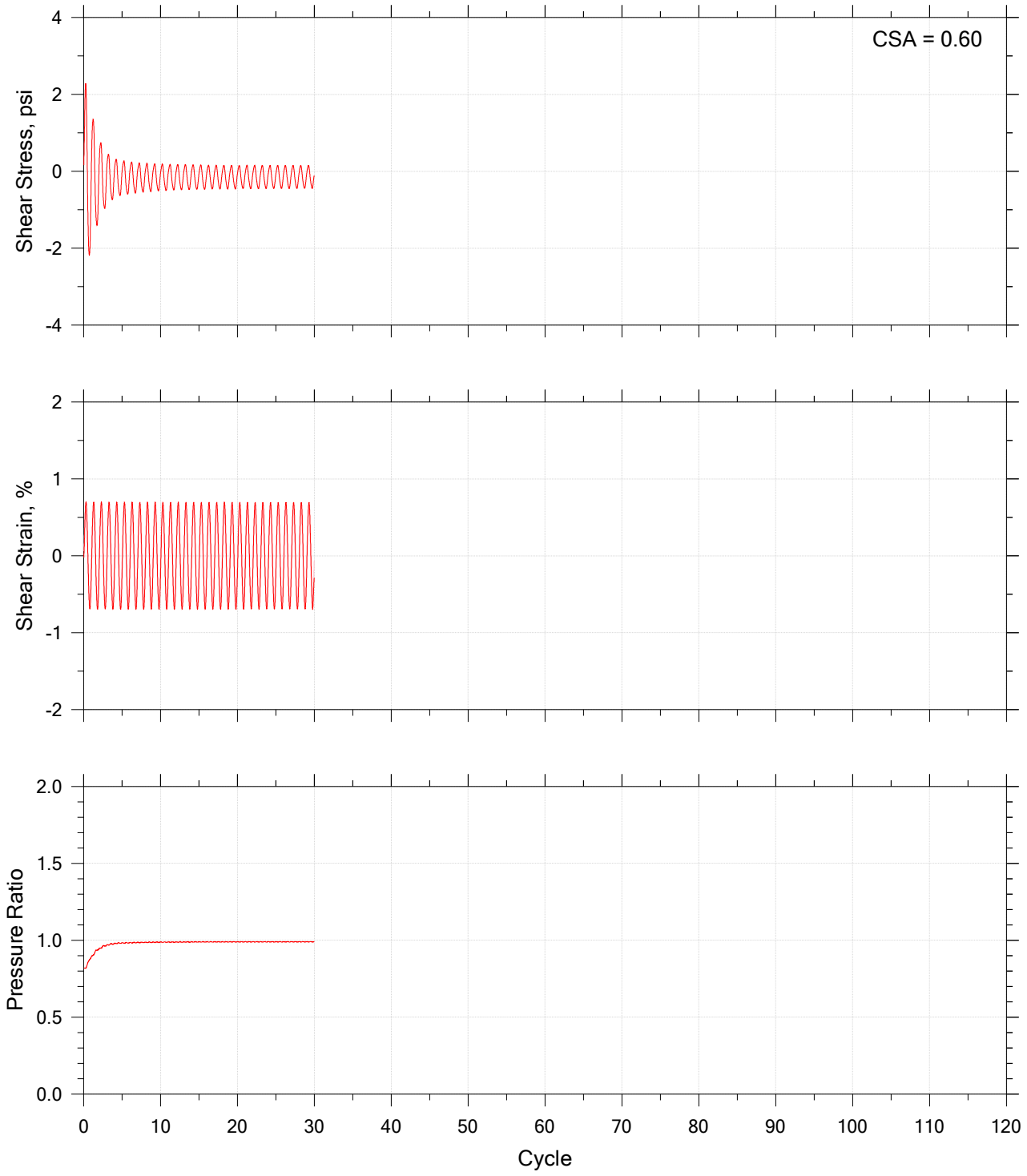


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



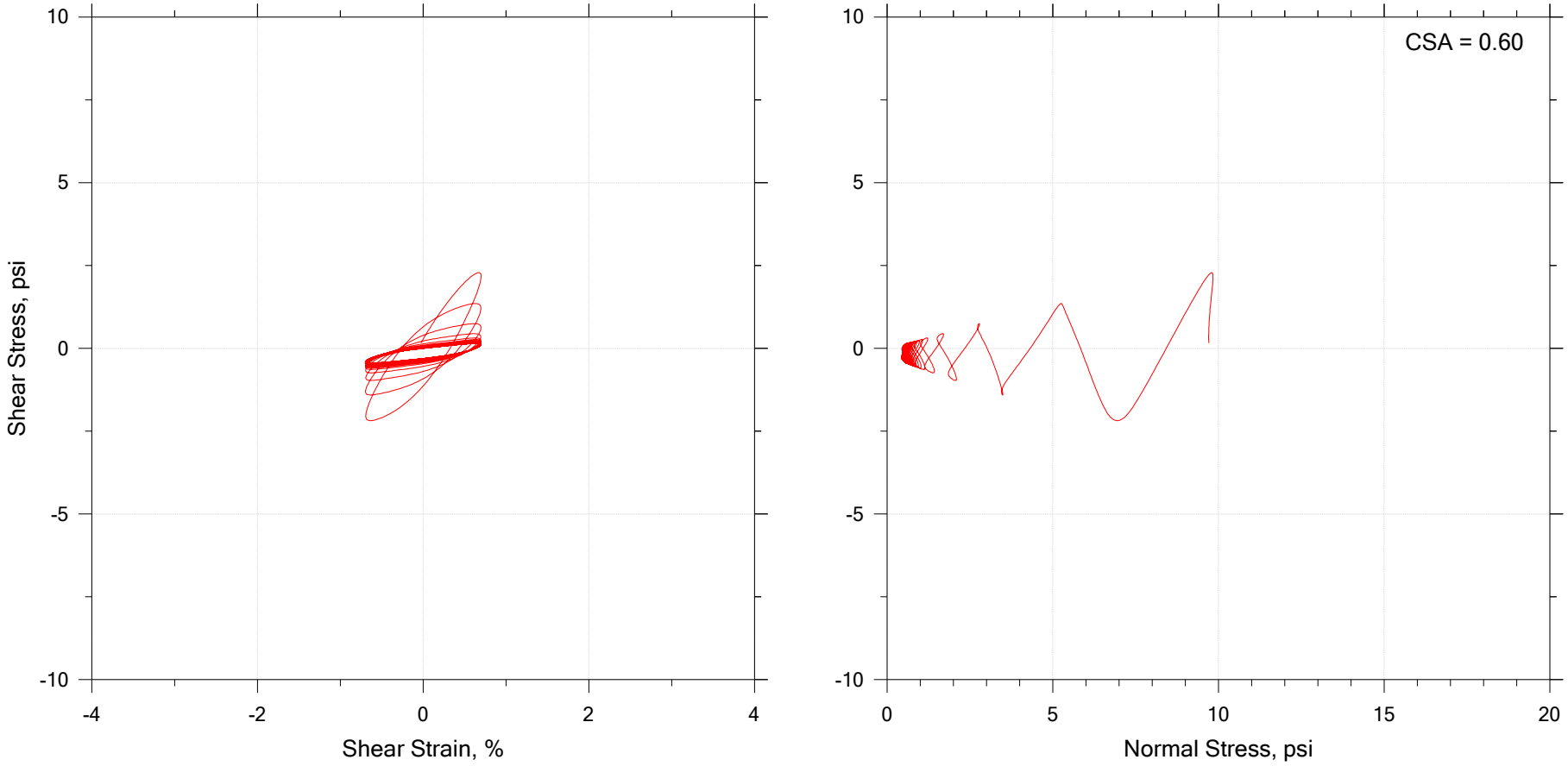
Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
Boring Number: B-1013	Tester: sjt	Checker: njh
Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
Test Number: CDSS-7R	Preparation: intact	Elevation: ---
Description: Moist, very pale brown sand		
Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0

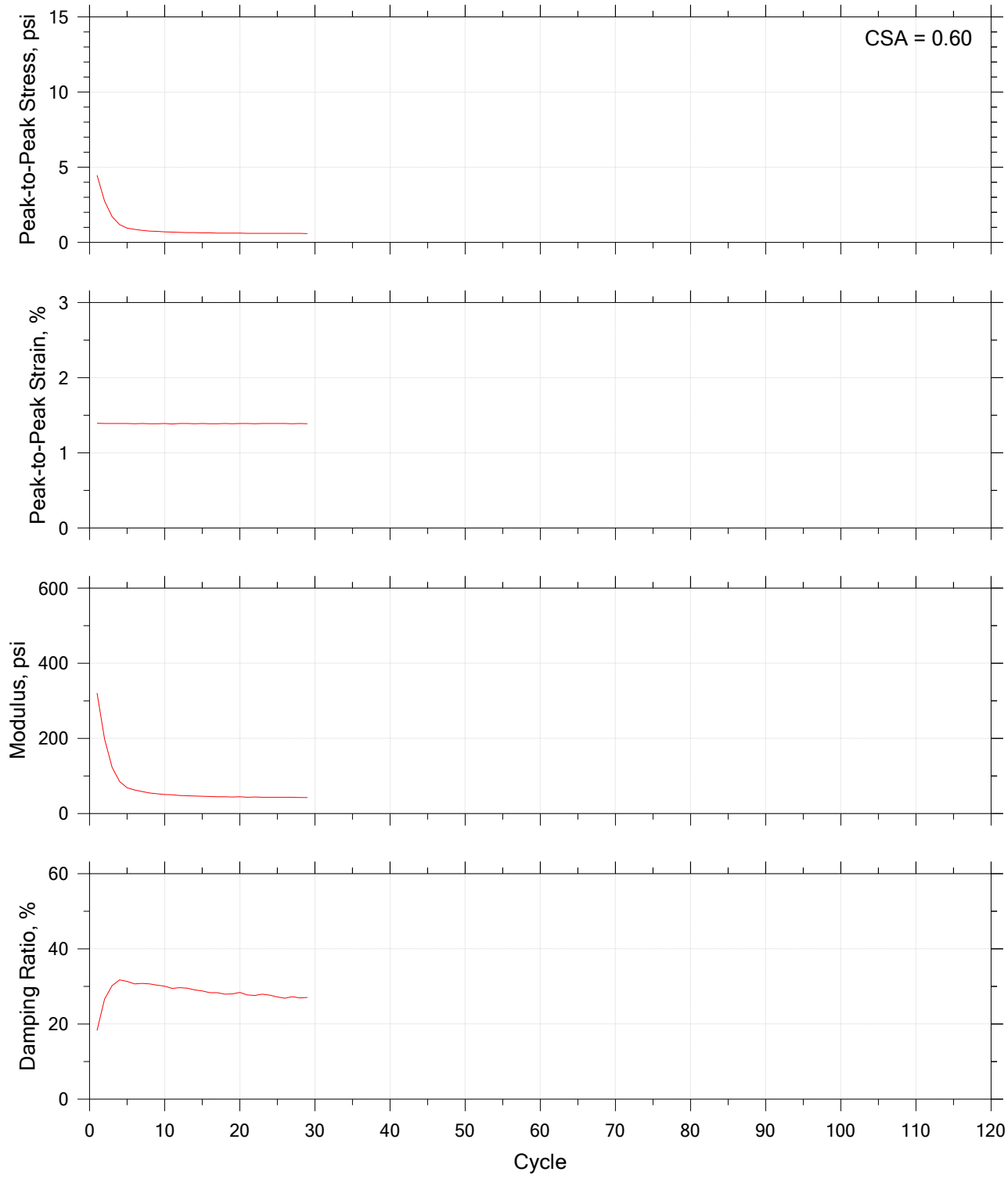


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

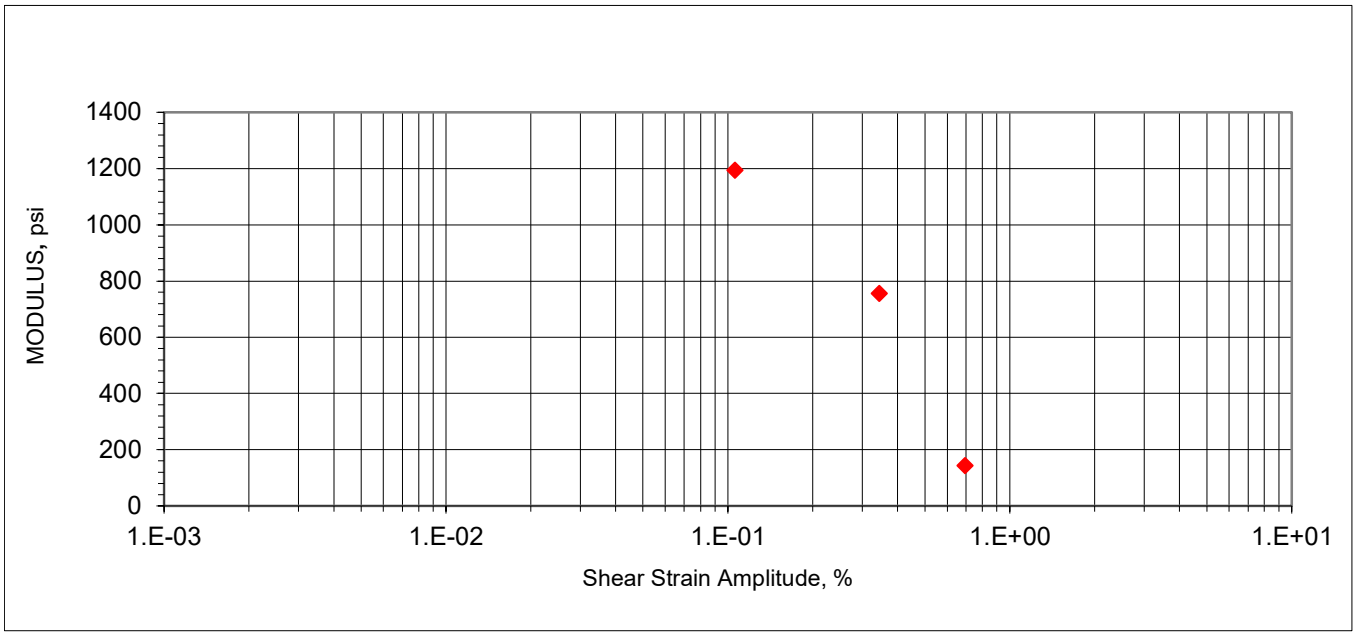


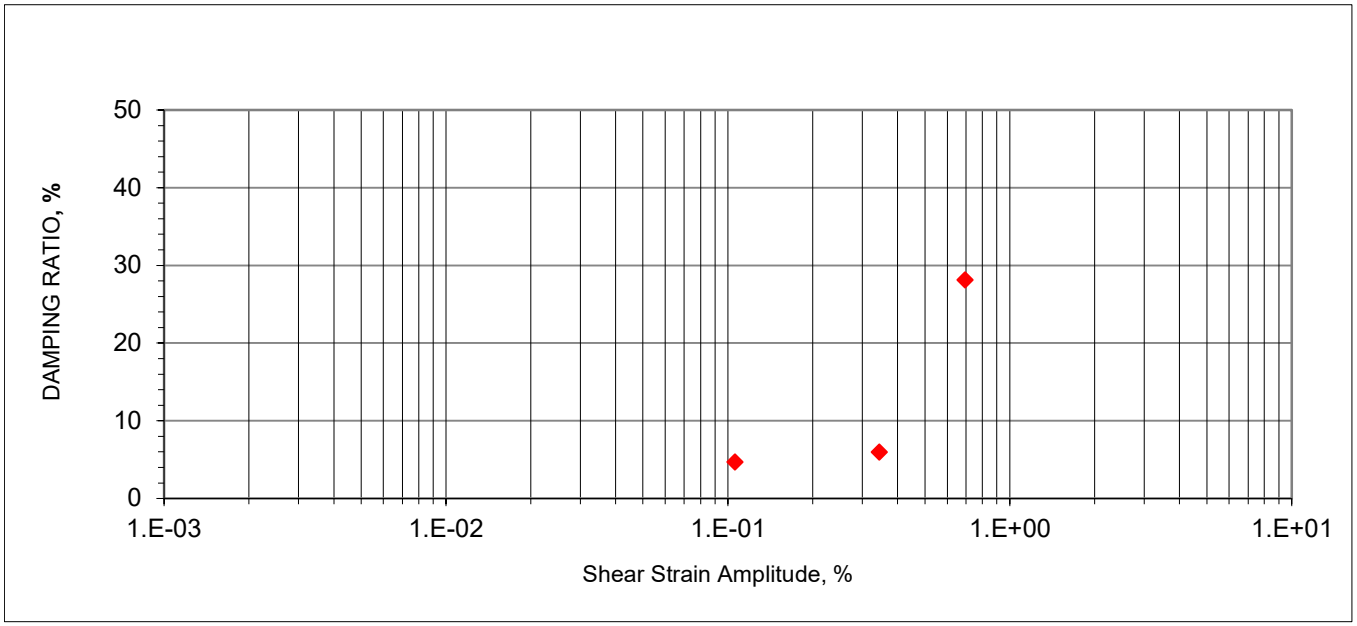
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1013	Tester: sjt	Checker: njh
	Sample Number: GT-4	Test Date: 01/13/25	Depth: 131.8-133.8
	Test Number: CDSS-7R	Preparation: intact	Elevation: ---
	Description: Moist, very pale brown sand		
	Remarks: CST-005		

GeoTesting EXPRESS
A Sercel Business

Modulus and Damping Properties of Soils

Using the Cyclic Direct Simple Shear Apparatus





Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1013	Tested By: jlw	Checked By:	njh
Sample No.: GT-4	Test Date: 1/13/25	Test No.:	CDSS-7R
Depth: 131.8-133.8	Sample Type: intact	Elevation:	---
Description: Moist, very pale brown sand			
Remarks: Average values of G and D from 30 cycles in Step 1 and Step 2 and 6 cycles in Step 3.			

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	10/22/24
Project Location:	Kentucky		

Boring ID:	B-1018
Sample ID:	ST-8
Depth, ft:	88.8-90.8

Visual Description: Moist, very light gray sand

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 35 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-1				
Initial Moisture Content, %	19.4				
Initial Dry Density, pcf	102.5				
Vertical Consolidation Stress, psi	35				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	24	---	---	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				20.6	
Delay before shearing, sec				---	
Nominal Rate of Shear Strain, %/hr				---	
Measured Post-Cyclic Peak Shear Stress, psi				---	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				---	
Membrane Correction, psi				---	
Corrected Post-Cyclic Peak Shear Stress, psi				---	
S_r/σ'_{vc}				---	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Specimen reached an R value approaching 1 and liquified the sample at about 24 cycles into Step 2 of the test. Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

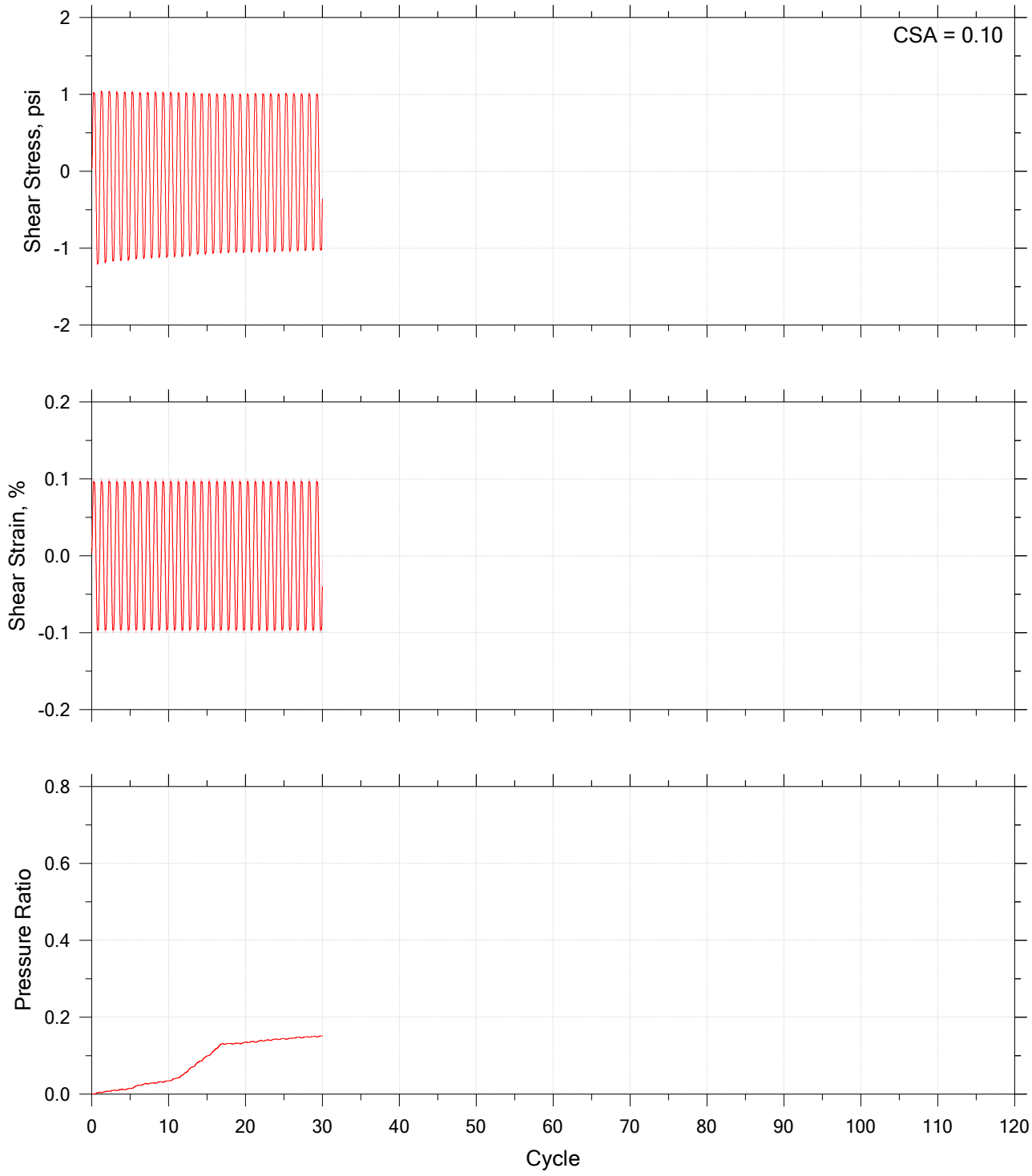
Tested By: jlw Checked By: njh

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



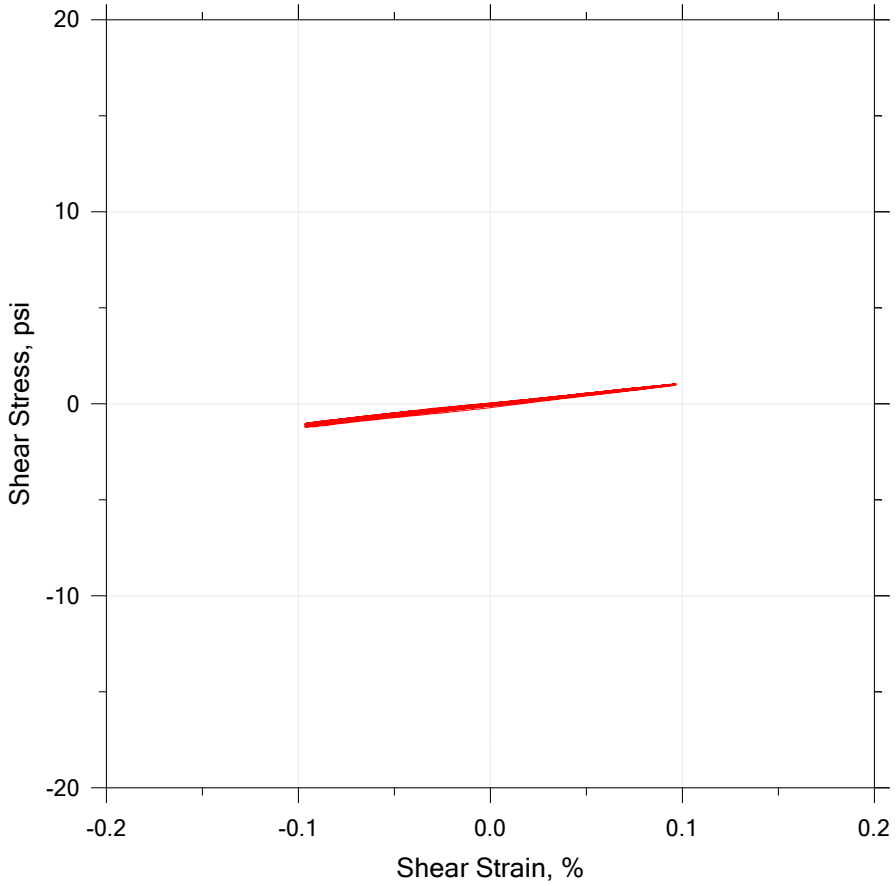
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

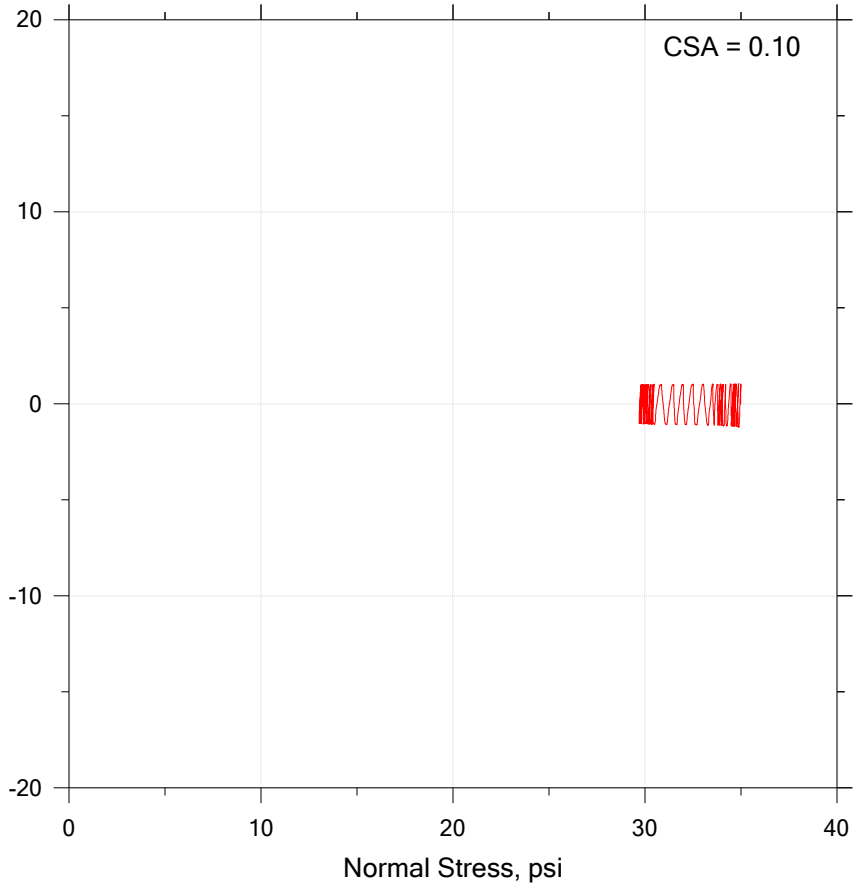
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0



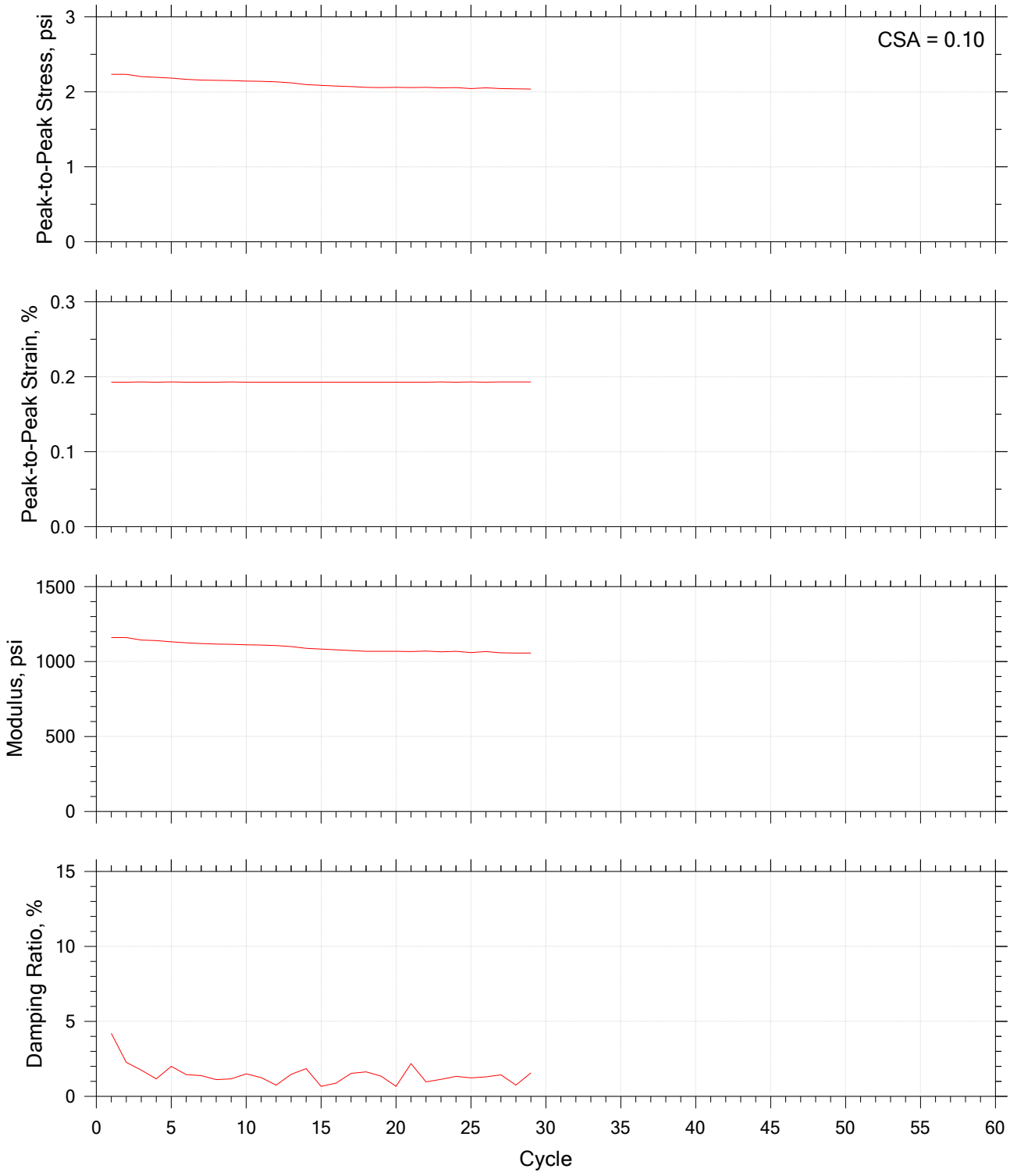


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

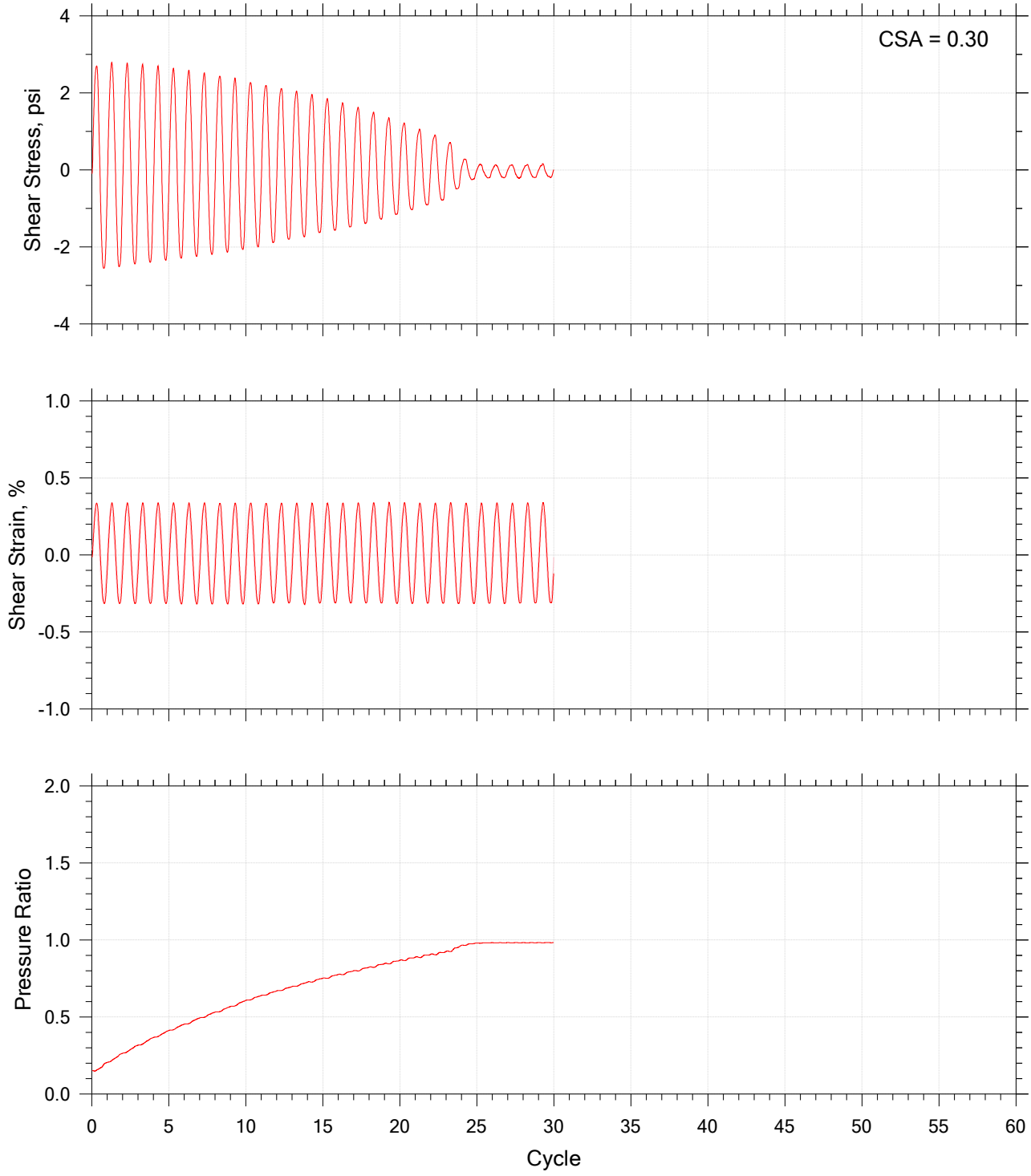


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



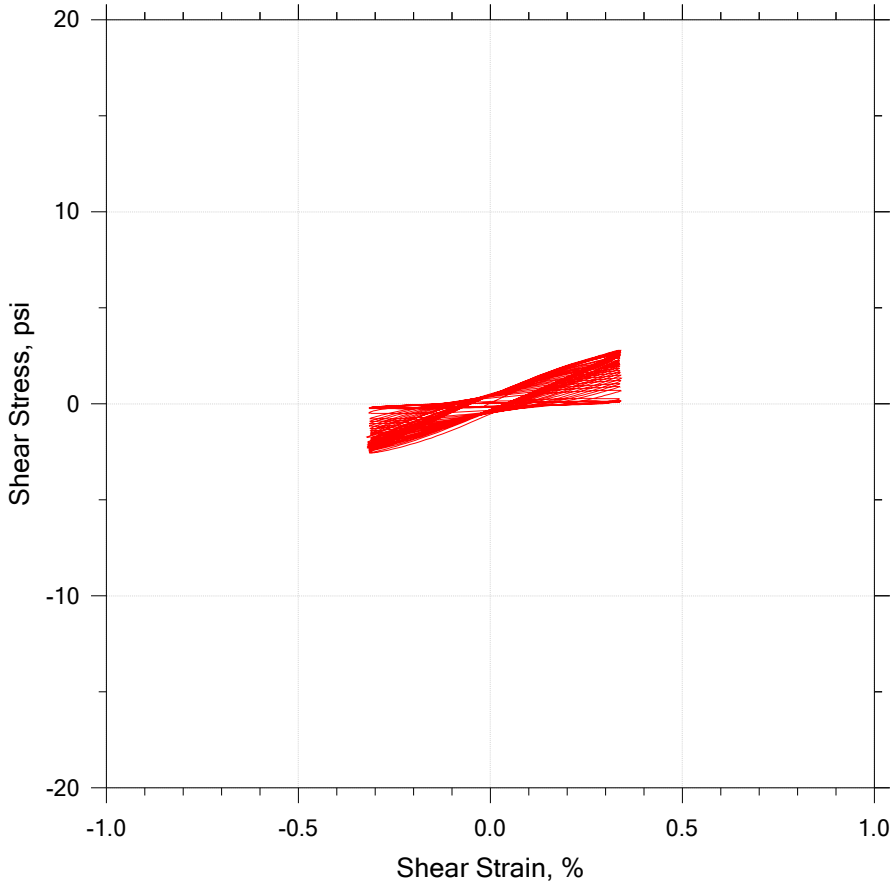
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

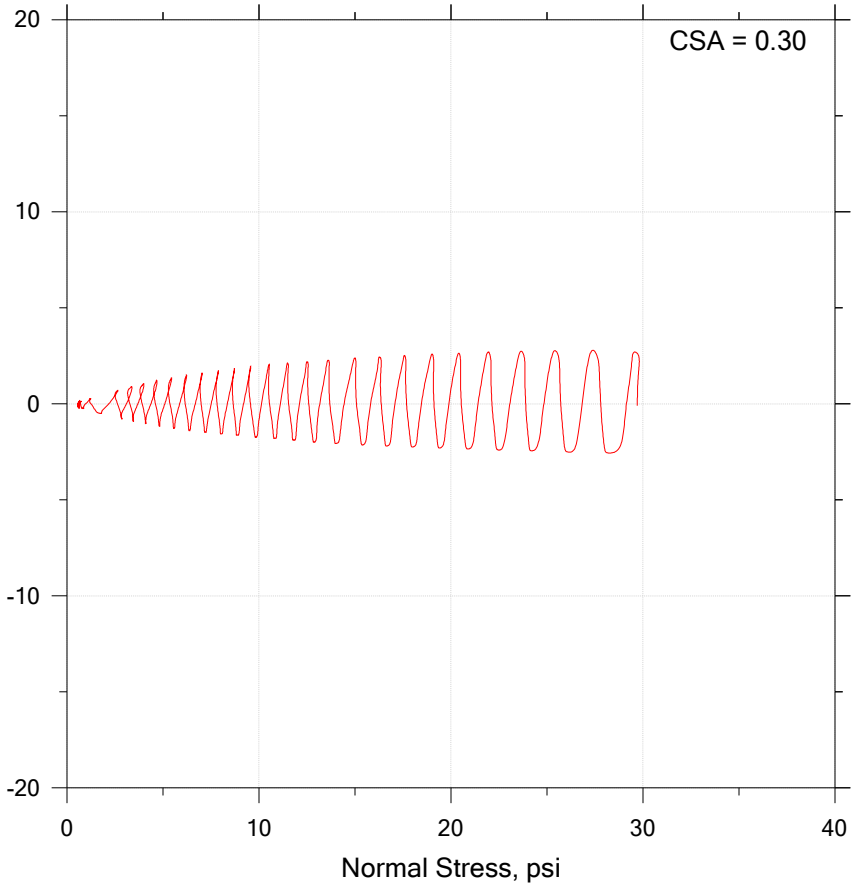
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



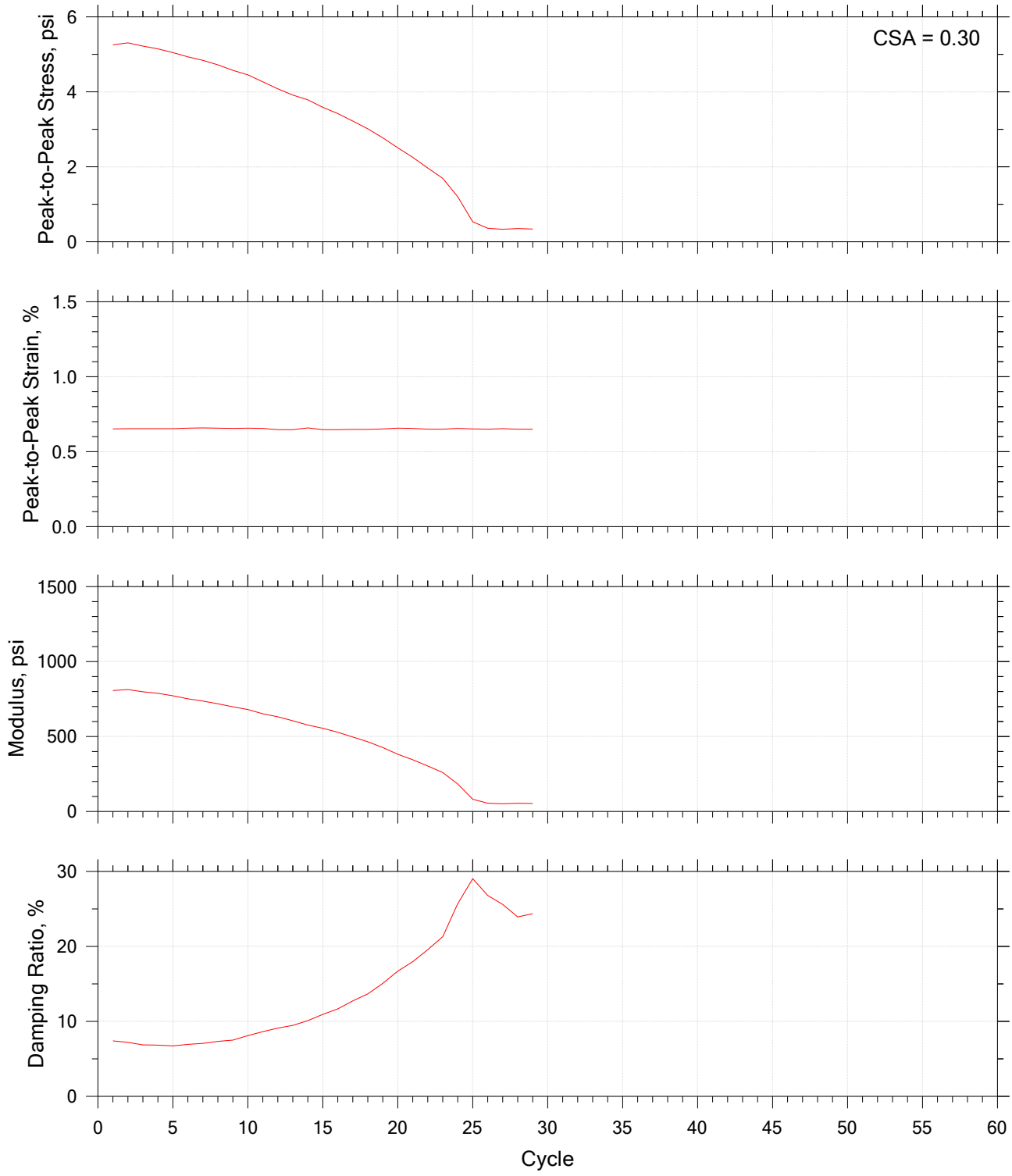


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

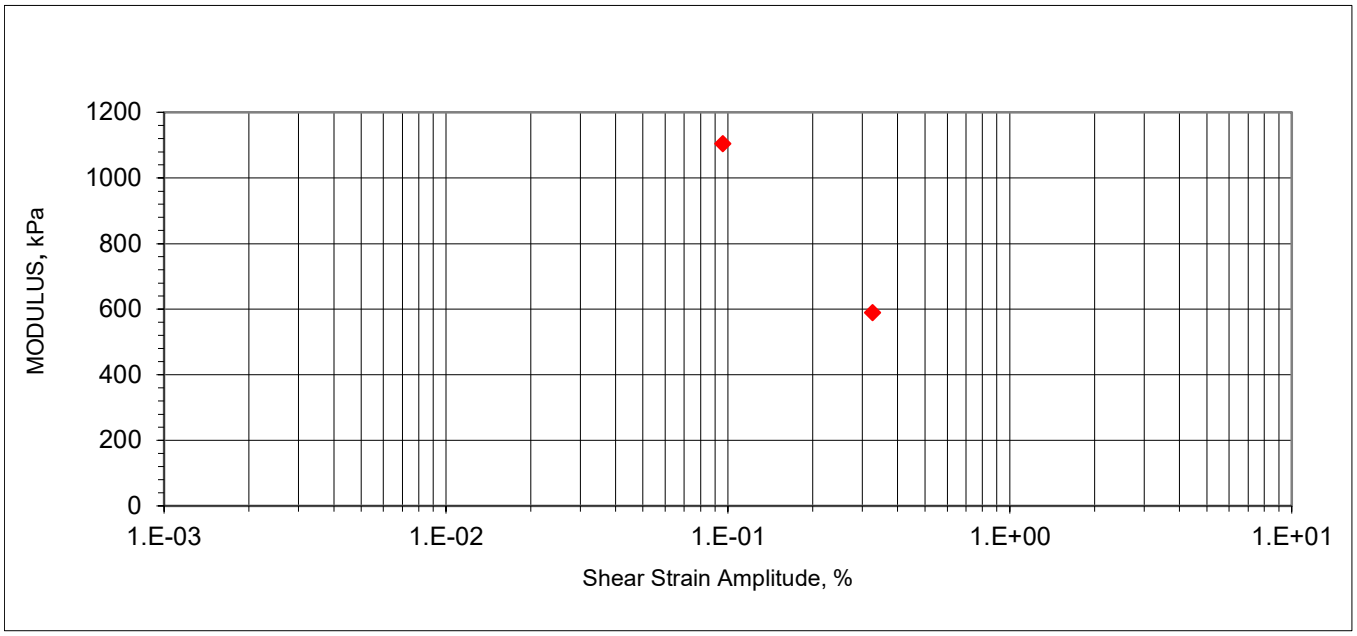


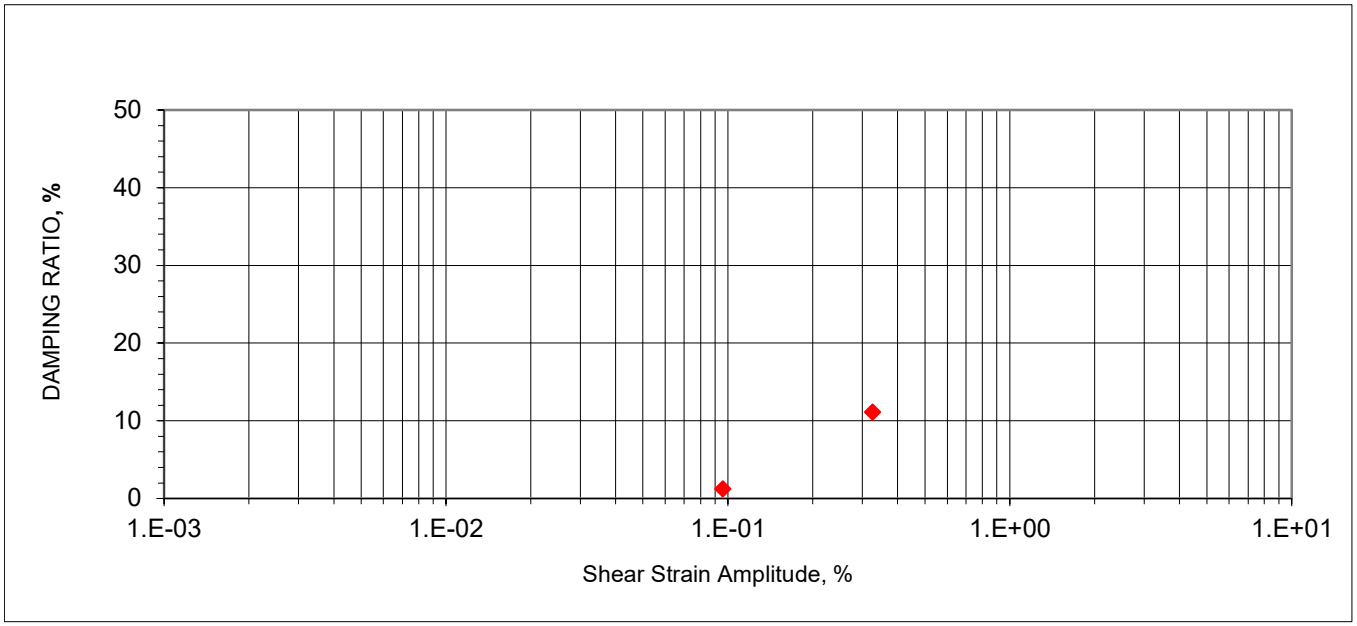
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1018	Tester: jlw	Checker: njh
	Sample Number: ST-8	Test Date: 10/22/24	Depth: 88.8-90.8
	Test Number: CDSS-1	Preparation: intact	Elevation: ---
	Description: Moist, very light gray sand		
	Remarks: CST-005		

GeoTesting EXPRESS
A Sercel Business

Modulus and Damping Properties of Soils

Using the Cyclic Direct Simple Shear Apparatus





Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1018	Tested By: jlw	Checked By:	njh
Sample No.: ST-8	Test Date: 10/22/24	Test No.:	CDSS-1
Depth: 88.8-90.8	Sample Type: intact	Elevation:	---
Description: Moist, very light gray sand			
Remarks: Average values of G and D from 30 cycles in Step 1 and 24 cycles in Step 2.			

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	12/09/24
Project Location:	Kentucky		

Boring ID: B-1021
Sample ID: GT-2
Depth, ft: 7.9-9.9

Visual Description: Moist, grayish brown sand with silt

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 26 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-3				
Initial Moisture Content, %	15.7				
Initial Dry Density, pcf	84.2				
Vertical Consolidation Stress, psi	26				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	30	25	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				14.5	
Delay before shearing, sec				---	
Nominal Rate of Shear Strain, %/hr				---	
Measured Post-Cyclic Peak Shear Stress, psi				---	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				---	
Membrane Correction, psi				---	
Corrected Post-Cyclic Peak Shear Stress, psi				---	
S_r/σ'_{vc}				---	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Specimen reached an R value approaching 1 and liquified the sample at about 25 cycles into Step 4 of the test. Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

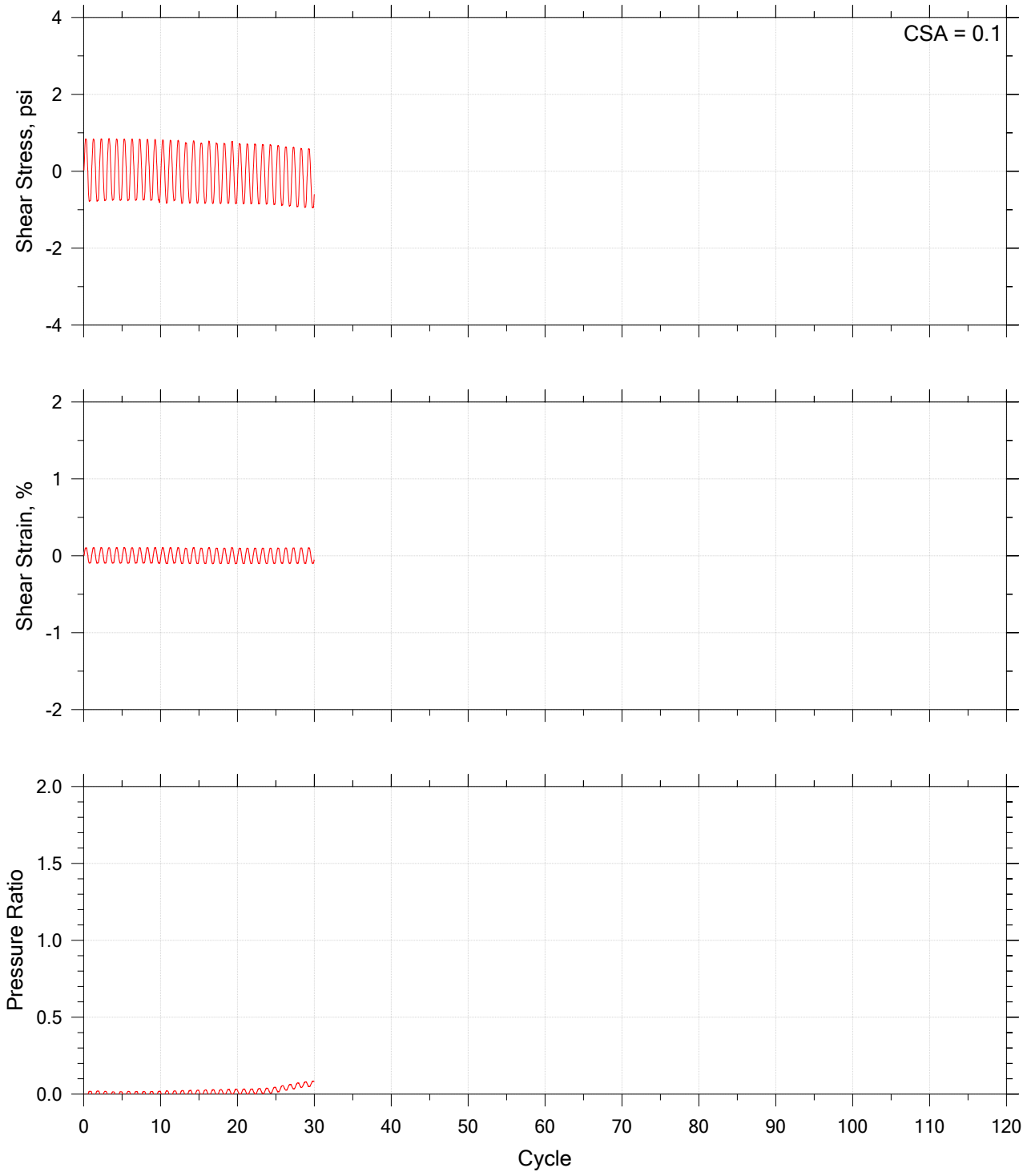
Tested By: sjt Checked By: dgz

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



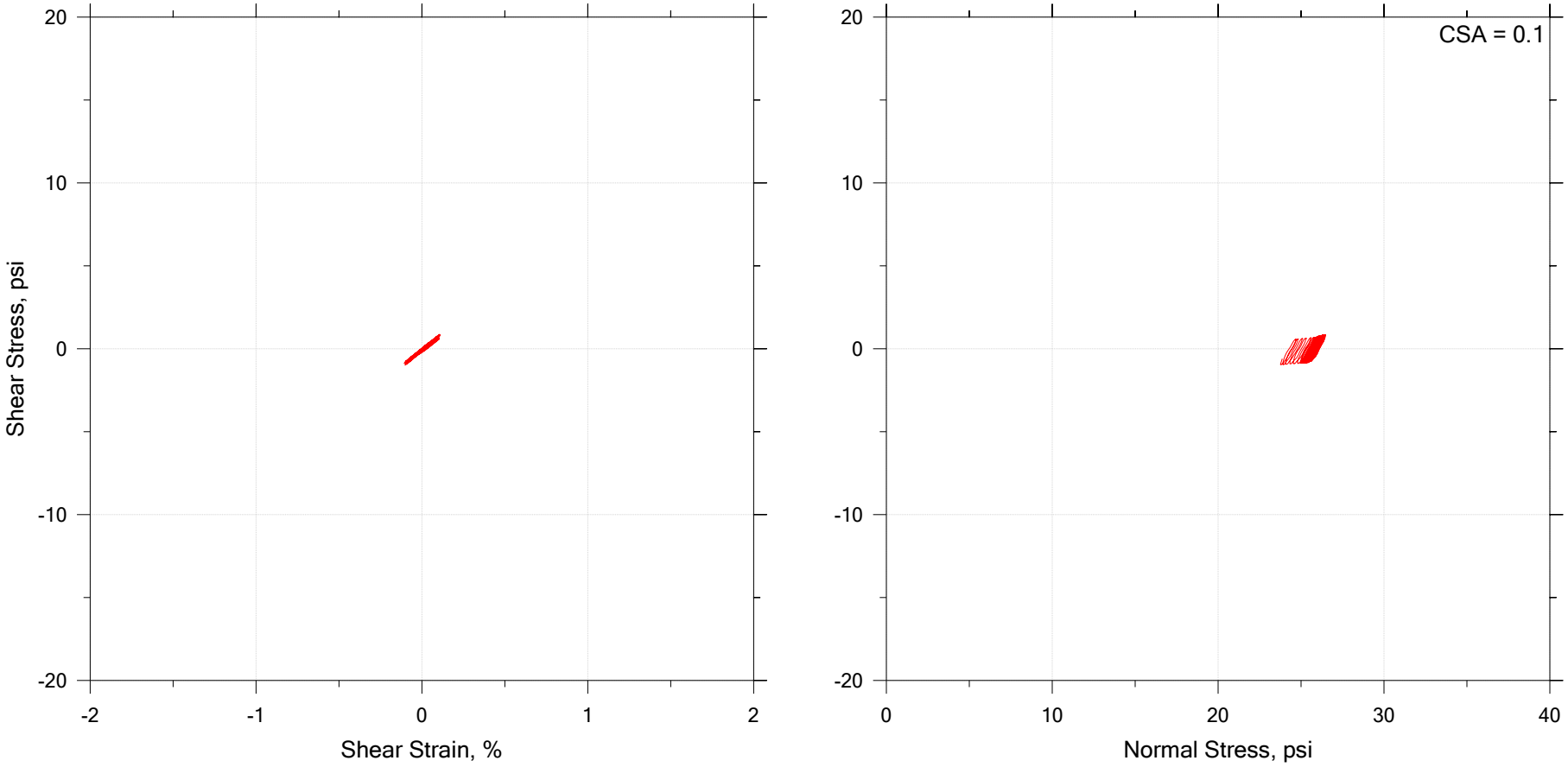
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0

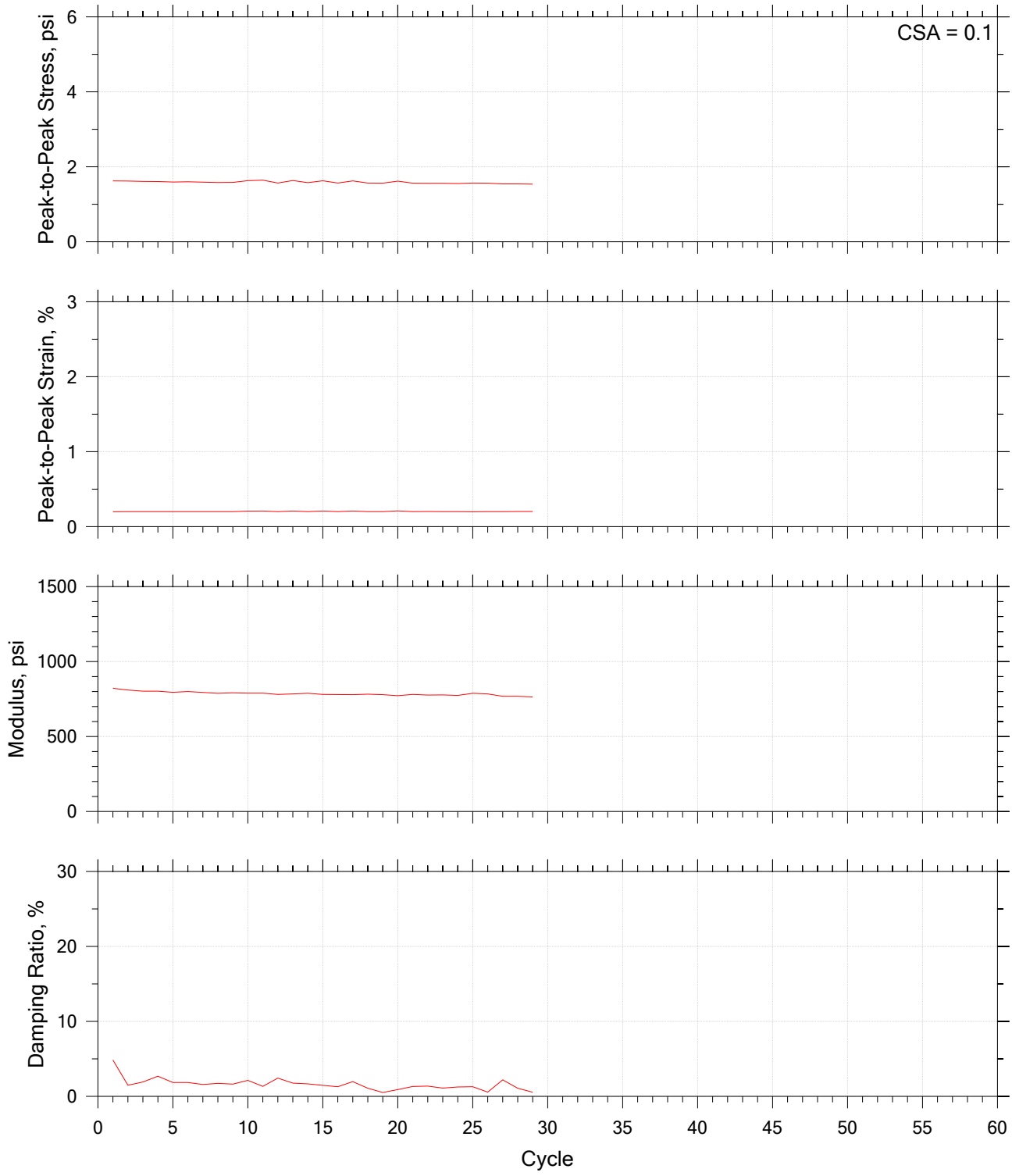


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

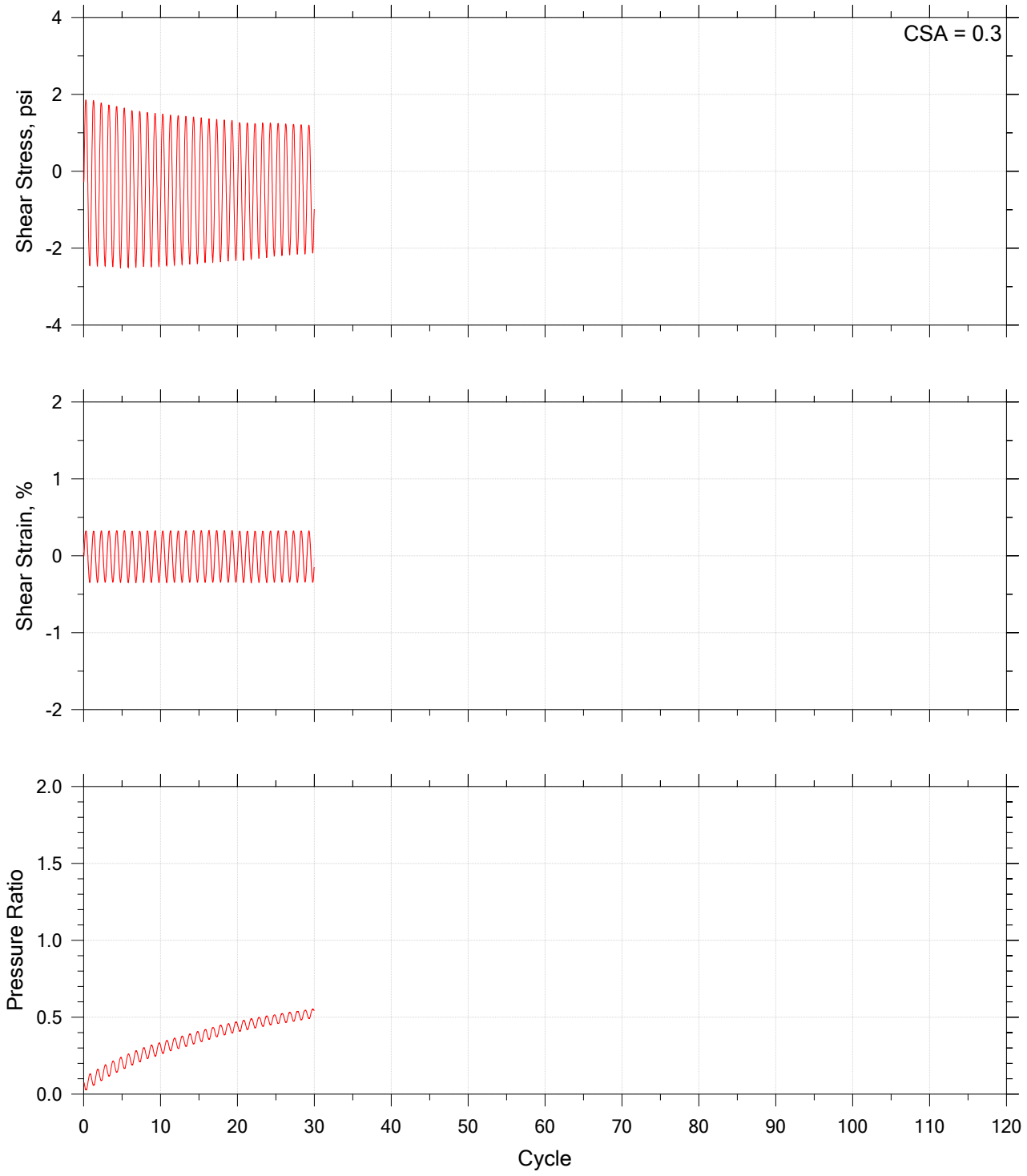


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



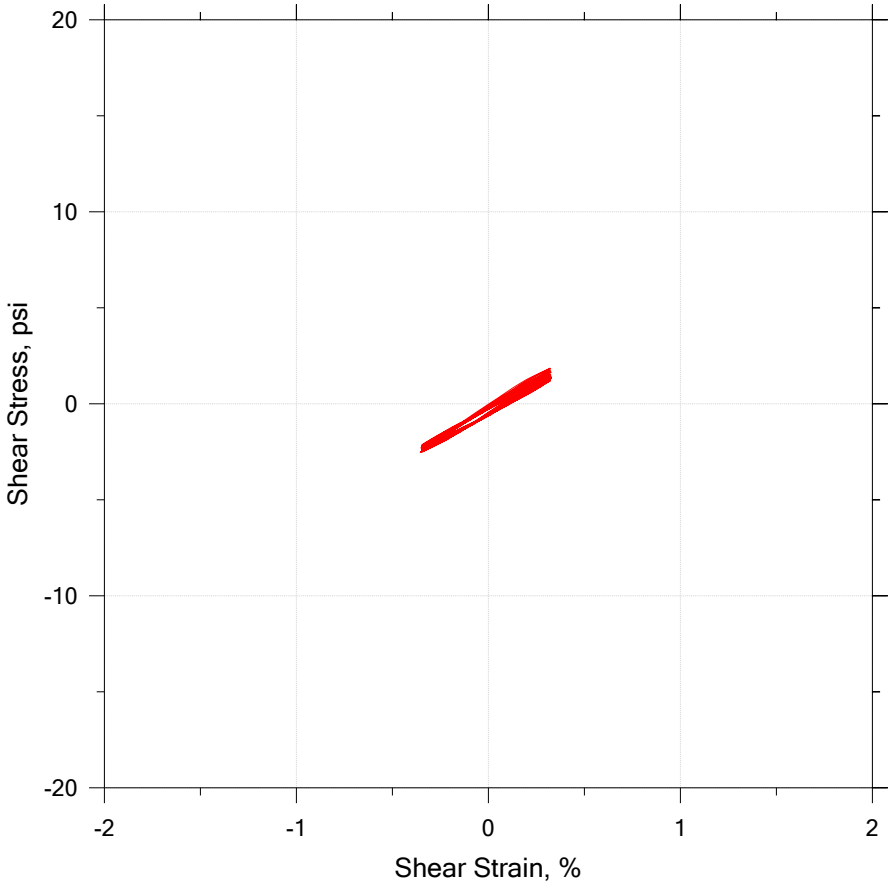
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

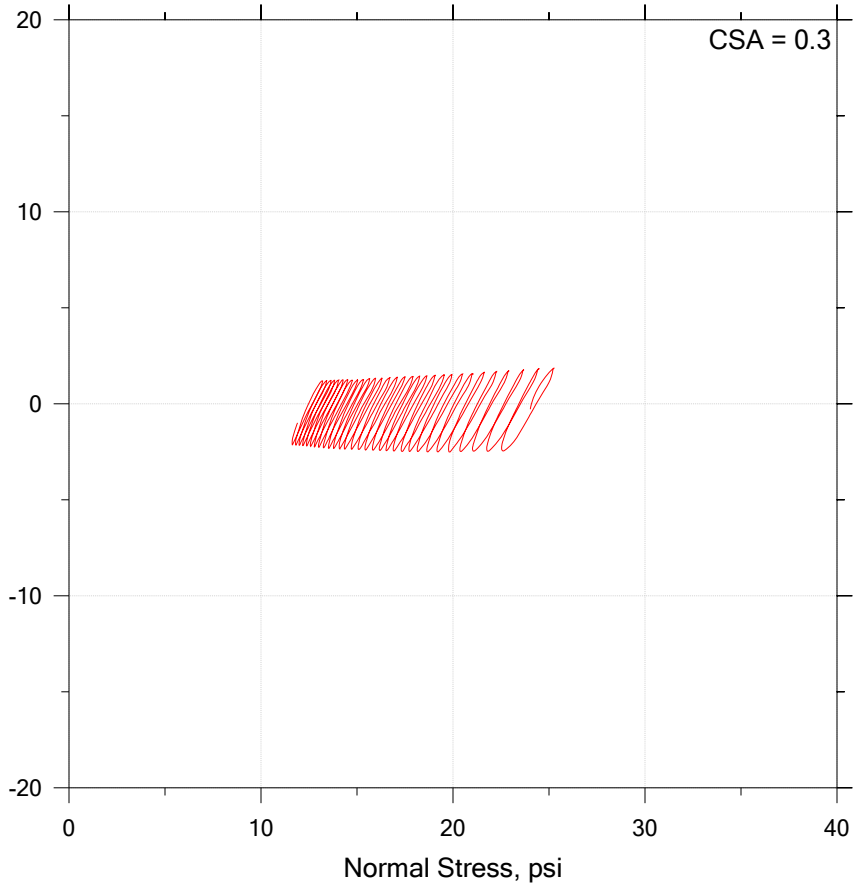
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



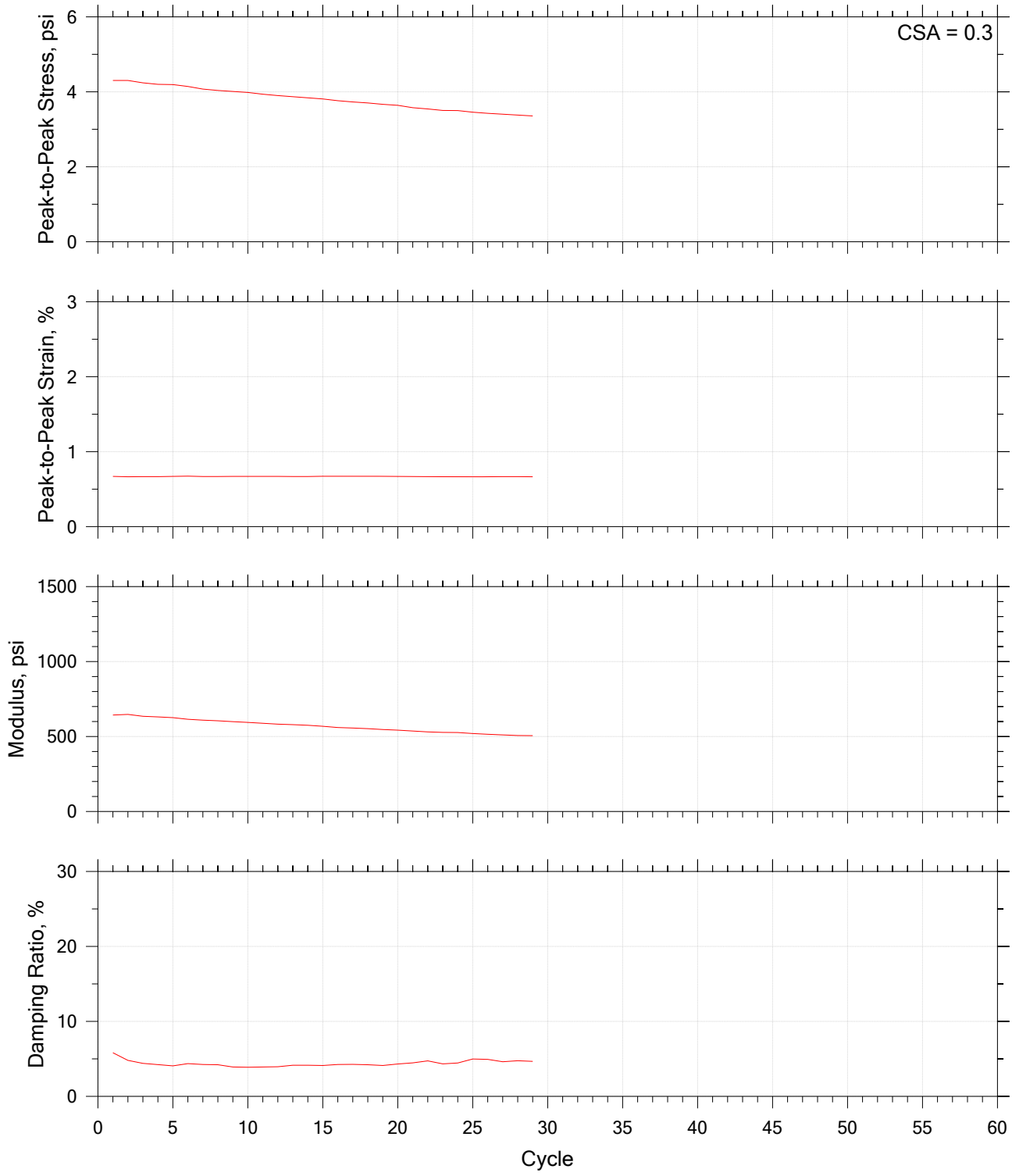


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

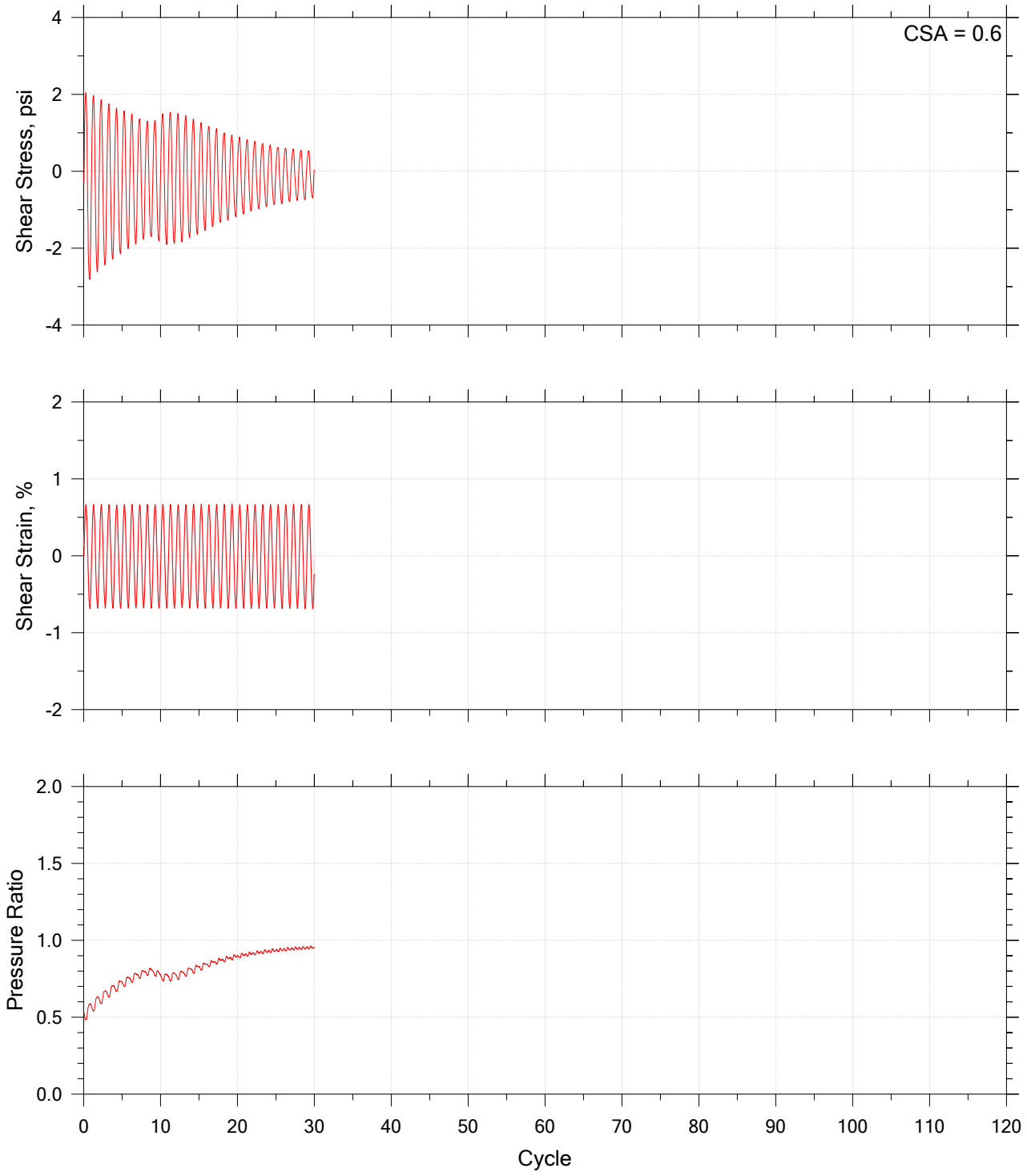


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



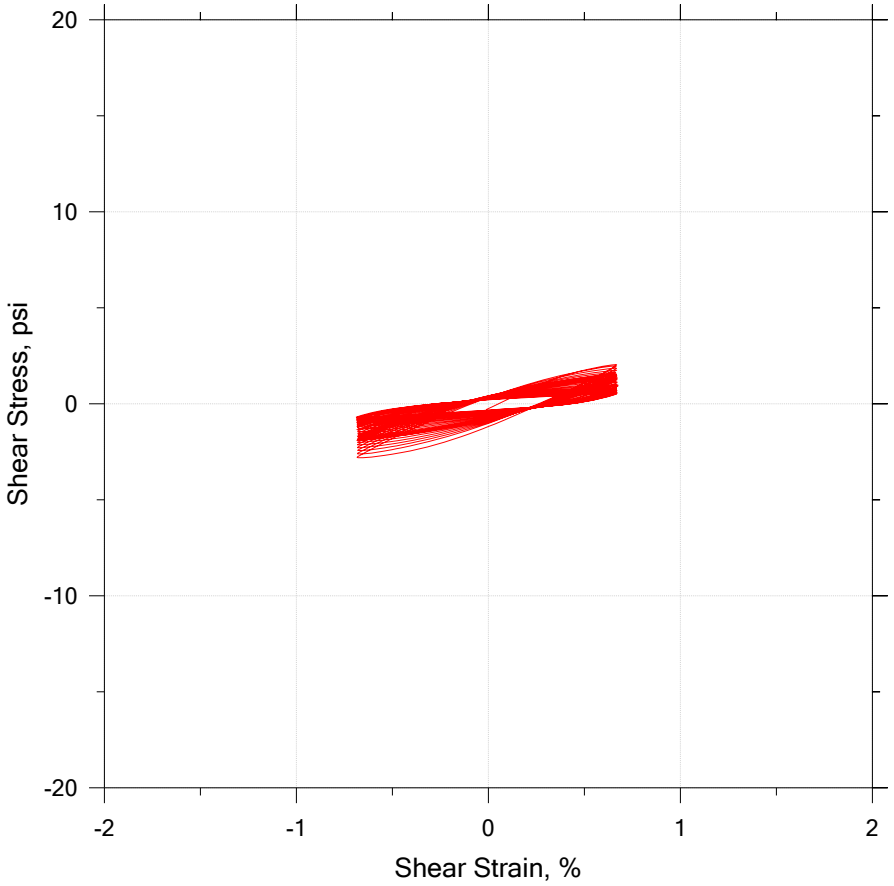
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

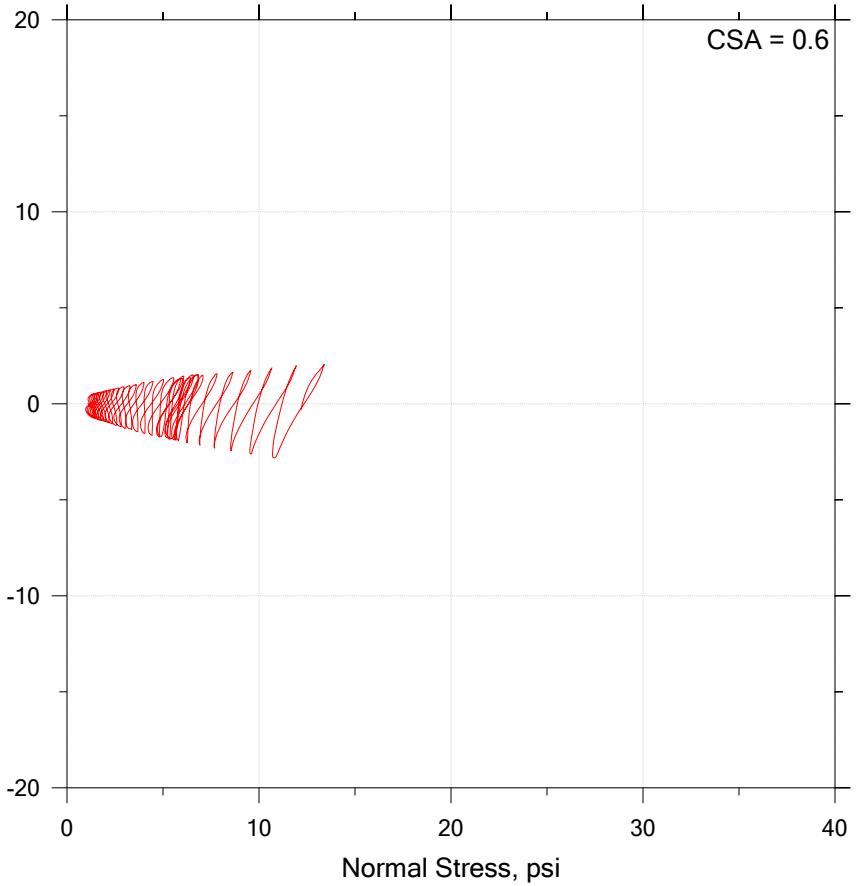
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0



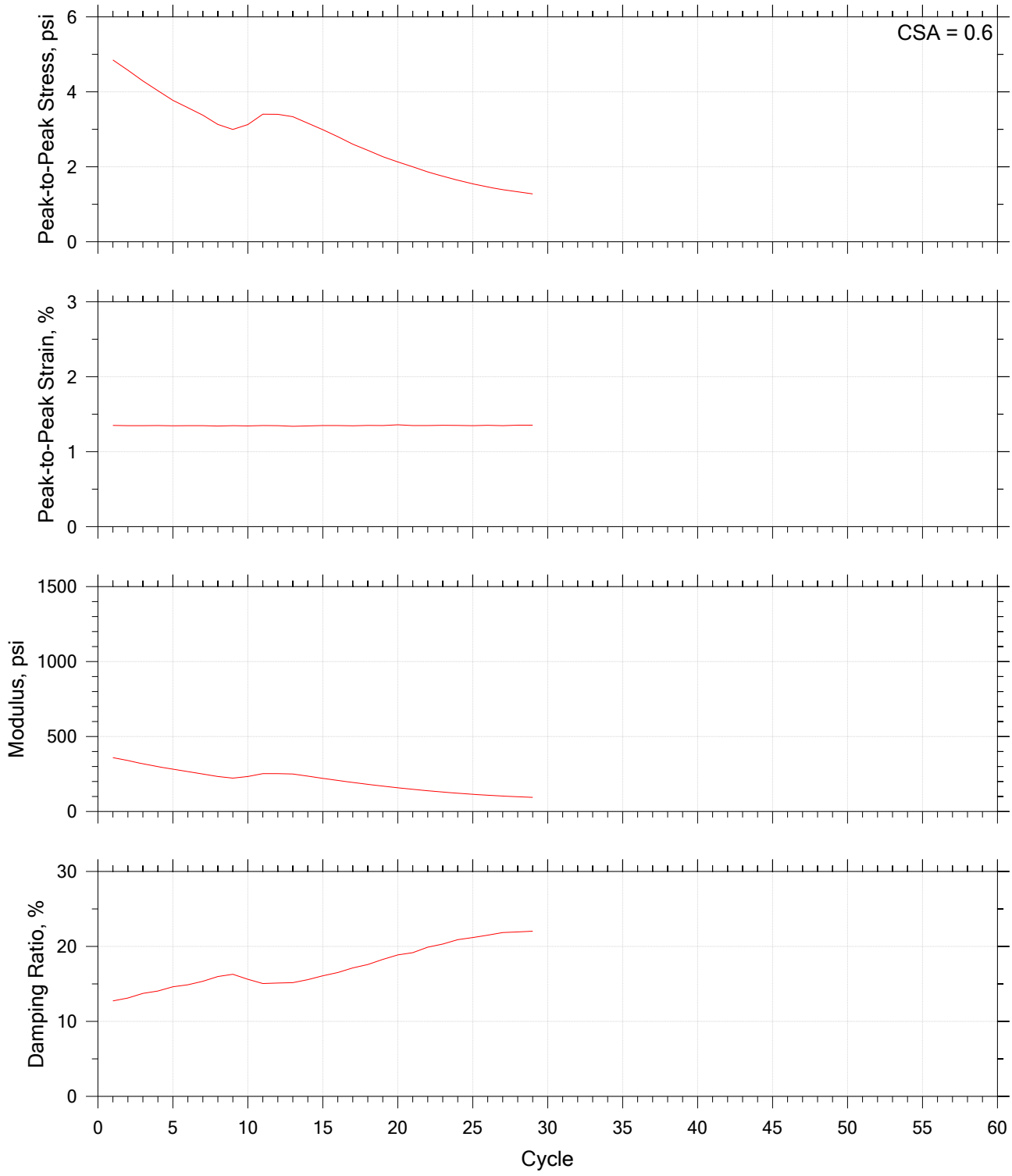


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

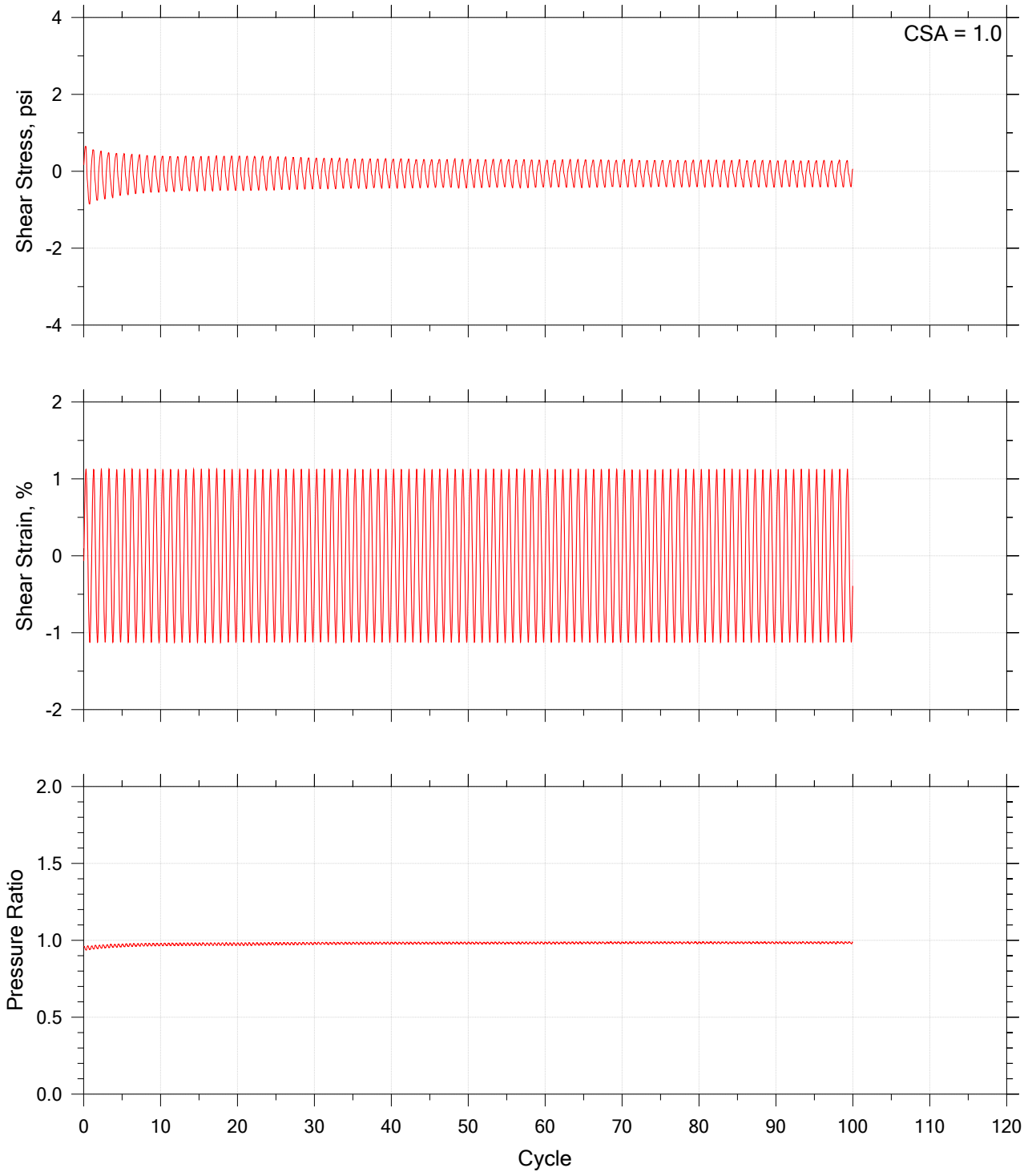


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 4 of 4



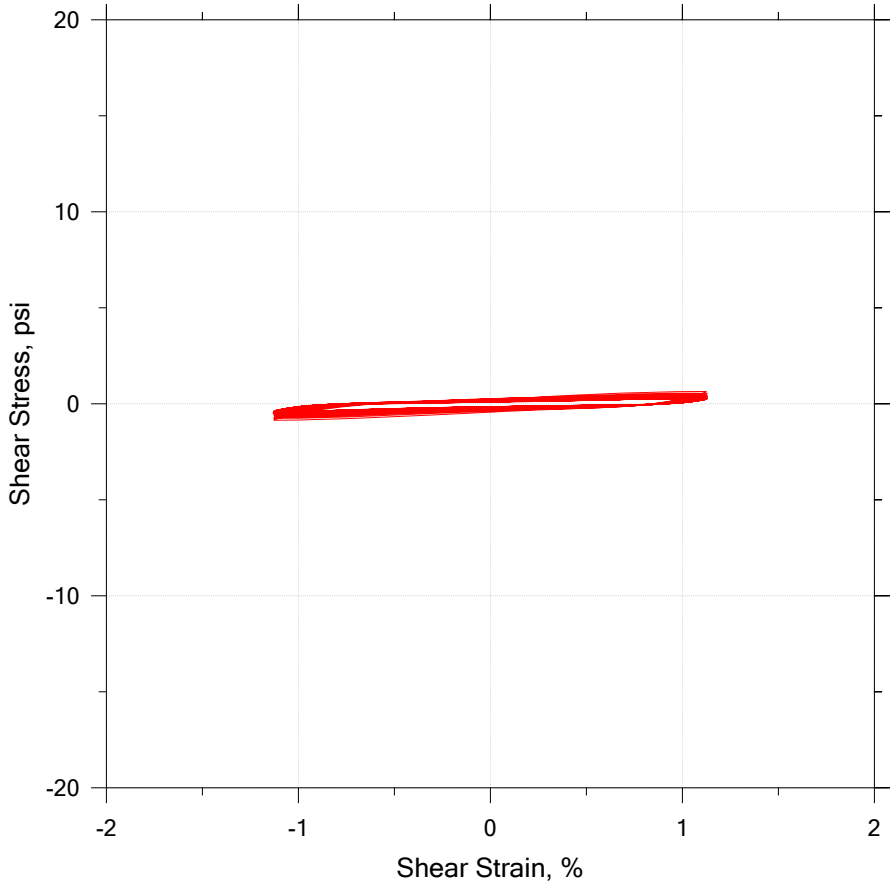
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

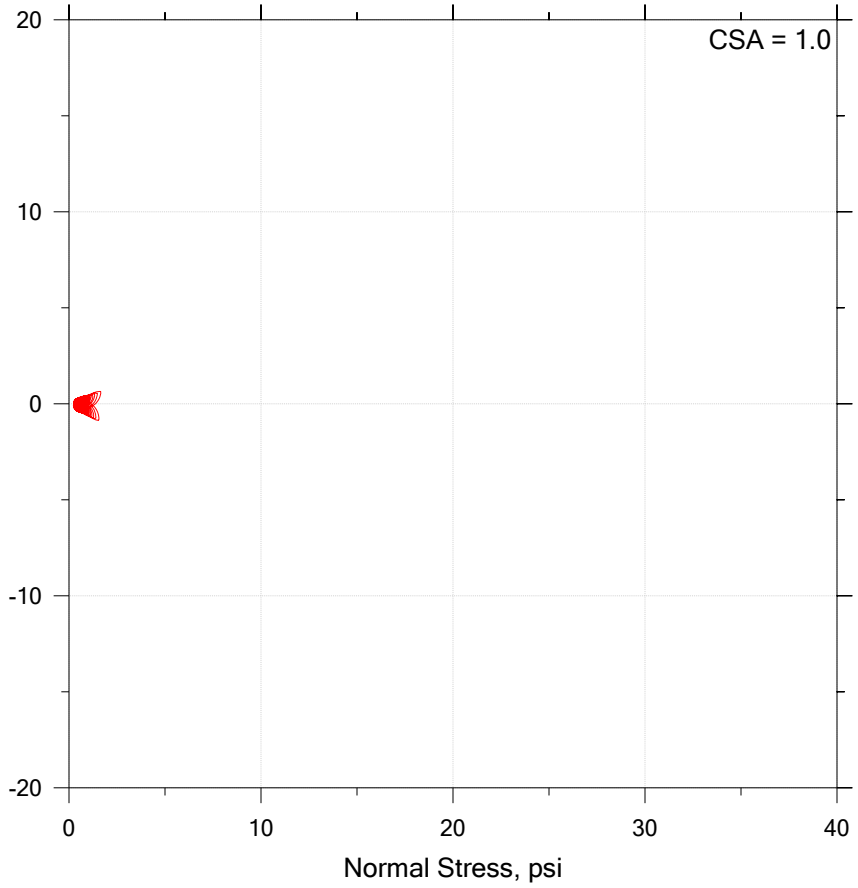
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 4 of 4

Cycle 0.0 to 100.0



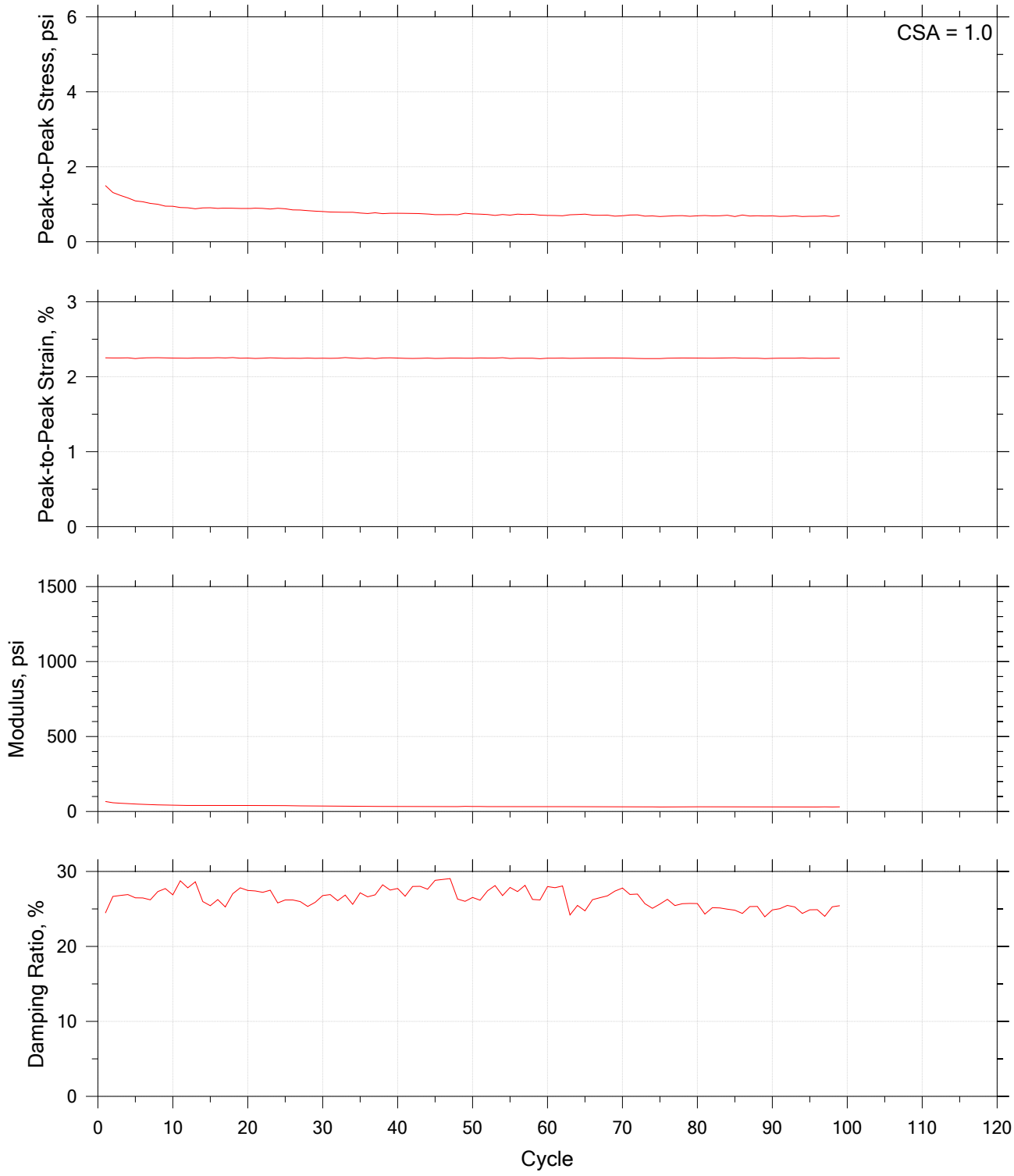


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

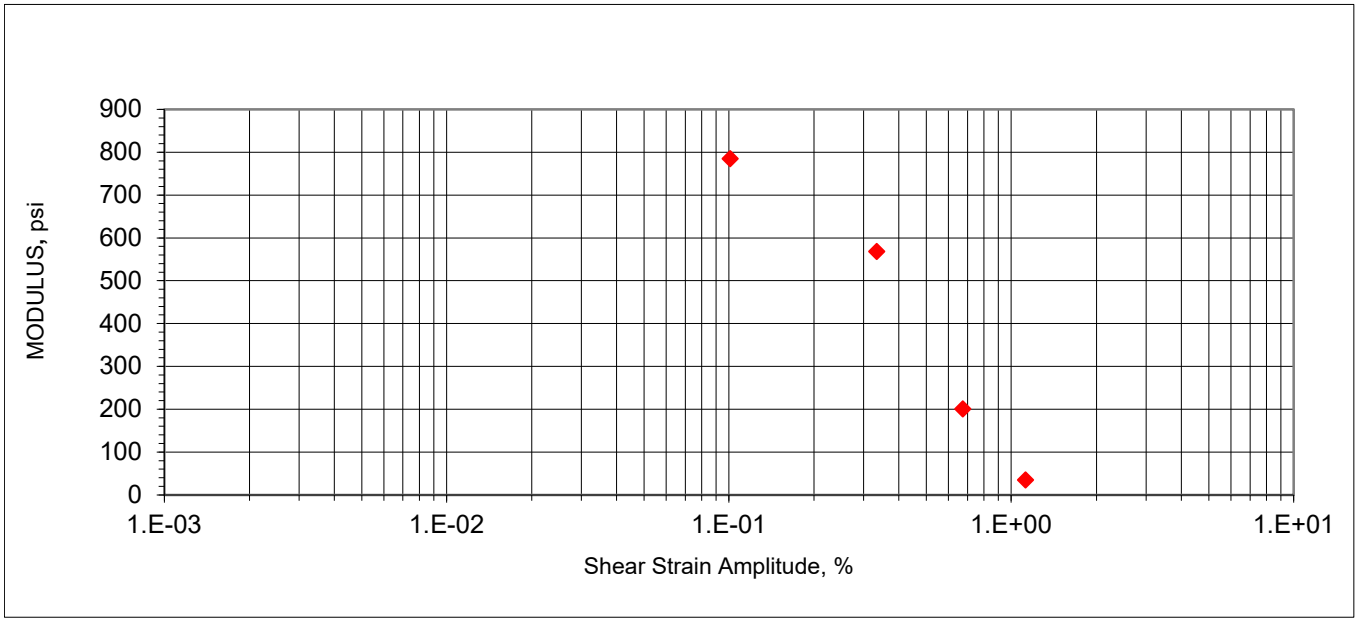
Step 4 of 4

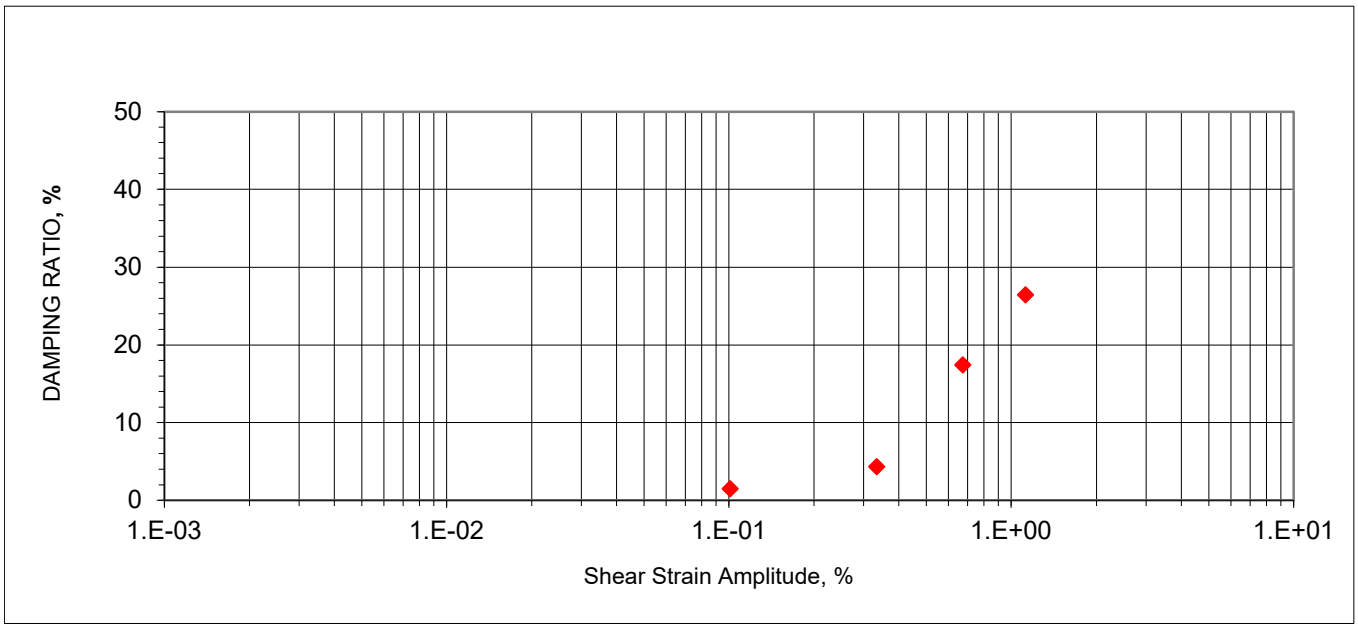


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Phio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1021	Tester: sjt	Checker: dgz
	Sample Number: GT-2	Test Date: 12/09/24	Depth: 7.9-9.9
	Test Number: CDSS-3	Preparation: intact	Elevation: ---
	Description: Moist, grayish brown sand with silt		
	Remarks: CST-005		

Modulus and Damping Properties of Soils

Using the Cyclic Direct Simple Shear Apparatus





Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1021	Tested By: sjt	Checked By:	dgz
Sample No.: GT-2	Test Date: 12/09/24	Test No.:	CDSS-3
Depth: 7.9-9.9	Sample Type: intact	Elevation:	---
Description: Moist, grayish brown sand with silt			
Remarks: Average values of G and D from 30 cycles in Step 1, 2 & 3 and 100 cycles in Step 4.			

GeoTesting EXPRESS
A Sercel Business

Consolidated Undrained Cyclic Direct Simple Shear Test under Constant Volume with Load Control or Displacement Control by ASTM D8296

Client:	HDR Engineering, Inc.	GTX#:	319809
Project Name:	US-51 Over Ohio River Updated	Test Date:	11/13/24
Project Location:	Kentucky		

Boring ID: B-1023
Sample ID: ST-2
Depth, ft: 48.1-50.1

Visual Description: Moist, light brownish gray clay

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked Ring set-up used, which included porous stones with pins.

Test Condition: Inundated prior to consolidating to 18 psi

Sample Type and Preparation: Extruded from tube, cut, trimmed, and placed into apparatus at as-received density and moisture content.

Parameter	Step 1	Step 2	Step 3	Step 4	
Test No.	CDSS-2RR				
Initial Moisture Content, %	27.0				
Initial Dry Density, pcf	94.5				
Vertical Consolidation Stress, psi	18				
Cyclic Strain Amplitude, %	0.1	0.3	0.6	1.0	
Number of cycles completed	30	30	30	100	
Frequency, Hz	1	1	1	1	
Final Moisture Content, %				29.7	
Delay before shearing, sec				60	
Nominal Rate of Shear Strain, %/hr				5.0	
Measured Post-Cyclic Peak Shear Stress, psi				8.63	
Shear Strain at Post-Cyclic Peak Shear Stress, % (relative 20% shear)				19.8	
Membrane Correction, psi				0.35	
Corrected Post-Cyclic Peak Shear Stress, psi				8.28	
S_r/σ'_{vc}				0.46	
Post Shear Axial Strain when re-applying Vertical Consolidation Stress on the consolidated height, %				---	

Comments: Actual post cyclic strength parameters should be determined by an engineer familiar with dynamic testing data.

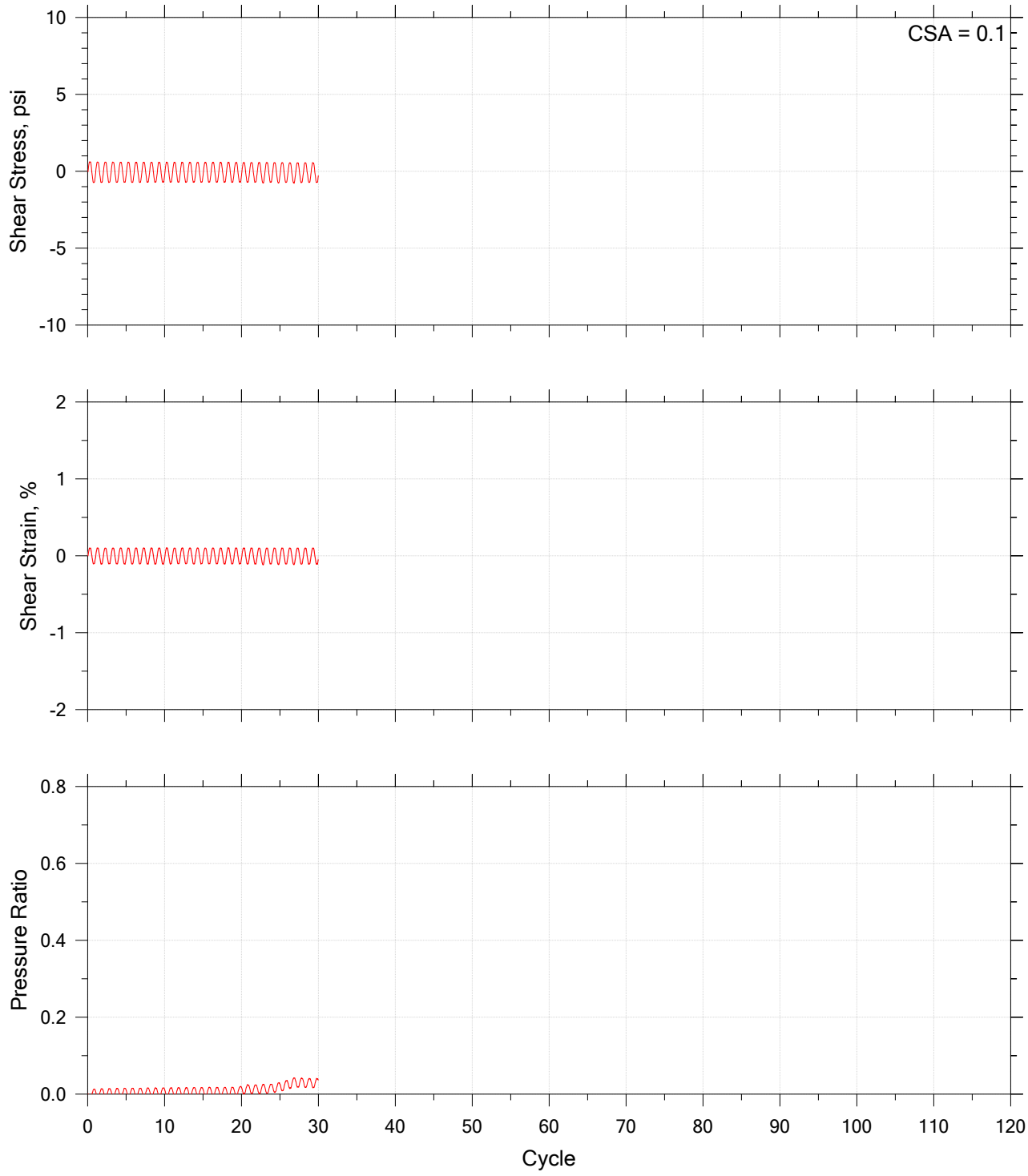
Tested By: sjt Checked By: dgz

Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Cyclic Simple Shear Test

Cyclic Data

Step 1 of 4



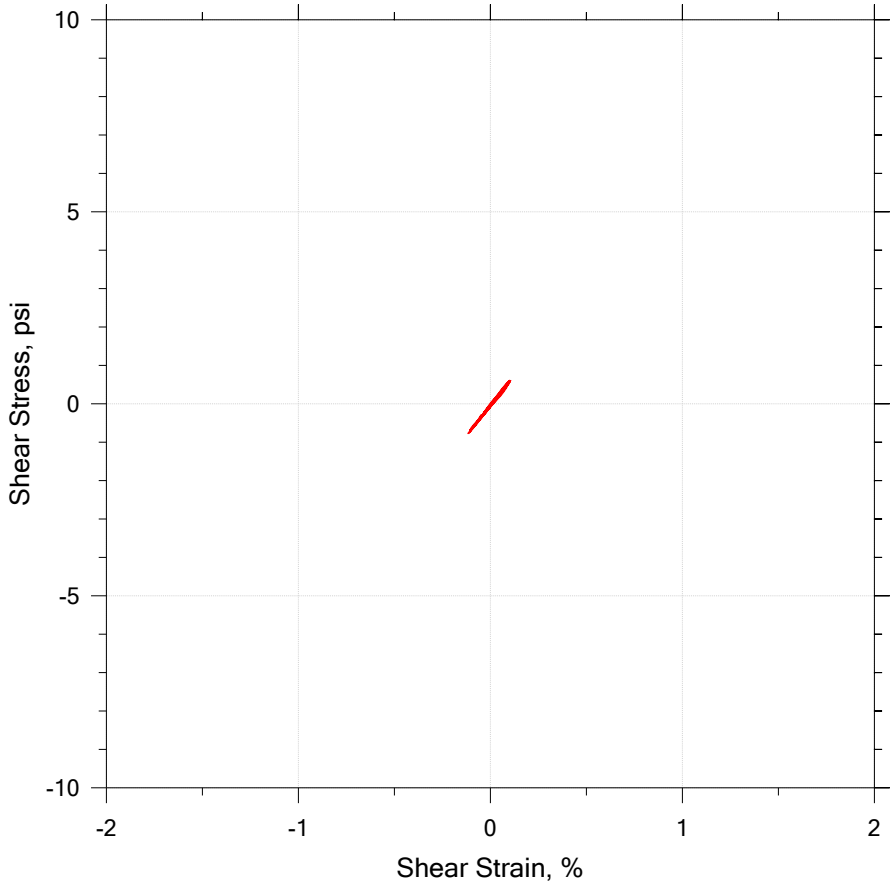
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

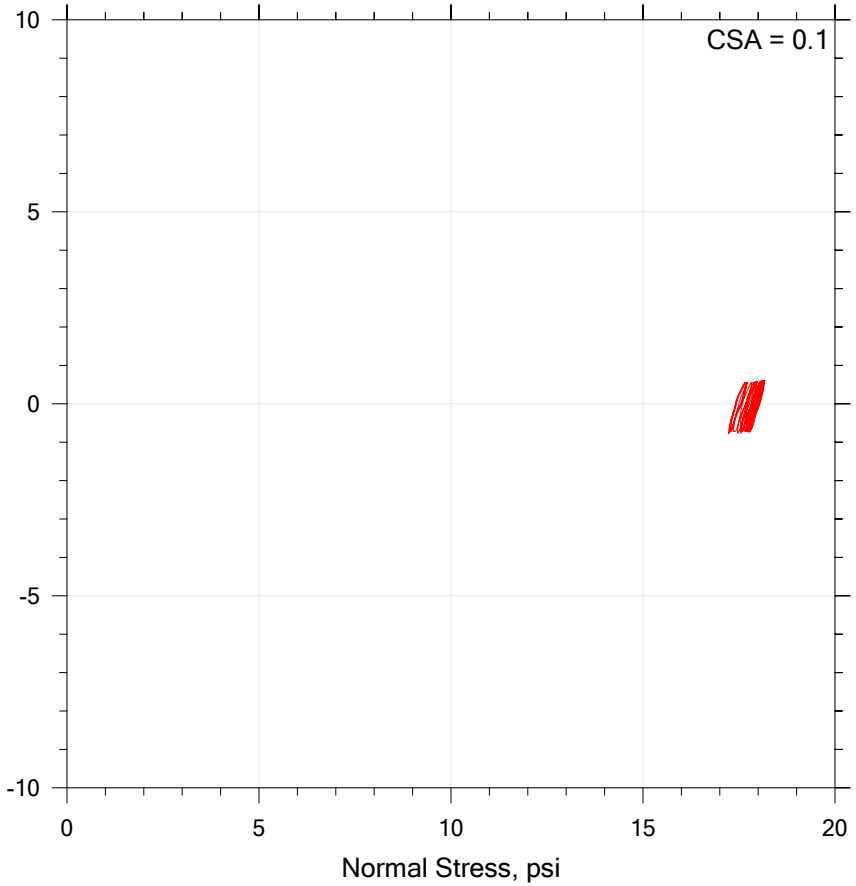
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 1 of 4

Cycle 0.0 to 30.0



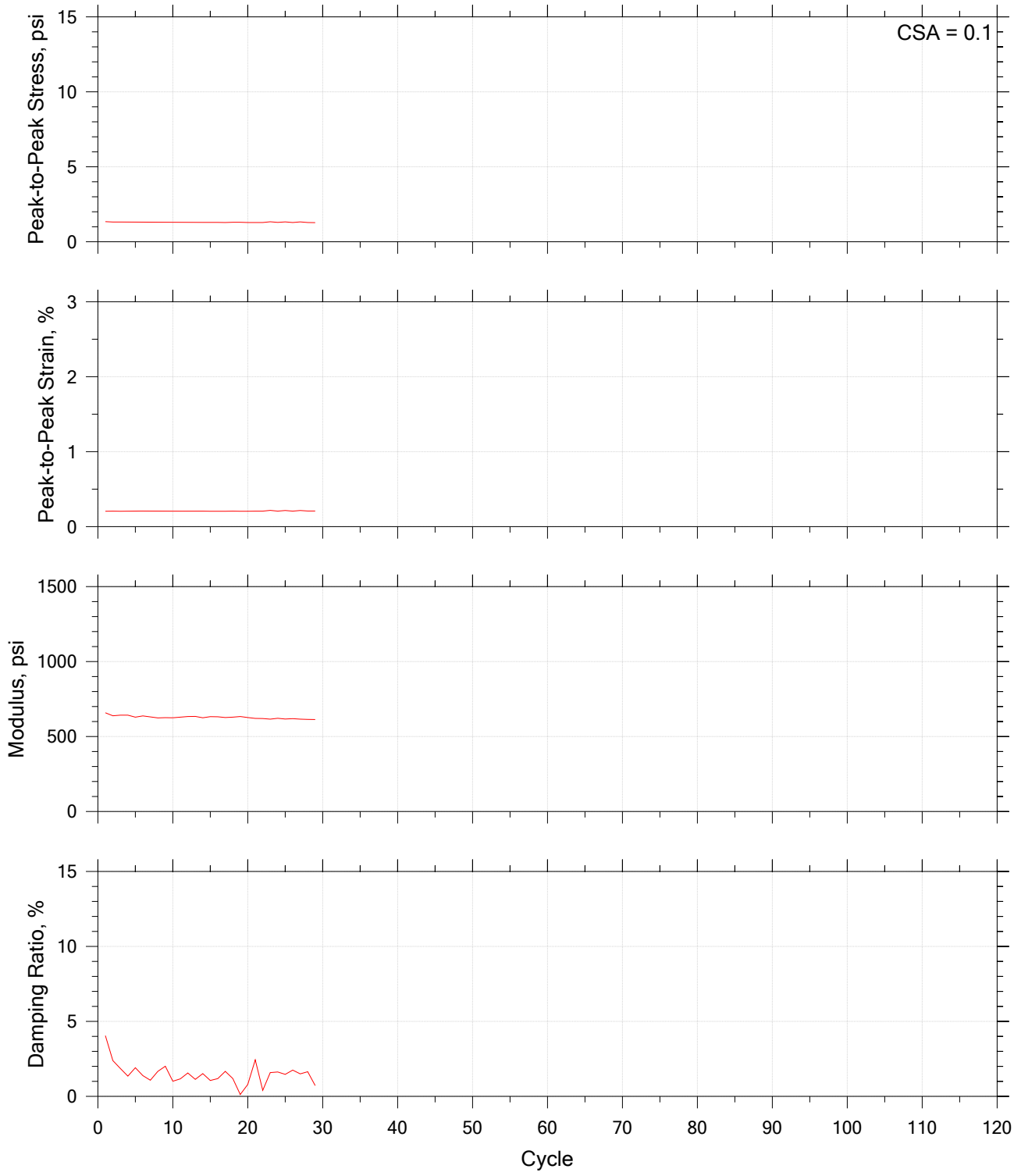


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 1 of 4

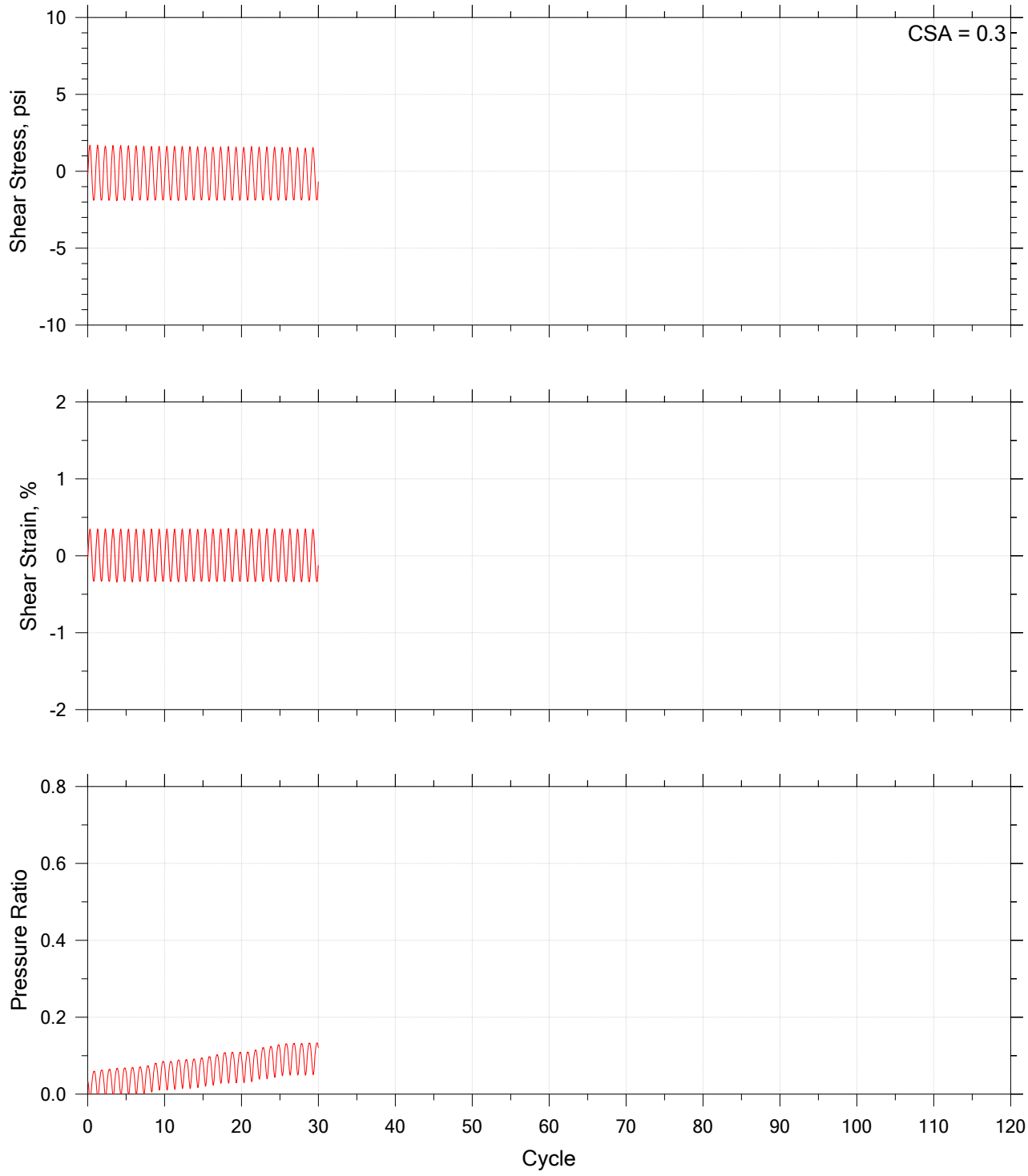


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 2 of 4



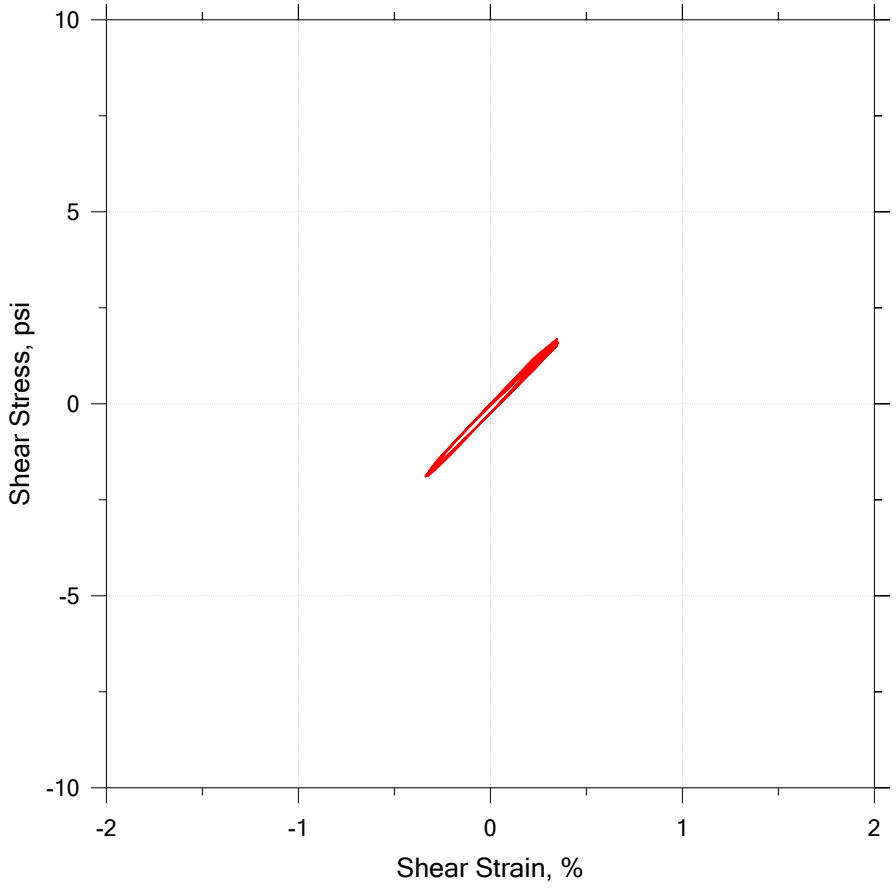
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

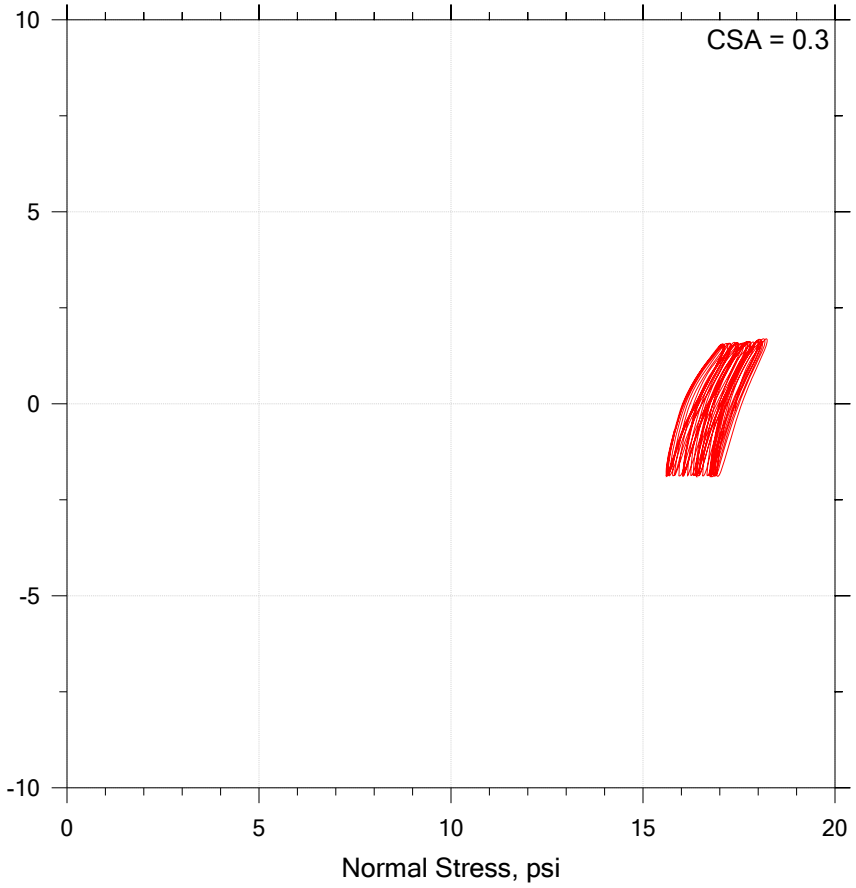
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 2 of 4

Cycle 0.0 to 30.0



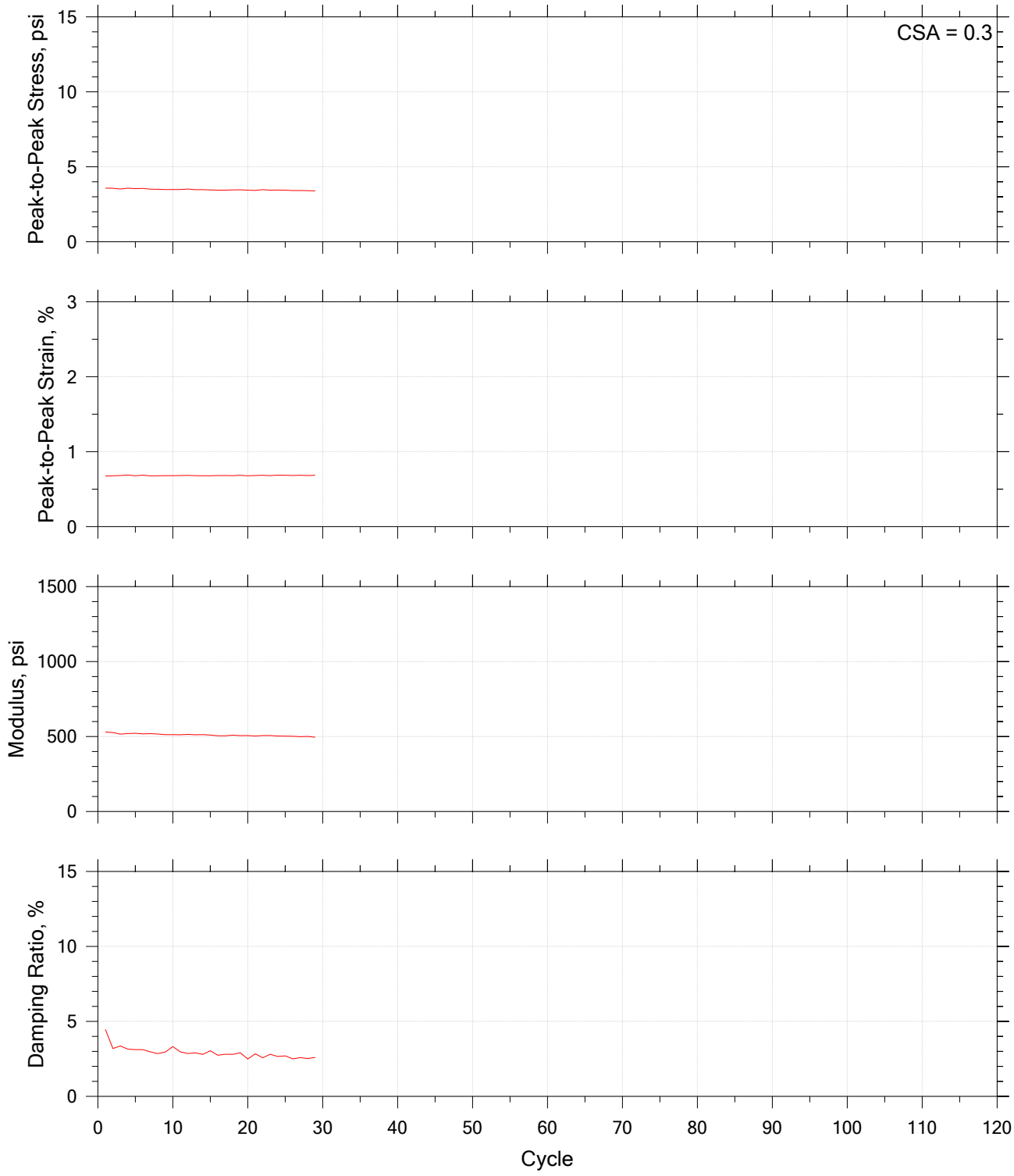


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 2 of 4

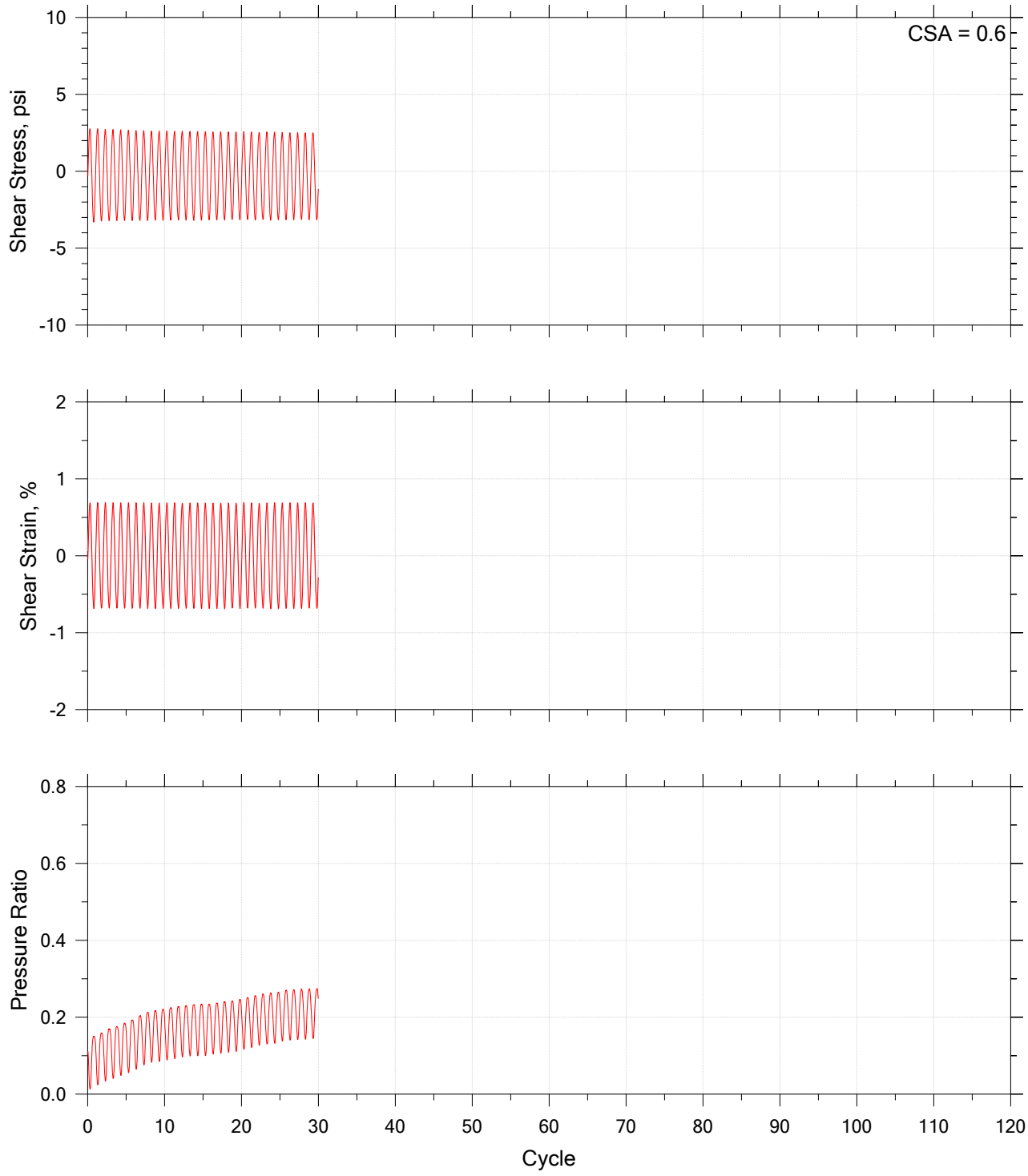


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 3 of 4



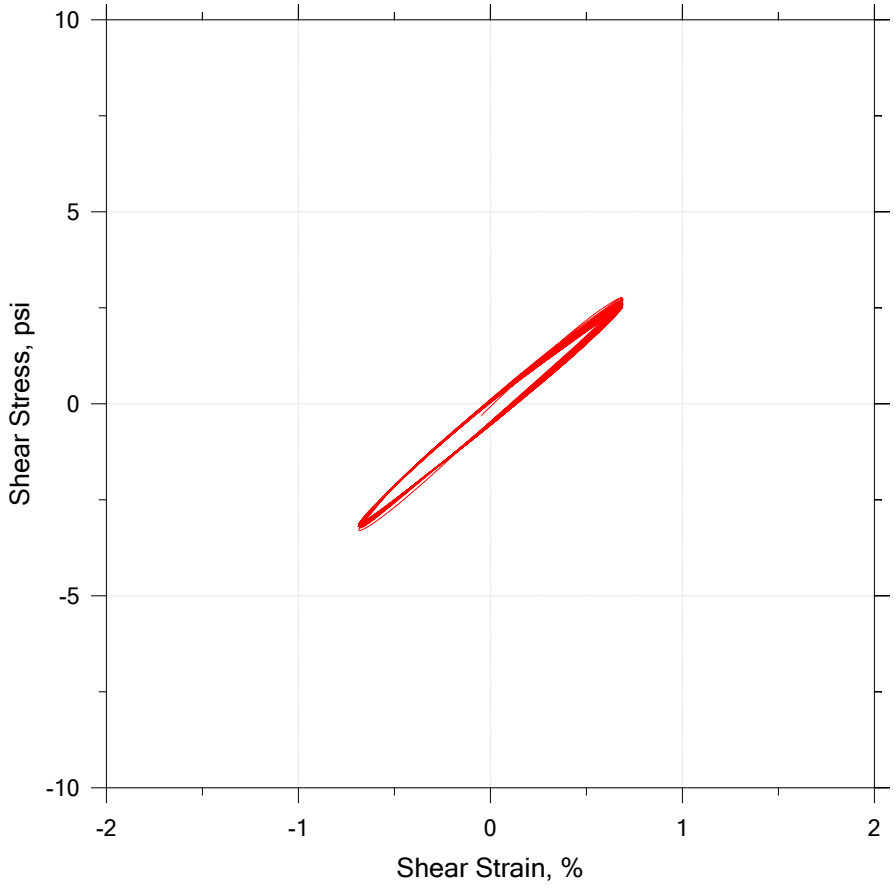
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

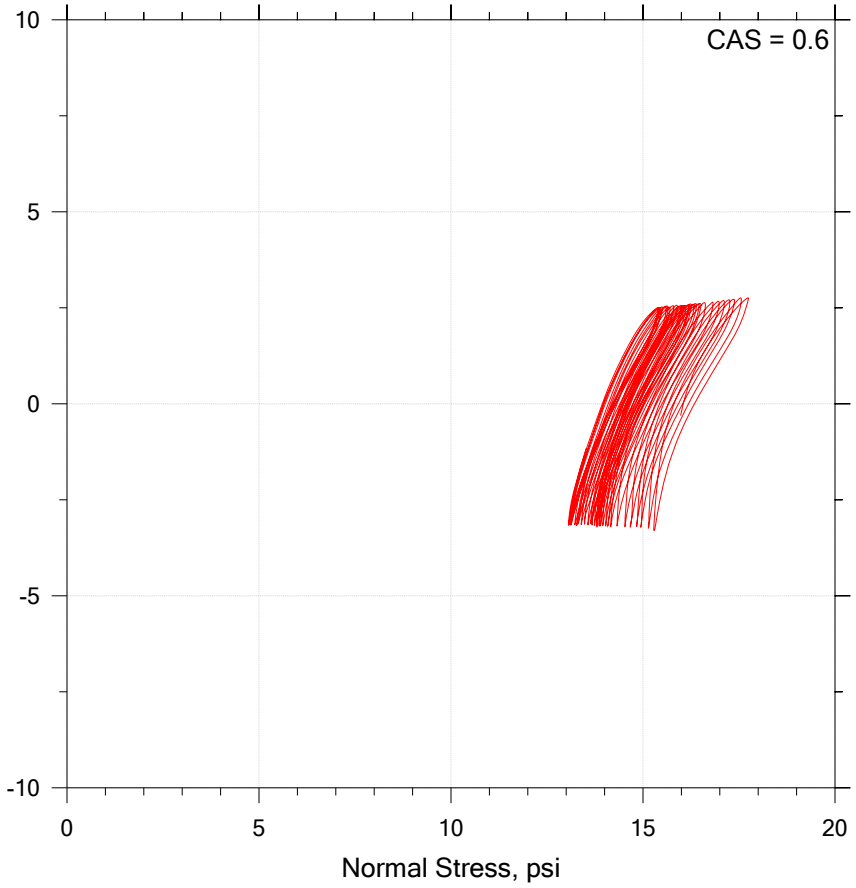
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 3 of 4

Cycle 0.0 to 30.0



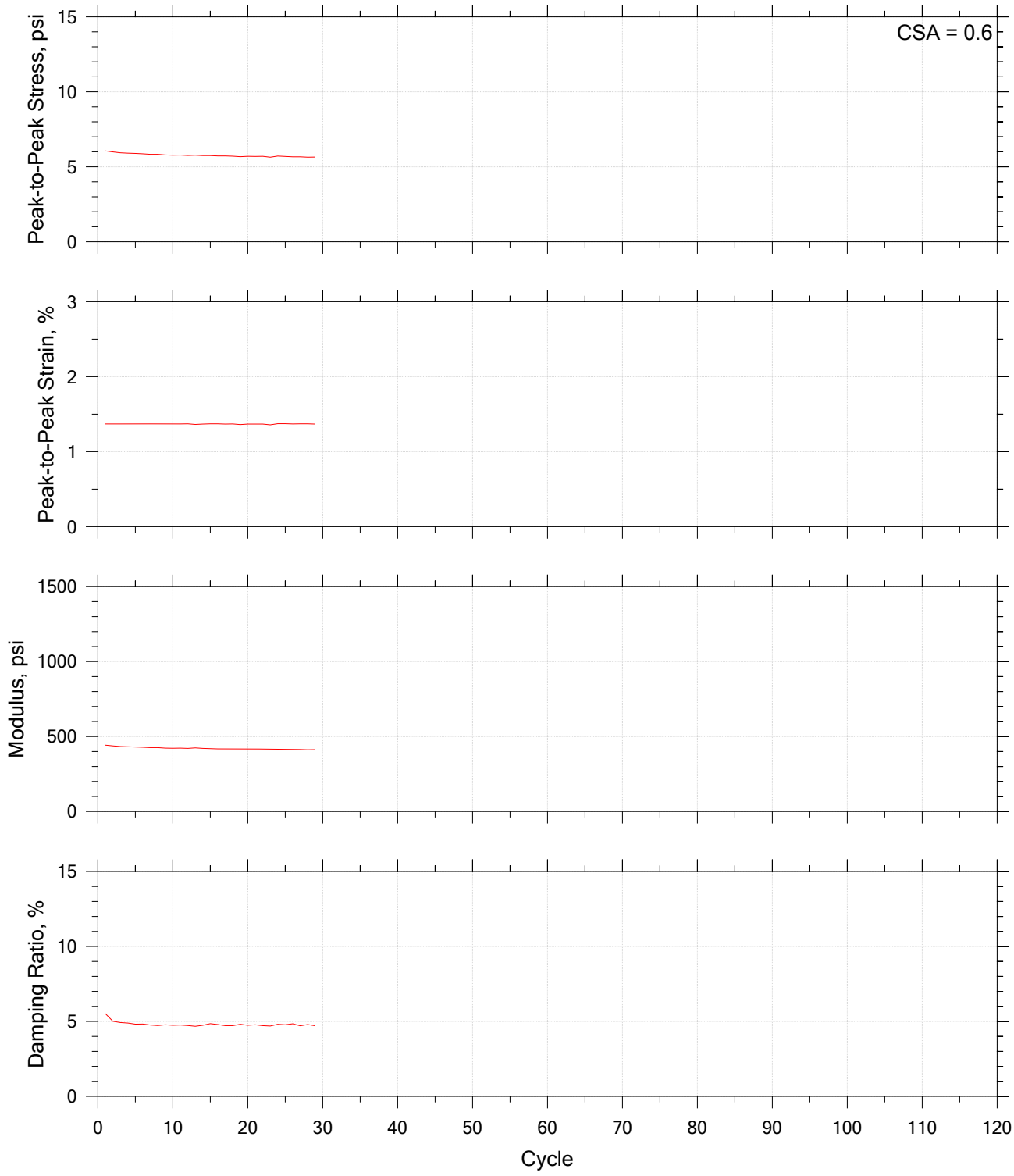


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

Step 3 of 4

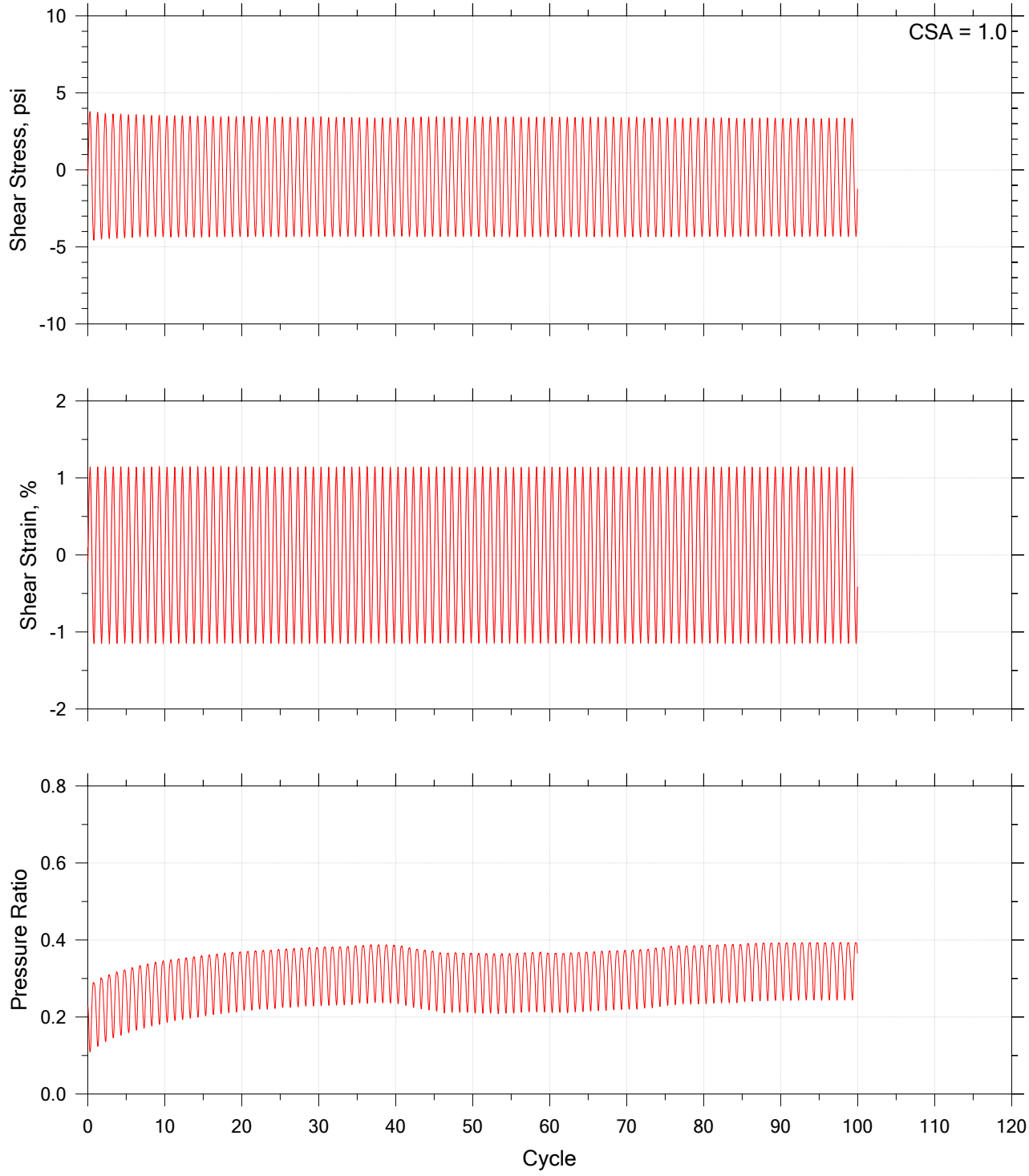


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Data

Step 4 of 4



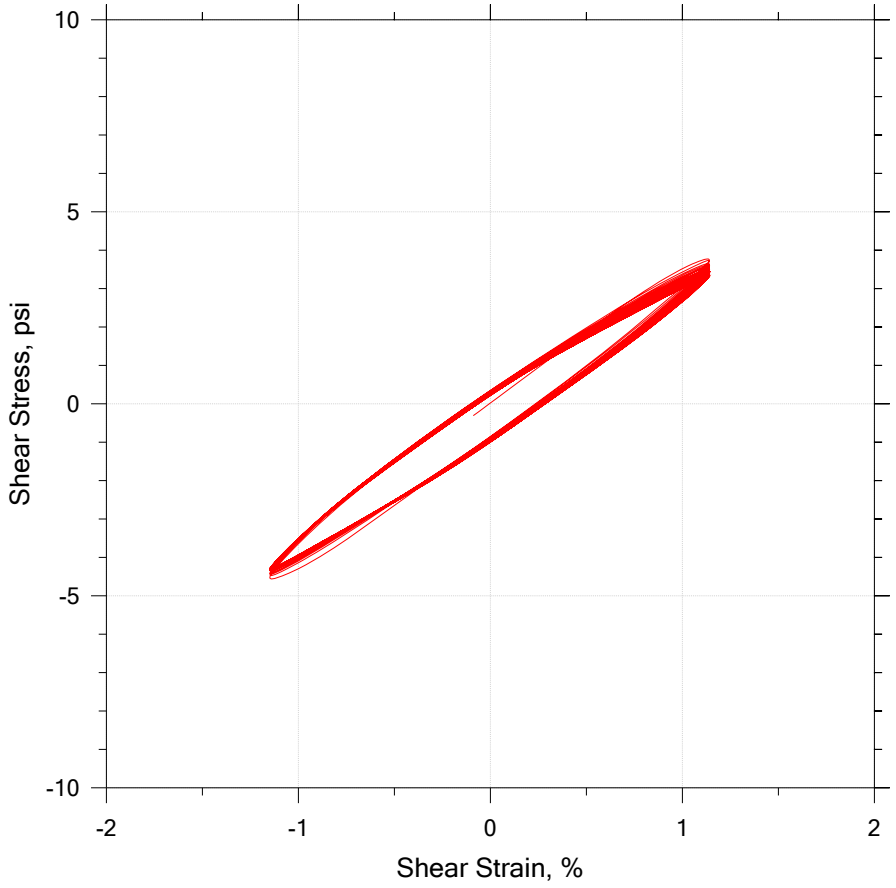
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

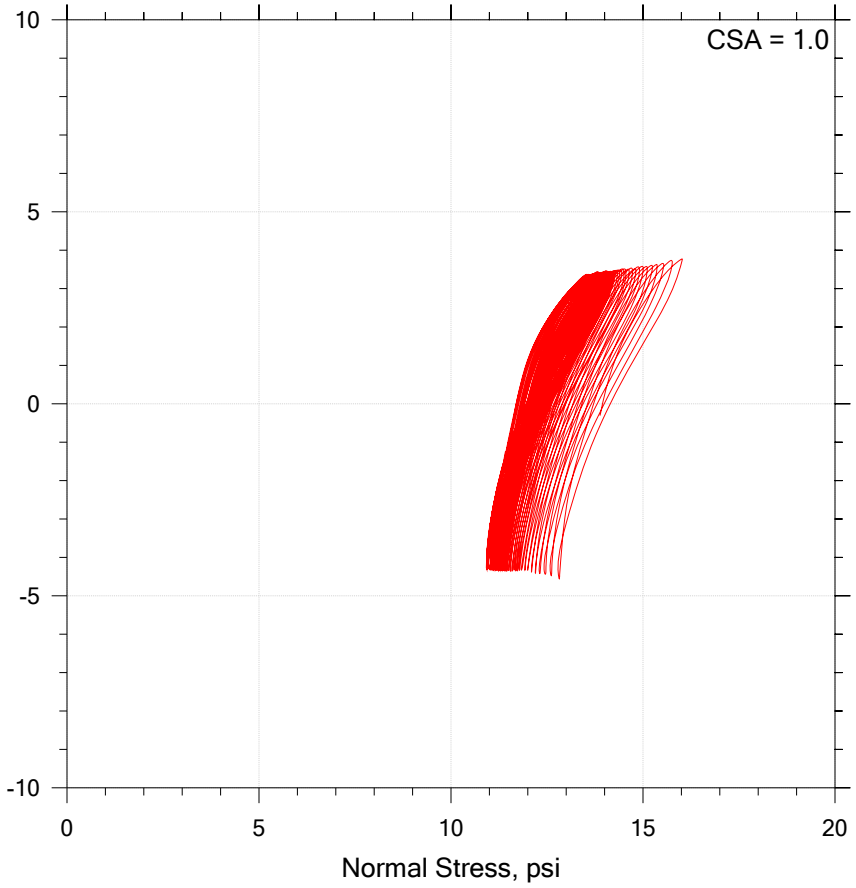
Cyclic Simple Shear Test

Cyclic Stress Strain Results

Step 4 of 4

Cycle 0.0 to 100.0



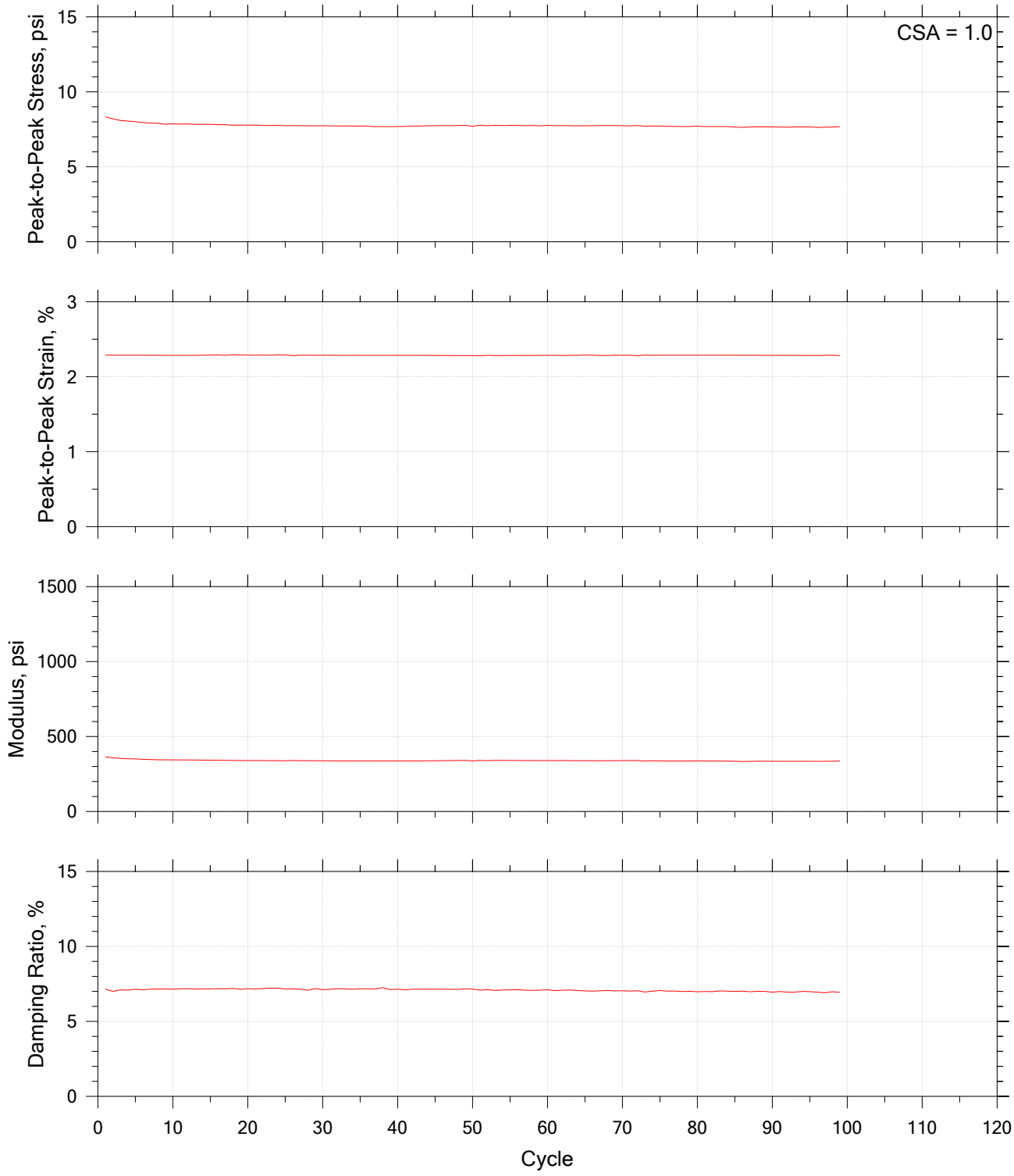


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Cyclic Simple Shear Test

Cyclic Modulus/Damping Results

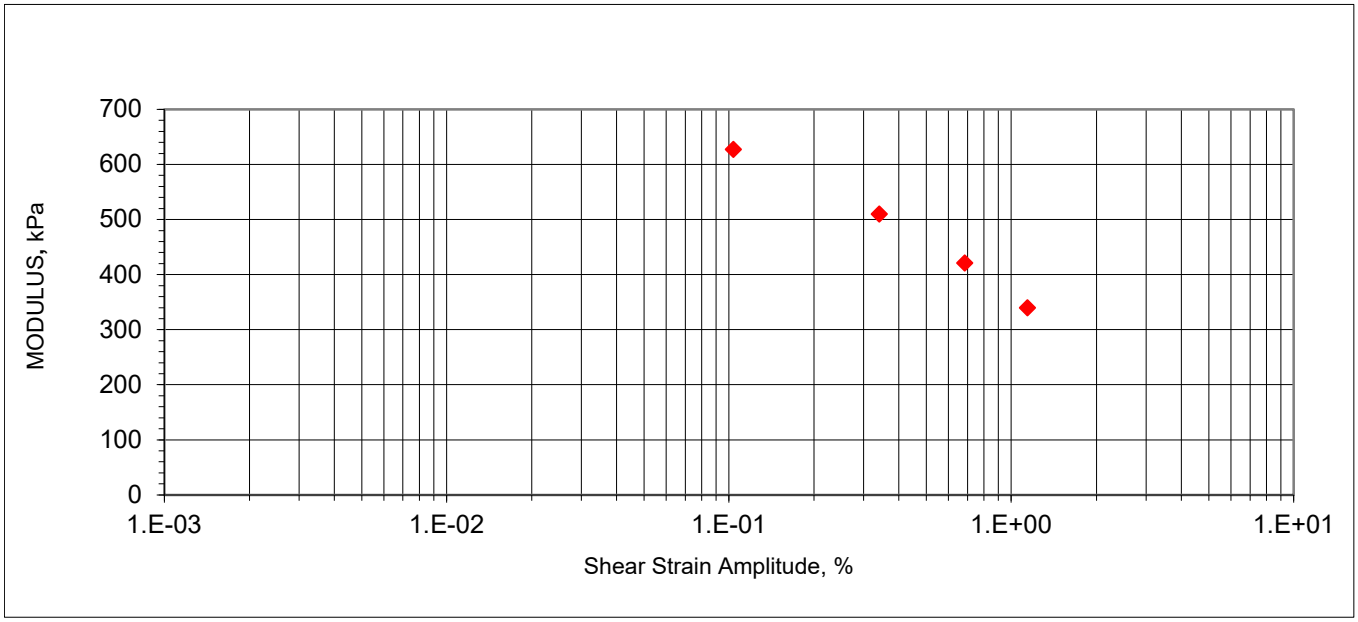
Step 4 of 4

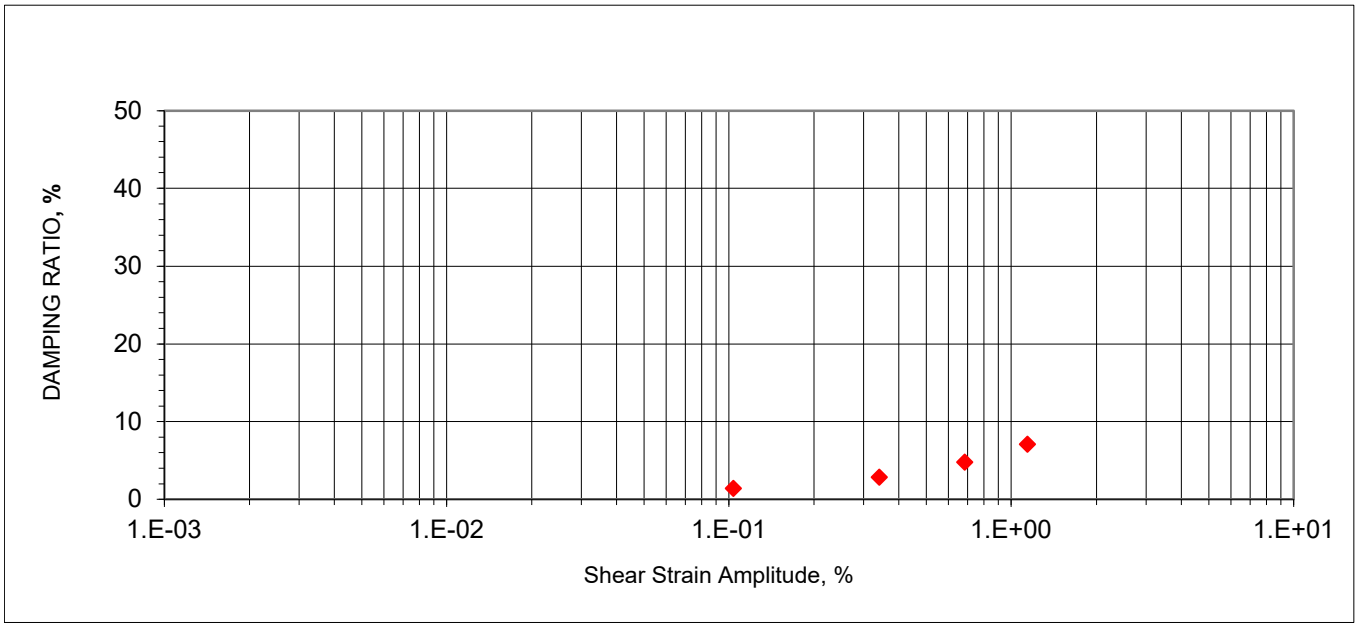


GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Modulus and Damping Properties of Soils

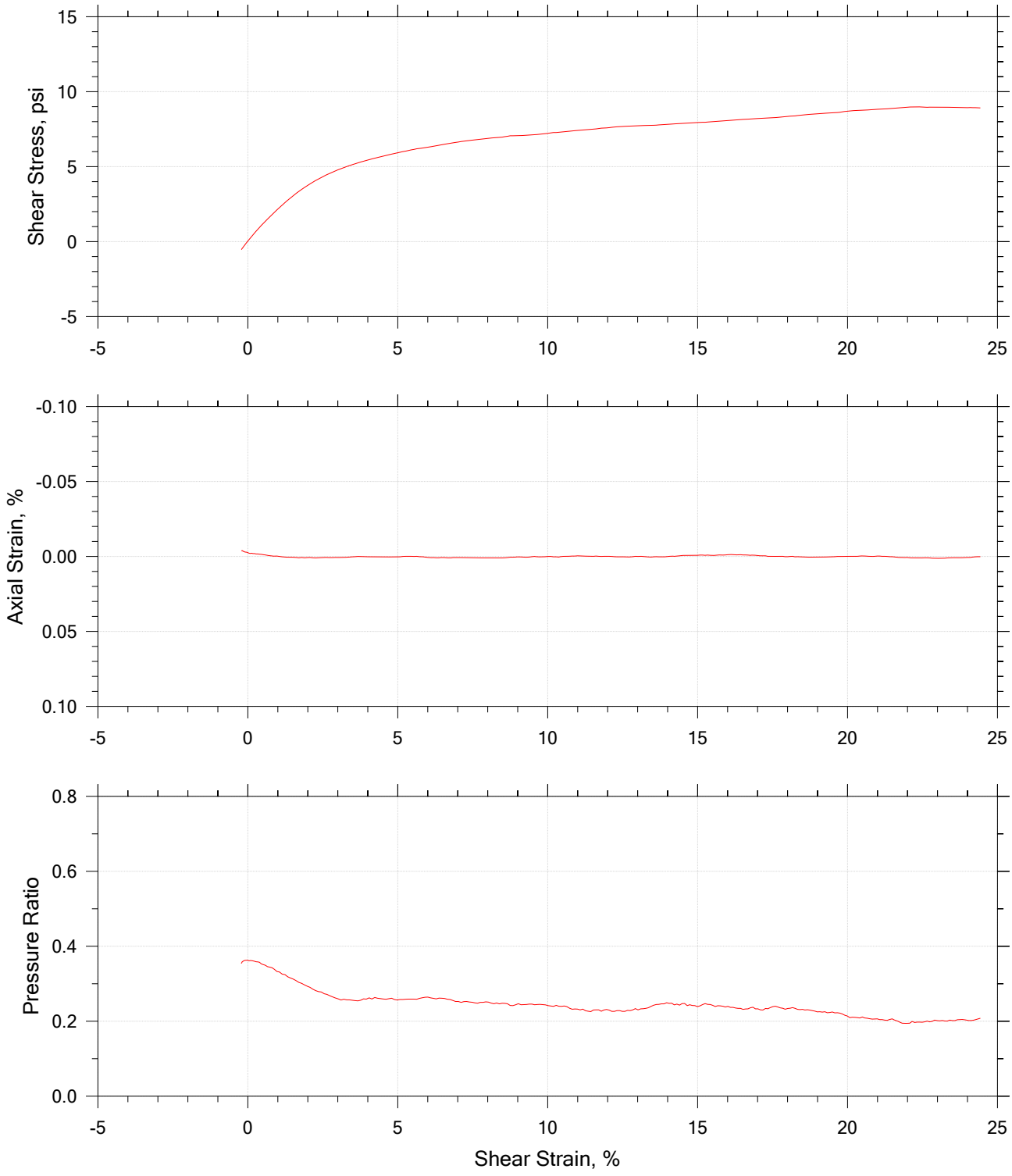
Using the Cyclic Direct Simple Shear Apparatus





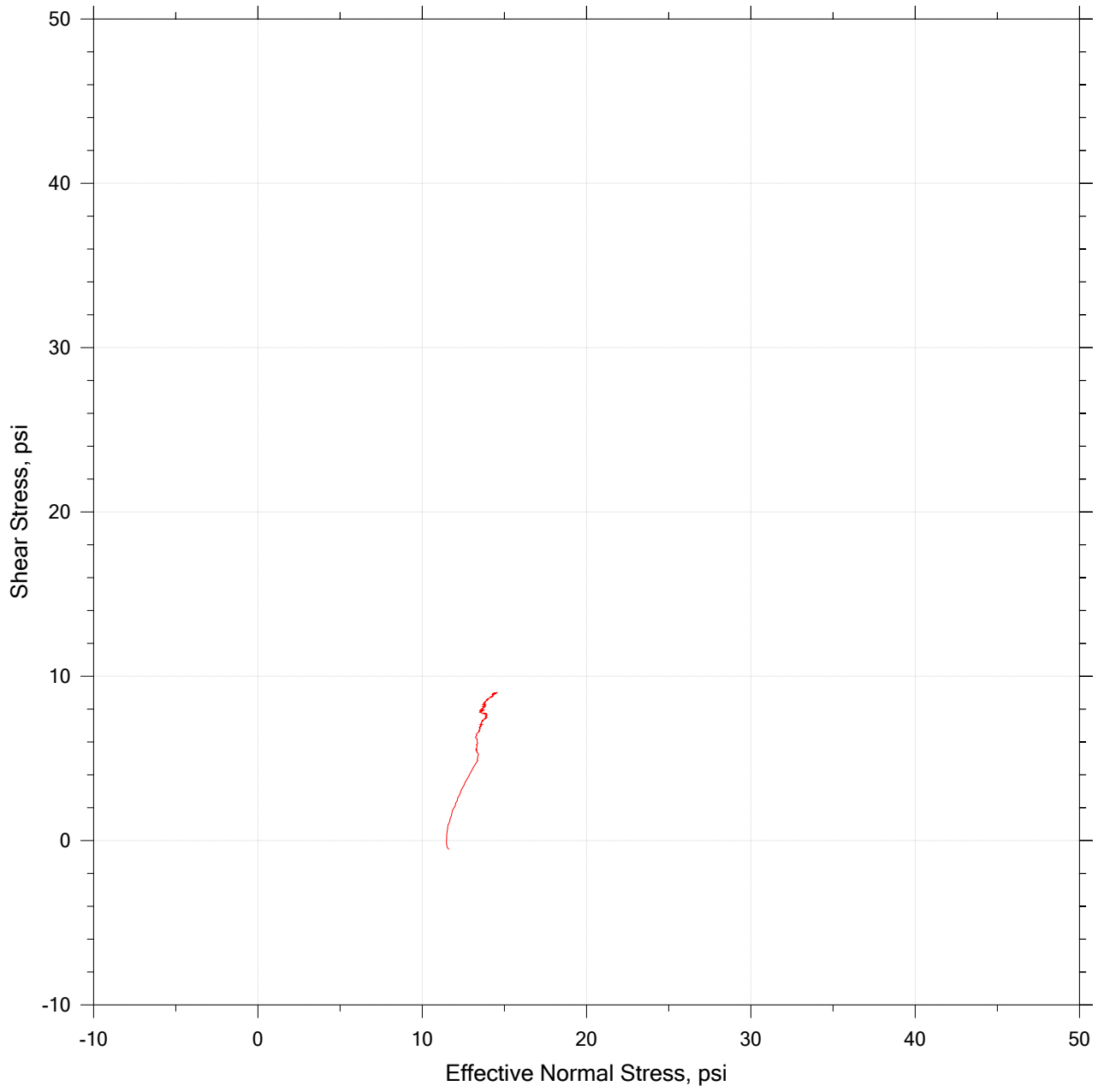
Project: US-51 Over Ohio River	Location: ---	Project No.:	GTX-319809
Boring No.: B-1023	Tested By: jlw	Checked By:	dgz
Sample No.: ST-2	Test Date: 11/26/24	Test No.:	CDSS-2RR
Depth: 48.1-50.1	Sample Type: intact	Elevation:	---
Description: Moist, light brownish gray clay			
Remarks: Average values of G and D from 30 cycles in Step 1, 2 & 3 and 100 cycles in Step 4.			

Post Cyclic Simple Shear Test



GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

Post Cyclic Simple Shear Test



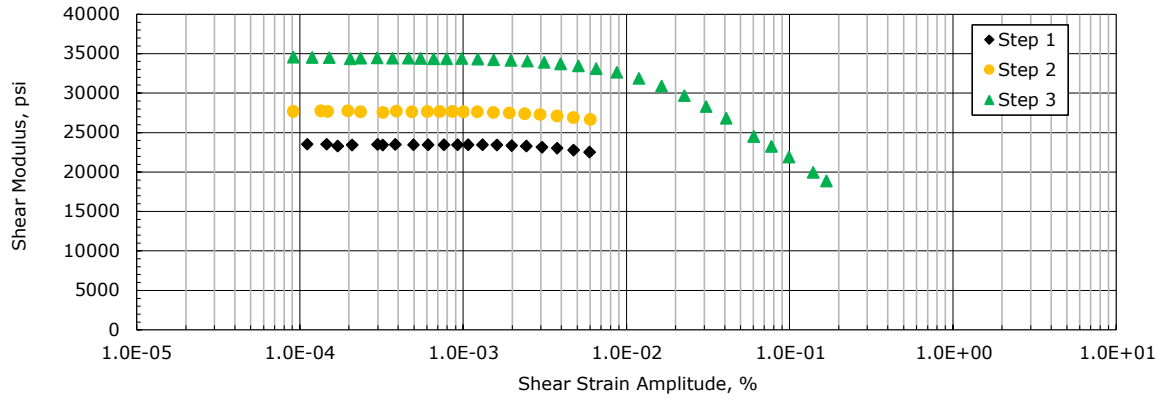
GeoTesting EXPRESS A Sercel Business	Project Name: US-51 Over Ohio River	Location: ---	Project Number: GTX-319809
	Boring Number: B-1023	Tester: sjt	Checker: dgz
	Sample Number: ST-2	Test Date: 11/26/24	Depth: 48.1-50.1
	Test Number: CDSS-2RR	Preparation: intact	Elevation: ---
	Description: Moist, light brownish gray clay		
	Remarks: CST-005		

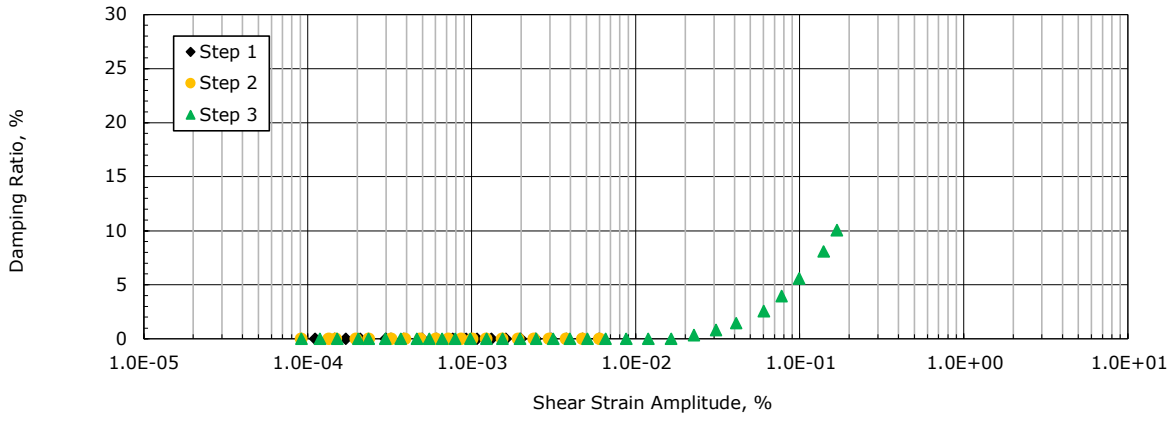
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**44**	**59**	**89**
Horizontal Confining Pressure, psi:	**44**	**59**	**89**

Visual Description:	Moist, light gray sand
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.85
Initial Height, in:	6.05
Initial Mass, grams:	1138
Initial Moisture Content, %:	12.3
Initial Dry Density, pcf:	100.1
Initial Bulk Density, pcf:	112.4
Initial Degree of Saturation:	49.9
Initial Void Ratio:	0.65

Final Diameter, in:	2.82
Final Height, in:	6.03
Final Mass, grams:	1185
Final Moisture Content, %:	22.0
Final Dry Density, pcf:	102.5
Final Bulk Density, pcf:	125.1
Final Degree of Saturation:	95.3
Final Void Ratio:	0.61

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.651
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4
Test Confining Pressure, psi:	**44** **STEP 1**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 44 psi over a range of strains from 0.000111 to 0.00596% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System			
Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.41	0.025	189	0.0	44	1.11E-04	23531	0.00
0.52	0.032	189	0.0	44	1.46E-04	23532	0.00
0.62	0.040	189	0.0	44	1.70E-04	23300	0.00
0.73	0.050	188	0.0	44	2.09E-04	23434	0.00
0.83	0.063	188	0.0	44	3.00E-04	23497	0.00
0.93	0.080	188	0.0	44	3.21E-04	23449	0.00
1.04	0.101	188	0.0	44	3.85E-04	23509	0.00
1.14	0.127	188	0.0	43	4.97E-04	23491	0.00
1.24	0.160	188	0.0	43	6.11E-04	23489	0.00
1.35	0.202	188	0.0	43	7.64E-04	23490	0.00
1.45	0.254	188	0.0	44	9.24E-04	23480	0.00
1.56	0.320	188	0.0	44	1.07E-03	23485	0.00
1.66	0.403	188	0.0	44	1.31E-03	23463	0.00
1.76	0.507	188	0.0	44	1.61E-03	23454	0.00
1.87	0.638	188	0.0	44	1.98E-03	23386	0.00
1.97	0.803	188	0.0	44	2.44E-03	23308	0.00
2.07	1.011	188	0.0	44	3.04E-03	23179	0.00
2.18	1.273	187	0.0	44	3.77E-03	23027	0.00
2.28	1.602	187	0.0	44	4.74E-03	22817	0.00
2.39	2.017	186	0.0	44	5.96E-03	22546	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4
Test Confining Pressure, psi:	**59** **STEP 2**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 59 psi over a range of strains from 0.0000910 to 0.00601% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.52	0.032	203	0.0	59	9.10E-05	27703	0.00
0.62	0.040	203	0.0	59	1.34E-04	27784	0.00
0.73	0.050	203	0.0	58	1.48E-04	27725	0.00
0.83	0.063	203	0.0	59	1.97E-04	27798	0.00
0.93	0.080	204	0.0	59	2.35E-04	27655	0.00
1.04	0.101	203	0.0	59	3.23E-04	27587	0.00
1.14	0.127	203	0.0	59	3.90E-04	27753	0.00
1.25	0.160	203	0.0	59	4.85E-04	27650	0.00
1.35	0.202	203	0.0	59	6.04E-04	27686	0.00
1.45	0.254	203	0.0	59	7.20E-04	27667	0.00
1.56	0.320	203	0.0	58	8.59E-04	27669	0.00
1.66	0.403	203	0.0	58	1.01E-03	27661	0.00
1.76	0.507	203	0.0	59	1.22E-03	27638	0.00
1.87	0.638	203	0.0	59	1.53E-03	27576	0.00
1.97	0.803	203	0.0	58	1.92E-03	27514	0.00
2.08	1.011	203	0.0	58	2.39E-03	27421	0.00
2.18	1.273	202	0.0	59	2.97E-03	27309	0.00
2.28	1.602	202	0.0	58	3.75E-03	27156	0.00
2.39	2.016	202	0.0	58	4.73E-03	26948	0.00
2.49	2.539	201	0.0	59	6.01E-03	26672	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4
Test Confining Pressure, psi:	**89** **STEP 3**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 89 psi over a range of strains from 0.0000914 to 0.168% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System			
Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.62	0.040	224	0.0	89	9.14E-05	34595	0.00
0.73	0.050	225	0.0	89	1.19E-04	34546	0.00
0.83	0.063	225	0.0	89	1.52E-04	34522	0.00
0.93	0.080	225	0.0	89	2.03E-04	34381	0.00
1.04	0.101	224	0.0	89	2.35E-04	34457	0.00
1.14	0.127	224	0.0	89	2.97E-04	34483	0.00
1.24	0.160	225	0.0	89	3.70E-04	34444	0.00
1.35	0.202	224	0.0	89	4.63E-04	34461	0.00
1.45	0.254	224	0.0	89	5.50E-04	34428	0.00
1.56	0.320	224	0.0	89	6.59E-04	34396	0.00
1.66	0.403	224	0.0	89	7.93E-04	34389	0.00
1.76	0.506	224	0.0	88	9.82E-04	34397	0.00
1.87	0.638	224	0.0	88	1.23E-03	34353	0.00
1.97	0.803	224	0.0	88	1.54E-03	34257	0.00
2.07	1.011	224	0.0	89	1.96E-03	34182	0.00
2.18	1.273	224	0.0	89	2.47E-03	34071	0.00
2.28	1.602	223	0.0	89	3.14E-03	33919	0.00
2.38	2.016	223	0.0	89	3.96E-03	33724	0.00
2.49	2.539	222	0.0	89	5.08E-03	33469	0.00
2.59	3.196	222	0.0	89	6.54E-03	33131	0.00
2.70	4.024	221	0.0	89	8.76E-03	32650	0.00
2.80	5.066	220	0.0	88	1.19E-02	31903	0.00
2.90	6.378	217	0.0	88	1.64E-02	30902	0.00
3.01	8.030	215	0.0	88	2.26E-02	29693	0.35
3.11	10.110	211	0.0	88	3.08E-02	28337	0.83
3.21	12.728	207	0.0	88	4.10E-02	26849	1.46
3.42	16.023	197	0.1	88	6.03E-02	24505	2.57
3.52	20.171	193	0.1	88	7.76E-02	23269	3.97
3.63	25.394	189	0.1	88	9.93E-02	21923	5.59
3.83	31.971	179	0.2	88	1.40E-01	19976	8.11
3.94	40.252	176	0.2	88	1.68E-01	18882	10.07

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

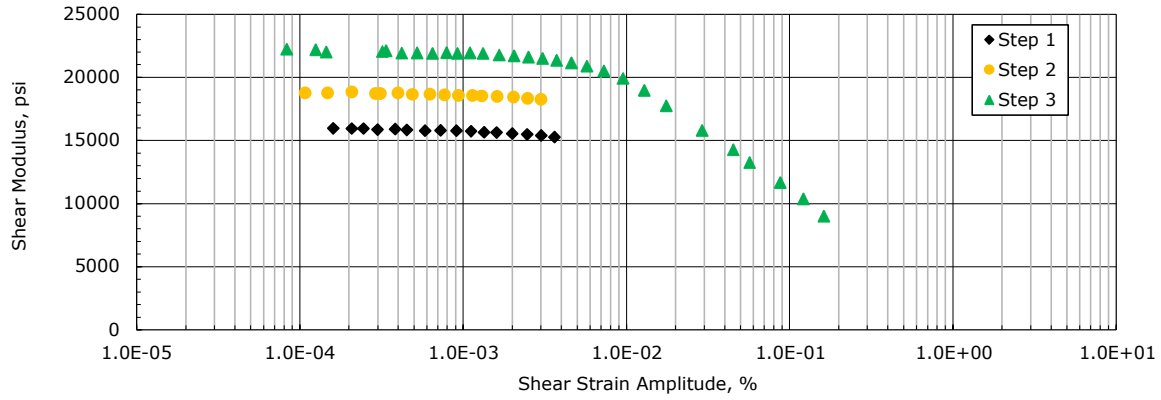
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

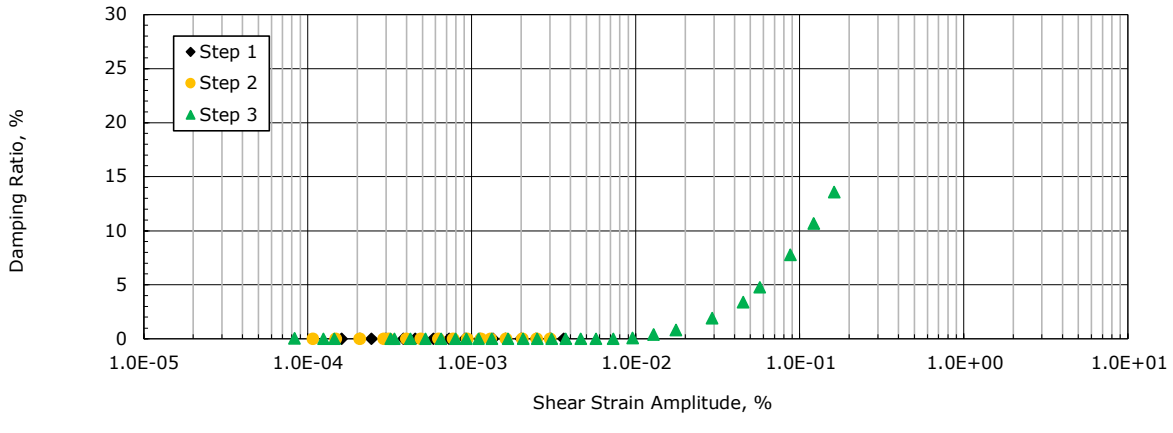
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm
Checked By:	njh
Boring ID:	B-1009
Sample ID:	GT-3
Depth:	64.4-66.4

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**19**	**26**	**38**
Horizontal Confining Pressure, psi:	**19**	**26**	**38**

Visual Description:	Moist, white sand
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.86
Initial Height, in:	6.12
Initial Mass, grams:	1304
Initial Moisture Content, %:	18.9
Initial Dry Density, pcf:	106.3
Initial Bulk Density, pcf:	126.3
Initial Degree of Saturation:	89.5
Initial Void Ratio:	0.56

Final Diameter, in:	2.85
Final Height, in:	6.11
Final Mass, grams:	1234
Final Moisture Content, %:	19.9
Final Dry Density, pcf:	107.3
Final Bulk Density, pcf:	128.6
Final Degree of Saturation:	96.9
Final Void Ratio:	0.55

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.661
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1009
Sample ID:	GT-3
Depth:	64.4-66.4
Test Confining Pressure, psi:	**19** **STEP 1**
Visual Description:	Moist, white sand
Test Conditions:	Confining Stress of 19 psi over a range of strains from 0.000160 to 0.00363% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.42	0.025	154	0.0	19	1.60E-04	15969	0.00
0.63	0.040	155	0.0	19	2.08E-04	15951	0.00
0.73	0.050	155	0.0	19	2.45E-04	15948	0.00
0.83	0.063	155	0.0	19	2.99E-04	15865	0.00
0.94	0.080	155	0.0	19	3.83E-04	15914	0.00
1.04	0.100	155	0.0	19	4.52E-04	15854	0.00
1.15	0.127	155	0.0	19	5.85E-04	15792	0.00
1.25	0.160	155	0.0	19	7.26E-04	15814	0.00
1.35	0.202	155	0.0	19	9.11E-04	15778	0.00
1.46	0.254	155	0.0	19	1.12E-03	15744	0.00
1.56	0.320	154	0.0	19	1.34E-03	15661	0.00
1.67	0.403	154	0.0	19	1.61E-03	15630	0.00
1.77	0.506	154	0.0	19	2.00E-03	15565	0.00
1.87	0.638	154	0.0	19	2.46E-03	15484	0.00
1.98	0.803	153	0.0	19	3.01E-03	15403	0.00
2.08	1.010	153	0.0	19	3.63E-03	15275	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1009
Sample ID:	GT-3
Depth:	64.4-66.4
Test Confining Pressure, psi:	**26** **STEP 2**
Visual Description:	Moist, white sand
Test Conditions:	Confining Stress of 26 psi over a range of strains from 0.000107 to 0.00300% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.42	0.025	169	0.0	26	1.07E-04	18784	0.00
0.62	0.040	168	0.0	26	1.48E-04	18784	0.00
0.73	0.050	168	0.0	26	2.08E-04	18851	0.00
0.83	0.063	168	0.0	26	2.90E-04	18740	0.00
0.94	0.080	168	0.0	26	3.10E-04	18734	0.00
1.04	0.100	168	0.0	26	4.00E-04	18765	0.00
1.14	0.127	168	0.0	26	4.88E-04	18669	0.00
1.25	0.160	167	0.0	26	6.26E-04	18689	0.00
1.35	0.202	167	0.0	26	7.68E-04	18633	0.00
1.46	0.254	167	0.0	26	9.36E-04	18582	0.00
1.56	0.320	167	0.0	26	1.14E-03	18589	0.00
1.66	0.403	167	0.0	26	1.30E-03	18546	0.00
1.77	0.506	167	0.0	26	1.62E-03	18494	0.00
1.87	0.638	167	0.0	26	2.04E-03	18462	0.00
1.98	0.803	167	0.0	26	2.49E-03	18358	0.00
2.08	1.010	166	0.0	26	3.00E-03	18261	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1009
Sample ID:	GT-3
Depth:	64.4-66.4
Test Confining Pressure, psi:	**38** **STEP 3**
Visual Description:	Moist, white sand
Test Conditions:	Confining Stress of 38 psi over a range of strains from 0.000083 to 0.162% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.31	0.020	179	0.0	38	8.30E-05	22252	0.06
0.63	0.040	182	0.0	38	1.25E-04	22192	0.00
0.73	0.050	182	0.0	38	1.45E-04	22003	0.00
0.94	0.080	180	0.0	38	3.20E-04	22048	0.00
1.04	0.100	181	0.0	38	3.37E-04	22124	0.00
1.15	0.127	181	0.0	38	4.22E-04	21920	0.00
1.25	0.160	181	0.0	38	5.22E-04	21948	0.00
1.35	0.202	181	0.0	38	6.49E-04	21912	0.00
1.46	0.254	181	0.0	38	7.94E-04	21969	0.00
1.56	0.320	181	0.0	38	9.25E-04	21906	0.00
1.67	0.403	180	0.0	38	1.10E-03	21940	0.00
1.77	0.506	181	0.0	38	1.33E-03	21910	0.00
1.87	0.638	181	0.0	38	1.67E-03	21791	0.00
1.98	0.803	180	0.0	38	2.06E-03	21726	0.00
2.08	1.010	180	0.0	38	2.51E-03	21611	0.00
2.19	1.273	179	0.0	38	3.07E-03	21504	0.00
2.29	1.601	179	0.0	38	3.74E-03	21356	0.00
2.40	2.016	178	0.0	38	4.62E-03	21158	0.00
2.50	2.538	178	0.0	38	5.72E-03	20896	0.00
2.60	3.195	177	0.0	38	7.28E-03	20519	0.00
2.71	4.021	175	0.0	38	9.55E-03	19921	0.09
2.81	5.064	173	0.0	38	1.29E-02	18993	0.41
2.92	6.374	170	0.0	37	1.76E-02	17755	0.83
3.12	8.025	159	0.0	38	2.92E-02	15800	1.94
3.33	10.104	151	0.1	37	4.52E-02	14271	3.41
3.44	12.720	148	0.1	38	5.70E-02	13261	4.79
3.64	16.015	138	0.1	36	8.76E-02	11680	7.78
3.85	20.163	130	0.3	37	1.22E-01	10385	10.67
4.06	25.385	122	0.4	36	1.62E-01	9008	13.58

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

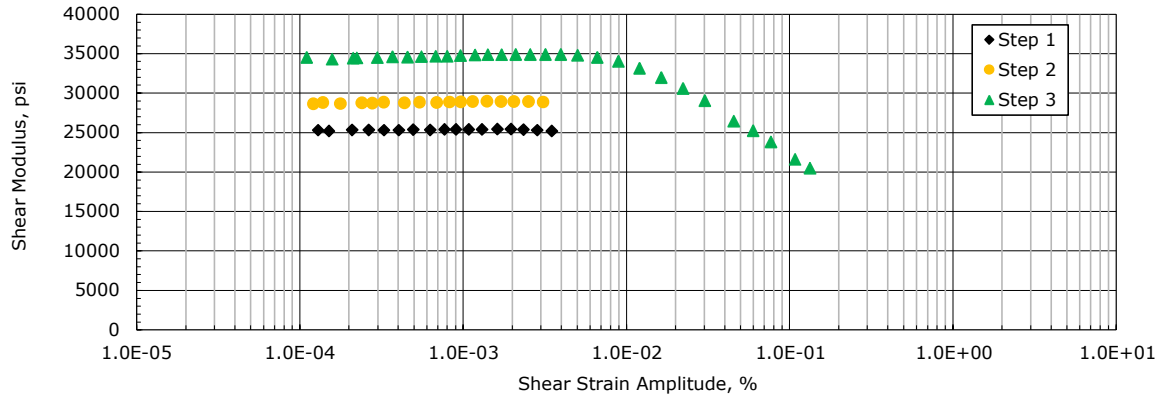
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

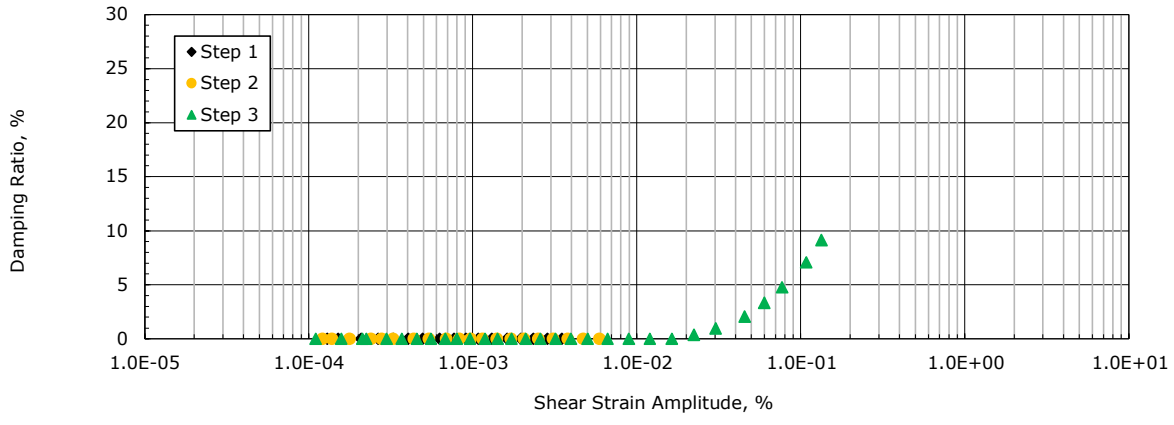
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**40**	**54**	**80**
Horizontal Confining Pressure, psi:	**40**	**54**	**80**

Visual Description:	Moist, very pale brown sand
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.85
Initial Height, in:	5.80
Initial Mass, grams:	1109
Initial Moisture Content, %:	6.4
Initial Dry Density, pcf:	107.3
Initial Bulk Density, pcf:	114.2
Initial Degree of Saturation:	30.4
Initial Void Ratio:	0.57

Final Diameter, in:	2.73
Final Height, in:	5.78
Final Mass, grams:	1076
Final Moisture Content, %:	15.8
Final Dry Density, pcf:	117.1
Final Bulk Density, pcf:	135.6
Final Degree of Saturation:	97.1
Final Void Ratio:	0.44

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.702
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8
Test Confining Pressure, psi:	**40** **STEP 1**
Visual Description:	Moist, very pale brown sand
Test Conditions:	Confining Stress of 40 psi over a range of strains from 0.000129 to 0.00529% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.62	0.040	199	0.0	40	1.29E-04	25318	0.00
0.73	0.050	198	0.0	40	1.51E-04	25234	0.00
0.83	0.063	198	0.0	40	2.09E-04	25367	0.00
0.94	0.080	198	0.0	40	2.64E-04	25372	0.00
1.04	0.100	198	0.0	40	3.27E-04	25330	0.00
1.14	0.127	198	0.0	40	4.04E-04	25335	0.00
1.25	0.160	198	0.0	40	4.95E-04	25378	0.00
1.35	0.202	198	0.0	40	6.28E-04	25370	0.00
1.46	0.254	198	0.0	40	7.68E-04	25425	0.00
1.56	0.320	198	0.0	40	9.05E-04	25430	0.00
1.66	0.402	199	0.0	40	1.08E-03	25433	0.00
1.77	0.506	199	0.0	40	1.31E-03	25428	0.00
1.87	0.638	199	0.0	40	1.62E-03	25450	0.00
1.98	0.803	199	0.0	40	1.97E-03	25450	0.00
2.08	1.010	199	0.0	40	2.34E-03	25404	0.00
2.18	1.272	199	0.0	40	2.84E-03	25329	0.00
2.29	1.601	198	0.0	40	3.49E-03	25241	0.00
2.39	2.016	198	0.0	40	4.28E-03	25136	0.00
2.50	2.538	198	0.0	40	5.29E-03	24934	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8
Test Confining Pressure, psi:	**54** **STEP 2**
Visual Description:	Moist, very pale brown sand
Test Conditions:	Confining Stress of 54 psi over a range of strains from 0.000121 to 0.00592% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.62	0.040	211	0.0	54	1.21E-04	28649	0.00
0.73	0.050	211	0.0	54	1.38E-04	28827	0.00
0.83	0.063	211	0.0	54	1.77E-04	28701	0.00
0.94	0.080	211	0.0	54	2.40E-04	28798	0.00
1.04	0.100	211	0.0	54	2.78E-04	28761	0.00
1.15	0.127	211	0.0	54	3.27E-04	28852	0.00
1.25	0.160	211	0.0	54	4.36E-04	28792	0.00
1.35	0.202	211	0.0	54	5.40E-04	28866	0.00
1.46	0.254	211	0.0	54	6.87E-04	28831	0.00
1.56	0.320	211	0.0	54	8.28E-04	28910	0.00
1.67	0.402	211	0.0	54	9.68E-04	28929	0.00
1.77	0.506	211	0.0	54	1.14E-03	28953	0.00
1.87	0.638	212	0.0	54	1.40E-03	28979	0.00
1.98	0.803	212	0.0	54	1.71E-03	28973	0.00
2.08	1.010	212	0.0	54	2.05E-03	28976	0.00
2.19	1.272	212	0.0	54	2.51E-03	28947	0.00
2.29	1.601	212	0.0	54	3.09E-03	28899	0.00
2.40	2.016	211	0.0	54	3.80E-03	28826	0.00
2.50	2.537	211	0.0	54	4.71E-03	28727	0.00
2.60	3.194	211	0.0	54	5.92E-03	28520	0.00

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/12/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8
Test Confining Pressure, psi:	**80** **STEP 3**
Visual Description:	Moist, very pale brown sand
Test Conditions:	Confining Stress of 80 psi over a range of strains from 0.000110 to 0.0133% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.73	0.050	228	0.0	80	1.10E-04	34535	0.00
0.83	0.063	229	0.0	80	1.58E-04	34306	0.00
0.94	0.080	228	0.0	80	2.12E-04	34449	0.00
1.04	0.100	228	0.0	80	2.24E-04	34473	0.00
1.15	0.127	228	0.0	80	2.98E-04	34509	0.00
1.25	0.160	228	0.0	80	3.69E-04	34617	0.00
1.35	0.202	229	0.0	80	4.57E-04	34593	0.00
1.46	0.254	229	0.0	80	5.56E-04	34649	0.00
1.56	0.320	229	0.0	80	6.79E-04	34675	0.00
1.67	0.402	229	0.0	80	7.99E-04	34692	0.00
1.77	0.506	229	0.0	80	9.63E-04	34772	0.00
1.87	0.638	229	0.0	80	1.18E-03	34861	0.00
1.98	0.803	229	0.0	80	1.42E-03	34885	0.00
2.08	1.010	230	0.0	80	1.72E-03	34892	0.00
2.19	1.272	230	0.0	80	2.10E-03	34926	0.00
2.29	1.601	230	0.0	80	2.58E-03	34924	0.00
2.40	2.015	230	0.0	80	3.20E-03	34920	0.00
2.50	2.537	230	0.0	80	3.97E-03	34907	0.00
2.60	3.194	230	0.0	80	5.02E-03	34819	0.00
2.71	4.021	230	0.0	80	6.64E-03	34562	0.00
2.81	5.062	229	0.0	80	8.94E-03	34040	0.00
2.92	6.372	228	0.0	80	1.20E-02	33152	0.00
3.02	8.022	225	0.0	80	1.64E-02	32002	0.00
3.12	10.099	222	0.0	80	2.23E-02	30594	0.39
3.23	12.713	218	0.1	80	3.03E-02	29045	0.98
3.44	16.004	208	0.1	80	4.55E-02	26471	2.09
3.54	20.146	204	0.1	80	5.99E-02	25256	3.36
3.64	25.359	200	0.2	80	7.68E-02	23861	4.77
3.85	31.927	190	0.2	80	1.08E-01	21615	7.08
3.96	40.200	186	0.2	80	1.33E-01	20502	9.17

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

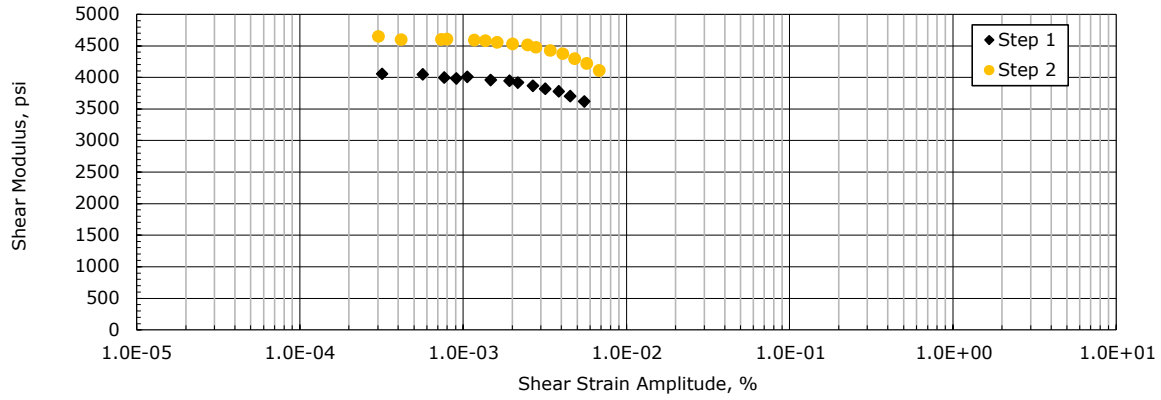
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

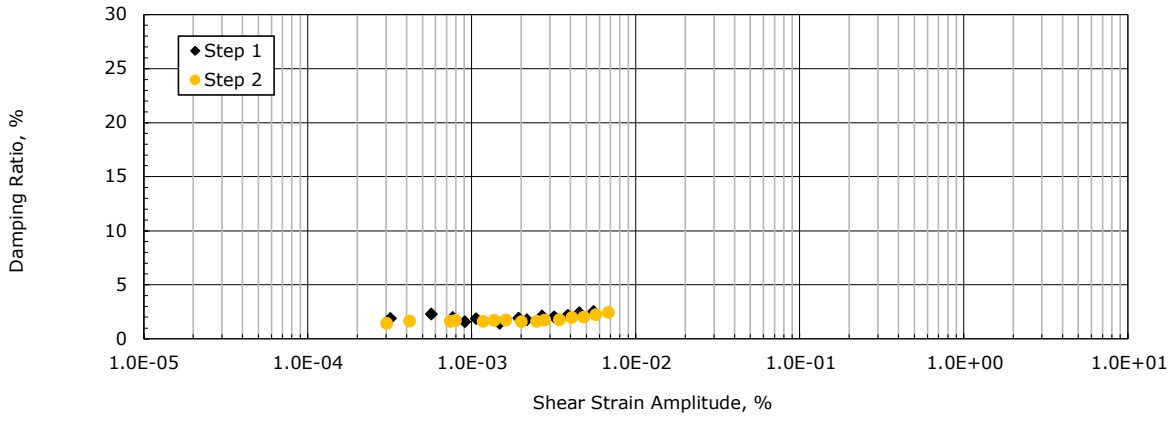
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	12/30/24
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8

	Step 1	Step 2
Vertical Confining Pressure, psi:	**1.5**	**2.0**
Horizontal Confining Pressure, psi:	**1.5**	**2.0**

Visual Description:	Moist, dark yellowish brown sand with clay
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.85
Initial Height, in:	6.05
Initial Mass, grams:	1125
Initial Moisture Content, %:	20.4
Initial Dry Density, pcf:	92.3
Initial Bulk Density, pcf:	111.1
Initial Degree of Saturation:	67.5
Initial Void Ratio:	0.81

Final Diameter, in:	2.85
Final Height, in:	6.03
Final Mass, grams:	1164
Final Moisture Content, %:	28.8
Final Dry Density, pcf:	92.7
Final Bulk Density, pcf:	119.4
Final Degree of Saturation:	96.3
Final Void Ratio:	0.80

Notes: Data from two test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.675
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	12/30/24
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8
Test Confining Pressure, psi:	**1.5** **STEP 1**
Visual Description:	Moist, dark yellowish brown sand with clay
Test Conditions:	Confining Stress of 1.5 psi over a range of strains from 0.000319 to 0.00552% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.10	0.013	82	0.0	1.5	3.19E-04	4058	1.90
0.31	0.020	81	0.0	1.4	5.67E-04	4048	2.30
0.42	0.025	81	0.0	1.4	9.06E-04	3985	1.58
0.52	0.032	80	0.0	1.4	7.67E-04	3999	1.98
0.62	0.040	80	0.0	1.5	1.06E-03	4011	1.88
0.73	0.050	80	0.0	1.5	1.48E-03	3962	1.44
0.83	0.063	80	0.0	1.5	1.93E-03	3949	1.92
0.94	0.080	80	0.0	1.5	2.17E-03	3920	1.80
1.04	0.100	79	0.0	1.5	2.68E-03	3868	2.14
1.15	0.127	79	0.0	1.5	3.18E-03	3824	2.05
1.25	0.160	79	0.0	1.5	3.86E-03	3779	2.21
1.35	0.202	78	0.0	1.5	4.53E-03	3706	2.42
1.46	0.254	77	0.0	1.5	5.52E-03	3619	2.55

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	12/30/24
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8
Test Confining Pressure, psi:	**2.0** **STEP 2**
Visual Description:	Moist, dark yellowish brown sand with clay
Test Conditions:	Confining Stress of 2.0 psi over a range of strains from 0.000302 to 0.00682% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.10	0.013	86	0.0	2.0	3.02E-04	4649	1.44
0.31	0.020	86	0.0	2.0	4.18E-04	4601	1.65
0.42	0.025	86	0.0	1.9	7.37E-04	4603	1.63
0.52	0.032	86	0.0	2.0	7.97E-04	4607	1.72
0.62	0.040	86	0.0	2.0	1.17E-03	4593	1.64
0.73	0.050	86	0.0	2.0	1.37E-03	4582	1.72
0.83	0.063	86	0.0	2.0	1.62E-03	4558	1.75
0.94	0.080	86	0.0	2.0	2.01E-03	4535	1.58
1.04	0.100	85	0.0	2.0	2.49E-03	4515	1.65
1.15	0.127	85	0.0	2.0	2.79E-03	4477	1.77
1.25	0.160	85	0.0	2.0	3.42E-03	4428	1.78
1.35	0.202	84	0.0	1.9	4.08E-03	4377	1.98
1.46	0.254	84	0.0	1.9	4.82E-03	4299	2.03
1.56	0.320	83	0.0	1.9	5.72E-03	4220	2.24
1.67	0.403	83	0.0	2.1	6.82E-03	4112	2.45

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

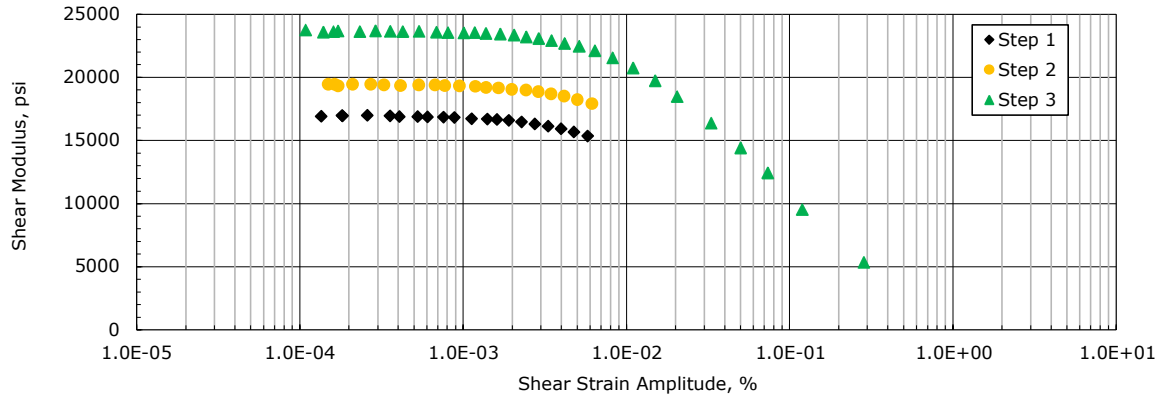
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

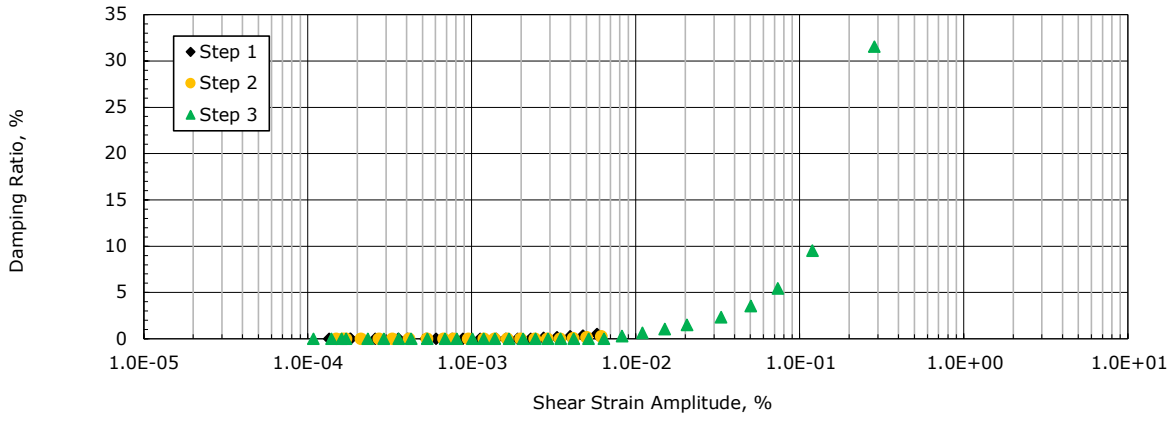
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/06/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**23**	**31**	**47**
Horizontal Confining Pressure, psi:	**23**	**31**	**47**

Visual Description:	Moist, light gray sand
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.85
Initial Height, in:	5.81
Initial Mass, grams:	1249
Initial Moisture Content, %:	21.1
Initial Dry Density, pcf:	106.0
Initial Bulk Density, pcf:	128.4
Initial Degree of Saturation:	98.9
Initial Void Ratio:	0.57

Final Diameter, in:	2.84
Final Height, in:	5.78
Final Mass, grams:	1231
Final Moisture Content, %:	20.4
Final Dry Density, pcf:	107.5
Final Bulk Density, pcf:	129.4
Final Degree of Saturation:	99.4
Final Void Ratio:	0.55

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.668
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/06/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2
Test Confining Pressure, psi:	**23** **STEP 1**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 23 psi over a range of strains from 0.000181 to 0.00579% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.42	0.025	163	0.0	23	1.81E-04	16995	0.00
0.52	0.032	164	0.0	23	1.36E-04	16921	0.00
0.62	0.040	163	0.0	23	1.82E-04	16970	0.00
0.73	0.050	164	0.0	23	2.58E-04	17003	0.00
0.83	0.063	164	0.0	23	3.57E-04	16956	0.00
0.94	0.080	164	0.0	23	4.07E-04	16911	0.00
1.04	0.100	163	0.0	23	5.27E-04	16908	0.00
1.15	0.127	163	0.0	23	6.06E-04	16874	0.00
1.25	0.160	163	0.0	23	7.57E-04	16868	0.00
1.35	0.202	163	0.0	23	8.84E-04	16831	0.00
1.46	0.254	163	0.0	23	1.13E-03	16738	0.00
1.56	0.320	163	0.0	23	1.40E-03	16715	0.00
1.67	0.403	163	0.0	23	1.61E-03	16663	0.00
1.77	0.506	162	0.0	23	1.91E-03	16603	0.00
1.87	0.638	162	0.0	23	2.28E-03	16484	0.02
1.98	0.803	162	0.0	23	2.75E-03	16319	0.10
2.08	1.010	161	0.0	23	3.31E-03	16139	0.15
2.19	1.273	160	0.0	23	3.98E-03	15936	0.27
2.29	1.601	159	0.0	23	4.77E-03	15679	0.37
2.39	2.016	158	0.0	23	5.79E-03	15376	0.52

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/06/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2
Test Confining Pressure, psi:	**31** **STEP 2**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 31 psi over a range of strains from 0.000149 to 0.00616% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.42	0.025	174	0.0	31	1.49E-04	19464	0.00
0.52	0.032	174	0.0	31	1.63E-04	19473	0.00
0.62	0.040	175	0.0	31	1.71E-04	19340	0.00
0.73	0.050	174	0.0	31	2.11E-04	19463	0.00
0.83	0.063	175	0.0	31	2.72E-04	19462	0.00
0.94	0.080	175	0.0	31	3.27E-04	19433	0.00
1.04	0.100	175	0.0	31	4.14E-04	19353	0.00
1.15	0.127	174	0.0	31	5.34E-04	19398	0.00
1.25	0.160	174	0.0	31	6.74E-04	19414	0.00
1.35	0.202	174	0.0	31	7.72E-04	19357	0.00
1.46	0.254	174	0.0	31	9.50E-04	19334	0.00
1.56	0.320	174	0.0	31	1.19E-03	19299	0.00
1.67	0.403	174	0.0	31	1.38E-03	19225	0.00
1.77	0.506	174	0.0	31	1.65E-03	19163	0.00
1.87	0.638	173	0.0	31	1.98E-03	19073	0.00
1.98	0.803	173	0.0	31	2.43E-03	19007	0.00
2.08	1.010	173	0.0	31	2.89E-03	18884	0.00
2.19	1.273	172	0.0	31	3.45E-03	18717	0.00
2.29	1.601	172	0.0	31	4.15E-03	18514	0.06
2.40	2.016	171	0.0	31	5.02E-03	18245	0.16
2.50	2.538	170	0.0	31	6.16E-03	17931	0.27

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	01/06/25
Tested By:	jlw
Checked By:	njh
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2
Test Confining Pressure, psi:	**47** **STEP 3**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 47 psi over a range of strains from 0.000108 to 0.285% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.42	0.025	191	0.0	47	1.08E-04	23763	0.00
0.52	0.032	192	0.0	47	1.39E-04	23601	0.00
0.62	0.040	191	0.0	47	1.61E-04	23626	0.00
0.73	0.050	191	0.0	47	1.71E-04	23674	0.00
0.83	0.063	191	0.0	47	2.33E-04	23636	0.00
0.94	0.080	191	0.0	47	2.90E-04	23705	0.00
1.04	0.100	191	0.0	47	3.59E-04	23651	0.00
1.15	0.127	191	0.0	47	4.27E-04	23628	0.00
1.25	0.160	191	0.0	47	5.36E-04	23653	0.00
1.35	0.202	191	0.0	47	6.88E-04	23599	0.00
1.46	0.254	191	0.0	47	8.09E-04	23549	0.00
1.56	0.320	191	0.0	47	1.01E-03	23536	0.00
1.67	0.402	191	0.0	47	1.18E-03	23545	0.00
1.77	0.506	191	0.0	47	1.38E-03	23496	0.00
1.87	0.638	191	0.0	47	1.69E-03	23450	0.00
1.98	0.803	191	0.0	47	2.06E-03	23349	0.00
2.08	1.010	190	0.0	47	2.44E-03	23215	0.00
2.19	1.273	190	0.0	47	2.91E-03	23086	0.00
2.29	1.601	189	0.0	47	3.48E-03	22916	0.00
2.40	2.016	189	0.0	47	4.18E-03	22692	0.00
2.50	2.538	188	0.0	47	5.15E-03	22478	0.00
2.60	3.195	187	0.0	47	6.40E-03	22125	0.01
2.71	4.021	186	0.0	47	8.26E-03	21558	0.31
2.81	5.064	184	0.0	47	1.10E-02	20750	0.66
2.92	6.374	181	0.0	47	1.50E-02	19745	1.09
3.02	8.024	177	0.0	47	2.05E-02	18487	1.51
3.23	10.102	166	0.0	47	3.31E-02	16376	2.34
3.43	12.718	157	0.1	46	5.02E-02	14421	3.57
3.64	16.011	147	0.2	47	7.36E-02	12441	5.47
3.95	20.159	130	0.4	45	1.19E-01	9545	9.53
5.30	40.229	100	1.2	47	2.85E-01	5360	31.56

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

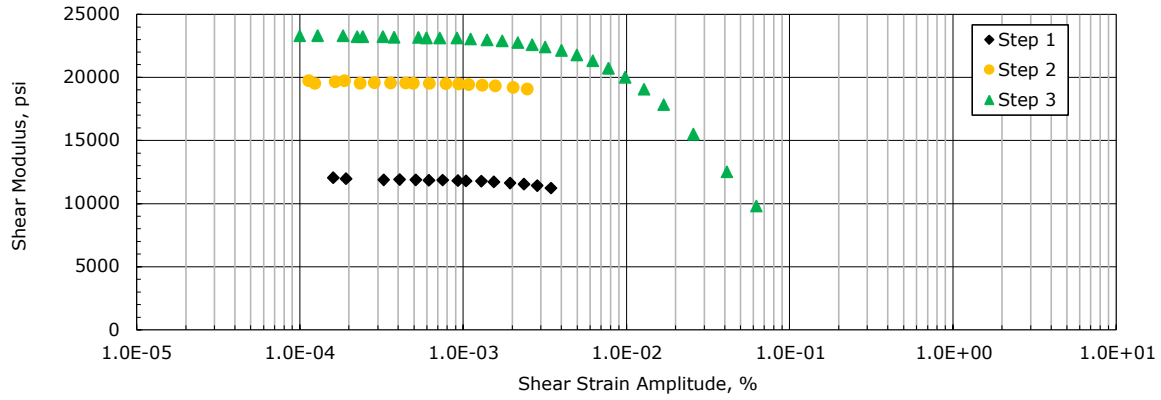
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

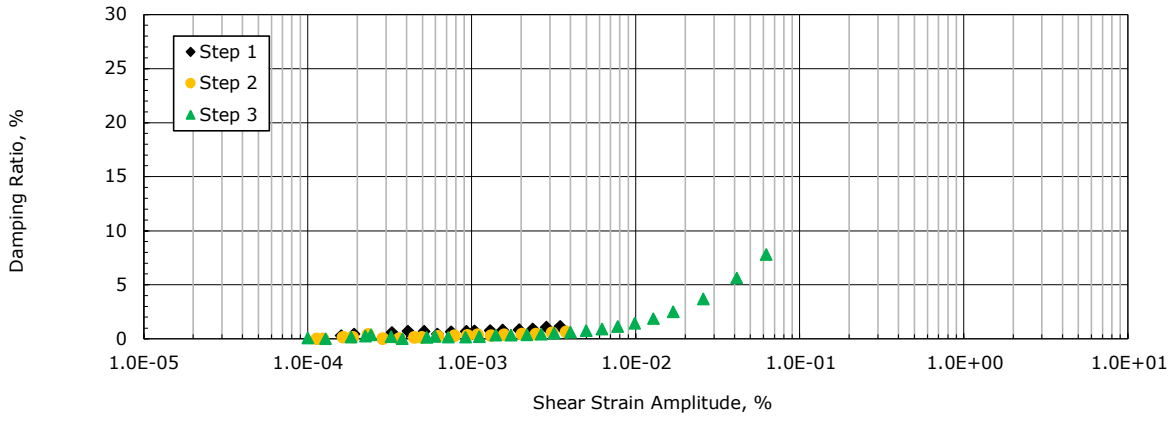
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm
Checked By:	njh
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**25**	**35**	**52**
Horizontal Confining Pressure, psi:	**25**	**35**	**52**

Visual Description:	Moist, light gray sand
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.86
Initial Height, in:	6.05
Initial Mass, grams:	1255
Initial Moisture Content, %:	17.7
Initial Dry Density, pcf:	104.5
Initial Bulk Density, pcf:	123.0
Initial Degree of Saturation:	78.8
Initial Void Ratio:	0.60

Final Diameter, in:	2.84
Final Height, in:	6.01
Final Mass, grams:	1240
Final Moisture Content, %:	20.3
Final Dry Density, pcf:	106.6
Final Bulk Density, pcf:	128.3
Final Degree of Saturation:	95.7
Final Void Ratio:	0.57

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.684
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8
Test Confining Pressure, psi:	**25** **STEP 1**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 25 psi over a range of strains from 0.000160 to 0.00346% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.21	0.016	137	0.0	25	1.60E-04	12056	0.31
0.31	0.020	137	0.0	25	1.91E-04	11984	0.46
0.52	0.032	136	0.0	25	3.26E-04	11890	0.61
0.62	0.040	136	0.0	25	4.08E-04	11908	0.74
0.73	0.050	136	0.0	25	5.13E-04	11899	0.69
0.83	0.063	136	0.0	25	6.17E-04	11862	0.47
0.93	0.080	136	0.0	25	7.50E-04	11882	0.65
1.04	0.101	136	0.0	25	9.26E-04	11824	0.71
1.14	0.127	136	0.0	25	1.04E-03	11808	0.76
1.24	0.160	136	0.0	25	1.29E-03	11793	0.77
1.35	0.202	136	0.0	25	1.54E-03	11723	0.83
1.45	0.254	135	0.0	25	1.94E-03	11639	0.86
1.55	0.320	135	0.0	25	2.36E-03	11548	0.94
1.66	0.403	135	0.0	25	2.85E-03	11427	1.11
1.76	0.507	134	0.0	25	3.46E-03	11244	1.17

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8
Test Confining Pressure, psi:	**35** **STEP 2**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 35 psi over a range of strains from 0.000114 to 0.00376% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.21	0.016	175	0.0	35	1.14E-04	19742	0.00
0.31	0.020	174	0.0	35	1.24E-04	19537	0.00
0.41	0.025	173	0.0	35	1.64E-04	19684	0.16
0.52	0.032	173	0.0	35	1.88E-04	19733	0.17
0.62	0.040	174	0.0	35	2.33E-04	19543	0.42
0.72	0.050	173	0.0	35	2.87E-04	19600	0.04
0.83	0.063	173	0.0	35	3.60E-04	19565	0.03
0.93	0.080	173	0.0	35	4.46E-04	19571	0.14
1.03	0.101	173	0.0	35	4.94E-04	19547	0.14
1.14	0.127	173	0.0	35	6.22E-04	19521	0.24
1.24	0.160	173	0.0	35	7.84E-04	19517	0.29
1.34	0.202	173	0.0	35	9.39E-04	19492	0.33
1.45	0.254	173	0.0	35	1.08E-03	19451	0.38
1.55	0.320	173	0.0	35	1.31E-03	19391	0.31
1.65	0.403	172	0.0	35	1.57E-03	19347	0.38
1.76	0.507	172	0.0	35	2.02E-03	19222	0.42
1.86	0.638	172	0.0	35	2.47E-03	19088	0.45
1.96	0.803	171	0.0	35	3.09E-03	18903	0.57
2.07	1.011	170	0.0	35	3.76E-03	18657	0.65

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/07/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8
Test Confining Pressure, psi:	**52** **STEP 3**
Visual Description:	Moist, light gray sand
Test Conditions:	Confining Stress of 52 psi over a range of strains from 0.0000999 to 0.0625% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System			
Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.360798
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	3065.972
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3021.626

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.21	0.016	186	0.0	52	9.99E-05	23301	0.08
0.52	0.032	188	0.0	52	1.28E-04	23323	0.00
0.62	0.040	188	0.0	52	1.84E-04	23314	0.16
0.72	0.050	188	0.0	52	2.25E-04	23223	0.26
0.83	0.063	188	0.0	52	2.43E-04	23230	0.38
0.93	0.080	188	0.0	52	3.22E-04	23235	0.21
1.03	0.101	188	0.0	52	3.78E-04	23187	0.02
1.14	0.127	187	0.0	52	5.32E-04	23178	0.13
1.24	0.160	187	0.0	52	5.97E-04	23132	0.25
1.34	0.202	187	0.0	52	7.18E-04	23127	0.17
1.45	0.254	187	0.0	52	9.17E-04	23122	0.17
1.55	0.320	187	0.0	52	1.11E-03	23045	0.21
1.65	0.403	187	0.0	52	1.40E-03	22973	0.35
1.76	0.507	187	0.0	52	1.74E-03	22887	0.36
1.86	0.638	186	0.0	52	2.17E-03	22770	0.38
1.96	0.803	186	0.0	52	2.65E-03	22610	0.44
2.07	1.011	185	0.0	52	3.19E-03	22403	0.53
2.17	1.273	185	0.0	52	3.99E-03	22130	0.62
2.27	1.602	184	0.0	52	4.98E-03	21779	0.77
2.38	2.017	182	0.0	52	6.22E-03	21310	0.93
2.48	2.539	181	0.0	52	7.75E-03	20732	1.15
2.58	3.197	179	0.0	52	9.85E-03	20020	1.45
2.69	4.025	176	0.0	52	1.28E-02	19074	1.88
2.79	5.067	172	0.0	52	1.69E-02	17848	2.51
2.99	6.380	161	0.0	52	2.58E-02	15503	3.70
3.30	8.031	145	0.0	52	4.12E-02	12525	5.63
3.61	10.112	130	0.1	52	6.25E-02	9804	7.84

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

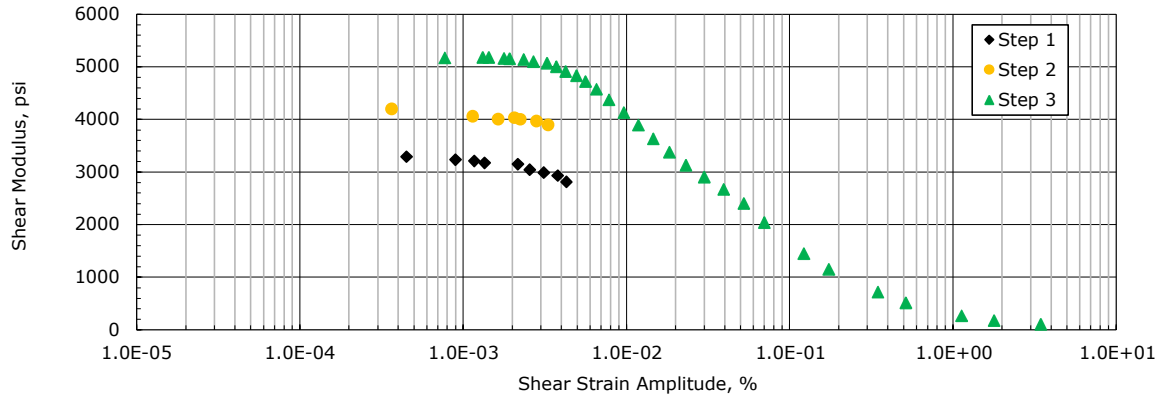
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

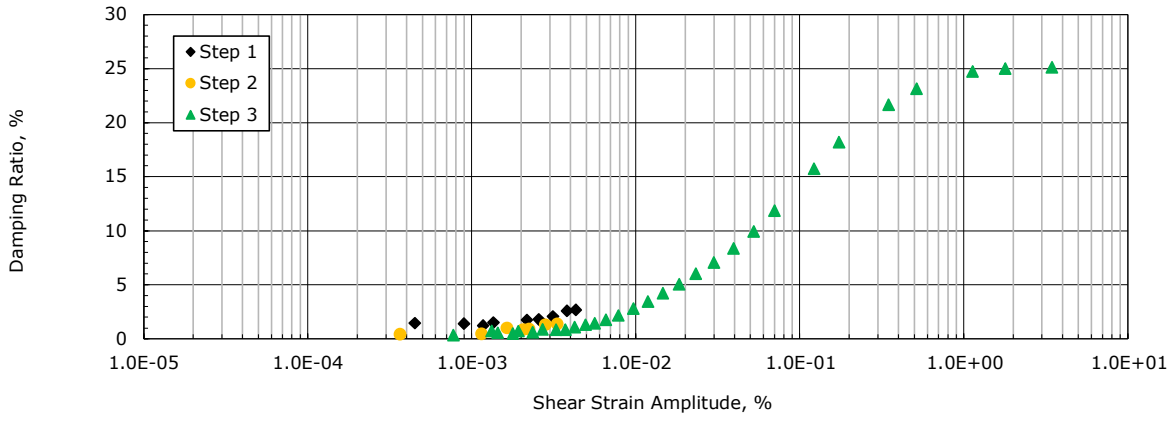
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/14/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**2**	**3**	**5**
Horizontal Confining Pressure, psi:	**2**	**3**	**5**

Visual Description:	Moist, grayish brown sand with clay
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.85
Initial Height, in:	5.90
Initial Mass, grams:	1085
Initial Moisture Content, %:	19.2
Initial Dry Density, pcf:	92.1
Initial Bulk Density, pcf:	109.8
Initial Degree of Saturation:	63.1
Initial Void Ratio:	0.82

Final Diameter, in:	2.83
Final Height, in:	5.88
Final Mass, grams:	1082
Final Moisture Content, %:	29.0
Final Dry Density, pcf:	93.5
Final Bulk Density, pcf:	120.6
Final Degree of Saturation:	98.5
Final Void Ratio:	0.79

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.682
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/14/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9
Test Confining Pressure, psi:	**2** **STEP 1**
Visual Description:	Moist, grayish brown sand with clay
Test Conditions:	Confining Stress of 2 psi over a range of strains from 0.000450 to 0.00430% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.21	0.016	73	0.0	2	4.50E-04	3296	1.47
0.42	0.025	73	0.0	2	8.97E-04	3236	1.41
0.62	0.040	73	0.0	2	1.17E-03	3215	1.24
0.73	0.050	73	0.0	2	1.35E-03	3178	1.50
0.83	0.063	73	0.0	2	2.17E-03	3151	1.75
0.94	0.080	72	0.0	2	2.57E-03	3046	1.81
1.04	0.100	71	0.0	2	3.12E-03	2991	2.09
1.15	0.127	71	0.0	2	3.80E-03	2934	2.61
1.25	0.160	70	0.0	2	4.30E-03	2815	2.68

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/14/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9
Test Confining Pressure, psi:	**3** **STEP 2**
Visual Description:	Moist, grayish brown sand with clay
Test Conditions:	Confining Stress of 3 psi over a range of strains from 0.000365 to 0.00332% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.10	0.013	83	0.0	3	3.65E-04	4205	0.43
0.62	0.040	82	0.0	3	1.15E-03	4063	0.48
0.73	0.050	82	0.0	3	1.64E-03	4013	1.02
0.83	0.063	82	0.0	3	2.06E-03	4036	0.87
0.94	0.080	82	0.0	3	2.24E-03	4007	0.92
1.04	0.100	81	0.0	3	2.81E-03	3969	1.32
1.15	0.127	81	0.0	3	3.32E-03	3900	1.38

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/14/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9
Test Confining Pressure, psi:	**5** **STEP 3**
Visual Description:	Moist, grayish brown sand with clay
Test Conditions:	Confining Stress of 5 psi over a range of strains from 0.000773 to 3.45% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.52	0.032	93	0.0	5	7.73E-04	5174	0.35
0.63	0.040	93	0.0	5	1.32E-03	5183	0.75
0.73	0.050	92	0.0	5	1.44E-03	5184	0.59
0.84	0.063	92	0.0	5	1.78E-03	5163	0.50
0.94	0.080	92	0.0	5	1.92E-03	5155	0.72
1.04	0.100	92	0.0	5	2.35E-03	5144	0.62
1.15	0.127	92	0.0	5	2.70E-03	5104	0.90
1.25	0.160	92	0.0	5	3.27E-03	5070	0.86
1.36	0.202	92	0.0	5	3.73E-03	5007	0.86
1.46	0.254	91	0.0	5	4.24E-03	4915	1.10
1.57	0.320	90	0.0	5	4.94E-03	4835	1.33
1.67	0.403	90	0.0	5	5.62E-03	4721	1.44
1.77	0.506	89	0.0	5	6.57E-03	4576	1.79
1.88	0.638	87	0.0	5	7.82E-03	4374	2.17
1.98	0.803	86	0.0	5	9.66E-03	4135	2.81
2.09	1.011	83	0.0	5	1.19E-02	3894	3.47
2.19	1.273	81	0.0	5	1.46E-02	3630	4.24
2.30	1.602	78	0.0	5	1.84E-02	3379	5.06
2.40	2.016	76	0.1	5	2.32E-02	3135	6.03
2.50	2.539	73	0.1	5	3.00E-02	2906	7.06
2.61	3.196	70	0.1	5	3.95E-02	2672	8.36
2.71	4.023	68	0.2	5	5.24E-02	2406	9.95
2.82	5.065	64	0.2	5	7.00E-02	2043	11.87
3.03	6.376	55	0.3	4	1.22E-01	1454	15.74
3.13	8.027	51	0.4	4	1.74E-01	1153	18.20
3.34	10.105	40	0.7	5	3.48E-01	719	21.66
3.44	12.722	36	0.8	5	5.16E-01	518	23.17
3.65	16.013	26	1.1	5	1.13E+00	268	24.76
3.75	20.159	22	1.5	4	1.79E+00	180	25.03
3.96	31.948	20	1.9	4	3.45E+00	106	25.12

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

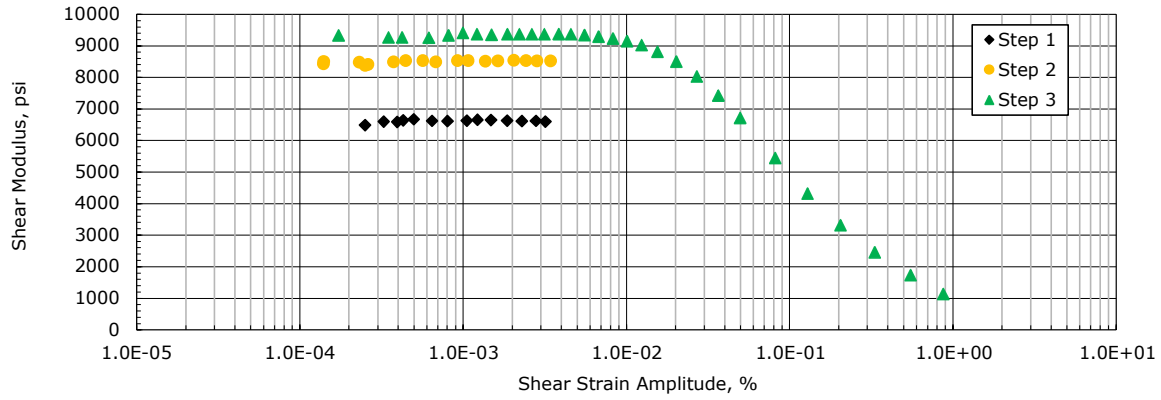
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

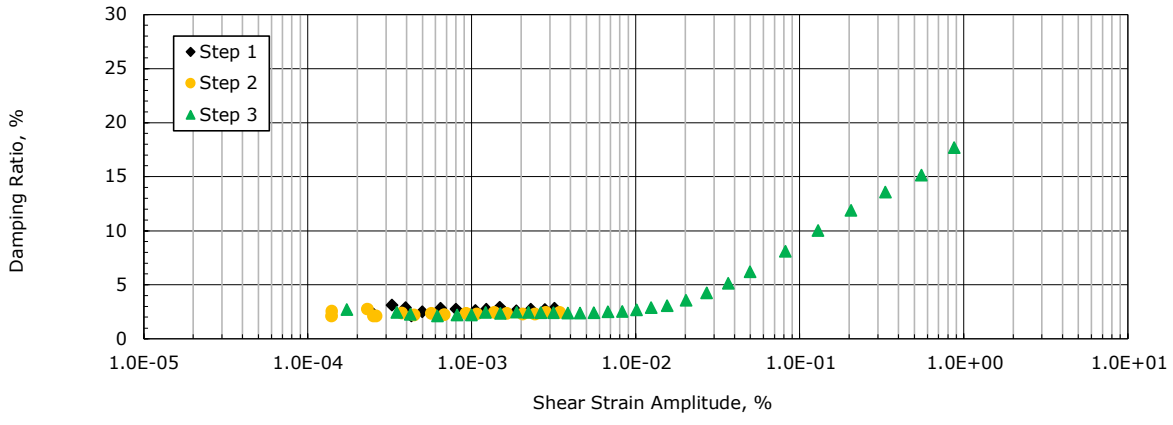
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/09/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

	Step 1	Step 2	Step 3
Vertical Confining Pressure, psi:	**13**	**18**	**27**
Horizontal Confining Pressure, psi:	**13**	**18**	**27**

Visual Description:	Moist, light brownish gray clay
Preparation:	Extruded from tube, cut, trimmed and placed into apparatus at the as-received density and moisture content
Test Procedure:	Step 1 -Consolidated to T100 and resonated Step 2 -Consolidation Pressures increased and applied and resonated again Step 3 -Consolidation Pressures increased and applied and resonated again

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015





Initial Diameter, in:	2.87
Initial Height, in:	6.10
Initial Mass, grams:	1237
Initial Moisture Content, %:	27.0
Initial Dry Density, pcf:	94.02
Initial Bulk Density, pcf:	119.46
Initial Degree of Saturation:	92.3
Initial Void Ratio:	0.79

Final Diameter, in:	2.85
Final Height, in:	6.05
Final Mass, grams:	1238
Final Moisture Content, %:	27.8
Final Dry Density, pcf:	96.00
Final Bulk Density, pcf:	122.60
Final Degree of Saturation:	99.3
Final Void Ratio:	0.75

Notes: Data from three test steps, plotted together on the same graph.
Initial Moisture Content from trimmings
Measured Specific Gravity of 2.699
Isotropic stress conditions

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/09/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1
Test Confining Pressure, psi:	**13** **STEP 1**
Visual Description:	Moist, light brownish gray clay
Test Conditions:	Confining Stress of 13 psi over a range of strains from 0.000251 to 0.00319% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.00	0.010	102	0.0	13	2.51E-04	6489	2.33
0.31	0.020	102	0.0	13	3.26E-04	6597	3.14
0.42	0.025	102	0.0	13	3.95E-04	6595	2.90
0.52	0.032	102	0.0	13	4.29E-04	6645	2.12
0.63	0.040	103	0.0	13	4.99E-04	6679	2.51
0.73	0.050	103	0.0	13	6.45E-04	6626	2.85
0.83	0.063	103	0.0	13	8.02E-04	6618	2.77
0.94	0.080	103	0.0	13	1.05E-03	6632	2.64
1.04	0.100	103	0.0	13	1.23E-03	6658	2.73
1.15	0.127	103	0.0	13	1.48E-03	6648	2.95
1.25	0.160	103	0.0	13	1.87E-03	6636	2.60
1.36	0.202	103	0.0	13	2.29E-03	6614	2.75
1.46	0.254	103	0.0	13	2.80E-03	6627	2.72
1.56	0.320	103	0.0	13	3.19E-03	6603	2.84

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/09/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1
Test Confining Pressure, psi:	**18** **STEP 2**
Visual Description:	Moist, light brownish gray clay
Test Conditions:	Confining Stress of 18 psi over a range of strains from 0.000139 to 0.00343% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System

Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.00	0.010	115	0.0	18	1.39E-04	8437	2.13
0.10	0.013	115	0.0	18	1.40E-04	8512	2.56
0.31	0.020	115	0.0	18	2.31E-04	8486	2.78
0.42	0.025	116	0.0	18	2.51E-04	8385	2.14
0.52	0.032	115	0.0	18	2.61E-04	8418	2.12
0.63	0.040	115	0.0	18	3.75E-04	8492	2.41
0.73	0.050	116	0.0	18	4.45E-04	8539	2.23
0.83	0.063	116	0.0	18	5.65E-04	8539	2.38
0.94	0.080	116	0.0	18	6.79E-04	8494	2.25
1.04	0.100	116	0.0	18	9.23E-04	8534	2.36
1.15	0.127	116	0.0	18	1.07E-03	8536	2.32
1.25	0.160	116	0.0	18	1.37E-03	8522	2.44
1.36	0.202	116	0.0	18	1.63E-03	8525	2.37
1.46	0.254	116	0.0	18	2.04E-03	8544	2.31
1.56	0.320	116	0.0	18	2.43E-03	8536	2.31
1.67	0.403	116	0.0	18	2.83E-03	8528	2.47
1.77	0.506	116	0.0	18	3.43E-03	8525	2.44

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/09/24
Tested By:	trm/jlw
Checked By:	njh
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1
Test Confining Pressure, psi:	**27** **STEP 3**
Visual Description:	Moist, light brownish gray clay
Test Conditions:	Confining Stress of 27 psi over a range of strains from 0.000173 to 0.876% with a forced sinusoidal vibration.
Preparation:	Extruded from cylinder mold and placed into test chamber at as-received density and moisture content.

Modulus and Damping of Soils by Resonant-Column Method by ASTM D4015

Apparatus Used: Type 2 - Geocomp Corp. quasi-fixed/free boundry condition automated RCTS Test System			
Torque Transducer Stiffness (k_p), N-m/rad:	47616.8	Torque Calibration Factor, N-m/V:	9.773774
Passive Inertia (Jp), kg-m2:	0.001394	Accelerometer 1 Calibration Factor, rad/s^2/V:	2962.813
		Accelerometer 2 Calibration Factor, rad/s^2/V:	3052.071

Elapsed Time	Excitation	Frequency	Axial Strain	Effective Confining Stress	Average Strain Amplitude	Shear Modulus, G	Damping Ratio, D
min	%	Hz	%	psi	%	psi	%
0.52	0.020	123	0.0	27	1.73E-04	9337	2.71
0.83	0.040	122	0.0	27	3.48E-04	9269	2.46
0.94	0.050	121	0.0	26	4.22E-04	9266	2.28
1.15	0.080	121	0.0	27	6.17E-04	9263	2.12
1.25	0.100	121	0.0	27	8.13E-04	9339	2.22
1.36	0.127	121	0.0	27	9.96E-04	9407	2.22
1.46	0.160	122	0.0	26	1.21E-03	9371	2.44
1.56	0.202	122	0.0	27	1.49E-03	9353	2.37
1.67	0.254	122	0.0	27	1.87E-03	9372	2.46
1.77	0.320	122	0.0	27	2.21E-03	9368	2.44
1.88	0.403	122	0.0	27	2.64E-03	9369	2.43
1.98	0.506	122	0.0	27	3.15E-03	9370	2.43
2.08	0.639	122	0.0	27	3.86E-03	9379	2.41
2.19	0.803	122	0.0	27	4.57E-03	9368	2.41
2.29	1.011	122	0.0	27	5.54E-03	9342	2.43
2.40	1.273	122	0.0	27	6.76E-03	9293	2.51
2.50	1.601	121	0.0	27	8.28E-03	9233	2.56
2.61	2.016	121	0.0	27	1.01E-02	9146	2.70
2.71	2.537	121	0.0	27	1.24E-02	9027	2.89
2.82	3.195	120	0.0	27	1.55E-02	8816	3.09
2.92	4.022	119	0.0	27	2.02E-02	8501	3.59
3.02	5.065	117	0.0	27	2.71E-02	8034	4.27
3.13	6.375	114	0.0	26	3.66E-02	7426	5.15
3.23	8.026	110	0.0	27	4.98E-02	6718	6.20
3.44	10.102	99	0.0	27	8.16E-02	5445	8.12
0.00	12.719	89	0.0	27	1.29E-01	4317	10.03
0.00	16.013	79	0.0	27	2.05E-01	3319	11.90
0.00	20.158	69	0.0	26	3.33E-01	2457	13.57
0.00	25.378	59	0.1	26	5.51E-01	1738	15.16
0.00	31.952	49	0.1	26	8.76E-01	1137	17.70

The Shear Wave Velocity can be determined by the following equation:

Vs = sqrt(G*g/bulk density)

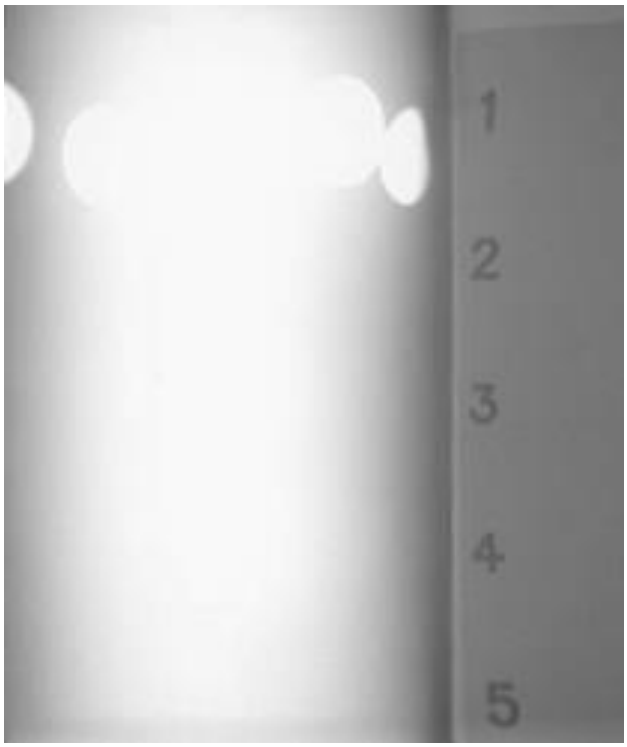
where: Vs = shear wave velocity
G = shear modulus
g = acceleration due to gravity, 9.81 m/sec^2
final bulk density

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
3	
4	
5	
6	
	Bottom of Tube

Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
3	
4	
5	
6	
	Bottom of Tube

Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
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4	
5	
6	
	Bottom of Tube

Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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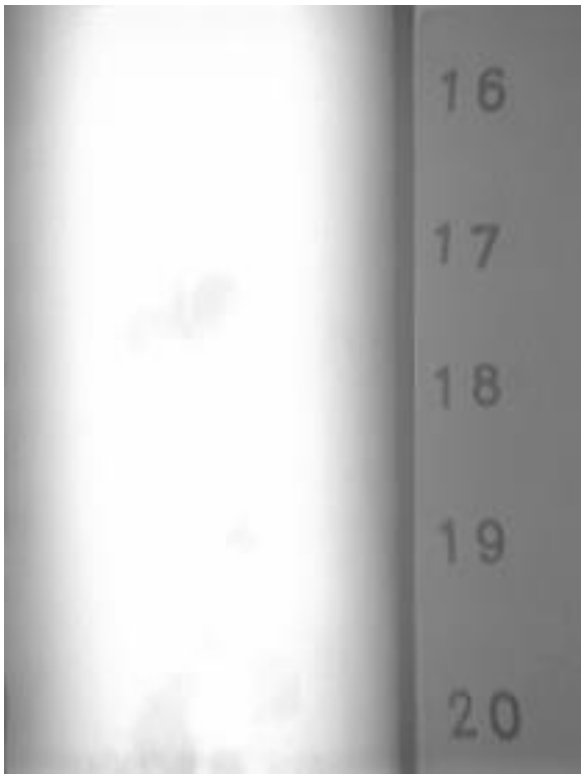
	Bottom of Tube

Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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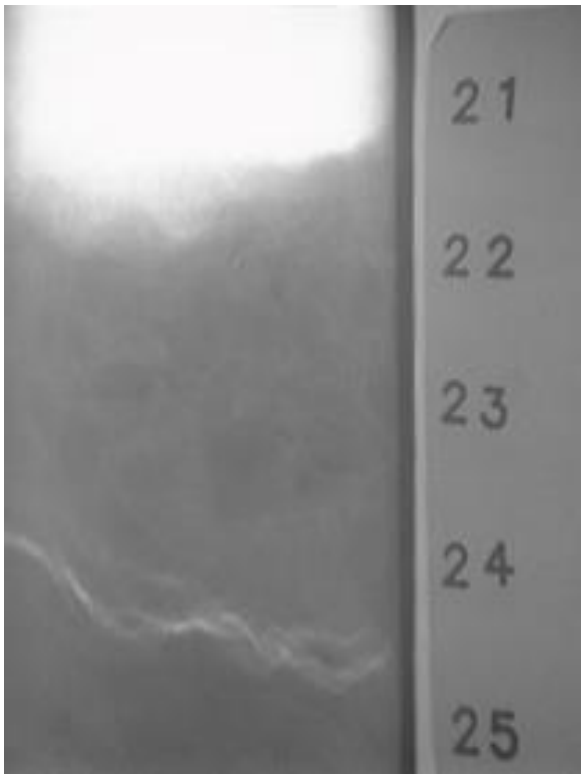
5	
6	
	Bottom of Tube



Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-1
Depth:	4.8-6.8'

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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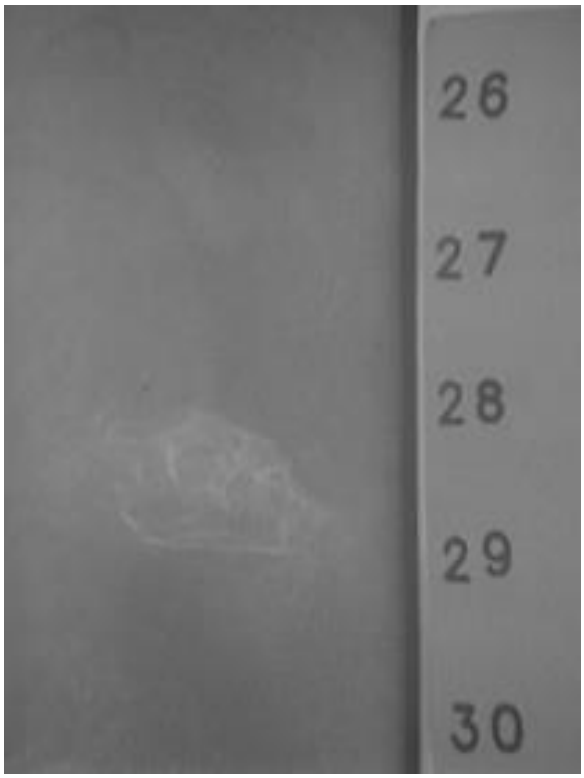
	Bottom of Tube



Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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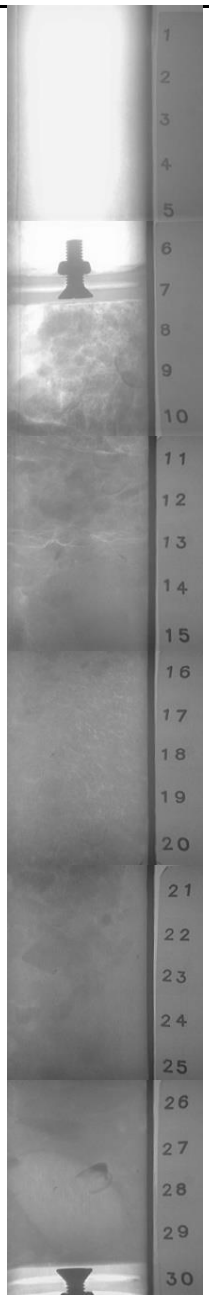
	Bottom of Tube

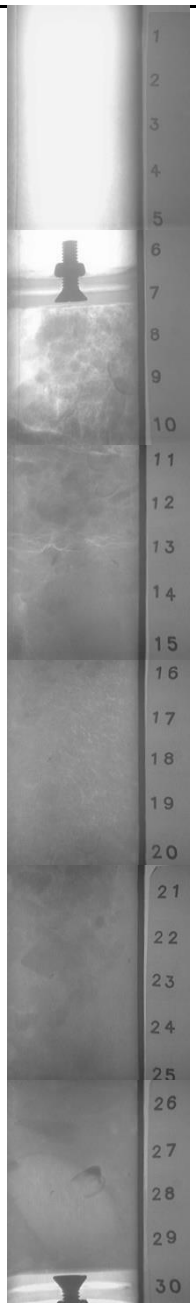


Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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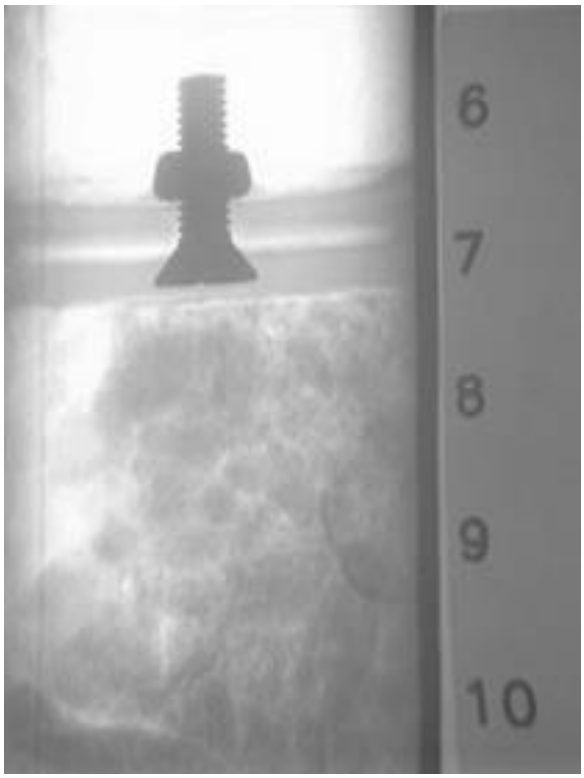
Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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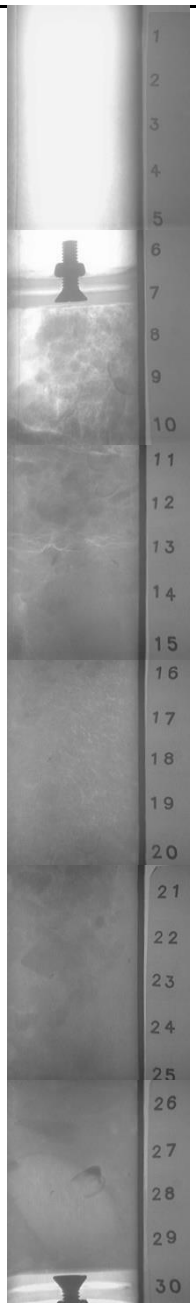
	Bottom of Tube



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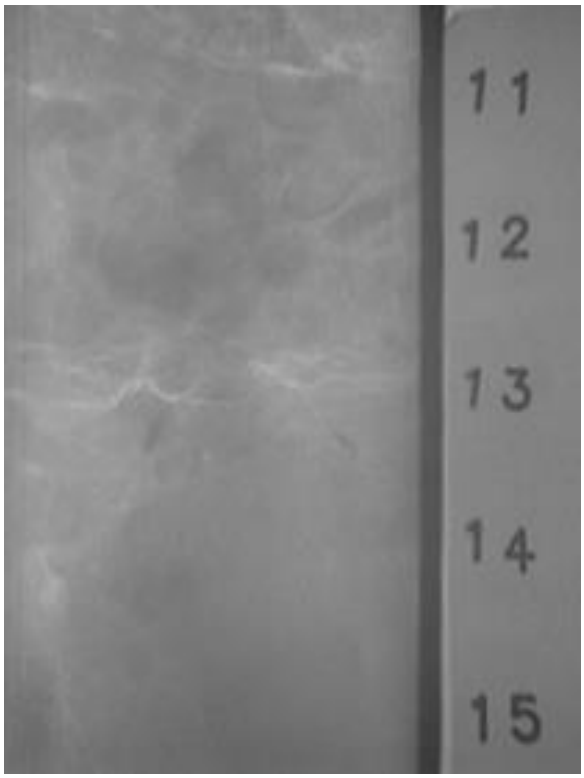

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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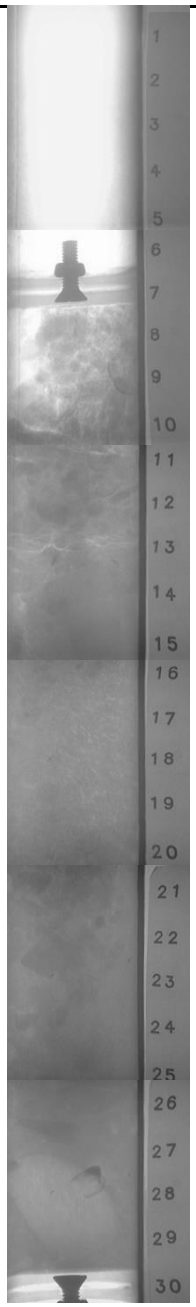
	Bottom of Tube



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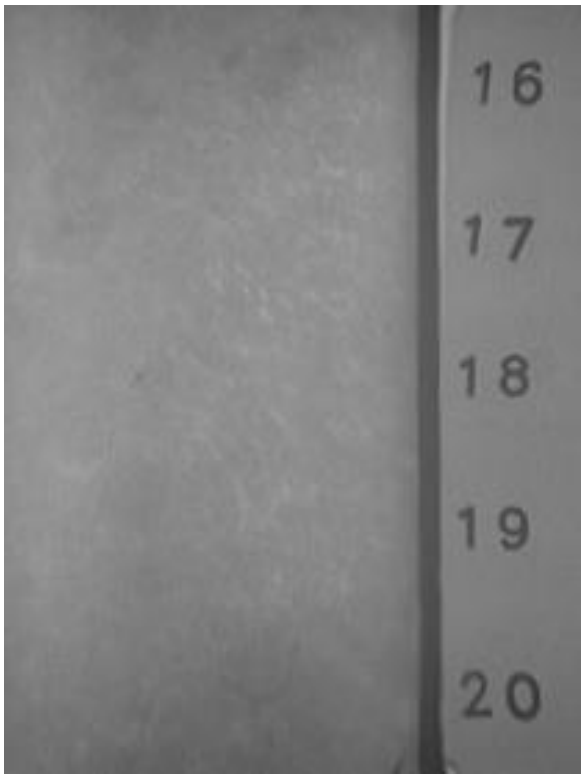

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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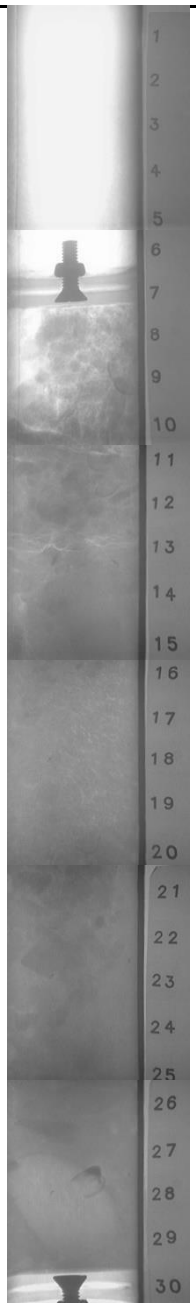
	Bottom of Tube



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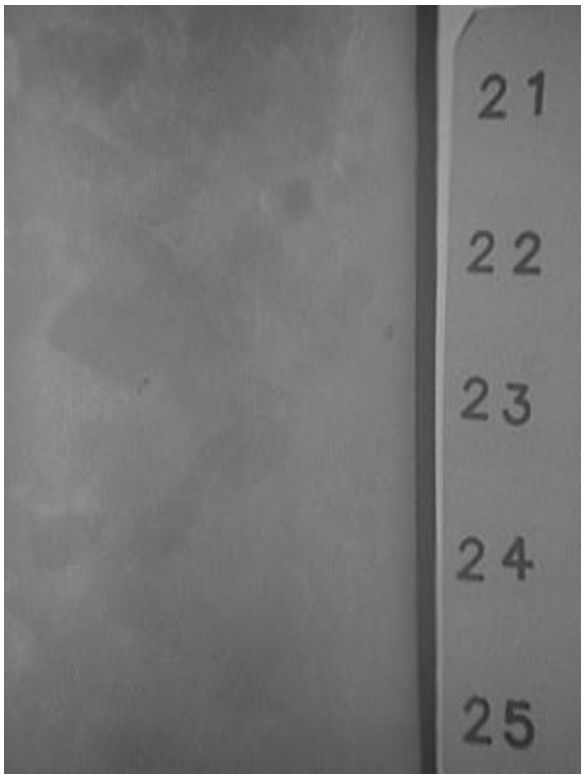

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1021
Sample ID:	GT-2
Depth:	7.9-9.9

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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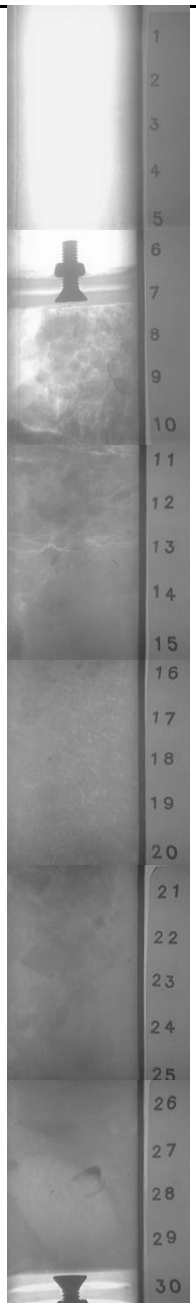
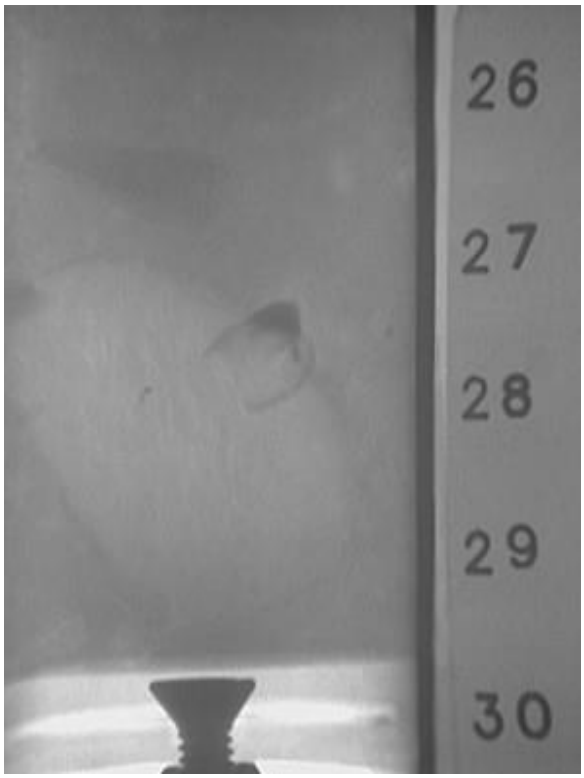
	Bottom of Tube

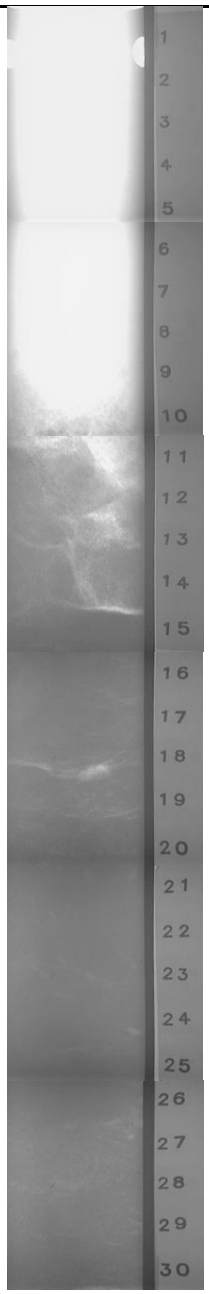


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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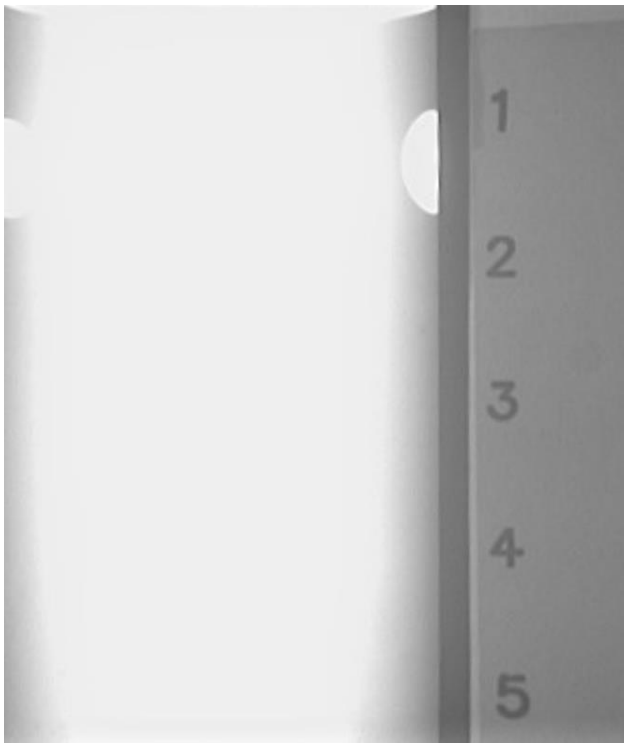
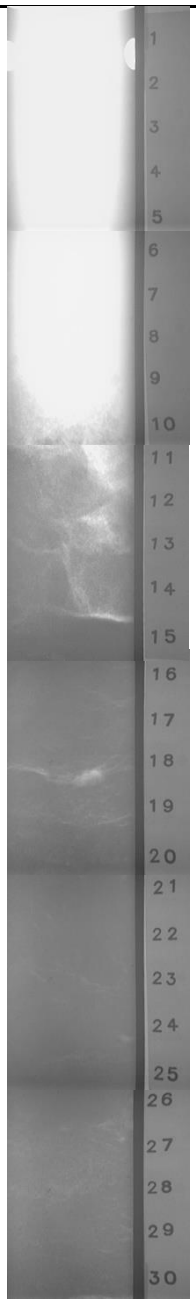
Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

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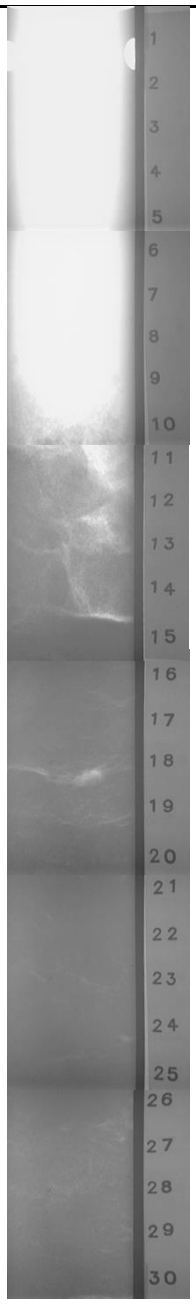
1	
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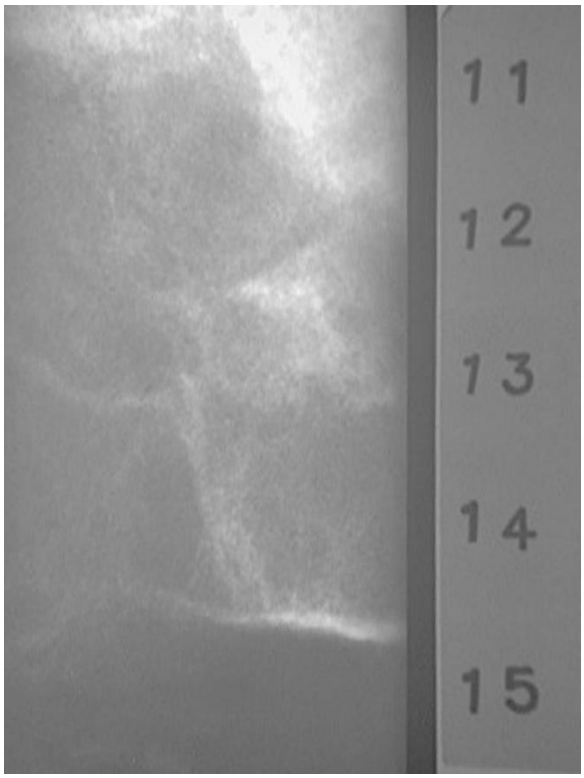
Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

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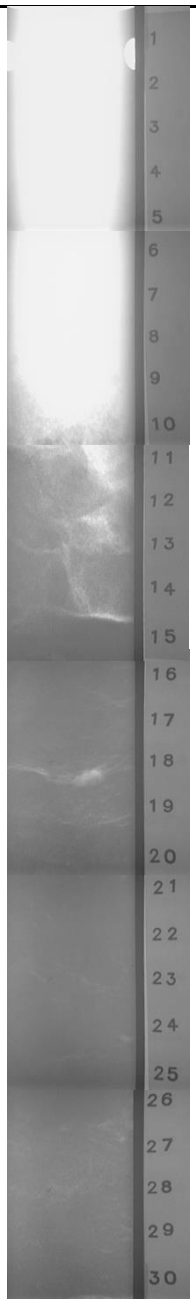
1	
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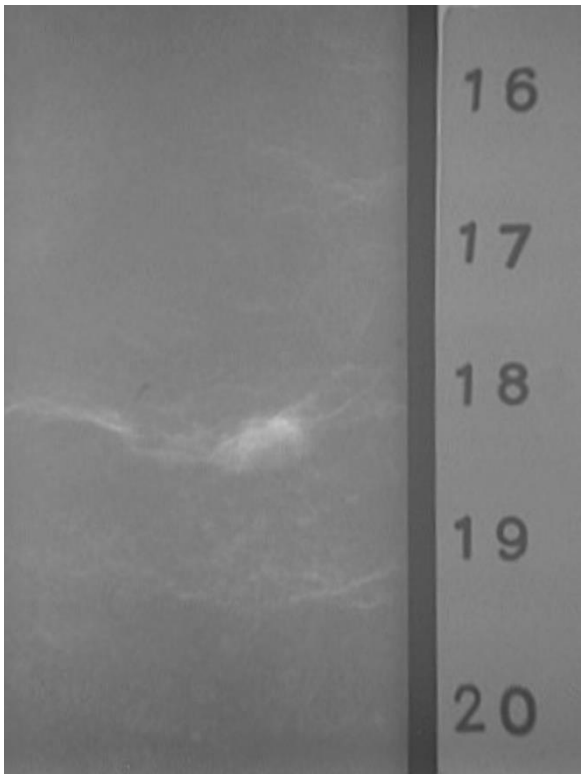
Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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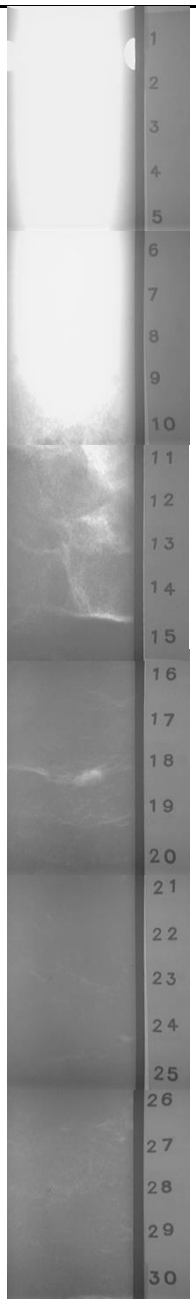
	Bottom of Tube



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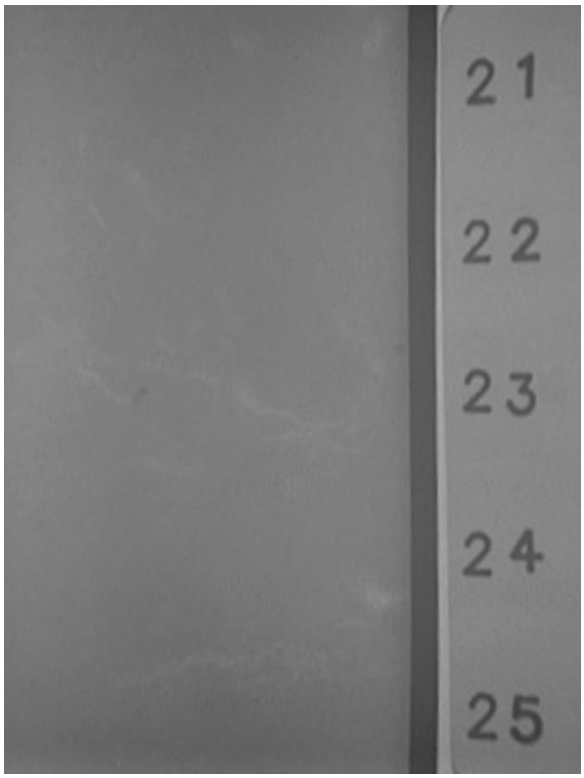

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1008
Sample ID:	GT-3
Depth:	140.4-142.4

X-Ray of Soil Sample by ASTM D4452

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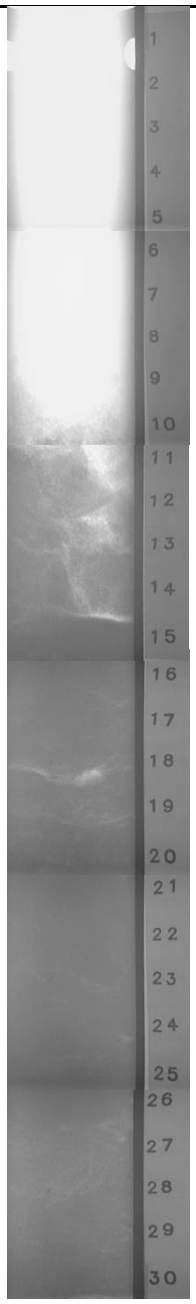
1	
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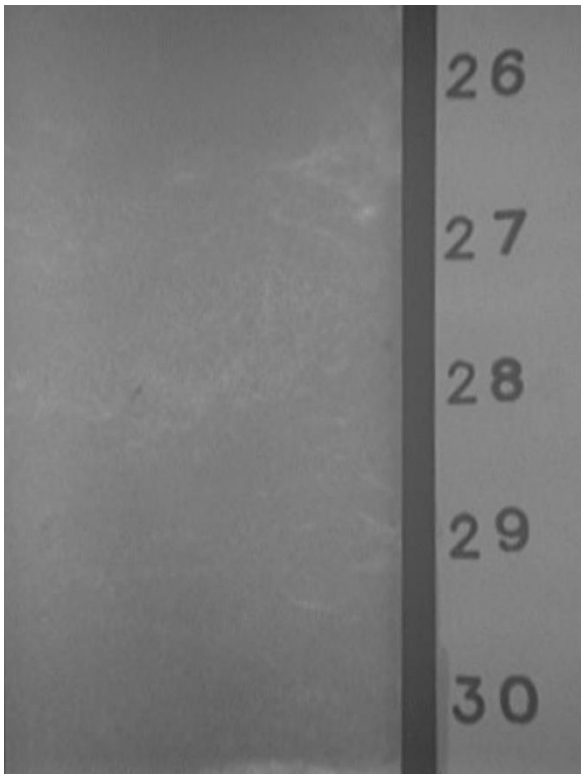
Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

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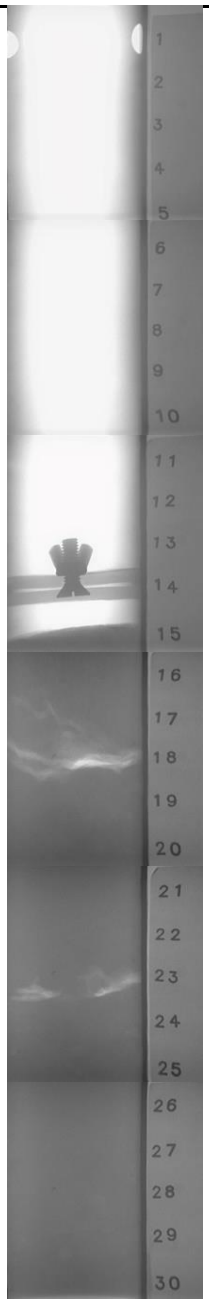
1	
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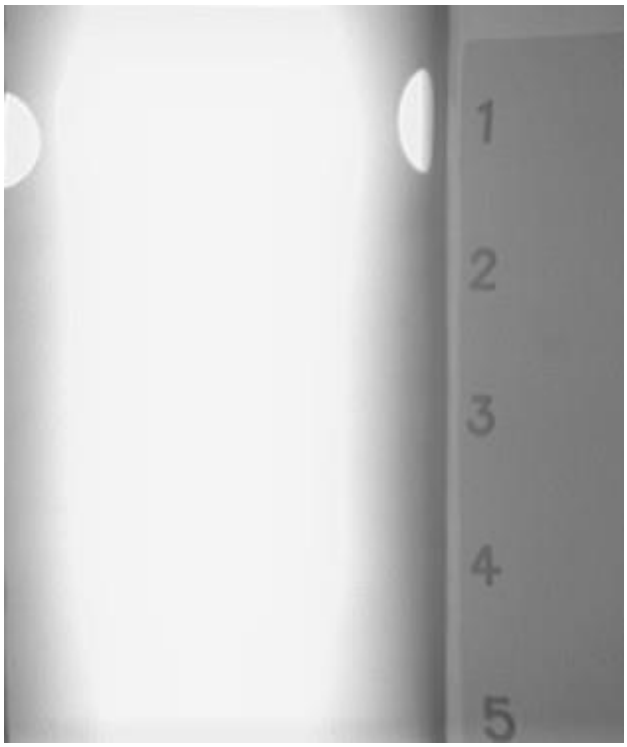
Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

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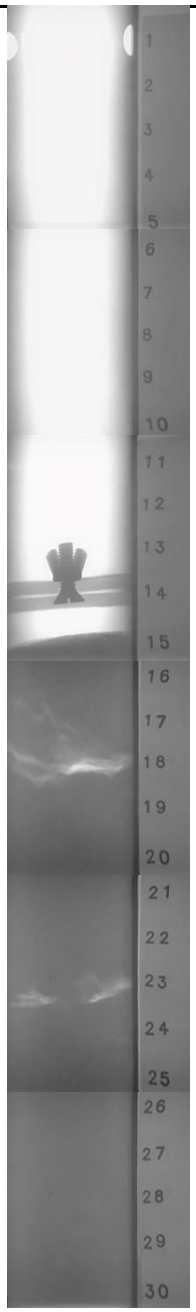

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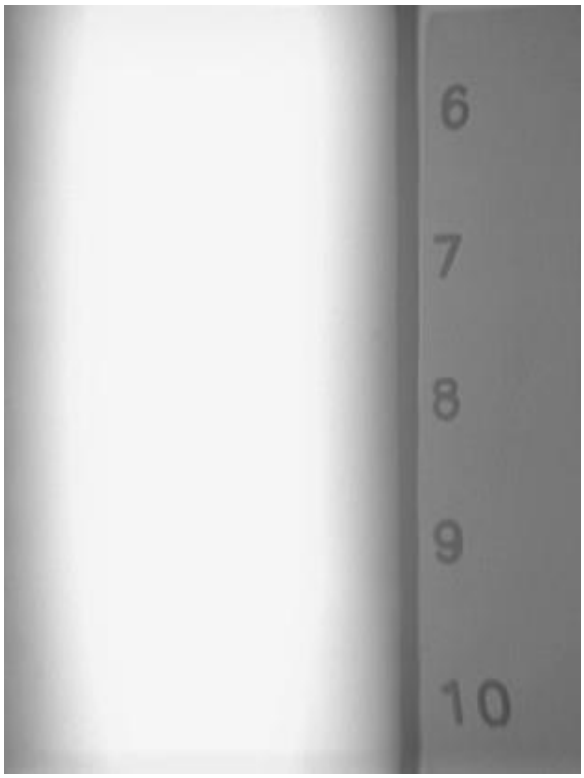
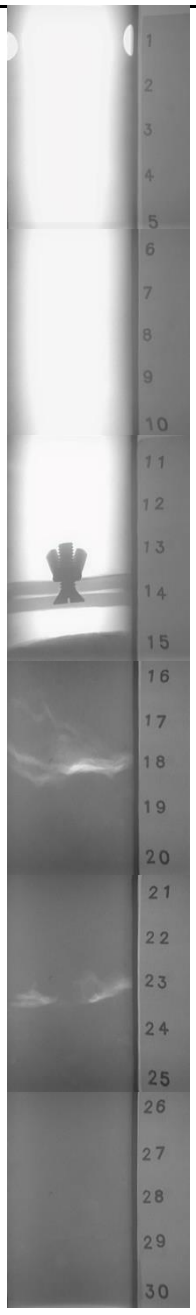


Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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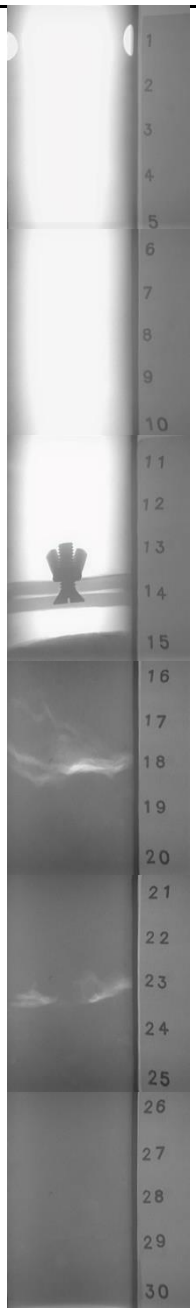

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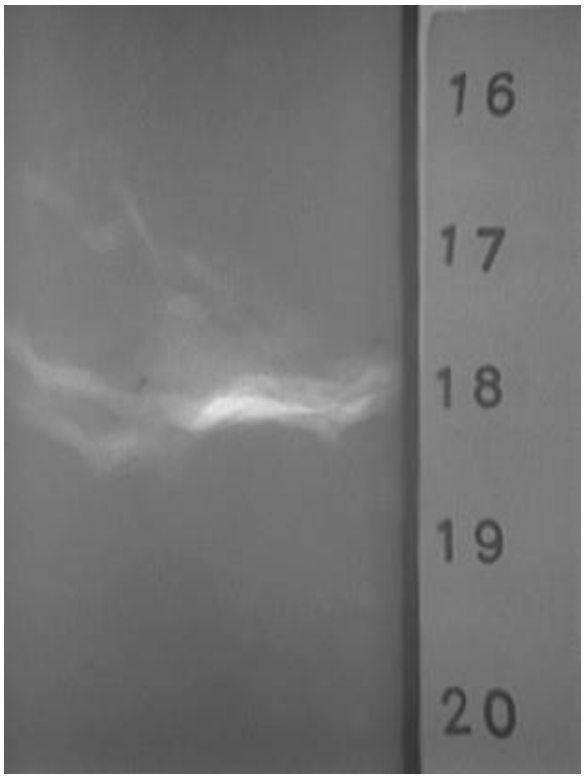

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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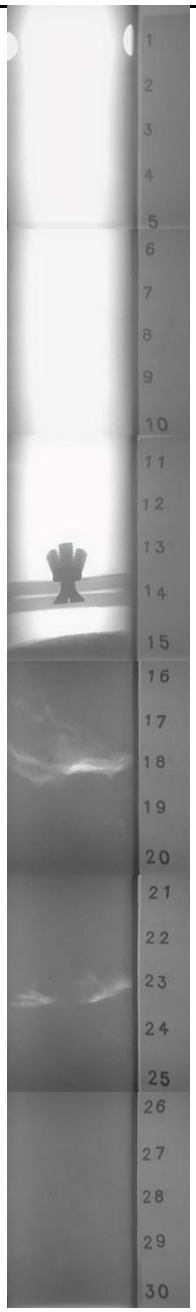

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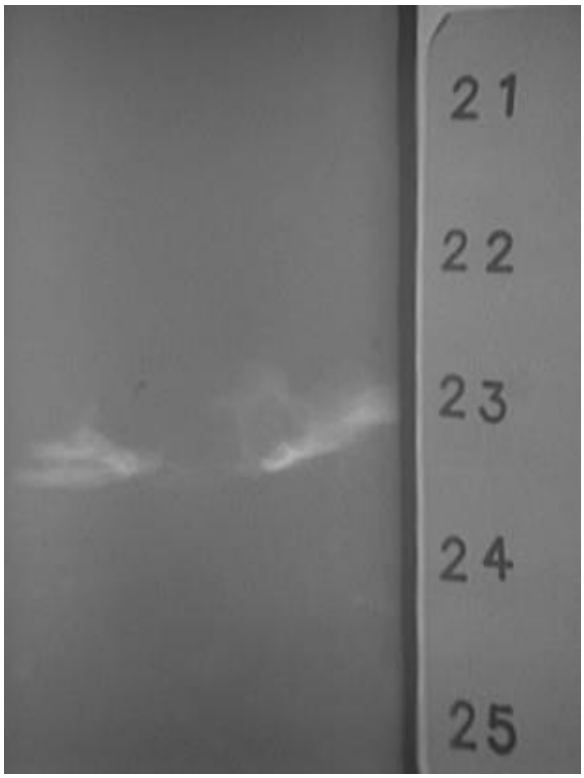

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-10009
Sample ID:	GT-3
Depth:	64.4-66.4

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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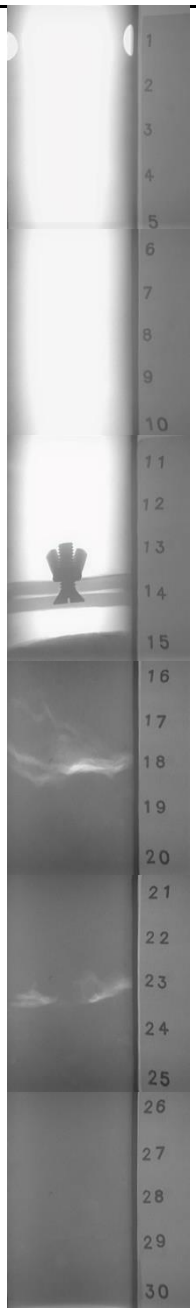
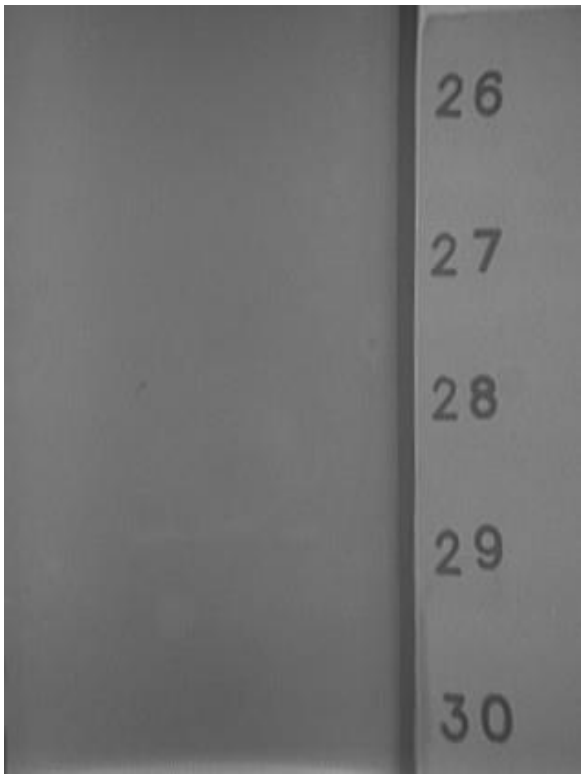


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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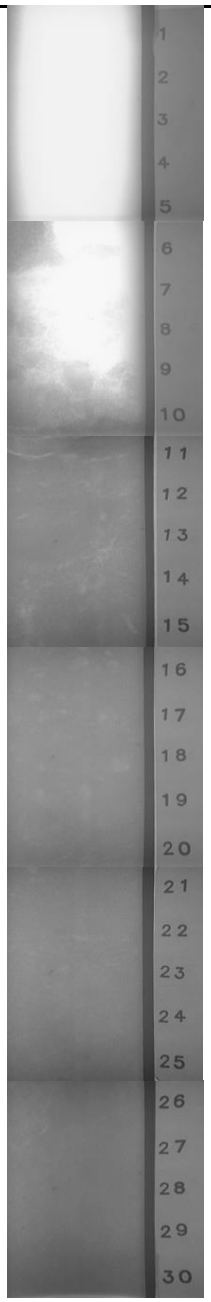

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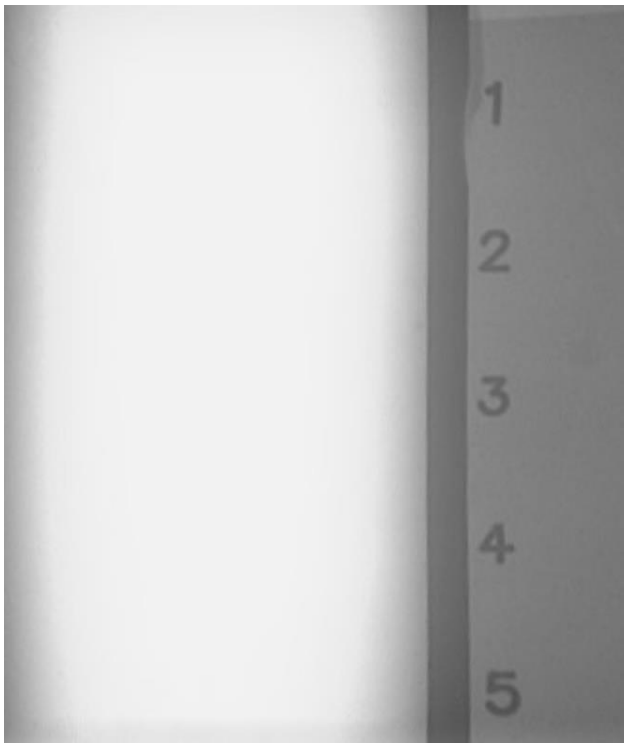

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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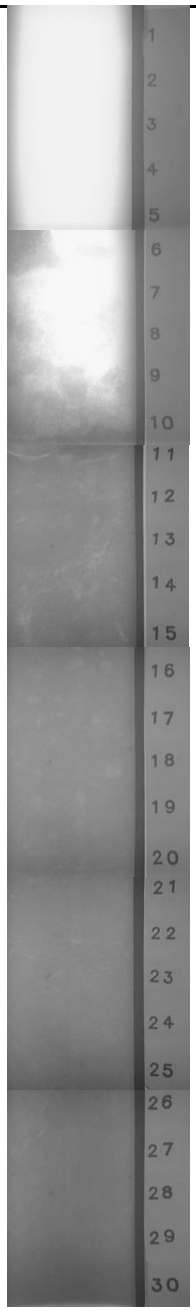
	Bottom of Tube



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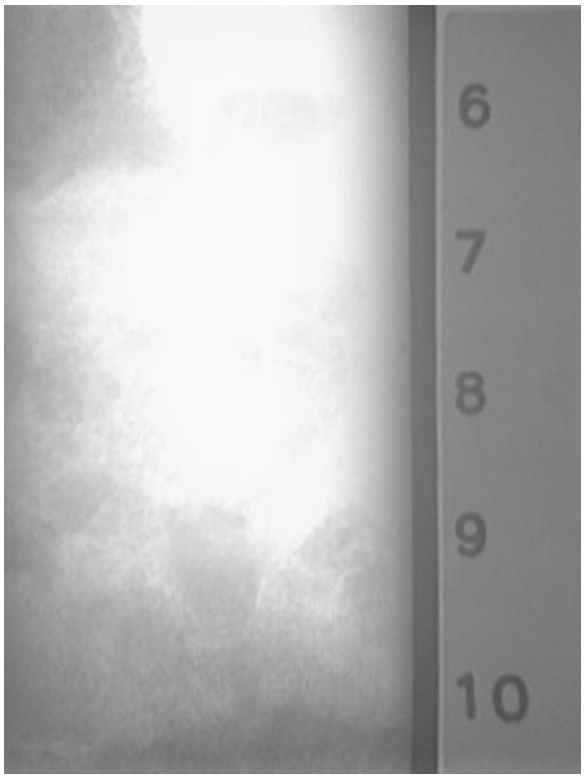

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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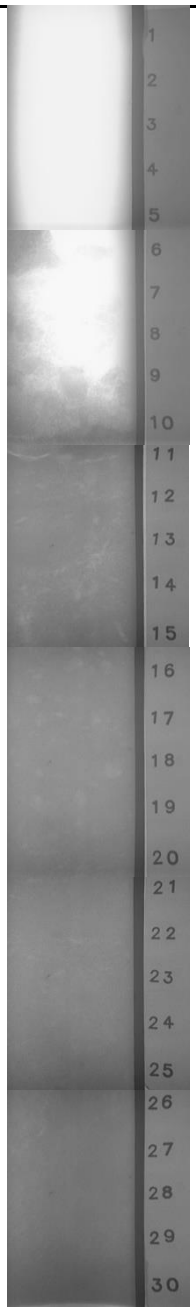
	Bottom of Tube



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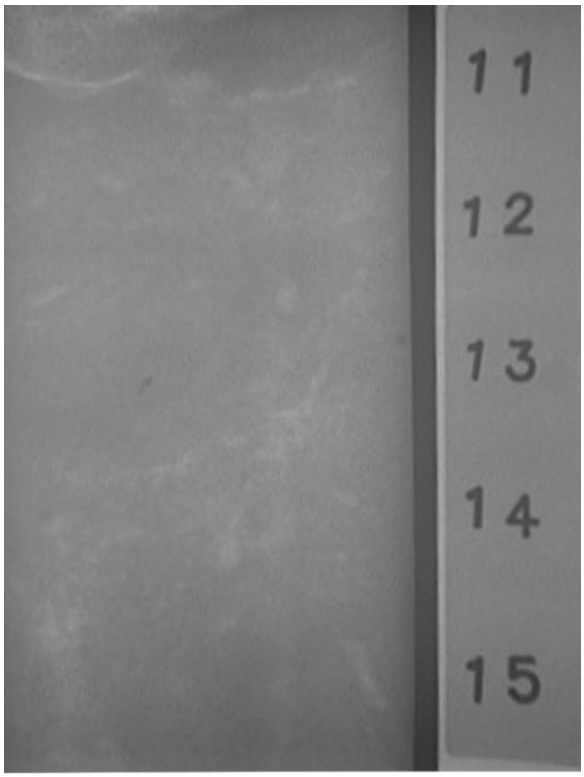

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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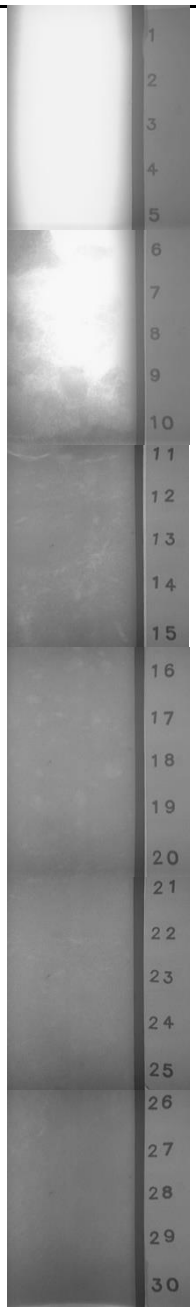
	Bottom of Tube



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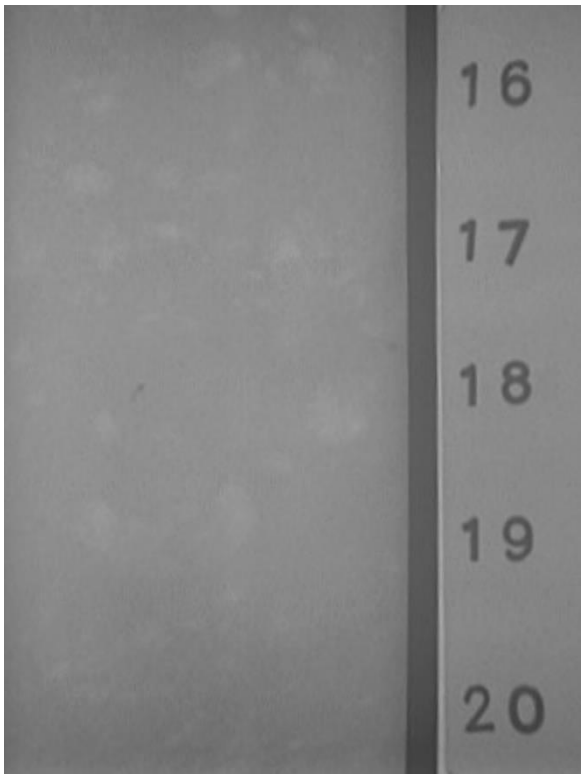

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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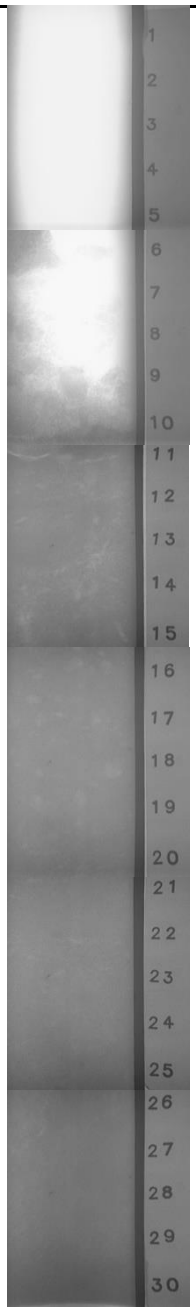
	Bottom of Tube



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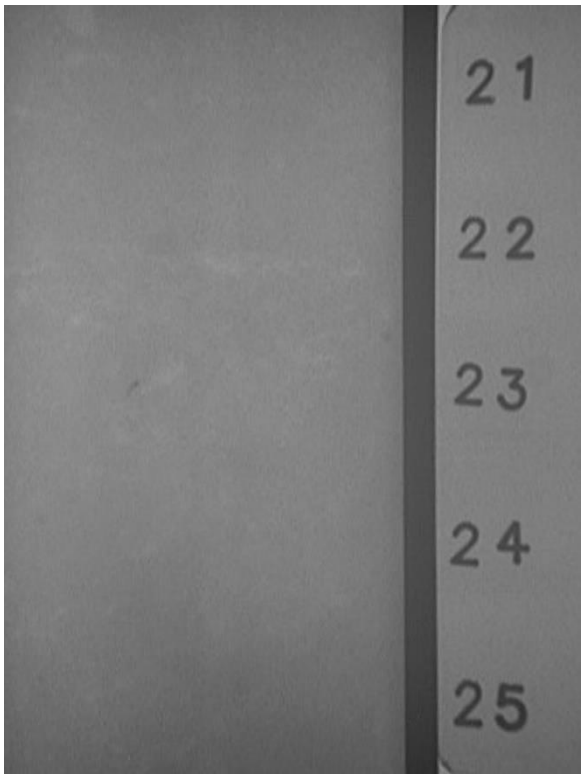

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1013
Sample ID:	GT-4
Depth:	131.8-133.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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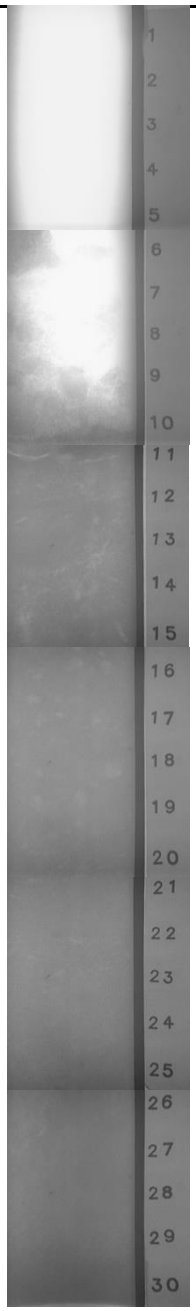
	Bottom of Tube



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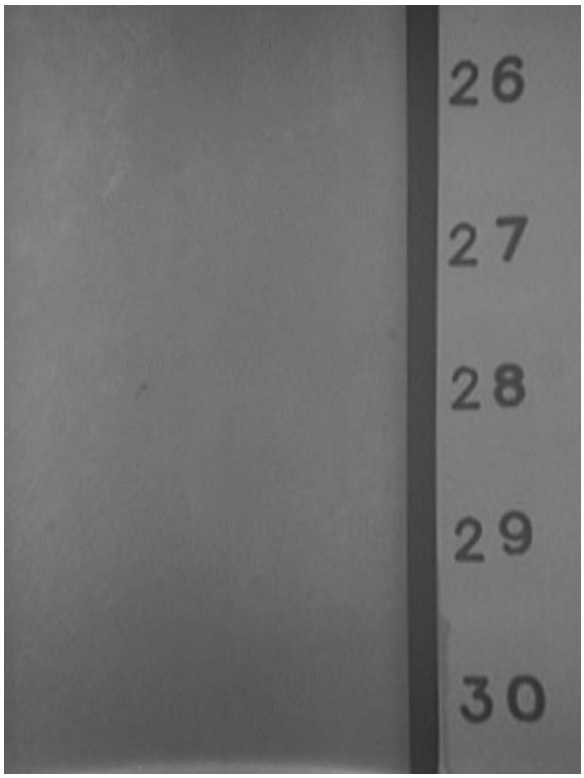

Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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	Bottom of Tube

Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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	Bottom of Tube

Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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	Bottom of Tube



Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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	Bottom of Tube

Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
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5	
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	Bottom of Tube



Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1017
Sample ID:	GT-4
Depth:	80.2-82.2

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
3	
4	
5	
6	
	Bottom of Tube

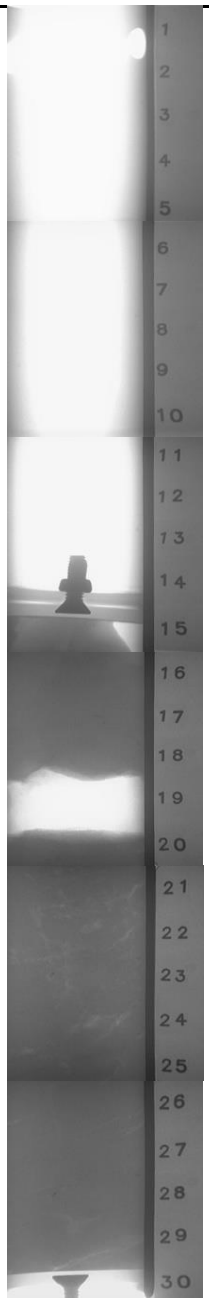


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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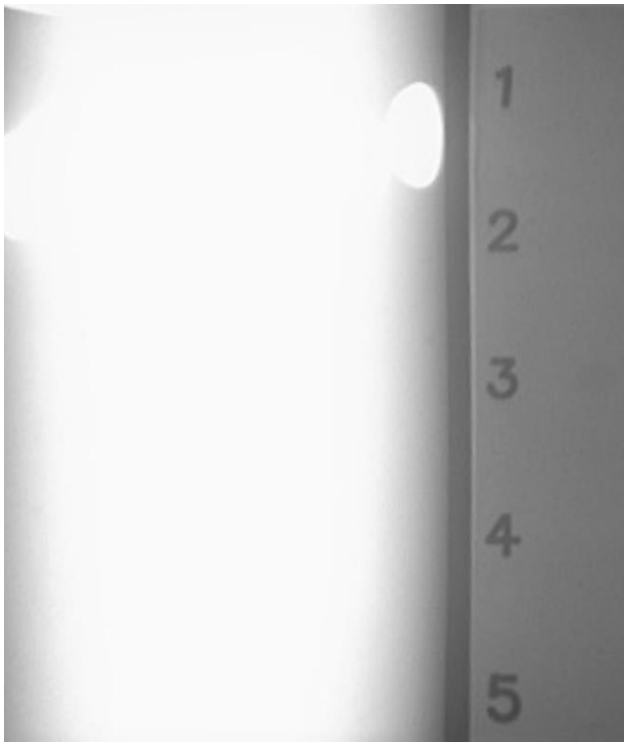
	Bottom of Tube

Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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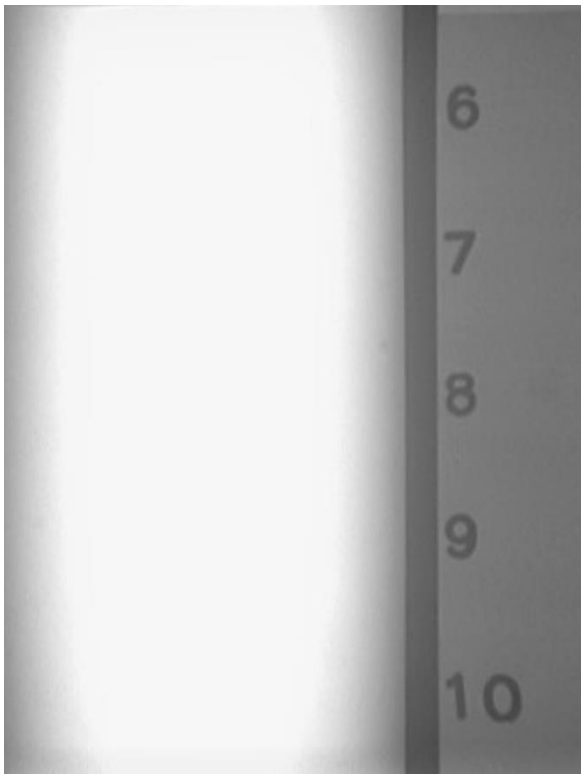
	Bottom of Tube

Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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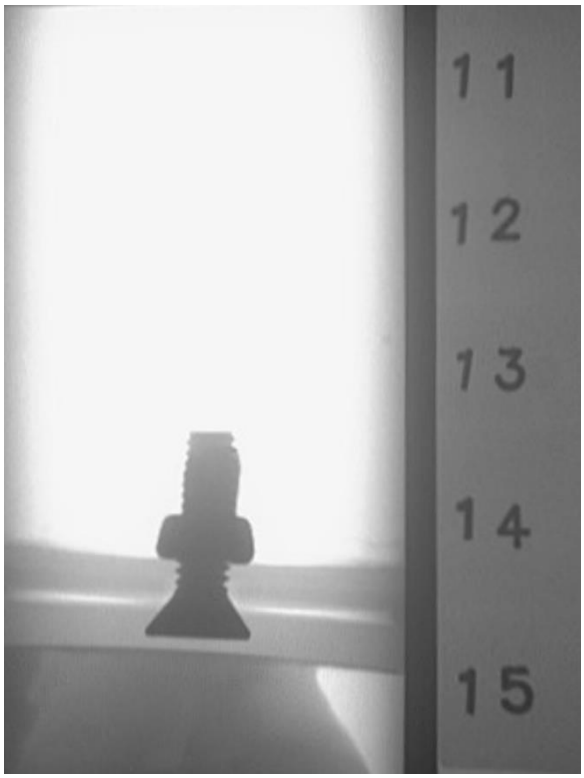
	Bottom of Tube



Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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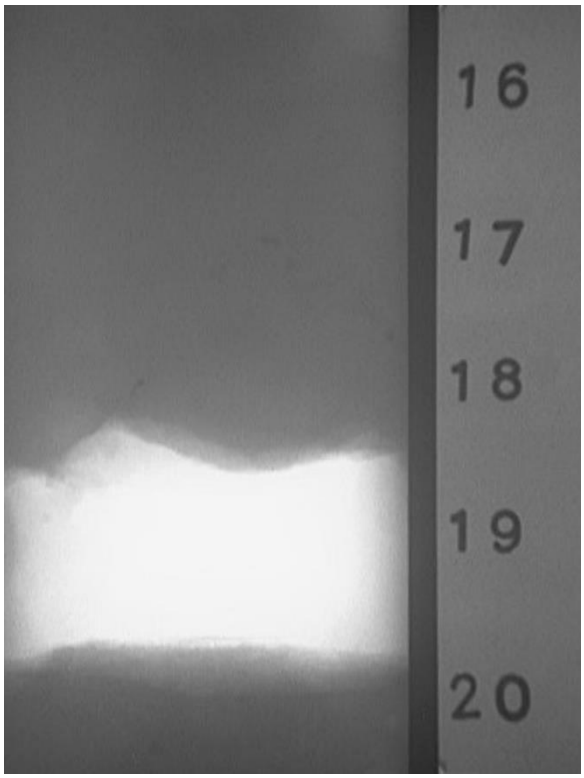
	Bottom of Tube



Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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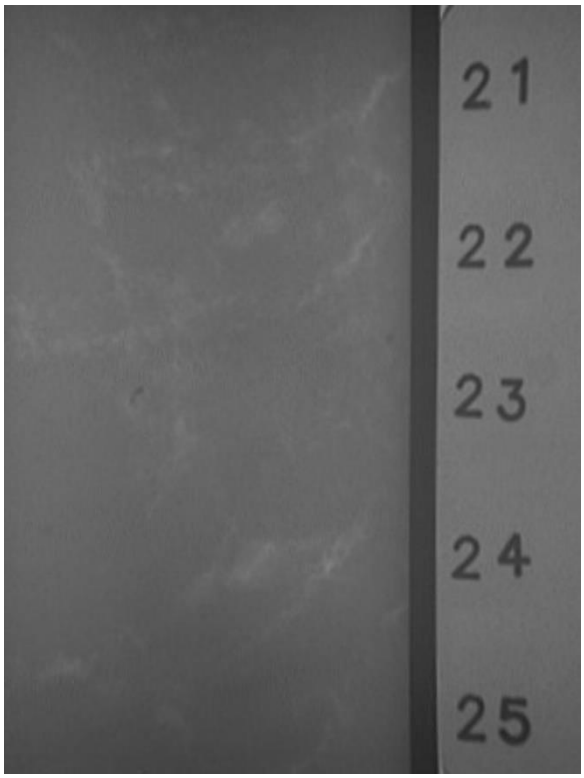
	Bottom of Tube



Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1007
Sample ID:	ST-1
Depth:	88.7-90.7

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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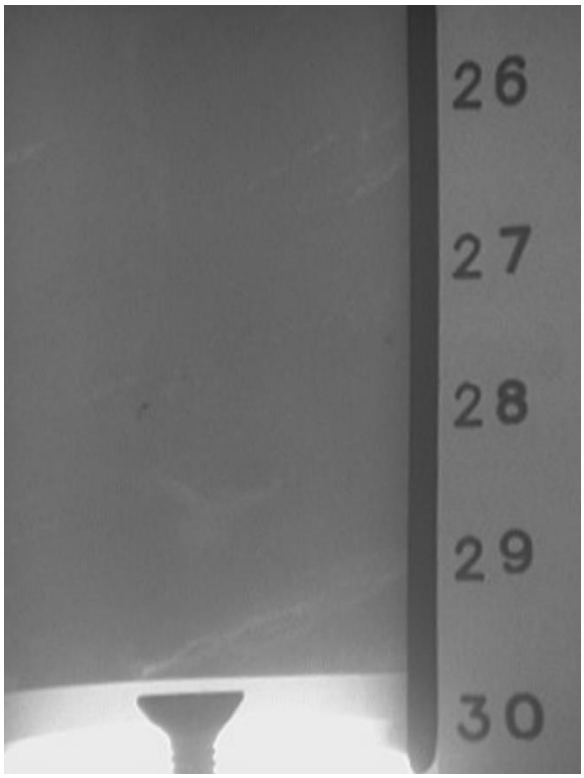
6	
	Bottom of Tube

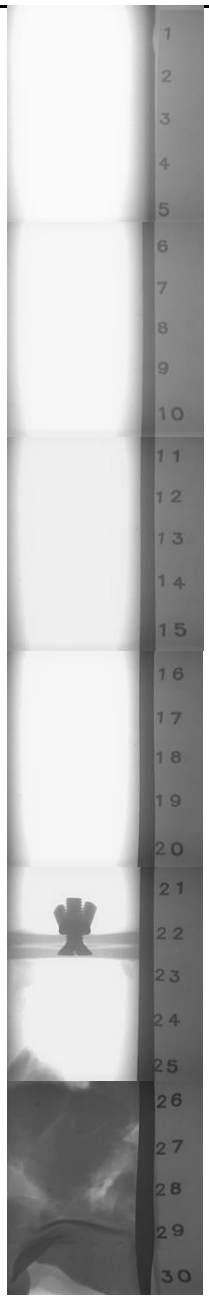


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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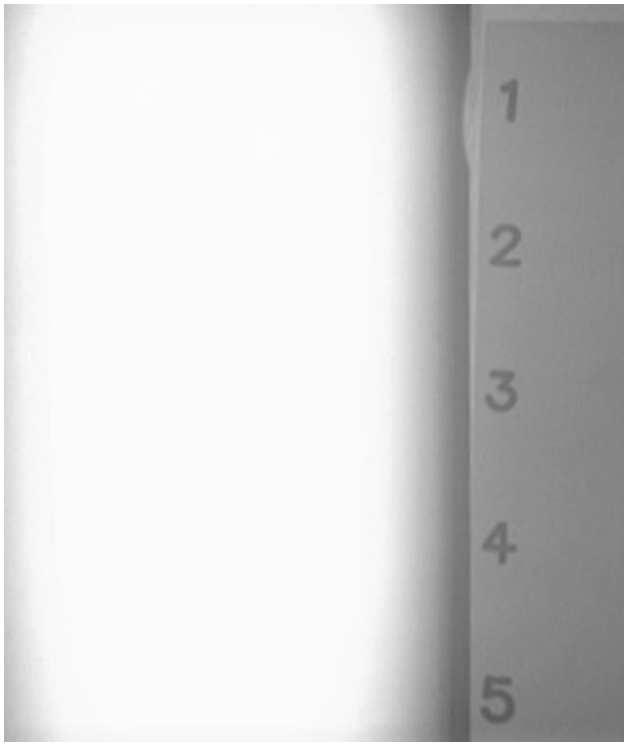
	Bottom of Tube

Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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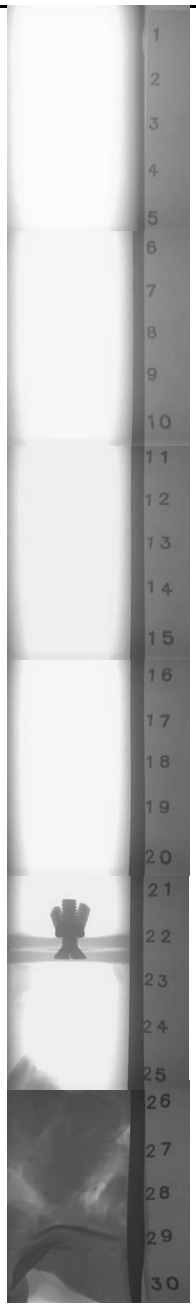
	Bottom of Tube



Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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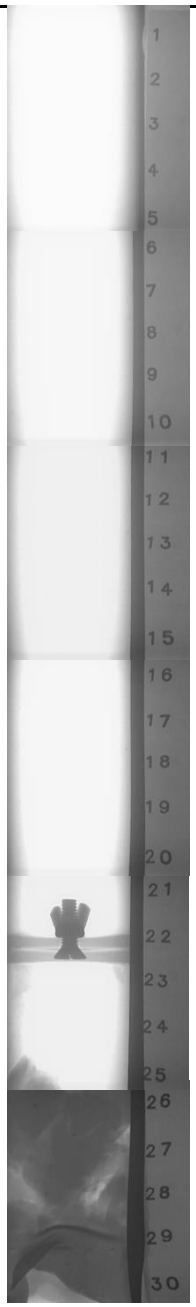
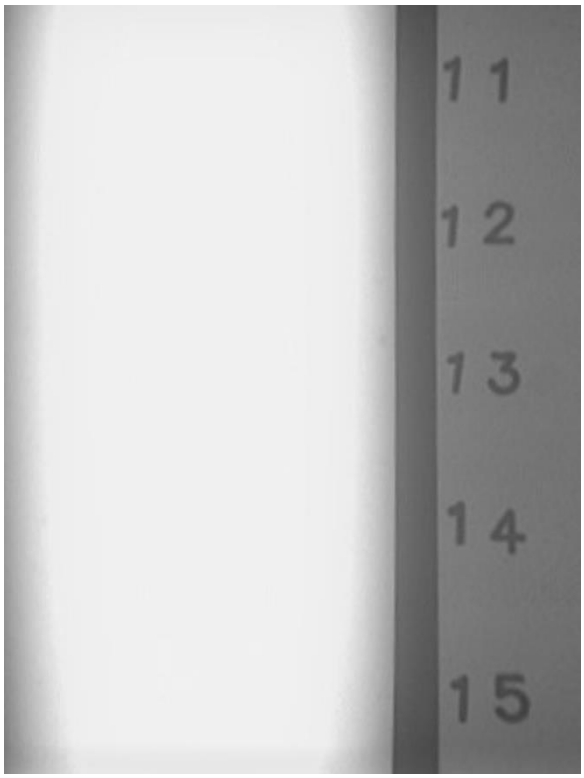
	Bottom of Tube

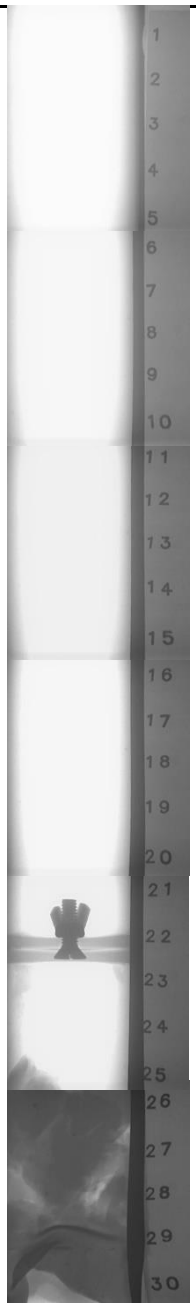


Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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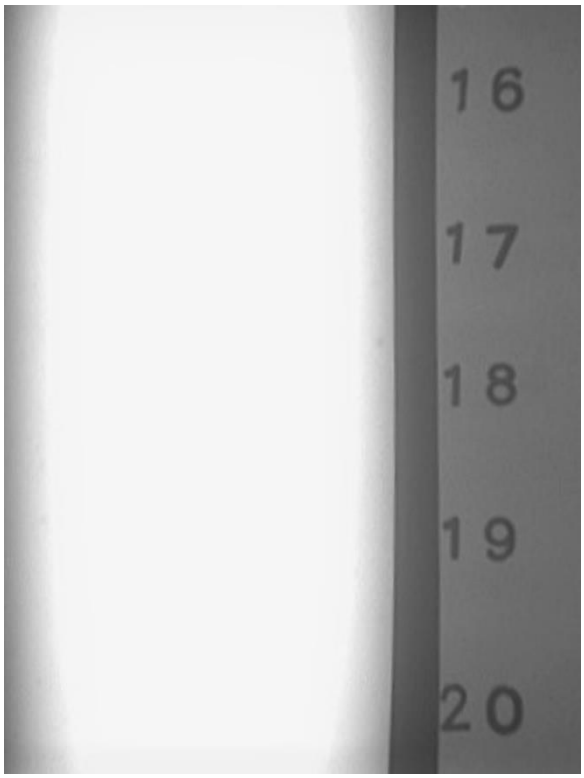
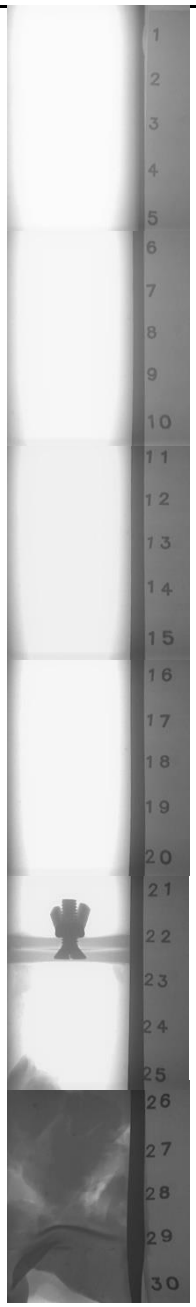
Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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	Bottom of Tube

Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	10/25/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1012
Sample ID:	ST-1
Depth:	209.9-210.3

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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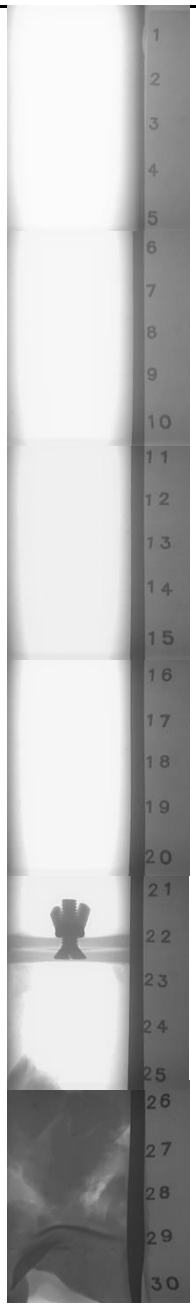
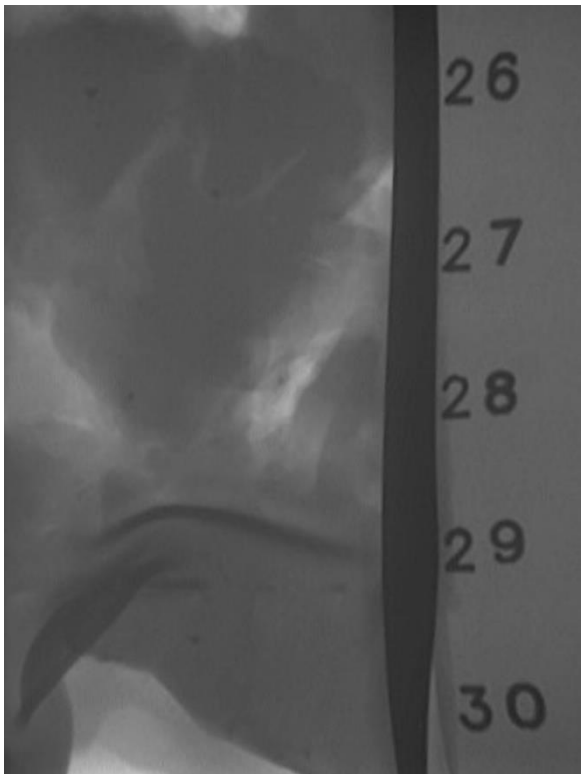
	Bottom of Tube

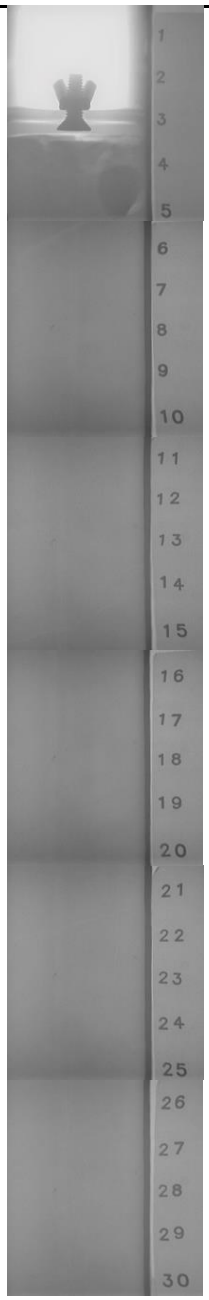


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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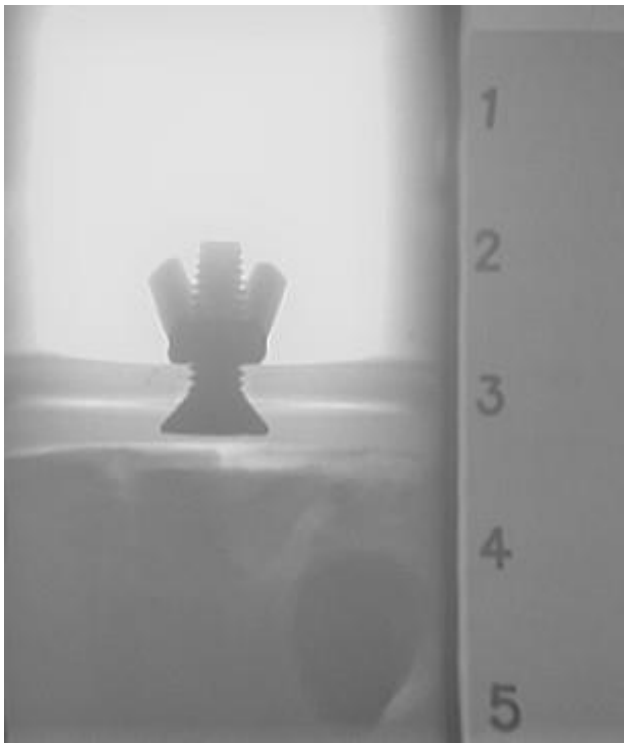
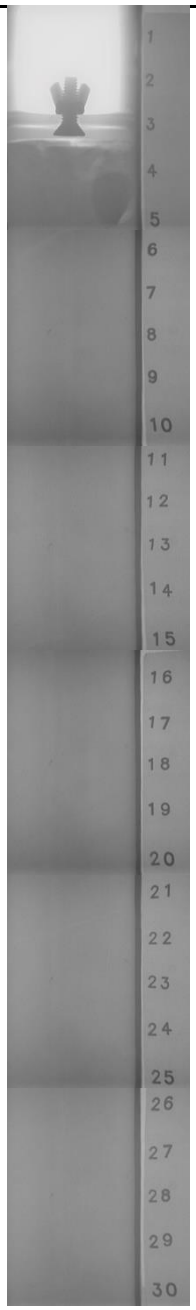
Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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	Bottom of Tube

Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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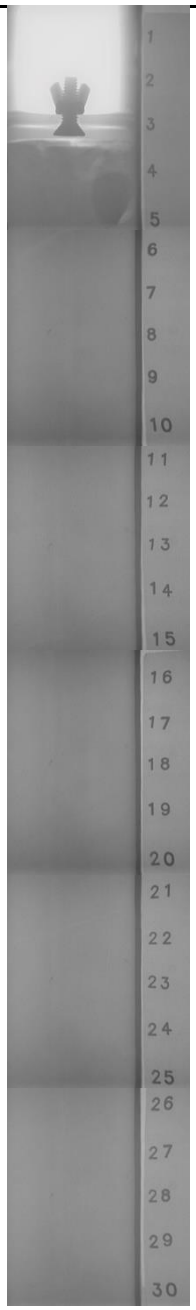
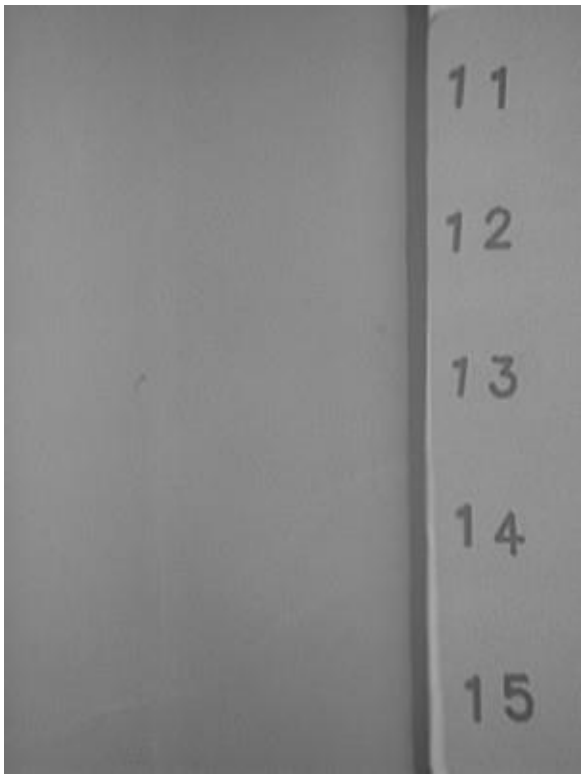
	Bottom of Tube



Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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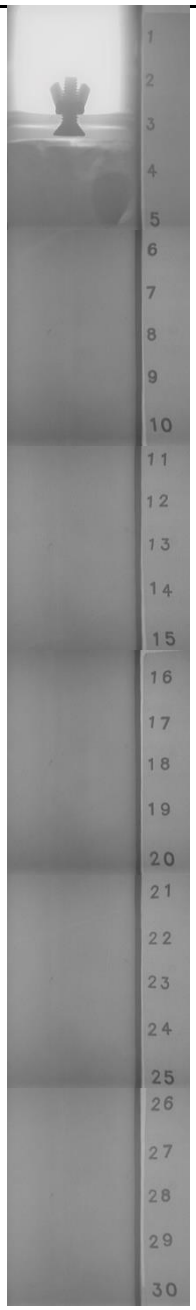

Section 4



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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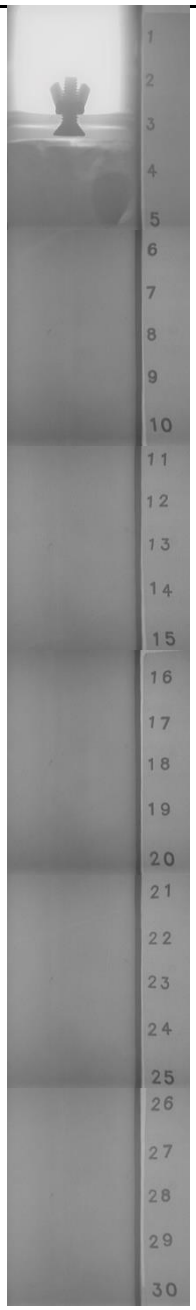
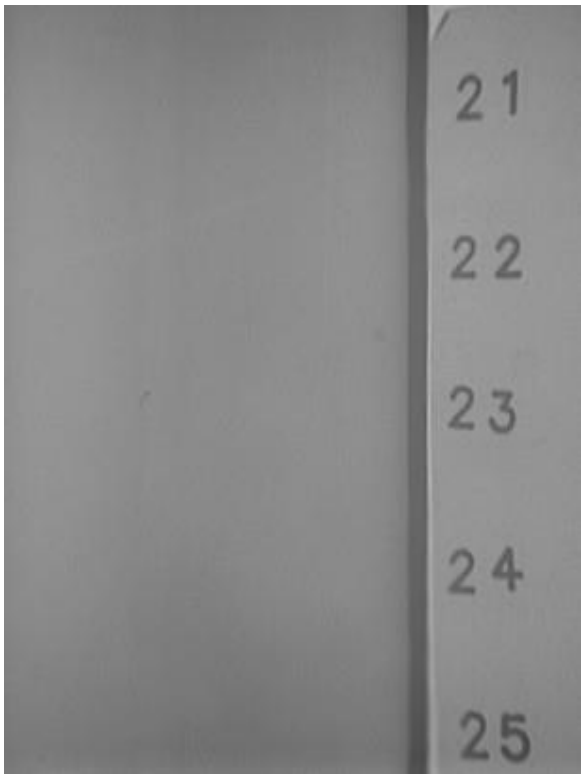
	Bottom of Tube



Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1023
Sample ID:	ST-2
Depth:	48.1-50.1

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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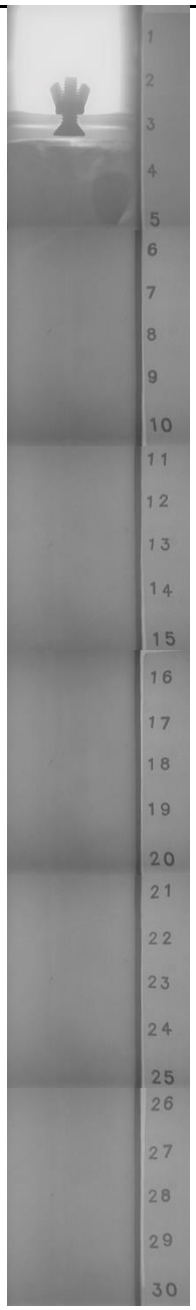
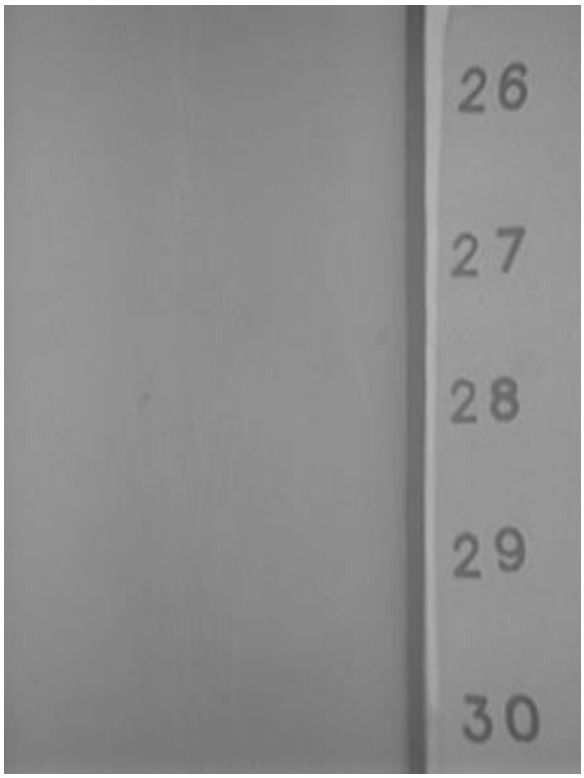
	Bottom of Tube

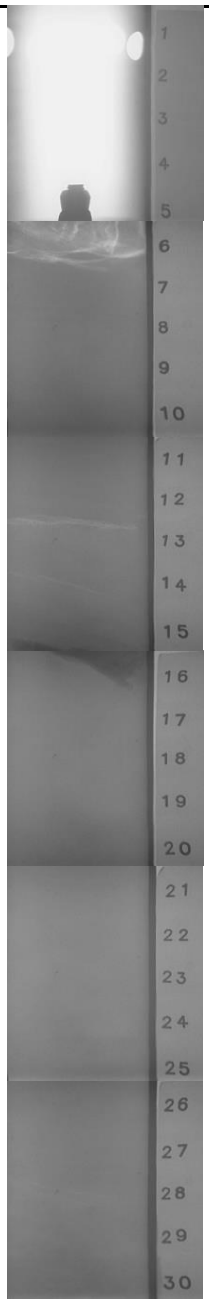


Section 6



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
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Section 1



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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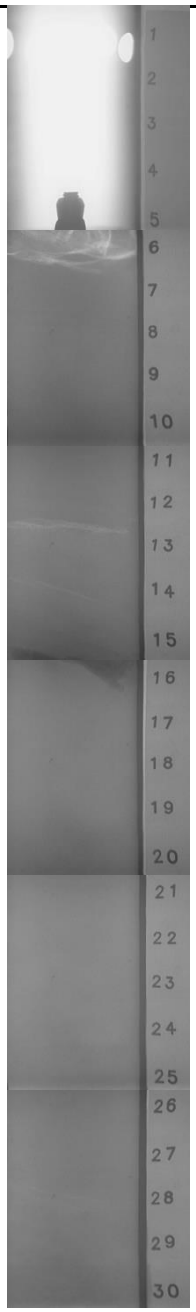
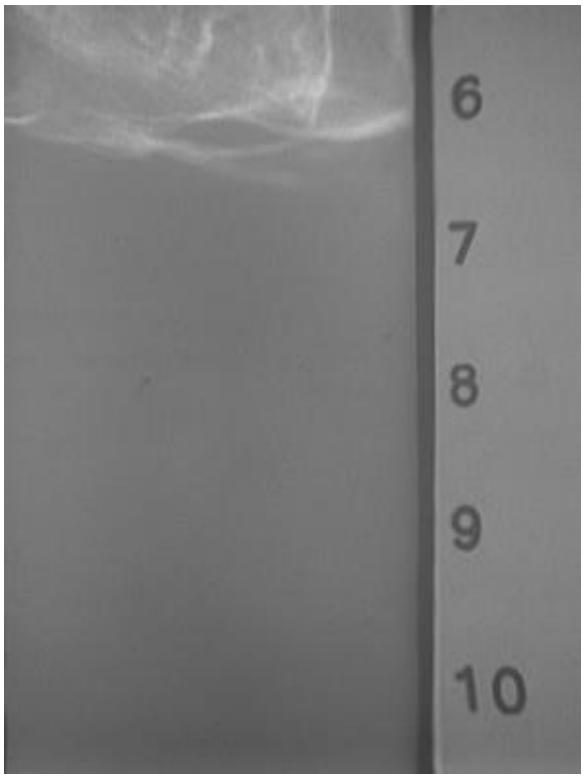
	Bottom of Tube



Section 2



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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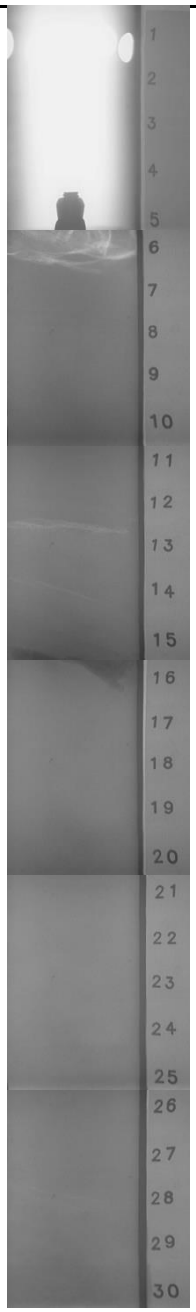
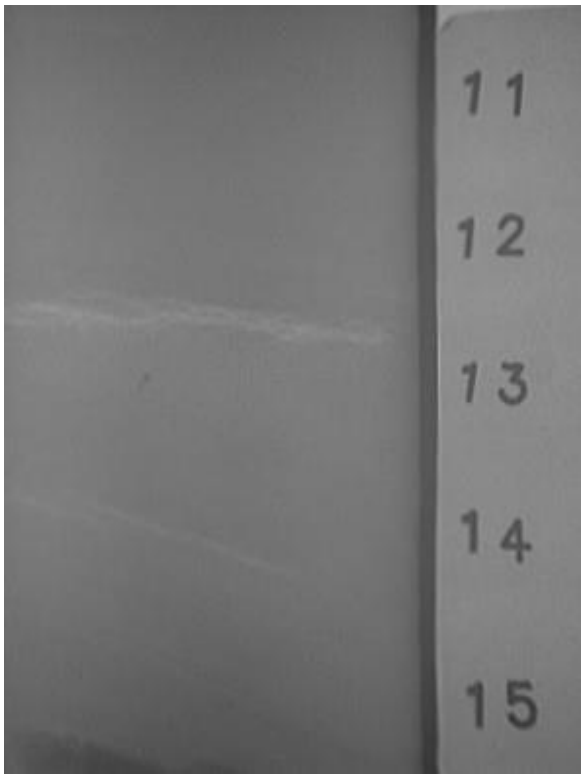
	Bottom of Tube



Section 3



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
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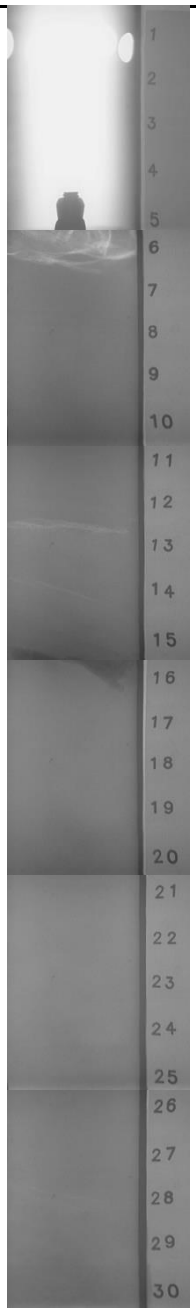
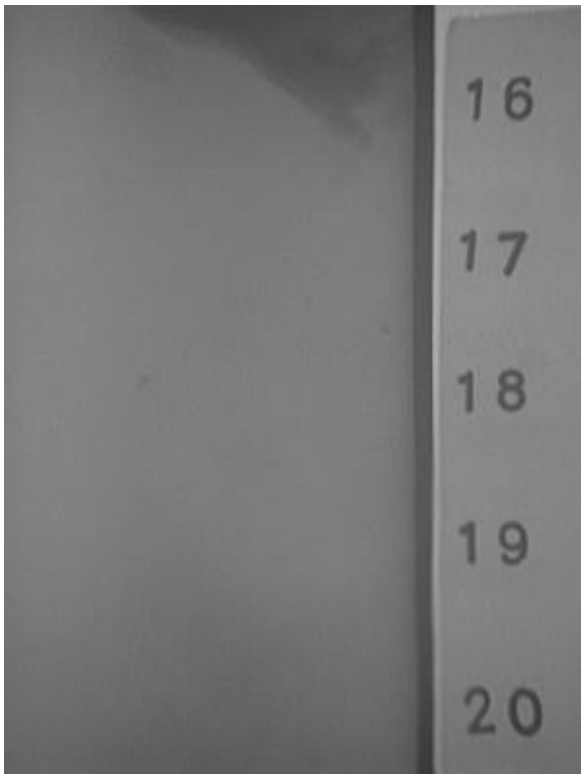
	Bottom of Tube



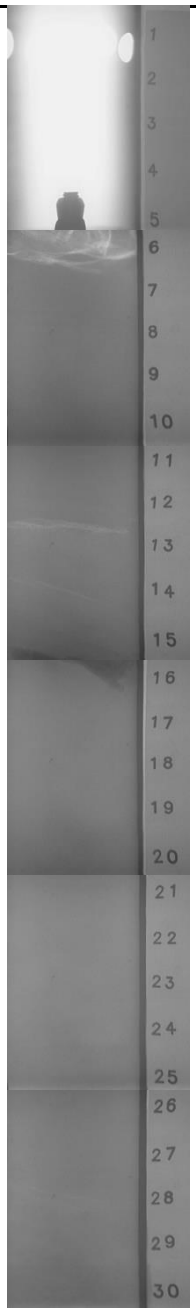
Section 4



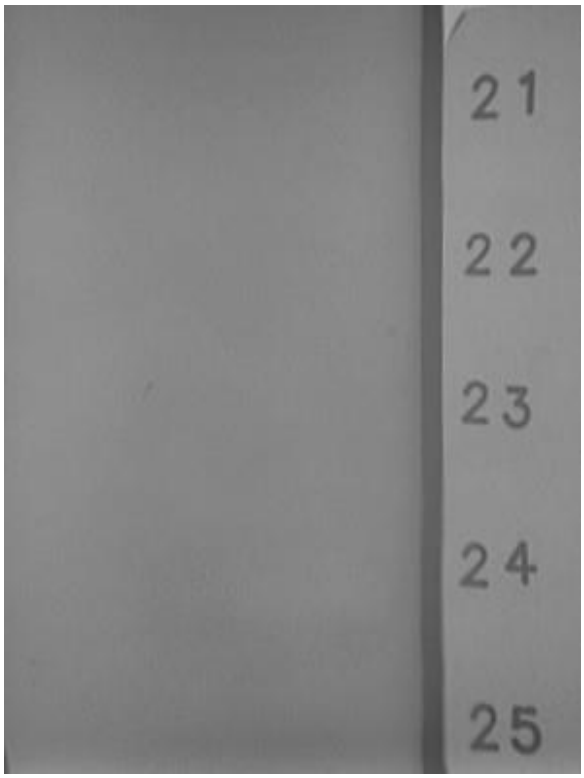
Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
Checked By:	jsc
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
3	
4	
5	
6	
	Bottom of Tube



Section 5



Client:	HDR Engineering, Inc.
Project Name:	US-51 Over Ohio River Updated
Project Location:	---
GTX #:	319809
Test Date:	09/16/24
Tested By:	te
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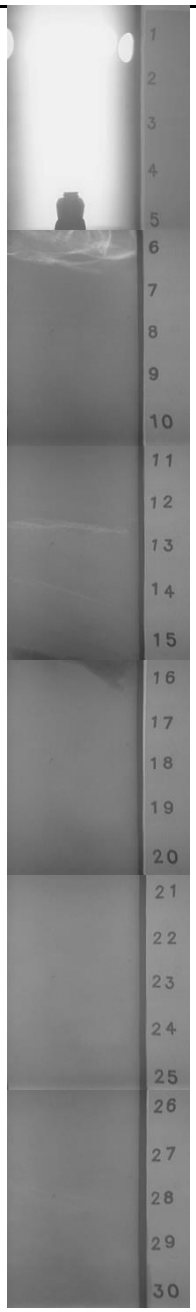
Boring ID:	B-1018
Sample ID:	ST-8
Depth:	88.8-90.8

X-Ray of Soil Sample by ASTM D4452

Section	Top of Tube
1	
2	
3	
4	
5	
6	
	Bottom of Tube



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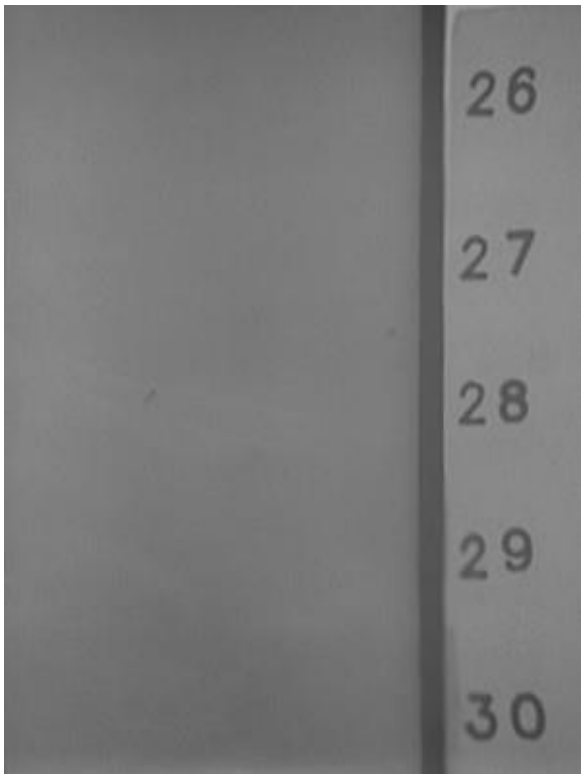

GeoTesting EXPRESS

WARRANTY and LIABILITY

GeoTesting Express (GTX) warrants that all tests it performs are run in general accordance with the specified test procedures and accepted industry practice. GTX will correct or repeat any test that does not comply with this warranty. GTX has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

GTX may report engineering parameters that require us to interpret the test data. Such parameters are determined using accepted engineering procedures. However, GTX does not warrant that these parameters accurately reflect the true engineering properties of the *in situ* material. Responsibility for interpretation and use of the test data and these parameters for engineering and/or construction purposes rests solely with the user and not with GTX or any of its employees.

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Commonly Used Symbols

A	pore pressure parameter for $\Delta\sigma_1 - \Delta\sigma_3$
B	pore pressure parameter for $\Delta\sigma_3$
CAI	CERCHAR Abrasiveness Index
CIU	isotropically consolidated undrained triaxial shear test
CR	compression ratio for one dimensional consolidation
CSR	cyclic stress ratio
C_c	coefficient of curvature, $(D_{30})^2 / (D_{10} \times D_{60})$
C_u	coefficient of uniformity, D_{60}/D_{10}
C_c	compression index for one dimensional consolidation
C_α	coefficient of secondary compression
c_v	coefficient of consolidation
c	cohesion intercept for total stresses
c'	cohesion intercept for effective stresses
D	diameter of specimen
D	damping ratio
D_{10}	diameter at which 10% of soil is finer
D_{15}	diameter at which 15% of soil is finer
D_{30}	diameter at which 30% of soil is finer
D_{50}	diameter at which 50% of soil is finer
D_{60}	diameter at which 60% of soil is finer
D_{85}	diameter at which 85% of soil is finer
d_{50}	displacement for 50% consolidation
d_{90}	displacement for 90% consolidation
d_{100}	displacement for 100% consolidation
E	Young's modulus
e	void ratio
e_c	void ratio after consolidation
e_o	initial void ratio
G	shear modulus
G_s	specific gravity of soil particles
H	height of specimen
H_R	Rebound Hardness number
i	gradient
I_S	Uncorrected point load strength
$I_{S(50)}$	Size corrected point load strength index
H_A	Modified Taber Abrasion
H_T	Total hardness
K_o	lateral stress ratio for one dimensional strain
k	permeability
LI	Liquidity Index
m_v	coefficient of volume change
n	porosity
PI	plasticity index
P_c	preconsolidation pressure
p	$(\sigma_1 + \sigma_3) / 2$, $(\sigma_v + \sigma_h) / 2$
p'	$(\sigma'_1 + \sigma'_3) / 2$, $(\sigma'_v + \sigma'_h) / 2$
p'_c	p' at consolidation
Q	quantity of flow
q	$(\sigma_1 - \sigma_3) / 2$
q_f	q at failure
q_o, q_i	initial q
q_c	q at consolidation
S_r	Post cyclic undrained shear strength
T	temperature
t	time
U, UC	unconfined compression test
UU, Q	unconsolidated undrained triaxial test
u_a	pore gas pressure
u_e	excess pore water pressure
u, u_w	pore water pressure
V	total volume
V_g	volume of gas
V_s	volume of solids
V_s	shear wave velocity
V_v	volume of voids
V_w	volume of water
V_o	initial volume
v	velocity
W	total weight
W_s	weight of solids
W_w	weight of water
w	water content
w_c	water content at consolidation
w_f	final water content
w_l	liquid limit
w_n	natural water content
w_p	plastic limit
w_s	shrinkage limit
w_o, w_i	initial water content
α	slope of q_f versus p_f
α'	slope of q_f versus p_f'
γ_t	total unit weight
γ_d	dry unit weight
γ_s	unit weight of solids
γ_w	unit weight of water
ε	strain
ε_{vol}	volume strain
ε_h, ε_v	horizontal strain, vertical strain
μ	Poisson's ratio, also viscosity
σ	normal stress
σ'	effective normal stress
σ_c, σ'_c	consolidation stress in isotropic stress system
σ_h, σ'_h	horizontal normal stress
σ_v, σ'_v	vertical normal stress
σ'_{vc}	Effective vertical consolidation stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
τ	shear stress
φ	friction angle based on total stresses
φ'	friction angle based on effective stresses
φ'_r	residual friction angle
φ_{ult}	φ for ultimate strength

Appendix D – Soil Parameters

Static Soil Profiles

Static Soil Profile at Pier 3

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 3: 294.6 ft

Elevation: 270.0 ft (0.0 ft BPC | 0.0 ft BML) Bottom of Pile Cap @ Elev. 270.0 ft

Soil No. I c = 0 psf ϕ = 30° γ = 125 pcf

100-yrs Scour: Elev. 248.4 ft (21.6 ft BPC | 21.6 ft BML)

Elevation: 244.3 ft (25.7 ft BPC | 25.7 ft BML | 4.1 ft *100-yrs*)

Soil No. II c = 0 psf ϕ = 36° γ = 130 pcf

500-yrs Scour: Elev. 215.2 ft (54.8 ft BPC | 54.8 ft BML)

Elevation: 210.0 ft (60.0 ft BPC | 60.0 ft BML | 38.4 ft *100-yrs* | 5.2 ft *500-yrs*)

Soil No. III c = 0 psf ϕ = 31° γ = 125 pcf

Elevation: 181.1 ft (88.9 ft BPC | 88.9 ft BML | 67.3 ft *100-yrs* | 34.1 ft *500yrs*)

Soil No. IV c = 0 psf ϕ = 36° γ = 140 pcf

Elevation: 30.9 ft (239.1 ft BPC | 239.1 ft BML | 217.5 ft *100-yrs* | 184.3 ft *500-yrs*)

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) Axial resistance estimation developed for 48-in diameter pipe pile.

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001, B-1002, & B-1002-A**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SM, SP-SM, SP, SW, GP-GM	270.0	-	244.3	125	62.6	0	30	0	30	Sand (Reese)	10	20	20	--	0.20	0.4
II	SM, SP, SP-SM	244.3	-	210.0	130	67.6	0	36	0	36	Sand (Reese)	40	90	90	--	0.30	1.5
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	125	62.6	0	31	0	31	Sand (Reese)	26	60	60	--	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001, B-1002, & B-1002-A**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
I	SM, SP-SM, SP, SW, GP-GM	270.0	-	244.3	7	0.10	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	8
II	SM, SP, SP-SM	244.3	-	210.0	1049	0.80	20	0.80	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	32
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	1685	0.78	853	0.78	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	25
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	2080	1.46	2076	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Based on 100-YR Scour (El. 248.4 ft MSL)
4. Based on 500-YR Scour (El. 215.2 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 3 - 96-IN DIA. SHAFTS **Borings: B-1001, B-1002, B-1002-A**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SM, SP-SM, SP, SW, GP-GM	270.0	-	244.3	125	62.6	0	30	0	30	Sand (Reese)	10	16	20	20.000	0.20	0.4
II	SM, SP, SP-SM	244.3	-	210.0	130	67.6	0	36	0	36	Sand (Reese)	40	90	90	125.000	0.30	1.5
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	125	62.6	0	31	0	31	Sand (Reese)	26	31	60	60.000	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	Sand (Reese)	100	31	125	125.000	0.40	3.5

Pier 3 - 96-IN DIA. SHAFTS **Borings: B-1001, B-1002, B-1002-A**

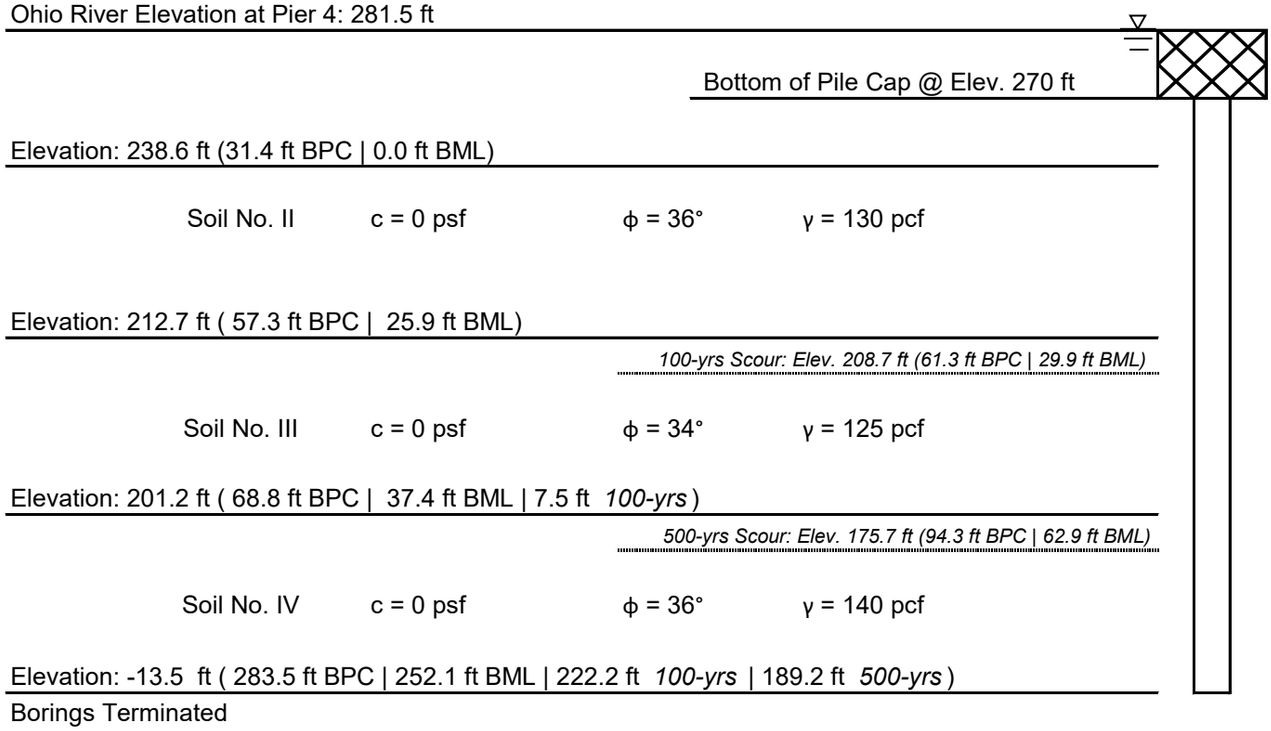
Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	SM, SP-SM, SP, SW, GP-GM	270.0	-	244.3	7	0.01	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	8
III	SM, SP, SP-SM	244.3	-	210.0	693	0.05	15	0.00	Drilled Shaft Sand	Drilled Shaft Sand	32
IV	SC-SM, SM, SP-SM, ML	210.0	-	181.1	1402	0.05	651	0.05	Drilled Shaft Sand	Drilled Shaft Sand	25
V	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	3458	0.12	3367.79	0.12	Drilled Shaft Sand	Drilled Shaft Sand	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Based on 100-YR Scour (El. 248.4 ft MSL)
4. Based on 500-YR Scour (El. 215.2 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Static Soil Profile at Pier 4

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Note:

(1) BPC - Below Pile Cap

(2) BML - Below Mudline

(3) Axial resistance estimation developed for 48-in diameter pipe pile.

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
II	GP, SP, SP-SM, SM, GW, GW-GM	238.6	-	212.7	130	67.6	0	36	0	36	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, SP-SM, SC-SM	212.7	-	201.2	125	62.6	0	34	0	34	Sand (Reese)	37	60	60	--	0.30	1.4
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	140	77.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
II	GP, SP, SP-SM, SM, GW, GW-GM	238.6	-	212.7	0	0.00	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	25
III	SM, SP-SM, SC-SM	212.7	-	201.2	108	0.52	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	35
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	1966	1.40	1661	1.40	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Based on 100-YR Scour (El. 208.7 ft MSL)
4. Based on 500-YR Scour (El. 175.7 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 4 - 96-IN DIA. SHAFTS **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
II	GP, SP, SP-SM, SM, GW, GW-GM	238.6	-	212.7	130	67.6	0	36	0	36	Sand (Reese)	30	90	90	125.000	0.25	1.2
III	SM, SP-SM, SC-SM	212.7	-	201.2	125	62.6	0	34	0	34	Sand (Reese)	37	42	60	60.000	0.30	1.4
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	140	77.6	0	36	0	36	Sand (Reese)	100	38	125	125.000	0.40	3.5

Pier 4 - 96-IN DIA. SHAFTS **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	GP, SP, SP-SM, SM, GW, GW-GM	238.6	-	212.7	0	0.00	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	25
III	SM, SP-SM, SC-SM	212.7	-	201.2	84	0.04	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	35
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	3206	0.11	2831	0.10	Drilled Shaft Sand	Drilled Shaft Sand	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Based on 100-YR Scour (El. 208.7 ft MSL)
4. Based on 500-YR Scour (El. 175.7 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Static Soil Profile at Pier 5

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 5: 287.2 ft

Bottom of Pile Cap @ Elev. 270.0 ft

Elevation: 244.3 ft (25.7 ft BPC | 0 ft BML)

100-YR Scour: Elev. 214.6 ft (55.4 ft BPC | 29.7 ft BML)

Soil No. II c = 0 psf ϕ = 36° γ = 130 pcf

Elevation: 179.9 ft (90.1 ft BPC | 64.4 ft BML | 34.7 ft B100YS)

Soil No. III c = 0 psf ϕ = 34° γ = 125 pcf

Elevation: 157.6 ft (112.4 ft BPC | 86.7 ft BML | 57 ft B100YS)

500-YR Scour: Elev. 153.3 ft (116.7 ft BPC | 91 ft BML)

Soil No. IV c = 0 psf ϕ = 36° γ = 135 pcf

Elevation: -27.6 ft (297.6 ft BPC | 271.9 ft BML | 242.2 ft B100YS | 180.9 ft B500YS)

Soil No. V c = 0 psf ϕ = 31° γ = 140 pcf

Elevation: -84.4 ft (354.4 ft BPC | 328.7 ft BML | 299 ft B100YS | 237.7 ft B500YS)

Soil No. VI c = 4,000 psf ϕ = 0° γ = 125 pcf

Elevation: -159 ft (429 ft BPC | 403.3 ft BML | 373.6 ft B100YS | 312.3 ft B500YS)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) B100YS - Below 100-YR Scour Elevation
(4) B500YS - Below 500-YR Scour Elevation
(5) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
II	GM, SW, SP, SP-SM, SM	244.3	-	179.9	130	67.6	0	36	0	36	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
II	GM, SW, SP, SP-SM, SM	244.3	-	179.9	481	0.62	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1913	1.21	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	2080	1.46	1815	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SM	-27.6	-	-84.4	***	***	***	***	***	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Based on 100-YR Scour (El. 214.6 ft MSL)
4. Based on 500-YR Scour (El. 153.3 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
II	GM, SW, SP, SP-SM, SM	244.3	-	179.9	130	67.6	0	36	0	36	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	GM, SW, SP, SP-SM, SM	244.3	-	179.9	309	0.04	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1494	0.09	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	3735	0.11	3023	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SM	-27.6	-	-84.4	***	***	***	***	Drilled Shaft Sand	Drilled Shaft Sand	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Based on 100-YR Scour (El. 214.6 ft MSL)
4. Based on 500-YR Scour (El. 153.3 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Static Soil Profile at Pier 6

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 6: 286.5 ft

Bottom of Pile Cap @ Elev. 270.0 ft

Elevation: 257.7 ft (12.3 ft BPC | 0.0 ft BML)

Soil No. I	c = 0 psf	ϕ = 28°	γ = 125 pcf

Elevation: 242.7 ft (27.3 ft BPC | 15.0 ft BML)

100-YR Scour: Elev. 235.2 ft (34.8 ft BPC | 22.5 ft BML)

Soil No. II	c = 0 psf	ϕ = 36°	γ = 125 pcf

Elevation: 212.7 ft (57.3 ft BPC | 45.0 ft BML | 22.5 ft B100YS)

Soil No. III	c = 0 psf	ϕ = 32°	γ = 120 pcf

Elevation: 177.7 ft (92.3 ft BPC | 80.0 ft BML | 57.5 ft B100YS)

500-YR Scour: Elev. 174.7 ft (95.3 ft BPC | 83.0 ft BML)

Soil No. IV	c = 0 psf	ϕ = 36°	γ = 135 pcf

Elevation: -42.3 ft (312.3 ft BPC | 300.0 ft BML | 277.5 ft B100YS | 217.0 ft B500YS)

Soil No. V	c = 0 psf	ϕ = 32°	γ = 130 pcf

Elevation: -87.3 ft (357.3 ft BPC | 345.0 ft BML | 322.5 ft B100YS | 262.0 ft B500YS)

Soil No. VI	c = 4,000 psf	ϕ = 0°	γ = 125 pcf

Elevation: -145 ft (415 ft BPC | 402.7 ft BML | 380.2 ft B100YS | 319.7 ft B500YS)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) B100YS - Below 100-YR Scour Elevation
(4) B500YS - Below 500-YR Scour Elevation
(5) Axial resistance estimation developed for 72-in diameter pipe pile & 96-in diameter drilled shaft.

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SW, CL, SM, SW-SM, SP, SC	257.7	-	242.7	125	62.6	0	28	0	28	Sand (Reese)	12	20	20	--	0.25	0.5
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.7	-	212.7	125	62.6	0	36	0	36	Sand (Reese)	37	90	90	--	0.30	1.4
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	120	57.6	0	32	0	32	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	Stiff Clay w/ Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
I	SW, CL, SM, SW-SM, SP, SC	257.7	-	242.7	0	0.00	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	6
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.7	-	212.7	428	0.55	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	30
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	1453	0.74	0	0.00	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	20
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	2080	1.46	1871.00	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	***	***	***	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	39
VI	SM	-87.3	-	-145.0	***	***	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 257.7 ft MSL
3. Based on 100-YR Scour (El. 235.2 ft MSL)
4. Based on 500-YR Scour (El. 174.7 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 6 - 96-IN DIA. SHAFTS **Borings: B-1012, B-1013, B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SW, CL, SM, SW-SM, SP, SC	257.7	-	242.7	125	62.6	0	28	0	28	Sand (Reese)	12	20	20	--	0.25	0.5
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.7	-	212.7	125	62.6	0	36	0	36	Sand (Reese)	37	90	90	--	0.30	1.4
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	120	57.6	0	32	0	32	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	Stiff Clay w/ Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 96-IN DIA. SHAFTS **Borings: B-1012, B-1013, B-1014**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	SW, CL, SM, SW-SM, SP, SC	257.7	-	242.7	0	0.00	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	6
III	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.7	-	212.7	279	0.03	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	38
IV	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	1103	0.06	0	0.00	Drilled Shaft Sand	Drilled Shaft Sand	29
V	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	3857	0.11	3411.80	0.11	Drilled Shaft Sand	Drilled Shaft Sand	47
VI	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	***	***	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	SM	-87.3	-	-145.0	***	***	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

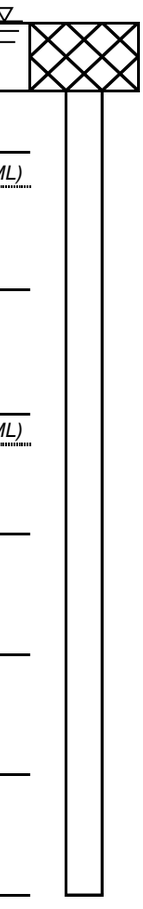
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 257.7 ft MSL
3. Based on 100-YR Scour (El. 235.2 ft MSL)
4. Based on 500-YR Scour (El. 174.7 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Static Soil Profile at Pier 7

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 7: 295.6 ft

Bottom of Pile Cap @ Elev. 270.0 ft



Elevation: 265.4 ft (4.6 ft BPC | 0 ft BML)

100-YR Scour: Elev. 243.5 ft (26.5 ft BPC | 21.9 ft BML)

Soil No. I	c = 0 psf	ϕ = 30°	γ = 120 pcf

Elevation: 238.2 ft (31.8 ft BPC | 27.2 ft BML | 5.3 ft B100YS)

Soil No. II	c = 0 psf	ϕ = 36°	γ = 125 pcf

Elevation: 212.9 ft (57.1 ft BPC | 52.5 ft BML | 30.6 ft B100YS)

500-YR Scour: Elev. 209.8 ft (60.2 ft BPC | 55.6 ft BML)

Soil No. III	c = 1600 psf	ϕ = 0°	γ = 120 pcf

Elevation: 173.2 ft (96.8 ft BPC | 92.2 ft BML | 70.3 ft B100YS) | 36.6 ft B500YS)

Soil No. IV	c = 0 psf	ϕ = 36°	γ = 135 pcf

Elevation: 39.1 ft (230.9 ft BPC | 226.3 ft BML | 204.4 ft B100YS) | 170.7 ft B500YS)

Soil No. V	c = 0 psf	ϕ = 34°	γ = 135 pcf

Elevation: -33.2 ft (303.2 ft BPC | 298.6 ft BML | 276.7 ft B100YS) | 243 ft B500YS)

Soil No. VI	c = 4,000 psf	ϕ = 0°	γ = 125 pcf

Elevation: -38.1 ft (308.1 ft BPC | 303.5 ft BML | 281.6 ft B100YS) | 247.9 ft B500YS)

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) B100YS - Below 100-yr Scour
(4) B500YS - Below 500-yr Scour
(5) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shaft.

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SM, SP-SM, GP, GM, ML	265.4	-	238.2	120	57.6	0	30	0	30	Sand (Reese)	16	20	20	--	0.20	0.6
II	SM	238.2	-	212.9	125	62.6	0	36	0	36	Sand (Reese)	55	90	90	--	0.30	2.1
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	120	57.6	1600	0	50	32	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
I	SM, SP-SM, GP, GM, ML	265.4	-	238.2	17	0.10	***	***	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	10
II	SM	238.2	-	212.9	843	0.68	***	***	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	40
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	1000	0.10	744	0.10	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	20
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	2080	1.46	2075.59	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SP, SP-SM, SM	39.1	-	-33.2	1940	1.25	1940.00	1.25	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	39
VI	MH	-33.2	-	-38.1	1000	0.25	1000.00	0.25	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Based on 100-YR Scour (El. 243.5 ft MSL)
4. Based on 500-YR Scour (El. 209.8 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 7 - 96-IN DIA. SHAFTS **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SM, SP-SM, GP, GM, ML	265.4	-	238.2	120	57.6	0	30	0	30	Sand (Reese)	16	20	20	--	0.20	0.6
II	SM	238.2	-	212.9	125	62.6	0	36	0	36	Sand (Reese)	55	90	90	--	0.30	2.1
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	120	57.6	1600	0	50	32	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 96-IN DIA. SHAFTS **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	SM, SP-SM, GP, GM, ML	265.4	-	238.2	16	0.01	***	***	Drilled Shaft Sand	Drilled Shaft Sand	10
III	SM	238.2	-	212.9	548	0.07	***	***	Drilled Shaft Sand	Drilled Shaft Sand	40
IV	SM, CL, CL-ML, SC-SM	212.9	-	173.2	880	0.09	792	0.09	Drilled Shaft Clay	Drilled Shaft Clay	20
V	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	3097	0.11	3013.90	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
VI	SW, SP, SP-SM, SM	39.1	-	-33.2	5035	0.08	5035.38	0.08	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	MH	-33.2	-	-38.1	2799	0.17	2799.20	0.17	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

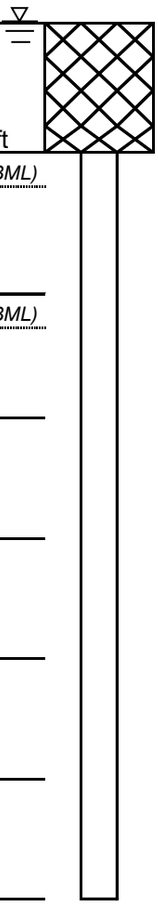
Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Based on 100-YR Scour (El. 243.5 ft MSL)
4. Based on 500-YR Scour (El. 209.8 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Static Soil Profile at Pier 8

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 8: 292.6 ft



Elevation: 270 ft (0 ft BPC | 0 ft BML) — Bottom of Pile Cap @ Elev. 270.0 ft

100-YR Scour: Elev. 252.6 ft (17.4 ft BPC | 17.4 ft BML)

Soil No. I c = 450 psf ϕ = 0° γ = 110 pcf

Elevation: 245.9 ft (24.1 ft BPC | 24.1 ft BML | 6.7 ft B100YS)

500-YR Scour: Elev. 220.3 ft (49.7 ft BPC | 49.7 ft BML)

Soil No. II c = 0 psf ϕ = 33° γ = 125 pcf

Elevation: 210.9 ft (59.1 ft BPC | 59.1 ft BML | 41.7 ft B100YS) | 9.4 ft B500YS)

Soil No. III c = 1600 psf ϕ = 0° γ = 125 pcf

Elevation: 171.9 ft (98.1 ft BPC | 98.1 ft BML | 80.7 ft B100YS) | 48.4 ft B500YS)

Soil No. IV c = 0 psf ϕ = 36° γ = 135 pcf

Elevation: 86.9 ft (183.1 ft BPC | 183.1 ft BML | 165.7 ft B100YS) | 133.4 ft B500YS)

Soil No. V c = 0 psf ϕ = 33° γ = 130 pcf

Elevation: 43.9 ft (226.1 ft BPC | 226.1 ft BML | 208.7 ft B100YS) | 176.4 ft B500YS)

Soil No. VI c = 4,000 psf ϕ = 0° γ = 125 pcf

Elevation: -31.2 ft (301.2 ft BPC | 301.2 ft BML | 283.8 ft B100YS) | 251.5 ft B500YS)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) B100YS - Below 100-yr Scour
(4) B500YS - Below 500-yr Scour
(5) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shaft.

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SP-SM, SC, CH, SP, CL, ML	270.0	-	245.9	110	47.6	450	0	50	28	Soft Clay (Matlock)	6	30	--	0.020	0.50	0.3
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	125	62.6	0	33	0	33	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	125	62.6	1600	0	50	32	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	Sand (Reese)	21	60	60	--	0.25	0.8
VI	CL, ML, SM	43.9	-	-31.2	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	13	2000	1000	0.004	0.50	2.8

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters				
					STR-I, SER-I [3]		EE-II [4]		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)					
I	SP-SM, SC, CH, SP, CL, ML	270.0	-	245.9	55	0.03	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	4
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	846	0.50	51	0.50	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	20
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	1000	0.10	937	0.10	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	24
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2080	1.46	2080.00	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SM, SP, SP-SM	86.9	-	43.9	1880	1.11	1880.00	1.11	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	29
VI	CL, ML, SM	43.9	-	-31.2	1000	0.25	1000.00	0.25	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	26

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Based on 100-YR Scour (El. 252.6 ft MSL)
4. Based on 500-YR Scour (El. 220.3 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 8 - 96-IN DIA. SHAFTS **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)							
I	SP-SM, SC, CH, SP, CL, ML	270.0	-	245.9	110	47.6	450	0	50	28	Soft Clay (Matlock)	6	30	--	0.020	0.50	0.3
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	125	62.6	0	33	0	33	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	125	62.6	1600	0	50	32	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	Sand (Reese)	21	60	60	--	0.25	0.8
VI	CL, ML, SM	43.9	-	-31.2	125	62.6	4000	0	4000	0	Stiff Clay w/o Free Water (Reese)	13	2000	1000	0.004	0.50	2.8

Pier 8 - 96-IN DIA. SHAFTS **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Average Axial Resistance				Axial Soil Resistance - FBMP Parameters		
					STR-I, SER-I [3]		EE-II [4]		t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)	Unit Skin (psf)	Unit Toe (ksi)			
II	SP-SM, SC, CH, SP, CL, ML	270.0	-	245.9	69	0.01	***	***	Drilled Shaft Clay	Drilled Shaft Clay	4
III	SM, CL, SP-SM, GP-GM	245.9	-	210.9	641	0.05	40	0.02	Drilled Shaft Sand	Drilled Shaft Sand	20
IV	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	880	0.09	880	0.09	Drilled Shaft Clay	Drilled Shaft Clay	24
V	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2668	0.11	2633.60	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
VI	SW, SM, SP, SP-SM	86.9	-	43.9	4029	0.08	4029.30	0.08	Drilled Shaft Sand	Drilled Shaft Sand	29
VI	CL, ML, SM	43.9	-	-31.2	2799	0.17	2799.20	0.17	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	26

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Based on 100-YR Scour (El. 252.6 ft MSL)
4. Based on 500-YR Scour (El. 220.3 ft MSL)
5. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

West Riverbank Toe **Borings: B-1024**

Soil	*Soil Type*	*Elevation*			*Shear Strength Properties*					
					Unit Weight (pcf)	*Effective Unit Weight (pcf)*	*Total Shear Strength*		*Effective Shear Strength*	
							c (psf)	*φ (°)*	*c' (psf)*	*φ' (°)*
II	GM, SP-SM, SP, SM	231.7	-	205.0	130	67.6	--	36	--	36
III	SC-SM, SM	205.0	-	190.3	125	62.6	--	31	--	31
IV	SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	190.3	-	78.9	140	77.6	--	36	--	36

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

Pier 3 **Borings: B-1001, B-1002**

Soil	*Soil Type*	*Elevation*			*Shear Strength Properties*					
					Unit Weight (pcf)	*Effective Unit Weight (pcf)*	*Total Shear Strength*		*Effective Shear Strength*	
							c (psf)	*φ (°)*	*c' (psf)*	*φ' (°)*
I	SM, SP-SM, SP, SW, GP-GM	272.7	-	244.3	125	62.6	--	30	--	30
II	SM, SP, SP-SM	244.3	-	210.0	130	67.6	--	36	--	36
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	125	62.6	--	31	--	31
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	--	36	--	36

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

East Riverbank Toe **Borings: B-1023**

Soil	Soil Type	Elevation			Shear Strength Properties					
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength	
							c (psf)	φ (°)	c' (psf)	φ' (°)
I	CL, CL-ML, SM	272.7	-	257.1	115	52.6	850	0	50	28
II	SM, GM, SP, SP-SM	257.1	-	225.1	125	62.6	0	32	0	32
III	ML, SM, CL, SC-SM	225.1	-	182.1	125	62.6	1600	0	50	29
IV	SM, SP-SM, SW, SP, SW-SM	184.0	-	115.2	135	72.6	0	36	0	36

Notes:
1. Normal pool elevation is at El. 300.0 ft MSL

East Riverbank Crest **Borings: B-3**

Soil	Soil Type	Elevation			Shear Strength Properties					
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength	
							c (psf)	φ (°)	c' (psf)	φ' (°)
I	CL, SM, SP-SM	315.1	-	300.0	115	115	850	0	50	28
I	CL, SM, SP-SM	300.0	-	268.1	115	52.6	850	0	50	28
II	SM, SP, SW. SW-SM	268.1	-	239.1	125	62.6	0	32	0	32
III	SC, SM, SC-SM, ML	239.1	-	186.1	125	62.6	1600	0	50	29
IV	SC-SM, SC, SP-SM, SM, SW-SM, SW	186.1	-	112.1	135	72.6	0	36	0	36

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

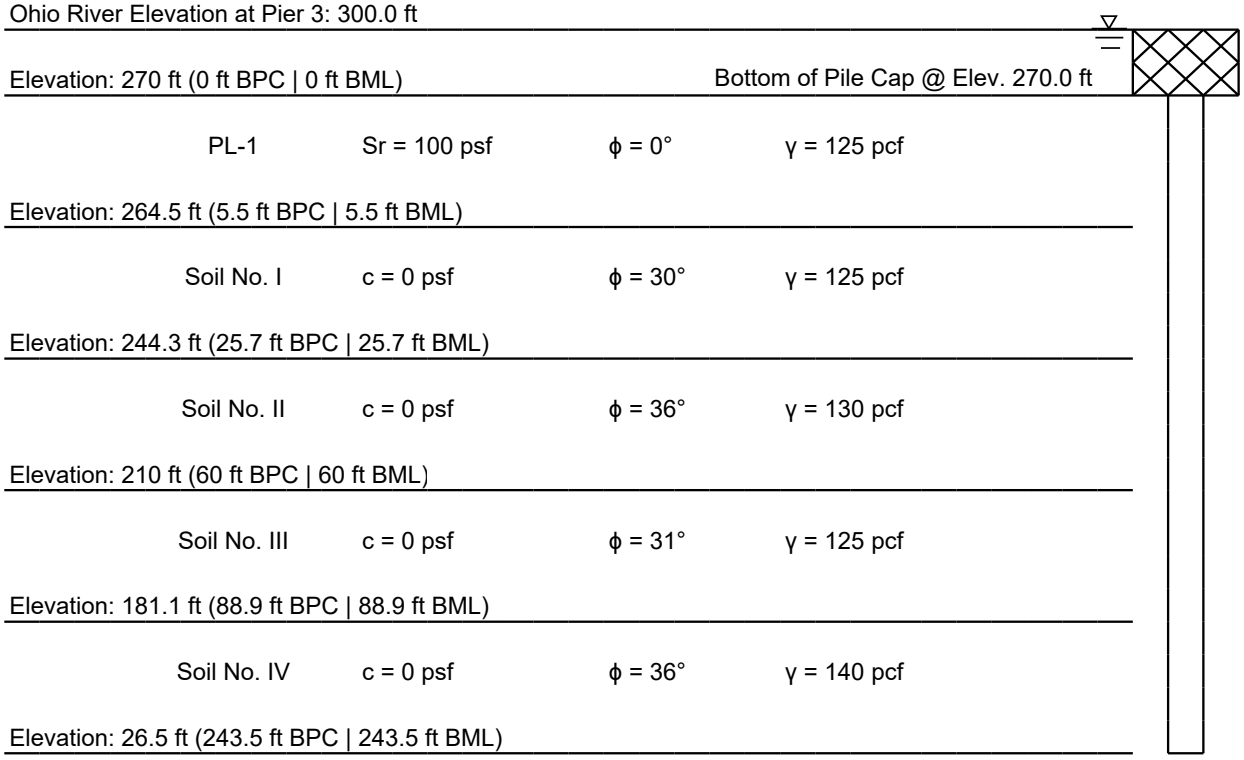
Seismic Soil Profiles

PIER 3

100-YR RETURN PERIOD

Seismic Soil Profile at Pier 3 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 48-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	125	62.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
I	SM, SP-SM, SP, SW, GP-GM	264.5	-	244.3	125	62.6	0	30	0	30	--	Sand (Reese)	10	20	20	--	0.20	0.4
II	SM, SP, SP-SM	244.3	-	210.0	130	67.6	0	36	0	36	--	Sand (Reese)	40	90	90	--	0.30	1.5
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	125	62.6	0	31	0	31	--	Sand (Reese)	26	60	60	--	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters				
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	51	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
I	SM, SP-SM, SP, SW, GP-GM	264.5	-	244.3	350	0.13	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	8
II	SM, SP, SP-SM	244.3	-	210.0	1319	0.80	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	32
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	1736	0.79	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	25
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 3 - 96-IN DIA. DRILLED SHAFT **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	125	62.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
I	SM, SP-SM, SP, SW, GP-GM	264.5	-	244.3	125	62.6	0	30	0	30	--	Sand (Reese)	10	20	20	--	0.20	0.4
II	SM, SP, SP-SM	244.3	-	210.0	130	67.6	0	36	0	36	--	Sand (Reese)	40	90	90	--	0.30	1.5
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	125	62.6	0	31	0	31	--	Sand (Reese)	26	60	60	--	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 3 - 96-IN DIA. DRILLED SHAFT **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters		
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	46	0.00	Drilled Shaft Clay	Drilled Shaft Clay	--
I	SM, SP-SM, SP, SW, GP-GM	264.5	-	244.3	281	0.02	Drilled Shaft Sand	Drilled Shaft Sand	8
II	SM, SP, SP-SM	244.3	-	210.0	833	0.05	Drilled Shaft Sand	Drilled Shaft Sand	32
III	SC-SM, SM, SP-SM, ML	210.0	-	181.1	1439	0.05	Drilled Shaft Sand	Drilled Shaft Sand	25
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	3255	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50

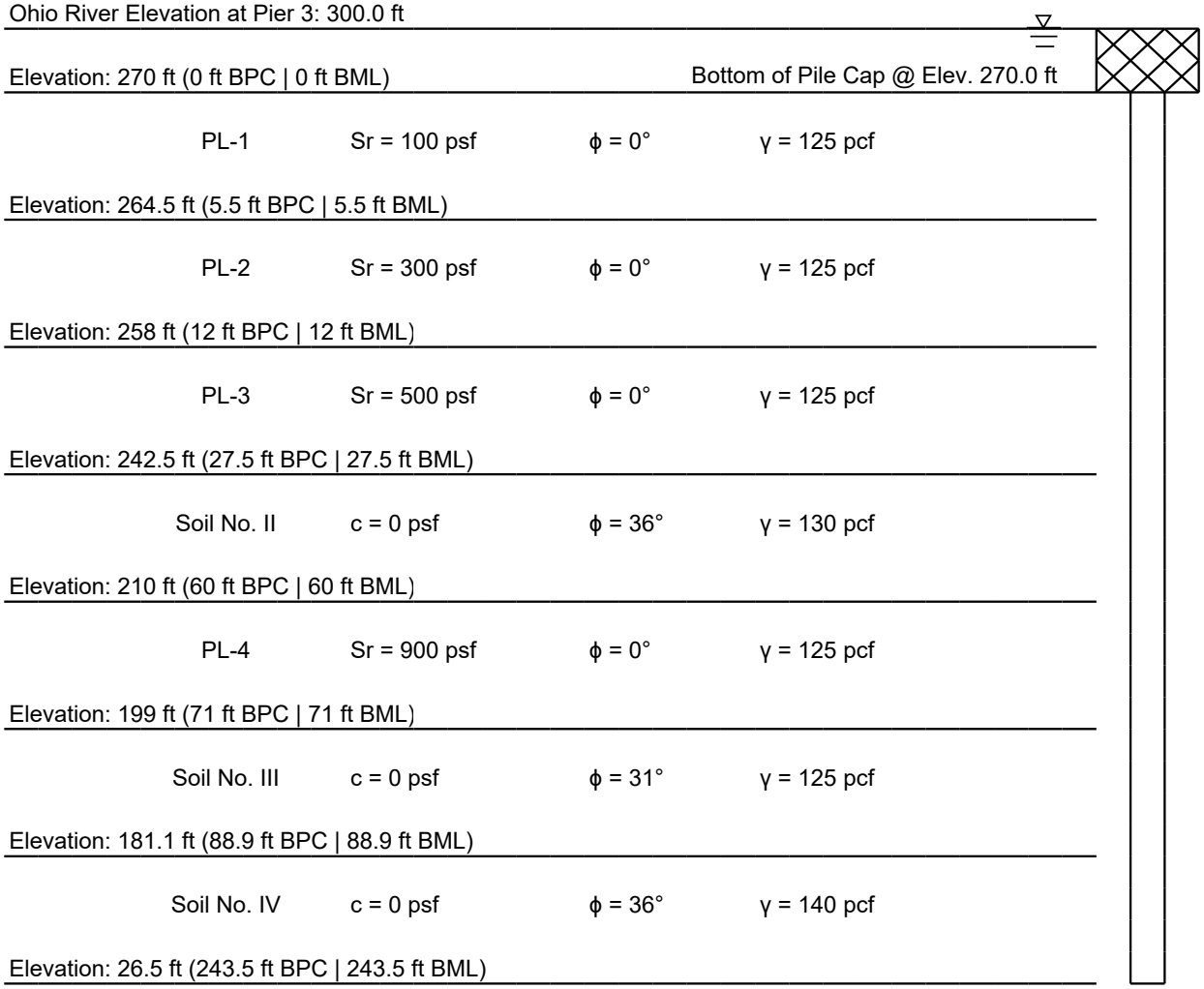
Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 3 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 48-in diameter pipe pile and 96-in diameter drilled shafts.

Project: US-51 Bridge Replacement
Subject: Geotechnical
Task: FB Multipier Parameters
Job #: 10174706

Computed by: SGL Date: 2/9/2026
Checked by: SKB Date: 2/9/2026
Workbook: Pier 1 Piles FBMP (Print)

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	125	62.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	264.5	-	258.0	125	62.6	--	--	--	--	300	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	258.0	-	242.5	125	62.6	--	--	--	--	500	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.015	--	--
II	SM, SP, SP-SM	242.5	-	210.0	130	67.6	0	36	0	36	--	Sand (Reese)	40	90	90	--	0.30	1.5
PL-4	Potentially Liquefiable Soil	210.0	-	199.0	125	62.6	--	--	--	--	900	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.010	--	--
III	SC-SM, SM, SP-SM, ML	199.0	-	181.1	125	62.6	0	31	0	31	--	Sand (Reese)	26	60	60	--	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 3 - 72-IN O.D. PIPE PILES **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters				
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	51	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	264.5	-	258.0	198	0.02	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	258.0	-	242.5	388	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM, SP, SP-SM	242.5	-	210.0	1347	0.82	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	32
PL-4	Potentially Liquefiable Soil	210.0	-	199.0	987	0.06	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
III	SC-SM, SM, SP-SM, ML	199.0	-	181.1	1760	0.81	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	25
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	2080	1.46	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 3 - 96-IN DIA. DRILLED SHAFT **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	125	62.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	264.5	-	258.0	125	62.6	--	--	--	--	300	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	258.0	-	242.5	125	62.6	--	--	--	--	500	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.015	--	--
II	SM, SP, SP-SM	242.5	-	210.0	130	67.6	0	36	0	36	--	Sand (Reese)	40	90	90	--	0.30	1.5
PL-4	Potentially Liquefiable Soil	210.0	-	199.0	125	62.6	--	--	--	--	900	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.010	--	--
III	SC-SM, SM, SP-SM, ML	199.0	-	181.1	125	62.6	0	31	0	31	--	Sand (Reese)	26	60	60	--	0.25	1.0
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 3 - 96-IN DIA. DRILLED SHAFT **Borings: B-1001 & B-1002**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters		
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	264.5	46	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	264.5	-	258.0	165	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	258.0	-	242.5	275	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM, SP, SP-SM	242.5	-	210.0	851	0.06	Drilled Shaft Sand	Drilled Shaft Sand	--
PL-4	Potentially Liquefiable Soil	210.0	-	199.0	495	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
III	SC-SM, SM, SP-SM, ML	199.0	-	181.1	1452	0.08	Drilled Shaft Sand	Drilled Shaft Sand	--
IV	SP, SP-SM, SM, SW-SM, SW	181.1	-	26.5	3255	0.11	Drilled Shaft Sand	Drilled Shaft Sand	--

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

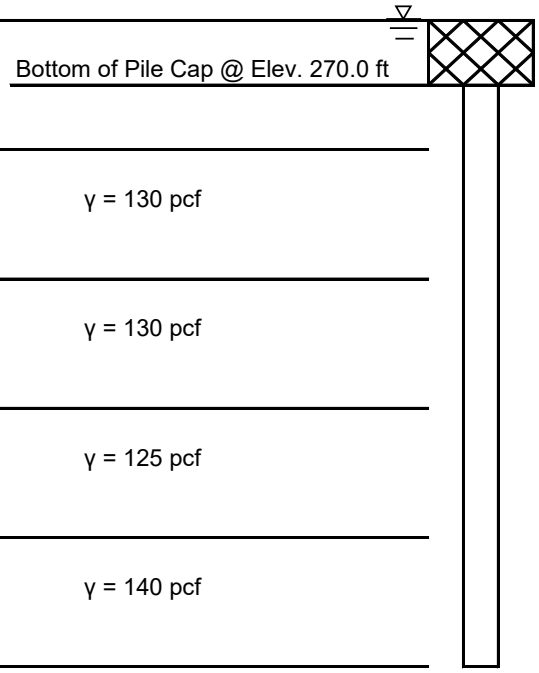
PIER 4

100-YR RETURN PERIOD

Seismic Soil Profile at Pier 4 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 4: 300.0 ft



Elevation: 238.6 ft (31.4 ft BPC | 0 ft BML)

PL-1	Sr = 75 psf	ϕ = 0°	γ = 130 pcf

Elevation: 233 ft (37 ft BPC | 5.6 ft BML)

Soil No. II	c = 0 psf	ϕ = 36°	γ = 130 pcf

Elevation: 212.7 ft (57.3 ft BPC | 25.9 ft BML)

Soil No. III	c = 0 psf	ϕ = 34°	γ = 125 pcf

Elevation: 201.2 ft (68.8 ft BPC | 37.4 ft BML)

Soil No. IV	c = 0 psf	ϕ = 36°	γ = 140 pcf

Elevation: -13.5 ft (283.5 ft BPC | 252.1 ft BML)

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 48-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	130	67.6	0	36	0	36	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, SP-SM. SC-SM	212.7	-	201.2	125	62.6	0	34	0	34	--	Sand (Reese)	37	60	60	--	0.30	1.4
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters				
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	45	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	487	0.30	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	25
III	SM, SP-SM. SC-SM	212.7	-	201.2	918	0.52	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	35
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	2021	1.39	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 4 - 96-IN DIA. DRILLED SHAFT **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	130	67.6	0	36	0	36	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, SP-SM. SC-SM	212.7	-	201.2	125	62.6	0	34	0	34	--	Sand (Reese)	37	60	60	--	0.30	1.4
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 4 - 96-IN DIA. DRILLED SHAFT **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters		
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	34	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	314	0.03	Drilled Shaft Sand	Drilled Shaft Sand	25
III	SM, SP-SM. SC-SM	212.7	-	201.2	630	0.06	Drilled Shaft Sand	Drilled Shaft Sand	35
IV	SP, SP-SM, SW, SW-SM, CL, ML	201.2	-	-13.5	3009	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50

Notes:

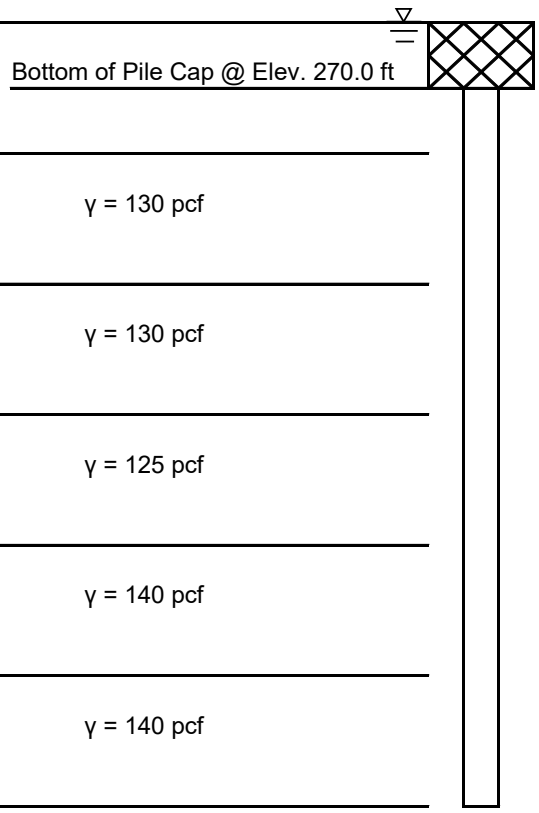
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 4 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 4: 300.0 ft



Elevation: 238.6 ft (31.4 ft BPC | 0 ft BML)

PL-1 Sr = 75 psf ϕ = 0° γ = 130 pcf

Elevation: 233 ft (37 ft BPC | 5.6 ft BML)

Soil No. II c = 0 psf ϕ = 36° γ = 130 pcf

Elevation: 212.7 ft (57.3 ft BPC | 25.9 ft BML)

Soil No. III c = 0 psf ϕ = 34° γ = 125 pcf

Elevation: 201 ft (69 ft BPC | 37.6 ft BML)

PL-2 Sr = 800 psf ϕ = 0° γ = 140 pcf

Elevation: 195 ft (75 ft BPC | 43.6 ft BML)

Soil No. IV c = 0 psf ϕ = 36° γ = 140 pcf

Elevation: -13.5 ft (283.5 ft BPC | 252.1 ft BML)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 48-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	130	67.6	0	36	0	36	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, SP-SM, SC-SM	212.7	-	201.0	125	62.6	0	34	0	34	--	Sand (Reese)	37	60	60	--	0.30	1.4
PL-2	Potentially Liquefiable Soil	201.0	-	195.0	140	77.6	--	--	--	--	800	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.010	--	--
IV	SP, SP-SSM, SW, SW-SM, CL, ML	195.0	-	-13.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 4 - 72-IN O.D. PIPE PILES **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)					
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	46	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	487	0.30	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	25
III	SM, SP-SM, SC-SM	212.7	-	201.0	918	0.52	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	35
PL-2	Potentially Liquefiable Soil	201.0	-	195.0	714	0.05	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
IV	SP, SP-SSM, SW, SW-SM, CL, ML	195.0	-	-13.5	2065	1.43	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	50

Notes:
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 4 - 96-IN DIA. DRILLED SHAFT **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.020	--	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	130	67.6	0	36	0	36	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, SP-SM, SC-SM	212.7	-	201.0	125	62.6	0	34	0	34	--	Sand (Reese)	37	60	60	--	0.30	1.4
PL-2	Potentially Liquefiable Soil	201.0	-	195.0	140	77.6	--	--	--	--	800	Hybrid Liquefied Sand (Franke and Rollins)	--	--	--	0.010	--	--
IV	SP, SP-SSM, SW, SW-SM, CL, ML	195.0	-	-13.5	140	77.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5

Pier 4 - 96-IN DIA. DRILLED SHAFT **Borings: B-1004 & B-1005**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	238.6	-	233.0	34	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GP, SP, SP-SM, SM, GW, GW-GM	233.0	-	212.7	314	0.03	Drilled Shaft Sand	Drilled Shaft Sand	25
III	SM, SP-SM, SC-SM	212.7	-	201.0	630	0.05	Drilled Shaft Sand	Drilled Shaft Sand	35
PL-2	Potentially Liquefiable Soil	201.0	-	195.0	440	0.07	Drilled Shaft Clay	Drilled Shaft Clay	--
IV	SP, SP-SSM, SW, SW-SM, CL, ML	195.0	-	-13.5	3248	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50

Notes:
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 238.6 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

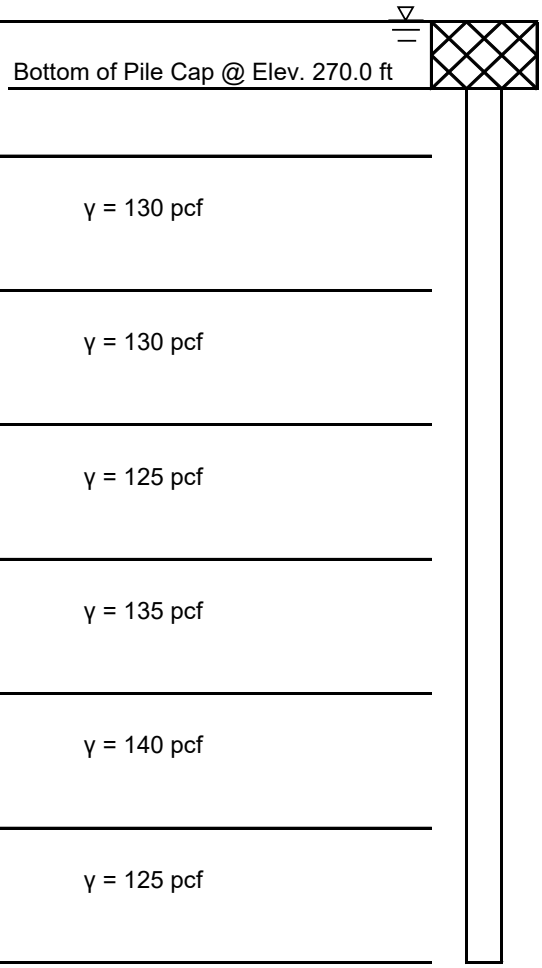
PIER 5

100-YR RETURN PERIOD

Seismic Soil Profile at Pier 5 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 5: 287.2 ft



Bottom of Pile Cap @ Elev. 270.0 ft

Elevation: 244.3 ft (25.7 ft BPC | 0 ft BML)

PL-1 Sr = 75 psf ϕ = 0° γ = 130 pcf

Elevation: 238 ft (32 ft BPC | 6.3 ft BML)

Soil No. II c = 0 psf ϕ = 36° γ = 130 pcf

Elevation: 179.9 ft (90.1 ft BPC | 64.4 ft BML)

Soil No. III c = 0 psf ϕ = 34° γ = 125 pcf

Elevation: 157.6 ft (112.4 ft BPC | 86.7 ft BML)

Soil No. IV c = 0 psf ϕ = 36° γ = 135 pcf

Elevation: -27.6 ft (297.6 ft BPC | 271.9 ft BML)

Soil No. V c = 0 psf ϕ = 31° γ = 140 pcf

Elevation: -84.4 ft (354.4 ft BPC | 328.7 ft BML)

Soil No. VI c = 4,000 psf ϕ = 0° γ = 125 pcf

Elevation: -159 ft (429 ft BPC | 403.3 ft BML)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	238.0	-	179.9	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	--	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	--	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I						
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	50	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GM, SW, SP, SP-SM, SM	238.0	-	179.9	1137	0.69	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1940	1.21	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SM	-27.6	-	-84.4	***	***	***	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	238.0	-	179.9	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	--	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	--	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Avg Axial Resistance[3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	35	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GM, SW, SP, SP-SM, SM	238.0	-	179.9	720	0.06	Drilled Shaft Sand	Drilled Shaft Sand	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1515	0.09	Drilled Shaft Sand	Drilled Shaft Sand	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	3638	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SM	-27.6	-	-84.4	***	***	Drilled Shaft Sand	Drilled Shaft Sand	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

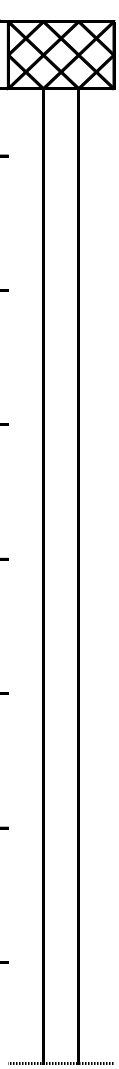
1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 5 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 5: 287.2 ft

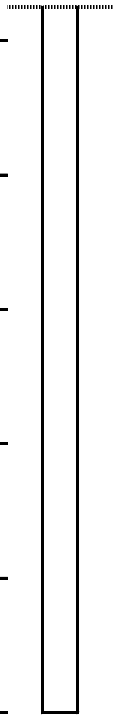
Bottom of Pile Cap @ Elev. 270.0 ft



Elevation: 244.3 ft (25.7 ft BPC | 0 ft BML)			
PL-1	Sr = 75 psf	ϕ = 0°	γ = 130 pcf
Elevation: 238 ft (32 ft BPC | 6.3 ft BML)			
PL-2	Sr = 150 psf	ϕ = 0°	γ = 130 pcf
Elevation: 237 ft (33 ft BPC | 7.3 ft BML)			
PL-3	Sr = 200 psf	ϕ = 0°	γ = 130 pcf
Elevation: 236 ft (34 ft BPC | 8.3 ft BML)			
Soil No. II	c = 0 psf	ϕ = 36°	γ = 130 pcf
Elevation: 234 ft (36 ft BPC | 10.3 ft BML)			
PL-4	Sr = 450 psf	ϕ = 0°	γ = 130 pcf
Elevation: 230 ft (40 ft BPC | 14.3 ft BML)			
Soil No. II	c = 0 psf	ϕ = 36°	γ = 130 pcf
Elevation: 228 ft (42 ft BPC | 16.3 ft BML)			
PL-5	Sr = 650 psf	ϕ = 0°	γ = 130 pcf

Seismic Soil Profile at Pier 5 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Elevation: 224 ft (46 ft BPC | 20.3 ft BML)

Soil No. II c = 0 psf ϕ = 36° γ = 130 pcf

Elevation: 179.9 ft (90.1 ft BPC | 64.4 ft BML)

Soil No. III c = 0 psf ϕ = 34° γ = 125 pcf

Elevation: 157.6 ft (112.4 ft BPC | 86.7 ft BML)

Soil No. IV c = 0 psf ϕ = 36° γ = 135 pcf

Elevation: -27.6 ft (297.6 ft BPC | 271.9 ft BML)

Soil No. V c = 0 psf ϕ = 31° γ = 140 pcf

Elevation: -84.4 ft (354.4 ft BPC | 328.7 ft BML)

Soil No. VI c = 4,000 psf ϕ = 0° γ = 125 pcf

Elevation: -159 ft (429 ft BPC | 403.3 ft BML)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Project: US-51 Bridge Replacement
Subject: Geotechnical
Task: FB Multipier Parameters
Job #: 10174706

Computed by: Borders Stephen Date: 4/1/2026
Checked by: Robbins, Bryan Date: 4/1/2026
Workbook: Pier 1 Piles FBMP (Print)

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	238.0	-	237.0	130	67.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	237.0	-	236.0	130	67.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	236.0	-	234.0	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
PL-4	Potentially Liquefiable Soil	234.0	-	230.0	130	67.6	--	--	--	--	450	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	230.0	-	228.0	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
PL-5	Potentially Liquefiable Soil	228.0	-	224.0	130	67.6	--	--	--	--	650	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.010	--	--
II	GM, SW, SP, SP-SM, SM	224.0	-	179.9	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	--	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	--	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 72-IN O.D. PIPE PILES **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I						
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	51	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	238.0	-	237.0	128	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	237.0	-	236.0	178	0.02	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GM, SW, SP, SP-SM, SM	236.0	-	234.0	292	0.18	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	33
PL-4	Potentially Liquefiable Soil	234.0	-	230.0	302	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GM, SW, SP, SP-SM, SM	230.0	-	228.0	487	0.30	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	33
PL-5	Potentially Liquefiable Soil	228.0	-	224.0	444	0.04	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	GM, SW, SP, SP-SM, SM	224.0	-	179.9	1365	0.83	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1940	1.21	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SM	-27.6	-	-84.4	***	***	***	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	130	67.6	--	--	--	--	75	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	238.0	-	237.0	130	67.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	237.0	-	236.0	130	67.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	236.0	-	234.0	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
PL-4	Potentially Liquefiable Soil	234.0	-	230.0	130	67.6	--	--	--	--	450	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	GM, SW, SP, SP-SM, SM	230.0	-	228.0	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
PL-5	Potentially Liquefiable Soil	228.0	-	224.0	130	67.6	--	--	--	--	650	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.010	--	--
II	GM, SW, SP, SP-SM, SM	224.0	-	179.9	130	67.6	0	36	0	36	--	Sand (Reese)	41	90	90	--	0.30	1.5
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	125	62.6	0	34	0	34	--	Sand (Reese)	33	60	60	--	0.30	1.2
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	3.5
V	SM	-27.6	-	-84.4	140	77.6	0	31	0	31	--	Sand (Reese)	15	60	60	--	0.25	0.6
VI	SP, SM, MH	-84.4	-	-159.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	20	2000	985	0.004	0.50	4.0

Pier 5 - 96-IN DIA. DRILLED SHAFT **Borings: B-1007, B-1008, & B-1009**

Soil	Soil Type	Elevation			Avg Axial Resistance[3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	244.3	-	238.0	35	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	238.0	-	237.0	83	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	237.0	-	236.0	138	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GM, SW, SP, SP-SM, SM	236.0	-	234.0	193	0.03	Drilled Shaft Sand	Drilled Shaft Sand	33
PL-4	Potentially Liquefiable Soil	234.0	-	230.0	248	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GM, SW, SP, SP-SM, SM	230.0	-	228.0	314	0.04	Drilled Shaft Sand	Drilled Shaft Sand	33
PL-5	Potentially Liquefiable Soil	228.0	-	224.0	358	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	GM, SW, SP, SP-SM, SM	224.0	-	179.9	862	0.07	Drilled Shaft Sand	Drilled Shaft Sand	33
III	SP-SM, SM, SC-SM, CL	179.9	-	157.6	1515	0.09	Drilled Shaft Sand	Drilled Shaft Sand	37
IV	SP, SW, SW-SM, SP-SM, SC-SM, CL	157.6	-	-27.6	3639	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SM	-27.6	-	-84.4	***	***	Drilled Shaft Sand	Drilled Shaft Sand	34
VI	SP, SM, MH	-84.4	-	-159.0	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

PIER 6

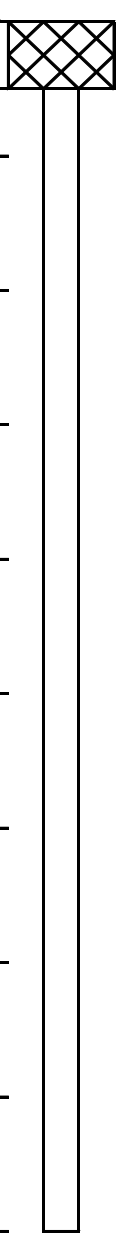
100-YR RETURN PERIOD

Seismic Soil Profile at Pier 6 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 6: 286.5 ft

Bottom of Pile Cap @ Elev. 270.0 ft



Elevation: 257.7 ft (12.3 ft BPC | 0 ft BML)			
PL-1	Sr = 25 psf	ϕ = 0°	γ = 125 pcf
Elevation: 254 ft (16 ft BPC | 3.7 ft BML)			
PL-2	Sr = 110 psf	ϕ = 0°	γ = 125 pcf
Elevation: 250 ft (20 ft BPC | 7.7 ft BML)			
PL-3	Sr = 150 psf	ϕ = 0°	γ = 125 pcf
Elevation: 242 ft (28 ft BPC | 15.7 ft BML)			
Soil No. II	c = 0 psf	ϕ = 36°	γ = 125 pcf
Elevation: 212.7 ft (57.3 ft BPC | 45 ft BML)			
Soil No. III	c = 0 psf	ϕ = 32°	γ = 120 pcf
Elevation: 177.7 ft (92.3 ft BPC | 80 ft BML)			
Soil No. IV	c = 0 psf	ϕ = 36°	γ = 135 pcf
Elevation: -42.3 ft (312.3 ft BPC | 300 ft BML)			
Soil No. V	c = 0 psf	ϕ = 32°	γ = 130 pcf
Elevation: -87.3 ft (357.3 ft BPC | 345 ft BML)			
Soil No. VI	c = 4,000 psf	ϕ = 0°	γ = 125 pcf
Elevation: -145 ft (415 ft BPC | 402.7 ft BML)			

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	125	62.6	--	--	--	--	25	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	125	62.6	--	--	--	--	110	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	125	62.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.0	-	212.7	125	62.6	0	36	0	36	--	Sand (Reese)	37	90	90	--	0.30	1.4
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	120	57.6	0	32	0	32	--	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters				
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	17	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	92	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	160	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.0	-	212.7	903	0.55	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	30
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	1545	0.74	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	20
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	***	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	39
VI	SM	-87.3	-	-145.0	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 257.7 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 6 - 96-IN DIA. DRILLED SHAFT **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	125	62.6	--	--	--	--	25	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	125	62.6	--	--	--	--	110	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	125	62.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.0	-	212.7	125	62.6	0	36	0	36	--	Sand (Reese)	37	90	90	--	0.30	1.4
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	120	57.6	0	32	0	32	--	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 96-IN DIA. DRILLED SHAFT **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters		
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	0	0.00	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	30	0.01	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	83	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	242.0	-	212.7	572	0.04	Drilled Shaft Sand	Drilled Shaft Sand	30
III	SM, SC-SM, ML, SP-SM, CL	212.7	-	177.7	1132	0.06	Drilled Shaft Sand	Drilled Shaft Sand	20
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	3783	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	SM	-87.3	-	-145.0	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

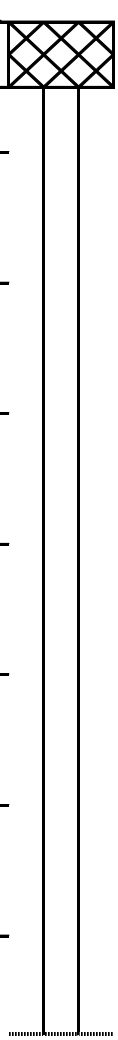
1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 6 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Ohio River Elevation at Pier 6: 286.5 ft

Bottom of Pile Cap @ Elev. 270.0 ft



Elevation: 257.7 ft (12.3 ft BPC | 0 ft BML)

PL-1	Sr = 25 psf	ϕ = 0°	γ = 125 pcf

Elevation: 254 ft (16 ft BPC | 3.7 ft BML)

PL-2	Sr = 110 psf	ϕ = 0°	γ = 125 pcf

Elevation: 250 ft (20 ft BPC | 7.7 ft BML)

PL-3	Sr = 150 psf	ϕ = 0°	γ = 125 pcf

Elevation: 242 ft (28 ft BPC | 15.7 ft BML)

PL-4	Sr = 400 psf	ϕ = 0°	γ = 125 pcf

Elevation: 236 ft (34 ft BPC | 21.7 ft BML)

Soil No. II	c = 0 psf	ϕ = 36°	γ = 125 pcf

Elevation: 222 ft (48 ft BPC | 35.7 ft BML)

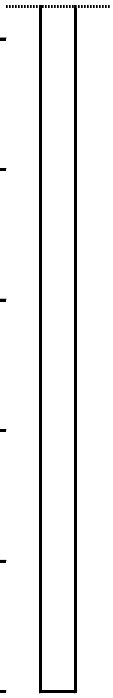
PL-5	Sr = 800 psf	ϕ = 0°	γ = 125 pcf

Elevation: 212 ft (58 ft BPC | 45.7 ft BML)

PL-6	Sr = 1000 psf	ϕ = 0°	γ = 120 pcf

Seismic Soil Profile at Pier 6 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Elevation: 205 ft (65 ft BPC | 52.7 ft BML)

PL-7 Sr = 1150 psf ϕ = 0° γ = 120 pcf

Elevation: 200 ft (70 ft BPC | 57.7 ft BML)

Soil No. III c = 0 psf ϕ = 32° γ = 120 pcf

Elevation: 177.7 ft (92.3 ft BPC | 80 ft BML)

Soil No. IV c = 0 psf ϕ = 36° γ = 135 pcf

Elevation: -42.3 ft (312.3 ft BPC | 300 ft BML)

Soil No. V c = 0 psf ϕ = 32° γ = 130 pcf

Elevation: -87.3 ft (357.3 ft BPC | 345 ft BML)

Soil No. VI c = 4,000 psf ϕ = 0° γ = 125 pcf

Elevation: -145 ft (415 ft BPC | 402.7 ft BML)

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	125	62.6	--	--	--	--	25	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	125	62.6	--	--	--	--	110	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	125	62.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-4	Potentially Liquefiable Soil	242.0	-	236.0	125	62.6	--	--	--	--	400	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	236.0	-	222.0	125	62.6	0	36	0	36	--	Sand (Reese)	37	90	90	--	0.30	1.4
PL-5	Potentially Liquefiable Soil	222.0	-	212.0	125	62.6	--	--	--	--	800	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-6	Potentially Liquefiable Soil	212.0	-	205.0	120	57.6	--	--	--	--	1000	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-7	Potentially Liquefiable Soil	205.0	-	200.0	120	57.6	--	--	--	--	1150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
III	SM, SC-SM, ML, SP-SM, CL	200.0	-	177.7	120	57.6	0	32	0	32	--	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 72-IN O.D. PIPE PILES **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I						
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	17	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	92	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	159	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-4	Potentially Liquefiable Soil	242.0	-	236.0	335	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	236.0	-	222.0	843	0.51	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	30
PL-5	Potentially Liquefiable Soil	222.0	-	212.0	707	0.05	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-6	Potentially Liquefiable Soil	212.0	-	205.0	869	0.06	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-7	Potentially Liquefiable Soil	205.0	-	200.0	984	0.07	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
III	SM, SC-SM, ML, SP-SM, CL	200.0	-	177.7	1780	0.91	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	20
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	***	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	39
VI	SM	-87.3	-	-145.0	***	***	***	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 257.7 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 6 - 96-IN DIA. DRILLED SHAFT **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters							
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	125	62.6	--	--	--	--	25	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	125	62.6	--	--	--	--	110	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	125	62.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-4	Potentially Liquefiable Soil	242.0	-	236.0	125	62.6	--	--	--	--	400	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	236.0	-	222.0	125	62.6	0	36	0	36	--	Sand (Reese)	37	90	90	--	0.30	1.4
PL-5	Potentially Liquefiable Soil	222.0	-	212.0	125	62.6	--	--	--	--	800	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-6	Potentially Liquefiable Soil	212.0	-	205.0	120	57.6	--	--	--	--	1000	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
PL-7	Potentially Liquefiable Soil	205.0	-	200.0	120	57.6	--	--	--	--	1150	Hybrid Liquefied Sand (Franke and Rollins)	--	125	--	0.010	--	--
III	SM, SC-SM, ML, SP-SM, CL	200.0	-	177.7	120	57.6	0	32	0	32	--	Sand (Reese)	25	60	60	--	0.25	1.0
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.40	2.5
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	130	67.6	0	32	0	32	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	SM	-87.3	-	-145.0	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	20	20	0.004	0.25	3.3

Pier 6 - 96-IN DIA. DRILLED SHAFT **Borings: B-1012, B-1013, & B-1014**

Soil	Soil Type	Elevation			Avg Axial Resistance[3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	257.7	-	254.0	0	0.00	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	254.0	-	250.0	30	0.01	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	250.0	-	242.0	83	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-4	Potentially Liquefiable Soil	242.0	-	236.0	220	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM, GM, SP-SM, GP-GM, SW-SM, SP, GP, SW	236.0	-	222.0	534	0.05	Drilled Shaft Sand	Drilled Shaft Sand	30
PL-5	Potentially Liquefiable Soil	222.0	-	212.0	440	0.06	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-6	Potentially Liquefiable Soil	212.0	-	205.0	550	0.05	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-7	Potentially Liquefiable Soil	205.0	-	200.0	633	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
III	SM, SC-SM, ML, SP-SM, CL	200.0	-	177.7	1167	0.07	Drilled Shaft Sand	Drilled Shaft Sand	20
IV	SM, SP-SM, SP, SW, CL, ML, SC, SW-SM, CL-ML	177.7	-	-42.3	3783	0.11	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SP-SC, SW-SM, SM	-42.3	-	-87.3	***	***	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	SM	-87.3	-	-145.0	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

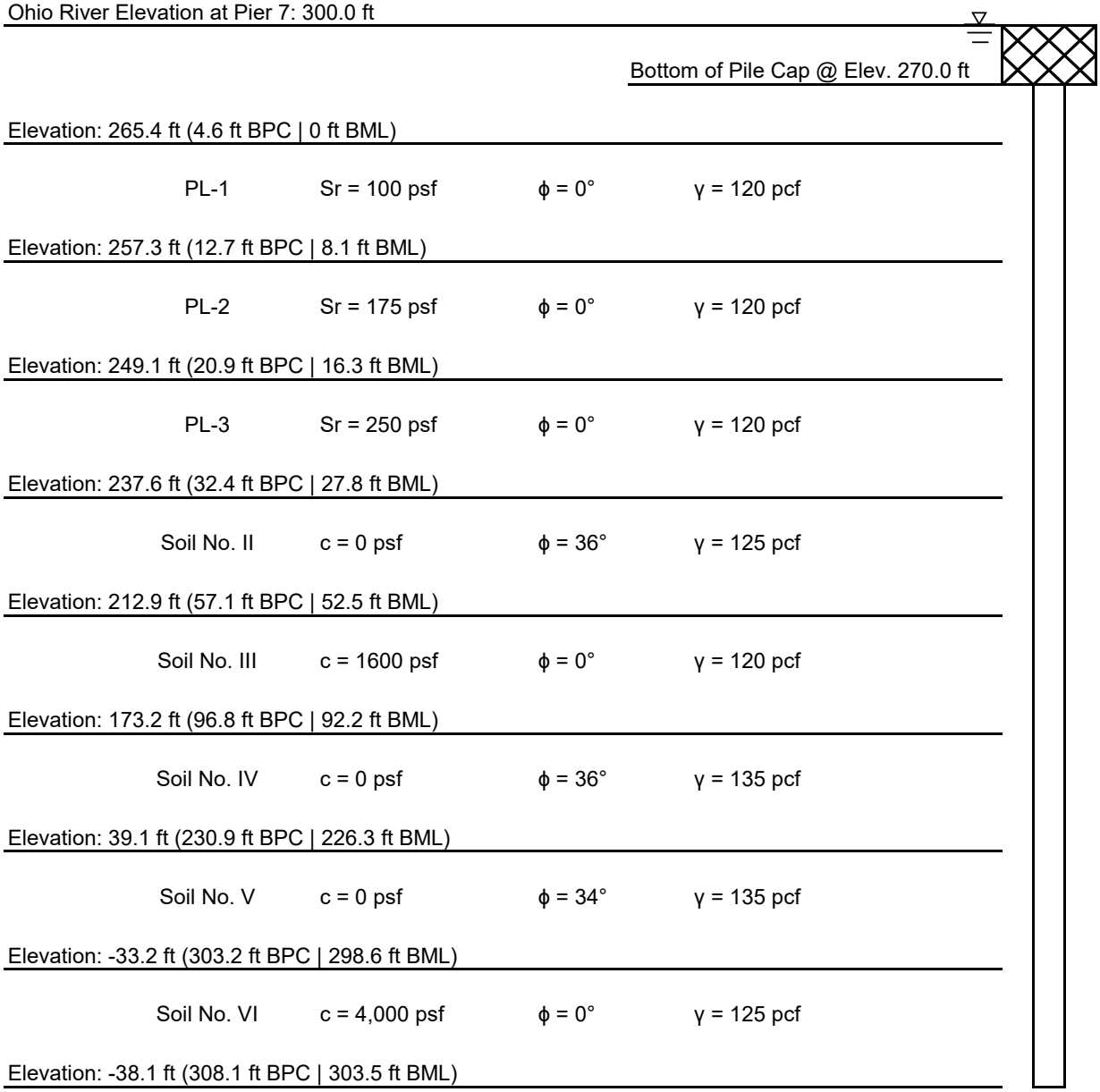
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 244.3 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

PIER 7

100-YR RETURN PERIOD

Seismic Soil Profile at Pier 7 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	120	57.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	120	57.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	120	57.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM	237.6	-	212.9	125	62.6	0	36	0	36	--	Sand (Reese)	55	90	90	--	0.30	2.1
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	120	57.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Avg Axial Resistance [3] EE-I		Axial Soil Resistance - FBMP Parameters				
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	65	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	173	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	277	0.02	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM	237.6	-	212.9	1122	0.68	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	40
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	20
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SP, SP-SM, SM	39.1	-	-33.2	***	***	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	39
VI	MH	-33.2	-	-38.1	***	***	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 7 - 96-IN DIA. DRILLED SHAFT **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	120	57.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	120	57.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	120	57.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM	237.6	-	212.9	125	62.6	0	36	0	36	--	Sand (Reese)	55	90	90	--	0.30	2.1
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	120	57.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 96-IN DIA. DRILLED SHAFT **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Avg Axial Resistance[3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	49	0.01	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	96	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	138	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM	237.6	-	212.9	710	0.07	Drilled Shaft Sand	Drilled Shaft Sand	40
III	SM, CL, CL-ML, SC-SM	212.9	-	173.2	880	0.09	Drilled Shaft Clay	Drilled Shaft Clay	20
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	3085	0.12	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SW, SP, SP-SM, SM	39.1	-	-33.2	***	***	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	MH	-33.2	-	-38.1	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 7 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

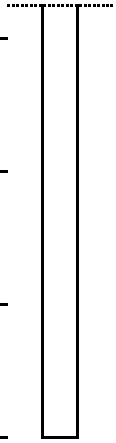
Ohio River Elevation at Pier 7: 300.0 ft

Bottom of Pile Cap @ Elev. 270.0 ft

Elevation: 265.4 ft (4.6 ft BPC | 0 ft BML)			
PL-1	Sr = 100 psf	ϕ = 0°	γ = 120 pcf
Elevation: 257.3 ft (12.7 ft BPC | 8.1 ft BML)			
PL-2	Sr = 175 psf	ϕ = 0°	γ = 120 pcf
Elevation: 249.1 ft (20.9 ft BPC | 16.3 ft BML)			
PL-3	Sr = 250 psf	ϕ = 0°	γ = 120 pcf
Elevation: 237.6 ft (32.4 ft BPC | 27.8 ft BML)			
Soil No. II	c = 0 psf	ϕ = 36°	γ = 125 pcf
Elevation: 217.2 ft (52.8 ft BPC | 48.2 ft BML)			
PL-4	Sr = 700 psf	ϕ = 0°	γ = 120 pcf
Elevation: 199.7 ft (70.3 ft BPC | 65.7 ft BML)			
Soil No. III	c = 1600 psf	ϕ = 0°	γ = 120 pcf
Elevation: 196.2 ft (73.8 ft BPC | 69.2 ft BML)			
PL-5	Sr = 1000 psf	ϕ = 0°	γ = 120 pcf

Seismic Soil Profile at Pier 7 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Elevation: 173.2 ft (96.8 ft BPC | 92.2 ft BML)

Soil No. IV	c = 0 psf	ϕ = 36°	γ = 135 pcf

Elevation: 39.1 ft (230.9 ft BPC | 226.3 ft BML)

Soil No. V	c = 0 psf	ϕ = 34°	γ = 135 pcf

Elevation: -33.2 ft (303.2 ft BPC | 298.6 ft BML)

Soil No. VI	c = 4000 psf	ϕ = 0°	γ = 125 pcf

Elevation: -38.1 ft (308.1 ft BPC | 303.5 ft BML)

Borings Terminated

Note:

(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	120	57.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	120	57.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	120	57.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM	237.6	-	217.2	125	62.6	0	36	0	36	--	Sand (Reese)	55	90	90	--	0.30	2.1
PL-4	Potentially Liquefiable Soil	217.2	-	199.7	120	57.6	--	--	--	--	700	Hybrid Liquefied Sand (Franke and Rollins)	--	100	--	0.010	--	--
III	SM, CL, CL-ML, SC-SM	199.7	-	196.2	120	57.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
PL-5	Potentially Liquefiable Soil	196.2	-	173.2	120	57.6	--	--	--	--	1000	Hybrid Liquefied Sand (Franke and Rollins)	--	100	--	0.010	--	--
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 72-IN O.D. PIPE PILES **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I						
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	65	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	173	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	277	0.02	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM	237.6	-	217.2	1062	0.64	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	40
PL-4	Potentially Liquefiable Soil	217.2	-	199.7	781	0.04	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
III	SM, CL, CL-ML, SC-SM	199.7	-	196.2	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	20
PL-5	Potentially Liquefiable Soil	196.2	-	173.2	1000	0.06	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SP, SP-SM, SM	39.1	-	-33.2	***	***	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	39
VI	MH	-33.2	-	-38.1	***	***	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	50

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 7 - 96-IN DIA. DRILLED SHAFT **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	120	57.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	120	57.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	120	57.6	--	--	--	--	250	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM	237.6	-	217.2	125	62.6	0	36	0	36	--	Sand (Reese)	55	90	90	--	0.30	2.1
PL-4	Potentially Liquefiable Soil	217.2	-	199.7	120	57.6	--	--	--	--	700	Hybrid Liquefied Sand (Franke and Rollins)	--	100	--	0.010	--	--
III	SM, CL, CL-ML, SC-SM	199.7	-	196.2	120	57.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	25	500	200	0.007	0.50	1.1
PL-5	Potentially Liquefiable Soil	196.2	-	173.2	120	57.6	--	--	--	--	1000	Hybrid Liquefied Sand (Franke and Rollins)	--	100	--	0.010	--	--
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SP, SP-SM, SM	39.1	-	-33.2	135	72.6	0	34	0	34	--	Sand (Reese)	18	60	60	--	0.25	1.0
VI	MH	-33.2	-	-38.1	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	21	2000	1000	0.004	0.50	2.8

Pier 7 - 96-IN DIA. DRILLED SHAFT **Borings: B-1017 & B-1018**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	265.4	-	257.3	49	0.01	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	257.3	-	249.1	96	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	249.1	-	237.6	138	0.04	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM	237.6	-	217.2	672	0.05	Drilled Shaft Sand	Drilled Shaft Sand	40
PL-4	Potentially Liquefiable Soil	217.2	-	199.7	385	0.06	Drilled Shaft Clay	Drilled Shaft Clay	--
III	SM, CL, CL-ML, SC-SM	199.7	-	196.2	880	0.06	Drilled Shaft Clay	Drilled Shaft Clay	20
PL-5	Potentially Liquefiable Soil	196.2	-	173.2	550	0.08	Drilled Shaft Clay	Drilled Shaft Clay	--
IV	SM, SP, SP-SM, SW-SM, CL-ML, SW, CL, ML	173.2	-	39.1	3079	0.12	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SW, SP, SP-SM, SM	39.1	-	-33.2	***	***	Drilled Shaft Sand	Drilled Shaft Sand	39
VI	MH	-33.2	-	-38.1	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	50

Notes:

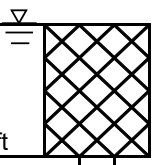
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 265.4 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

PIER 8

100-YR RETURN PERIOD

Seismic Soil Profile at Pier 8 (100YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Ohio River Elevation at Pier 8: 300.0 ft			
Elevation: 270 ft (0 ft BPC | 0 ft BML)			Bottom of Pile Cap @ Elev. 270.0 ft
PL-1	Sr = 100 psf	ϕ = 0°	γ = 110 pcf
Elevation: 252.8 ft (17.2 ft BPC | 17.2 ft BML)			
Soil No. I	c = 450 psf	ϕ = 0°	γ = 110 pcf
Elevation: 245.9 ft (24.1 ft BPC | 24.1 ft BML)			
Soil No. II	c = 0 psf	ϕ = 33°	γ = 125 pcf
Elevation: 210.9 ft (59.1 ft BPC | 59.1 ft BML)			
Soil No. III	c = 1600 psf	ϕ = 0°	γ = 125 pcf
Elevation: 171.9 ft (98.1 ft BPC | 98.1 ft BML)			
Soil No. IV	c = 0 psf	ϕ = 36°	γ = 135 pcf
Elevation: 86.9 ft (183.1 ft BPC | 183.1 ft BML)			
Soil No. V	c = 0 psf	ϕ = 33°	γ = 130 pcf
Elevation: 43.9 ft (226.1 ft BPC | 226.1 ft BML)			
Soil No. VI	c = 4000 psf	ϕ = 0°	γ = 125 pcf
Elevation: -31.2 ft (301.2 ft BPC | 301.2 ft BML)			
Borings Terminated			

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	252.8	110	47.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	245.9	110	47.6	450	0	50	28	--	Clay (Soft, Matlock)	6	30	--	0.020	0.50	0.3
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	125	62.6	0	33	0	33	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	--	Sand (Reese)	21	60	60	--	0.25	0.8
VI	CL, ML, SM	43.9	-	-31.2	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	13	2000	1000	0.004	0.50	2.8

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I		Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
					Unit Skin (psf)	Unit Toe (ksi)					
PL-1	Potentially Liquefiable Soil	270.0	-	252.8	90	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	245.9	331	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	4
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	951	0.50	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	20
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	24
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SM, SP, SP-SM	86.9	-	43.9	***	***	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	29
VI	CL, ML, SM	43.9	-	-31.2	***	***	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	26

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 8 - 96-IN DIA. DRILLED SHAFT **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	252.8	110	47.6	--	--	--	--	100	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	245.9	110	47.6	450	0	50	28	--	Clay (Soft, Matlock)	6	30	--	0.020	0.50	0.3
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	125	62.6	0	33	0	33	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	--	Sand (Reese)	21	60	60	--	0.25	0.8
VI	CL, ML, SM	43.9	-	-31.2	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	13	2000	1000	0.004	0.50	2.8

Pier 8 - 96-IN DIA. DRILLED SHAFT **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	252.8	52	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	245.9	248	0.02	Drilled Shaft Clay	Drilled Shaft Clay	4
II	SM, CL, SP-SM, GP-GM	245.9	-	210.9	680	0.05	Drilled Shaft Sand	Drilled Shaft Sand	20
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	171.9	880	0.09	Drilled Shaft Clay	Drilled Shaft Clay	24
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2035	0.12	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SW, SM, SP, SP-SM	86.9	-	43.9	***	***	Drilled Shaft Sand	Drilled Shaft Sand	29
VI	CL, ML, SM	43.9	-	-31.2	***	***	Drilled Shaft IGM (Cohesive)	Drilled Shaft IGM (Cohesive)	26

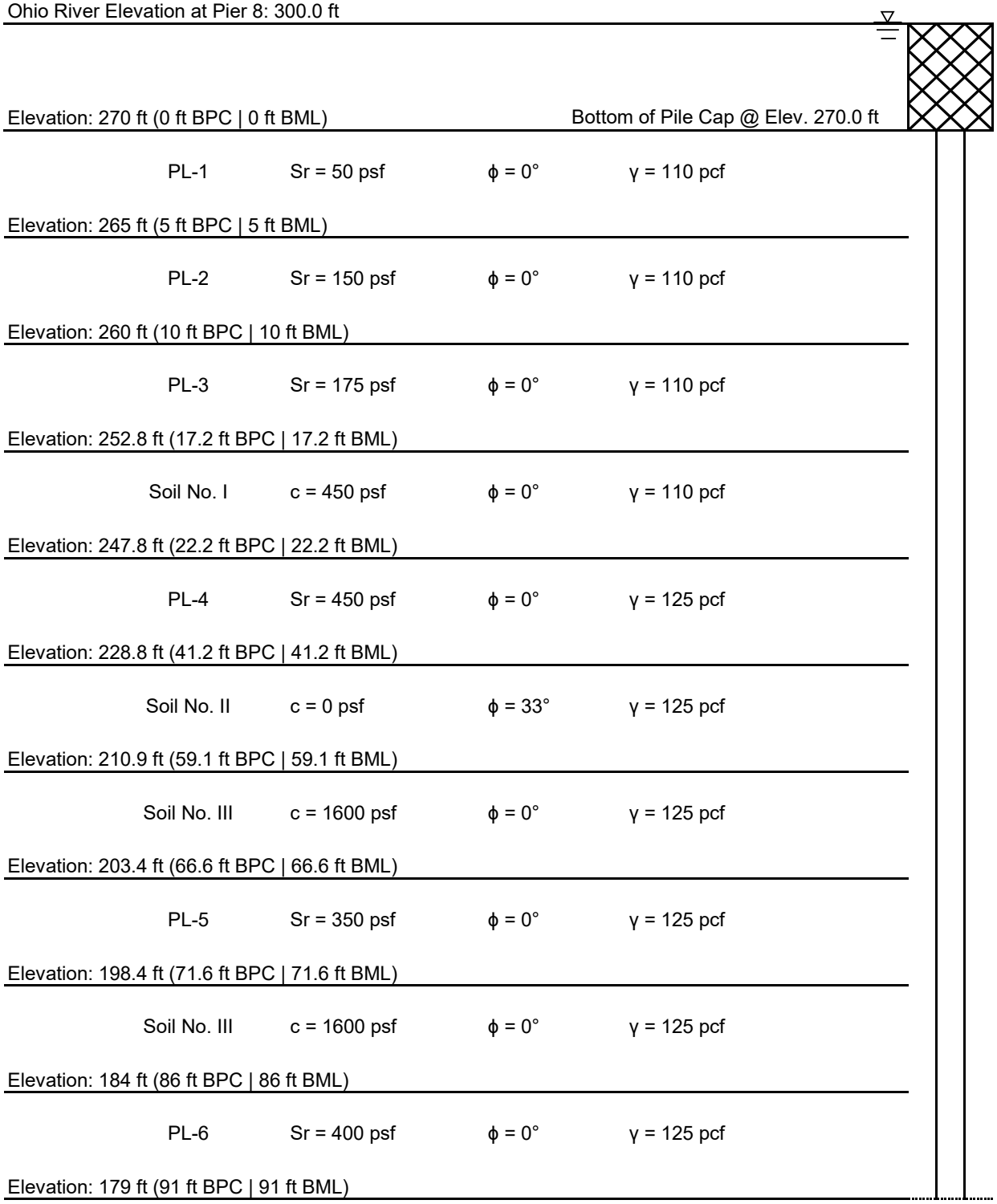
Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

1,000-YR RETURN PERIOD

Seismic Soil Profile at Pier 8 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.



Seismic Soil Profile at Pier 8 (1000YR)

The subsurface profile below is based on the soil horizons obtained from the borings drilled at the indicated bridge pier for the proposed US-51 Bridge replacement near Cairo, Illinois. Potential liquefiable layers were evaluated using industry accepted resources with the subsurface data. A pile cutoff elevation was estimated from the bottom of cap elevation supplied by the structural design team.

Elevation: 179 ft (91 ft BPC | 91 ft BML)

Soil No. III	c = 1600 psf	ϕ = 0°	γ = 125 pcf

Elevation: 171.9 ft (98.1 ft BPC | 98.1 ft BML)

Soil No. IV	c =0 psf	ϕ =36°	γ = 135 pcf

Elevation: 86.9 ft (183.1 ft BPC | 183.1 ft BML)

Soil No. V	c = 0 psf	ϕ = 33°	γ = 130 pcf

Elevation: 43.9 ft (226.1 ft BPC | 226.1 ft BML)

Soil No. VI	c = 4000 psf	ϕ = 0°	γ = 125 pcf

Elevation: -31.2 ft (301.2 ft BPC | 301.2 ft BML)

Borings Terminated

Note:
(1) BPC - Below Pile Cap
(2) BML - Below Mudline
(3) PL - Potentially Liquefiable
(4) Axial resistance estimation developed for 72-in diameter pipe pile and 96-in diameter drilled shafts.

Project: US-51 Bridge Replacement
Subject: Geotechnical
Task: FB Multipier Parameters
Job #: 10174706

Computed by: RRP Date: 4/1/2026
Checked by:BAR Date:10/06/2025
Workbook: Pier U3-2 Piles FBMP (Print)

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties							Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	265.0	110	47.6	--	--	--	--	50	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	265.0	-	260.0	110	47.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	260.0	-	252.8	110	47.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	247.8	110	47.6	450	0	50	28	--	Clay (Soft, Matlock)	6	30	--	0.020	0.50	0.3
PL-4	Potentially Liquefiable Soil	247.8	-	228.8	125	62.6	--	--	--	--	450	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM, CL, SP-SM, GP-GM	228.8	-	210.9	125	62.6	0	33	0	33	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	203.4	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
PL-5	Potentially Liquefiable Soil	203.4	-	198.4	125	62.6	--	--	--	--	350	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
III	SM, CL-ML, SC-SM, SC, CL	198.4	-	184.0	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
PL-6	Potentially Liquefiable Soil	184.0	-	179.0	125	62.6	--	--	--	--	400	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
III	SM, CL-ML, SC-SM, SC, CL	179.0	-	171.9	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	--	Sand (Reese)	21	60	60	--	0.25	0.8
VI	CL, ML, SM	43.9	-	-31.2	125	62.6	4000	0	4000	0	--	Stiff Clay w/o Free Water (Reese)	13	2000	1000	0.004	0.50	2.8

Pier 8 - 72-IN O.D. PIPE PILES **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters				
					EE-I						
					Unit Skin (psf)	Unit Toe (ksi)	Lat. Earth Press. Coeff., K_δ	t-z Curve Type	Z_{peak} (in)	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	265.0	31	0.00	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-2	Potentially Liquefiable Soil	265.0	-	260.0	115	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
PL-3	Potentially Liquefiable Soil	260.0	-	252.8	167	0.01	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	247.8	323	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	4
PL-4	Potentially Liquefiable Soil	247.8	-	228.8	427	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
II	SM, CL, SP-SM, GP-GM	228.8	-	210.9	1327	0.69	0.8	Driven Pile Sand (API)	0.72	Driven Piles Sand (API)	20
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	203.4	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	24
PL-5	Potentially Liquefiable Soil	203.4	-	198.4	613	0.02	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
III	SM, CL-ML, SC-SM, SC, CL	198.4	-	184.0	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	24
PL-6	Potentially Liquefiable Soil	184.0	-	179.0	744	0.03	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	--
III	SM, CL-ML, SC-SM, SC, CL	179.0	-	171.9	1000	0.10	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	24
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2080	1.46	0.8	Driven Piles Sand (API)	0.72	Driven Piles Sand (API)	50
V	SW, SM, SP, SP-SM	86.9	-	43.9	***	***	0.8	Driven Pile Sand (API)	0.72	Driven Pile Sand (API)	29
VI	CL, ML, SM	43.9	-	-31.2	***	***	0.8	Driven Pile Clay (API)	0.72	Driven Pile Clay (API)	26

Notes:
1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

Pier 8 - 96-IN DIA. DRILLED SHAFT **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Shear Strength Properties						Lateral Soil Resistance - FBMP Parameters						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	p-y Curve Type	$N_{1,60}$ (bpf)	Static Subgrade Modulus, k_s (pci)	Cyclic Subgrade Modulus, k_c (pci)	Major Principal Strain at 50%, ε_{50}	Poisson's Ratio, ν	Shear Modulus, G (ksi)
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)							
PL-1	Potentially Liquefiable Soil	270.0	-	265.0	110	47.6	--	--	--	--	50	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-2	Potentially Liquefiable Soil	265.0	-	260.0	110	47.6	--	--	--	--	150	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
PL-3	Potentially Liquefiable Soil	260.0	-	252.8	110	47.6	--	--	--	--	175	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	247.8	110	47.6	450	0	50	28	--	Soft Clay (Matlock)	6	30	--	0.020	0.50	0.3
PL-4	Potentially Liquefiable Soil	247.8	-	228.8	125	62.6	--	--	--	--	450	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
II	SM, CL, SP-SM, GP-GM	228.8	-	210.9	125	62.6	0	33	0	33	--	Sand (Reese)	30	90	90	--	0.25	1.2
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	203.4	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
PL-5	Potentially Liquefiable Soil	203.4	-	198.4	125	62.6	--	--	--	--	350	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
III	SM, CL-ML, SC-SM, SC, CL	198.4	-	184.0	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
PL-6	Potentially Liquefiable Soil	184.0	-	179.0	125	62.6	--	--	--	--	400	Hybrid Liquefied Sand (Franke and Rollins)	--	30	--	0.020	--	--
III	SM, CL-ML, SC-SM, SC, CL	179.0	-	171.9	125	62.6	1600	0	50	32	--	Stiff Clay w/ Free Water (Reese)	23	500	200	0.007	0.50	1.1
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	135	72.6	0	36	0	36	--	Sand (Reese)	100	125	125	--	0.30	3.7
V	SW, SM, SP, SP-SM	86.9	-	43.9	130	67.6	0	33	0	33	--	Sand (Reese)	21	60	60	--	0.25	0.8

Pier 8 - 96-IN DIA. DRILLED SHAFT **Borings: B-1020 & B-1021**

Soil	Soil Type	Elevation			Avg Axial Resistance [3]		Axial Soil Resistance - FBMP Parameters		
					EE-I				
					Unit Skin (psf)	Unit Toe (ksi)	t-z Curve Type	q-z Curve Type	Uncorrected N (bpf)
PL-1	Potentially Liquefiable Soil	270.0	-	265.0	23	0.01	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-2	Potentially Liquefiable Soil	265.0	-	260.0	83	0.02	Drilled Shaft Clay	Drilled Shaft Clay	--
PL-3	Potentially Liquefiable Soil	260.0	-	252.8	96	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
I	SP-SM, SC, CH, SP, CL, ML	252.8	-	247.8	248	0.03	Drilled Shaft Clay	Drilled Shaft Clay	4
PL-4	Potentially Liquefiable Soil	247.8	-	228.8	248	0.03	Drilled Shaft Clay	Drilled Shaft Clay	--
II	SM, CL, SP-SM, GP-GM	228.8	-	210.9	948	0.06	Drilled Shaft Sand	Drilled Shaft Sand	20
III	SM, CL-ML, SC-SM, SC, CL	210.9	-	203.4	880	0.06	Drilled Shaft Clay	Drilled Shaft Clay	24
PL-5	Potentially Liquefiable Soil	203.4	-	198.4	193	0.08	Drilled Shaft Clay	Drilled Shaft Clay	--
III	SM, CL-ML, SC-SM, SC, CL	198.4	-	184.0	880	0.07	Drilled Shaft Clay	Drilled Shaft Clay	24
PL-6	Potentially Liquefiable Soil	184.0	-	179.0	220	0.07	Drilled Shaft Clay	Drilled Shaft Clay	--
III	SM, CL-ML, SC-SM, SC, CL	179.0	-	171.9	880	0.11	Drilled Shaft Clay	Drilled Shaft Clay	24
IV	SM, SW-SM, SW, SP, SP-SM	171.9	-	86.9	2145	0.12	Drilled Shaft Sand	Drilled Shaft Sand	50
V	SW, SM, SP, SP-SM	86.9	-	43.9	***	***	Drilled Shaft Sand	Drilled Shaft Sand	29

Notes:

1. Bottom of pile cap is at El. 270.0 ft MSL
2. Mudline is approximately El. 270.0 ft MSL
3. Average Unit Resistance Values below Layer IV were not computed; however, see the foundations computation output for unit resistance values at each depth.

WESTERN RIVERBANK

100-YR RETURN PERIOD

West Riverbank Toe **Borings: B-1024**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
PL-2	Potentially Liquefiable Soil	233.2	-	226.6	130	67.6	--	--	--	--	100
II	GM, Sp-SM, SP, SM	226.6	-	205.0	130	67.6	--	36	--	36	--
III	SC-SM, SM	205.0	-	190.3	125	62.6	--	31	--	31	--
IV	SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	190.3	-	78.9	140	77.6	--	36	--	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

Pier 3 **Borings: B-1001, B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
PL-1	Potentially Liquefiable Soil	271.9	-	264.5	125	62.6	--	--	--	--	35
I	SM, SP-SM, SP, SW, GP-GM	264.5	-	244.3	125	62.6	--	30	--	30	--
II	GM, SP-SM, SP, SM	244.3	-	210.0	130	67.6	--	36	--	36	--
III	SC-SM, SM	210.0	-	181.1	125	62.6	--	31	--	31	--
IV	SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	181.1	-	26.5	140	77.6	--	36	--	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

1,000-YR RETURN PERIOD

West Riverbank Toe **Borings: B-1024**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
PL-4	Potentially Liquefiable Soil	231.7	-	221.0	130	67.6	--	--	--	--	235
II	GM, SP-SM, SP, SM	221.0	-	205.0	130	67.6	--	36	--	36	--
PL-5	Potentially Liquefiable Soil	205.0	-	192.4	130	67.6	--	--	--	--	1000
III	SC-SM, SM	192.4	-	190.3	125	62.6	--	31	--	31	--
IV	SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	190.3	-	78.9	140	77.6	--	36	--	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

Pier 3 **Borings: B-1001, B-1002**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
PL-1	Potentially Liquefiable Soil	271.9	-	264.5	125	62.6	--	--	--	--	100
PL-2	Potentially Liquefiable Soil	264.5	-	258.0	125	62.6	--	--	--	--	300
PL-3	Potentially Liquefiable Soil	258.0	-	242.5	125	62.6	--	--	--	--	500
II	GM, SP-SM, SP, SM	242.5	-	210.0	130	67.6	--	36	--	36	--
PL-5	Potentially Liquefiable Soil	210.0	-	199.0	130	67.6	--	--	--	--	1000
III	SC-SM, SM	199.0	-	181.1	125	62.6	--	31	--	31	--
IV	SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	181.1	-	26.5	140	77.6	--	36	--	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

EASTERN RIVERBANK

100-YR RETURN PERIOD

East Riverbank Toe **Borings: B-1023**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
I	CL, CL-ML, SM	272.7	-	271.0	115	52.6	850	0	50	28	--
Pl-1	Potentially Liquefiable Soil	271.0	-	262.0	115	52.6	--	--	--	--	100
I	CL, CL-ML, SM	262.0	-	257.1	115	52.6	850	0	50	28	--
II	SM, GM, SP, SP-SM	257.1	-	225.1	125	62.6	0	32	0	32	--
III	ML, SM, CL, SC-SM	225.1	-	182.1	125	62.6	1600	0	50	29	--
IV	SM, SP-SM, SW, SP, SW-SM	182.1	-	115.2	135	72.6	0	36	0	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

East Riverbank Crest **Borings: B-3**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)
I	CL, SM, SP-SM	315.1	-	300.0	115	115	850	0	50	28	--
I	CL, SM, SP-SM	300.0	-	271.0	115	52.6	850	0	50	28	--
PL-1	Potentially Liquefiable Soil	271.0	-	262.0	120	52.6	--	--	--	--	100
II	SM, SP, SW. SW-SM	262.0	-	239.1	125	62.6	0	32	0	32	--
III	SC, SM, SC-SM, ML	239.1	-	186.1	125	62.6	1600	0	50	29	--
IV	SC-SM, SC, SP-SM, SM, SW-SM, SW	186.1	-	112.1	135	72.6	0	36	0	36	--

Notes:

1. Normal pool elevation is at El. 300.0 ft MSL

1,000-YR RETURN PERIOD

East Riverbank Toe **Borings: B-1023**

Soil	Soil Type	Elevation			Shear Strength Properties							
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Res. Shear Strength	Ratio of Res. Shear Strength to Effective Stress
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r (psf)	S_r/σ'_v
PL-1	Potentially Liquefiable Soil	272.7	-	225.0	120	57.6	--	--	--	--	--	0.5
III	ML, SM, CL, SC-SM	225.0	-	216.0	125	62.6	1600	0	50	29	--	--
PL-2	Potentially Liquefiable Soil	216.0	-	198.0	120	57.6	--	--	--	--	1000	--
III	ML, SM, CL, SC-SM	198.0	-	182.1	125	62.6	1600	0	50	29	--	--
IV	SM, SP-SM, SW, SP, SW-SM	182.1	-	115.2	135	72.6	0	36	0	36	--	--

Notes:
1. Normal pool elevation is at El. 300.0 ft MSL

East Riverbank Crest **Borings: B-3**

Soil	Soil Type	Elevation			Shear Strength Properties						
					Unit Weight (pcf)	Effective Unit Weight (pcf)	Total Shear Strength		Effective Shear Strength		Ratio of Res. Shear Strength to Effective Stress
							c (psf)	φ (°)	c' (psf)	φ' (°)	S_r/σ'_v
I	CL, SM, SP-SM	315.1	-	305.0	115	115	850	0	50	28	--
PL-1	Potentially Liquefiable Soil	305.0	-	300.0	120	52.6	--	--	--	--	0.5
PL-1	Potentially Liquefiable Soil	300.0	-	225.0	120	52.6	--	--	--	--	0.5
III	SC, SM, SC-SM, ML	225.0	-	186.1	125	62.6	1600	0	50	29	--
IV	SC-SM, SC, SP-SM, SM, SW-SM, SW	186.1	-	112.1	135	72.6	0	36	0	36	--

Notes:
1. Normal pool elevation is at El. 300.0 ft MSL

Appendix E – Seismic & Liquefaction Analyses

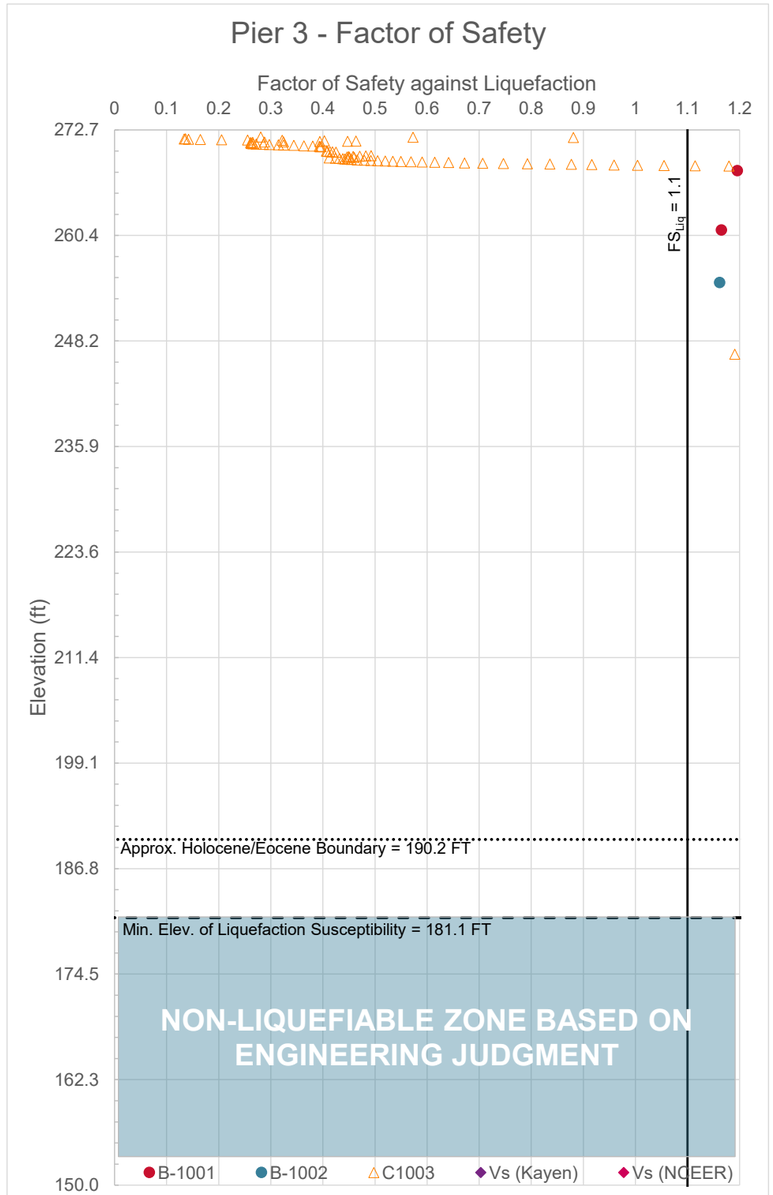
Liquefaction Analysis and Seismic Settlement Results Plot

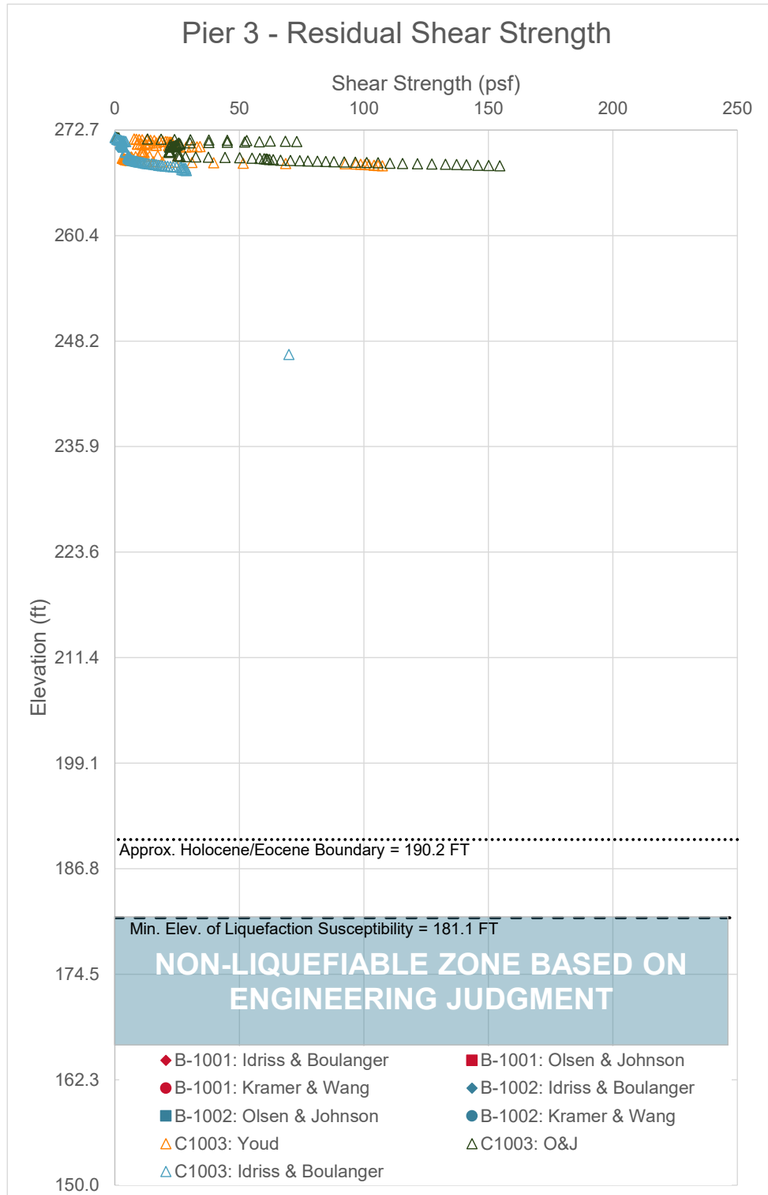
PIER 3

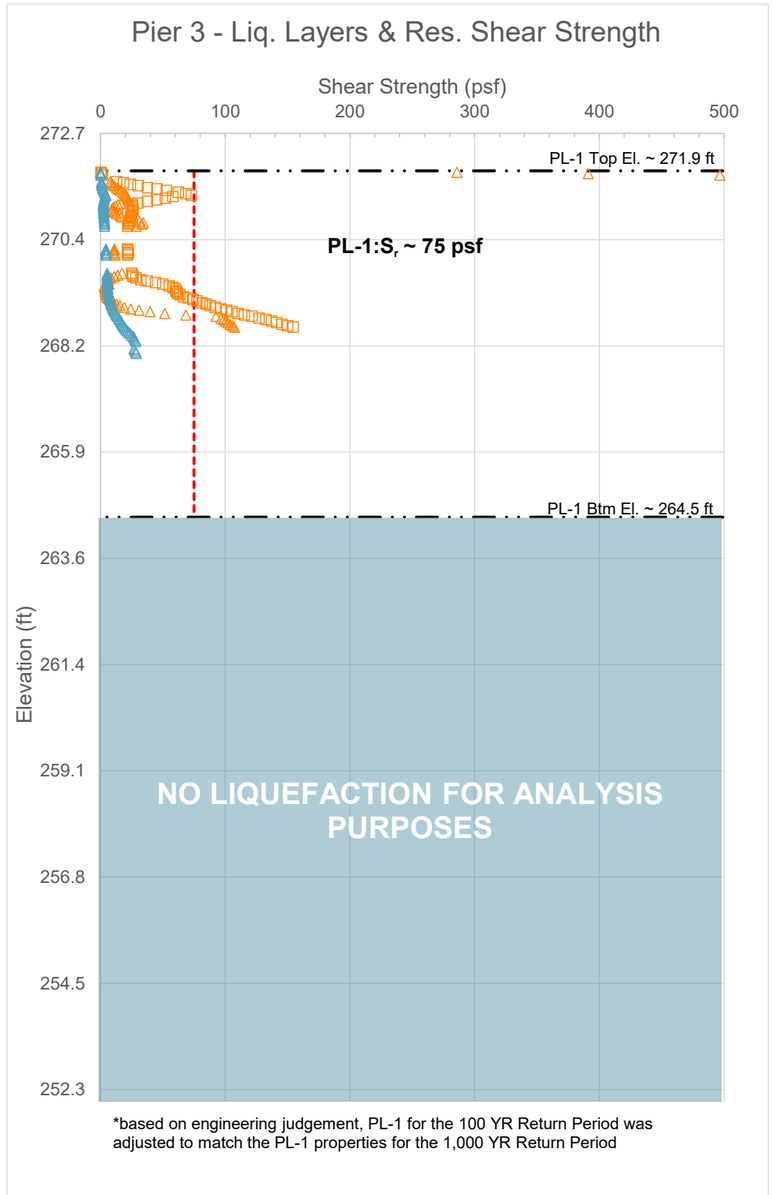
100-YR RETURN PERIOD

Project: US-51 Bridge Replacement
Subject: Seismic
Task: Liquefaction
Job #: 10174706

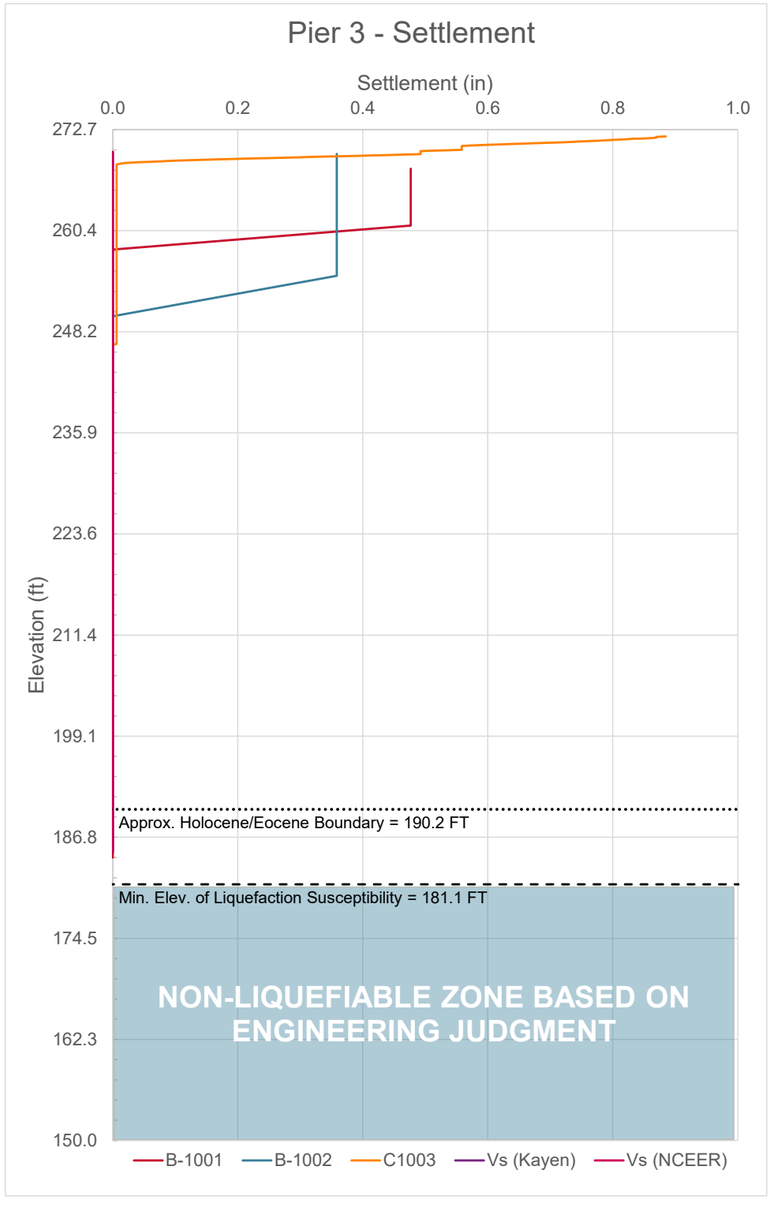
Computed by: BAR Date: 07/09/2025
Checked by: SKB Date: 07/10/2025
Page: 1 of 2

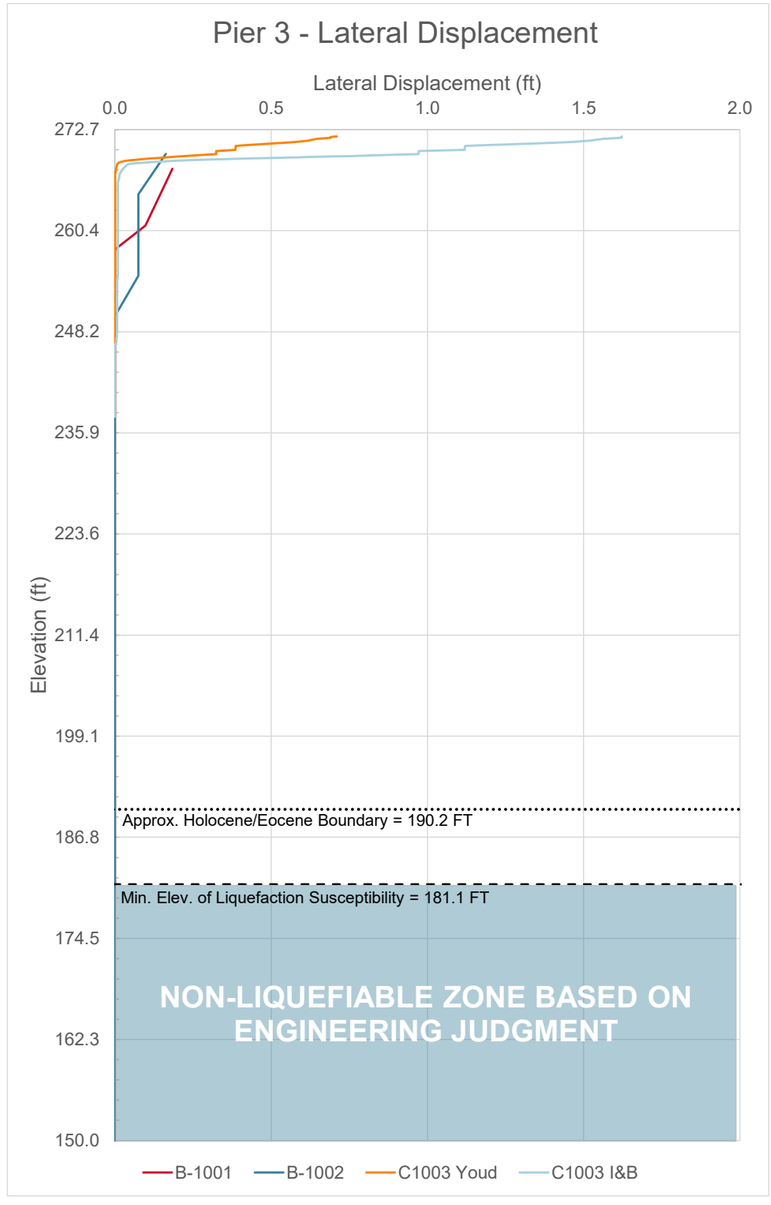




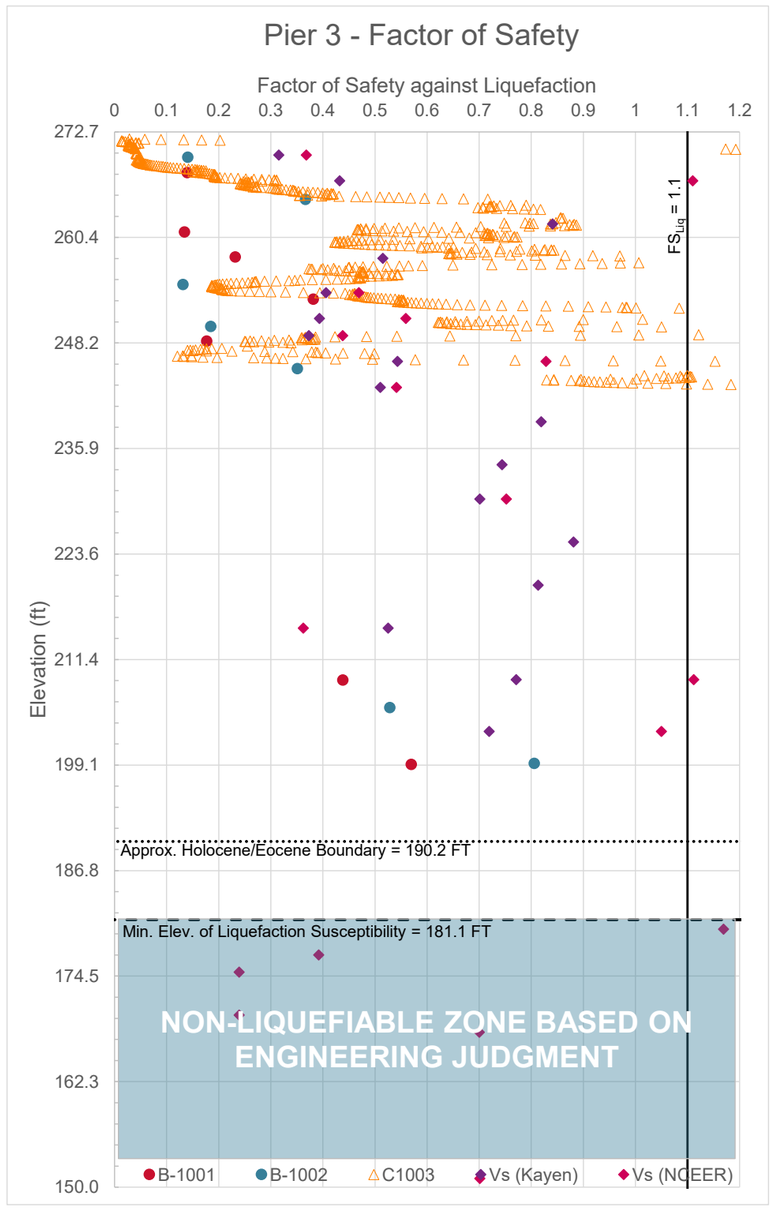


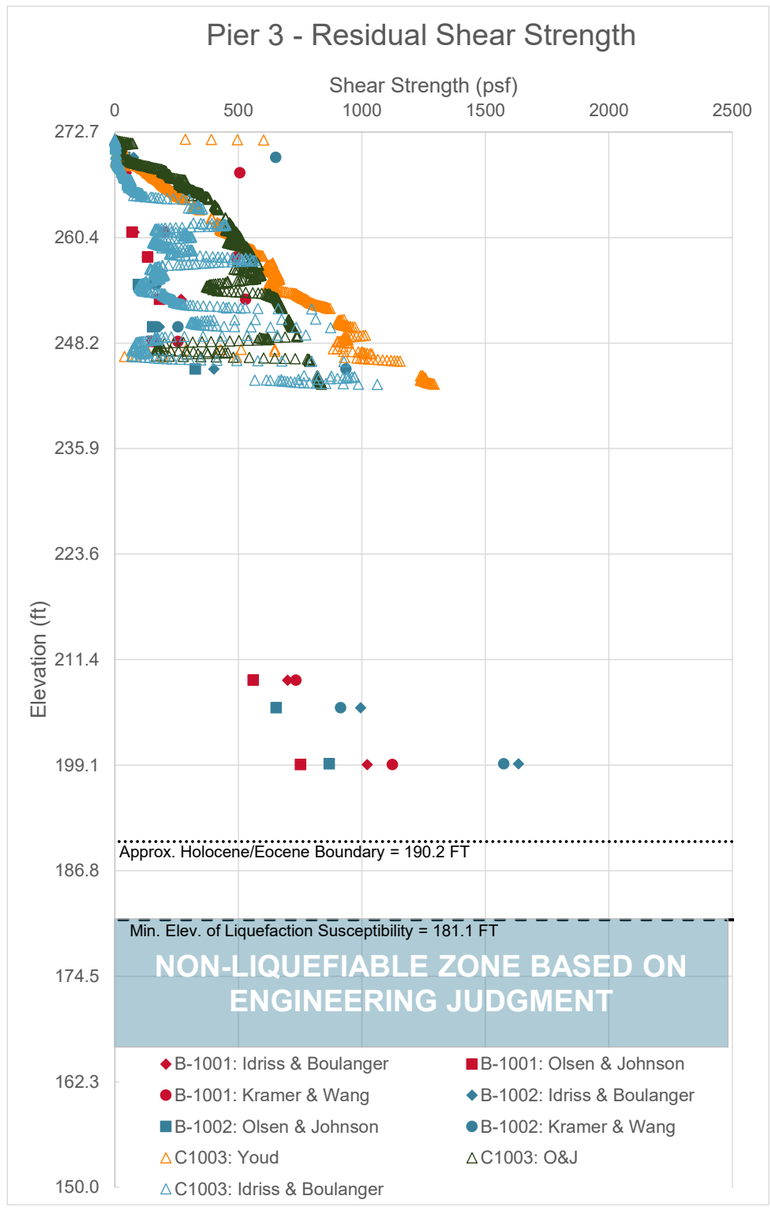
*based on engineering judgement, PL-1 for the 100 YR Return Period was adjusted to match the PL-1 properties for the 1,000 YR Return Period

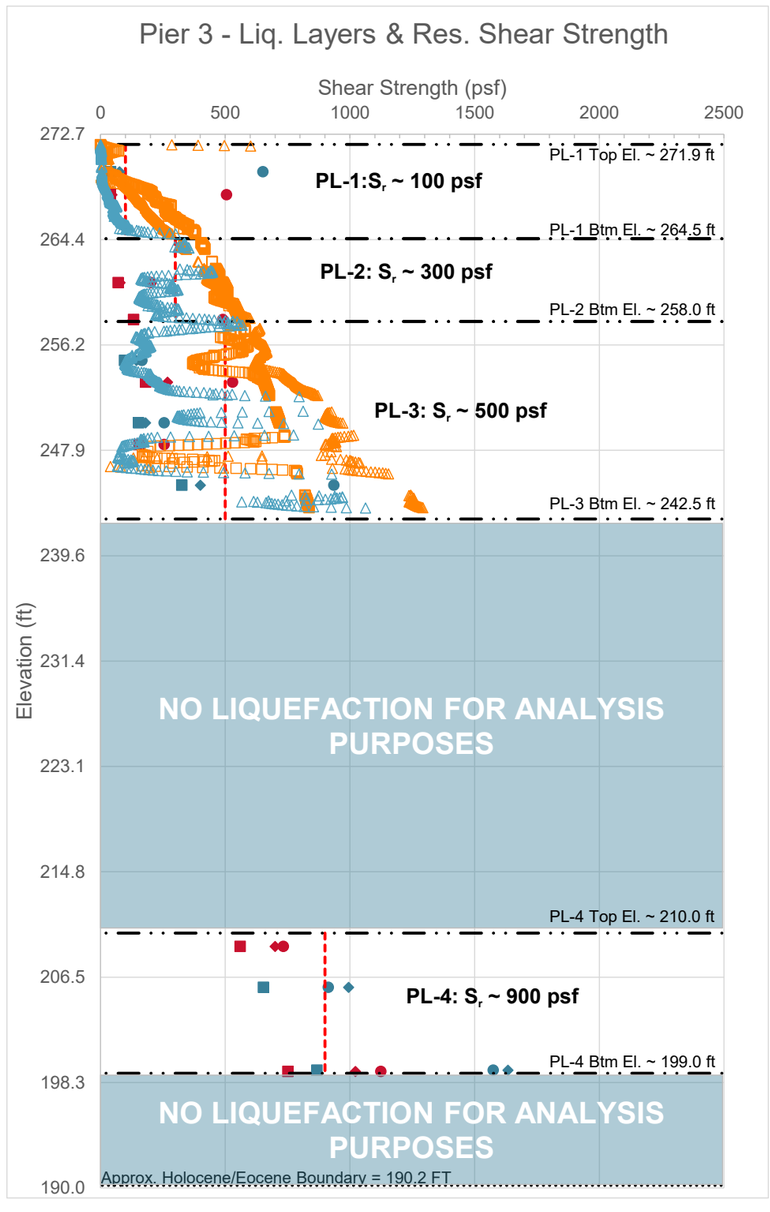

Pier 3 - Settlement
Settlement (in)
0.0
0.2
0.4
0.6
0.8
1.0
Elevation (ft)
272.7
260.4
248.2
235.9
223.6
211.4
199.1
186.8
174.5
162.3
150.0
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001
B-1002
C1003
Vs (Kayen)
Vs (NCEER)

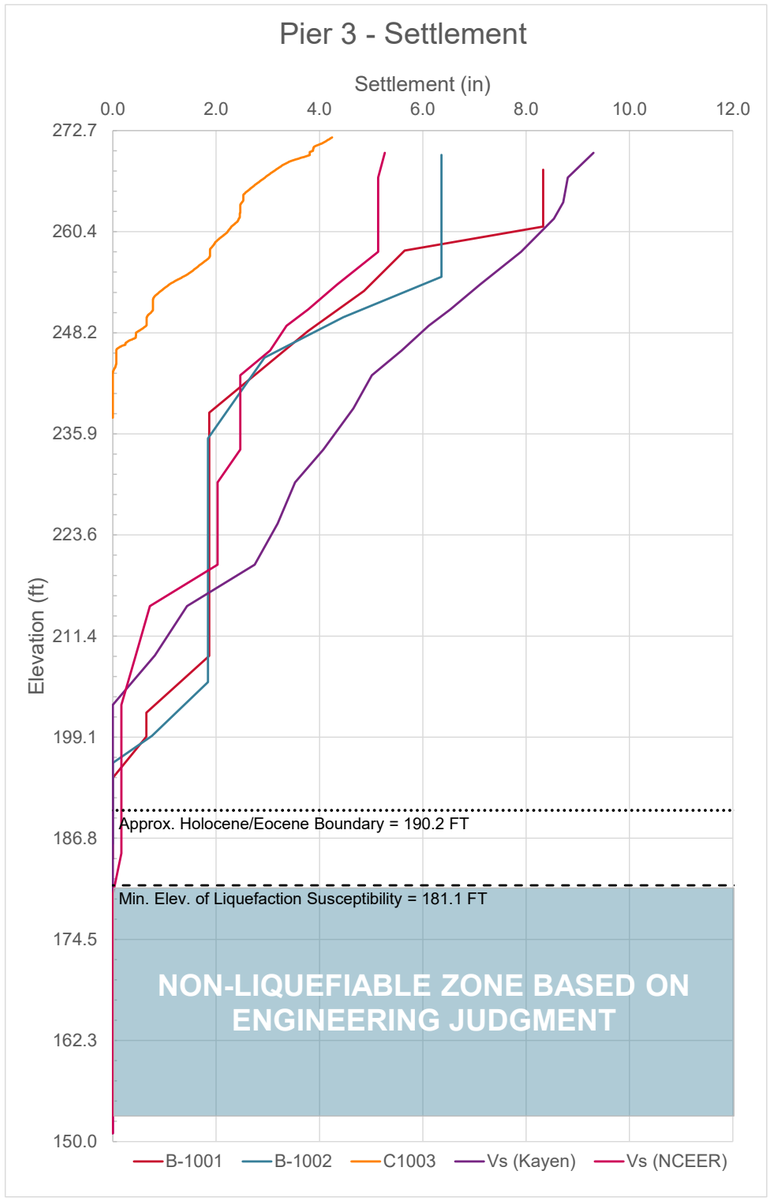

Pier 3 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
Elevation (ft)
272.7
260.4
248.2
235.9
223.6
211.4
199.1
186.8
174.5
162.3
150.0
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001
B-1002
C1003 Youd
C1003 I&B

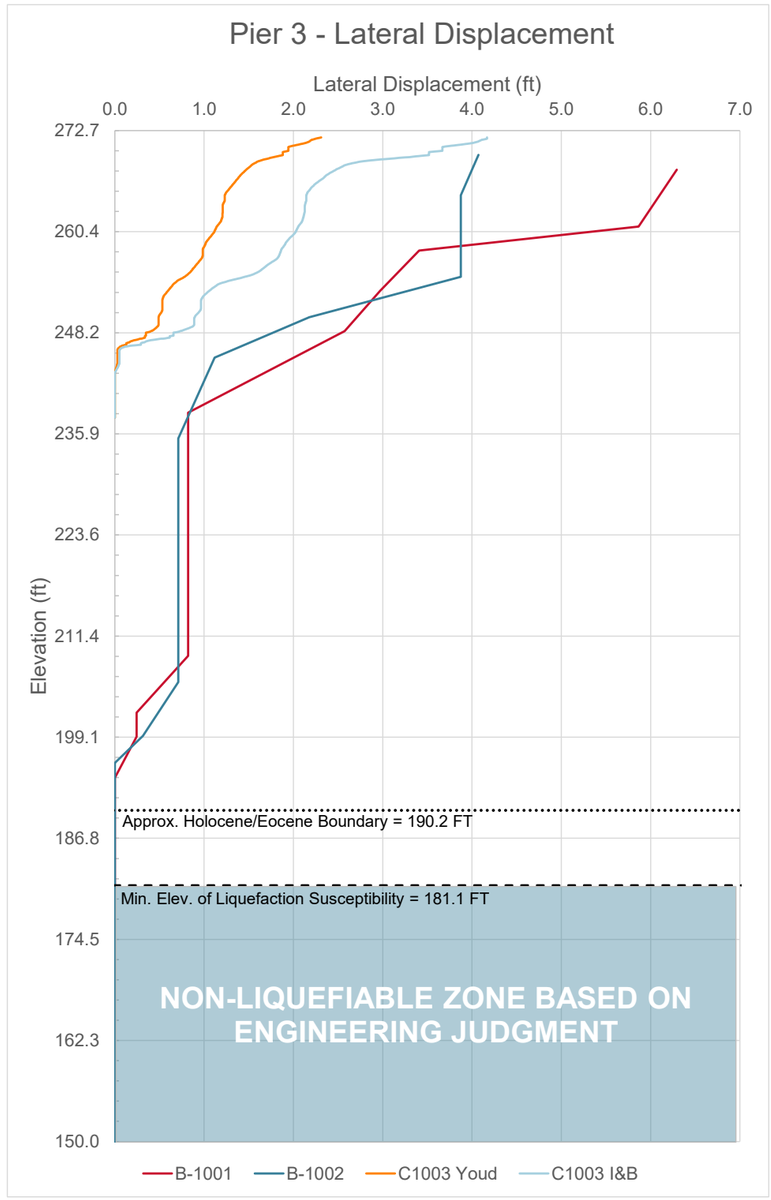
1,000-YR RETURN PERIOD


Pier 3 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
272.7 260.4 248.2 235.9 223.6 211.4 199.1 186.8 174.5 162.3 150.0
Elevation (ft)
FS_Liq = 1.1
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001 B-1002 C1003 Vs (Kayen) Vs (NCEER)


Pier 3 - Residual Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500
272.7 260.4 248.2 235.9 223.6 211.4 199.1 186.8 174.5 162.3 150.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001: Idriss & Boulanger
B-1001: Olsen & Johnson
B-1001: Kramer & Wang
B-1002: Idriss & Boulanger
B-1002: Olsen & Johnson
B-1002: Kramer & Wang
C1003: Youd
C1003: O&J
C1003: Idriss & Boulanger

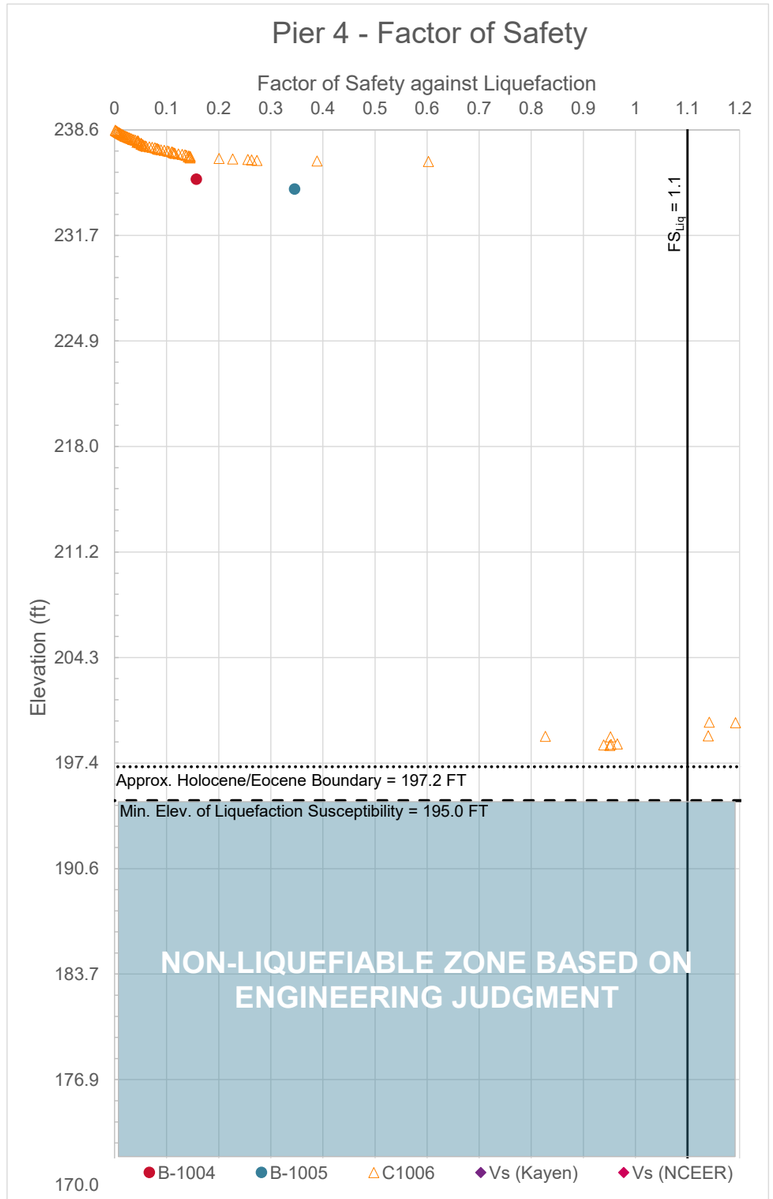

Pier 3 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500
272.7 264.4 256.2 247.9 239.6 231.4 223.1 214.8 206.5 198.3 190.0
Elevation (ft)
PL-1 Top El. ~ 271.9 ft
PL-1:S_r ~ 100 psf
PL-1 Btm El. ~ 264.5 ft
PL-2: S_r ~ 300 psf
PL-2 Btm El. ~ 258.0 ft
PL-3: S_r ~ 500 psf
PL-3 Btm El. ~ 242.5 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-4 Top El. ~ 210.0 ft
PL-4: S_r ~ 900 psf
PL-4 Btm El. ~ 199.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Approx. Holocene/Eocene Boundary = 190.2 FT

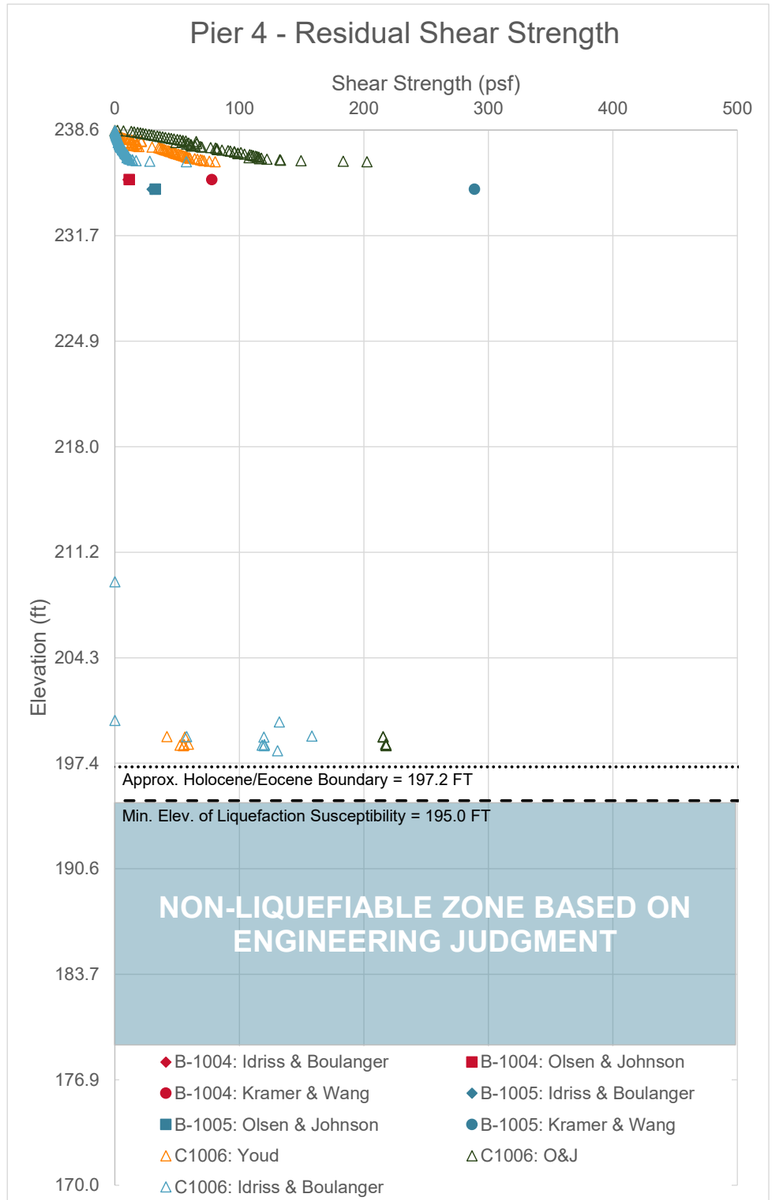

Pier 3 - Settlement
Settlement (in)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Elevation (ft)
272.7
260.4
248.2
235.9
223.6
211.4
199.1
186.8
174.5
162.3
150.0
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001
B-1002
C1003
Vs (Kayen)
Vs (NCEER)

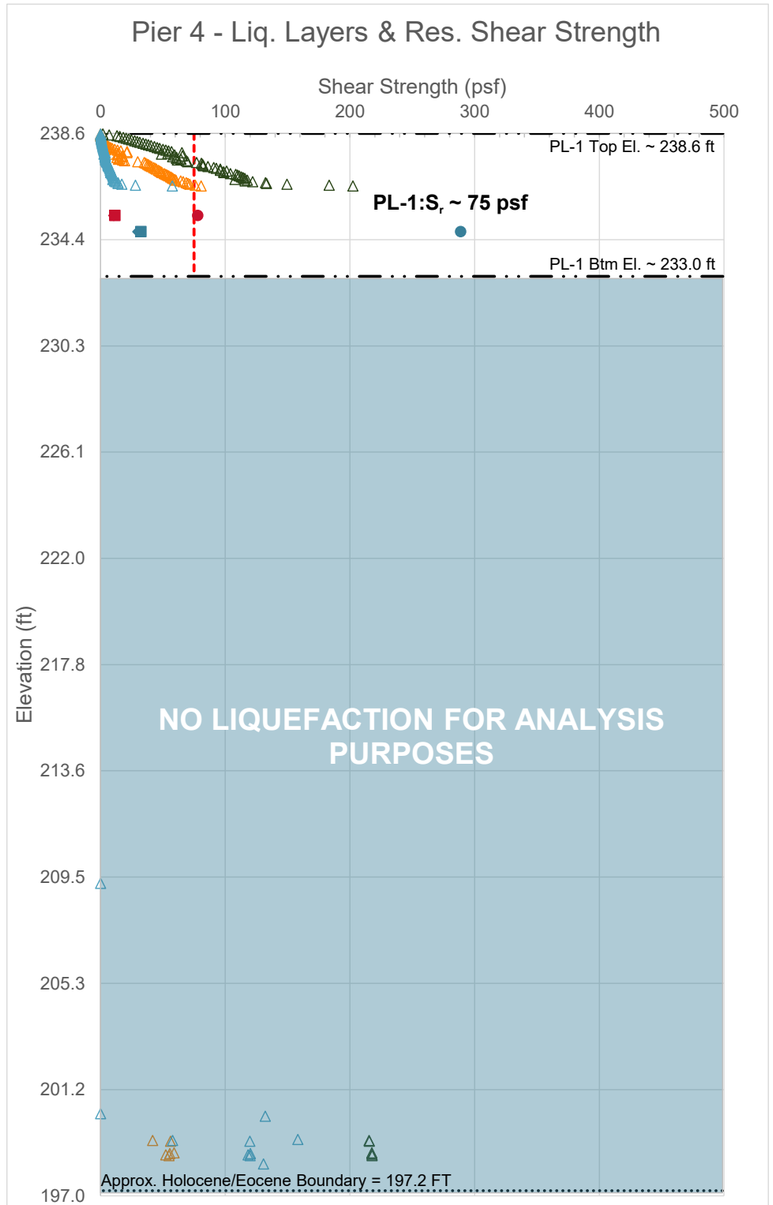

Pier 3 - Lateral Displacement
Lateral Displacement (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Elevation (ft)
272.7
260.4
248.2
235.9
223.6
211.4
199.1
186.8
174.5
162.3
150.0
Approx. Holocene/Eocene Boundary = 190.2 FT
Min. Elev. of Liquefaction Susceptibility = 181.1 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1001
B-1002
C1003 Youd
C1003 I&B

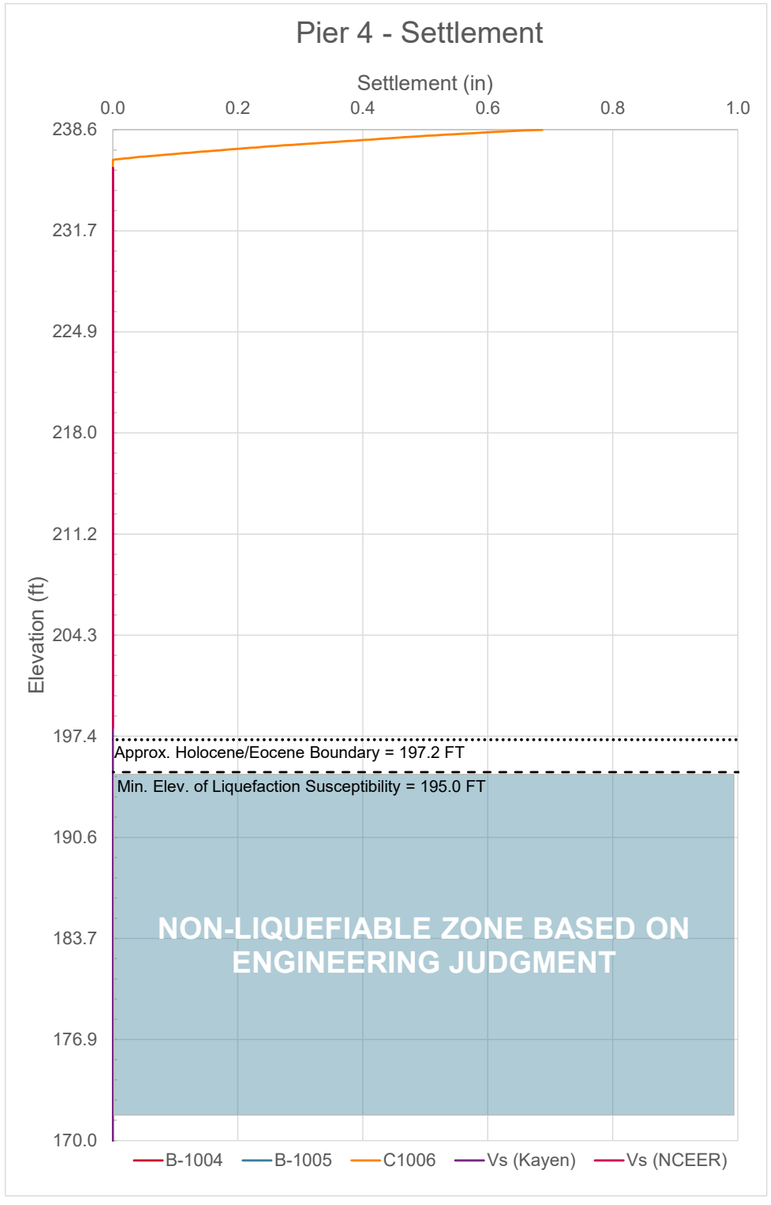
PIER 4

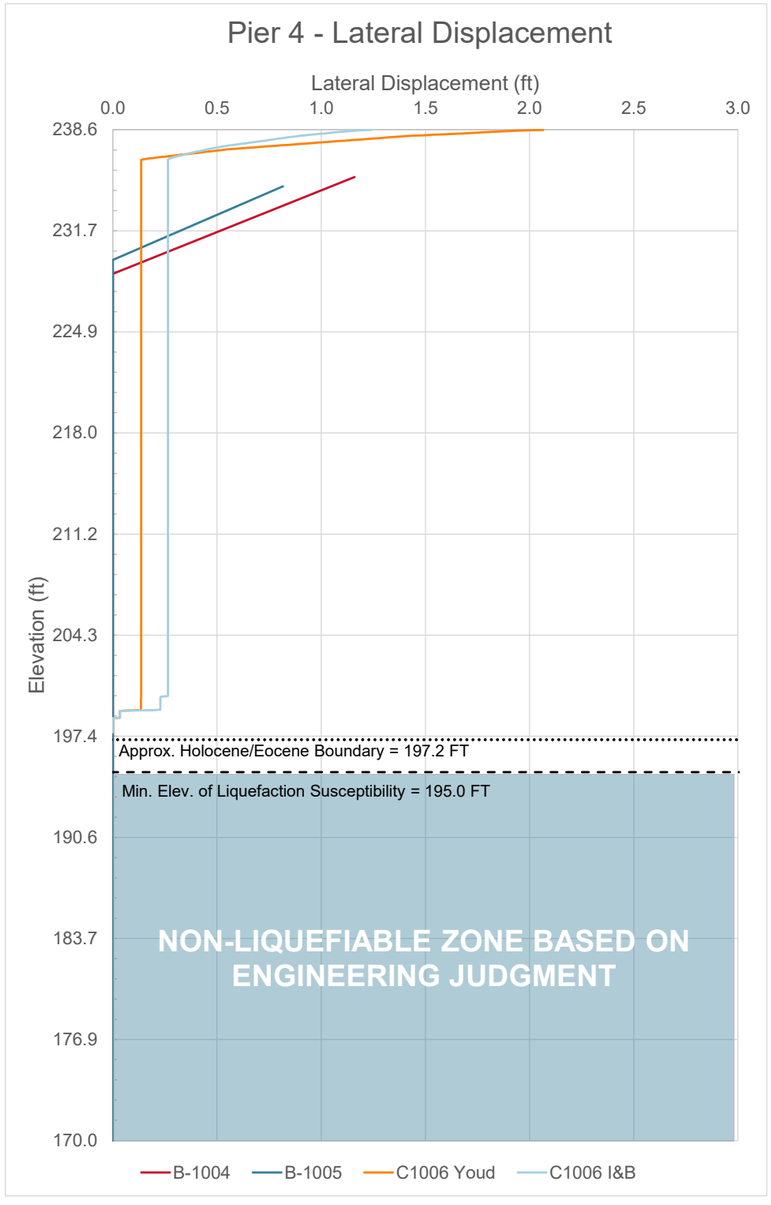
100-YR RETURN PERIOD


Pier 4 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Elevation (ft)
FS_liq = 1.1
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004
B-1005
C1006
Vs (Kayen)
Vs (NCEER)


Pier 4 - Residual Shear Strength
Shear Strength (psf)
0 100 200 300 400 500
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004: Idriss & Boulanger
B-1004: Olsen & Johnson
B-1004: Kramer & Wang
B-1005: Idriss & Boulanger
B-1005: Olsen & Johnson
B-1005: Kramer & Wang
C1006: Youd
C1006: O&J
C1006: Idriss & Boulanger


Pier 4 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 100 200 300 400 500
238.6
234.4
230.3
226.1
222.0
217.8
213.6
209.5
205.3
201.2
197.0
Elevation (ft)
PL-1 Top El. ~ 238.6 ft
PL-1:S_r ~ 75 psf
PL-1 Btm El. ~ 233.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Approx. Holocene/Eocene Boundary = 197.2 FT

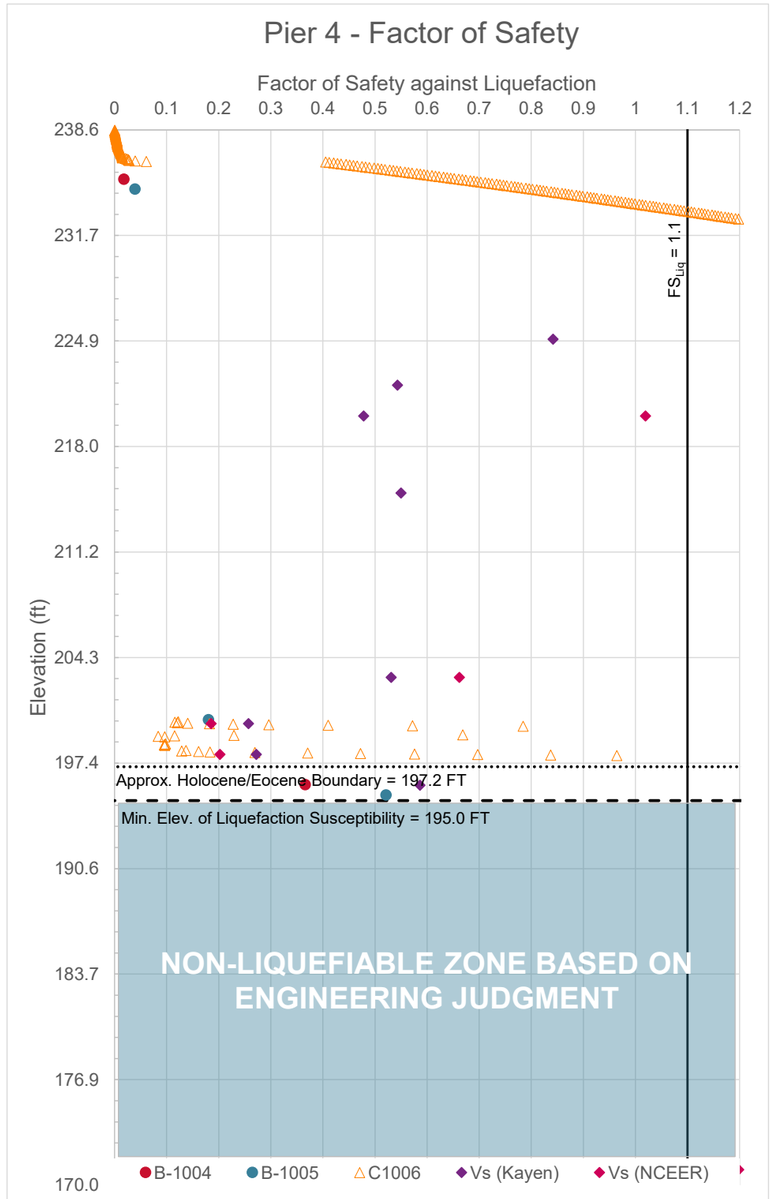

Pier 4 - Settlement
Settlement (in)
0.0
0.2
0.4
0.6
0.8
1.0
Elevation (ft)
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004
B-1005
C1006
Vs (Kayen)
Vs (NCEER)

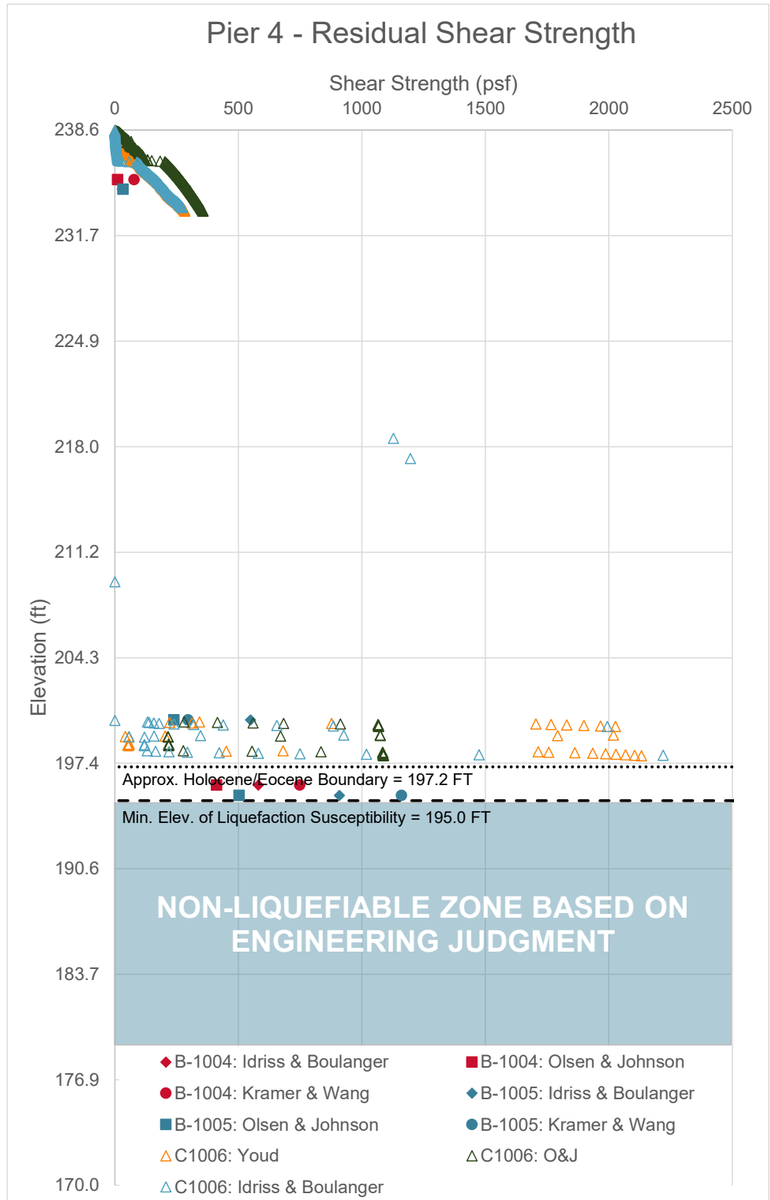

Pier 4 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Elevation (ft)
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004
B-1005
C1006 Youd
C1006 I&B

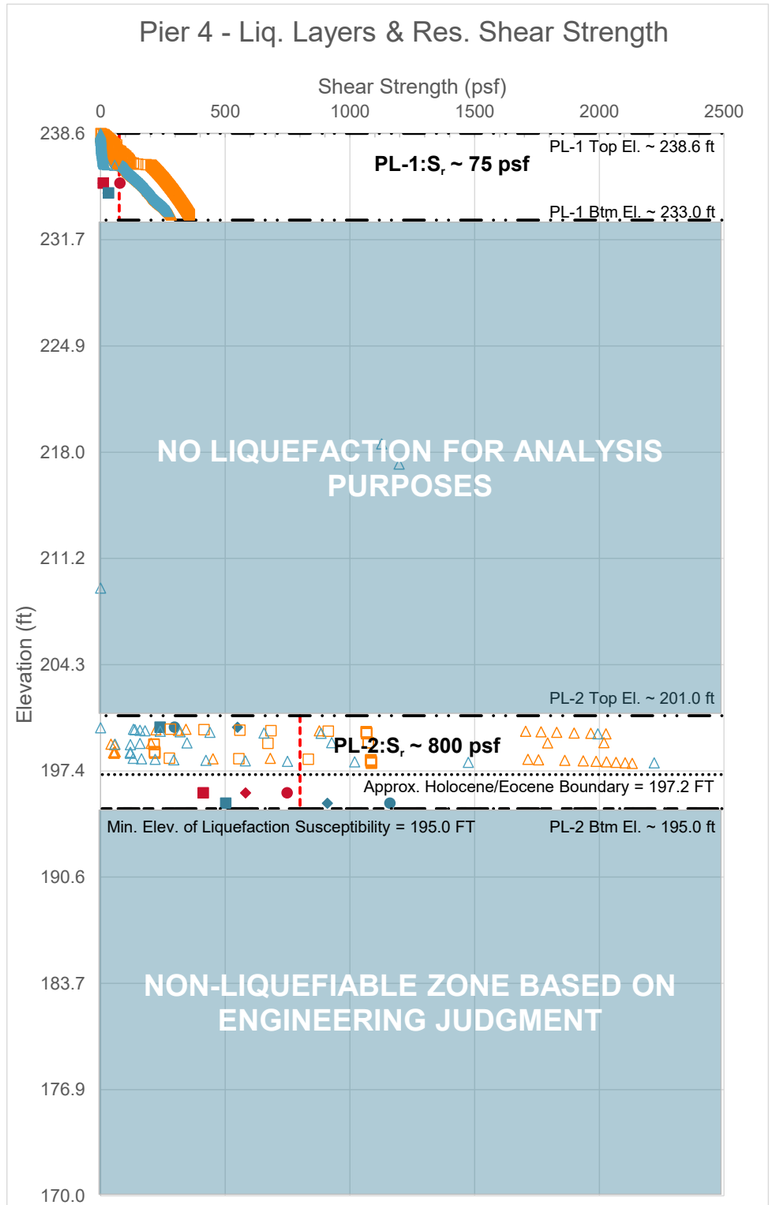
1,000-YR RETURN PERIOD

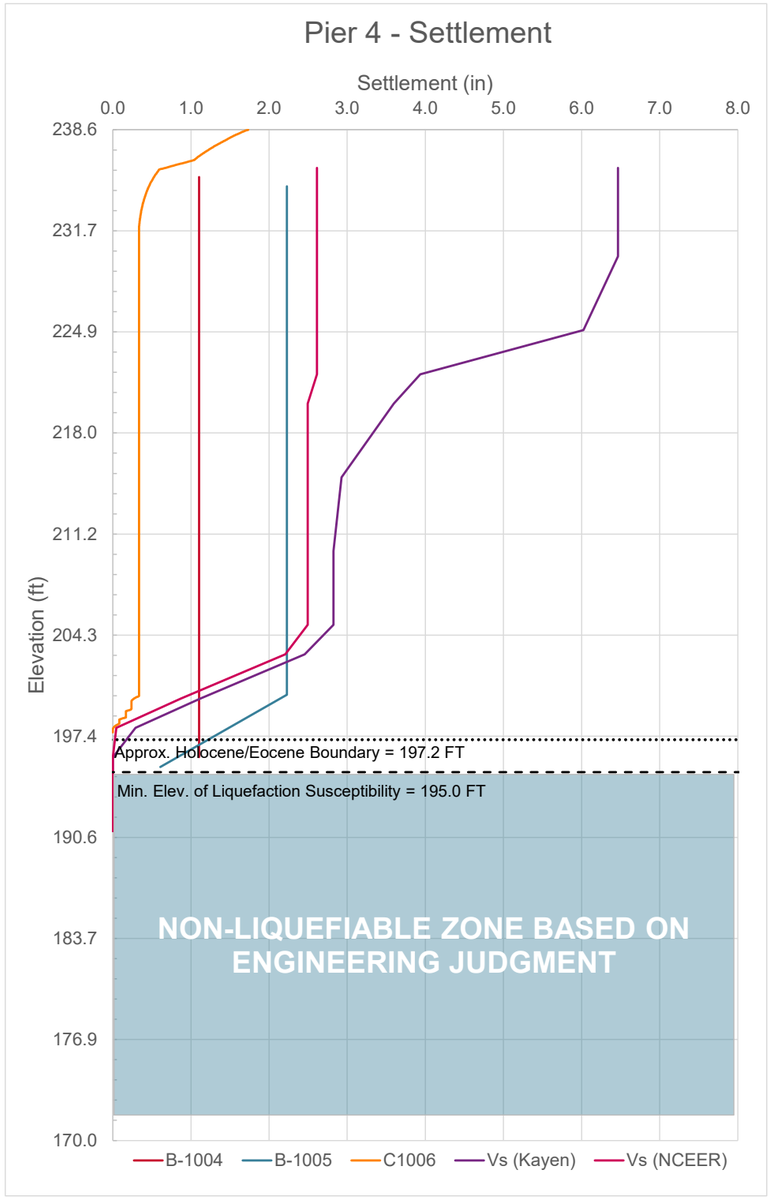
Project: US-51 Bridge Replacement
Subject: Seismic
Task: Liquefaction
Job #: 10174706

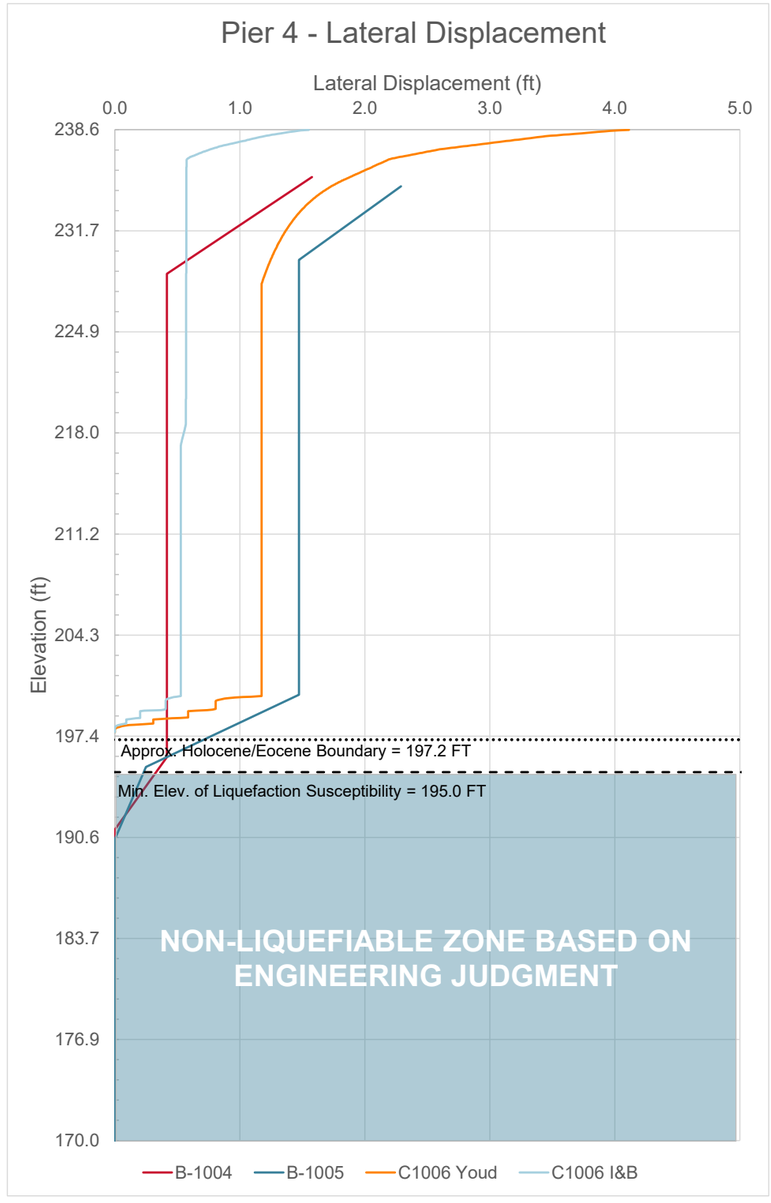
Computed by: BAR Date: 07/09/2025
Checked by: SKB Date: 07/10/2025
Page: 1 of 2





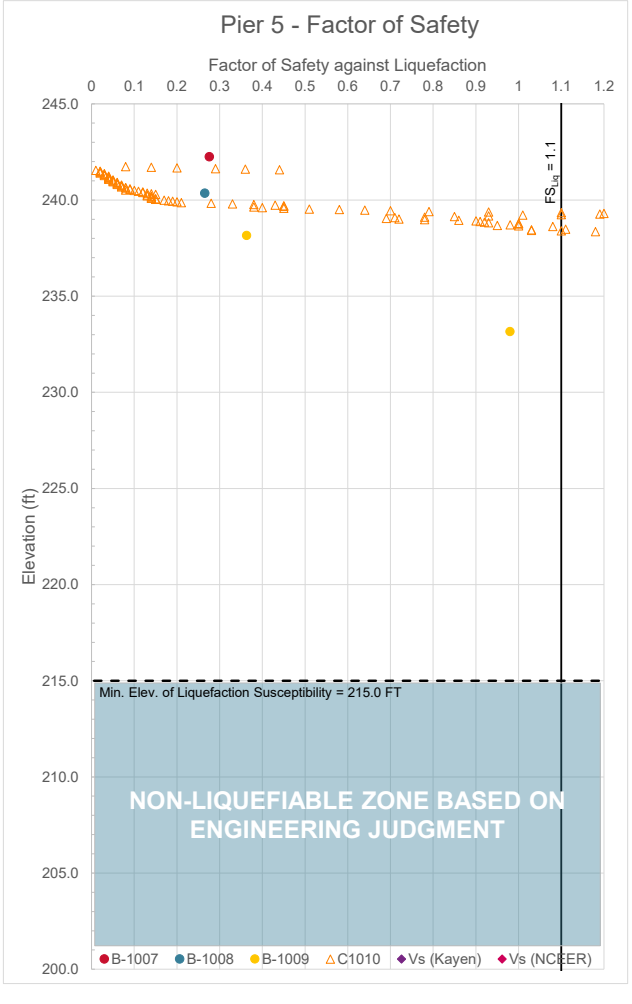


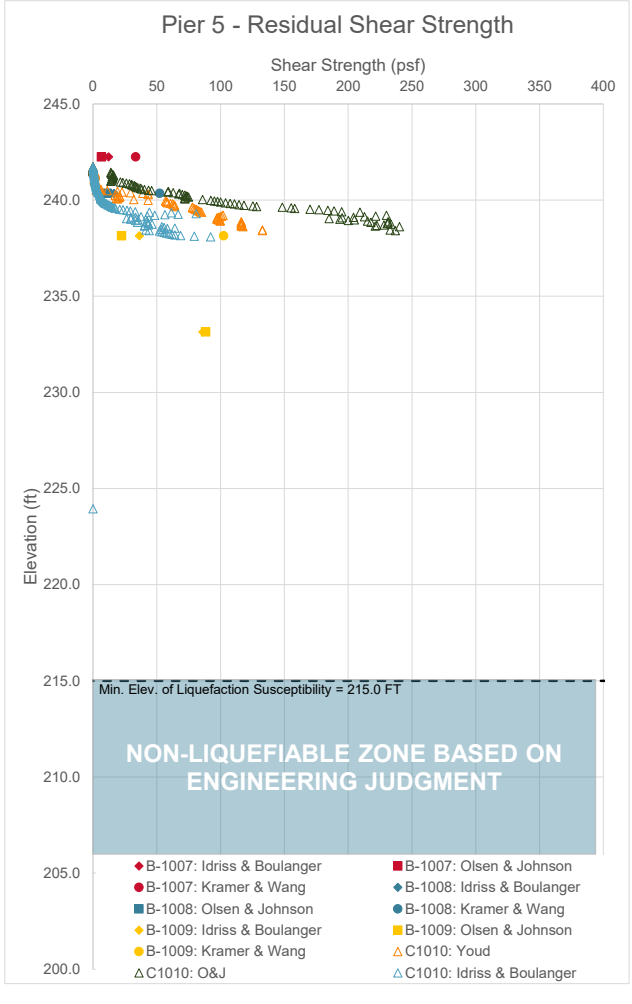

Pier 4 - Settlement
Settlement (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Elevation (ft)
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004
B-1005
C1006
Vs (Kayen)
Vs (NCEER)

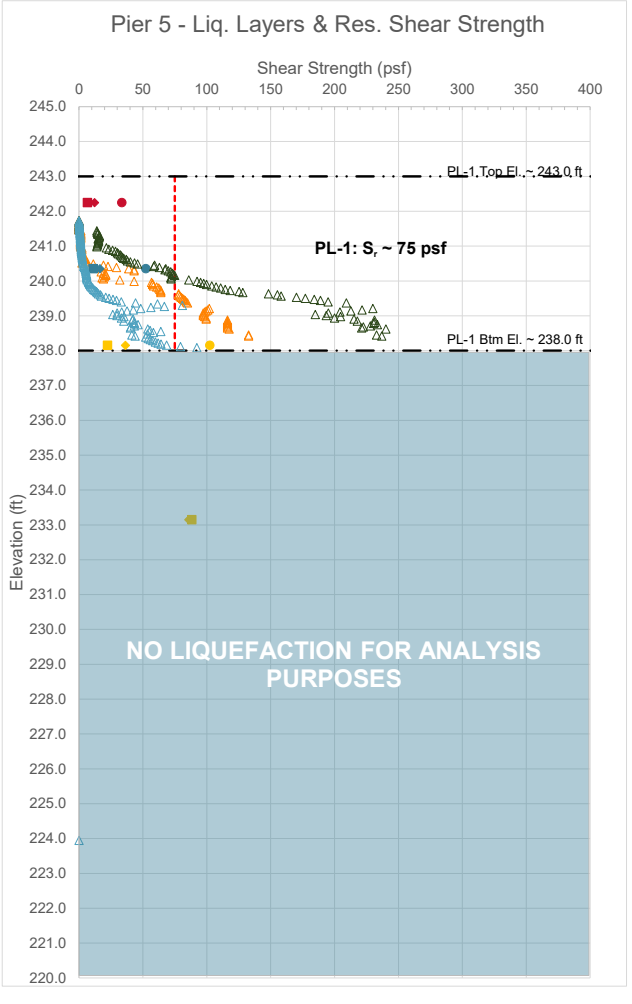

Pier 4 - Lateral Displacement
Lateral Displacement (ft)
0.0
1.0
2.0
3.0
4.0
5.0
Elevation (ft)
238.6
231.7
224.9
218.0
211.2
204.3
197.4
190.6
183.7
176.9
170.0
Approx. Holocene/Eocene Boundary = 197.2 FT
Min. Elev. of Liquefaction Susceptibility = 195.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1004
B-1005
C1006 Youd
C1006 I&B

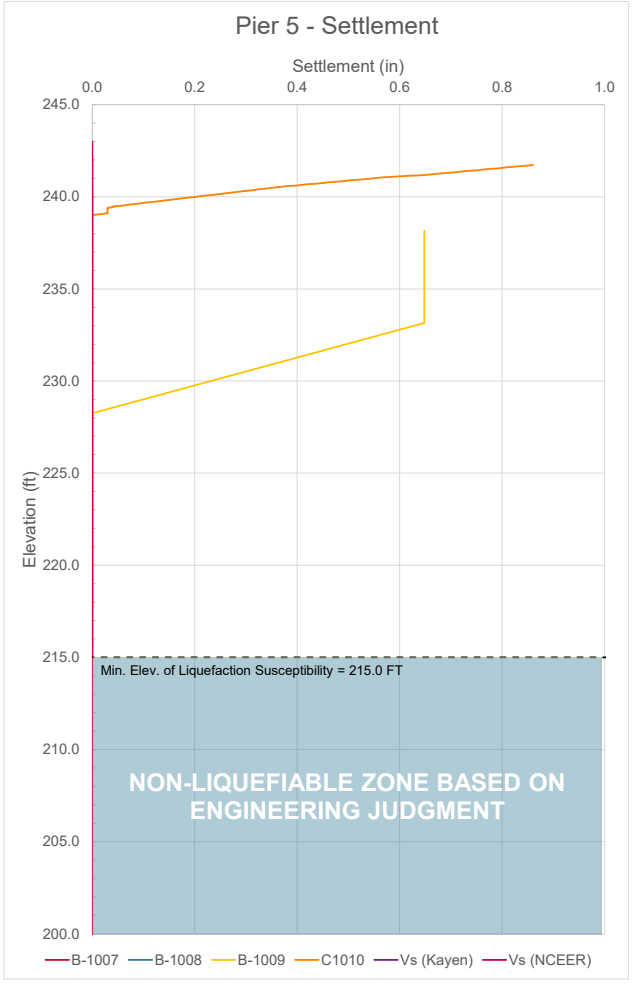
PIER 5

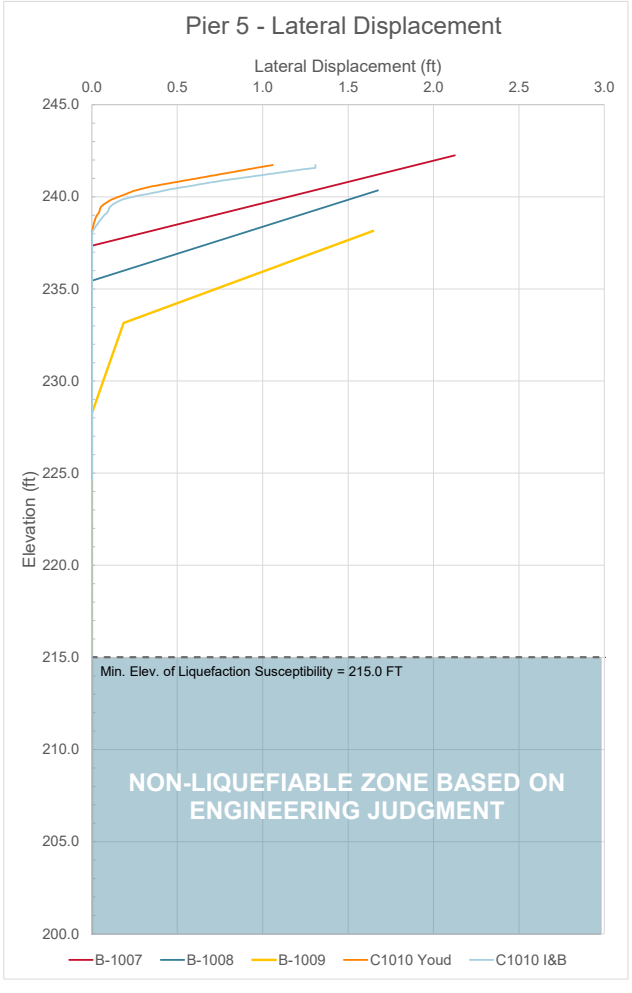
100-YR RETURN PERIOD


Pier 5 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
245.0 240.0 235.0 230.0 225.0 220.0 215.0 210.0 205.0 200.0
Elevation (ft)
FS_Liq = 1.1
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007 B-1008 B-1009 C1010 Vs (Kayen) Vs (NCEER)

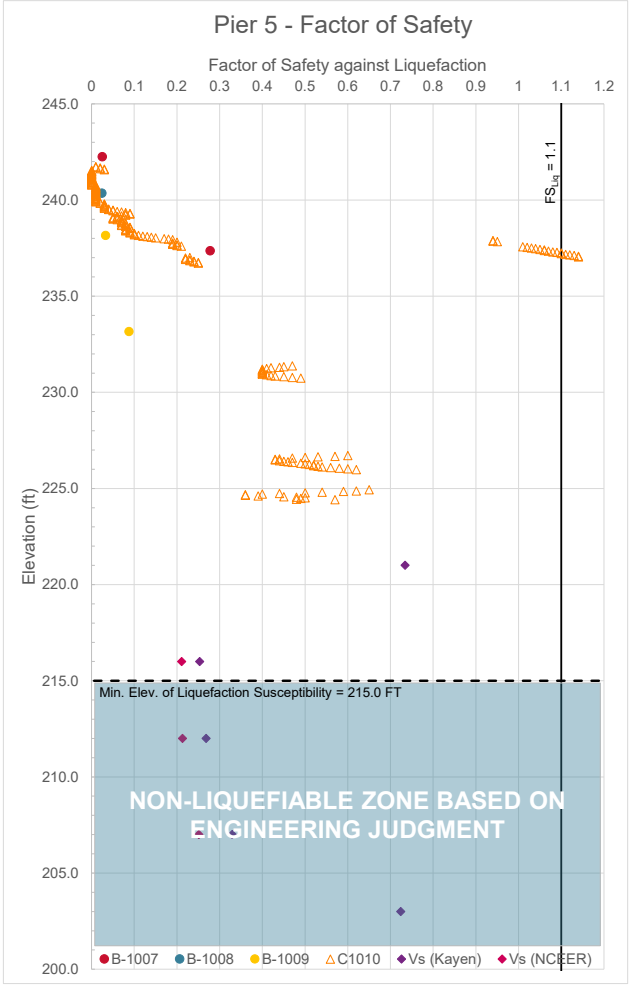

Pier 5 - Residual Shear Strength
Shear Strength (psf)
0 50 100 150 200 250 300 350 400
245.0 240.0 235.0 230.0 225.0 220.0 215.0 210.0 205.0 200.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007: Idriss & Boulanger
B-1007: Olsen & Johnson
B-1007: Kramer & Wang
B-1008: Idriss & Boulanger
B-1008: Olsen & Johnson
B-1008: Kramer & Wang
B-1009: Idriss & Boulanger
B-1009: Olsen & Johnson
B-1009: Kramer & Wang
C1010: Youd
C1010: O&J
C1010: Idriss & Boulanger

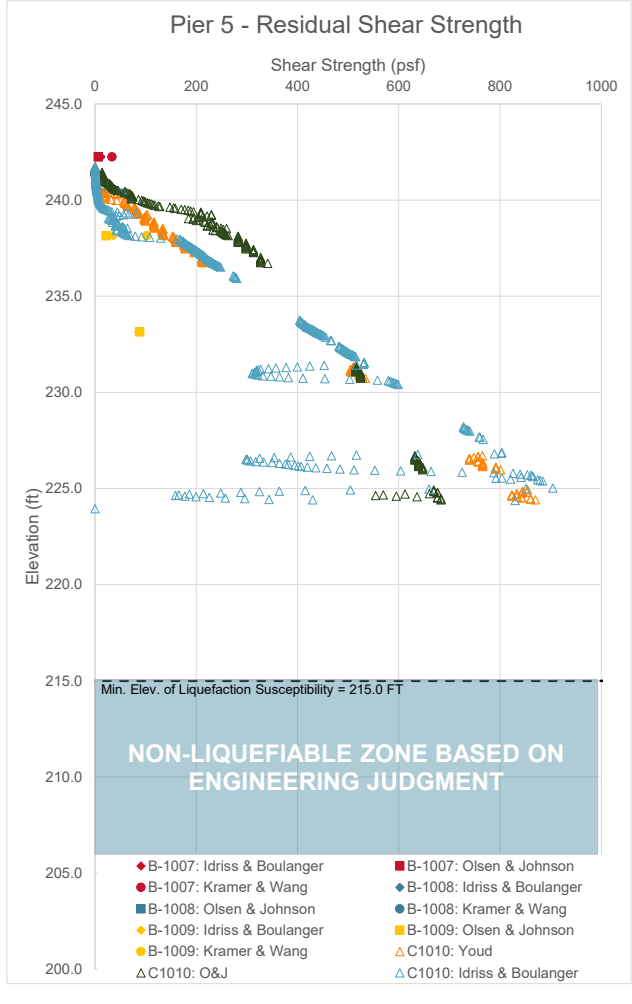

Pier 5 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 50 100 150 200 250 300 350 400
245.0 244.0 243.0 242.0 241.0 240.0 239.0 238.0 237.0 236.0 235.0 234.0 233.0 232.0 231.0 230.0 229.0 228.0 227.0 226.0 225.0 224.0 223.0 222.0 221.0 220.0
Elevation (ft)
PL-1 Top El. ~ 243.0 ft
PL-1: S, ~ 75 psf
PL-1 Btm El. ~ 238.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES

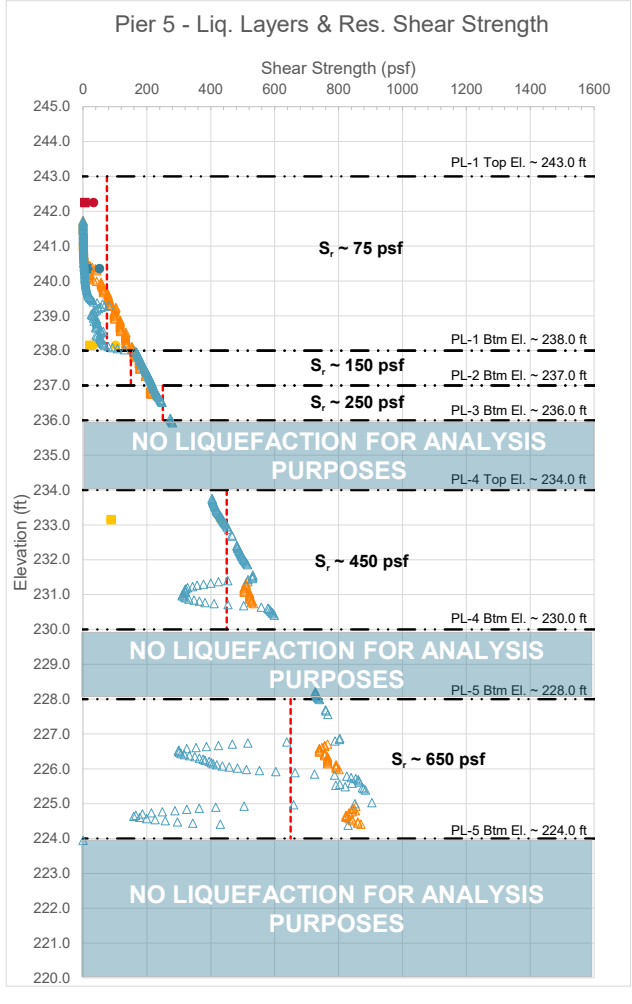

Pier 5 - Settlement
Settlement (in)
0.0
0.2
0.4
0.6
0.8
1.0
Elevation (ft)
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007
B-1008
B-1009
C1010
Vs (Kayen)
Vs (NCEER)

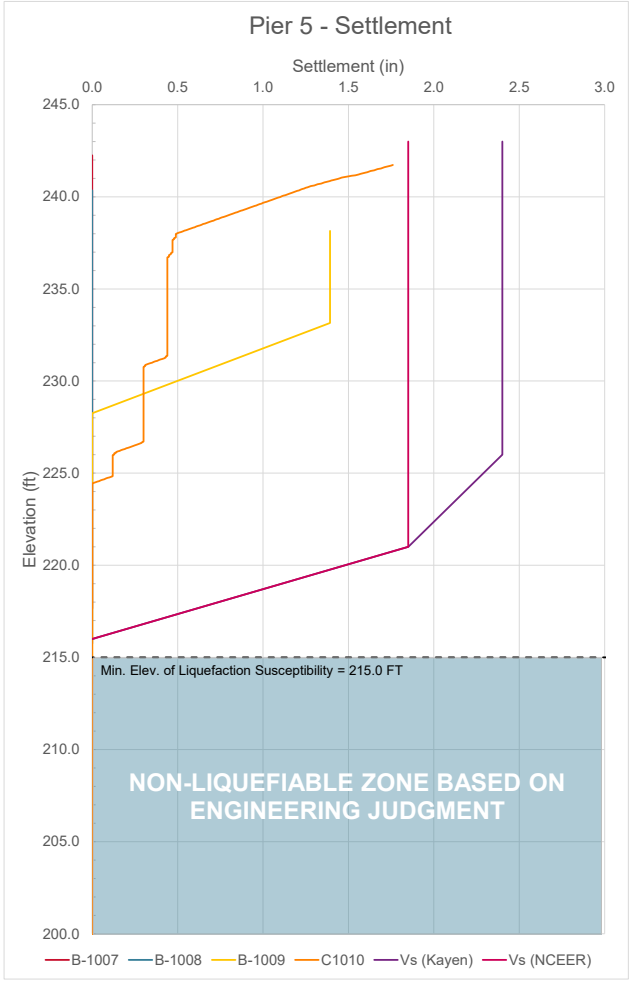

Pier 5 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Elevation (ft)
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007
B-1008
B-1009
C1010 Youd
C1010 I&B

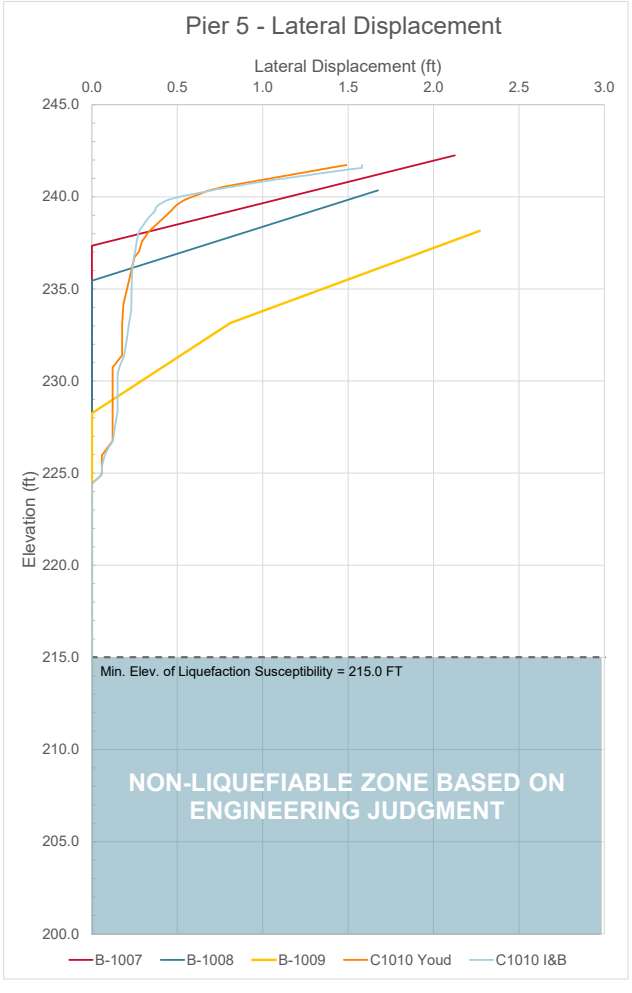
1,000-YR RETURN PERIOD


Pier 5 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
245.0 240.0 235.0 230.0 225.0 220.0 215.0 210.0 205.0 200.0
Elevation (ft)
FS_Liq = 1.1
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007 B-1008 B-1009 C1010 Vs (Kayen) Vs (NCEER)


Pier 5 - Residual Shear Strength
Shear Strength (psf)
0 200 400 600 800 1000
245.0 240.0 235.0 230.0 225.0 220.0 215.0 210.0 205.0 200.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007: Idriss & Boulanger
B-1007: Kramer & Wang
B-1008: Olsen & Johnson
B-1009: Idriss & Boulanger
B-1009: Kramer & Wang
C1010: O&J
B-1007: Olsen & Johnson
B-1008: Idriss & Boulanger
B-1008: Kramer & Wang
B-1009: Olsen & Johnson
C1010: Youd
C1010: Idriss & Boulanger

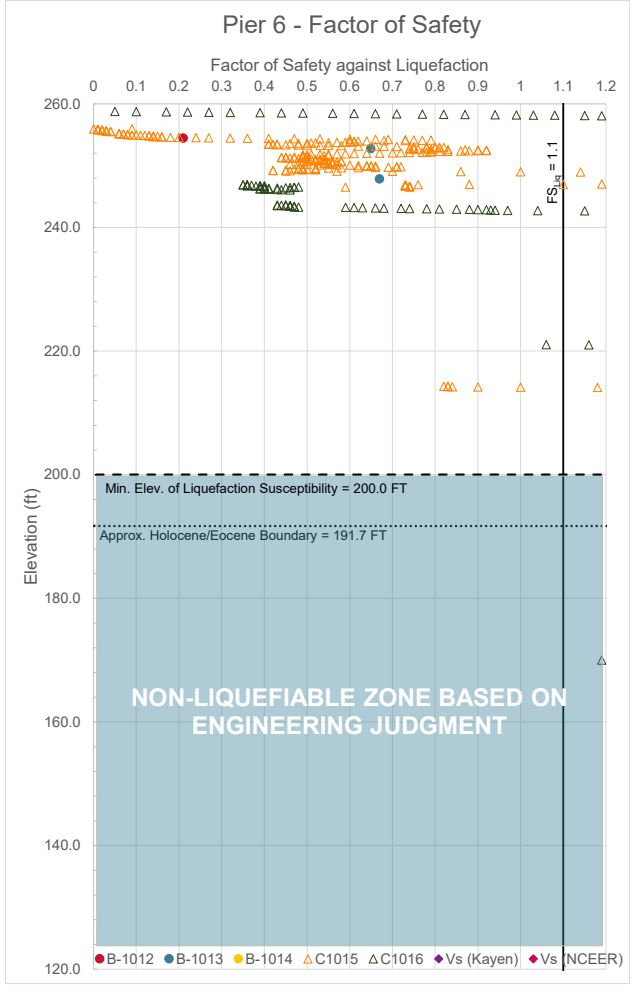

Pier 5 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 200 400 600 800 1000 1200 1400 1600
245.0 244.0 243.0 242.0 241.0 240.0 239.0 238.0 237.0 236.0 235.0 234.0 233.0 232.0 231.0 230.0 229.0 228.0 227.0 226.0 225.0 224.0 223.0 222.0 221.0 220.0
Elevation (ft)
PL-1 Top El. ~ 243.0 ft
S_r ~ 75 psf
PL-1 Btm El. ~ 238.0 ft
S_r ~ 150 psf
PL-2 Btm El. ~ 237.0 ft
S_r ~ 250 psf
PL-3 Btm El. ~ 236.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-4 Top El. ~ 234.0 ft
S_r ~ 450 psf
PL-4 Btm El. ~ 230.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-5 Btm El. ~ 228.0 ft
S_r ~ 650 psf
PL-5 Btm El. ~ 224.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES

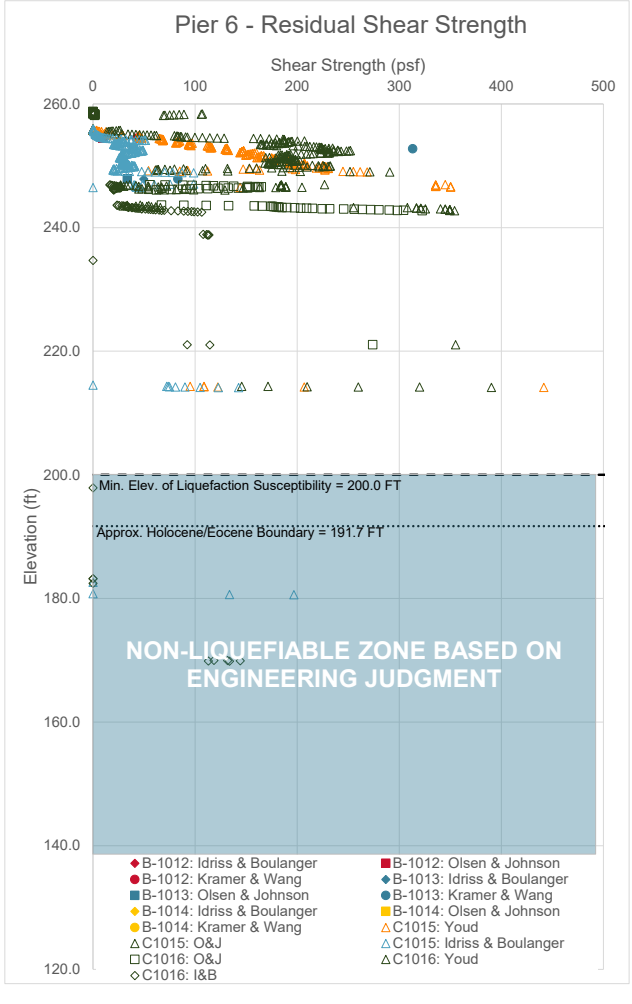

Pier 5 - Settlement
Settlement (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007
B-1008
B-1009
C1010
Vs (Kayen)
Vs (NCEER)

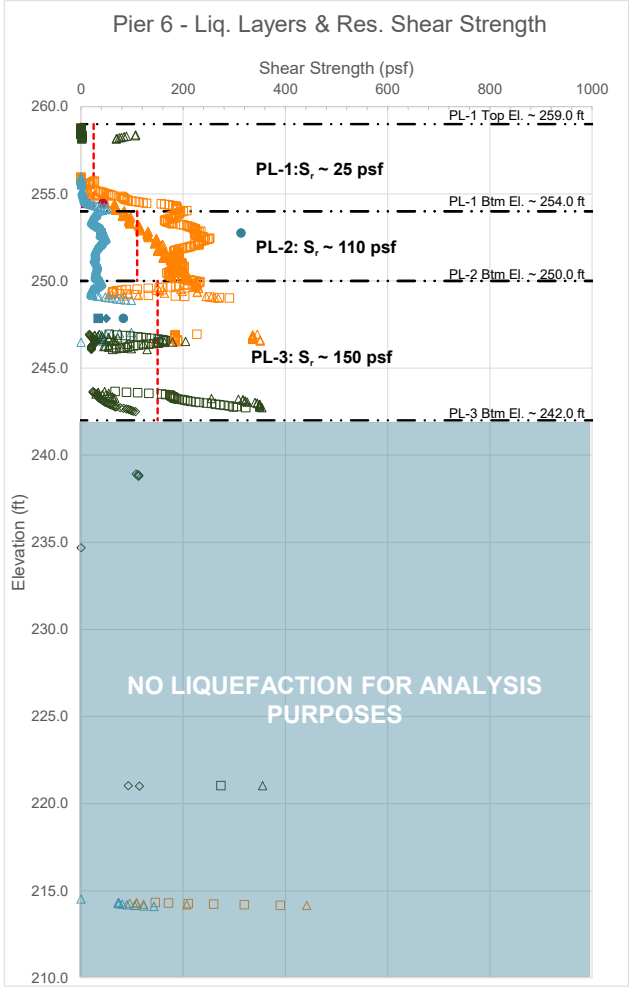

Pier 5 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 215.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1007
B-1008
B-1009
C1010 Youd
C1010 I&B

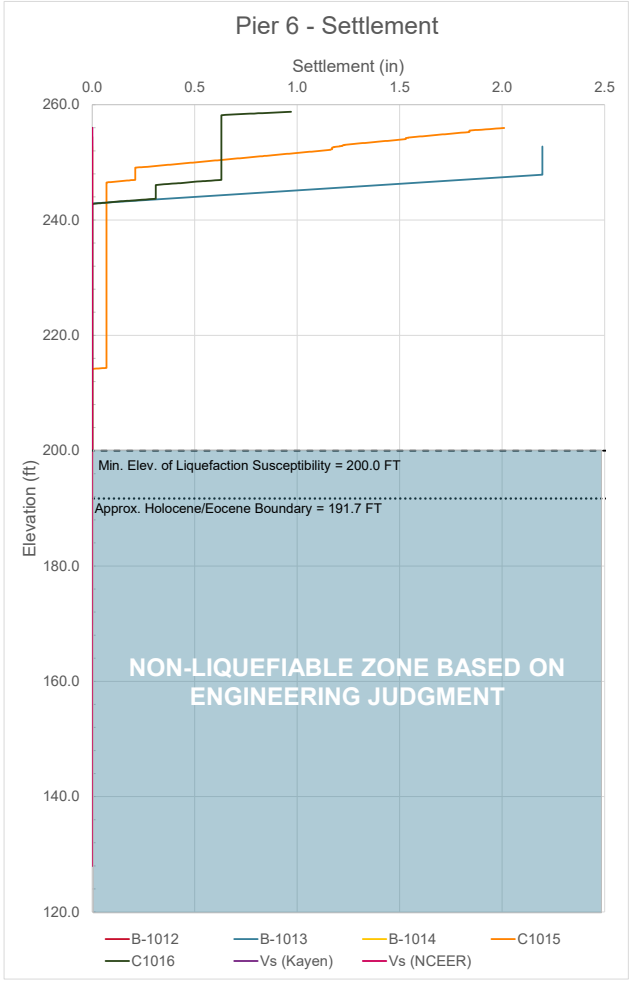
PIER 6

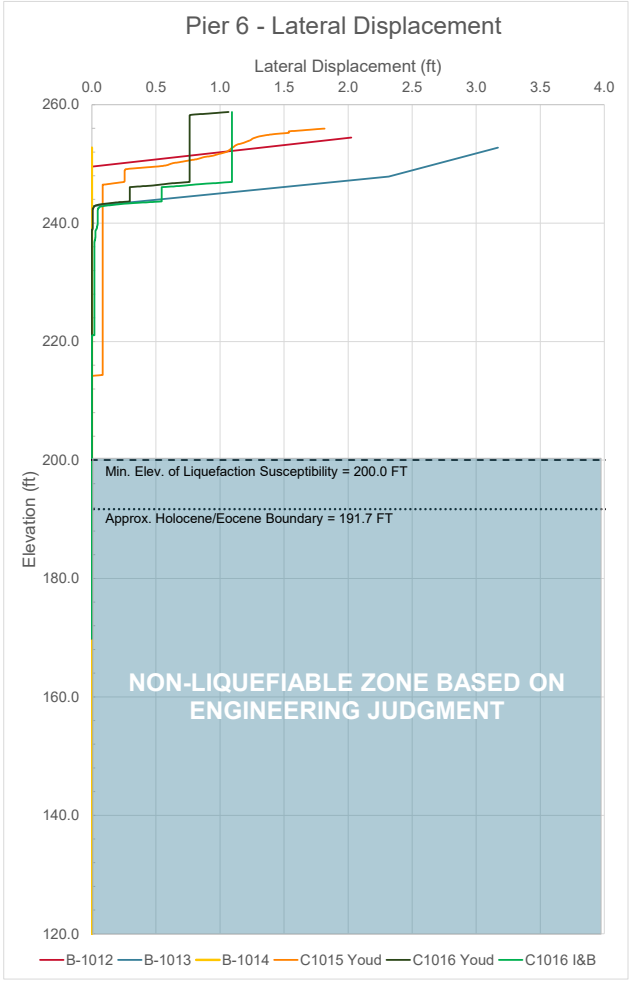
100-YR RETURN PERIOD


Pier 6 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
260.0 240.0 220.0 200.0 180.0 160.0 140.0 120.0
Elevation (ft)
FS_liq = 1.1
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012 B-1013 B-1014 C1015 C1016 Vs (Kayen) Vs (NCEER)

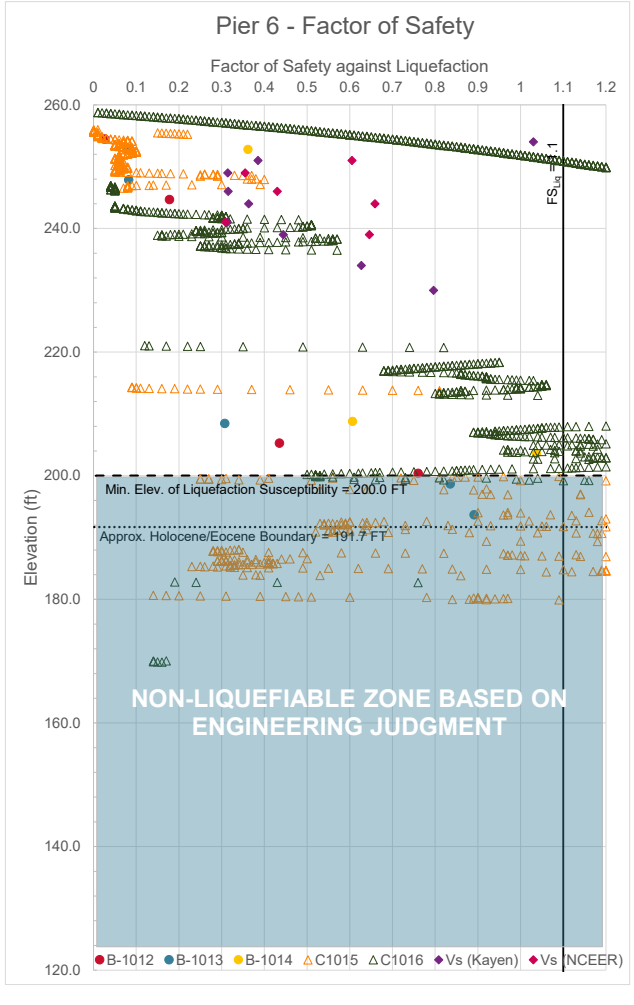

Pier 6 - Residual Shear Strength
Shear Strength (psf)
0 100 200 300 400 500
260.0 240.0 220.0 200.0 180.0 160.0 140.0 120.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012: Idriss & Boulanger
B-1012: Kramer & Wang
B-1013: Olsen & Johnson
B-1014: Idriss & Boulanger
B-1014: Kramer & Wang
C1015: O&J
C1016: O&J
C1016: I&B
B-1012: Olsen & Johnson
B-1013: Idriss & Boulanger
B-1013: Kramer & Wang
B-1014: Olsen & Johnson
C1015: Youd
C1015: Idriss & Boulanger
C1016: Youd

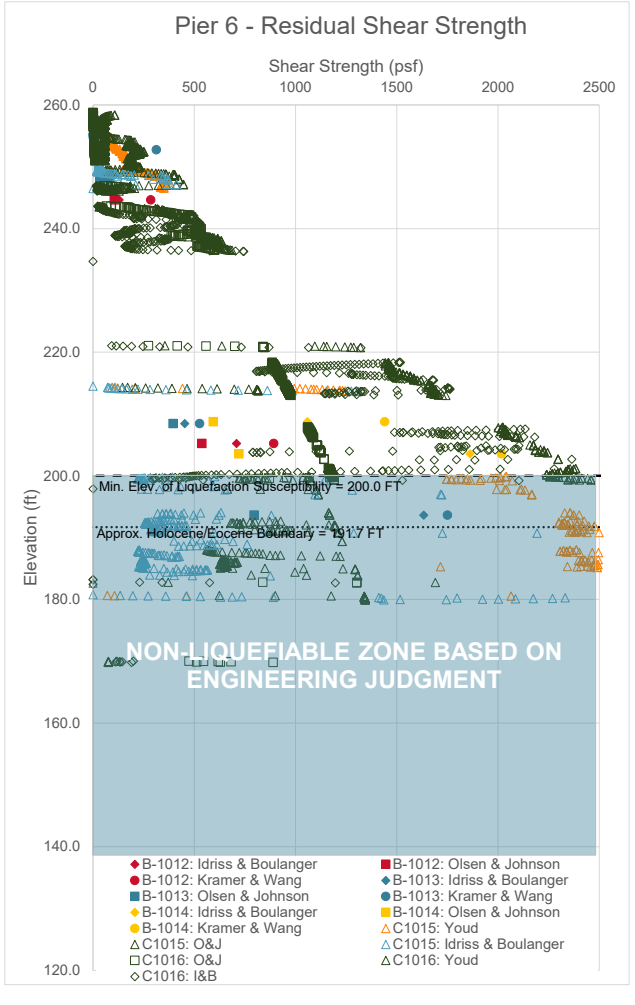

Pier 6 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 200 400 600 800 1000
260.0 255.0 250.0 245.0 240.0 235.0 230.0 225.0 220.0 215.0 210.0
Elevation (ft)
PL-1 Top El. ~ 259.0 ft
PL-1:S_r ~ 25 psf
PL-1 Btm El. ~ 254.0 ft
PL-2: S_r ~ 110 psf
PL-2 Btm El. ~ 250.0 ft
PL-3: S_r ~ 150 psf
PL-3 Btm El. ~ 242.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES

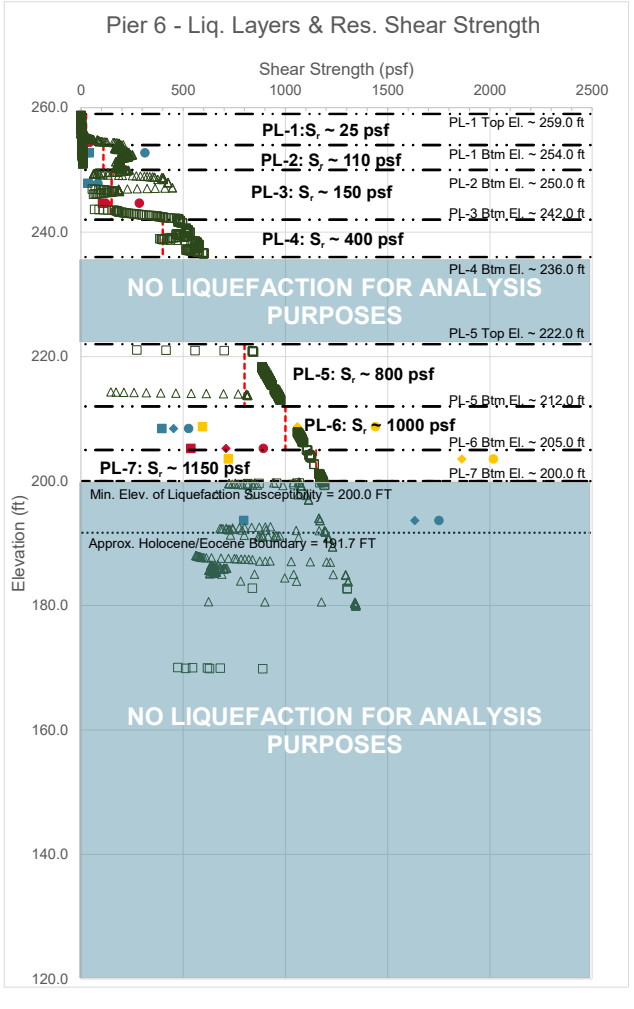

Pier 6 - Settlement
Settlement (in)
0.0
0.5
1.0
1.5
2.0
2.5
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012
B-1013
B-1014
C1015
C1016
Vs (Kayen)
Vs (NCEER)

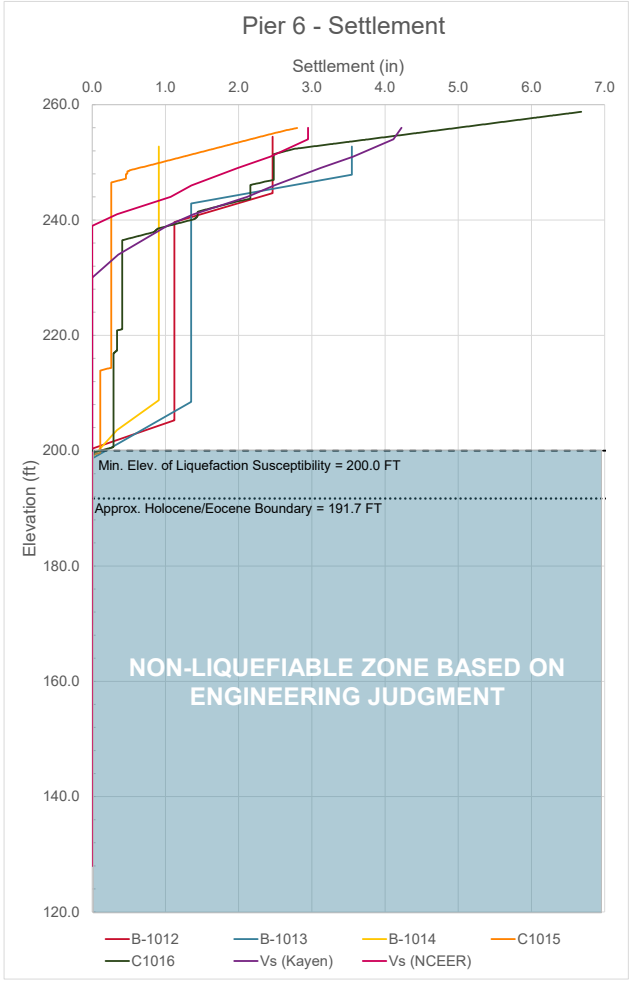

Pier 6 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012
B-1013
B-1014
C1015 Youd
C1016 Youd
C1016 I&B

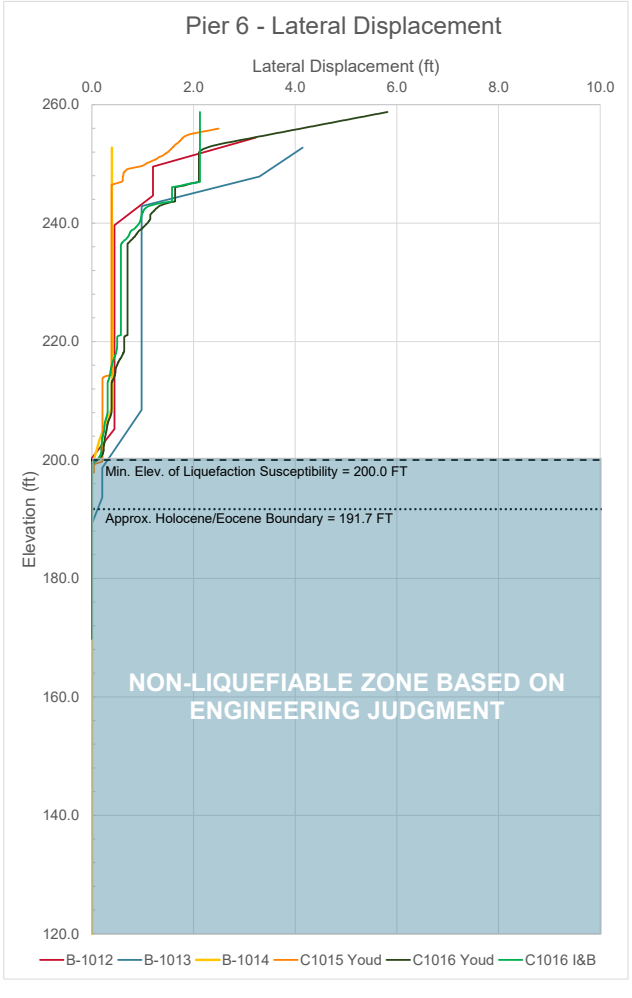
1,000-YR RETURN PERIOD


Pier 6 - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
260.0 240.0 220.0 200.0 180.0 160.0 140.0 120.0
Elevation (ft)
FS_Liq = 1
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012 B-1013 B-1014 C1015 C1016 Vs (Kayen) Vs (NCEER)


Pier 6 - Residual Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500
260.0 240.0 220.0 200.0 180.0 160.0 140.0 120.0
Elevation (ft)
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012: Idriss & Boulanger
B-1012: Kramer & Wang
B-1013: Olsen & Johnson
B-1014: Idriss & Boulanger
B-1014: Kramer & Wang
C1015: O&J
C1016: O&J
C1016: I&B
B-1012: Olsen & Johnson
B-1013: Idriss & Boulanger
B-1013: Kramer & Wang
B-1014: Olsen & Johnson
C1015: Youd
C1015: Idriss & Boulanger
C1016: Youd


Pier 6 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500
260.0 240.0 220.0 200.0 180.0 160.0 140.0 120.0
Elevation (ft)
PL-1:S, ~ 25 psf
PL-2: S, ~ 110 psf
PL-3: S, ~ 150 psf
PL-4: S, ~ 400 psf
PL-5: S, ~ 800 psf
PL-6: S, ~ 1000 psf
PL-7: S, ~ 1150 psf
PL-1 Top El. ~ 259.0 ft
PL-1 Btm El. ~ 254.0 ft
PL-2 Btm El. ~ 250.0 ft
PL-3 Btm El. ~ 242.0 ft
PL-4 Btm El. ~ 236.0 ft
PL-5 Top El. ~ 222.0 ft
PL-5 Btm El. ~ 212.0 ft
PL-6 Btm El. ~ 205.0 ft
PL-7 Btm El. ~ 200.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NO LIQUEFACTION FOR ANALYSIS PURPOSES


Pier 6 - Settlement
Settlement (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Elevation (ft)
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012
B-1013
B-1014
C1015
C1016
Vs (Kayen)
Vs (NCEER)

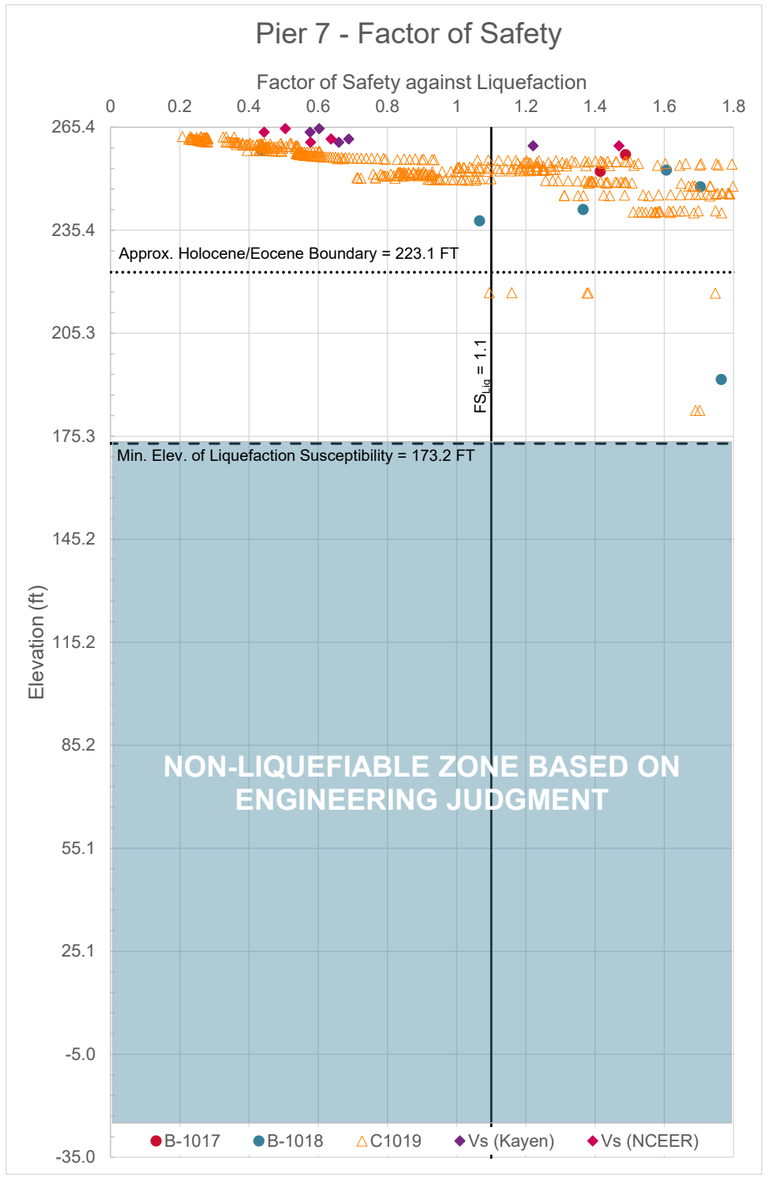

Pier 6 - Lateral Displacement
Lateral Displacement (ft)
0.0
2.0
4.0
6.0
8.0
10.0
Elevation (ft)
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
Min. Elev. of Liquefaction Susceptibility = 200.0 FT
Approx. Holocene/Eocene Boundary = 191.7 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1012
B-1013
B-1014
C1015 Youd
C1016 Youd
C1016 I&B

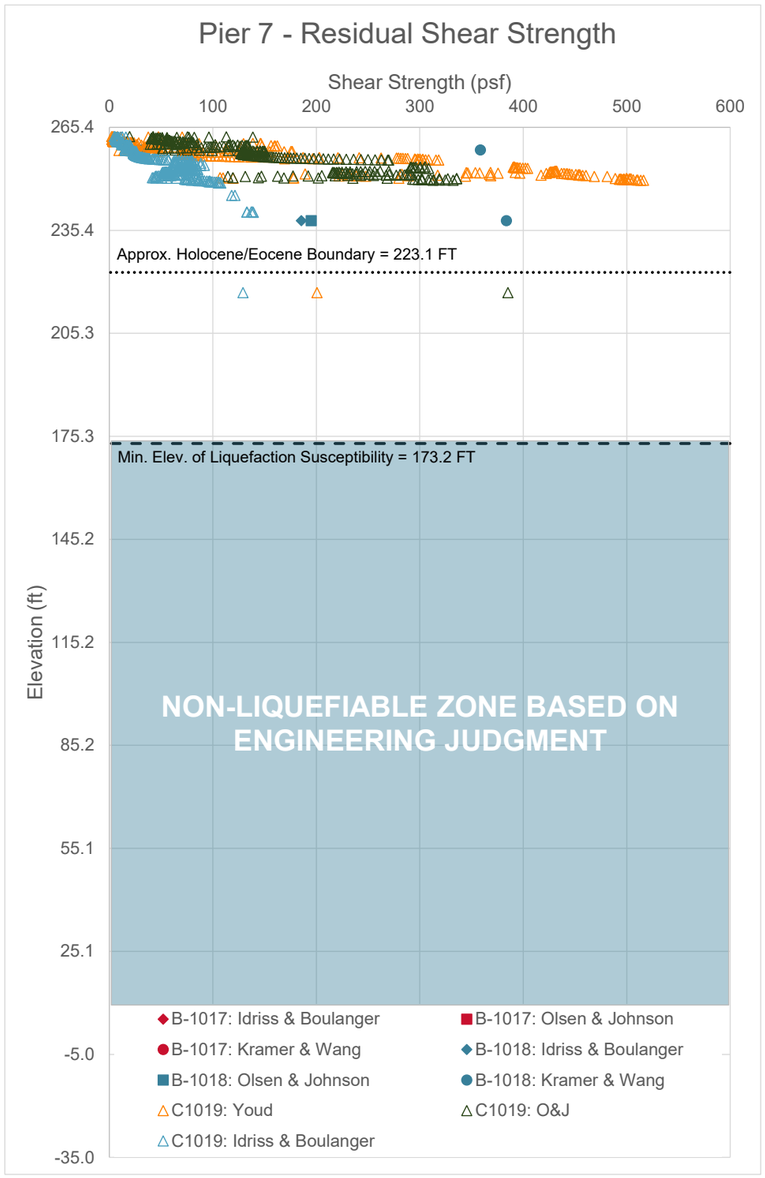
PIER 7

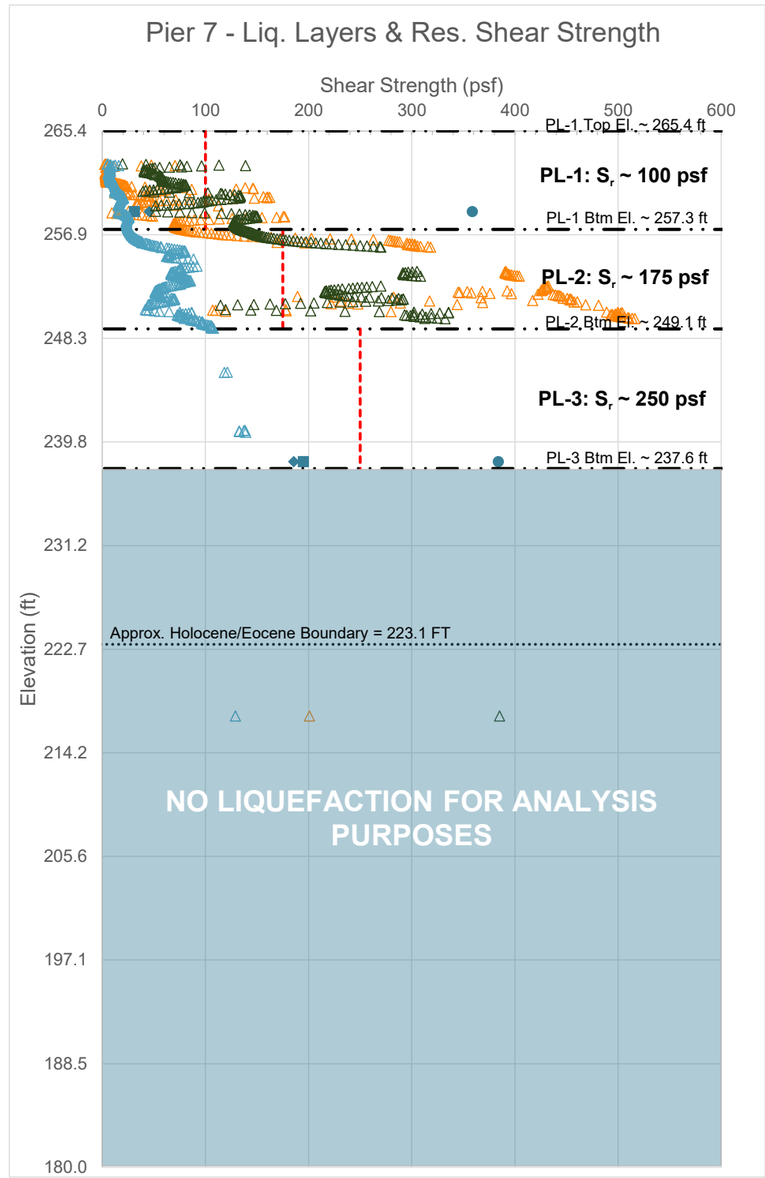
100-YR RETURN PERIOD

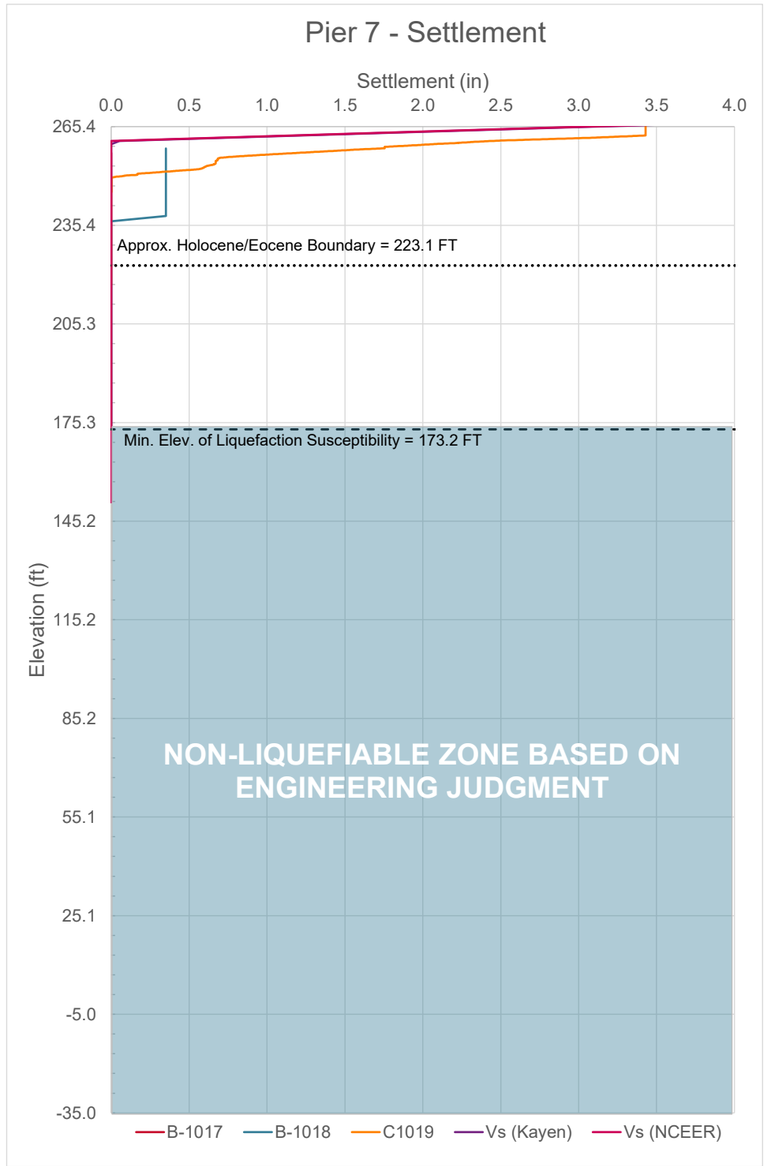
Project: US-51 Bridge Replacement
Subject: Seismic
Task: Liquefaction
Job #: 10174706

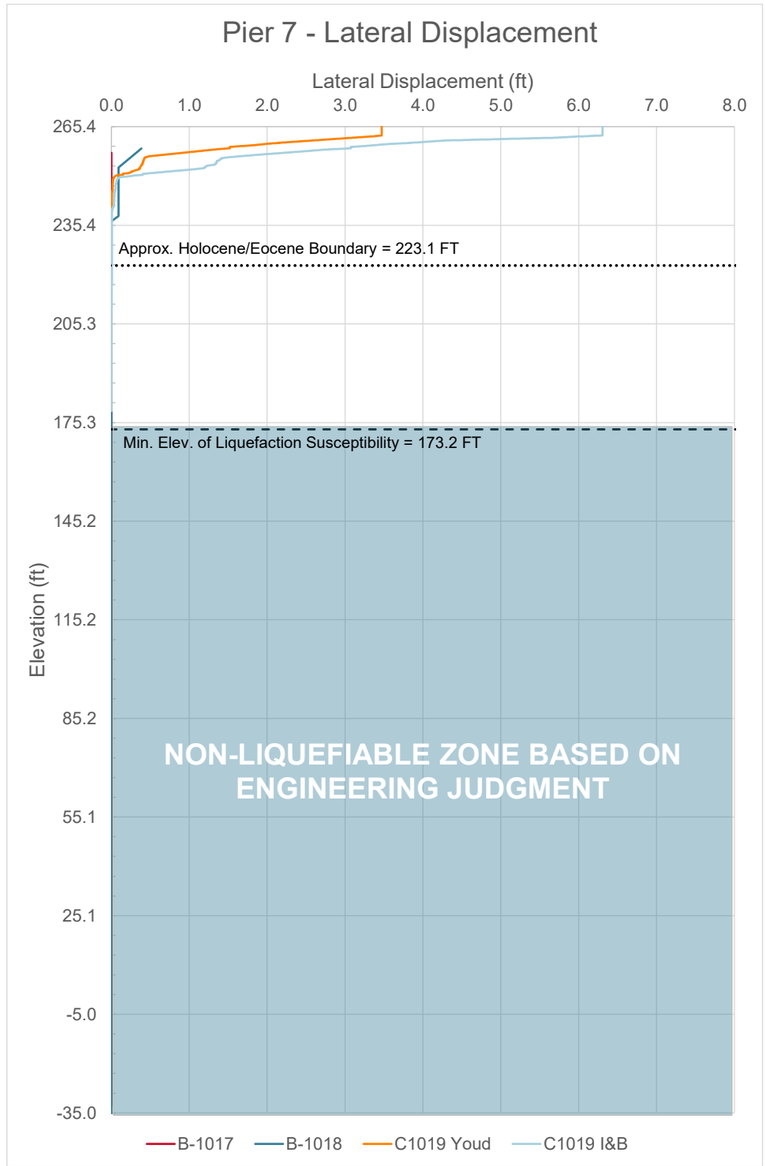
Computed by: BAR Date: 07/09/2025
Checked by: SKB Date: 07/10/2025
Page: 1 of 2



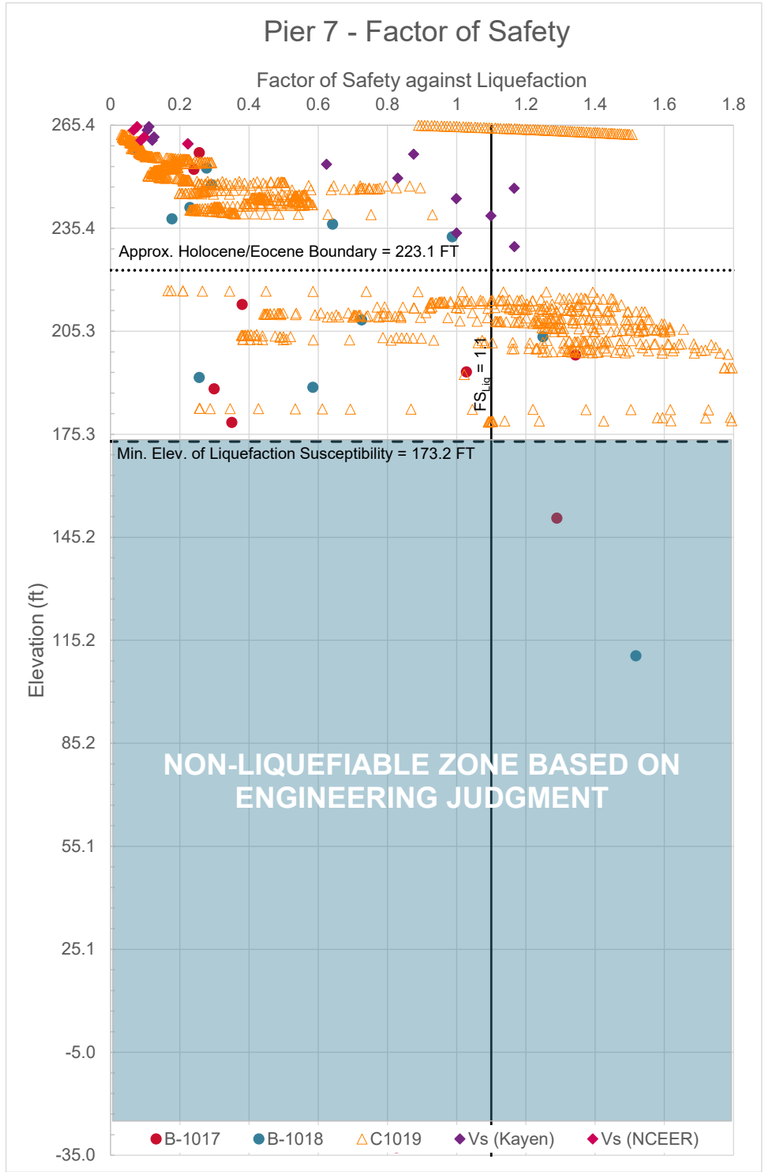


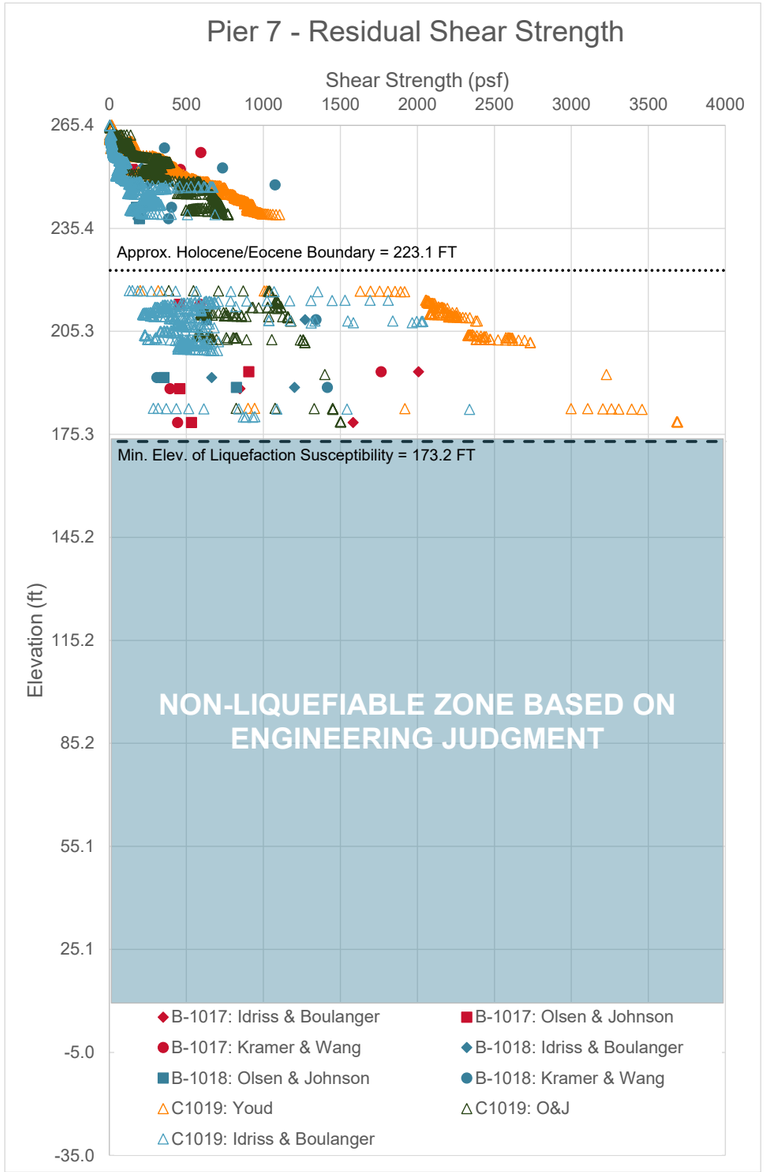


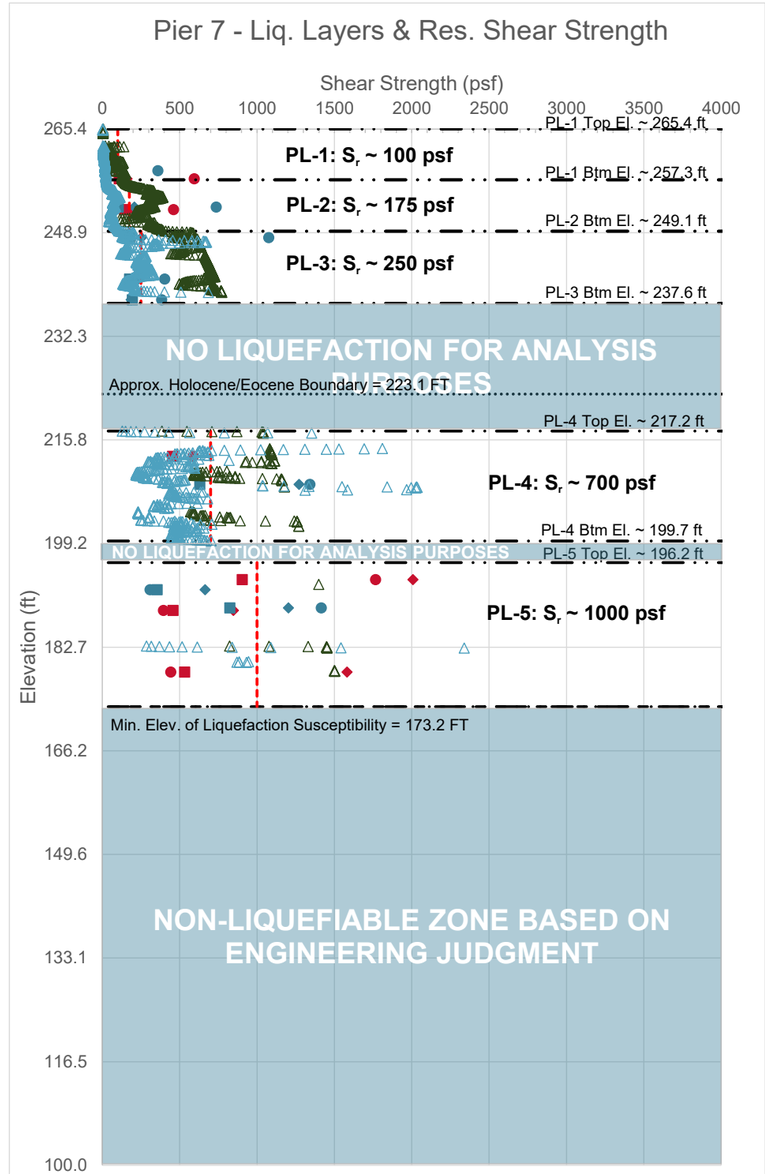

Pier 7 - Settlement
Settlement (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Elevation (ft)
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017
B-1018
C1019
Vs (Kayen)
Vs (NCEER)

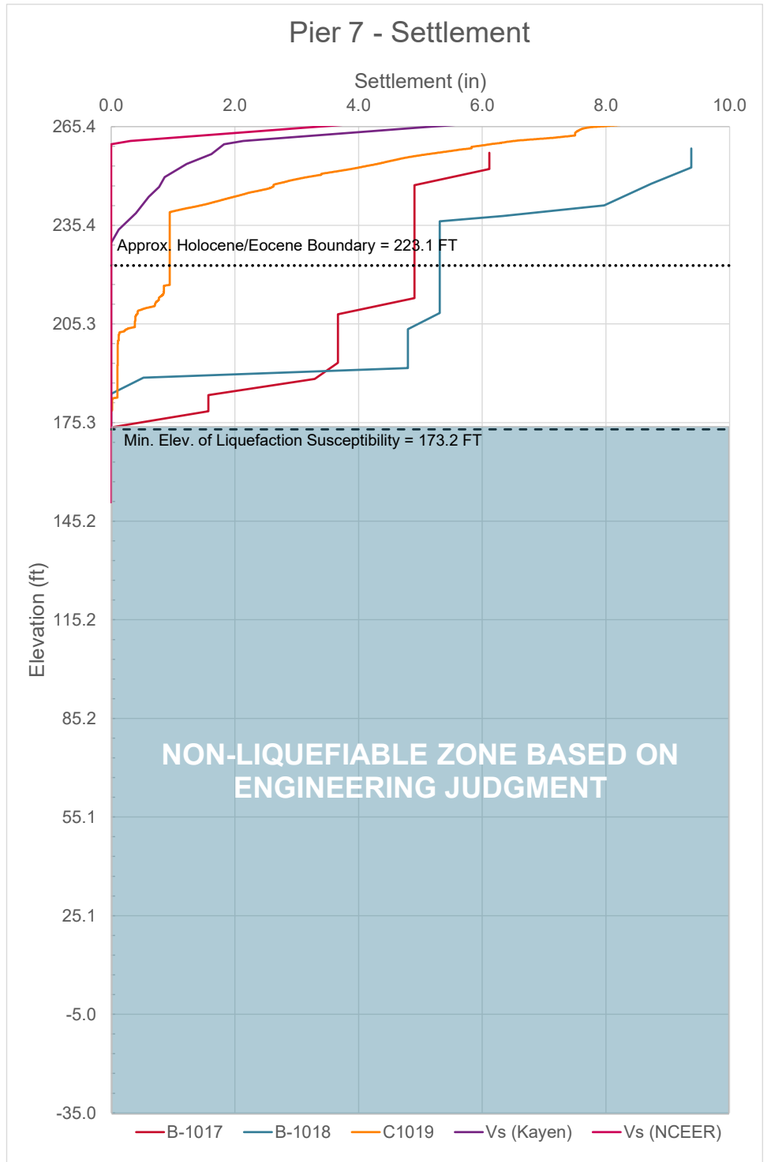

Pier 7 - Lateral Displacement
Lateral Displacement (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Elevation (ft)
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017
B-1018
C1019 Youd
C1019 I&B

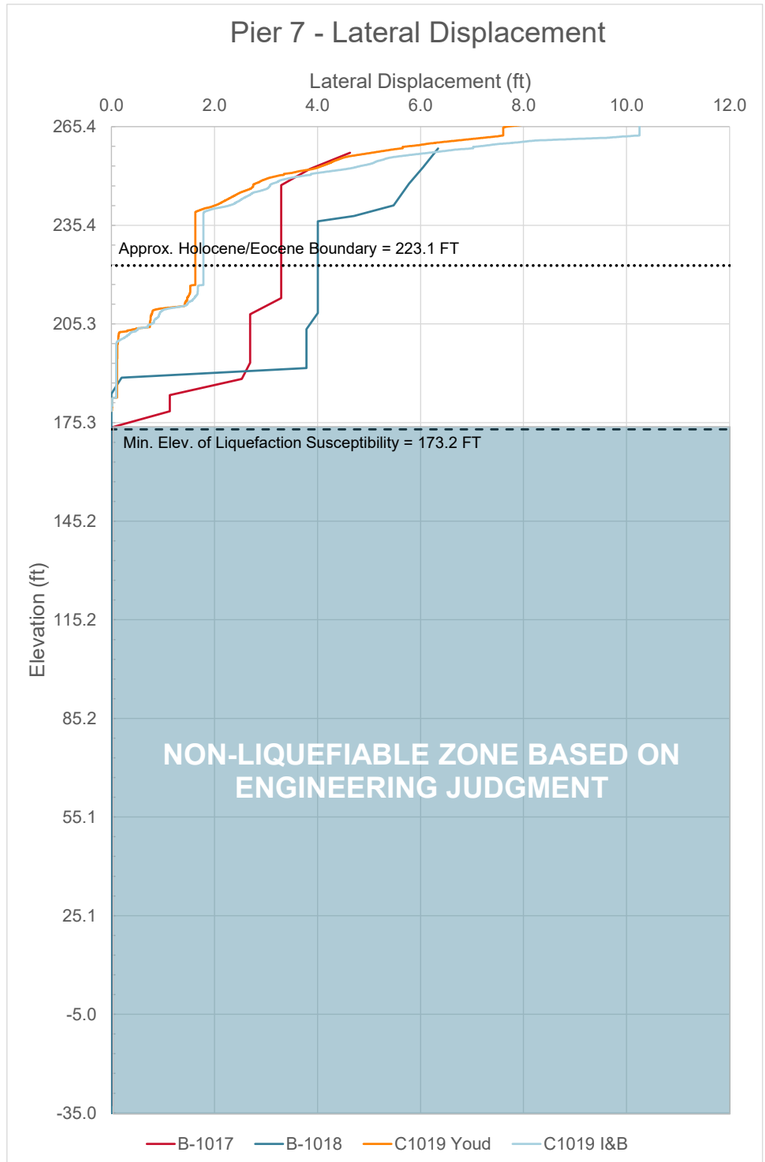
1,000-YR RETURN PERIOD


Pier 7 - Factor of Safety
Factor of Safety against Liquefaction
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
FS_liq = 1.1
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017
B-1018
C1019
Vs (Kayen)
Vs (NCEER)


Pier 7 - Residual Shear Strength
Shear Strength (psf)
0
500
1000
1500
2000
2500
3000
3500
4000
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017: Idriss & Boulanger
B-1017: Olsen & Johnson
B-1017: Kramer & Wang
B-1018: Idriss & Boulanger
B-1018: Olsen & Johnson
B-1018: Kramer & Wang
C1019: Youd
C1019: O&J
C1019: Idriss & Boulanger

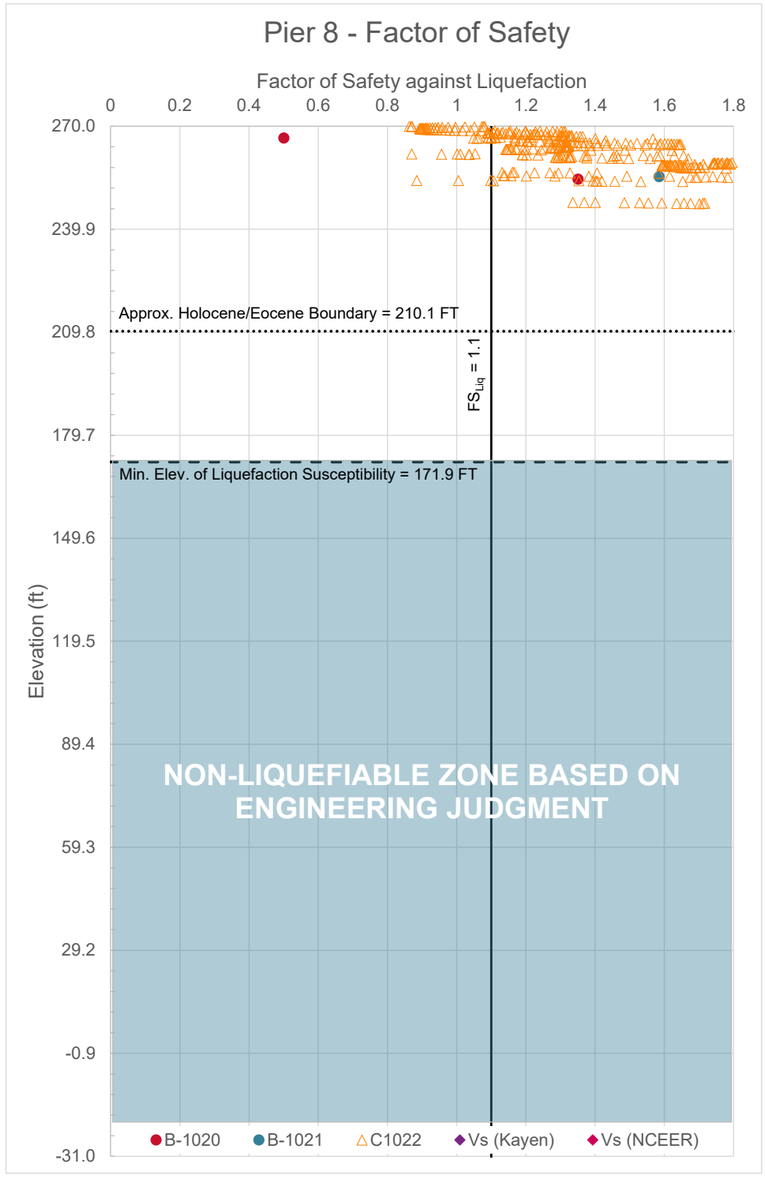

Pier 7 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0
500
1000
1500
2000
2500
3000
3500
4000
265.4
248.9
232.3
215.8
199.2
182.7
166.2
149.6
133.1
116.5
100.0
Elevation (ft)
PL-1 Top El. ~ 265.4 ft
PL-1: S_r ~ 100 psf
PL-1 Btm El. ~ 257.3 ft
PL-2: S_r ~ 175 psf
PL-2 Btm El. ~ 249.1 ft
PL-3: S_r ~ 250 psf
PL-3 Btm El. ~ 237.6 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Approx. Holocene/Eocene Boundary = 223.1 FT
PL-4 Top El. ~ 217.2 ft
PL-4: S_r ~ 700 psf
PL-4 Btm El. ~ 199.7 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-5 Top El. ~ 196.2 ft
PL-5: S_r ~ 1000 psf
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT

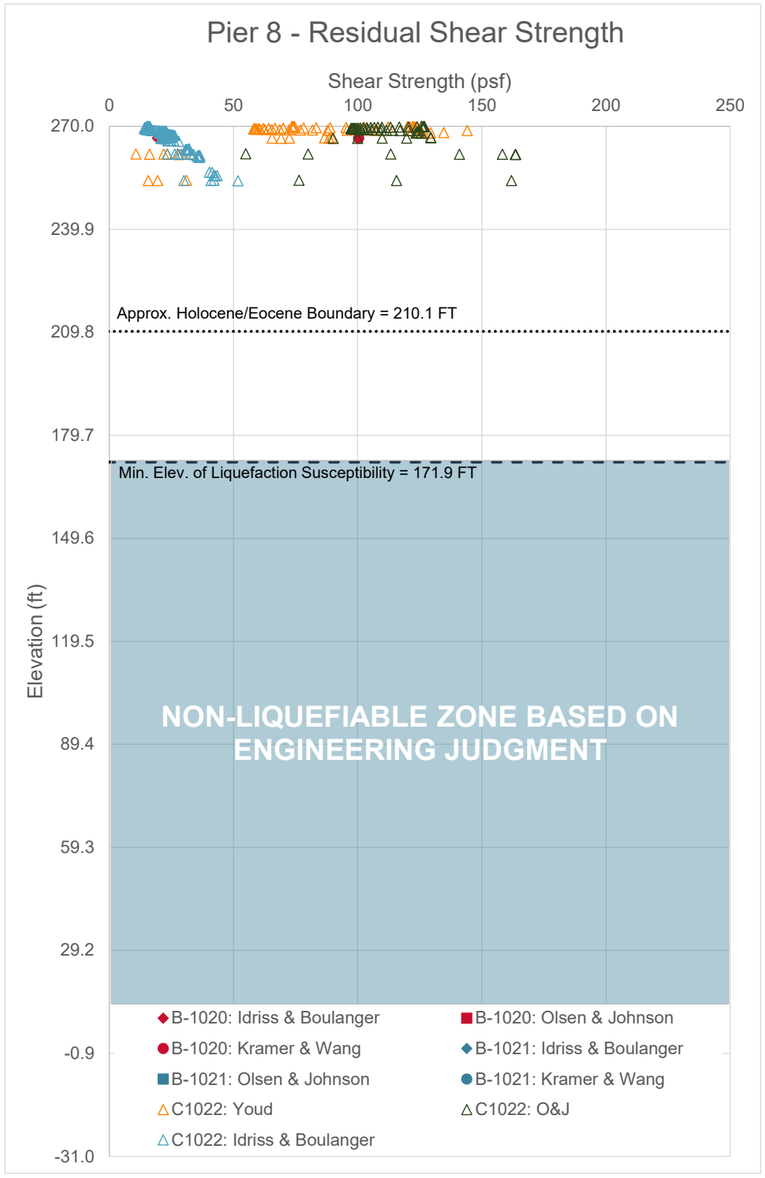

Pier 7 - Settlement
Settlement (in)
0.0
2.0
4.0
6.0
8.0
10.0
Elevation (ft)
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017
B-1018
C1019
Vs (Kayen)
Vs (NCEER)

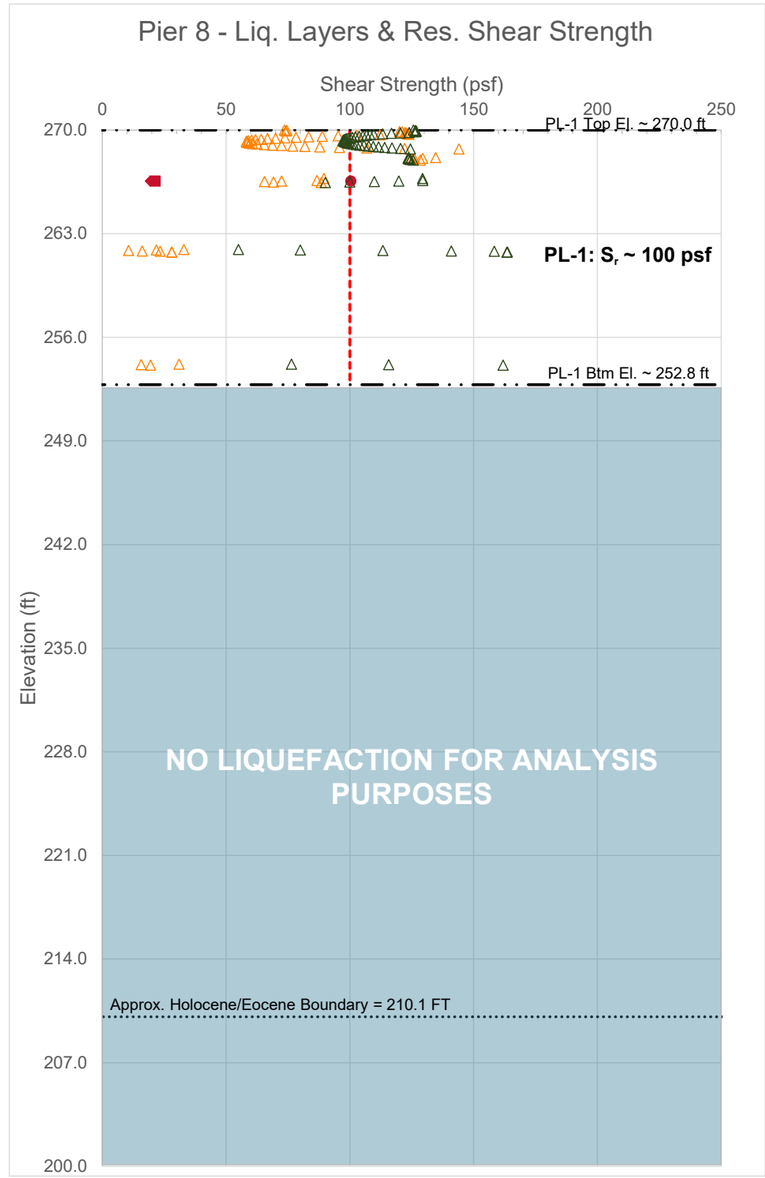

Pier 7 - Lateral Displacement
Lateral Displacement (ft)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Elevation (ft)
265.4
235.4
205.3
175.3
145.2
115.2
85.2
55.1
25.1
-5.0
-35.0
Approx. Holocene/Eocene Boundary = 223.1 FT
Min. Elev. of Liquefaction Susceptibility = 173.2 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1017
B-1018
C1019 Youd
C1019 I&B

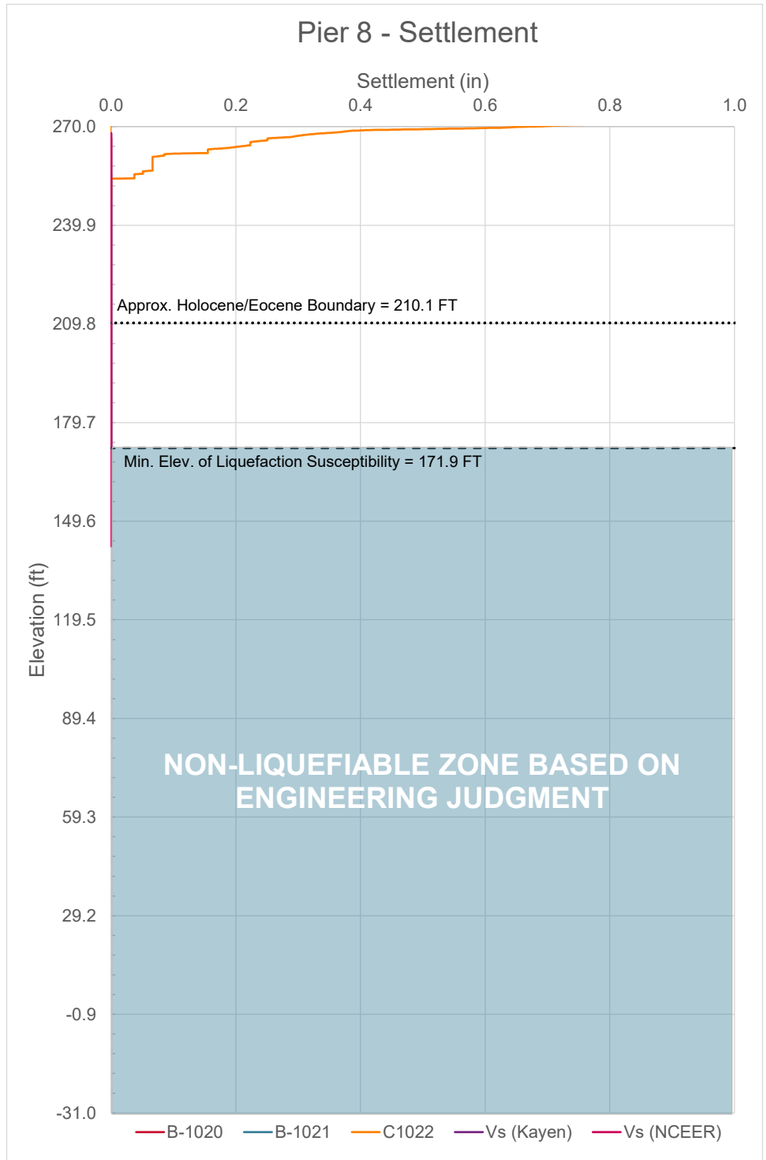
PIER 8

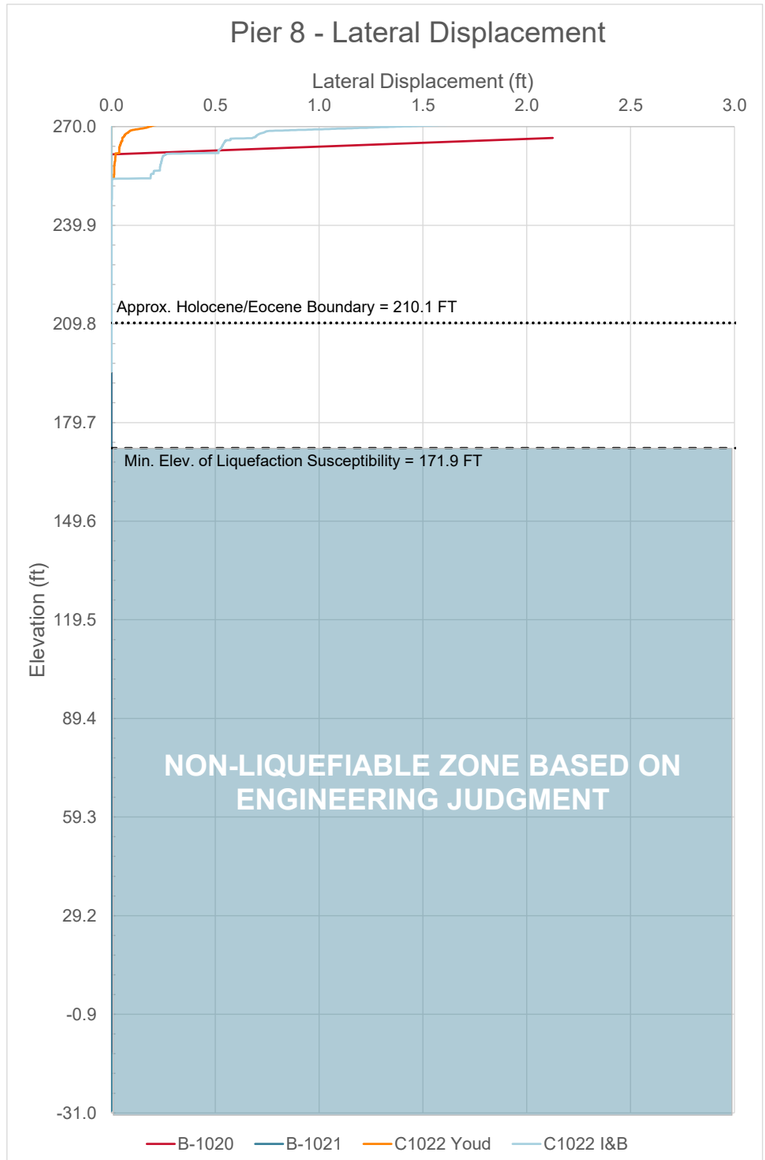
100-YR RETURN PERIOD


Pier 8 - Factor of Safety
Factor of Safety against Liquefaction
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 210.1 FT
FS$_{liq}$ = 1.1
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022
Vs (Kayen)
Vs (NCEER)

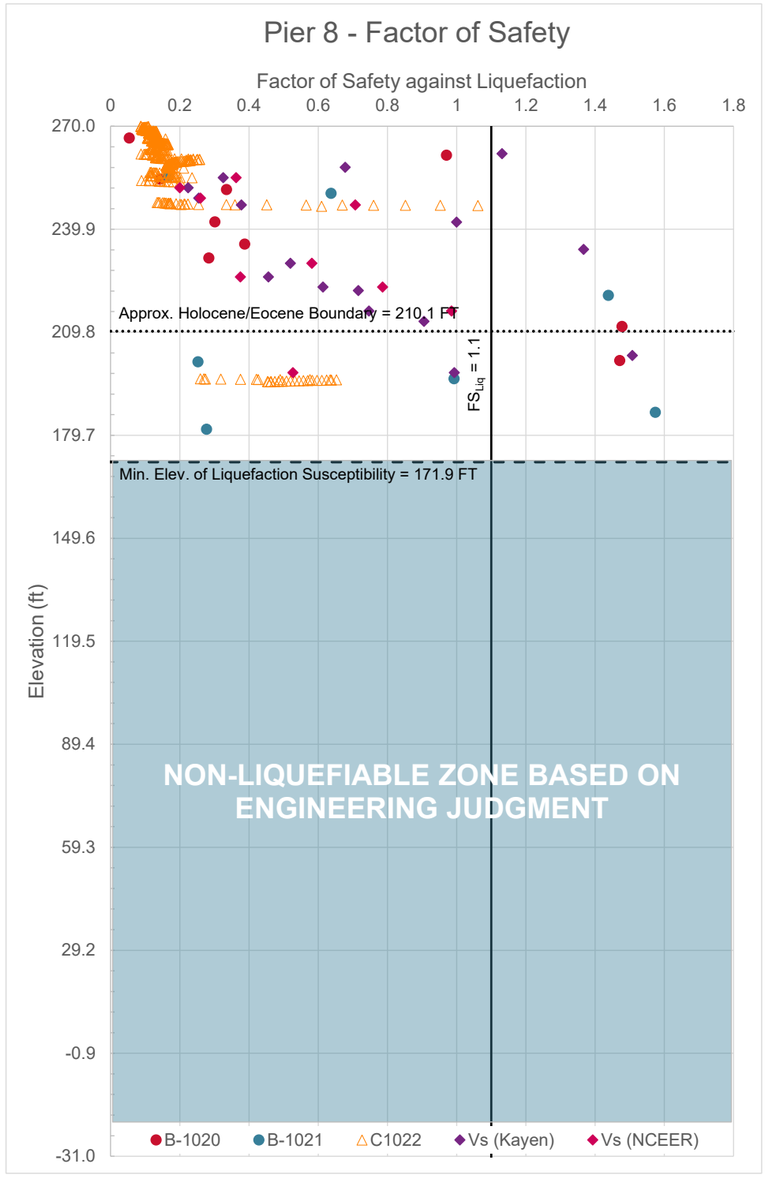

Pier 8 - Residual Shear Strength
Shear Strength (psf)
0
50
100
150
200
250
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020: Idriss & Boulanger
B-1020: Olsen & Johnson
B-1020: Kramer & Wang
B-1021: Idriss & Boulanger
B-1021: Olsen & Johnson
B-1021: Kramer & Wang
C1022: Youd
C1022: O&J
C1022: Idriss & Boulanger

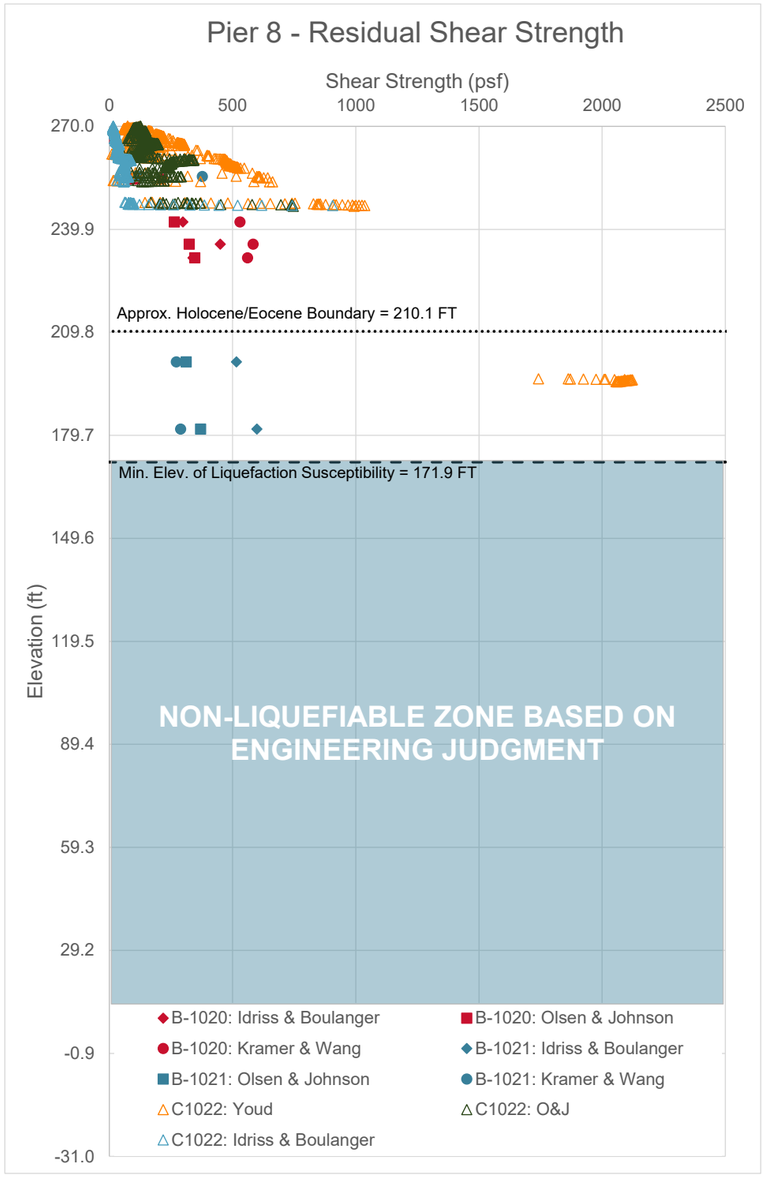

Pier 8 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0
50
100
150
200
250
270.0
263.0
256.0
249.0
242.0
235.0
228.0
221.0
214.0
207.0
200.0
Elevation (ft)
PL-1 Top El. ~ 270.0 ft
PL-1: S$_r$ ~ 100 psf
PL-1 Btm El. ~ 252.8 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Approx. Holocene/Eocene Boundary = 210.1 FT

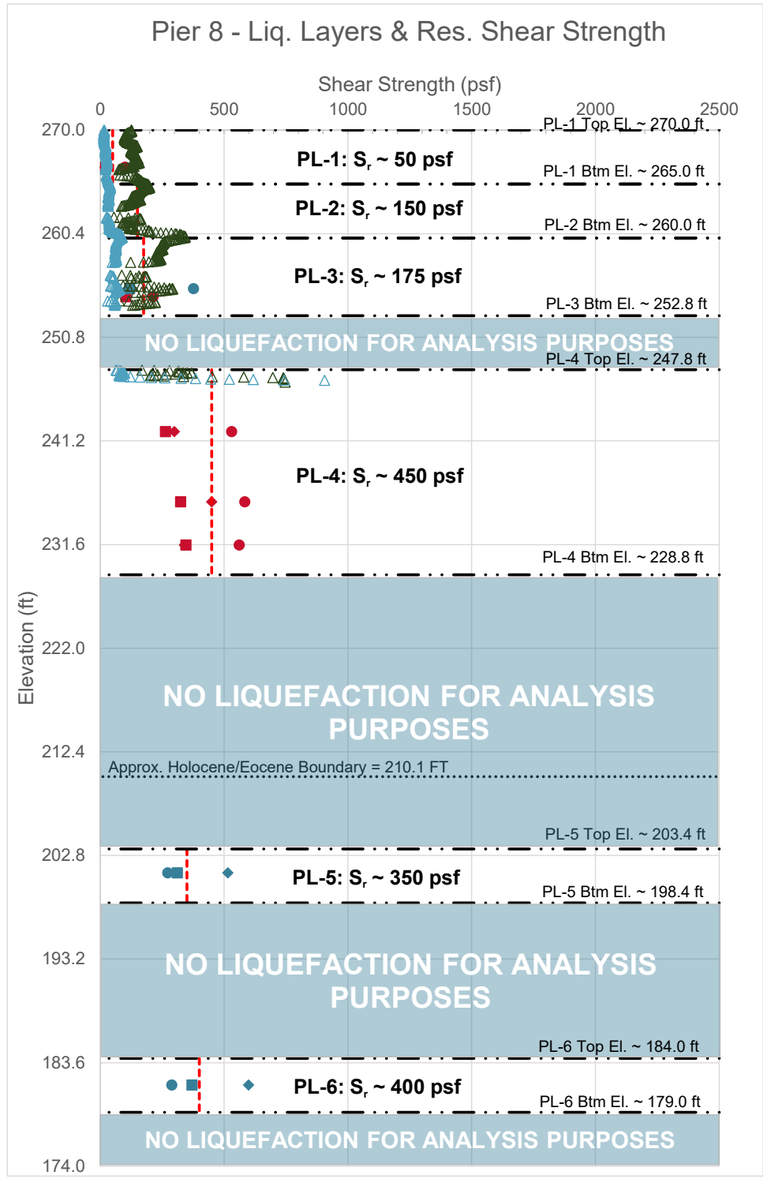

Pier 8 - Settlement
Settlement (in)
0.0
0.2
0.4
0.6
0.8
1.0
Elevation (ft)
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022
Vs (Kayen)
Vs (NCEER)

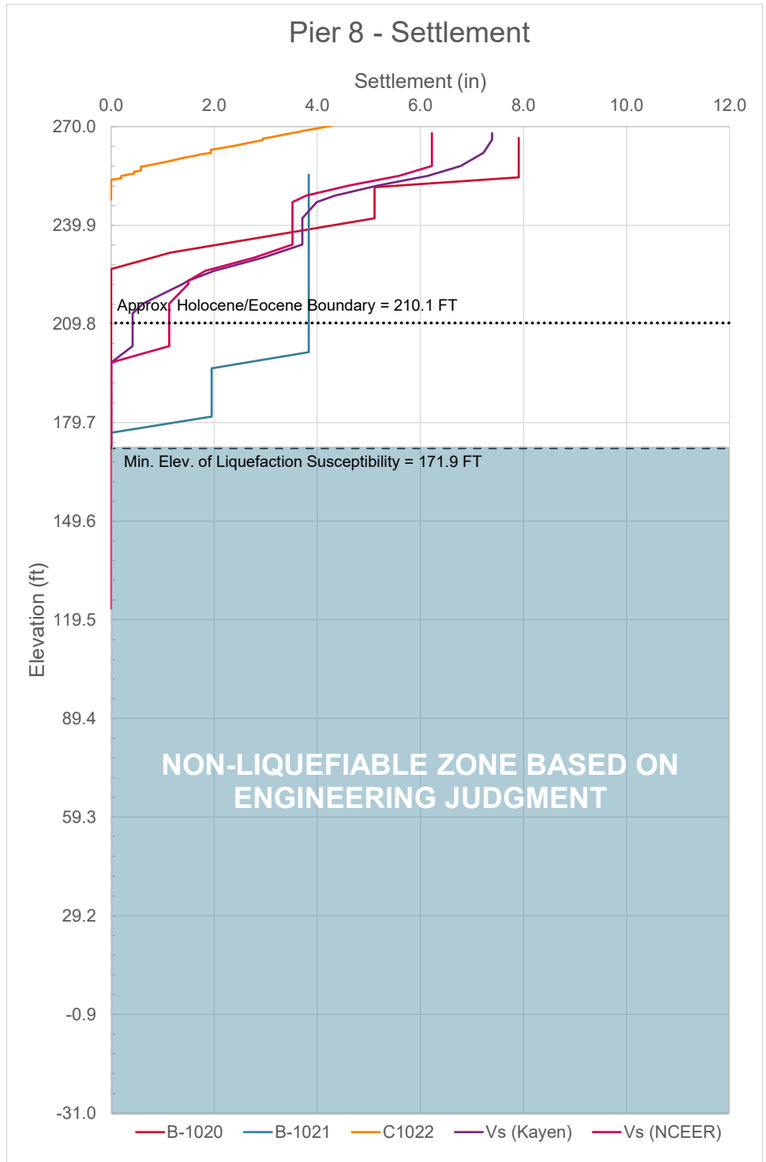

Pier 8 - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Elevation (ft)
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022 Youd
C1022 I&B

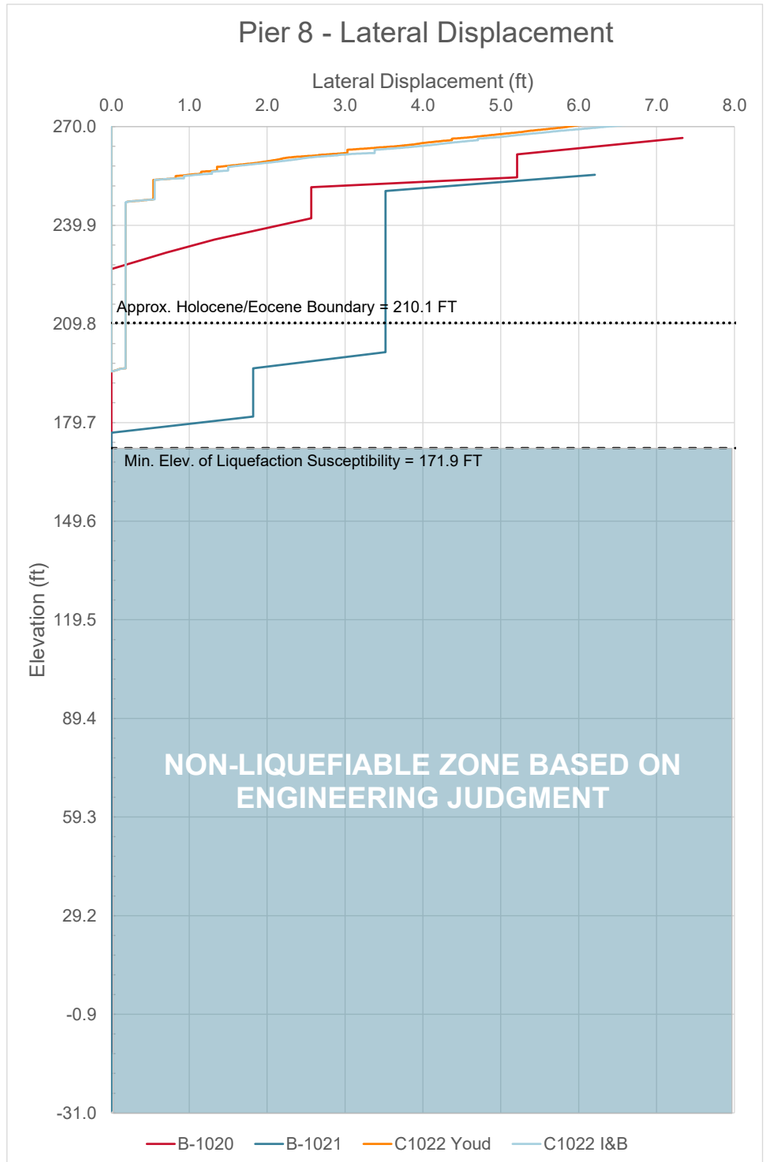
1,000-YR RETURN PERIOD


Pier 8 - Factor of Safety
Factor of Safety against Liquefaction
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 210.1 FT
FS$_{Liq}$ = 1.1
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022
Vs (Kayen)
Vs (NCEER)


Pier 8 - Residual Shear Strength
Shear Strength (psf)
0
500
1000
1500
2000
2500
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020: Idriss & Boulanger
B-1020: Olsen & Johnson
B-1020: Kramer & Wang
B-1021: Idriss & Boulanger
B-1021: Olsen & Johnson
B-1021: Kramer & Wang
C1022: Youd
C1022: O&J
C1022: Idriss & Boulanger


Pier 8 - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0
500
1000
1500
2000
2500
270.0
260.4
250.8
241.2
231.6
222.0
212.4
202.8
193.2
183.6
174.0
Elevation (ft)
PL-1 Top El. ~ 270.0 ft
PL-1: S$_r$ ~ 50 psf
PL-1 Btm El. ~ 265.0 ft
PL-2: S$_r$ ~ 150 psf
PL-2 Btm El. ~ 260.0 ft
PL-3: S$_r$ ~ 175 psf
PL-3 Btm El. ~ 252.8 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-4 Top El. ~ 247.8 ft
PL-4: S$_r$ ~ 450 psf
PL-4 Btm El. ~ 228.8 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
Approx. Holocene/Eocene Boundary = 210.1 FT
PL-5 Top El. ~ 203.4 ft
PL-5: S$_r$ ~ 350 psf
PL-5 Btm El. ~ 198.4 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-6 Top El. ~ 184.0 ft
PL-6: S$_r$ ~ 400 psf
PL-6 Btm El. ~ 179.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES


Pier 8 - Settlement
Settlement (in)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Elevation (ft)
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022
Vs (Kayen)
Vs (NCEER)


Pier 8 - Lateral Displacement
Lateral Displacement (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Elevation (ft)
270.0
239.9
209.8
179.7
149.6
119.5
89.4
59.3
29.2
-0.9
-31.0
Approx. Holocene/Eocene Boundary = 210.1 FT
Min. Elev. of Liquefaction Susceptibility = 171.9 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1020
B-1021
C1022 Youd
C1022 I&B

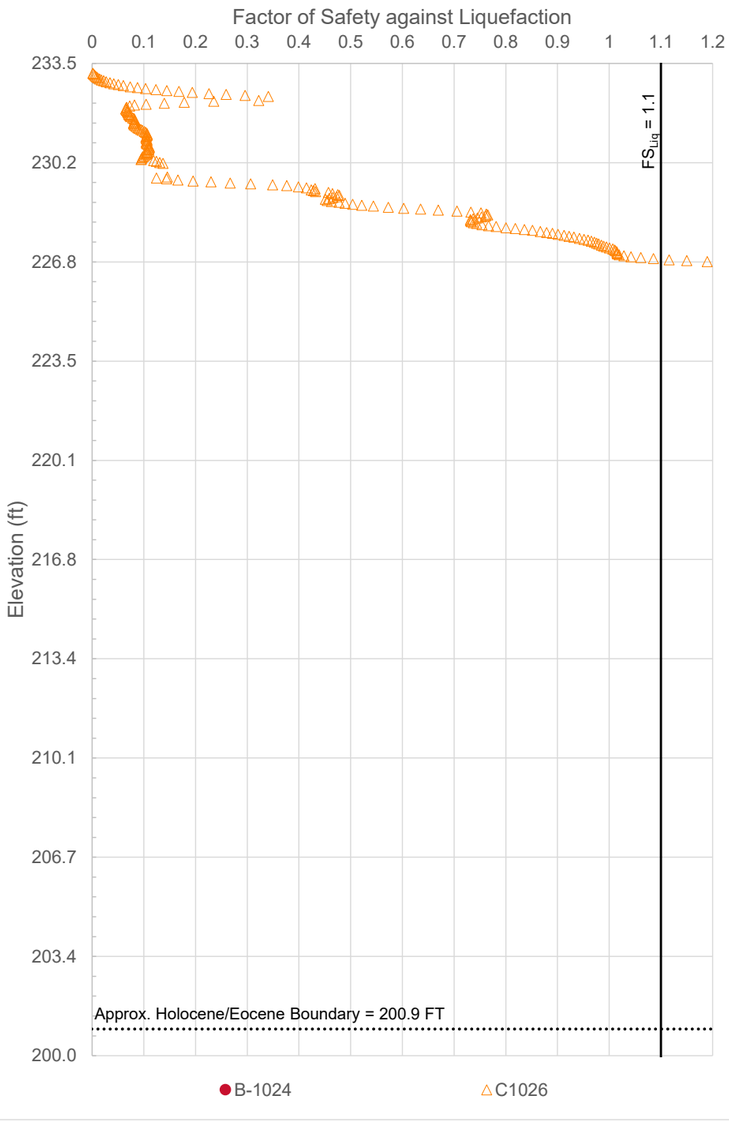
WESTERN RIVERBANK

100-YR RETURN PERIOD

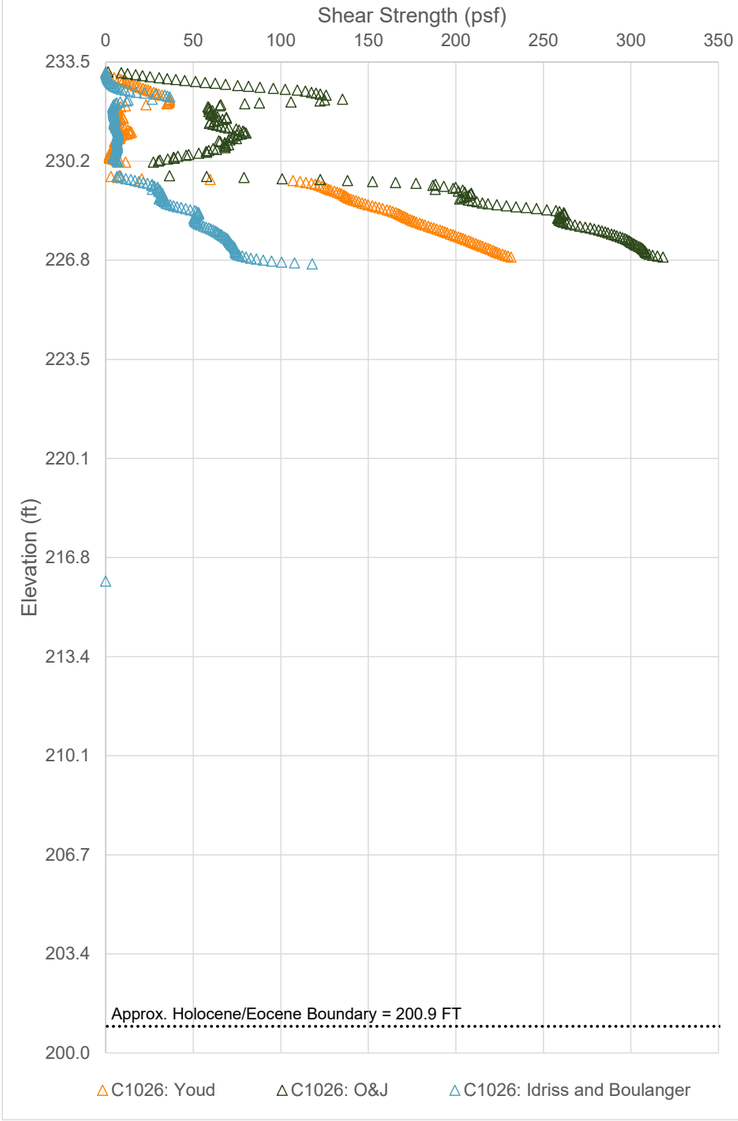
Project: US-51 Bridge Replacement
Subject: Seismic
Task: Liquefaction
Job #: 10174706

Computed by: SGL Date: 9/29/2025
Checked by: SKB Date: 9/29/2025
Page: 1 of 2

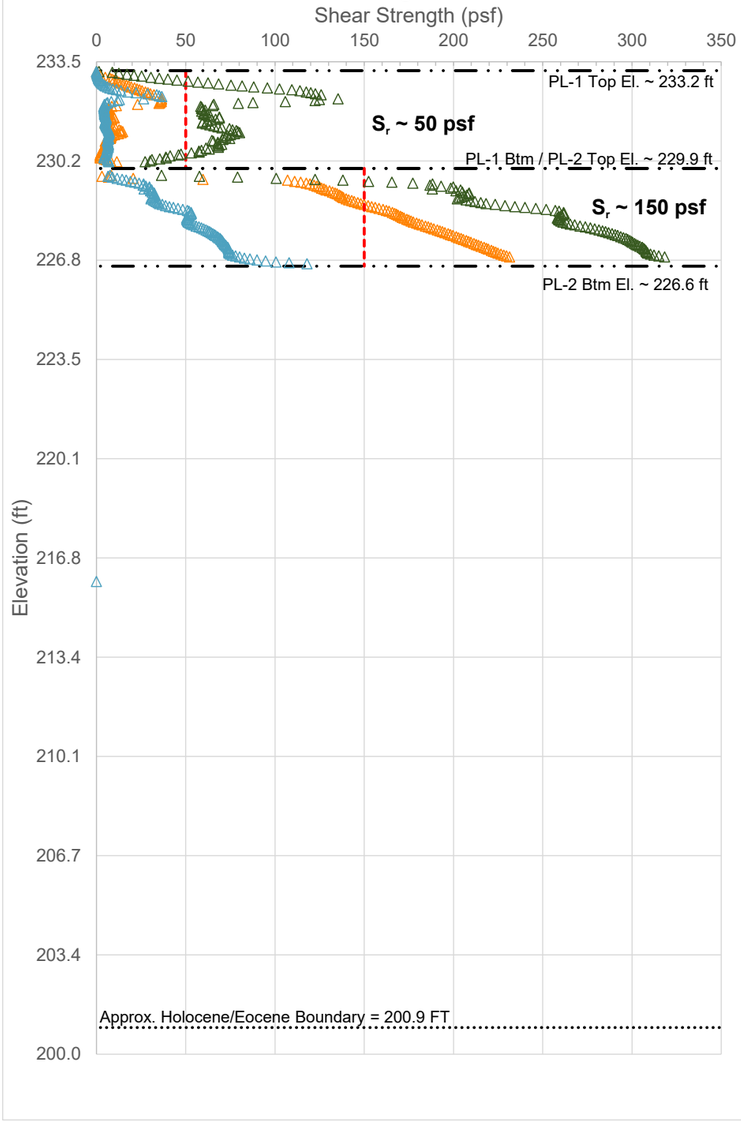
West Bank Slope - Factor of Safety

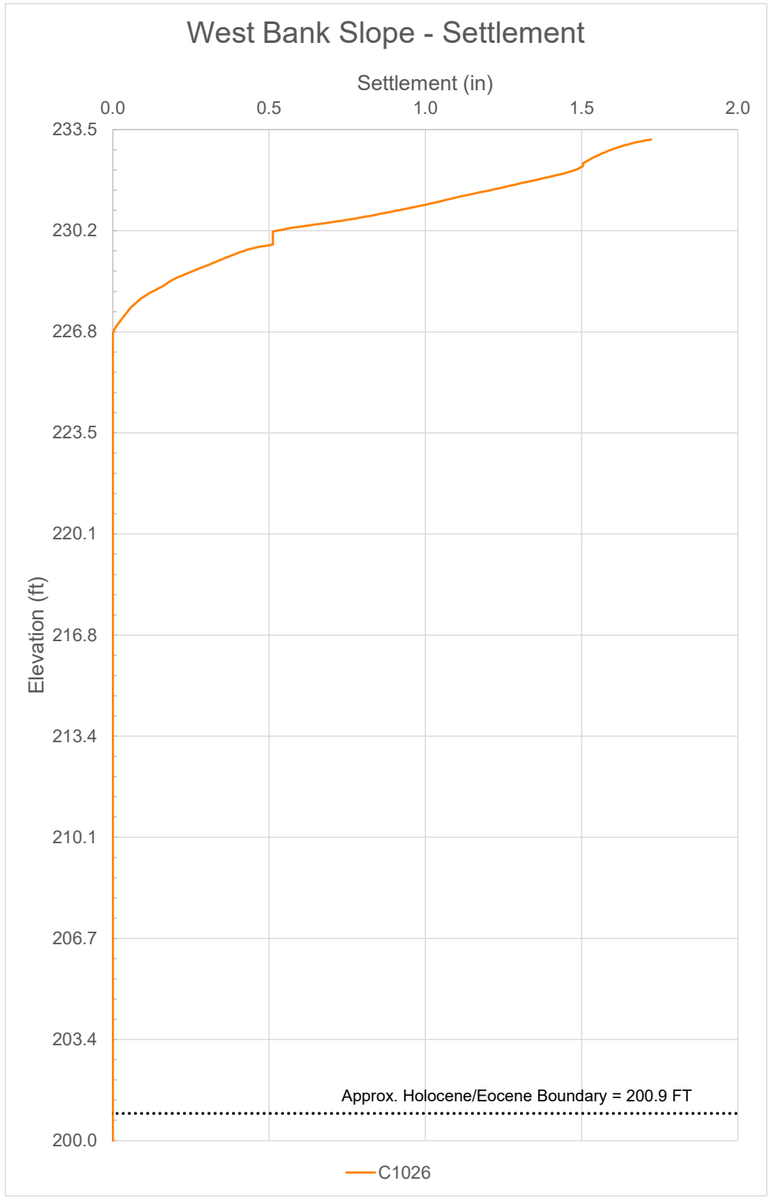


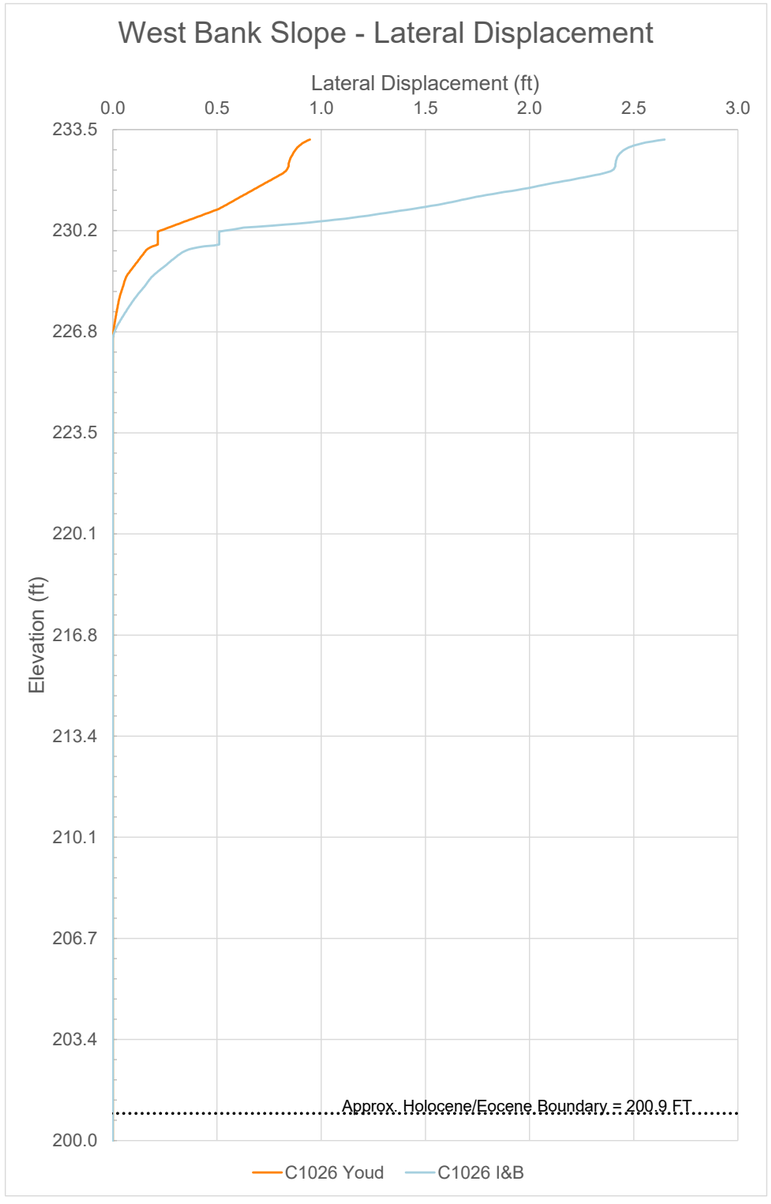
West Bank Slope - Residual Shear Strength



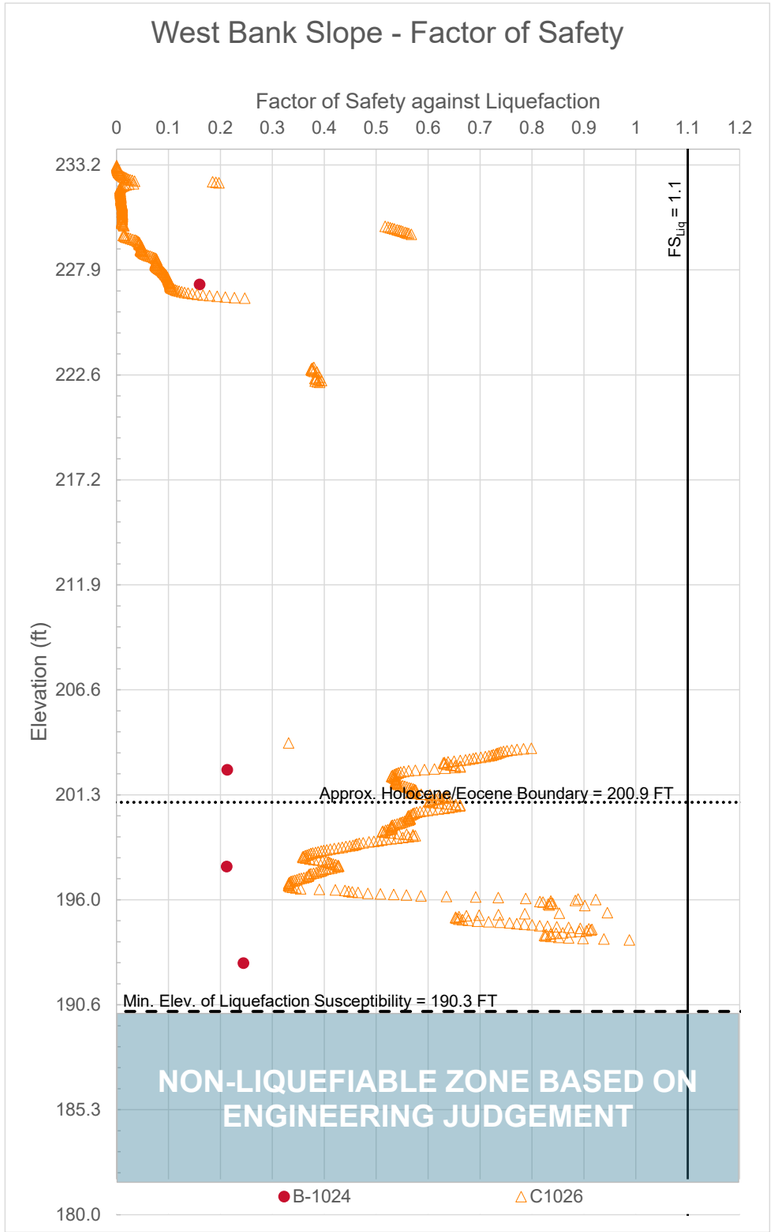
West Bank Slope - Liq. Layers & Res. Shear Strength

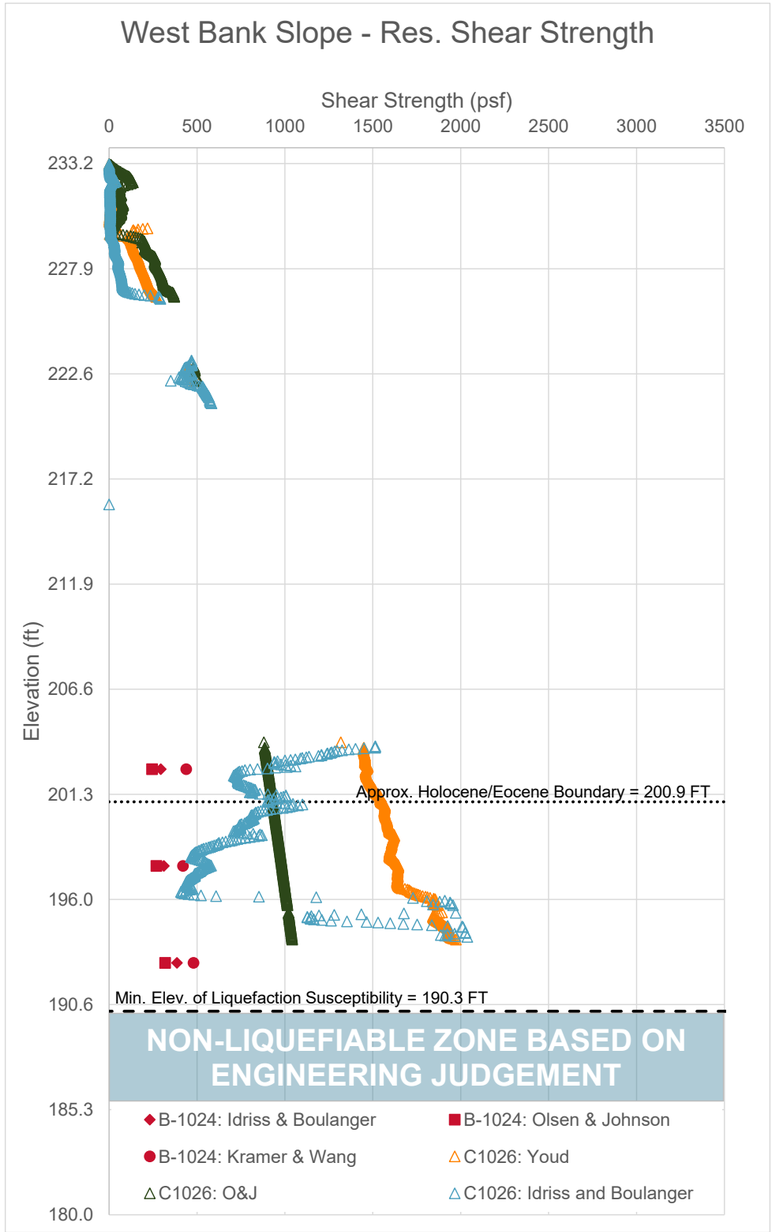


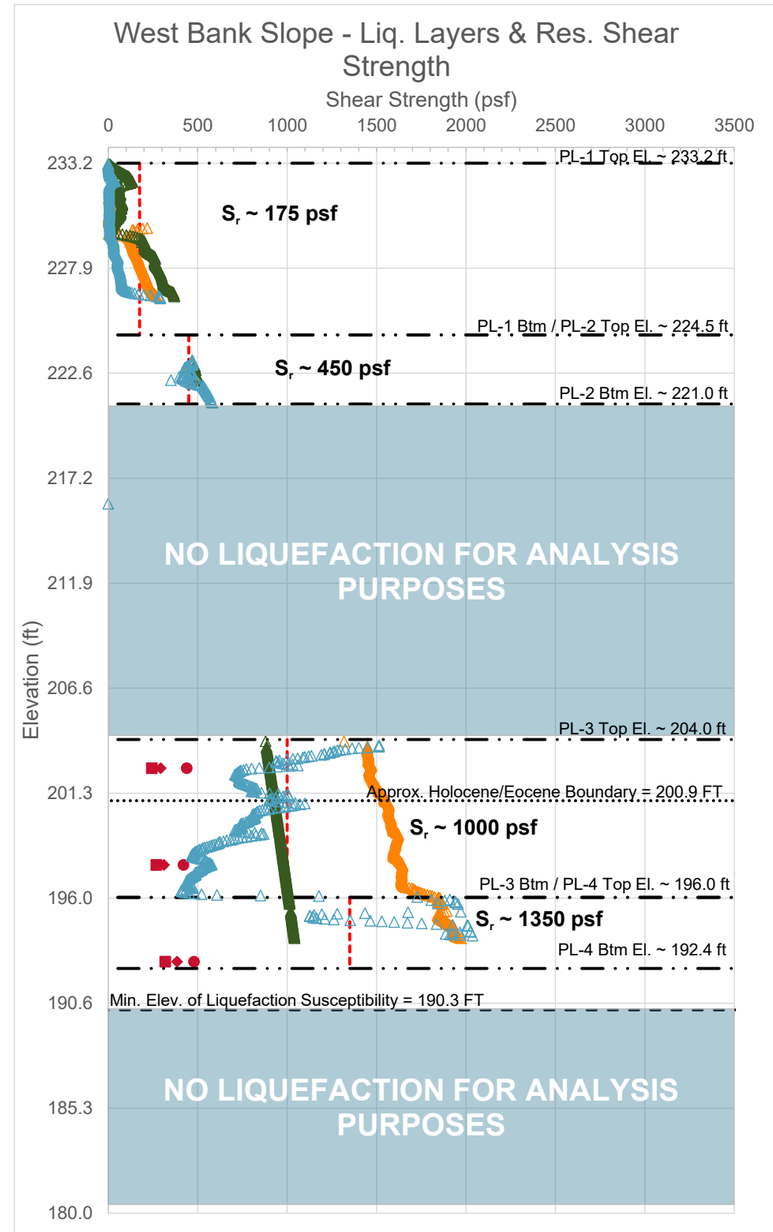

West Bank Slope - Settlement
Settlement (in)
0.0
0.5
1.0
1.5
2.0
Elevation (ft)
233.5
230.2
226.8
223.5
220.1
216.8
213.4
210.1
206.7
203.4
200.0
Approx. Holocene/Eocene Boundary = 200.9 FT
C1026

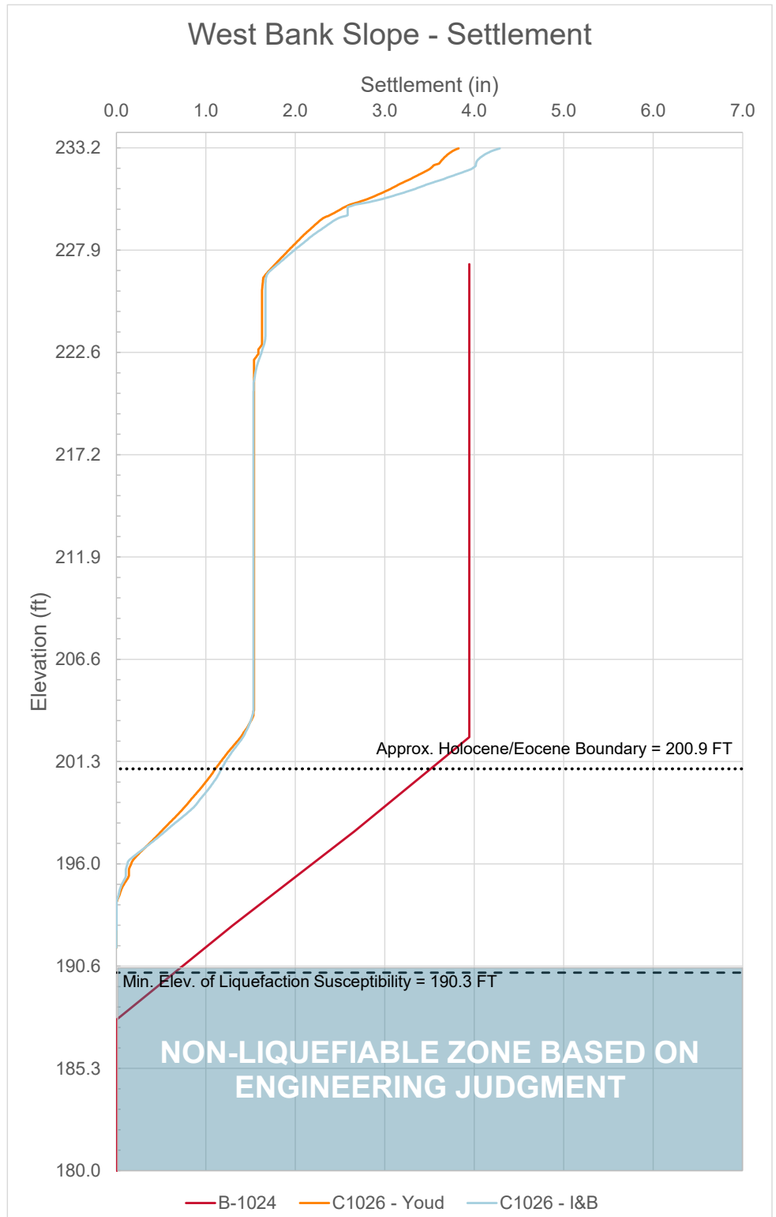

West Bank Slope - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Elevation (ft)
233.5
230.2
226.8
223.5
220.1
216.8
213.4
210.1
206.7
203.4
200.0
Approx. Holocene/Eocene Boundary = 200.9 FT
C1026 Youd
C1026 I&B

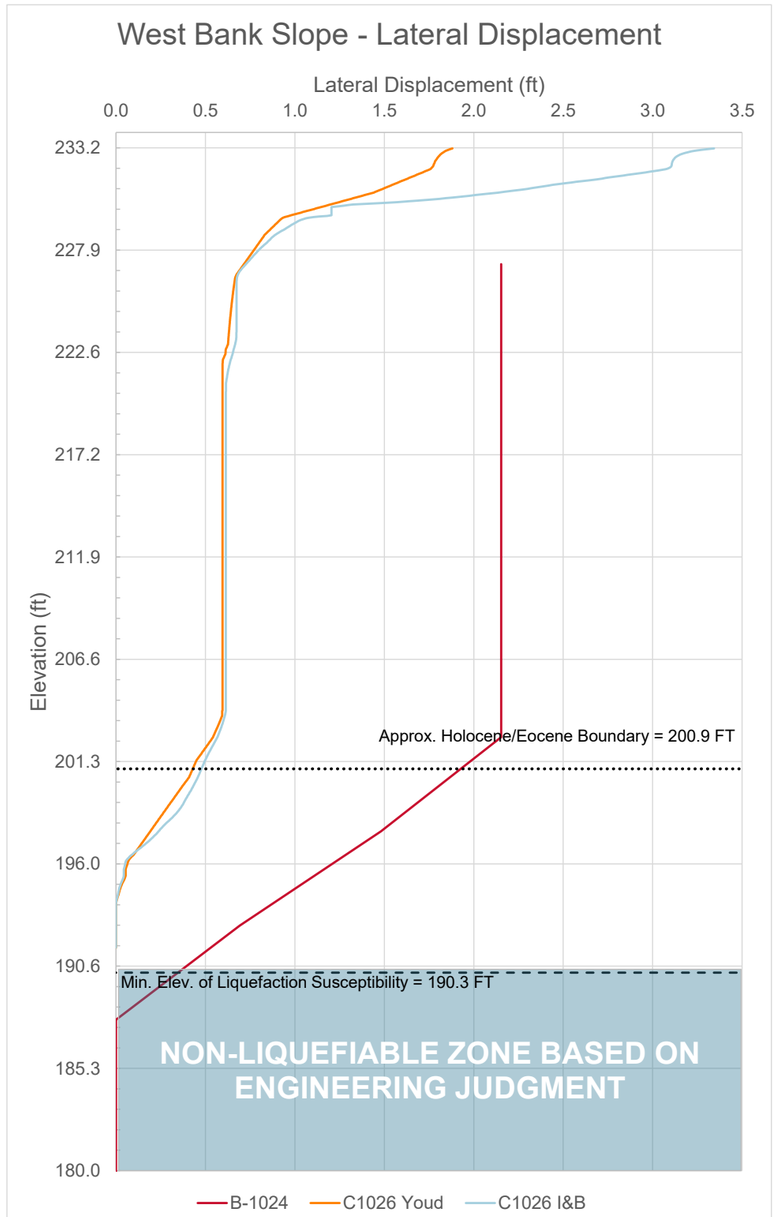
1,000-YR RETURN PERIOD


West Bank Slope - Factor of Safety
Factor of Safety against Liquefaction
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
233.2 227.9 222.6 217.2 211.9 206.6 201.3 196.0 190.6 185.3 180.0
Elevation (ft)
FS_Liq = 1.1
Approx. Holocene/Eocene Boundary = 200.9 FT
Min. Elev. of Liquefaction Susceptibility = 190.3 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGEMENT
B-1024
C1026


West Bank Slope - Res. Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500 3000 3500
233.2 227.9 222.6 217.2 211.9 206.6 201.3 196.0 190.6 185.3 180.0
Elevation (ft)
Approx. Holocene/Eocene Boundary = 200.9 FT
Min. Elev. of Liquefaction Susceptibility = 190.3 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGEMENT
B-1024: Idriss & Boulanger
B-1024: Olsen & Johnson
B-1024: Kramer & Wang
C1026: Youd
C1026: O&J
C1026: Idriss and Boulanger


West Bank Slope - Liq. Layers & Res. Shear Strength
Shear Strength (psf)
0 500 1000 1500 2000 2500 3000 3500
233.2 227.9 222.6 217.2 211.9 206.6 201.3 196.0 190.6 185.3 180.0
Elevation (ft)
PL-1 Top El. ~ 233.2 ft
S_r ~ 175 psf
PL-1 Btm / PL-2 Top El. ~ 224.5 ft
S_r ~ 450 psf
PL-2 Btm El. ~ 221.0 ft
NO LIQUEFACTION FOR ANALYSIS PURPOSES
PL-3 Top El. ~ 204.0 ft
Approx. Holocene/Eocene Boundary = 200.9 FT
S_r ~ 1000 psf
PL-3 Btm / PL-4 Top El. ~ 196.0 ft
S_r ~ 1350 psf
PL-4 Btm El. ~ 192.4 ft
Min. Elev. of Liquefaction Susceptibility = 190.3 FT
NO LIQUEFACTION FOR ANALYSIS PURPOSES


West Bank Slope - Settlement
Settlement (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Elevation (ft)
233.2
227.9
222.6
217.2
211.9
206.6
201.3
196.0
190.6
185.3
180.0
Approx. Holocene/Eocene Boundary = 200.9 FT
Min. Elev. of Liquefaction Susceptibility = 190.3 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1024
C1026 - Youd
C1026 - I&B

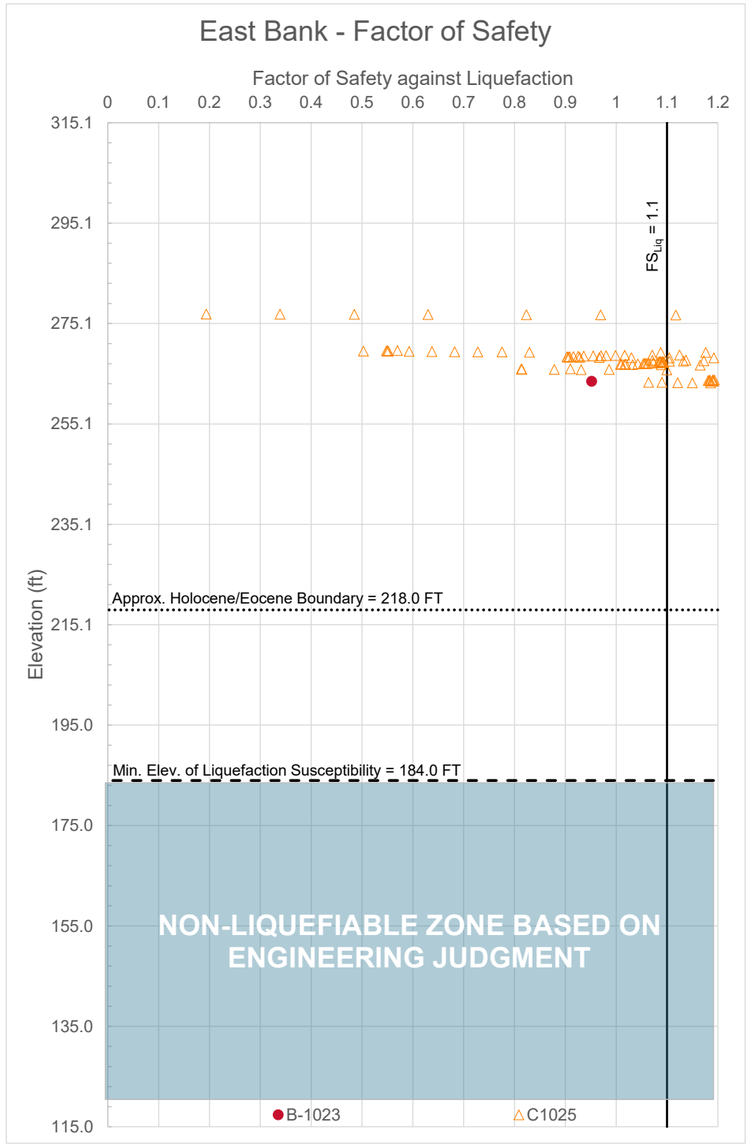

West Bank Slope - Lateral Displacement
Lateral Displacement (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Elevation (ft)
233.2
227.9
222.6
217.2
211.9
206.6
201.3
196.0
190.6
185.3
180.0
Approx. Holocene/Eocene Boundary = 200.9 FT
Min. Elev. of Liquefaction Susceptibility = 190.3 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1024
C1026 Youd
C1026 I&B

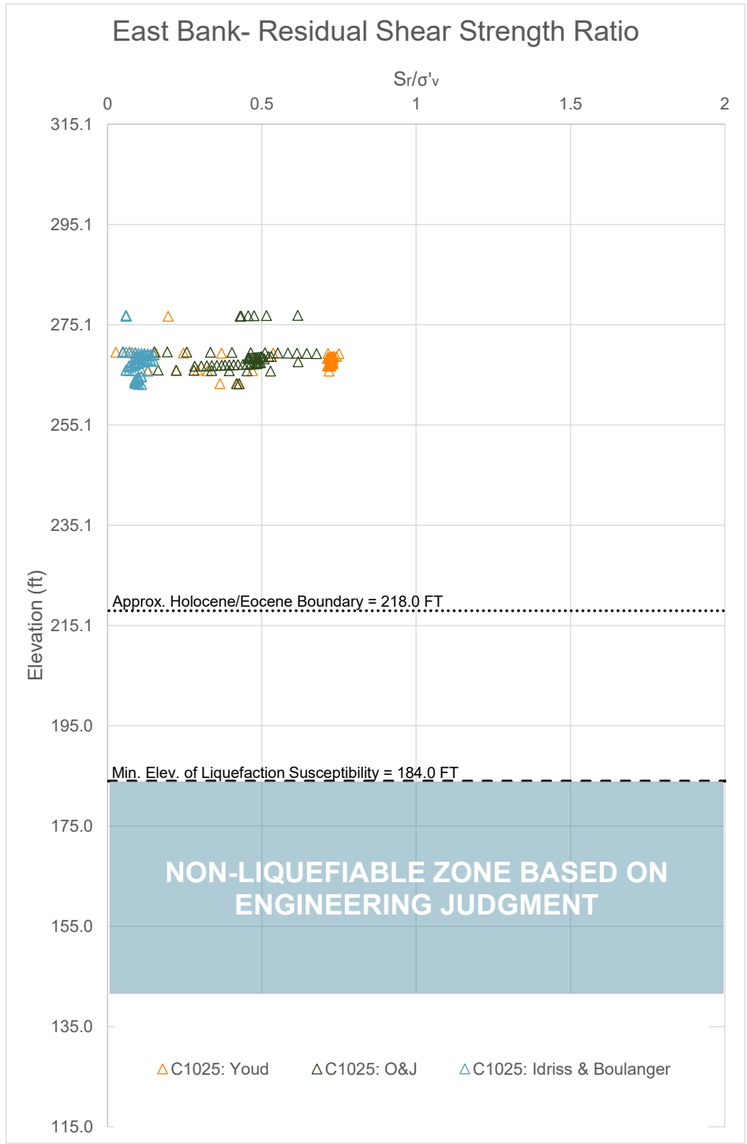
EASTERN RIVERBANK

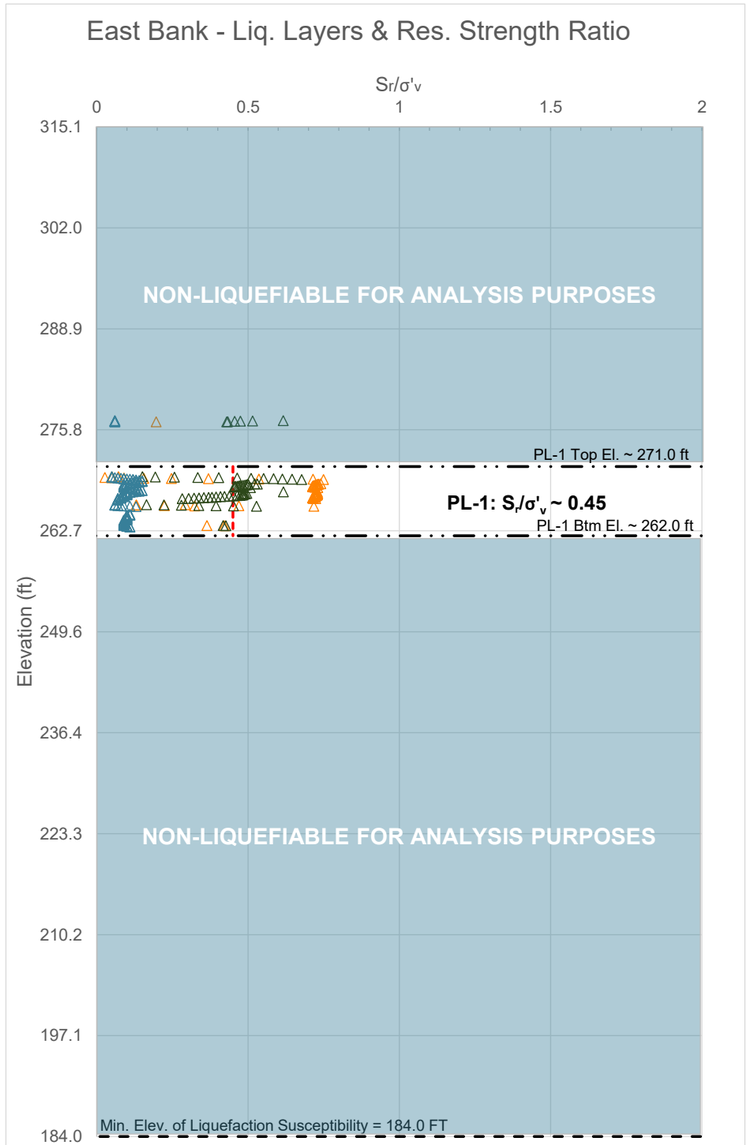
100-YR RETURN PERIOD

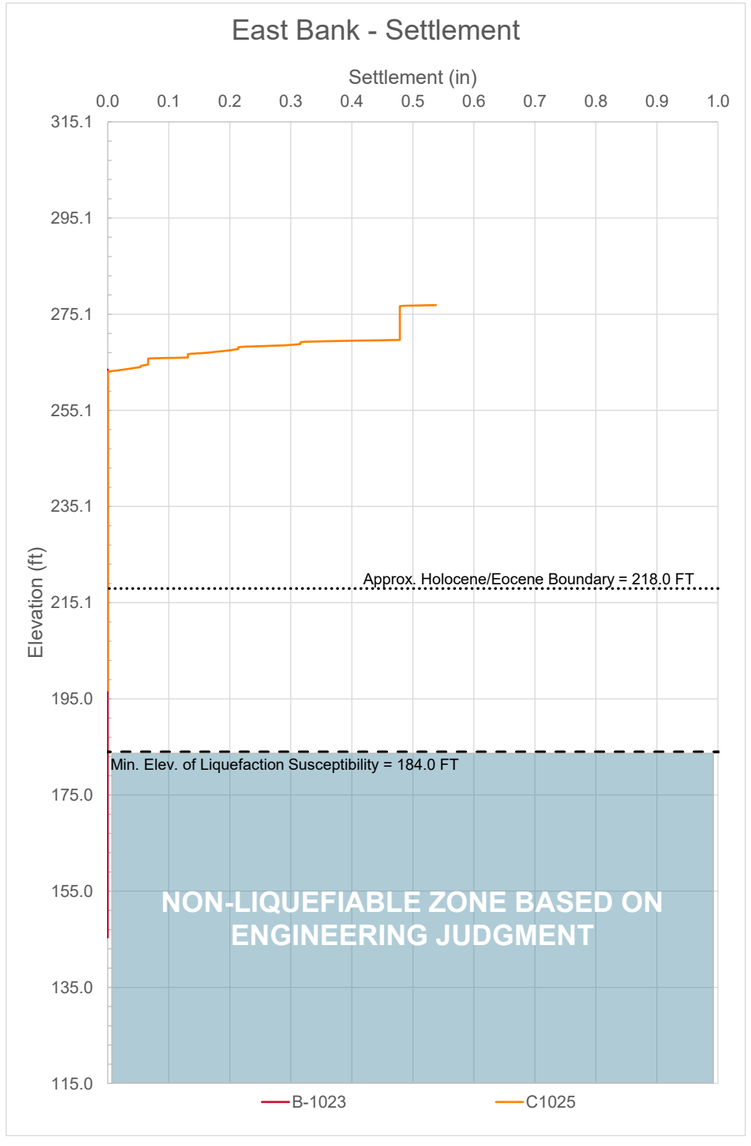
Project: US-51 Bridge Replacement
Subject: Liquefaction
Task: SPT-Based Liquefaction
Job #: 10174706

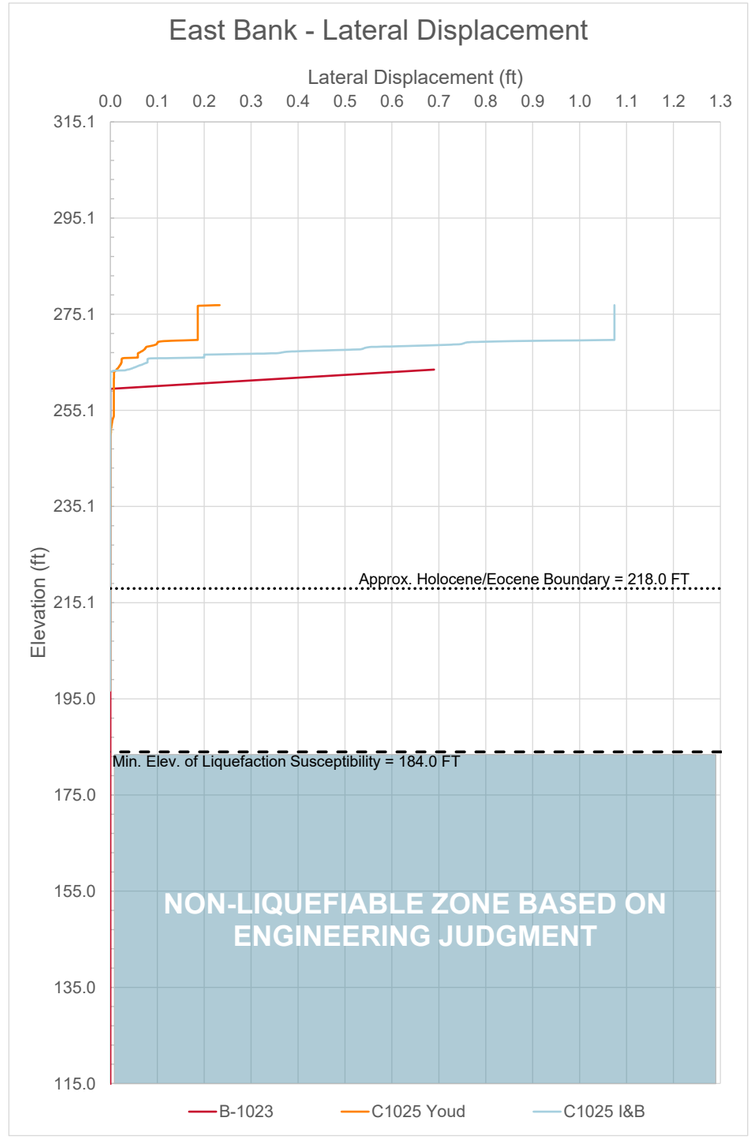
Computed by: RAY.P Date: 6/18/2026
Checked by: SKB Date: 6/18/2026







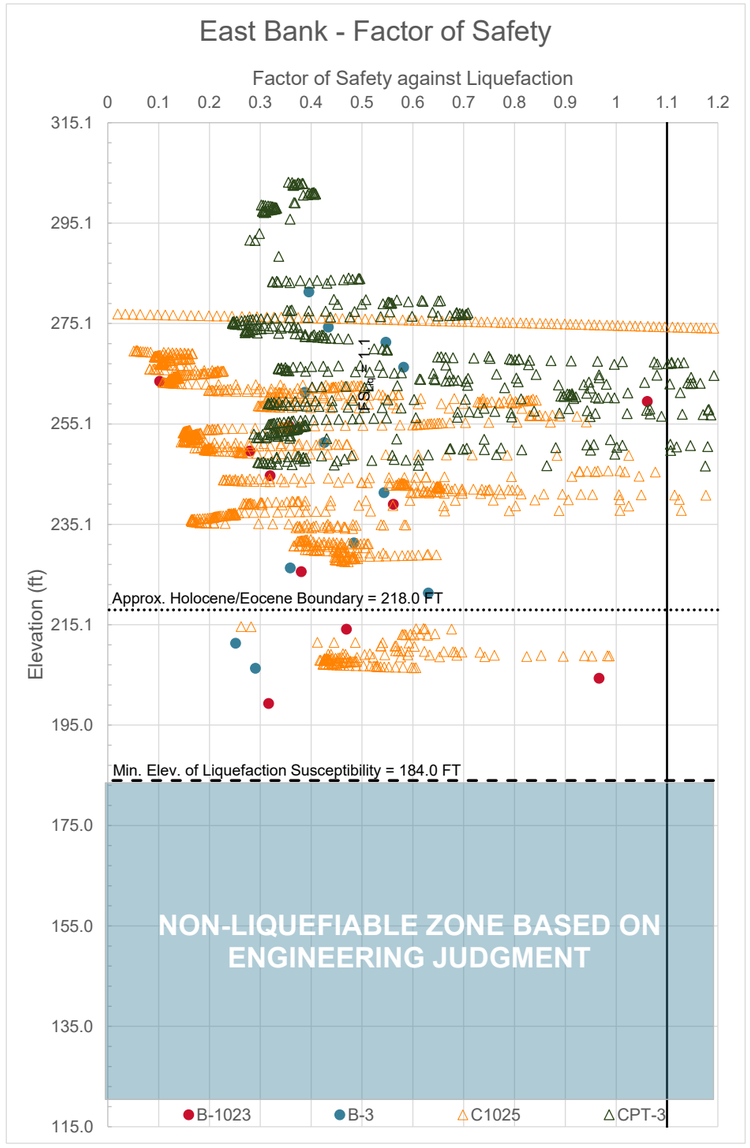

East Bank - Settlement
Settlement (in)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Elevation (ft)
315.1
295.1
275.1
255.1
235.1
215.1
195.0
175.0
155.0
135.0
115.0
Approx. Holocene/Eocene Boundary = 218.0 FT
Min. Elev. of Liquefaction Susceptibility = 184.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1023
C1025

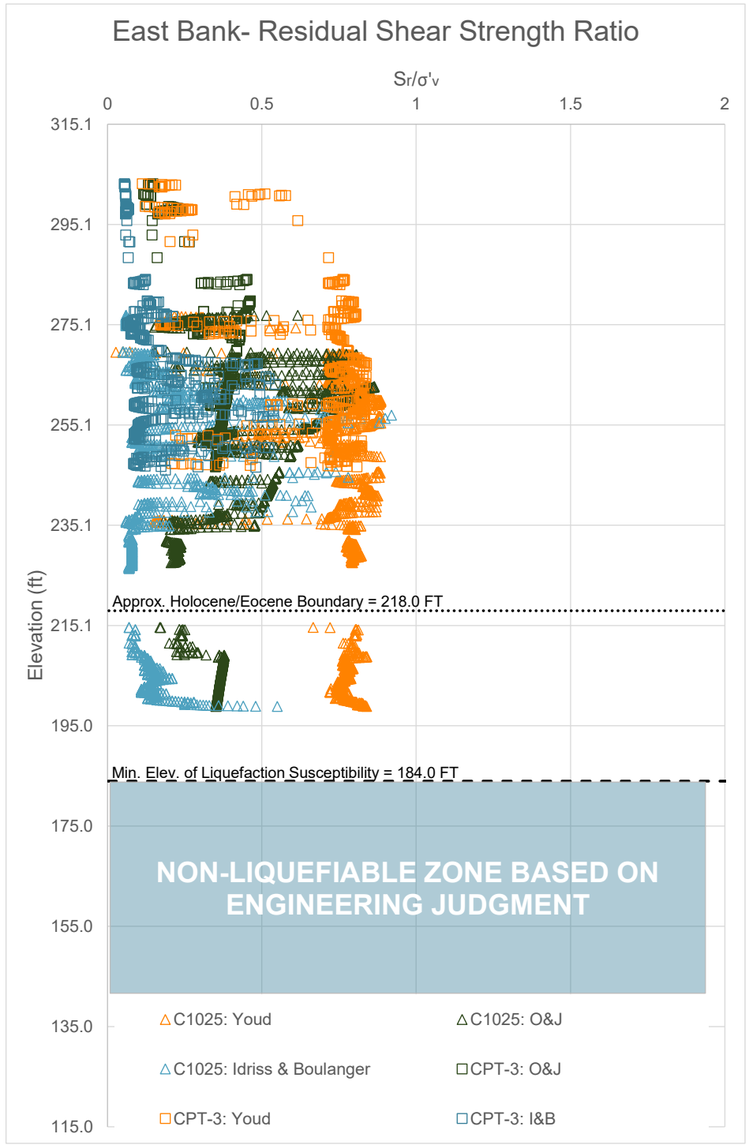

East Bank - Lateral Displacement
Lateral Displacement (ft)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3
Elevation (ft)
315.1
295.1
275.1
255.1
235.1
215.1
195.0
175.0
155.0
135.0
115.0
Approx. Holocene/Eocene Boundary = 218.0 FT
Min. Elev. of Liquefaction Susceptibility = 184.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1023
C1025 Youd
C1025 I&B

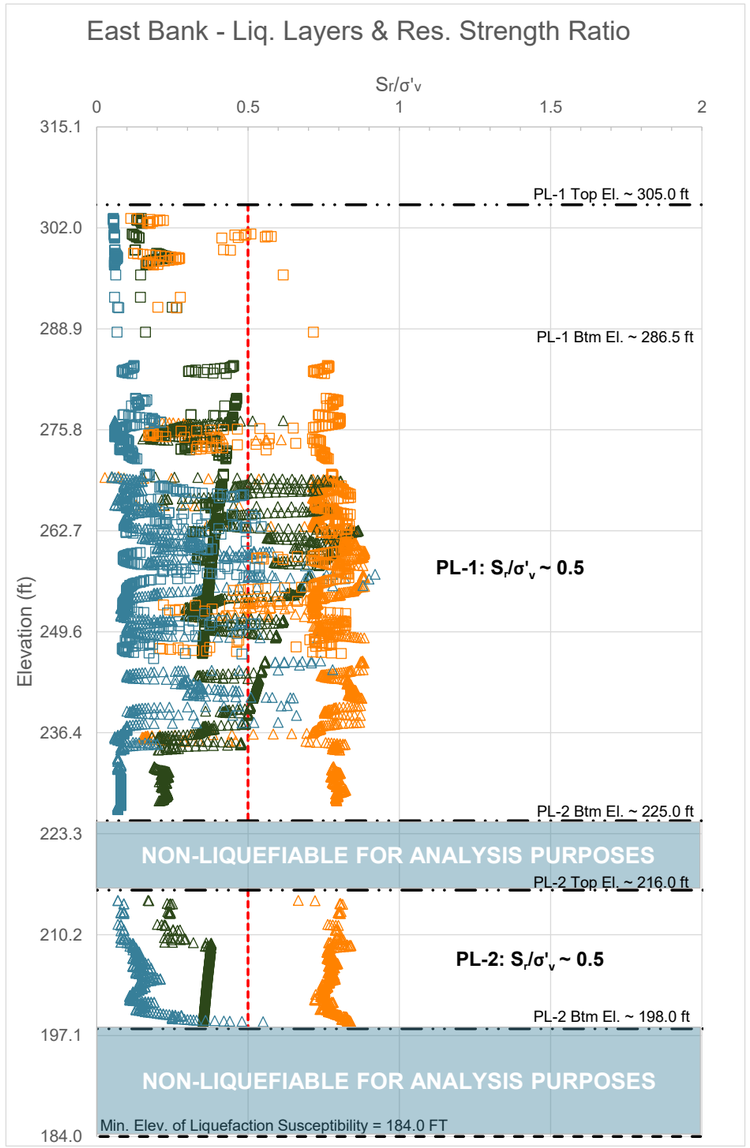
1,000-YR RETURN PERIOD

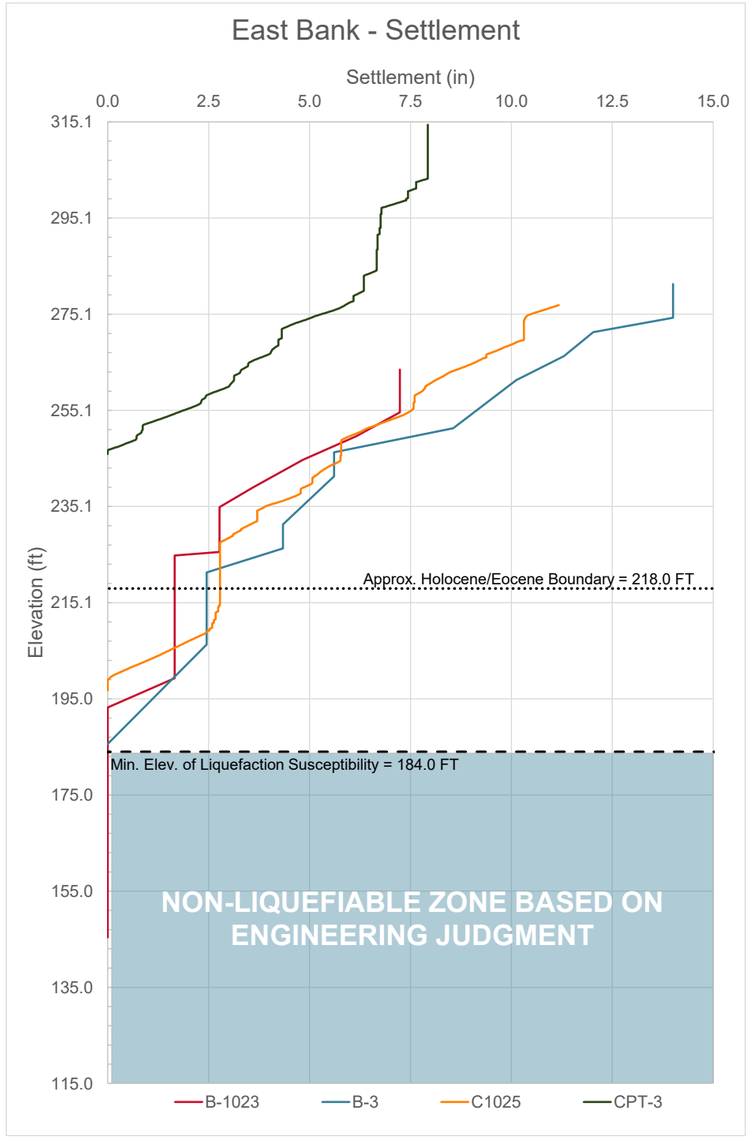
Project: US-51 Bridge Replacement
Subject: Liquefaction
Task: SPT-Based Liquefaction
Job #: 10174706

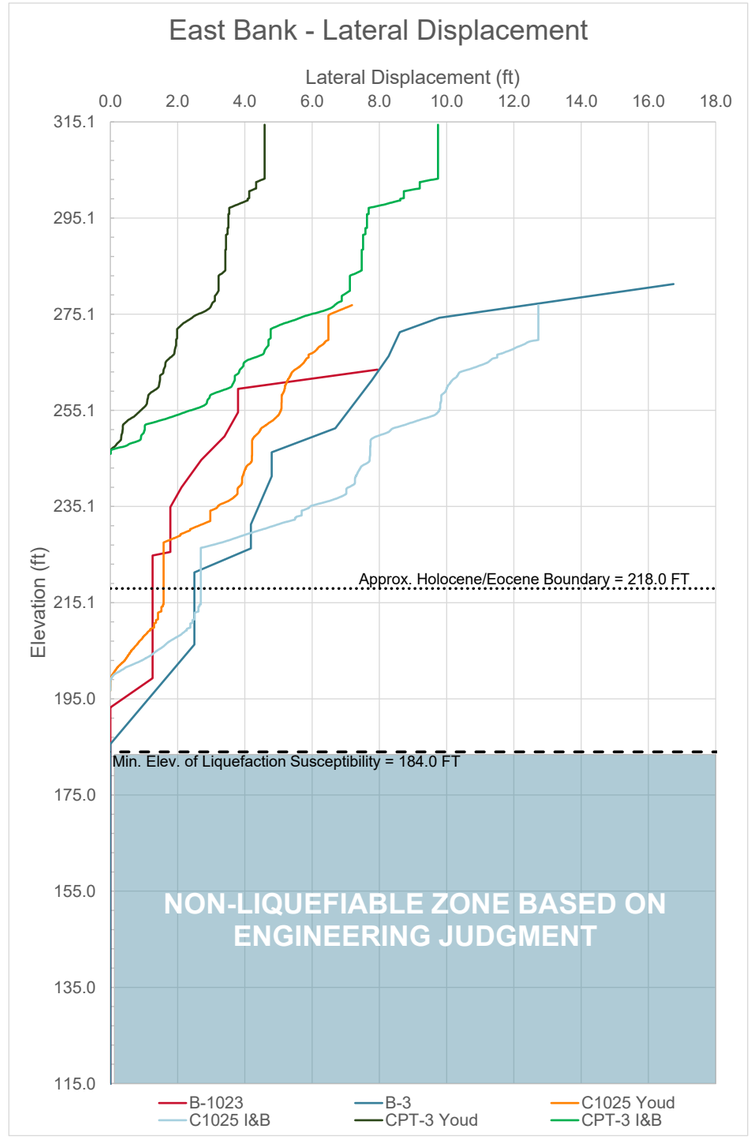
Computed by: RAY.P Date: 6/16/2026
Checked by: SKB Date: 6/16/2026








East Bank - Settlement
Settlement (in)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
Elevation (ft)
315.1
295.1
275.1
255.1
235.1
215.1
195.0
175.0
155.0
135.0
115.0
Approx. Holocene/Eocene Boundary = 218.0 FT
Min. Elev. of Liquefaction Susceptibility = 184.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1023
B-3
C1025
CPT-3


East Bank - Lateral Displacement
Lateral Displacement (ft)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Elevation (ft)
315.1
295.1
275.1
255.1
235.1
215.1
195.0
175.0
155.0
135.0
115.0
Approx. Holocene/Eocene Boundary = 218.0 FT
Min. Elev. of Liquefaction Susceptibility = 184.0 FT
NON-LIQUEFIABLE ZONE BASED ON ENGINEERING JUDGMENT
B-1023
B-3
C1025 Youd
C1025 I&B
CPT-3 Youd
CPT-3 I&B

Sample Liquefaction Analysis Calculations

SPT-Based Liquefaction Analysis & Seismic Settlement: 100-YR Return Period

Boring Information

Liner Required:	N
Liner Used:	N

Earthquake Information

Design Earthquake:	FEE
PGA:	0.086
Site Class:	D
M_w:	5.98
R(km):	127

Min. GW Depth, ft:	--
Max Depth to Compute Liquefaction, ft:	60

Boring Number	Latitude (Deg)	Longitude (Deg)	Surface Elev. (ft)	Water Elev. (ft)	Alignment	Structure	Hammer Efficiency (%)	Borehole Diameter (in.)
B-1012	36.995798	-89.148573	258.5	285.2	US-51	Pier 6	89	4.75
B-1013	36.995739	-89.148484	257.4	283.1	US-51	Pier 6	89	4.75
B-1014	36.995695	-89.148404	257.1	296.2	US-51	Pier 6	89	4.75
C1015	36.995671	-89.14855	256.0	285.1	US-51	Pier 6	--	--
C1016	36.995806	-89.148411	258.8	284.3	US-51	Pier 6	--	--

Boring 1012

Raw Data Input

Boring Number:	B-1012
Latitude:	36.99580
Longitude:	-89.14857
Ground Elevation, ft msl:	258.5
Groundwater Above Surface, ft:	26.7
Groundwater Elevation, ft msl:	285.2

Hammer Energy Ration (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.1	254.5	1	1	NP	NP	NP	31.2	SW	I		Holocene	1	Sand-Like	26	-		
SS-2	9.0	249.6	10	77	37	21	16	38.2	CL	I		Holocene	1	Clay-Like	-	2230		
SS-3	13.9	244.7	6	23	NP	NP	NP	19.1	SM	I		Holocene	1	Sand-Like	35	-		
SS-4	18.9	239.7	39	26	NP	NP	NP	14.8	SM	II		Holocene	1	Sand-Like	48	-		
SS-5	23.8	234.7	31	19.5	NP	NP	NP	0.5	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	28.7	229.9	32	13	NP	NP	NP	16.2	SM	II		Holocene	1	Sand-Like	48	-		
SS-7	33.6	225.0	22	26	NP	NP	NP	13.9	GM	II		Holocene	1	Sand-Like	45	-		
SS-8	38.5	220.1	26	5	NP	NP	NP	19.4	SP-SM	II		Holocene	1	Sand-Like	46	-		
SS-9	43.5	215.1	50	13	NP	NP	NP	13.9	SM	II		Holocene	1	Sand-Like	48	-		
SS-10	48.4	210.2	23	22	NP	NP	NP	22.9	SM	III		Holocene	1	Sand-Like	43	-		
SS-11	53.3	205.3	15	15	NP	NP	NP	20.9	SM	III		Holocene	1	Sand-Like	38	-		
SS-12	58.2	200.4	20	13	NP	NP	NP	20.8	SM	III		Holocene	1	Sand-Like	41	-		
SS-13	63.1	195.5	12	14	18	13	5	20.0	SC-SM	III	NL	Holocene	1	Sand-Like	36	-		
SS-14	68.1	190.5	0	87	NP	NP	NP	25.3	ML	III	NL	Eocene	1	Sand-Like	21	-		
SS-15	73.0	185.6	35	11	NP	NP	NP	20.4	SP-SM	III		Eocene	1	Sand-Like	46	-		
SS-16	77.9	180.7	50	13	0	13	0	20.1	SM	III		Eocene	1	Sand-Like	48	-		
SS-17	82.8	175.8	50	13	NP	NP	NP	18.5	SM	III		Eocene	1	Sand-Like	48	-		
SS-18	87.7	170.9	19	12	NP	NP	NP	20.1	SM	IV	NL	Eocene	1	Sand-Like	38	-		
SS-19	92.7	165.9	16	11	NP	NP	NP	22.5	SP-SM	IV	NL	Eocene	1	Sand-Like	36	-		
SS-20	97.5	161.1	50	3	NP	NP	NP	20.4	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	102.4	156.2	50	4	NP	NP	NP	21.0	SP	IV		Eocene	1	Sand-Like	48	-		
SS-22	112.2	146.3	50	6	NP	NP	NP	19.7	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-23	122.2	136.4	50	2	NP	NP	NP	20.6	SP	IV		Eocene	1	Sand-Like	47	-		
SS-24	131.9	126.6	50	8	NP	NP	NP	17.5	SW-SM	IV		Eocene	1	Sand-Like	47	-		
SS-25	141.7	116.8	50	2	NP	NP	NP	19.3	SP	IV		Eocene	1	Sand-Like	46	-		
SS-26	150.9	107.7	50	3	NP	NP	NP	20.9	SW	IV		Eocene	1	Sand-Like	46	-		
SS-27	161.2	97.4	50	4	NP	NP	NP	19.5	SP	IV		Eocene	1	Sand-Like	45	-		
SS-28	170.8	87.7	50	3	NP	NP	NP	25.8	SP	IV		Eocene	1	Sand-Like	45	-		
SS-29	180.6	77.9	50	3	NP	NP	NP	24.7	SP	IV		Eocene	1	Sand-Like	45	-		
SS-30	190.5	68.0	50	2	NP	NP	NP	22.1	SP	IV		Eocene	1	Sand-Like	44	-		
SS-31	200.6	57.9	50	9	NP	NP	NP	22.7	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-32	220.1	38.4	50	8	NP	NP	NP	16.7	SP-SM	IV		Eocene	1	Sand-Like	43	-		
SS-33	239.9	18.6	50	2	NP	NP	NP	23.6	SP	IV		Eocene	1	Sand-Like	43	-		
SS-34	259.5	-1.0	50	3	NP	NP	NP	24.4	SP	IV		Eocene	1	Sand-Like	42	-		
SS-35	279.6	-21.1	50	92	32	16	16	18.5	CL	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-36	299.3	-40.8	44	14	60	44	16	42.2	SM	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-37	317.0	-58.5	49	9	101	38	63	47.0	SP-SC	V	NL	Eocene	1	Clay-Like	-	7500		

Standard Penetration Test Correction

Boring Number:	B-1012	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99580	CE:	1.48
Longitude:	-89.14857	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	258.5	CB:	1.15
Groundwater Above Surface, ft:	26.7	Liner Required:	N
Groundwater Elevation, ft msl:	285.2	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.05	254.45	1	1.48	1.70	0.75	1.0	1.15	1.0	2132	213	1.0	1.5	2.5	1.3	2.2	2.2
SS-2	8.95	249.55	10	1.48	1.70	0.84	1.0	1.15	1.2	2695	471	77.0	14.8	25.2	14.3	24.4	29.6
SS-3	13.85	244.65	6	1.48	1.66	0.90	1.0	1.15	1.2	3259	729	23.0	8.9	14.7	9.3	15.3	17.9
SS-4	18.85	239.65	39	1.48	1.42	0.94	1.0	1.15	1.1	3834	992	26.0	50.0	71.0	62.8	50.0	56.5
SS-5	23.8	234.7	31	1.48	1.26	0.97	1.0	1.15	1.1	4403	1252	19.5	46.0	58.1	51.1	50.0	54.9
SS-6	28.65	229.85	32	1.48	1.15	0.98	1.0	1.15	1.1	4961	1507	13.0	47.5	54.7	53.5	50.0	53.3
SS-7	33.55	224.95	22	1.48	1.06	0.99	1.0	1.15	1.1	5524	1765	26.0	32.6	34.7	37.1	39.5	44.9
SS-8	38.45	220.05	26	1.48	0.99	0.99	1.0	1.15	1.0	6088	2022	5.0	38.6	38.4	44.1	43.8	44.9
SS-9	43.45	215.05	50	1.48	0.94	1.00	1.0	1.15	1.1	6663	2285	13.0	50.0	46.8	85.0	50.0	53.3
SS-10	48.35	210.15	23	1.48	0.89	1.00	1.0	1.15	1.1	7226	2543	22.0	34.1	30.3	39.1	34.7	38.9
SS-11	53.25	205.25	15	1.48	0.85	1.00	1.0	1.15	1.1	7790	2801	15.0	22.3	18.8	25.6	21.6	23.6
SS-12	58.15	200.35	20	1.48	0.81	1.00	1.0	1.15	1.1	8353	3059	13.0	29.7	24.0	34.1	27.6	29.6
SS-13	63.05	195.45	12	1.48	0.78	1.00	1.0	1.15	1.1	8917	3316	14.0	17.8	13.8	20.5	15.9	17.5
SS-14	68.05	190.45	0	1.48	0.75	1.00	1.0	1.15	1.3	9492	3579	87.0	0.1	0.1	0.2	0.1	0.2
SS-15	72.95	185.55	35	1.48	0.72	1.00	1.0	1.15	1.1	10055	3837	11.0	50.0	36.1	59.7	43.1	45.5
SS-16	77.85	180.65	50	1.48	0.70	1.00	1.0	1.15	1.1	10619	4095	13.0	50.0	34.9	85.3	50.0	53.3
SS-17	82.75	175.75	50	1.48	0.68	1.00	1.0	1.15	1.1	11182	4353	13.0	50.0	33.9	85.3	50.0	53.3
SS-18	87.65	170.85	19	1.48	0.66	1.00	1.0	1.15	1.1	11746	4610	12.0	28.2	18.6	32.4	21.3	23.0
SS-19	92.65	165.85	16	1.48	0.64	1.00	1.0	1.15	1.1	12321	4873	11.0	23.7	15.2	27.3	17.5	18.8
SS-20	97.45	161.05	50	1.48	0.62	1.00	1.0	1.15	1.0	12873	5126	3.0	50.0	31.2	85.3	50.0	50.0
SS-21	102.35	156.15	50	1.48	0.61	1.00	1.0	1.15	1.0	13436	5384	4.0	50.0	30.5	85.3	50.0	50.0
SS-22	112.2	146.3	50	1.48	0.58	1.00	1.0	1.15	1.0	14569	5902	6.0	50.0	29.1	85.3	49.7	51.1
SS-23	122.15	136.35	50	1.48	0.56	1.00	1.0	1.15	1.0	15713	6425	2.0	50.0	27.9	85.3	47.6	47.6
SS-24	131.9	126.6	50	1.48	0.54	1.00	1.0	1.15	1.0	16835	6938	8.0	50.0	26.8	85.3	45.8	47.7
SS-25	141.7	116.8	50	1.48	0.52	1.00	1.0	1.15	1.0	17962	7453	2.0	50.0	25.9	85.3	44.2	44.2
SS-26	150.85	107.65	50	1.48	0.50	1.00	1.0	1.15	1.0	19014	7935	3.0	50.0	25.1	85.3	42.8	42.8
SS-27	161.15	97.35	50	1.48	0.49	1.00	1.0	1.15	1.0	20198	8476	4.0	50.0	24.3	85.3	41.4	41.4
SS-28	170.8	87.7	50	1.48	0.47	1.00	1.0	1.15	1.0	21308	8984	3.0	50.0	23.6	85.3	40.2	40.2
SS-29	180.6	77.9	50	1.48	0.46	1.00	1.0	1.15	1.0	22435	9500	3.0	50.0	22.9	85.3	39.1	39.1
SS-30	190.5	68	50	1.48	0.45	1.00	1.0	1.15	1.0	23574	10020	2.0	50.0	22.3	85.3	38.1	38.1
SS-31	200.6	57.9	50	1.48	0.44	1.00	1.0	1.15	1.0	24735	10552	9.0	50.0	21.8	85.3	37.1	38.9
SS-32	220.1	38.4	50	1.48	0.42	1.00	1.0	1.15	1.0	26978	11577	8.0	50.0	20.8	85.3	35.5	37.0
SS-33	239.9	18.6	50	1.48	0.40	1.00	1.0	1.15	1.0	29255	12619	2.0	50.0	19.9	85.3	34.0	34.0
SS-34	259.5	-1	50	1.48	0.38	1.00	1.0	1.15	1.0	31509	13650	3.0	50.0	19.1	85.3	32.6	32.6
SS-35	279.55	-21.05	50	1.48	0.37	1.00	1.0	1.15	1.2	33814	14704	92.0	50.0	18.4	85.3	31.5	37.6
SS-36	299.25	-40.75	44	1.48	0.36	1.00	1.0	1.15	1.1	36080	15741	14.0	50.0	17.8	75.1	26.8	29.0
SS-37	316.95	-58.45	49	1.48	0.35	1.00	1.0	1.15	1.1	38115	16672	9.0	50.0	17.3	83.6	29.0	30.4

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1012	Design EQ:	FEE	M_w:	5.98
Latitude:	36.99580	Site Class:	D	R(km):	127
Longitude:	-89.14857	PGA:	0.086	MSF_{sand}:	1.49
Ground Elevation, ft msl:	258.5	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.08
Groundwater Above Surface, ft:	26.7	$\phi_{NSL\text{-}Sand}$	0.70		
Groundwater Elevation, ft msl:	285.2	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	$\sum S_{v\text{-}1D}$, in
SS-1	4.05	254.45	2.2	0.0	2.2	SSL	Sand-Like	4.77	0.9	Full Liquefaction	0.04	9.24	0.05	9.87	43.11	2.03	2.0	-	0.0
SS-2	8.95	249.55	24.4	5.5	29.9	PSL	HS Clay-Like	0.08	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-3	13.85	244.65	15.3	4.9	20.2	SSL	Sand-Like	0.68	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-4	18.85	239.65	50.0	5.1	55.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-5	23.8	234.7	50.0	4.4	54.4	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-6	28.65	229.85	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-7	33.55	224.95	39.5	5.1	44.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-8	38.45	220.05	43.8	0.0	43.8	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-9	43.45	215.05	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-10	48.35	210.15	34.7	4.8	39.5	NSL-S	Sand-Like	0.02	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-11	53.25	205.25	21.6	3.3	24.9	SSL	Sand-Like	0.25	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-12	58.15	200.35	27.6	2.5	30.1	NSL-S	Sand-Like	0.14	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	63.05	195.45	15.9	2.9	18.8	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	68.05	190.45	0.1	5.5	5.6	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	72.95	185.55	43.1	1.6	44.7	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	77.85	180.65	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	82.75	175.75	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	87.65	170.85	21.3	2.1	23.4	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	92.65	165.85	17.5	1.6	19.1	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	97.45	161.05	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	102.35	156.15	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	112.2	146.3	49.7	0.0	49.7	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	122.15	136.35	47.6	0.0	47.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	131.9	126.6	45.8	0.4	46.2	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	141.7	116.8	44.2	0.0	44.2	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	150.85	107.65	42.8	0.0	42.8	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	161.15	97.35	41.4	0.0	41.4	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	170.8	87.7	40.2	0.0	40.2	NSL-S	Sand-Like	0.02	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	180.6	77.9	39.1	0.0	39.1	NSL-S	Sand-Like	0.04	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	190.5	68	38.1	0.0	38.1	NSL-S	Sand-Like	0.06	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	200.6	57.9	37.1	0.7	37.9	NSL-S	Sand-Like	0.07	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	220.1	38.4	35.5	0.4	35.8	NSL-S	Sand-Like	0.13	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	239.9	18.6	34.0	0.0	34.0	NSL-S	Sand-Like	0.20	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	259.5	-1	32.6	0.0	32.6	NSL-S	Sand-Like	0.23	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	279.55	-21.05	31.5	5.5	37.0	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	299.25	-40.75	26.8	2.9	29.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-37	316.95	-58.45	29.0	0.7	29.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0

Boring 1013

Raw Data Input

Boring Number:	B-1013
Latitude:	36.99574
Longitude:	-89.14848
Ground Elevation, ft msl:	257.4
Groundwater Above Surface, ft:	25.7
Groundwater Elevation, ft msl:	283.1

Hammer Energy Ration (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.7	252.8	8	10	NP	NP	NP	27.7	SW-SM	I		Holocene	1	Sand-Like	36	-		
SS-2	9.6	247.9	2	25	NP	NP	NP	18.6	SM	I		Holocene	1	Sand-Like	29	-		
SS-3	14.6	242.9	13	2	NP	NP	NP	16.7	SP	I	NL	Holocene	1	Sand-Like	42	-		
SS-4	19.5	238.0	35	12	NP	NP	NP	14.7	GP-GM	II		Holocene	1	Sand-Like	48	-		
SS-5	24.4	233.1	32	12	NP	NP	NP	16.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	29.3	228.2	44	8	NP	NP	NP	13.2	SW-SM	II		Holocene	1	Sand-Like	48	-		
SS-7	34.2	223.3	47	15	NP	NP	NP	15.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-8	39.1	218.3	50	15	NP	NP	NP	15.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-9	44.1	213.4	50	16	NP	NP	NP	14.5	SM	II		Holocene	1	Sand-Like	48	-		
SS-10	49.0	208.5	11	16	NP	NP	NP	21.4	SM	III		Holocene	1	Sand-Like	36	-		
SS-11	58.8	198.7	20	15	NP	NP	NP	20.4	SM	III		Holocene	1	Sand-Like	41	-		
SS-12	63.8	193.7	21	15	16	14	2	22.1	SM	III		Holocene	1	Sand-Like	41	-		
SS-13	68.2	189.3	30	90	34	20	14	26.6	CL	III		Eocene	1	Clay-Like	-	6680		
SS-13	68.9	188.5	30	46	15	13	2	26.4	SM	III		Eocene	1	Sand-Like	44	-		
SS-14	73.6	183.9	42	82	23	14	9	22.2	CL	III		Eocene	1	Clay-Like	-	3750		
SS-15	80.2	177.3	50	17	NP	NP	NP	19.4	SM	III		Eocene	1	Sand-Like	48	-		
SS-16	83.3	174.1	50	13	NP	NP	NP	19.6	SM	IV		Eocene	1	Sand-Like	48	-		
SS-17	88.4	169.1	18	20	NP	NP	NP	21.8	SM	IV	NL	Eocene	1	Sand-Like	38	-		
SS-18	95.3	162.2	11	2	NP	NP	NP	20.4	SP	IV	NL	Eocene	1	Sand-Like	34	-		
SS-19	101.5	156.0	50	4	NP	NP	NP	18.5	SP	IV		Eocene	1	Sand-Like	48	-		
SS-20	113.0	144.5	50	3	NP	NP	NP	17.5	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	122.8	134.7	50	75	NP	NP	NP	19.0	ML	IV		Eocene	1	Sand-Like	47	-		
SS-22	142.5	115.0	50	3	NP	NP	NP	19.5	SW	IV		Eocene	1	Sand-Like	46	-		
SS-23	152.3	105.2	50	6	NP	NP	NP	17.0	SW-SM	IV		Eocene	1	Sand-Like	46	-		
SS-24	162.1	95.4	50	4	NP	NP	NP	20.6	SP	IV		Eocene	1	Sand-Like	45	-		
SS-25	171.5	86.0	50	5	NP	NP	NP	25.1	SP-SM	IV		Eocene	1	Sand-Like	45	-		
SS-26	181.5	76.0	50	6	NP	NP	NP	19.2	SW-SM	IV		Eocene	1	Sand-Like	45	-		
SS-27	191.2	66.2	50	6	NP	NP	NP	22.1	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-28	201.5	56.0	50	6	NP	NP	NP	24.0	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-29	220.7	36.7	50	39	14	14	0	25.6	SM	IV	NL	Eocene	1	Sand-Like	43	-		
SS-30	240.5	17.0	50	7	NP	NP	NP	25.0	SP-SM	IV		Eocene	1	Sand-Like	43	-		
SS-31	260.2	-2.8	50	5	NP	NP	NP	22.3	SP	IV		Eocene	1	Sand-Like	42	-		
SS-32	280.2	-22.8	50	9	NP	NP	NP	20.1	SP-SM	IV		Eocene	1	Sand-Like	42	-		
SS-33	299.9	-42.5	38	16	44	34	10	39.7	SM	IV	NL	Eocene	1	Clay-Like	-	3750		
SS-34	319.6	-62.2	22	8	58	43	15	43.6	SW-SM	V	NL	Eocene	1	Clay-Like	-	4900		
SS-35	339.3	-81.9	36	16	62	44	18	45.2	SM	V	NL	Eocene	1	Clay-Like	-	7500		
SS-36	359.0	-101.6	50	23	89	58	31	60.4	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-37	377.0	-119.6	50	23	86	59	27	54.8	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-38	396.9	-139.5	50	31	84	57	27	52.6	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-39	401.8	-144.4	50	40	76	53	23	48.2	SM	VI	NL	Eocene	1	Clay-Like	-	7500		

Standard Penetration Test Correction

Boring Number:	B-1013	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99574	CE:	1.48
Longitude:	-89.14848	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	257.4	CB:	1.15
Groundwater Above Surface, ft:	25.7	Liner Required:	N
Groundwater Elevation, ft msl:	283.1	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.65	252.75	8	1.48	1.70	0.76	1.0	1.15	1.1	2138	245	10.0	11.9	20.2	10.3	17.6	18.8
SS-2	9.55	247.85	2	1.48	1.70	0.85	1.0	1.15	1.4	2702	502	25.0	3.0	5.0	2.9	4.9	6.7
SS-3	14.55	242.85	13	1.48	1.62	0.91	1.0	1.15	1.0	3277	765	2.0	19.3	31.2	20.2	32.7	32.7
SS-4	19.45	237.95	35	1.48	1.40	0.95	1.0	1.15	1.1	3840	1023	12.0	50.0	69.9	56.5	50.0	53.0
SS-5	24.35	233.05	32	1.48	1.25	0.97	1.0	1.15	1.1	4404	1281	12.0	47.5	59.3	52.9	50.0	53.0
SS-6	29.25	228.15	44	1.48	1.14	0.98	1.0	1.15	1.0	4967	1539	8.0	50.0	57.0	73.7	50.0	52.0
SS-7	34.15	223.25	47	1.48	1.06	0.99	1.0	1.15	1.1	5531	1796	15.0	50.0	52.8	79.3	50.0	53.8
SS-8	39.1	218.3	50	1.48	0.99	0.99	1.0	1.15	1.1	6100	2057	15.0	50.0	49.3	84.8	50.0	53.8
SS-9	44.05	213.35	50	1.48	0.93	1.00	1.0	1.15	1.1	6669	2317	16.0	50.0	46.5	85.0	50.0	54.0
SS-10	48.95	208.45	11	1.48	0.88	1.00	1.0	1.15	1.1	7233	2575	16.0	16.3	14.4	18.7	16.5	18.4
SS-11	58.75	198.65	20	1.48	0.80	1.00	1.0	1.15	1.1	8360	3090	15.0	29.7	23.9	34.1	27.4	29.8
SS-12	63.75	193.65	21	1.48	0.77	1.00	1.0	1.15	1.1	8935	3353	15.0	31.2	24.1	35.8	27.7	30.1
SS-13	68.15	189.25	30	1.48	0.75	1.00	1.0	1.15	1.2	9441	3585	90.0	44.5	33.2	51.2	38.2	45.3
SS-13	68.9	188.5	30	1.48	0.74	1.00	1.0	1.15	1.2	9527	3624	46.0	44.5	33.1	51.2	38.0	45.1
SS-14	73.55	183.85	42	1.48	0.72	1.00	1.0	1.15	1.2	10062	3869	82.0	50.0	36.0	71.6	50.0	58.8
SS-15	80.15	177.25	50	1.48	0.69	1.00	1.0	1.15	1.1	10821	4216	17.0	50.0	34.4	85.3	50.0	54.3
SS-16	83.3	174.1	50	1.48	0.68	1.00	1.0	1.15	1.1	11183	4382	13.0	50.0	33.8	85.3	50.0	53.3
SS-17	88.35	169.05	18	1.48	0.66	1.00	1.0	1.15	1.1	11764	4647	20.0	26.7	17.5	30.7	20.1	22.8
SS-18	95.25	162.15	11	1.48	0.63	1.00	1.0	1.15	1.0	12557	5010	2.0	16.3	10.3	18.8	11.9	11.9
SS-19	101.45	155.95	50	1.48	0.61	1.00	1.0	1.15	1.0	13270	5336	4.0	50.0	30.6	85.3	50.0	50.0
SS-20	112.95	144.45	50	1.48	0.58	1.00	1.0	1.15	1.0	14593	5941	3.0	50.0	29.0	85.3	49.5	49.5
SS-21	122.75	134.65	50	1.48	0.56	1.00	1.0	1.15	1.2	15720	6457	75.0	50.0	27.8	85.3	47.5	55.9
SS-22	142.45	114.95	50	1.48	0.52	1.00	1.0	1.15	1.0	17985	7493	3.0	50.0	25.8	85.3	44.1	44.1
SS-23	152.25	105.15	50	1.48	0.50	1.00	1.0	1.15	1.0	19112	8008	6.0	50.0	25.0	85.3	42.6	43.9
SS-24	162.05	95.35	50	1.48	0.48	1.00	1.0	1.15	1.0	20239	8524	4.0	50.0	24.2	85.3	41.3	41.3
SS-25	171.45	85.95	50	1.48	0.47	1.00	1.0	1.15	1.0	21320	9018	5.0	50.0	23.5	85.3	40.2	41.2
SS-26	181.45	75.95	50	1.48	0.46	1.00	1.0	1.15	1.0	22470	9544	6.0	50.0	22.9	85.3	39.0	40.3
SS-27	191.2	66.2	50	1.48	0.45	1.00	1.0	1.15	1.0	23592	10057	6.0	50.0	22.3	85.3	38.0	39.2
SS-28	201.45	55.95	50	1.48	0.43	1.00	1.0	1.15	1.0	24770	10596	6.0	50.0	21.7	85.3	37.1	38.2
SS-29	220.7	36.7	50	1.48	0.42	1.00	1.0	1.15	1.2	26984	11609	39.0	50.0	20.8	85.3	35.4	42.1
SS-30	240.45	16.95	50	1.48	0.40	1.00	1.0	1.15	1.0	29255	12648	7.0	50.0	19.9	85.3	33.9	35.2
SS-31	260.15	-2.75	50	1.48	0.38	1.00	1.0	1.15	1.0	31521	13684	5.0	50.0	19.1	85.3	32.6	33.5
SS-32	280.15	-22.75	50	1.48	0.37	1.00	1.0	1.15	1.1	33821	14736	9.0	50.0	18.4	85.3	31.4	33.0
SS-33	299.85	-42.45	38	1.48	0.36	1.00	1.0	1.15	1.1	36086	15772	16.0	50.0	17.8	64.8	23.1	25.4
SS-34	319.55	-62.15	22	1.48	0.34	1.00	1.0	1.15	1.1	38352	16808	8.0	32.6	11.3	37.5	12.9	13.8
SS-35	339.25	-81.85	36	1.48	0.33	1.00	1.0	1.15	1.1	40617	17845	16.0	50.0	16.7	61.4	20.6	22.7
SS-36	358.95	-101.55	50	1.48	0.33	1.00	1.0	1.15	1.1	42883	18881	23.0	50.0	16.3	85.3	27.8	31.5
SS-37	377	-119.6	50	1.48	0.32	1.00	1.0	1.15	1.1	44959	19830	23.0	50.0	15.9	85.3	27.1	30.7
SS-38	396.9	-139.5	50	1.48	0.31	1.00	1.0	1.15	1.2	47247	20877	31.0	50.0	15.5	85.3	26.4	31.2
SS-39	401.75	-144.35	50	1.48	0.31	1.00	1.0	1.15	1.2	47805	21132	40.0	50.0	15.4	85.3	26.2	31.7

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1013	Design EQ:	FEE	M_w:	5.98
Latitude:	36.99574	Site Class:	D	R(km):	127
Longitude:	-89.14848	PGA:	0.086	MSF_{sand}:	1.49
Ground Elevation, ft msl:	257.4	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.08
Groundwater Above Surface, ft:	25.7	$\phi_{NSL\text{-}Sand}$	0.70		
Groundwater Elevation, ft msl:	283.1	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	$\sum S_{v\text{-}1D}$, in
SS-1	4.65	252.75	17.6	1.1	18.7	SSL	Sand-Like	1.54	0.9	Full Liquefaction	0.16	39.33	0.16	39.58	313.32	0.85	3.2	-	2.2
SS-2	9.55	247.85	4.9	5.1	10.0	SSL	Sand-Like	1.49	0.9	Full Liquefaction	0.10	49.71	0.07	33.65	83.22	2.32	2.3	2.20	2.2
SS-3	14.55	242.85	32.7	0.0	32.7	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-4	19.45	237.95	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-5	24.35	233.05	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-6	29.25	228.15	50.0	0.4	50.4	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-7	34.15	223.25	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-8	39.1	218.3	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-9	44.05	213.35	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-10	48.95	208.45	16.5	3.6	20.1	SSL	Sand-Like	0.36	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-11	58.75	198.65	27.4	3.3	30.7	NSL-S	Sand-Like	0.13	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-12	63.75	193.65	27.7	3.3	30.9	NSL-S	Sand-Like	0.12	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	68.15	189.25	38.2	5.5	43.7	PSL	NS Clay-Like	0.05	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	68.9	188.5	38.0	5.5	43.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	73.55	183.85	50.0	5.5	55.5	PSL	HS Clay-Like	0.05	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	80.15	177.25	50.0	3.9	53.9	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	83.3	174.1	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	88.35	169.05	20.1	4.5	24.6	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	95.25	162.15	11.9	0.0	11.9	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	101.45	155.95	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	112.95	144.45	49.5	0.0	49.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	122.75	134.65	47.5	5.5	53.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	142.45	114.95	44.1	0.0	44.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	152.25	105.15	42.6	0.0	42.7	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	162.05	95.35	41.3	0.0	41.3	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	171.45	85.95	40.2	0.0	40.2	NSL-S	Sand-Like	0.02	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	181.45	75.95	39.0	0.0	39.1	NSL-S	Sand-Like	0.04	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	191.2	66.2	38.0	0.0	38.1	NSL-S	Sand-Like	0.06	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	201.45	55.95	37.1	0.0	37.1	NSL-S	Sand-Like	0.09	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	220.7	36.7	35.4	5.5	40.9	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	240.45	16.95	33.9	0.1	34.1	NSL-S	Sand-Like	0.19	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	260.15	-2.75	32.6	0.0	32.6	NSL-S	Sand-Like	0.23	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	280.15	-22.75	31.4	0.7	32.1	NSL-S	Sand-Like	0.21	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	299.85	-42.45	23.1	3.6	26.7	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	319.55	-62.15	12.9	0.4	13.3	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	339.25	-81.85	20.6	3.6	24.1	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	358.95	-101.55	27.8	4.9	32.6	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-37	377	-119.6	27.1	4.9	32.0	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-38	396.9	-139.5	26.4	5.4	31.8	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-39	401.75	-144.35	26.2	5.5	31.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0

Boring 1014

Raw Data Input

Boring Number:	B-1014
Latitude:	36.99570
Longitude:	-89.14840
Ground Elevation, ft msl:	257.1
Groundwater Above Surface, ft:	39.1
Groundwater Elevation, ft msl:	296.2

Hammer Energy Ration (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.4	252.8	2	28	23	14	9	34.7	SC	I		Holocene	1	Clay-Like	-	220		
SS-2	14.0	243.2	9	1	NP	NP	NP	28.6	SP	I	NL	Holocene	1	Sand-Like	39	-		
SS-3	18.9	238.3	15	14	NP	NP	NP	19.0	SM	II	NL	Holocene	1	Sand-Like	43	-		
SS-4	23.8	233.3	40	16	NP	NP	NP	17.1	SM	II		Holocene	1	Sand-Like	48	-		
SS-5	25.5	231.7	31	16	NP	NP	NP	17.1	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	28.8	228.4	50	21	NP	NP	NP	8.5	GM	II		Holocene	1	Sand-Like	48	-		
SS-7	33.7	223.5	50	10	NP	NP	NP	17.0	SP-SM	II		Holocene	1	Sand-Like	48	-		
SS-8	38.6	218.6	50	12	NP	NP	NP	22.3	SP-SM	II		Holocene	1	Sand-Like	48	-		
SS-9	43.5	213.7	30	11	NP	NP	NP	16.6	SP-SM	II	NL	Holocene	1	Sand-Like	47	-		
SS-10	48.4	208.8	18	13	NP	NP	NP	23.2	SM	III		Holocene	1	Sand-Like	40	-		
SS-11	53.6	203.6	21	14	14	12	2	22.0	SM	III		Holocene	1	Sand-Like	42	-		
SS-12	58.3	198.9	31	28	15	12	3	22.2	SM	III		Holocene	1	Sand-Like	46	-		
SS-13	63.2	194.0	33	14	NP	NP	NP	21.8	SM	III		Eocene	1	Sand-Like	46	-		
SS-14	68.1	189.1	27	85	26	16	10	19.3	CL	III		Eocene	1	Clay-Like	-	3000		
SS-15	77.4	179.7	50	88	26	18	8	23.1	CL	III		Eocene	1	Clay-Like	-	3750		
SS-15	78.1	179.1	50	17	15	13	2	20.3	SM	III		Eocene	1	Sand-Like	48	-		
SS-16	82.9	174.3	50	15	14	12	2	21.0	SM	IV		Eocene	1	Sand-Like	48	-		
SS-17	87.8	169.4	50	13	NP	NP	NP	19.6	SM	IV		Eocene	1	Sand-Like	48	-		
SS-18	92.7	164.5	50	71	17	12	5	22.2	CL-ML	IV		Eocene	1	Sand-Like	48	-		
SS-19	97.6	159.6	50	5	NP	NP	NP	21.2	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-20	102.3	154.9	50	5	NP	NP	NP	21.8	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	113.0	144.2	50	7	NP	NP	NP	21.1	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-22	122.2	135.0	9	1	NP	NP	NP	23.4	SP	IV	NL	Eocene	1	Sand-Like	31	-		
SS-23	132.1	125.1	50	4	NP	NP	NP	20.5	SP	IV		Eocene	1	Sand-Like	47	-		
SS-24	141.7	115.4	50	4	NP	NP	NP	17.7	SW	IV		Eocene	1	Sand-Like	46	-		
SS-25	151.4	105.7	50	5	NP	NP	NP	22.7	SP-SM	IV		Eocene	1	Sand-Like	46	-		
SS-26	161.2	95.9	50	5	NP	NP	NP	24.4	SP-SM	IV		Eocene	1	Sand-Like	45	-		
SS-27	171.0	86.1	50	2	NP	NP	NP	22.8	SP	IV		Eocene	1	Sand-Like	45	-		
SS-28	180.9	76.2	50	18	NP	NP	NP	20.7	SM	IV		Eocene	1	Sand-Like	45	-		
SS-29	190.8	66.4	50	8	NP	NP	NP	20.6	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-30	200.6	56.5	50	23	NP	NP	NP	22.7	SM	IV		Eocene	1	Sand-Like	44	-		
SS-31	220.2	36.9	50	15	0	21	0	32.5	SM	IV	NL	Eocene	1	Sand-Like	43	-		
SS-32	239.7	17.4	50	4	NP	NP	NP	27.1	SP	IV		Eocene	1	Sand-Like	43	-		
SS-33	259.5	-2.3	50	4	NP	NP	NP	23.1	SP	IV		Eocene	1	Sand-Like	42	-		
SS-34	279.1	-22.0	50	4	NP	NP	NP	23.9	SP	IV	NL	Eocene	1	Sand-Like	42	-		
SS-35	299.4	-42.3	45	13	56	31	25	43.1	SM	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-36	304.3	-47.2	50	12	47	37	10	42.4	SM	V	NL	Eocene	1	Clay-Like	-	3750		

Standard Penetration Test Correction

Boring Number:	B-1014	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99570	CE:	1.48
Longitude:	-89.14840	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	257.1	CB:	1.15
Groundwater Above Surface, ft:	39.1	Liner Required:	N
Groundwater Elevation, ft msl:	296.2	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.35	252.75	2	1.48	1.70	0.75	1.0	1.15	1.4	2940	229	28.0	3.0	5.0	2.6	4.4	6.2
SS-2	13.95	243.15	9	1.48	1.65	0.91	1.0	1.15	1.0	4044	734	1.0	13.4	22.0	13.9	22.9	22.9
SS-3	18.85	238.25	15	1.48	1.42	0.94	1.0	1.15	1.1	4608	992	14.0	22.3	31.6	24.1	34.3	36.9
SS-4	23.8	233.3	40	1.48	1.26	0.97	1.0	1.15	1.1	5177	1252	16.0	50.0	63.2	66.0	50.0	54.0
SS-5	25.45	231.65	31	1.48	1.22	0.97	1.0	1.15	1.1	5367	1339	16.0	46.0	56.2	51.4	50.0	54.0
SS-6	28.75	228.35	50	1.48	1.15	0.98	1.0	1.15	1.1	5746	1512	21.0	50.0	57.5	83.6	50.0	55.3
SS-7	33.65	223.45	50	1.48	1.06	0.99	1.0	1.15	1.1	6310	1770	10.0	50.0	53.1	84.3	50.0	52.5
SS-8	38.55	218.55	50	1.48	0.99	0.99	1.0	1.15	1.1	6873	2028	12.0	50.0	49.7	84.7	50.0	53.0
SS-9	43.45	213.65	30	1.48	0.94	1.00	1.0	1.15	1.1	7437	2285	11.0	44.5	41.6	51.0	47.7	50.3
SS-10	48.35	208.75	18	1.48	0.89	1.00	1.0	1.15	1.1	8000	2543	13.0	26.7	23.7	30.6	27.2	29.2
SS-11	53.55	203.55	21	1.48	0.84	1.00	1.0	1.15	1.1	8598	2817	14.0	31.2	26.2	35.8	30.1	32.5
SS-12	58.25	198.85	31	1.48	0.81	1.00	1.0	1.15	1.1	9139	3064	28.0	46.0	37.2	52.8	42.7	48.9
SS-13	63.15	193.95	33	1.48	0.78	1.00	1.0	1.15	1.1	9702	3322	14.0	49.0	38.0	56.3	43.7	46.8
SS-14	68.05	189.05	27	1.48	0.75	1.00	1.0	1.15	1.2	10266	3579	85.0	40.1	29.9	46.0	34.4	41.0
SS-15	77.4	179.7	50	1.48	0.70	1.00	1.0	1.15	1.2	11341	4071	88.0	50.0	35.0	85.3	50.0	58.8
SS-15	78.05	179.05	50	1.48	0.70	1.00	1.0	1.15	1.1	11416	4105	17.0	50.0	34.9	85.3	50.0	54.3
SS-16	82.85	174.25	50	1.48	0.68	1.00	1.0	1.15	1.1	11968	4358	15.0	50.0	33.9	85.3	50.0	53.8
SS-17	87.75	169.35	50	1.48	0.66	1.00	1.0	1.15	1.1	12531	4616	13.0	50.0	32.9	85.3	50.0	53.3
SS-18	92.65	164.45	50	1.48	0.64	1.00	1.0	1.15	1.2	13095	4873	71.0	50.0	32.0	85.3	50.0	58.8
SS-19	97.55	159.55	50	1.48	0.62	1.00	1.0	1.15	1.0	13658	5131	5.0	50.0	31.2	85.3	50.0	51.3
SS-20	102.25	154.85	50	1.48	0.61	1.00	1.0	1.15	1.0	14199	5378	5.0	50.0	30.5	85.3	50.0	51.3
SS-21	112.95	144.15	50	1.48	0.58	1.00	1.0	1.15	1.0	15429	5941	7.0	50.0	29.0	85.3	49.5	51.2
SS-22	122.15	134.95	9	1.48	0.56	1.00	1.0	1.15	1.0	16487	6425	1.0	13.4	7.4	15.4	8.6	8.6
SS-23	132.05	125.05	50	1.48	0.54	1.00	1.0	1.15	1.0	17626	6946	4.0	50.0	26.8	85.3	45.8	45.8
SS-24	141.7	115.4	50	1.48	0.52	1.00	1.0	1.15	1.0	18735	7453	4.0	50.0	25.9	85.3	44.2	44.2
SS-25	151.4	105.7	50	1.48	0.50	1.00	1.0	1.15	1.0	19851	7964	5.0	50.0	25.1	85.3	42.7	43.8
SS-26	161.2	95.9	50	1.48	0.49	1.00	1.0	1.15	1.0	20978	8479	5.0	50.0	24.3	85.3	41.4	42.5
SS-27	171	86.1	50	1.48	0.47	1.00	1.0	1.15	1.0	22105	8995	2.0	50.0	23.6	85.3	40.2	40.2
SS-28	180.9	76.2	50	1.48	0.46	1.00	1.0	1.15	1.1	23243	9515	18.0	50.0	22.9	85.3	39.1	42.8
SS-29	190.75	66.35	50	1.48	0.45	1.00	1.0	1.15	1.0	24376	10033	8.0	50.0	22.3	85.3	38.1	39.7
SS-30	200.6	56.5	50	1.48	0.44	1.00	1.0	1.15	1.1	25509	10552	23.0	50.0	21.8	85.3	37.1	41.7
SS-31	220.2	36.9	50	1.48	0.42	1.00	1.0	1.15	1.1	27763	11583	15.0	50.0	20.8	85.3	35.4	38.3
SS-32	239.7	17.4	50	1.48	0.40	1.00	1.0	1.15	1.0	30005	12608	4.0	50.0	19.9	85.3	34.0	34.0
SS-33	259.45	-2.35	50	1.48	0.38	1.00	1.0	1.15	1.0	32277	13647	4.0	50.0	19.1	85.3	32.7	32.7
SS-34	279.1	-22	50	1.48	0.37	1.00	1.0	1.15	1.0	34536	14681	4.0	50.0	18.5	85.3	31.5	31.5
SS-35	299.35	-42.25	45	1.48	0.36	1.00	1.0	1.15	1.1	36865	15746	13.0	50.0	17.8	76.8	27.4	29.4
SS-36	304.25	-47.15	50	1.48	0.33	1.00	1.0	1.15	1.1	34989	18443	12.0	50.0	16.5	85.3	28.1	30.0

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1014	Design EQ:	FEE	M_w:	5.98
Latitude:	36.99570	Site Class:	D	R(km):	127
Longitude:	-89.14840	PGA:	0.086	MSF_{sand}:	1.49
Ground Elevation, ft msl:	257.1	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.08
Groundwater Above Surface, ft:	39.1	$\phi_{NSL\text{-}Sand}$	0.70		
Groundwater Elevation, ft msl:	296.2	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	$\sum S_{v\text{-}1D}$, in
SS-1	4.35	252.75	4.4	5.3	9.6	PSL	HS Clay-Like	0.42	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-2	13.95	243.15	22.9	0.0	22.9	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-3	18.85	238.25	34.3	2.9	37.2	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-4	23.8	233.3	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-5	25.45	231.65	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-6	28.75	228.35	50.0	4.6	54.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-7	33.65	223.45	50.0	1.1	51.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-8	38.55	218.55	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-9	43.45	213.65	47.7	1.6	49.3	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-10	48.35	208.75	27.2	2.5	29.7	SSL	Sand-Like	0.18	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-11	53.55	203.55	30.1	2.9	33.1	NSL-S	Sand-Like	0.10	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-12	58.25	198.85	42.7	5.3	48.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	63.15	193.95	43.7	2.9	46.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	68.05	189.05	34.4	5.5	39.9	PSL	NS Clay-Like	0.06	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	77.4	179.7	50.0	5.5	55.5	PSL	HS Clay-Like	0.05	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	78.05	179.05	50.0	3.9	53.9	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	82.85	174.25	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	87.75	169.35	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	92.65	164.45	50.0	5.5	55.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	97.55	159.55	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	102.25	154.85	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	112.95	144.15	49.5	0.1	49.6	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	122.15	134.95	8.6	0.0	8.6	SSL	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	132.05	125.05	45.8	0.0	45.8	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	141.7	115.4	44.2	0.0	44.2	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	151.4	105.7	42.7	0.0	42.7	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	161.2	95.9	41.4	0.0	41.4	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	171	86.1	40.2	0.0	40.2	NSL-S	Sand-Like	0.02	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	180.9	76.2	39.1	4.1	43.2	NSL-S	Sand-Like	0.01	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	190.75	66.35	38.1	0.4	38.4	NSL-S	Sand-Like	0.05	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	200.6	56.5	37.1	4.9	42.0	NSL-S	Sand-Like	0.02	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	220.2	36.9	35.4	3.3	38.7	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	239.7	17.4	34.0	0.0	34.0	NSL-S	Sand-Like	0.20	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	259.45	-2.35	32.7	0.0	32.7	NSL-S	Sand-Like	0.24	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	279.1	-22	31.5	0.0	31.5	NSL-S	Sand-Like	0.00	0.7	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	299.35	-42.25	27.4	2.5	29.9	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	304.25	-47.15	28.1	2.1	30.2	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	-	0.0		0.0

SPT-Based Liquefaction Analysis & Seismic Settlement: 1,000-YR Return Period

Boring Information

Liner Required:	N
Liner Used:	N

Earthquake Information

Design Earthquake:	SEE
PGA:	0.53
Site Class:	D
M_w:	6.99
R(km):	15

Min. GW Depth, ft:	--
Max Depth to Compute Liquefaction, ft:	60

Boring Number	Latitude (Deg)	Longitude (Deg)	Surface Elev. (ft)	Water Elev. (ft)	Alignment	Structure	Hammer Efficiency (%)	Borehole Diameter (in.)
B-1012	36.995798	-89.148573	258.5	285.2	US-51	Pier 6	89	4.75
B-1013	36.995739	-89.148484	257.4	283.1	US-51	Pier 6	89	4.75
B-1014	36.995695	-89.148404	257.1	296.2	US-51	Pier 6	89	4.75
C1015	36.995671	-89.14855	256.0	285.1	US-51	Pier 6	--	--
C1016	36.995806	-89.148411	258.8	284.3	US-51	Pier 6	--	--

Boring 1012

Raw Data Input

Boring Number:	B-1012
Latitude:	36.99580
Longitude:	-89.14857
Ground Elevation, ft msl:	258.5
Groundwater Above Surface, ft:	26.7
Groundwater Elevation, ft msl:	285.2

Hammer Energy Ration (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.1	254.5	1	1	NP	NP	NP	31.2	SW	I		Holocene	1	Sand-Like	26	-		
SS-2	9.0	249.6	10	77	37	21	16	38.2	CL	I		Holocene	1	Clay-Like	-	2230		
SS-3	13.9	244.7	6	23	NP	NP	NP	19.1	SM	I		Holocene	1	Sand-Like	35	-		
SS-4	18.9	239.7	39	26	NP	NP	NP	14.8	SM	II		Holocene	1	Sand-Like	48	-		
SS-5	23.8	234.7	31	19.5	NP	NP	NP	0.5	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	28.7	229.9	32	13	NP	NP	NP	16.2	SM	II		Holocene	1	Sand-Like	48	-		
SS-7	33.6	225.0	22	26	NP	NP	NP	13.9	GM	II		Holocene	1	Sand-Like	45	-		
SS-8	38.5	220.1	26	5	NP	NP	NP	19.4	SP-SM	II		Holocene	1	Sand-Like	46	-		
SS-9	43.5	215.1	50	13	NP	NP	NP	13.9	SM	II		Holocene	1	Sand-Like	48	-		
SS-10	48.4	210.2	23	22	NP	NP	NP	22.9	SM	III		Holocene	1	Sand-Like	43	-		
SS-11	53.3	205.3	15	15	NP	NP	NP	20.9	SM	III		Holocene	1	Sand-Like	38	-		
SS-12	58.2	200.4	20	13	NP	NP	NP	20.8	SM	III		Holocene	1	Sand-Like	41	-		
SS-13	63.1	195.5	12	14	18	13	5	20.0	SC-SM	III	NL	Holocene	1	Sand-Like	36	-		
SS-14	68.1	190.5	0	87	NP	NP	NP	25.3	ML	III	NL	Eocene	1	Sand-Like	21	-		
SS-15	73.0	185.6	35	11	NP	NP	NP	20.4	SP-SM	III		Eocene	1	Sand-Like	46	-		
SS-16	77.9	180.7	50	13	0	13	0	20.1	SM	III		Eocene	1	Sand-Like	48	-		
SS-17	82.8	175.8	50	13	NP	NP	NP	18.5	SM	III		Eocene	1	Sand-Like	48	-		
SS-18	87.7	170.9	19	12	NP	NP	NP	20.1	SM	IV	NL	Eocene	1	Sand-Like	38	-		
SS-19	92.7	165.9	16	11	NP	NP	NP	22.5	SP-SM	IV	NL	Eocene	1	Sand-Like	36	-		
SS-20	97.5	161.1	50	3	NP	NP	NP	20.4	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	102.4	156.2	50	4	NP	NP	NP	21.0	SP	IV		Eocene	1	Sand-Like	48	-		
SS-22	112.2	146.3	50	6	NP	NP	NP	19.7	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-23	122.2	136.4	50	2	NP	NP	NP	20.6	SP	IV		Eocene	1	Sand-Like	47	-		
SS-24	131.9	126.6	50	8	NP	NP	NP	17.5	SW-SM	IV		Eocene	1	Sand-Like	47	-		
SS-25	141.7	116.8	50	2	NP	NP	NP	19.3	SP	IV		Eocene	1	Sand-Like	46	-		
SS-26	150.9	107.7	50	3	NP	NP	NP	20.9	SW	IV		Eocene	1	Sand-Like	46	-		
SS-27	161.2	97.4	50	4	NP	NP	NP	19.5	SP	IV		Eocene	1	Sand-Like	45	-		
SS-28	170.8	87.7	50	3	NP	NP	NP	25.8	SP	IV		Eocene	1	Sand-Like	45	-		
SS-29	180.6	77.9	50	3	NP	NP	NP	24.7	SP	IV		Eocene	1	Sand-Like	45	-		
SS-30	190.5	68.0	50	2	NP	NP	NP	22.1	SP	IV		Eocene	1	Sand-Like	44	-		
SS-31	200.6	57.9	50	9	NP	NP	NP	22.7	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-32	220.1	38.4	50	8	NP	NP	NP	16.7	SP-SM	IV		Eocene	1	Sand-Like	43	-		
SS-33	239.9	18.6	50	2	NP	NP	NP	23.6	SP	IV		Eocene	1	Sand-Like	43	-		
SS-34	259.5	-1.0	50	3	NP	NP	NP	24.4	SP	IV		Eocene	1	Sand-Like	42	-		
SS-35	279.6	-21.1	50	92	32	16	16	18.5	CL	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-36	299.3	-40.8	44	14	60	44	16	42.2	SM	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-37	317.0	-58.5	49	9	101	38	63	47.0	SP-SC	V	NL	Eocene	1	Clay-Like	-	7500		

Standard Penetration Test Correction

Boring Number:	B-1012	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99580	CE:	1.48
Longitude:	-89.14857	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	258.5	CB:	1.15
Groundwater Above Surface, ft:	26.7	Liner Required:	N
Groundwater Elevation, ft msl:	285.2	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.05	254.45	1	1.48	1.70	0.75	1.0	1.15	1.0	2132	213	1.0	1.5	2.5	1.3	2.2	2.2
SS-2	8.95	249.55	10	1.48	1.70	0.84	1.0	1.15	1.2	2695	471	77.0	14.8	25.2	14.3	24.4	29.6
SS-3	13.85	244.65	6	1.48	1.66	0.90	1.0	1.15	1.2	3259	729	23.0	8.9	14.7	9.3	15.3	17.9
SS-4	18.85	239.65	39	1.48	1.42	0.94	1.0	1.15	1.1	3834	992	26.0	50.0	71.0	62.8	50.0	56.5
SS-5	23.8	234.7	31	1.48	1.26	0.97	1.0	1.15	1.1	4403	1252	19.5	46.0	58.1	51.1	50.0	54.9
SS-6	28.65	229.85	32	1.48	1.15	0.98	1.0	1.15	1.1	4961	1507	13.0	47.5	54.7	53.5	50.0	53.3
SS-7	33.55	224.95	22	1.48	1.06	0.99	1.0	1.15	1.1	5524	1765	26.0	32.6	34.7	37.1	39.5	44.9
SS-8	38.45	220.05	26	1.48	0.99	0.99	1.0	1.15	1.0	6088	2022	5.0	38.6	38.4	44.1	43.8	44.9
SS-9	43.45	215.05	50	1.48	0.94	1.00	1.0	1.15	1.1	6663	2285	13.0	50.0	46.8	85.0	50.0	53.3
SS-10	48.35	210.15	23	1.48	0.89	1.00	1.0	1.15	1.1	7226	2543	22.0	34.1	30.3	39.1	34.7	38.9
SS-11	53.25	205.25	15	1.48	0.85	1.00	1.0	1.15	1.1	7790	2801	15.0	22.3	18.8	25.6	21.6	23.6
SS-12	58.15	200.35	20	1.48	0.81	1.00	1.0	1.15	1.1	8353	3059	13.0	29.7	24.0	34.1	27.6	29.6
SS-13	63.05	195.45	12	1.48	0.78	1.00	1.0	1.15	1.1	8917	3316	14.0	17.8	13.8	20.5	15.9	17.5
SS-14	68.05	190.45	0	1.48	0.75	1.00	1.0	1.15	1.3	9492	3579	87.0	0.1	0.1	0.2	0.1	0.2
SS-15	72.95	185.55	35	1.48	0.72	1.00	1.0	1.15	1.1	10055	3837	11.0	50.0	36.1	59.7	43.1	45.5
SS-16	77.85	180.65	50	1.48	0.70	1.00	1.0	1.15	1.1	10619	4095	13.0	50.0	34.9	85.3	50.0	53.3
SS-17	82.75	175.75	50	1.48	0.68	1.00	1.0	1.15	1.1	11182	4353	13.0	50.0	33.9	85.3	50.0	53.3
SS-18	87.65	170.85	19	1.48	0.66	1.00	1.0	1.15	1.1	11746	4610	12.0	28.2	18.6	32.4	21.3	23.0
SS-19	92.65	165.85	16	1.48	0.64	1.00	1.0	1.15	1.1	12321	4873	11.0	23.7	15.2	27.3	17.5	18.8
SS-20	97.45	161.05	50	1.48	0.62	1.00	1.0	1.15	1.0	12873	5126	3.0	50.0	31.2	85.3	50.0	50.0
SS-21	102.35	156.15	50	1.48	0.61	1.00	1.0	1.15	1.0	13436	5384	4.0	50.0	30.5	85.3	50.0	50.0
SS-22	112.2	146.3	50	1.48	0.58	1.00	1.0	1.15	1.0	14569	5902	6.0	50.0	29.1	85.3	49.7	51.1
SS-23	122.15	136.35	50	1.48	0.56	1.00	1.0	1.15	1.0	15713	6425	2.0	50.0	27.9	85.3	47.6	47.6
SS-24	131.9	126.6	50	1.48	0.54	1.00	1.0	1.15	1.0	16835	6938	8.0	50.0	26.8	85.3	45.8	47.7
SS-25	141.7	116.8	50	1.48	0.52	1.00	1.0	1.15	1.0	17962	7453	2.0	50.0	25.9	85.3	44.2	44.2
SS-26	150.85	107.65	50	1.48	0.50	1.00	1.0	1.15	1.0	19014	7935	3.0	50.0	25.1	85.3	42.8	42.8
SS-27	161.15	97.35	50	1.48	0.49	1.00	1.0	1.15	1.0	20198	8476	4.0	50.0	24.3	85.3	41.4	41.4
SS-28	170.8	87.7	50	1.48	0.47	1.00	1.0	1.15	1.0	21308	8984	3.0	50.0	23.6	85.3	40.2	40.2
SS-29	180.6	77.9	50	1.48	0.46	1.00	1.0	1.15	1.0	22435	9500	3.0	50.0	22.9	85.3	39.1	39.1
SS-30	190.5	68	50	1.48	0.45	1.00	1.0	1.15	1.0	23574	10020	2.0	50.0	22.3	85.3	38.1	38.1
SS-31	200.6	57.9	50	1.48	0.44	1.00	1.0	1.15	1.0	24735	10552	9.0	50.0	21.8	85.3	37.1	38.9
SS-32	220.1	38.4	50	1.48	0.42	1.00	1.0	1.15	1.0	26978	11577	8.0	50.0	20.8	85.3	35.5	37.0
SS-33	239.9	18.6	50	1.48	0.40	1.00	1.0	1.15	1.0	29255	12619	2.0	50.0	19.9	85.3	34.0	34.0
SS-34	259.5	-1	50	1.48	0.38	1.00	1.0	1.15	1.0	31509	13650	3.0	50.0	19.1	85.3	32.6	32.6
SS-35	279.55	-21.05	50	1.48	0.37	1.00	1.0	1.15	1.2	33814	14704	92.0	50.0	18.4	85.3	31.5	37.6
SS-36	299.25	-40.75	44	1.48	0.36	1.00	1.0	1.15	1.1	36080	15741	14.0	50.0	17.8	75.1	26.8	29.0
SS-37	316.95	-58.45	49	1.48	0.35	1.00	1.0	1.15	1.1	38115	16672	9.0	50.0	17.3	83.6	29.0	30.4

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1012	Design EQ:	SEE	M_w:	6.99
Latitude:	36.99580	Site Class:	D	R(km):	15
Longitude:	-89.14857	PGA:	0.53	MSF_{sand}:	1.14
Ground Elevation, ft msl:	258.5	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.02
Groundwater Above Surface, ft:	26.7	$\phi_{NSL\text{-}Sand}$	0.75		
Groundwater Elevation, ft msl:	285.2	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	∑$S_{v\text{-}1D}$, in
SS-1	4.05	254.45	2.2	0.0	2.2	SSL	Sand-Like	38.43	0.9	Full Liquefaction	0.04	9.24	0.05	9.87	43.11	2.03	3.2	-	2.5
SS-2	8.95	249.55	24.4	5.5	29.9	PSL	HS Clay-Like	0.50	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	1.2	-	2.5
SS-3	13.85	244.65	15.3	4.9	20.2	SSL	Sand-Like	5.62	0.9	Full Liquefaction	0.18	129.32	0.14	105.62	285.89	0.76	1.2	1.34	2.5
SS-4	18.85	239.65	50.0	5.1	55.1	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-5	23.8	234.7	50.0	4.4	54.4	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-6	28.65	229.85	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-7	33.55	224.95	39.5	5.1	44.6	NSL-S	Sand-Like	0.03	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-8	38.45	220.05	43.8	0.0	43.8	NSL-S	Sand-Like	0.04	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-9	43.45	215.05	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-10	48.35	210.15	34.7	4.8	39.5	NSL-S	Sand-Like	0.20	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	1.1
SS-11	53.25	205.25	21.6	3.3	24.9	SSL	Sand-Like	2.30	0.9	Full Liquefaction	0.25	709.09	0.19	537.64	893.03	0.44	0.4	1.12	1.1
SS-12	58.15	200.35	27.6	2.5	30.1	NSL-S	Sand-Like	1.32	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	63.05	195.45	15.9	2.9	18.8	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	68.05	190.45	0.1	5.5	5.6	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	72.95	185.55	43.1	1.6	44.7	NSL-S	Sand-Like	0.02	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	77.85	180.65	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	82.75	175.75	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	87.65	170.85	21.3	2.1	23.4	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	92.65	165.85	17.5	1.6	19.1	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	97.45	161.05	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	102.35	156.15	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	112.2	146.3	49.7	0.0	49.7	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	122.15	136.35	47.6	0.0	47.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	131.9	126.6	45.8	0.4	46.2	NSL-S	Sand-Like	0.01	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	141.7	116.8	44.2	0.0	44.2	NSL-S	Sand-Like	0.03	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	150.85	107.65	42.8	0.0	42.8	NSL-S	Sand-Like	0.06	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	161.15	97.35	41.4	0.0	41.4	NSL-S	Sand-Like	0.12	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	170.8	87.7	40.2	0.0	40.2	NSL-S	Sand-Like	0.20	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	180.6	77.9	39.1	0.0	39.1	NSL-S	Sand-Like	0.31	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	190.5	68	38.1	0.0	38.1	NSL-S	Sand-Like	0.47	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	200.6	57.9	37.1	0.7	37.9	NSL-S	Sand-Like	0.56	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	220.1	38.4	35.5	0.4	35.8	NSL-S	Sand-Like	1.03	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	239.9	18.6	34.0	0.0	34.0	NSL-S	Sand-Like	1.59	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	259.5	-1	32.6	0.0	32.6	NSL-S	Sand-Like	1.96	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	279.55	-21.05	31.5	5.5	37.0	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	299.25	-40.75	26.8	2.9	29.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-37	316.95	-58.45	29.0	0.7	29.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0

Boring 1013

Raw Data Input

Boring Number:	B-1013
Latitude:	36.99574
Longitude:	-89.14848
Ground Elevation, ft msl:	257.4
Groundwater Above Surface, ft:	25.7
Groundwater Elevation, ft msl:	283.1

Hammer Energy Ration (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.7	252.8	8	10	NP	NP	NP	27.7	SW-SM	I		Holocene	1	Sand-Like	36	-		
SS-2	9.6	247.9	2	25	NP	NP	NP	18.6	SM	I		Holocene	1	Sand-Like	29	-		
SS-3	14.6	242.9	13	2	NP	NP	NP	16.7	SP	I	NL	Holocene	1	Sand-Like	42	-		
SS-4	19.5	238.0	35	12	NP	NP	NP	14.7	GP-GM	II		Holocene	1	Sand-Like	48	-		
SS-5	24.4	233.1	32	12	NP	NP	NP	16.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	29.3	228.2	44	8	NP	NP	NP	13.2	SW-SM	II		Holocene	1	Sand-Like	48	-		
SS-7	34.2	223.3	47	15	NP	NP	NP	15.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-8	39.1	218.3	50	15	NP	NP	NP	15.0	SM	II		Holocene	1	Sand-Like	48	-		
SS-9	44.1	213.4	50	16	NP	NP	NP	14.5	SM	II		Holocene	1	Sand-Like	48	-		
SS-10	49.0	208.5	11	16	NP	NP	NP	21.4	SM	III		Holocene	1	Sand-Like	36	-		
SS-11	58.8	198.7	20	15	NP	NP	NP	20.4	SM	III		Holocene	1	Sand-Like	41	-		
SS-12	63.8	193.7	21	15	16	14	2	22.1	SM	III		Holocene	1	Sand-Like	41	-		
SS-13	68.2	189.3	30	90	34	20	14	26.6	CL	III		Eocene	1	Clay-Like	-	6680		
SS-13	68.9	188.5	30	46	15	13	2	26.4	SM	III		Eocene	1	Sand-Like	44	-		
SS-14	73.6	183.9	42	82	23	14	9	22.2	CL	III		Eocene	1	Clay-Like	-	3750		
SS-15	80.2	177.3	50	17	NP	NP	NP	19.4	SM	III		Eocene	1	Sand-Like	48	-		
SS-16	83.3	174.1	50	13	NP	NP	NP	19.6	SM	IV		Eocene	1	Sand-Like	48	-		
SS-17	88.4	169.1	18	20	NP	NP	NP	21.8	SM	IV	NL	Eocene	1	Sand-Like	38	-		
SS-18	95.3	162.2	11	2	NP	NP	NP	20.4	SP	IV	NL	Eocene	1	Sand-Like	34	-		
SS-19	101.5	156.0	50	4	NP	NP	NP	18.5	SP	IV		Eocene	1	Sand-Like	48	-		
SS-20	113.0	144.5	50	3	NP	NP	NP	17.5	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	122.8	134.7	50	75	NP	NP	NP	19.0	ML	IV		Eocene	1	Sand-Like	47	-		
SS-22	142.5	115.0	50	3	NP	NP	NP	19.5	SW	IV		Eocene	1	Sand-Like	46	-		
SS-23	152.3	105.2	50	6	NP	NP	NP	17.0	SW-SM	IV		Eocene	1	Sand-Like	46	-		
SS-24	162.1	95.4	50	4	NP	NP	NP	20.6	SP	IV		Eocene	1	Sand-Like	45	-		
SS-25	171.5	86.0	50	5	NP	NP	NP	25.1	SP-SM	IV		Eocene	1	Sand-Like	45	-		
SS-26	181.5	76.0	50	6	NP	NP	NP	19.2	SW-SM	IV		Eocene	1	Sand-Like	45	-		
SS-27	191.2	66.2	50	6	NP	NP	NP	22.1	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-28	201.5	56.0	50	6	NP	NP	NP	24.0	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-29	220.7	36.7	50	39	14	14	0	25.6	SM	IV	NL	Eocene	1	Sand-Like	43	-		
SS-30	240.5	17.0	50	7	NP	NP	NP	25.0	SP-SM	IV		Eocene	1	Sand-Like	43	-		
SS-31	260.2	-2.8	50	5	NP	NP	NP	22.3	SP	IV		Eocene	1	Sand-Like	42	-		
SS-32	280.2	-22.8	50	9	NP	NP	NP	20.1	SP-SM	IV		Eocene	1	Sand-Like	42	-		
SS-33	299.9	-42.5	38	16	44	34	10	39.7	SM	IV	NL	Eocene	1	Clay-Like	-	3750		
SS-34	319.6	-62.2	22	8	58	43	15	43.6	SW-SM	V	NL	Eocene	1	Clay-Like	-	4900		
SS-35	339.3	-81.9	36	16	62	44	18	45.2	SM	V	NL	Eocene	1	Clay-Like	-	7500		
SS-36	359.0	-101.6	50	23	89	58	31	60.4	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-37	377.0	-119.6	50	23	86	59	27	54.8	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-38	396.9	-139.5	50	31	84	57	27	52.6	SM	VI	NL	Eocene	1	Clay-Like	-	7500		
SS-39	401.8	-144.4	50	40	76	53	23	48.2	SM	VI	NL	Eocene	1	Clay-Like	-	7500		

Standard Penetration Test Correction

Boring Number:	B-1013	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99574	CE:	1.48
Longitude:	-89.14848	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	257.4	CB:	1.15
Groundwater Above Surface, ft:	25.7	Liner Required:	N
Groundwater Elevation, ft msl:	283.1	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.65	252.75	8	1.48	1.70	0.76	1.0	1.15	1.1	2138	245	10.0	11.9	20.2	10.3	17.6	18.8
SS-2	9.55	247.85	2	1.48	1.70	0.85	1.0	1.15	1.4	2702	502	25.0	3.0	5.0	2.9	4.9	6.7
SS-3	14.55	242.85	13	1.48	1.62	0.91	1.0	1.15	1.0	3277	765	2.0	19.3	31.2	20.2	32.7	32.7
SS-4	19.45	237.95	35	1.48	1.40	0.95	1.0	1.15	1.1	3840	1023	12.0	50.0	69.9	56.5	50.0	53.0
SS-5	24.35	233.05	32	1.48	1.25	0.97	1.0	1.15	1.1	4404	1281	12.0	47.5	59.3	52.9	50.0	53.0
SS-6	29.25	228.15	44	1.48	1.14	0.98	1.0	1.15	1.0	4967	1539	8.0	50.0	57.0	73.7	50.0	52.0
SS-7	34.15	223.25	47	1.48	1.06	0.99	1.0	1.15	1.1	5531	1796	15.0	50.0	52.8	79.3	50.0	53.8
SS-8	39.1	218.3	50	1.48	0.99	0.99	1.0	1.15	1.1	6100	2057	15.0	50.0	49.3	84.8	50.0	53.8
SS-9	44.05	213.35	50	1.48	0.93	1.00	1.0	1.15	1.1	6669	2317	16.0	50.0	46.5	85.0	50.0	54.0
SS-10	48.95	208.45	11	1.48	0.88	1.00	1.0	1.15	1.1	7233	2575	16.0	16.3	14.4	18.7	16.5	18.4
SS-11	58.75	198.65	20	1.48	0.80	1.00	1.0	1.15	1.1	8360	3090	15.0	29.7	23.9	34.1	27.4	29.8
SS-12	63.75	193.65	21	1.48	0.77	1.00	1.0	1.15	1.1	8935	3353	15.0	31.2	24.1	35.8	27.7	30.1
SS-13	68.15	189.25	30	1.48	0.75	1.00	1.0	1.15	1.2	9441	3585	90.0	44.5	33.2	51.2	38.2	45.3
SS-13	68.9	188.5	30	1.48	0.74	1.00	1.0	1.15	1.2	9527	3624	46.0	44.5	33.1	51.2	38.0	45.1
SS-14	73.55	183.85	42	1.48	0.72	1.00	1.0	1.15	1.2	10062	3869	82.0	50.0	36.0	71.6	50.0	58.8
SS-15	80.15	177.25	50	1.48	0.69	1.00	1.0	1.15	1.1	10821	4216	17.0	50.0	34.4	85.3	50.0	54.3
SS-16	83.3	174.1	50	1.48	0.68	1.00	1.0	1.15	1.1	11183	4382	13.0	50.0	33.8	85.3	50.0	53.3
SS-17	88.35	169.05	18	1.48	0.66	1.00	1.0	1.15	1.1	11764	4647	20.0	26.7	17.5	30.7	20.1	22.8
SS-18	95.25	162.15	11	1.48	0.63	1.00	1.0	1.15	1.0	12557	5010	2.0	16.3	10.3	18.8	11.9	11.9
SS-19	101.45	155.95	50	1.48	0.61	1.00	1.0	1.15	1.0	13270	5336	4.0	50.0	30.6	85.3	50.0	50.0
SS-20	112.95	144.45	50	1.48	0.58	1.00	1.0	1.15	1.0	14593	5941	3.0	50.0	29.0	85.3	49.5	49.5
SS-21	122.75	134.65	50	1.48	0.56	1.00	1.0	1.15	1.2	15720	6457	75.0	50.0	27.8	85.3	47.5	55.9
SS-22	142.45	114.95	50	1.48	0.52	1.00	1.0	1.15	1.0	17985	7493	3.0	50.0	25.8	85.3	44.1	44.1
SS-23	152.25	105.15	50	1.48	0.50	1.00	1.0	1.15	1.0	19112	8008	6.0	50.0	25.0	85.3	42.6	43.9
SS-24	162.05	95.35	50	1.48	0.48	1.00	1.0	1.15	1.0	20239	8524	4.0	50.0	24.2	85.3	41.3	41.3
SS-25	171.45	85.95	50	1.48	0.47	1.00	1.0	1.15	1.0	21320	9018	5.0	50.0	23.5	85.3	40.2	41.2
SS-26	181.45	75.95	50	1.48	0.46	1.00	1.0	1.15	1.0	22470	9544	6.0	50.0	22.9	85.3	39.0	40.3
SS-27	191.2	66.2	50	1.48	0.45	1.00	1.0	1.15	1.0	23592	10057	6.0	50.0	22.3	85.3	38.0	39.2
SS-28	201.45	55.95	50	1.48	0.43	1.00	1.0	1.15	1.0	24770	10596	6.0	50.0	21.7	85.3	37.1	38.2
SS-29	220.7	36.7	50	1.48	0.42	1.00	1.0	1.15	1.2	26984	11609	39.0	50.0	20.8	85.3	35.4	42.1
SS-30	240.45	16.95	50	1.48	0.40	1.00	1.0	1.15	1.0	29255	12648	7.0	50.0	19.9	85.3	33.9	35.2
SS-31	260.15	-2.75	50	1.48	0.38	1.00	1.0	1.15	1.0	31521	13684	5.0	50.0	19.1	85.3	32.6	33.5
SS-32	280.15	-22.75	50	1.48	0.37	1.00	1.0	1.15	1.1	33821	14736	9.0	50.0	18.4	85.3	31.4	33.0
SS-33	299.85	-42.45	38	1.48	0.36	1.00	1.0	1.15	1.1	36086	15772	16.0	50.0	17.8	64.8	23.1	25.4
SS-34	319.55	-62.15	22	1.48	0.34	1.00	1.0	1.15	1.1	38352	16808	8.0	32.6	11.3	37.5	12.9	13.8
SS-35	339.25	-81.85	36	1.48	0.33	1.00	1.0	1.15	1.1	40617	17845	16.0	50.0	16.7	61.4	20.6	22.7
SS-36	358.95	-101.55	50	1.48	0.33	1.00	1.0	1.15	1.1	42883	18881	23.0	50.0	16.3	85.3	27.8	31.5
SS-37	377	-119.6	50	1.48	0.32	1.00	1.0	1.15	1.1	44959	19830	23.0	50.0	15.9	85.3	27.1	30.7
SS-38	396.9	-139.5	50	1.48	0.31	1.00	1.0	1.15	1.2	47247	20877	31.0	50.0	15.5	85.3	26.4	31.2
SS-39	401.75	-144.35	50	1.48	0.31	1.00	1.0	1.15	1.2	47805	21132	40.0	50.0	15.4	85.3	26.2	31.7

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1013	Design EQ:	SEE	M_w:	6.99
Latitude:	36.99574	Site Class:	D	R(km):	15
Longitude:	-89.14848	PGA:	0.53	MSF_{sand}:	1.14
Ground Elevation, ft msl:	257.4	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.02
Groundwater Above Surface, ft:	25.7	$\phi_{NSL\text{-}Sand}$	0.75		
Groundwater Elevation, ft msl:	283.1	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	$\sum S_{v\text{-}1D}$, in
SS-1	4.65	252.75	17.6	1.1	18.7	SSL	Sand-Like	12.43	0.9	Full Liquefaction	0.16	39.33	0.16	39.58	313.32	0.85	4.1	-	3.5
SS-2	9.55	247.85	4.9	5.1	10.0	SSL	Sand-Like	12.16	0.9	Full Liquefaction	0.10	49.71	0.07	33.65	83.22	2.32	3.3	2.20	3.5
SS-3	14.55	242.85	32.7	0.0	32.7	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-4	19.45	237.95	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-5	24.35	233.05	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-6	29.25	228.15	50.0	0.4	50.4	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-7	34.15	223.25	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-8	39.1	218.3	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-9	44.05	213.35	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	1.0	-	1.4
SS-10	48.95	208.45	16.5	3.6	20.1	SSL	Sand-Like	3.25	0.9	Full Liquefaction	0.18	452.84	0.15	395.92	526.56	0.77	1.0	1.35	1.4
SS-11	58.75	198.65	27.4	3.3	30.7	NSL-S	Sand-Like	1.20	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.2	-	0.0
SS-12	63.75	193.65	27.7	3.3	30.9	NSL-S	Sand-Like	1.12	0.9	Full Liquefaction	0.49	1632.97	0.24	796.08	1750.97	0.20	0.2	-	0.0
SS-13	68.15	189.25	38.2	5.5	43.7	PSL	NS Clay-Like	0.40	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	68.9	188.5	38.0	5.5	43.5	NSL-S	Sand-Like	0.04	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	73.55	183.85	50.0	5.5	55.5	PSL	HS Clay-Like	0.37	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	80.15	177.25	50.0	3.9	53.9	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	83.3	174.1	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	88.35	169.05	20.1	4.5	24.6	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	95.25	162.15	11.9	0.0	11.9	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	101.45	155.95	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	112.95	144.45	49.5	0.0	49.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	122.75	134.65	47.5	5.5	53.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	142.45	114.95	44.1	0.0	44.1	NSL-S	Sand-Like	0.03	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	152.25	105.15	42.6	0.0	42.7	NSL-S	Sand-Like	0.07	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	162.05	95.35	41.3	0.0	41.3	NSL-S	Sand-Like	0.12	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	171.45	85.95	40.2	0.0	40.2	NSL-S	Sand-Like	0.20	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	181.45	75.95	39.0	0.0	39.1	NSL-S	Sand-Like	0.32	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	191.2	66.2	38.0	0.0	38.1	NSL-S	Sand-Like	0.48	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	201.45	55.95	37.1	0.0	37.1	NSL-S	Sand-Like	0.69	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	220.7	36.7	35.4	5.5	40.9	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	240.45	16.95	33.9	0.1	34.1	NSL-S	Sand-Like	1.56	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	260.15	-2.75	32.6	0.0	32.6	NSL-S	Sand-Like	1.96	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	280.15	-22.75	31.4	0.7	32.1	NSL-S	Sand-Like	1.89	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	299.85	-42.45	23.1	3.6	26.7	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	319.55	-62.15	12.9	0.4	13.3	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	339.25	-81.85	20.6	3.6	24.1	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	358.95	-101.55	27.8	4.9	32.6	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-37	377	-119.6	27.1	4.9	32.0	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-38	396.9	-139.5	26.4	5.4	31.8	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-39	401.75	-144.35	26.2	5.5	31.7	PSL	NS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0

Boring 1014

Raw Data Input

Boring Number:	B-1014
Latitude:	36.99570
Longitude:	-89.14840
Ground Elevation, ft msl:	257.1
Groundwater Above Surface, ft:	39.1
Groundwater Elevation, ft msl:	296.2

Hammer Energy Ratio (ER), %:	89
C_E:	1.48
Bore Hole Diameter, in.:	4.75
C_B:	1.15
Liner Required:	N
Liner Used:	N
C_S:	1.00

Strength Loss
Limited Liquefcation
Full Liquefaction

															Calculated Strengths		Strength Override	
SPT Sample	Depth, ft	Elev., ft	N_{meas}, bpf	FC, %	LL	PL	PI	w, %	USCS Soil Type	Soil Layer	Flag: "NL" Non-Liq or Unreliable	General Geology	K_{DR}	SSL Soil Type	φ', deg	c, psf	φ', deg	c, psf
SS-1	4.4	252.8	2	28	23	14	9	34.7	SC	I		Holocene	1	Clay-Like	-	220		
SS-2	14.0	243.2	9	1	NP	NP	NP	28.6	SP	I	NL	Holocene	1	Sand-Like	39	-		
SS-3	18.9	238.3	15	14	NP	NP	NP	19.0	SM	II	NL	Holocene	1	Sand-Like	43	-		
SS-4	23.8	233.3	40	16	NP	NP	NP	17.1	SM	II		Holocene	1	Sand-Like	48	-		
SS-5	25.5	231.7	31	16	NP	NP	NP	17.1	SM	II		Holocene	1	Sand-Like	48	-		
SS-6	28.8	228.4	50	21	NP	NP	NP	8.5	GM	II		Holocene	1	Sand-Like	48	-		
SS-7	33.7	223.5	50	10	NP	NP	NP	17.0	SP-SM	II		Holocene	1	Sand-Like	48	-		
SS-8	38.6	218.6	50	12	NP	NP	NP	22.3	SP-SM	II		Holocene	1	Sand-Like	48	-		
SS-9	43.5	213.7	30	11	NP	NP	NP	16.6	SP-SM	II	NL	Holocene	1	Sand-Like	47	-		
SS-10	48.4	208.8	18	13	NP	NP	NP	23.2	SM	III		Holocene	1	Sand-Like	40	-		
SS-11	53.6	203.6	21	14	14	12	2	22.0	SM	III		Holocene	1	Sand-Like	42	-		
SS-12	58.3	198.9	31	28	15	12	3	22.2	SM	III		Holocene	1	Sand-Like	46	-		
SS-13	63.2	194.0	33	14	NP	NP	NP	21.8	SM	III		Eocene	1	Sand-Like	46	-		
SS-14	68.1	189.1	27	85	26	16	10	19.3	CL	III		Eocene	1	Clay-Like	-	3000		
SS-15	77.4	179.7	50	88	26	18	8	23.1	CL	III		Eocene	1	Clay-Like	-	3750		
SS-15	78.1	179.1	50	17	15	13	2	20.3	SM	III		Eocene	1	Sand-Like	48	-		
SS-16	82.9	174.3	50	15	14	12	2	21.0	SM	IV		Eocene	1	Sand-Like	48	-		
SS-17	87.8	169.4	50	13	NP	NP	NP	19.6	SM	IV		Eocene	1	Sand-Like	48	-		
SS-18	92.7	164.5	50	71	17	12	5	22.2	CL-ML	IV		Eocene	1	Sand-Like	48	-		
SS-19	97.6	159.6	50	5	NP	NP	NP	21.2	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-20	102.3	154.9	50	5	NP	NP	NP	21.8	SP	IV		Eocene	1	Sand-Like	48	-		
SS-21	113.0	144.2	50	7	NP	NP	NP	21.1	SP-SM	IV		Eocene	1	Sand-Like	48	-		
SS-22	122.2	135.0	9	1	NP	NP	NP	23.4	SP	IV	NL	Eocene	1	Sand-Like	31	-		
SS-23	132.1	125.1	50	4	NP	NP	NP	20.5	SP	IV		Eocene	1	Sand-Like	47	-		
SS-24	141.7	115.4	50	4	NP	NP	NP	17.7	SW	IV		Eocene	1	Sand-Like	46	-		
SS-25	151.4	105.7	50	5	NP	NP	NP	22.7	SP-SM	IV		Eocene	1	Sand-Like	46	-		
SS-26	161.2	95.9	50	5	NP	NP	NP	24.4	SP-SM	IV		Eocene	1	Sand-Like	45	-		
SS-27	171.0	86.1	50	2	NP	NP	NP	22.8	SP	IV		Eocene	1	Sand-Like	45	-		
SS-28	180.9	76.2	50	18	NP	NP	NP	20.7	SM	IV		Eocene	1	Sand-Like	45	-		
SS-29	190.8	66.4	50	8	NP	NP	NP	20.6	SP-SM	IV		Eocene	1	Sand-Like	44	-		
SS-30	200.6	56.5	50	23	NP	NP	NP	22.7	SM	IV		Eocene	1	Sand-Like	44	-		
SS-31	220.2	36.9	50	15	0	21	0	32.5	SM	IV	NL	Eocene	1	Sand-Like	43	-		
SS-32	239.7	17.4	50	4	NP	NP	NP	27.1	SP	IV		Eocene	1	Sand-Like	43	-		
SS-33	259.5	-2.3	50	4	NP	NP	NP	23.1	SP	IV		Eocene	1	Sand-Like	42	-		
SS-34	279.1	-22.0	50	4	NP	NP	NP	23.9	SP	IV	NL	Eocene	1	Sand-Like	42	-		
SS-35	299.4	-42.3	45	13	56	31	25	43.1	SM	IV	NL	Eocene	1	Clay-Like	-	7500		
SS-36	304.3	-47.2	50	12	47	37	10	42.4	SM	V	NL	Eocene	1	Clay-Like	-	3750		

Standard Penetration Test Correction

Boring Number:	B-1014	Hammer Energy Ratio (ER), %:	89
Latitude:	36.99570	CE:	1.48
Longitude:	-89.14840	Bore Hole Diameter, in.:	4.75
Ground Elevation, ft msl:	257.1	CB:	1.15
Groundwater Above Surface, ft:	39.1	Liner Required:	N
Groundwater Elevation, ft msl:	296.2	Liner Used:	N
		CS:	1.00

SPT Sample	Depth, ft	Elev, ft msl	N_{meas}, bpf	C_E	C_N	C_R	C_S	C_B	C_F	σ, psf	$\bar{\sigma}$, psf	FC, %	N_{60}	$N_{1,60}$	N^*_{60}	$N^*_{1,60}$	$N^*_{1,60,cs}$
SS-1	4.35	252.75	2	1.48	1.70	0.75	1.0	1.15	1.4	2940	229	28.0	3.0	5.0	2.6	4.4	6.2
SS-2	13.95	243.15	9	1.48	1.65	0.91	1.0	1.15	1.0	4044	734	1.0	13.4	22.0	13.9	22.9	22.9
SS-3	18.85	238.25	15	1.48	1.42	0.94	1.0	1.15	1.1	4608	992	14.0	22.3	31.6	24.1	34.3	36.9
SS-4	23.8	233.3	40	1.48	1.26	0.97	1.0	1.15	1.1	5177	1252	16.0	50.0	63.2	66.0	50.0	54.0
SS-5	25.45	231.65	31	1.48	1.22	0.97	1.0	1.15	1.1	5367	1339	16.0	46.0	56.2	51.4	50.0	54.0
SS-6	28.75	228.35	50	1.48	1.15	0.98	1.0	1.15	1.1	5746	1512	21.0	50.0	57.5	83.6	50.0	55.3
SS-7	33.65	223.45	50	1.48	1.06	0.99	1.0	1.15	1.1	6310	1770	10.0	50.0	53.1	84.3	50.0	52.5
SS-8	38.55	218.55	50	1.48	0.99	0.99	1.0	1.15	1.1	6873	2028	12.0	50.0	49.7	84.7	50.0	53.0
SS-9	43.45	213.65	30	1.48	0.94	1.00	1.0	1.15	1.1	7437	2285	11.0	44.5	41.6	51.0	47.7	50.3
SS-10	48.35	208.75	18	1.48	0.89	1.00	1.0	1.15	1.1	8000	2543	13.0	26.7	23.7	30.6	27.2	29.2
SS-11	53.55	203.55	21	1.48	0.84	1.00	1.0	1.15	1.1	8598	2817	14.0	31.2	26.2	35.8	30.1	32.5
SS-12	58.25	198.85	31	1.48	0.81	1.00	1.0	1.15	1.1	9139	3064	28.0	46.0	37.2	52.8	42.7	48.9
SS-13	63.15	193.95	33	1.48	0.78	1.00	1.0	1.15	1.1	9702	3322	14.0	49.0	38.0	56.3	43.7	46.8
SS-14	68.05	189.05	27	1.48	0.75	1.00	1.0	1.15	1.2	10266	3579	85.0	40.1	29.9	46.0	34.4	41.0
SS-15	77.4	179.7	50	1.48	0.70	1.00	1.0	1.15	1.2	11341	4071	88.0	50.0	35.0	85.3	50.0	58.8
SS-15	78.05	179.05	50	1.48	0.70	1.00	1.0	1.15	1.1	11416	4105	17.0	50.0	34.9	85.3	50.0	54.3
SS-16	82.85	174.25	50	1.48	0.68	1.00	1.0	1.15	1.1	11968	4358	15.0	50.0	33.9	85.3	50.0	53.8
SS-17	87.75	169.35	50	1.48	0.66	1.00	1.0	1.15	1.1	12531	4616	13.0	50.0	32.9	85.3	50.0	53.3
SS-18	92.65	164.45	50	1.48	0.64	1.00	1.0	1.15	1.2	13095	4873	71.0	50.0	32.0	85.3	50.0	58.8
SS-19	97.55	159.55	50	1.48	0.62	1.00	1.0	1.15	1.0	13658	5131	5.0	50.0	31.2	85.3	50.0	51.3
SS-20	102.25	154.85	50	1.48	0.61	1.00	1.0	1.15	1.0	14199	5378	5.0	50.0	30.5	85.3	50.0	51.3
SS-21	112.95	144.15	50	1.48	0.58	1.00	1.0	1.15	1.0	15429	5941	7.0	50.0	29.0	85.3	49.5	51.2
SS-22	122.15	134.95	9	1.48	0.56	1.00	1.0	1.15	1.0	16487	6425	1.0	13.4	7.4	15.4	8.6	8.6
SS-23	132.05	125.05	50	1.48	0.54	1.00	1.0	1.15	1.0	17626	6946	4.0	50.0	26.8	85.3	45.8	45.8
SS-24	141.7	115.4	50	1.48	0.52	1.00	1.0	1.15	1.0	18735	7453	4.0	50.0	25.9	85.3	44.2	44.2
SS-25	151.4	105.7	50	1.48	0.50	1.00	1.0	1.15	1.0	19851	7964	5.0	50.0	25.1	85.3	42.7	43.8
SS-26	161.2	95.9	50	1.48	0.49	1.00	1.0	1.15	1.0	20978	8479	5.0	50.0	24.3	85.3	41.4	42.5
SS-27	171	86.1	50	1.48	0.47	1.00	1.0	1.15	1.0	22105	8995	2.0	50.0	23.6	85.3	40.2	40.2
SS-28	180.9	76.2	50	1.48	0.46	1.00	1.0	1.15	1.1	23243	9515	18.0	50.0	22.9	85.3	39.1	42.8
SS-29	190.75	66.35	50	1.48	0.45	1.00	1.0	1.15	1.0	24376	10033	8.0	50.0	22.3	85.3	38.1	39.7
SS-30	200.6	56.5	50	1.48	0.44	1.00	1.0	1.15	1.1	25509	10552	23.0	50.0	21.8	85.3	37.1	41.7
SS-31	220.2	36.9	50	1.48	0.42	1.00	1.0	1.15	1.1	27763	11583	15.0	50.0	20.8	85.3	35.4	38.3
SS-32	239.7	17.4	50	1.48	0.40	1.00	1.0	1.15	1.0	30005	12608	4.0	50.0	19.9	85.3	34.0	34.0
SS-33	259.45	-2.35	50	1.48	0.38	1.00	1.0	1.15	1.0	32277	13647	4.0	50.0	19.1	85.3	32.7	32.7
SS-34	279.1	-22	50	1.48	0.37	1.00	1.0	1.15	1.0	34536	14681	4.0	50.0	18.5	85.3	31.5	31.5
SS-35	299.35	-42.25	45	1.48	0.36	1.00	1.0	1.15	1.1	36865	15746	13.0	50.0	17.8	76.8	27.4	29.4
SS-36	304.25	-47.15	50	1.48	0.33	1.00	1.0	1.15	1.1	34989	18443	12.0	50.0	16.5	85.3	28.1	30.0

SPT-Based Soil Shear Strength Loss Evaluation

Boring Number:	B-1014	Design EQ:	SEE	M_w:	6.99
Latitude:	36.99570	Site Class:	D	R(km):	15
Longitude:	-89.14840	PGA:	0.53	MSF_{sand}:	1.14
Ground Elevation, ft msl:	257.1	$\phi_{SL\text{-}Sand}$	0.90	MSF_{clay}:	1.02
Groundwater Above Surface, ft:	39.1	$\phi_{NSL\text{-}Sand}$	0.75		
Groundwater Elevation, ft msl:	296.2	$\phi_{SL\text{-}Clay}$	0.90		

								Soil Strength Loss Triggering Summary			Geotechnical Seismic Hazards Summary								
											Idriss & Boulanger (2007)		Olsen & Johnson (2008)		Kramer & Wang (2015)	Idriss & Boulanger (2008)			
SPT Sample	Depth, ft	Elev, ft msl	$N^*_{1,60}$	$\Delta N^*_{1,60}$	$N^*_{1,60,cs}$	SSL Potential	SSL Susceptibility Screening	$(D/C)_{SL}$	ϕ_{SL}	$(D/C)_{SL} \le \phi_{SL}$	S_r/σ'_{vo}	S_r (psf)	S_r/σ'_{vo}	S_r (psf)	S_r (psf)	LDI, ft	∑LDI, ft	$S_{v\text{-}1D}$, in	∑$S_{v\text{-}1D}$, in
SS-1	4.35	252.75	4.4	5.3	9.6	PSL	HS Clay-Like	2.76	0.9	Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-2	13.95	243.15	22.9	0.0	22.9	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-3	18.85	238.25	34.3	2.9	37.2	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-4	23.8	233.3	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-5	25.45	231.65	50.0	3.6	53.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-6	28.75	228.35	50.0	4.6	54.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-7	33.65	223.45	50.0	1.1	51.1	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-8	38.55	218.55	50.0	2.1	52.1	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-9	43.45	213.65	47.7	1.6	49.3	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.4	-	0.9
SS-10	48.35	208.75	27.2	2.5	29.7	SSL	Sand-Like	1.65	0.9	Full Liquefaction	0.42	1058.13	0.23	594.49	1440.81	0.24	0.4	0.57	0.9
SS-11	53.55	203.55	30.1	2.9	33.1	NSL-S	Sand-Like	0.96	0.9	Full Liquefaction	0.66	1862.16	0.26	721.37	2017.13	0.16	0.2	0.34	0.3
SS-12	58.25	198.85	42.7	5.3	48.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-13	63.15	193.95	43.7	2.9	46.6	NSL-S	Sand-Like	0.01	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-14	68.05	189.05	34.4	5.5	39.9	PSL	NS Clay-Like	0.49	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	77.4	179.7	50.0	5.5	55.5	PSL	HS Clay-Like	0.40	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-15	78.05	179.05	50.0	3.9	53.9	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-16	82.85	174.25	50.0	3.3	53.3	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-17	87.75	169.35	50.0	2.5	52.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-18	92.65	164.45	50.0	5.5	55.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-19	97.55	159.55	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-20	102.25	154.85	50.0	0.0	50.0	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-21	112.95	144.15	49.5	0.1	49.6	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-22	122.15	134.95	8.6	0.0	8.6	SSL	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-23	132.05	125.05	45.8	0.0	45.8	NSL-S	Sand-Like	0.01	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-24	141.7	115.4	44.2	0.0	44.2	NSL-S	Sand-Like	0.03	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-25	151.4	105.7	42.7	0.0	42.7	NSL-S	Sand-Like	0.07	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-26	161.2	95.9	41.4	0.0	41.4	NSL-S	Sand-Like	0.12	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-27	171	86.1	40.2	0.0	40.2	NSL-S	Sand-Like	0.21	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-28	180.9	76.2	39.1	4.1	43.2	NSL-S	Sand-Like	0.07	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-29	190.75	66.35	38.1	0.4	38.4	NSL-S	Sand-Like	0.44	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-30	200.6	56.5	37.1	4.9	42.0	NSL-S	Sand-Like	0.15	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-31	220.2	36.9	35.4	3.3	38.7	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-32	239.7	17.4	34.0	0.0	34.0	NSL-S	Sand-Like	1.63	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-33	259.45	-2.35	32.7	0.0	32.7	NSL-S	Sand-Like	2.01	0.9	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-34	279.1	-22	31.5	0.0	31.5	NSL-S	Sand-Like	0.00	0.75	No Liquefaction	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-35	299.35	-42.25	27.4	2.5	29.9	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	0.00	0.0	-	0.0
SS-36	304.25	-47.15	28.1	2.1	30.2	PSL	HS Clay-Like	0.00	0.9	No Strength Loss	NA	#N/A	NA	#N/A	#N/A	-	0.0		0.0

CPT-Based Liquefaction Analysis, Lateral Displacement & Seismic Settlement (CLiq): 100-YR Return Period

C1015

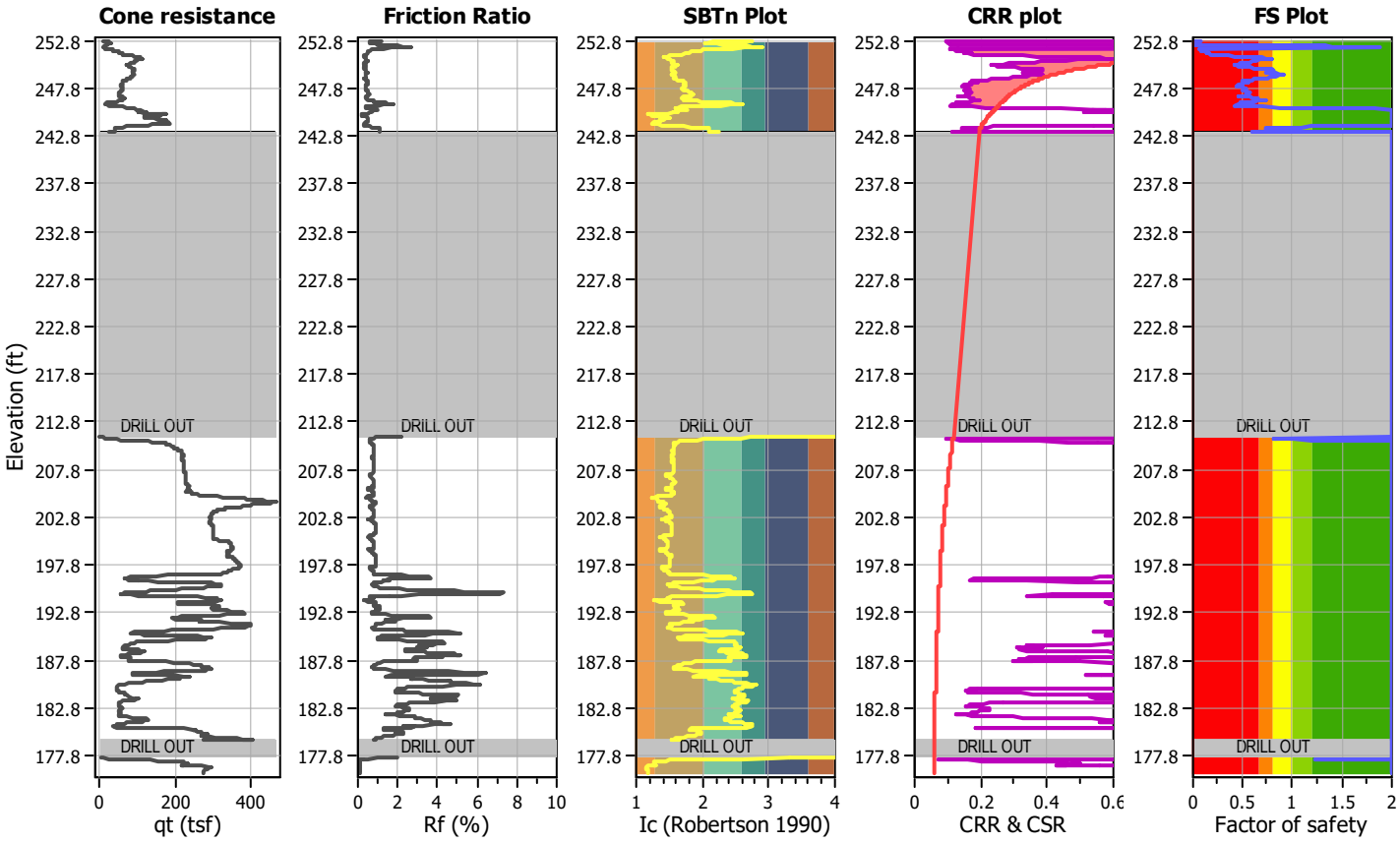
LIQUEFACTION ANALYSIS REPORT

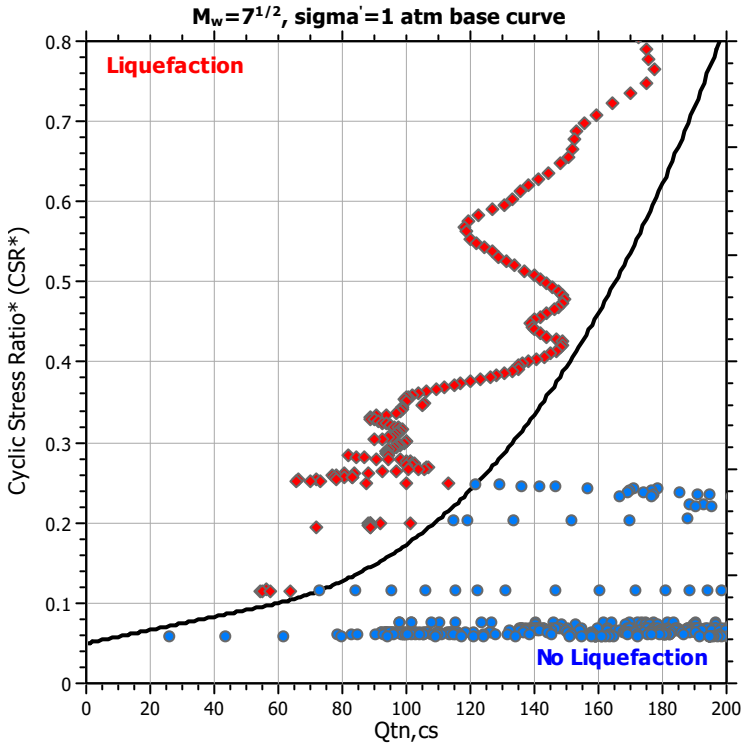
Project title : US-51 Bridge Replacement Project **Location : River Piers**

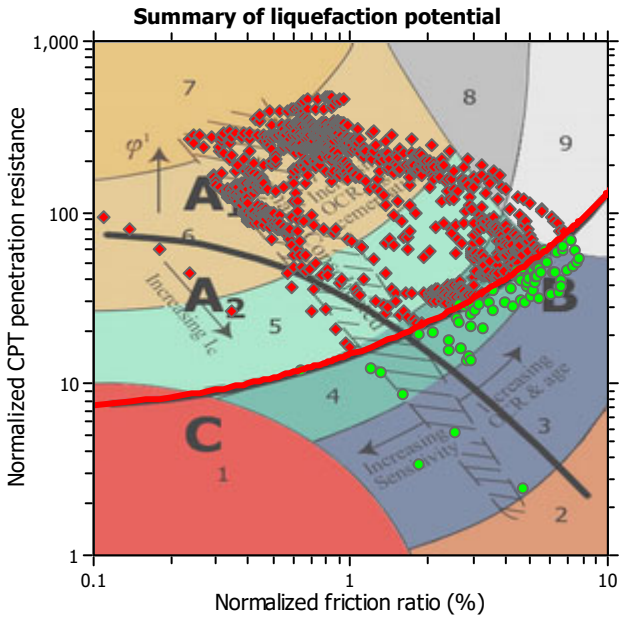
CPT file : C1015 100-YR

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	-29.06 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	-29.06 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.98	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.09	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

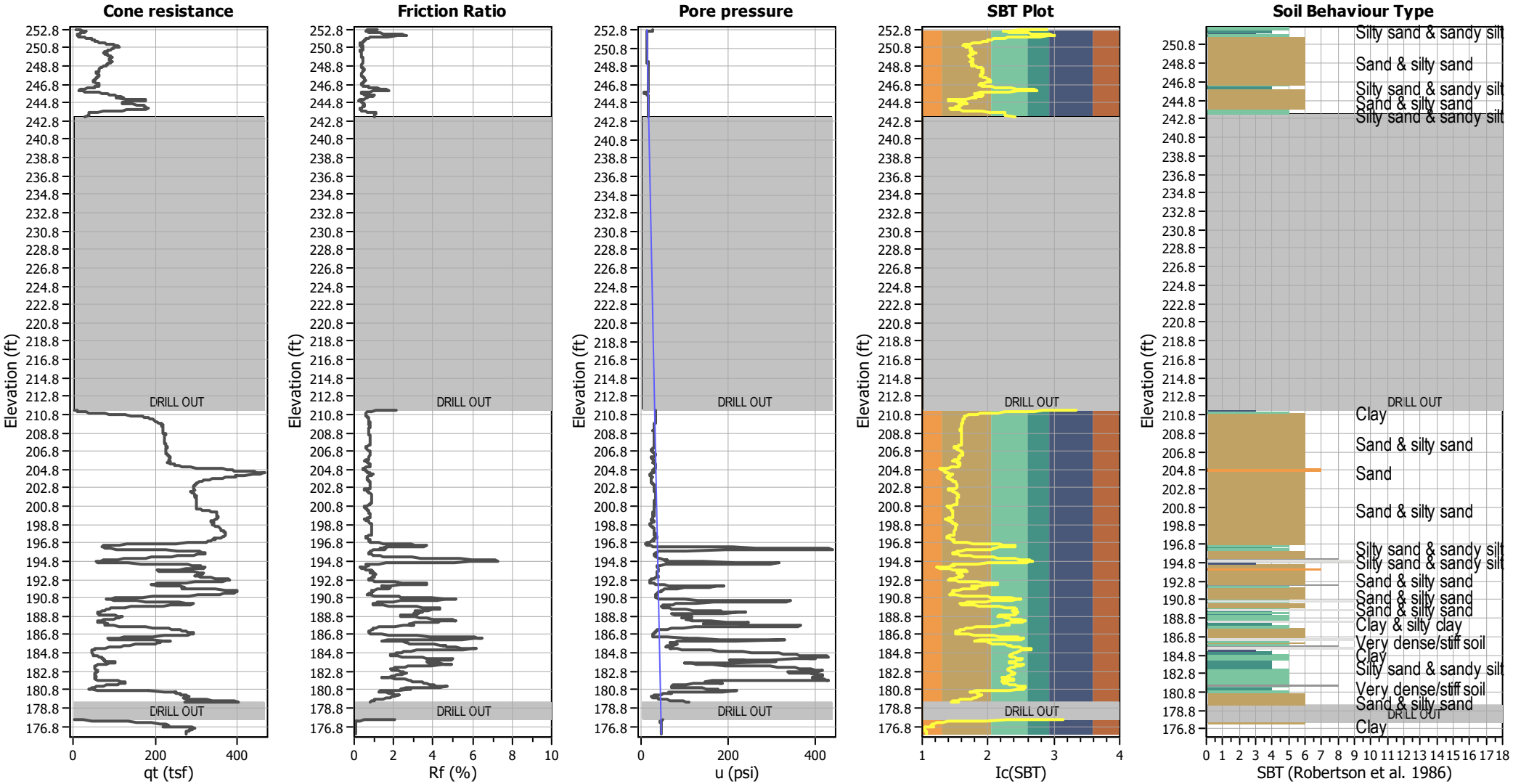






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



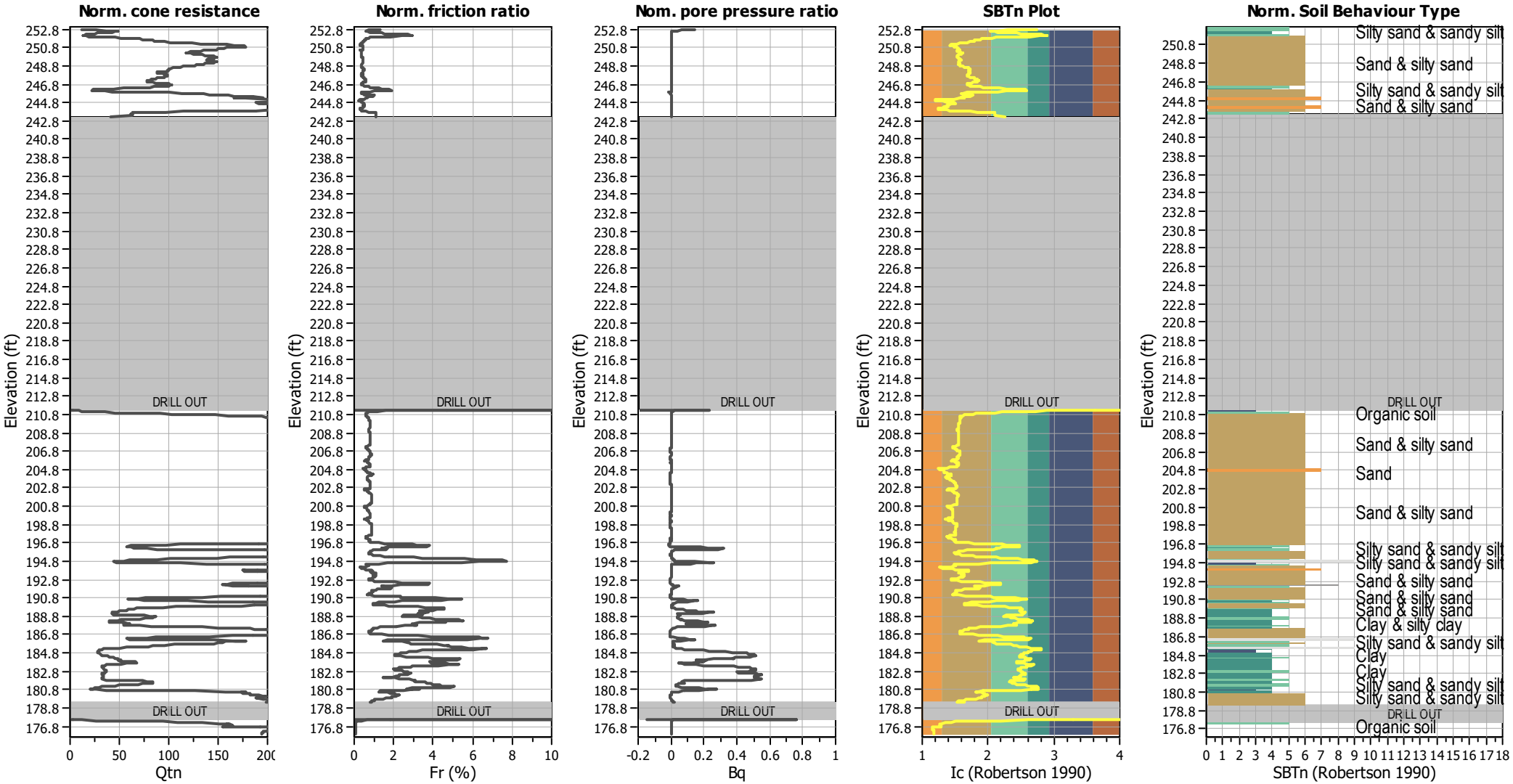
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



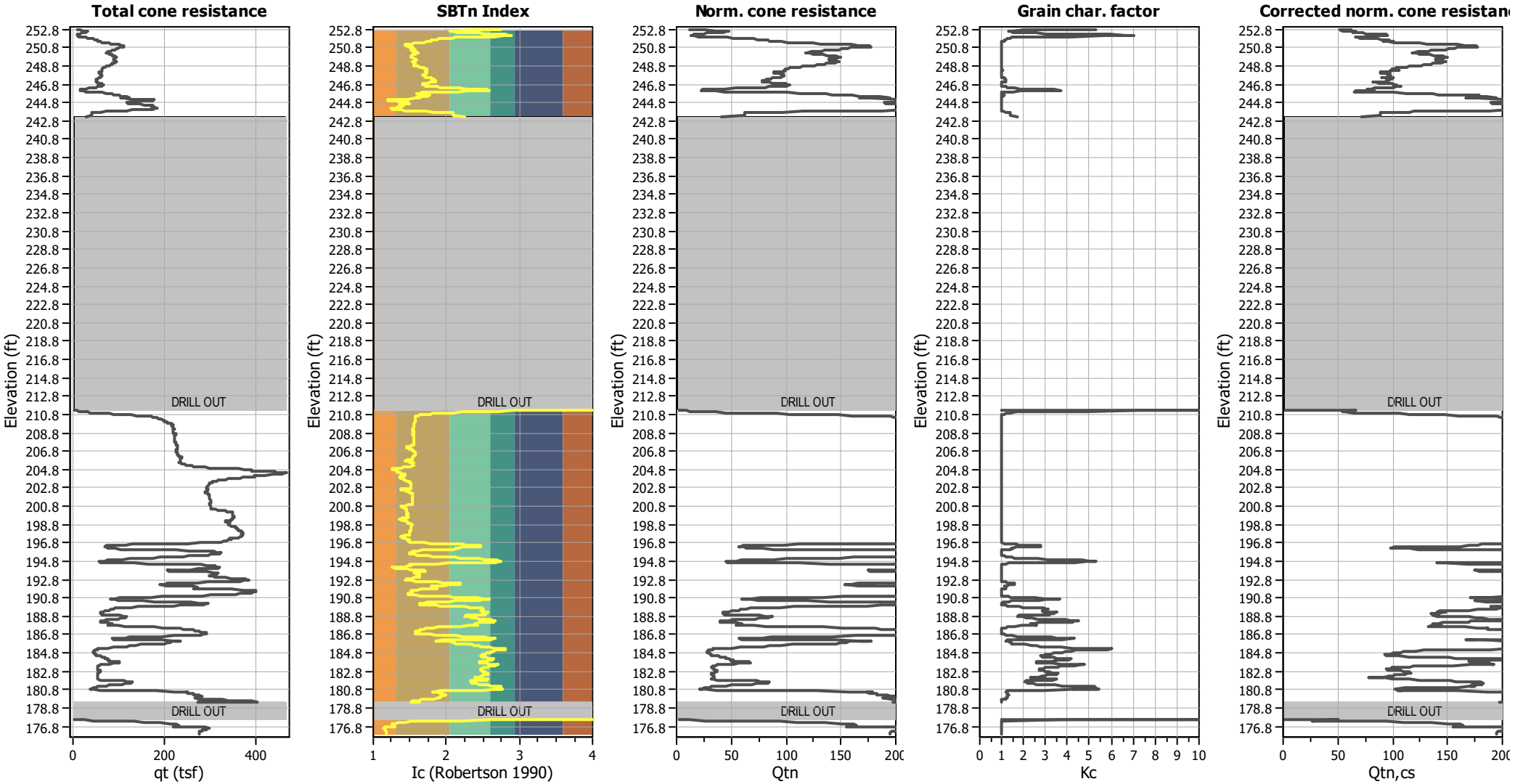
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

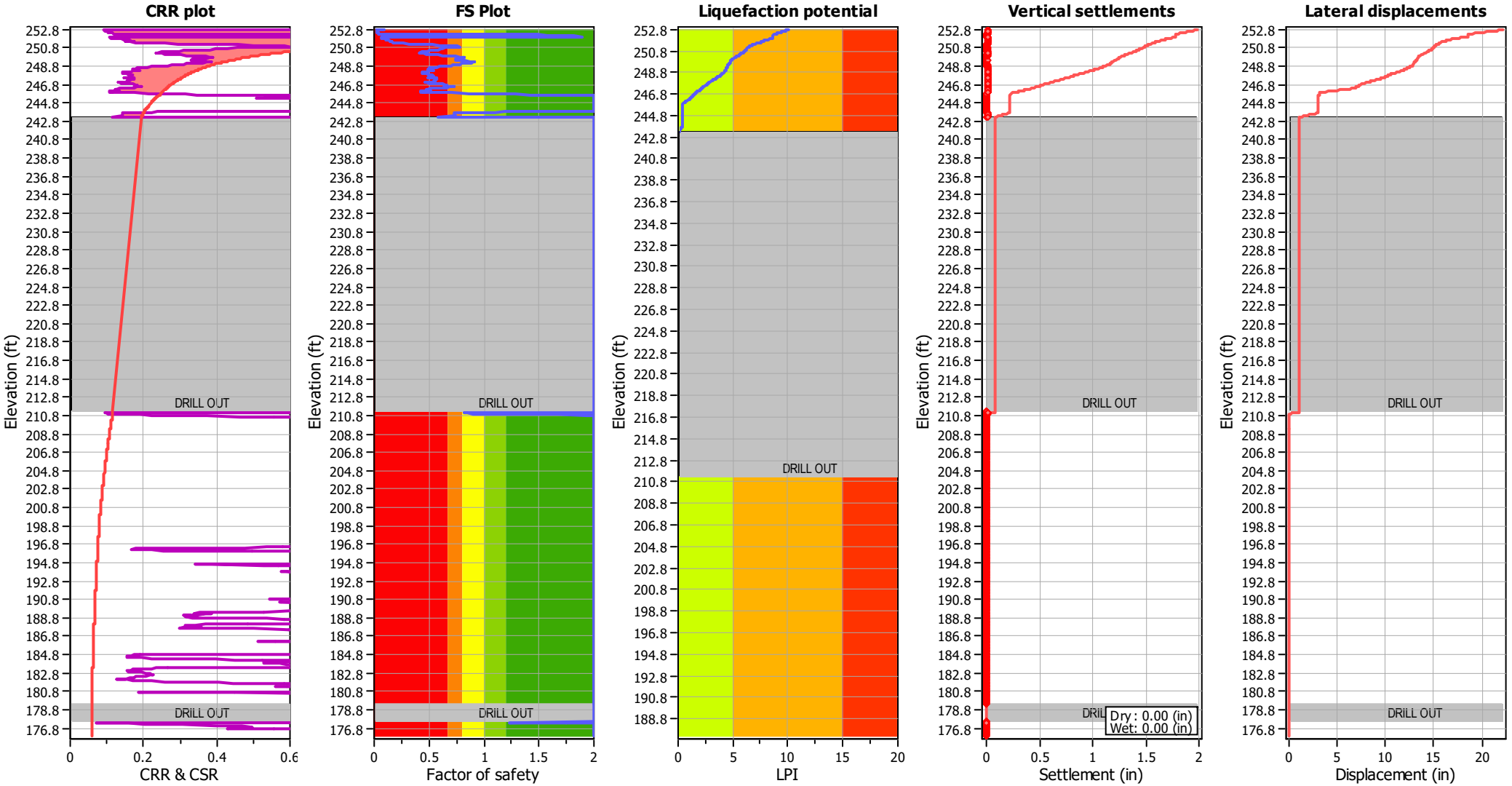
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

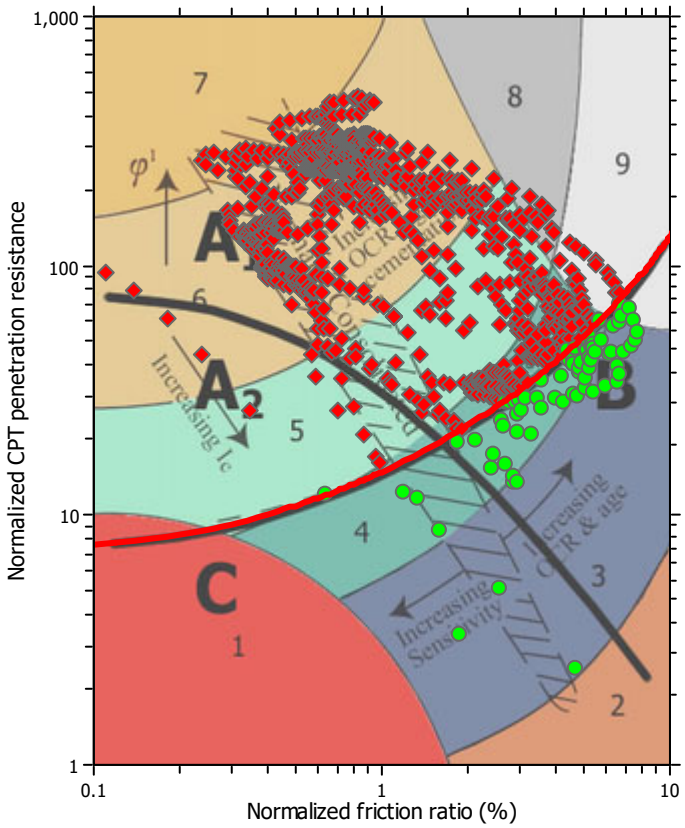
F.S. color scheme

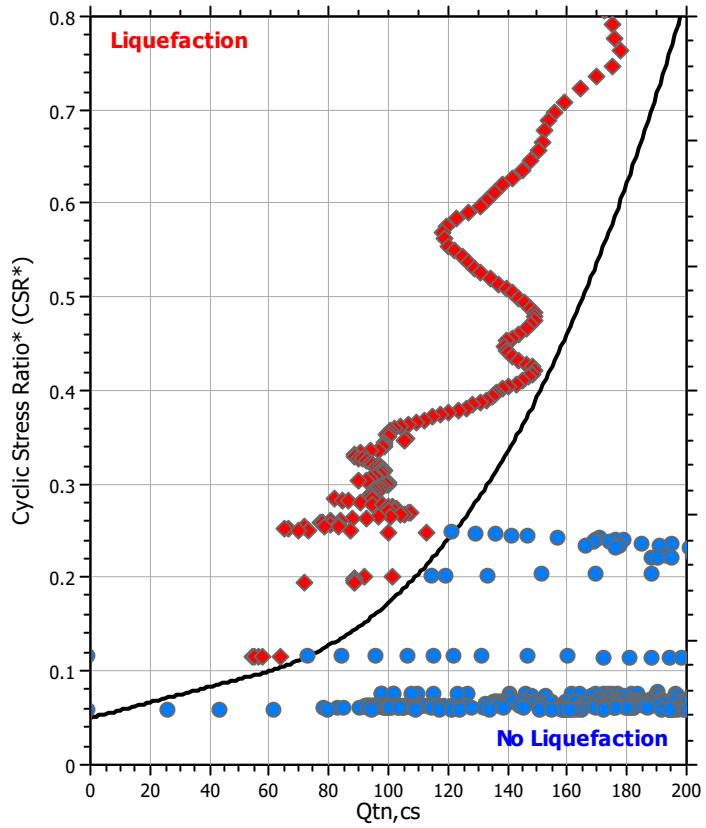
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

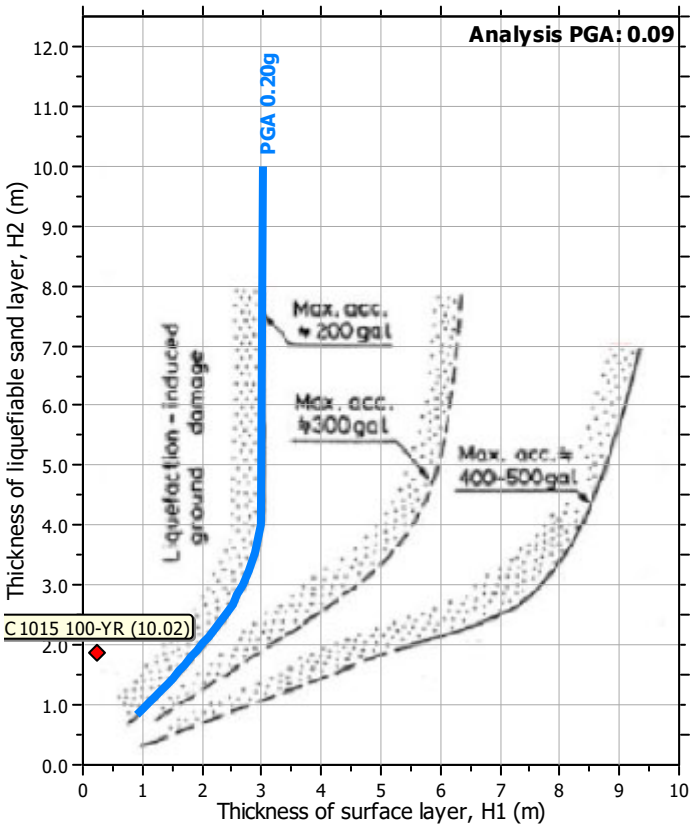
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots



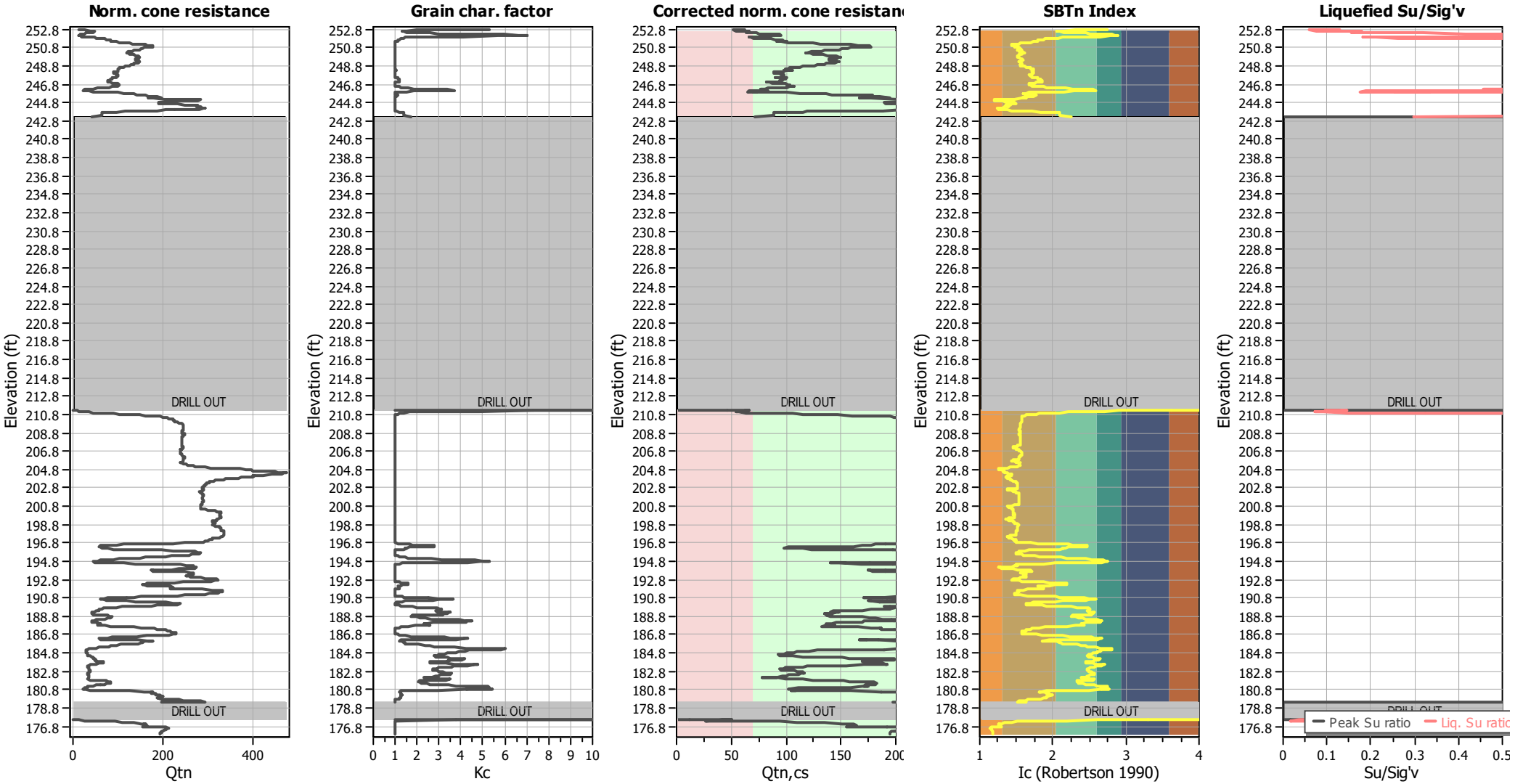




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

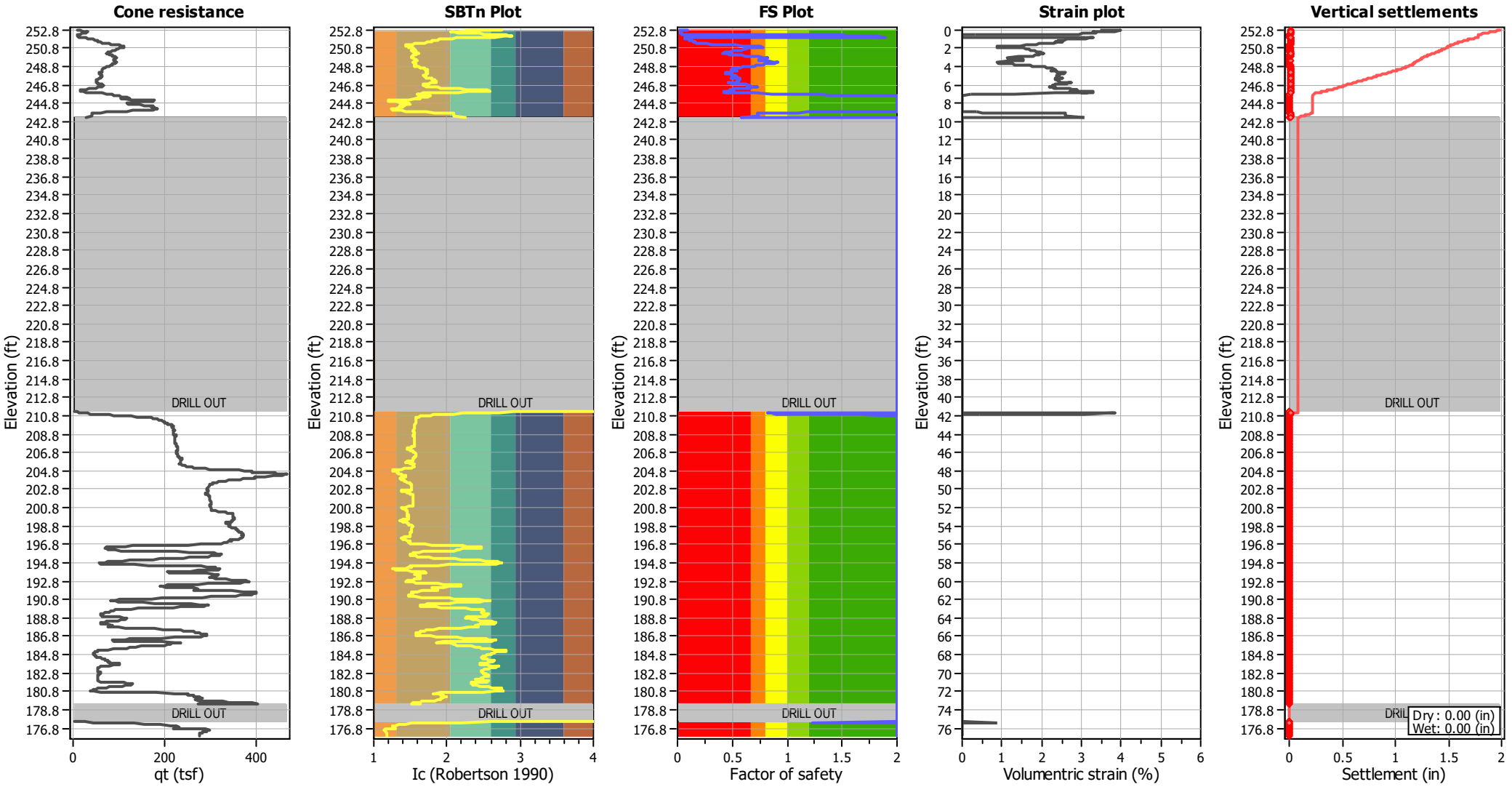
Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements

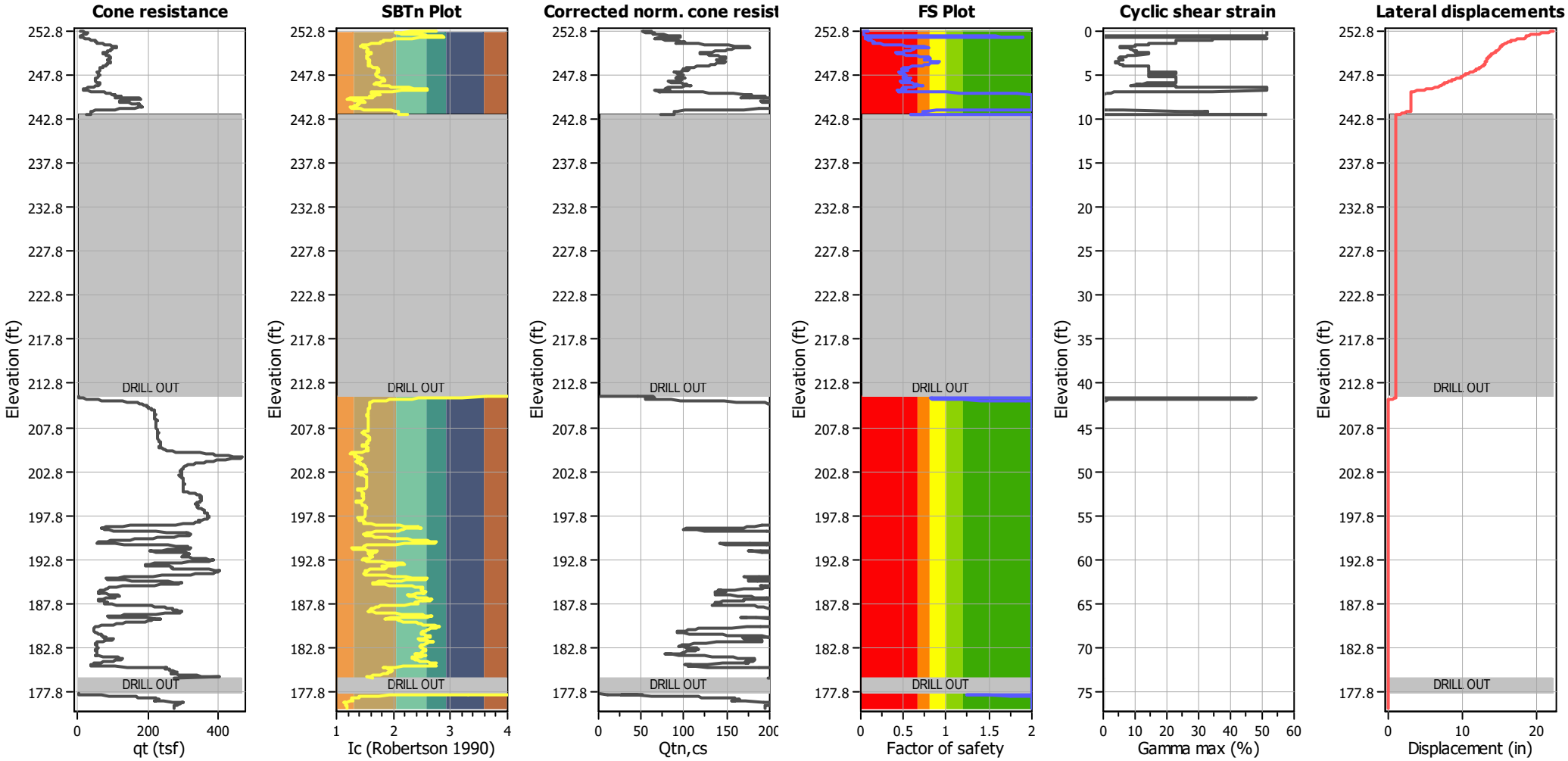


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements

Geometric parameters: Gently sloping ground without free face (Slope 1.00 %)



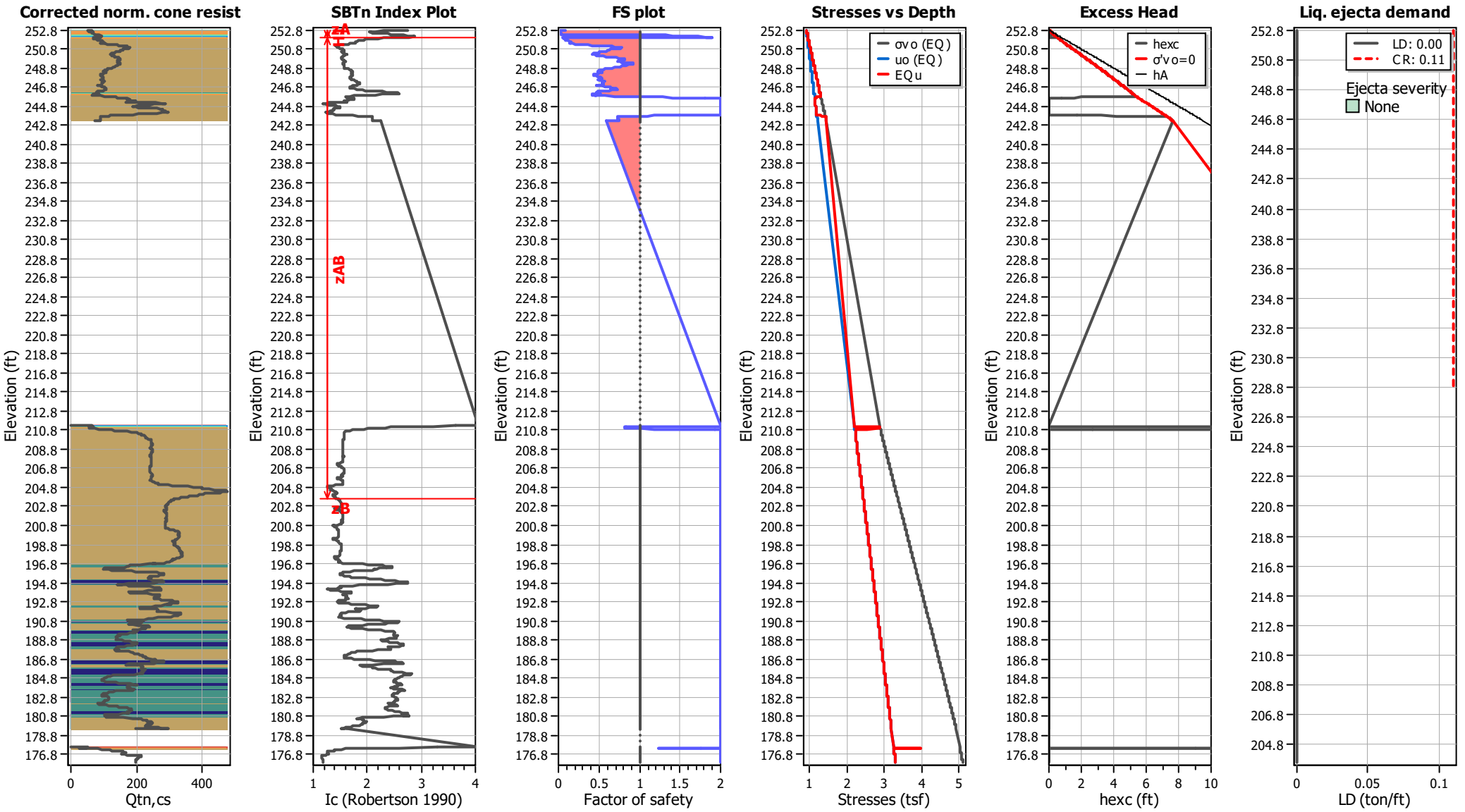
Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$Q_{tn,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Surface condition



Ejecta Severity Estimation



C1016

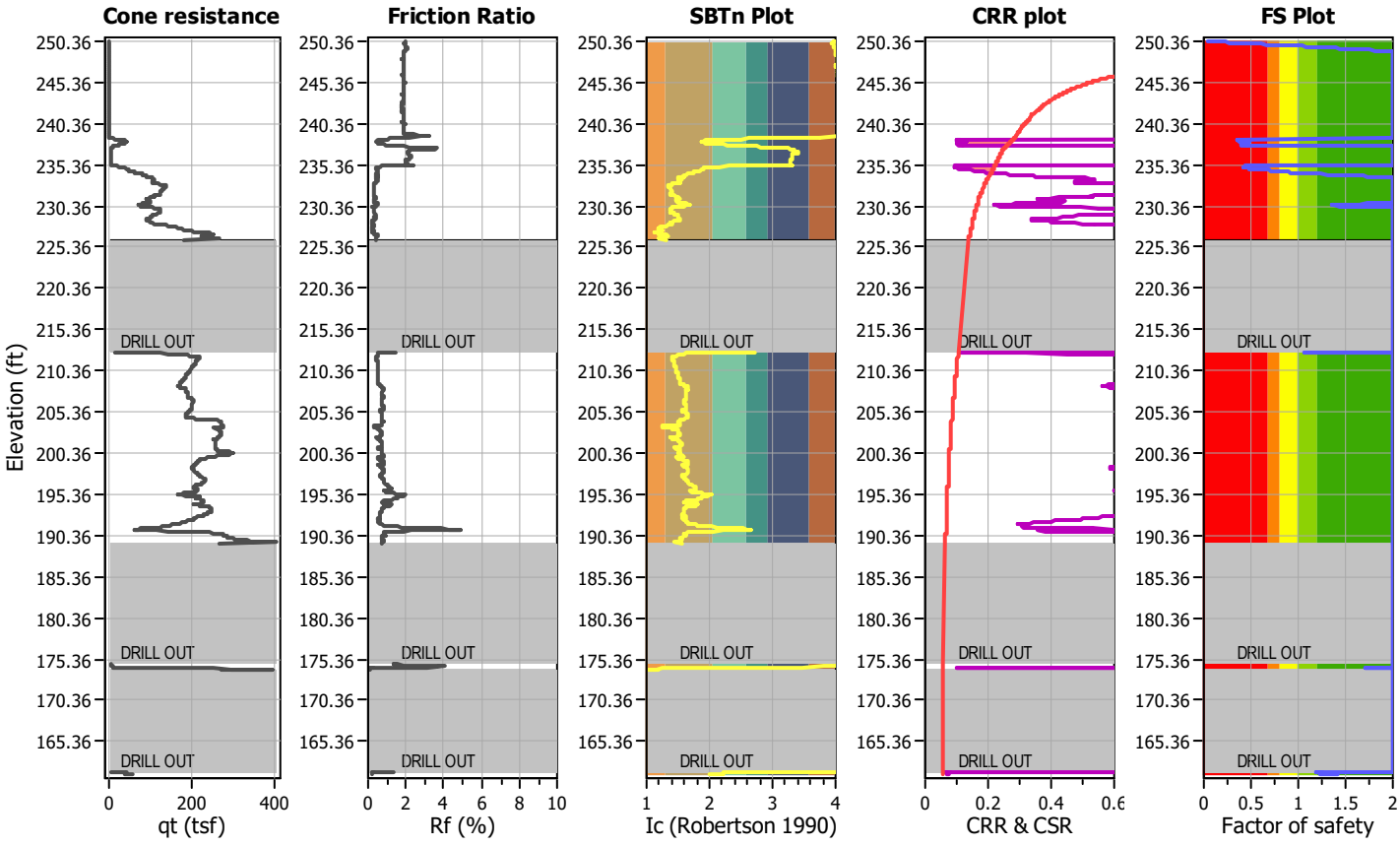
LIQUEFACTION ANALYSIS REPORT

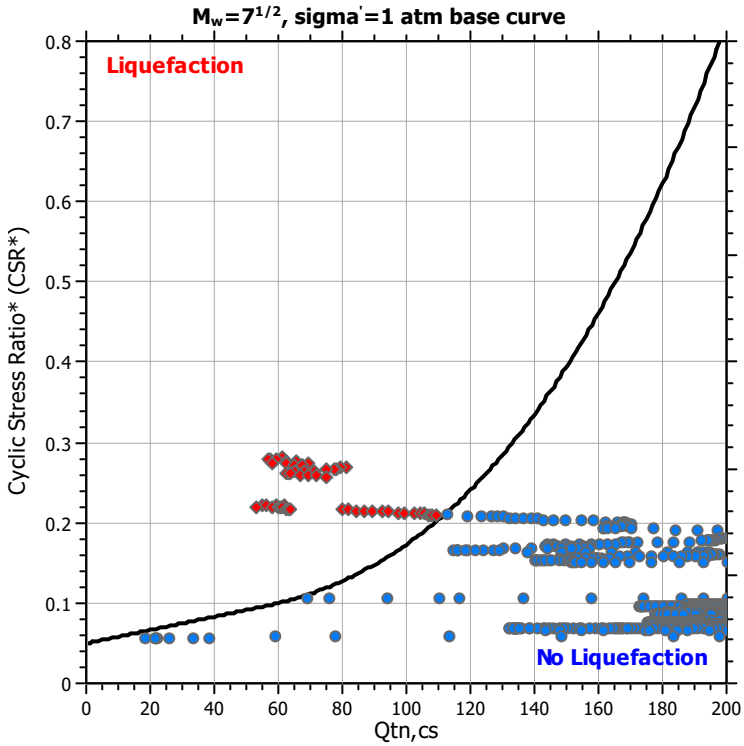
Project title : US-51 Bridge Replacement Project **Location : River Piers**

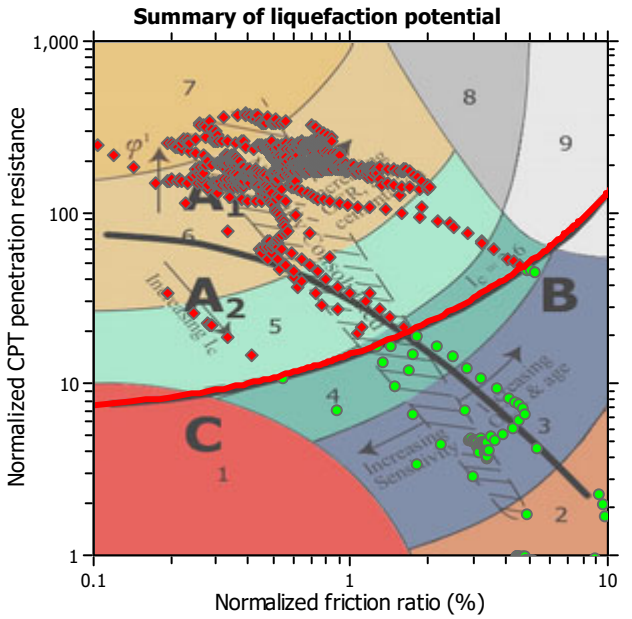
CPT file : C1016 100-YR

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	-25.48 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	-25.48 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	5.98	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.09	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

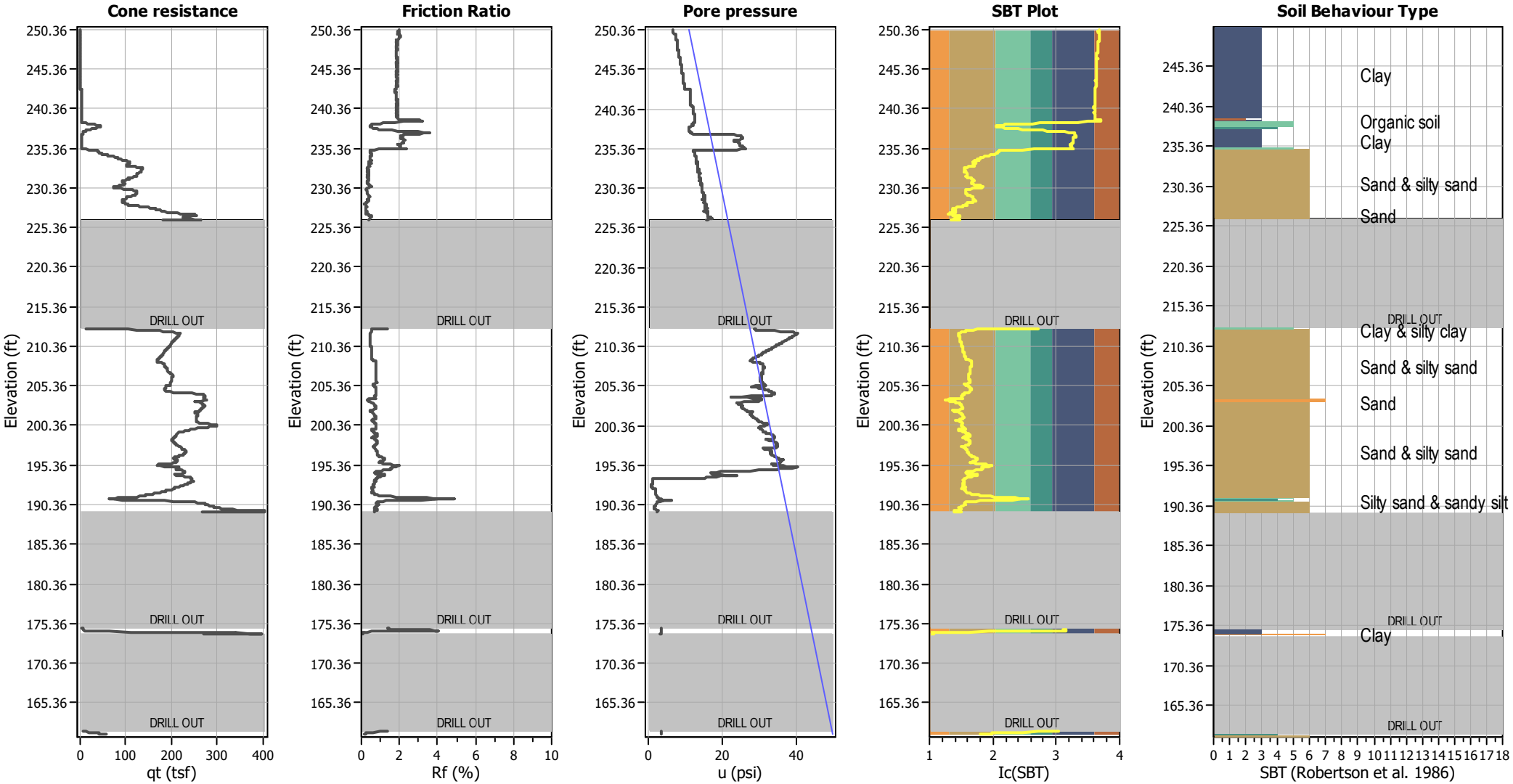






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



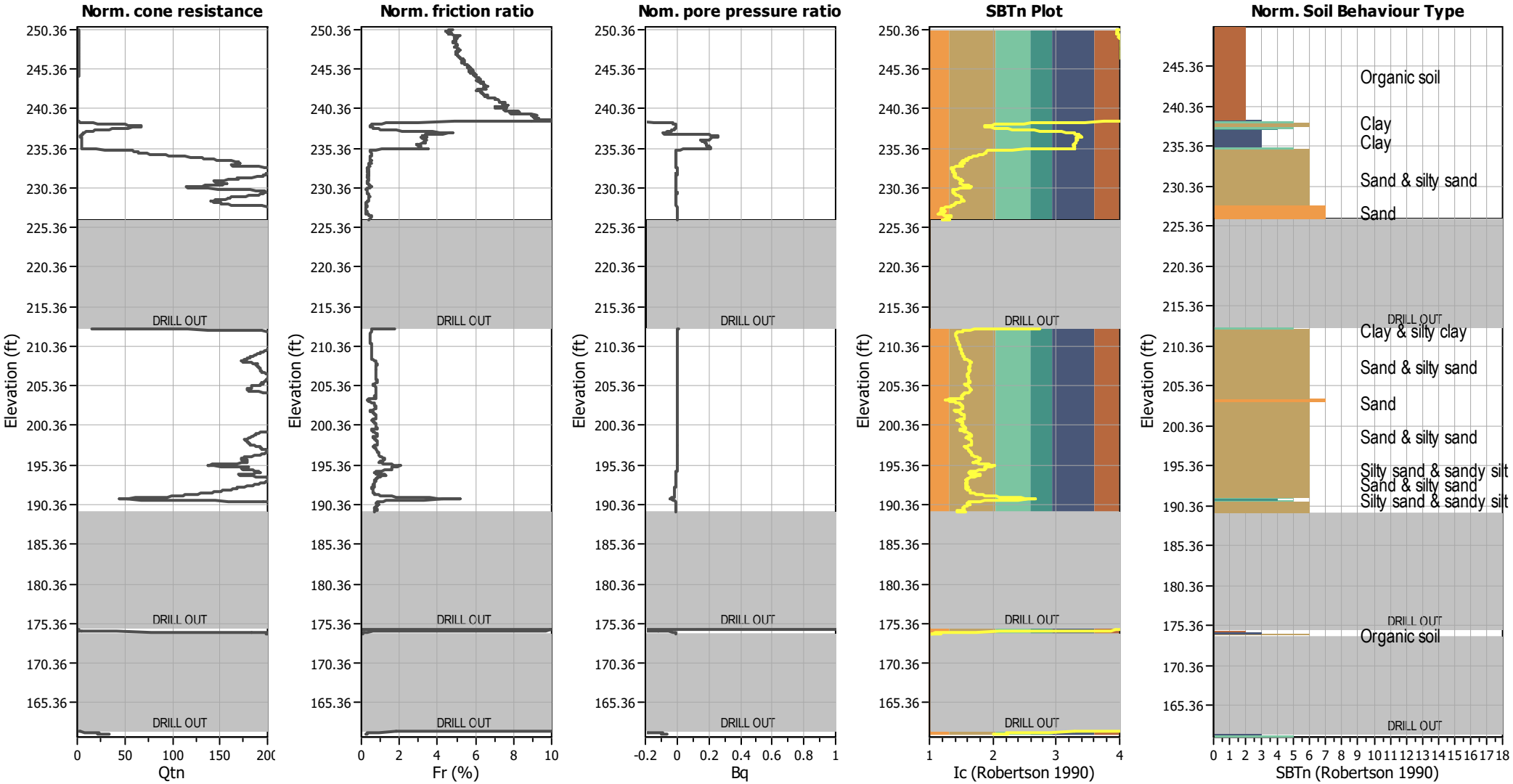
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



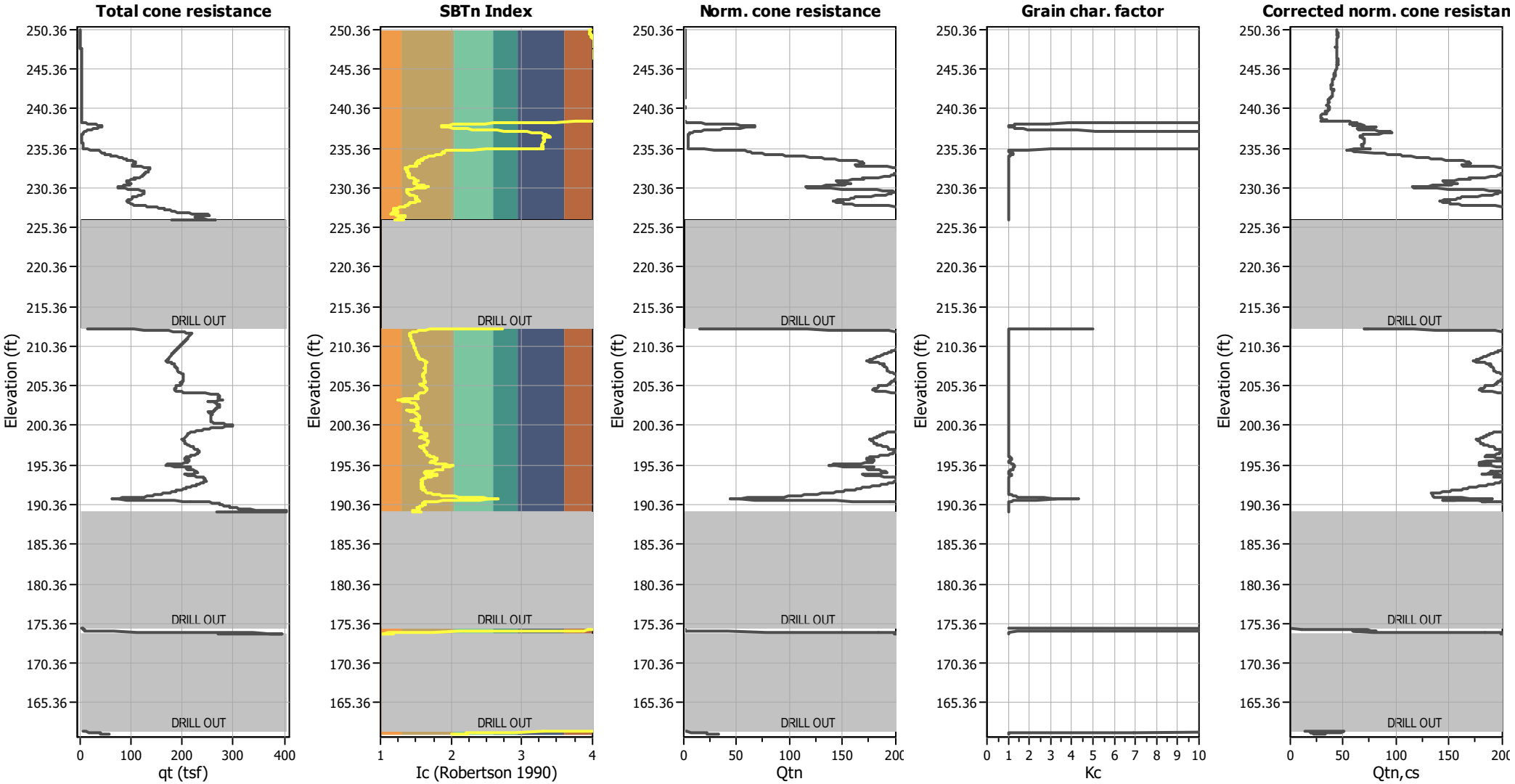
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

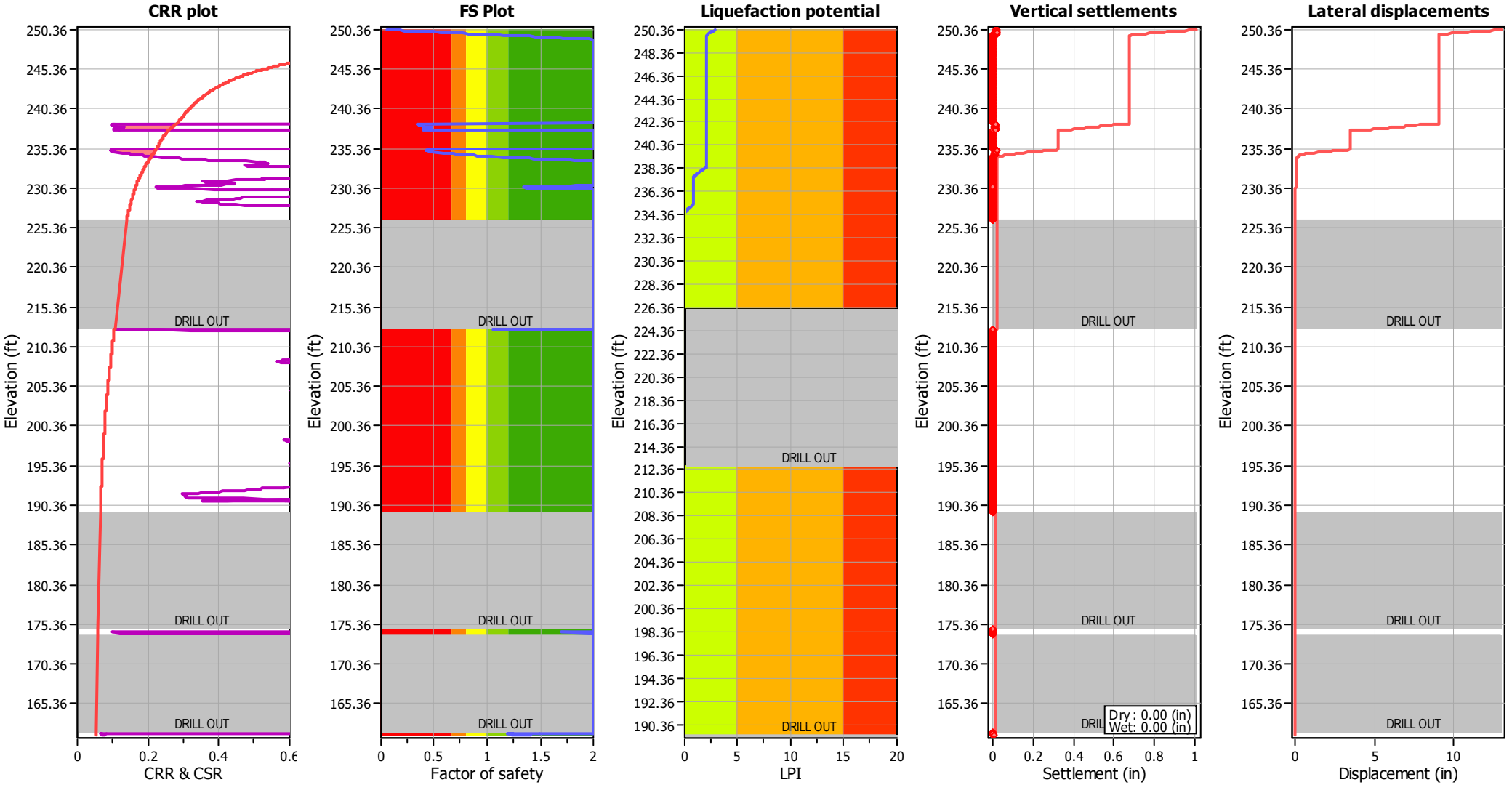
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

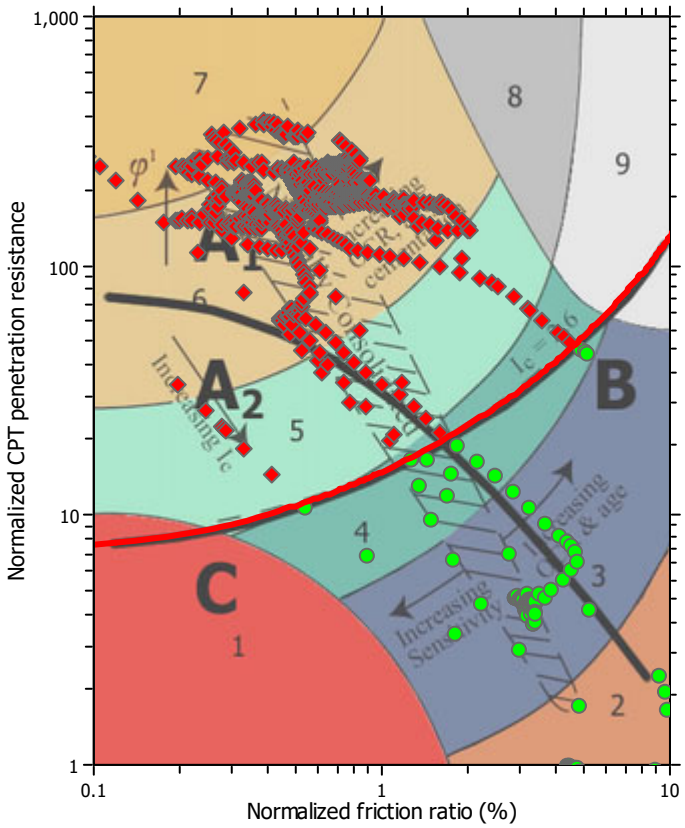
F.S. color scheme

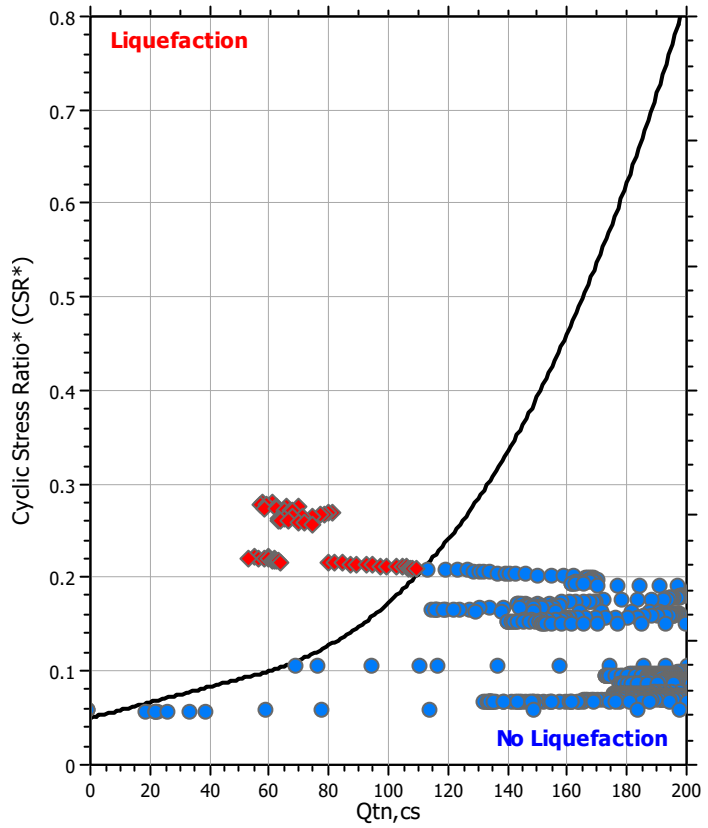
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

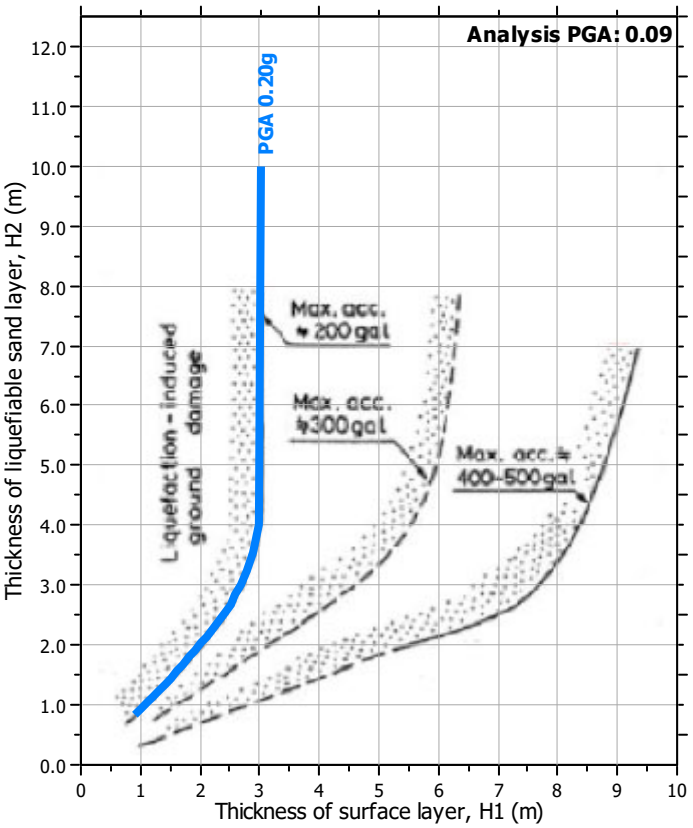
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots



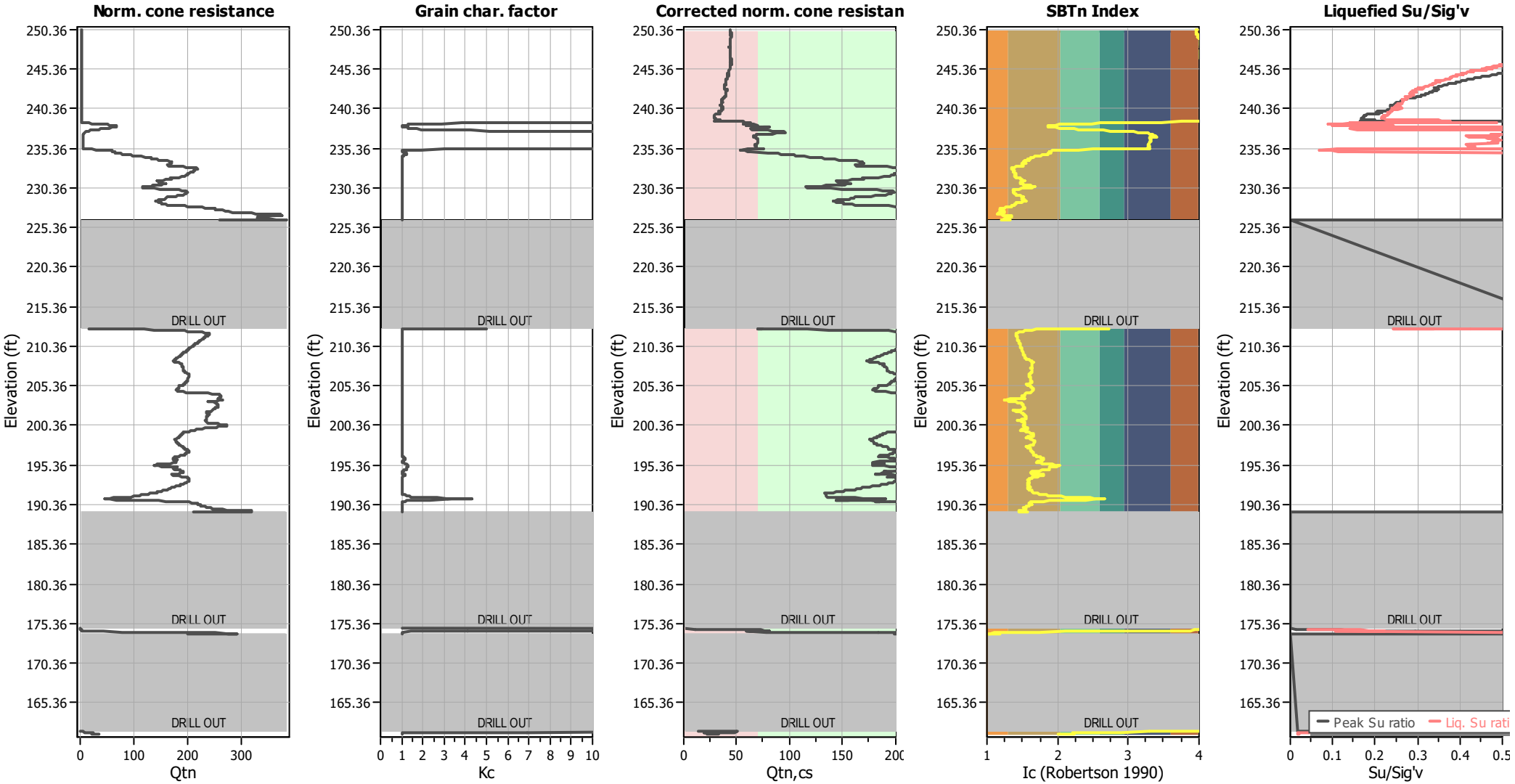




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

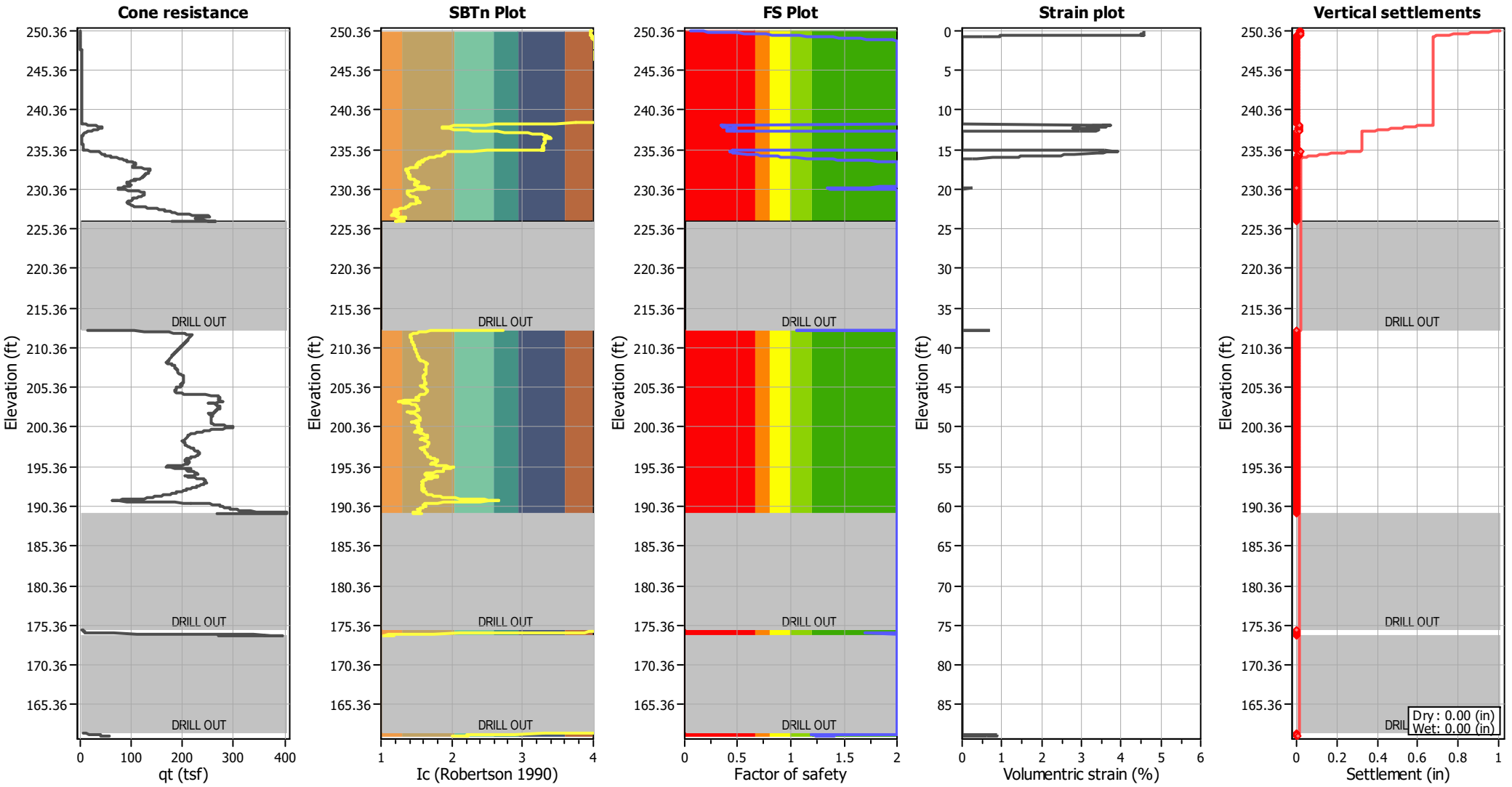
Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.98	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.09	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements

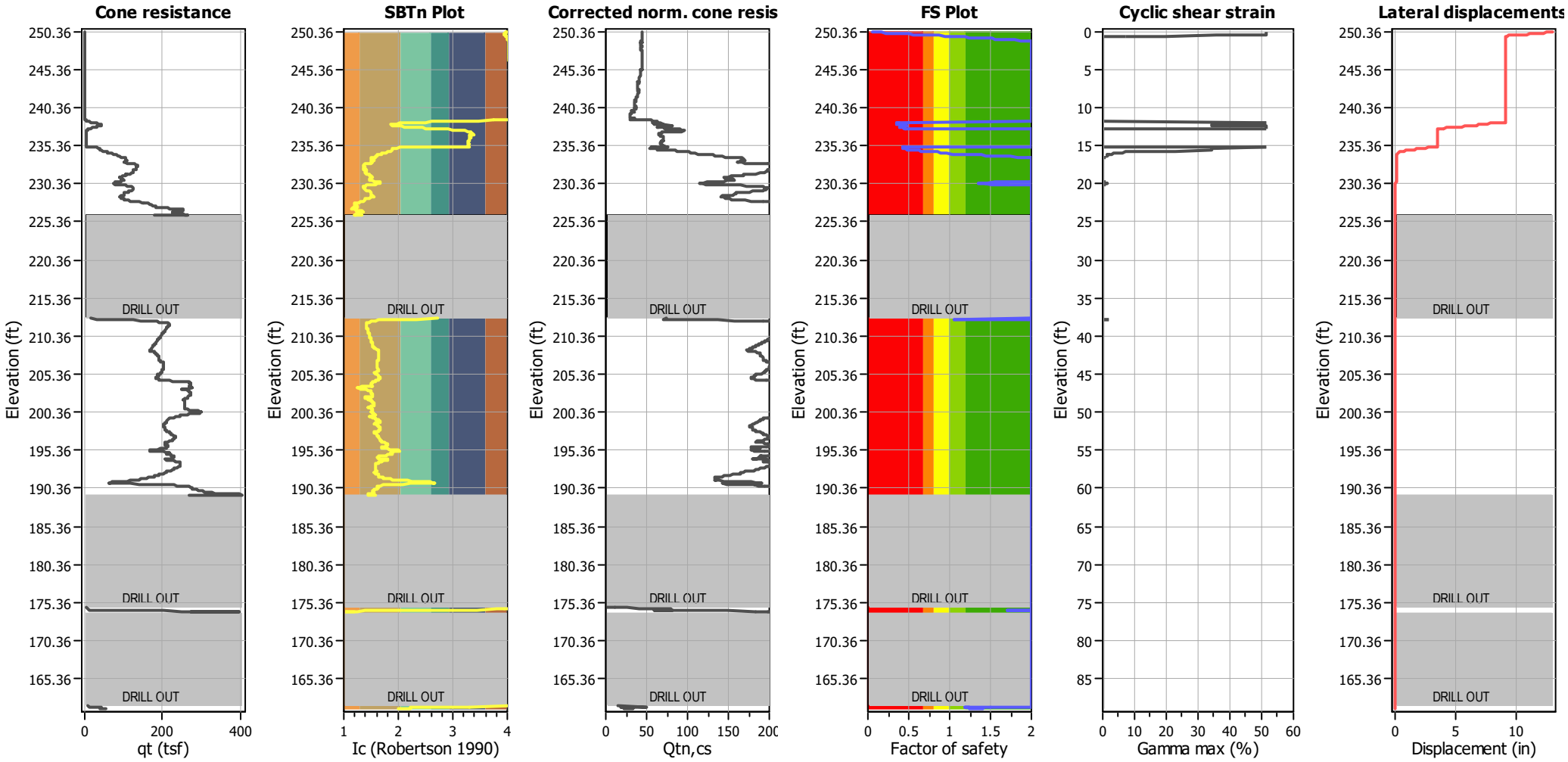


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements

Geometric parameters: Gently sloping ground without free face (Slope 1.00 %)



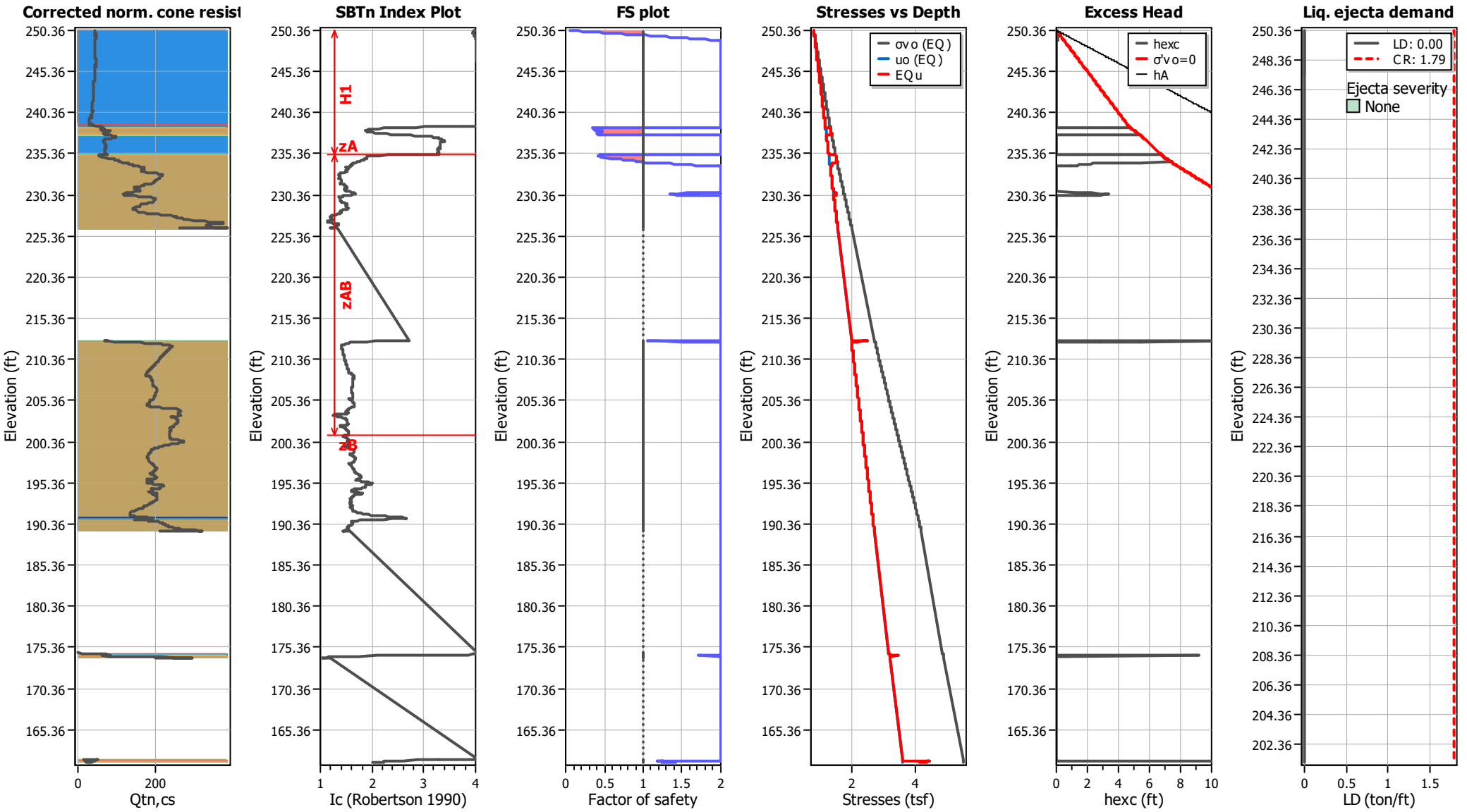
Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$Q_{tn,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Surface condition



Ejecta Severity Estimation



CPT-Based Liquefaction Analysis Lateral Displacement & Seismic Settlement (CLiq): 1,000-YR Return Period

C1015

HDR

http://www.geologismiki.gr

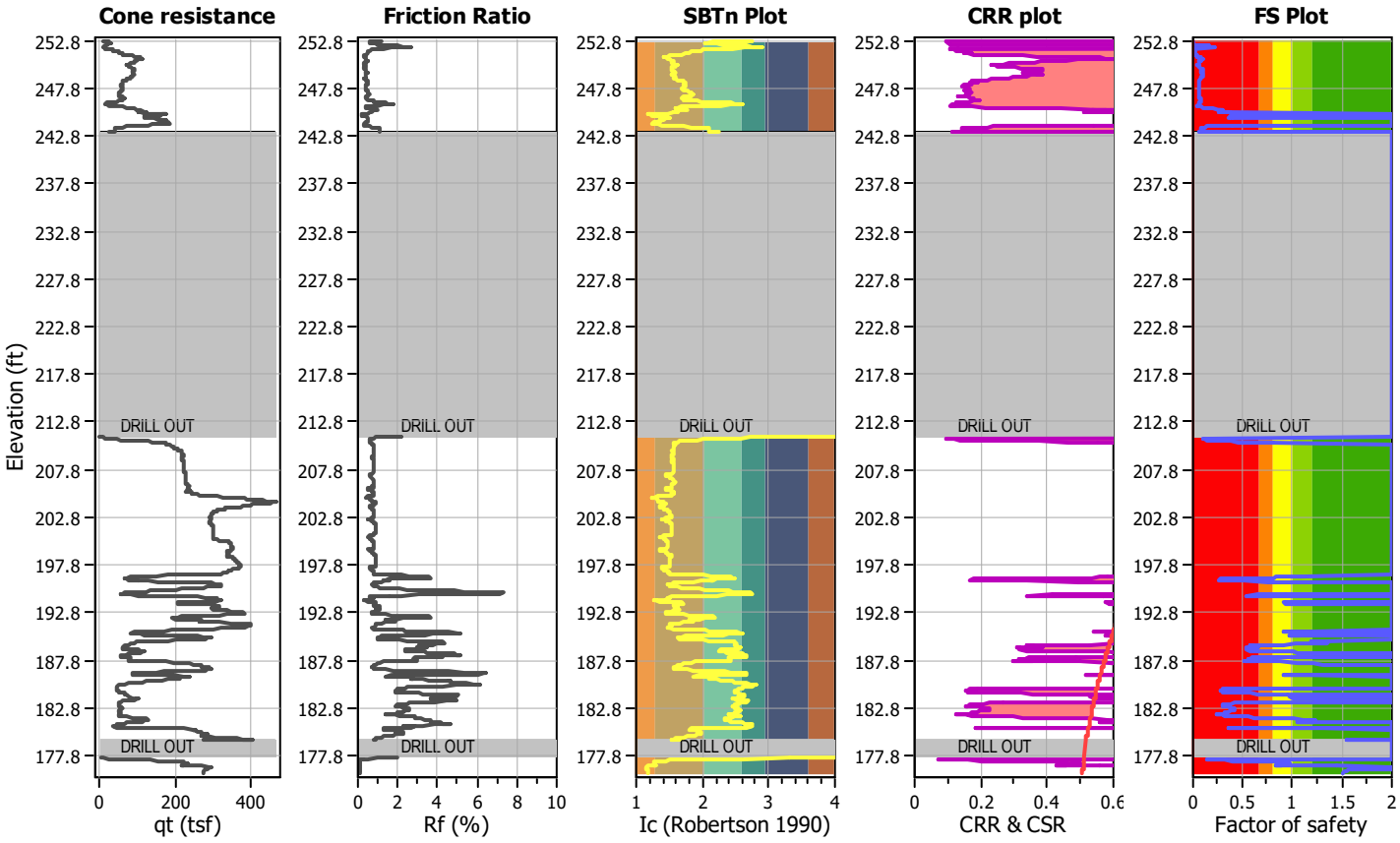
LIQUEFACTION ANALYSIS REPORT

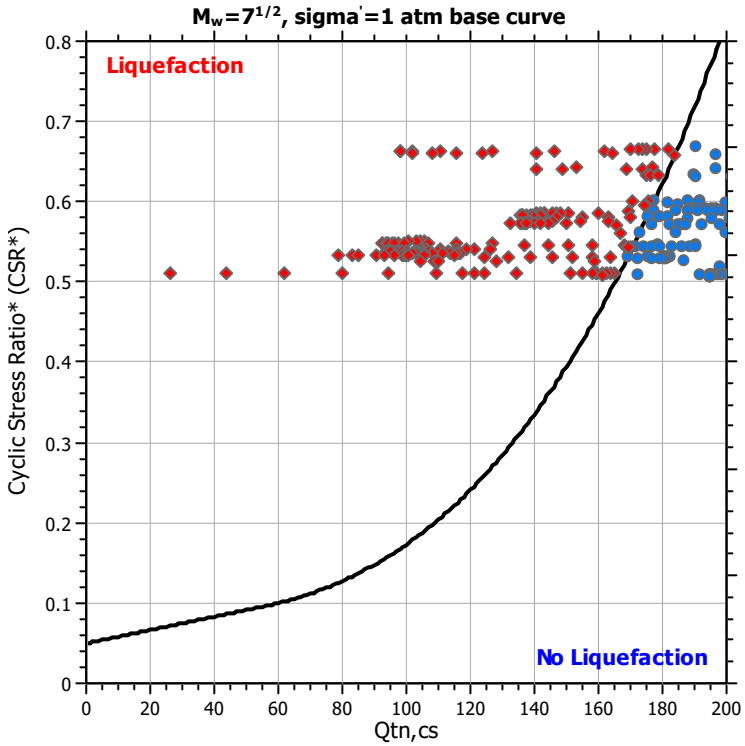
Project title : US-51 Bridge Replacement Project **Location : River Piers**

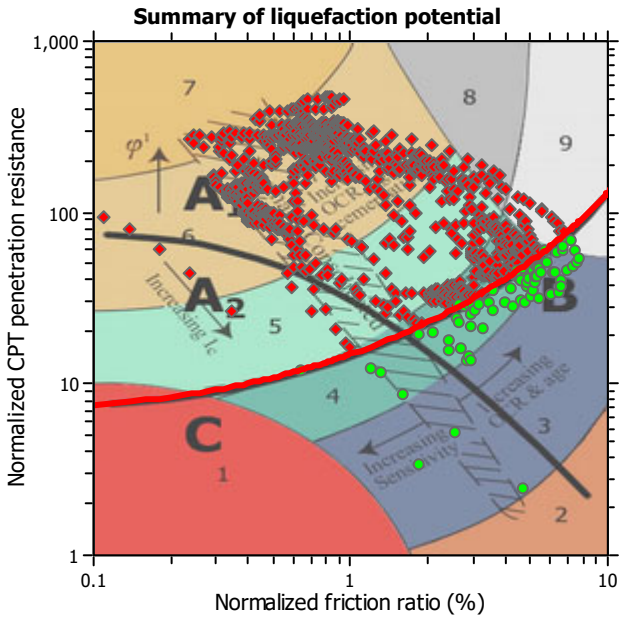
CPT file : C1015 1000 YR

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	-29.06 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	-29.06 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.99	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.53	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

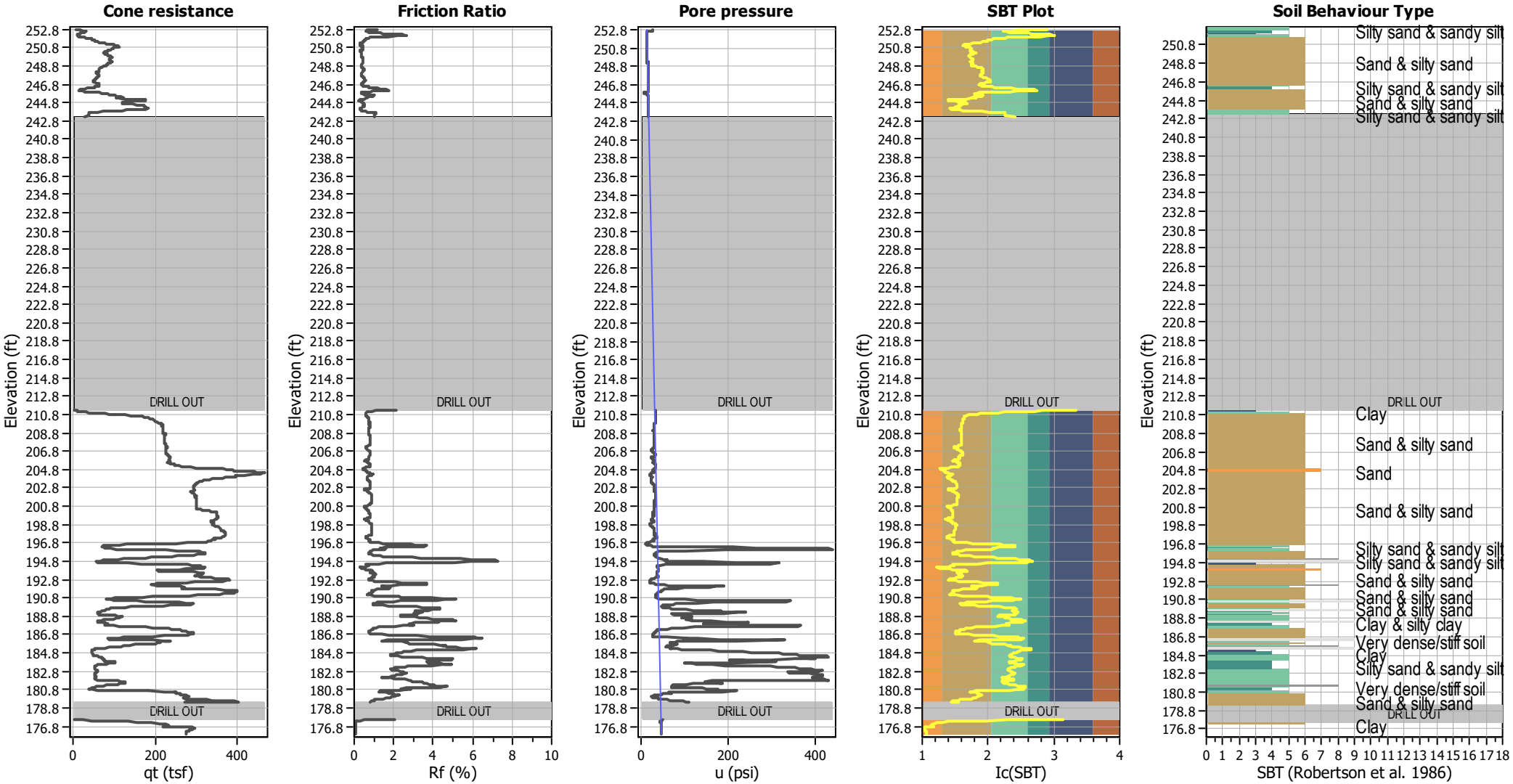






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



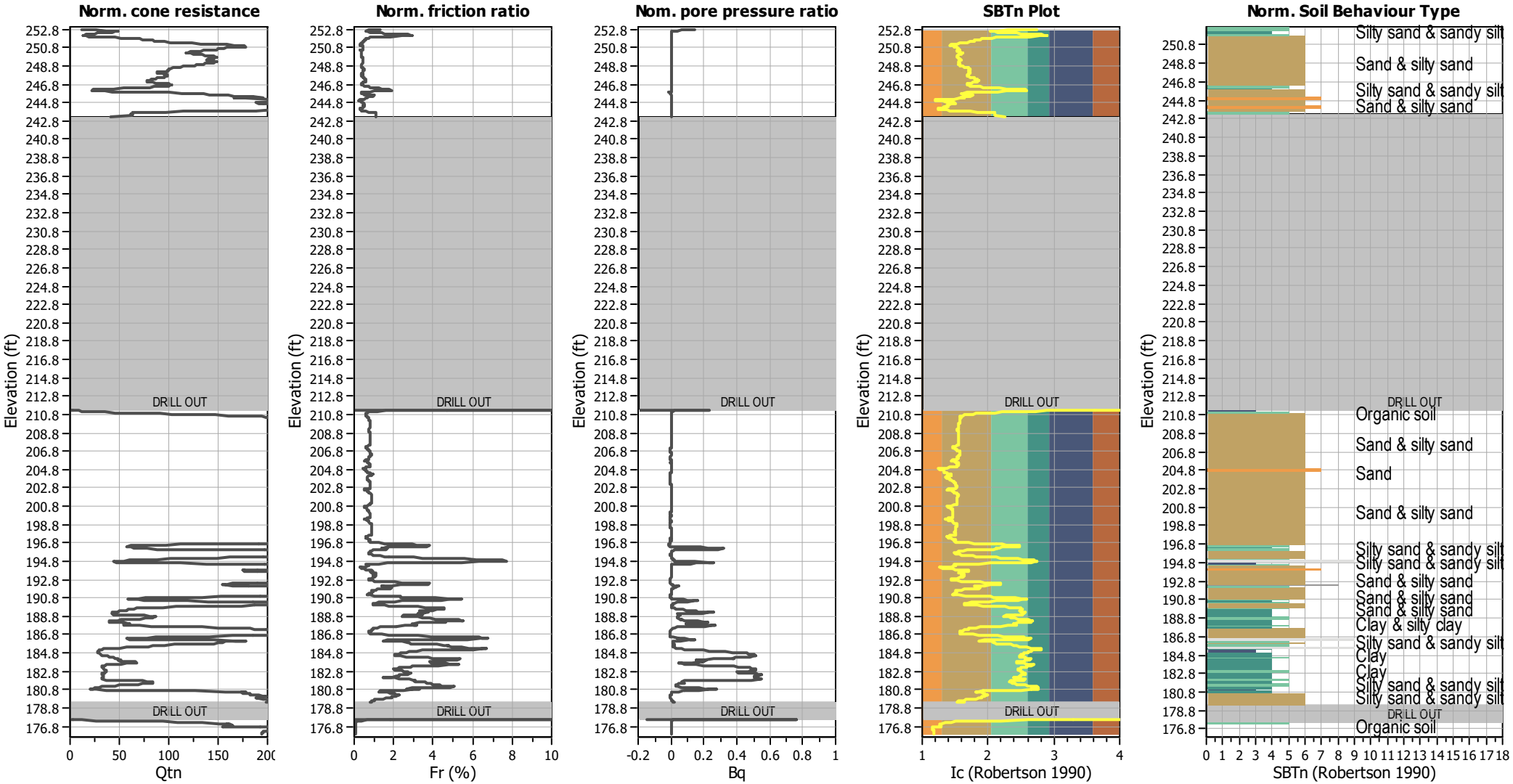
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



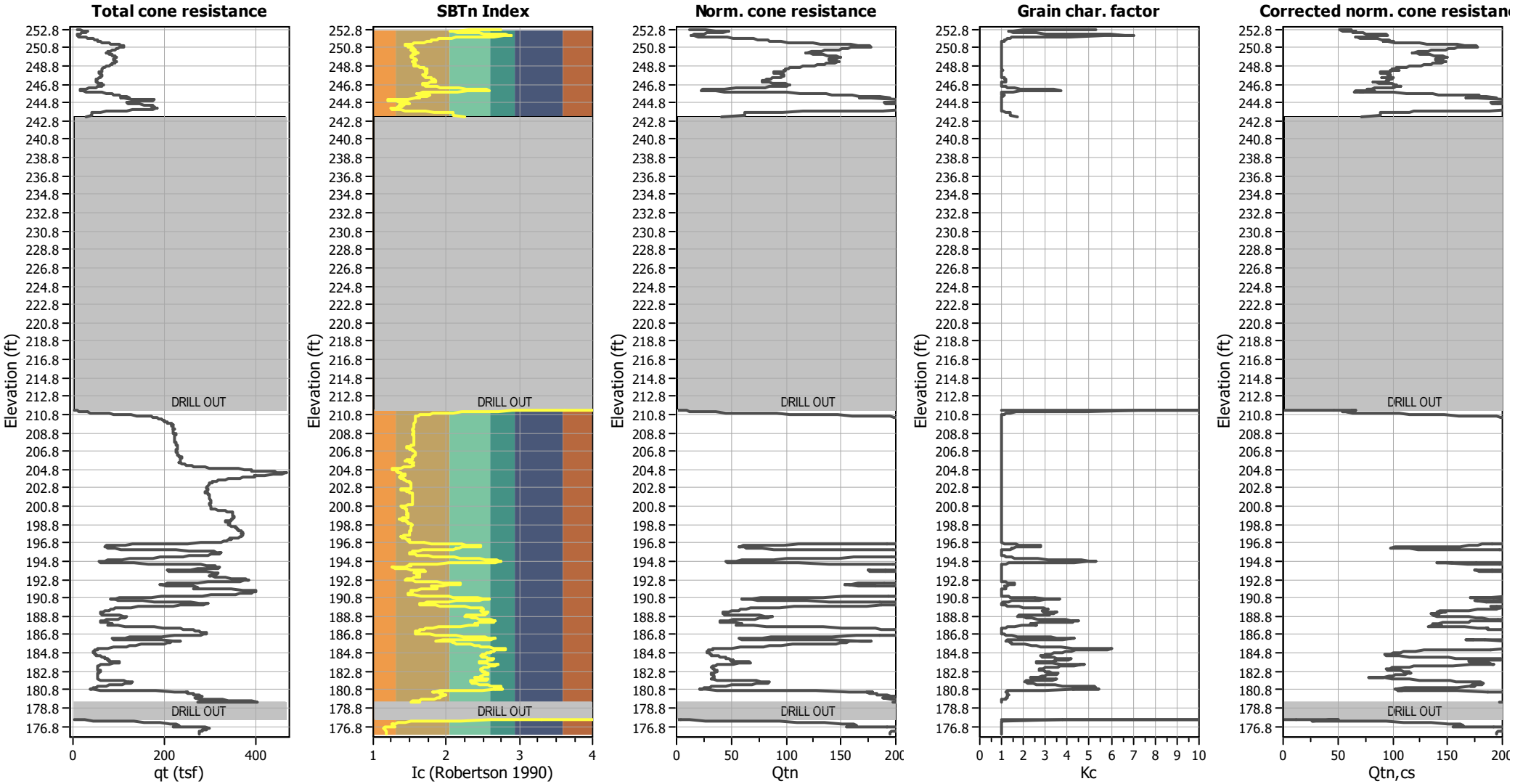
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

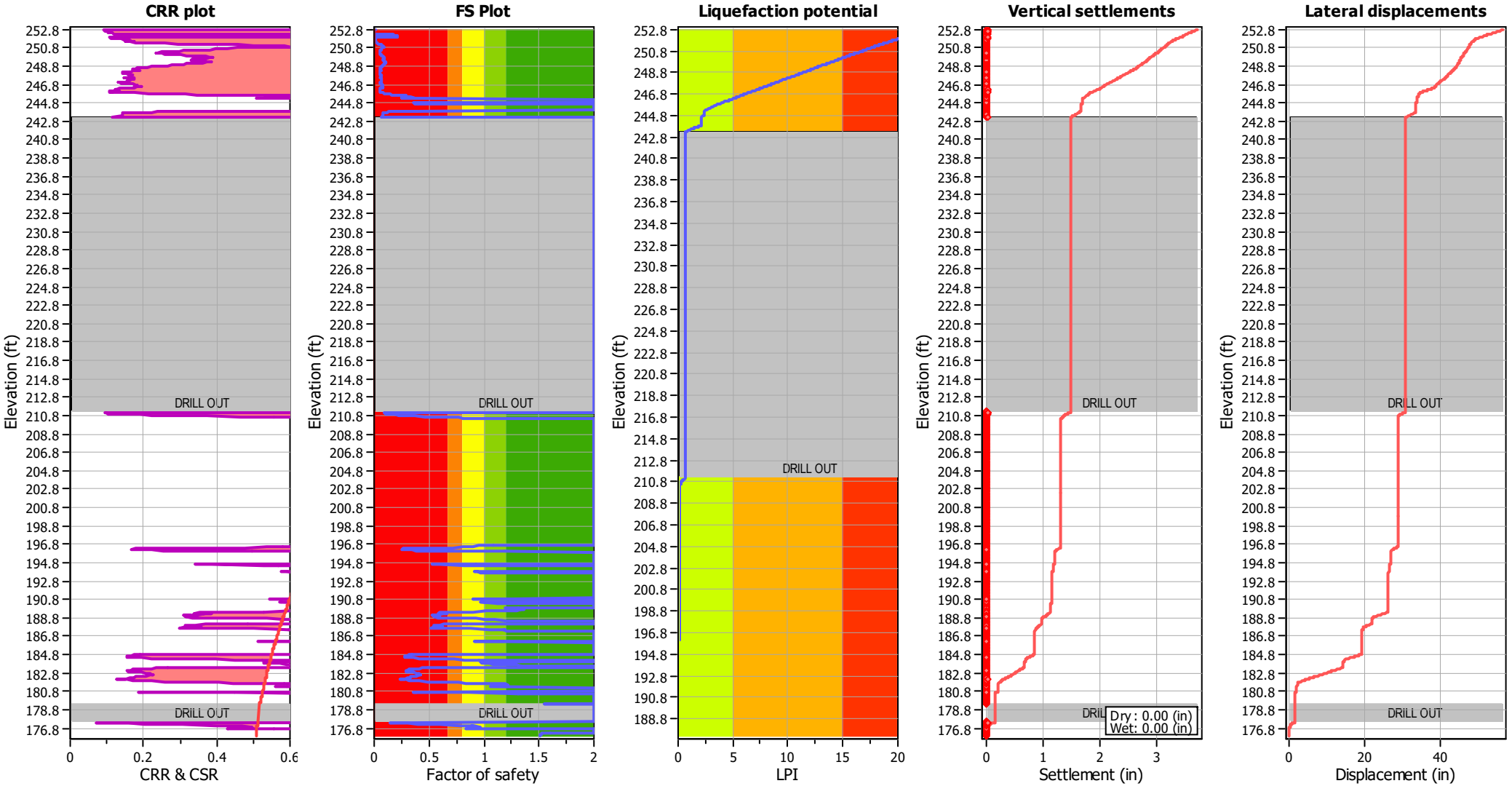
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

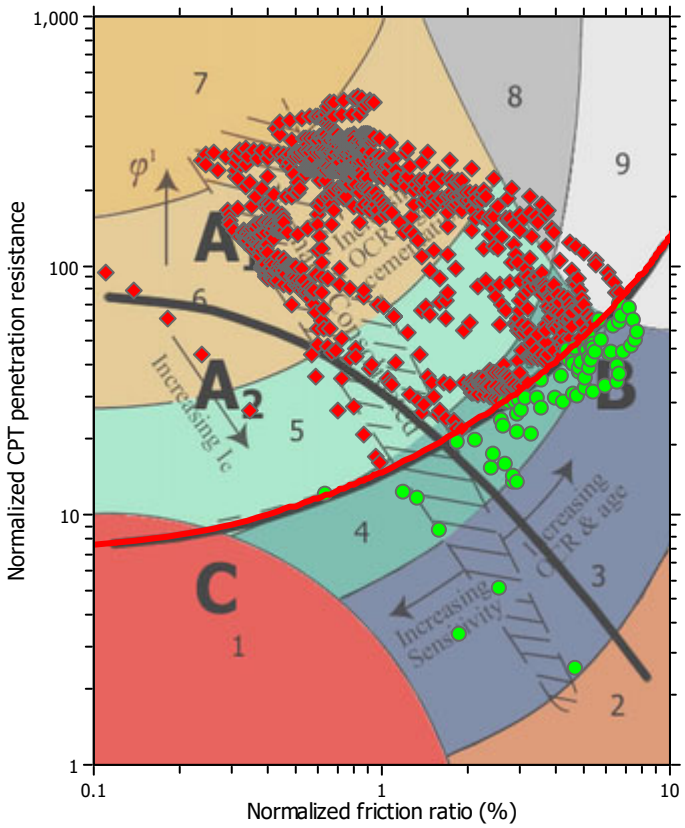
F.S. color scheme

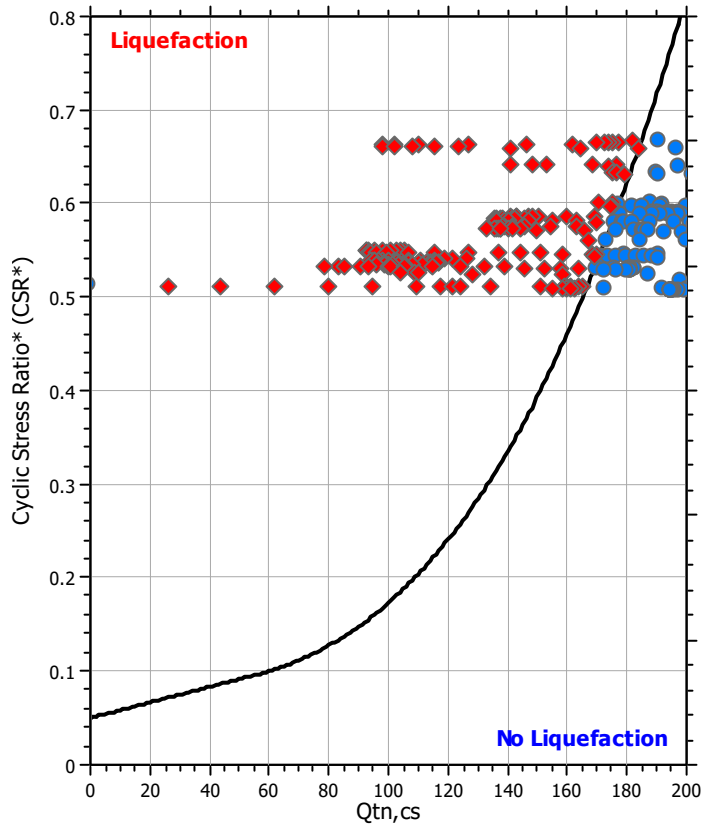
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

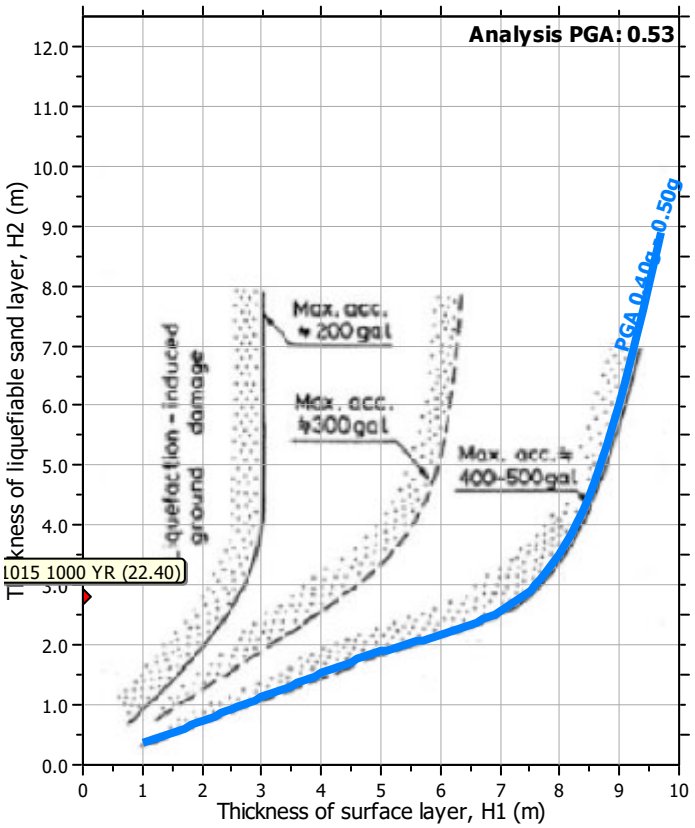
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots



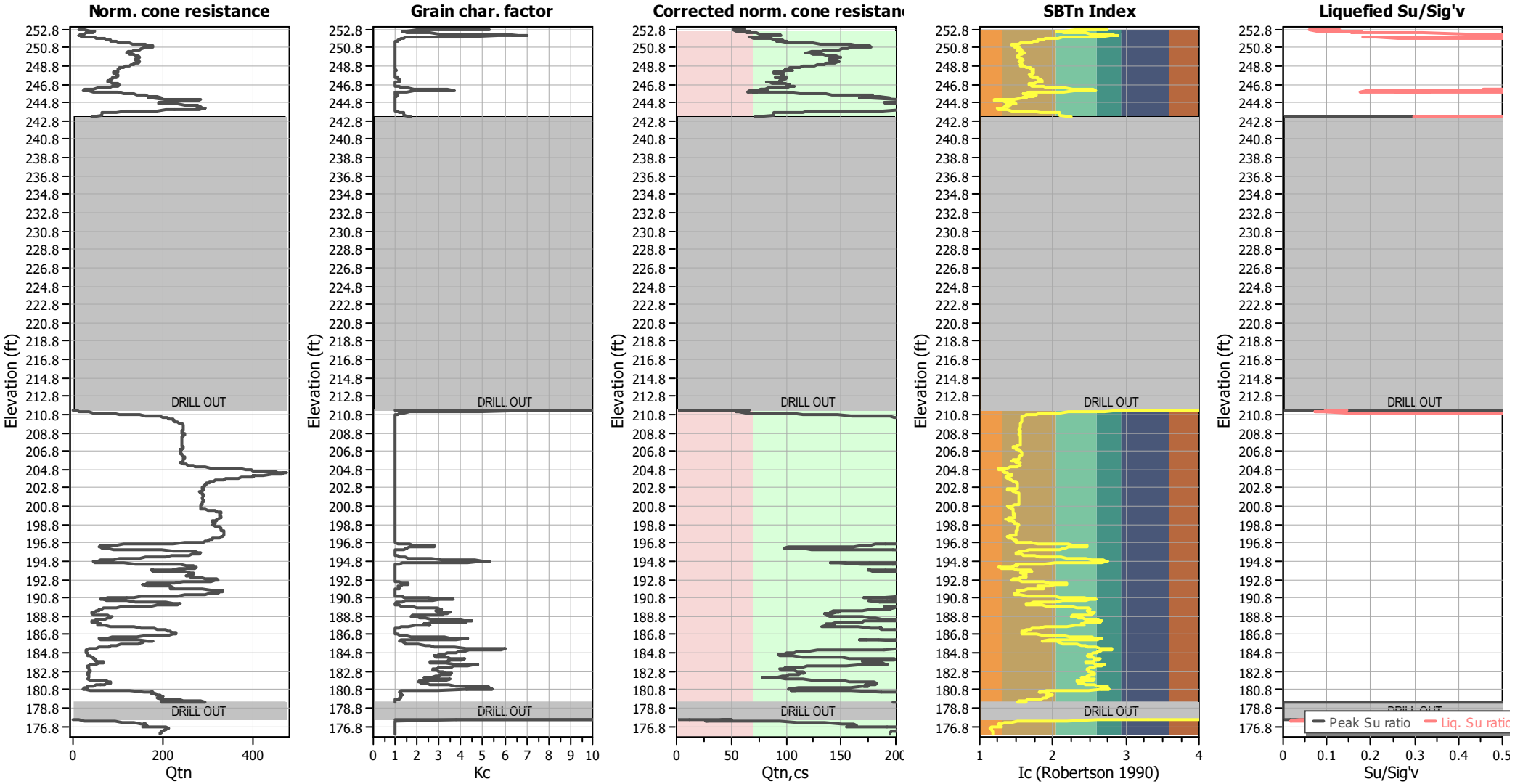




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

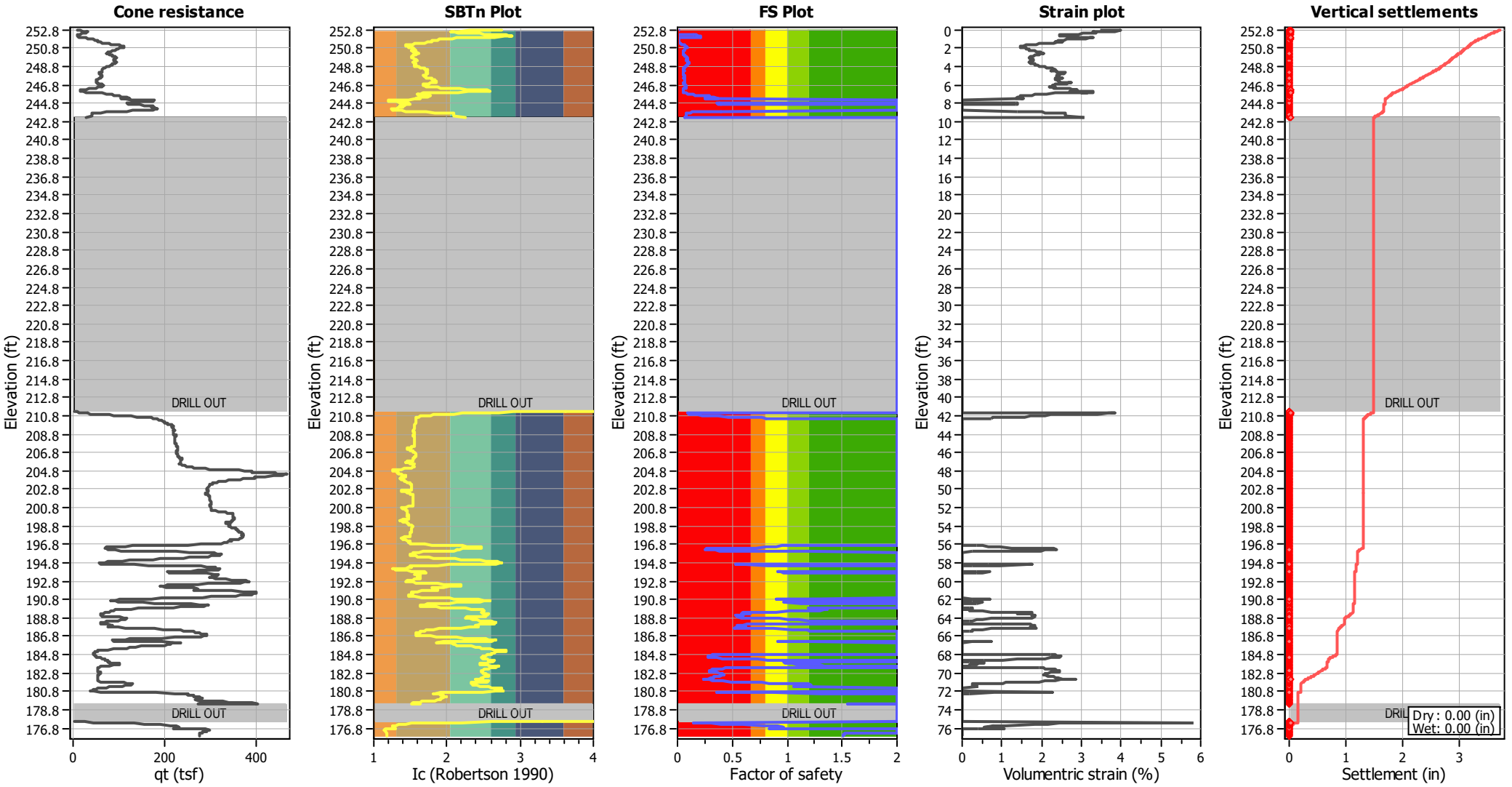
Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-29.06 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-29.06 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements

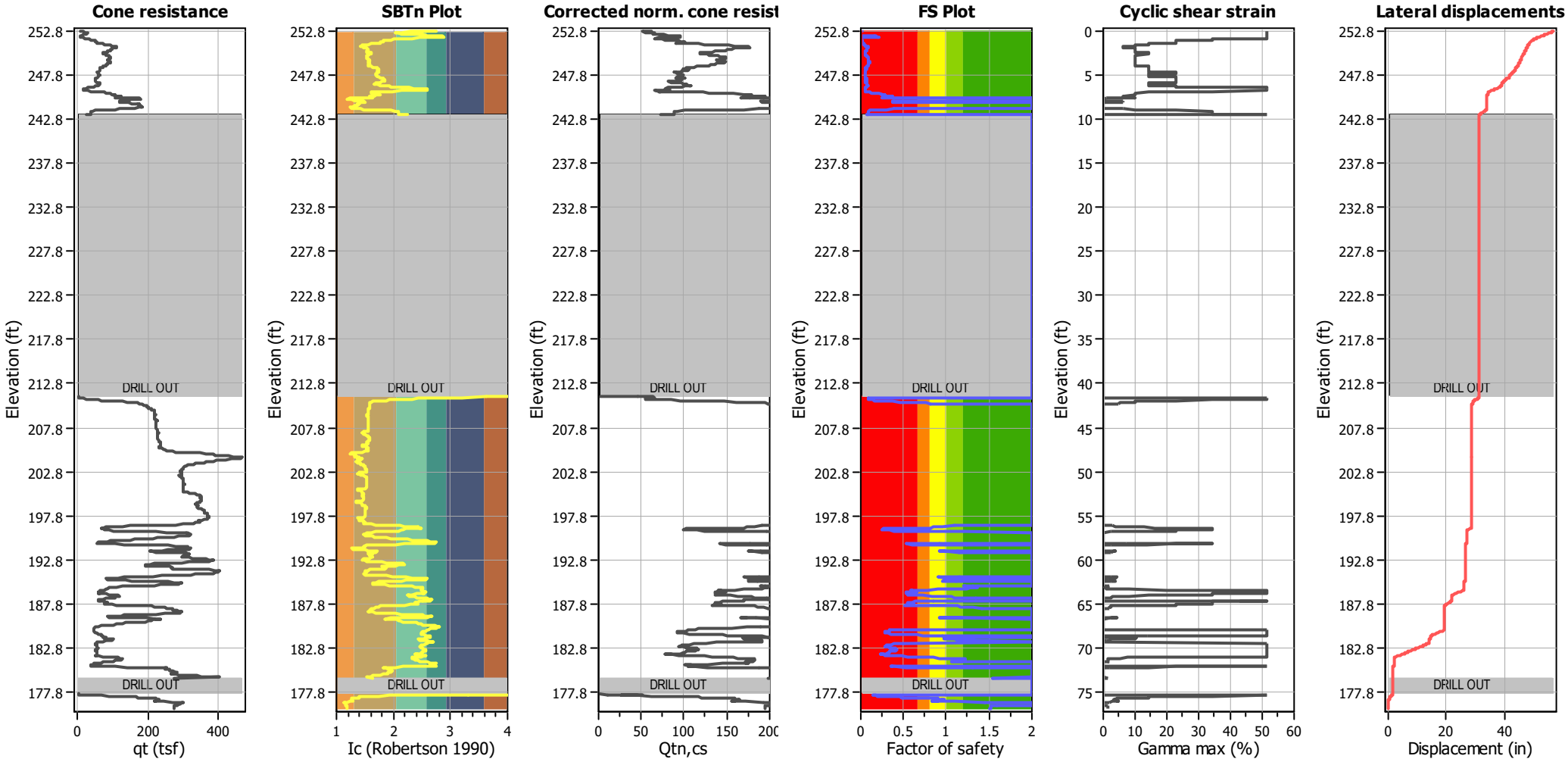


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements

Geometric parameters: Gently sloping ground without free face (Slope 1.00 %)



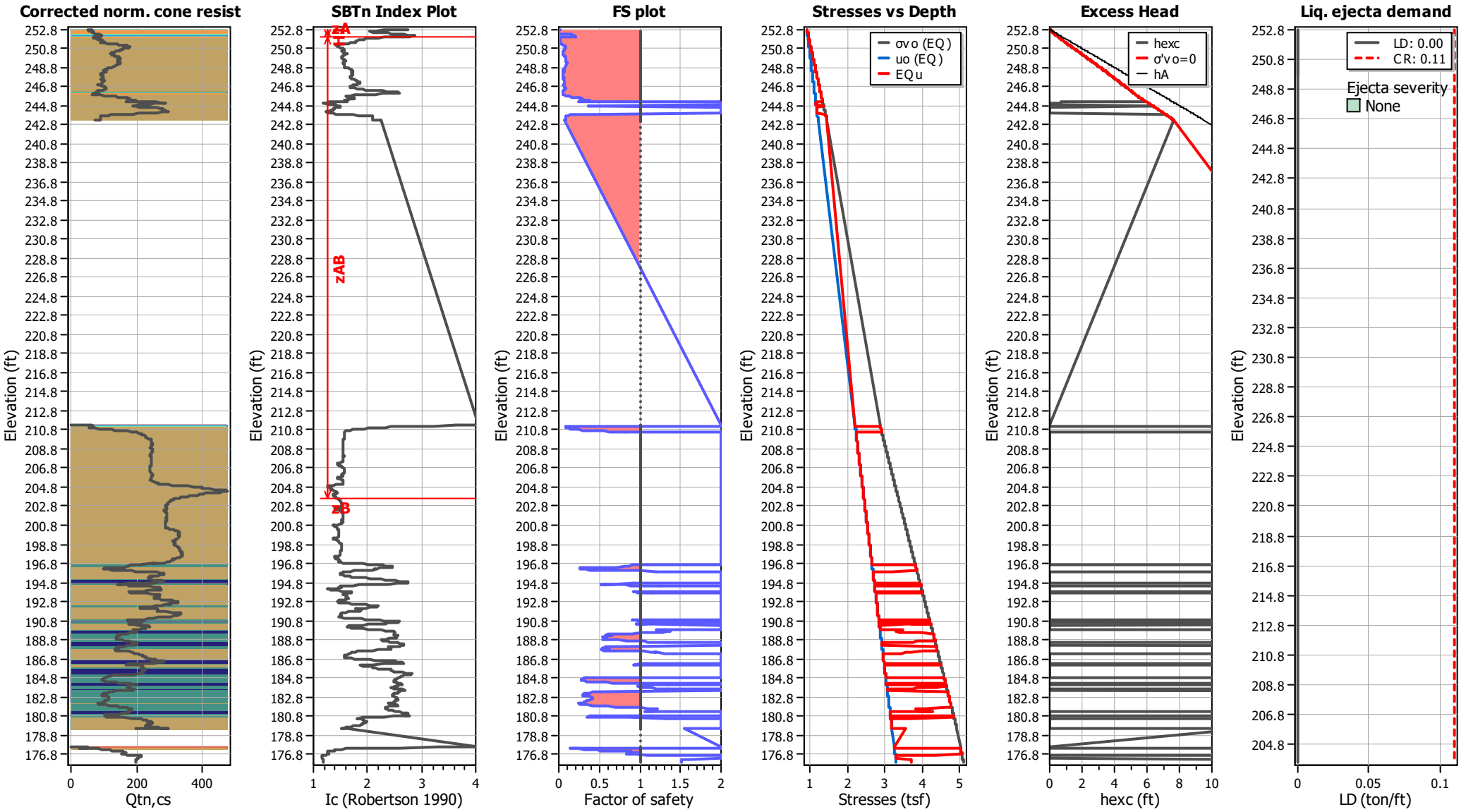
Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$Q_{tn,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Surface condition



Ejecta Severity Estimation



C1016

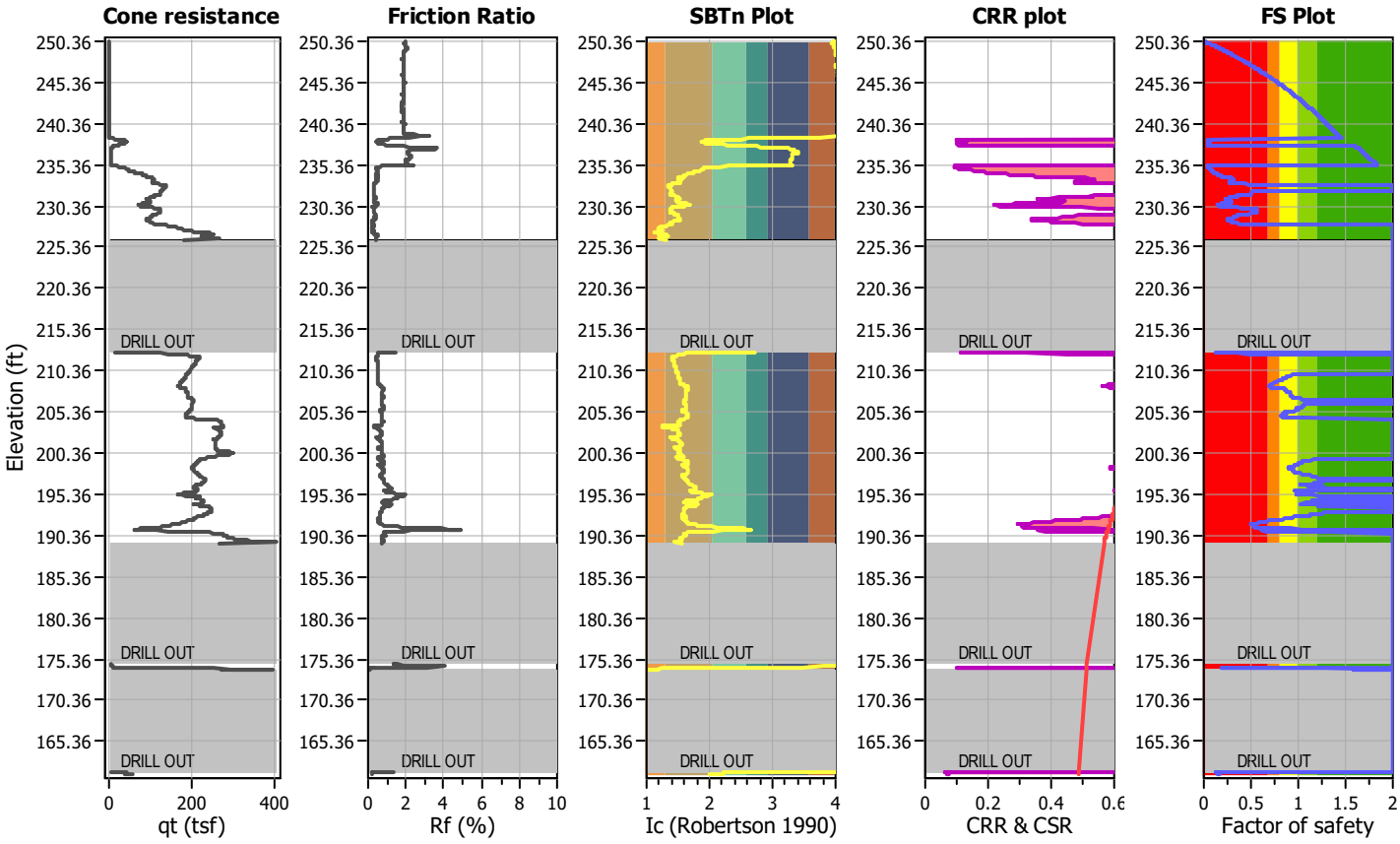
LIQUEFACTION ANALYSIS REPORT

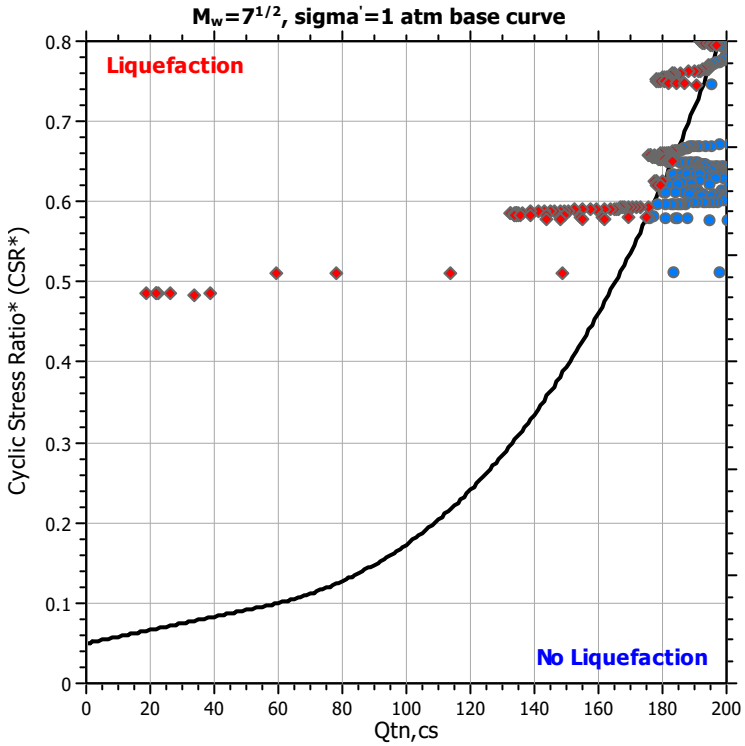
Project title : US-51 Bridge Replacement Project **Location : River Piers**

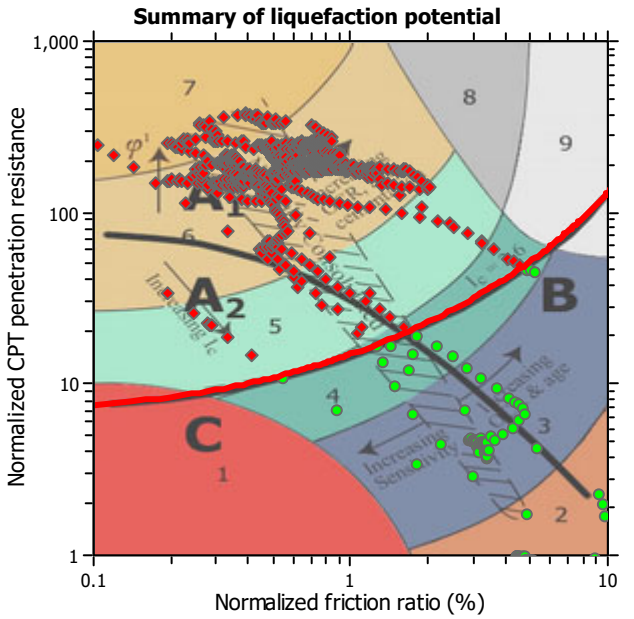
CPT file : C1016 1000 YR

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	-25.48 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	-25.48 ft	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w:	6.99	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.53	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based

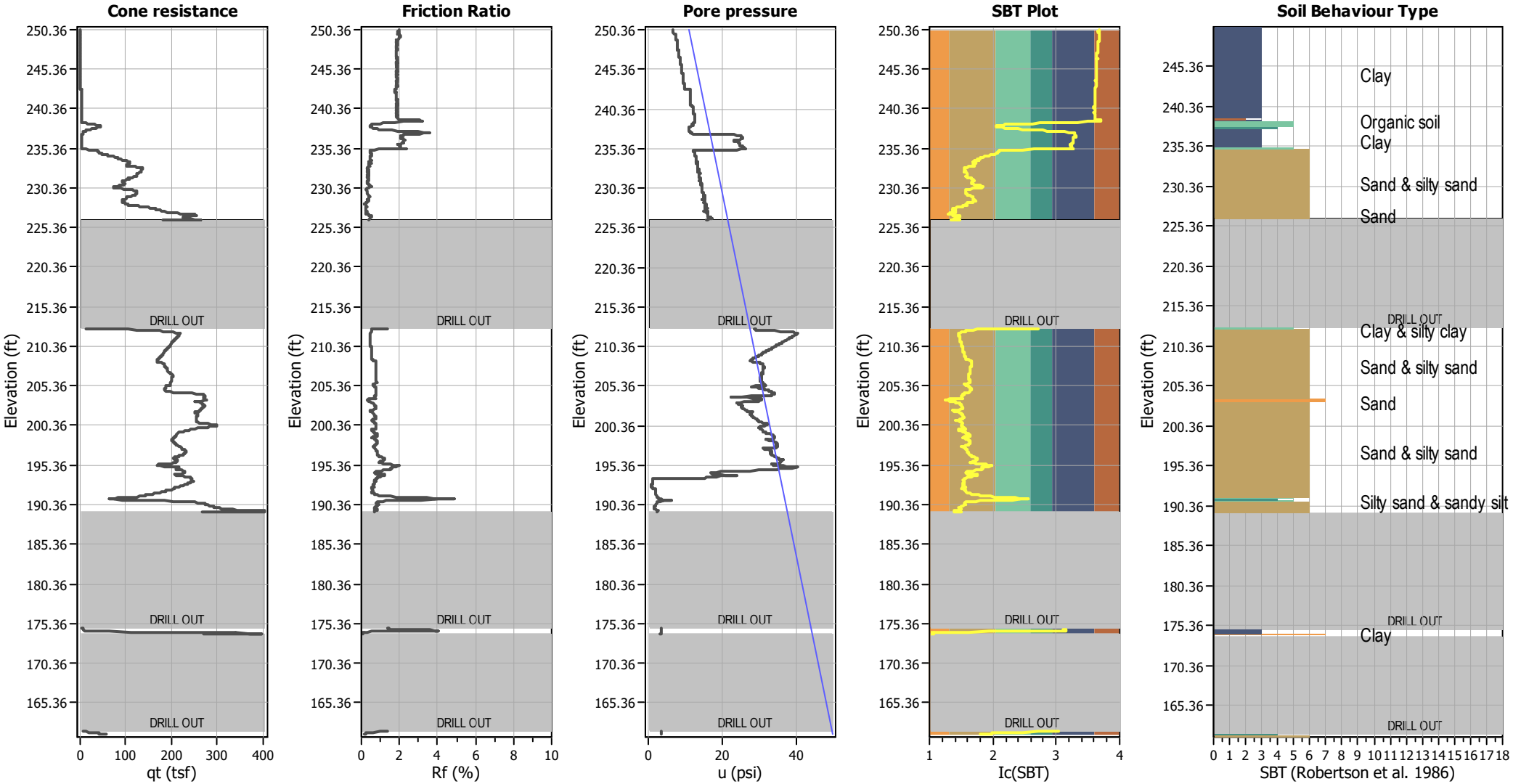






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



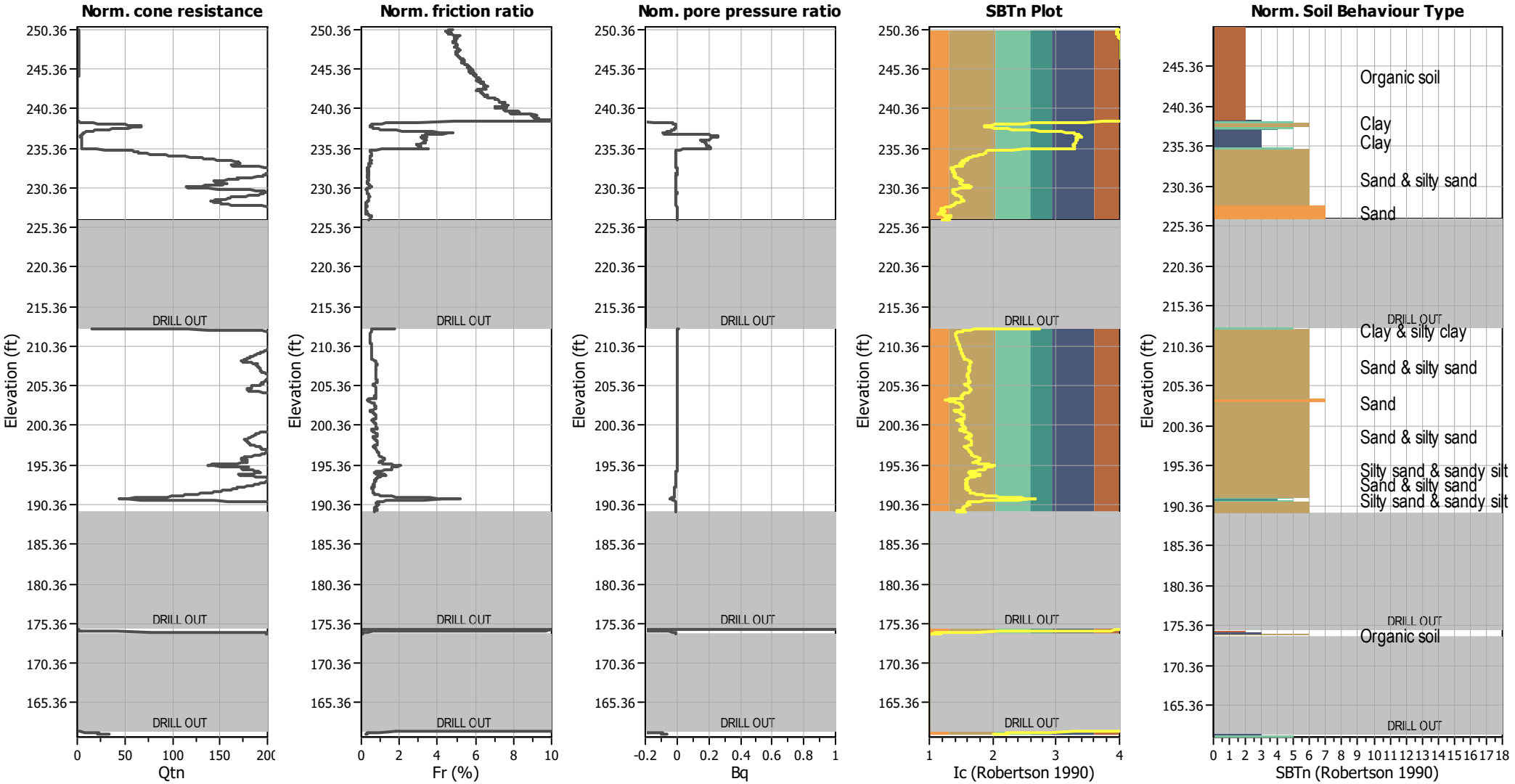
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
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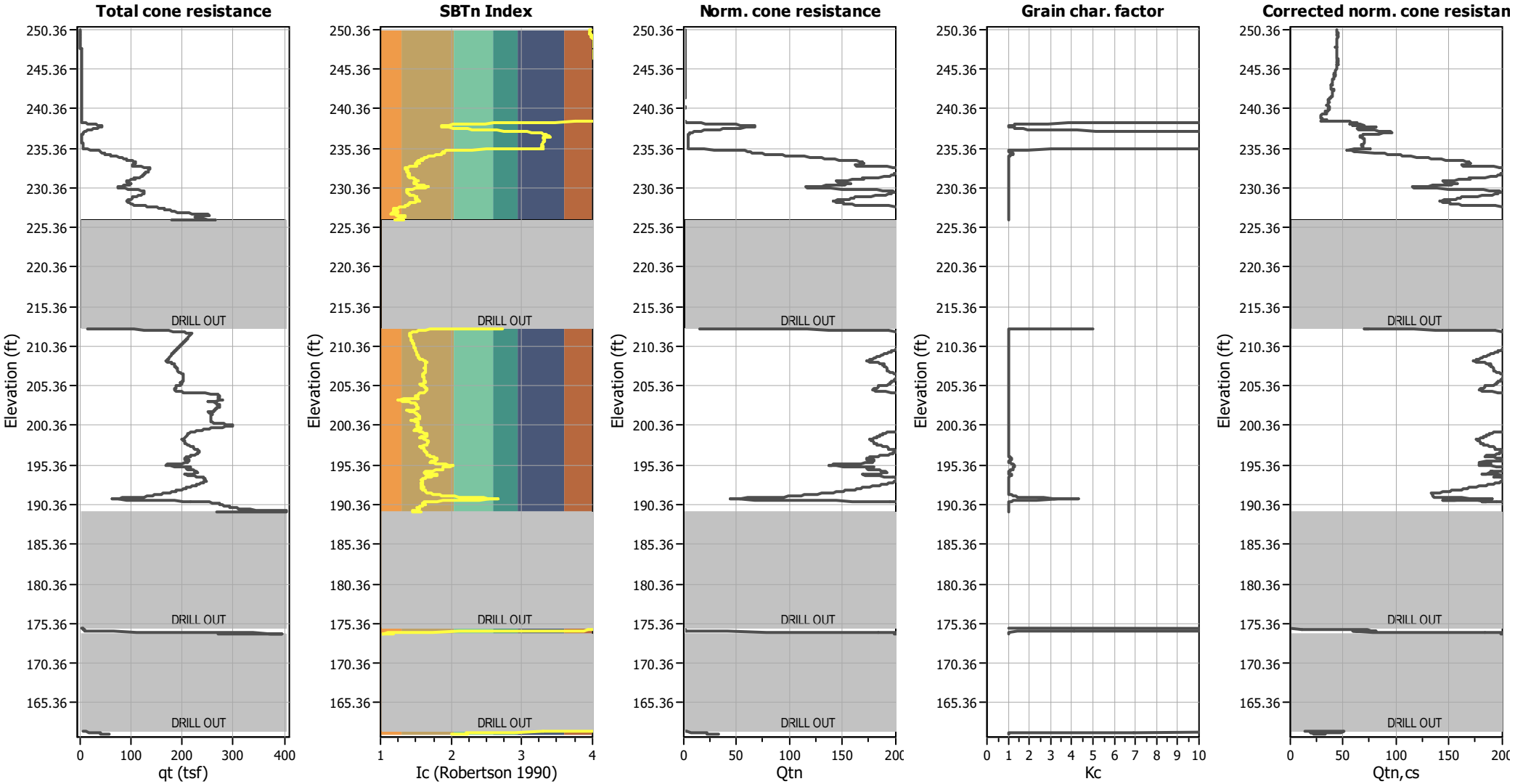
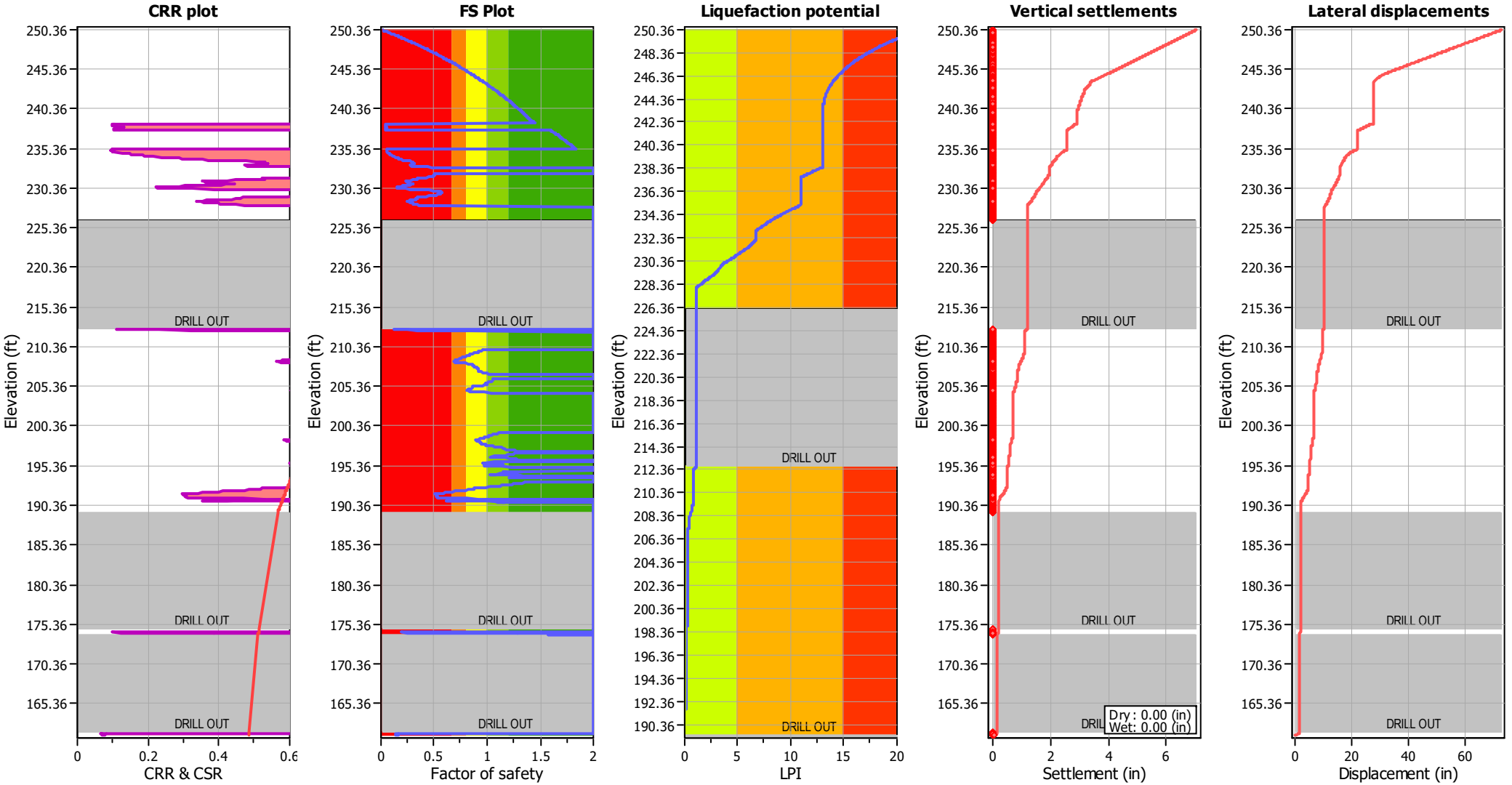
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

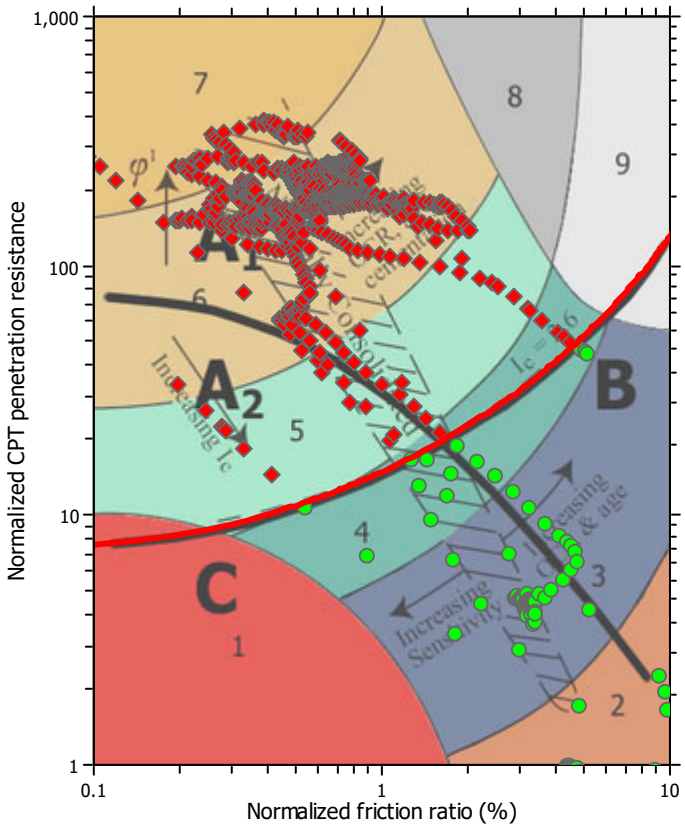
F.S. color scheme

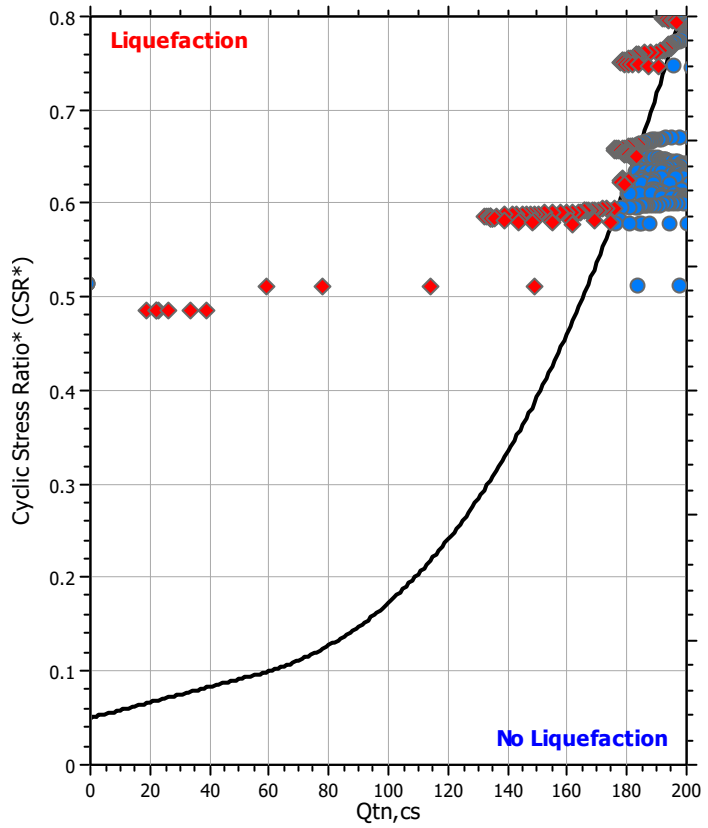
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

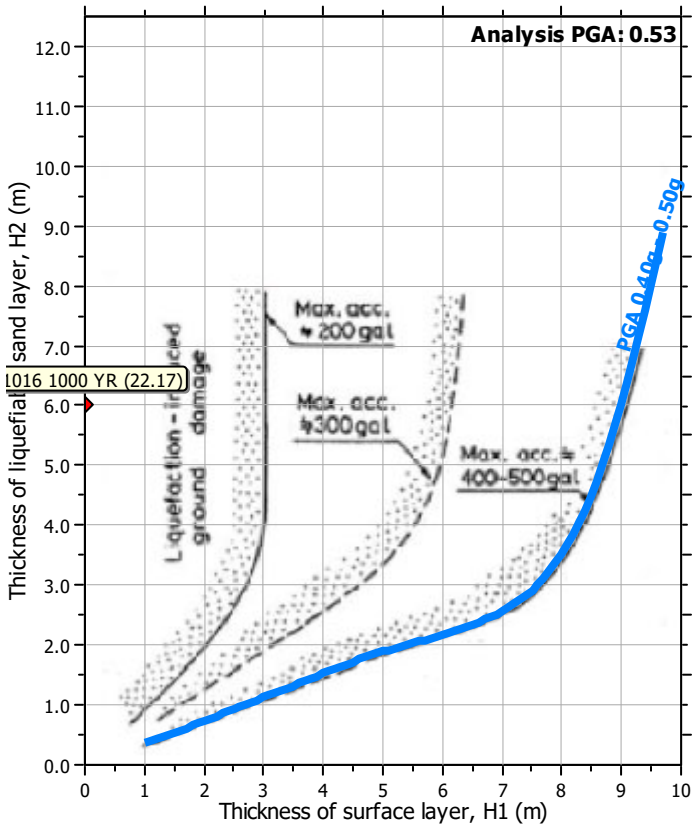
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots



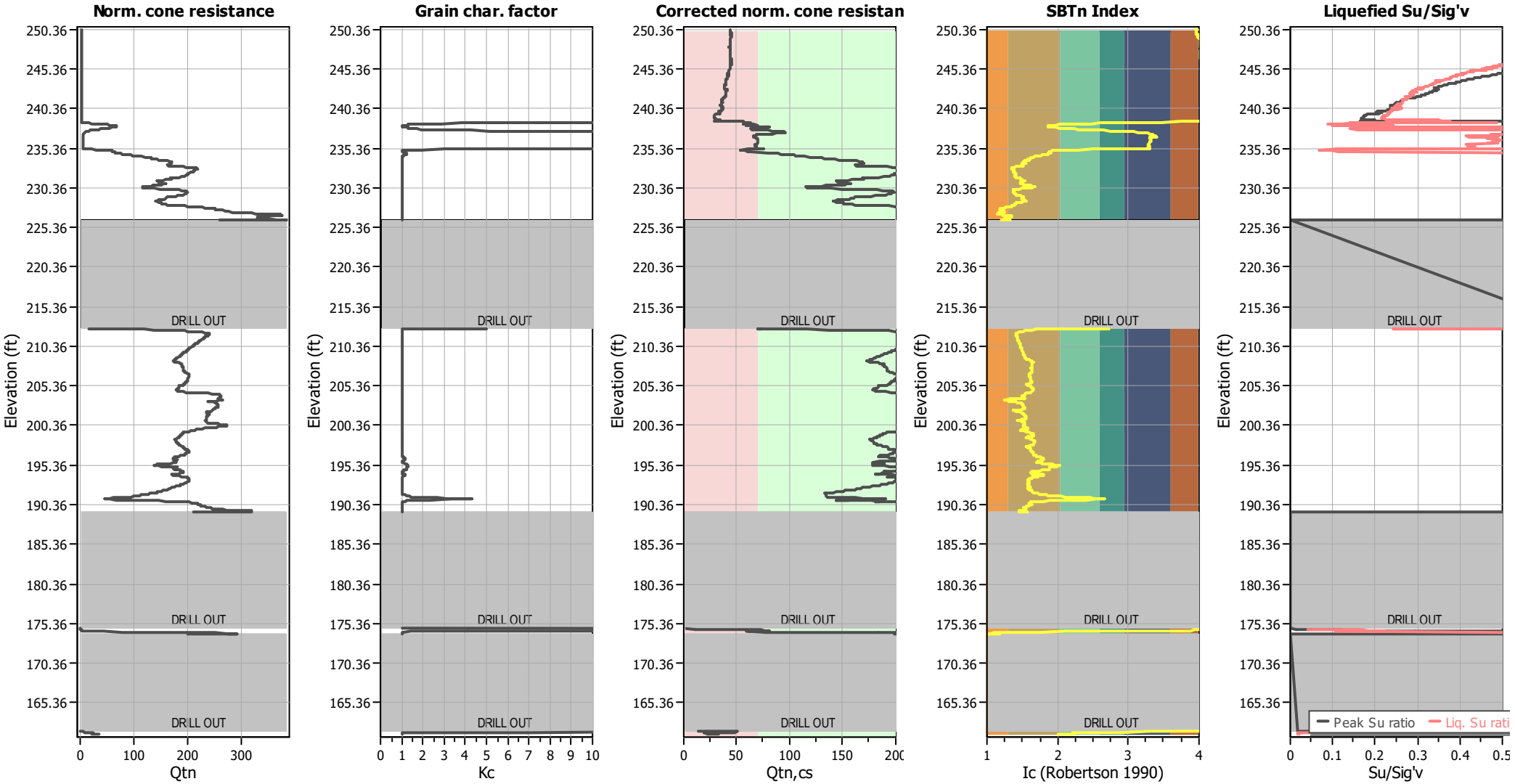




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

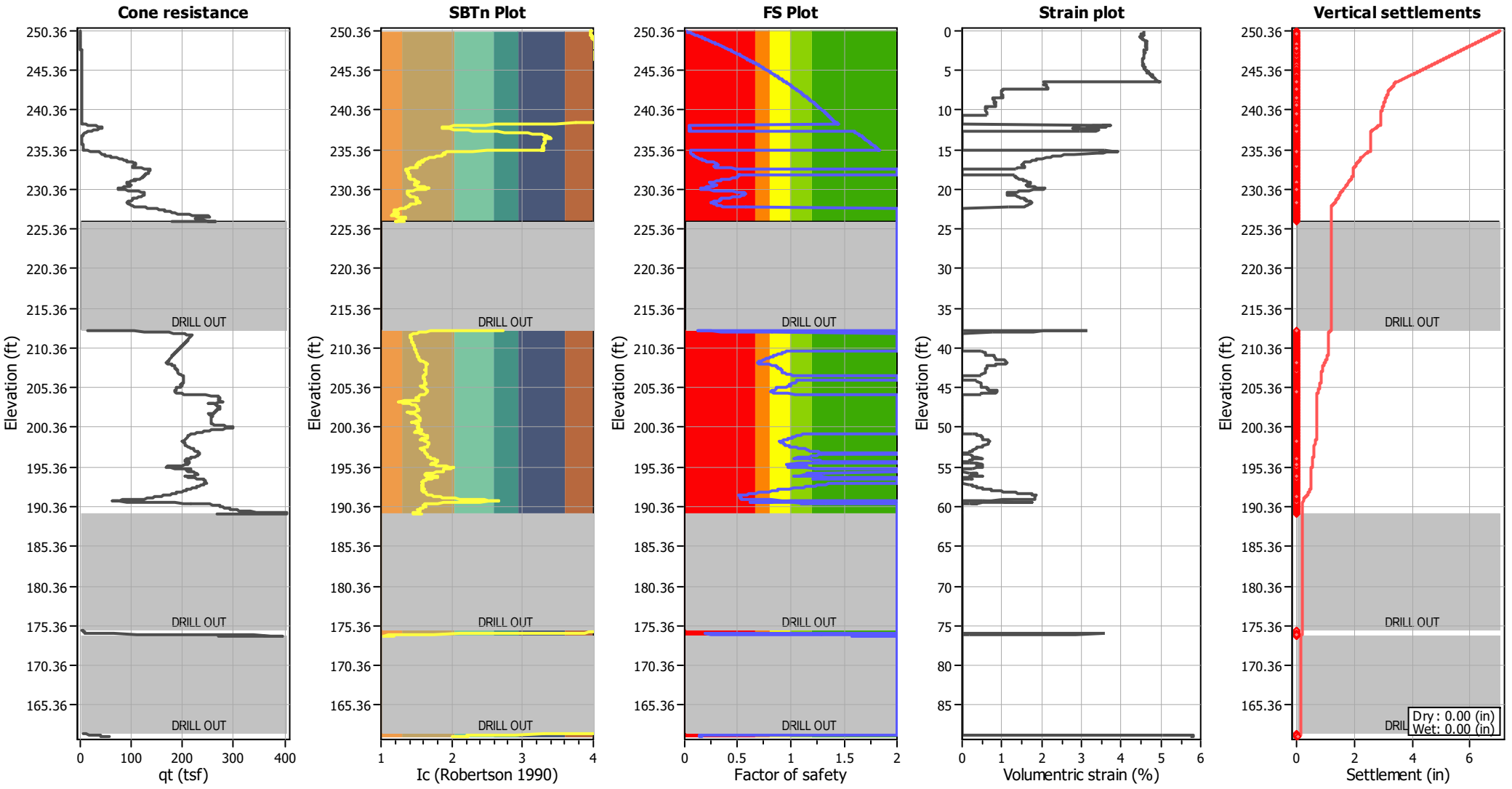
Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	-25.48 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.99	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.53	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	-25.48 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements

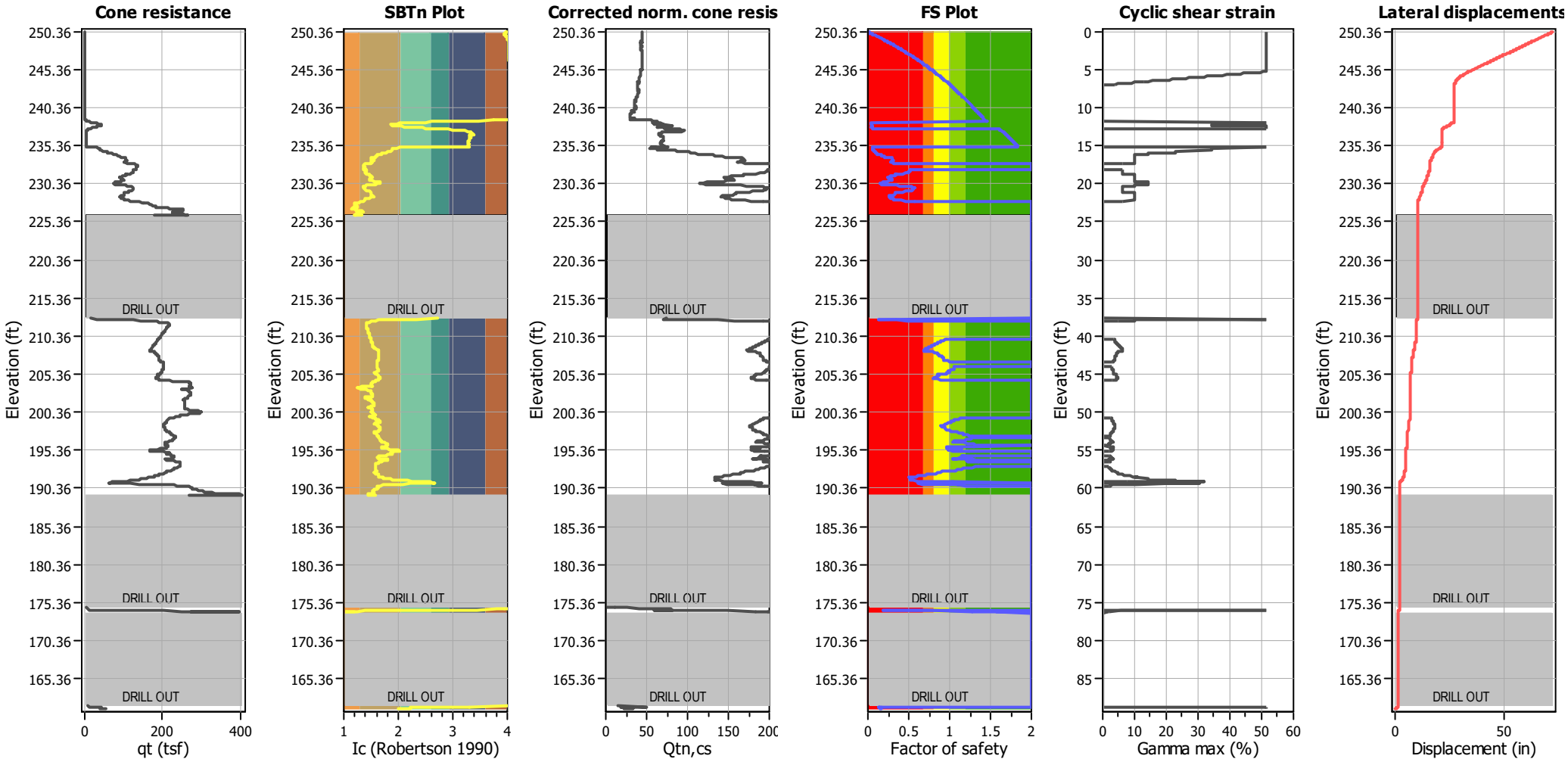


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements

Geometric parameters: Gently sloping ground without free face (Slope 1.00 %)



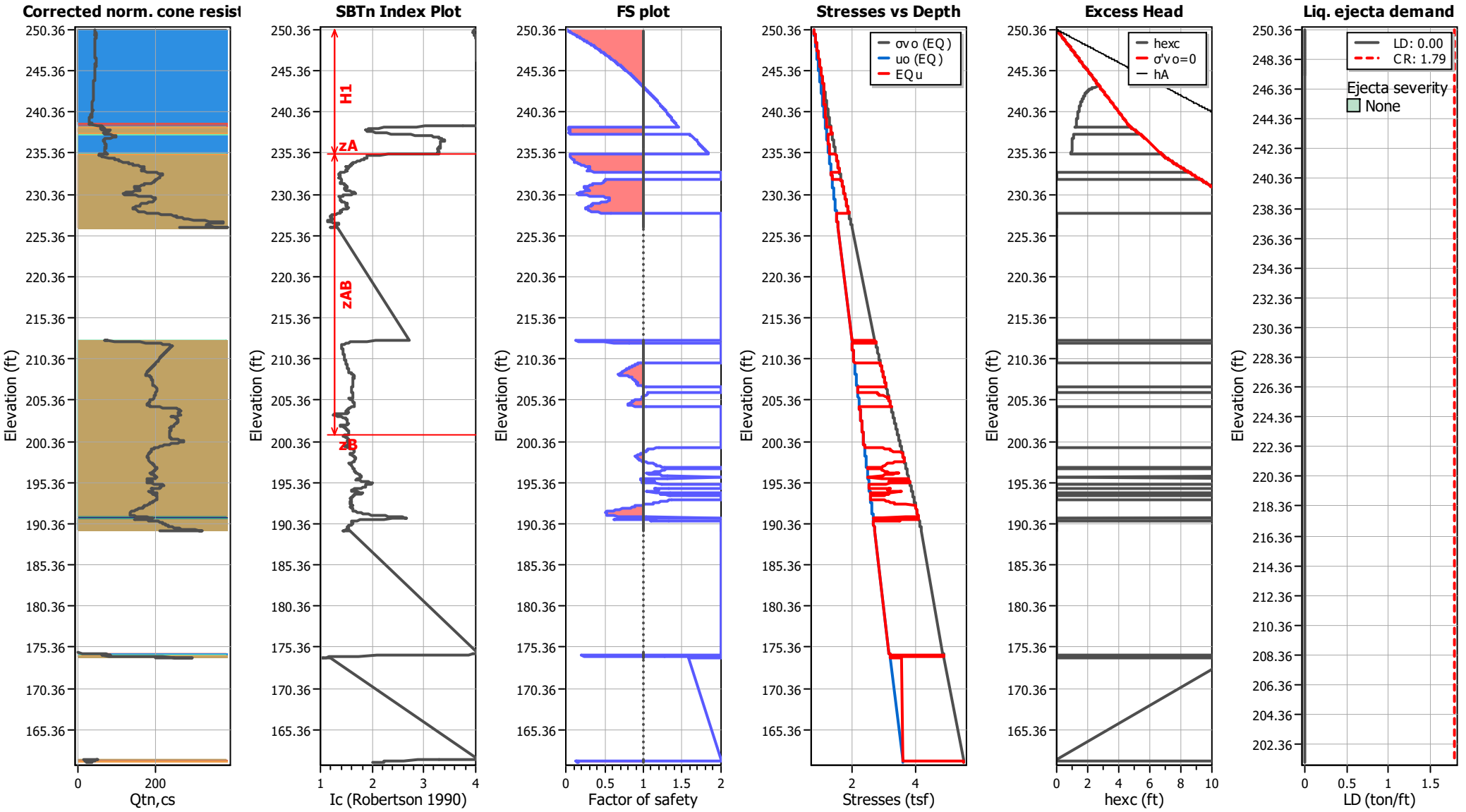
Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$Q_{tn,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Surface condition



Ejecta Severity Estimation

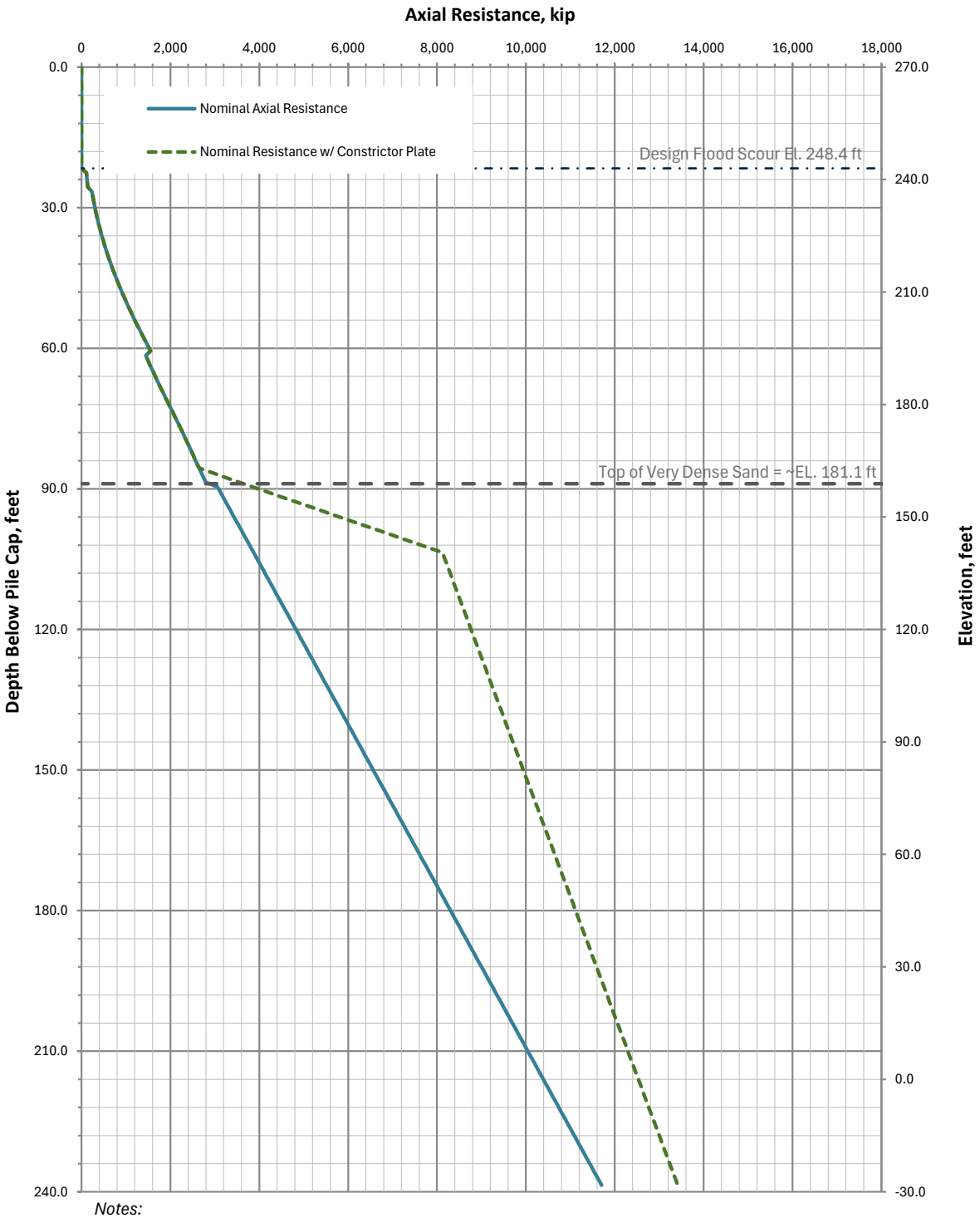


Appendix F – Deep Foundation Analyses

Static Axial Resistance Curves

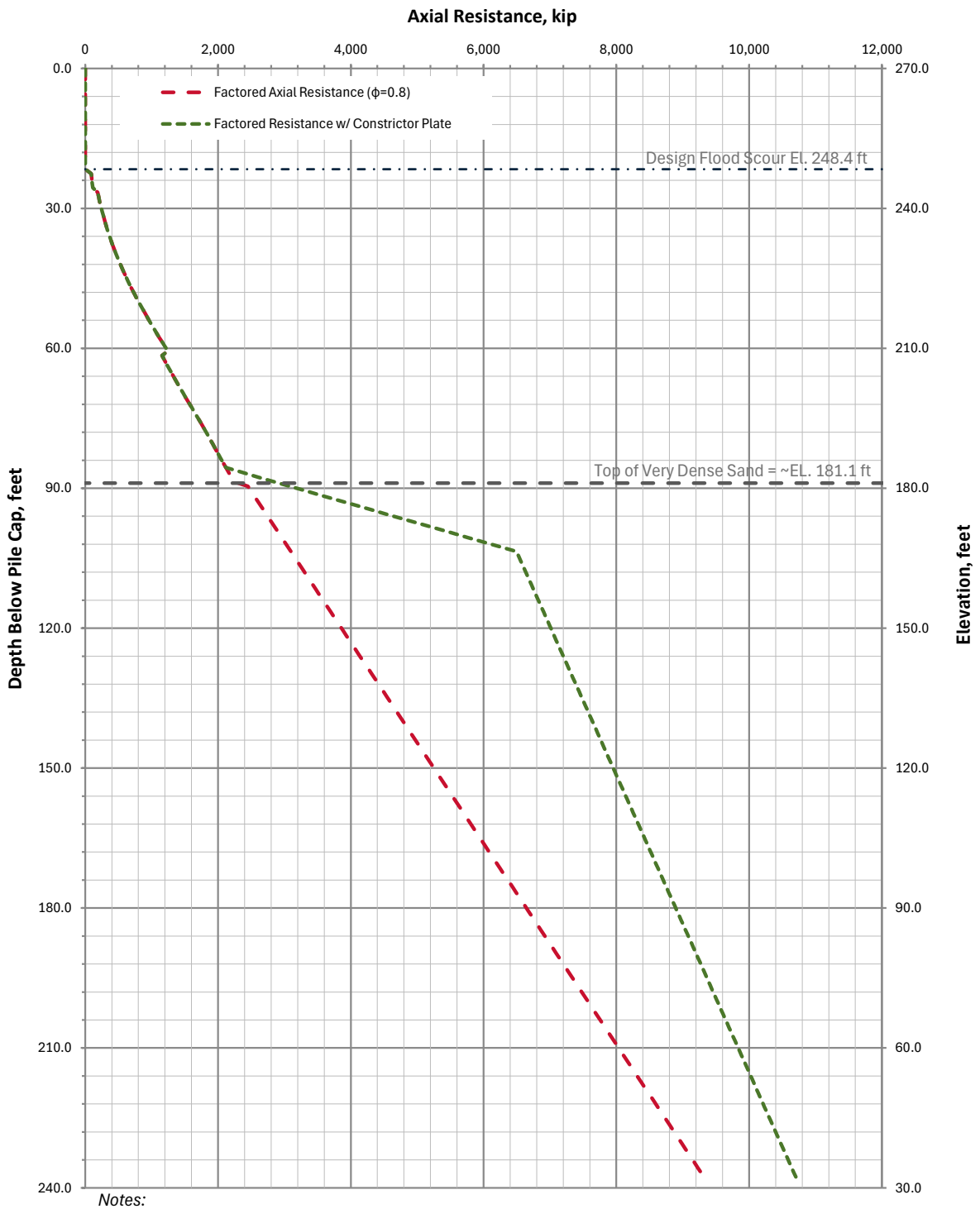
PIER 3

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



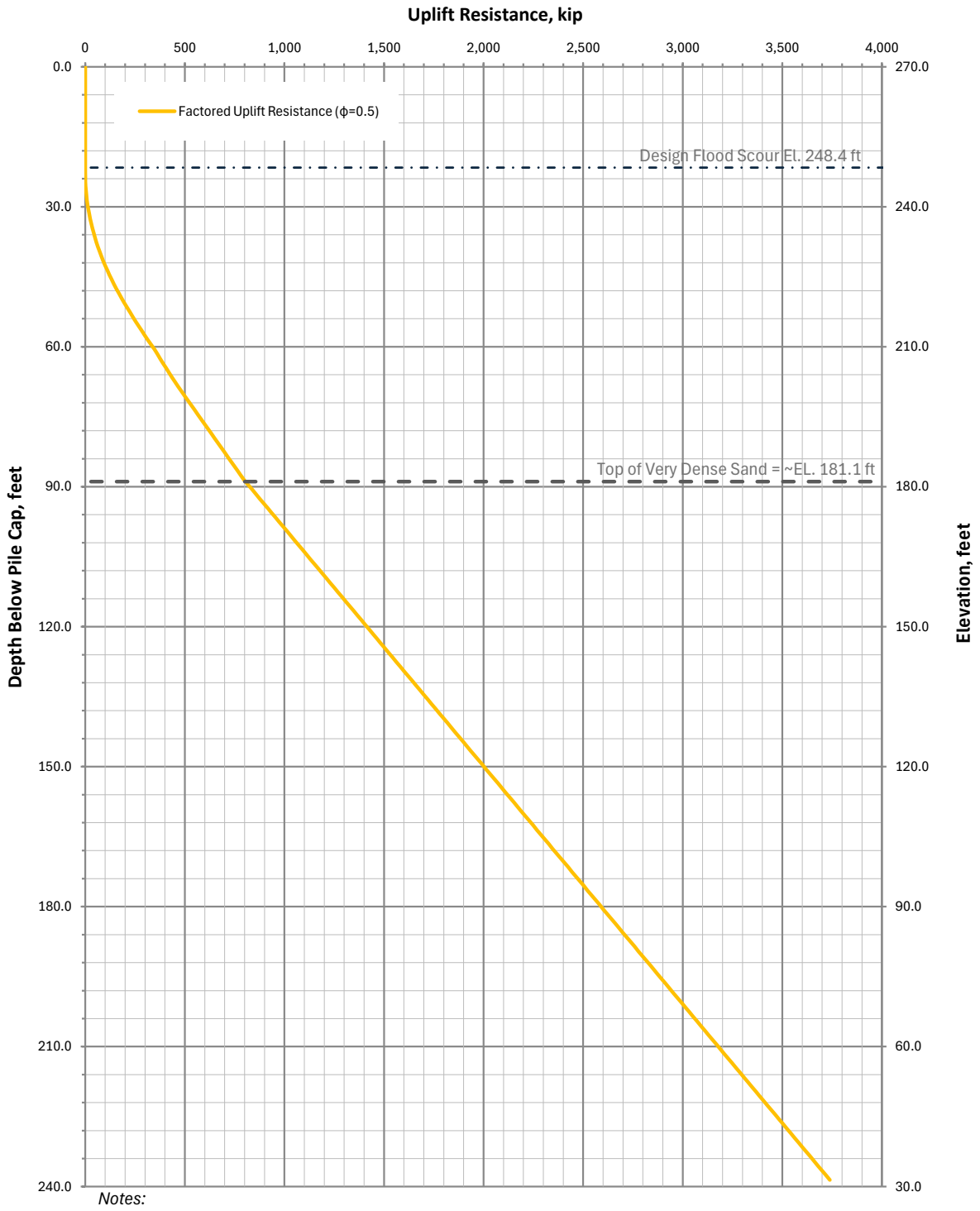
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

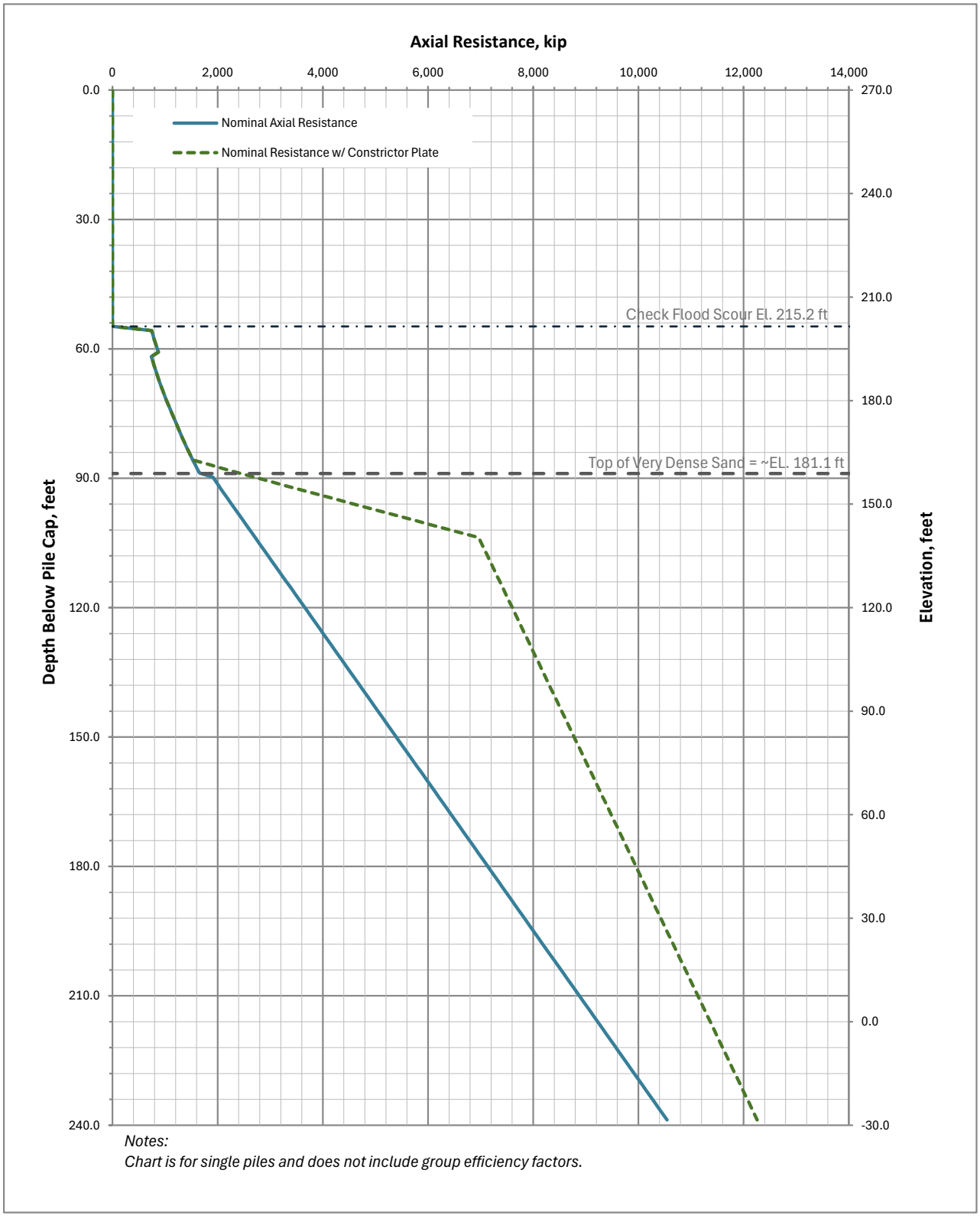
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.

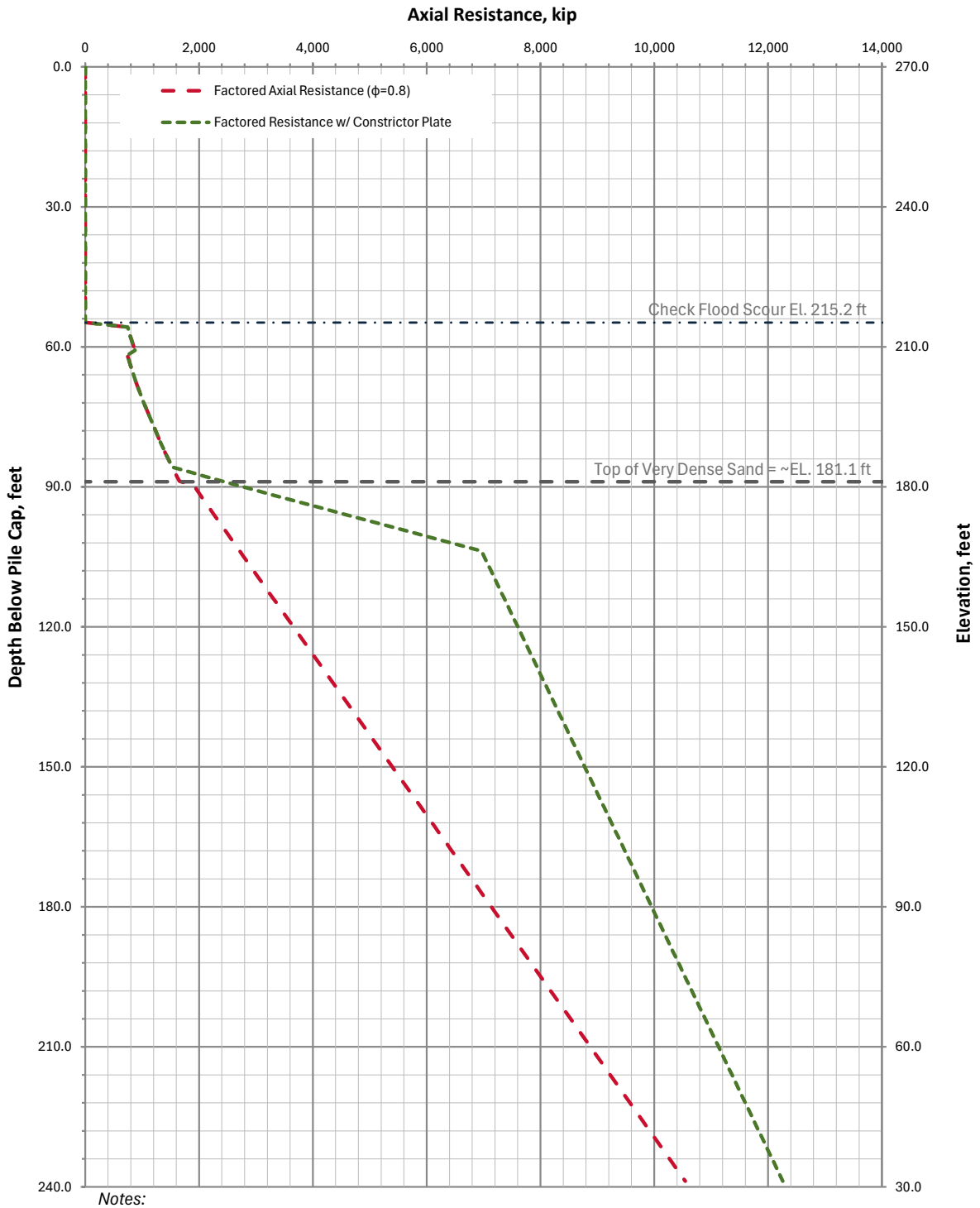
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



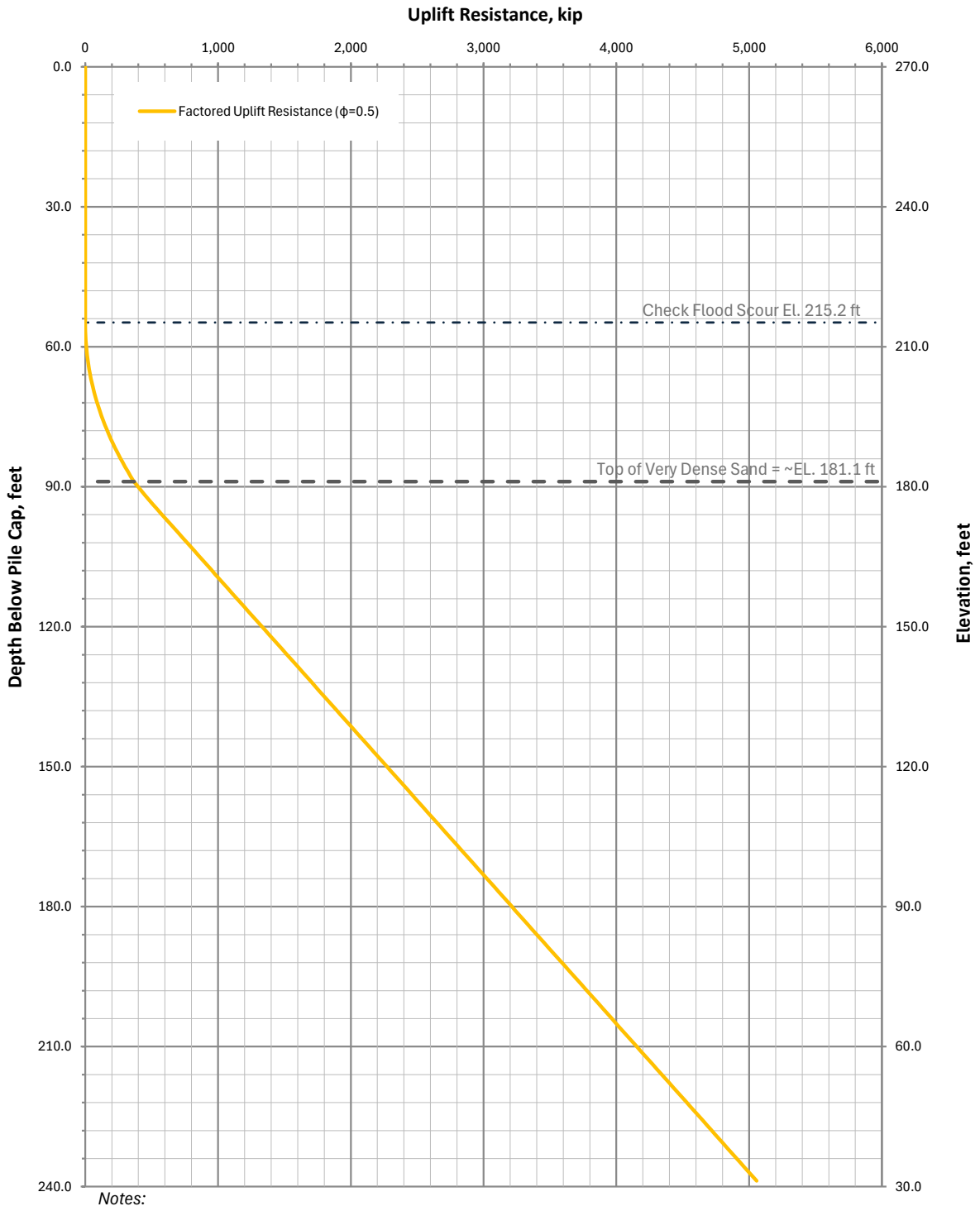
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.

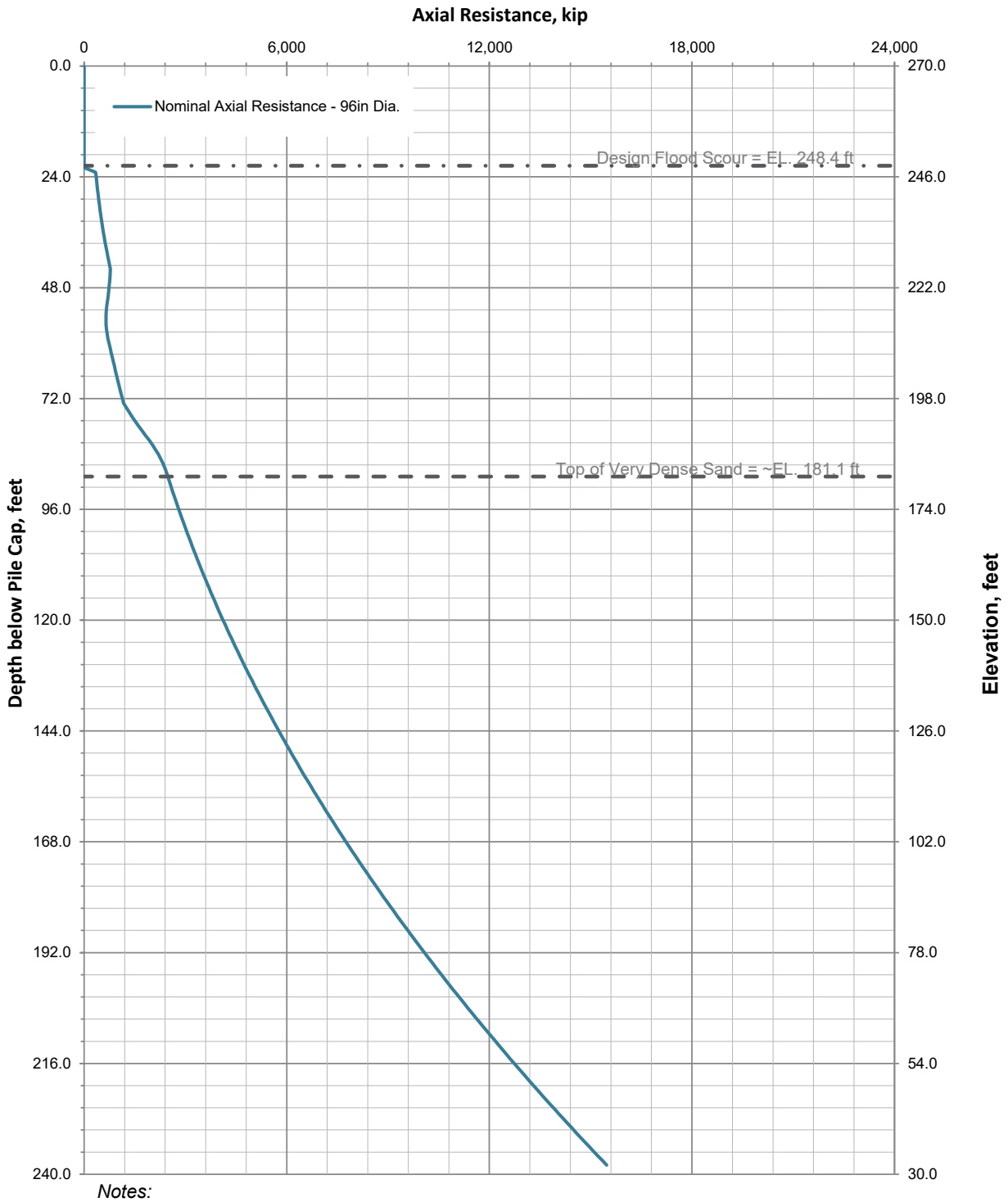
Prepared by:

Prepared for:

TEAM KENTUCKY
TRANSPORTATION CABINET

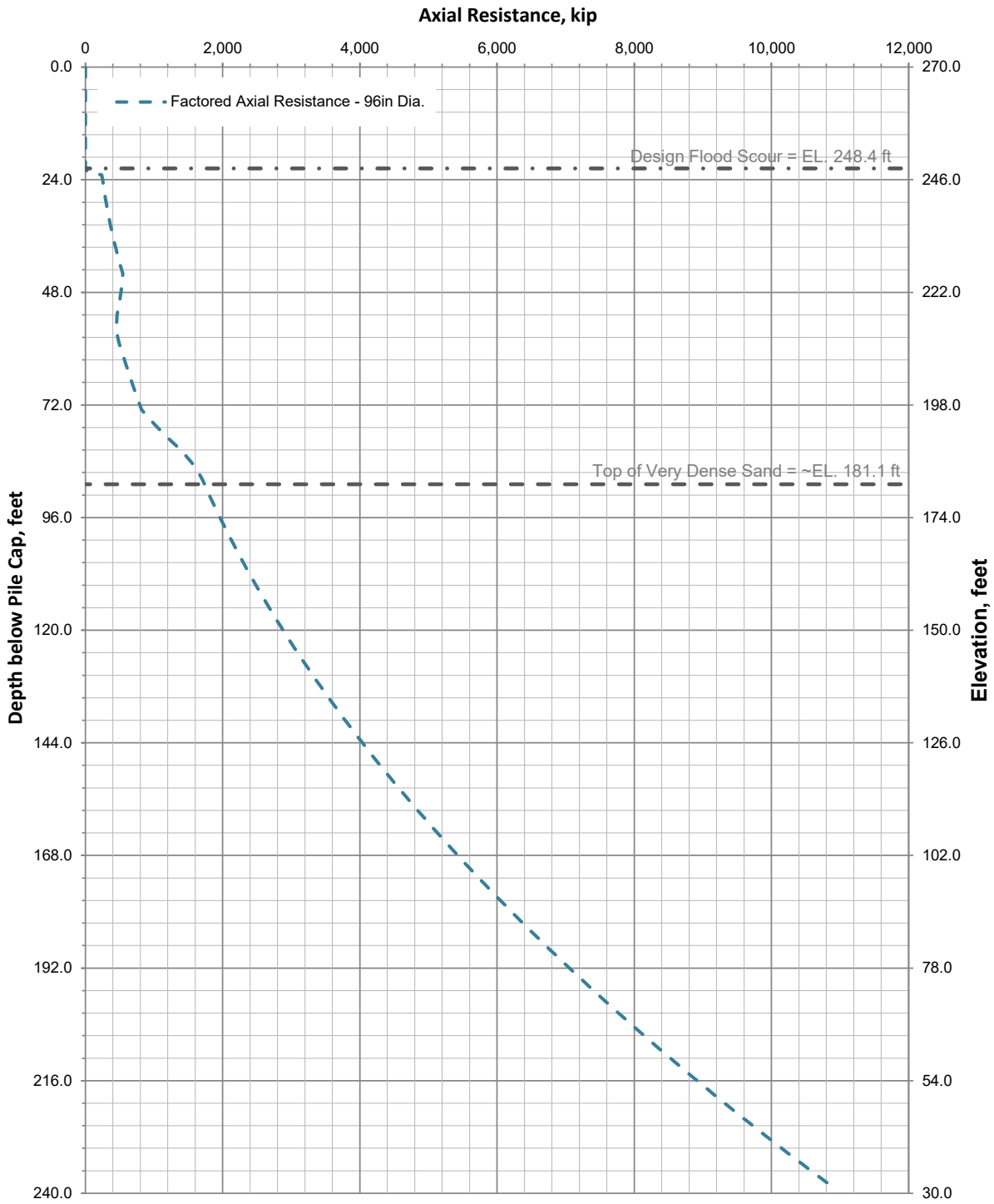
Pier 3
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Factored Uplift Resistance Graph
Extreme Event-II

Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 12/19/25
Drawn By: SKB **Figure No. ##**
Date: 12/16/25



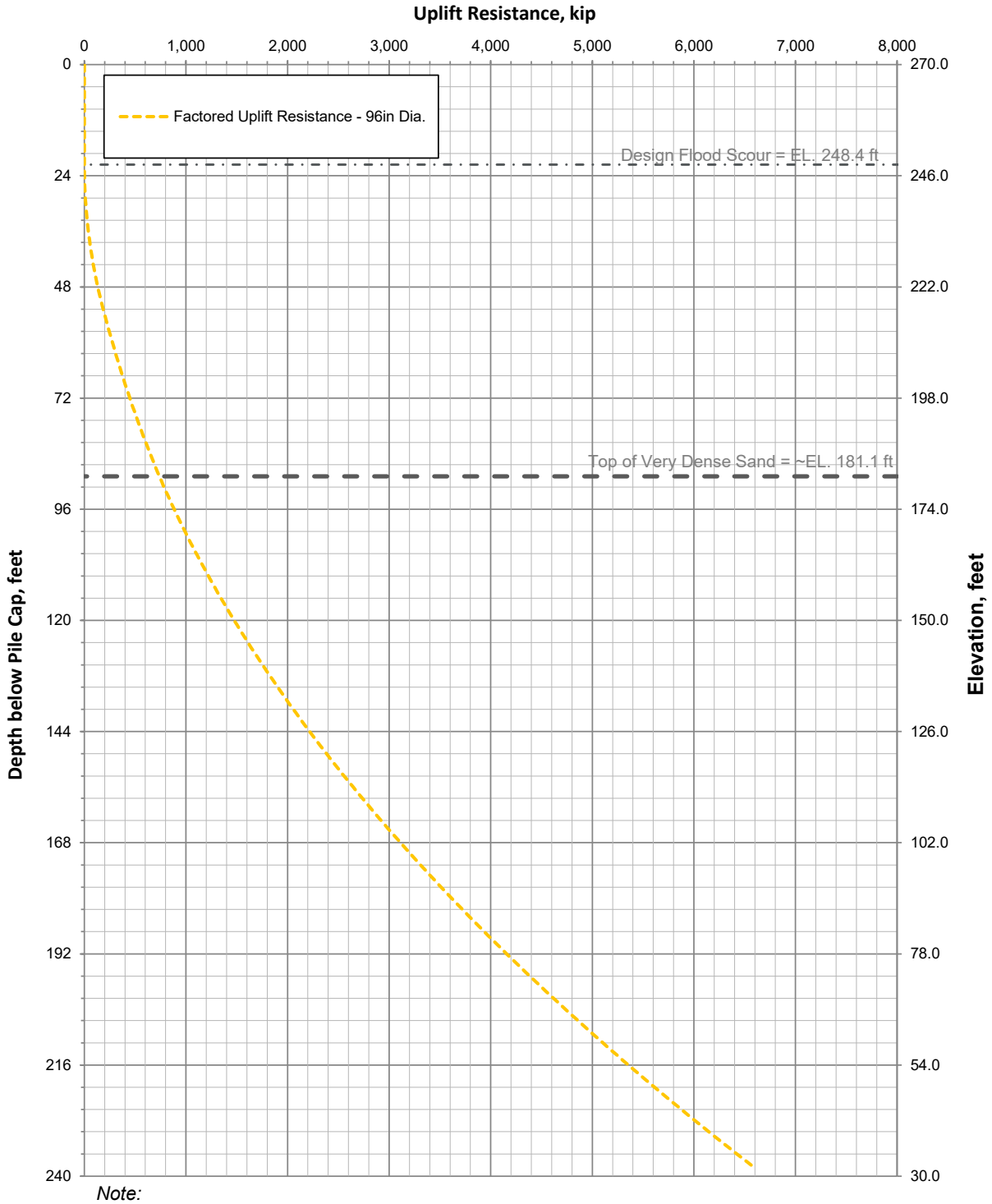
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



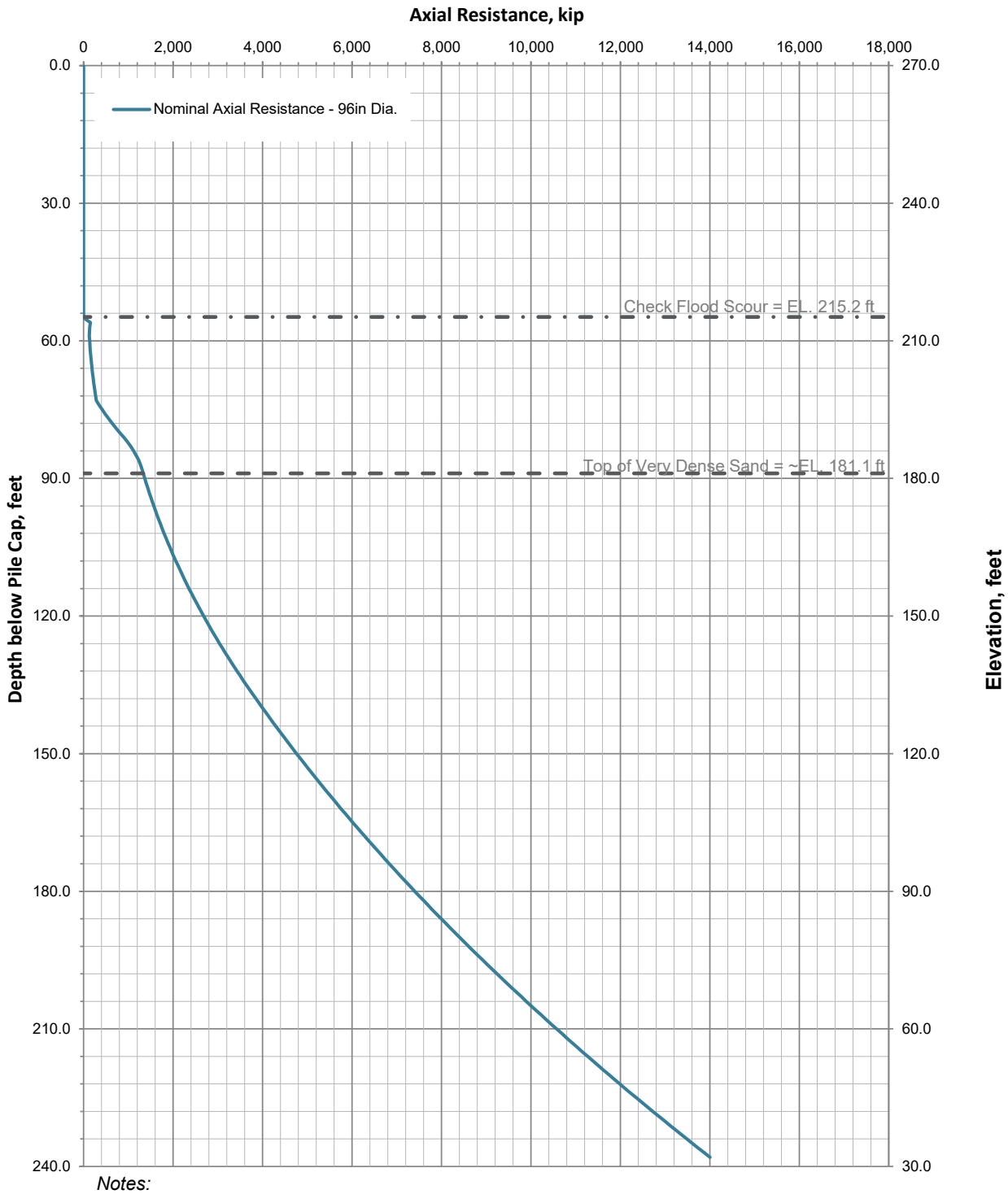
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



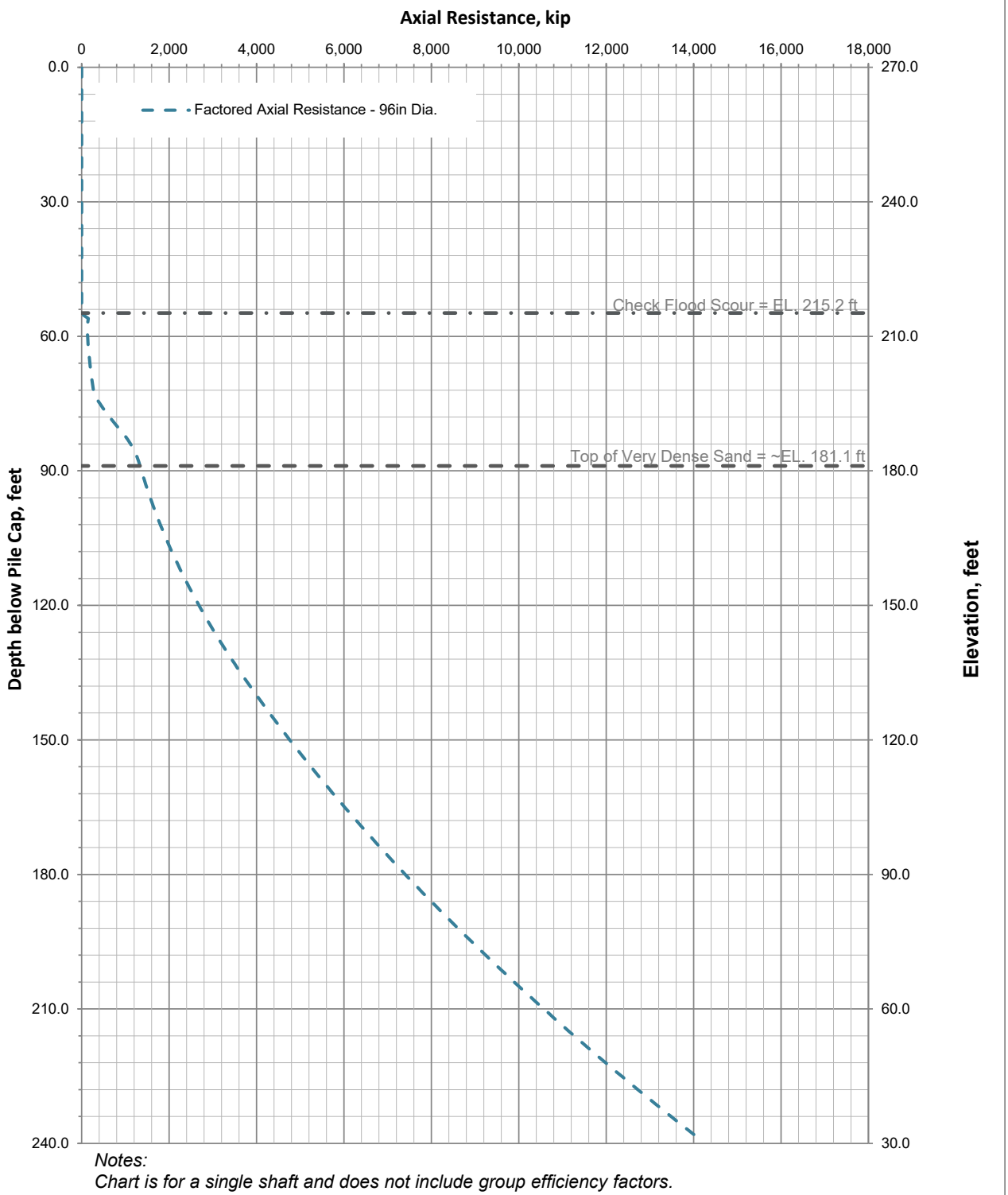
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



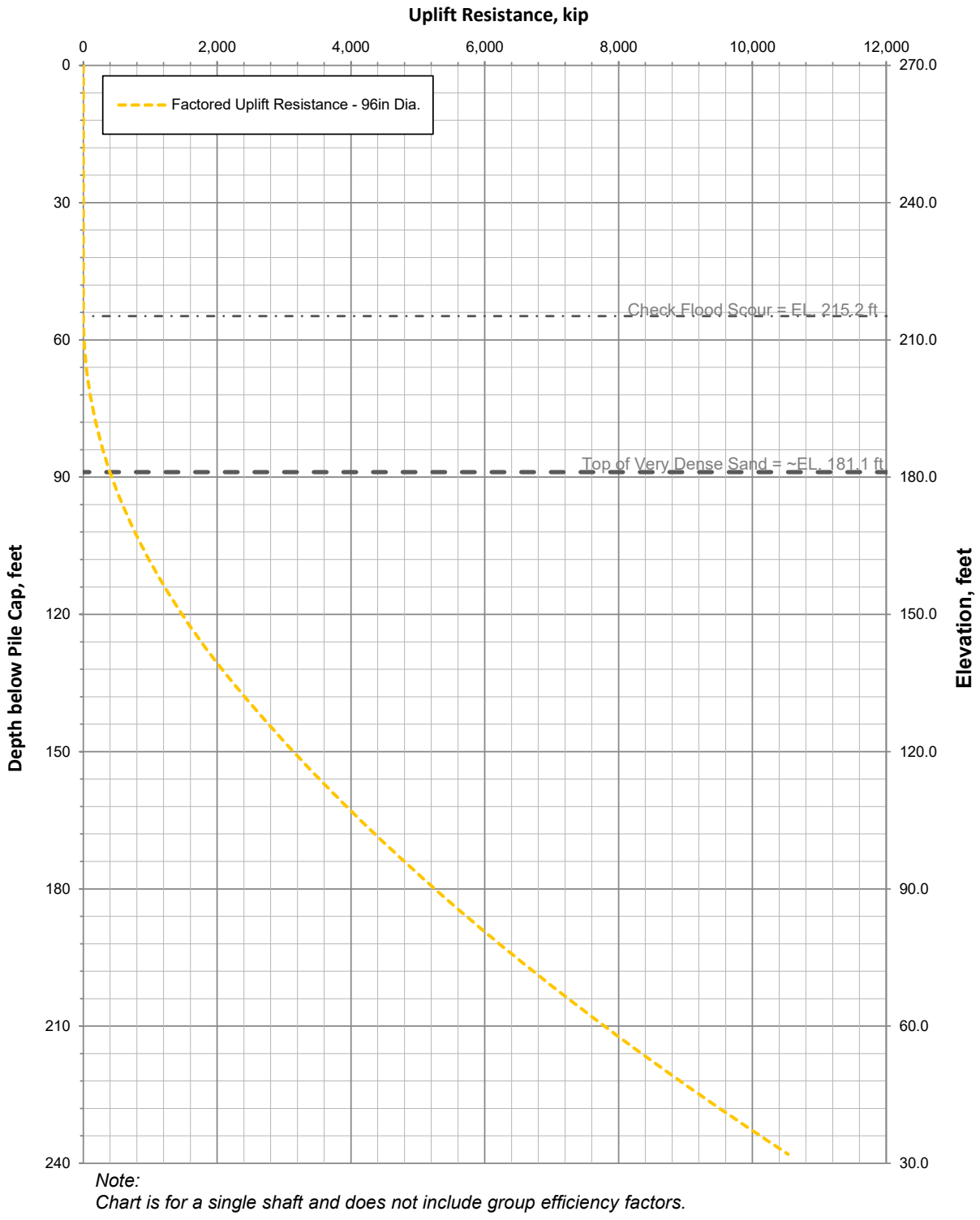
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph** **Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 03/31/2025 **Drawn By:** Ray P **Figure No. ##** **Date:** 03/31/2025

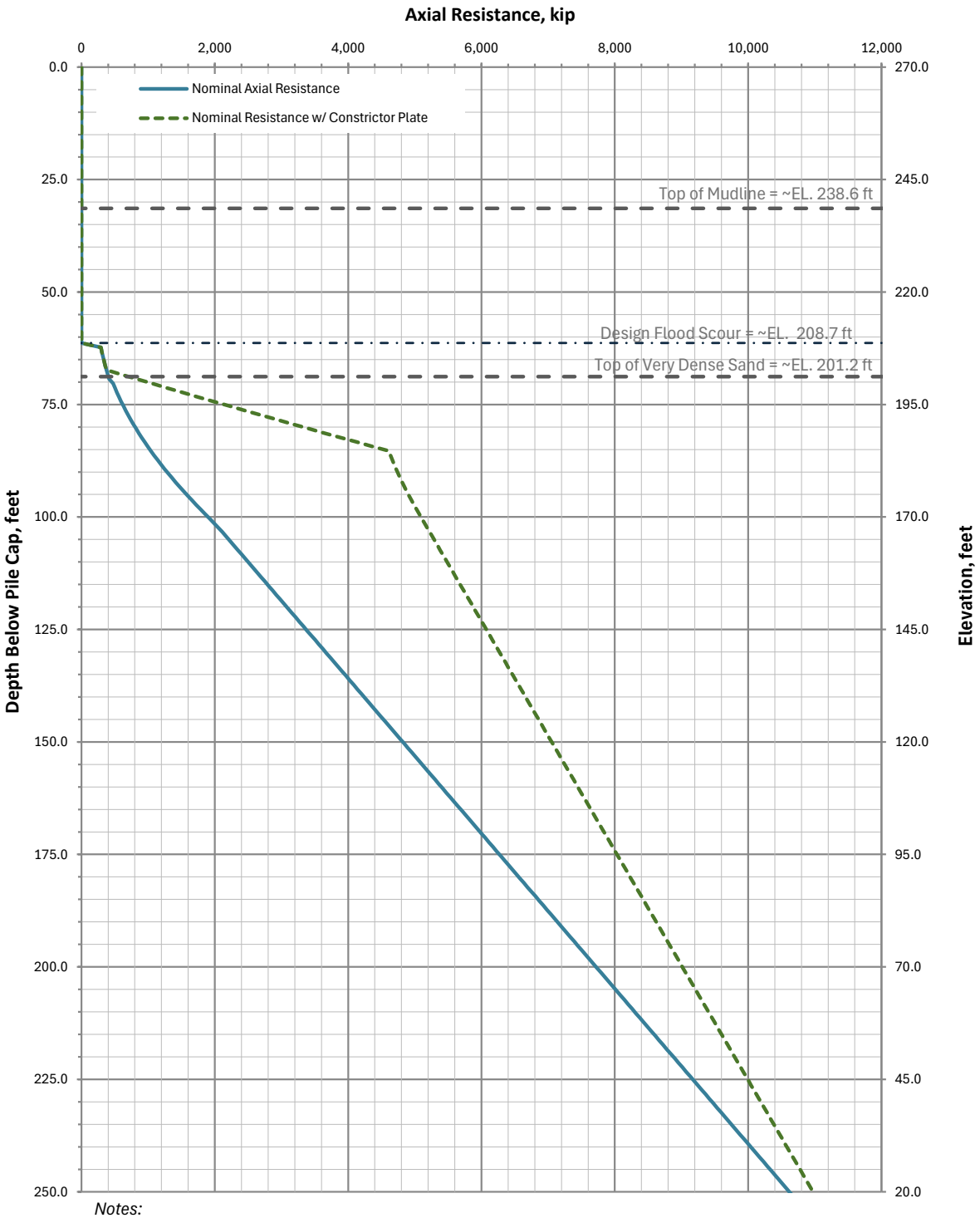


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025

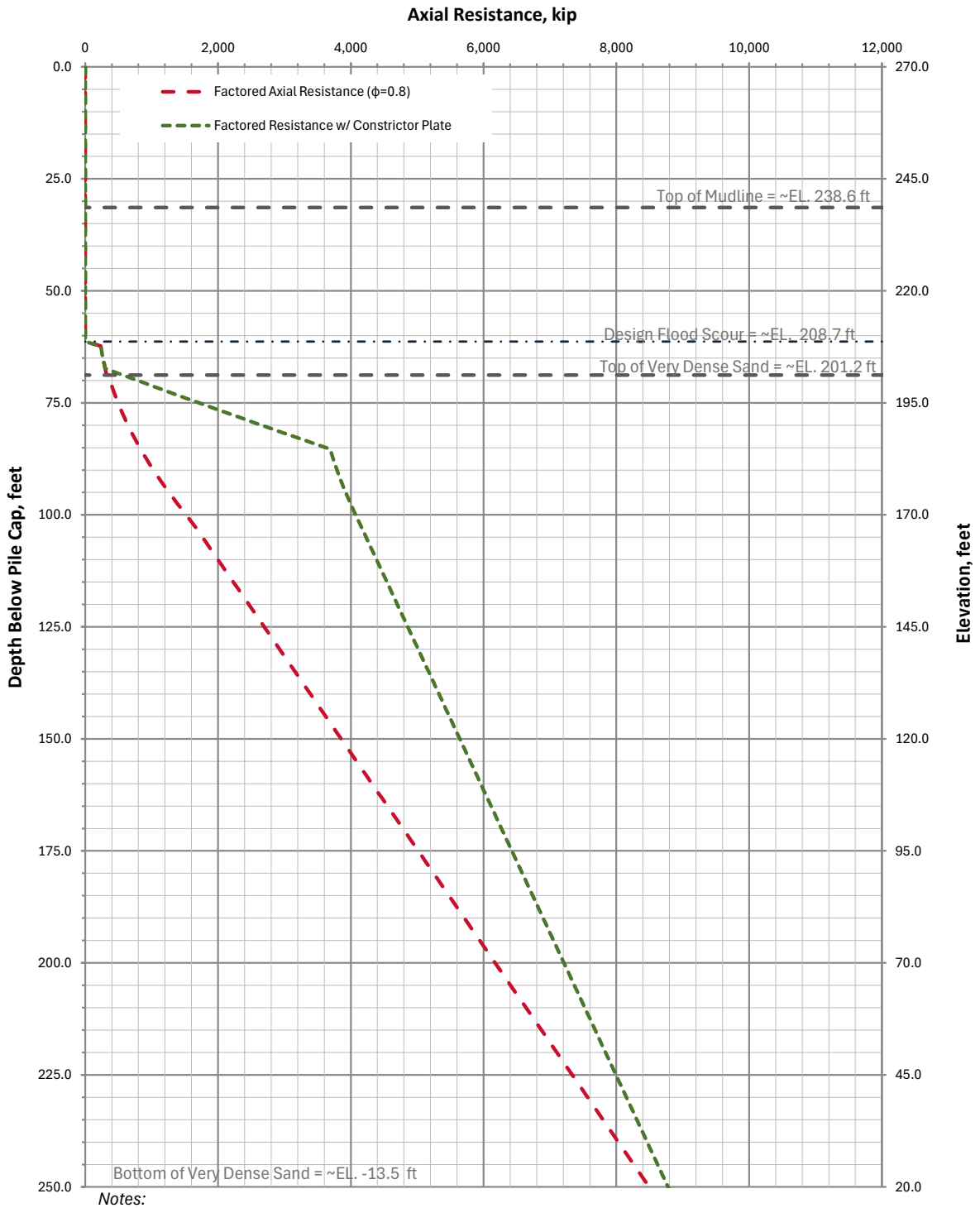
PIER 4

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



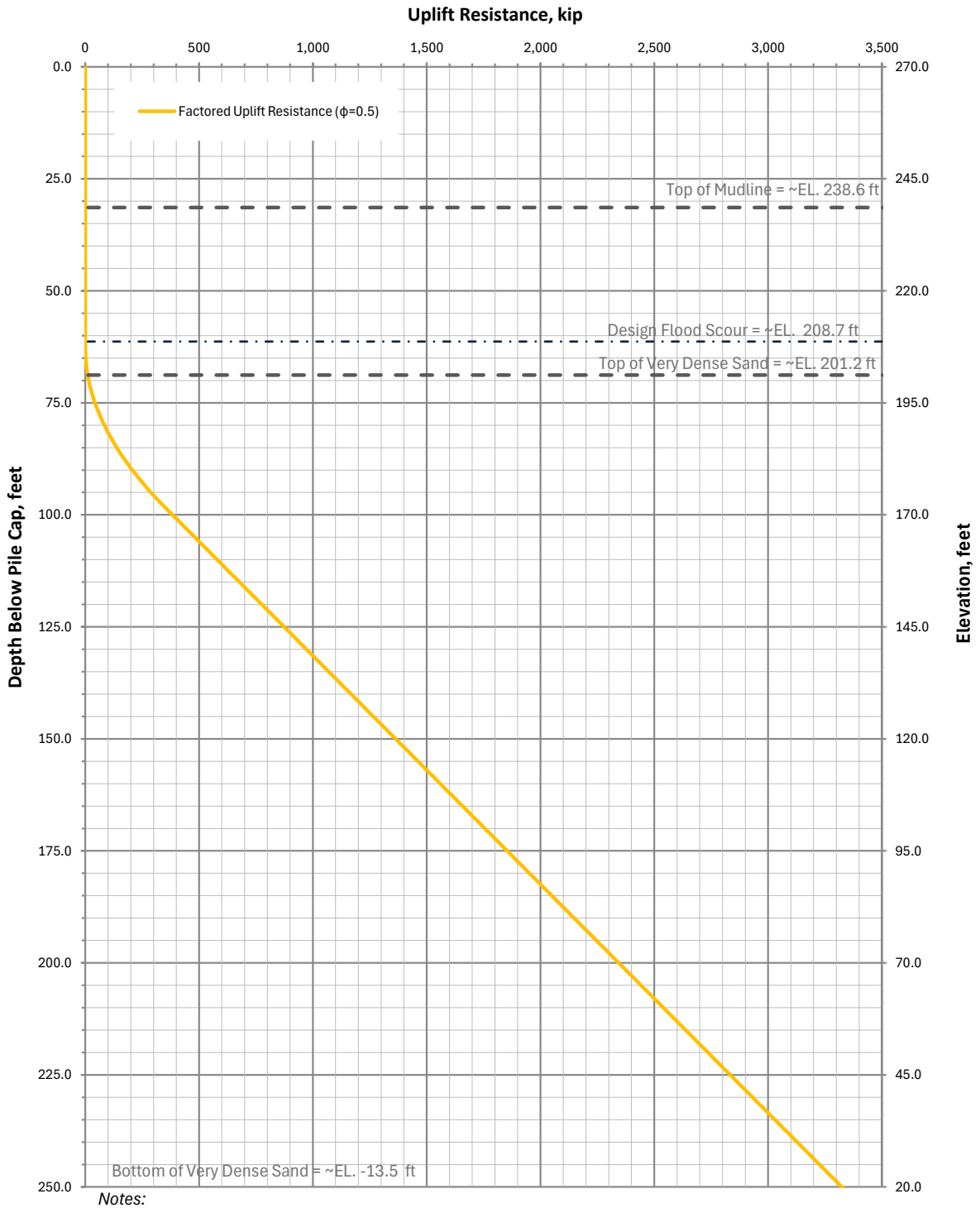
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

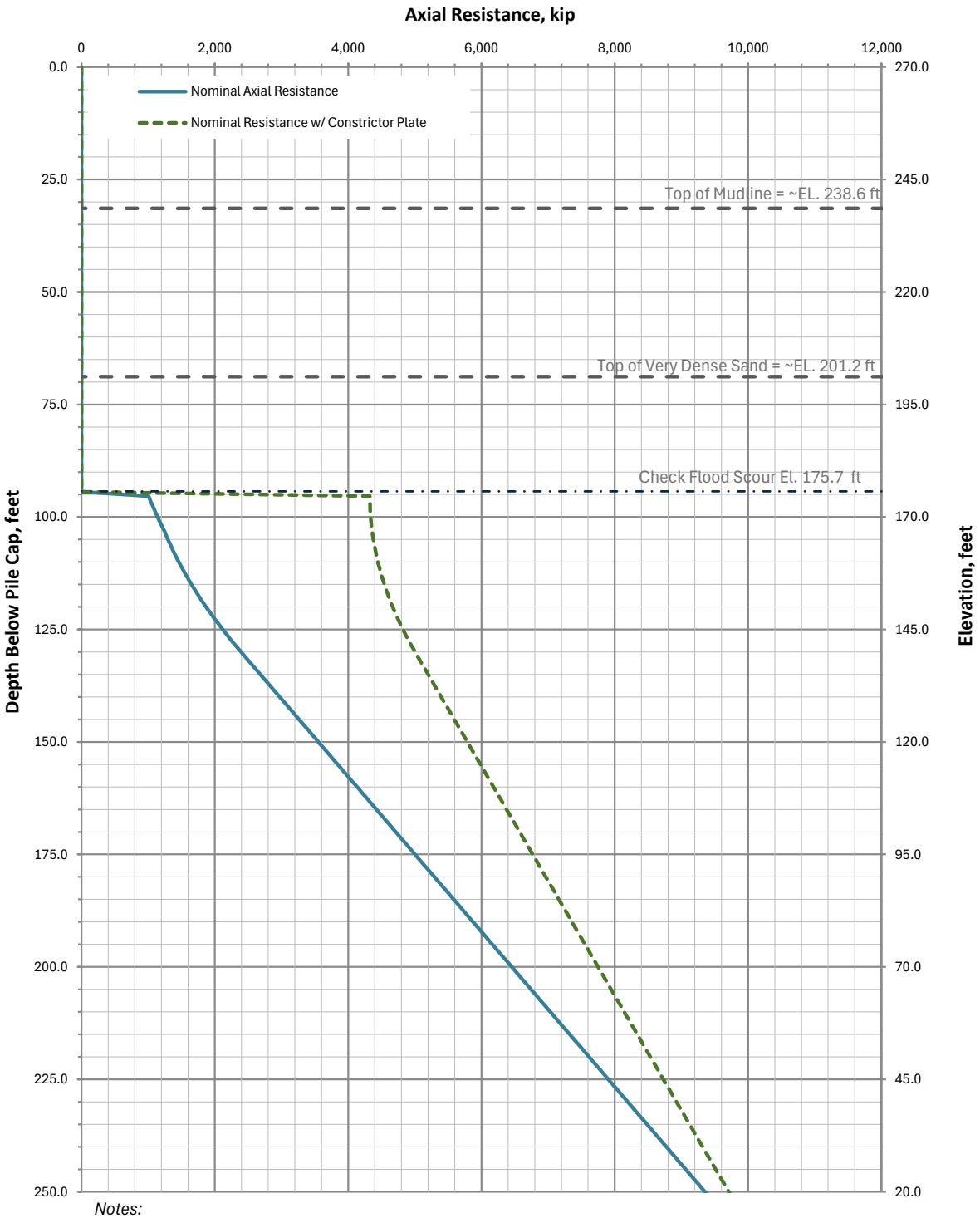
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



Notes:
Chart is for single piles and does not include group efficiency factors.

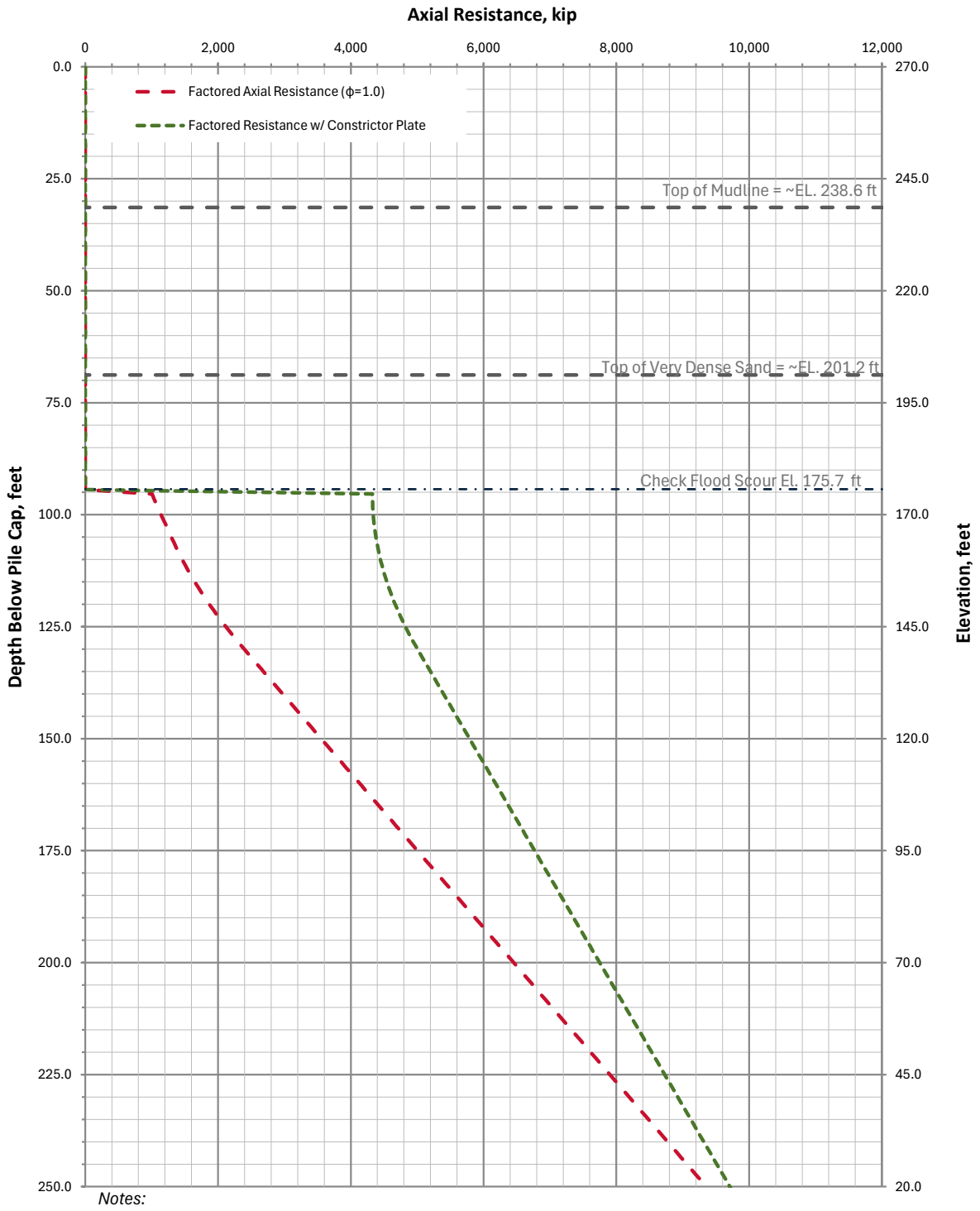
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



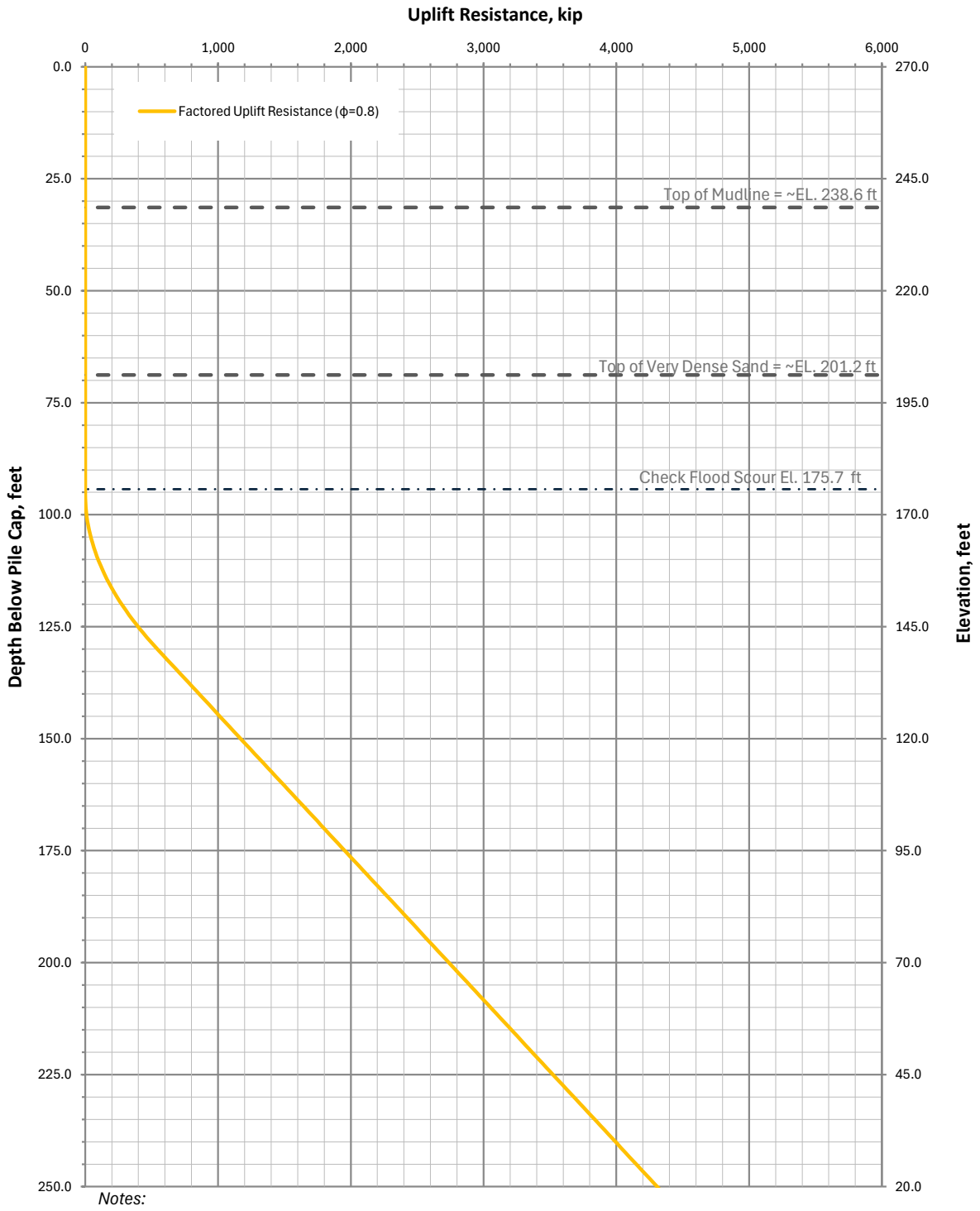
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



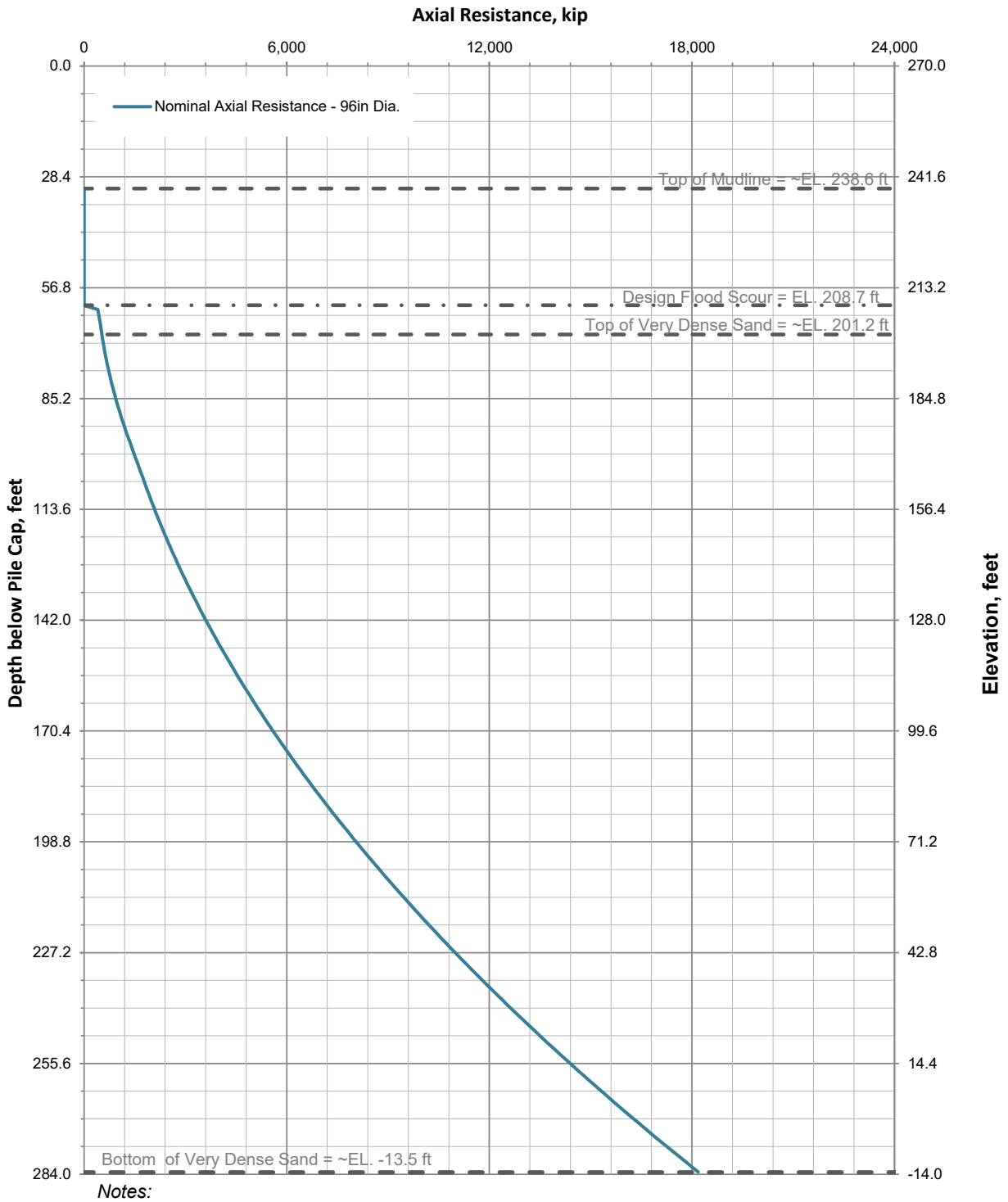
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



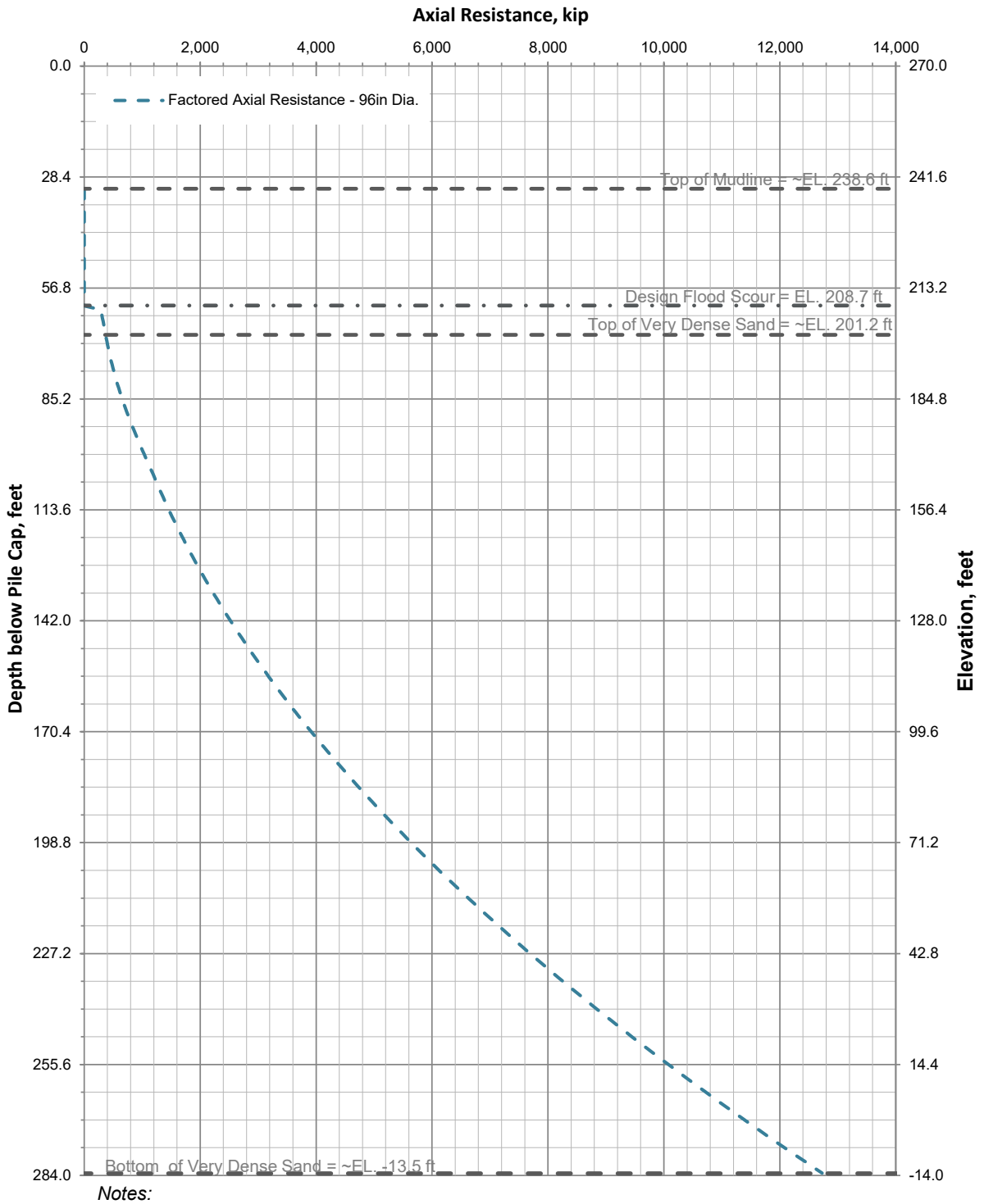
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 12/19/25 **Drawn By:** SKB **Figure No. ##** **Date:** 12/16/25



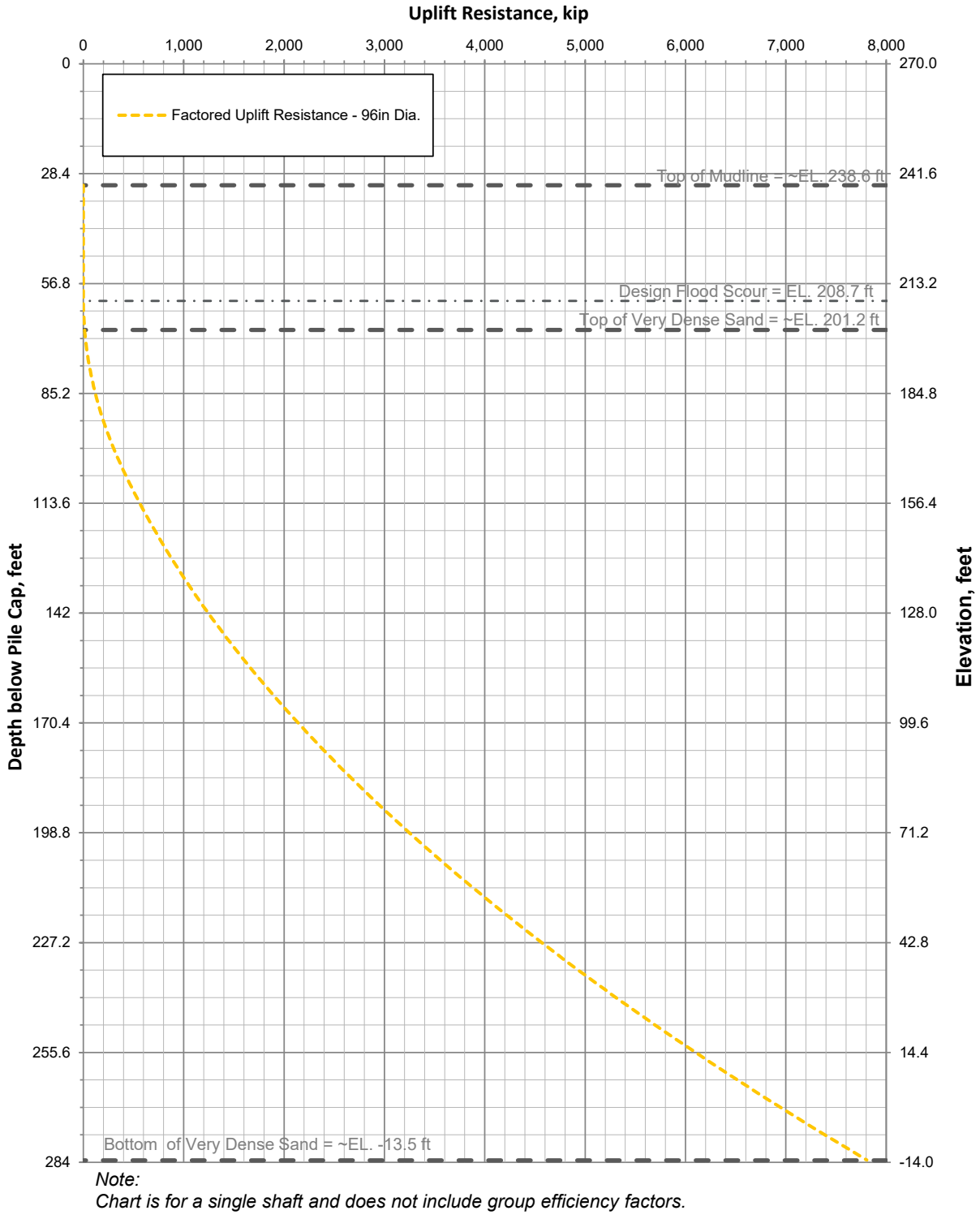
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



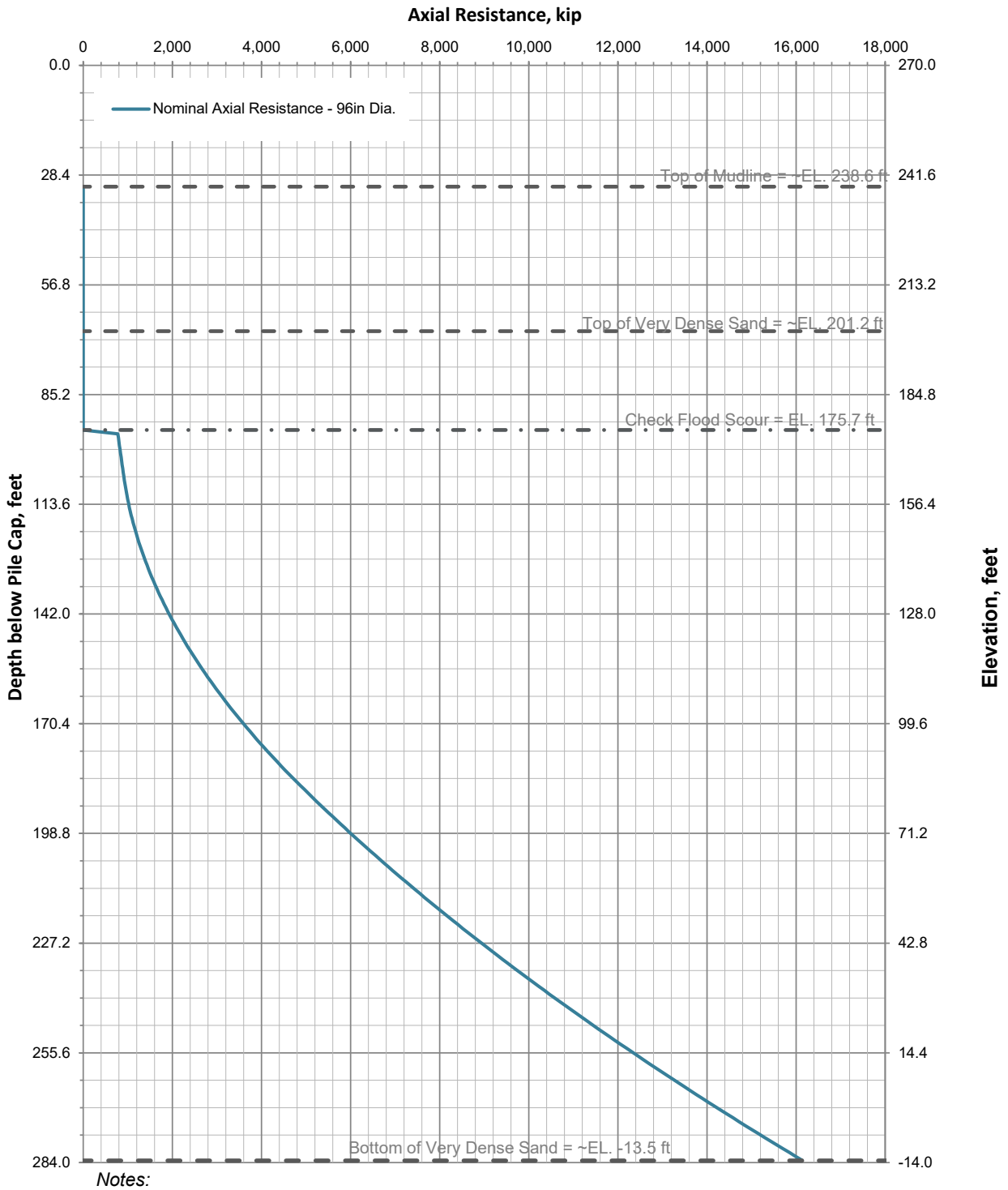
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



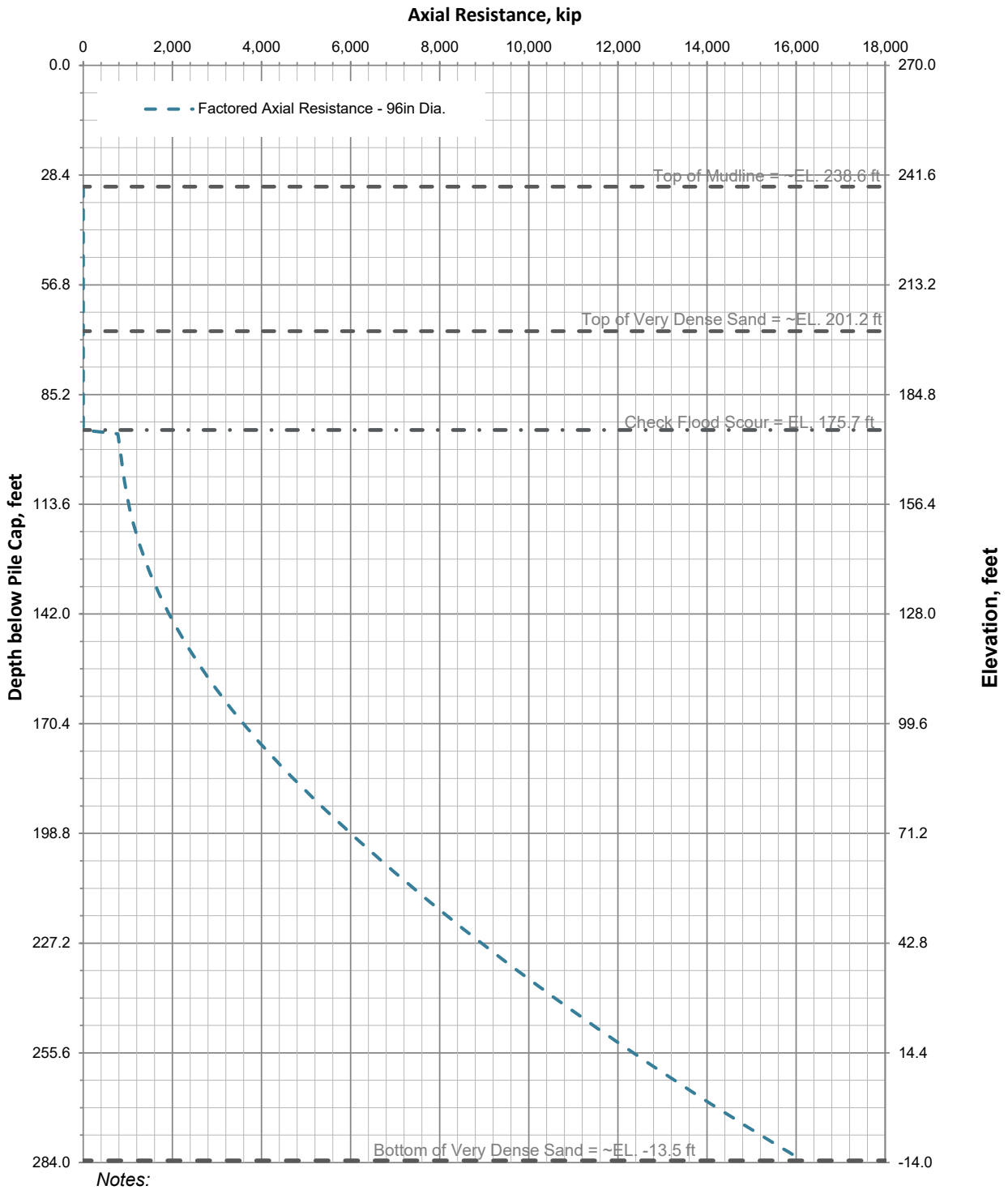
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



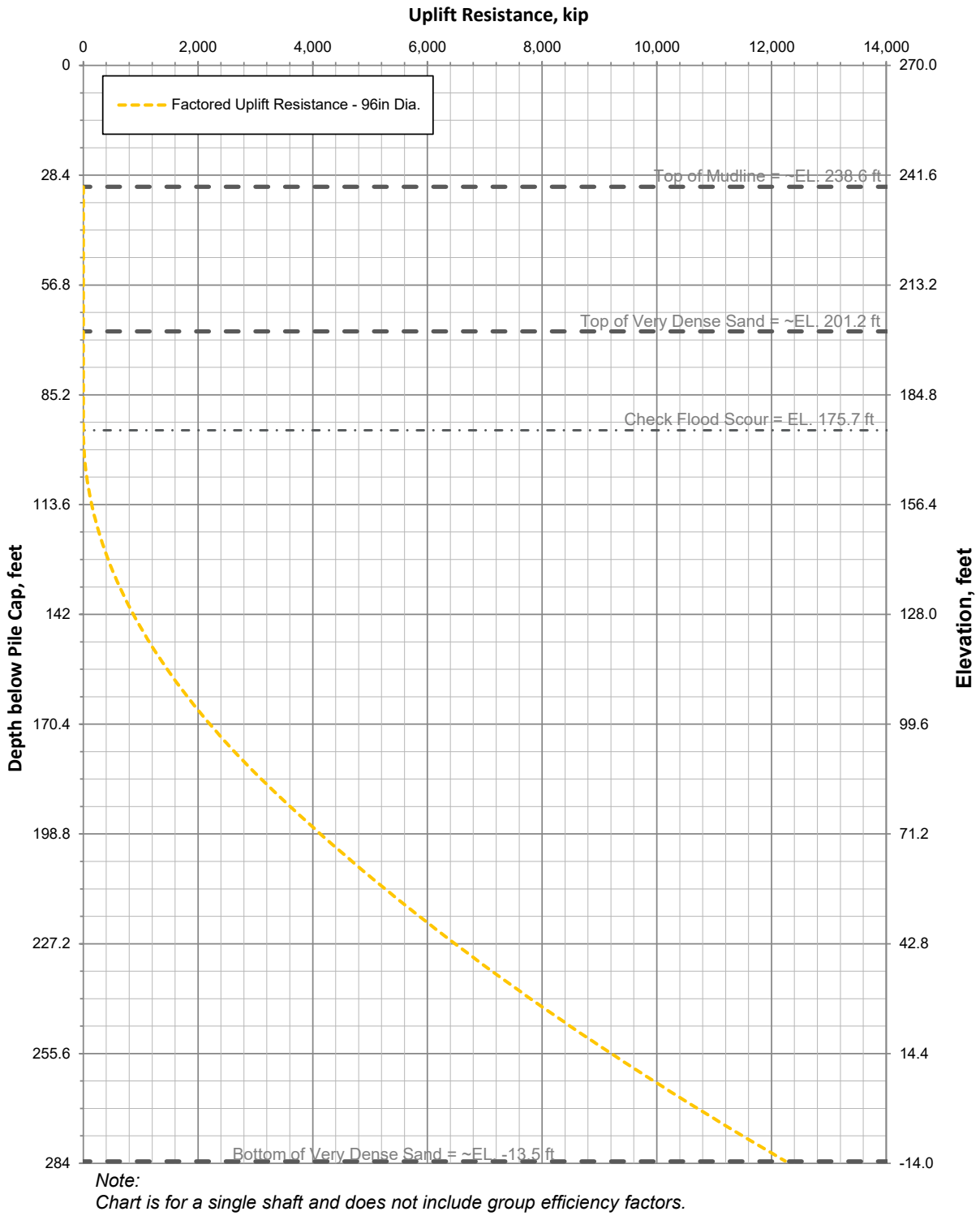
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph** **Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025

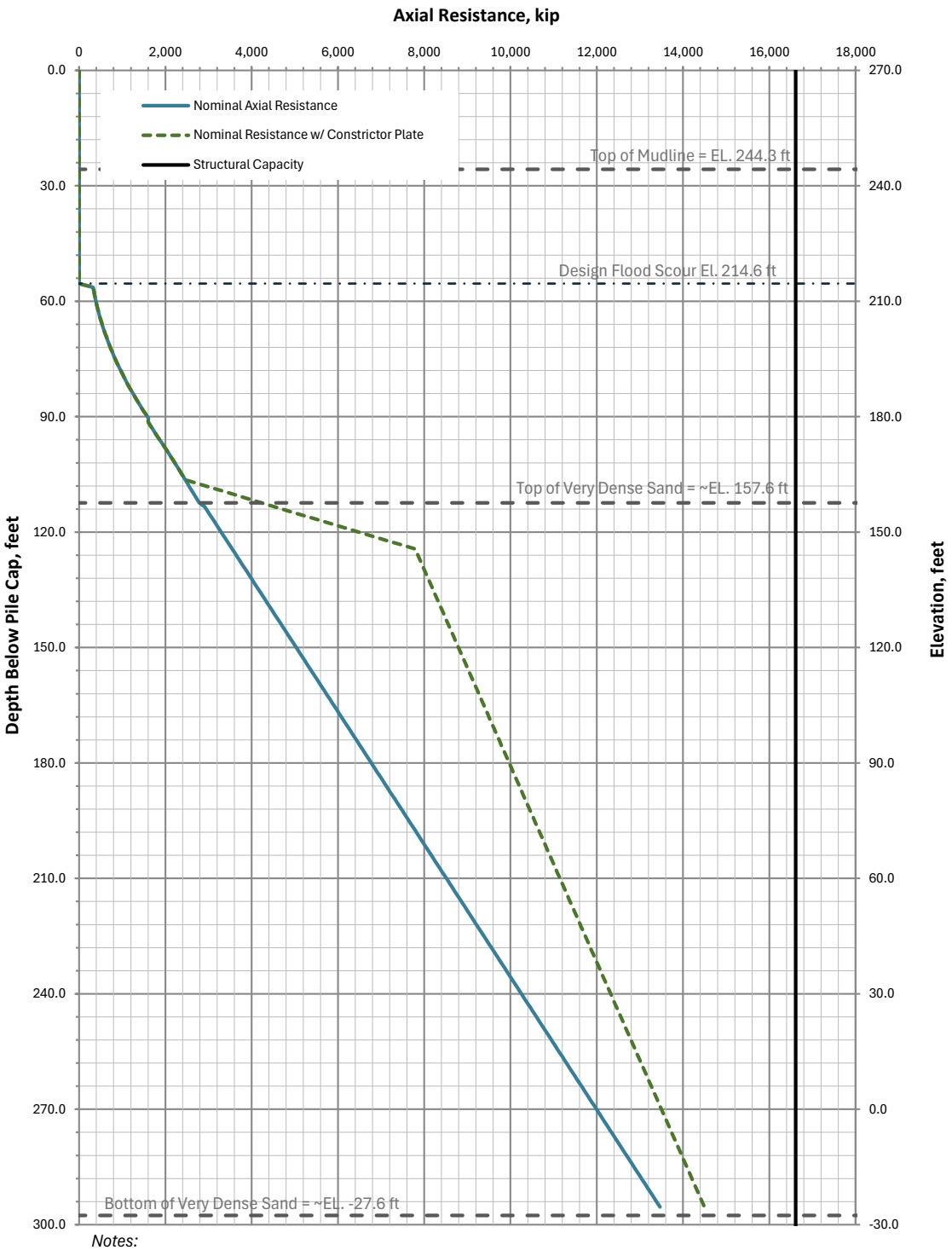


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/07/2025 **Drawn By:** Ray P. **Figure No. ##** **Date:** 04/07/2025

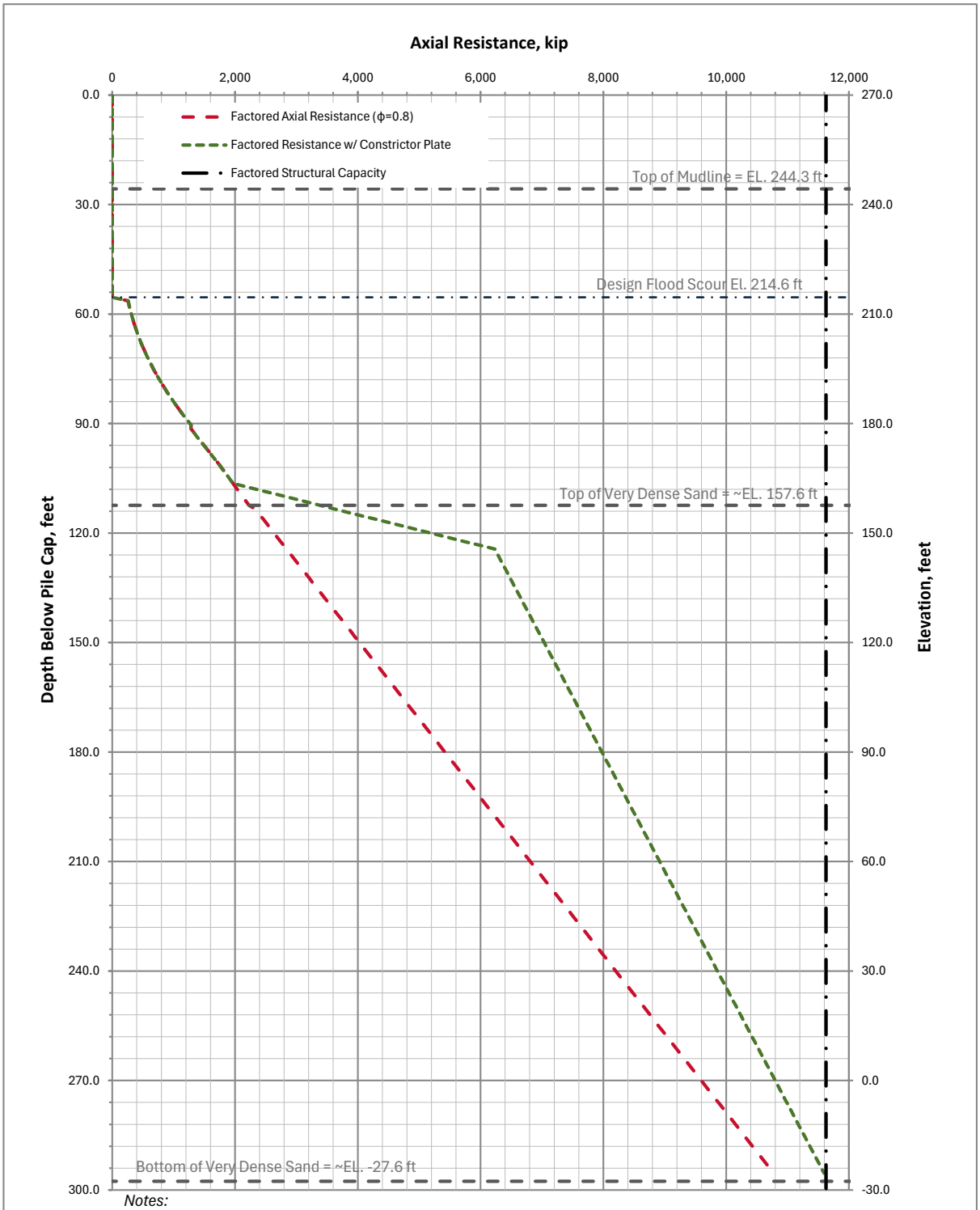
PIER 5

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



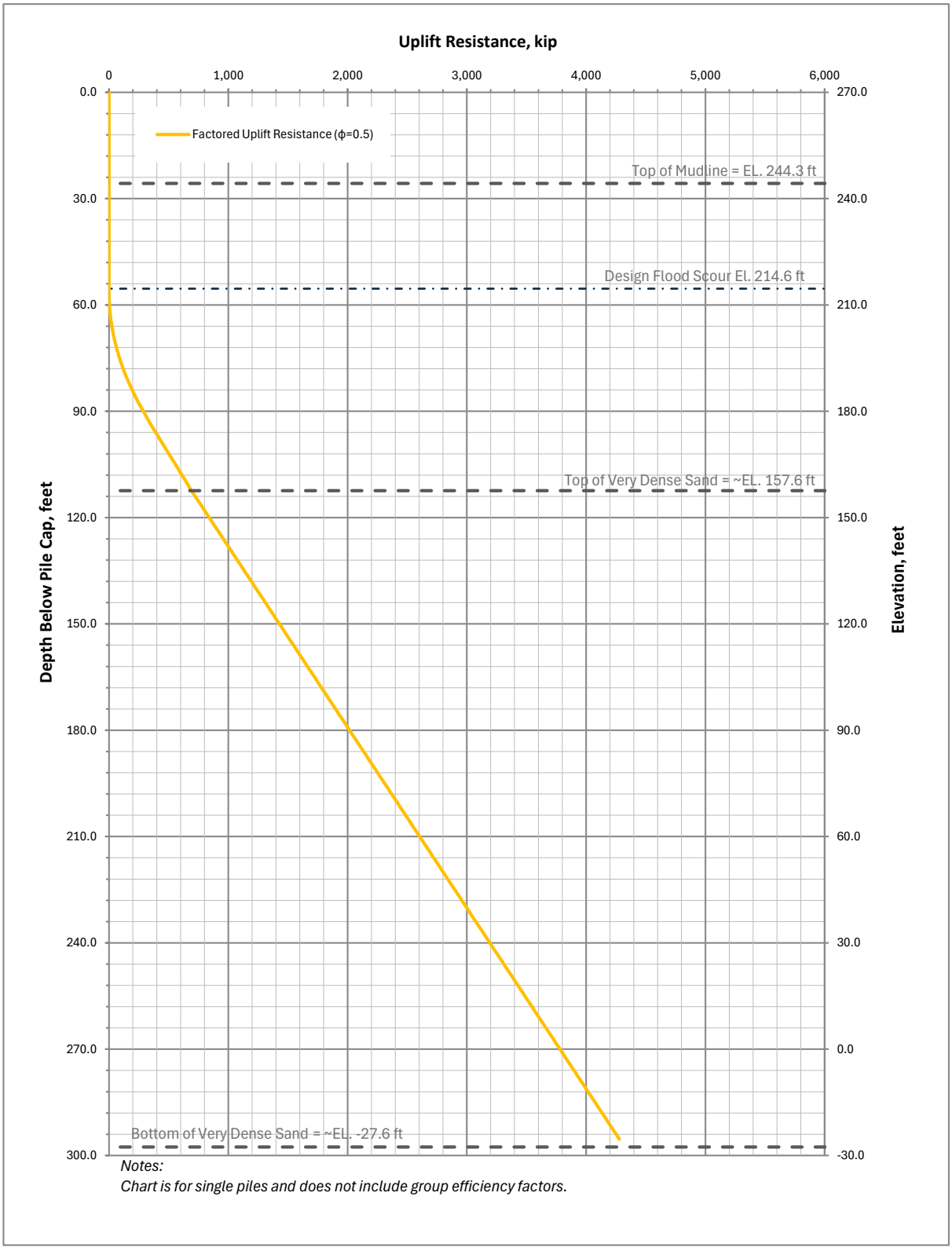
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for single piles and does not include group efficiency factors.
*Factored Structural Capacity of 72inx1.5in Pipe Pile = **11,628 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test.

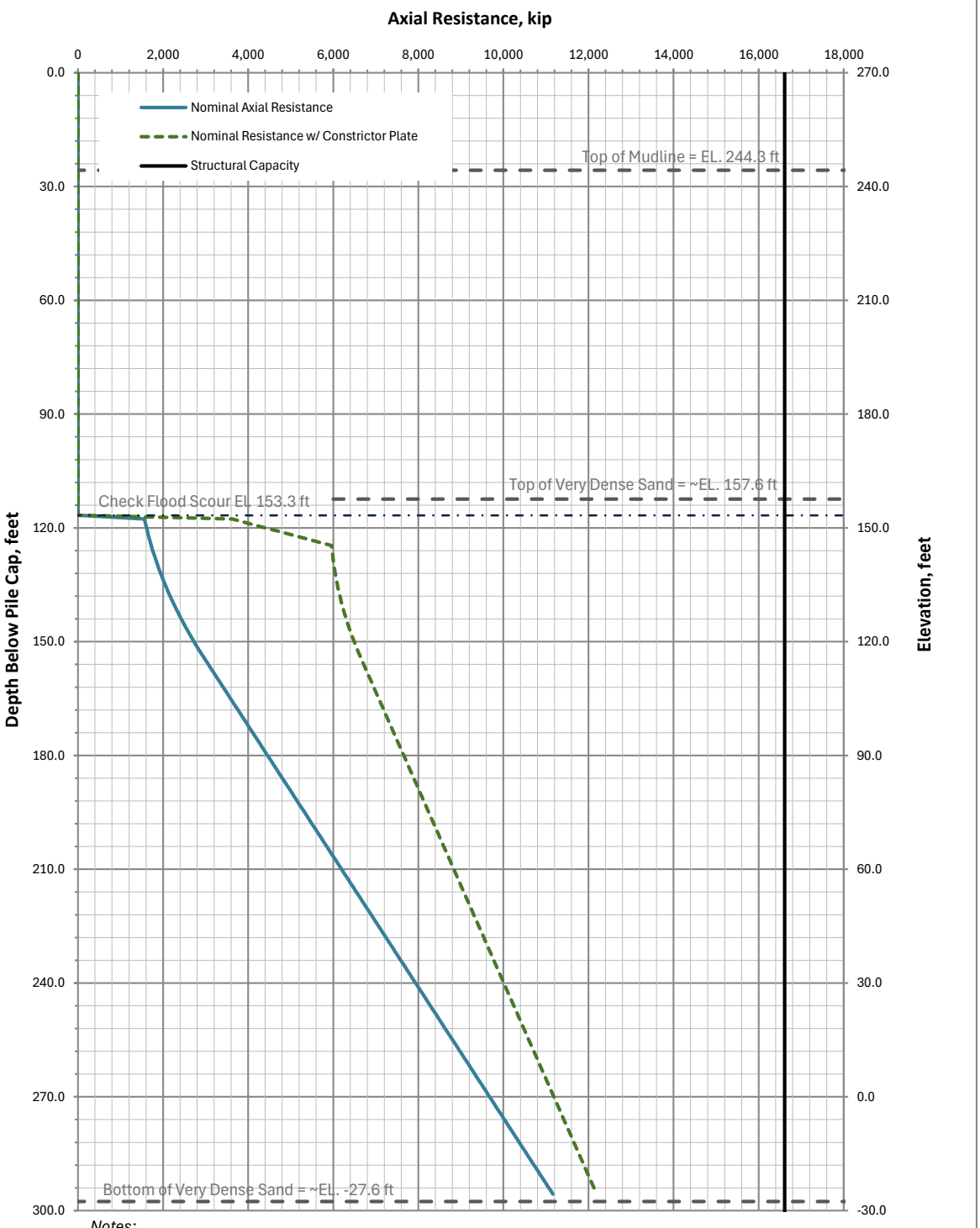
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

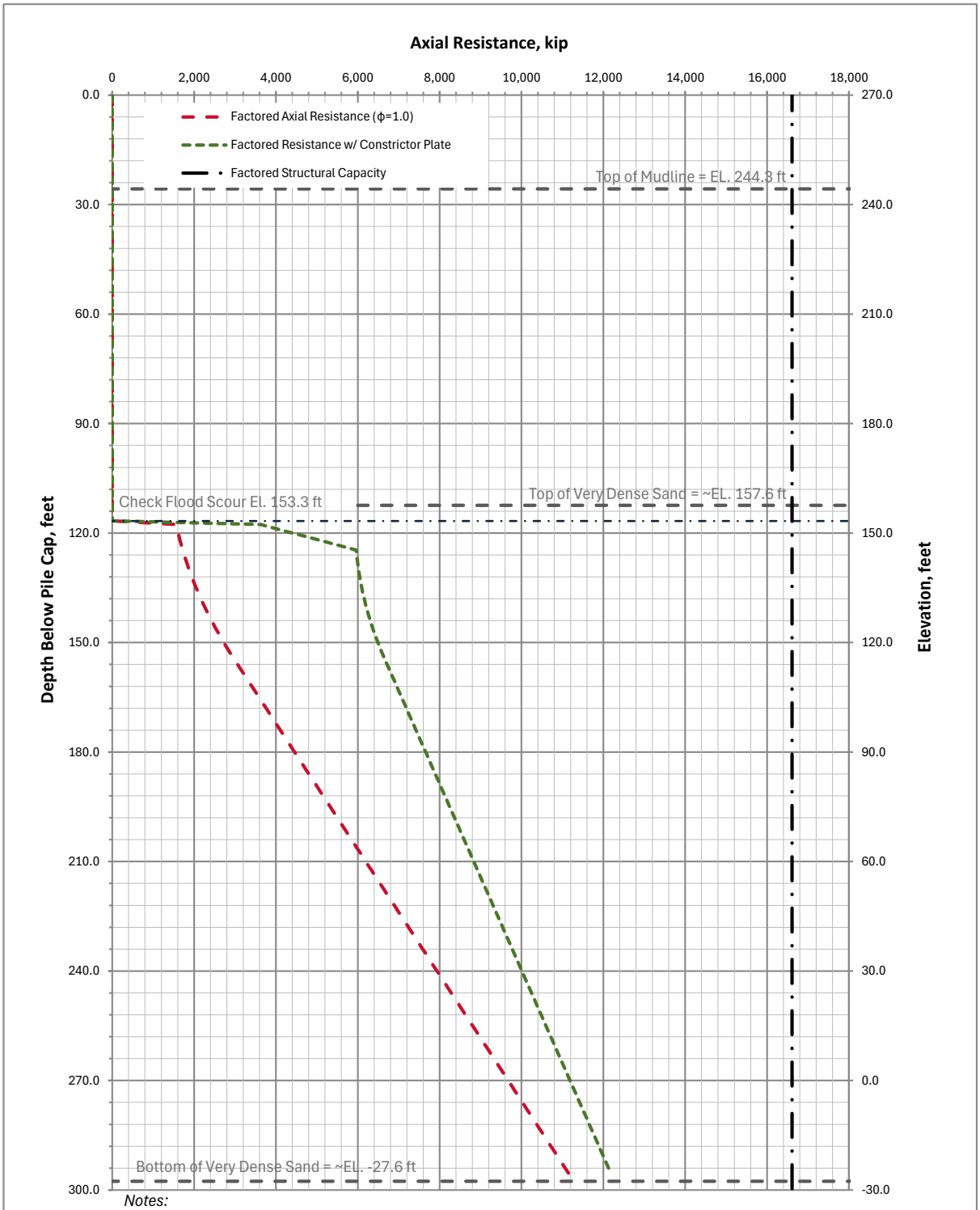
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



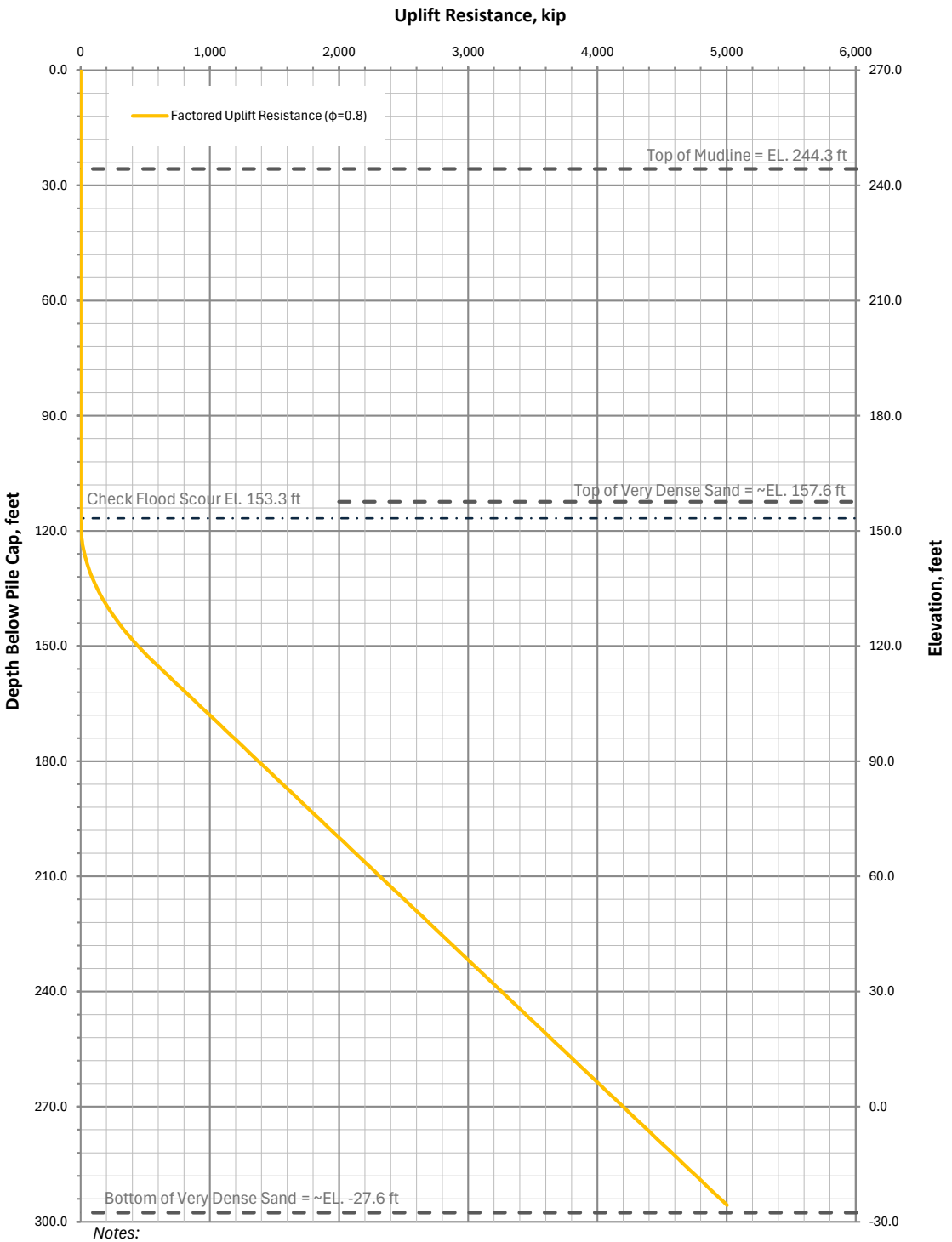
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



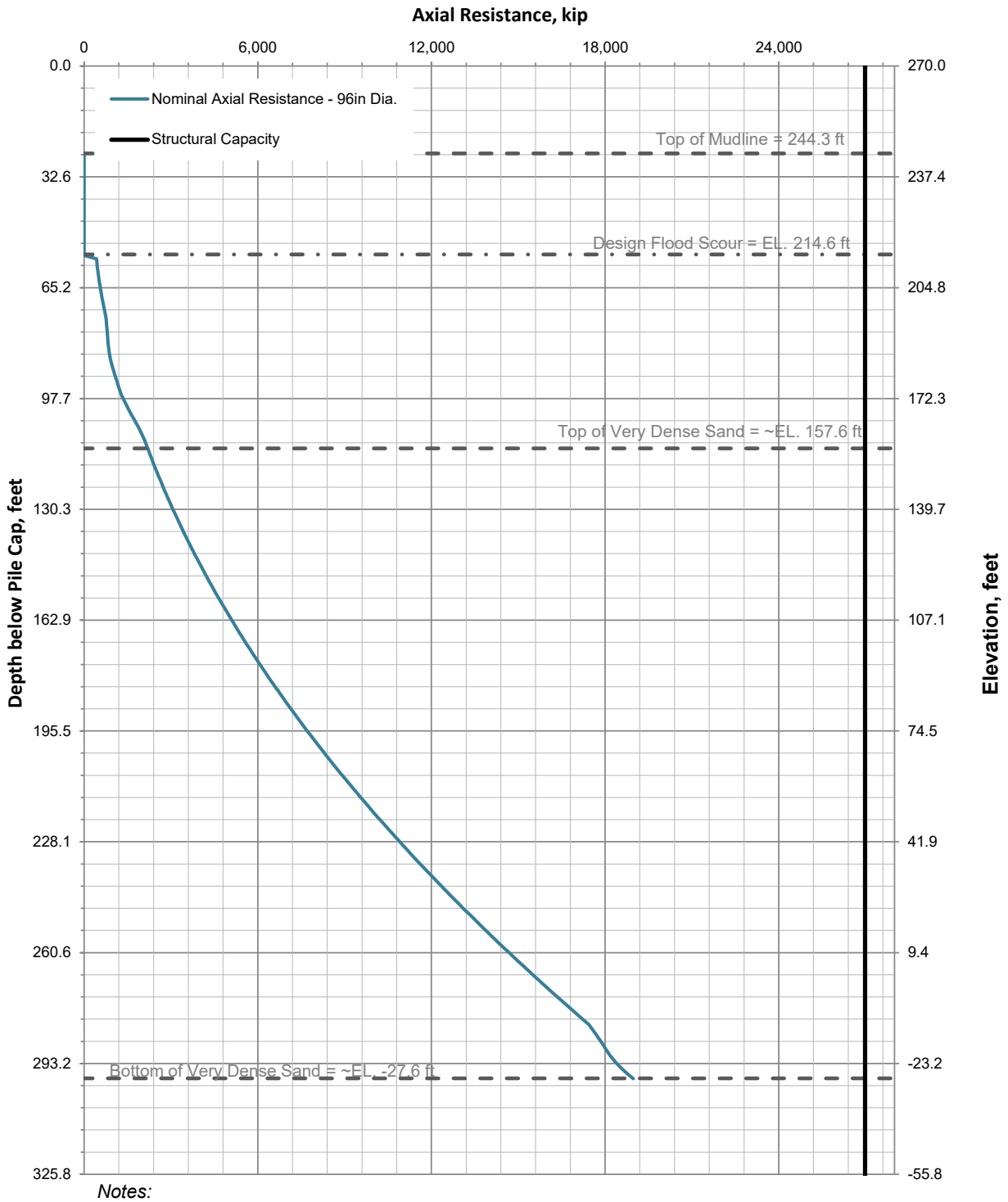
Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



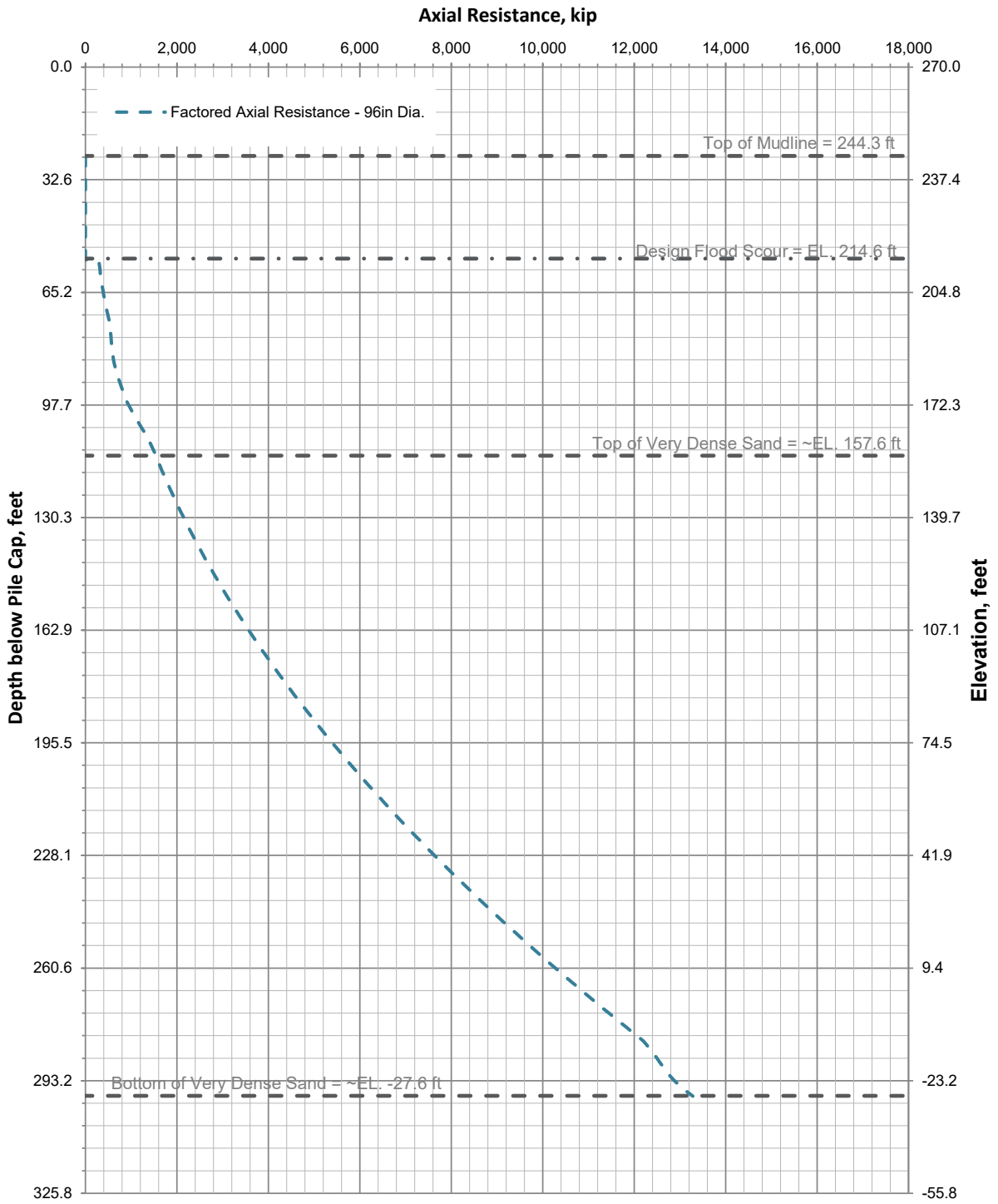
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



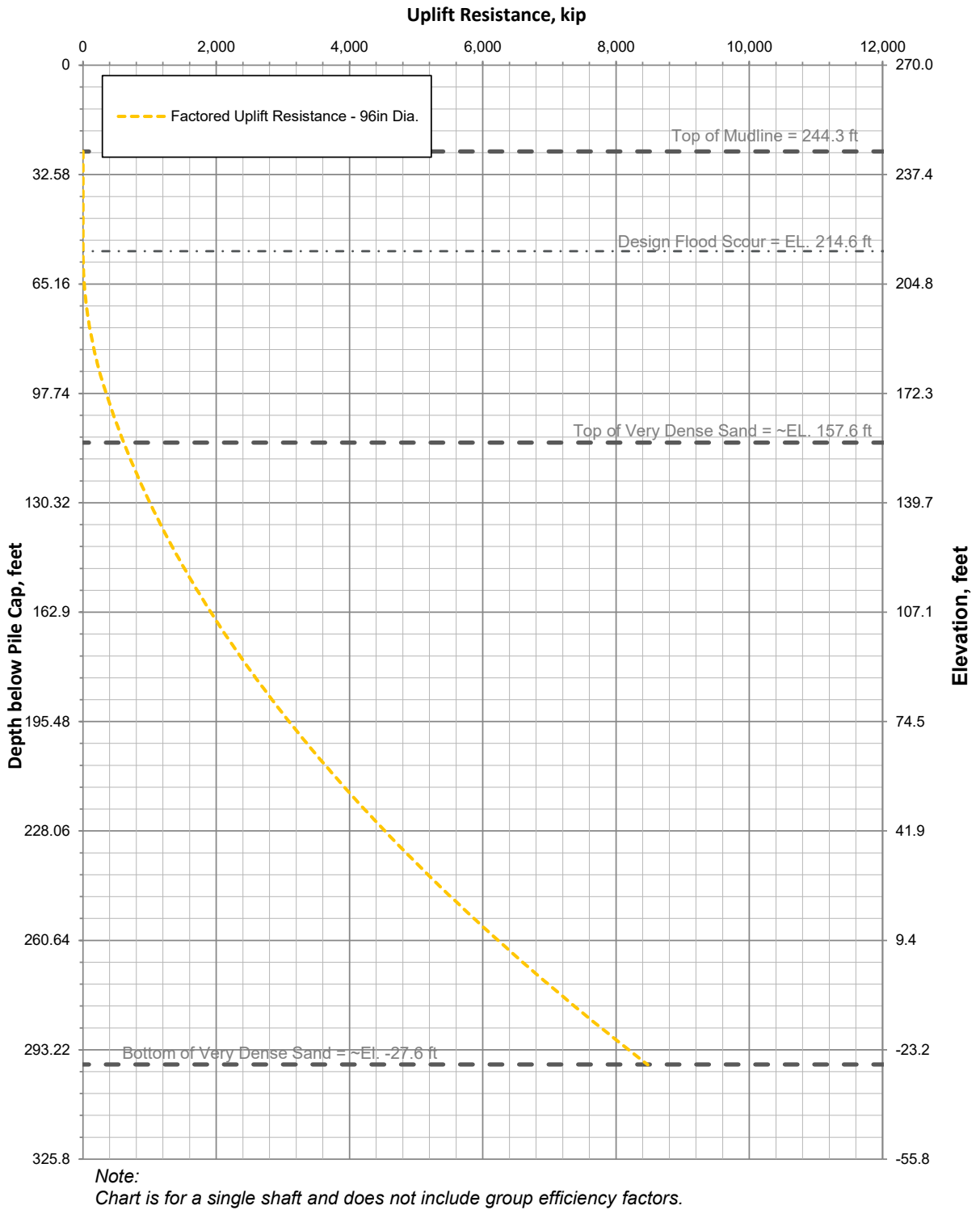
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



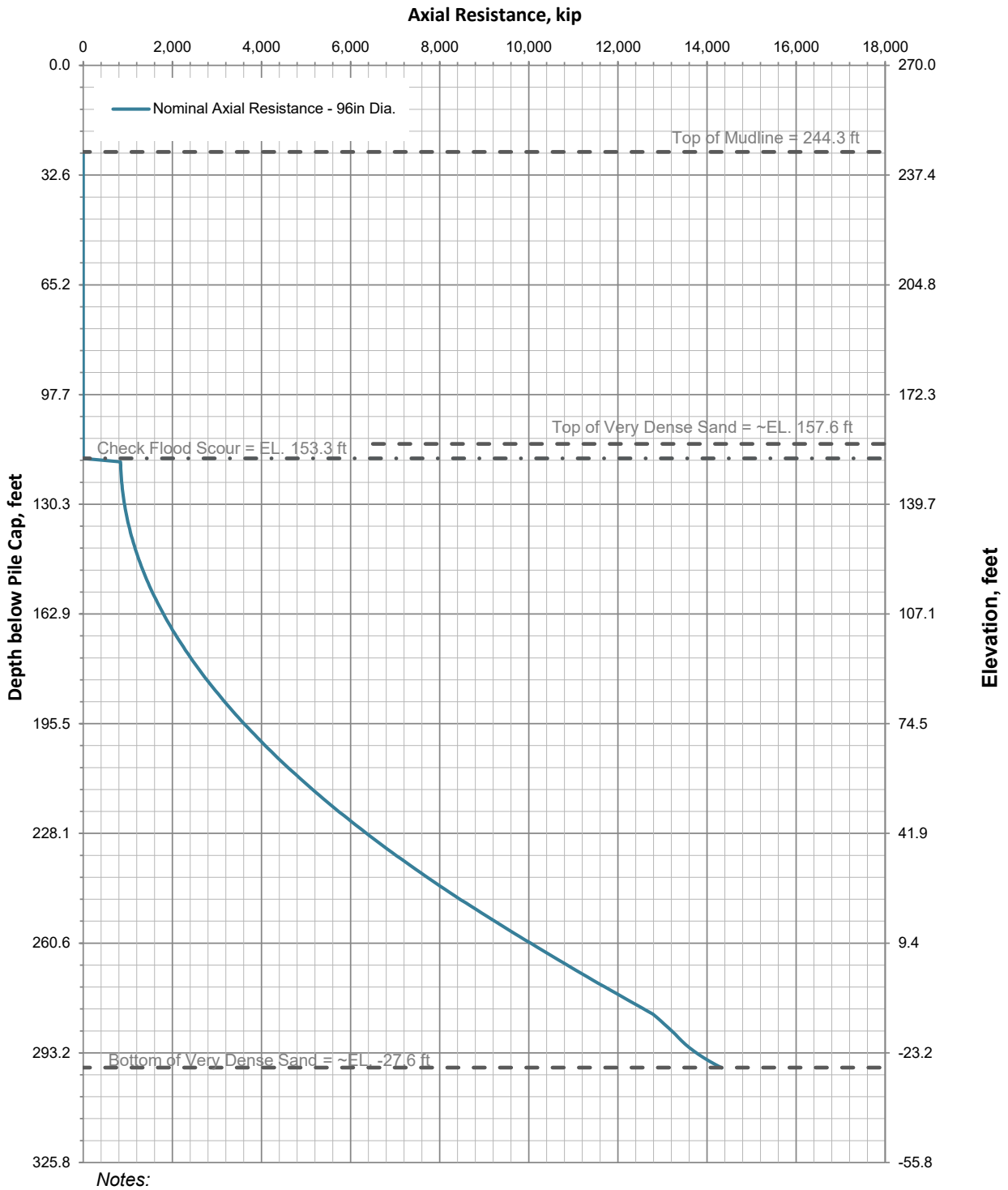
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



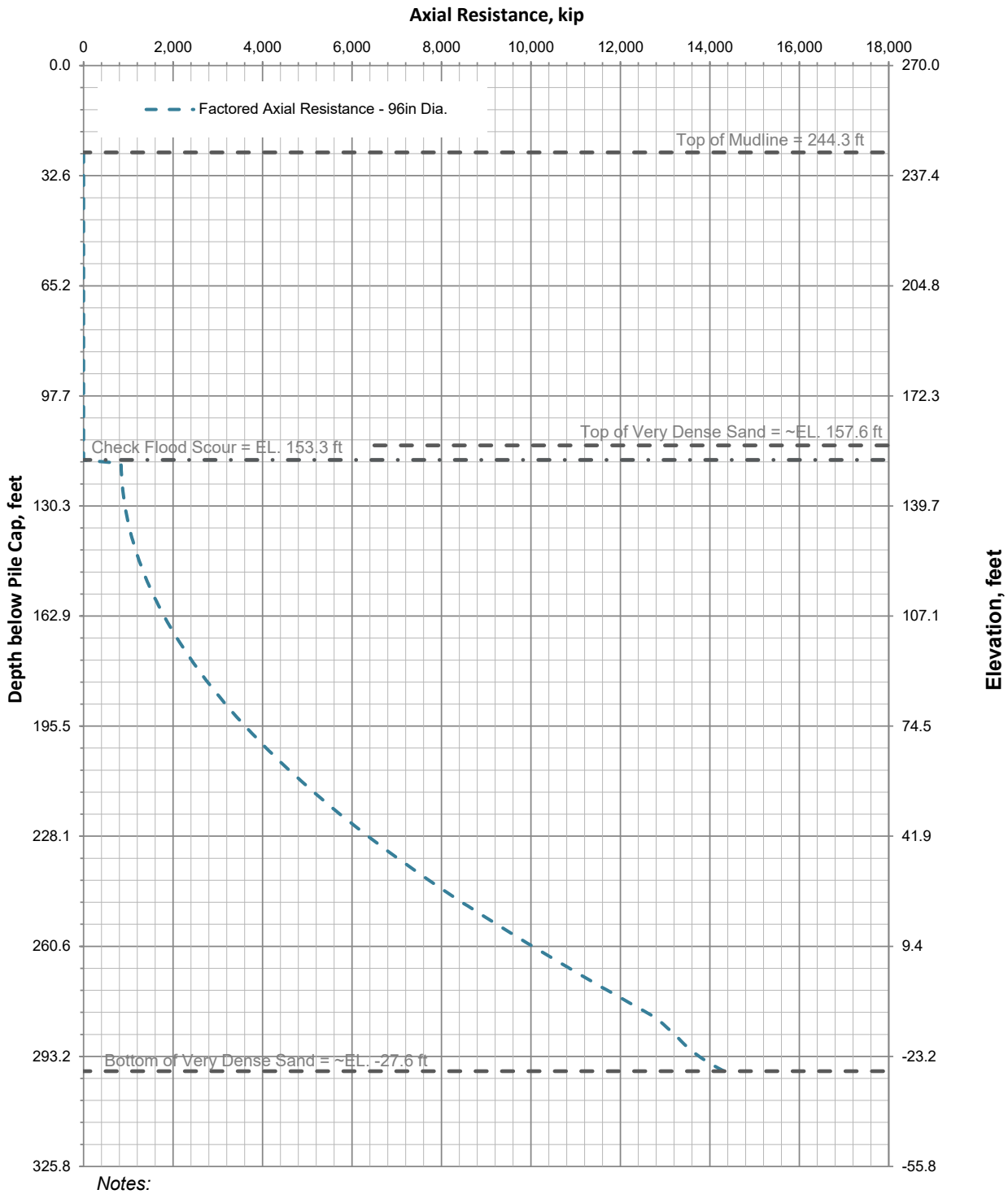
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Uplift Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



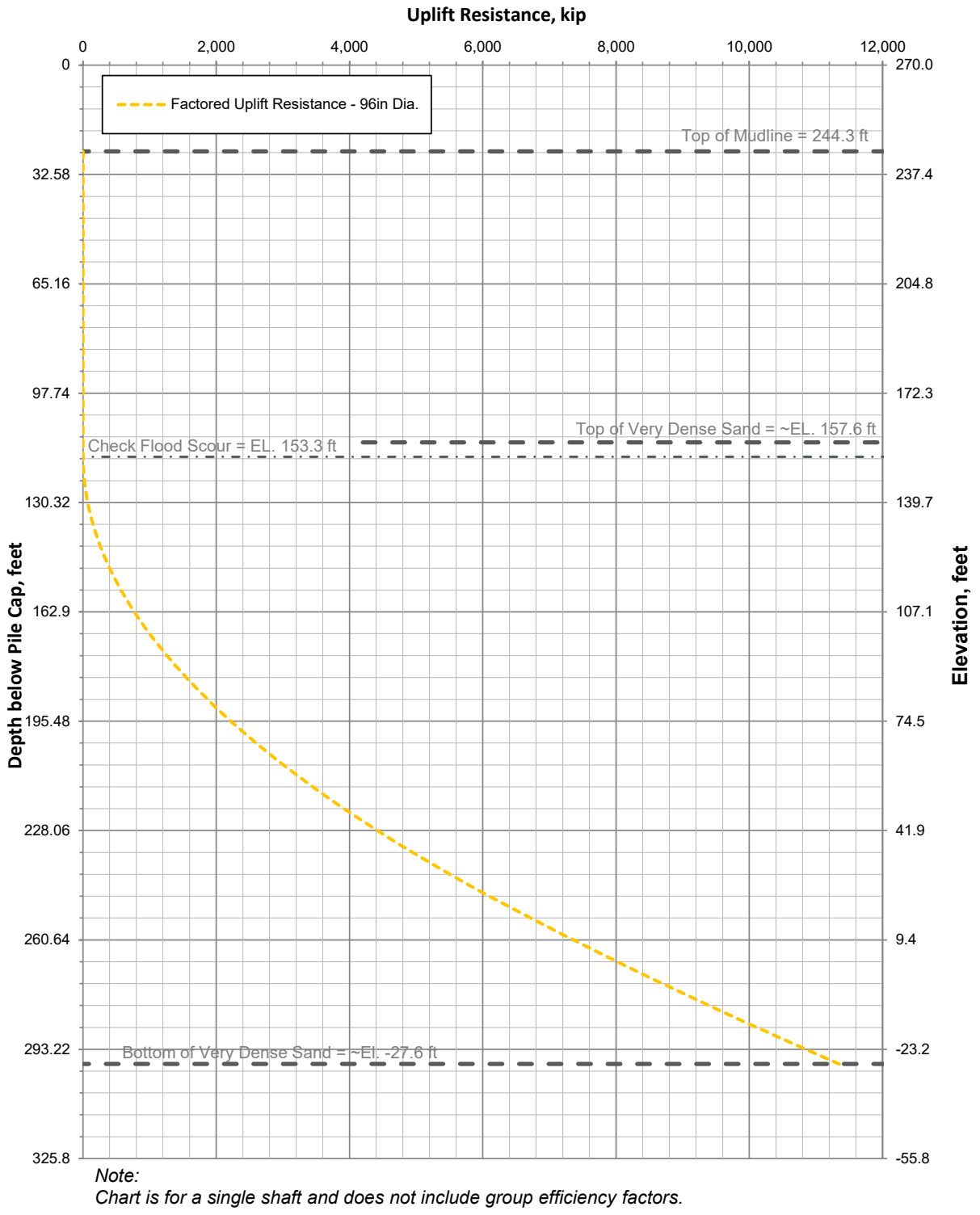
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

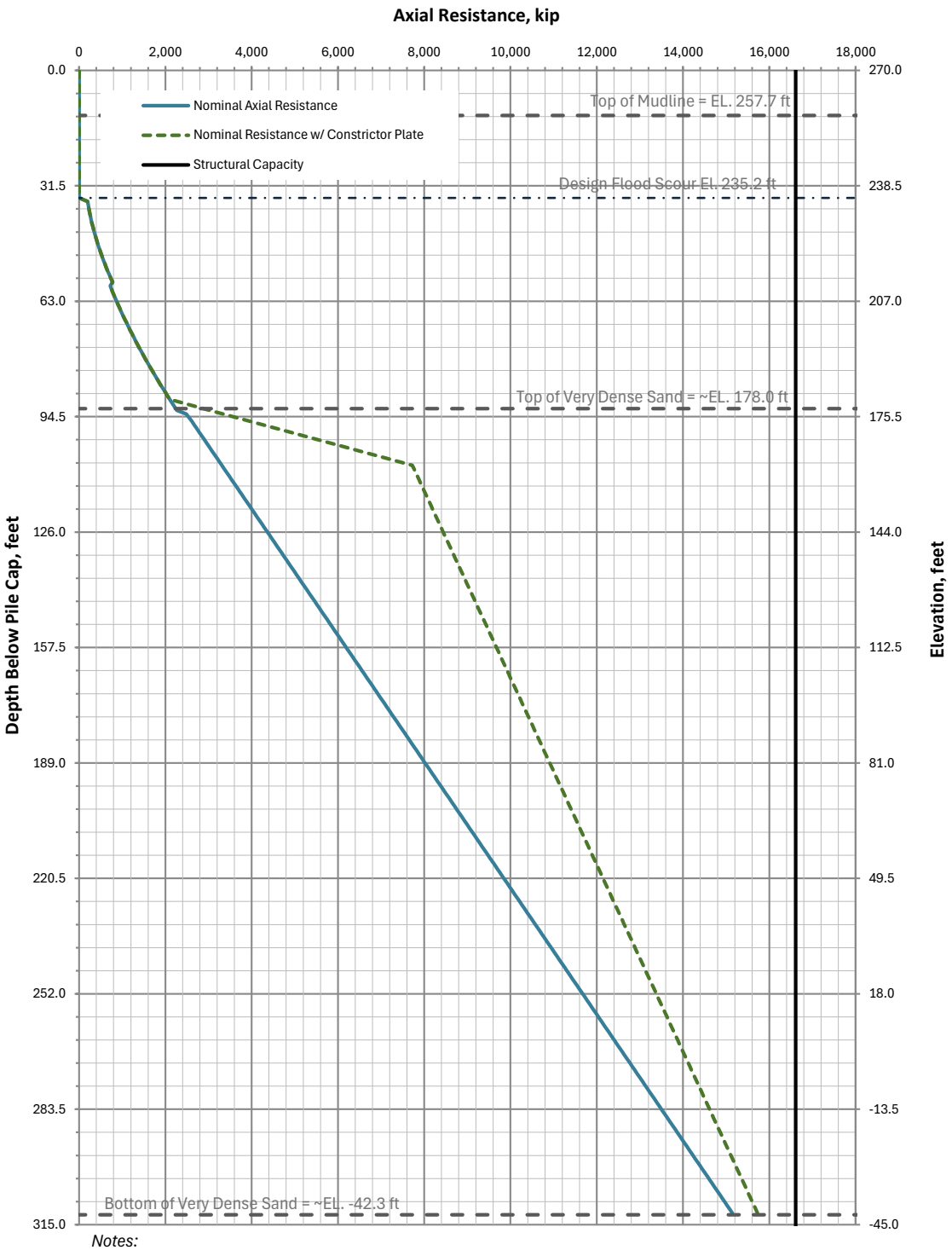


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Uplift Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

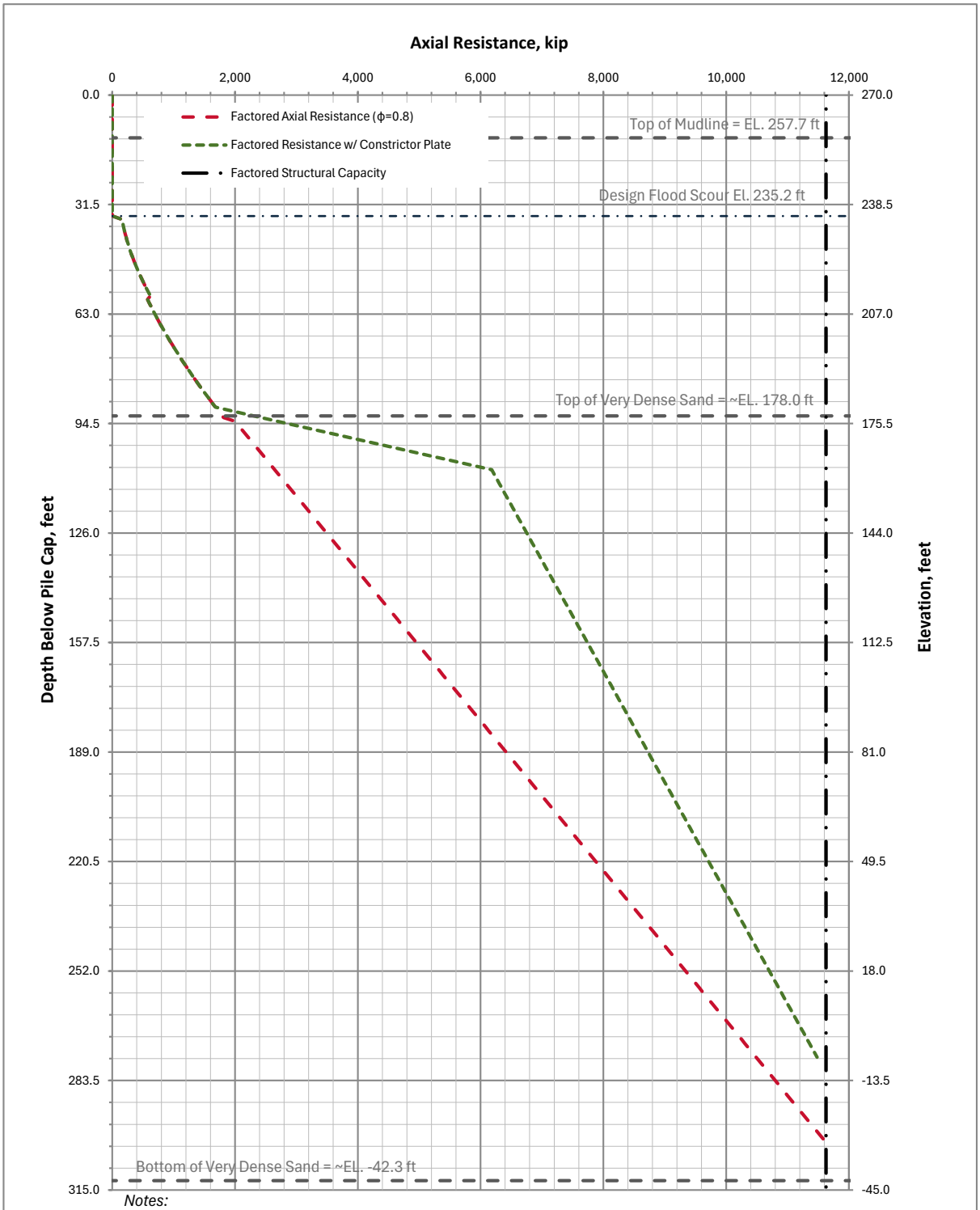
PIER 6

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



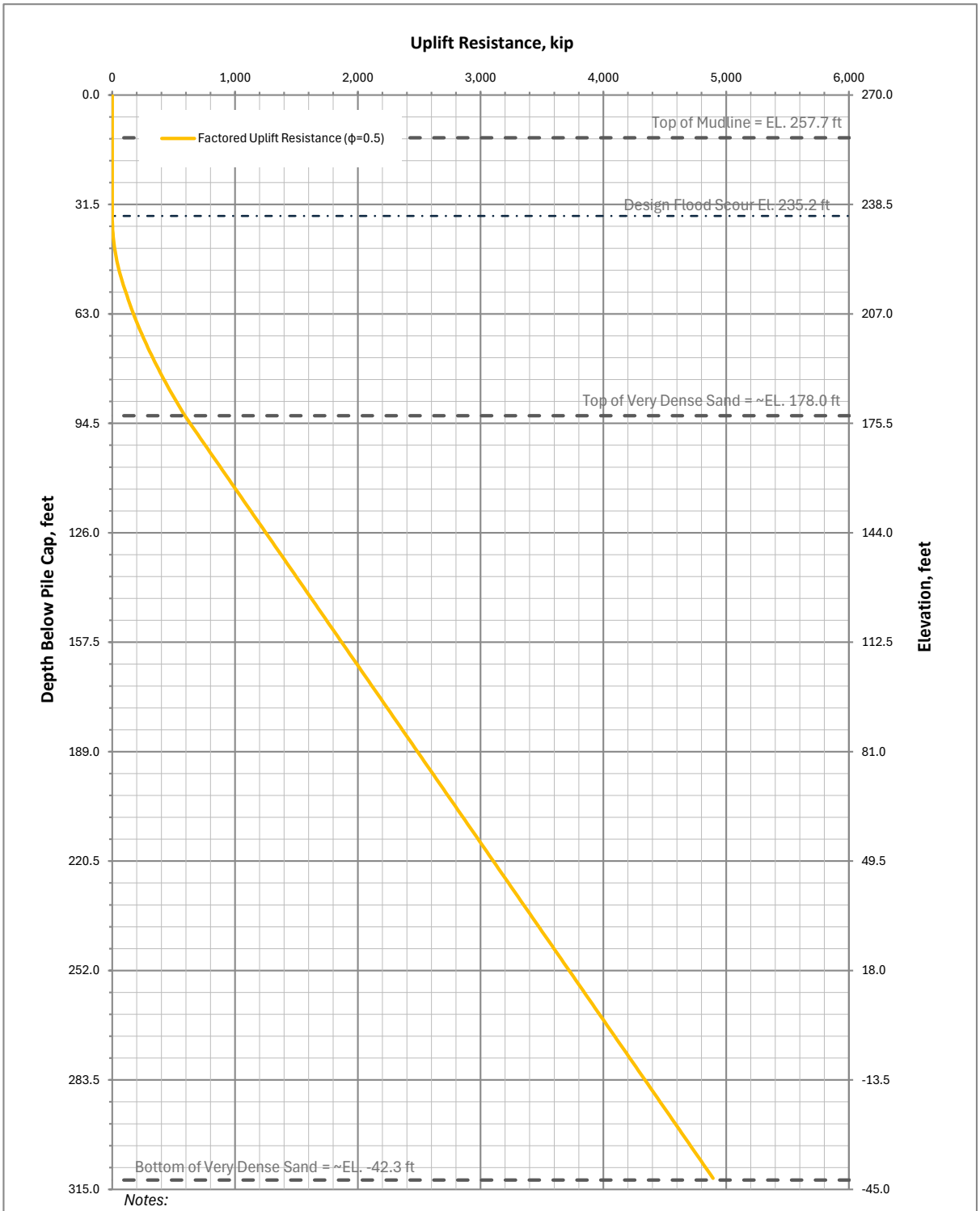
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for single piles and does not include group efficiency factors.
*Factored Structural Capacity of 72inx1.5in Pipe Pile = **11,628 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test.

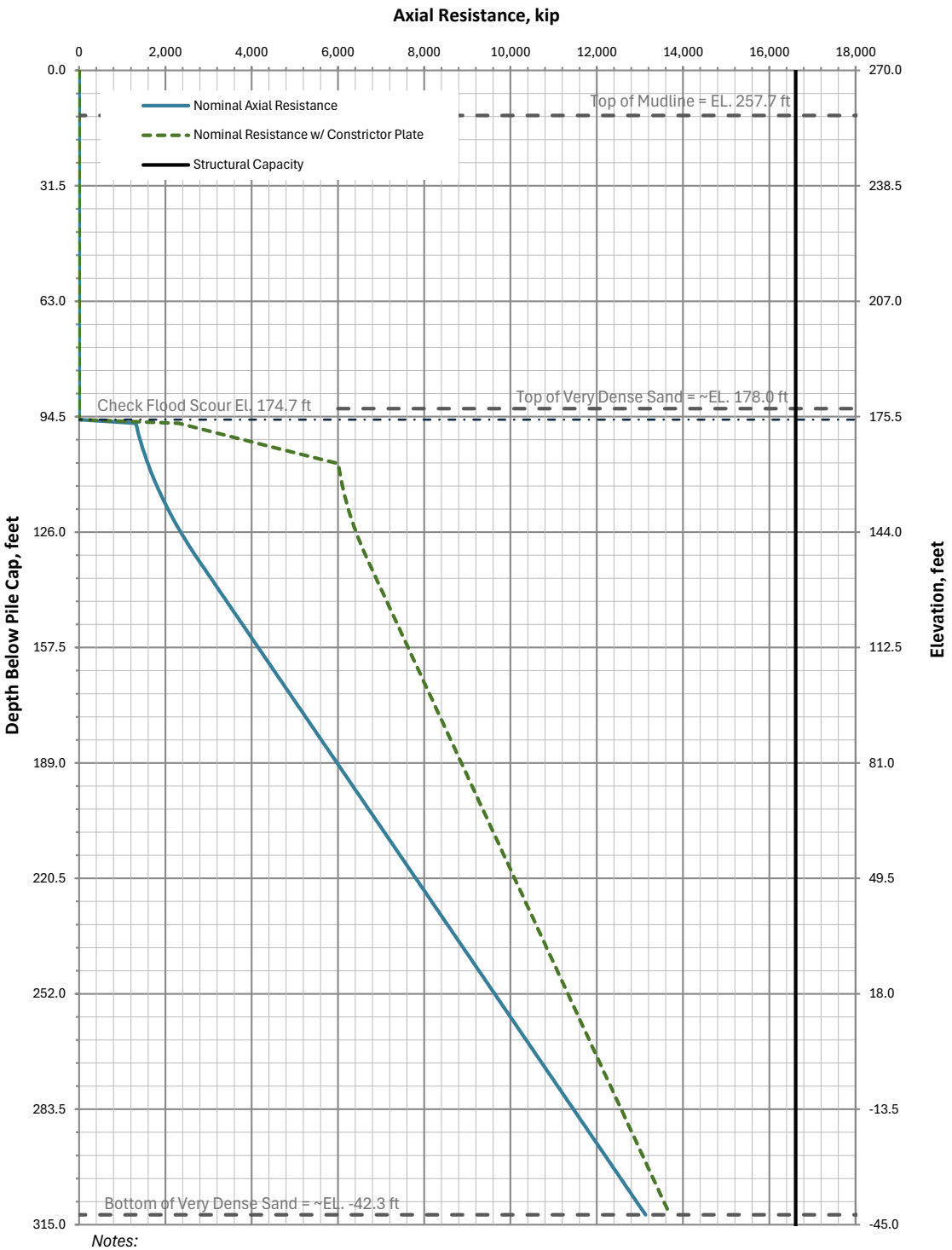
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

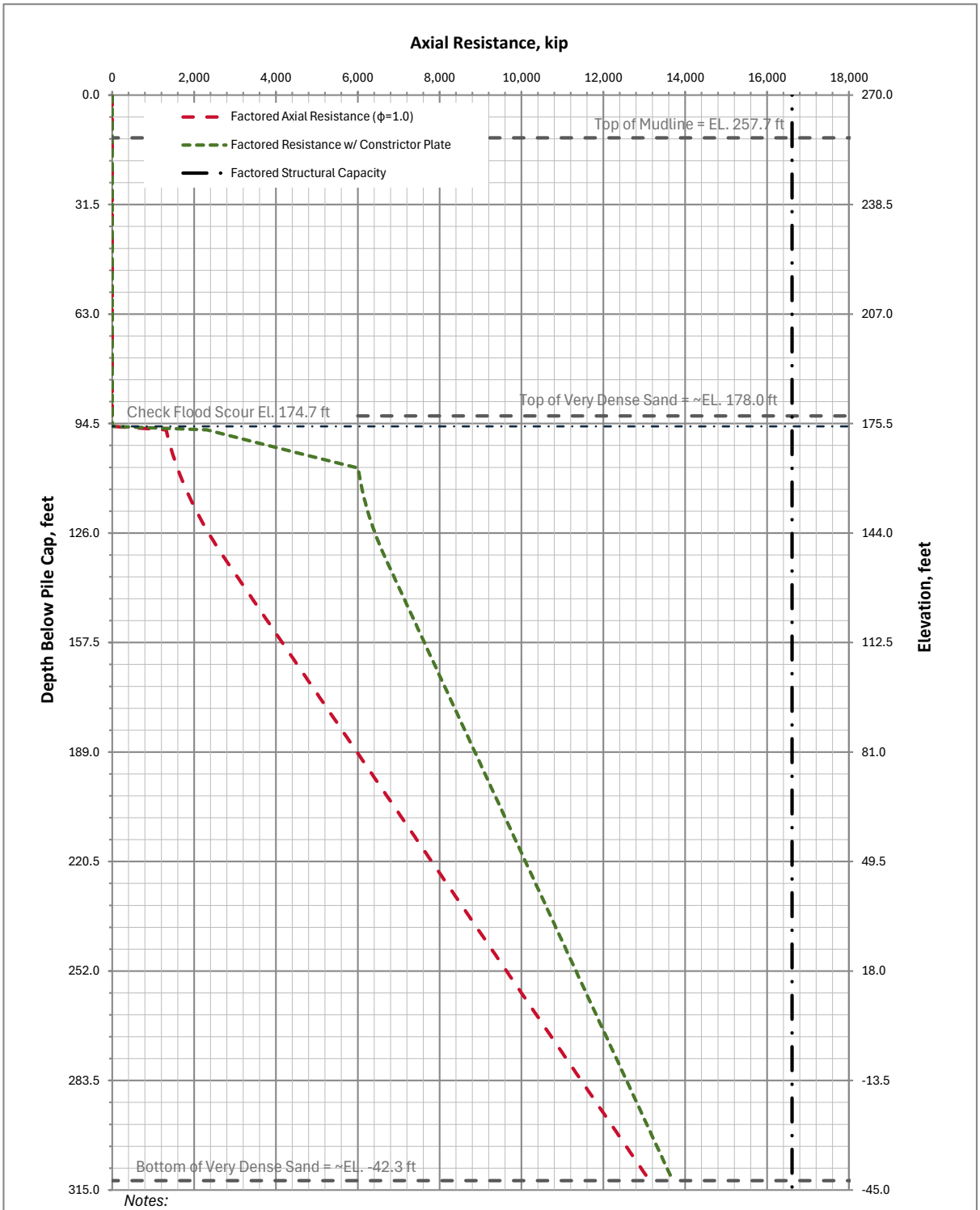
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



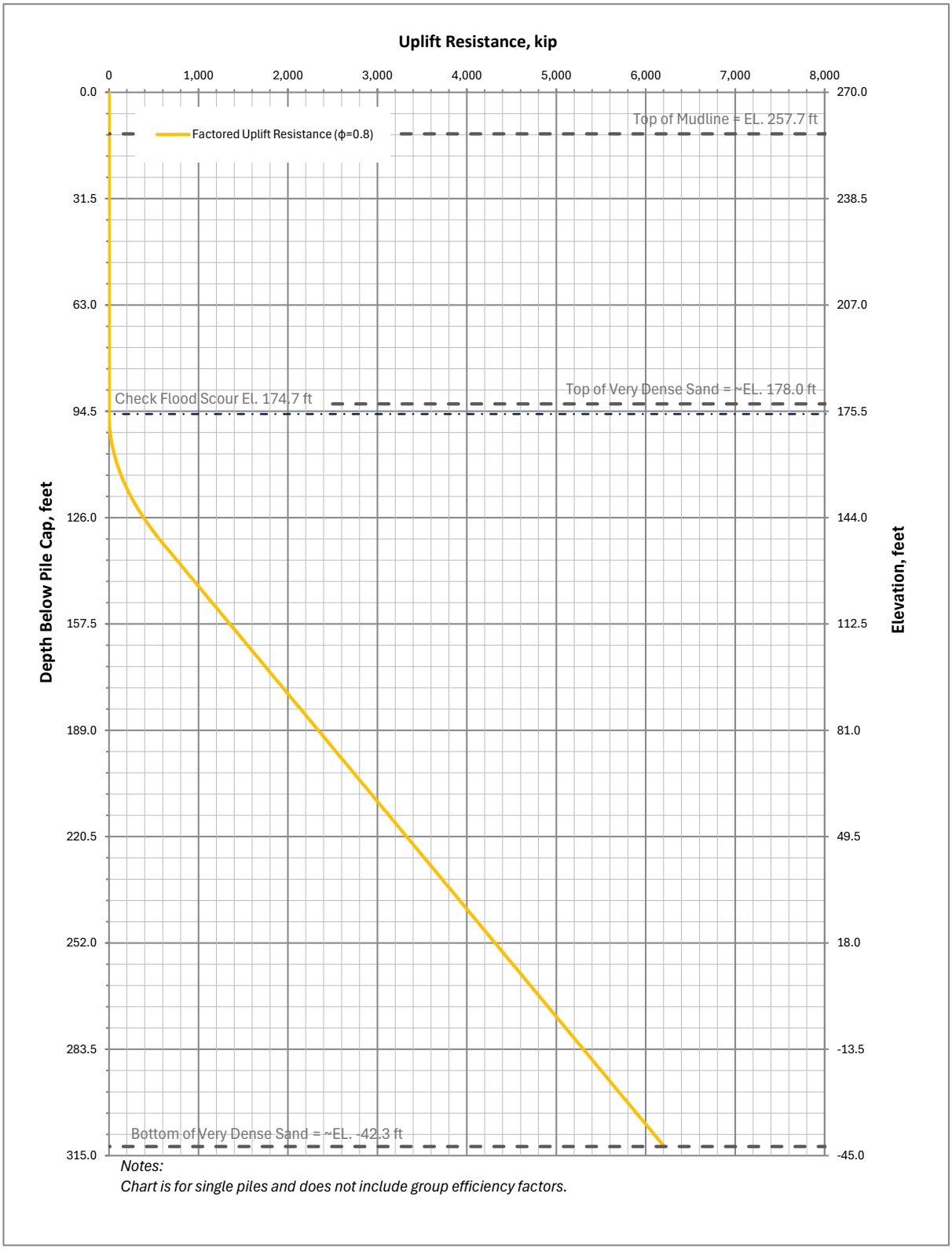
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



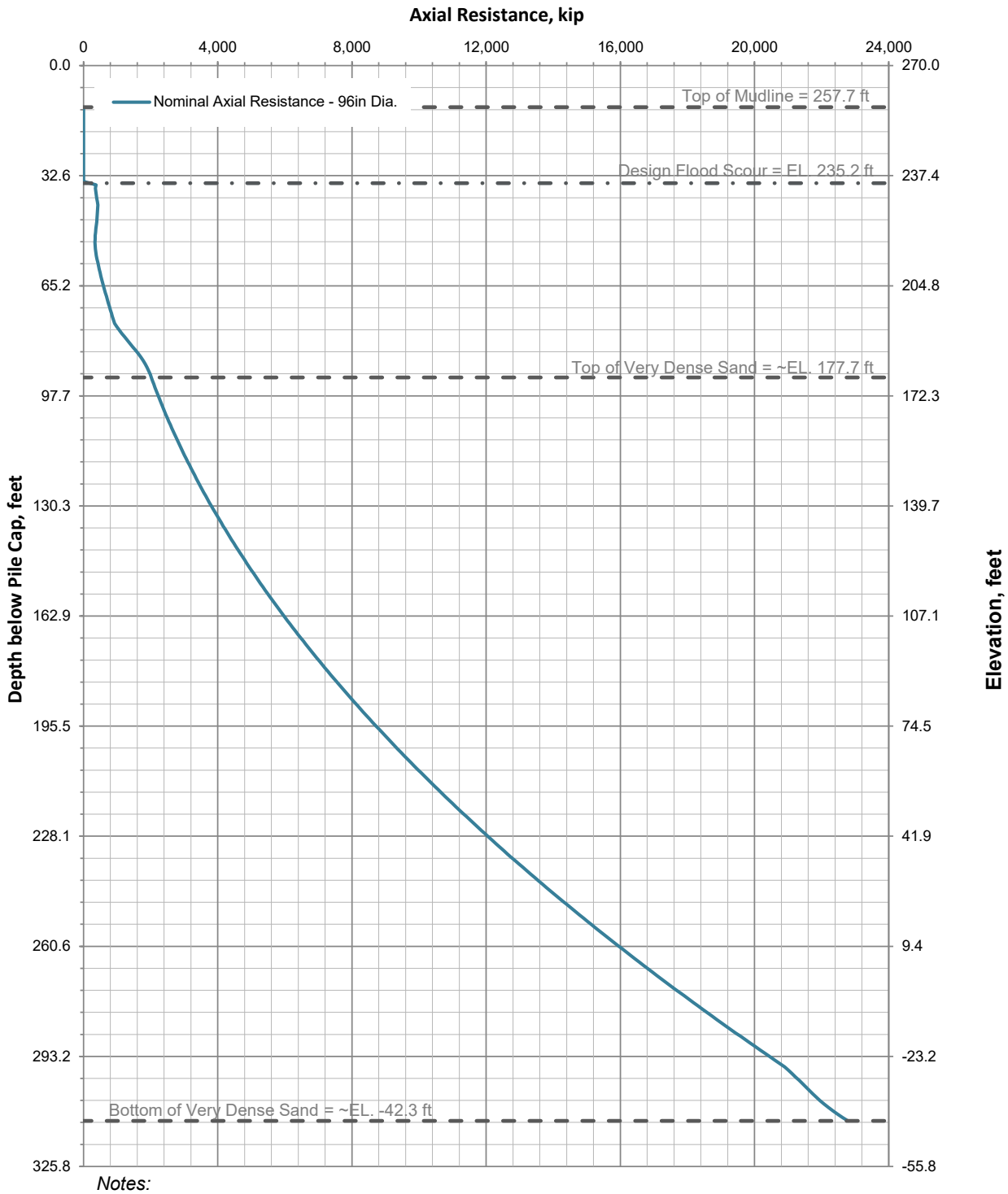
Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



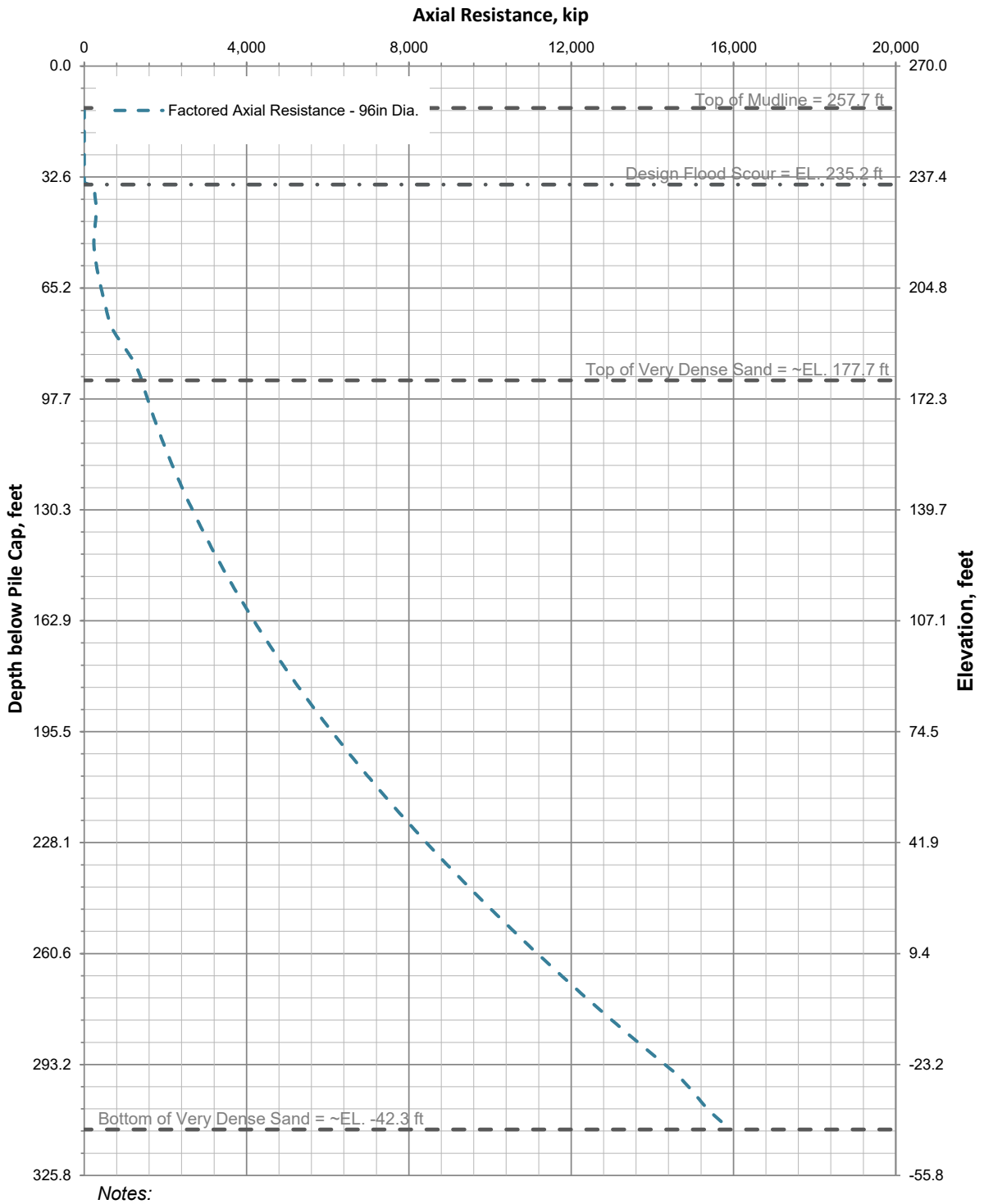
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



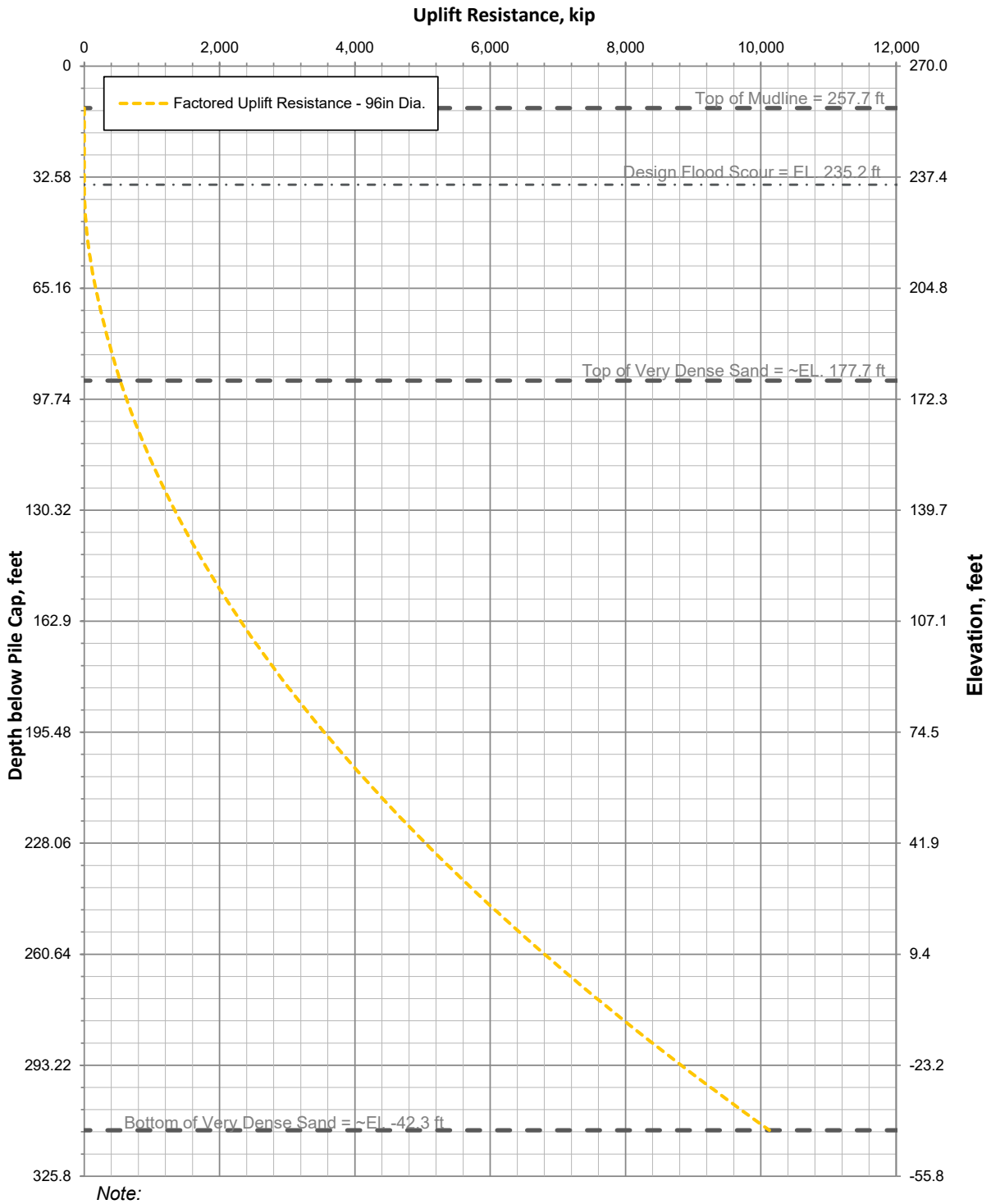
Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



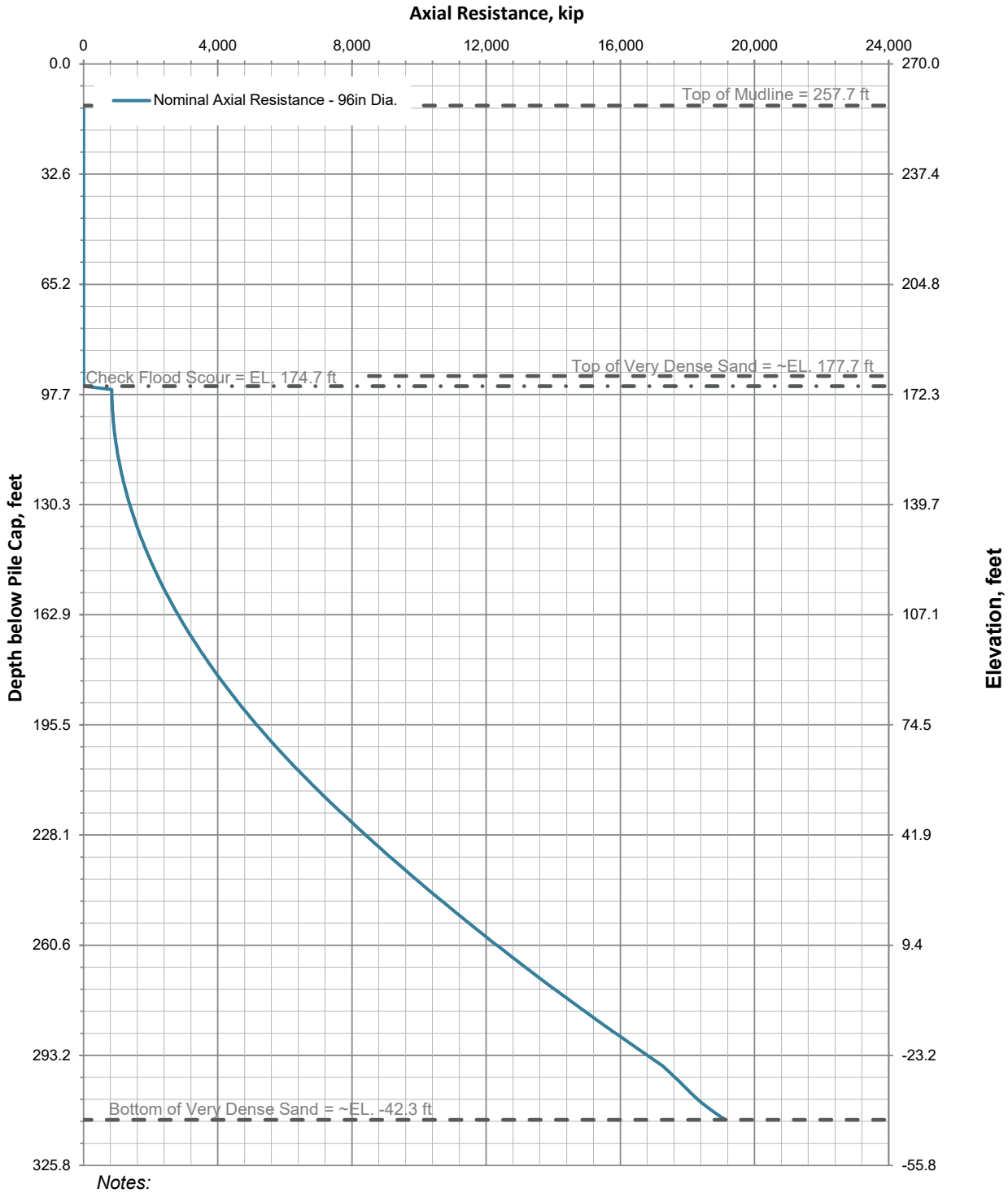
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



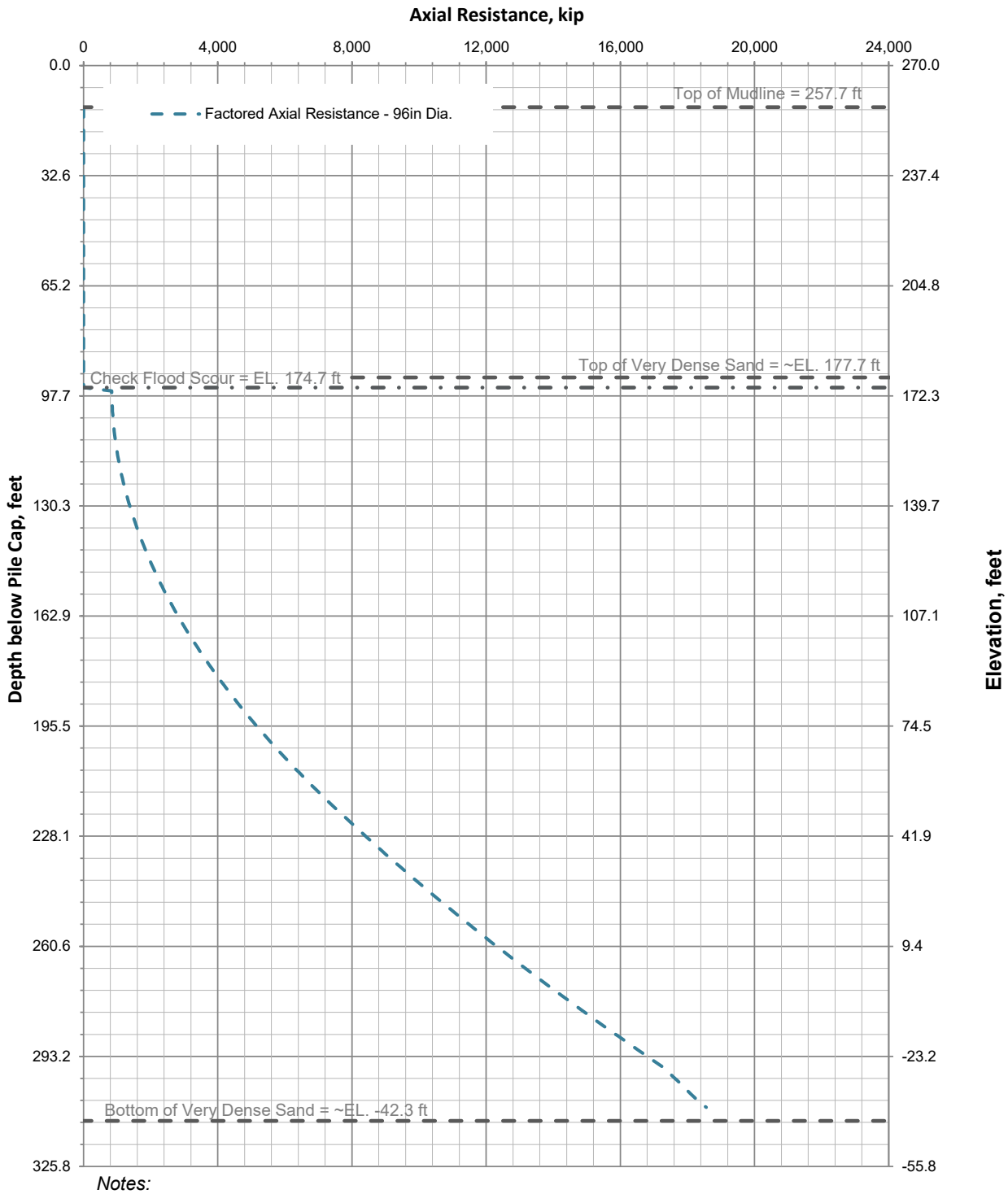
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Uplift Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



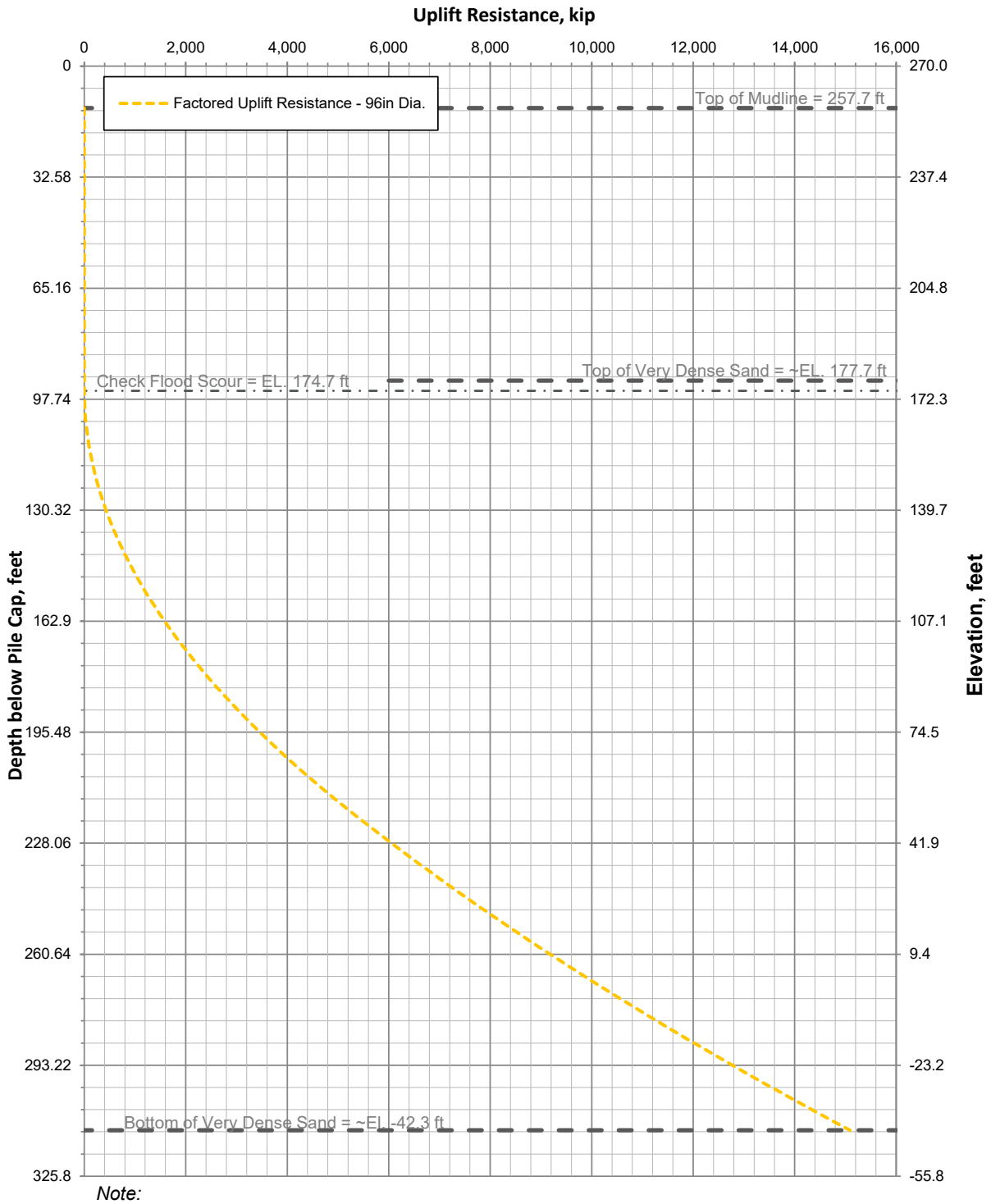
Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** I-55 Interchange at SR-14 **Location:** Shelby Co., TN **Approved:** **Review Date:** **Drawn By:** SKB **Figure No. ##** **Date:** 03/21/2025

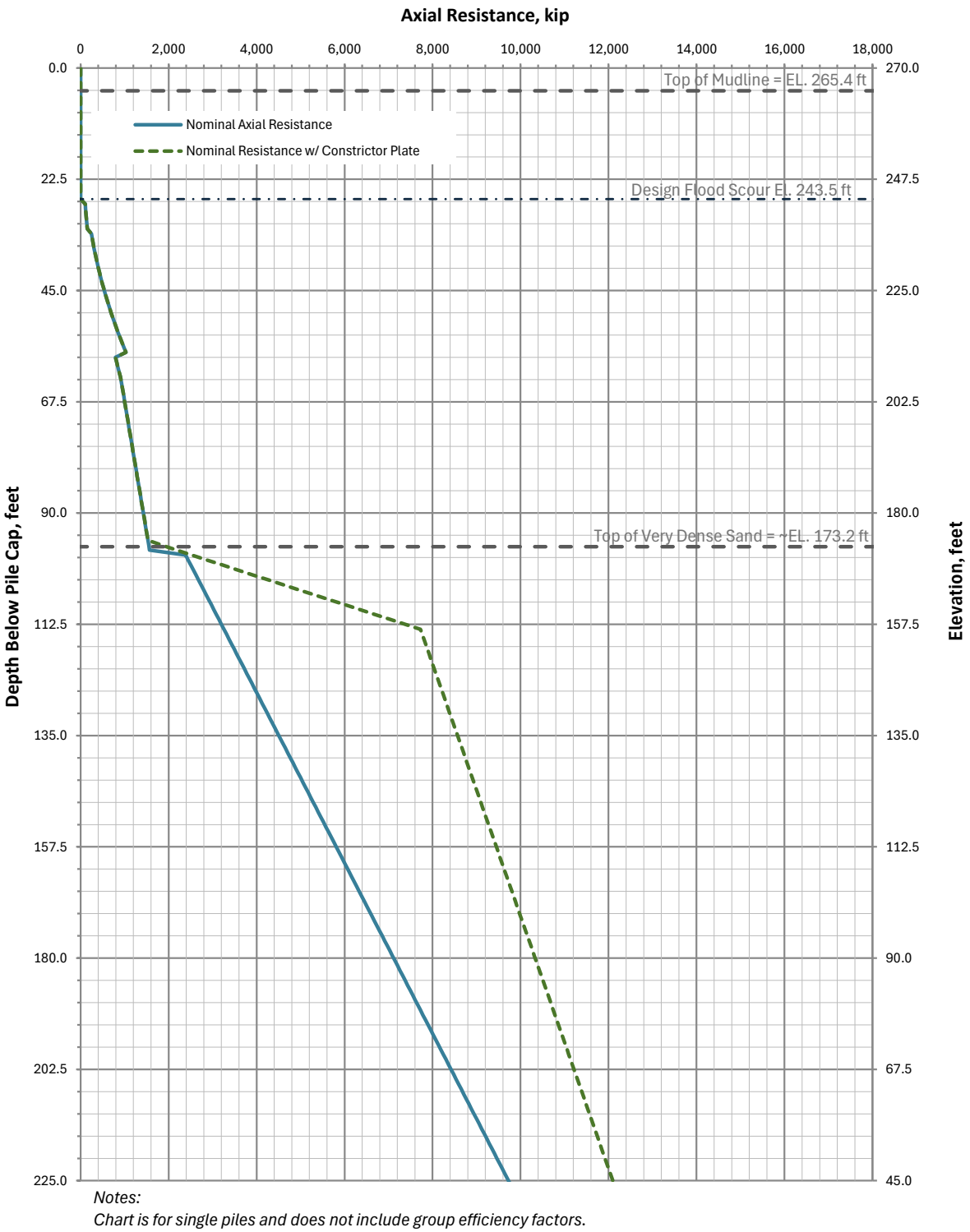


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Uplift Resistance Graph**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

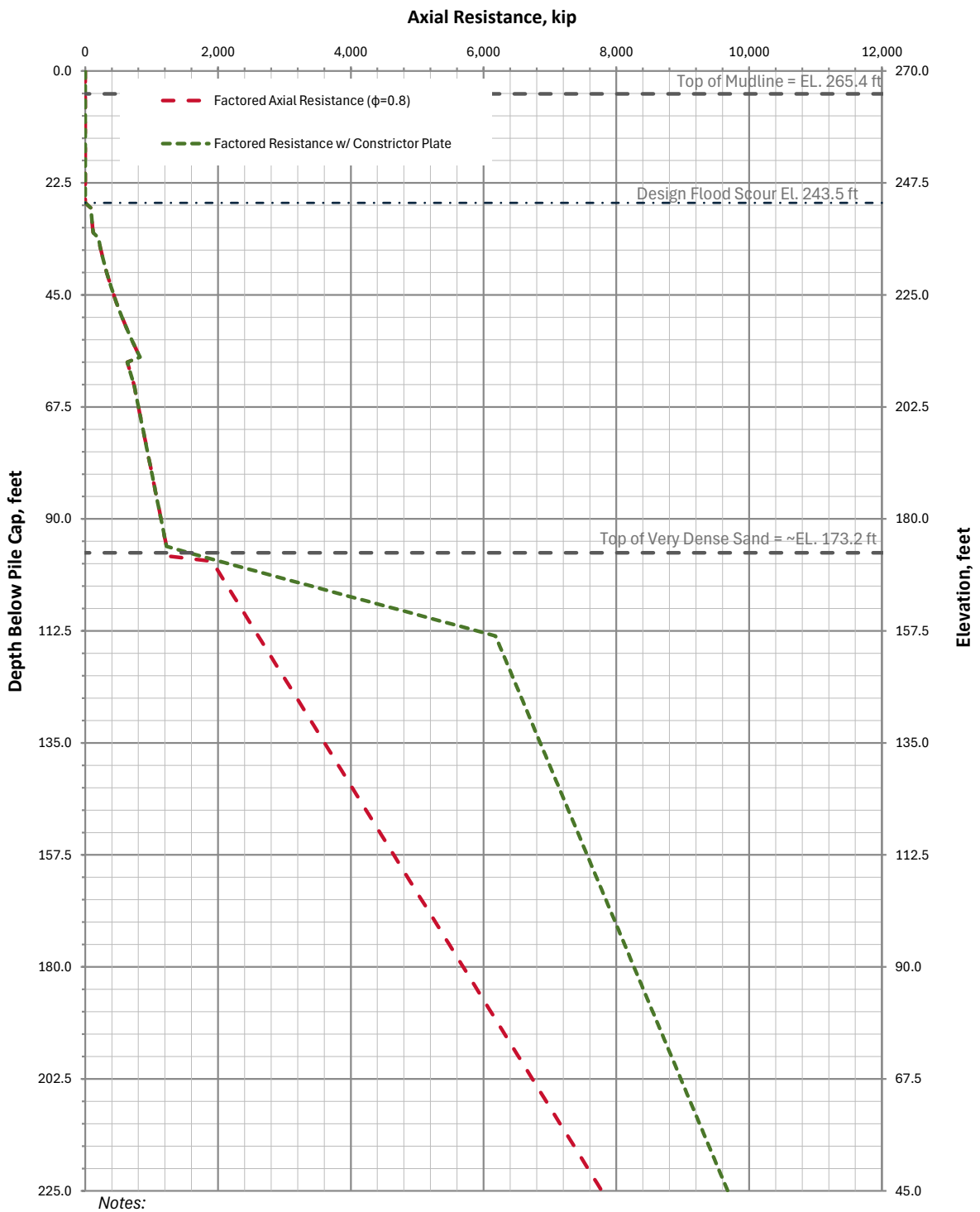
PIER 7

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



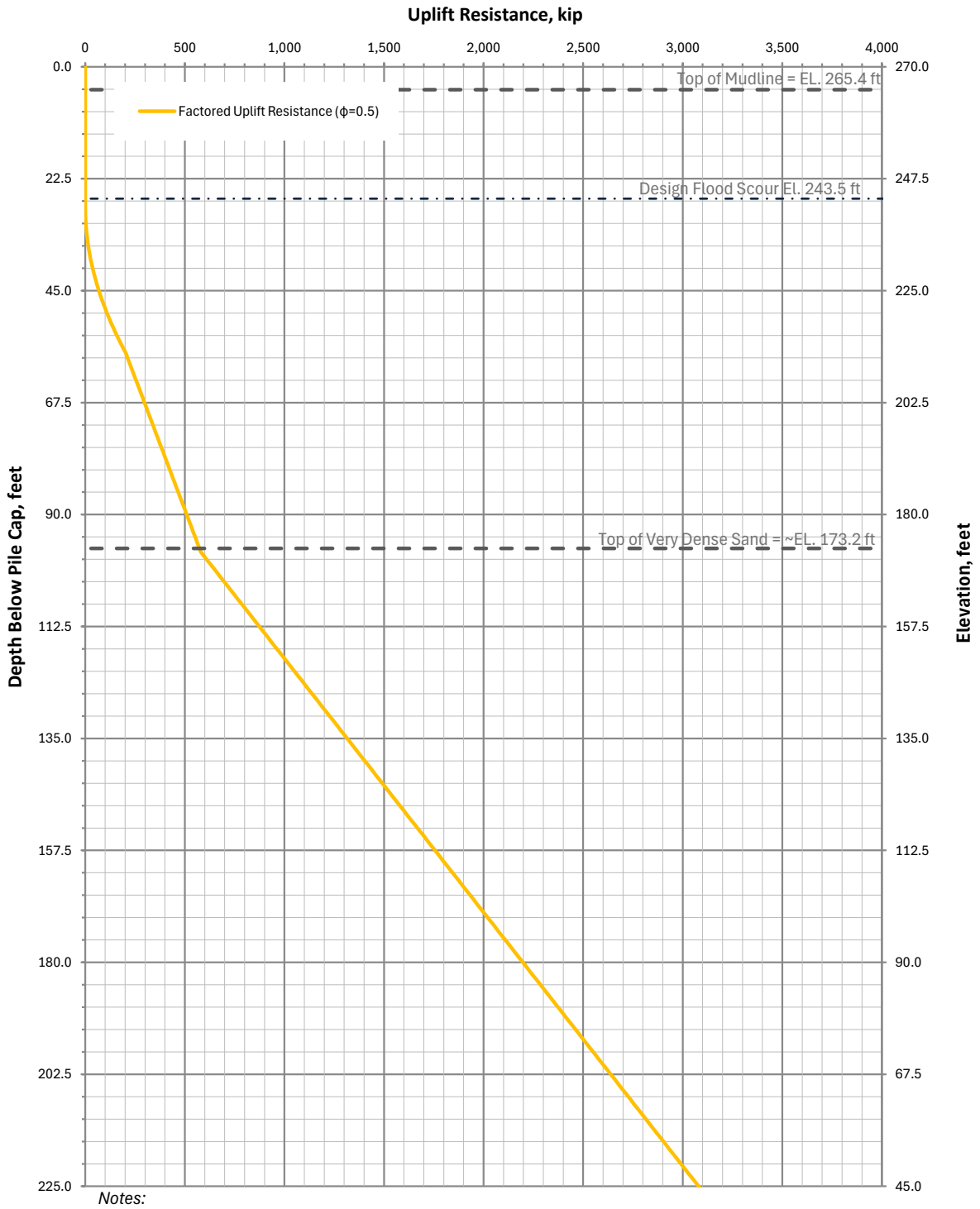
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

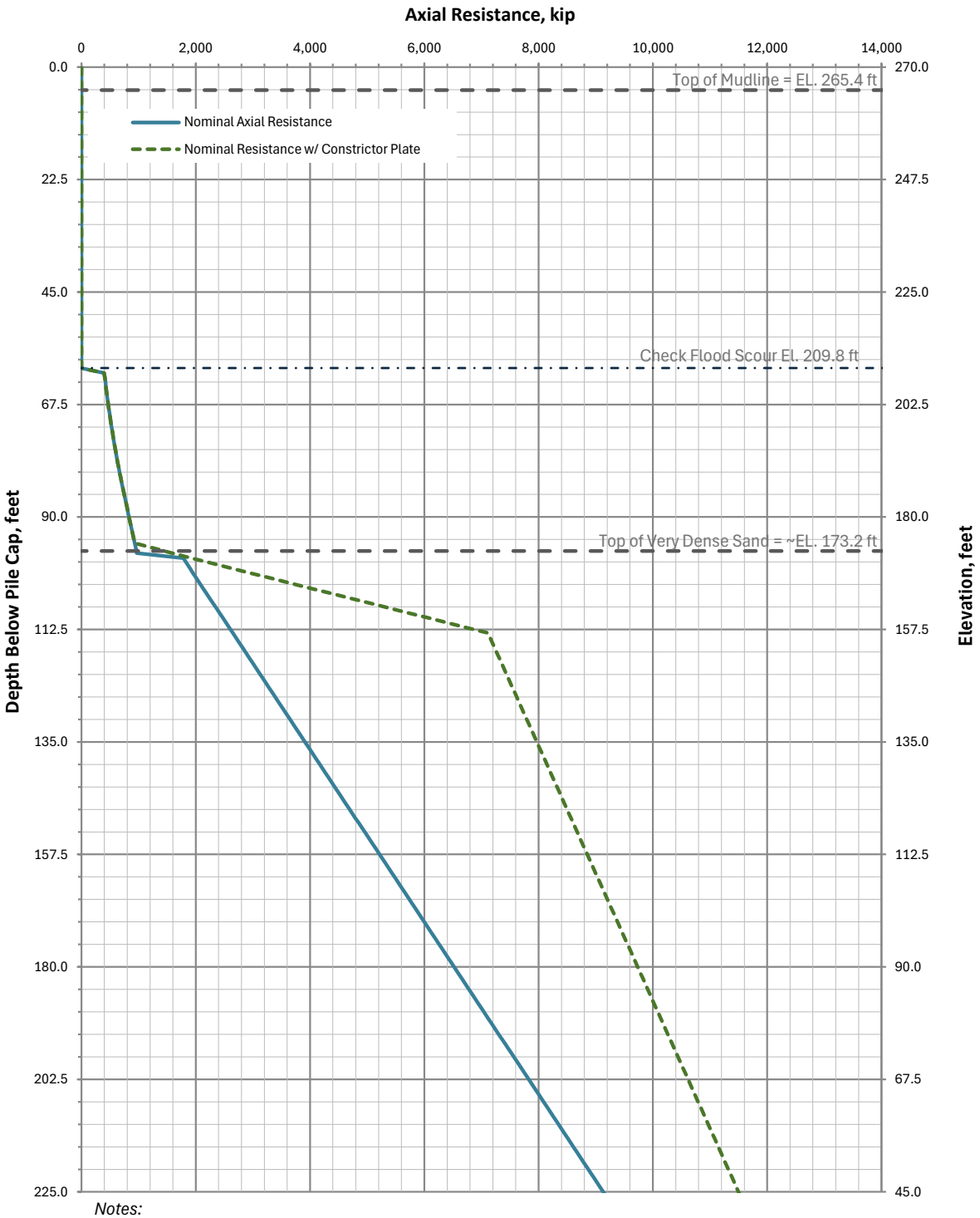
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

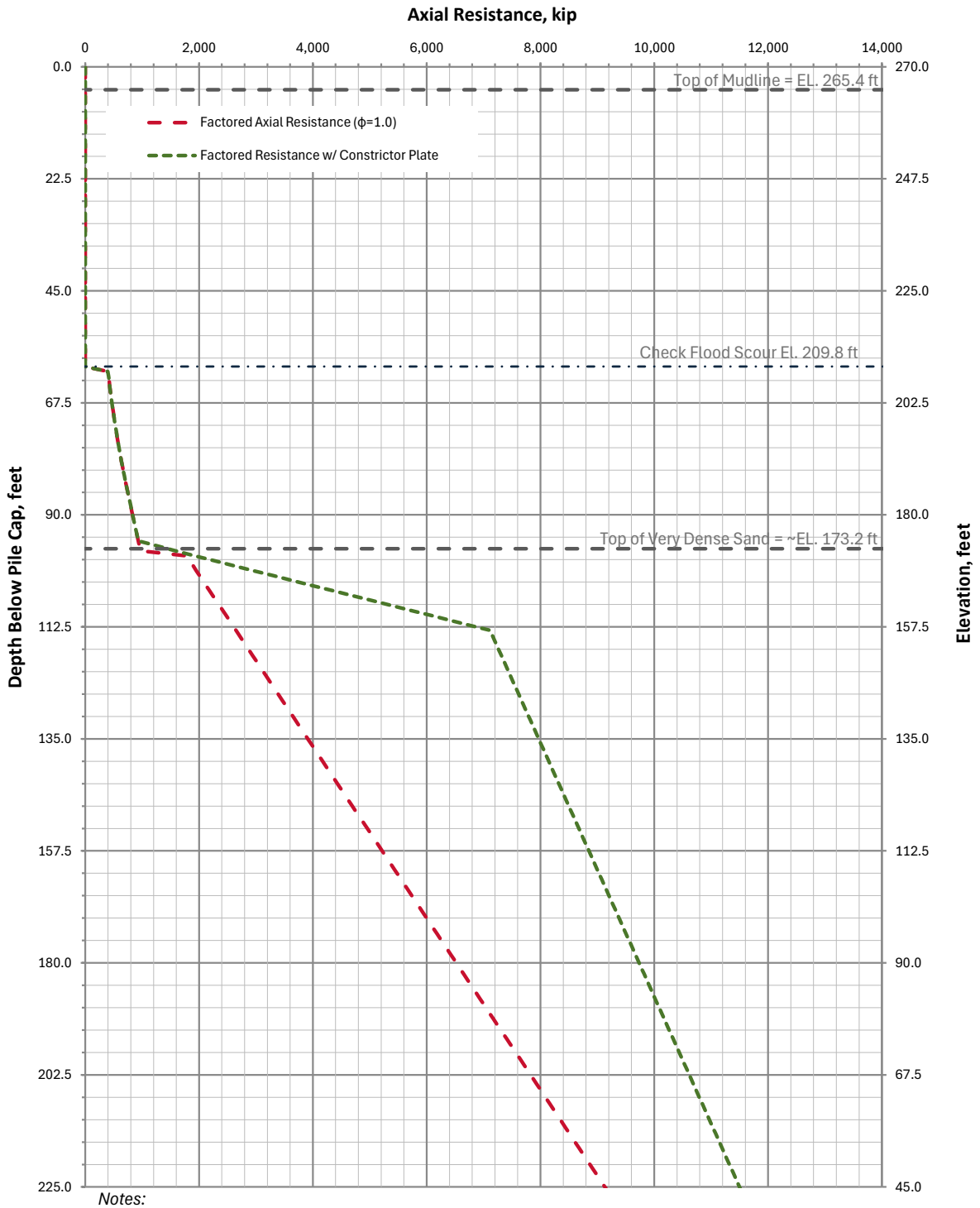
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



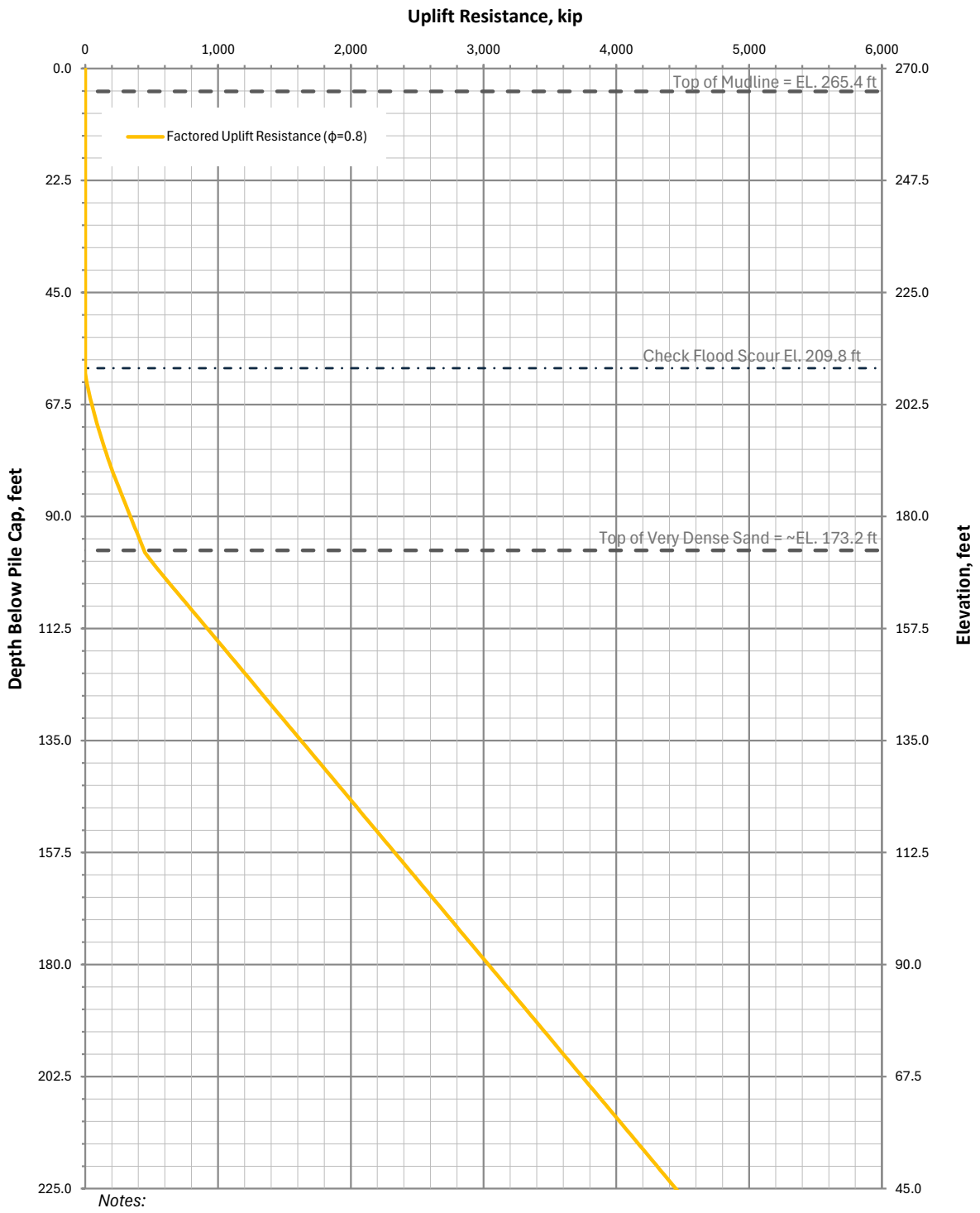
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



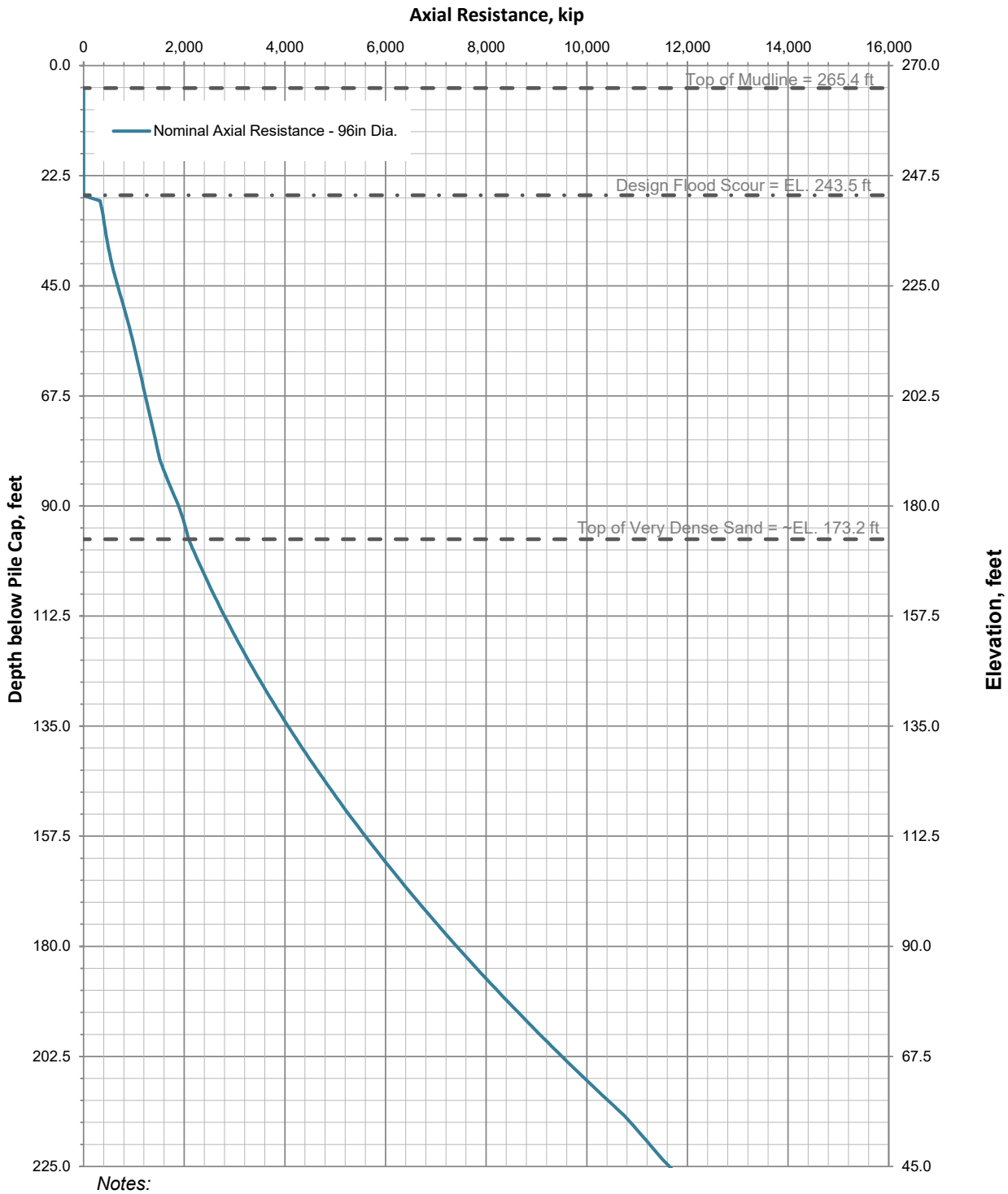
Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



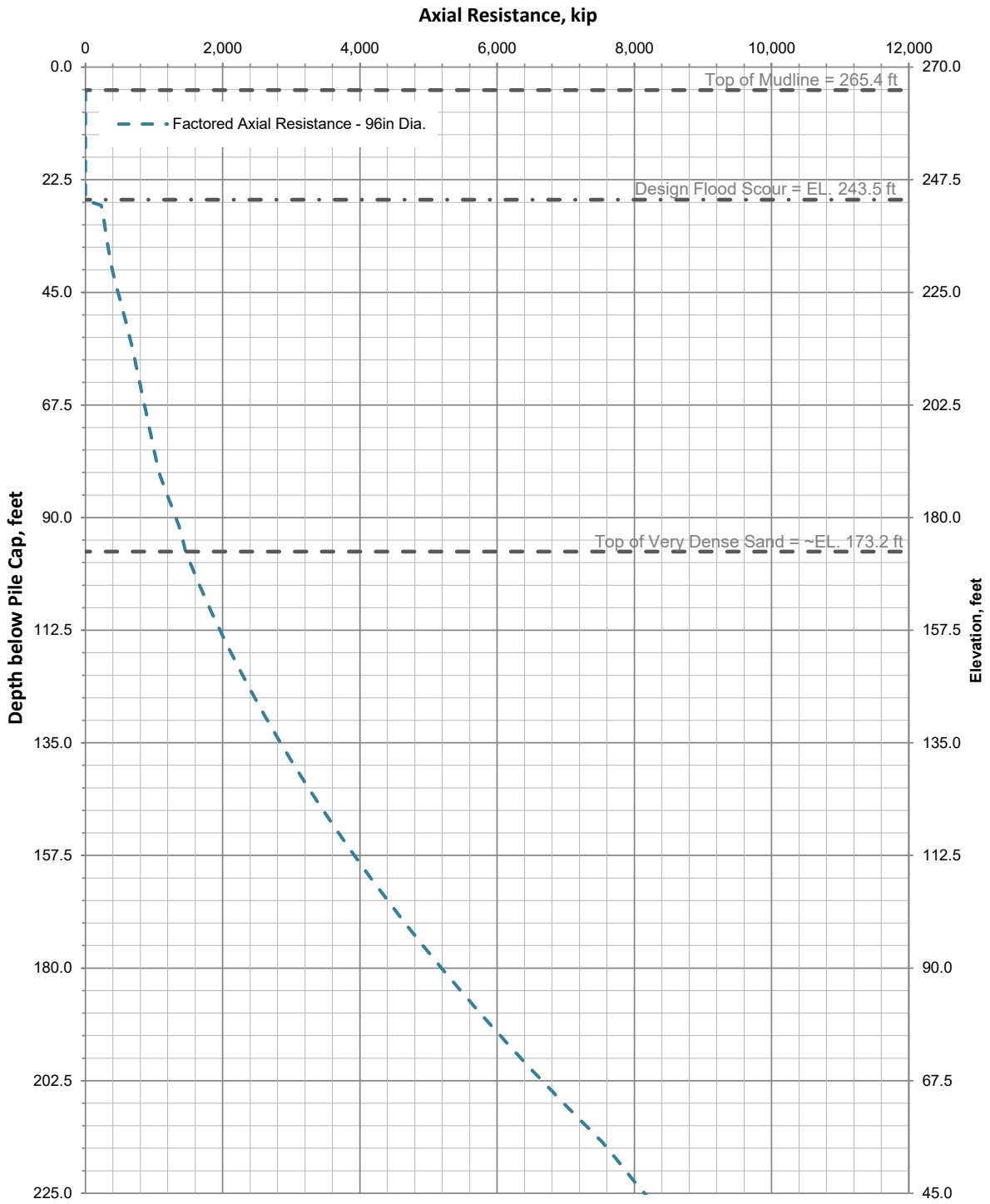
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



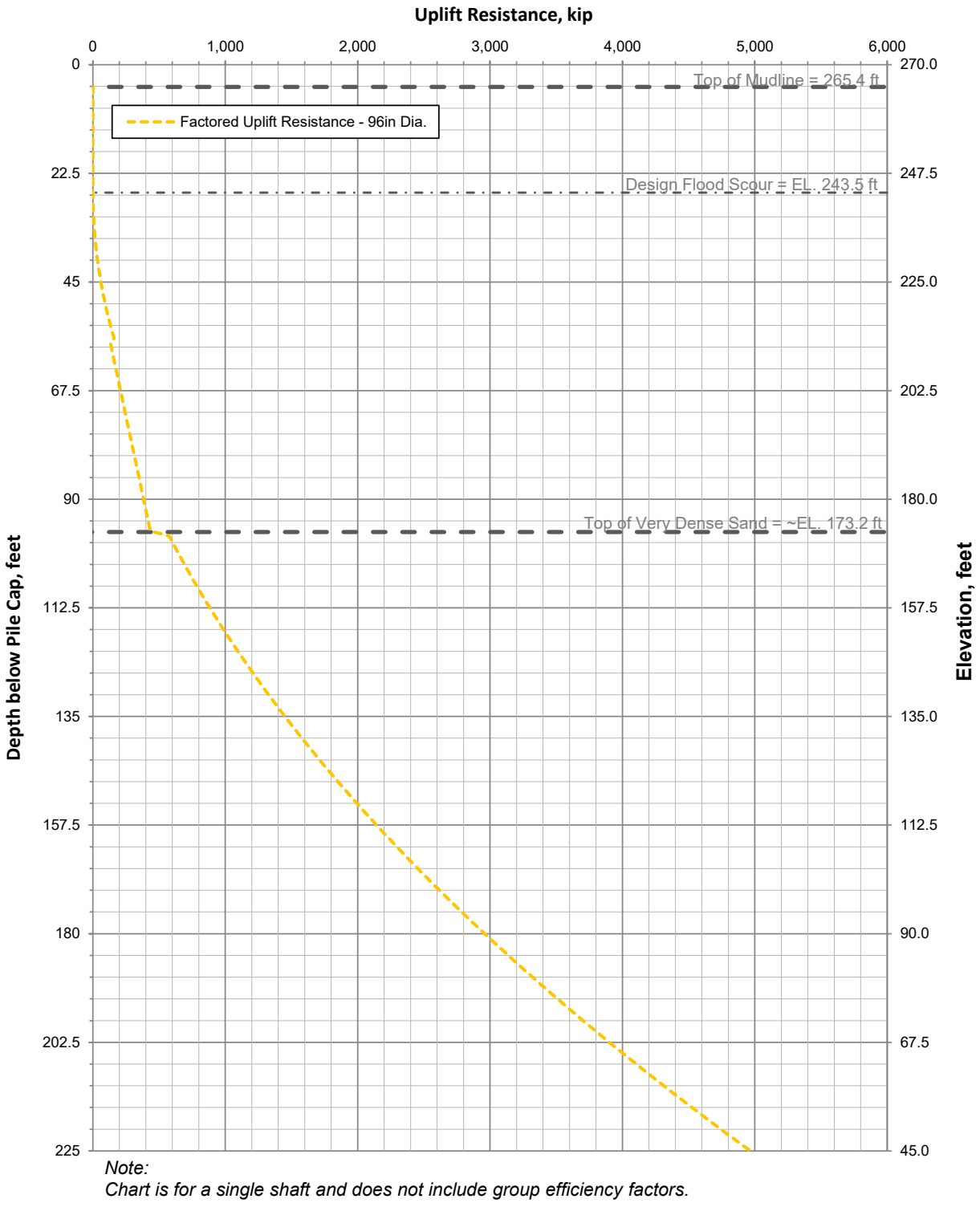
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



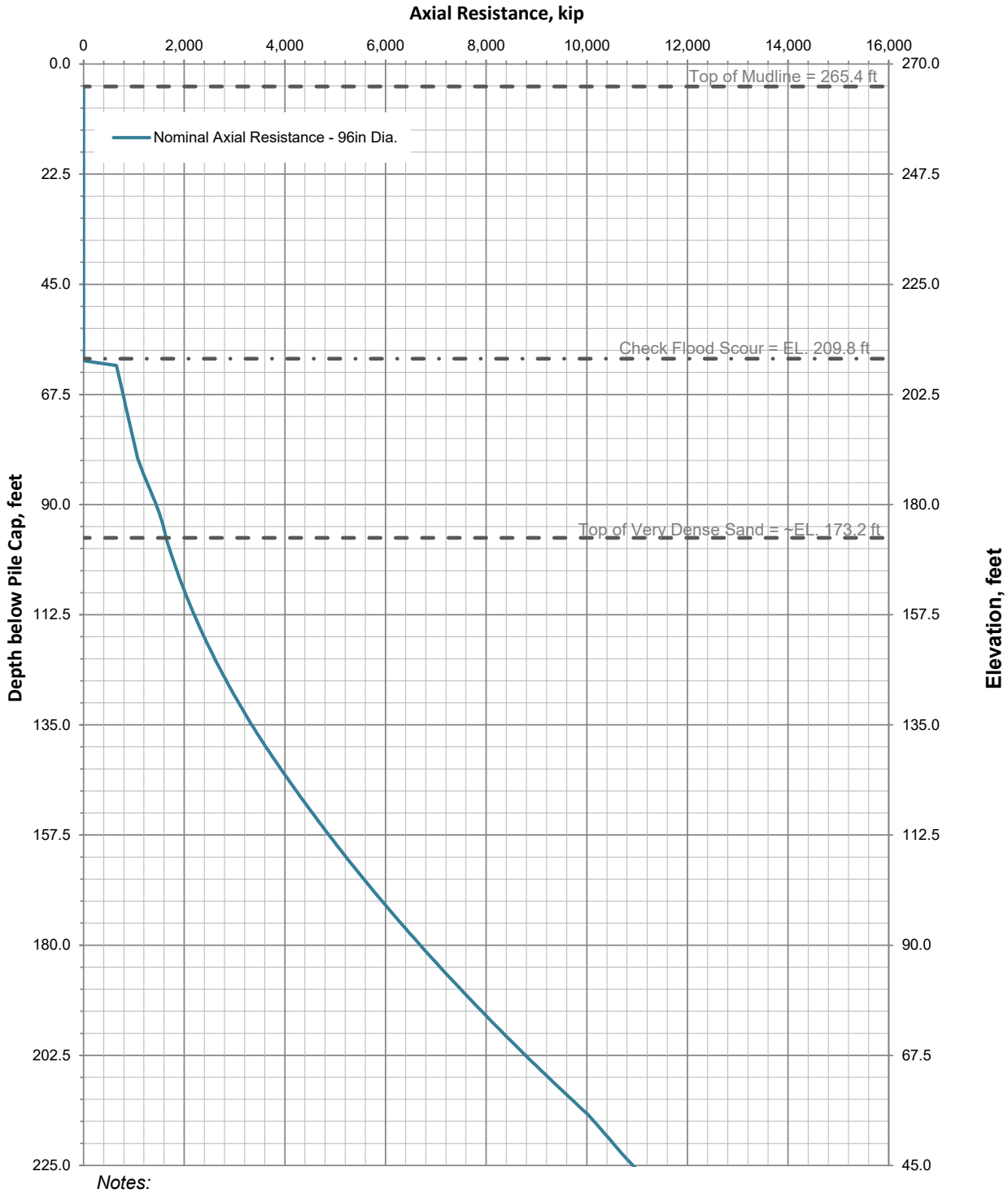
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



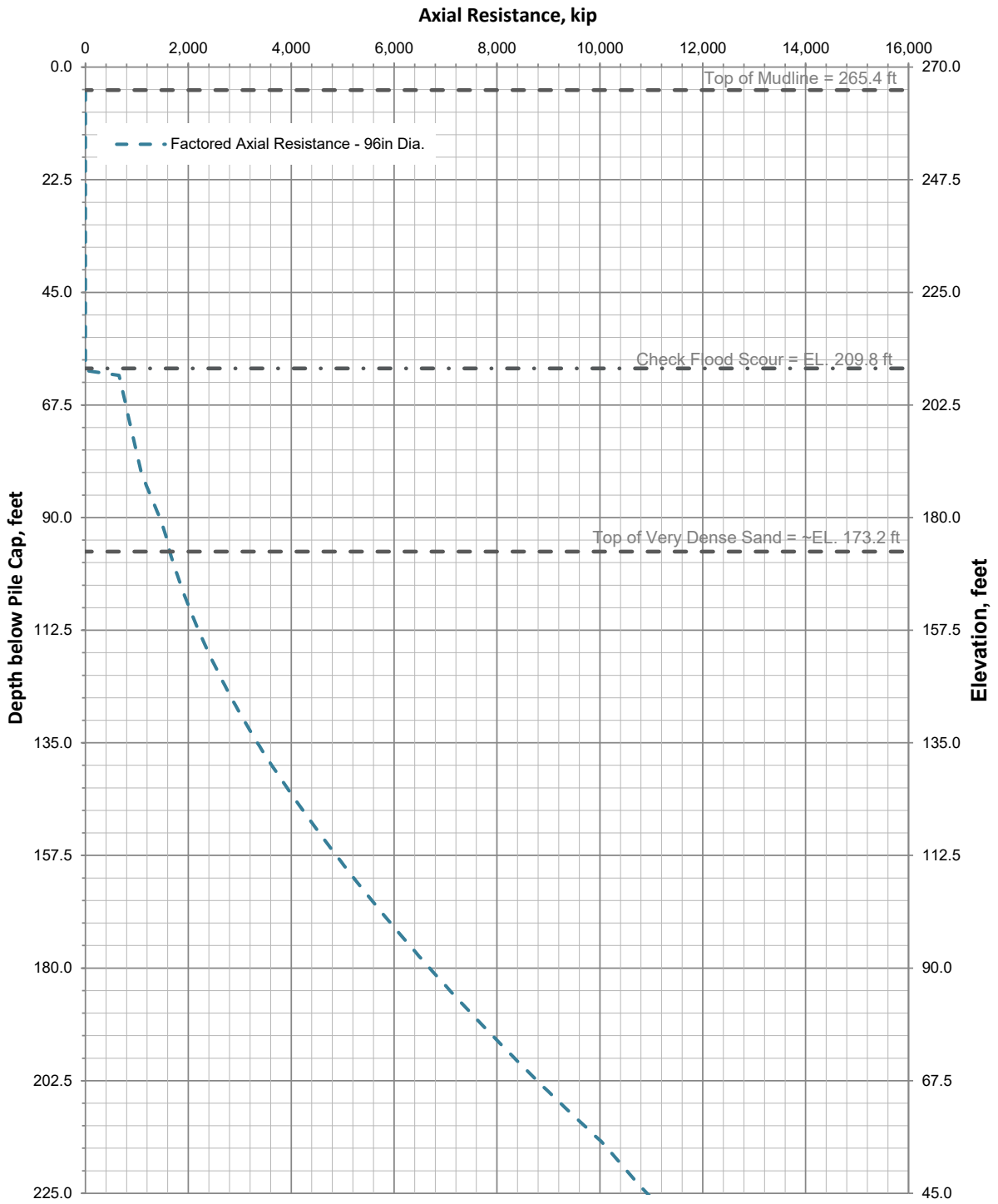
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



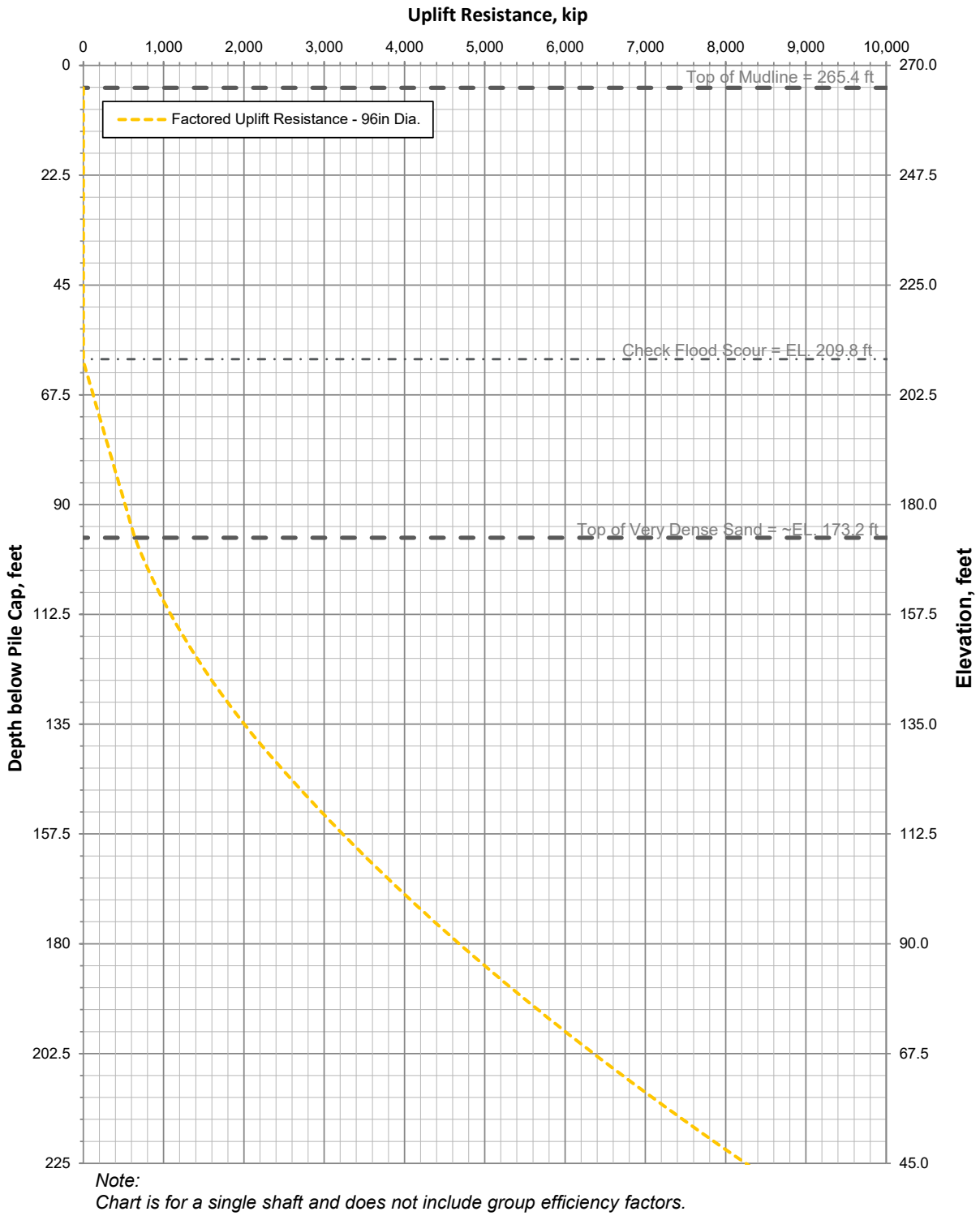
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

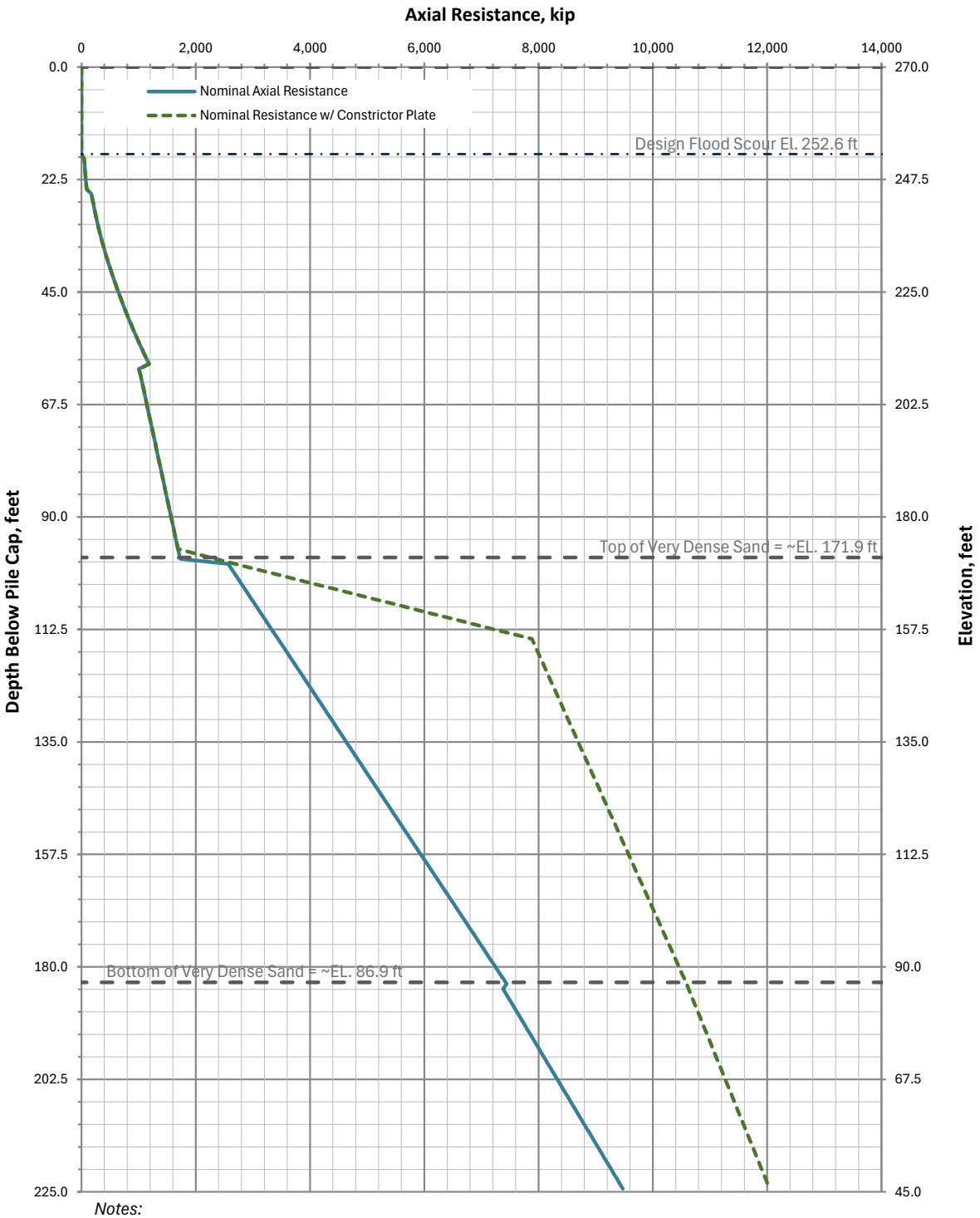


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 03/31/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 03/31/2025

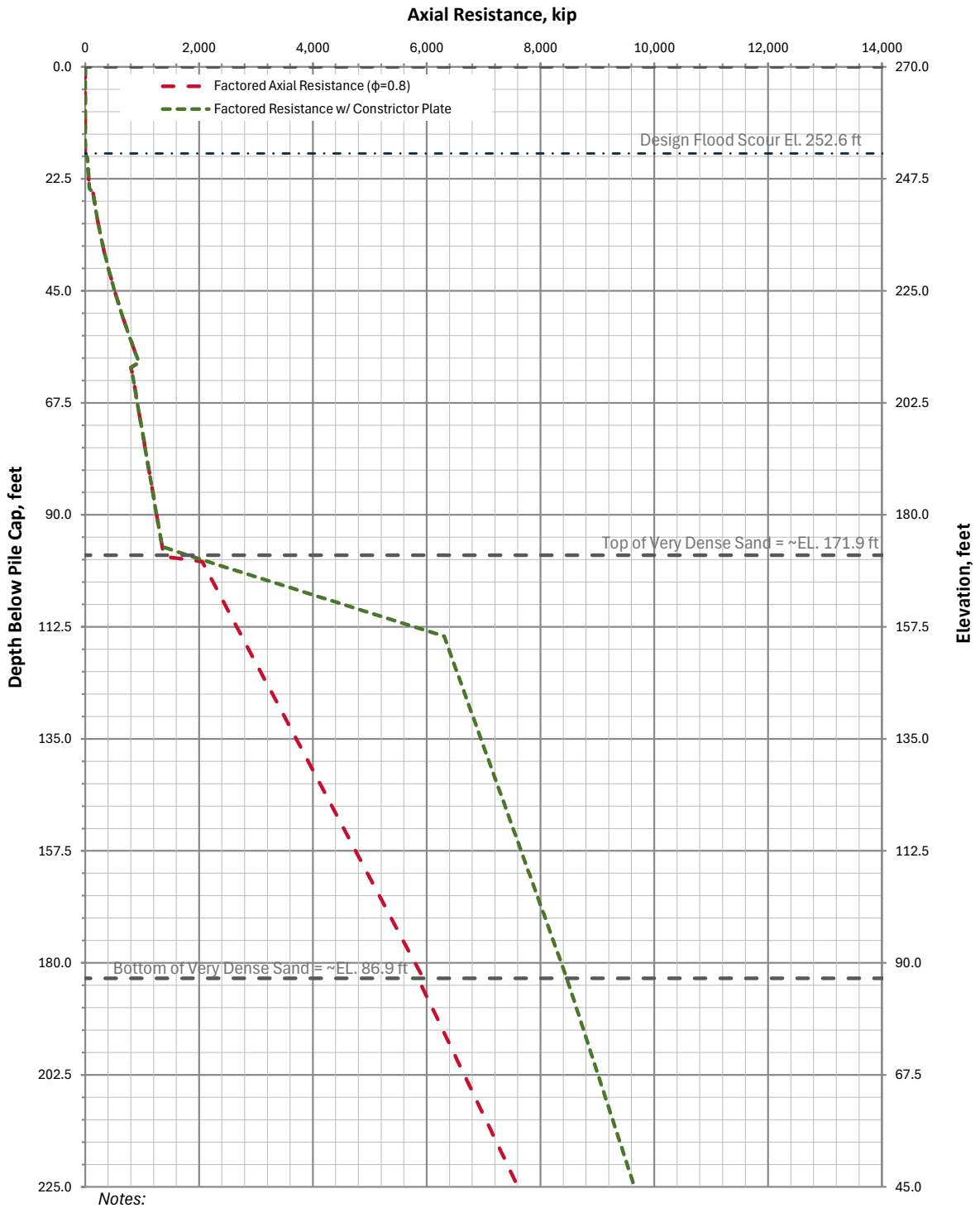
PIER 8

PIPE PILE AXIAL RESISTANCE GRAPHS – STRENGTH-I



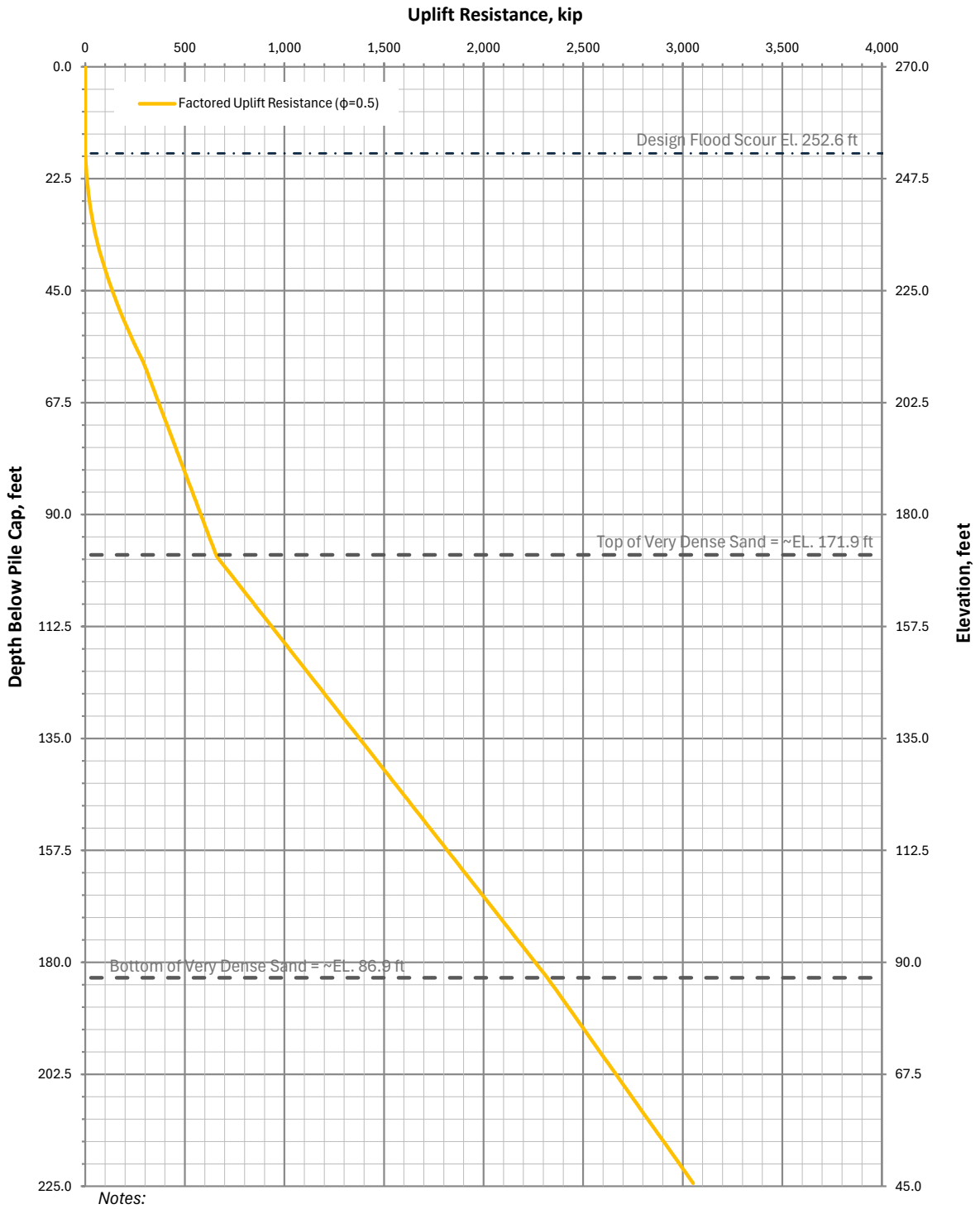
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

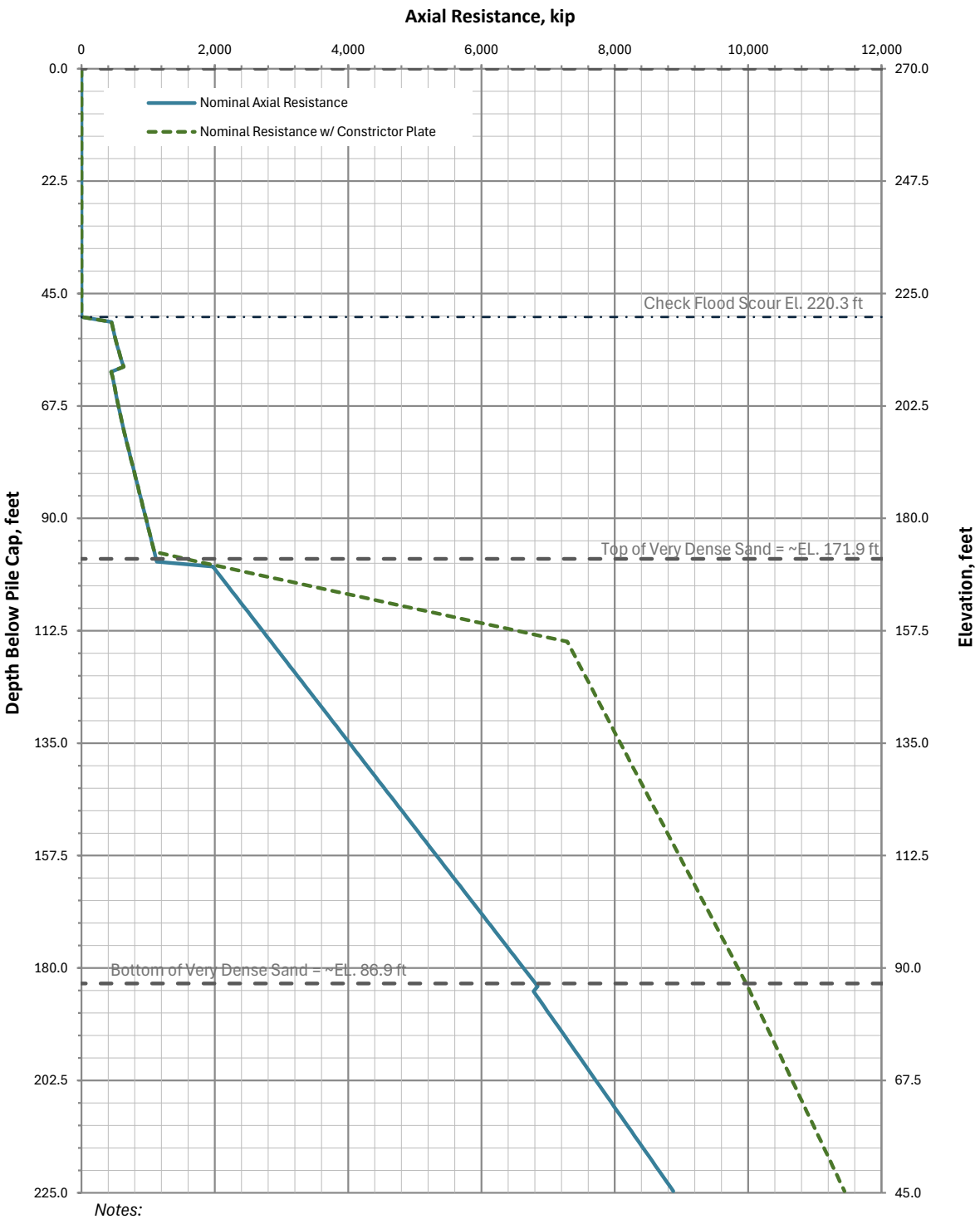
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Strength-I**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

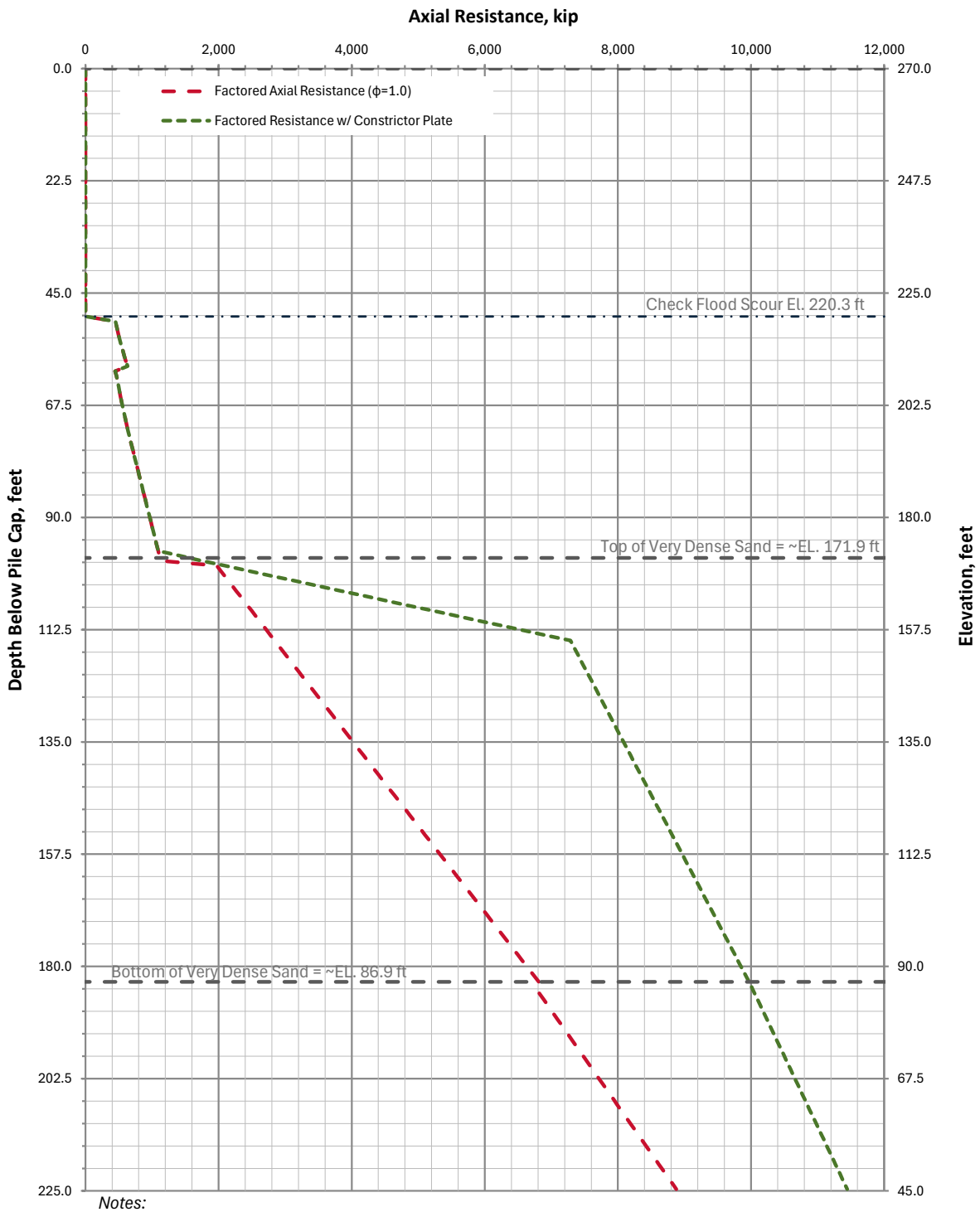
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – EXTREME EVENT-II



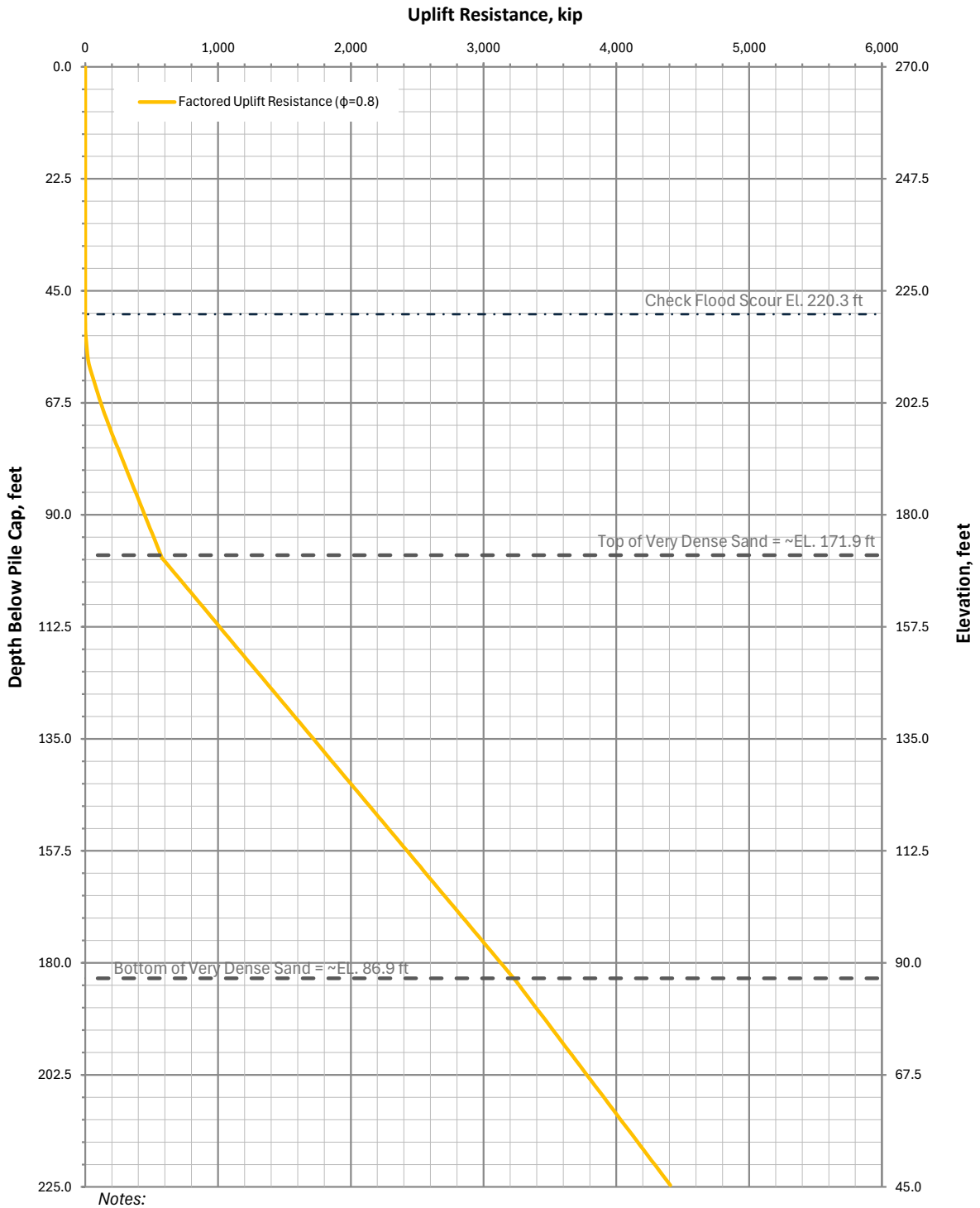
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



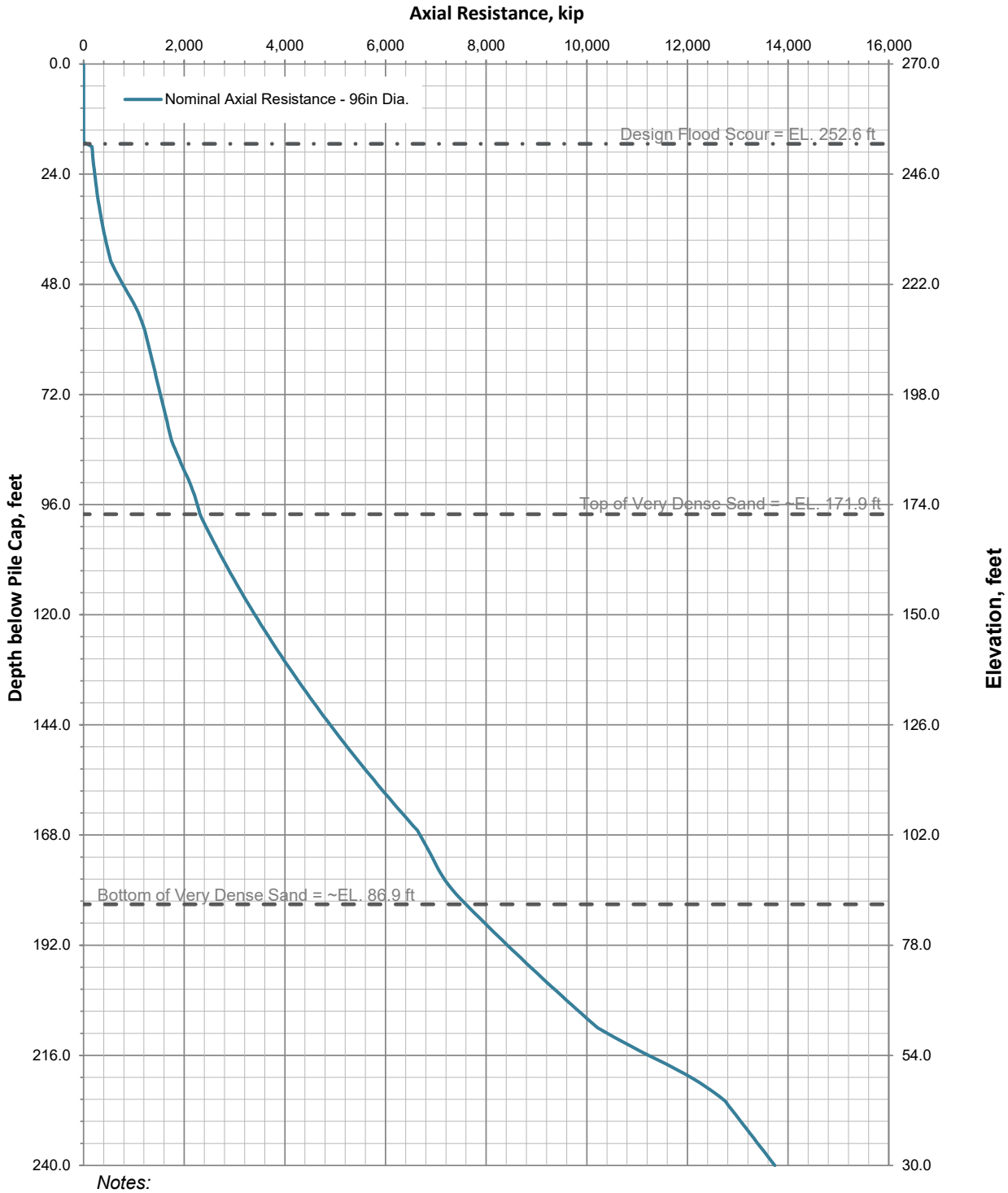
Notes:
Chart is for single piles and does not include group efficiency factors.
Factored Axial Resistance based on Implementation of Foundation Load Test.

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



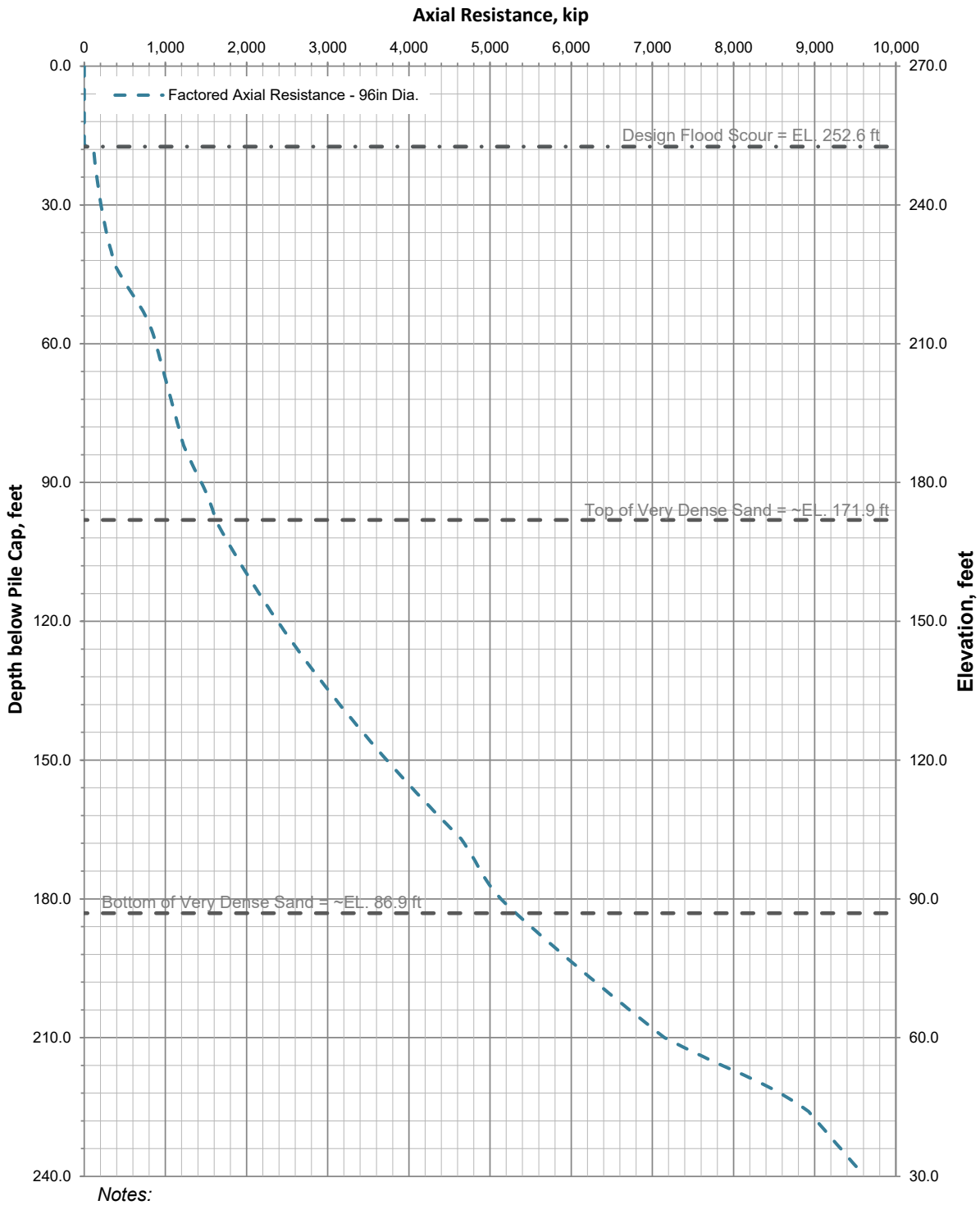
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



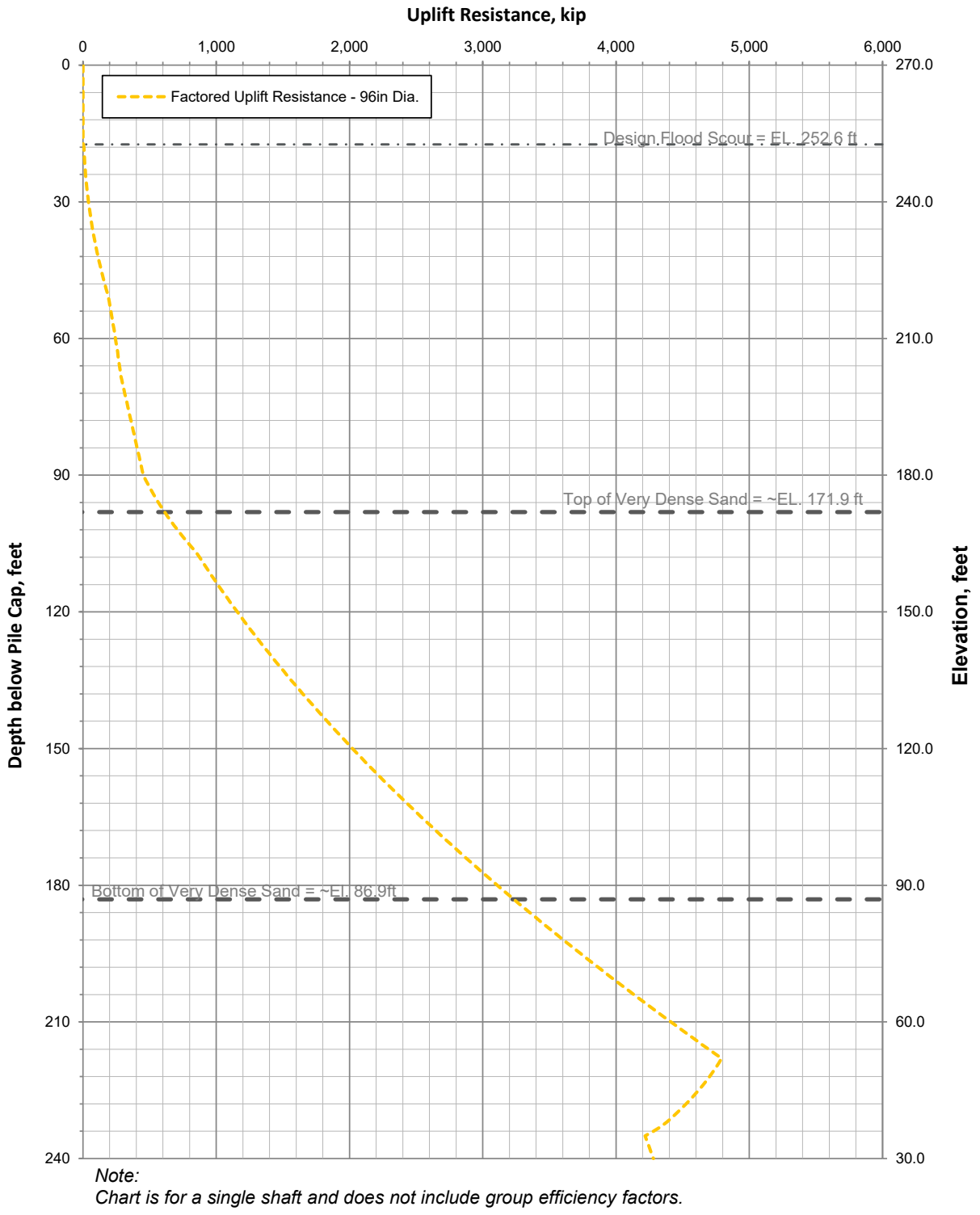
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Strength-I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



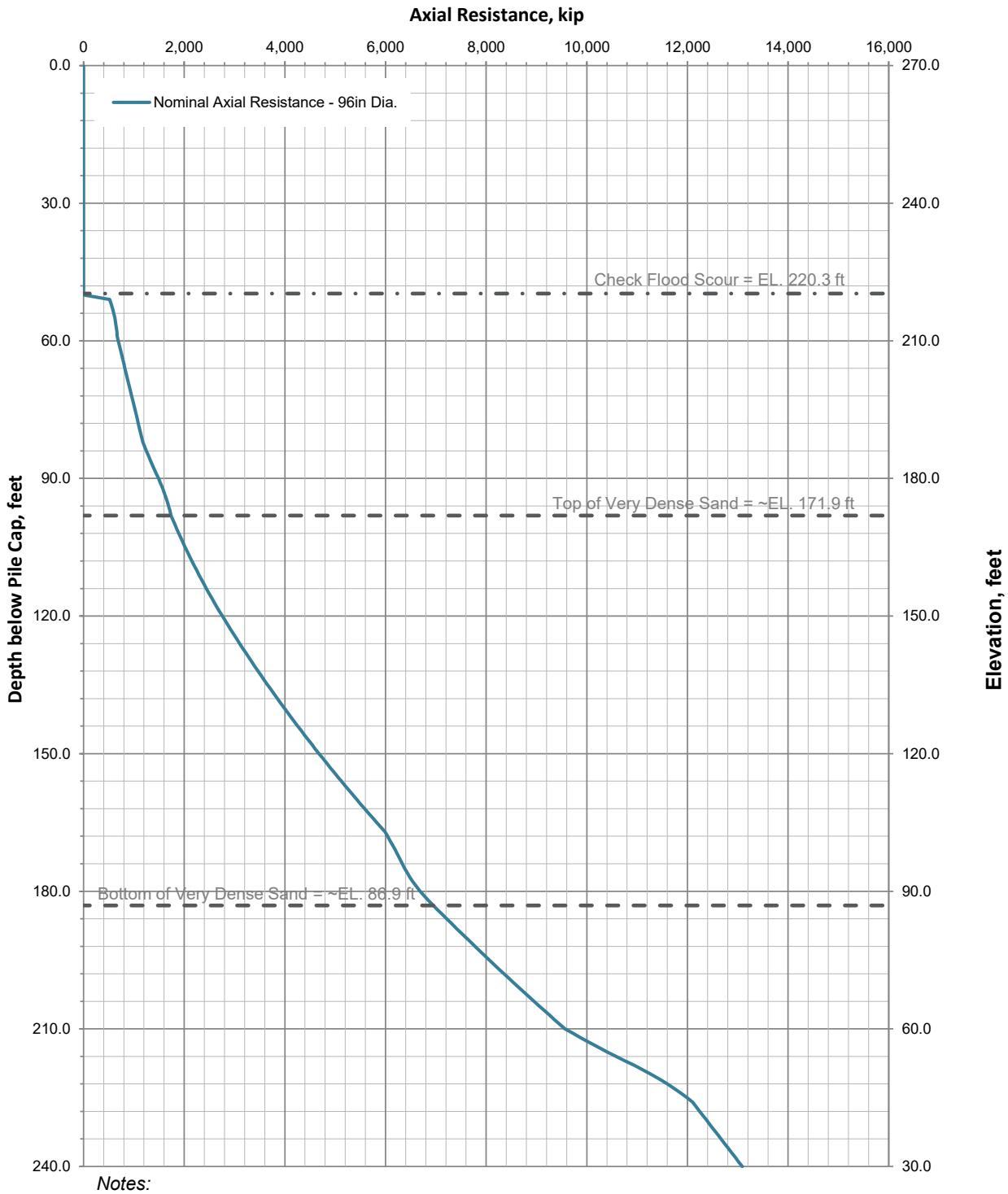
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



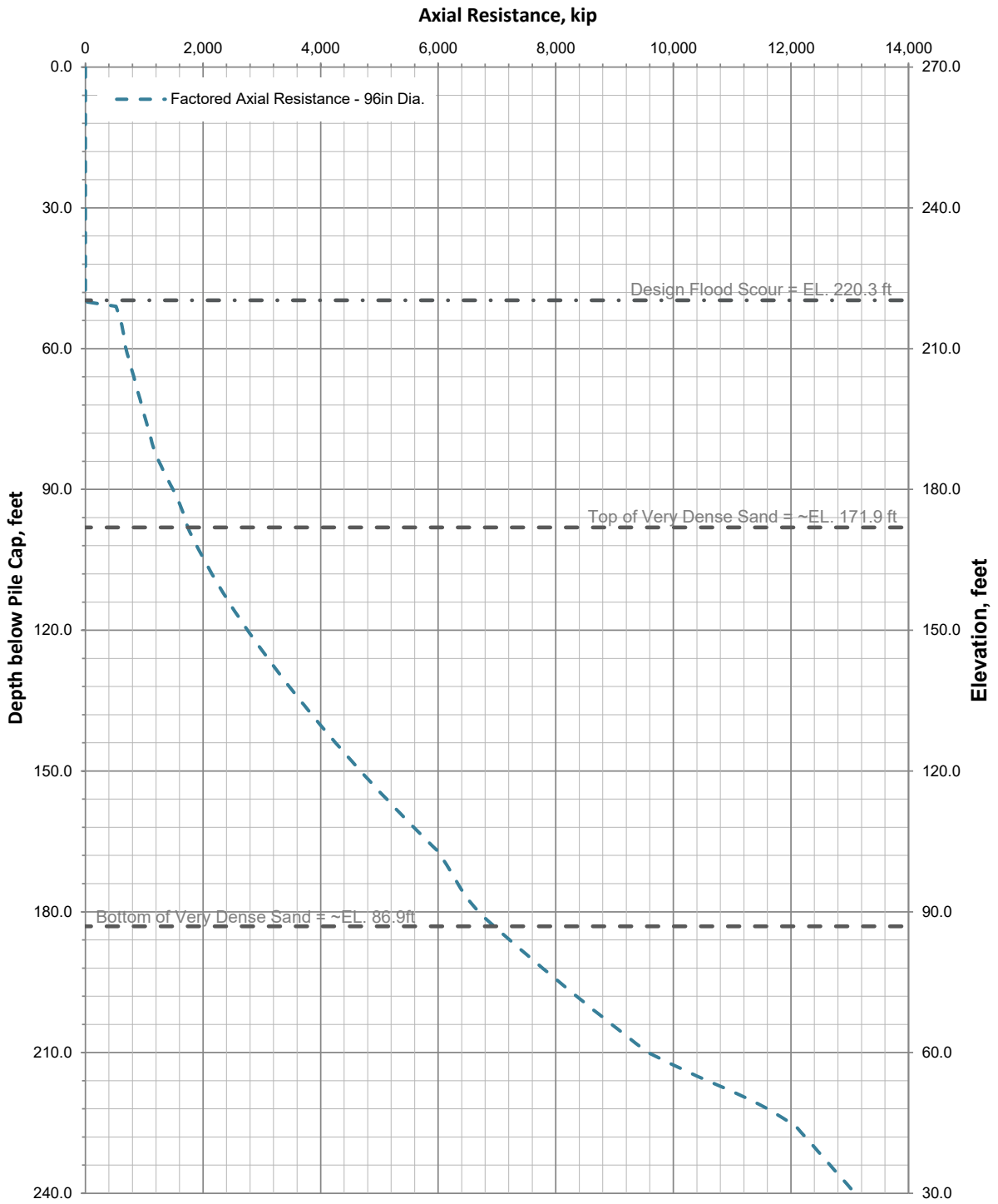
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Strength I**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



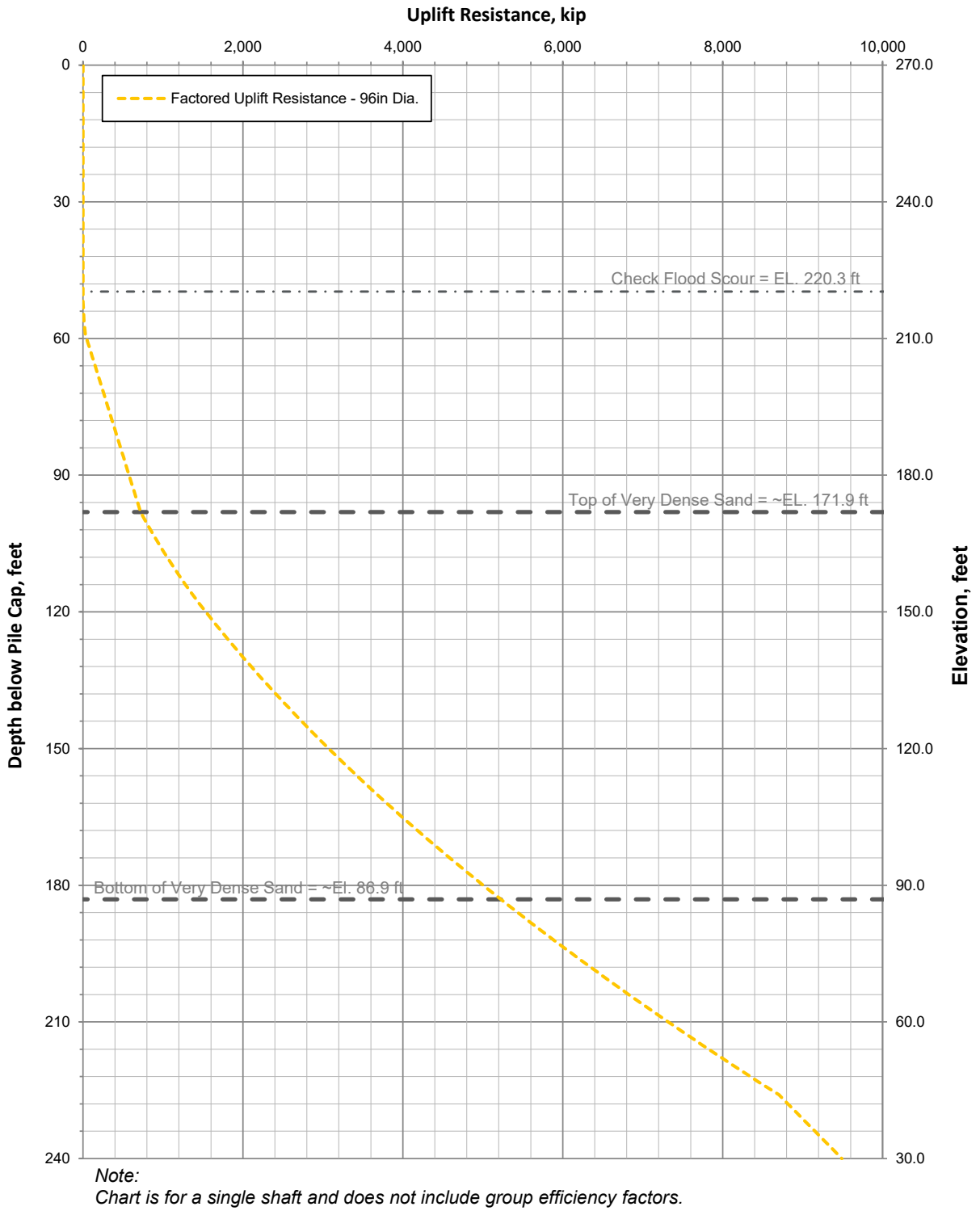
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event-II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.
Factored Structural Capacity of 96in Dia. Shaft (3% Steel) = ***20,237 kips***
Factored Axial Resistance based on Implementation of Foundation Load Test

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025



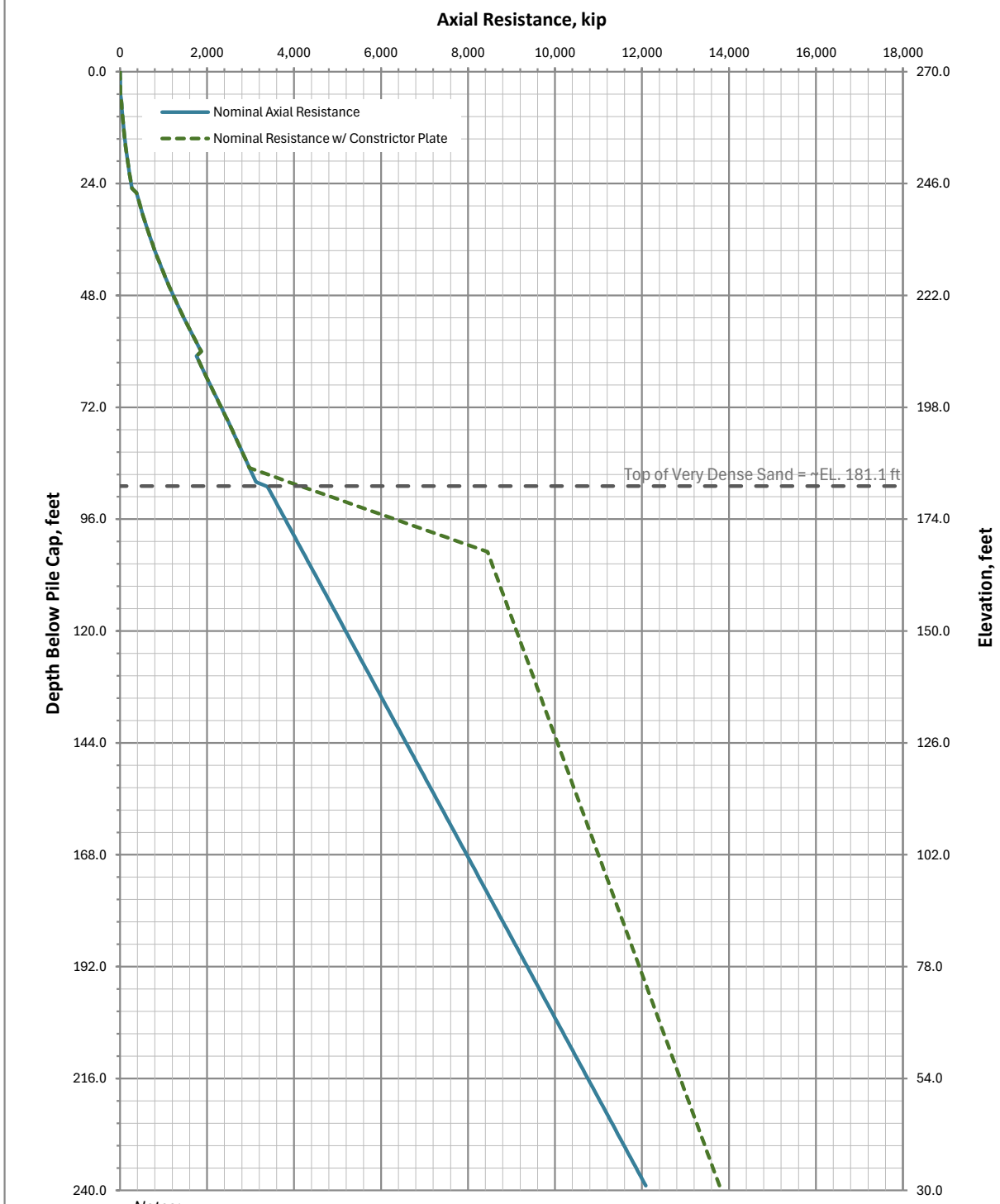
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event II**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 04/03/2025 **Drawn By:** BAR **Figure No. ##** **Date:** 04/03/2025

Seismic Axial Resistance Curves

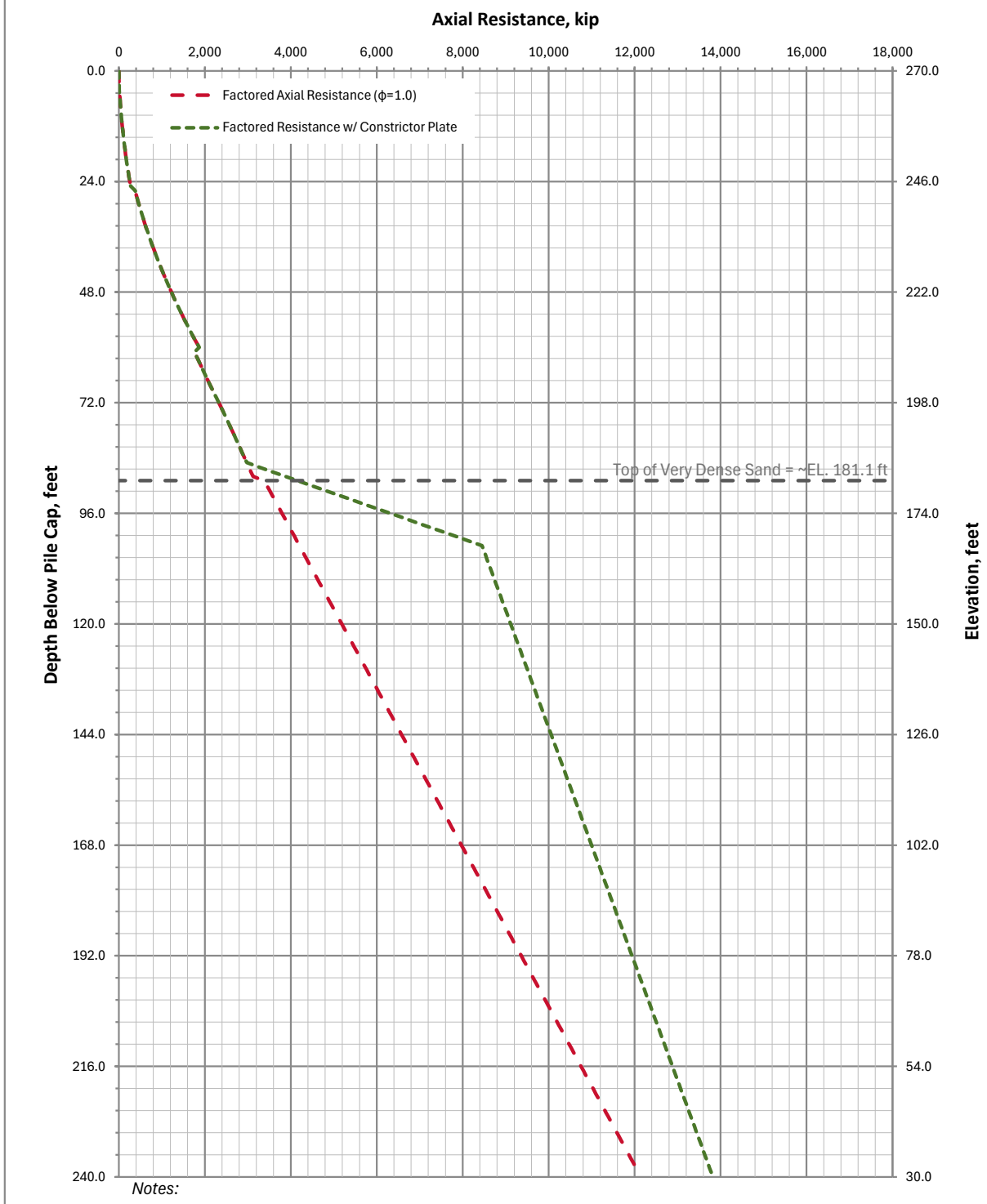
PIER 3

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



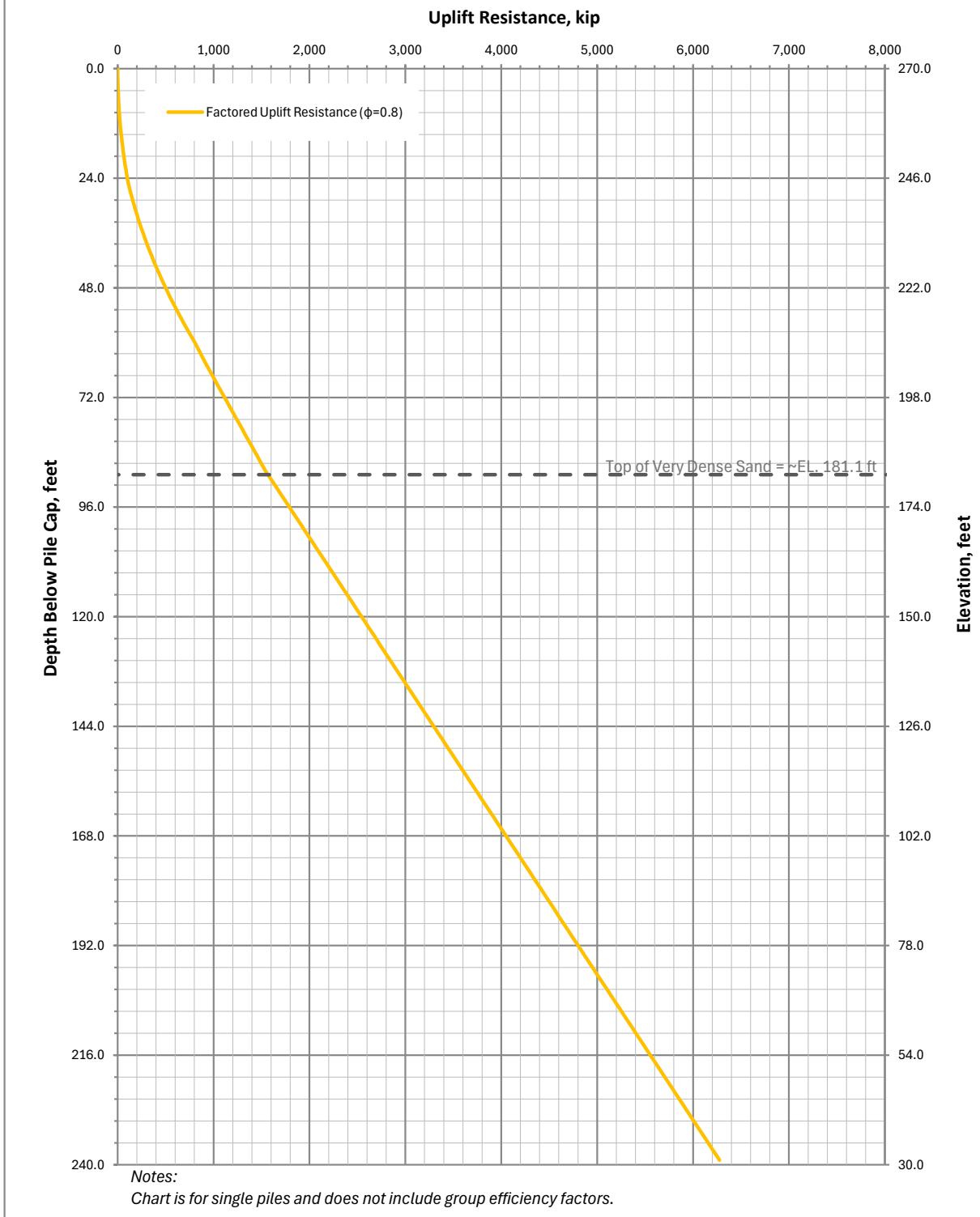
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 12/03/25 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/25



Notes:
Chart is for single piles and does not include group efficiency factors.

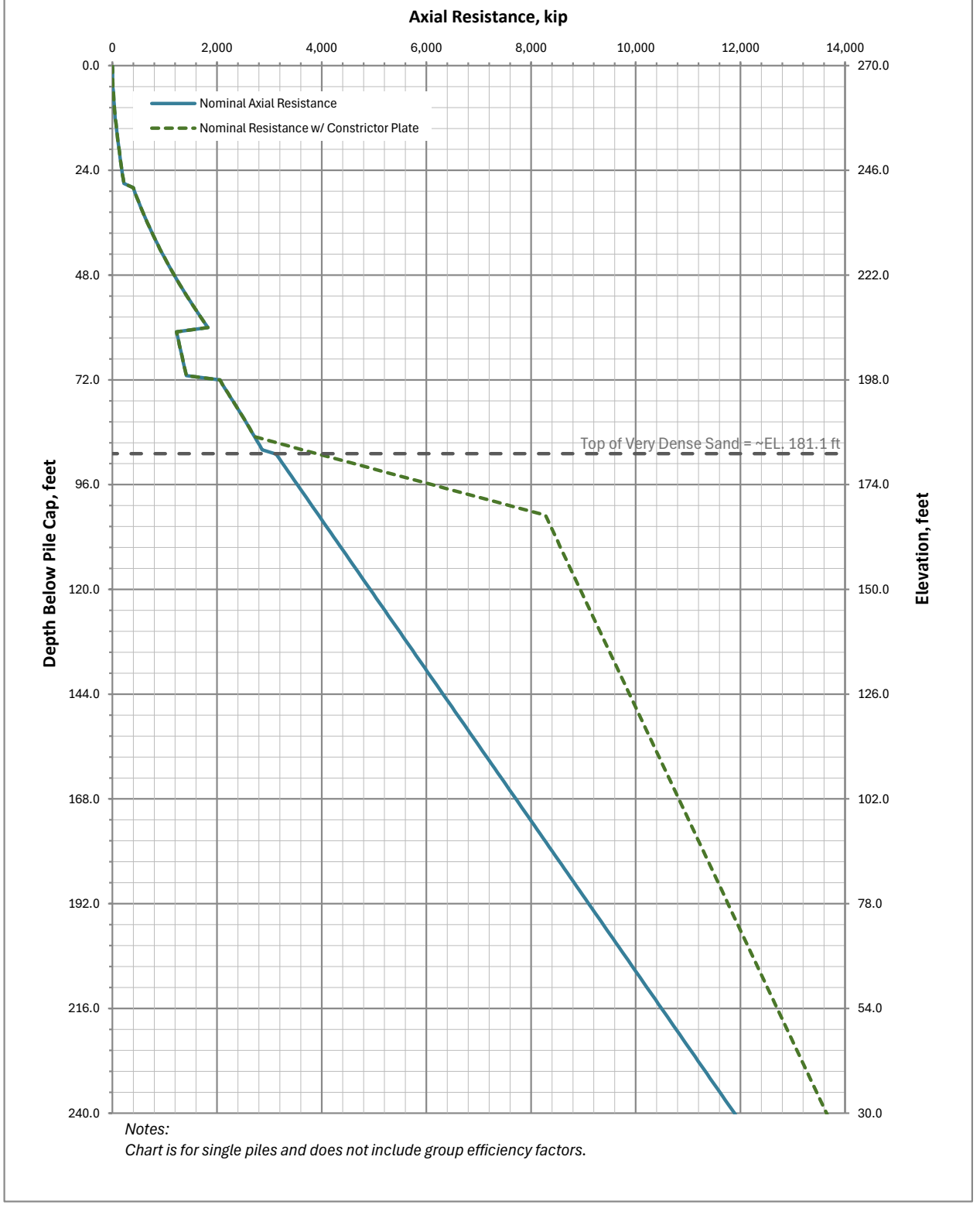
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 12/03/25 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/25



Notes:
Chart is for single piles and does not include group efficiency factors.

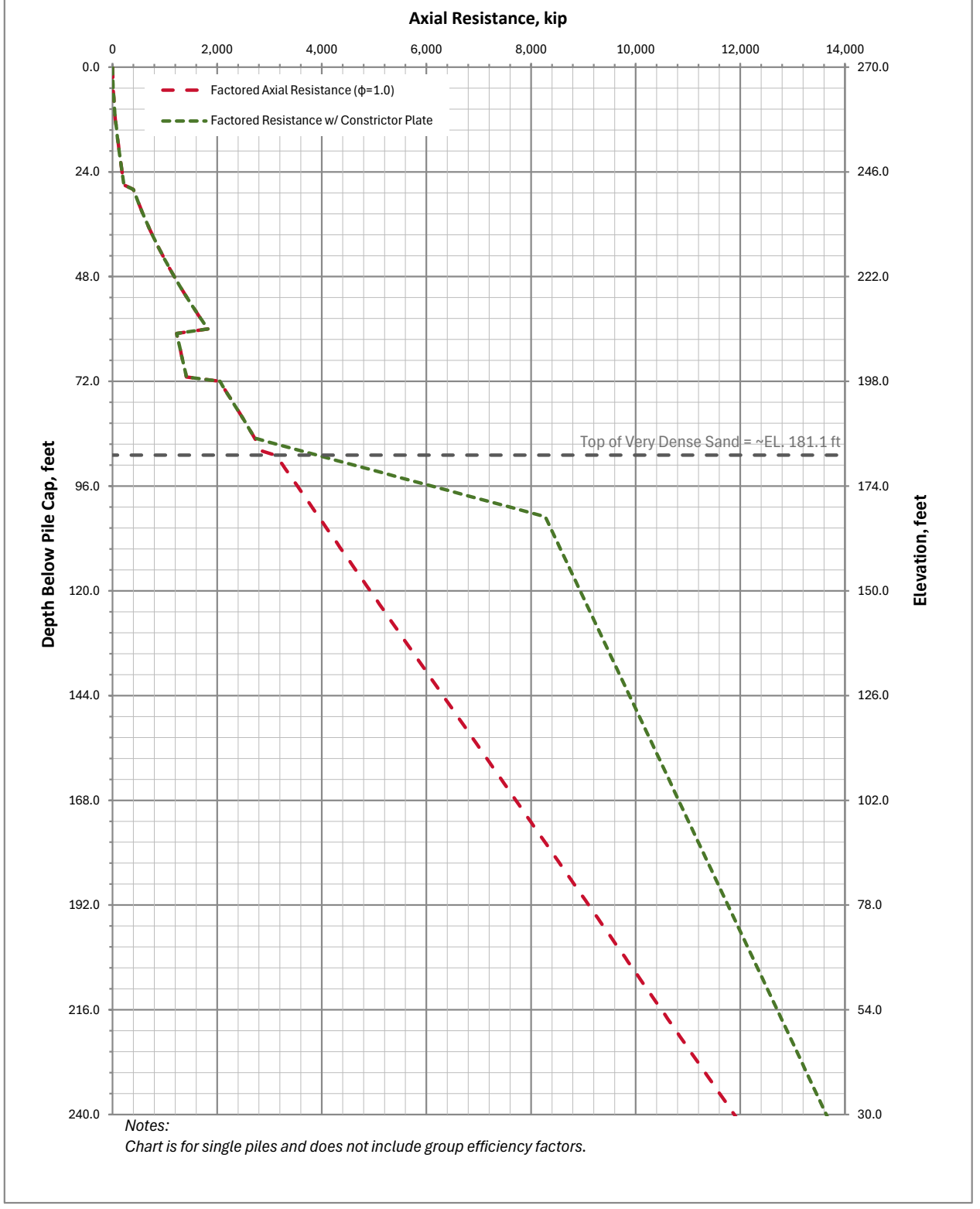
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 12/03/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



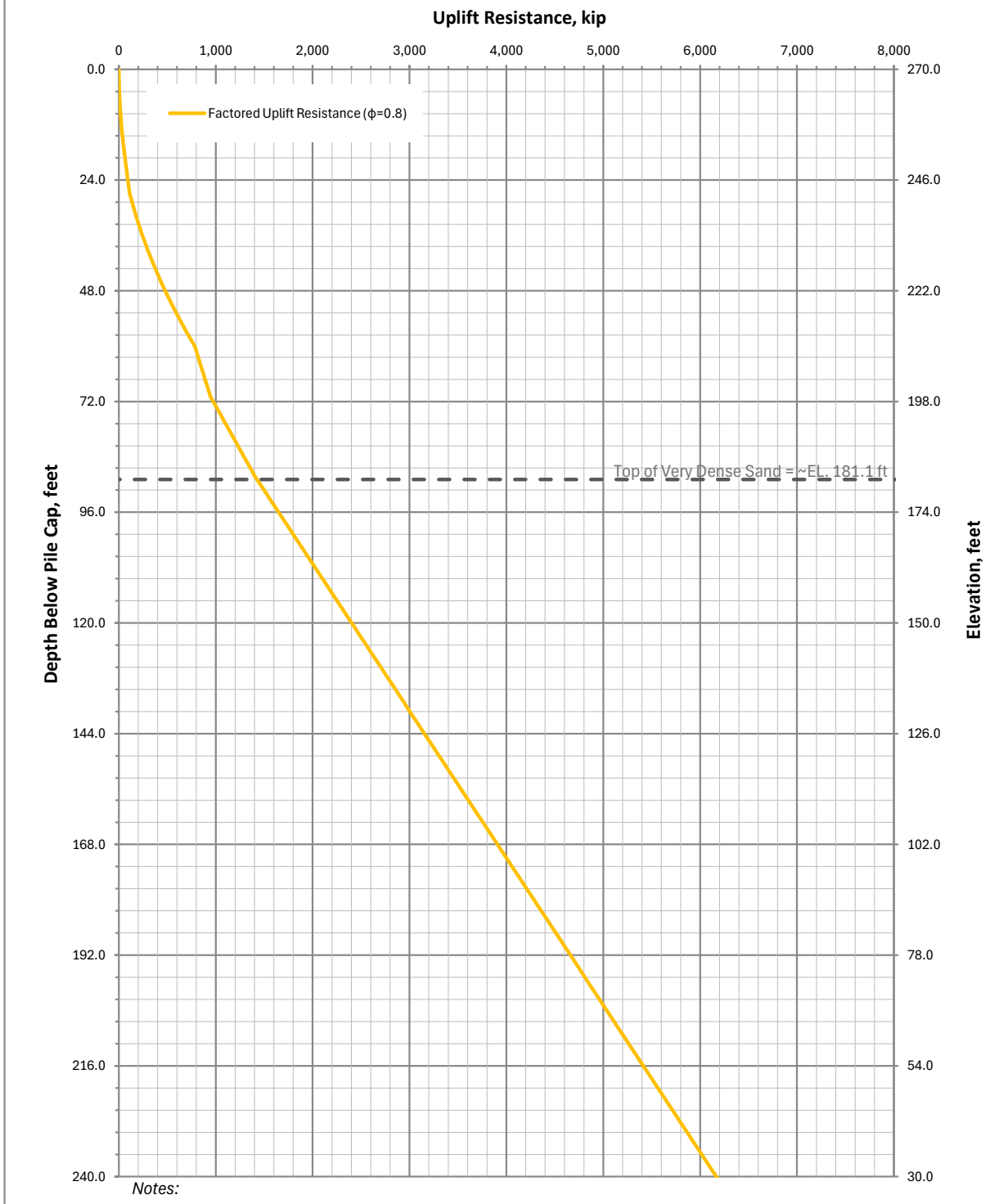
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 12/03/25 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/25



Notes:
Chart is for single piles and does not include group efficiency factors.

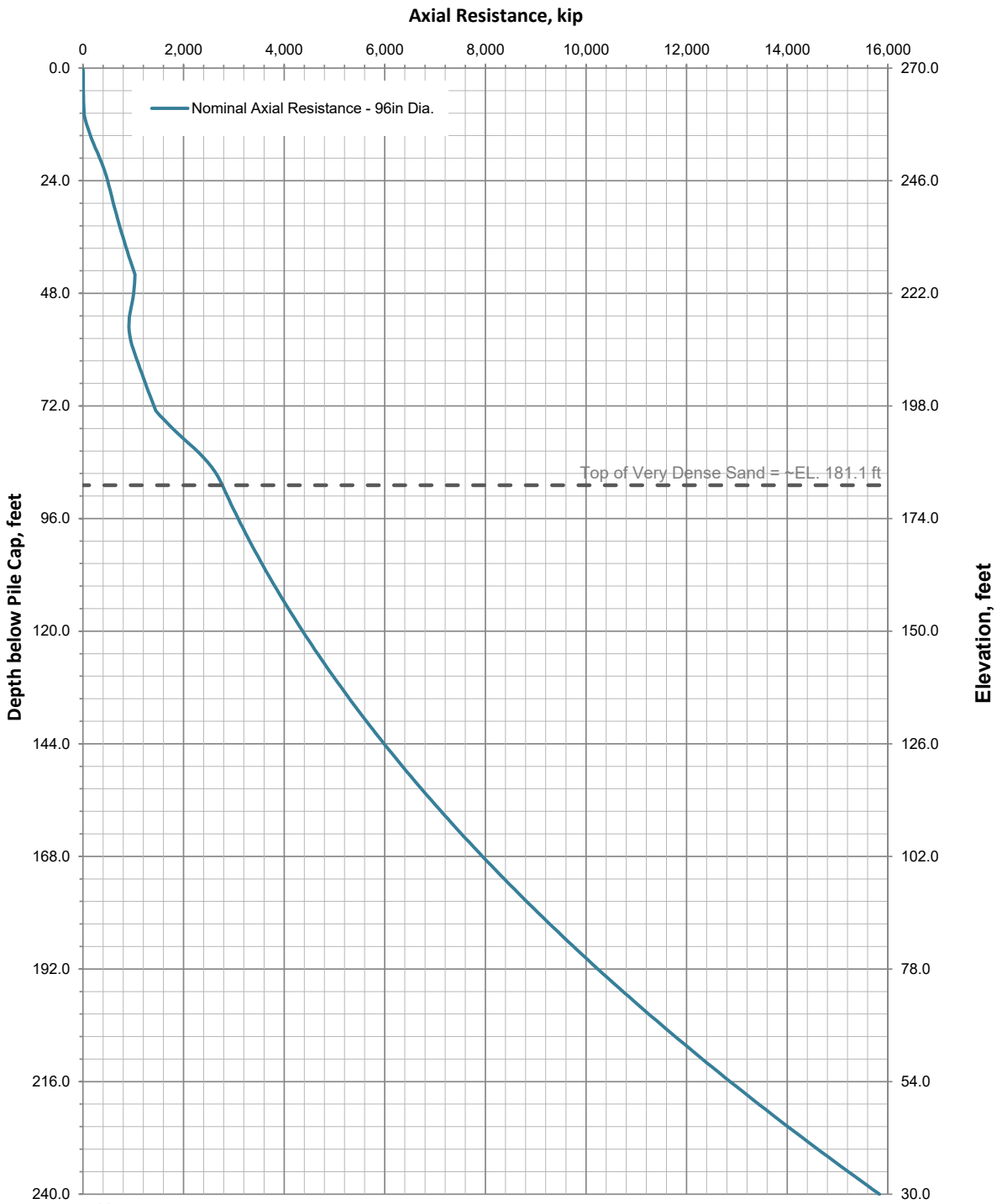
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 12/03/25 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/25



Notes:
Chart is for single piles and does not include group efficiency factors.

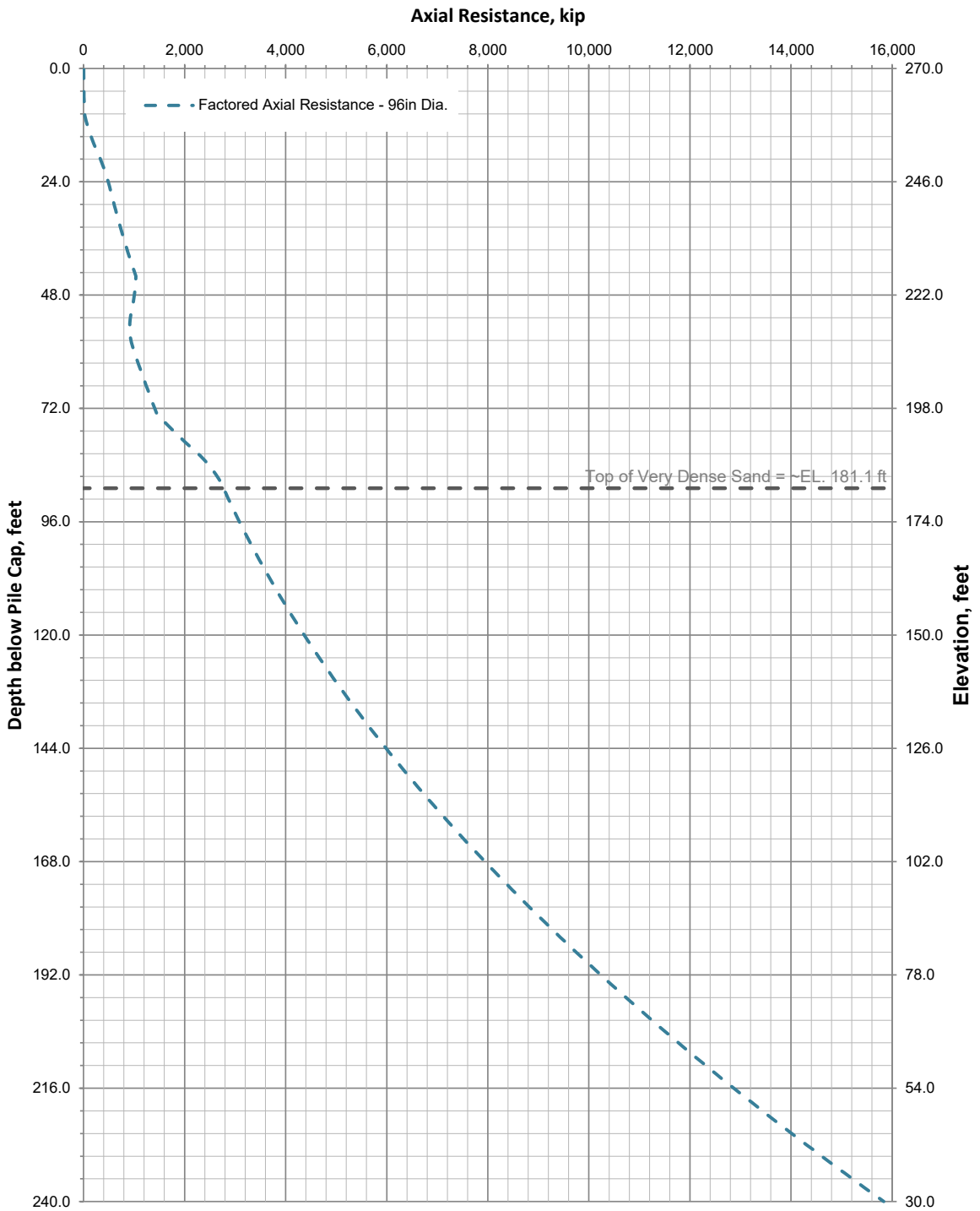
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 12/03/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 12/03/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/06/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/06/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

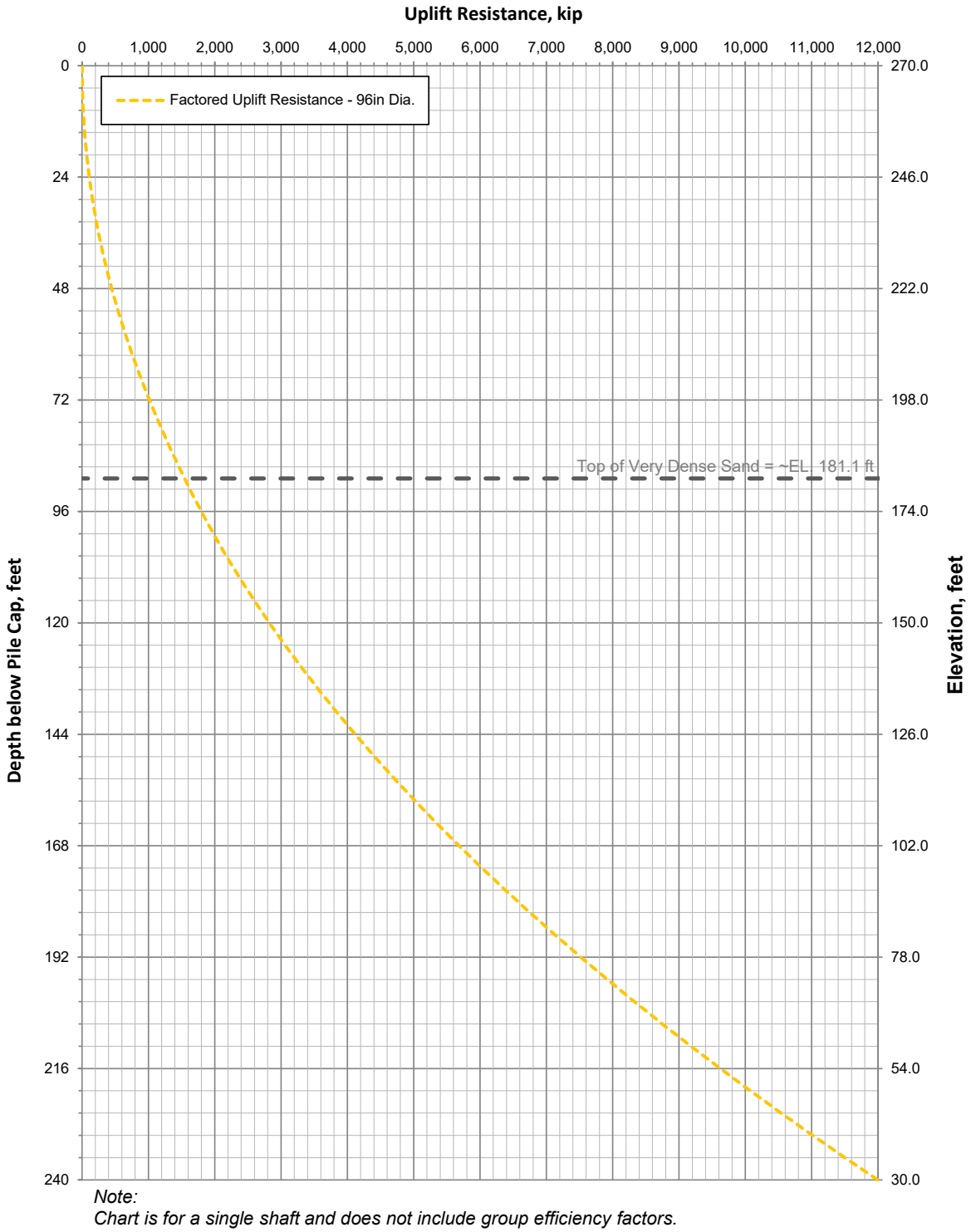
Prepared by:

Prepared for:

TEAM KENTUCKY TRANSPORTATION CABINET

Pier 3
96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)

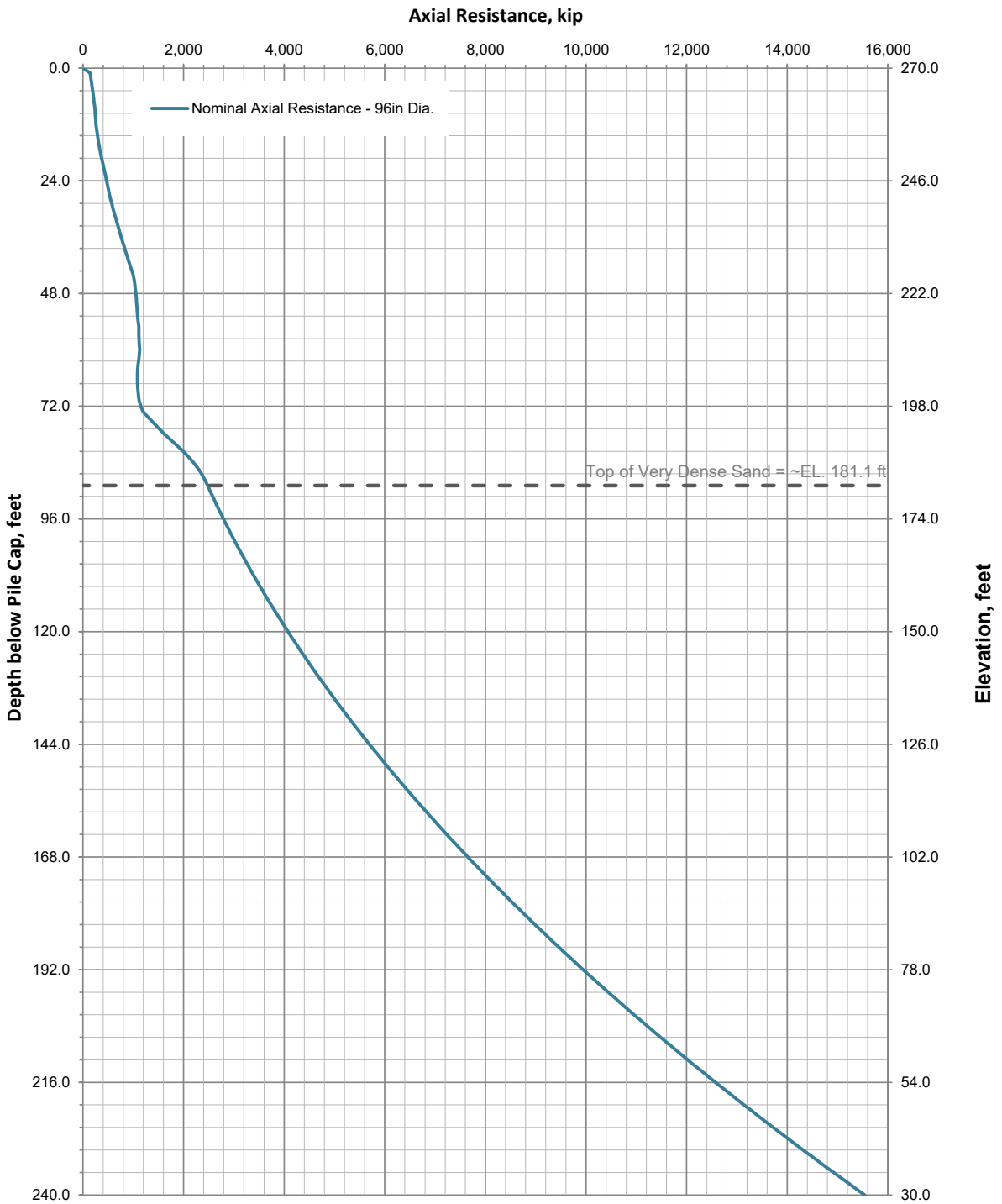
Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: SKB **Review Date:** 10/06/25
Drawn By: SGL **Figure No. ##**
Date: 10/06/25



Note:
Chart is for a single shaft and does not include group efficiency factors.

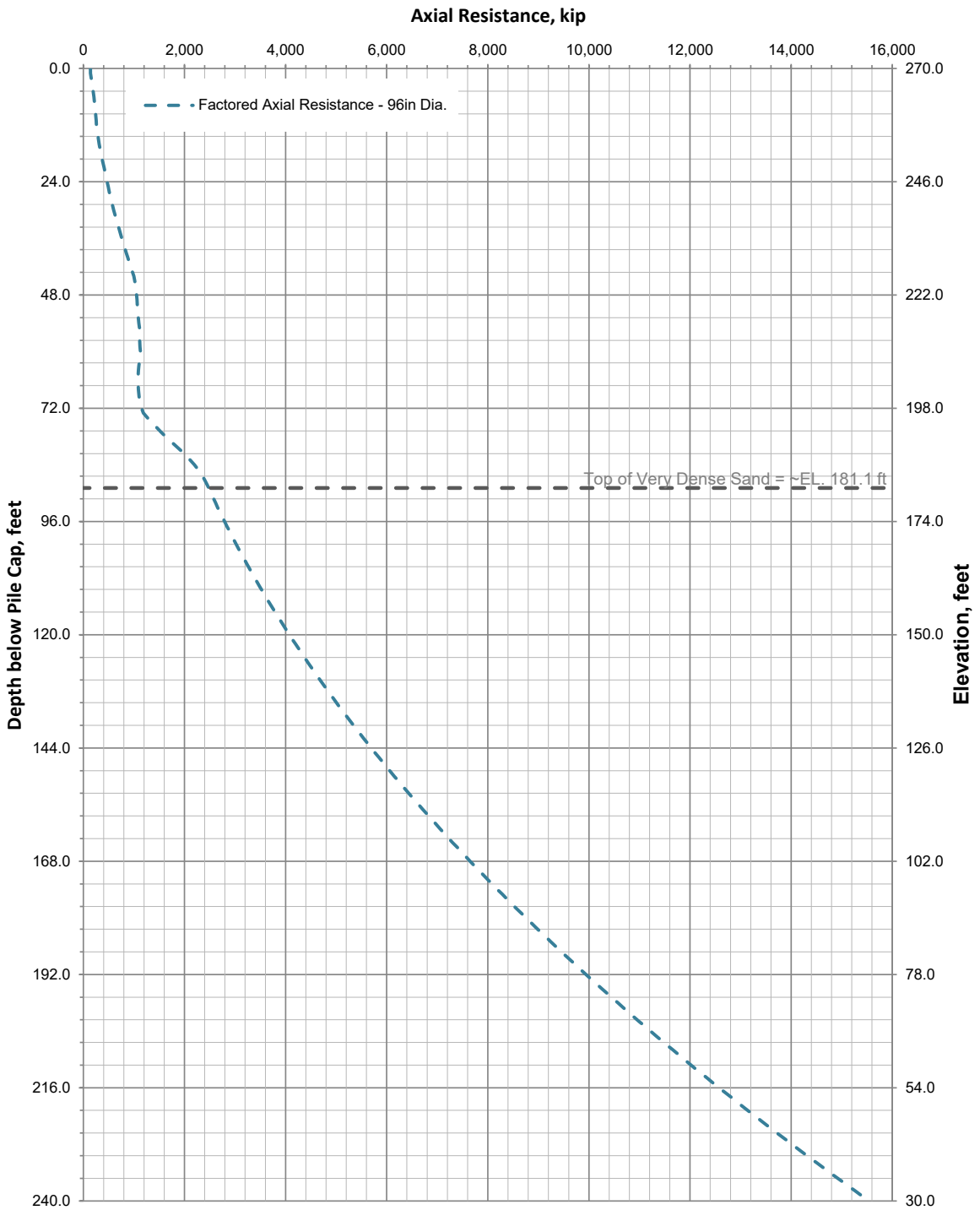
Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/06/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



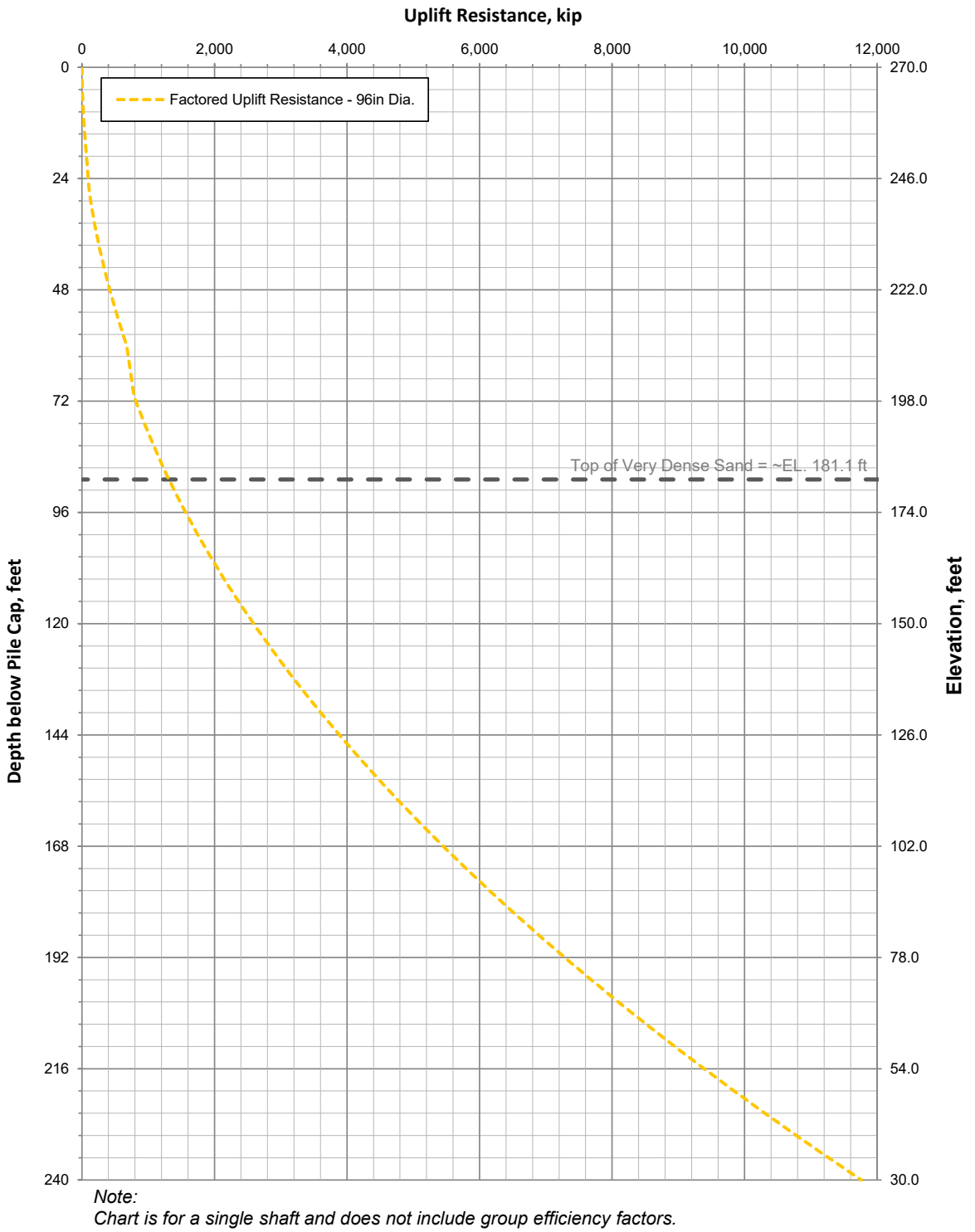
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/06/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/06/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/06/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/06/25

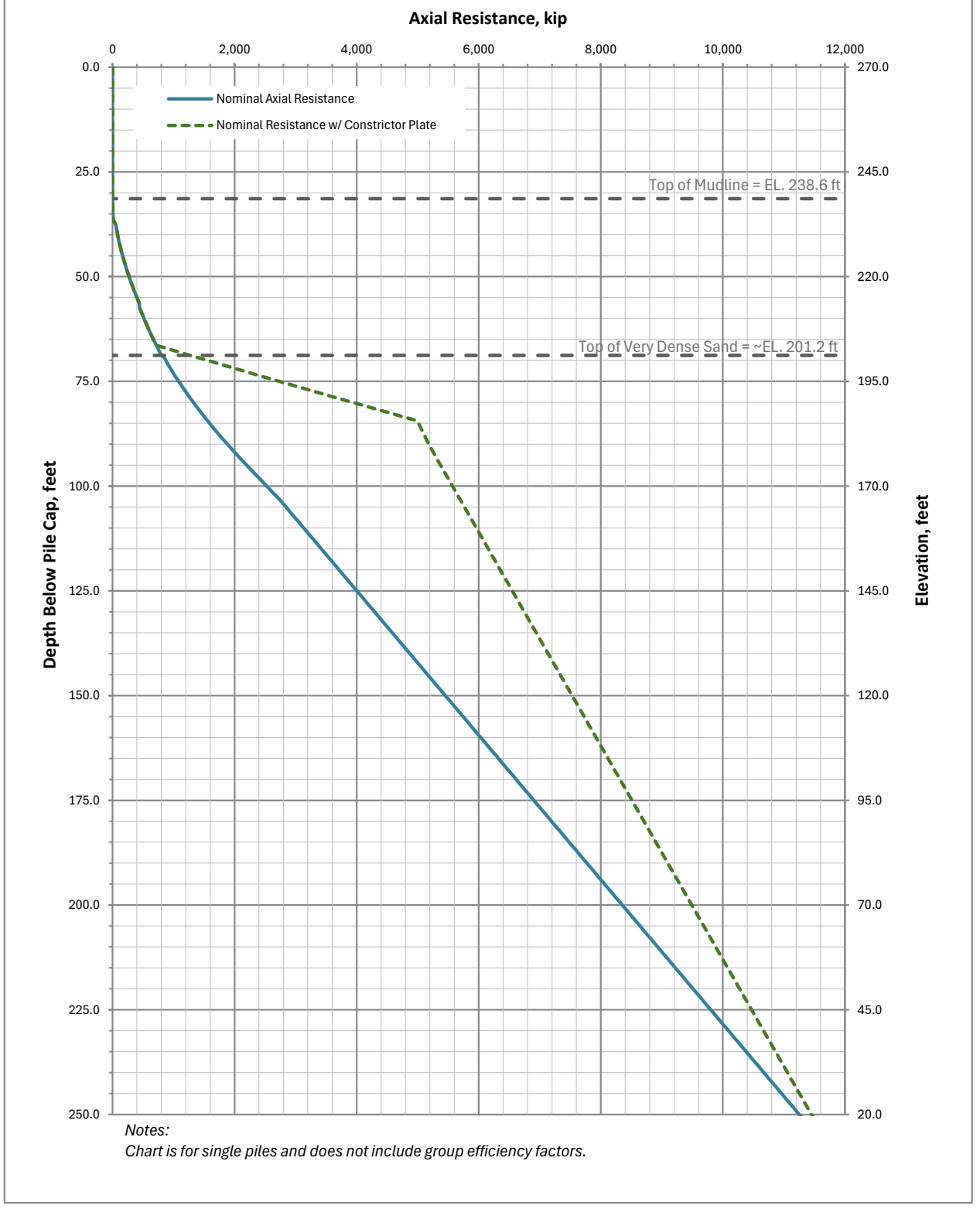


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/06/2025

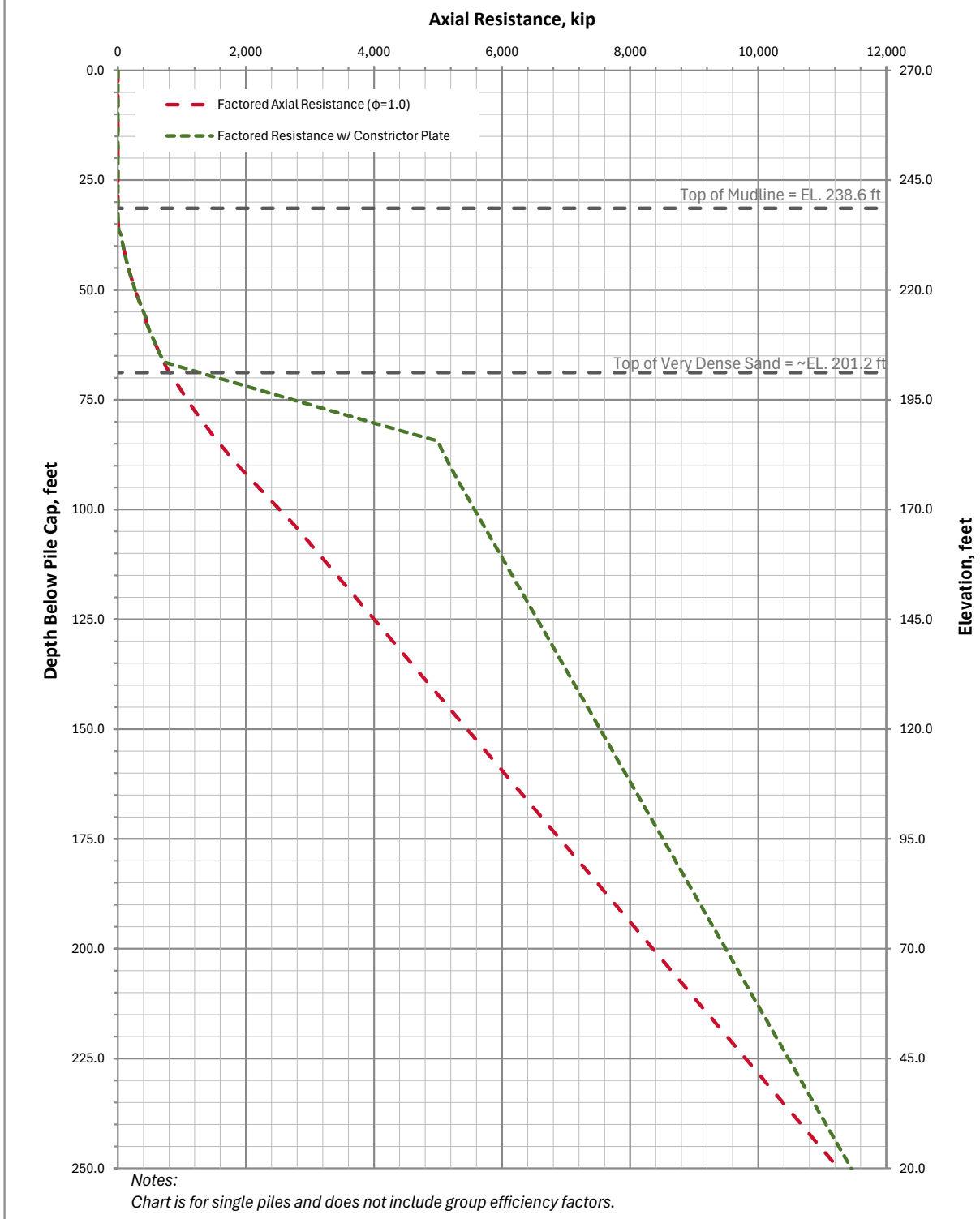
PIER 4

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



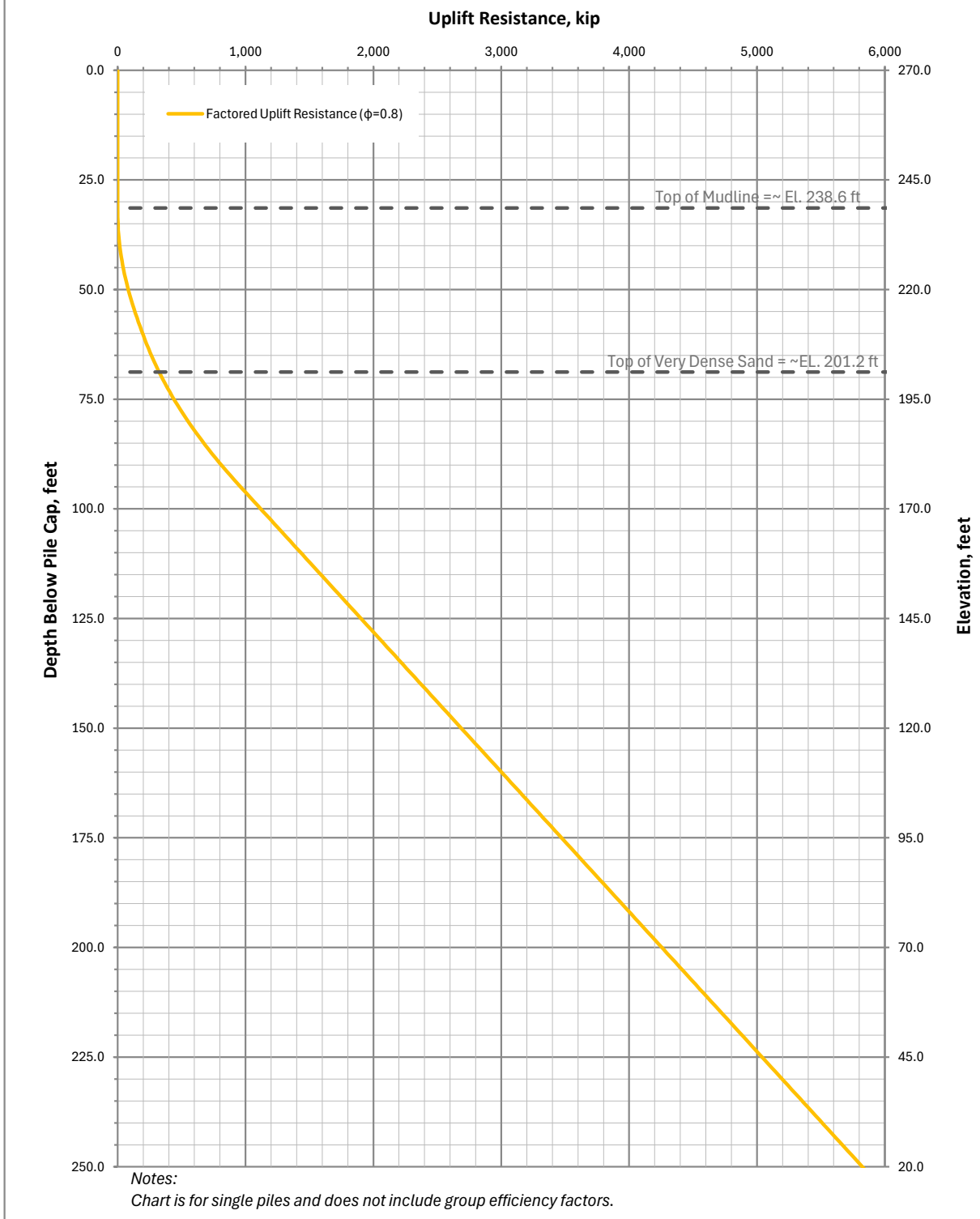
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/07/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/07/25



Notes:
Chart is for single piles and does not include group efficiency factors.

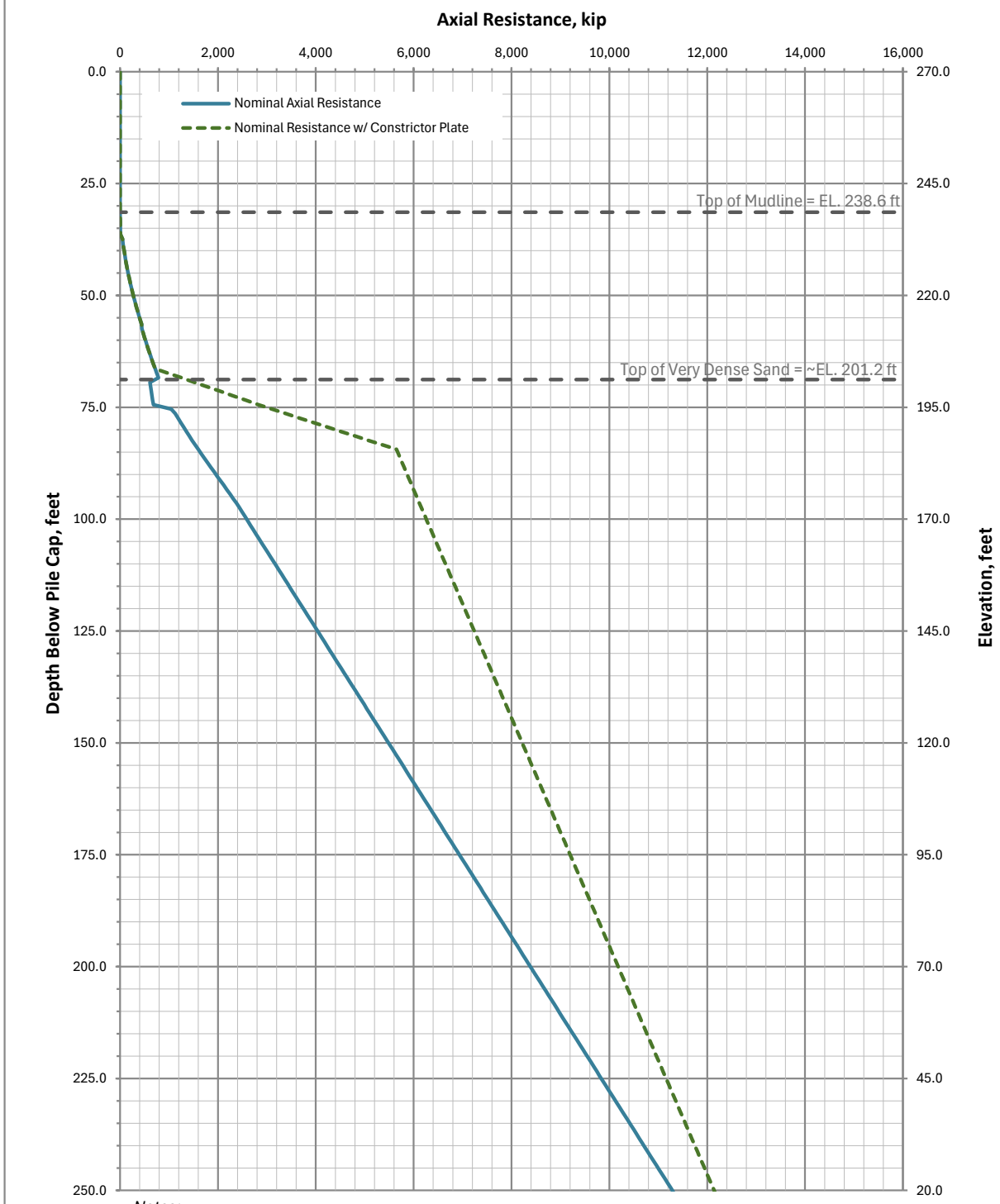
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/07/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/07/25



Notes:
Chart is for single piles and does not include group efficiency factors.

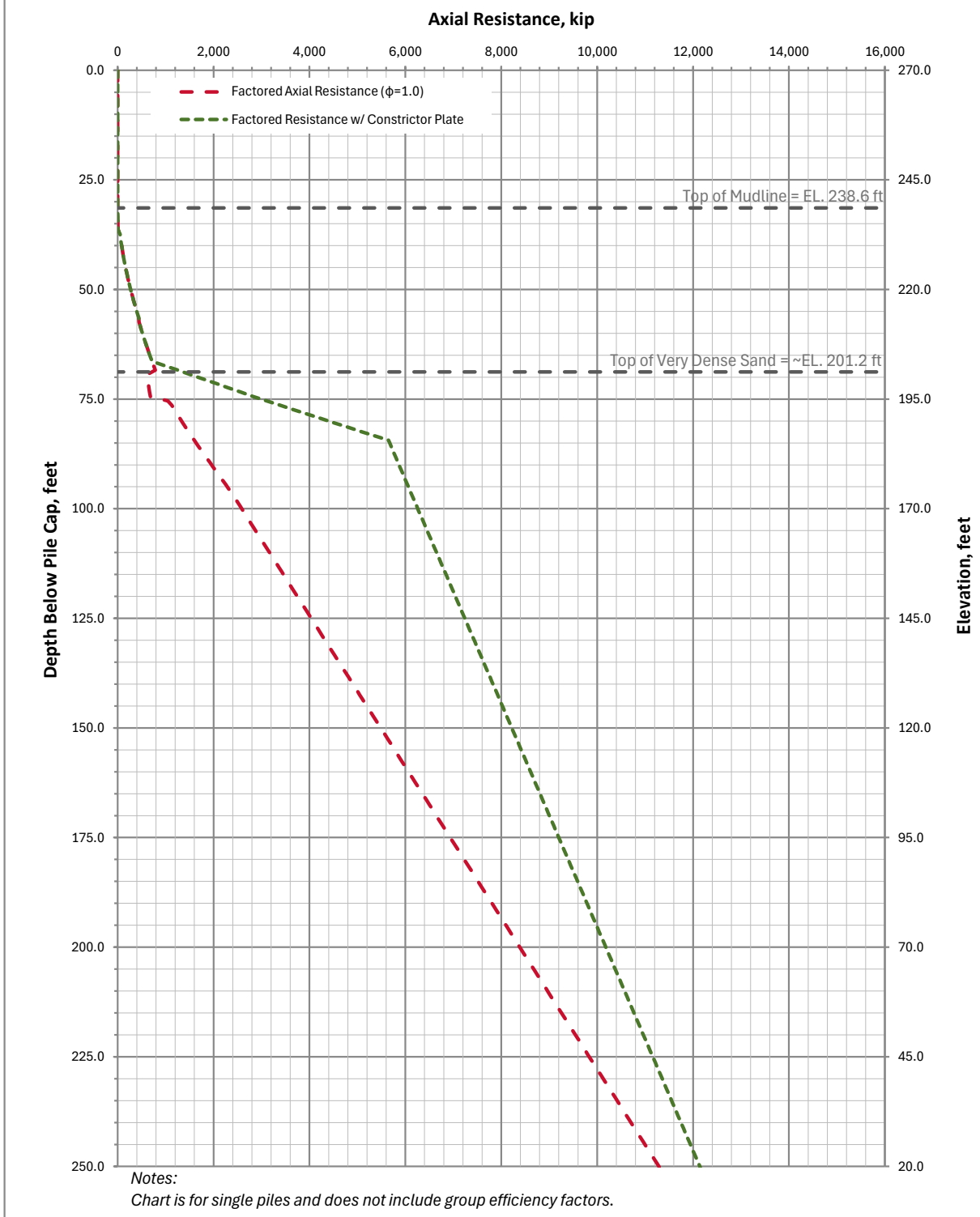
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/07/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/07/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



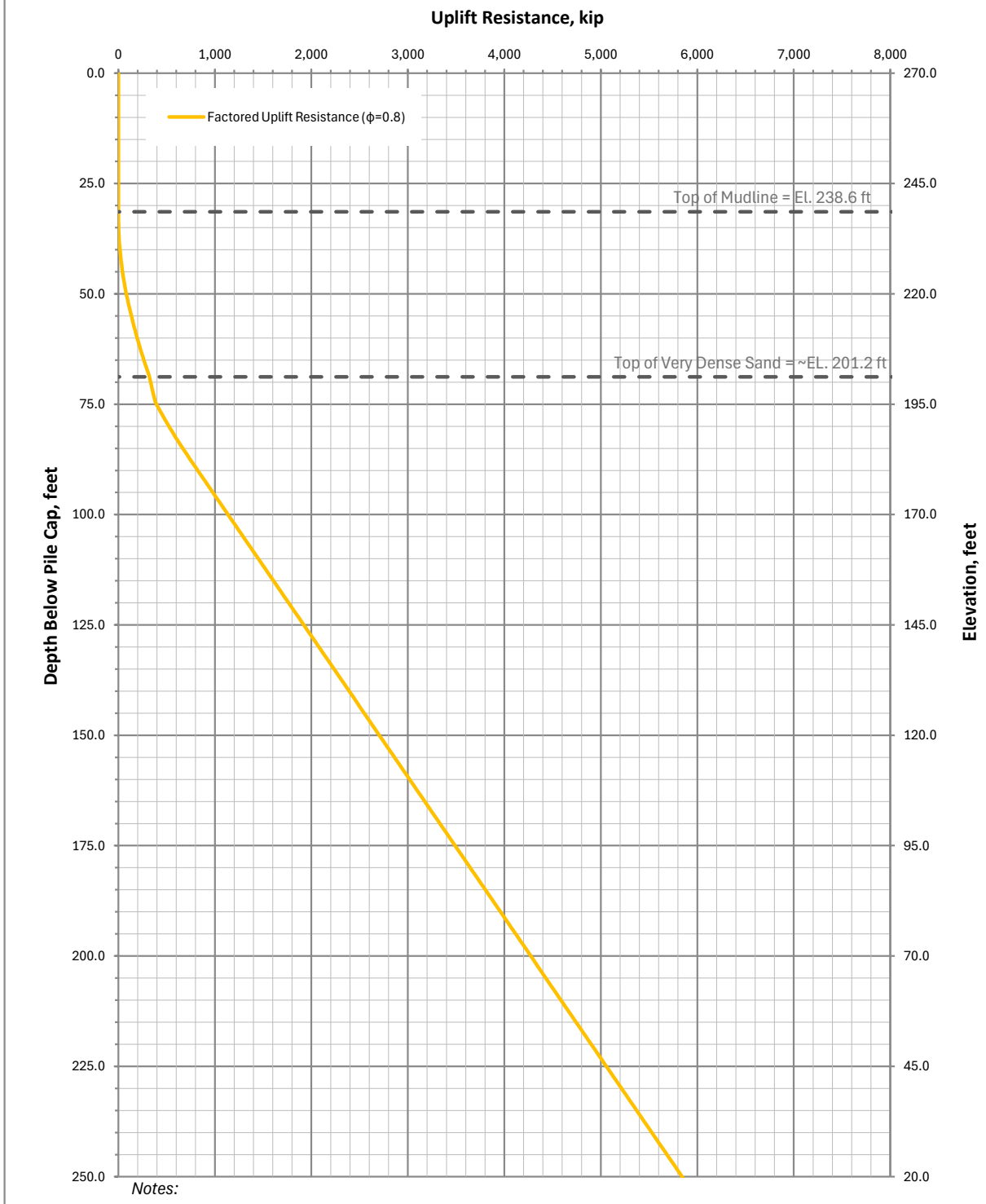
Notes:
Chart is for single piles and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/25



Notes:
Chart is for single piles and does not include group efficiency factors.

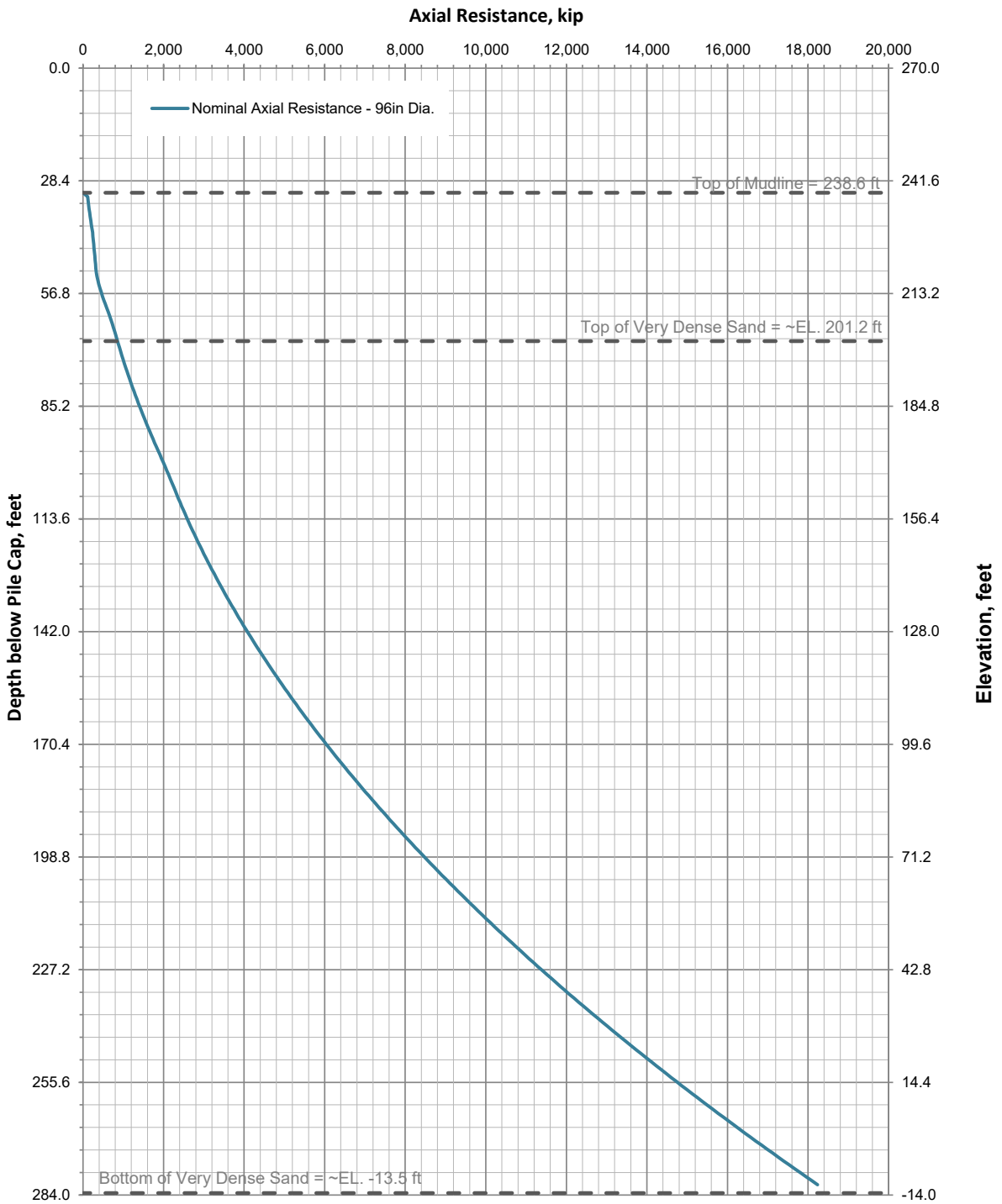
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/25 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/25



Notes:
Chart is for single piles and does not include group efficiency factors.

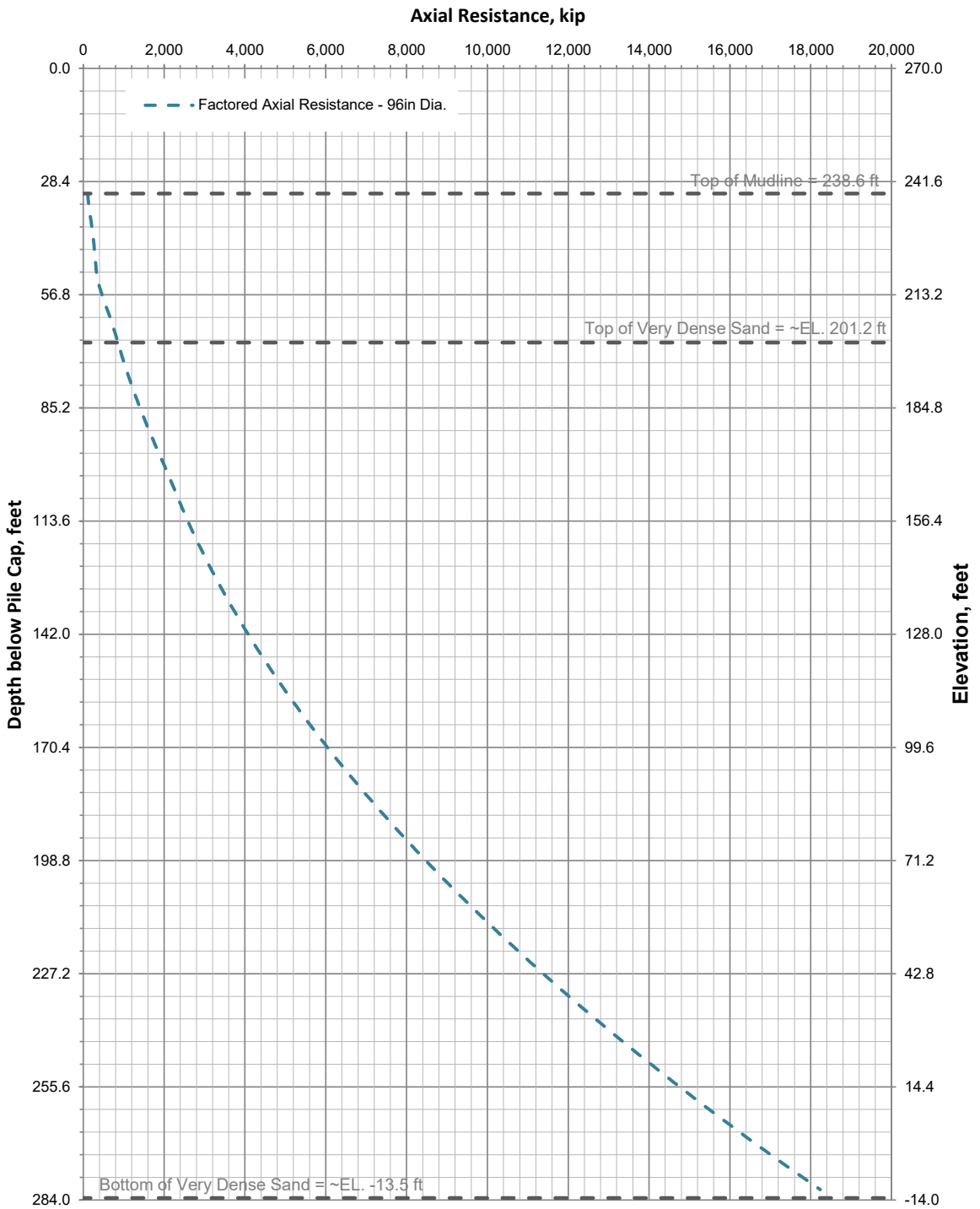
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



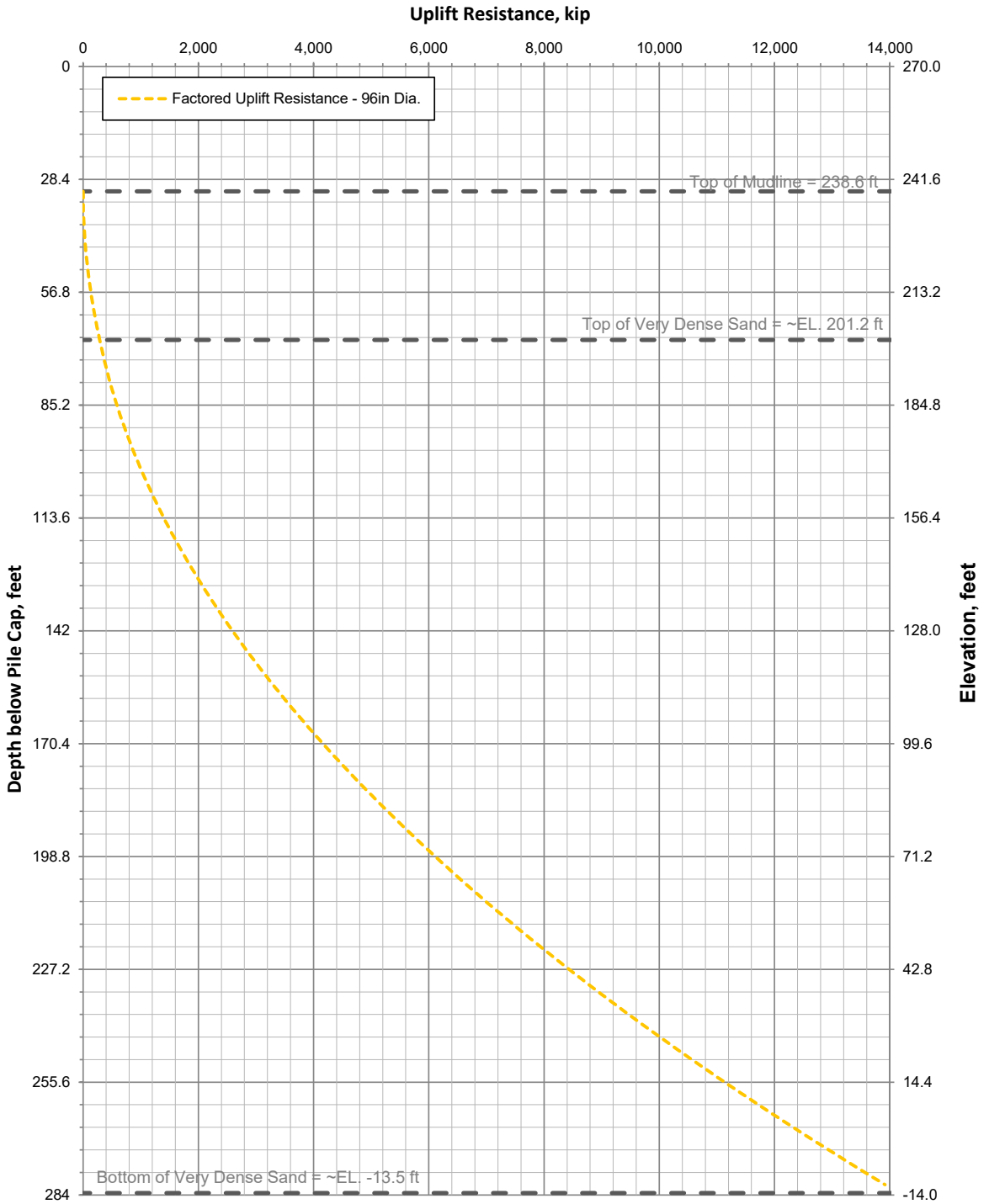
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

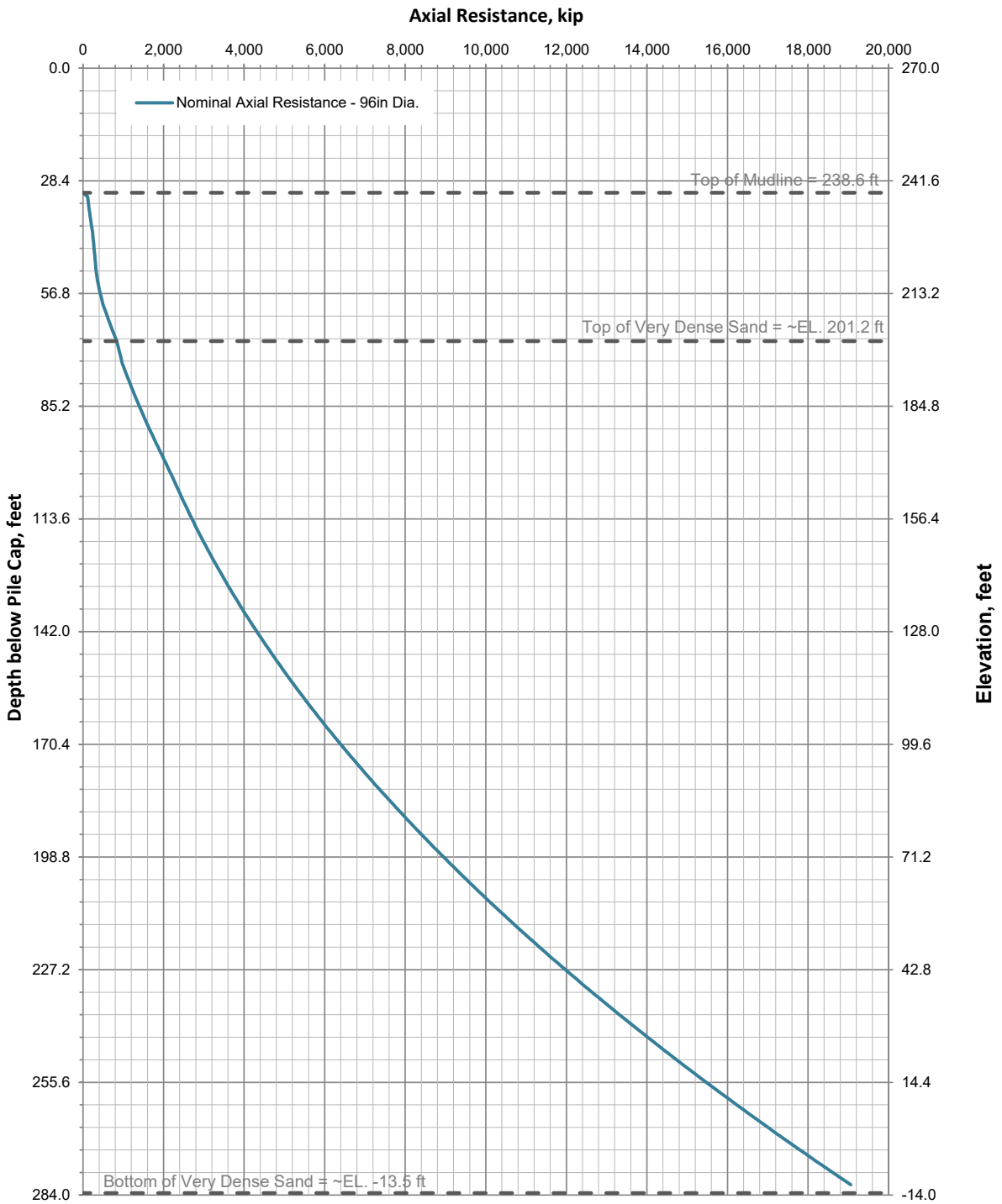
Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025



Note:
Chart is for a single shaft and does not include group efficiency factors.

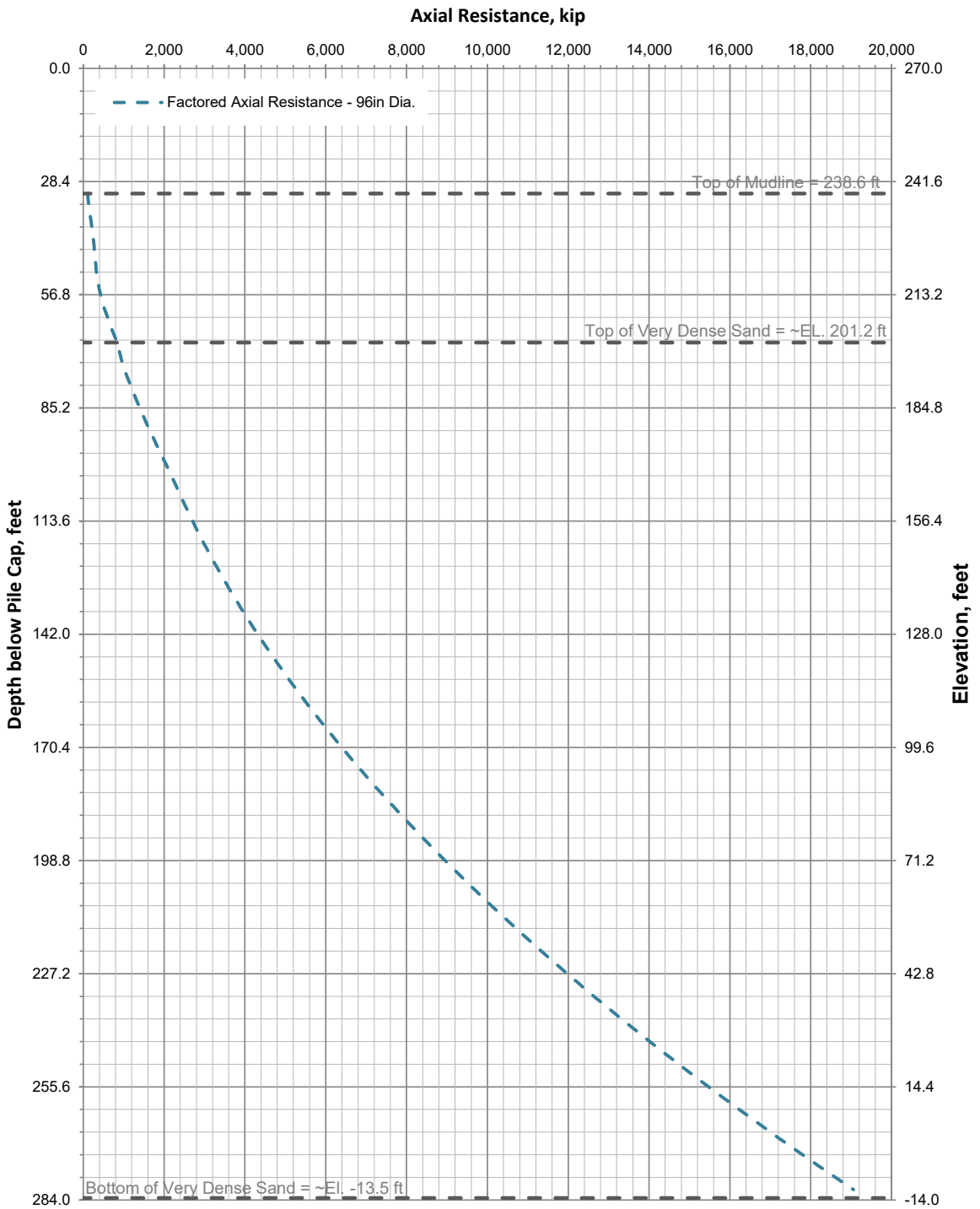
Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



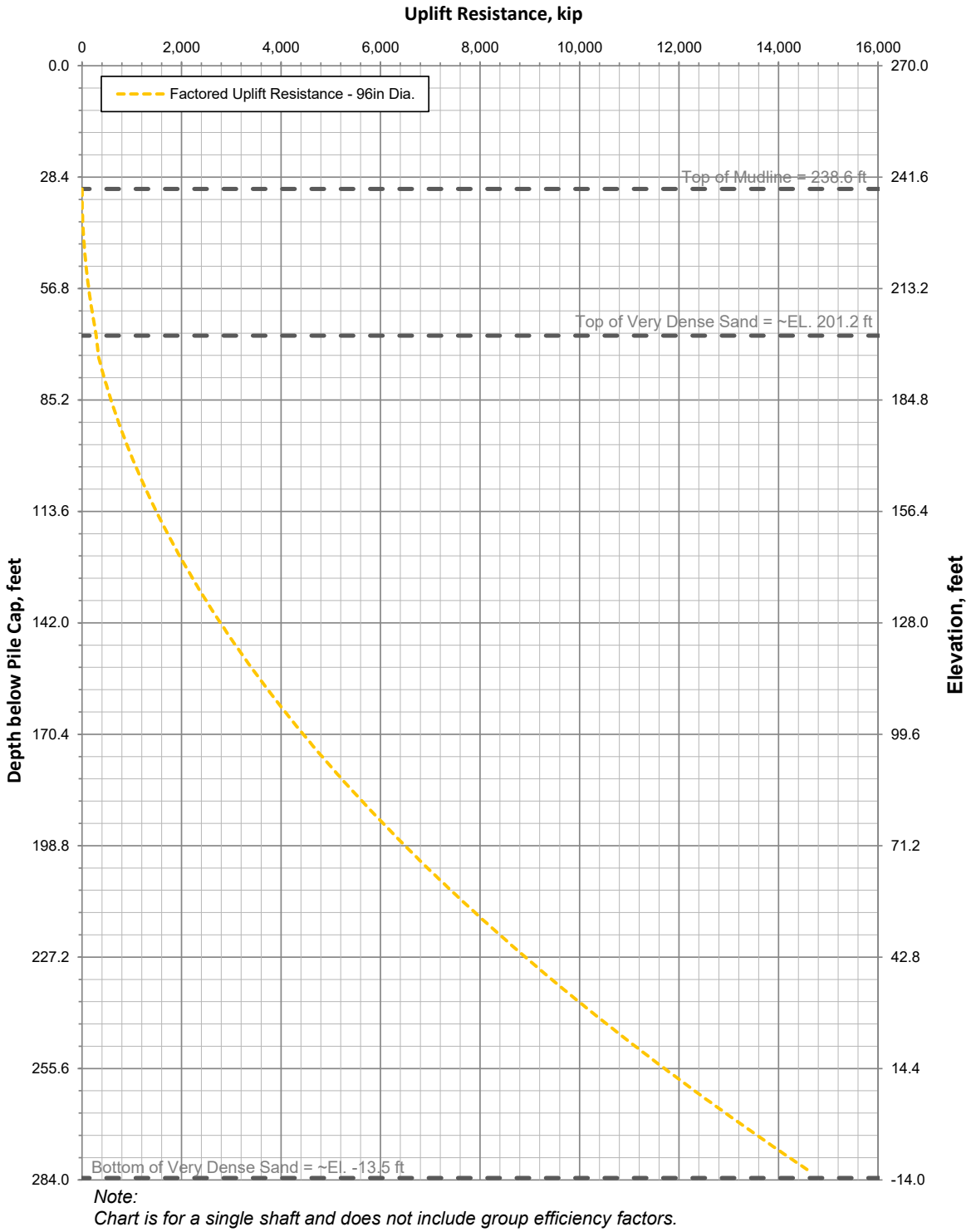
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** SKB **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025

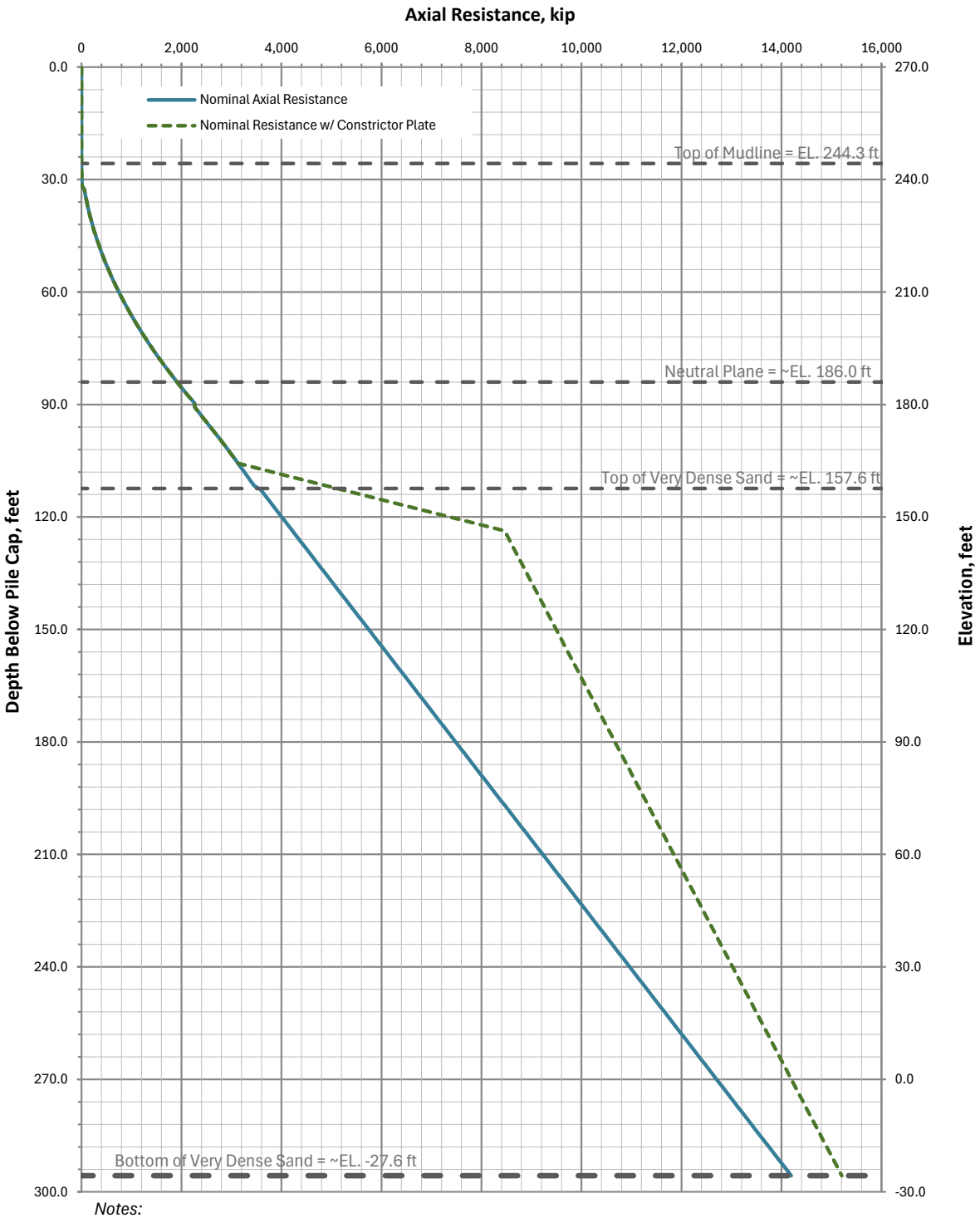


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** SGL **Figure No. ##** **Date:** 10/08/2025

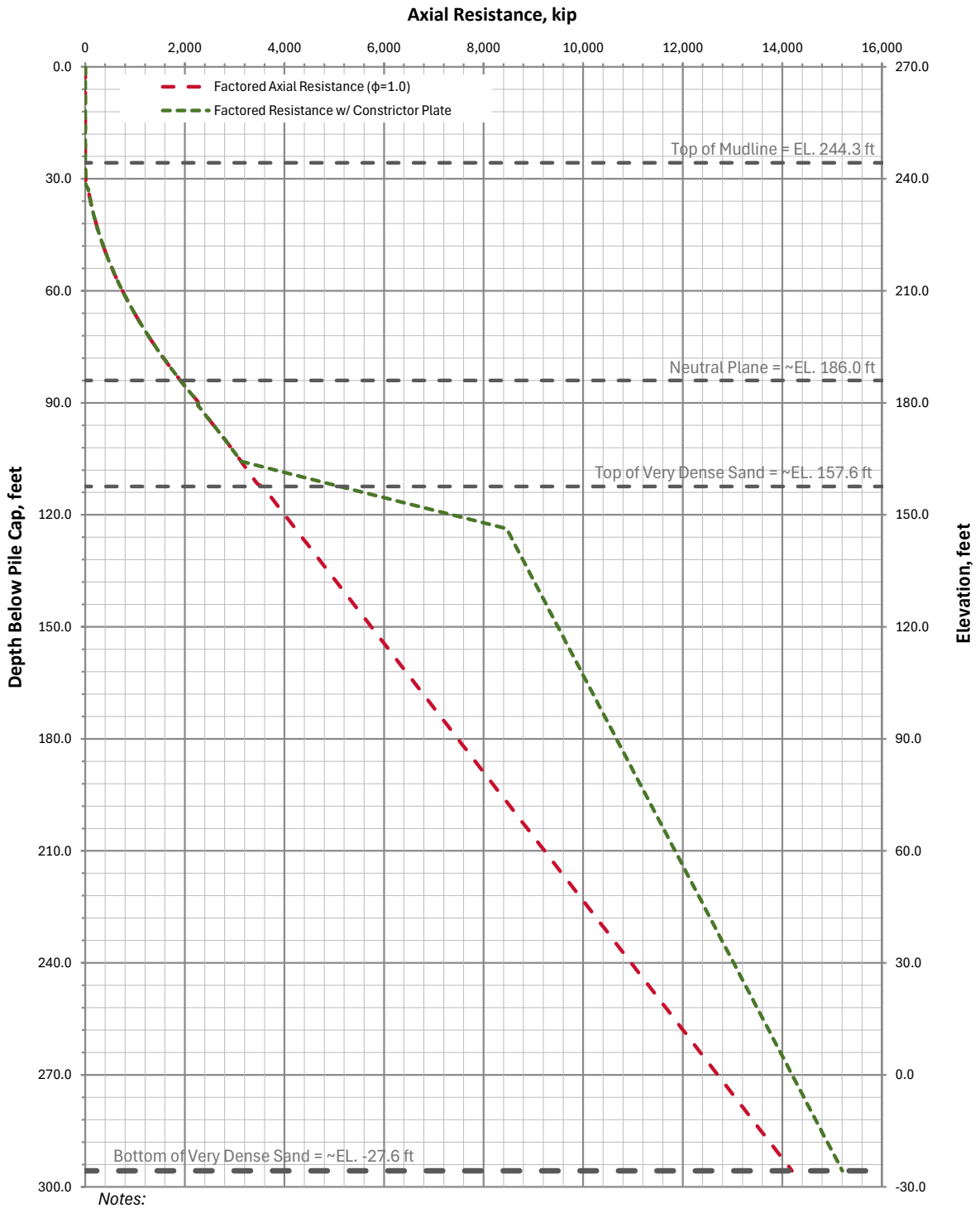
PIER 5

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



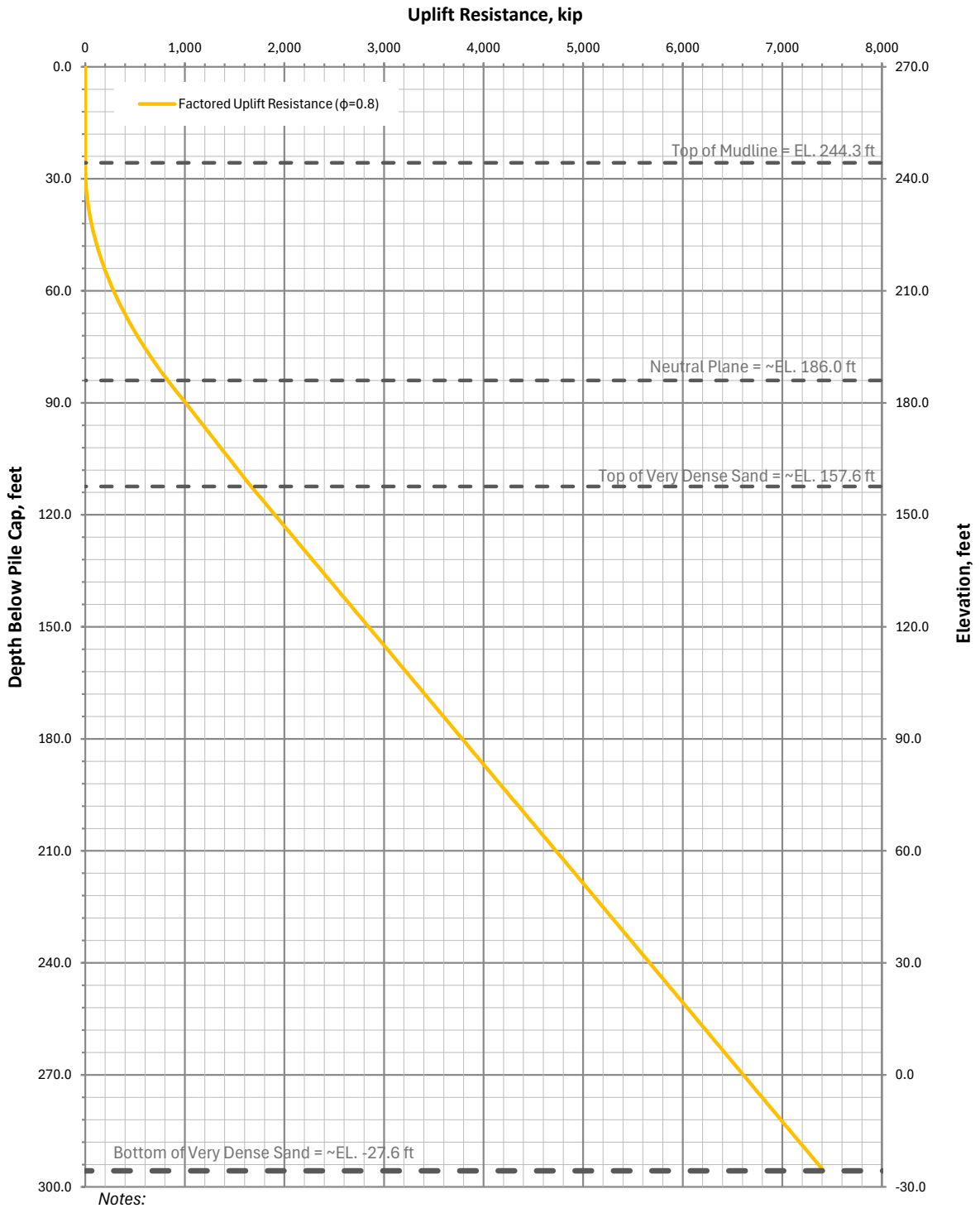
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Notes:
Chart is for single piles and does not include group efficiency factors.

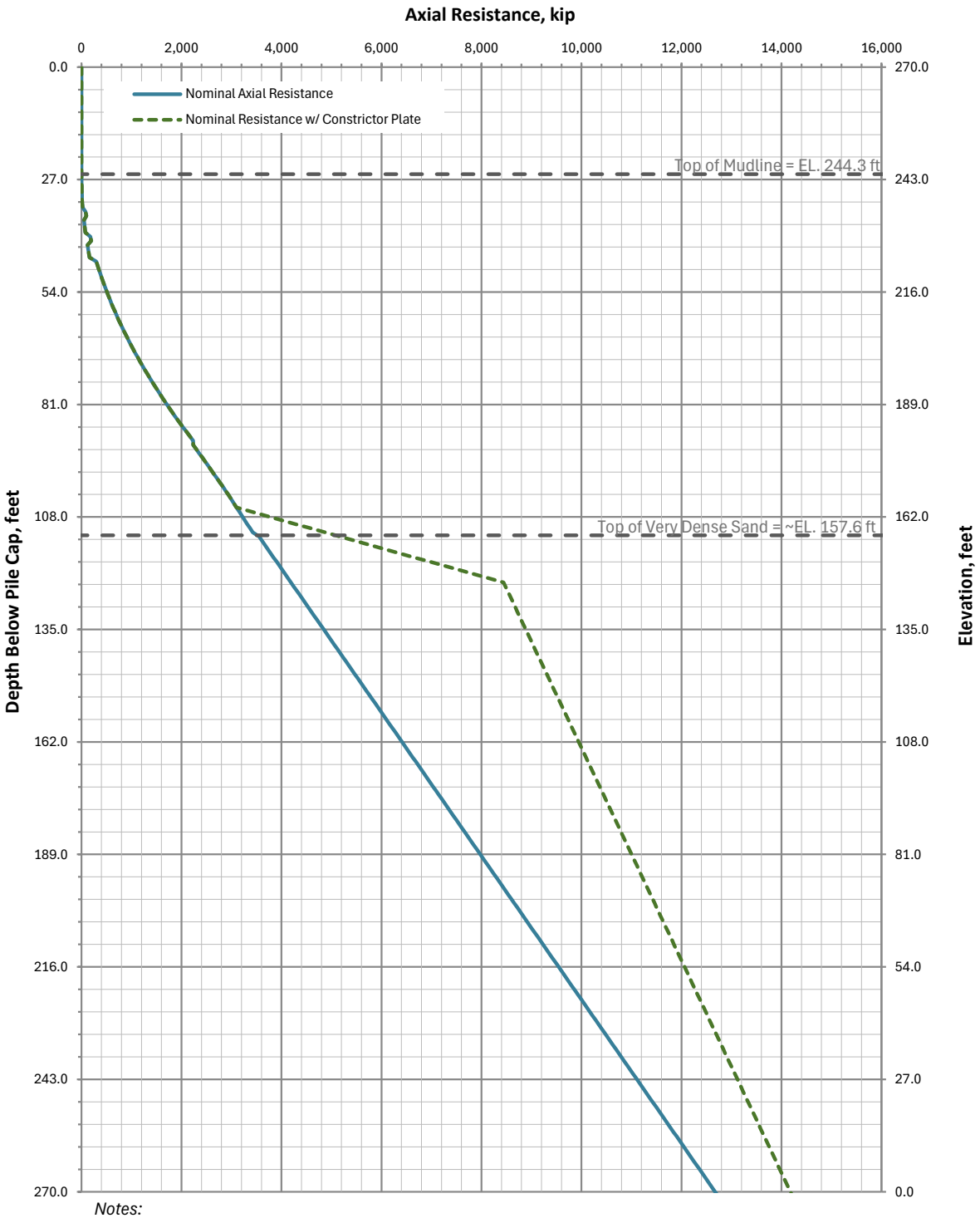
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Notes:
Chart is for single piles and does not include group efficiency factors.

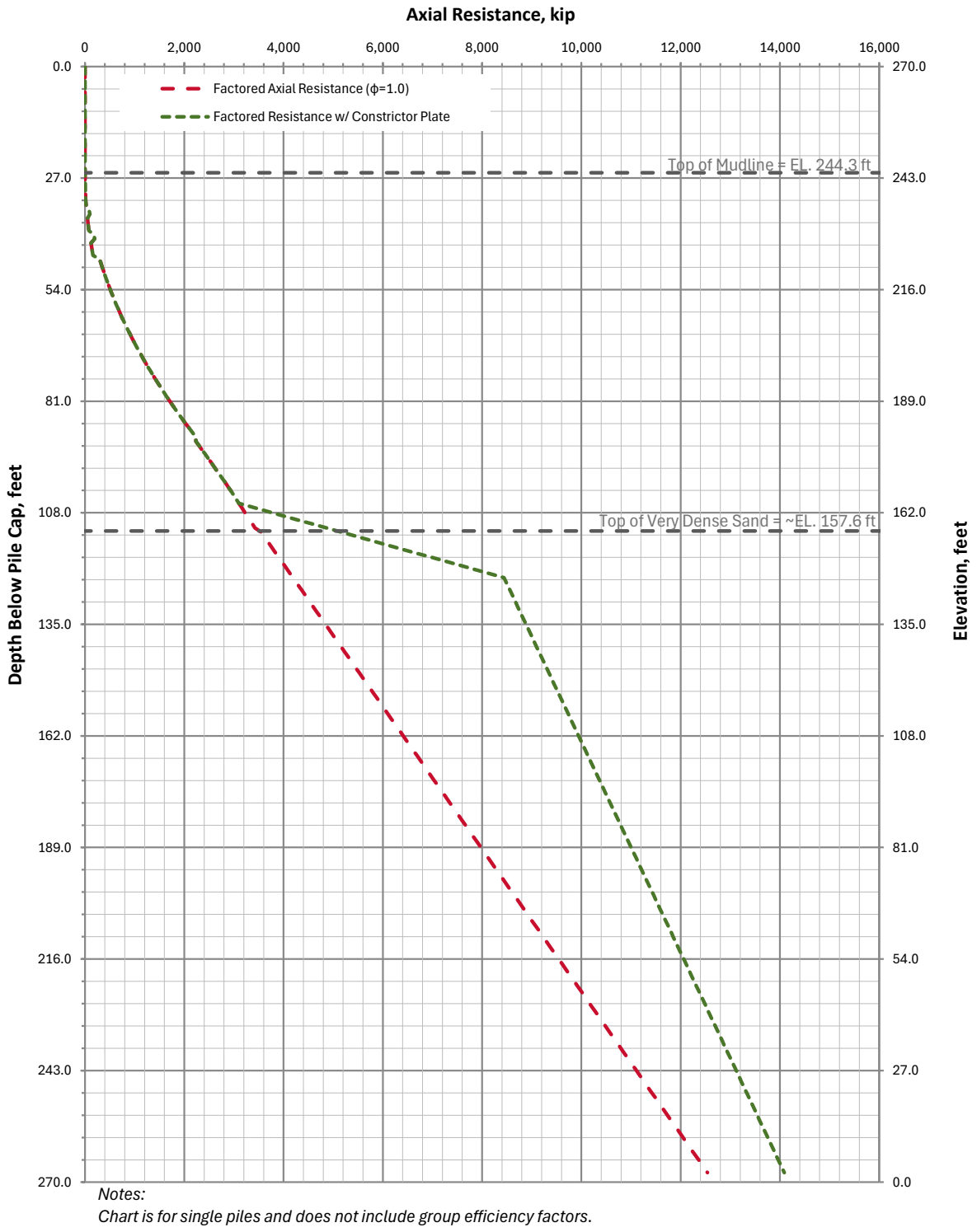
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



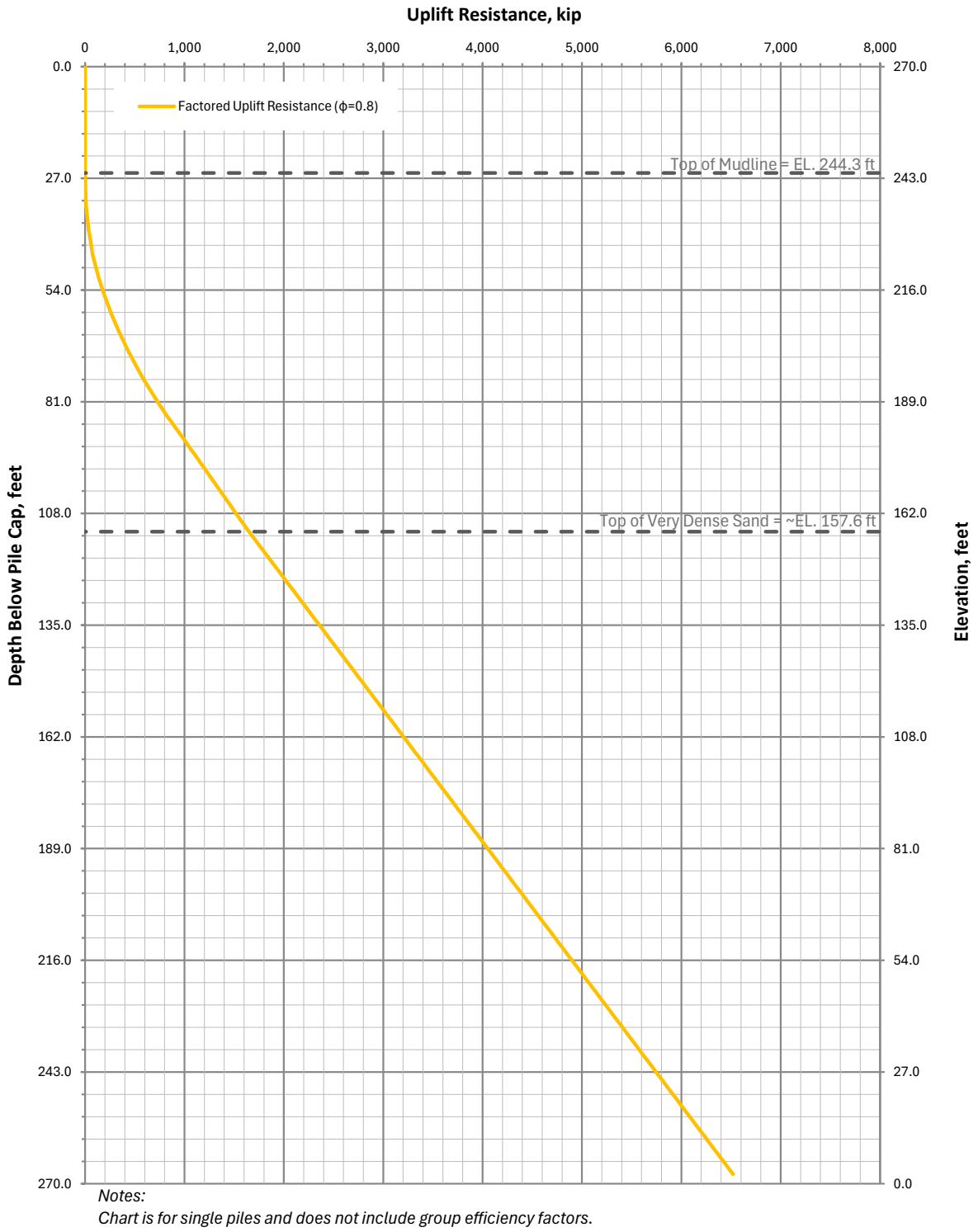
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 12/23/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 12/23/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

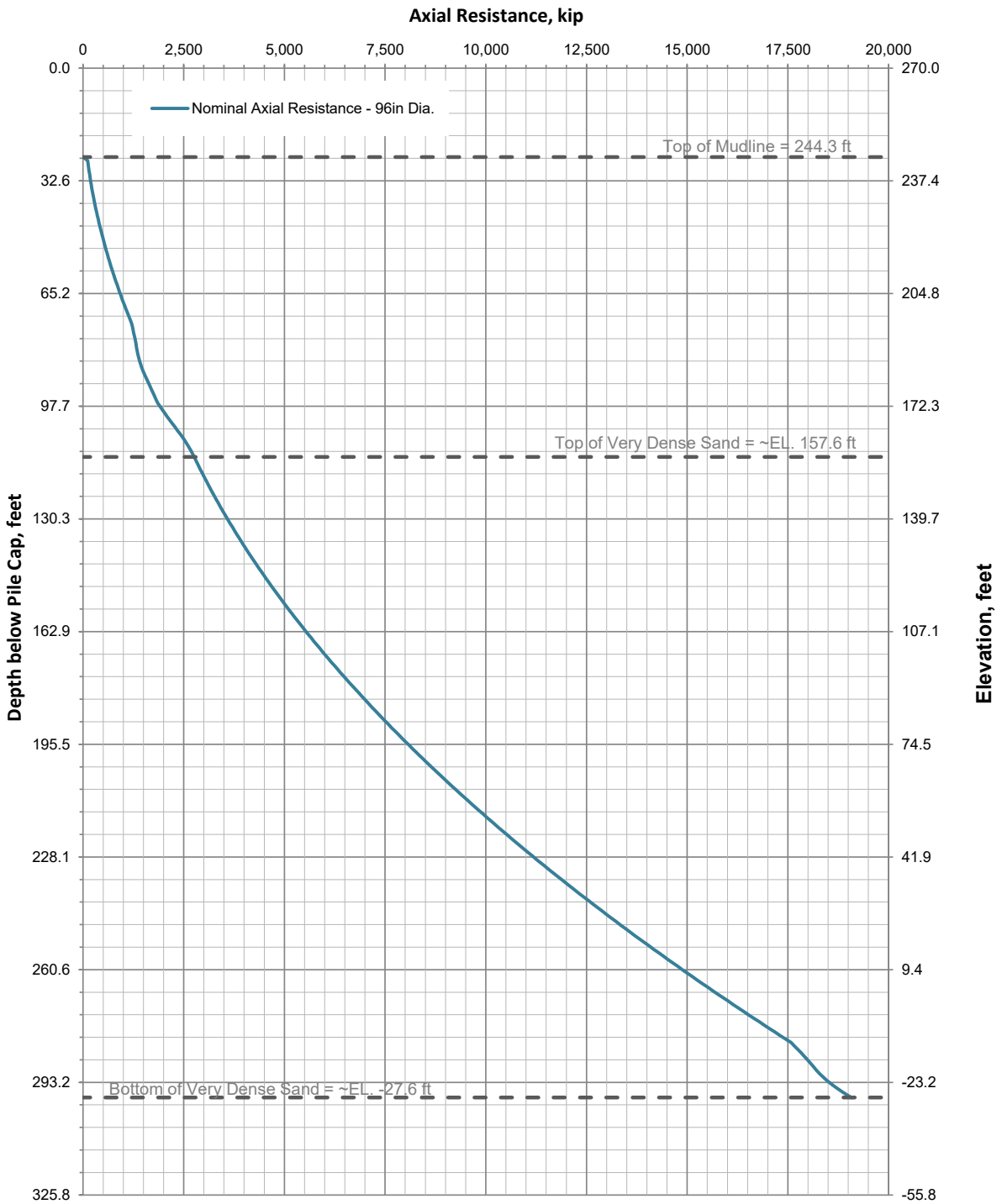
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Notes:
Chart is for single piles and does not include group efficiency factors.

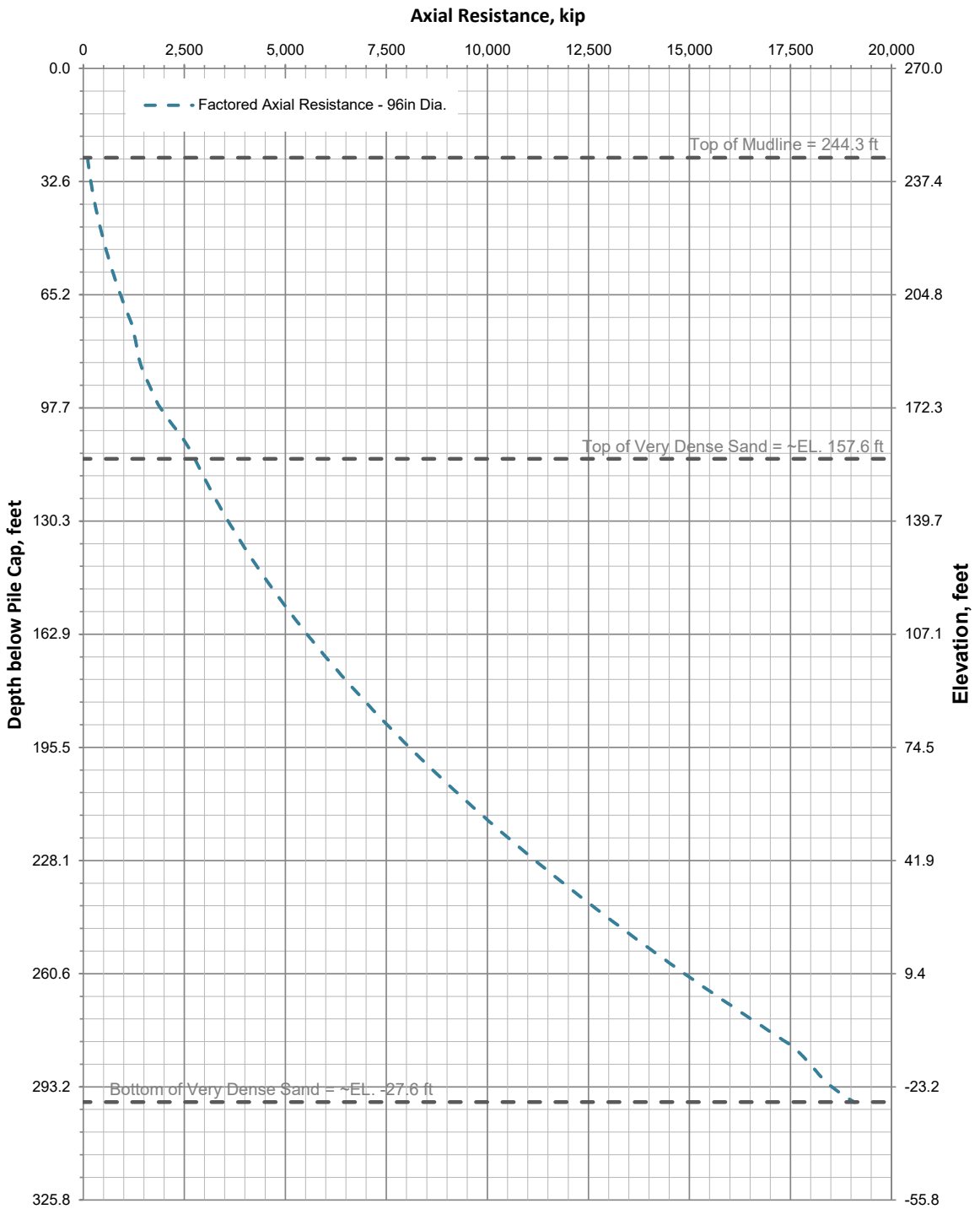
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



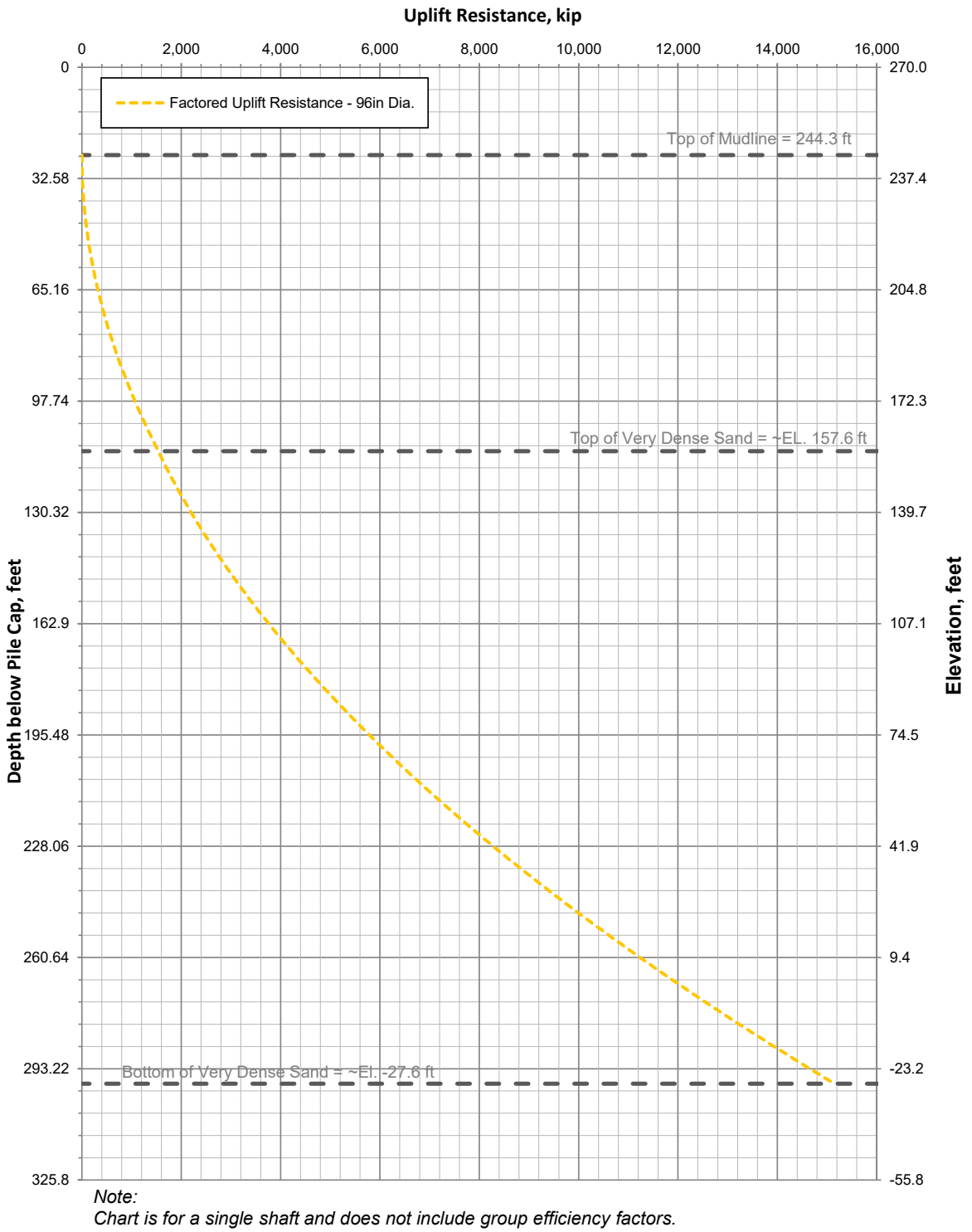
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

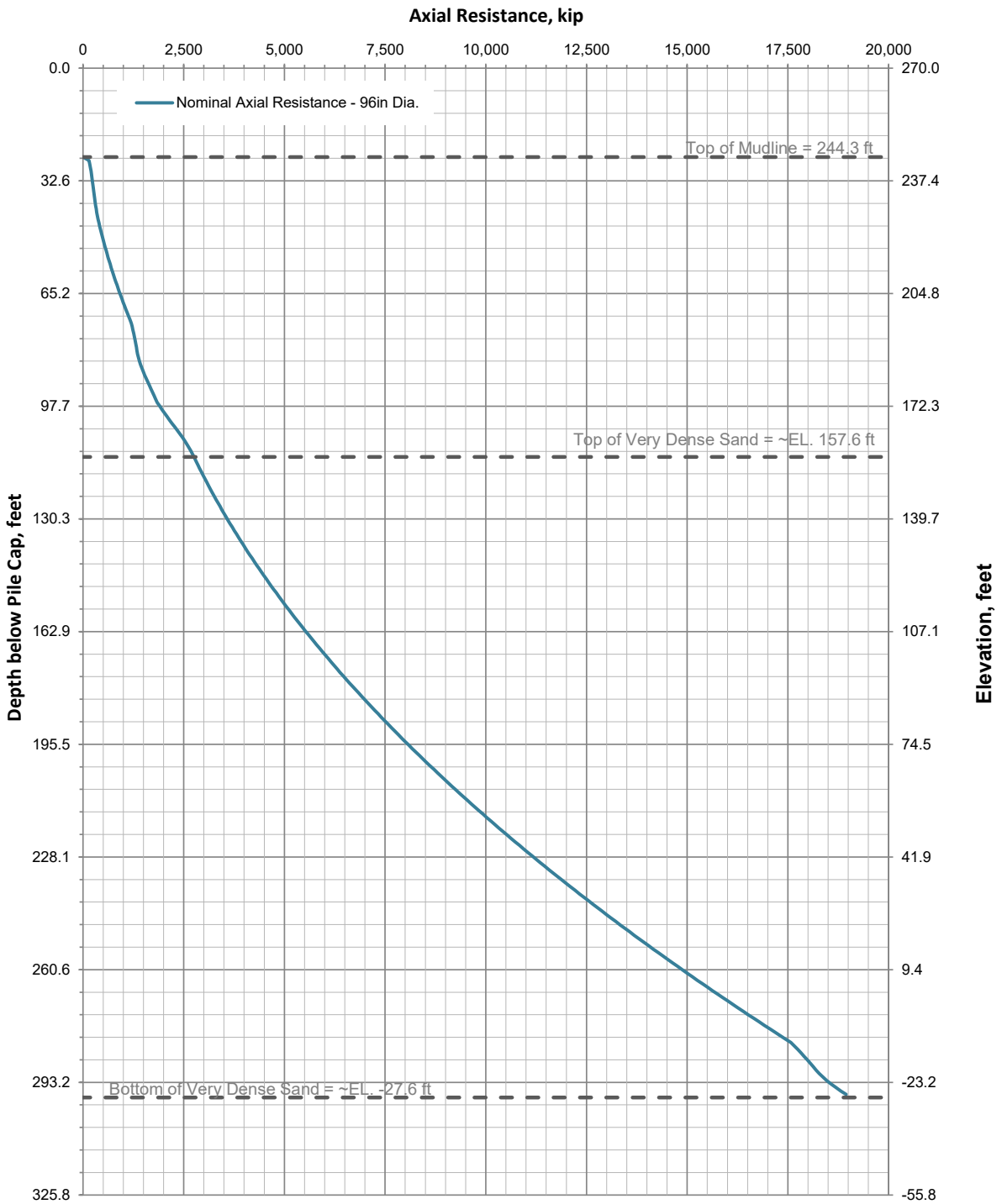
Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Note:
Chart is for a single shaft and does not include group efficiency factors.

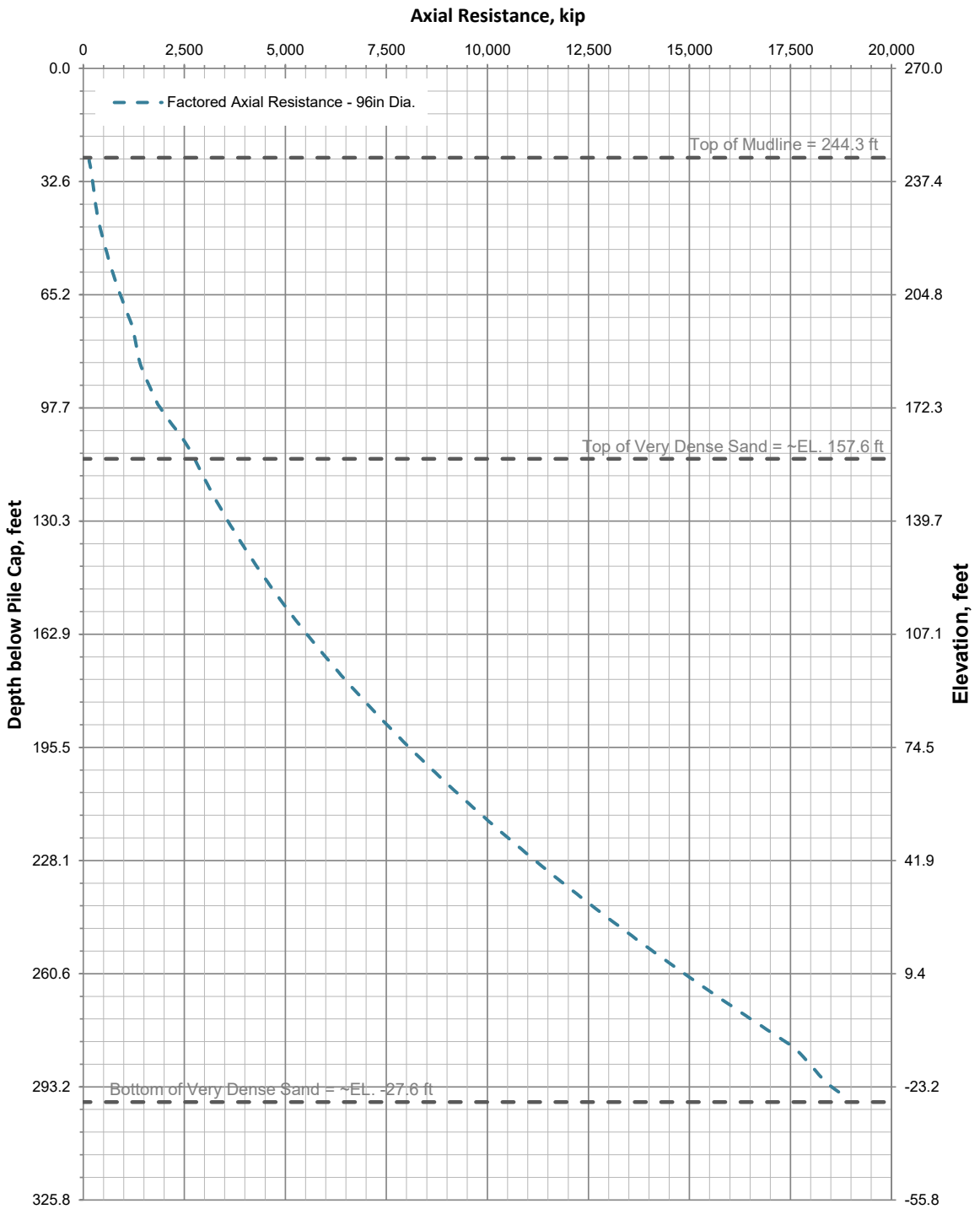
Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



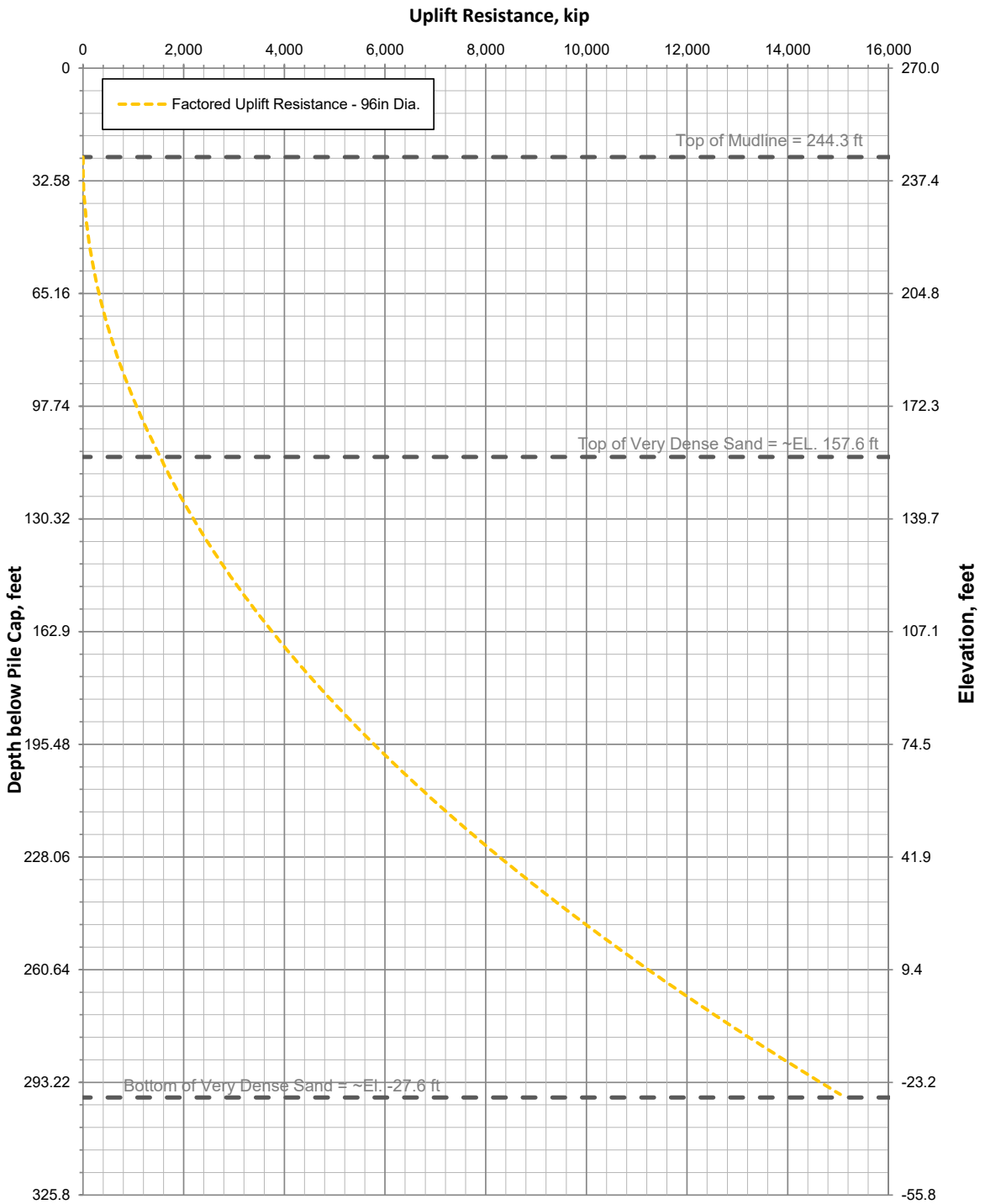
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

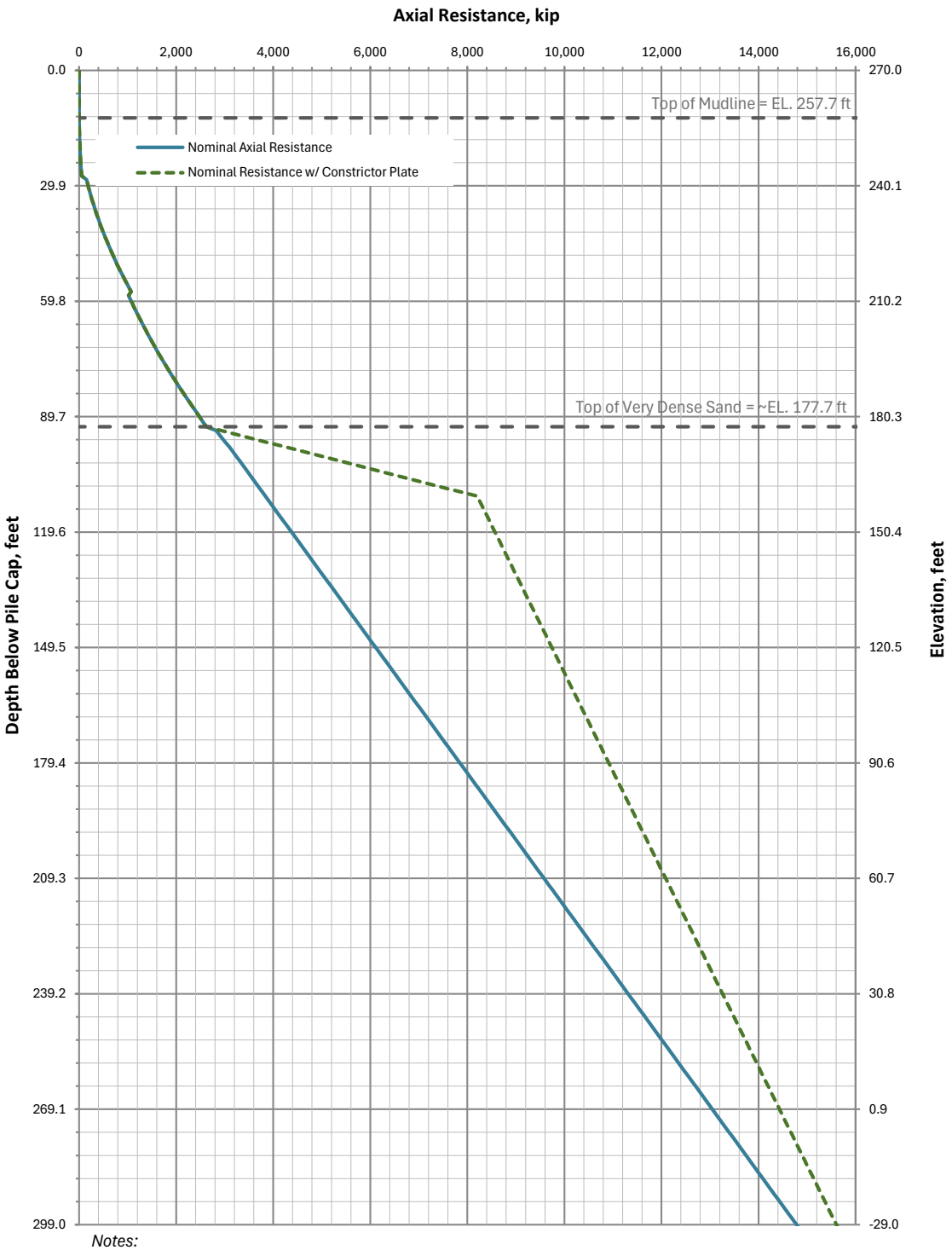


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

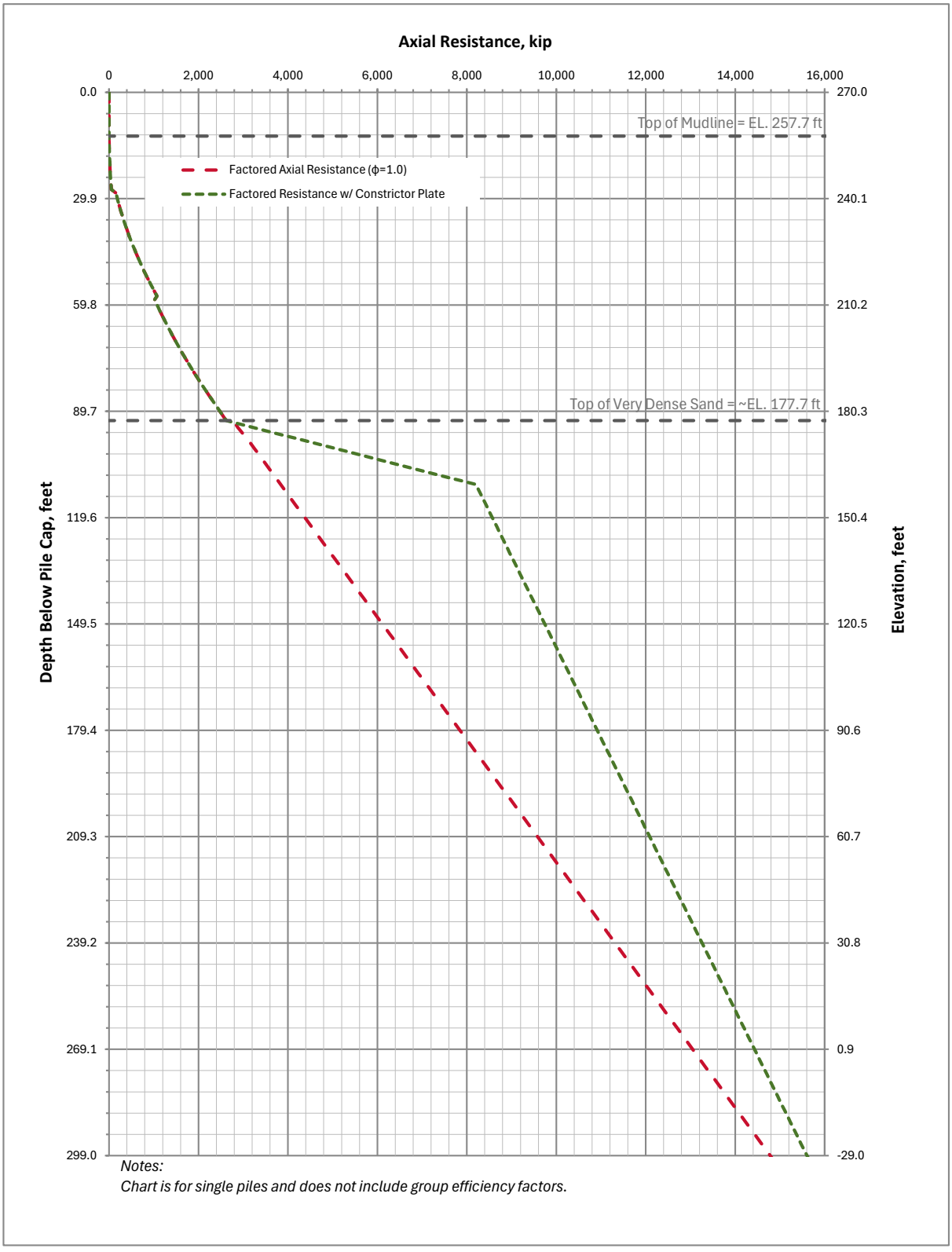
PIER 6

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



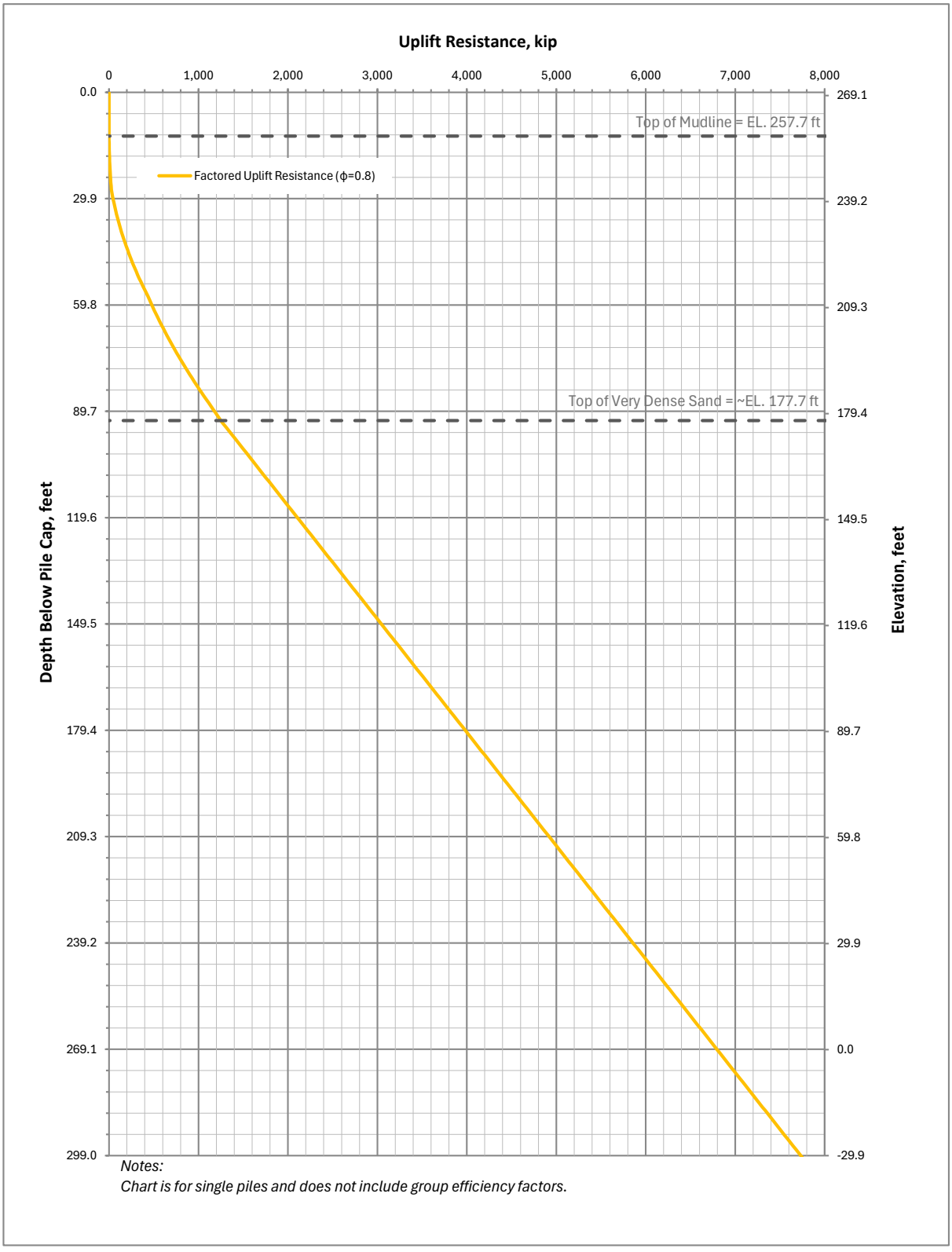
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for single piles and does not include group efficiency factors.

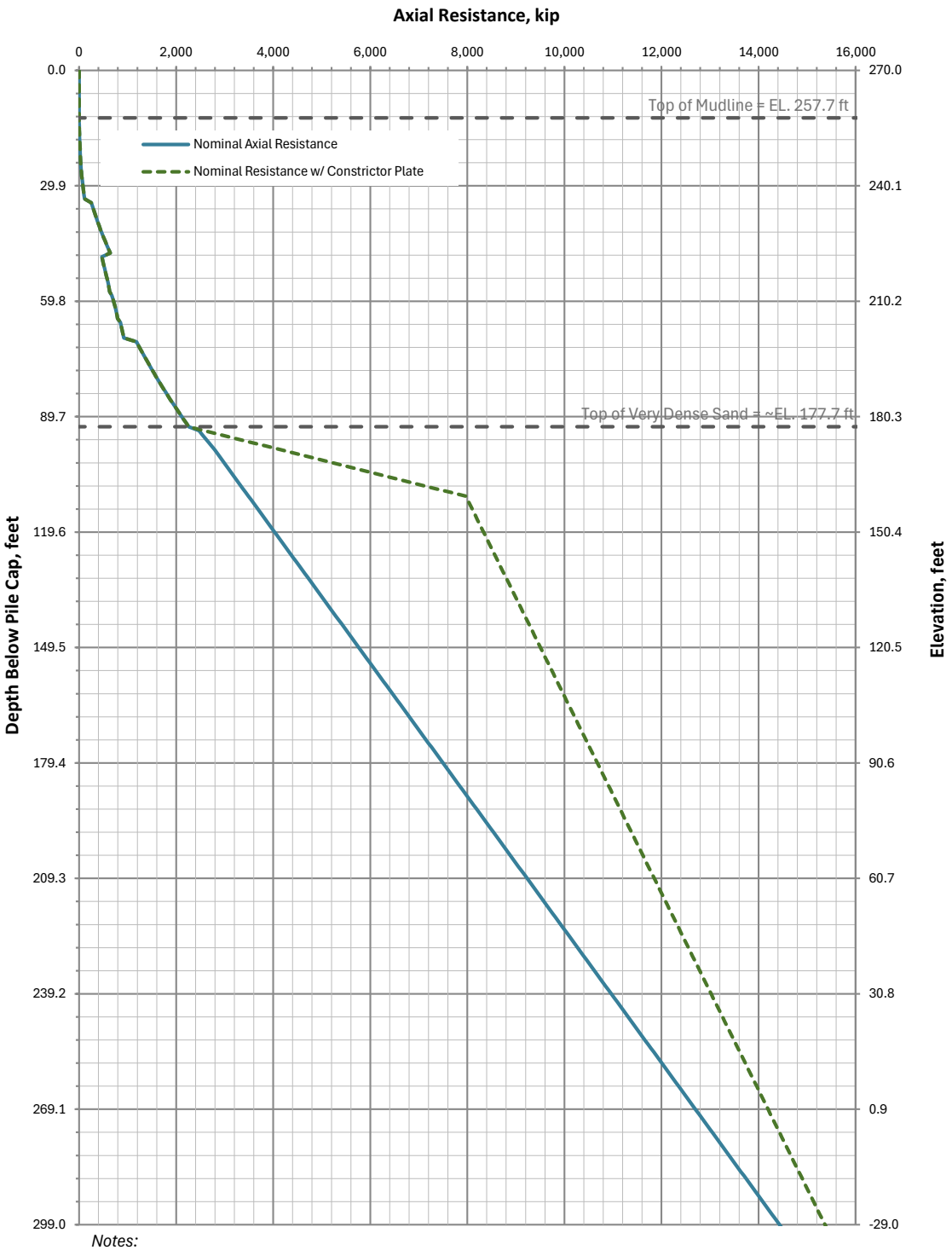
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for single piles and does not include group efficiency factors.

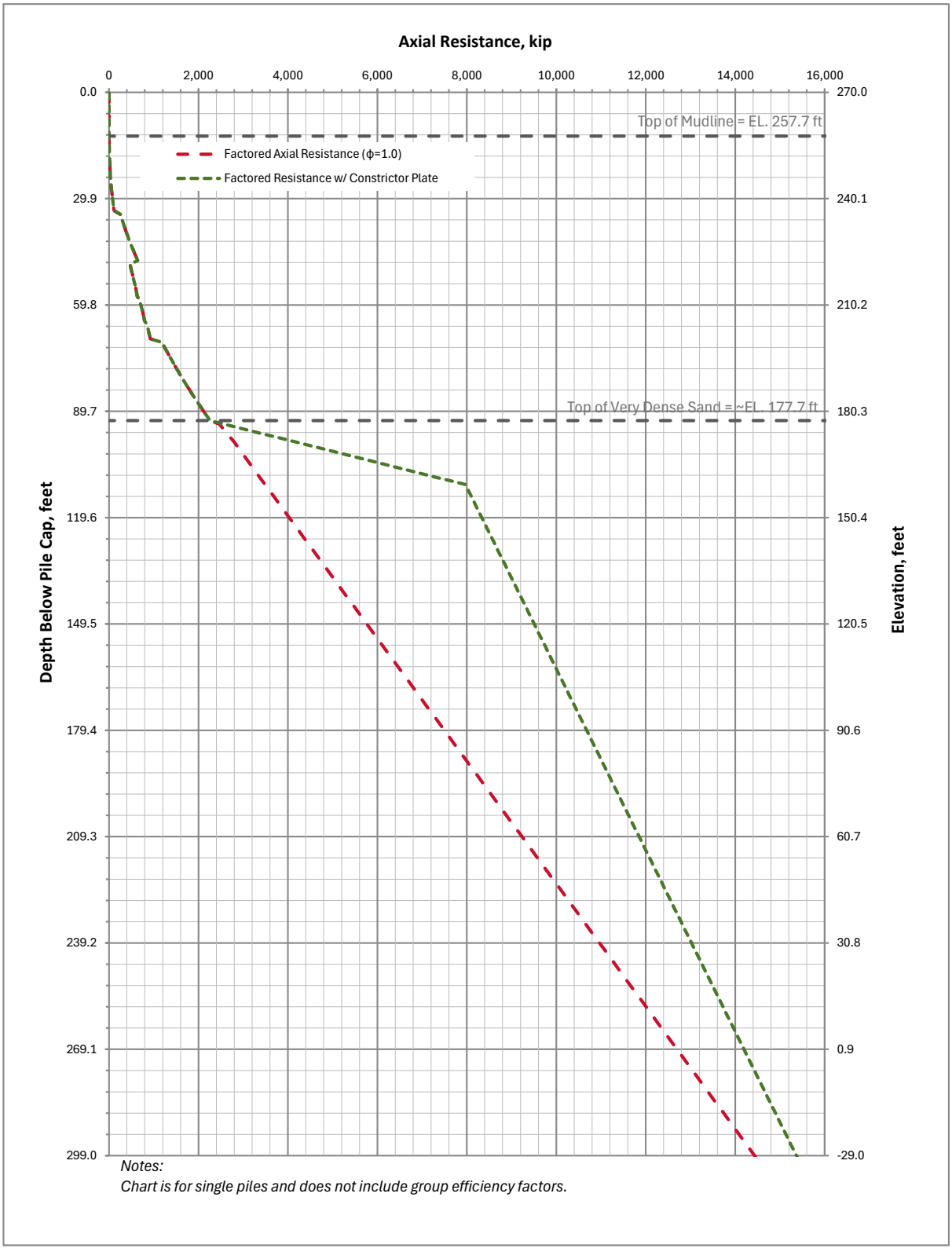
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/21/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 10/20/25

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



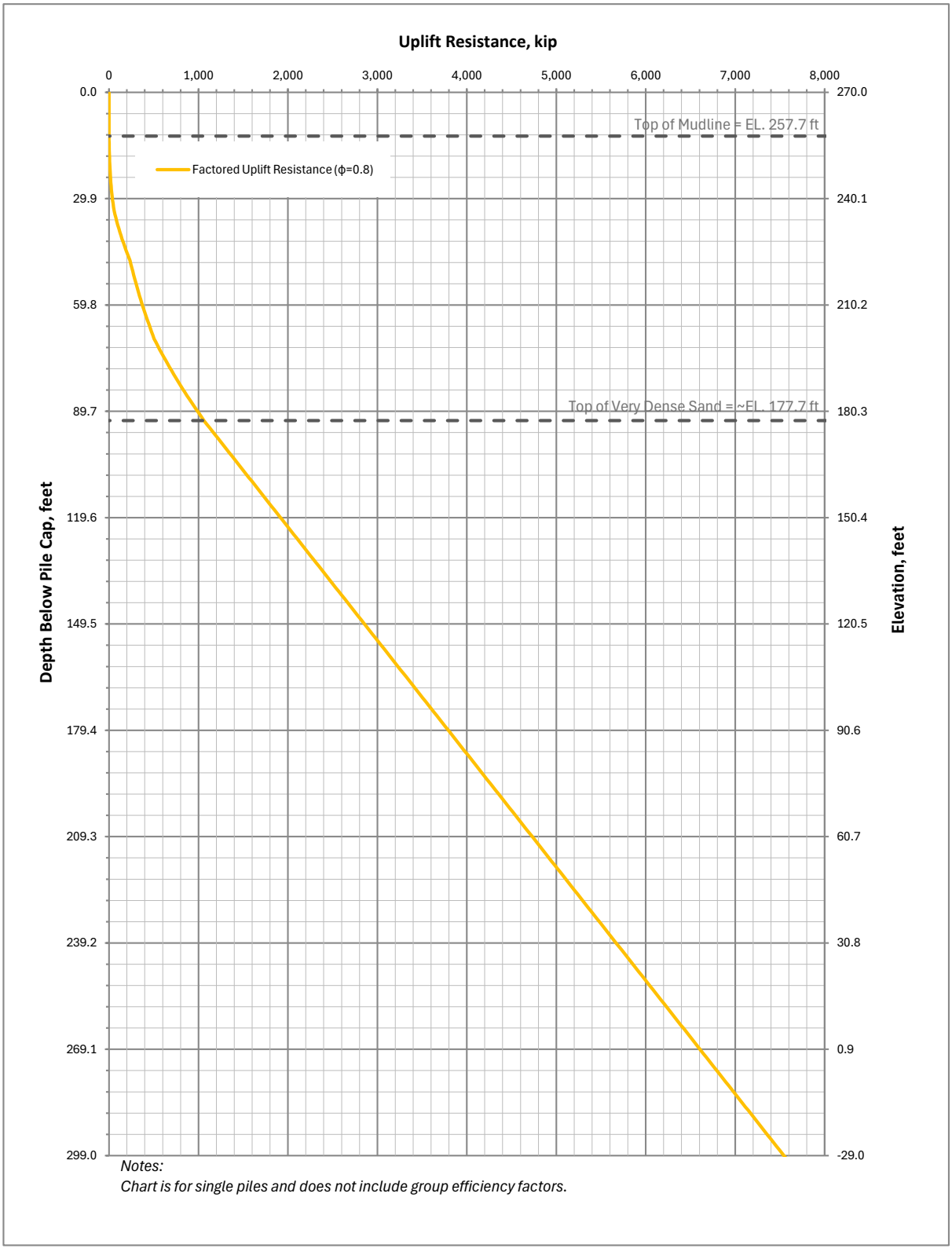
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for single piles and does not include group efficiency factors.

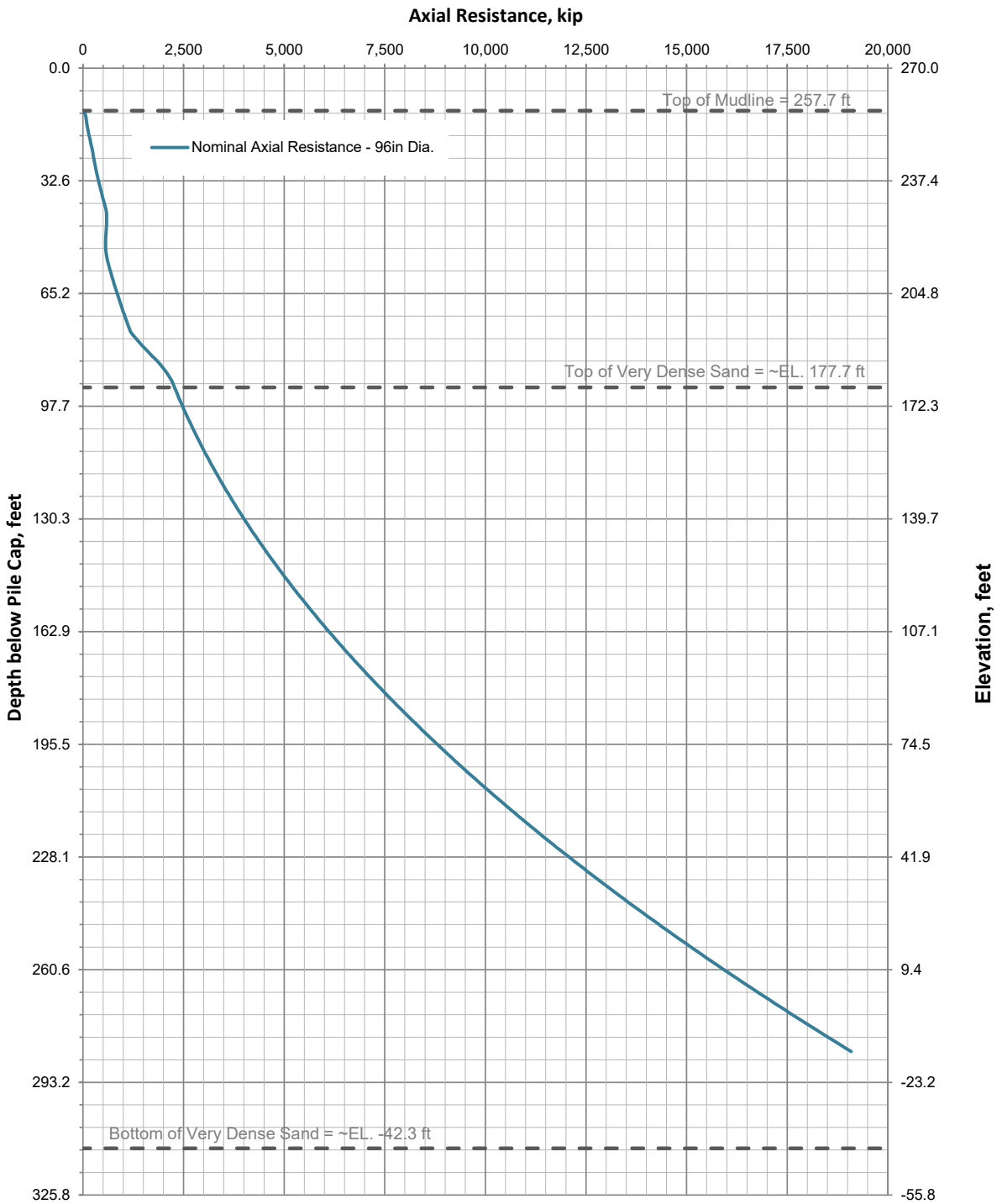
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for single piles and does not include group efficiency factors.

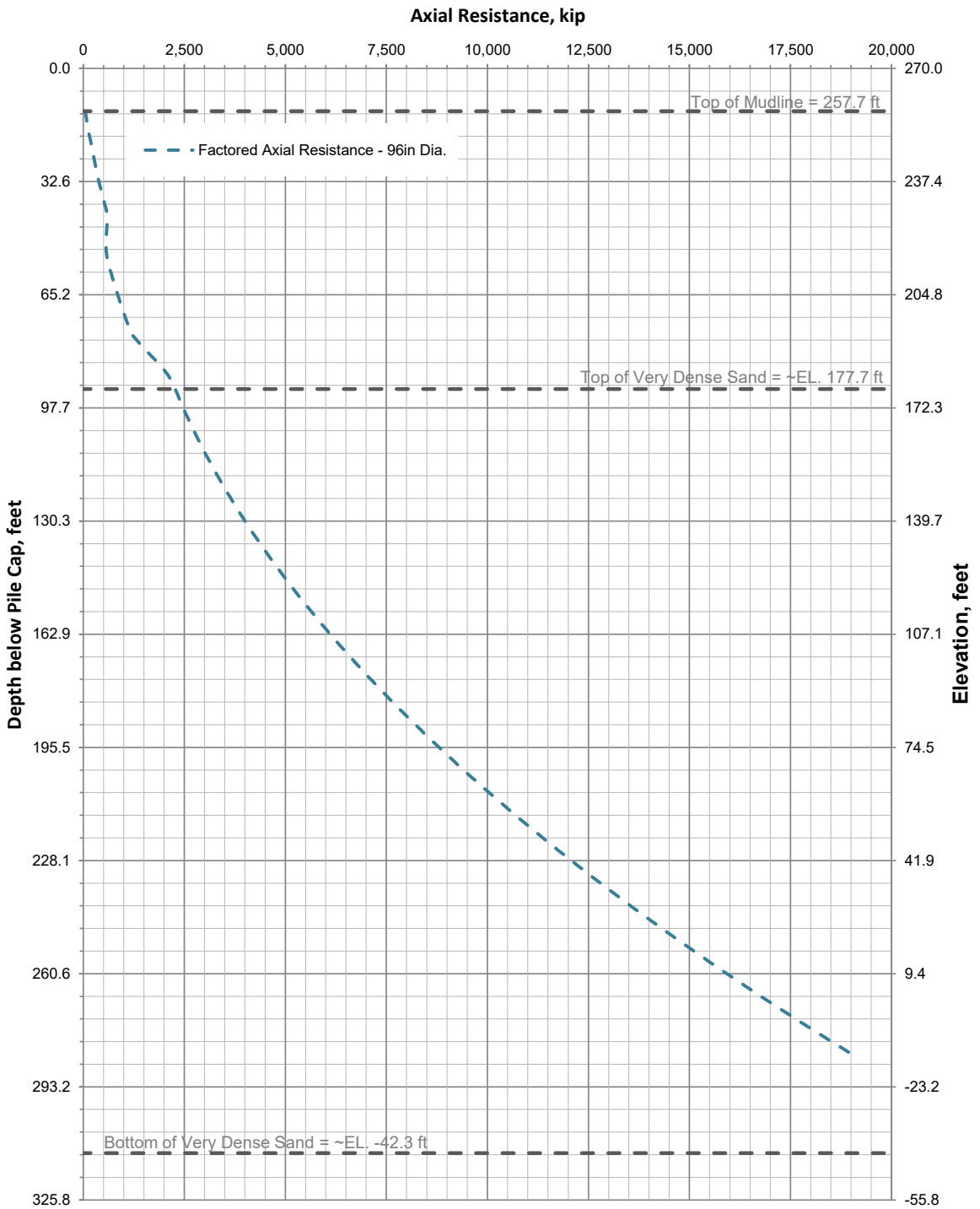
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 09/25/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



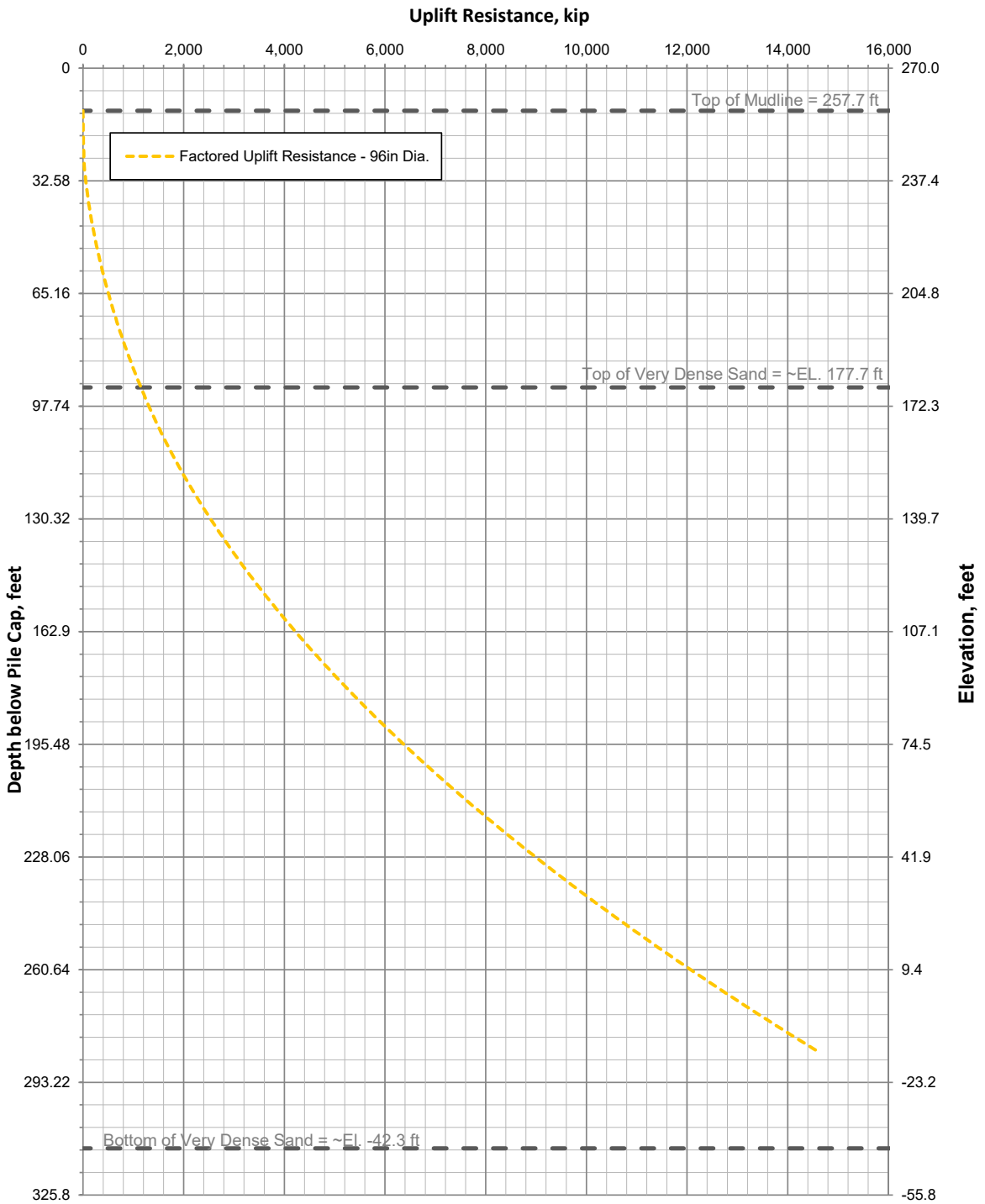
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

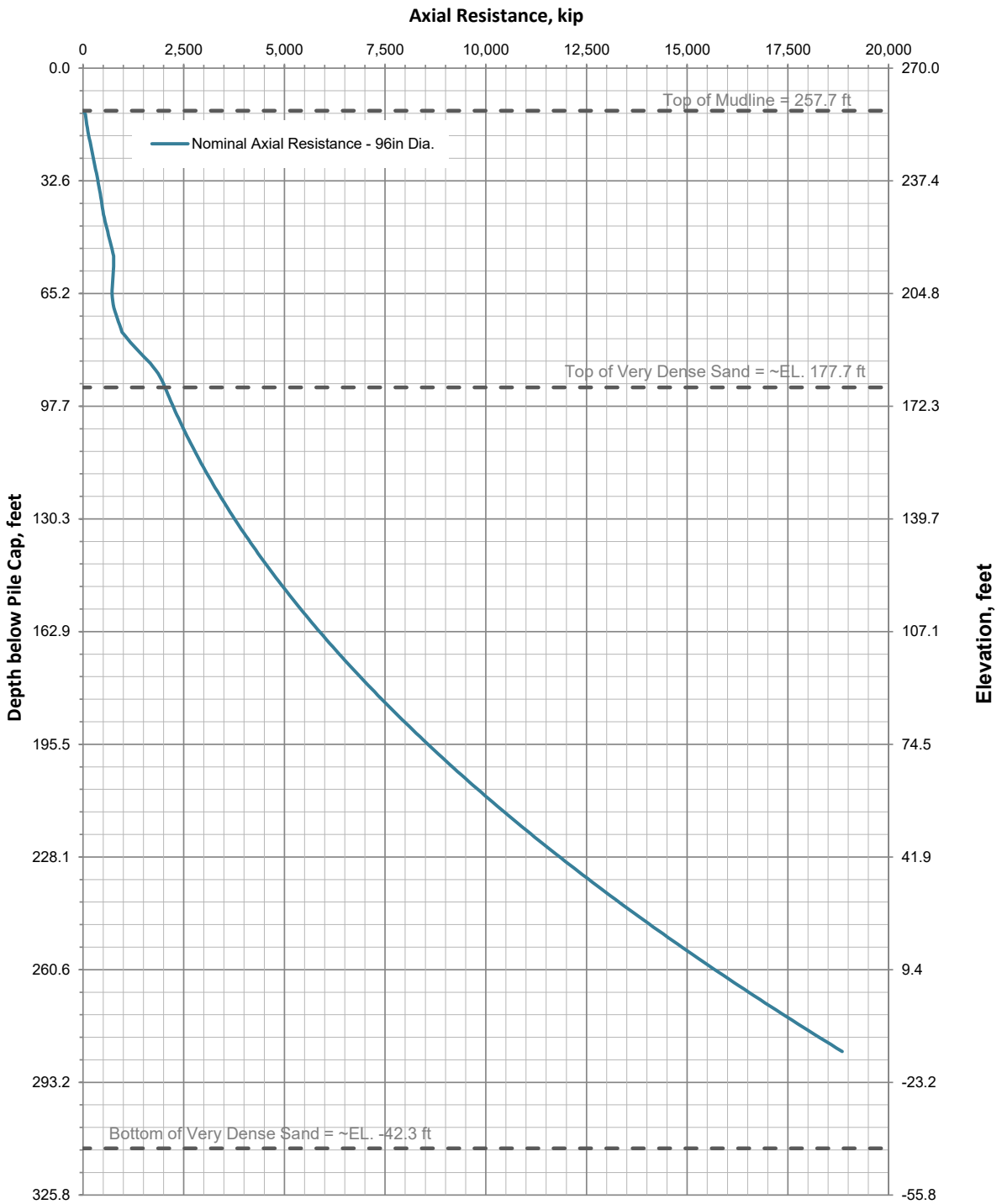
Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25



Note:
Chart is for a single shaft and does not include group efficiency factors.

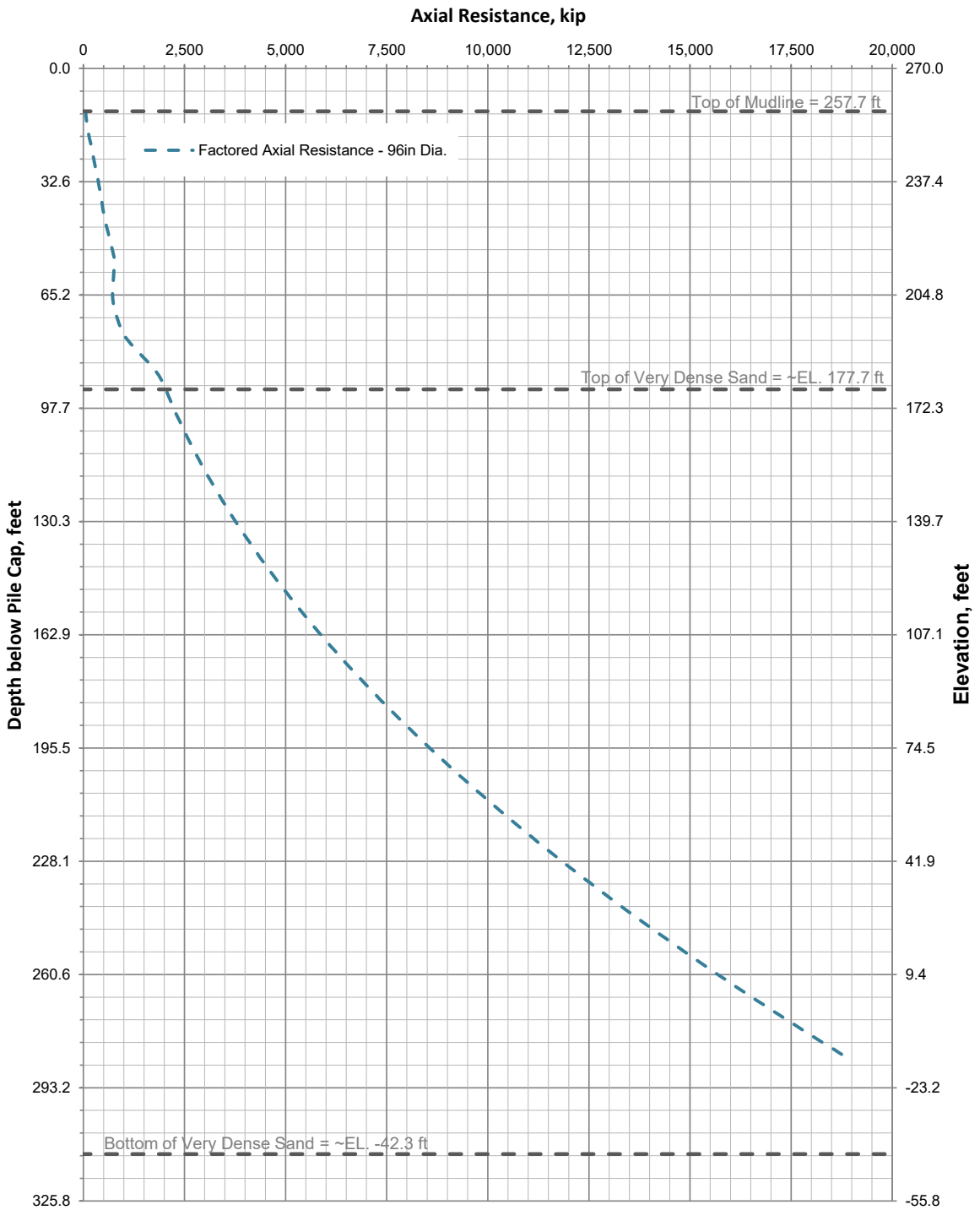
Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/21/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 10/20/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



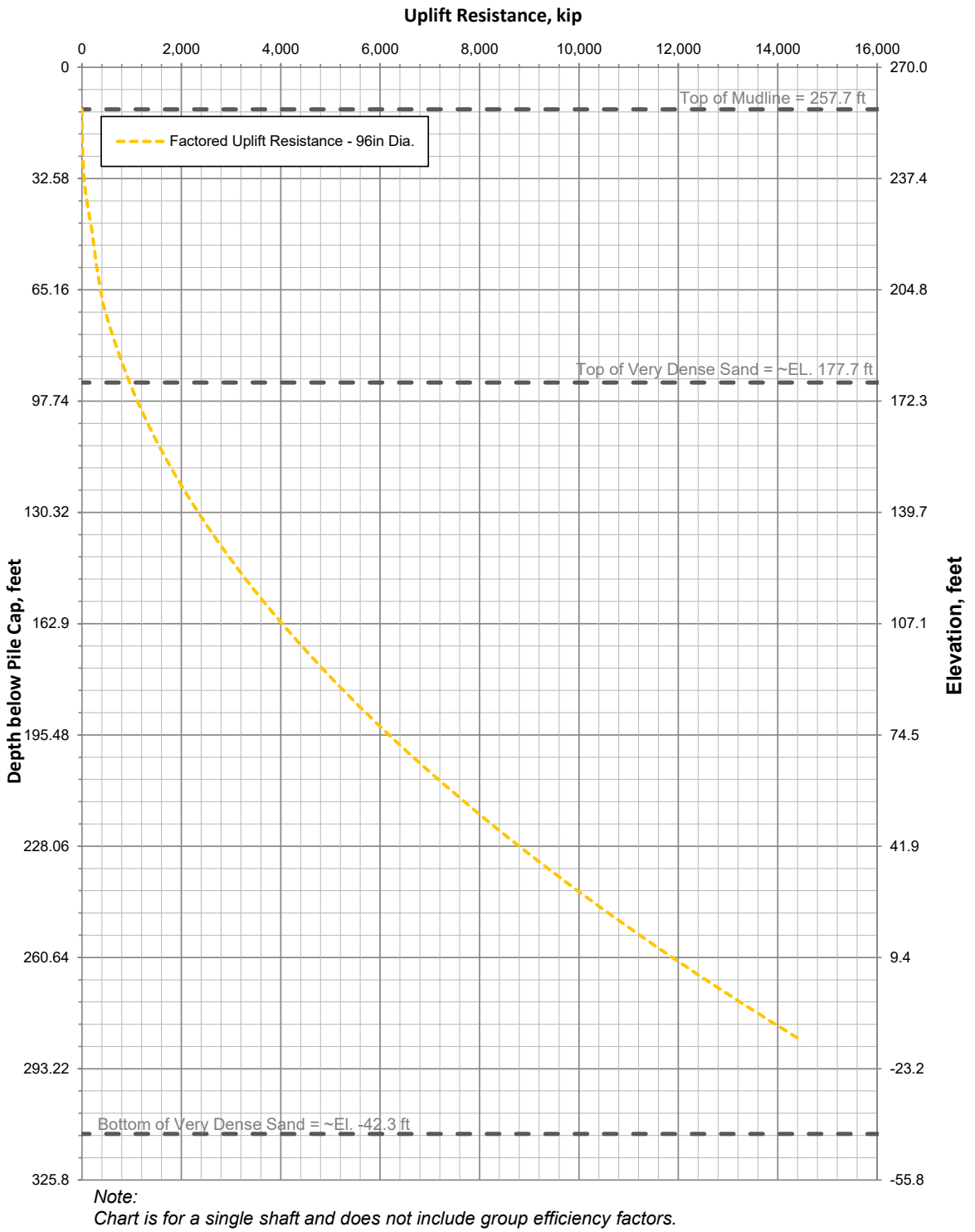
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/24/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 09/25/25 **Drawn By:** SKB **Figure No. ##** **Date:** 09/22/25

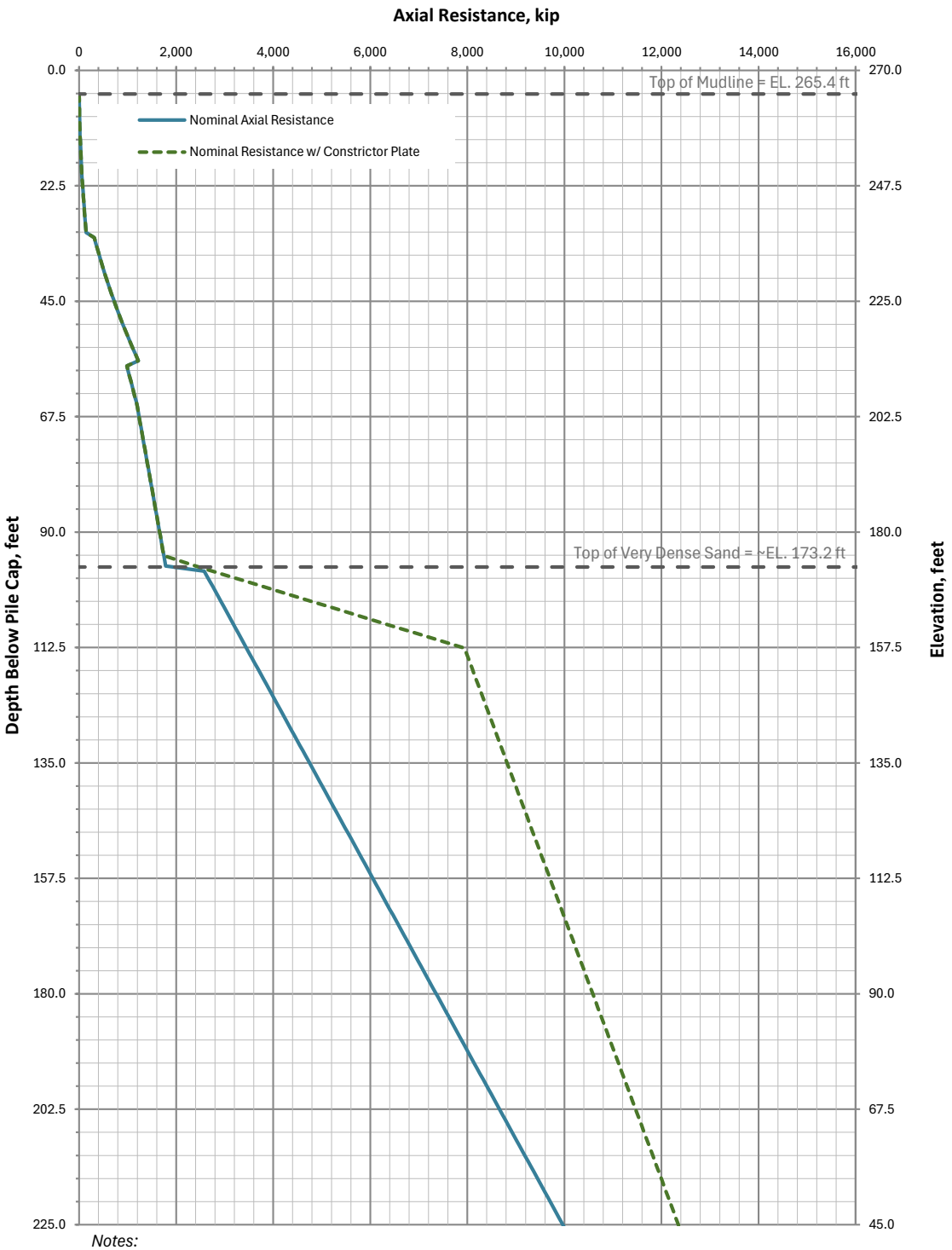


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/21/2025 **Drawn By:** SKB **Figure No. ##** **Date:** 10/20/2025

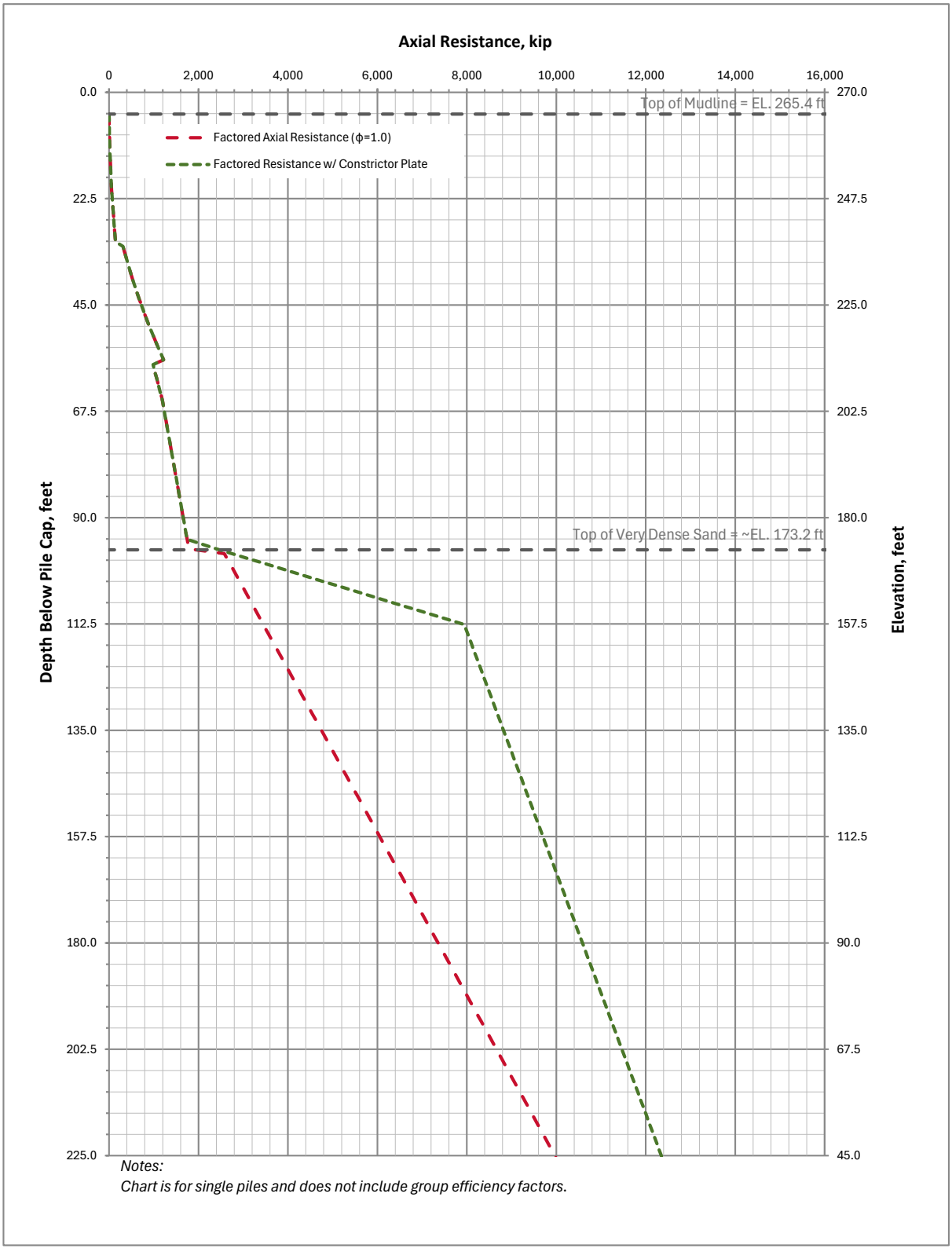
PIER 7

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



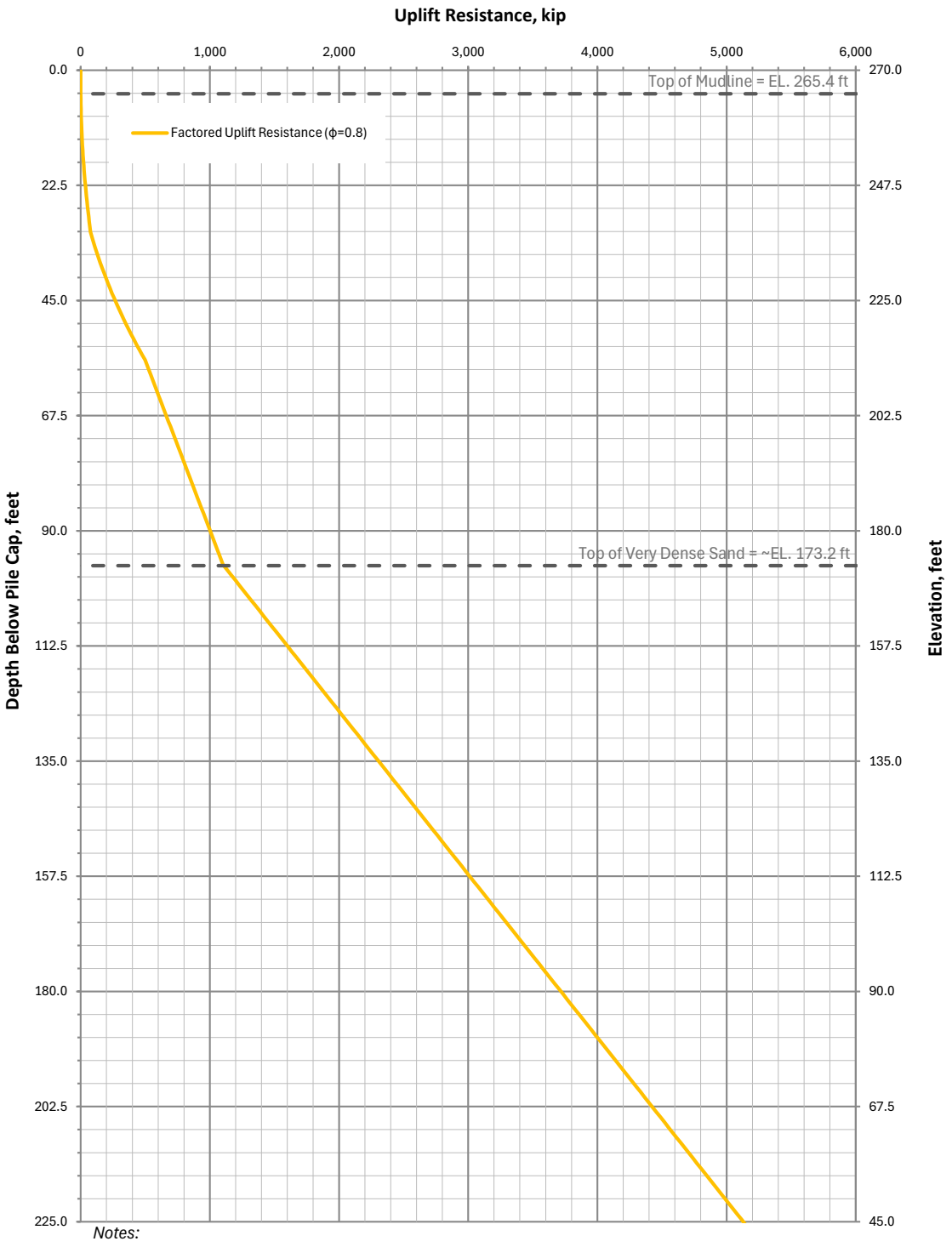
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

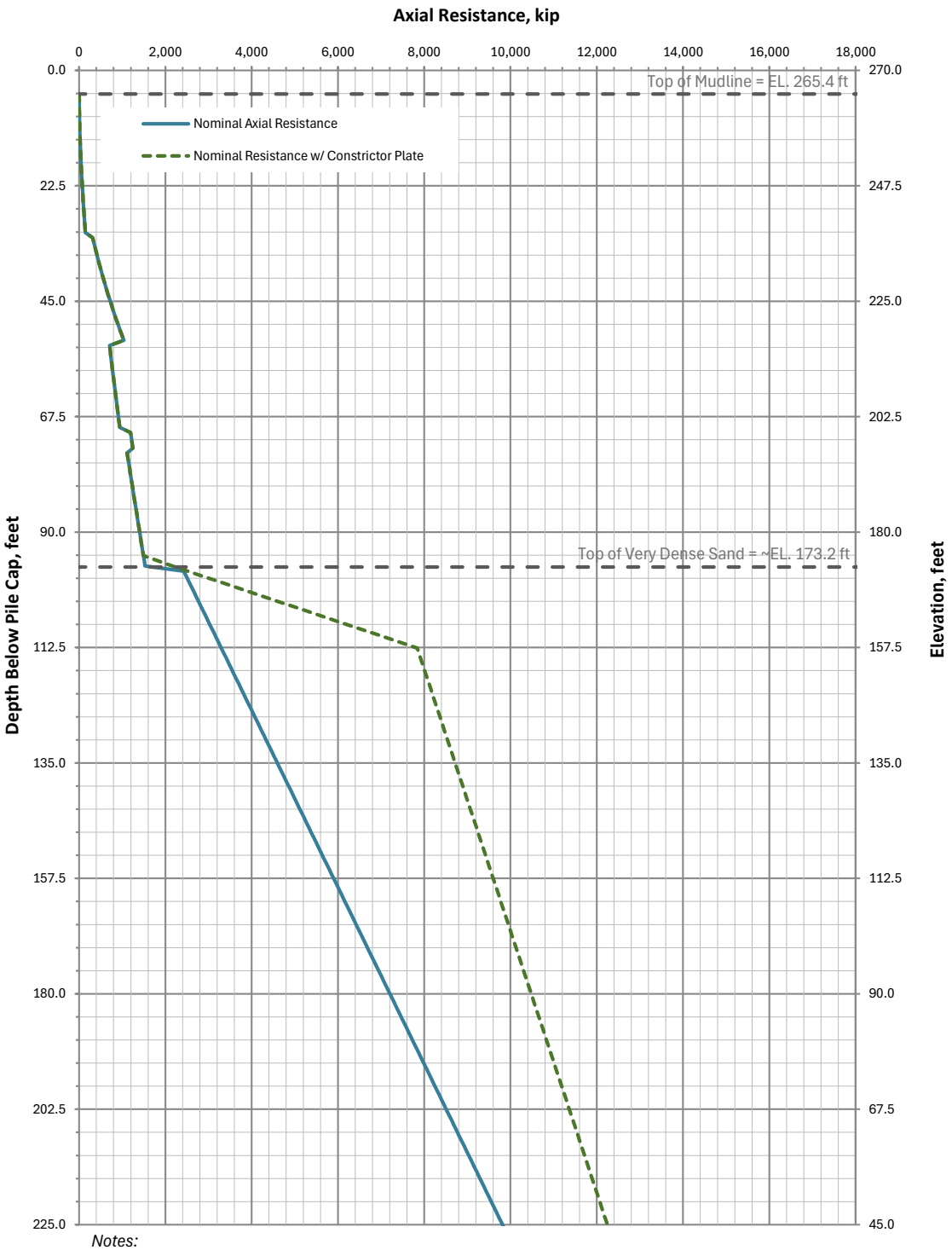
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

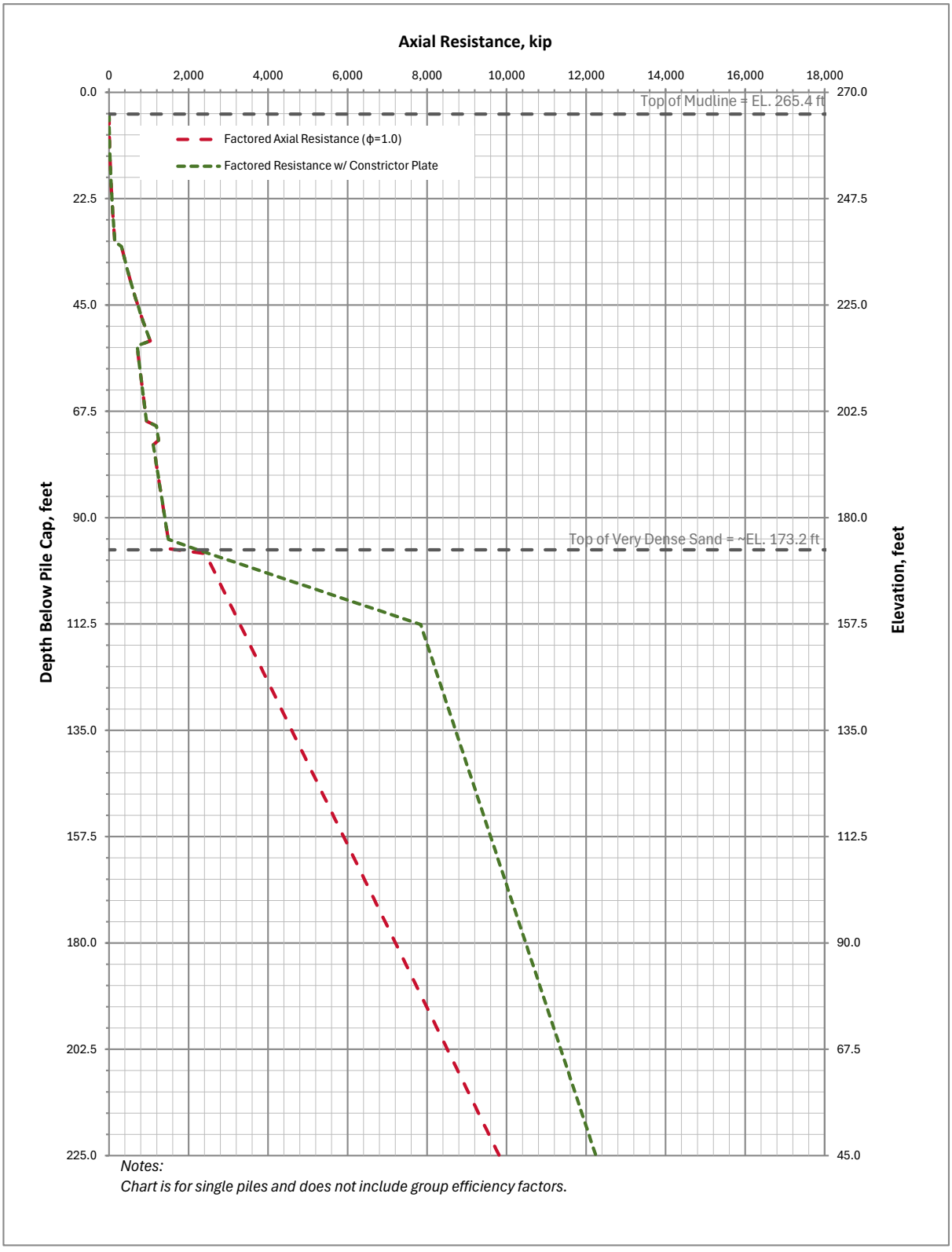
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



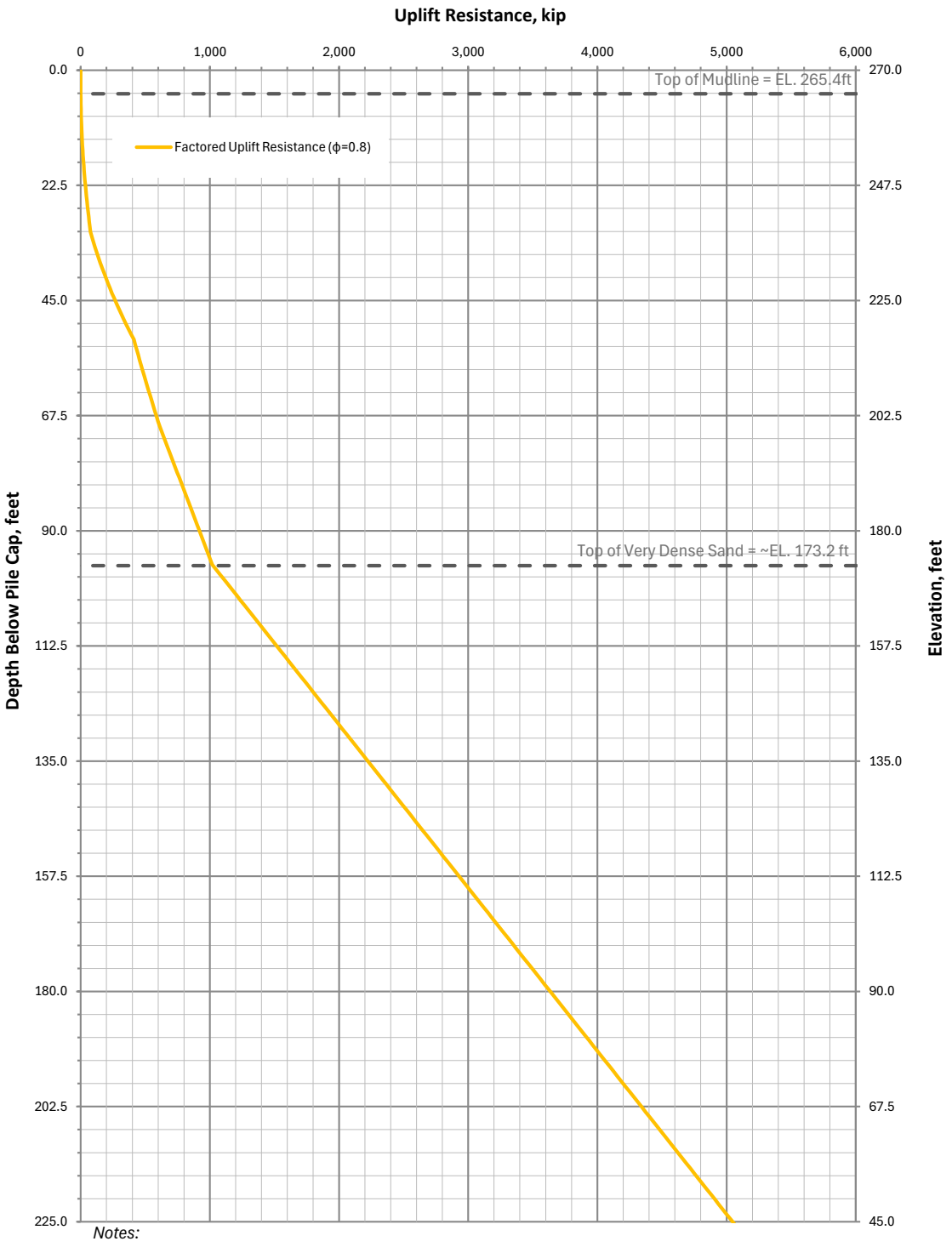
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

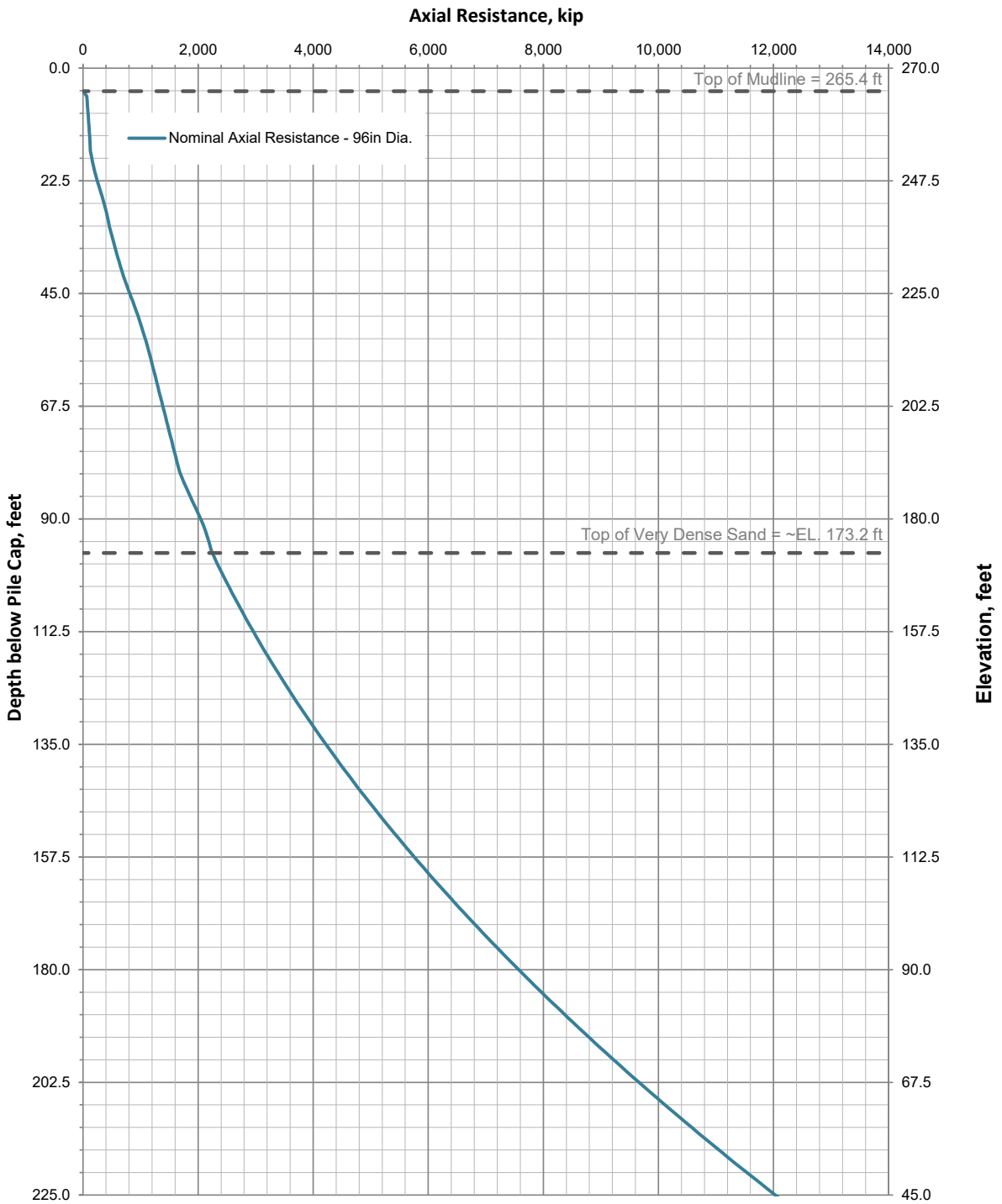
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

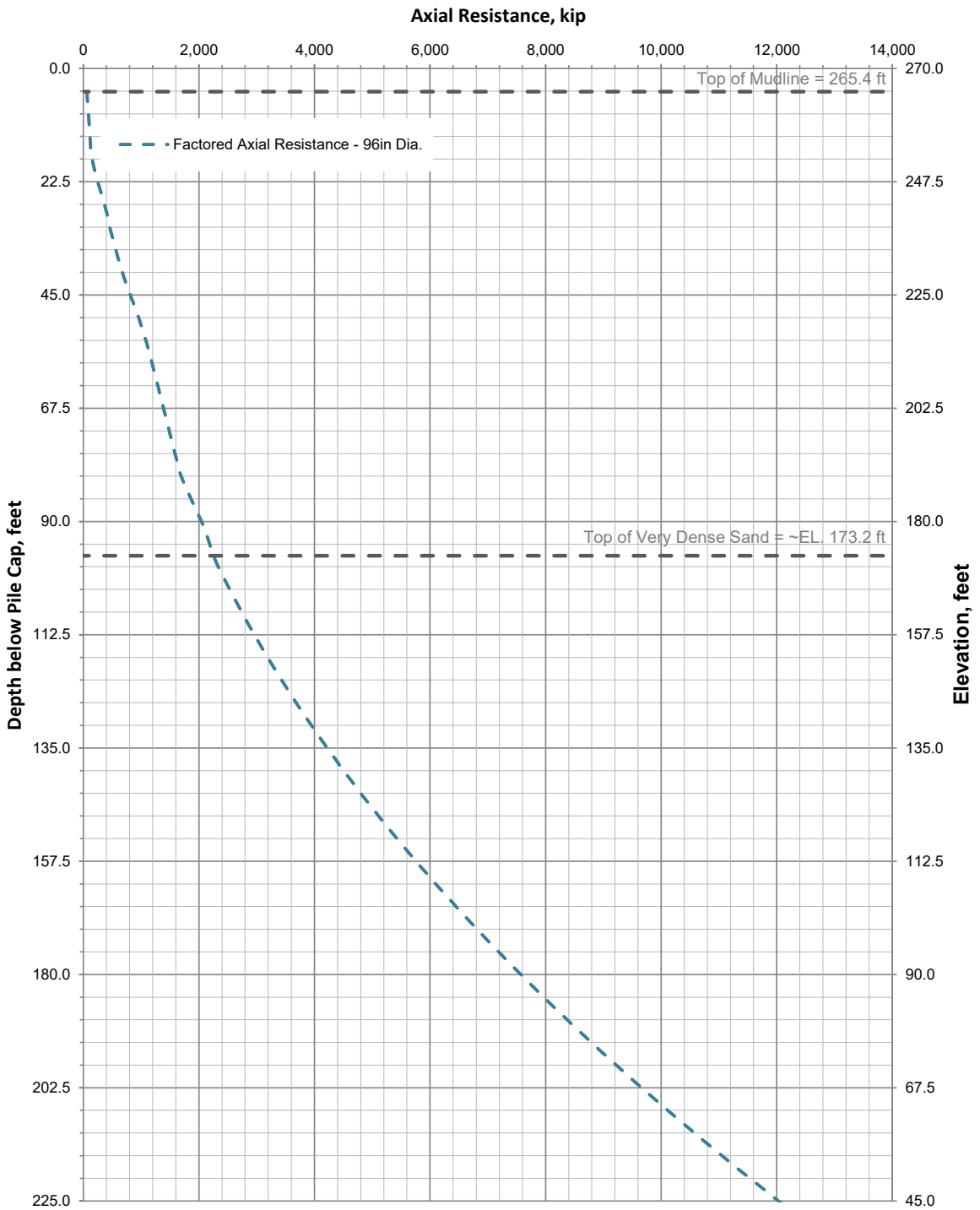
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



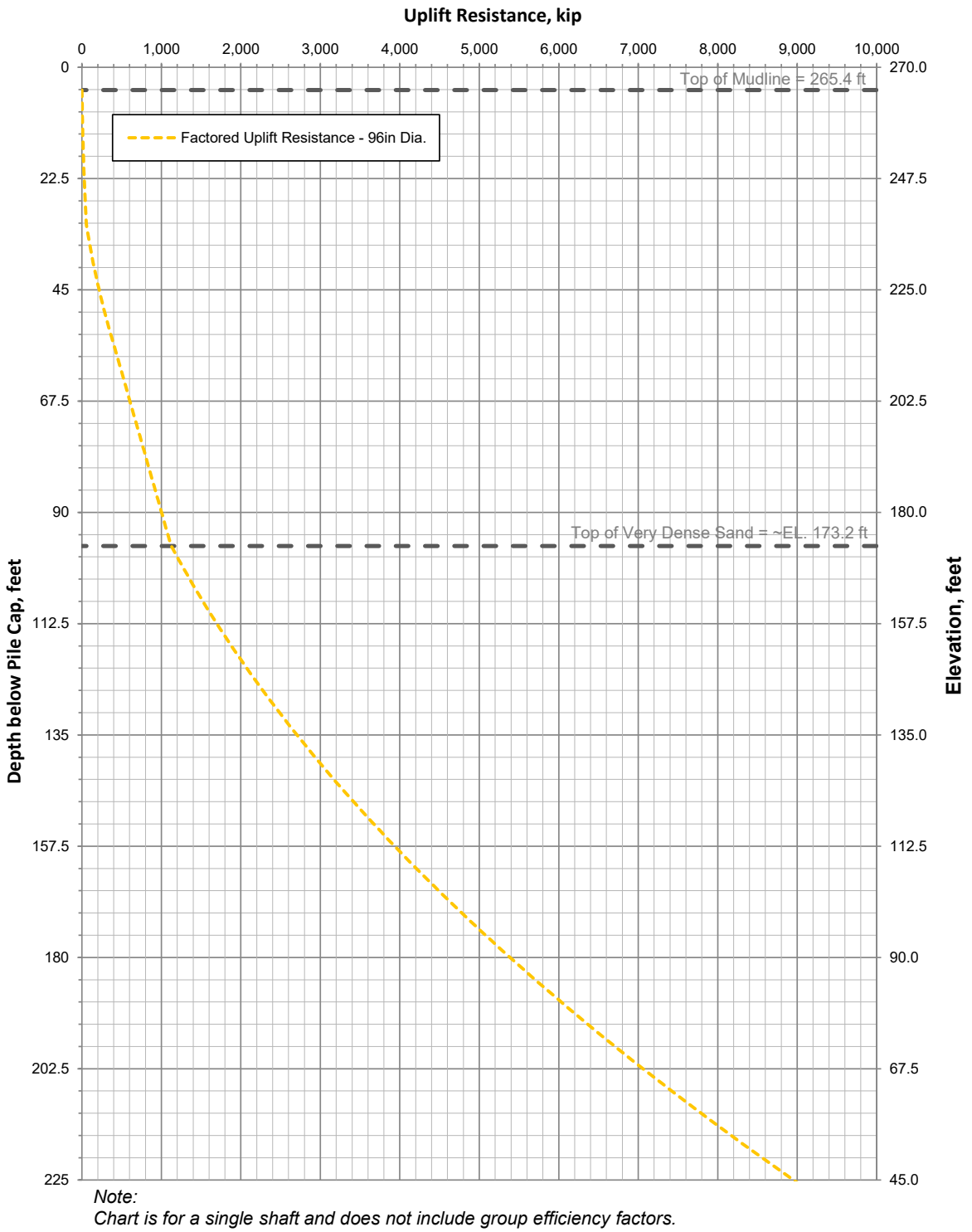
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

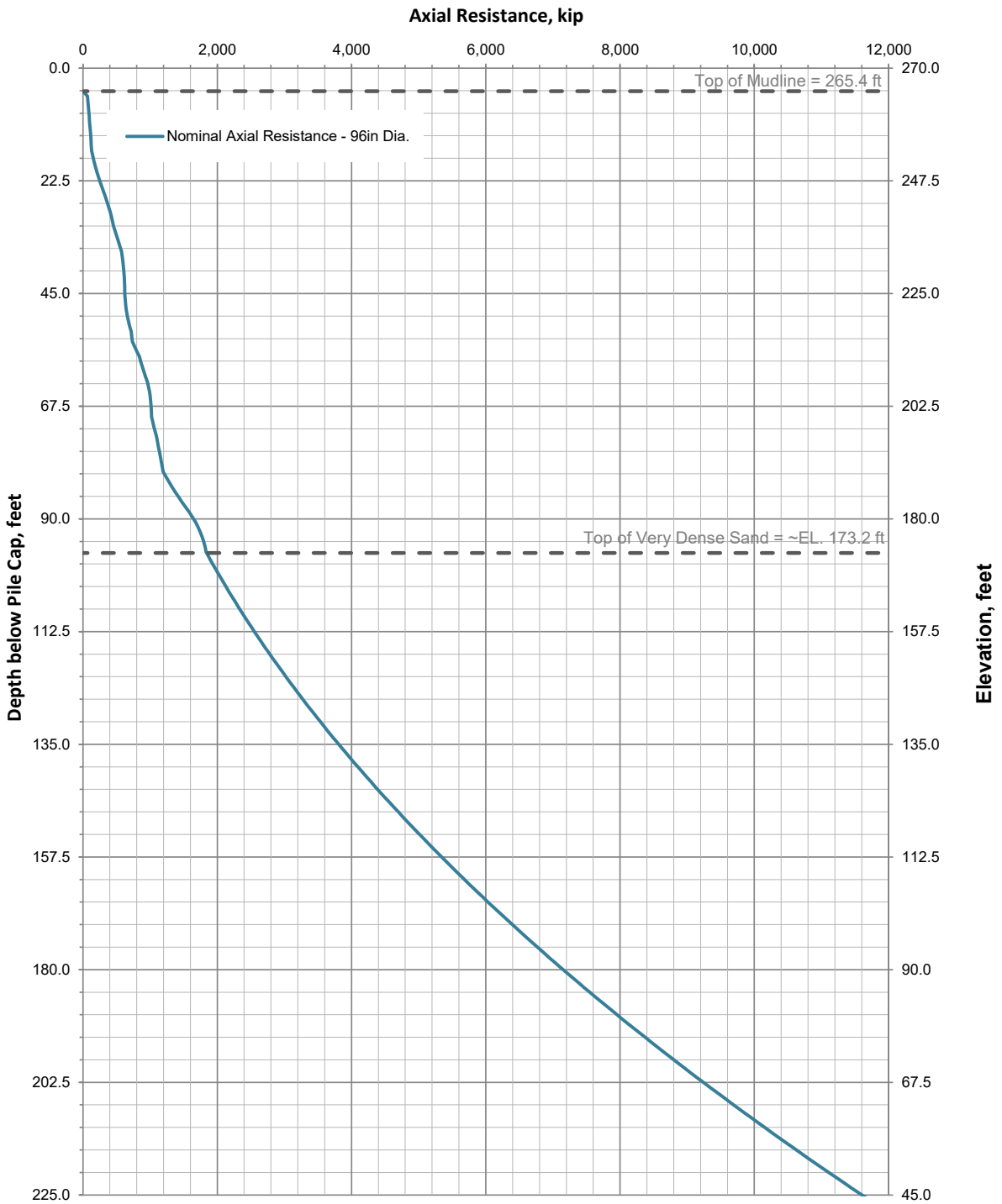
Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Note:
Chart is for a single shaft and does not include group efficiency factors.

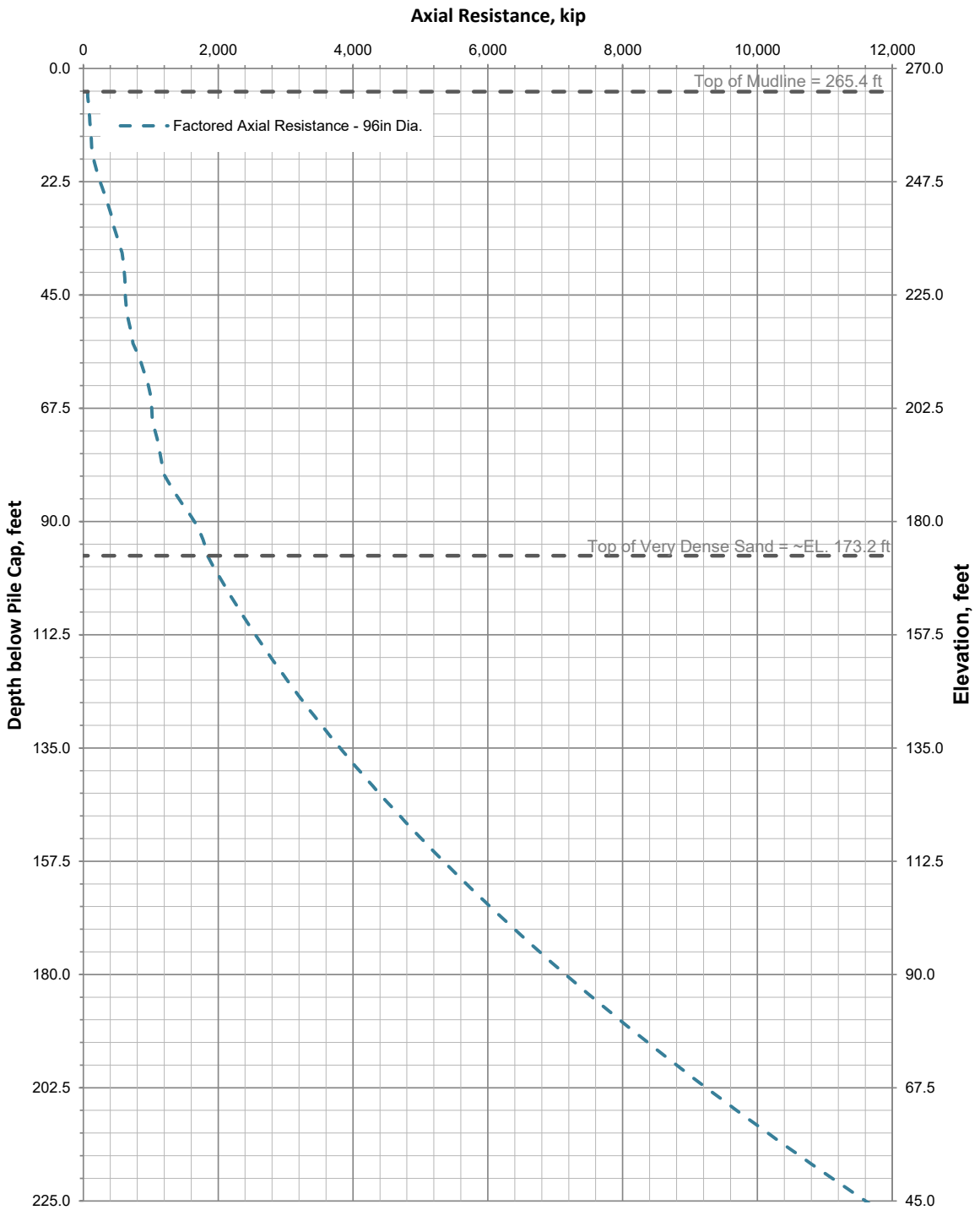
Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



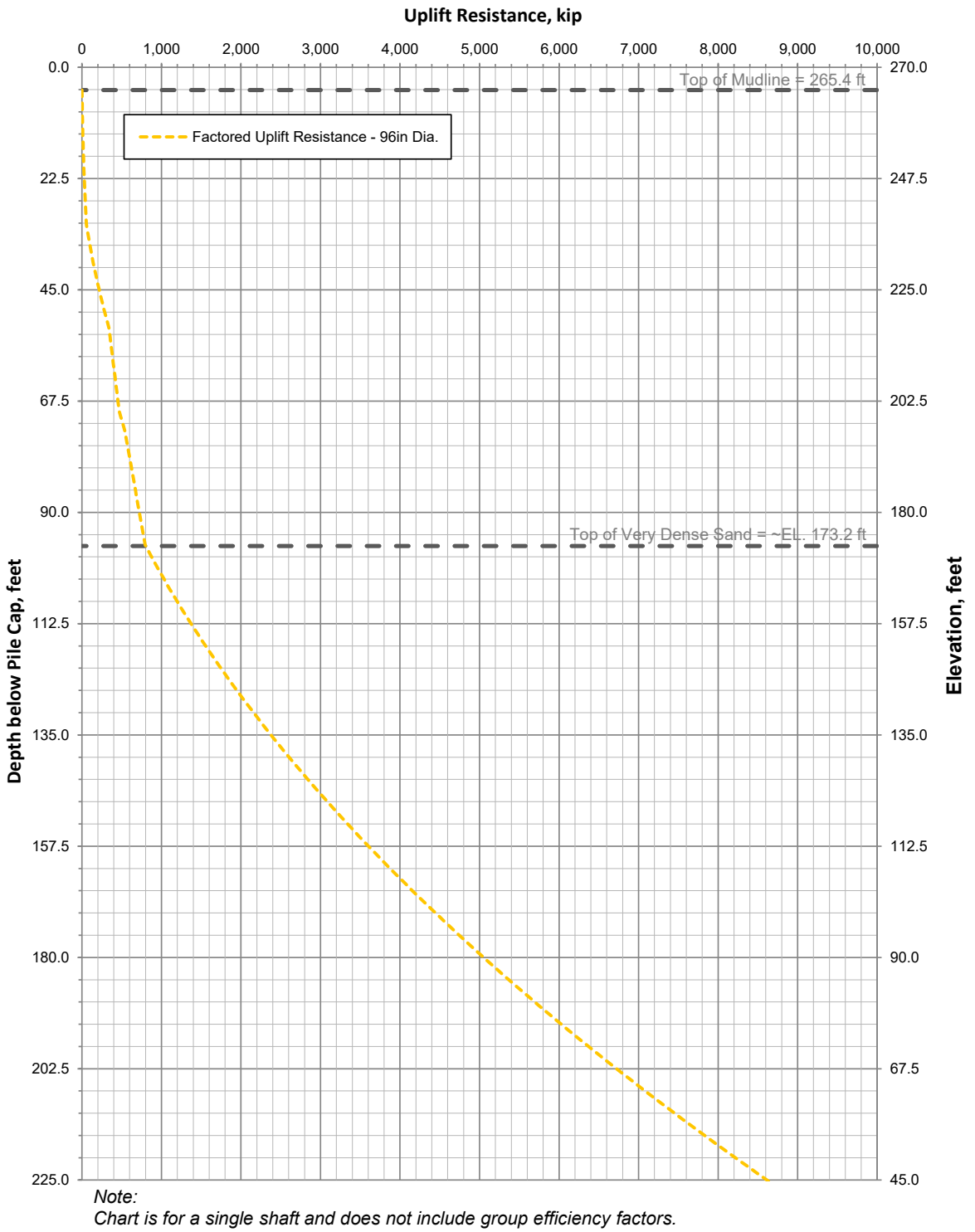
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/03/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/02/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/03/2025

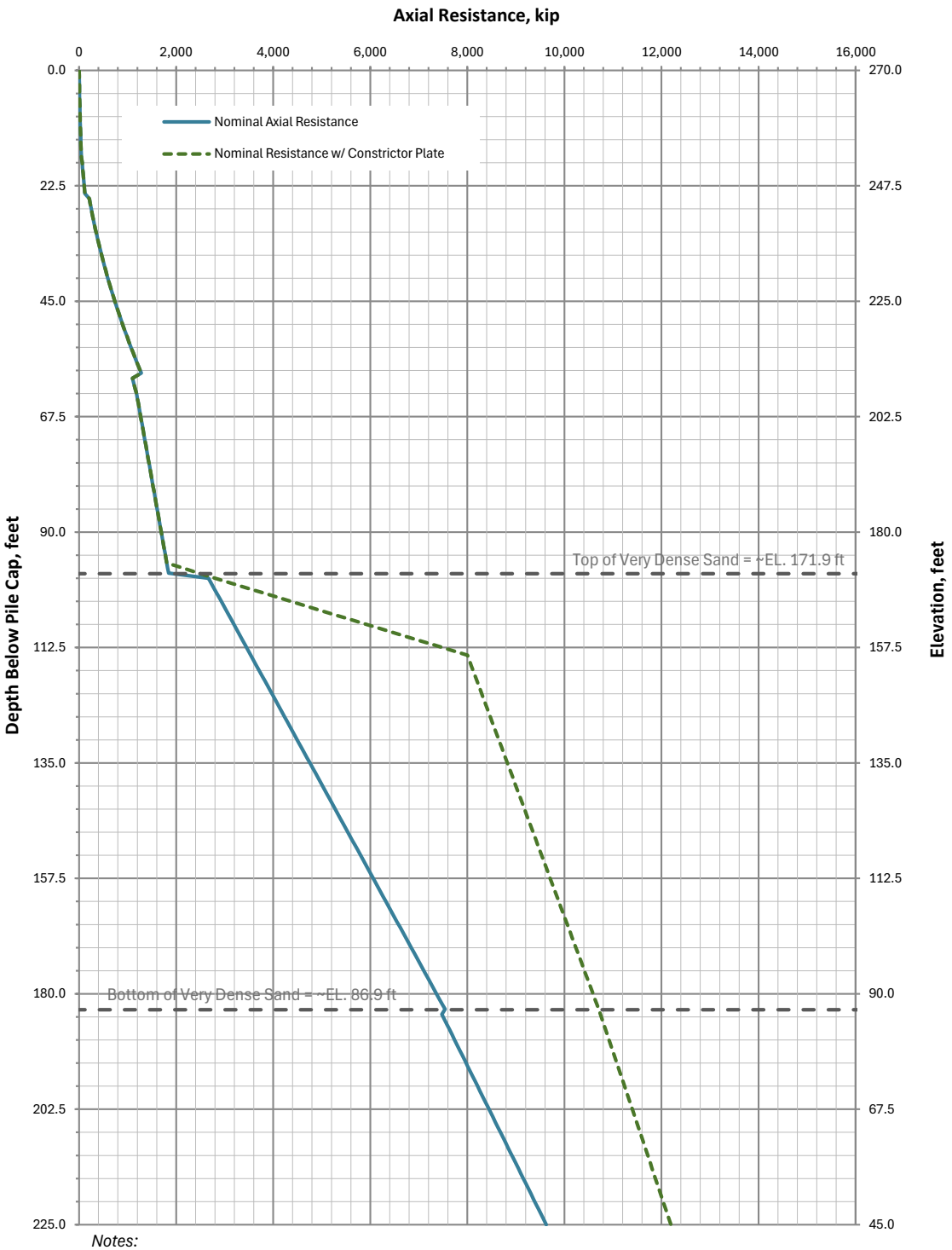


Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/03/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/03/2025

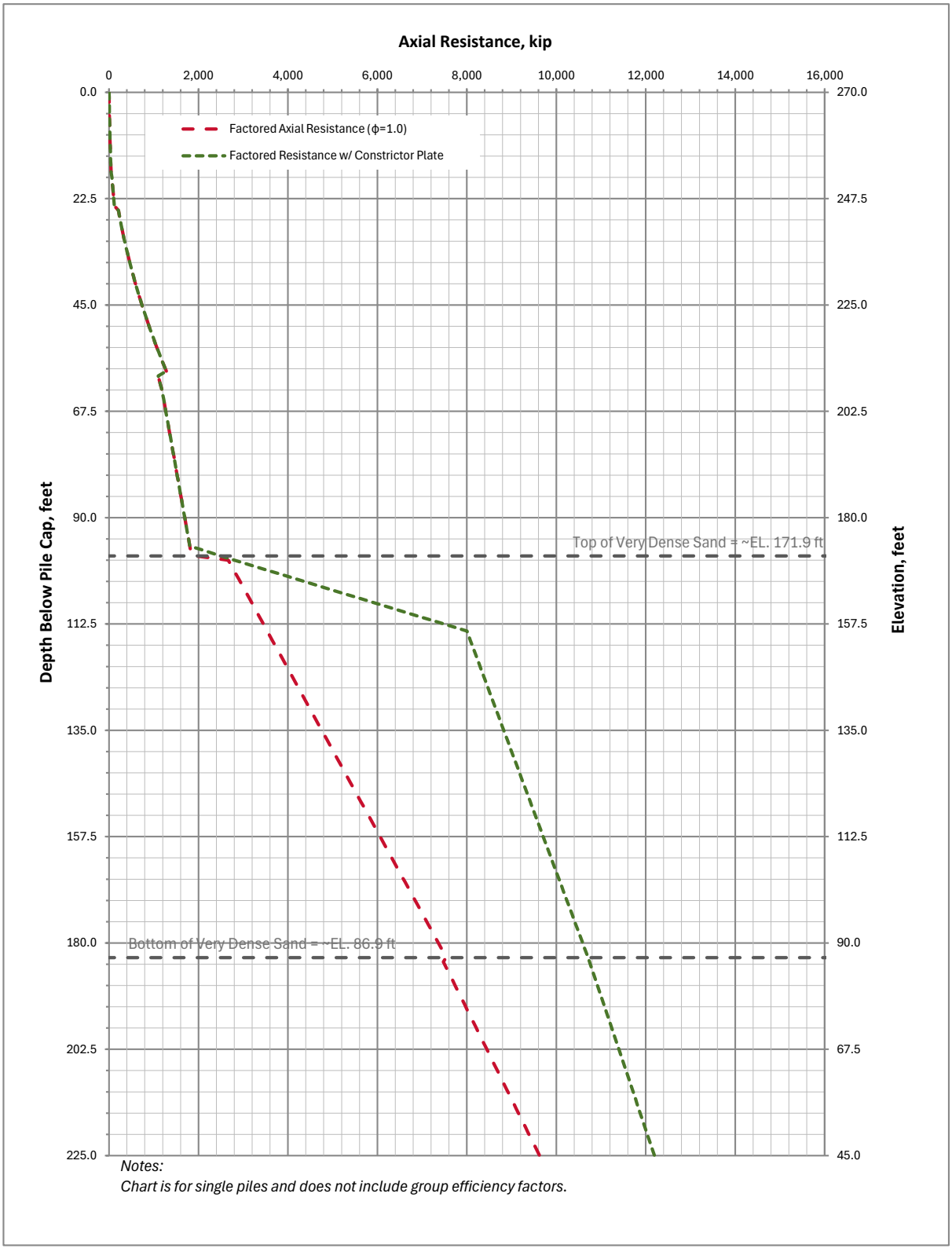
PIER 8

PIPE PILE AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



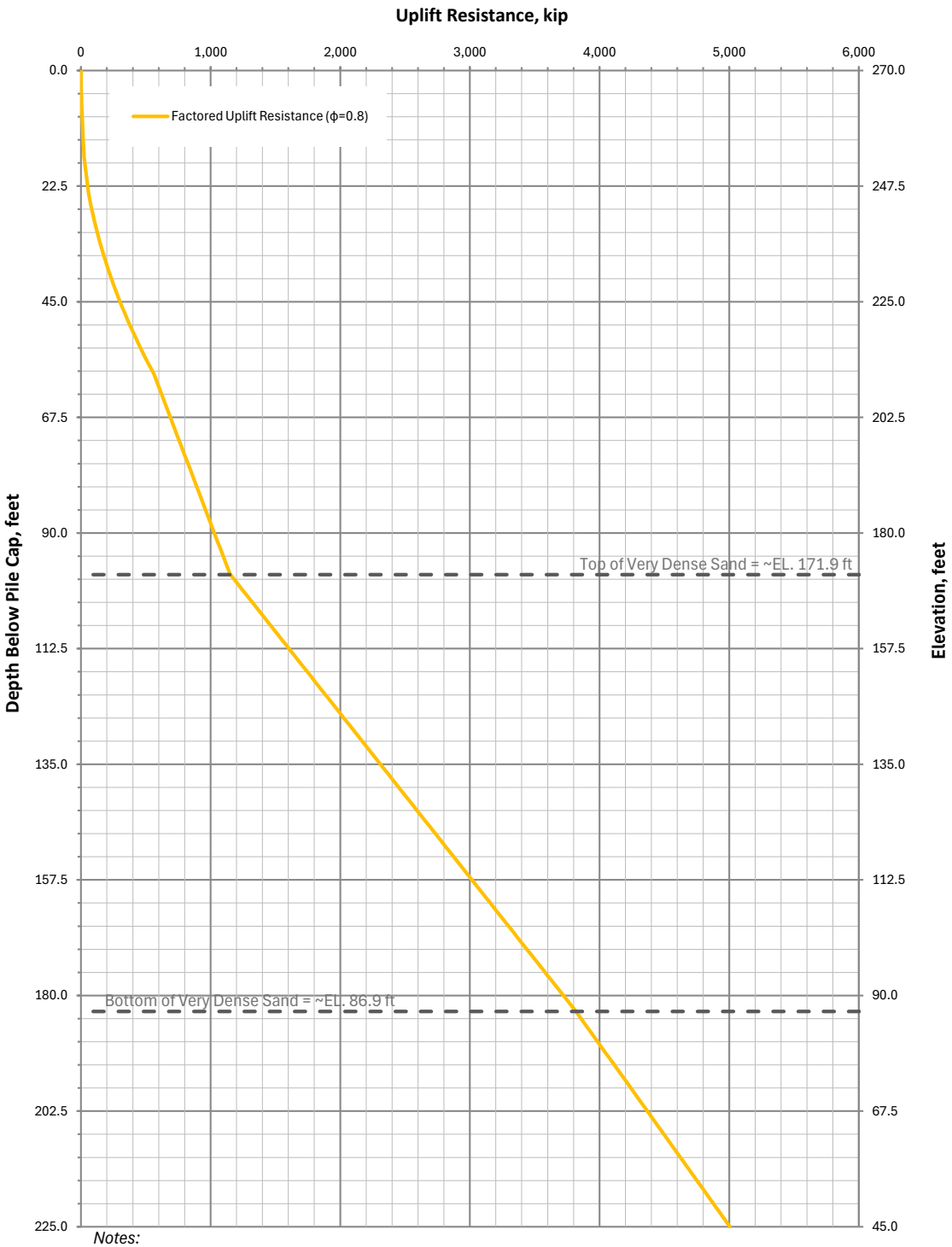
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

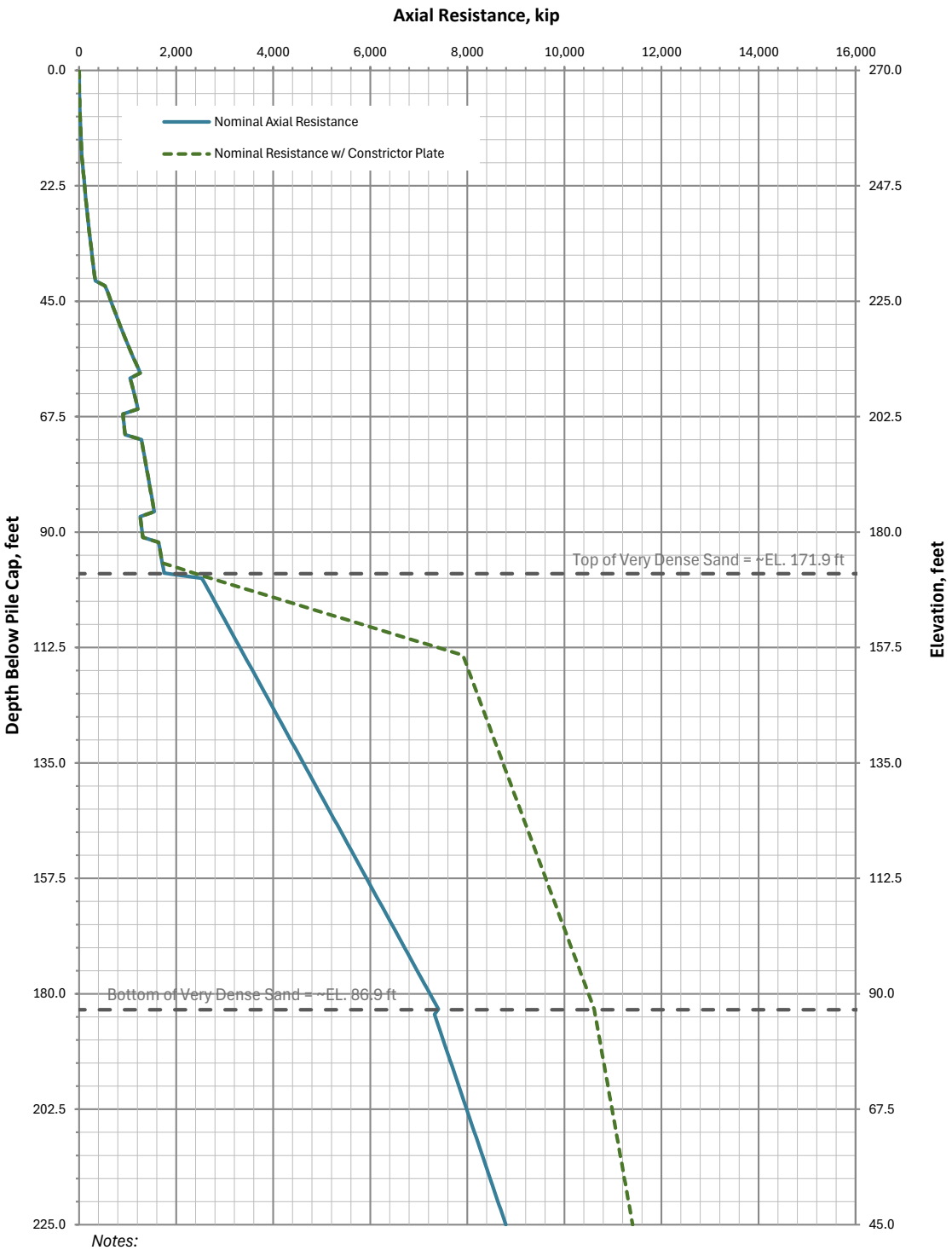
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

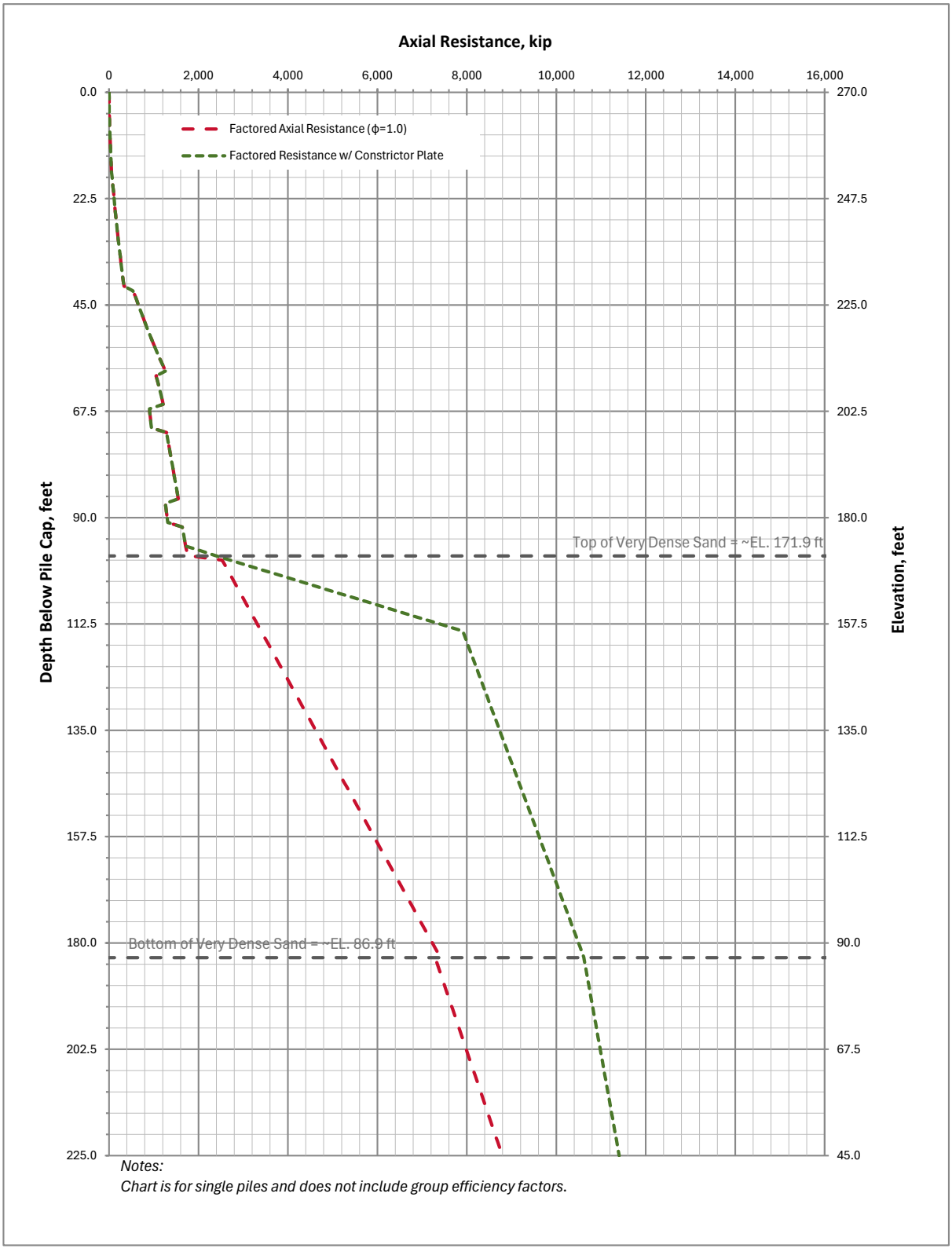
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025

PIPE PILE AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



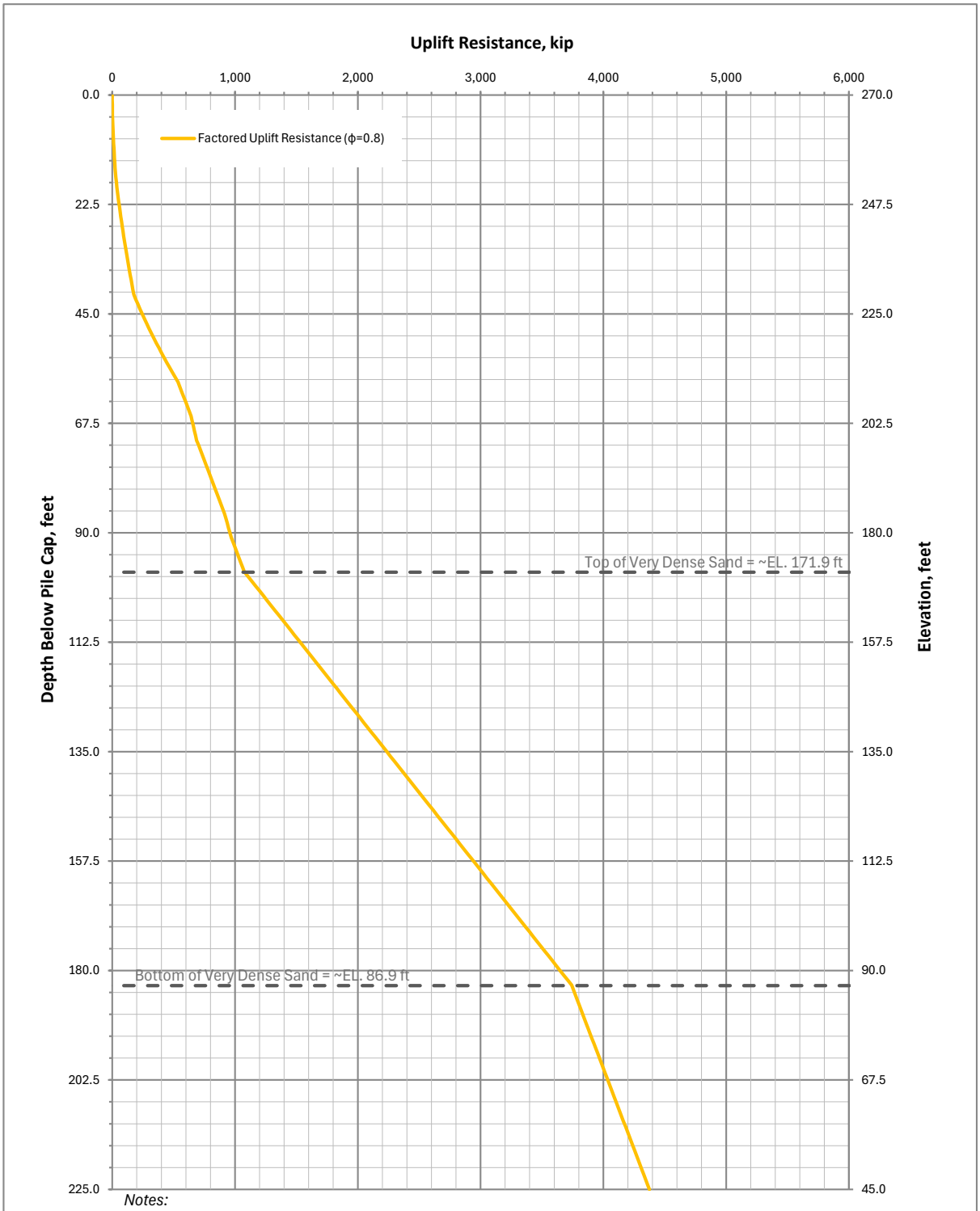
Notes:
Chart is for single piles and does not include group efficiency factors.
Nominal Structural Capacity of 72inx1.5in Pipe Pile = ***16,611 kips***

Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Nominal Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

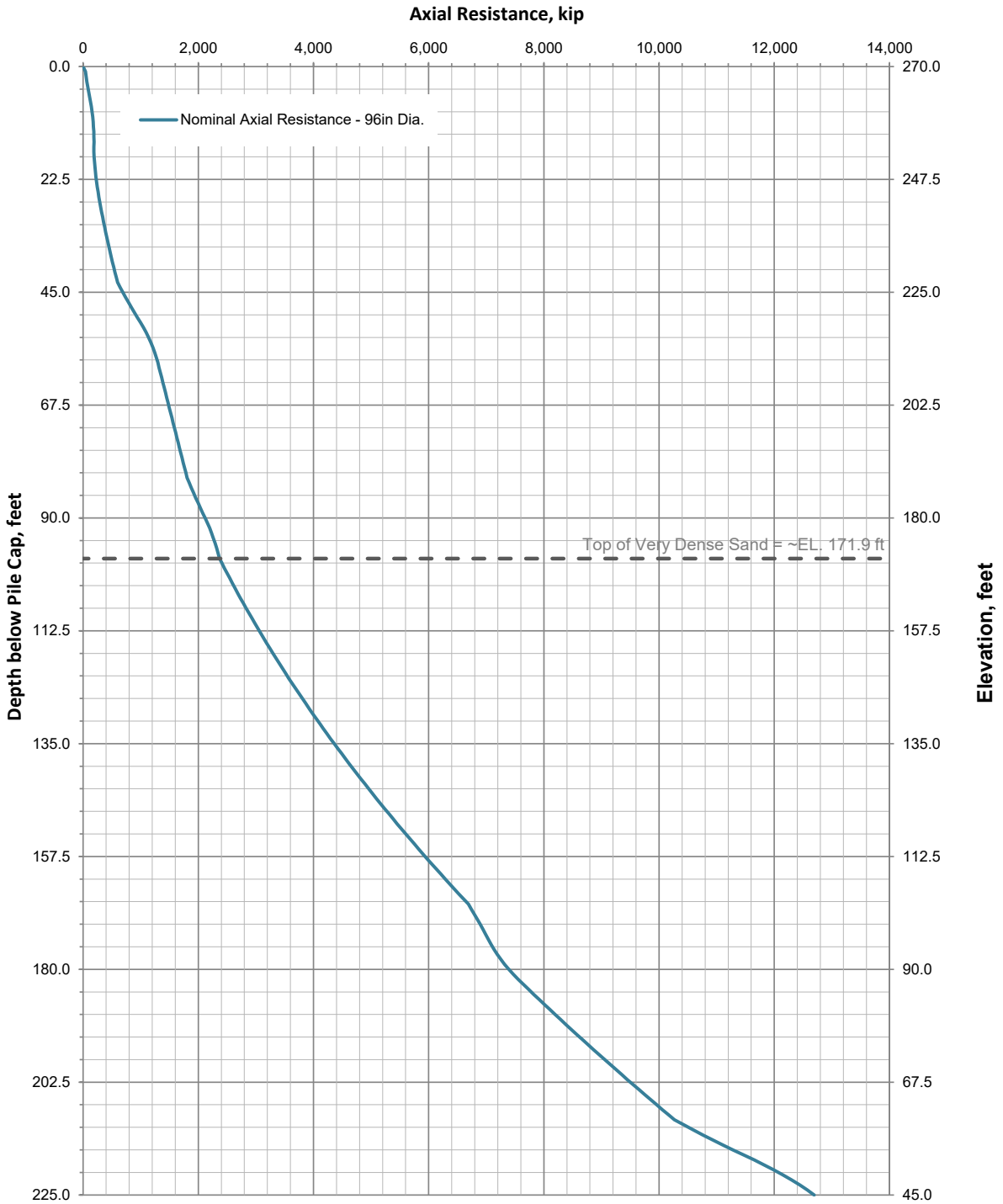
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/09/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/09/2025



Notes:
Chart is for single piles and does not include group efficiency factors.

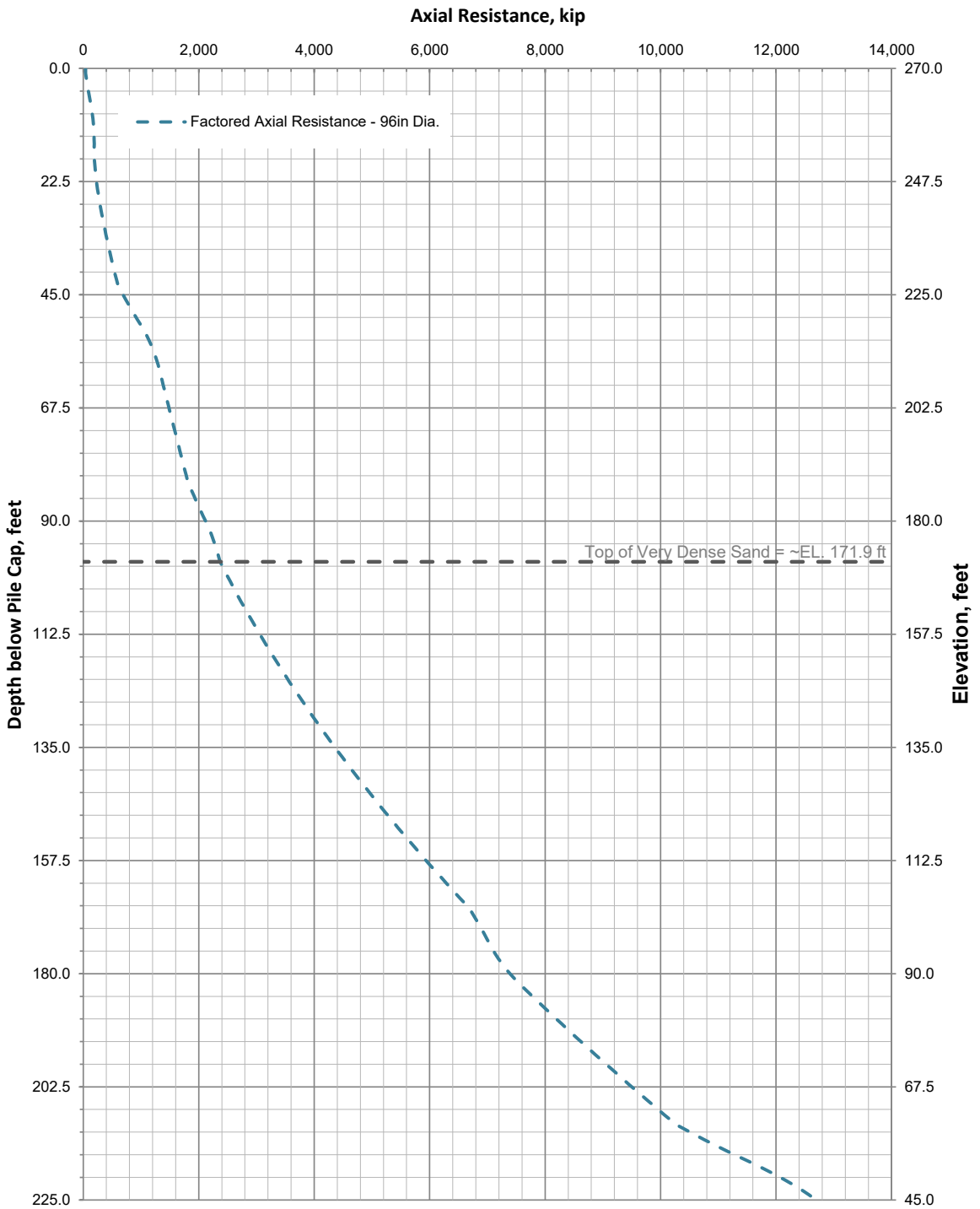
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Factored Uplift Resistance Graph** **Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 100-YR RETURN PERIOD



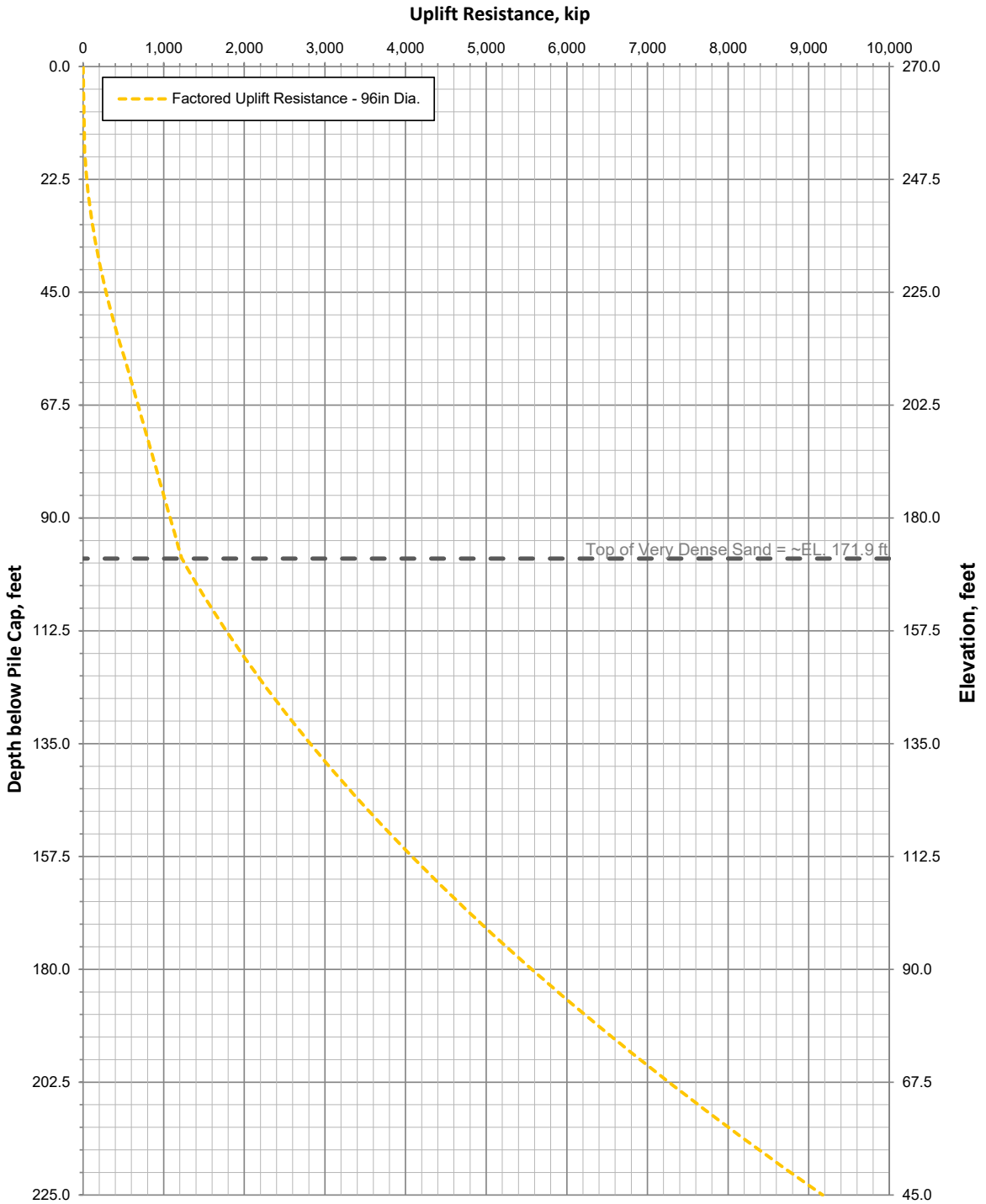
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025



Notes:
Chart is for a single shaft and does not include group efficiency factors.

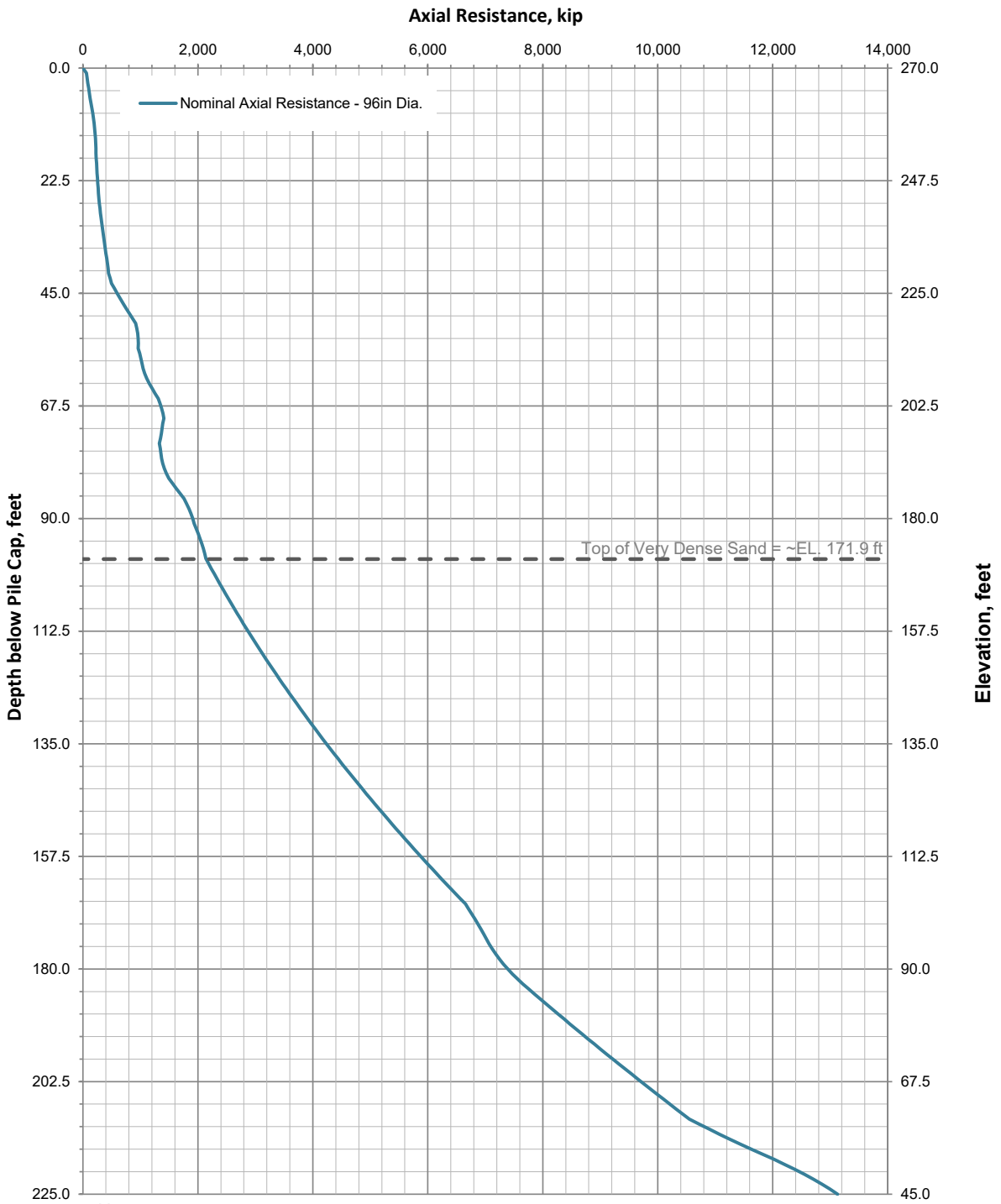
Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025



Note:
Chart is for a single shaft and does not include group efficiency factors.

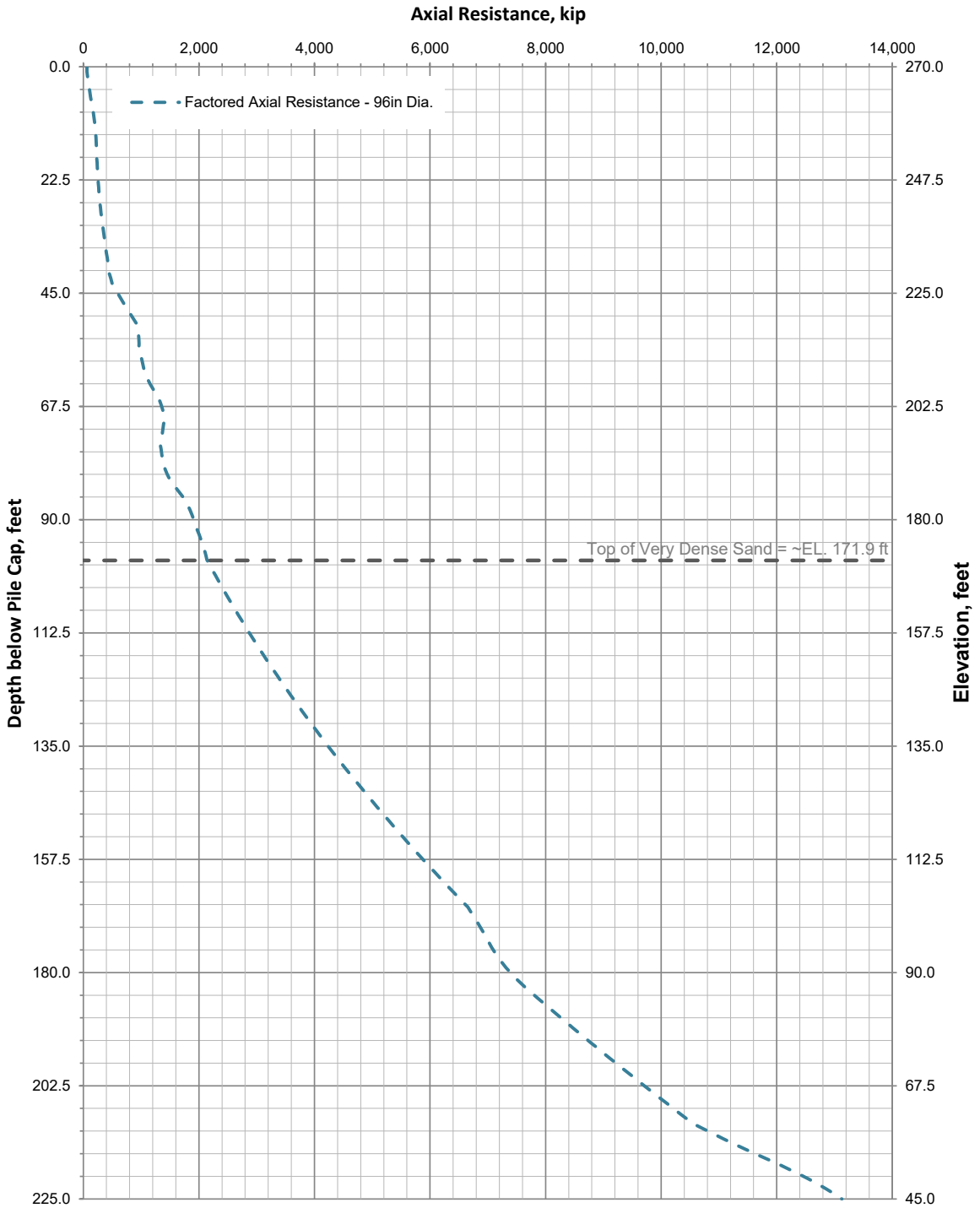
Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (100-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025

DRILLED SHAFTS AXIAL RESISTANCE GRAPHS – 1,000-YR RETURN PERIOD



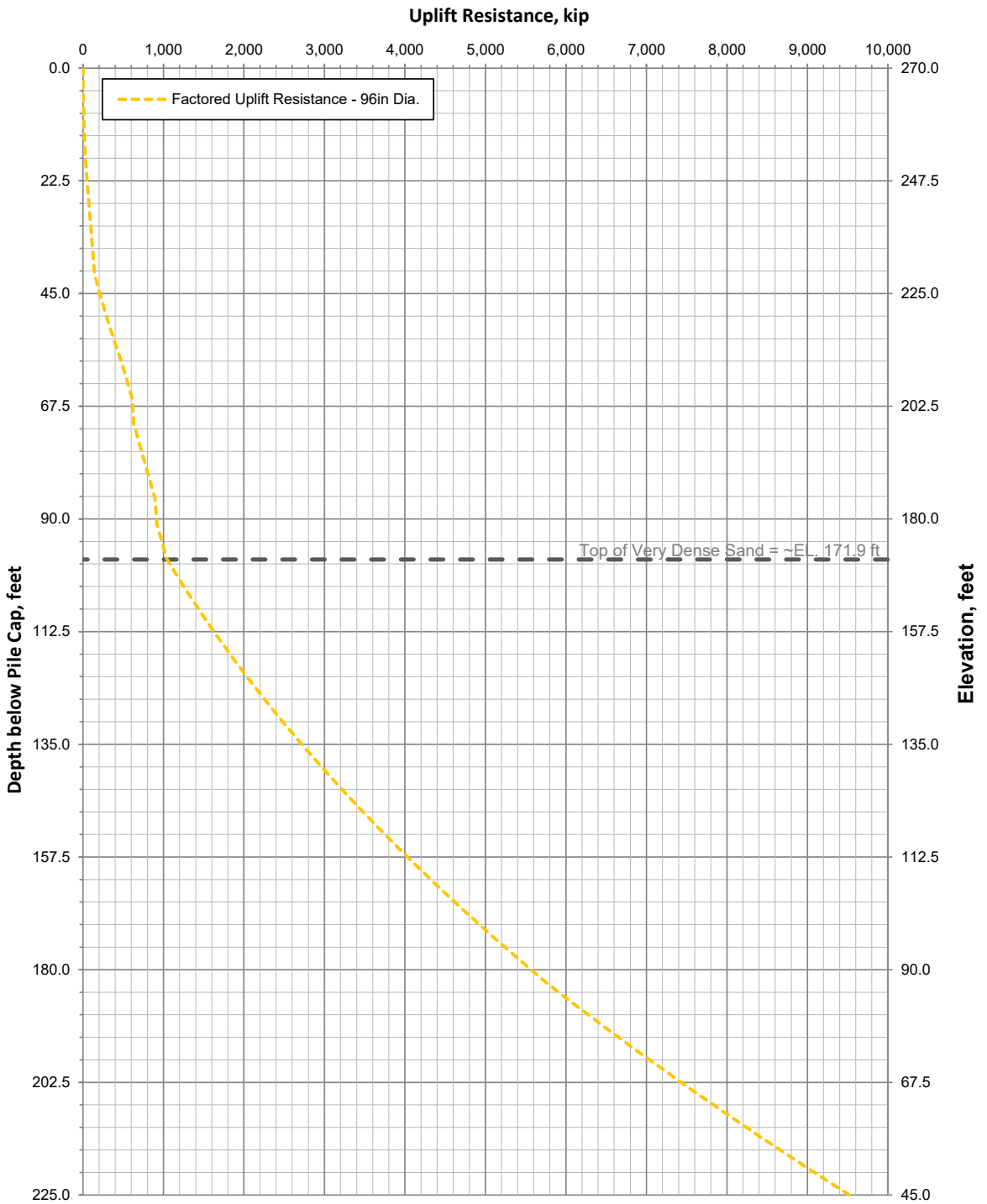
Notes:
Chart is for a single shaft and does not include group efficiency factors.
Nominal Structural Capacity of 96in Dia. Shaft (3% Steel) = ***26,983 kips***

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Nominal Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/25



Notes:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Axial Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/06/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/25



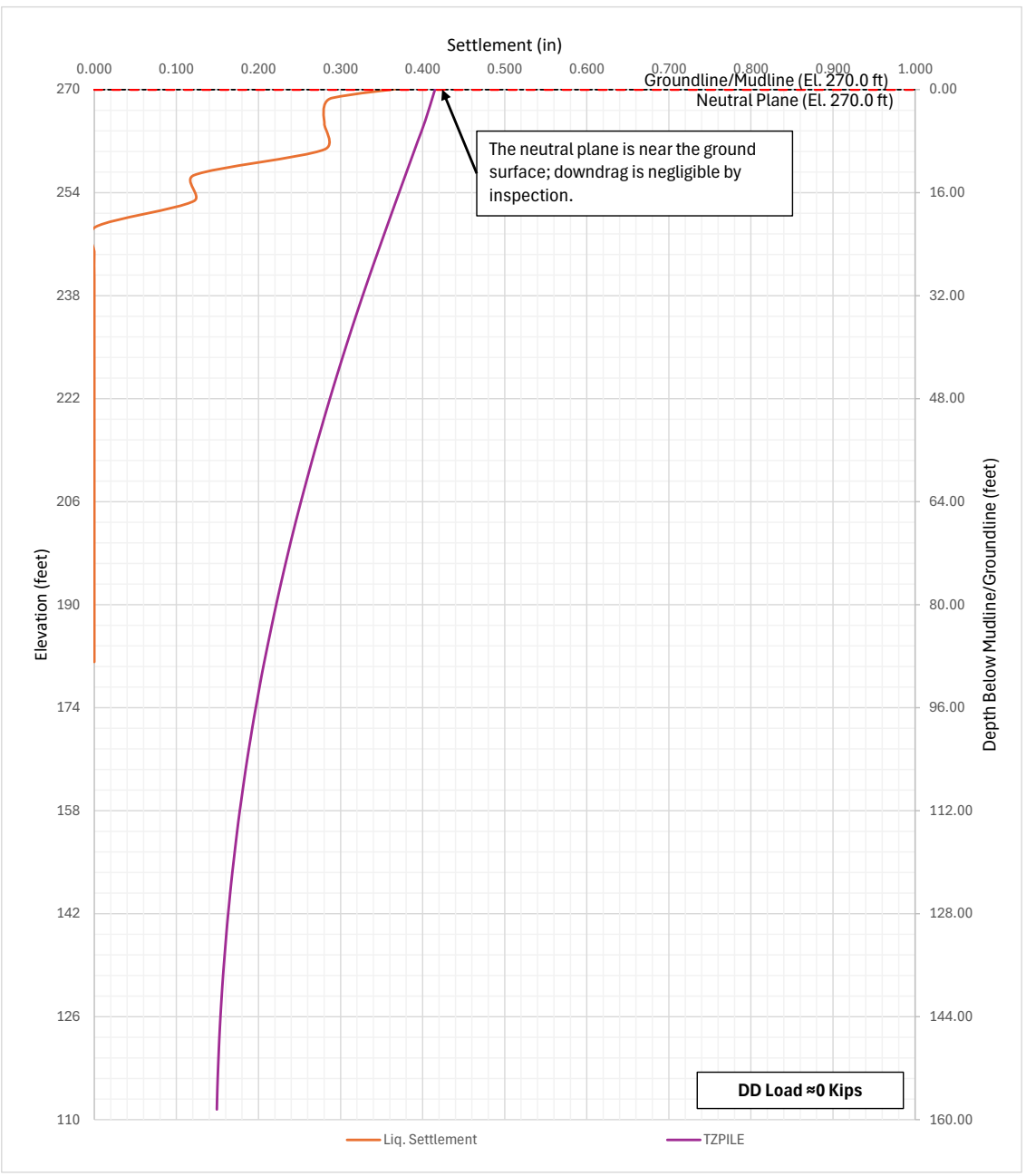
Note:
Chart is for a single shaft and does not include group efficiency factors.

Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft Factored Uplift Resistance Graph - Extreme Event I (1000-YR)**
HDR	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** BAR **Review Date:** 10/08/2025 **Drawn By:** RRP **Figure No. ##** **Date:** 10/08/2025

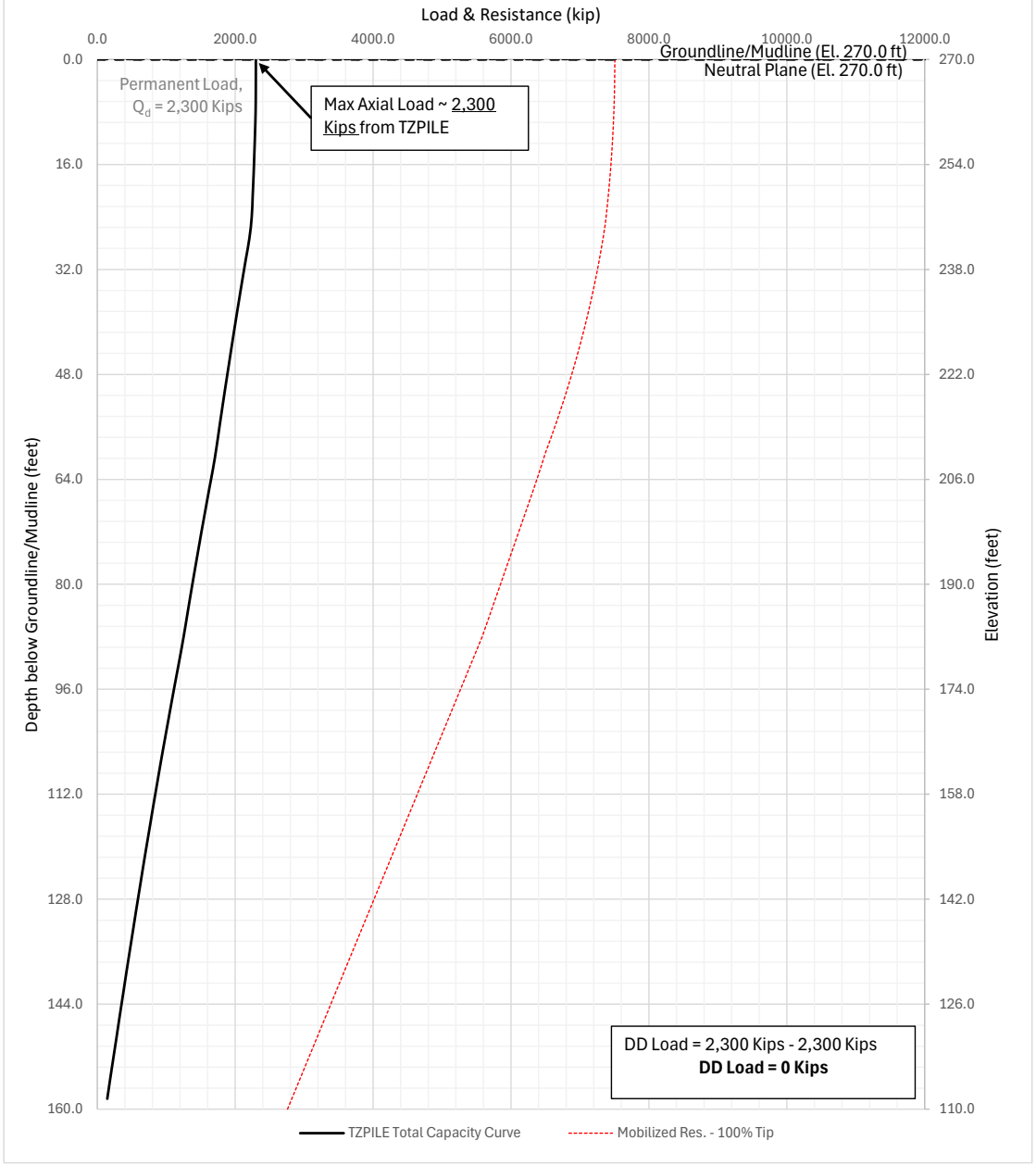
Seismic Downdrag Load and Neutral Plan Curves

PIER 3

PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



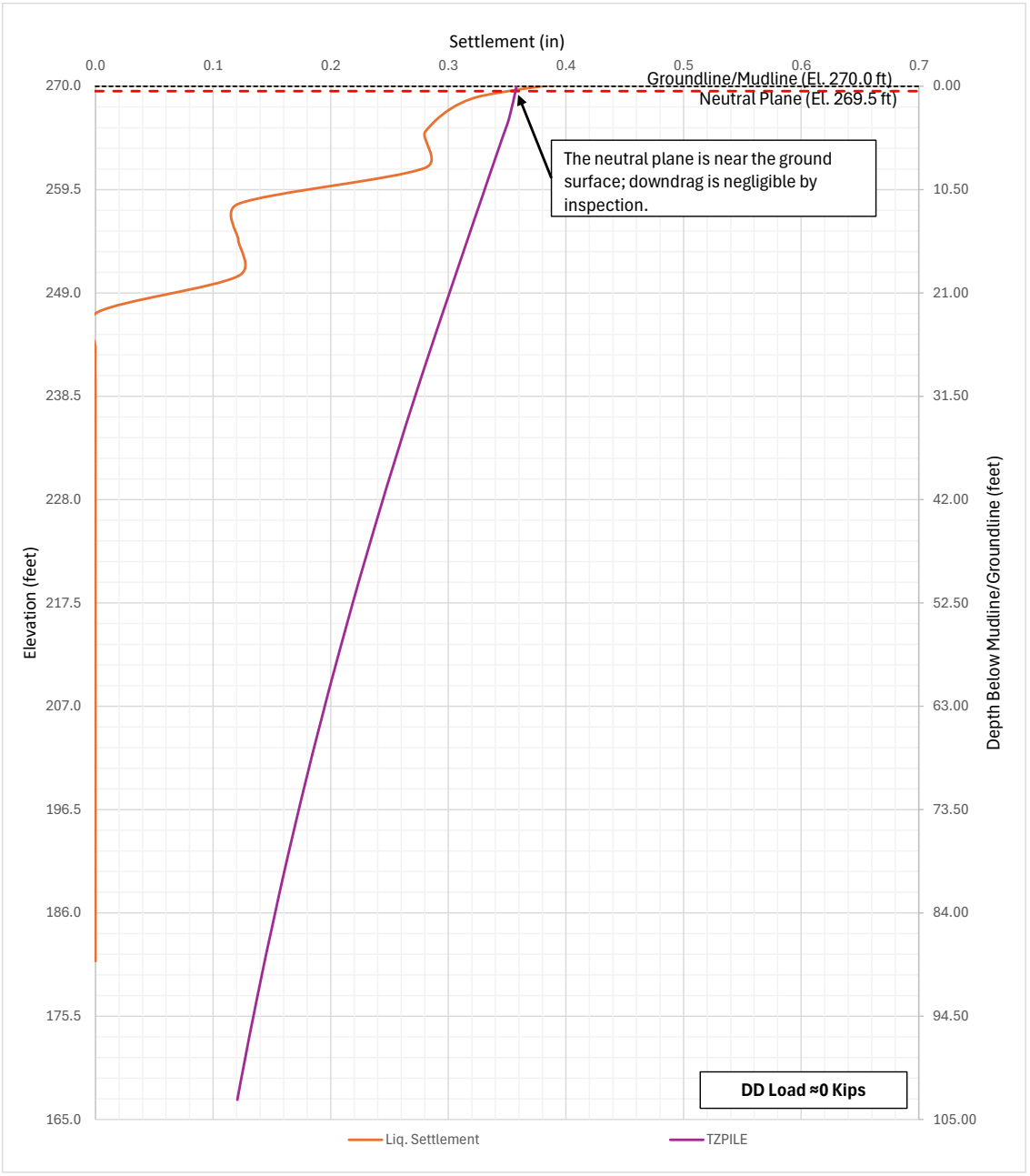
Prepared by:

Prepared for:

TEAM KENTUCKY TRANSPORTATION CABINET

Pier 3
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Downdrag via Partial Mobilization

Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: MJS **Review Date:** 01/29/2026
Drawn By: SKB **Figure No. ##**
Date: 11/25/2025



Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

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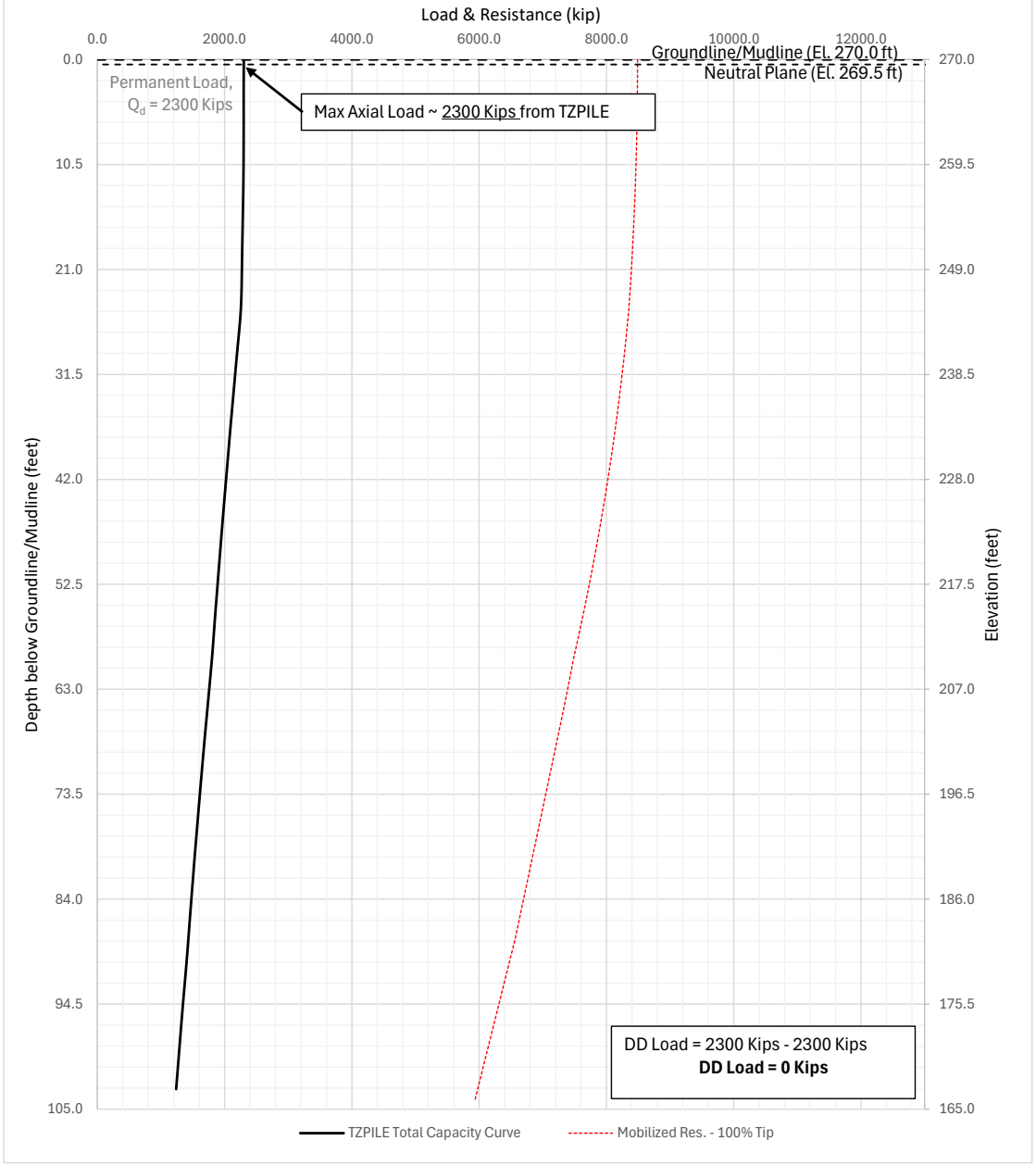

Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

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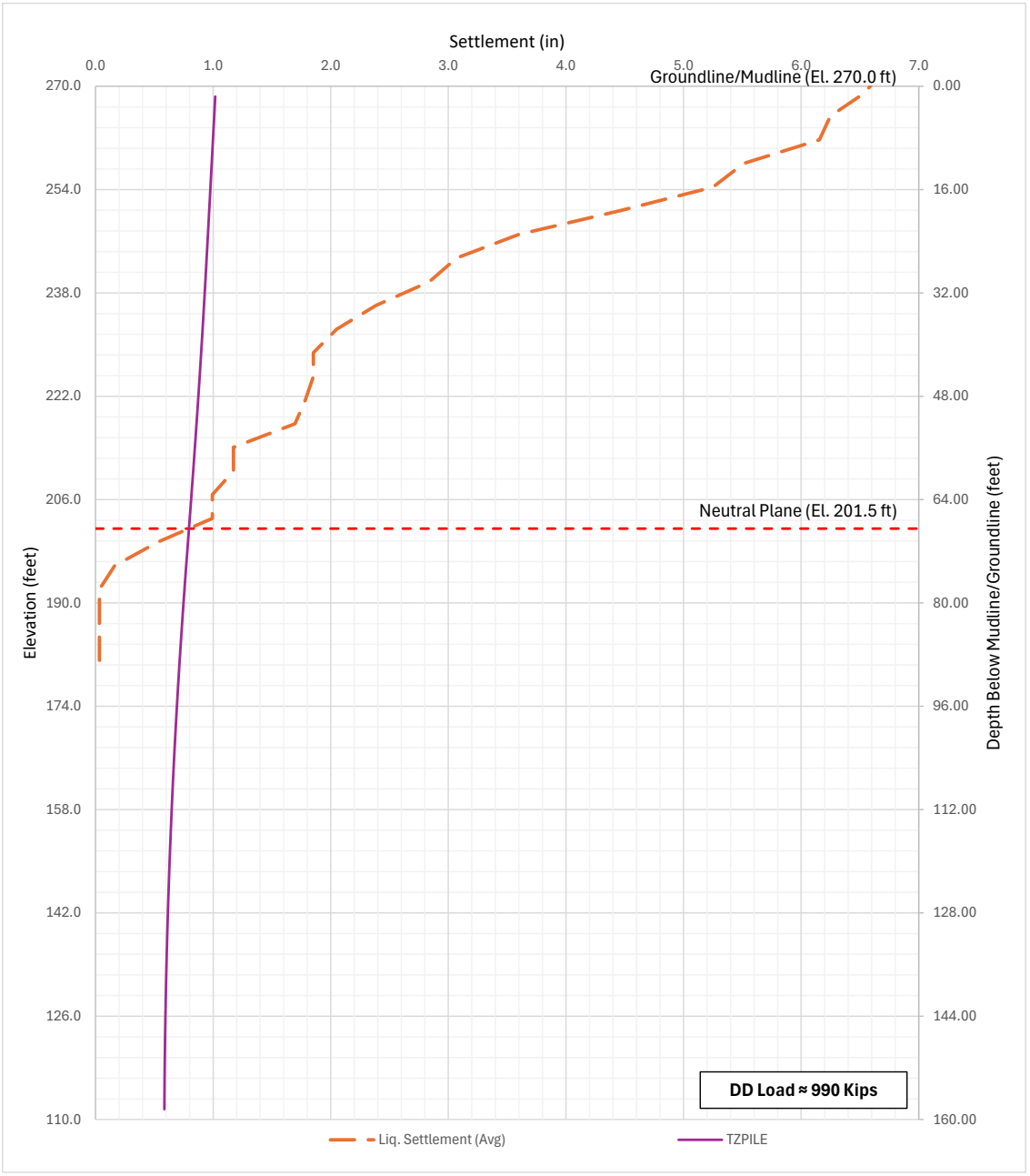
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



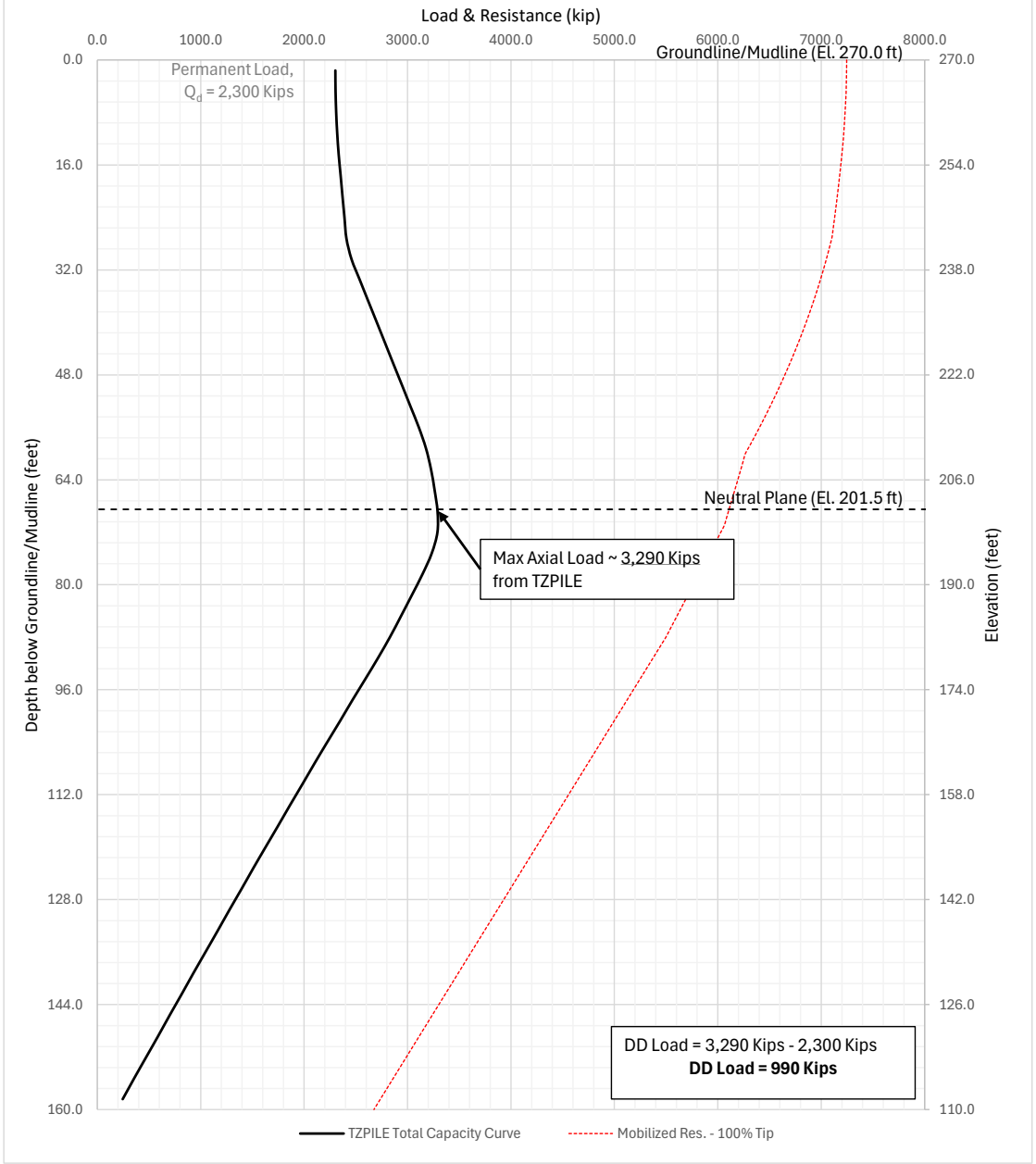
Prepared by:

Prepared for:

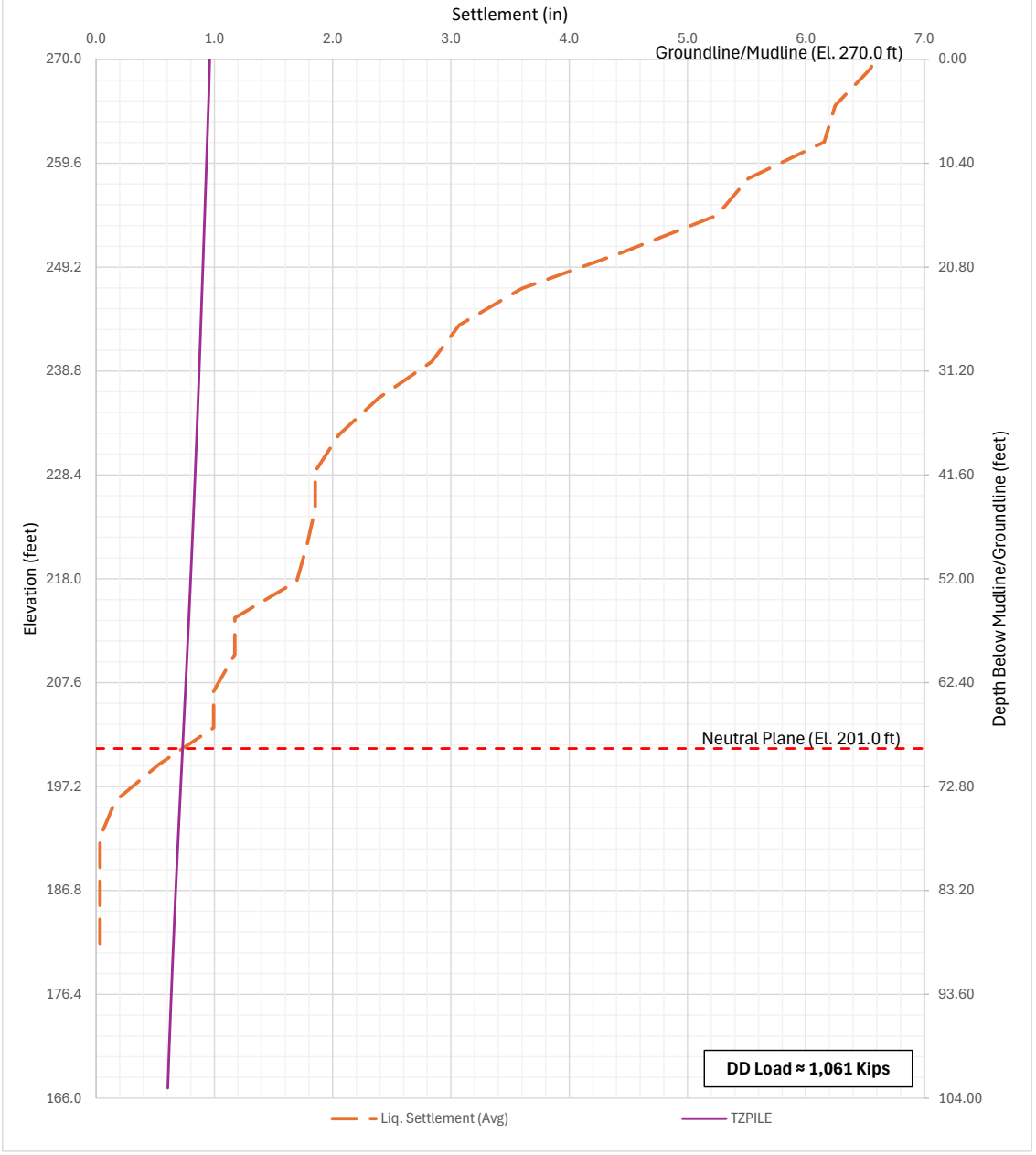
TEAM KENTUCKY
TRANSPORTATION CABINET

Pier 3
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Downdrag - 1000 YR Return Period

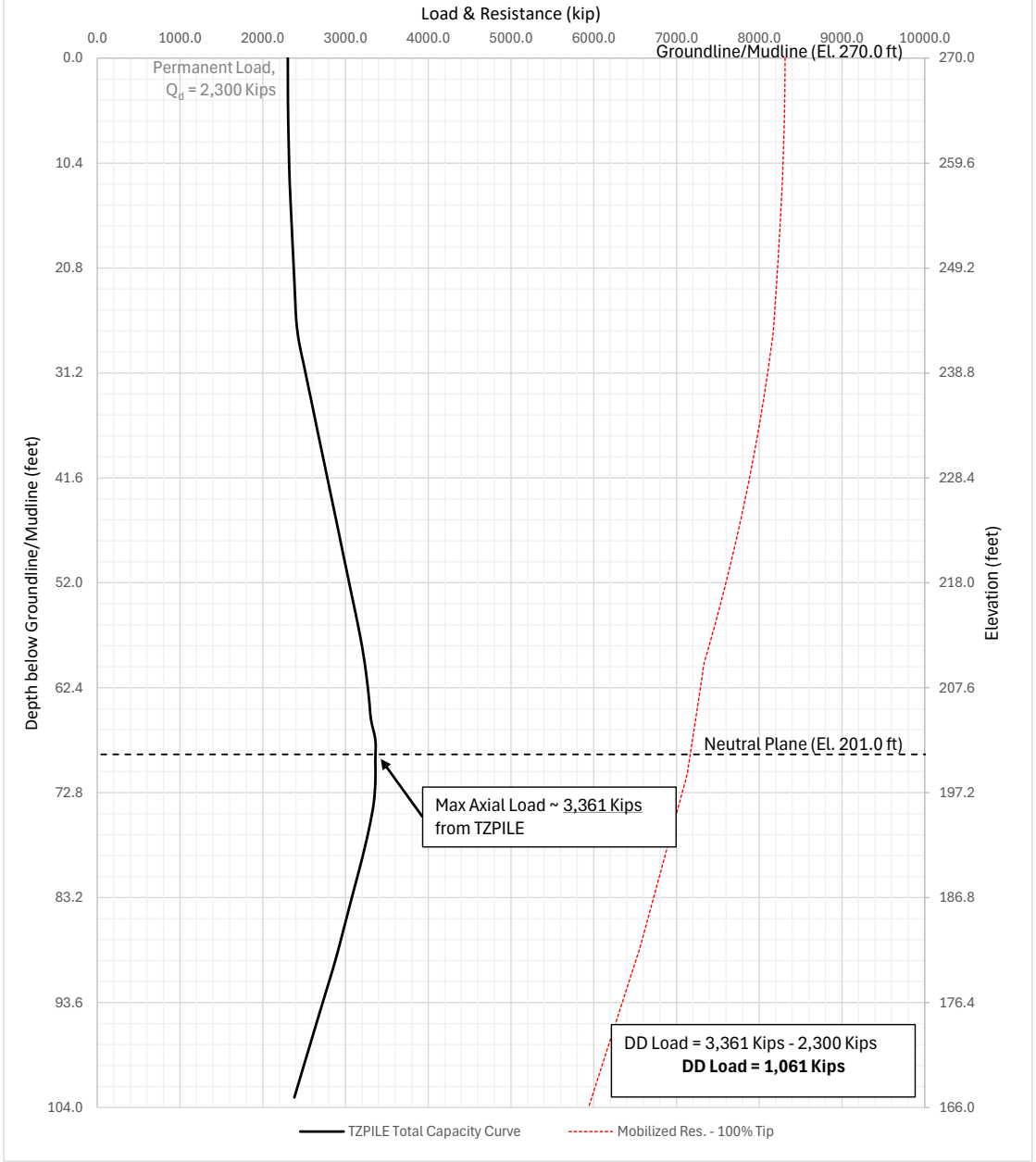
Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 01/27/2026
Drawn By: SKB **Figure No. ##**
Date: 01/26/2026



Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



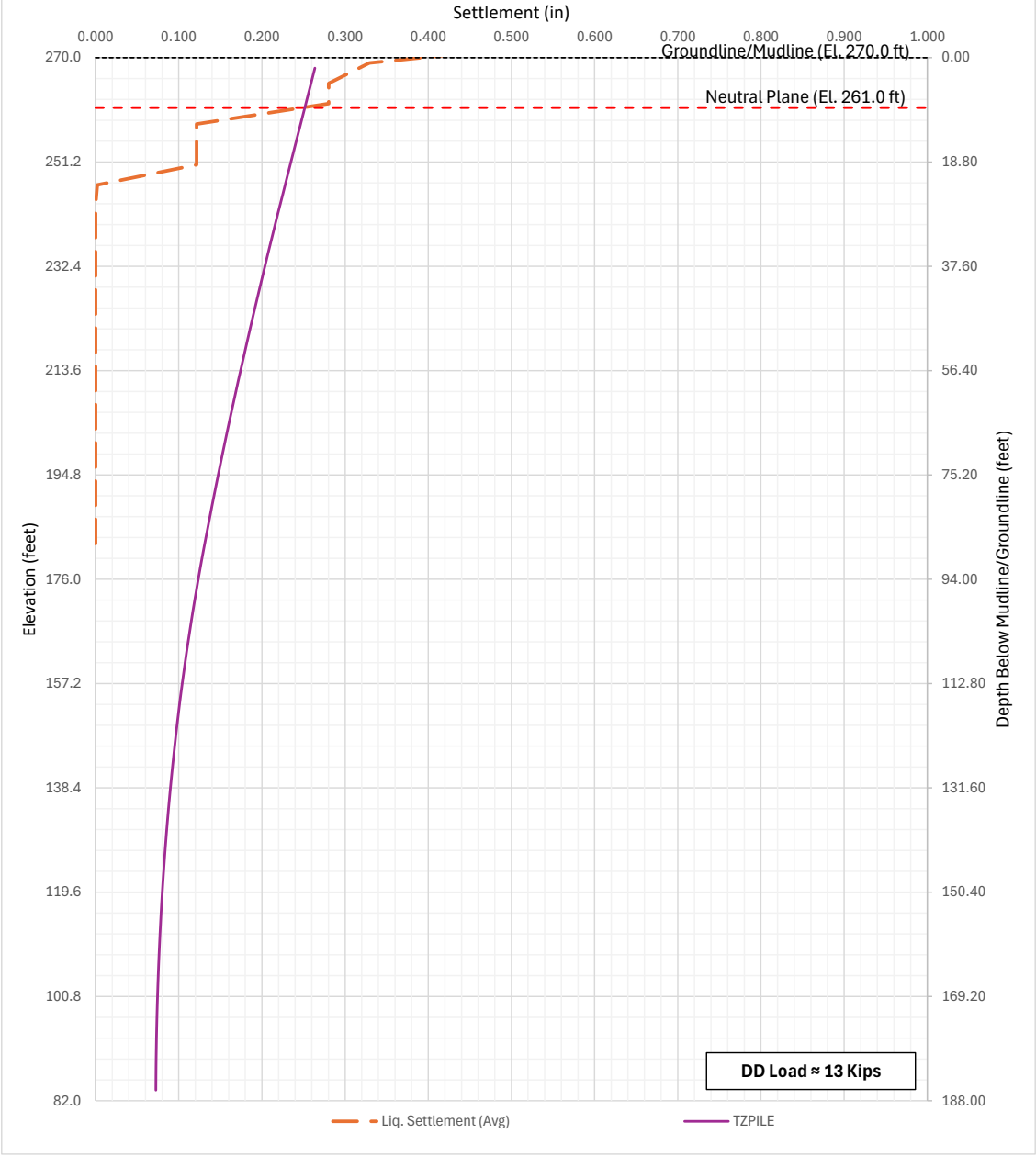
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



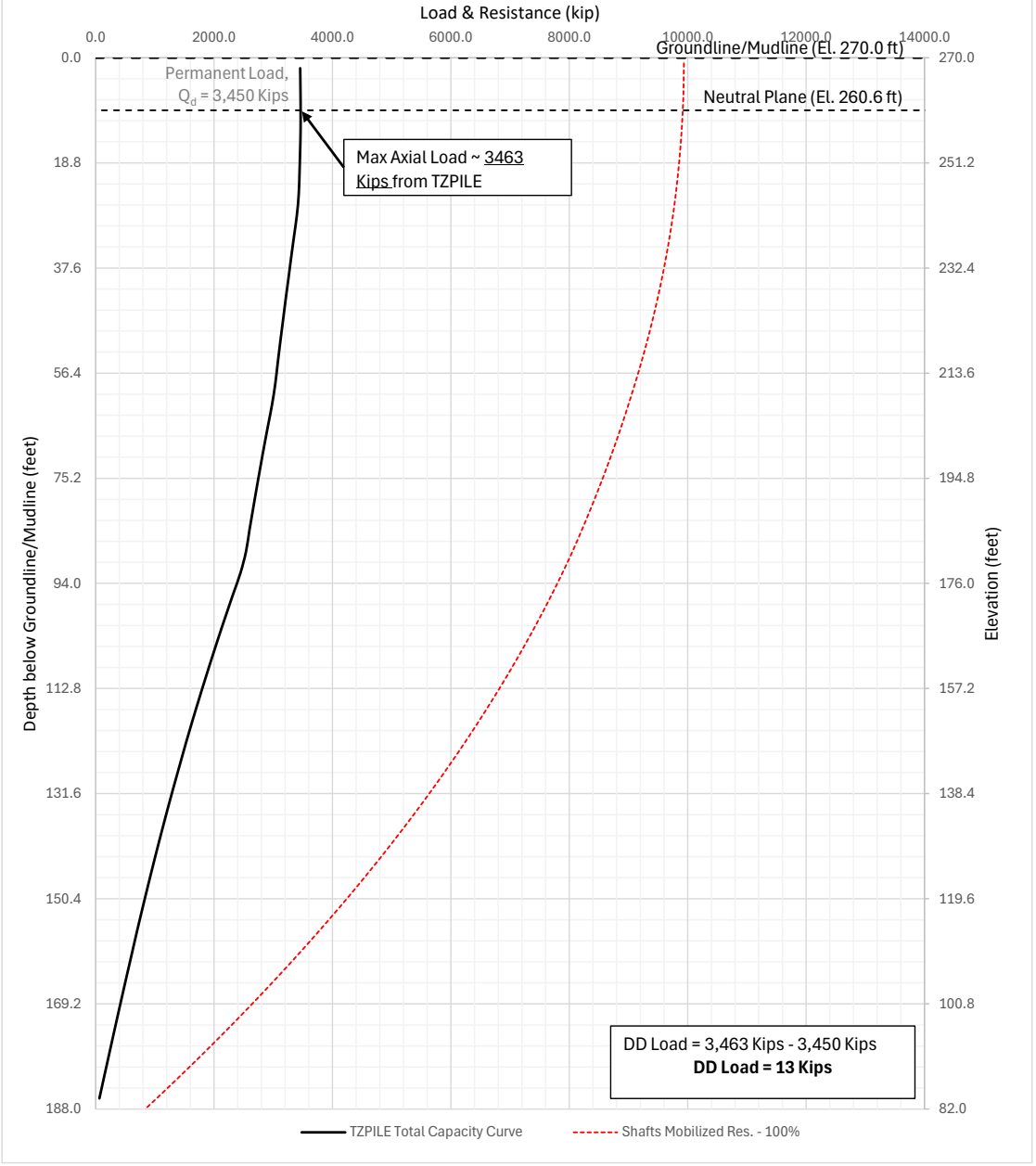
Prepared by:	Prepared for:	**Pier 3** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

https://hdrinc-my.sharepoint.com/personal/stborder_hdrinc_com/Documents/10174706 - US 51 Cairo Bridge/CM3 Final Design/Pipe Piles_Seismic/Pier 3 (U1-3)/Pier 3_Downdrag_1000YR_CP.xlsx

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



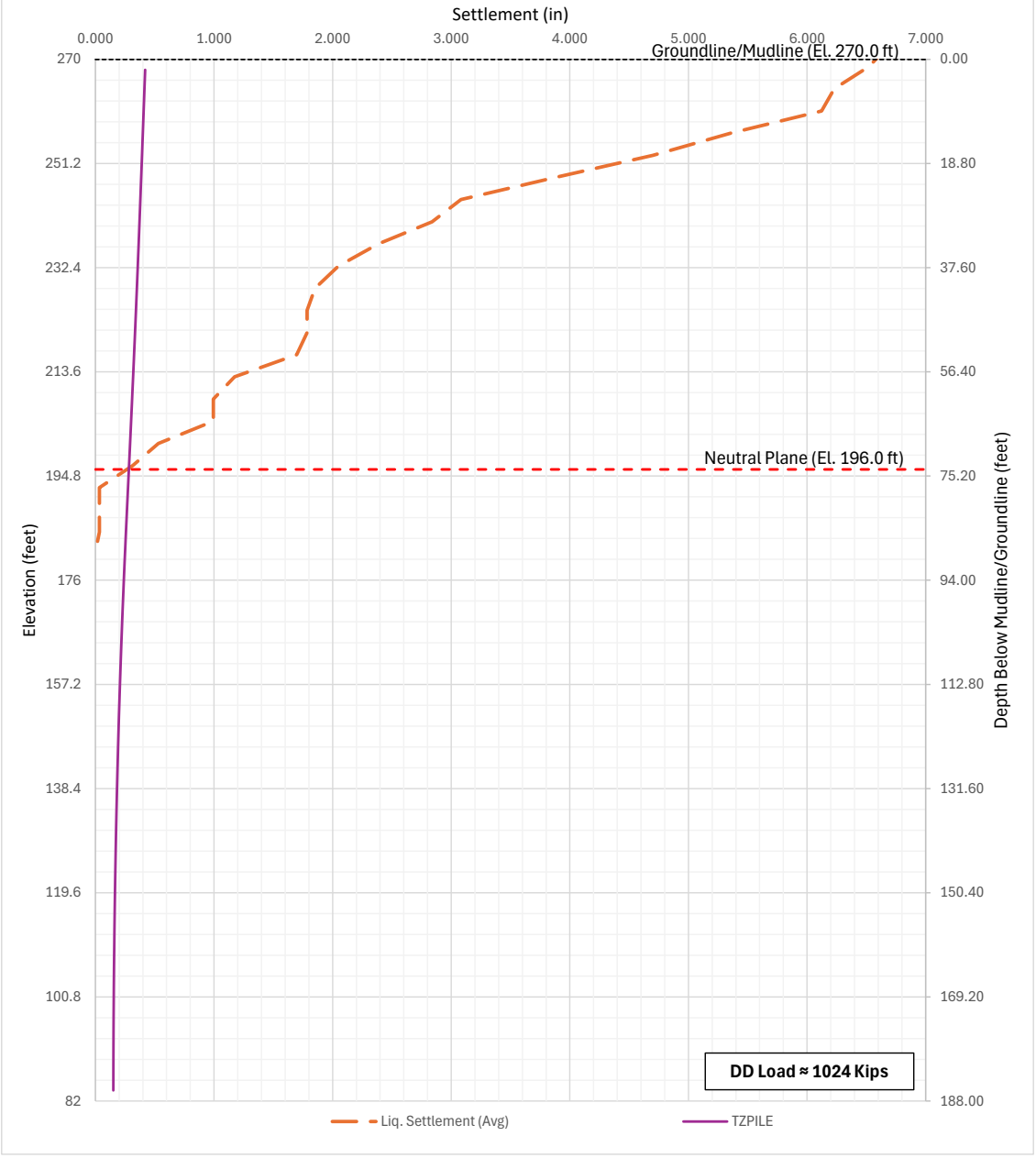
Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



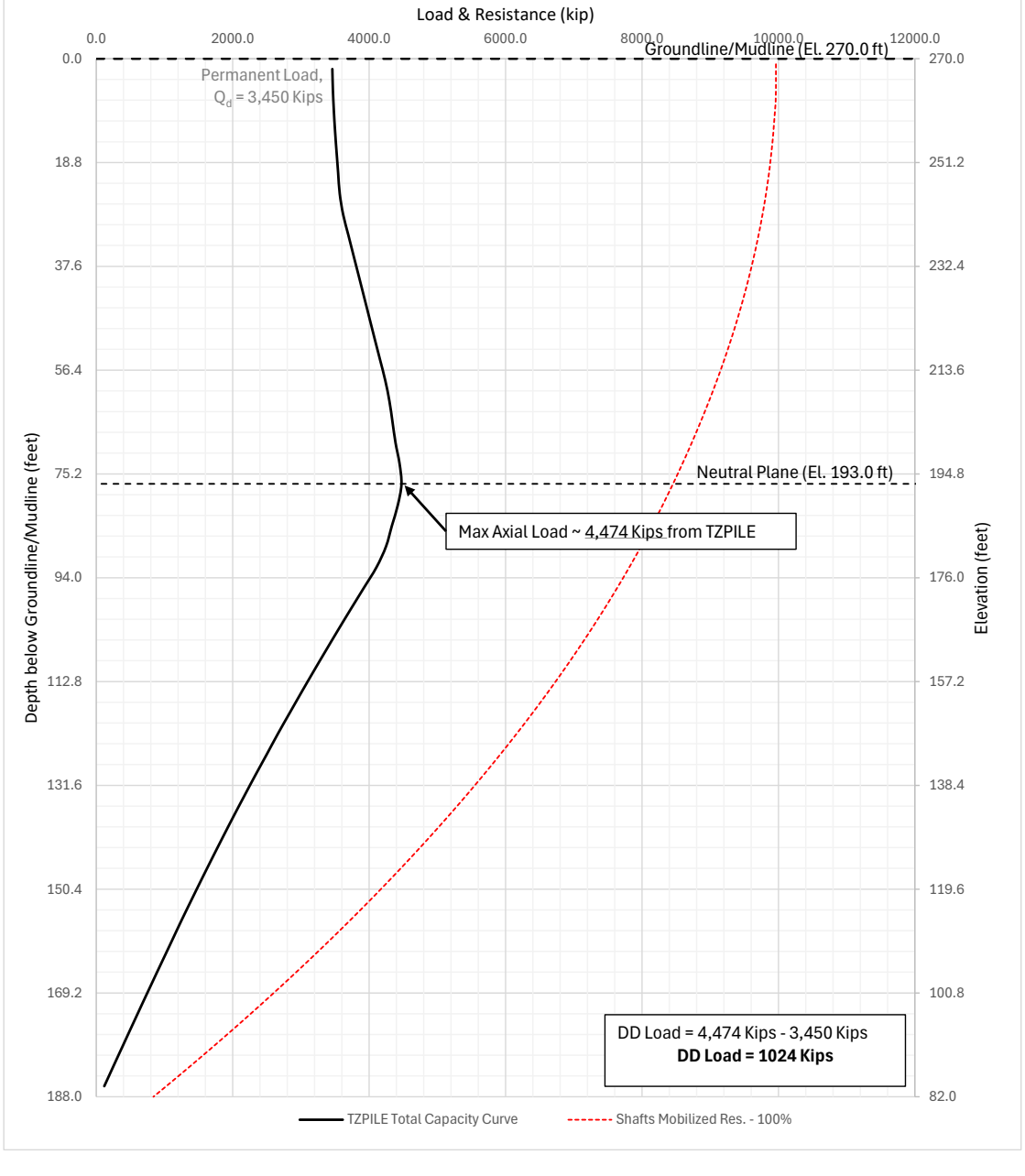
Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

https://hdrinc-my.sharepoint.com/personal/stborder_hdrinc_com/Documents/10174706 - US 51 Cairo Bridge/CM3 Final Design/Drilled Shafts_Seismic/Pier 3/Downdrag/Pier 3_Downdrag_100YR.xlsx

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 3** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



Prepared by:

Prepared for:

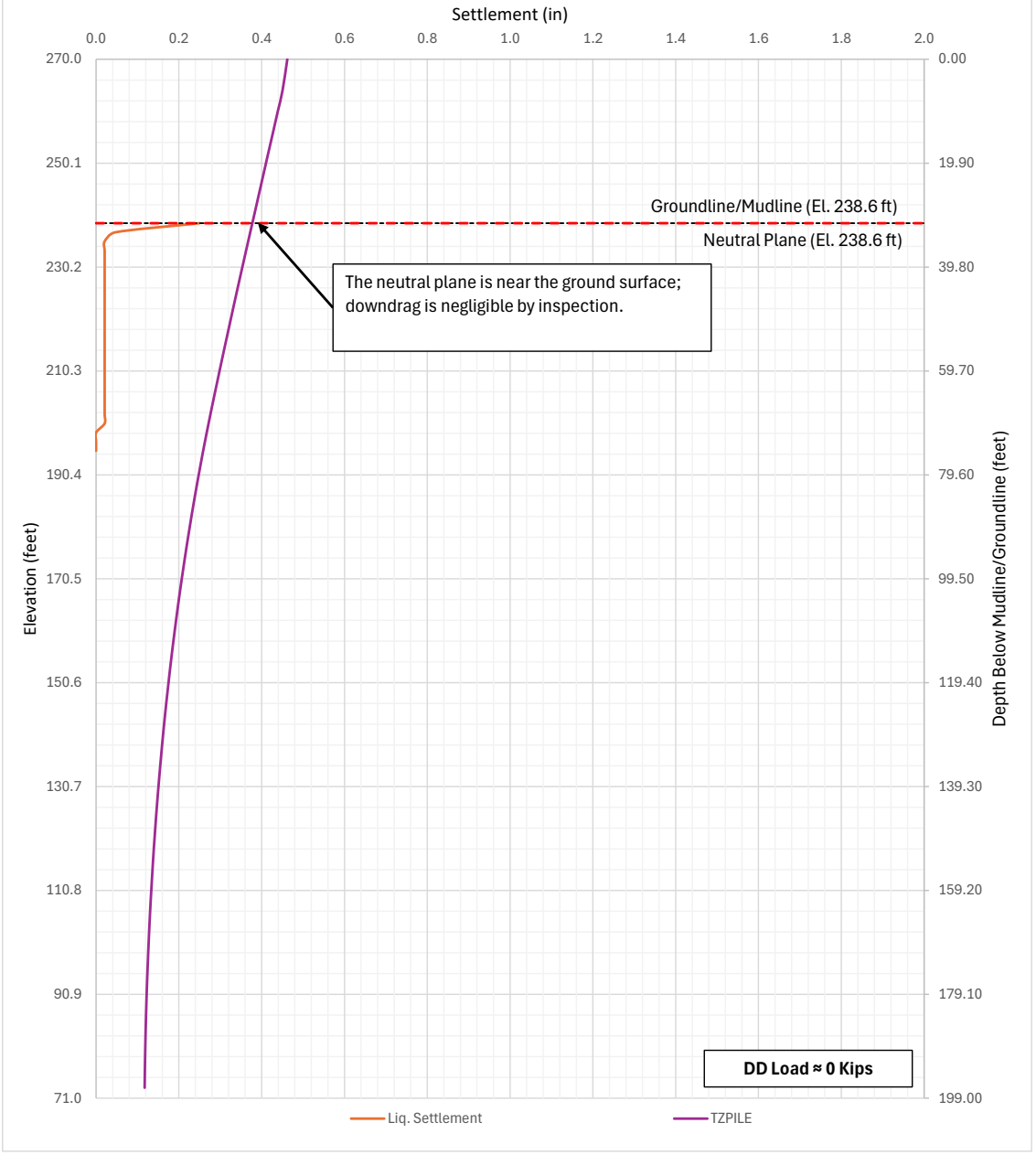
TEAM KENTUCKY TRANSPORTATION CABINET

Pier 3
96-inch Diameter Drilled Shaft
Downdrag - 1000 YR Return Period

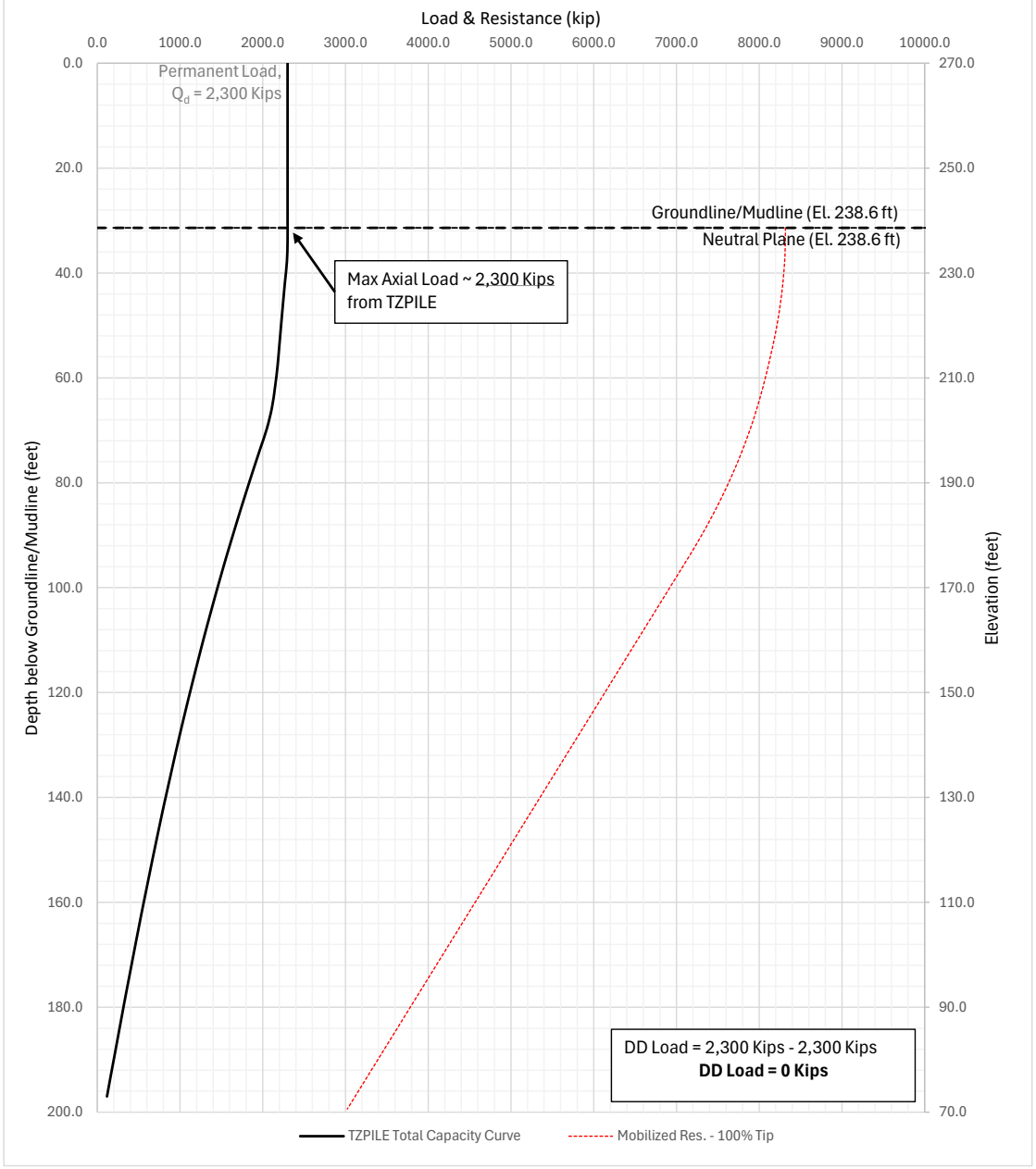
Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 01/27/2026
Drawn By: SKB **Figure No. ##**
Date: 01/26/2026

PIER 4

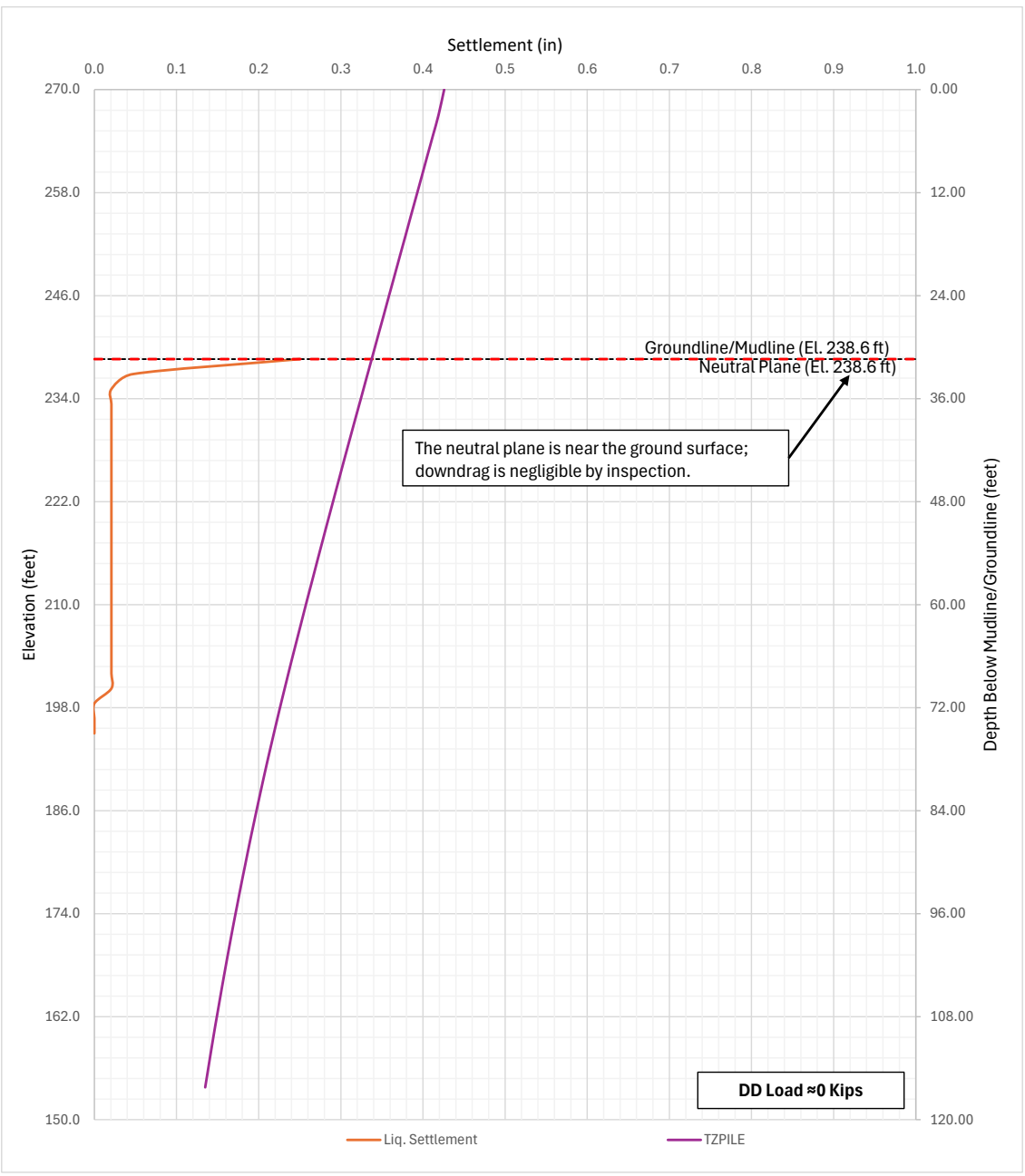
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



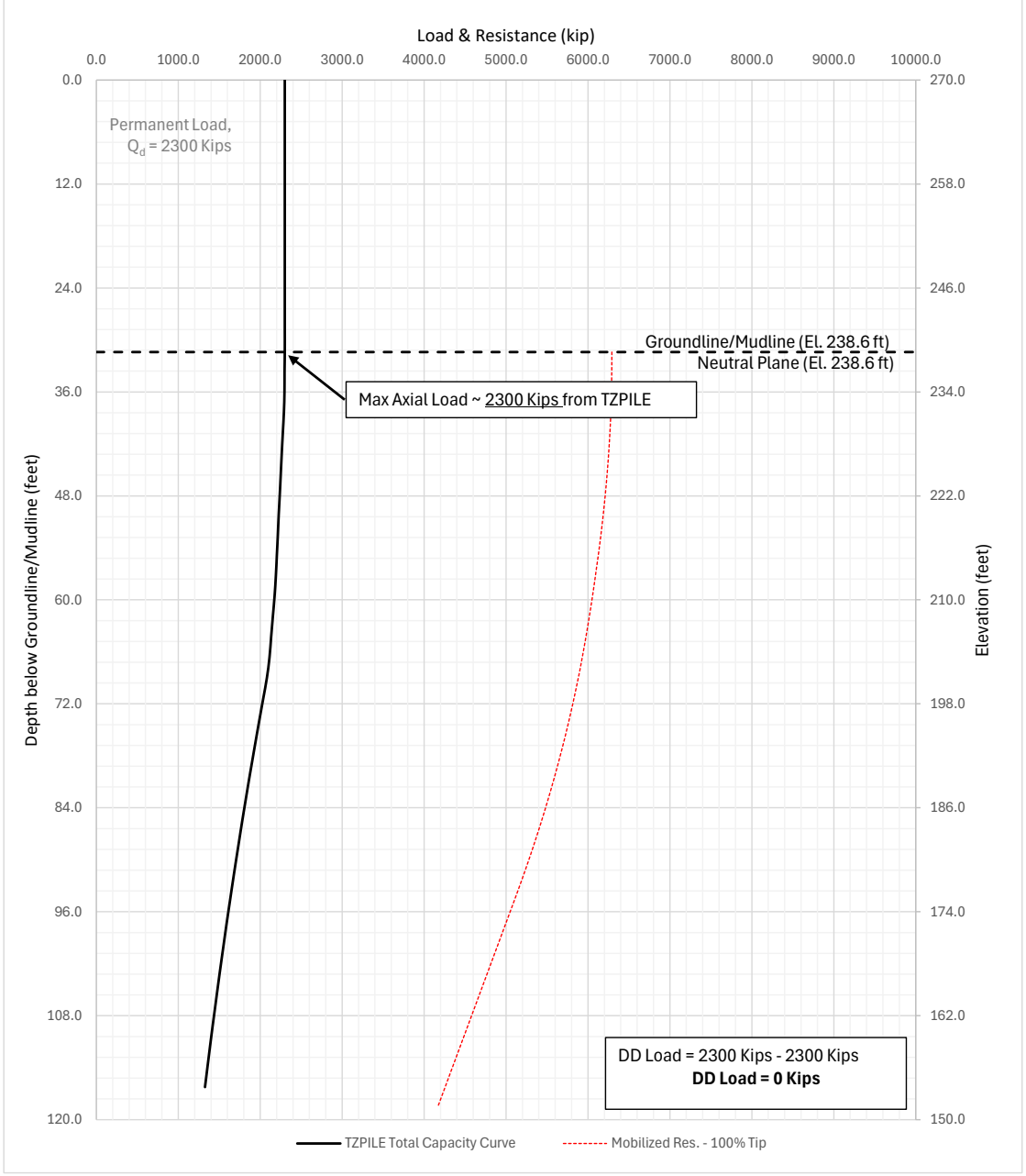
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

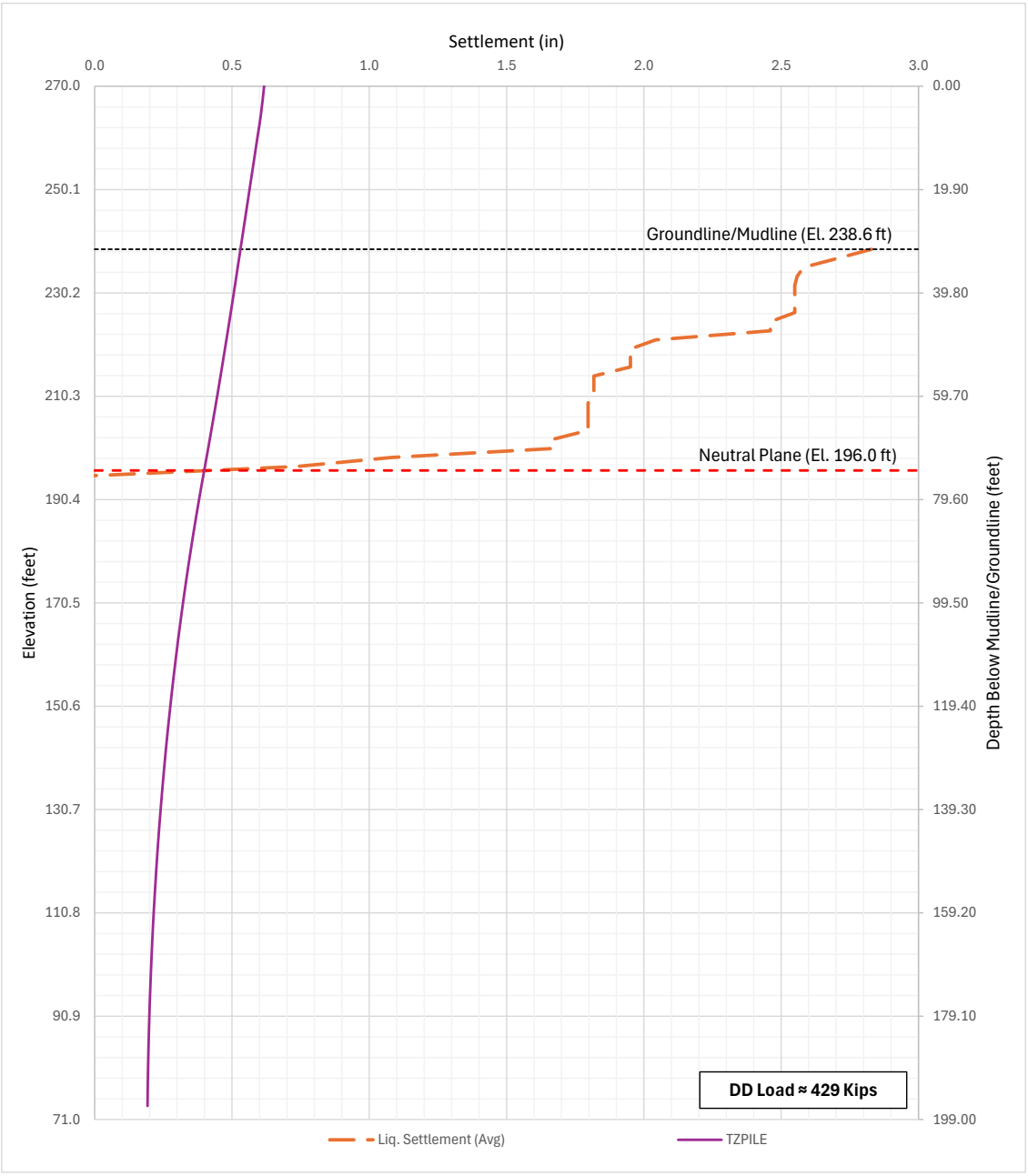


Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. 2** **Date:** 11/25/2025

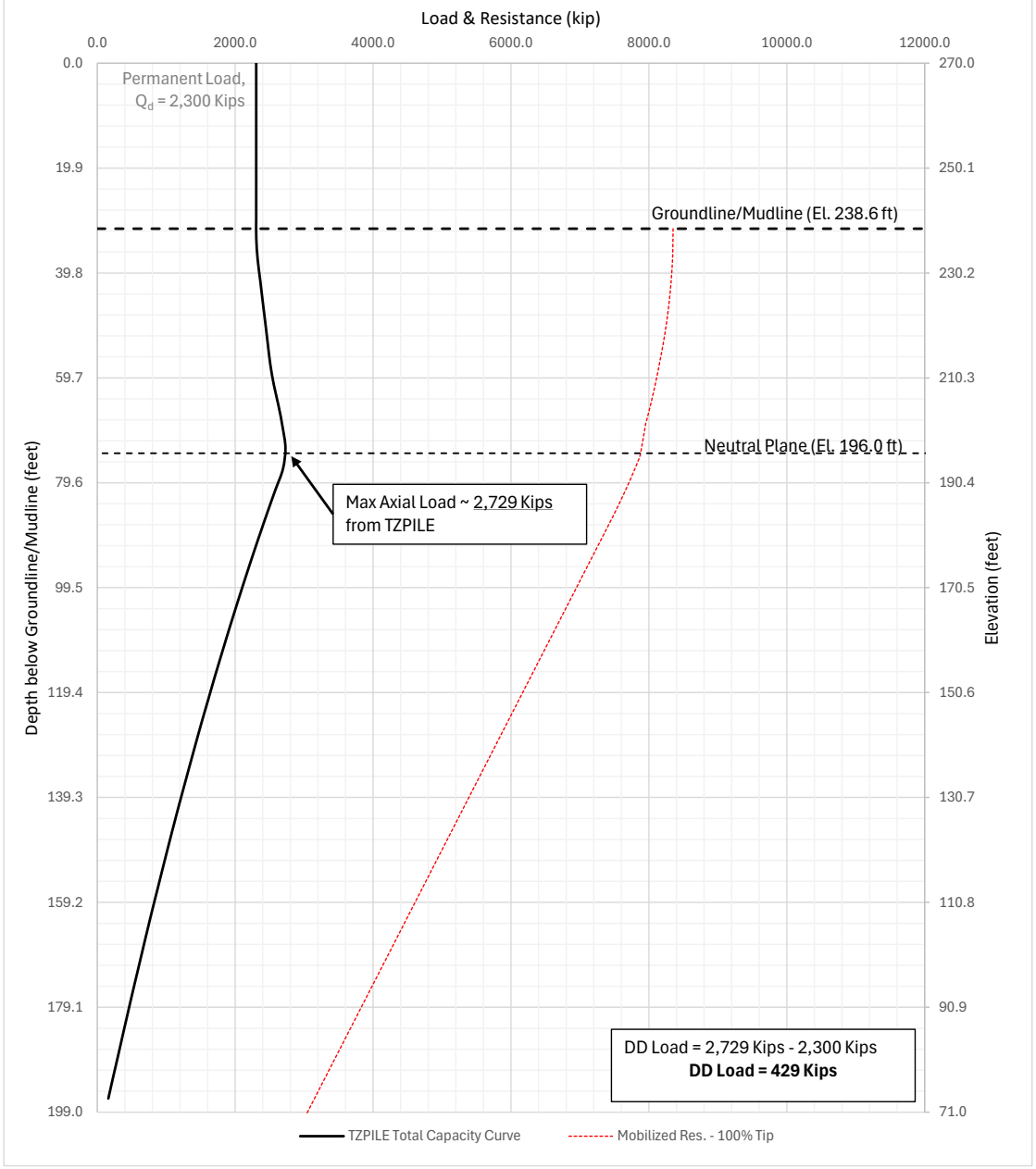


Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

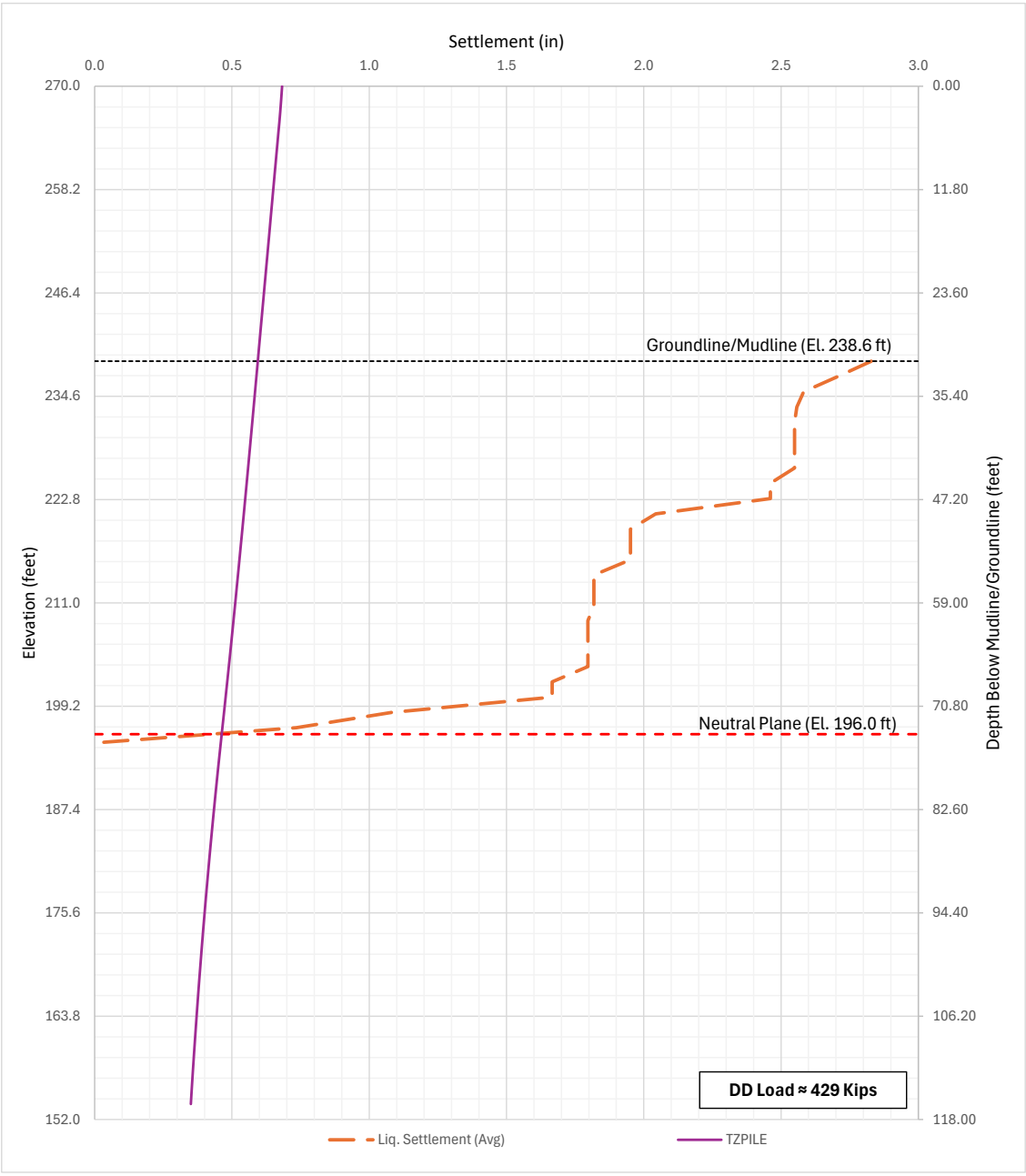
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



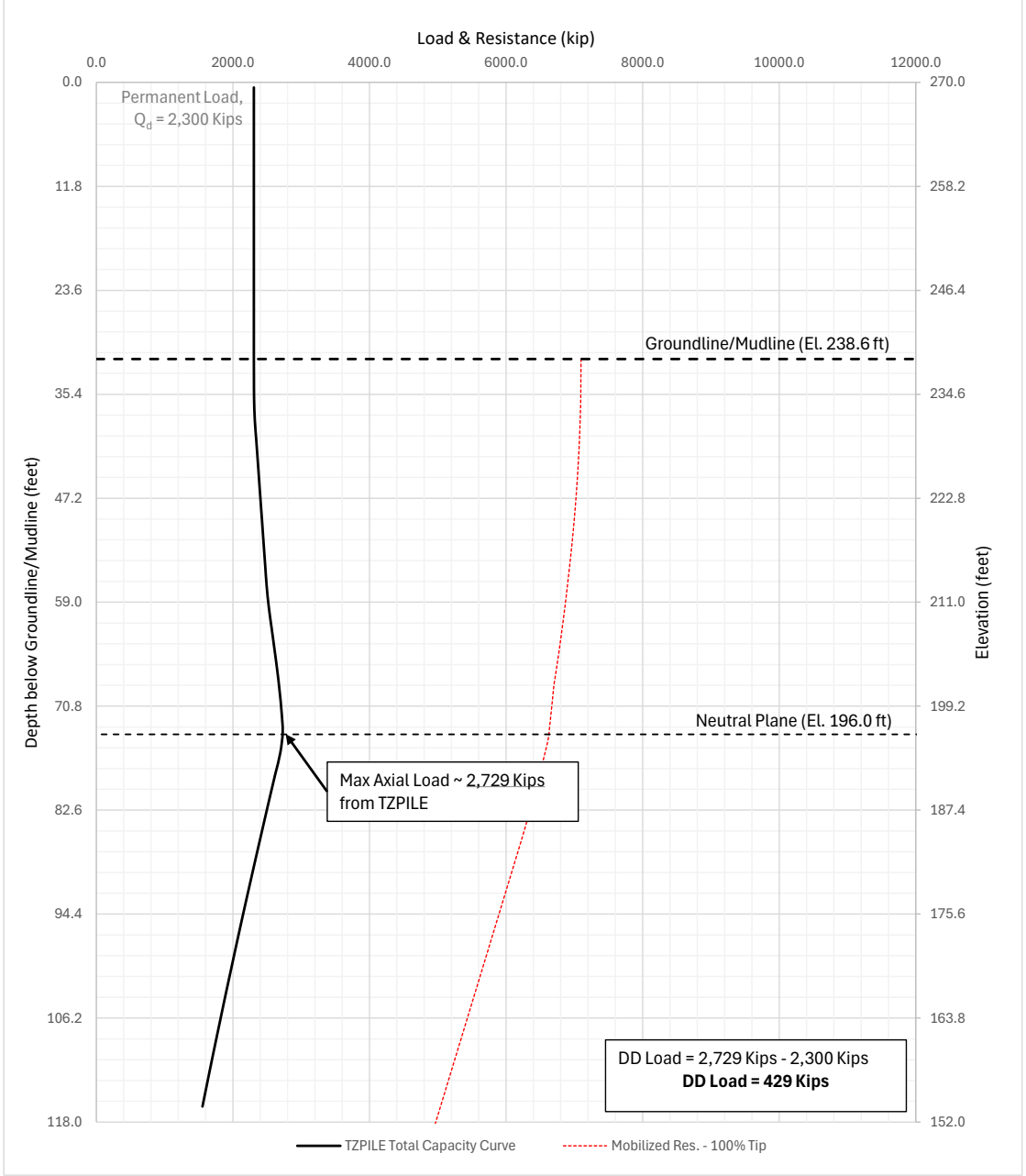
Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

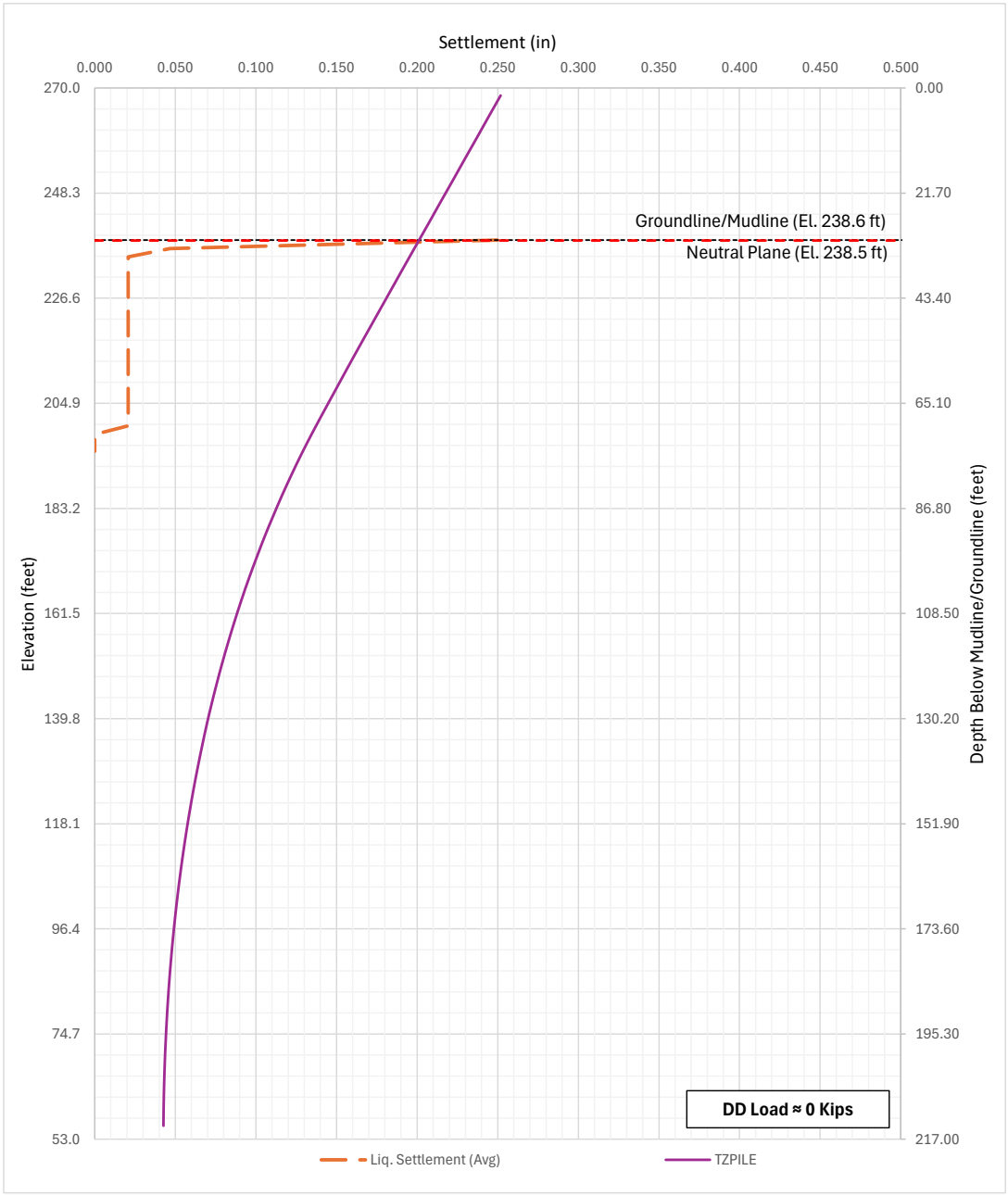


Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter Steel Pipe Pile w/ C.P. Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

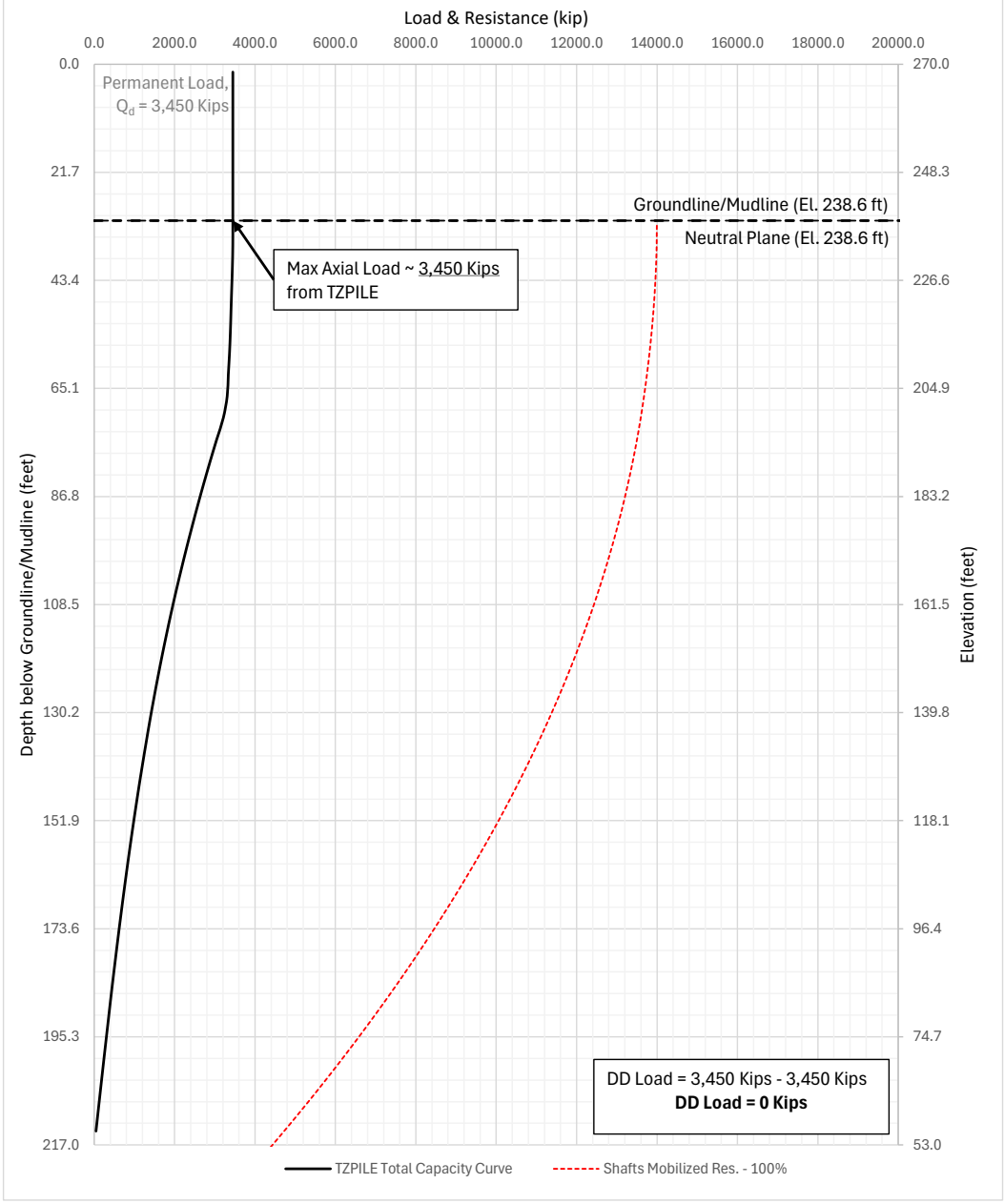


Prepared by:	Prepared for:	**Pier 4** **72-inch Diameter Steel Pipe Pile w/ C.P. Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD

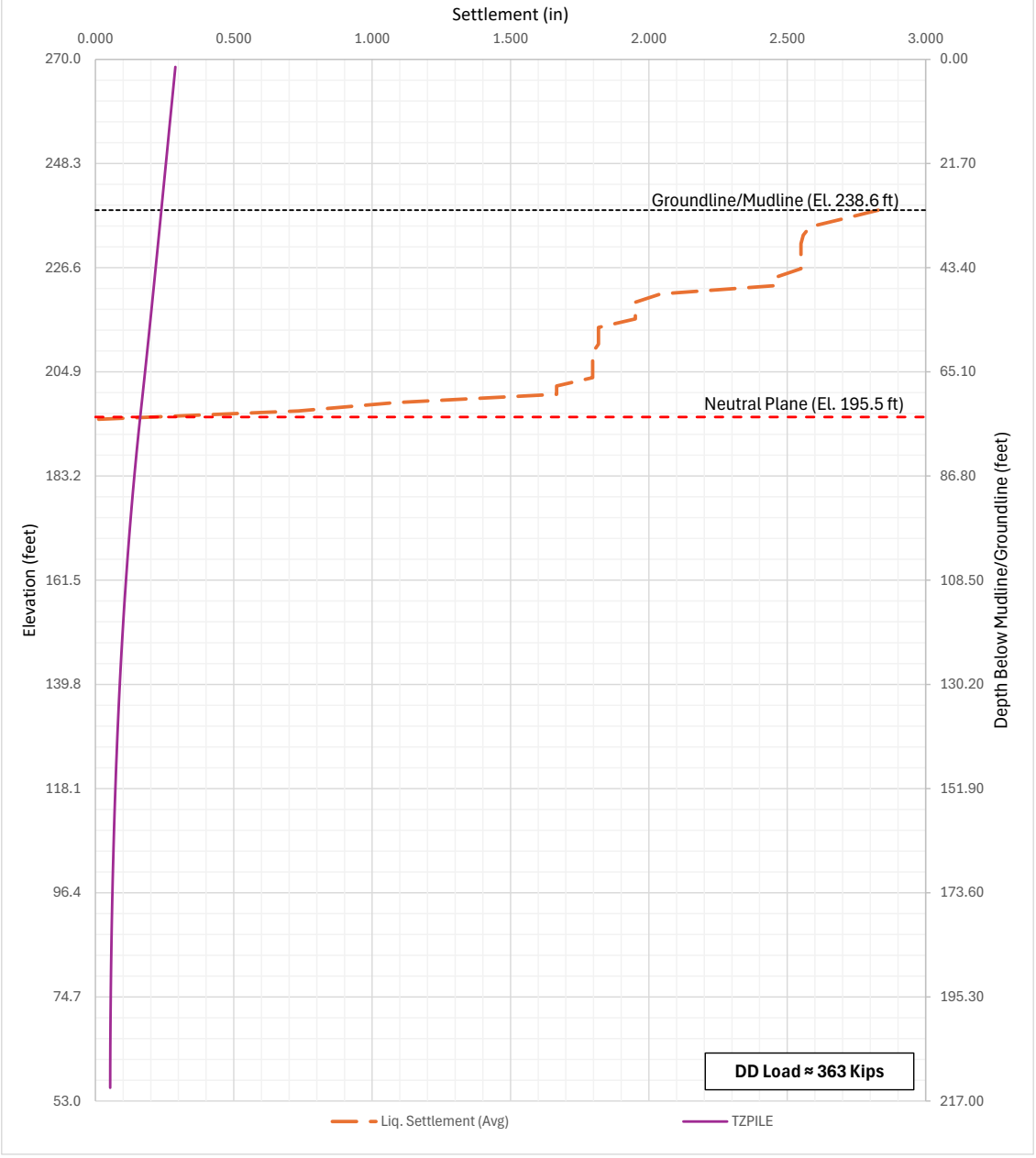


Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

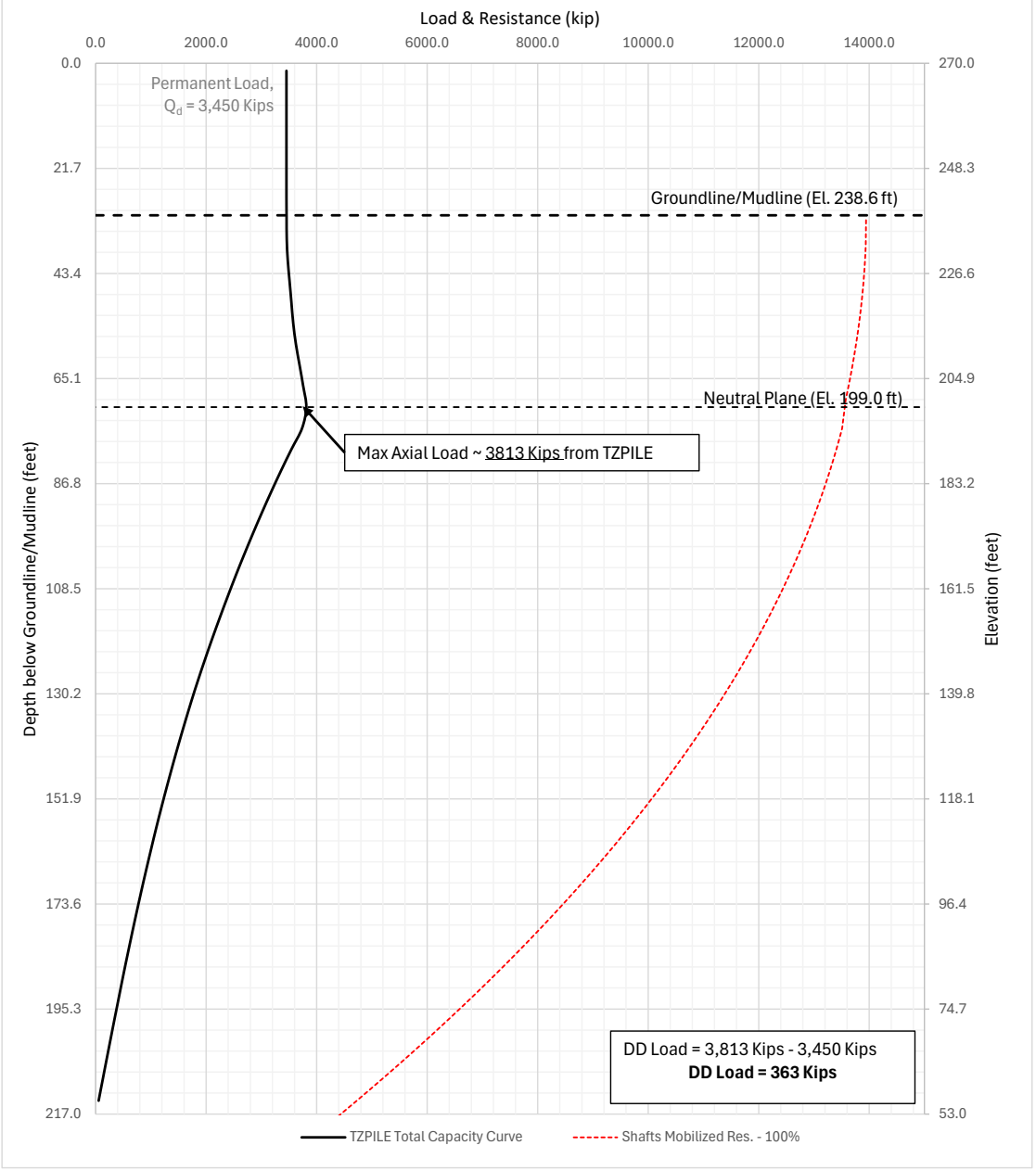


Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



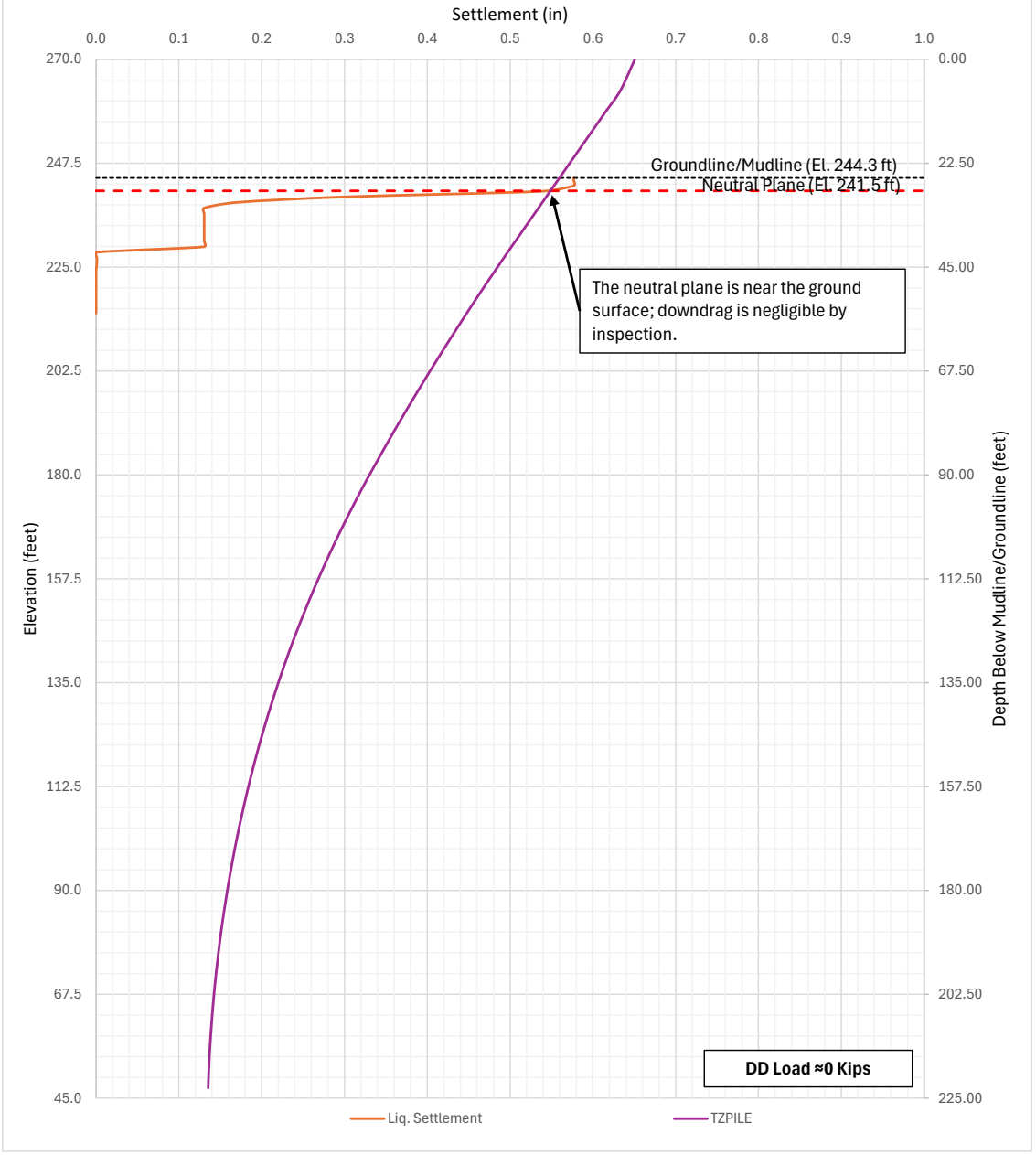
Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



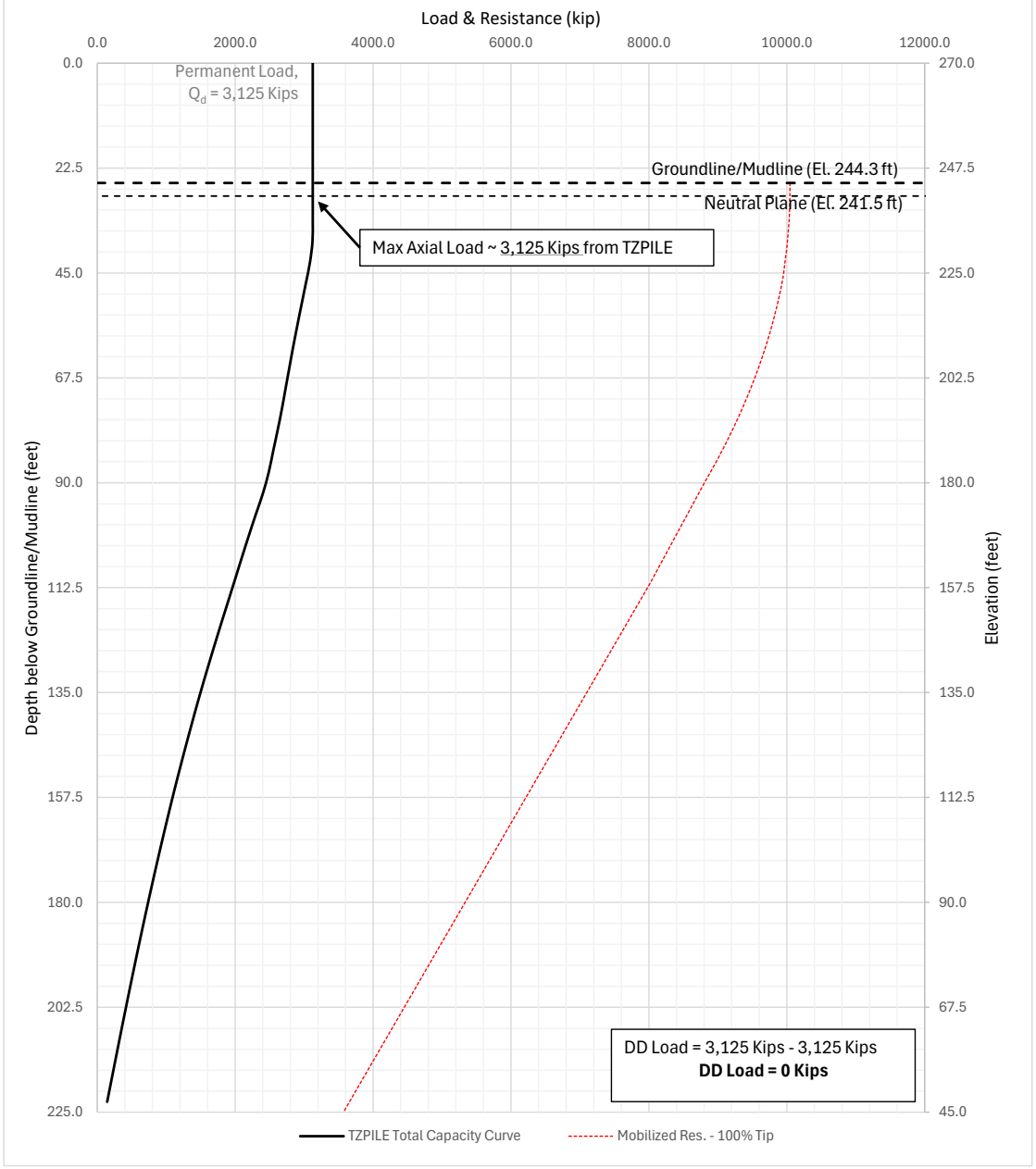
Prepared by:	Prepared for:	**Pier 4** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
	TEAM KENTUCKY TRANSPORTATION CABINET	**Project:** US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

PIER 5

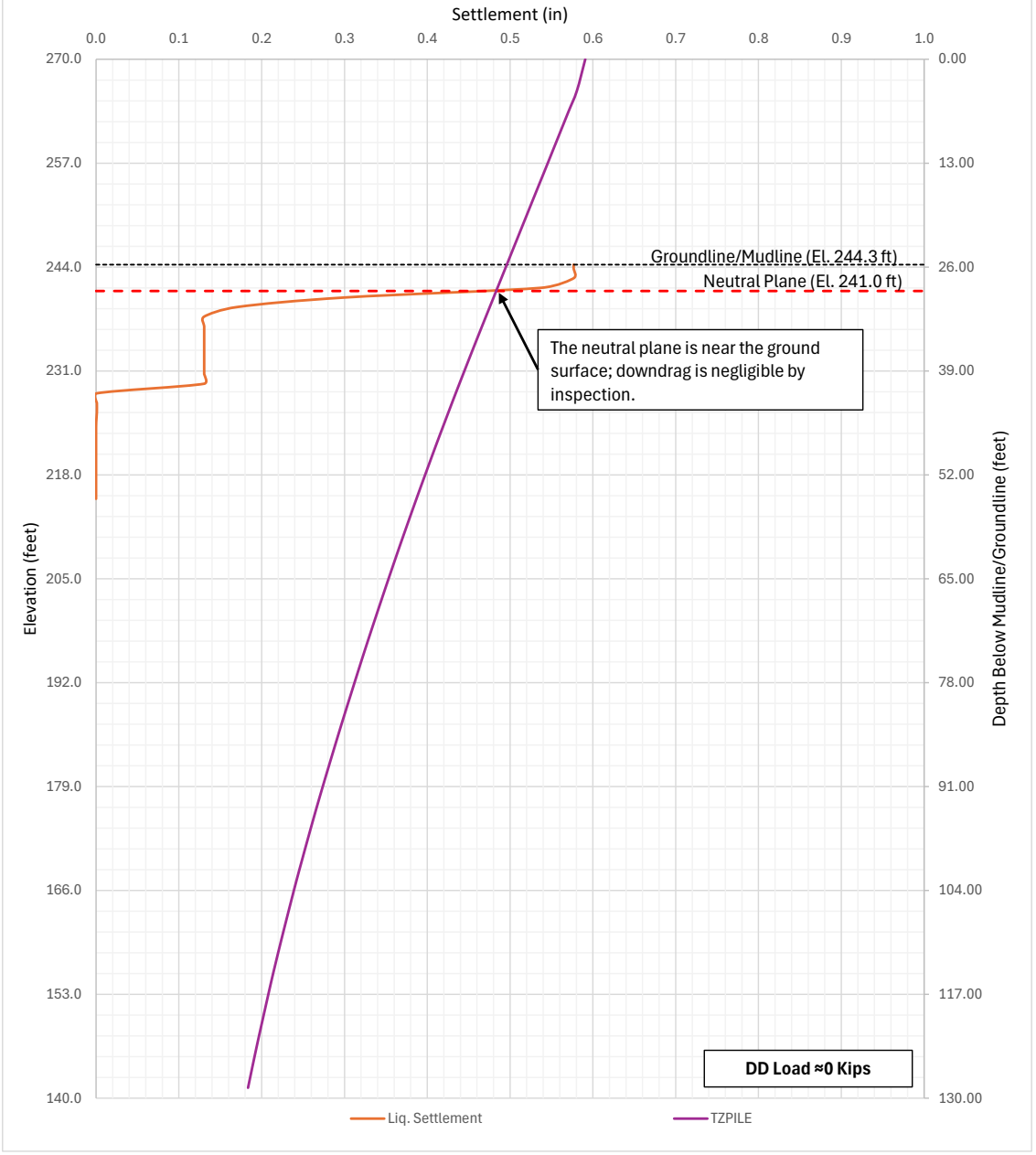
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



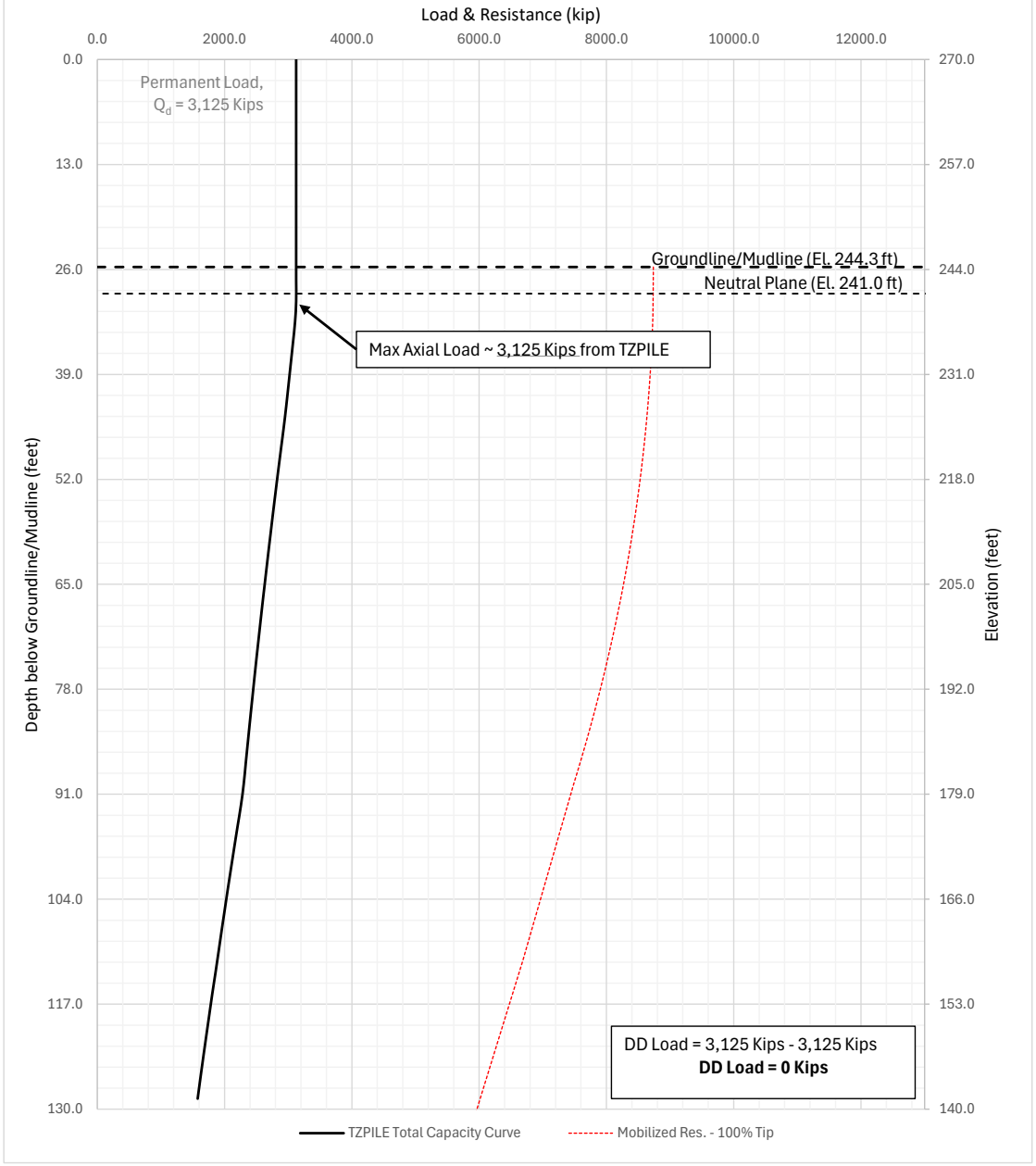
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

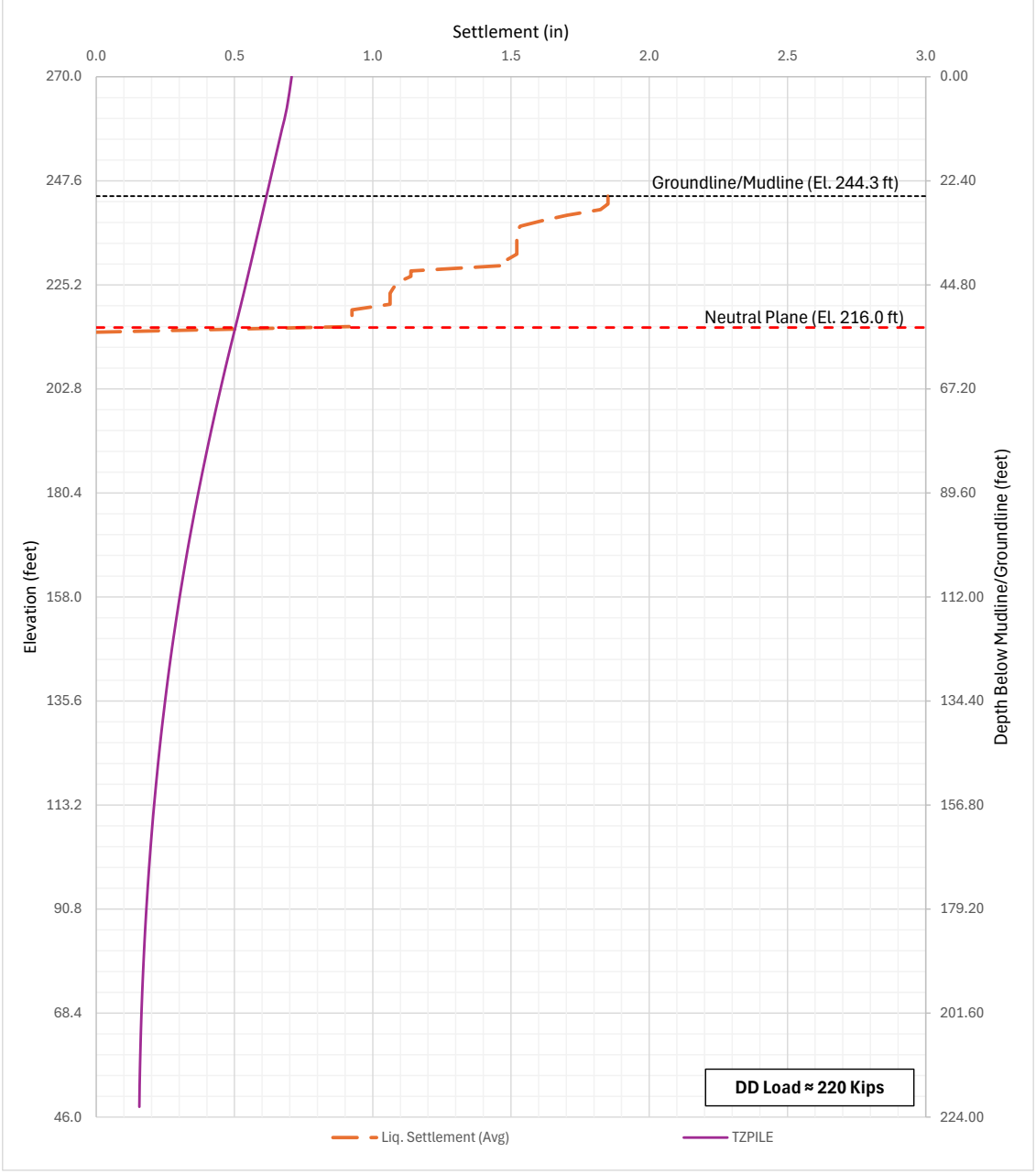


Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

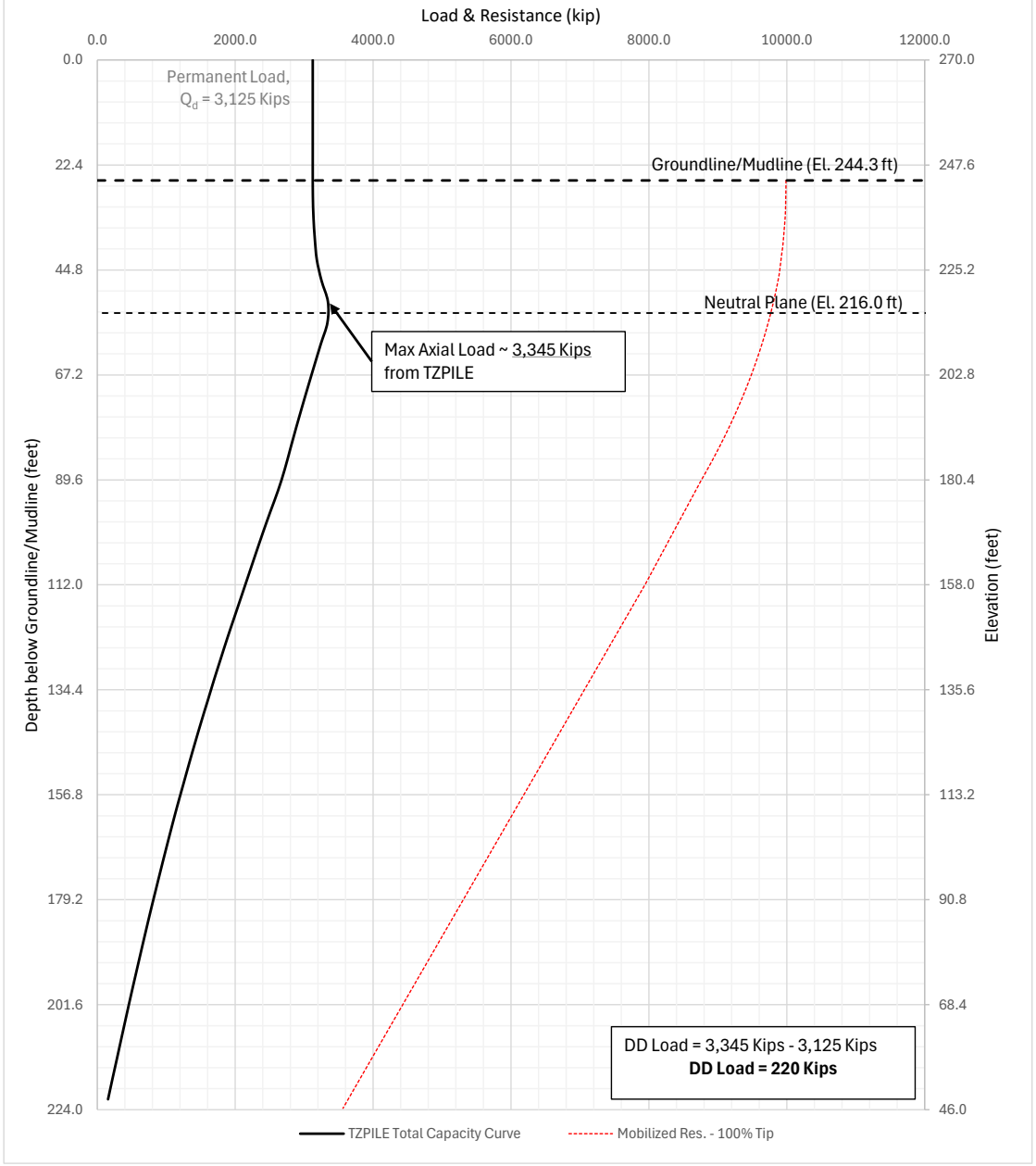


Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

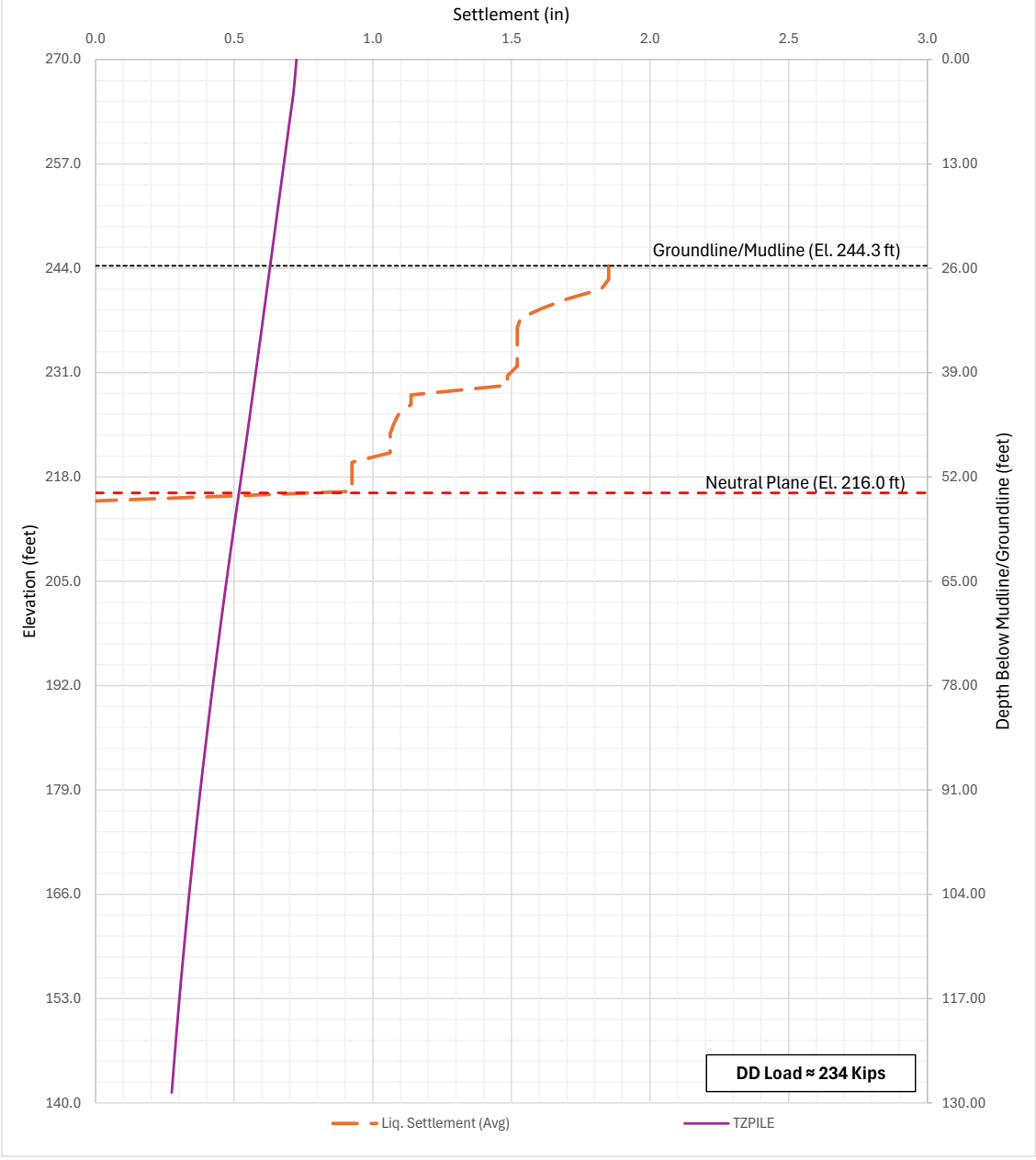
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

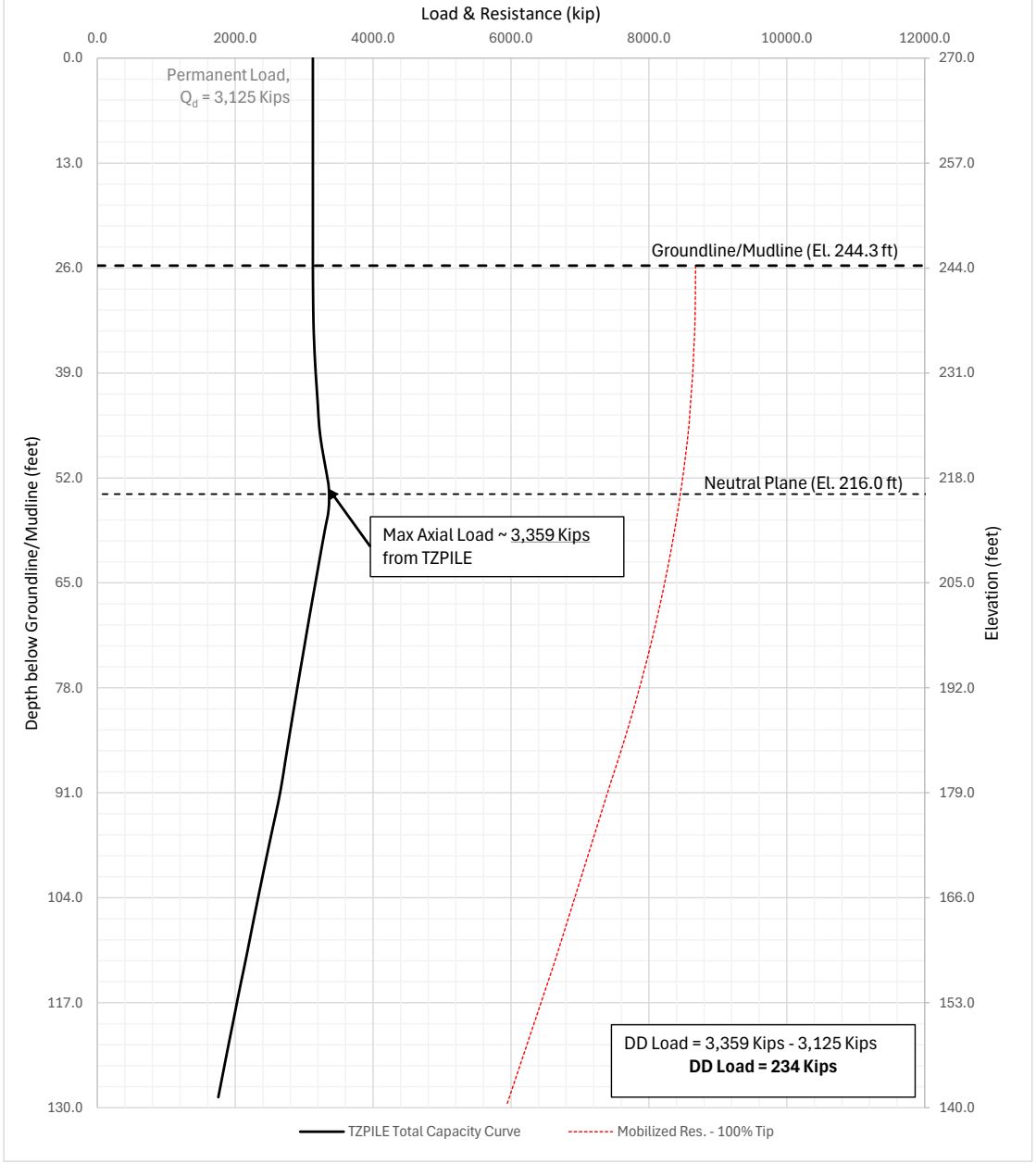


Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



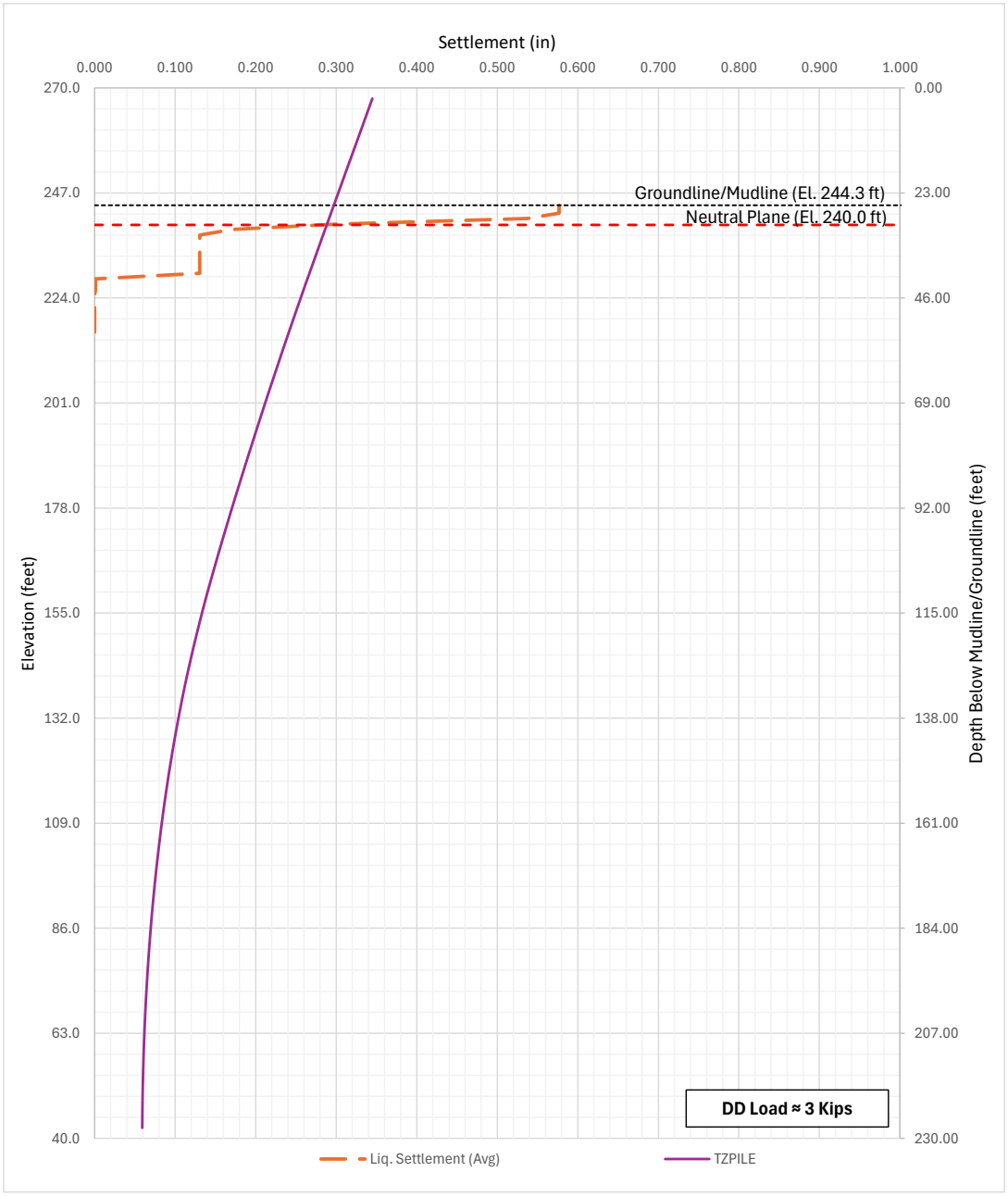
Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

https://hdrinc-my.sharepoint.com/personal/stborder_hdrinc_com/Documents/10174706 - US 51 Cairo Bridge/CM3 Final Design/Pipe Piles_Seismic/Pier 5 (U2-1)/Pier 5_Downdrag_1000YR_CP.xlsx

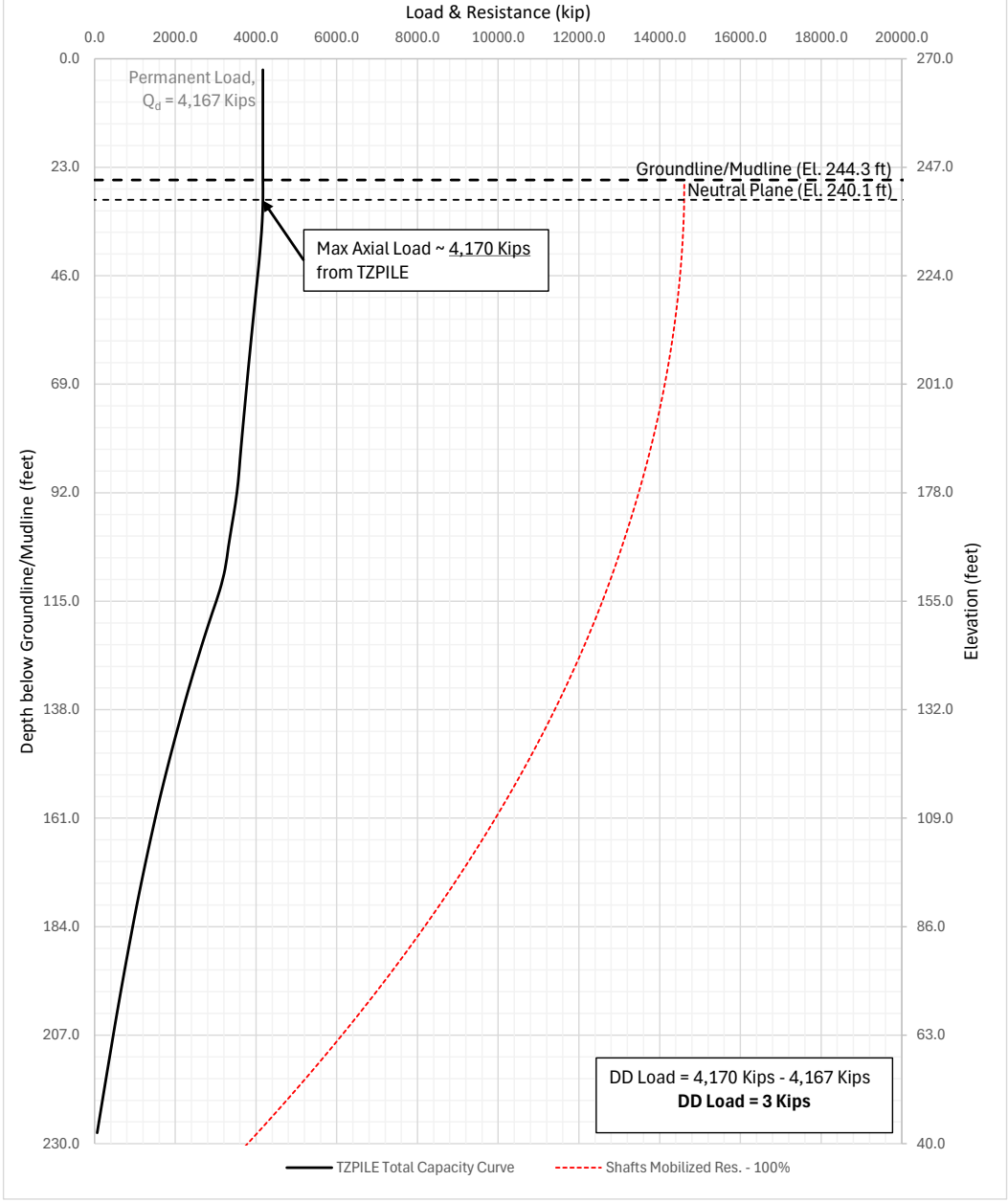


Prepared by:	Prepared for:	**Pier 5** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD

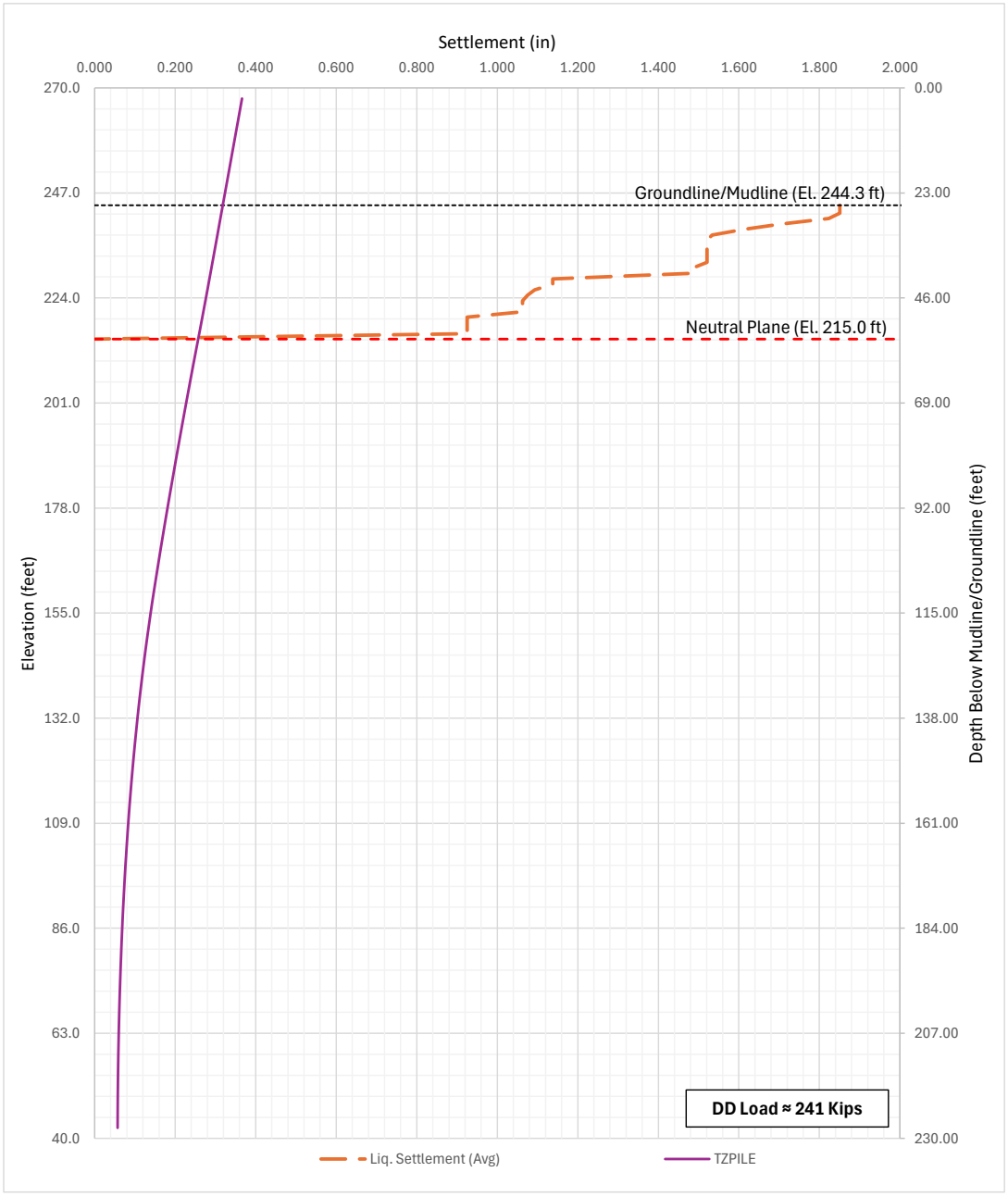


Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

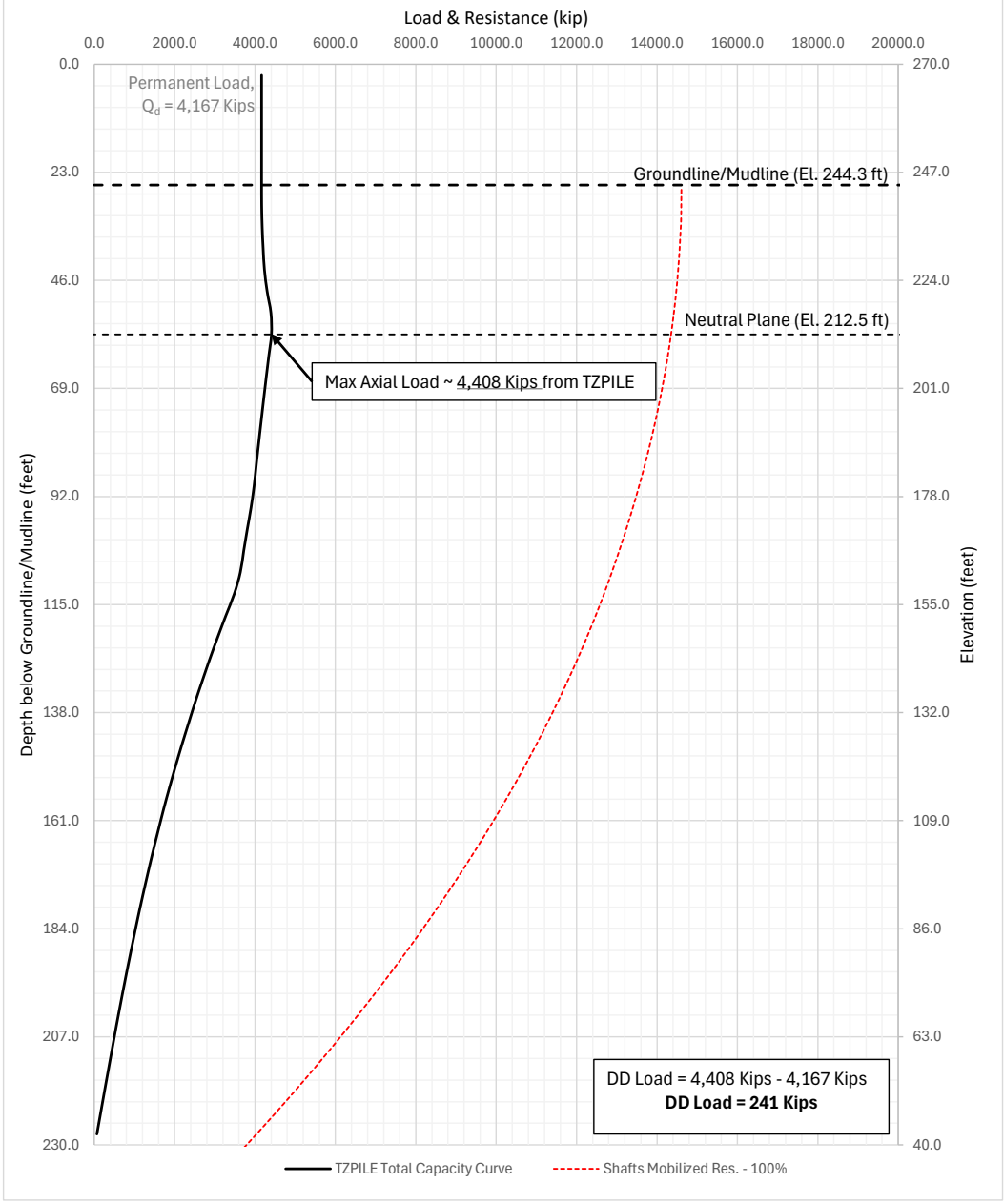


Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



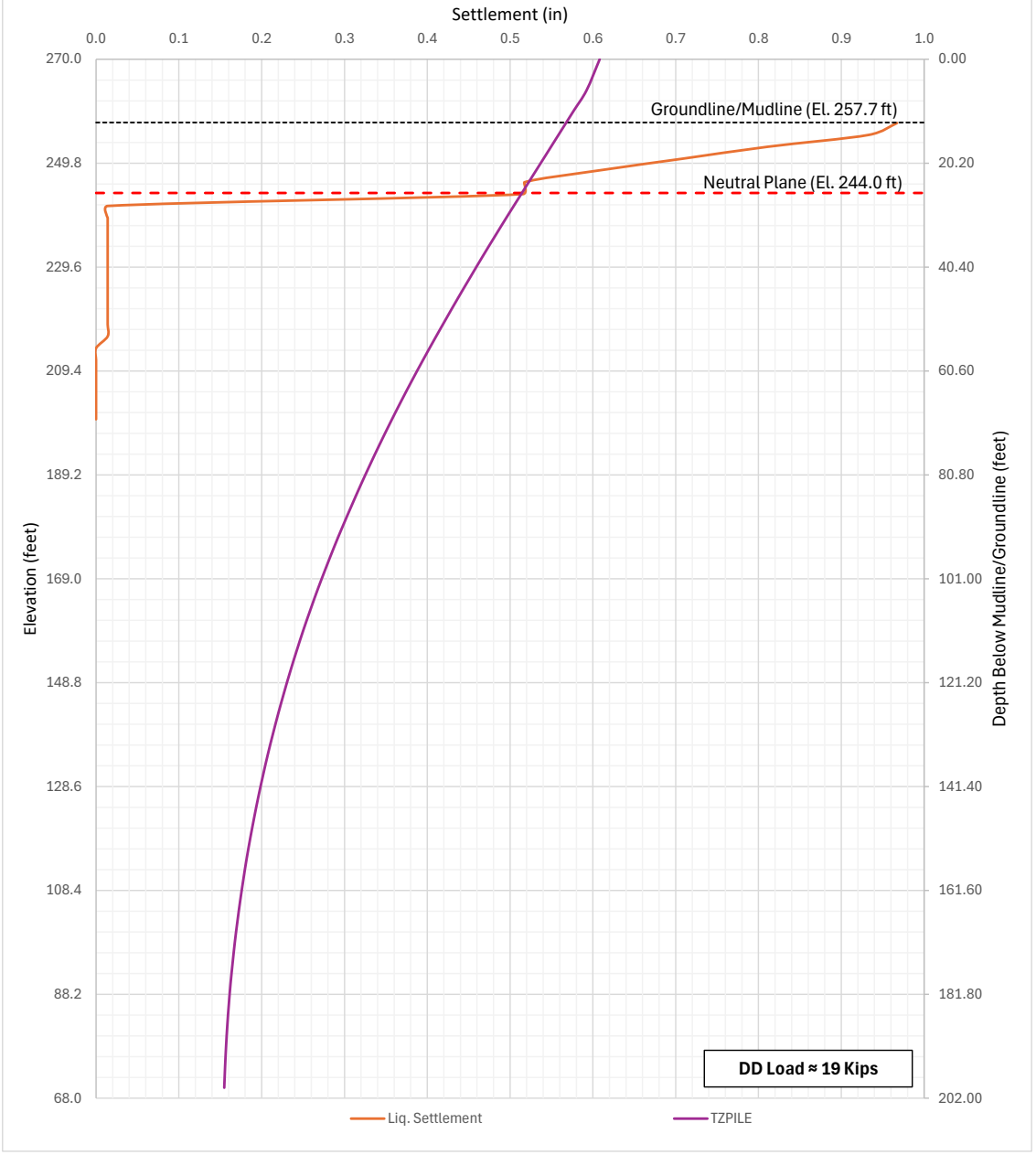
Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



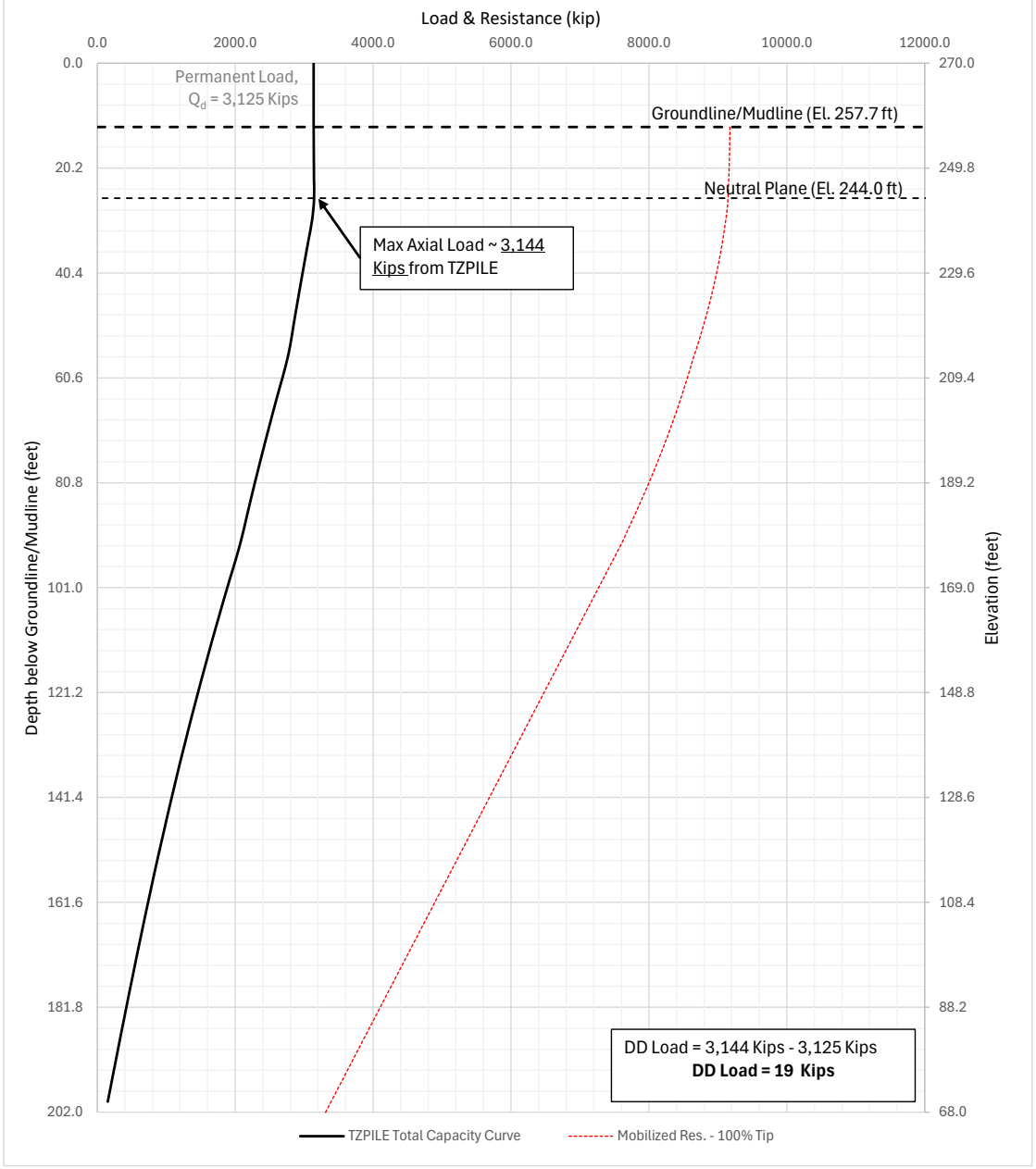
Prepared by:	Prepared for:	**Pier 5** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

PIER 6

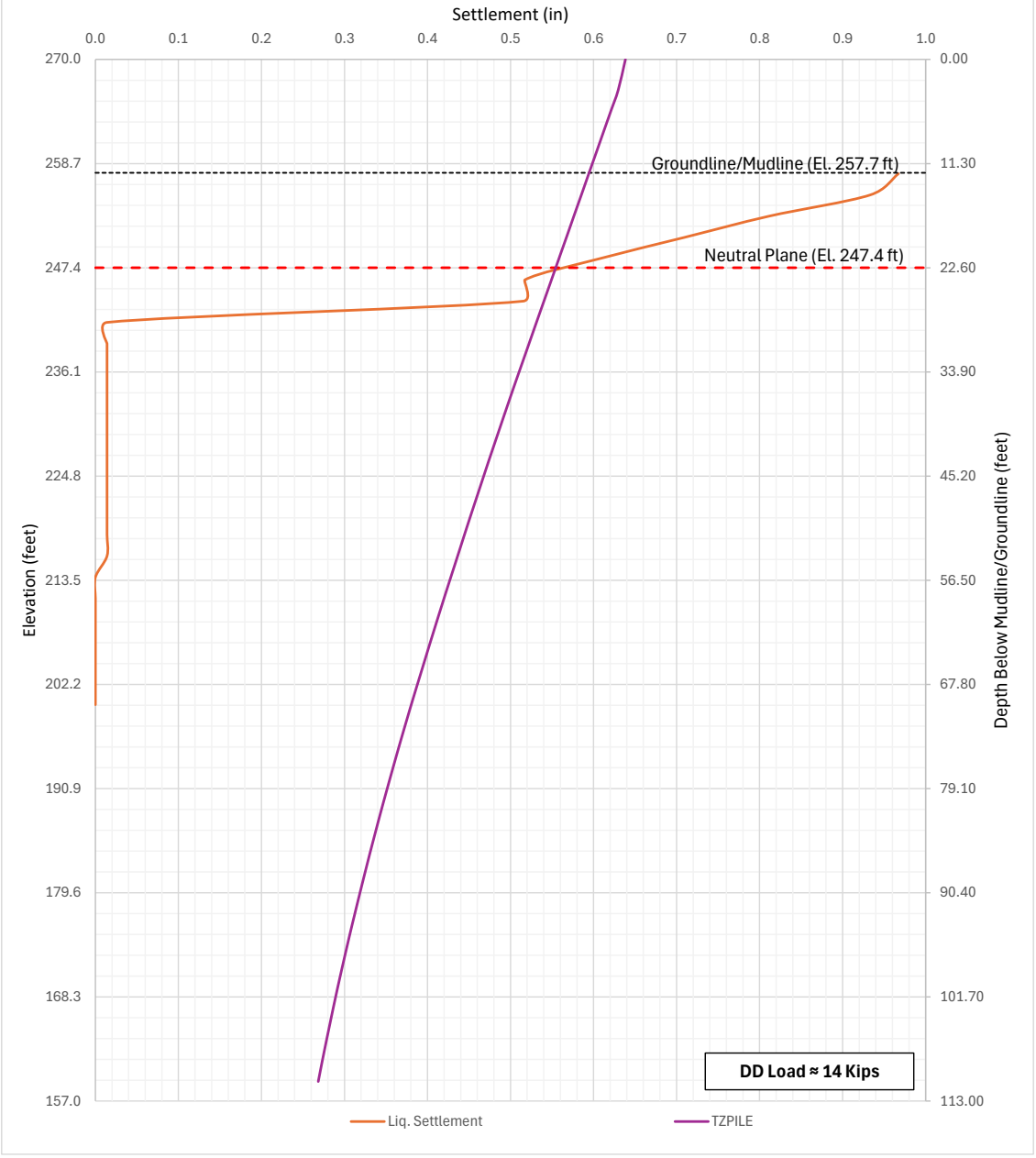
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



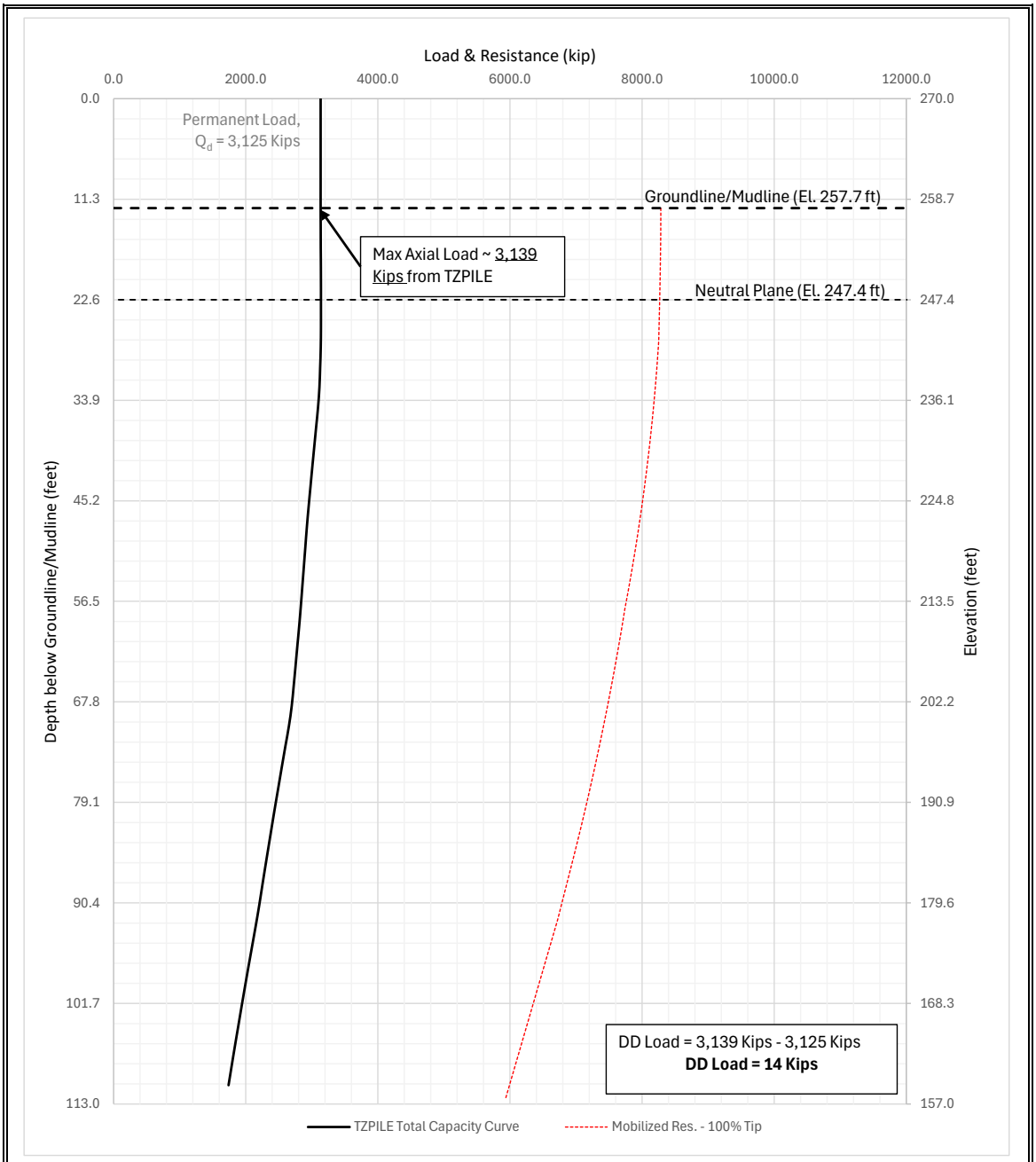
Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

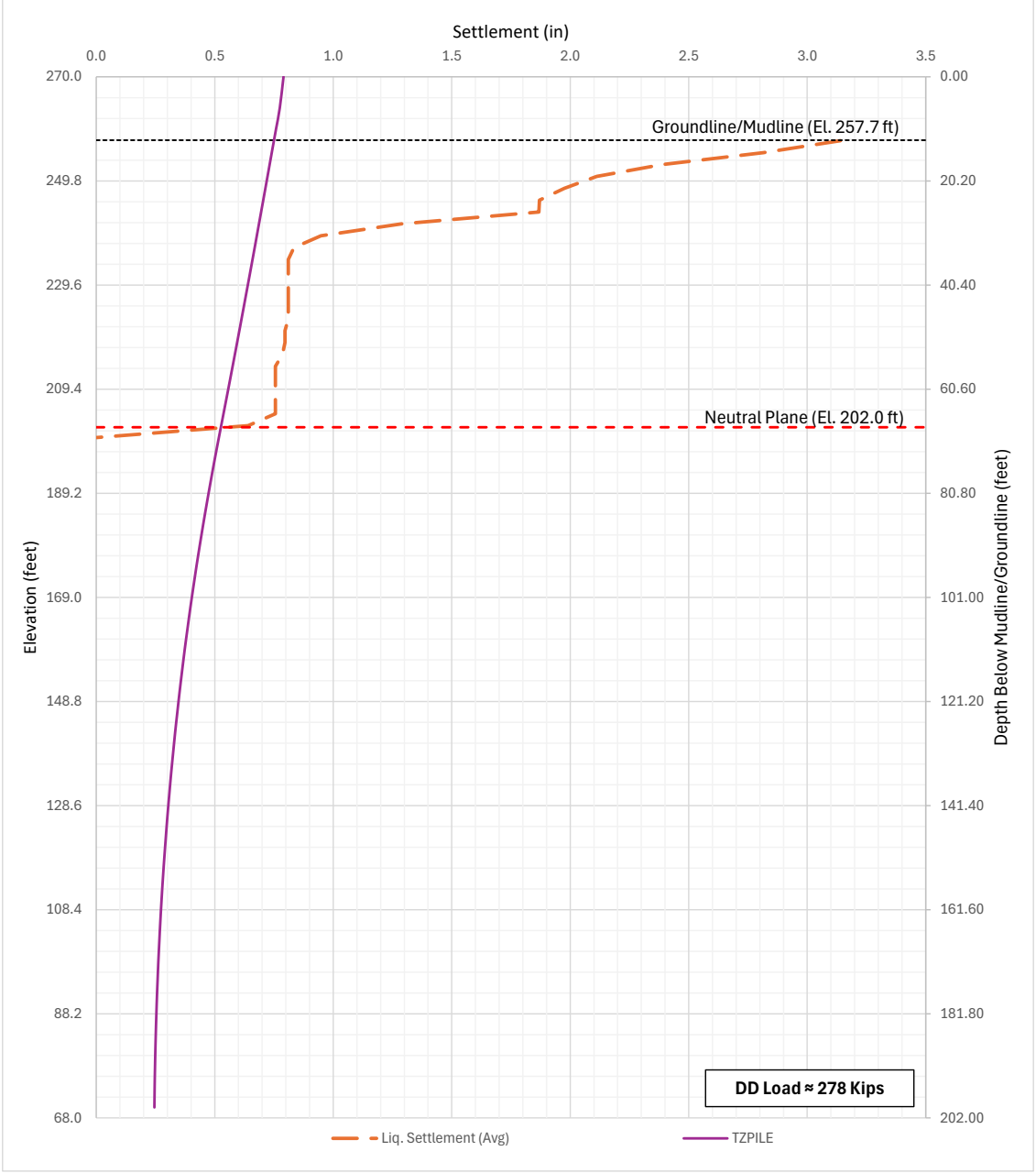


Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

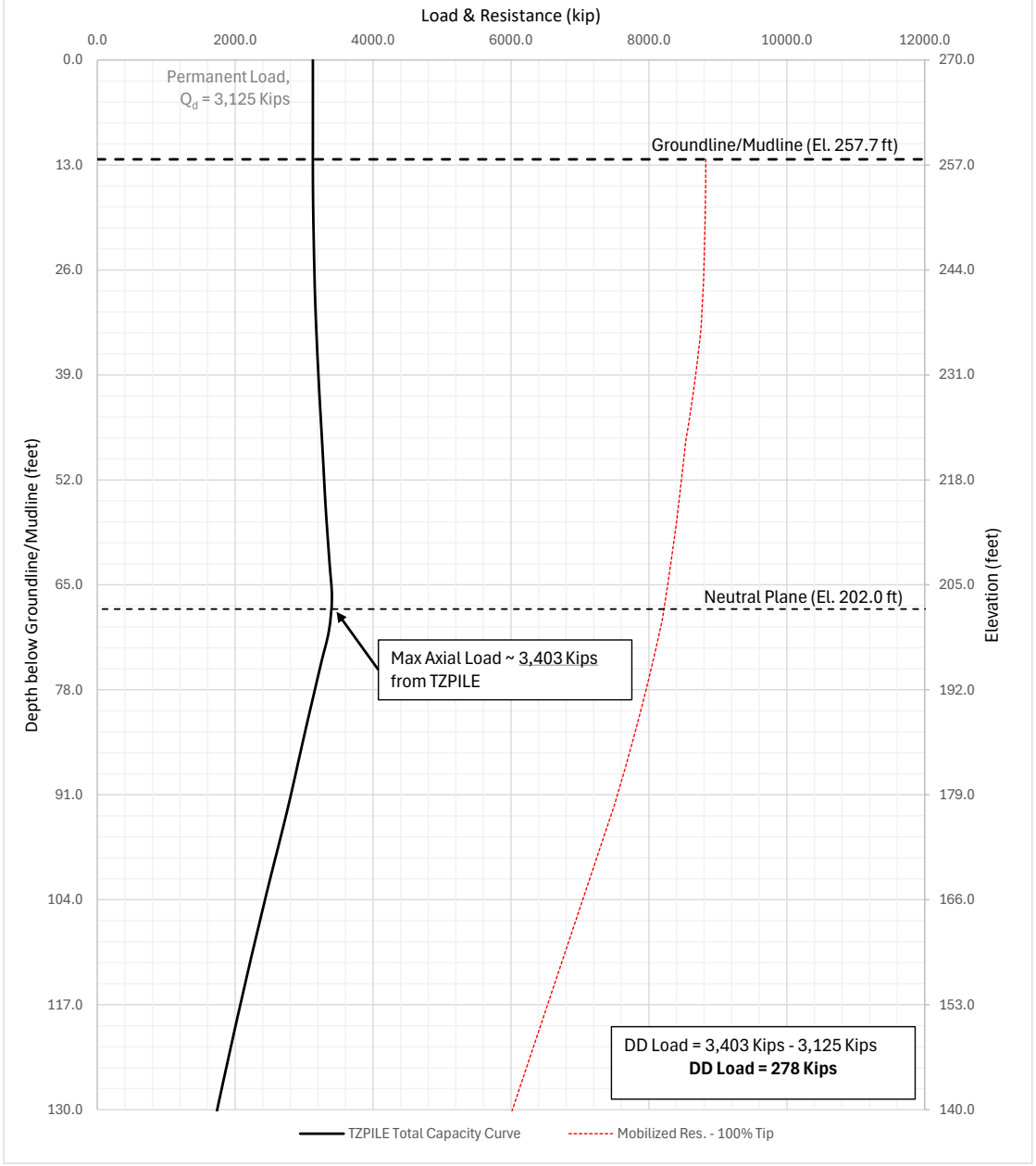


Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



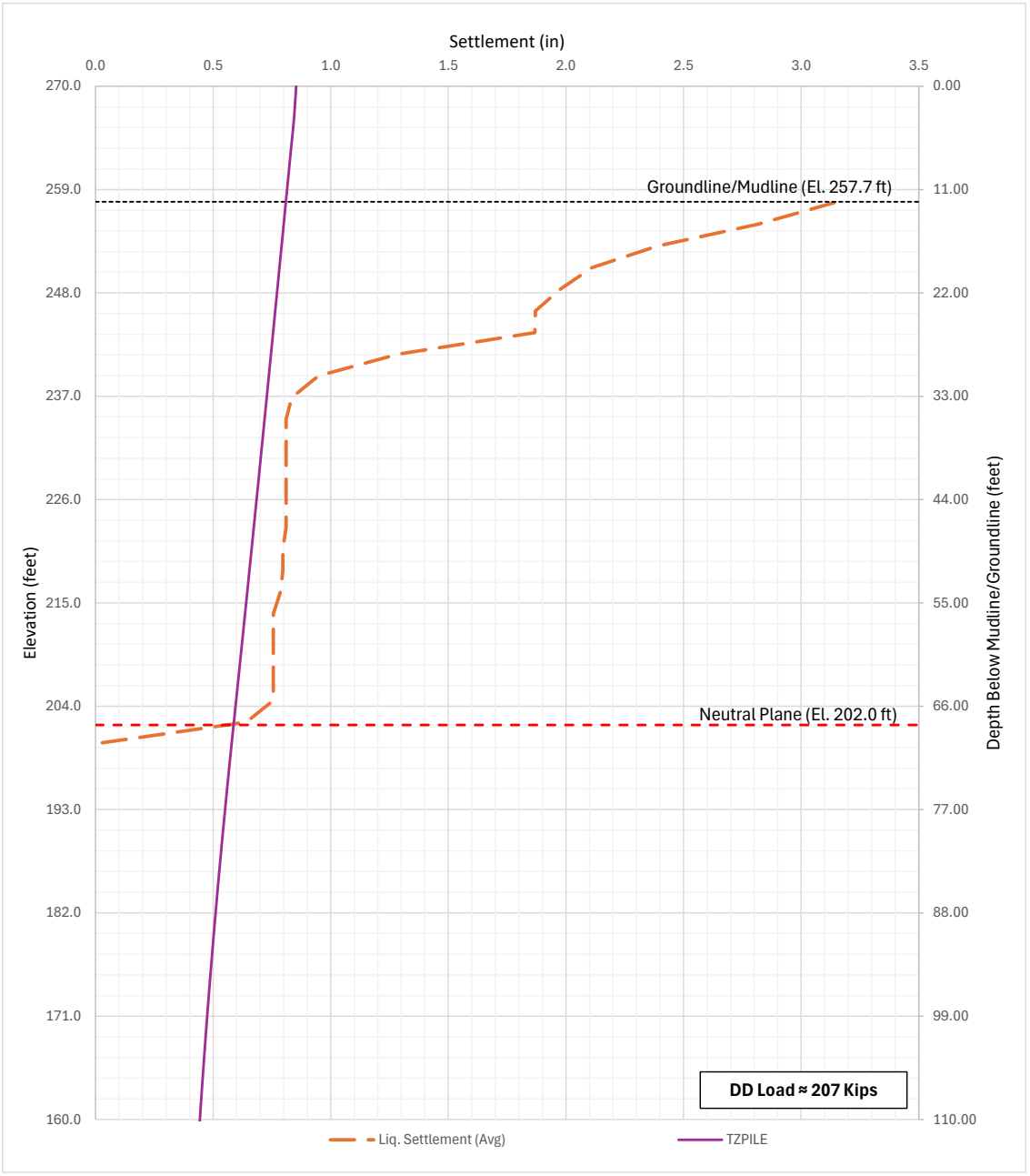
Prepared by:

Prepared for:

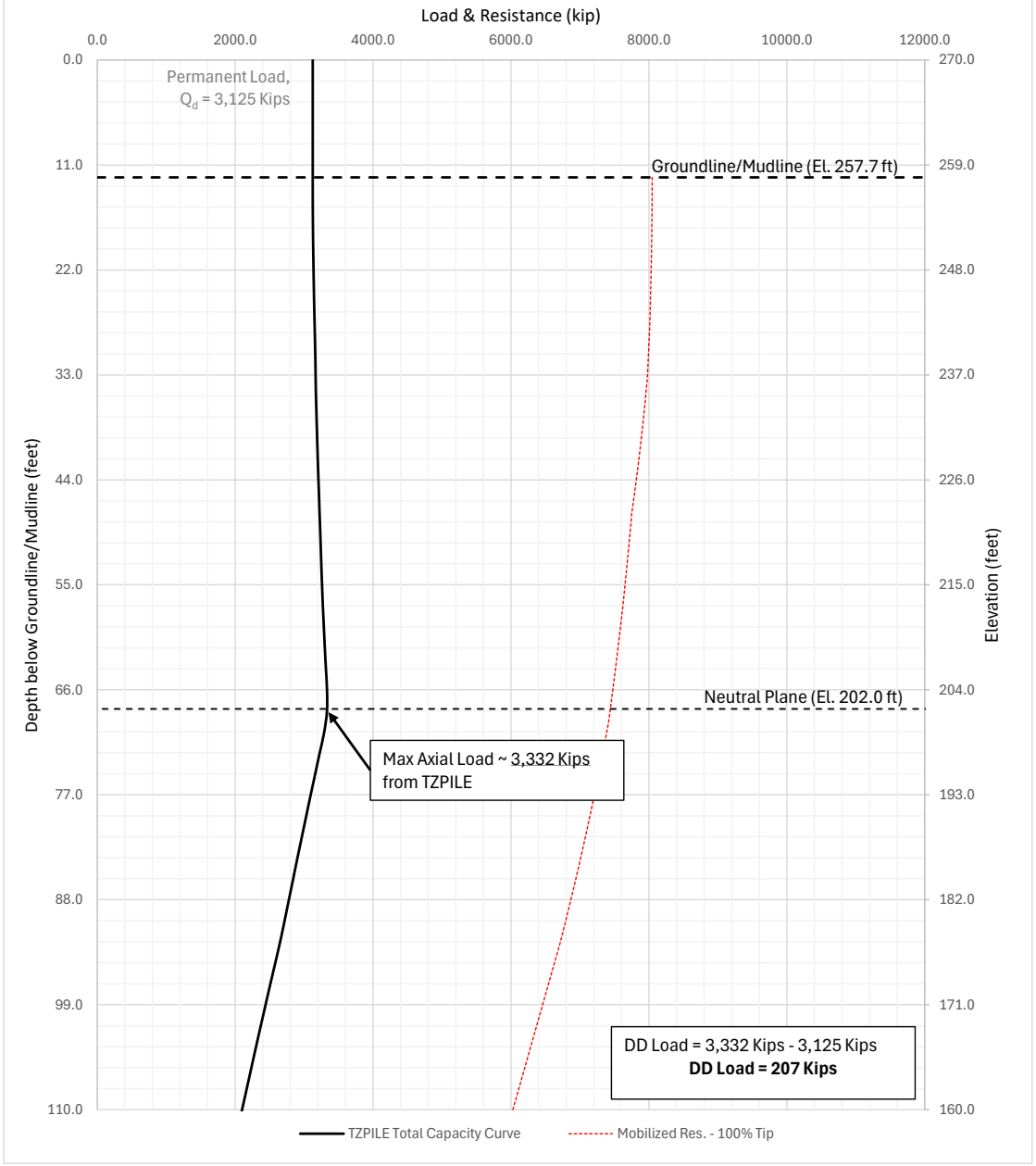
TEAM KENTUCKY TRANSPORTATION CABINET

Pier 6
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Downdrag via Partial Mobilization

Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 01/27/2026
Drawn By: SKB **Figure No. ##**
Date: 01/26/2026

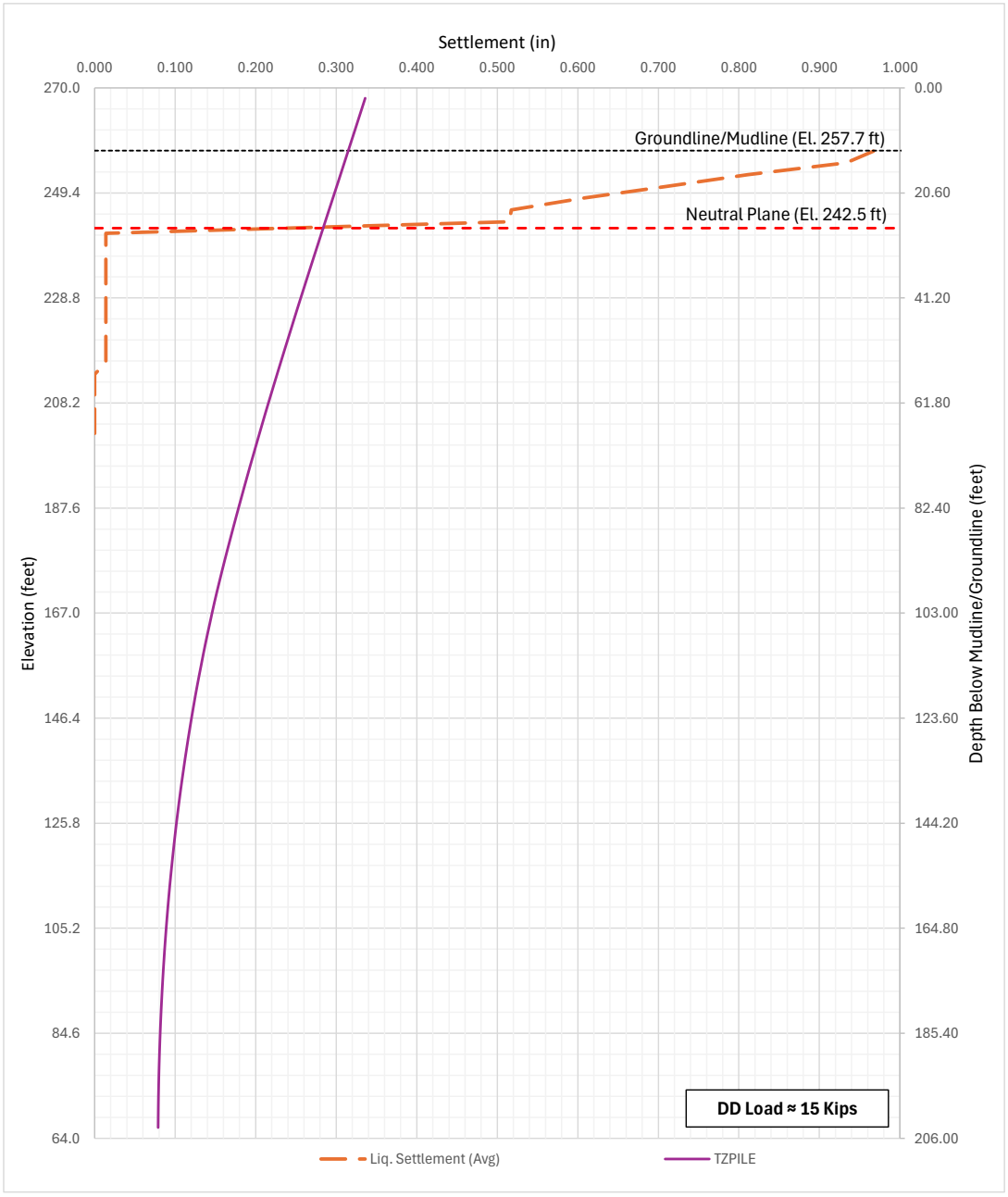


Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

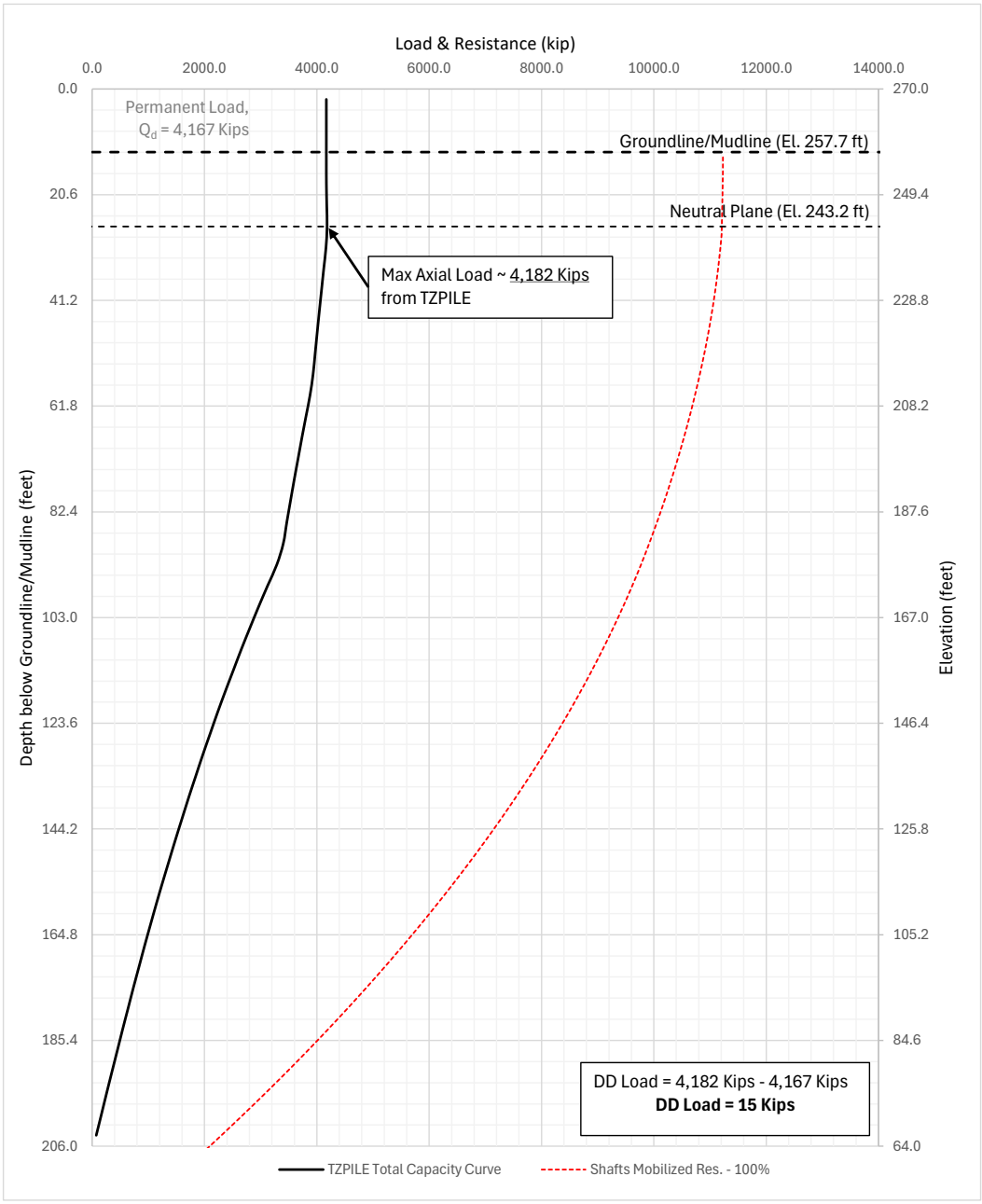


Prepared by:	Prepared for:	**Pier 6** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD

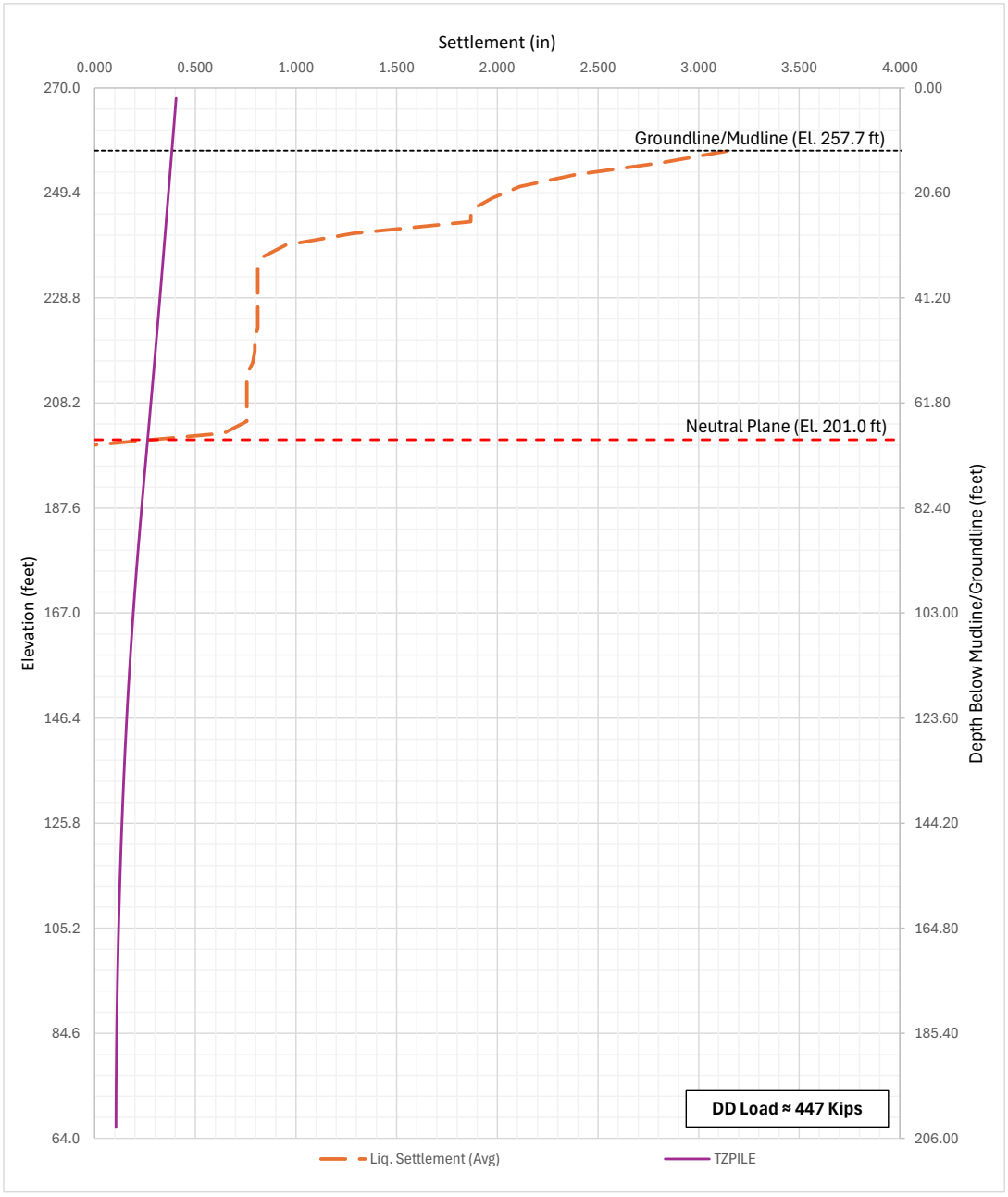


Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

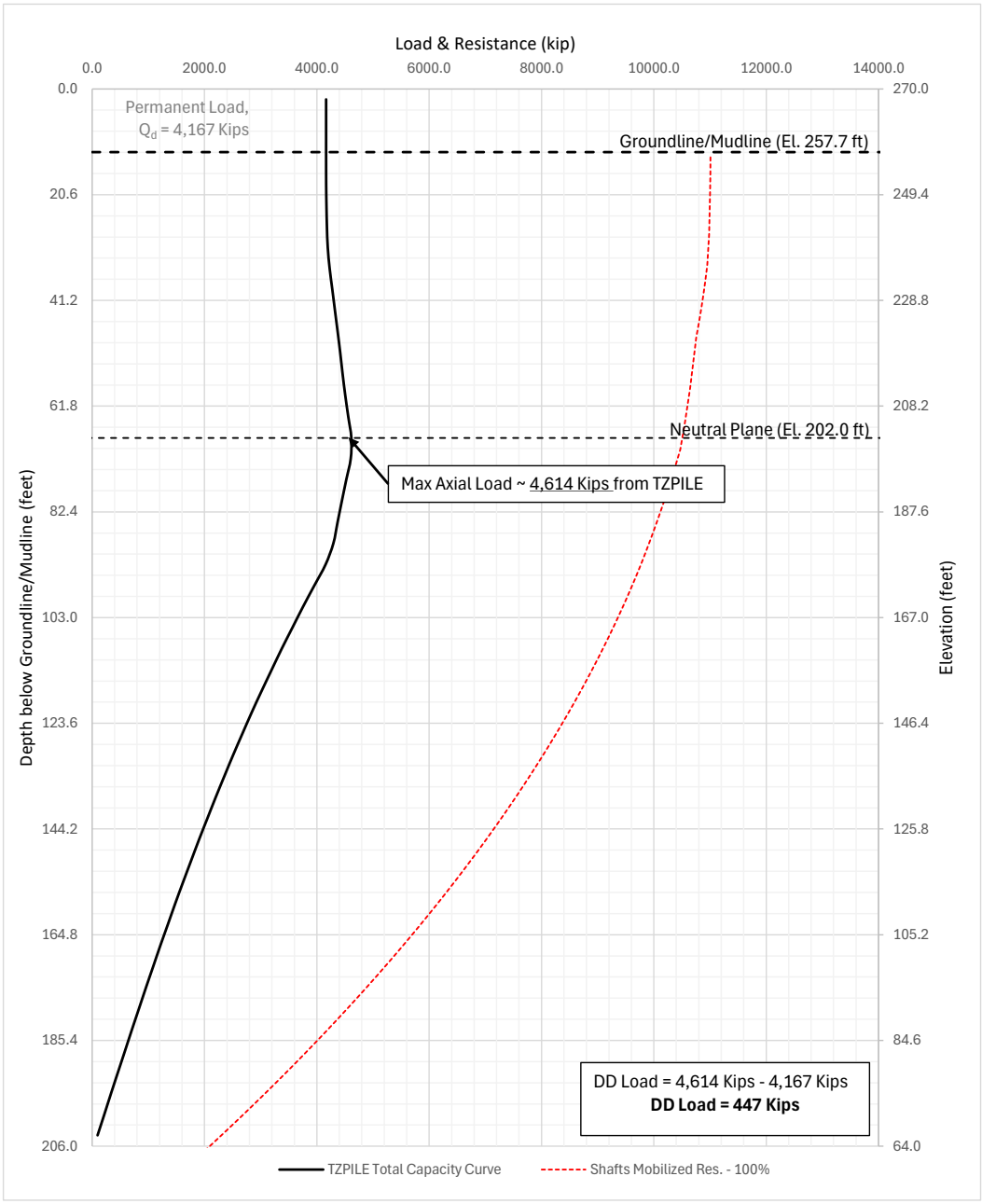


Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



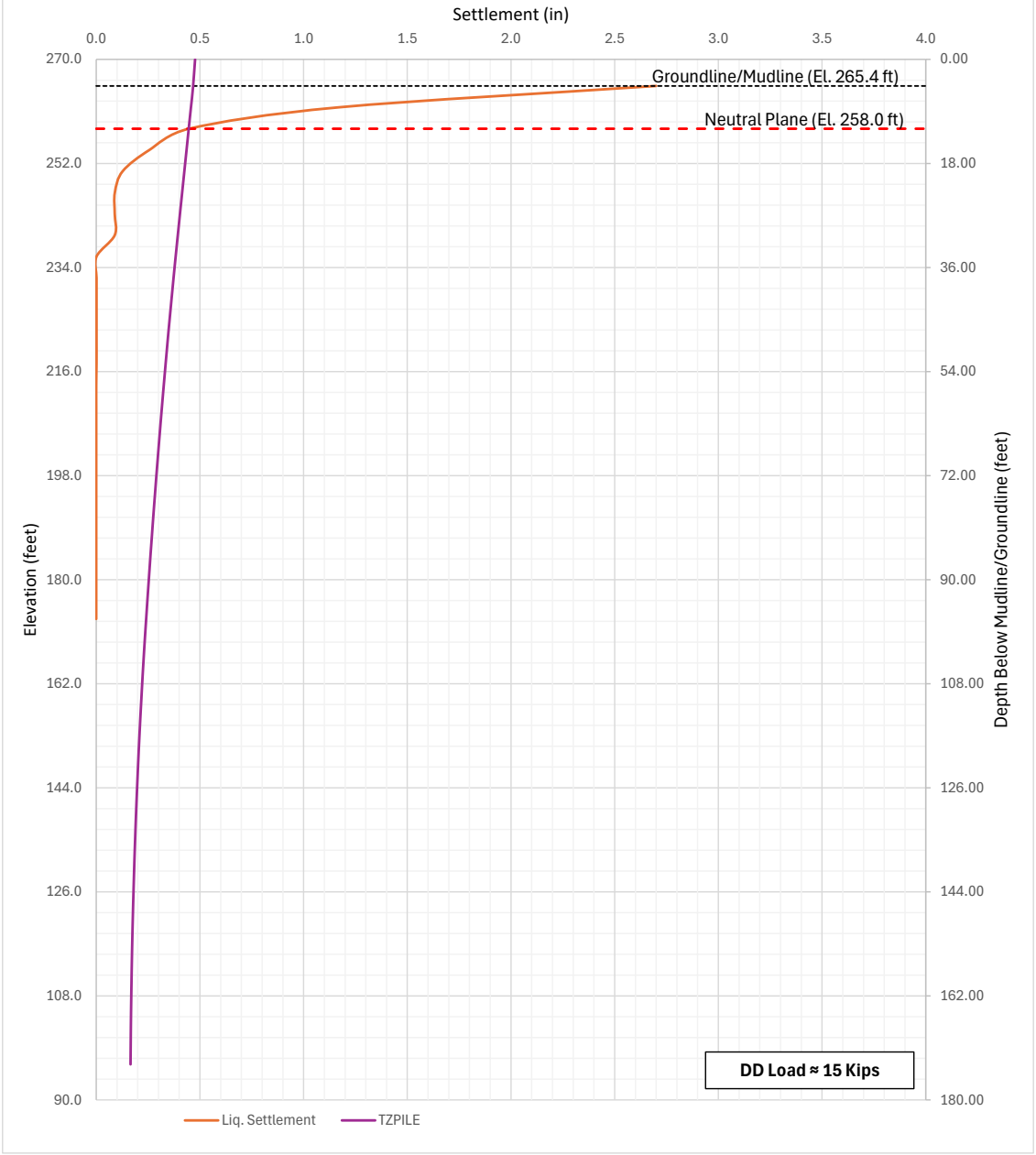
Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



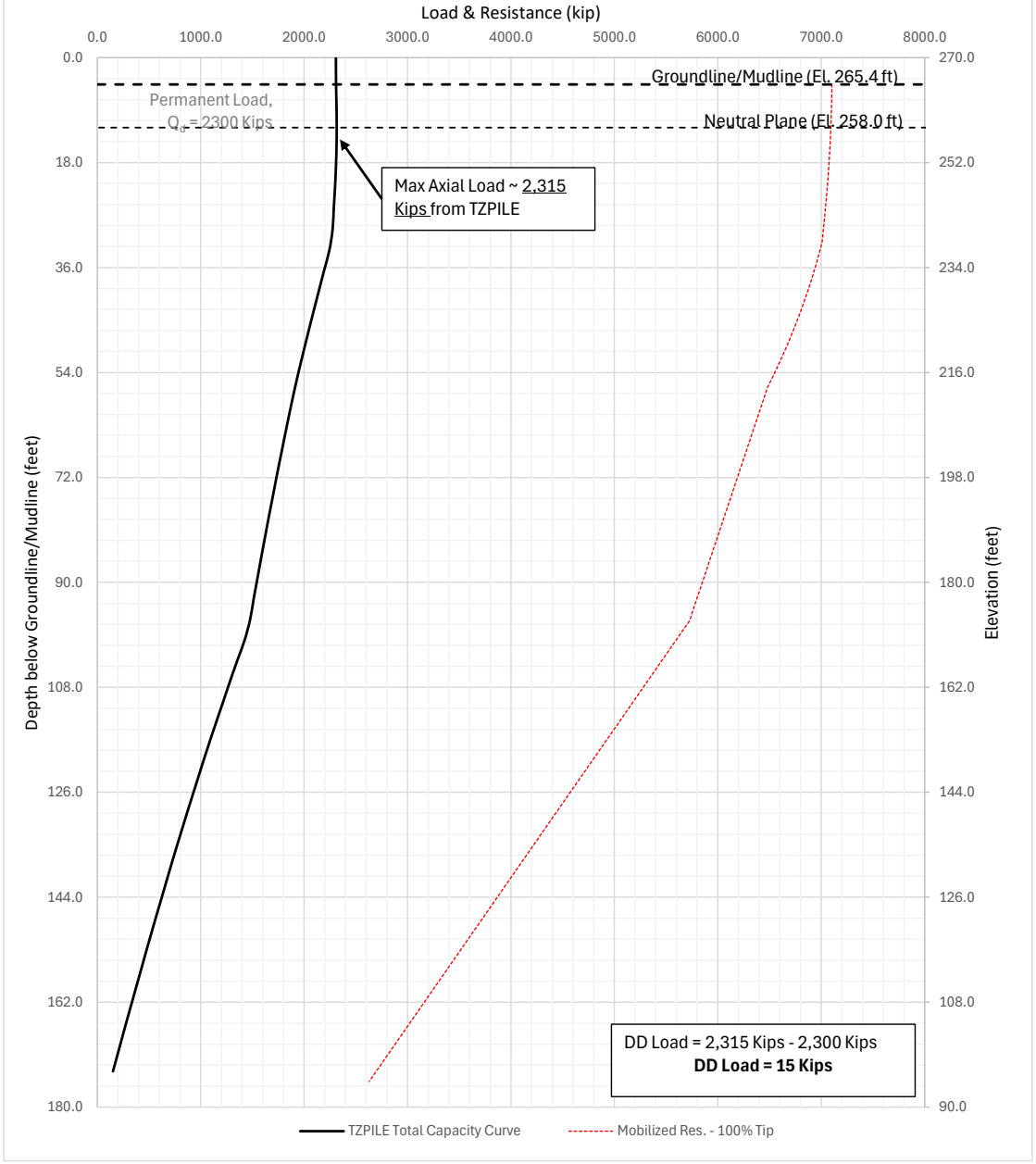
Prepared by:	Prepared for:	**Pier 6** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

PIER 7

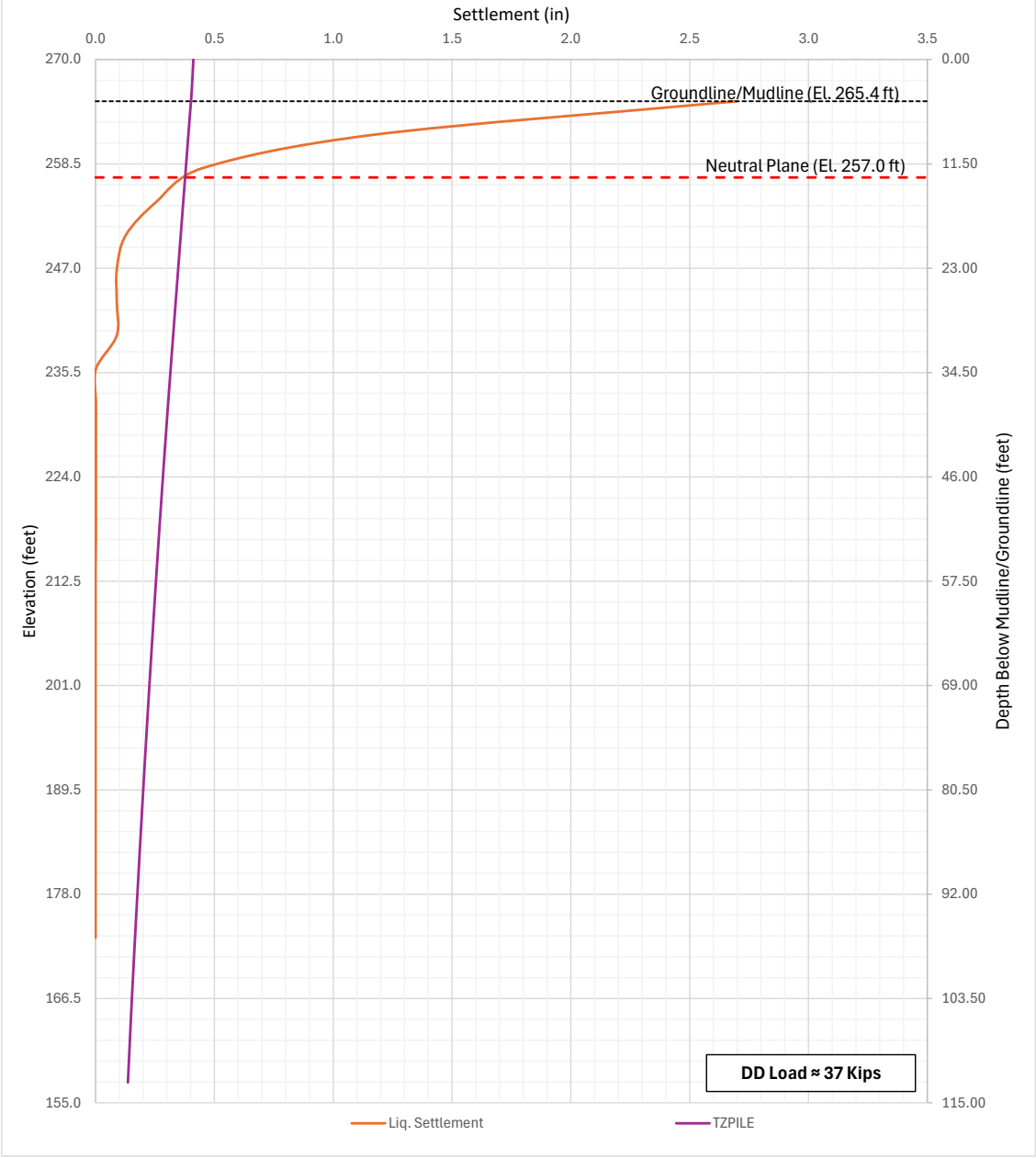
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date: 01/29/2026** **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

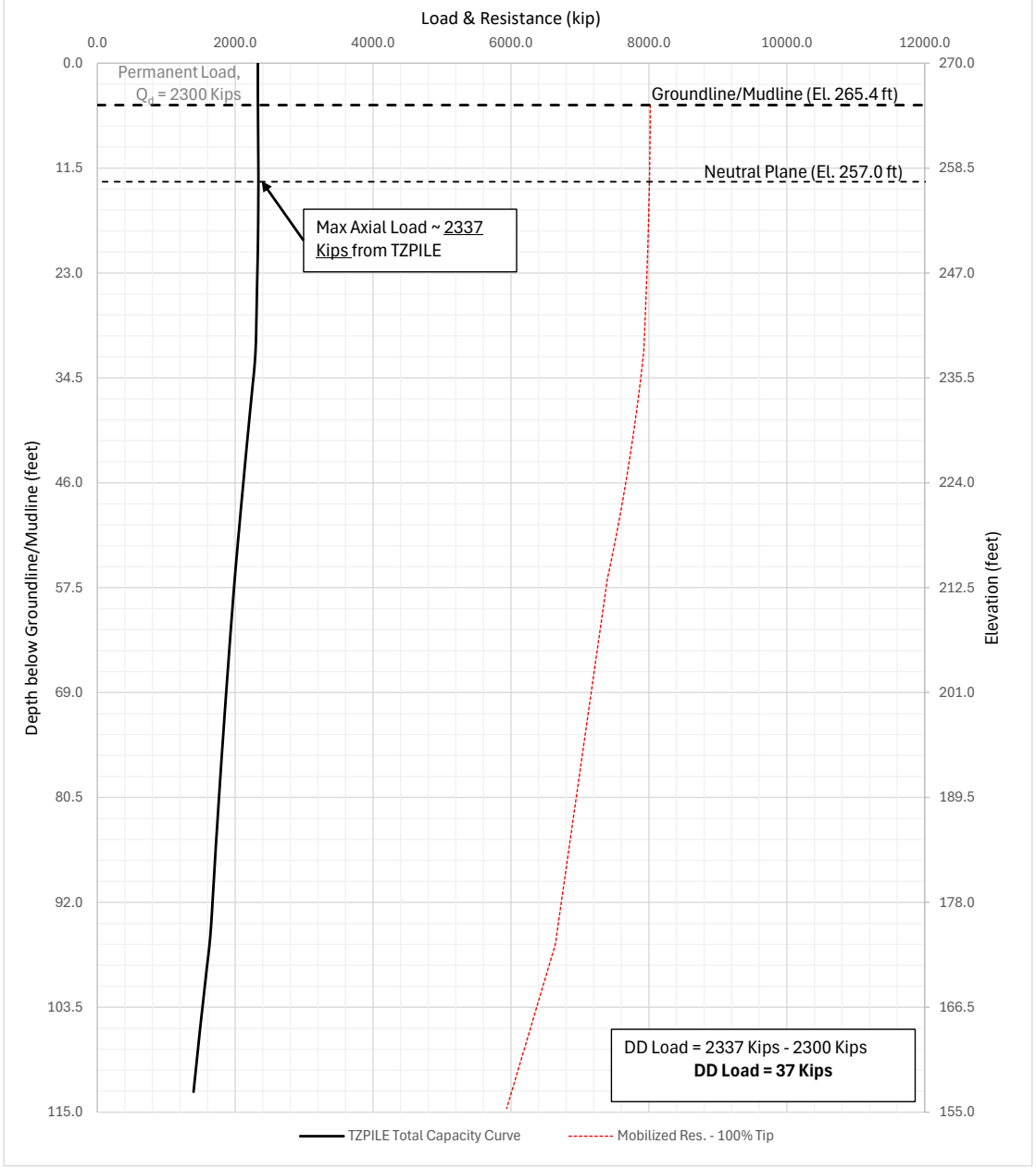


Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



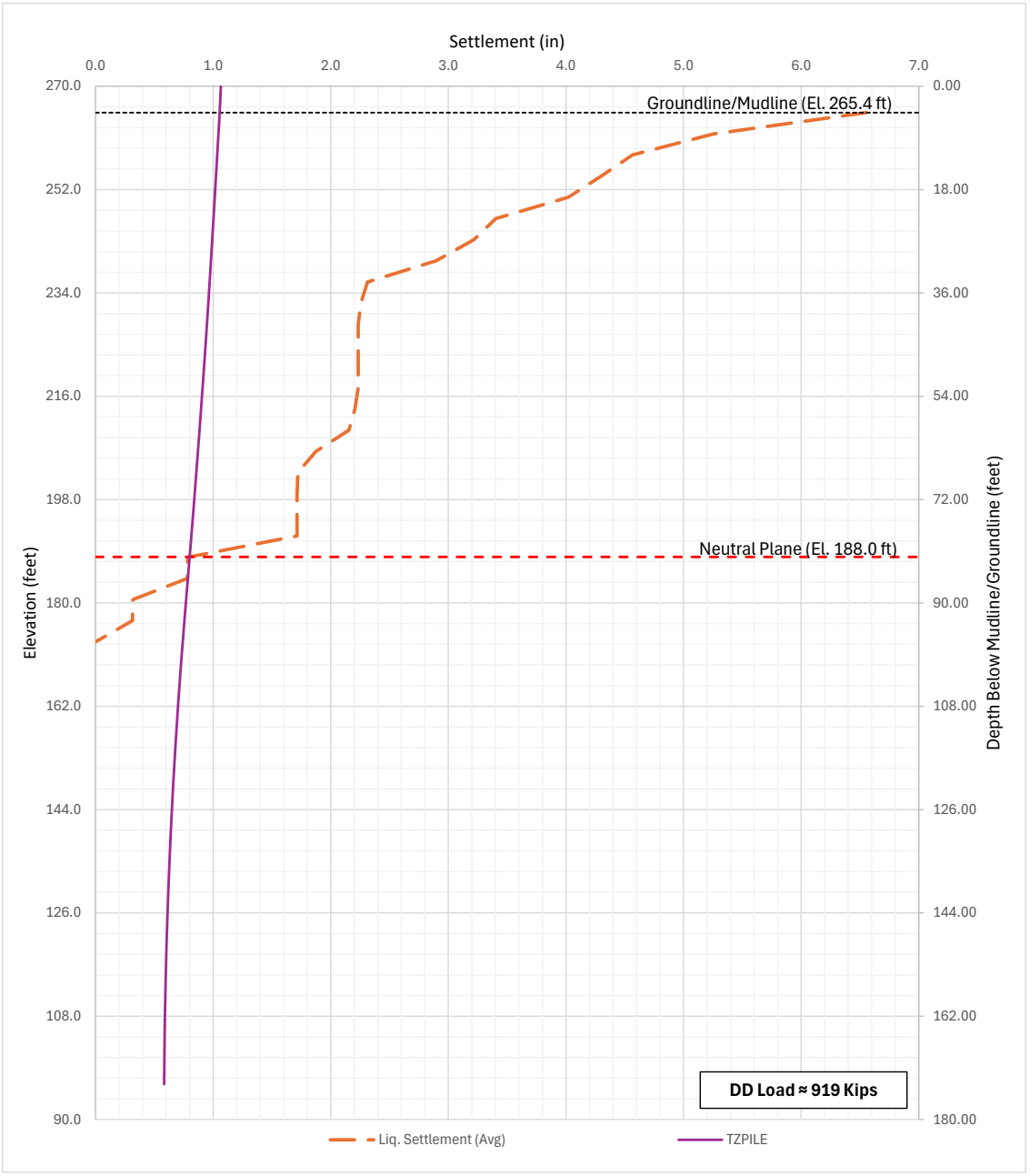
Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date: 01/29/2026** **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

C:\Users\RPINEDA\Documents\Geotechnical Engineering Resources\Cairo Bridge Stuff\Tzpile\Tzpile_100yr\Pier 7\Tzpile_With_CP\Pier 7_Downdrag_100YR_CP.xlsx



Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



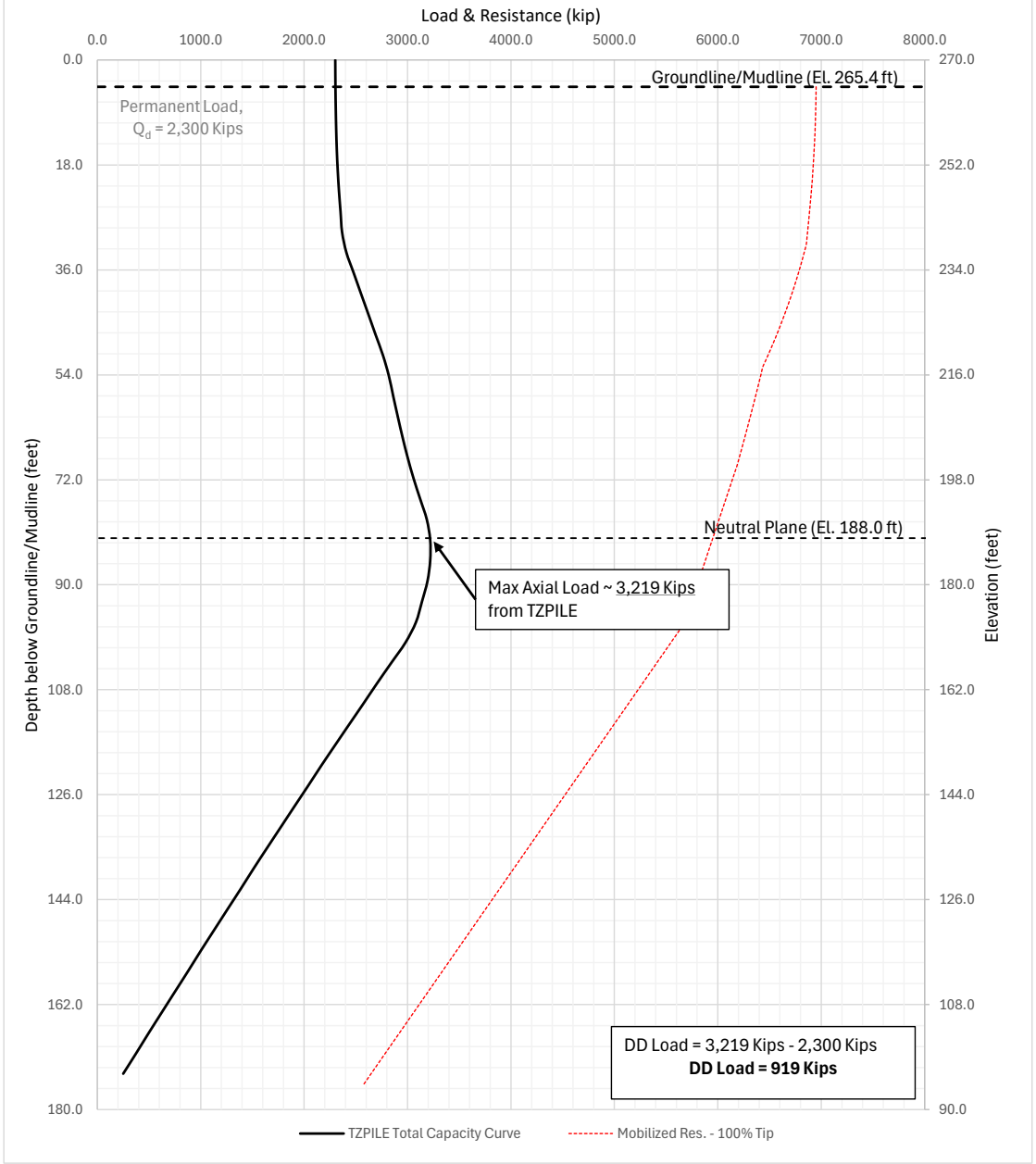
Prepared by:

Prepared for:

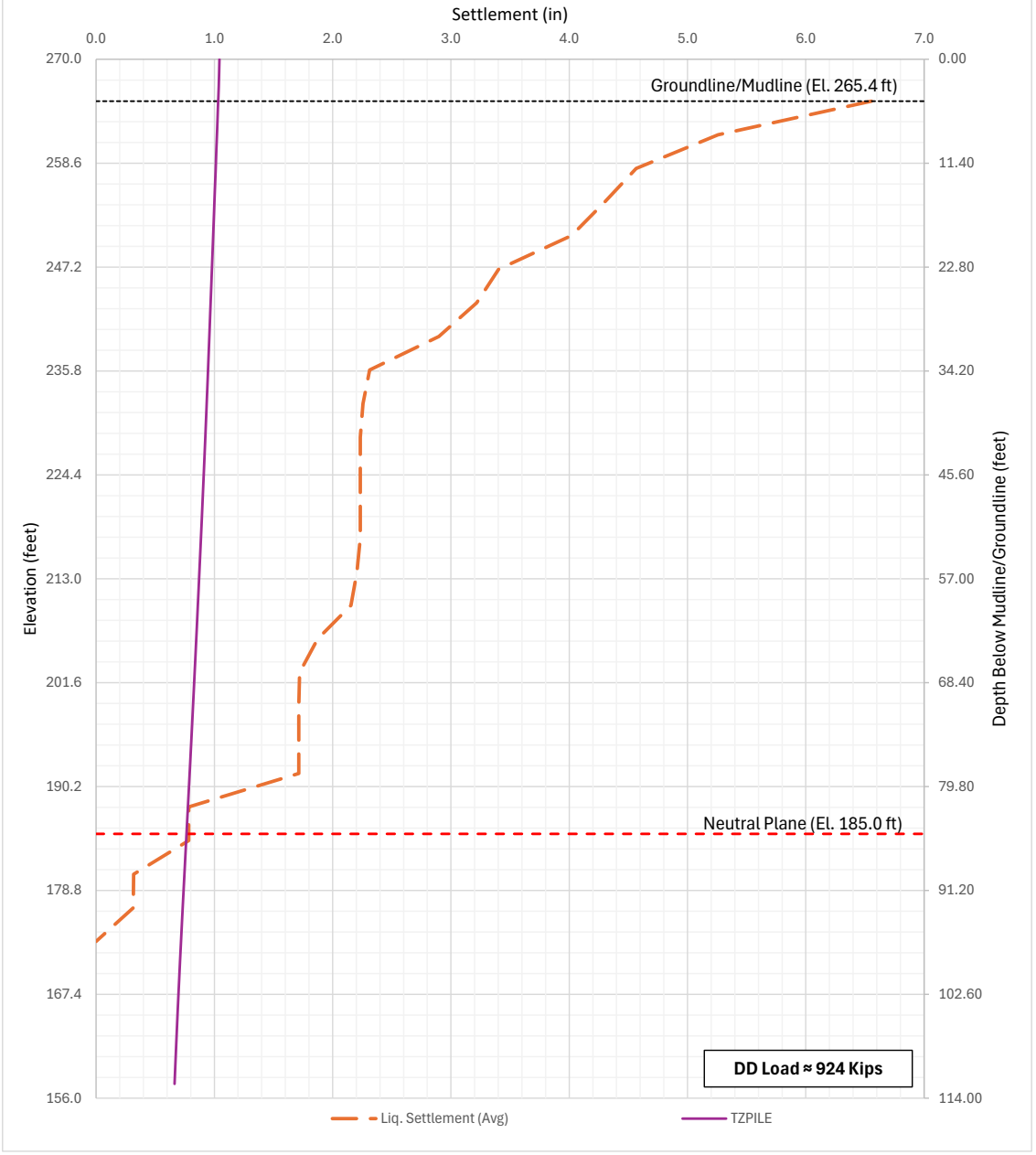
TEAM KENTUCKY
TRANSPORTATION CABINET

Pier 7
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Downdrag - 1000 YR Return Period

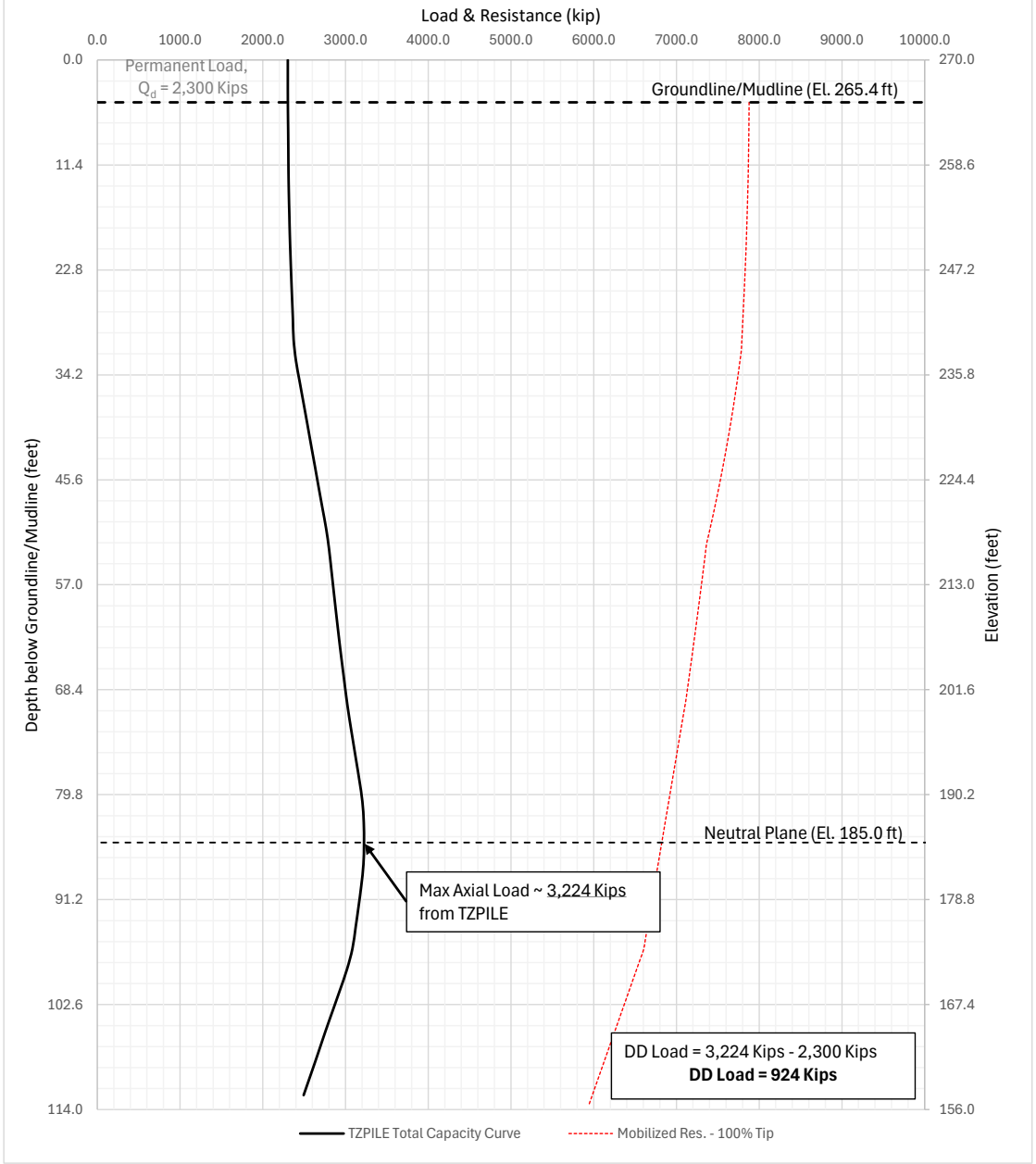
Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 01/27/2026
Drawn By: SKB **Figure No. ##**
Date: 01/26/2026



Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

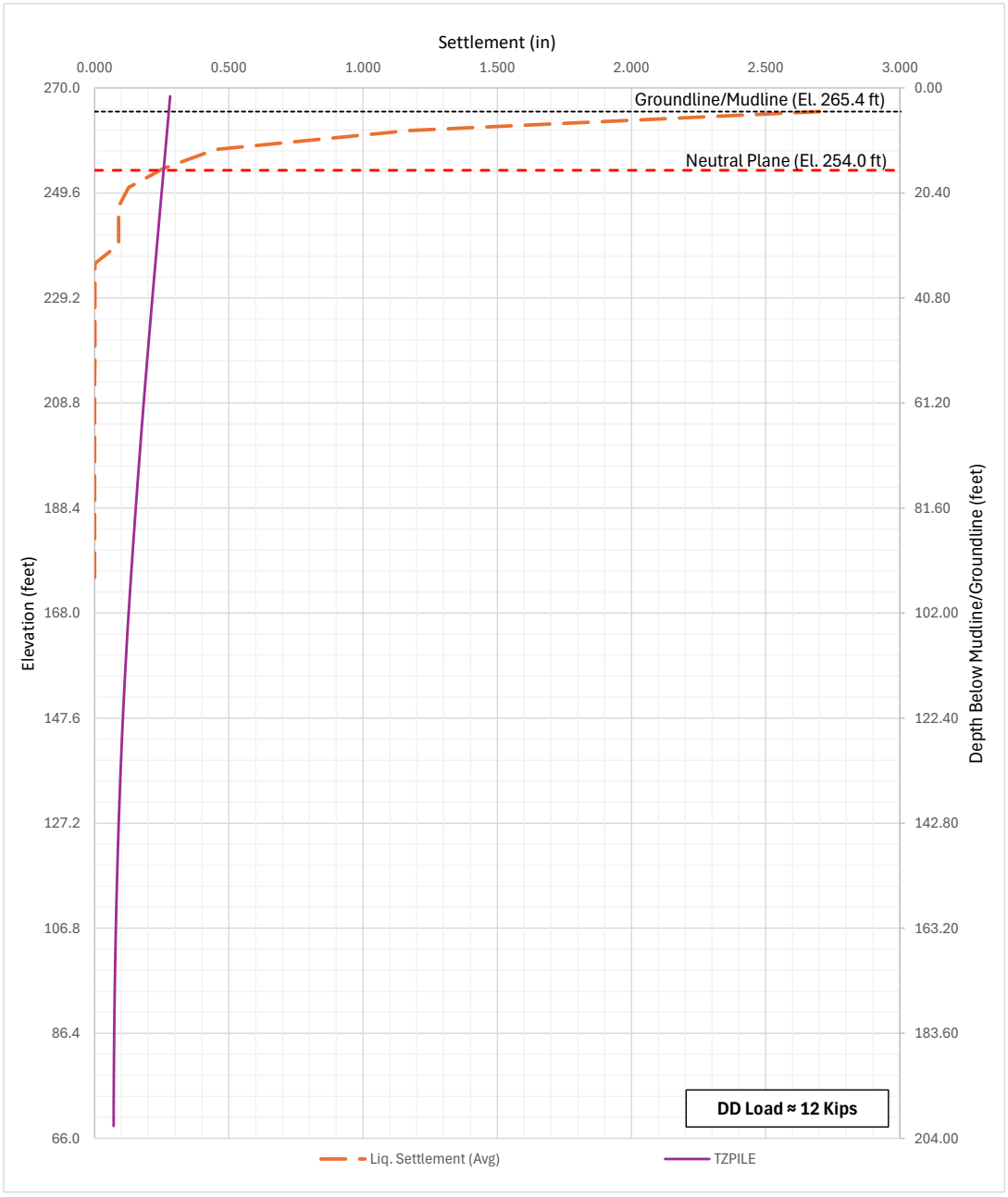


Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

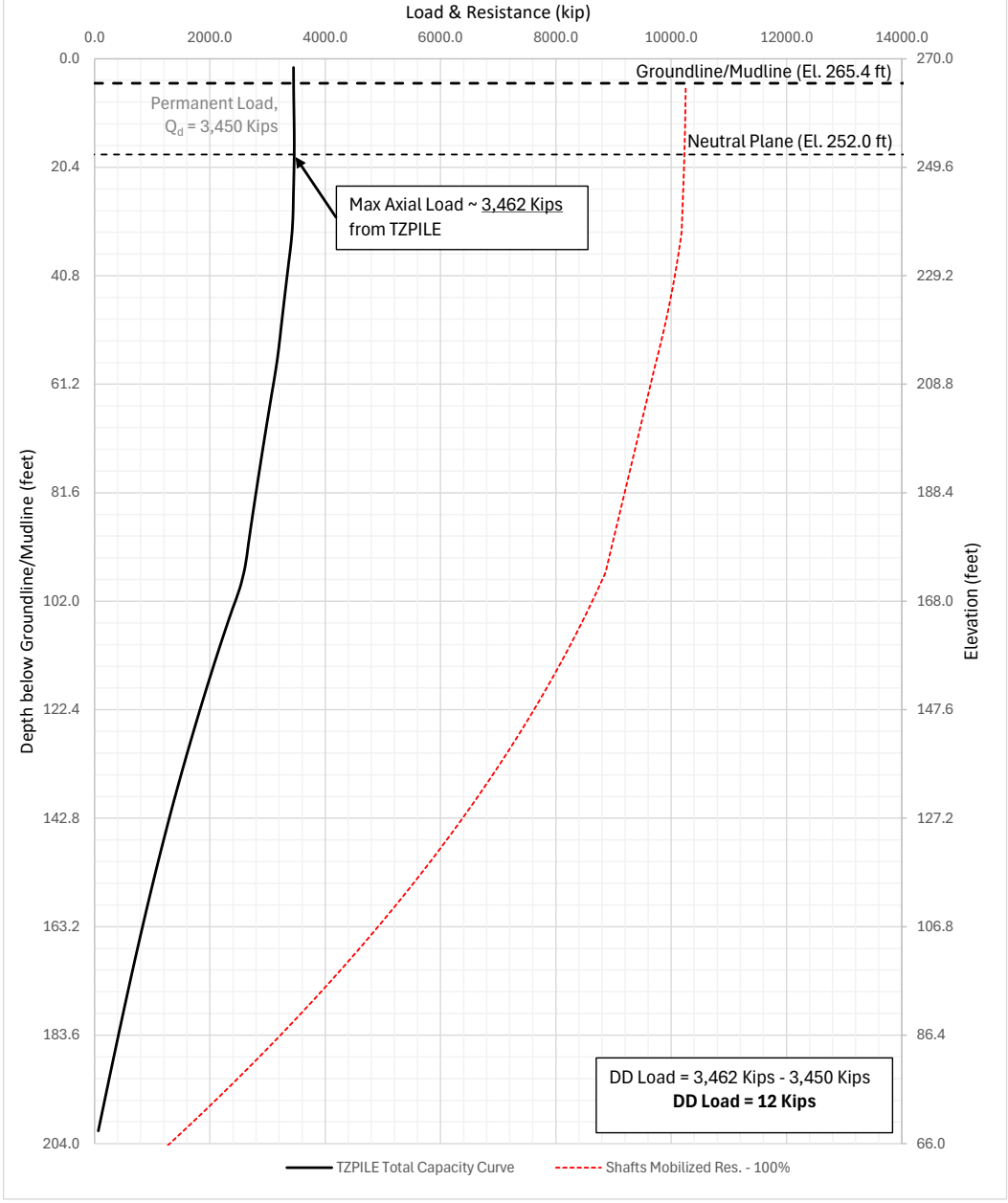


Prepared by:	Prepared for:	**Pier 7** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD

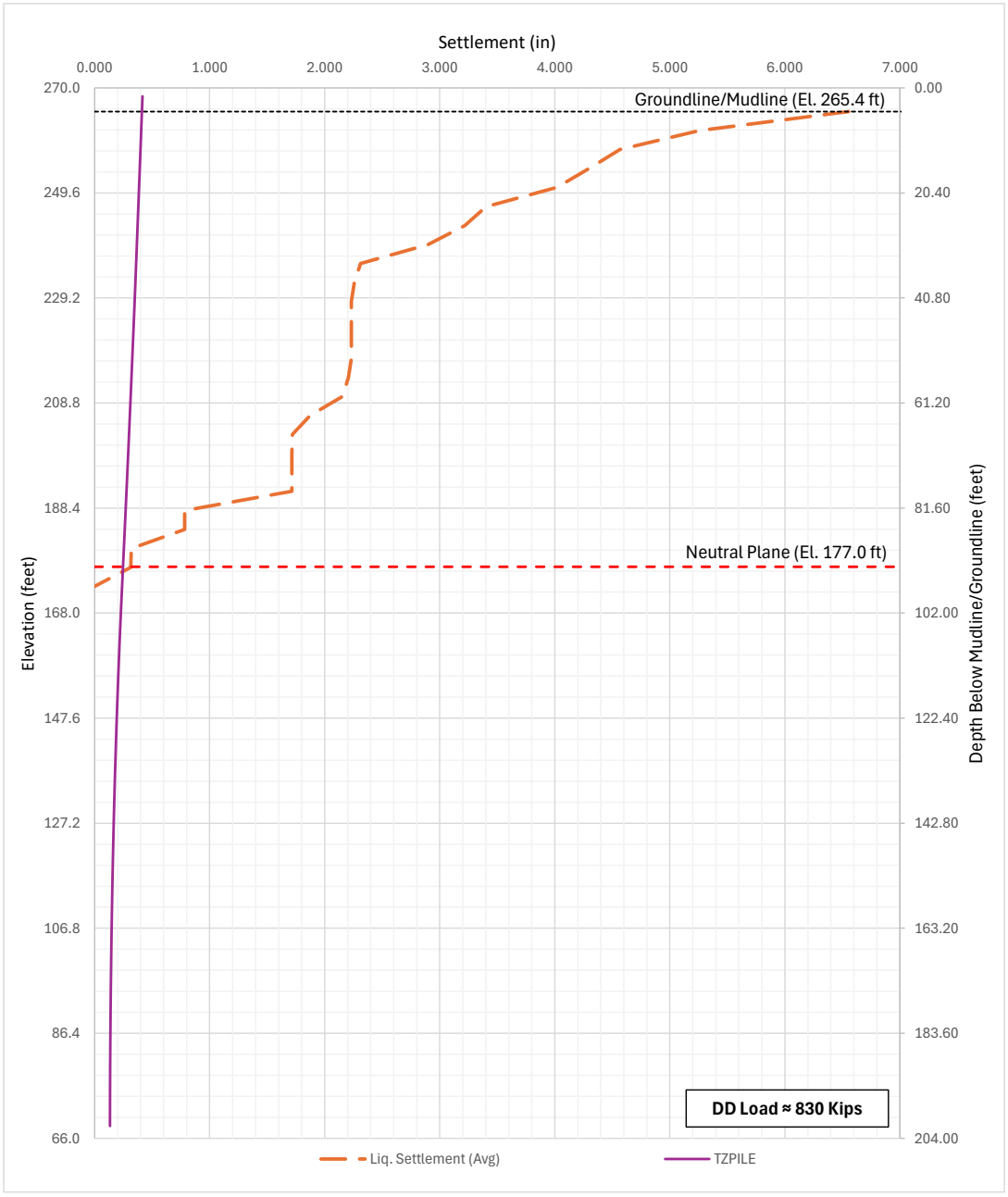


Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

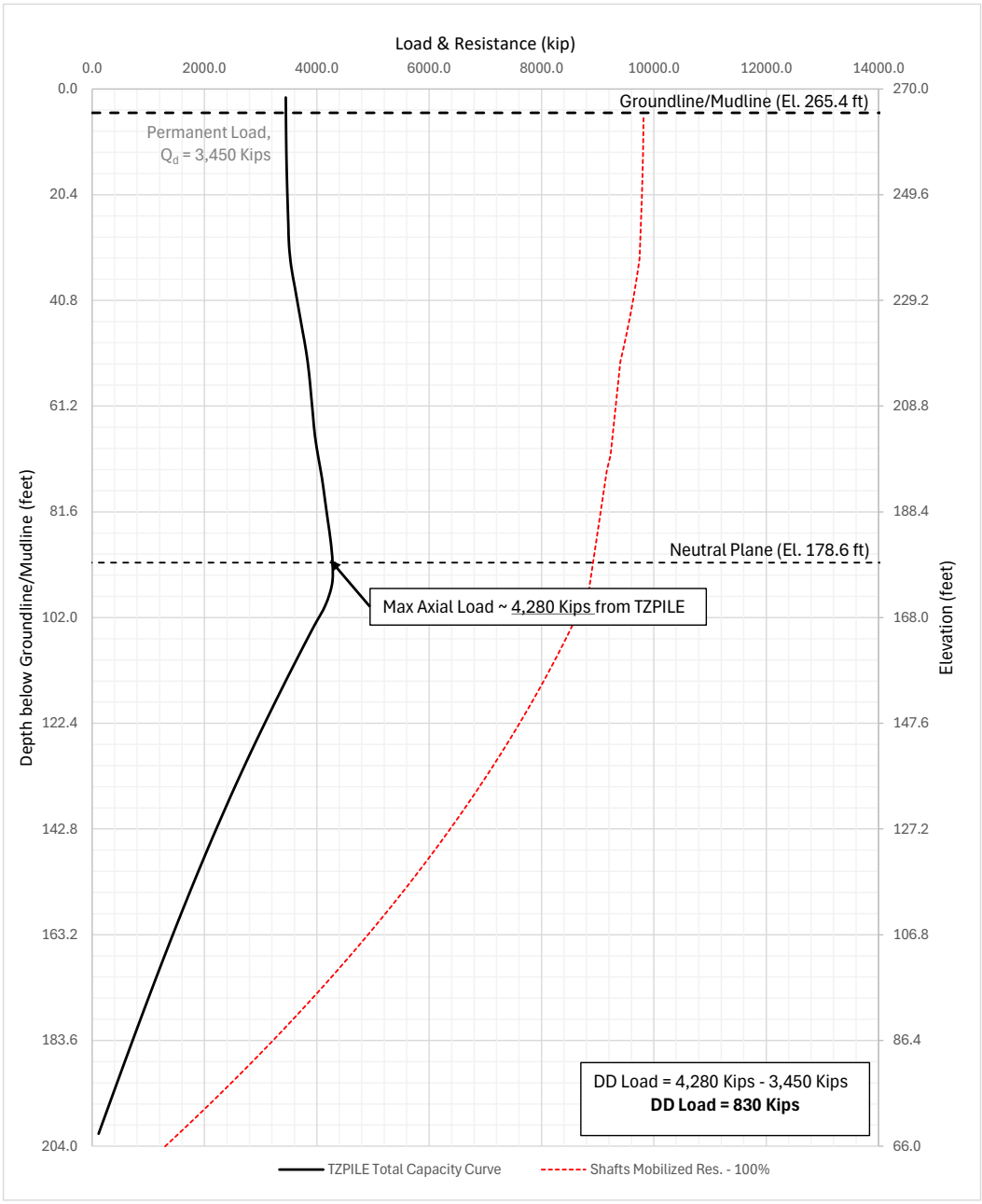


Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



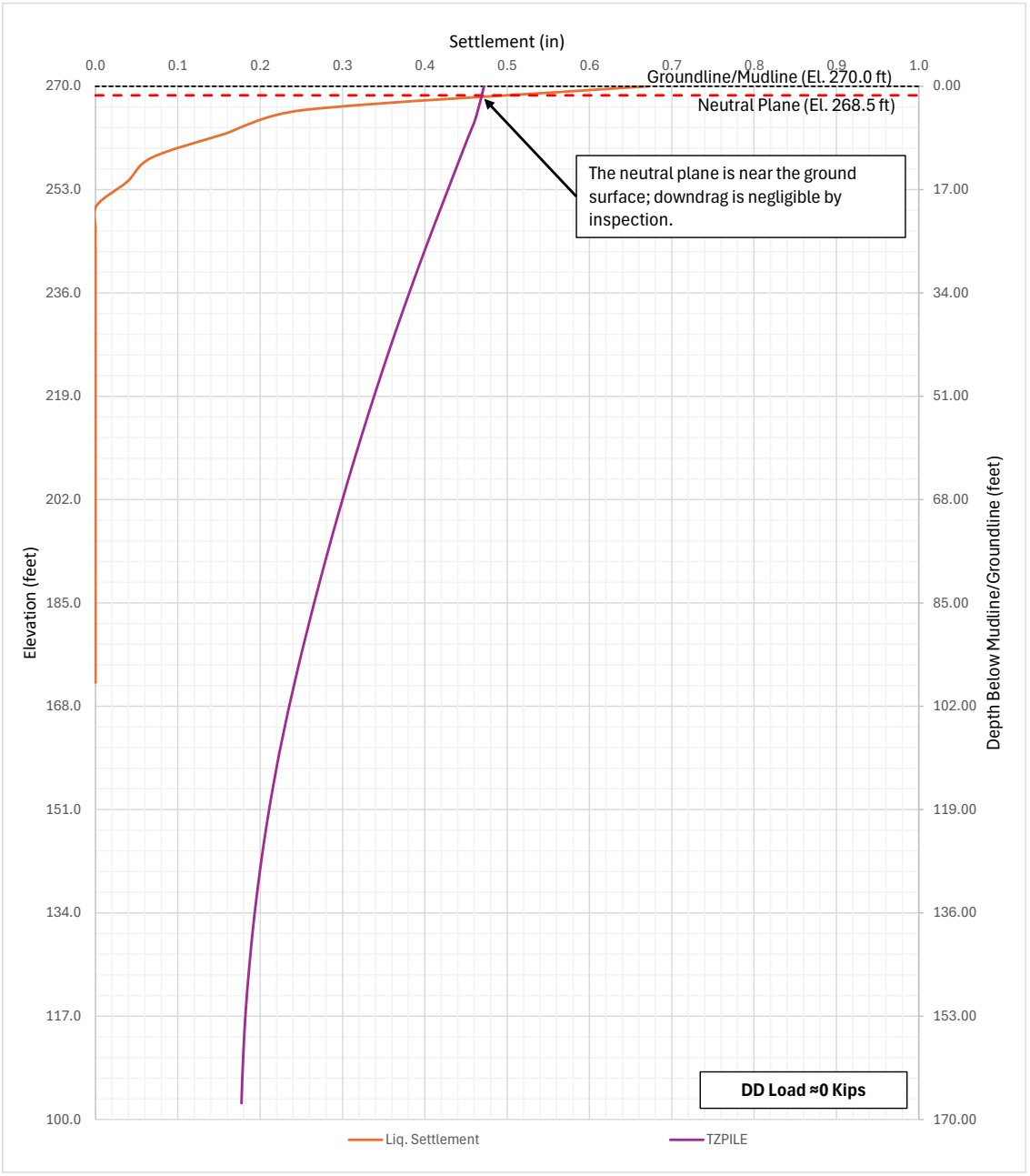
Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



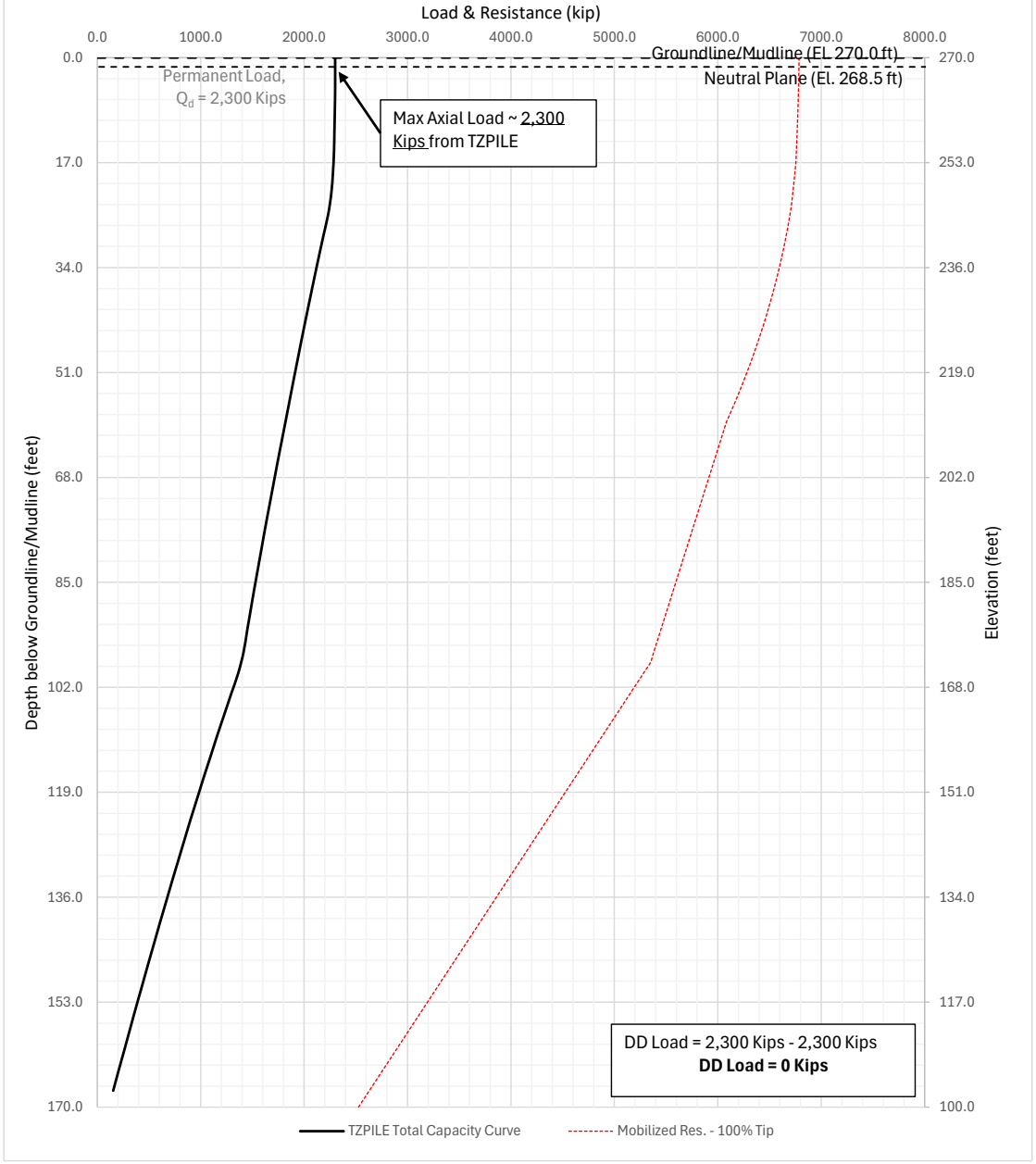
Prepared by:	Prepared for:	**Pier 7** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

PIER 8

PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 1/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025



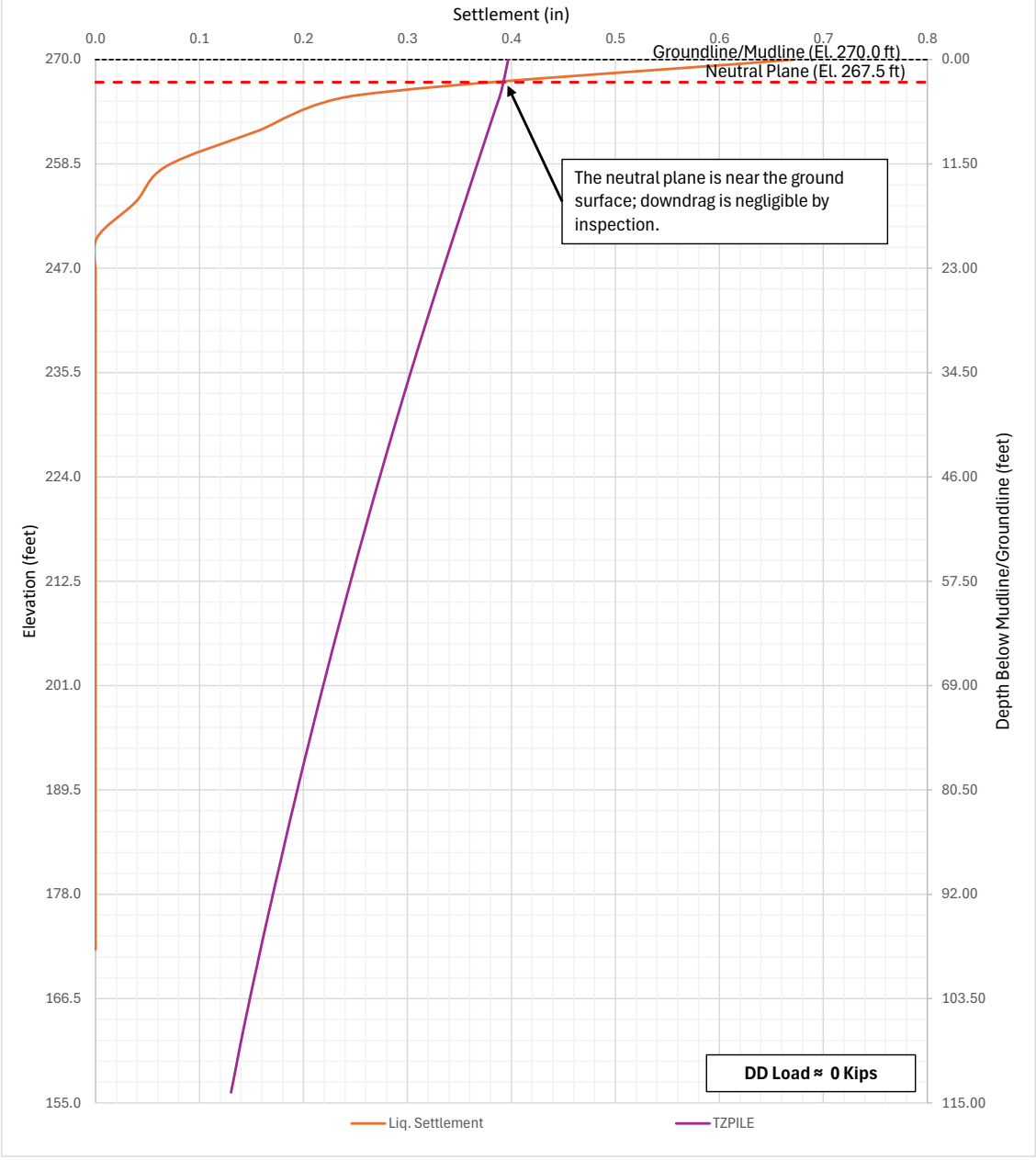
Prepared by:

Prepared for:

TEAM KENTUCKY
TRANSPORTATION CABINET

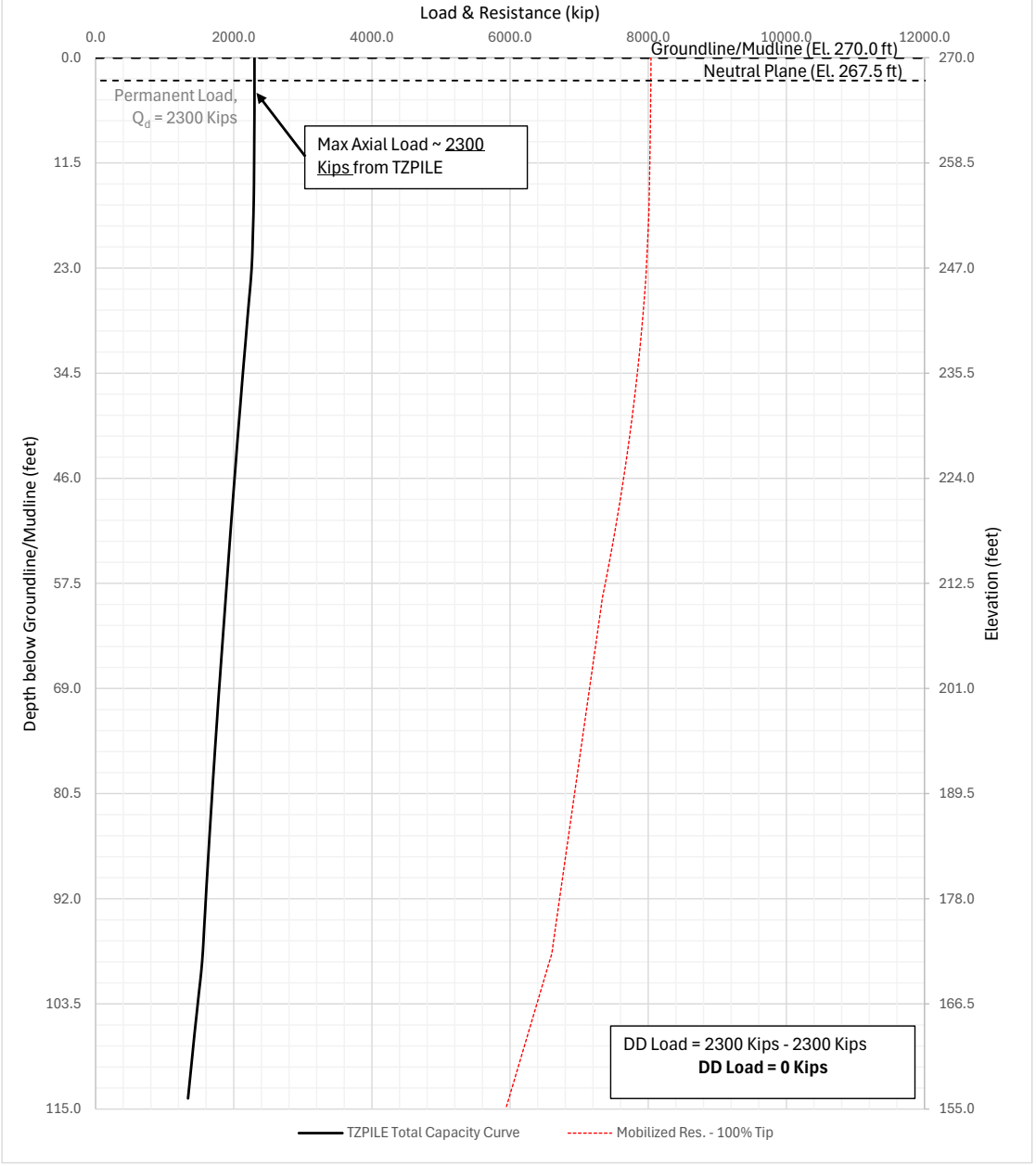
Pier 8
72-inch Diameter x 1.5-inch Wall Steel Pipe Pile
Downdrag via Partial Mobilization

Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: MJS **Review Date:** 1/29/2026
Drawn By: SKB **Figure No. ##**
Date: 11/25/2025



Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

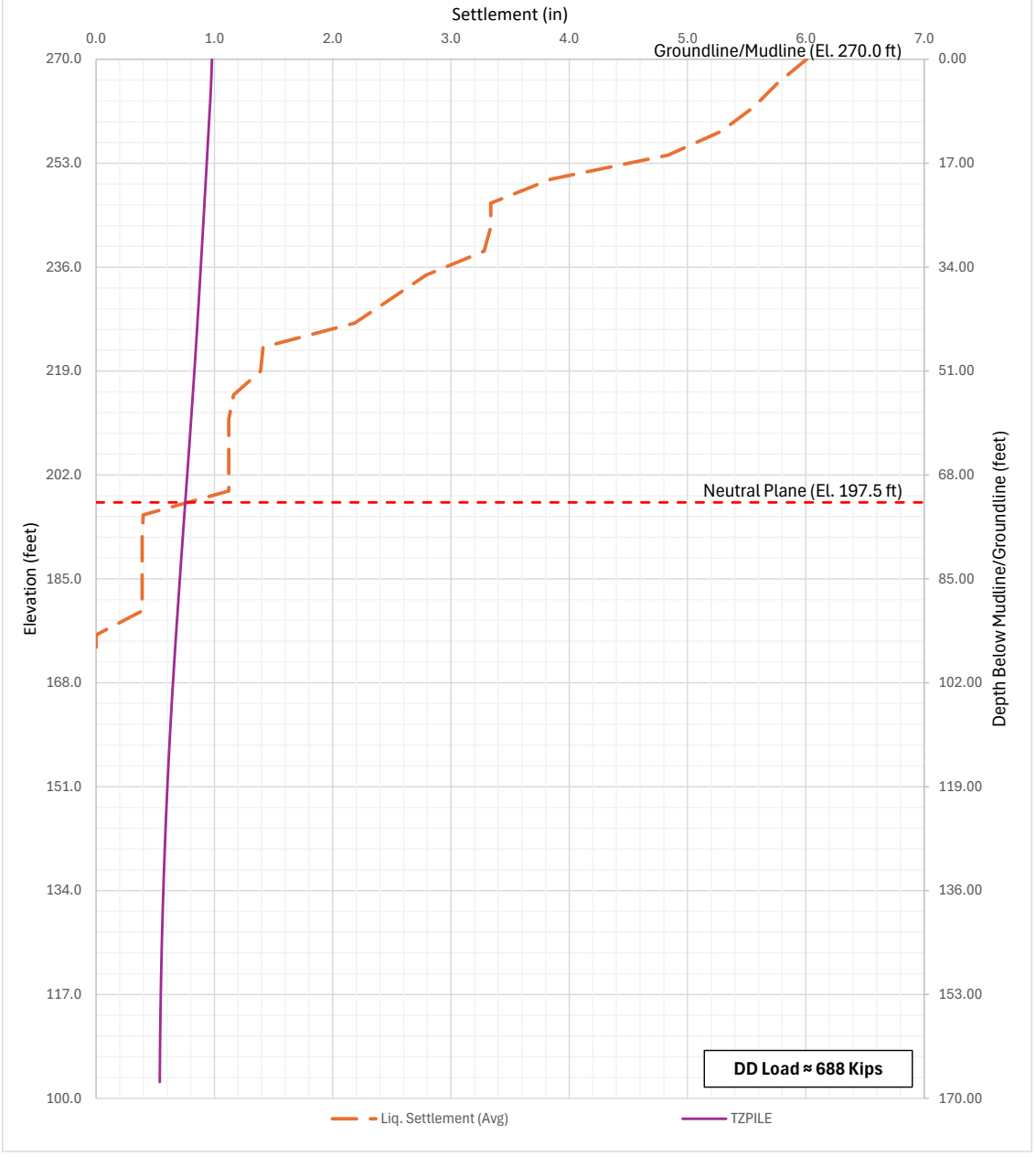
C:\Users\RPINEDA\Documents\Geotechnical Engineering Resources\Cairo Bridge Stuff\Tzpile\Tzpile_100yr\Pier 8\Tzpile_With_CP\Pier 8_Downdrag_100YR_CP.xlsx



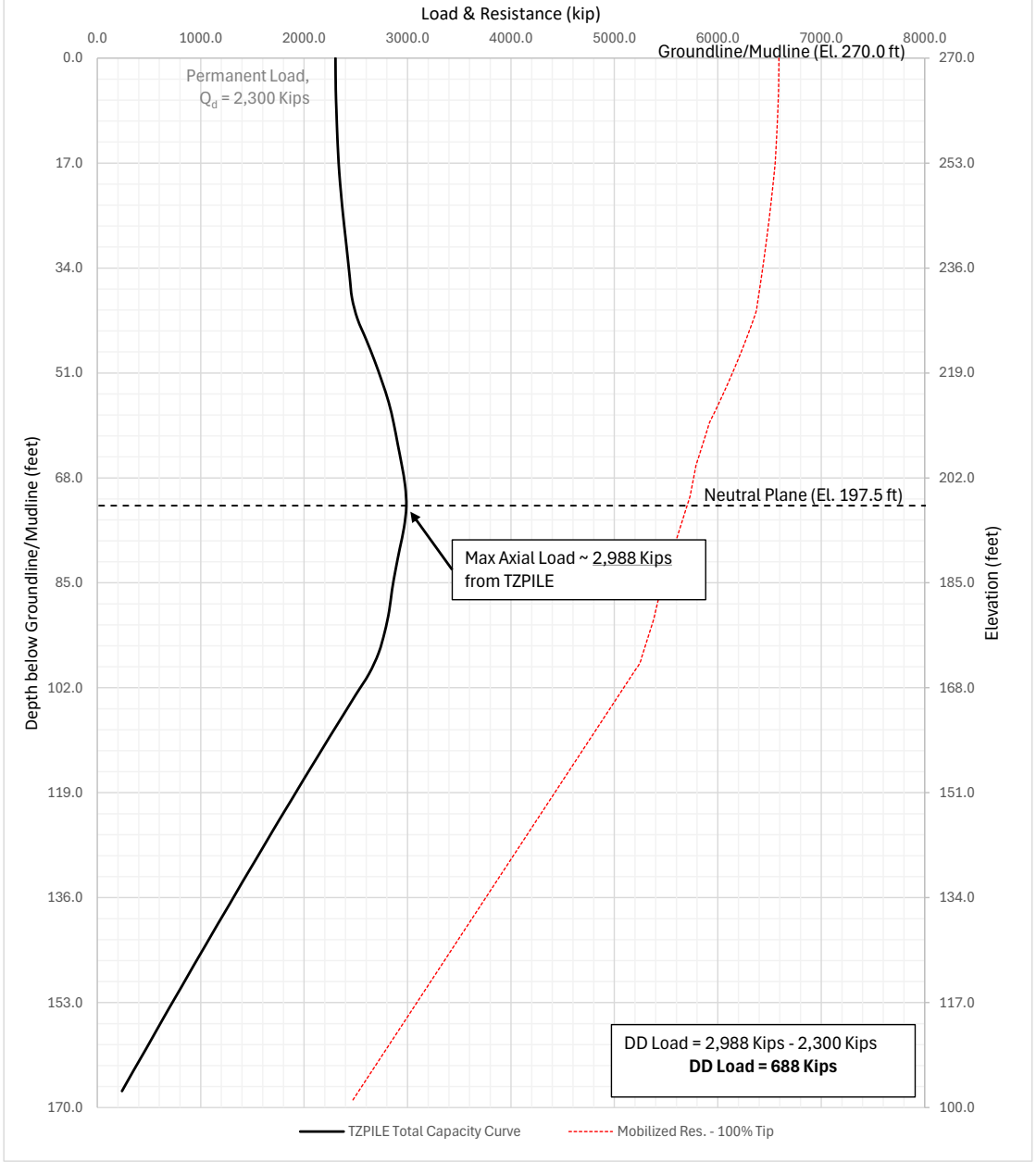
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** MJS **Review Date:** 01/29/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 11/25/2025

C:\Users\RPINEDA\Documents\Geotechnical Engineering Resources\Cairo Bridge Stuff\Tzpile\Tzpile_100yr\Pier 8\Tzpile_With_CP\Pier 8_Downdrag_100YR_CP.xlsx

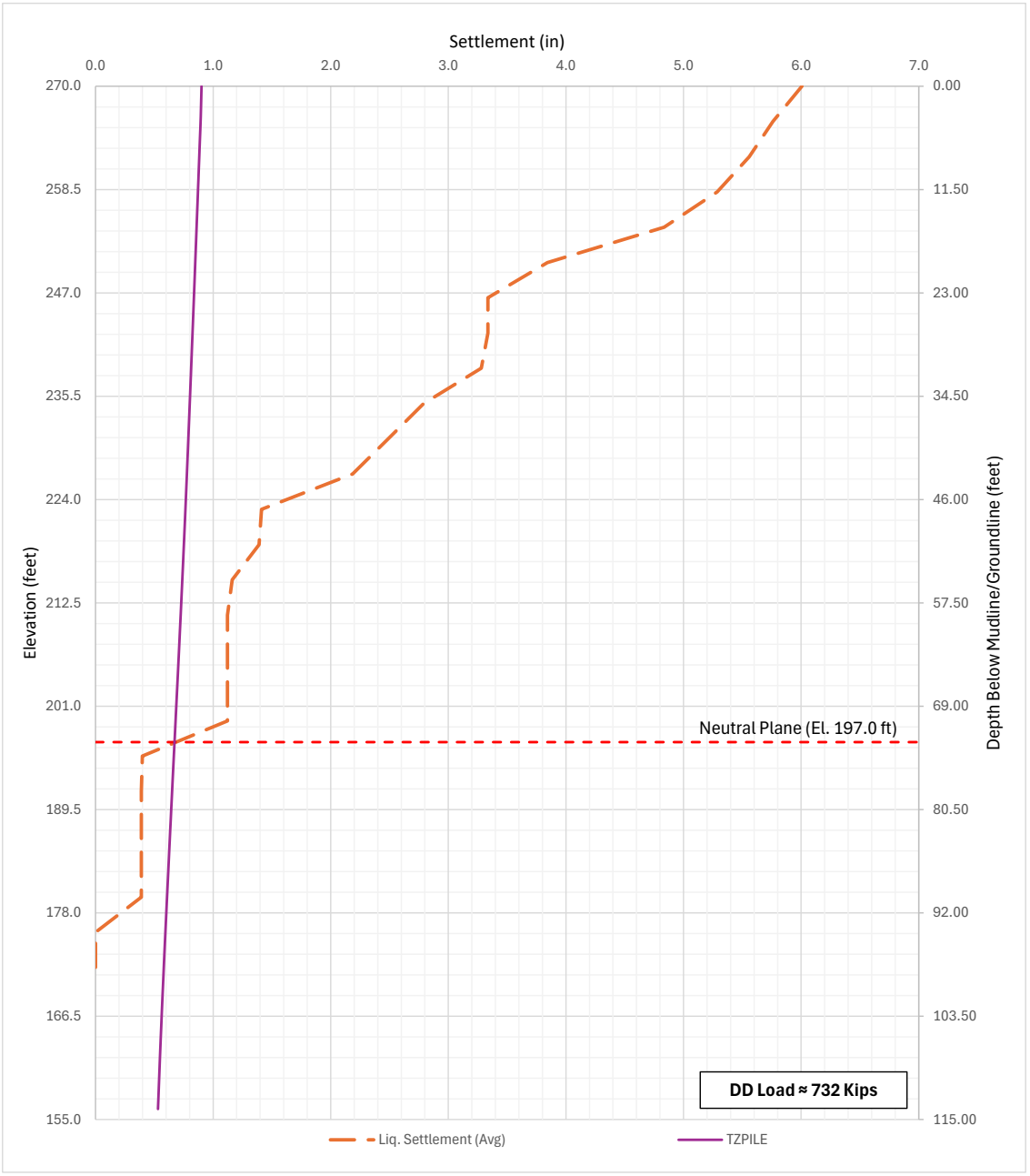
PIPE PILE NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



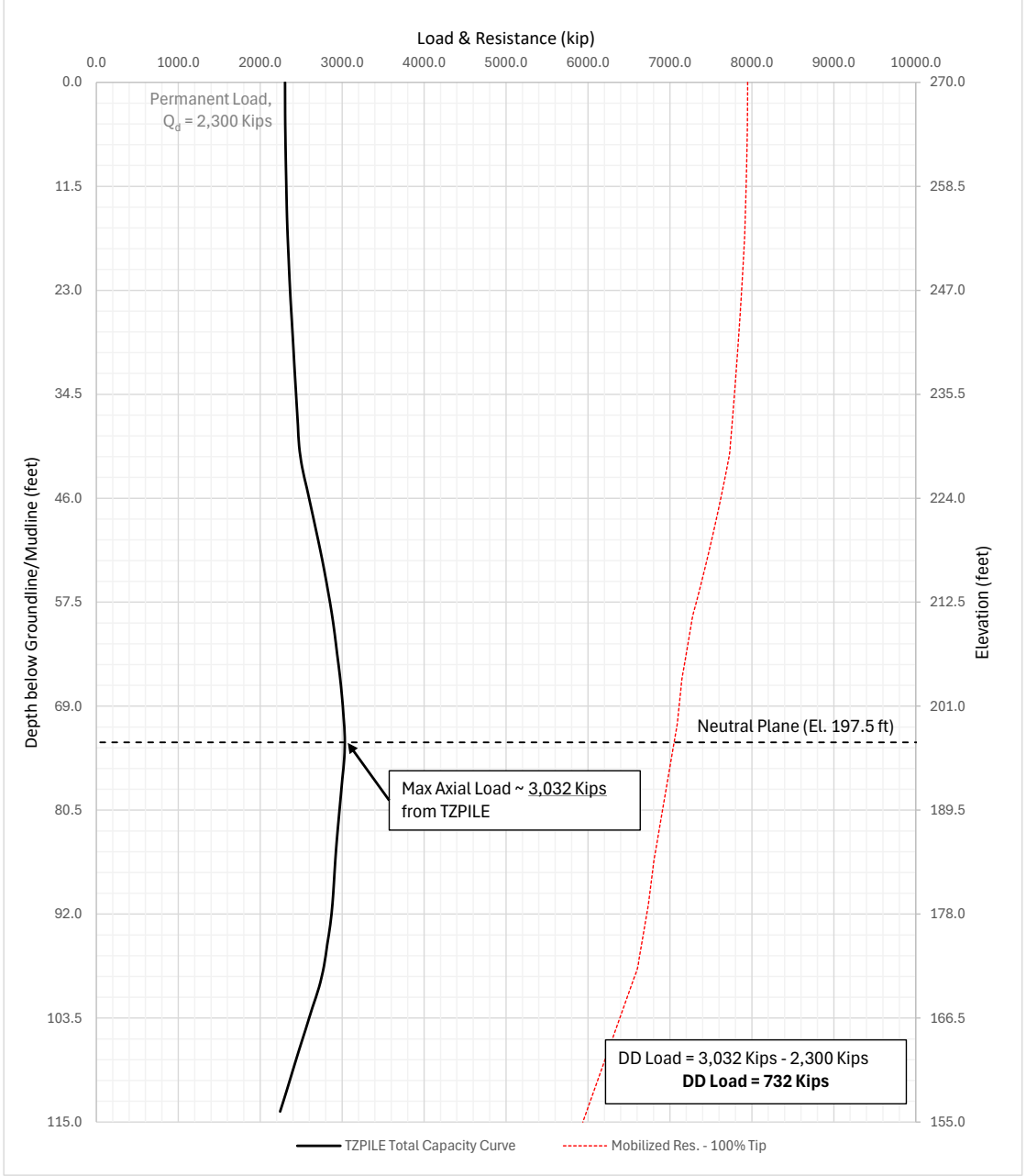
Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter x 1.5-inch Wall Steel Pipe Pile** **Downdrag via Partial Mobilization**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

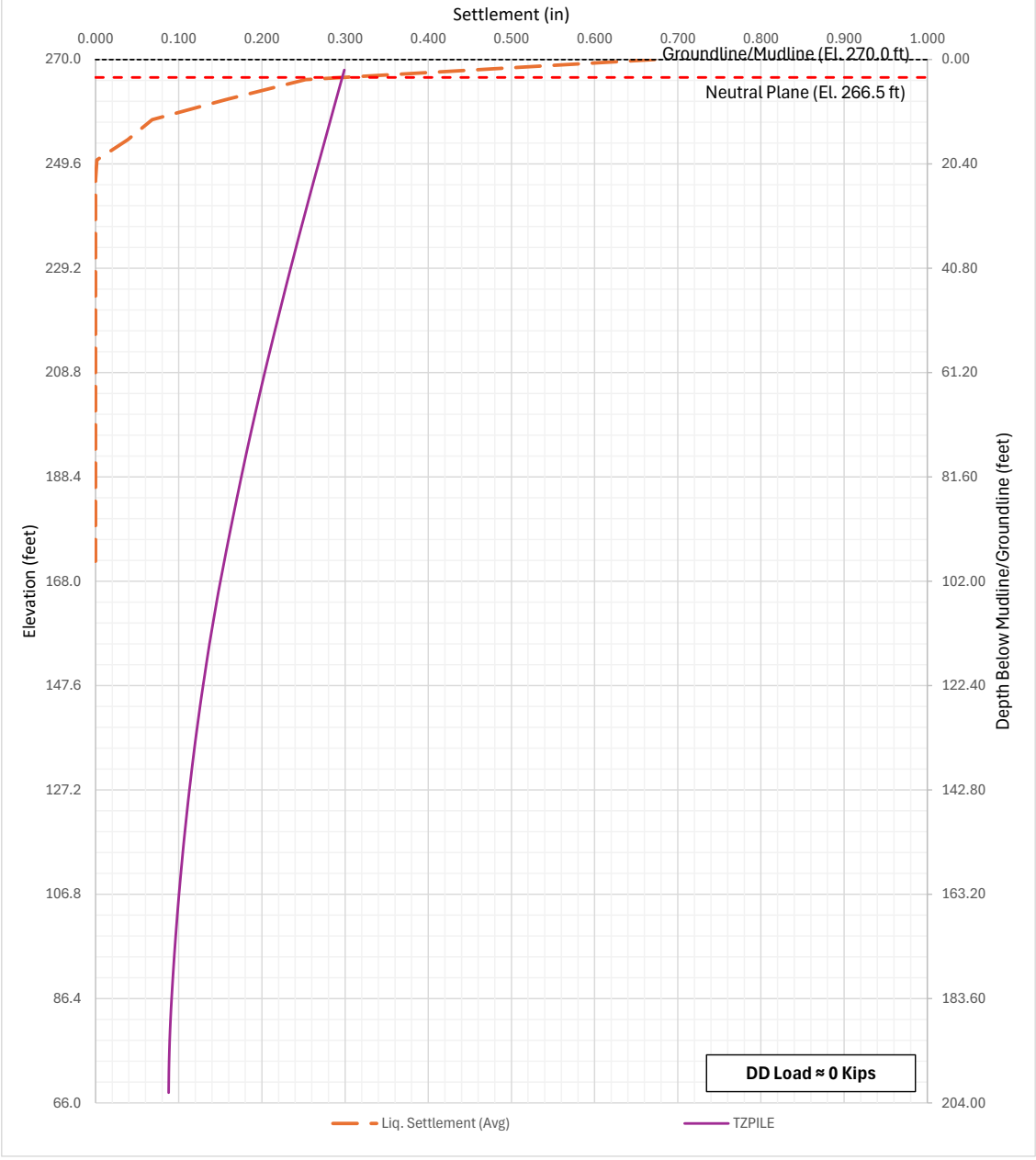


Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

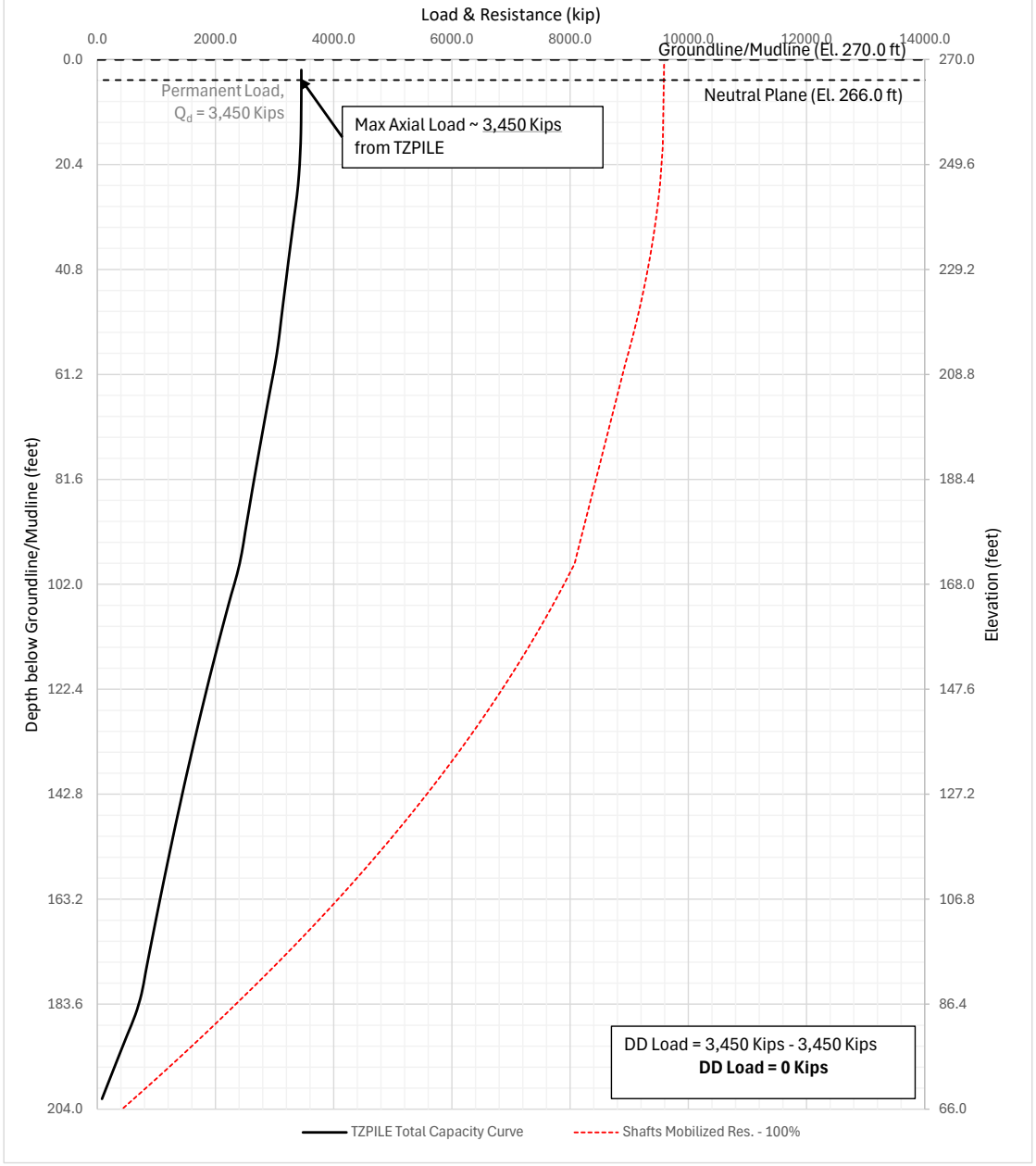


Prepared by:	Prepared for:	**Pier 8** **72-inch Diameter Pipe Pile w/ C.P.** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 100-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft** **Downdrag - 100 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



Prepared by:

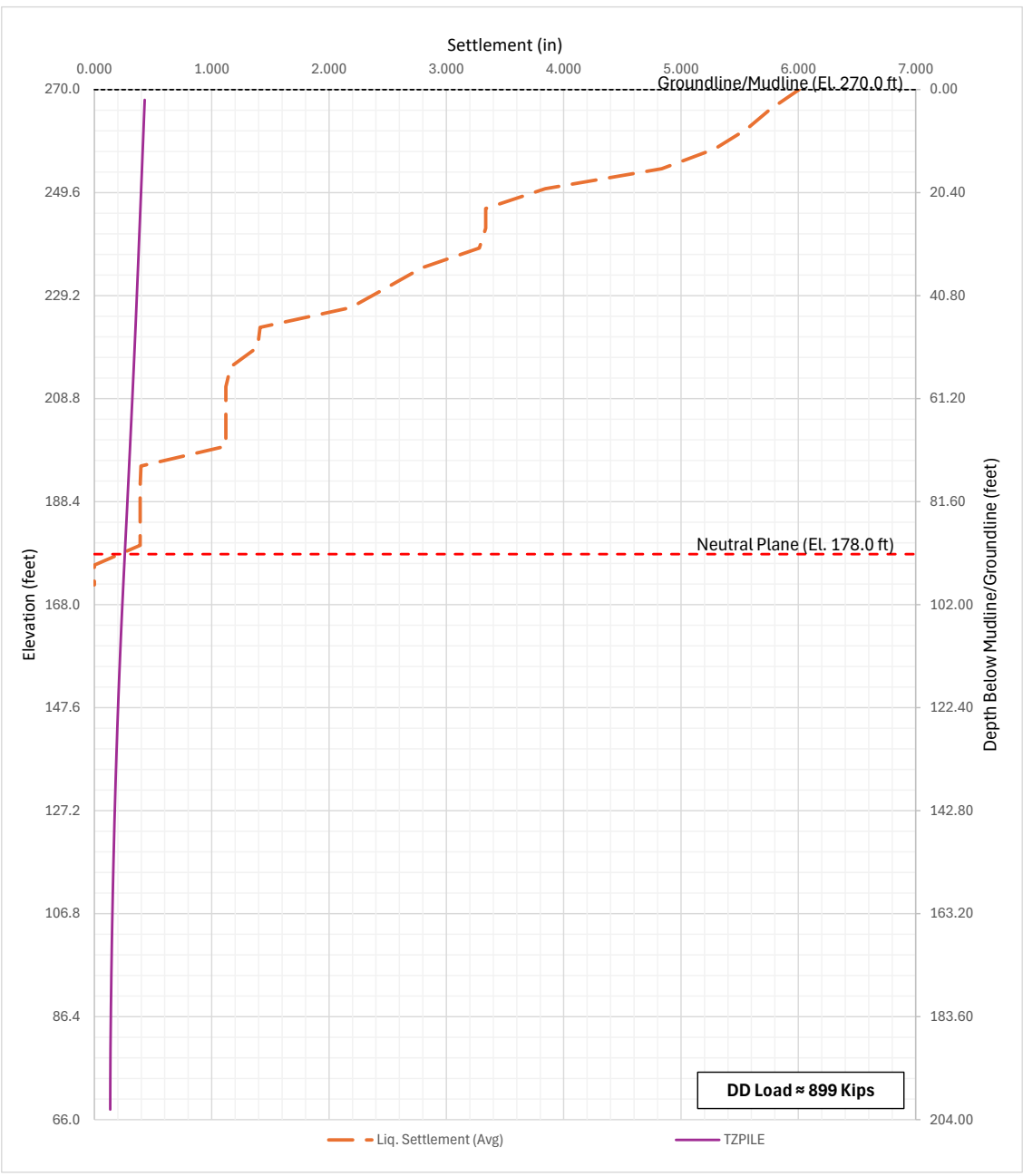
Prepared for:

TEAM KENTUCKY TRANSPORTATION CABINET

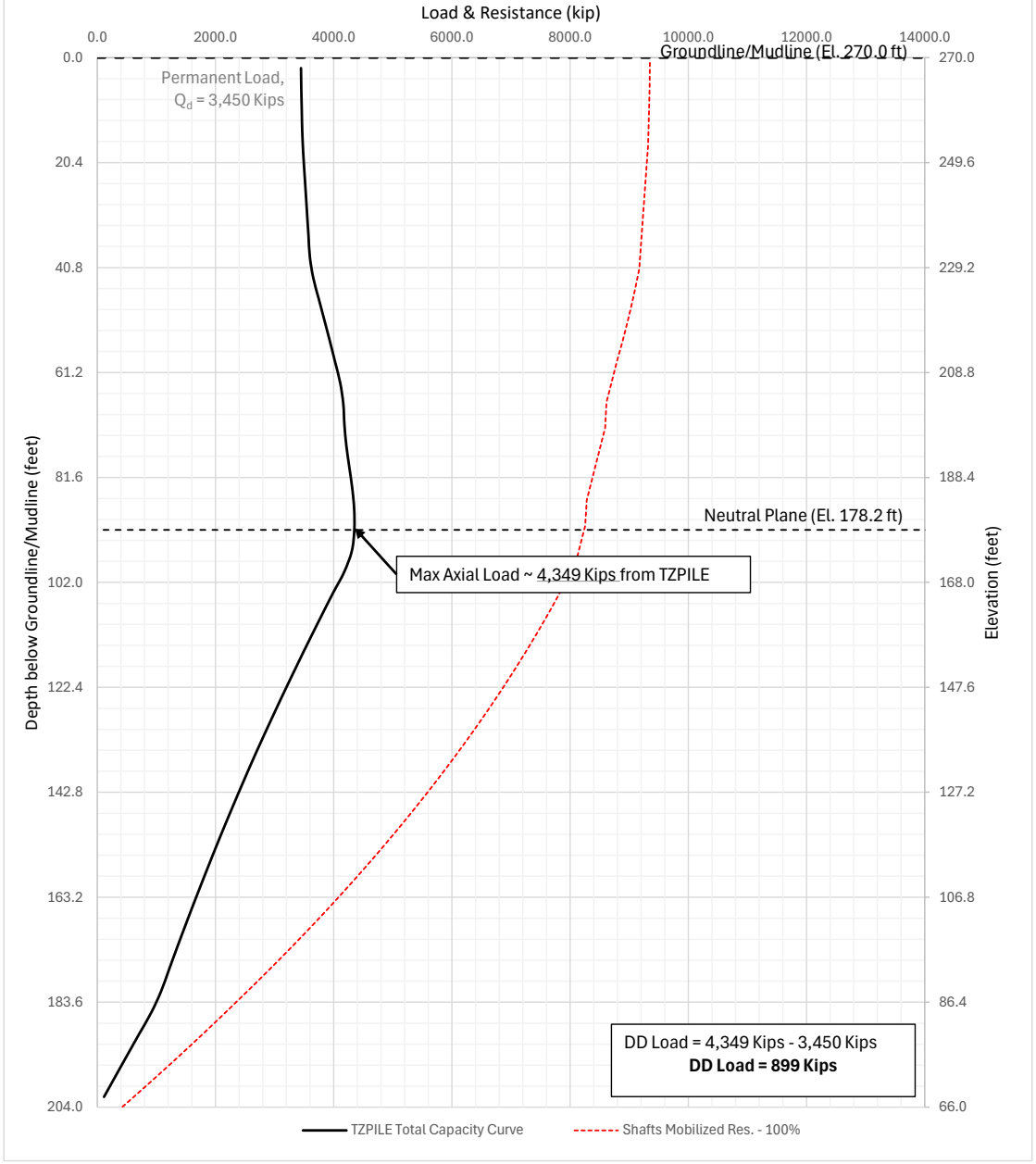
Pier 8
96-inch Diameter Drilled Shaft
Downdrag - 100 YR Return Period

Project: US-51 Bridge Replacement Project
Location: Ballard Co., Kentucky | Alexander Co., IL
Approved: RRP **Review Date:** 01/27/2026
Drawn By: SKB **Figure No. ##**
Date: 01/26/2026

DRILLED SHAFTS NEUTRAL PLANE METHOD DOWNDRAG GRAPHS – 1,000-YR RETURN PERIOD



Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026



Prepared by:	Prepared for:	**Pier 8** **96-inch Diameter Drilled Shaft** **Downdrag - 1000 YR Return Period**
		Project: US-51 Bridge Replacement Project **Location:** Ballard Co., Kentucky | Alexander Co., IL **Approved:** RRP **Review Date:** 01/27/2026 **Drawn By:** SKB **Figure No. ##** **Date:** 01/26/2026

Lateral Force Calculations

PIER 3

100-YR RETURN PERIOD

ROLLINS LIQUEFIED SAND P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

p-multiplier to take diameter effect into account, p_d: **7.90** kN/m

MATLOCK SOFT CLAY P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

Strain at 1/2 max difference in principal stresses[1], ε_{50}:	0.02			
Average submerged unit weight to desired depth, γ':	62.6	(pcf) ⟷	9.8	kN/m^3
Residual shear strength, S_r:	100	(psf) ⟷	4.8	kPa
Pile displacement at 1/2 ult. Soil resistance, y_{50}:	3.6	(in) ⟷	91.4	mm

[1] ε_{50} for the Hybrid Liquefied Sand P-Y Model should be between 0.0005 and 0.05. See FBMP Manual for equation with $(N_1)_{60\text{-}cs}$

FREE-FIELD GROUND DISPLACEMENTS

Elev (ft)	Depth (ft)	Lat. Displ. (ft)	Lat. Displ. (in)
282.0	0	0.7	8.0
278.3	3.7	0.2	2.1
274.7	7.3	0.1	1.1
267.3	14.7	0.0	0.3
256.4	25.6	0.0	0.0

ROLLINS LIQUEFIED SAND P-Y MODEL

Depth (m)	LD (mm)	A	B	C	$p_{0.3m}$ (kN/m)	p (kN/m)	p (lbf/in)
0.00	204.22	0.00	2.80	2.85	21.18	15.00	85.79
1.12	54.10	0.00	3.04	2.10	1.23	9.72	55.57
2.23	27.43	0.00	3.19	1.76	0.96	7.58	43.37
4.47	6.60	0.01	3.38	1.42	0.72	5.69	32.53
7.82	0.51	0.16	3.56	1.17	0.31	2.45	14.01

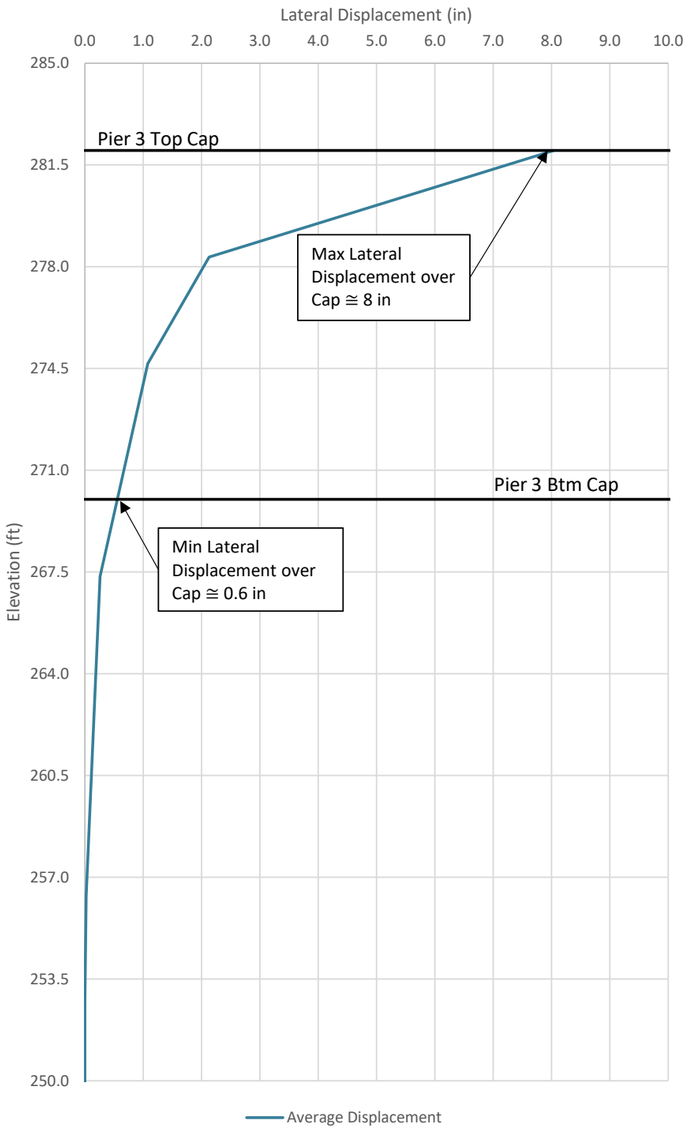
MATLOCK SOFT CLAY P-Y MODEL

p_{u1} (kN/m)	p_{u2} (kN/m)	p_u (kN/m)	p (kN/m)	p (lbf/in)
26.33	78.81	26.33	17.21	98.42
49.03	78.81	49.03	20.58	117.70
71.78	78.81	71.78	24.03	137.42
117.30	78.81	78.81	16.41	93.85
185.58	78.81	78.81	6.98	39.91

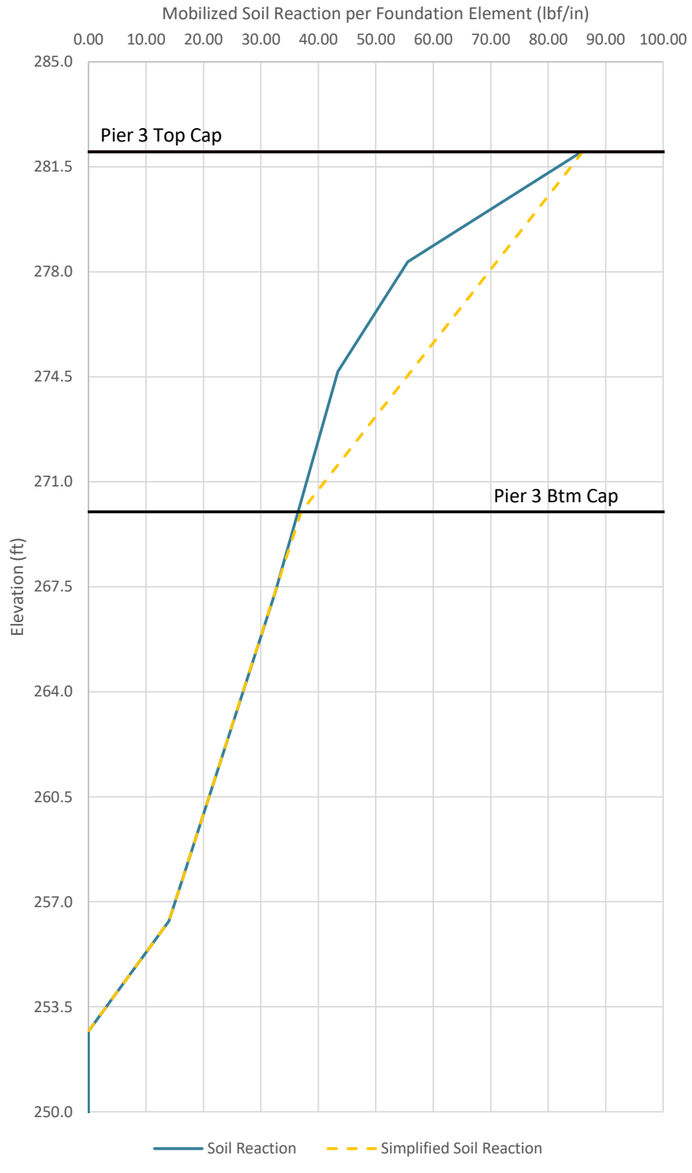
MIN P

p (lbf/in)
85.79
55.57
43.37
32.53
14.01

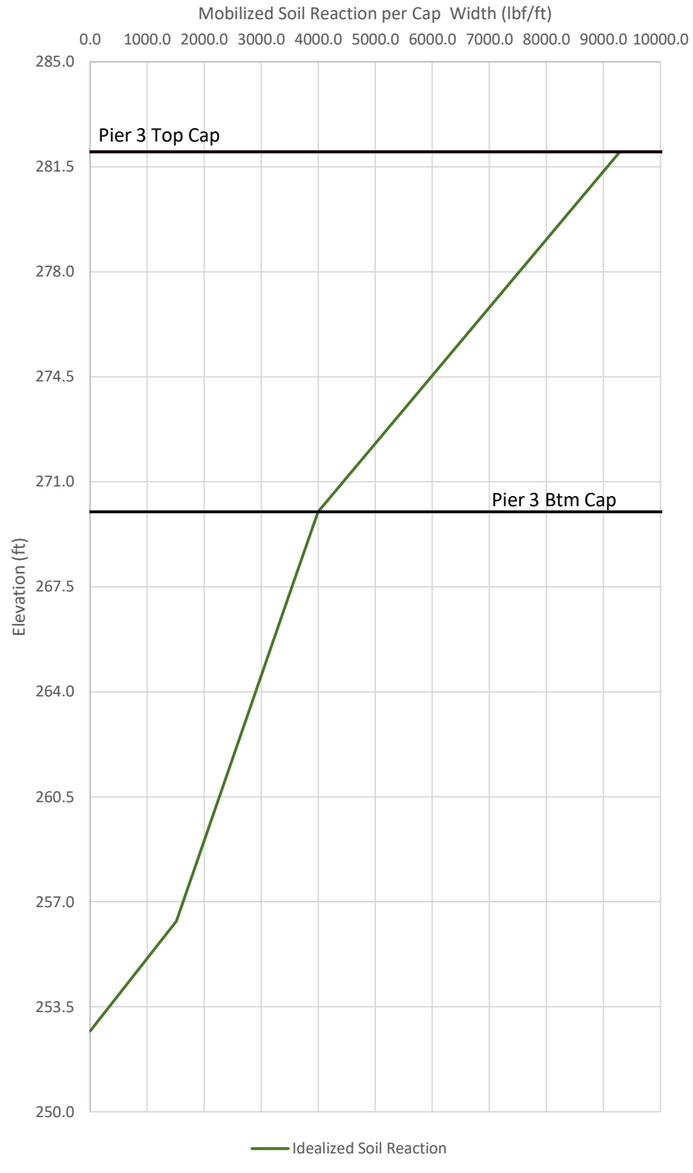
100yr Return Period Free-Field Ground Displacement Results



100yr Return Period Mobilized Soil Reaction



100yr Return Period Mobilized Soil Reaction



Calculated By: SKB Date: 02/13/2026
Checked By: BAR Date: 02/13/2026

LATERAL LOADS APPLIED TO PILE CAP DUE TO FLOW LIQUEFACTION

Inputs

$W_t := 54\ ft$ (Transverse Width of Pile Cap)

$W_l := 36\ ft$ (Longitudinal Length of Pile Cap)

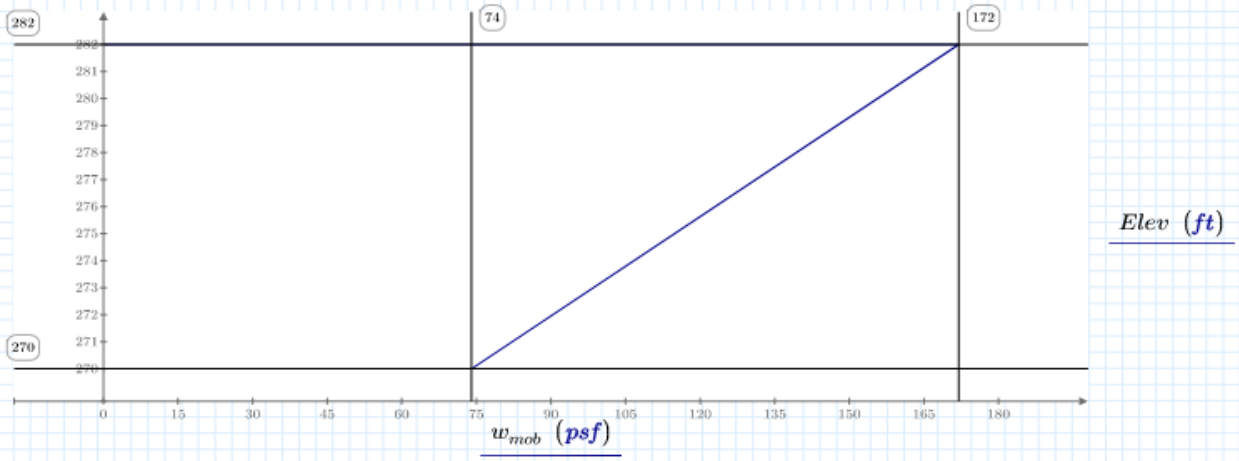
$\alpha := 0.5$ (Adhesion Factor, See MTD 20-15 Attachment 1)

$S_R := 100\ psf$ (Residual Shear Strength, See Seismic Soil Profile)

Plot of Mobilized Pressures (See Excel Spreadsheet)

(Table of Mobilized Soil Pressures at Respective Cap Elevations)

w_{mob} (psf)	$Elev$ (ft)
0	282
172	282
74	270
0	270



Resultant Forces

$h_1 := Elev_1 - Elev_2 = 12\ ft$

$P_1 := w_{mob_2} \cdot h_1 \cdot W_t = 47.952\ kip$

$P_2 := \frac{1}{2} \cdot \left(w_{mob_1} - w_{mob_2}\right) \cdot h_1 \cdot W_t = 31.752\ kip$

$P_{sides} := 2 \cdot \alpha \cdot S_R \cdot W_l \cdot \left(Elev_0 - Elev_3\right) = 43.2\ kip$

Total Force due to Flow Liquefaction

$F_{ULT} := P_1 + P_2 + P_{sides} = 122.904\ kip$

1,000-YR RETURN PERIOD

ROLLINS LIQUEFIED SAND P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

p-multiplier to take diameter effect into account, p_d: **7.90** kN/m

MATLOCK SOFT CLAY P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

Strain at 1/2 max difference in principal stresses[1], ε_{50}: **0.02**

Average submerged unit weight to desired depth, γ': **62.6** (pcf) ⟷ **9.8** kN/m^3

Residual shear strength, S_r: **100** (psf) ⟷ **4.8** kPa

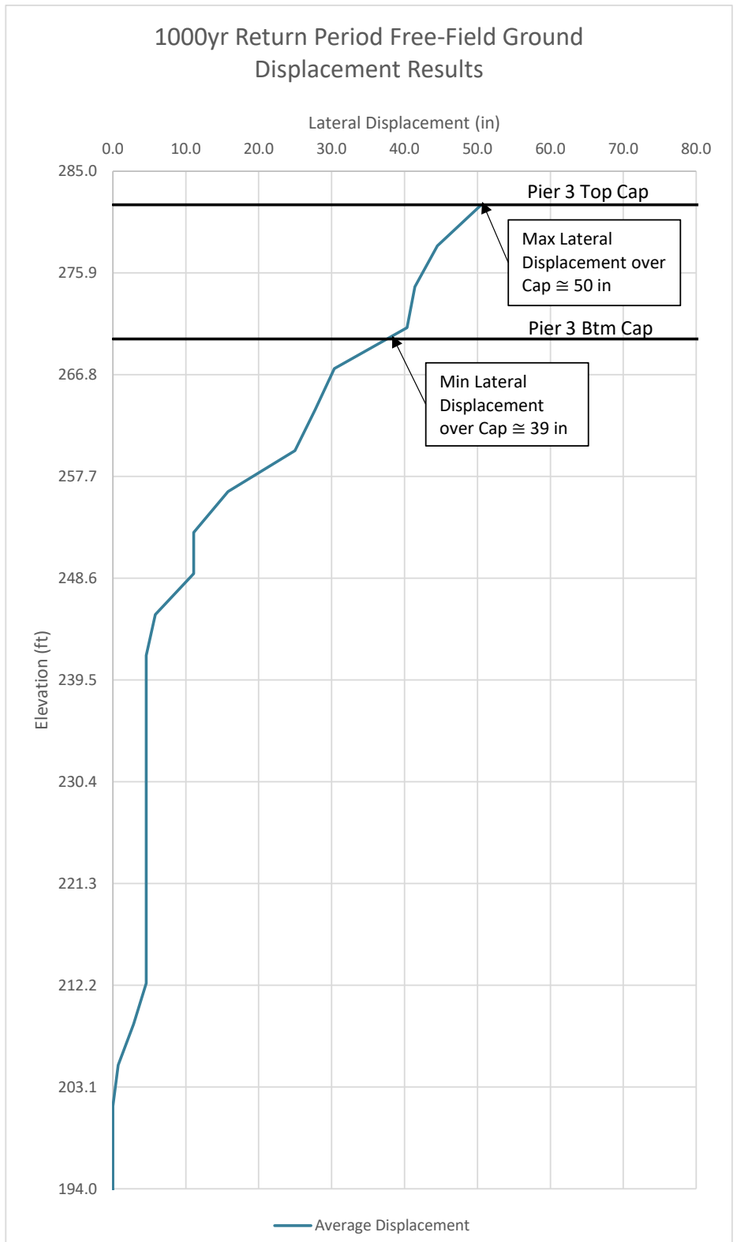
Pile displacement at 1/2 ult. Soil resistance, y_{50}: **3.6** (in) ⟷ **91.4** mm

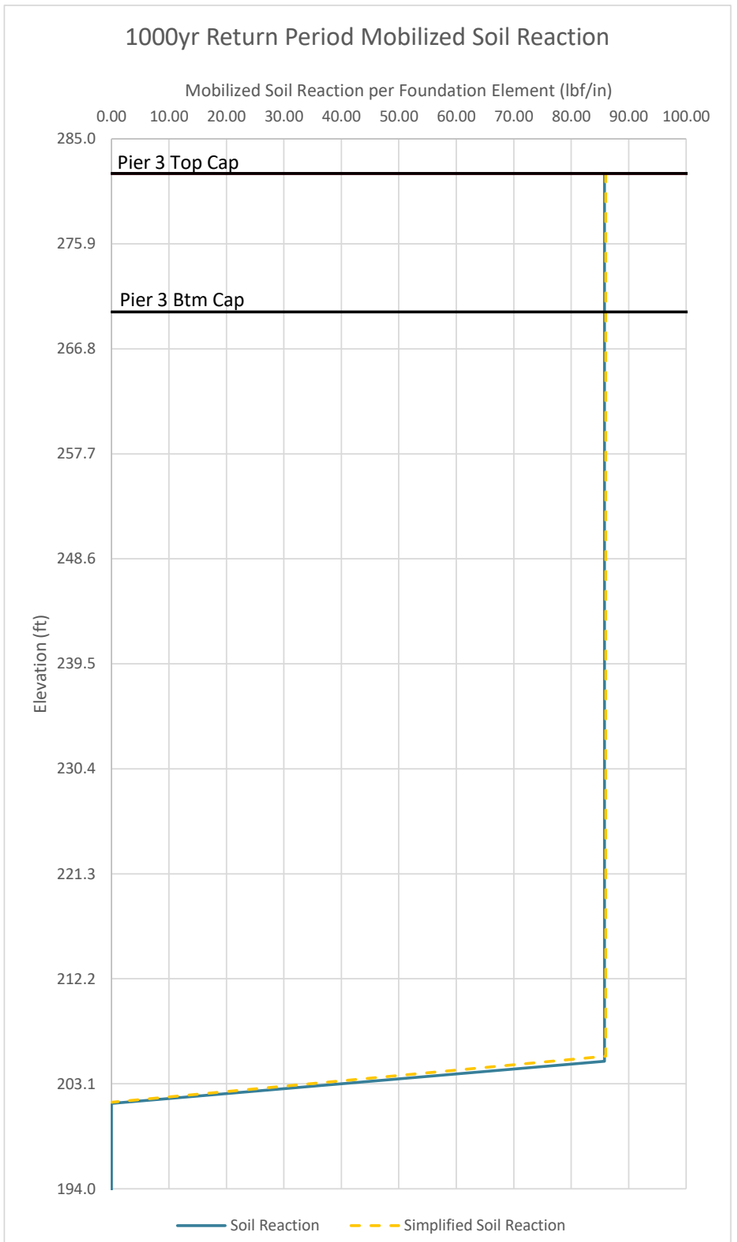
[1] ε_{50} for the Hybrid Liquefied Sand P-Y Model should be between 0.0005 and 0.05. See FBMP Manual for equation with $(N_1)_{60\text{-}cs}$

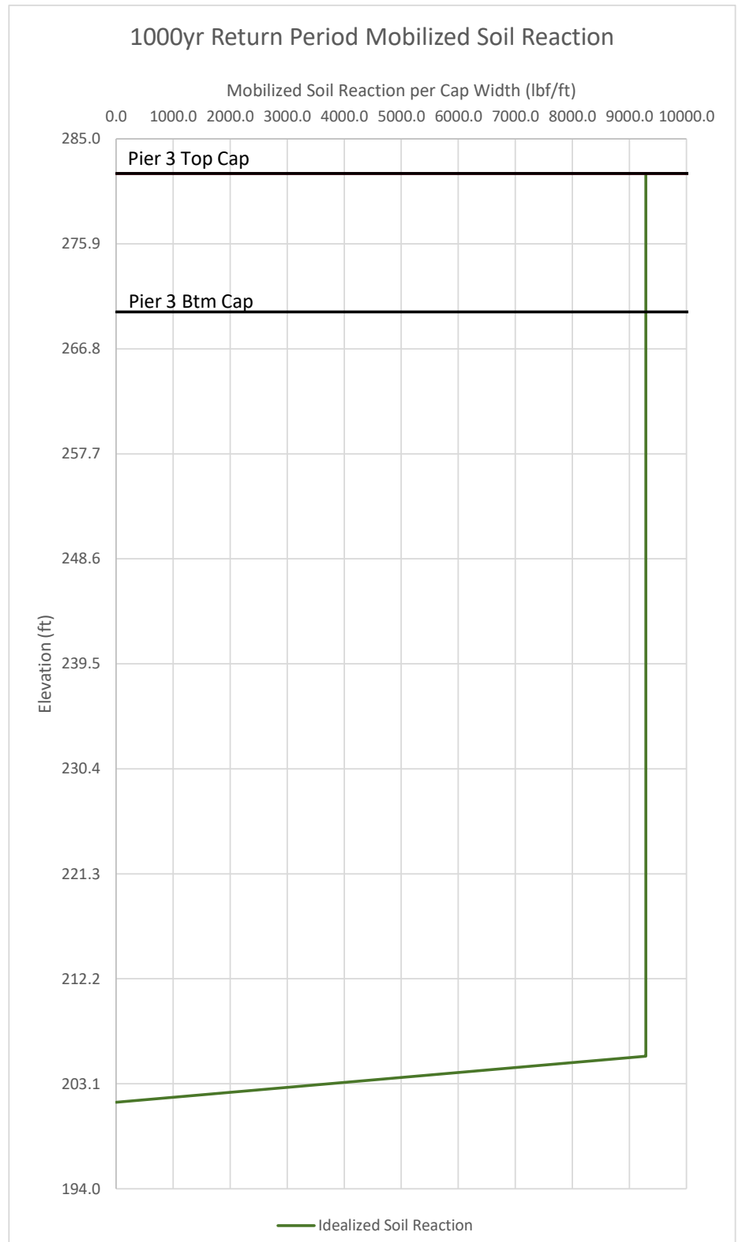
FREE-FIELD GROUND DISPLACEMENTS

Elev (ft)	Depth (ft)	Lat. Displ. (ft)	Lat. Displ. (in)
282.0	0	4.2	50.5
278.3	3.7	3.7	44.5
274.7	7.3	3.5	41.4
271.0	11.0	3.4	40.4
267.3	14.7	2.5	30.4
263.7	18.3	2.3	27.7
260.0	22.0	2.1	25.0
256.4	25.6	1.3	15.8
252.7	29.3	0.9	11.1
249.0	33.0	0.9	11.1
245.4	36.6	0.5	5.8
241.7	40.3	0.4	4.6
238.0	44.0	0.4	4.6
234.4	47.6	0.4	4.6
230.7	51.3	0.4	4.6
227.0	55.0	0.4	4.6
223.4	58.6	0.4	4.6
219.7	62.3	0.4	4.6
216.0	66.0	0.4	4.6
212.4	69.6	0.4	4.6
208.7	73.3	0.2	2.9
205.1	76.9	0.1	0.7
201.4	80.6	0.0	0.0
197.7	84.3	0.0	0.0
194.1	87.9	0.0	0.0
190.4	91.6	0.0	0.0

	ROLLINS LIQUEFIED SAND P-Y MODEL							MATLOCK SOFT CLAY P-Y MODEL					MIN P
Depth (m)	LD (mm)	A	B	C	$p_{0.3m}$ (kN/m)	p (kN/m)	p (lbf/in)	p_{u1} (kN/m)	p_{u2} (kN/m)	p_u (kN/m)	p (kN/m)	p (lbf/in)	p (lbf/in)
0.01	1283.60	0.00	2.80	2.84	3962.37	15.00	85.79	26.46	78.81	26.46	26.46	151.31	85.79
1.12	1130.21	0.00	3.04	2.10	721.04	15.00	85.79	49.03	78.81	49.03	49.03	280.40	85.79
2.23	1051.98	0.00	3.19	1.76	589.23	15.00	85.79	71.78	78.81	71.78	71.78	410.56	85.79
3.35	1025.26	0.00	3.29	1.56	697.09	15.00	85.79	94.54	78.81	78.81	78.81	450.72	85.79
4.47	771.43	0.01	3.38	1.42	618.83	15.00	85.79	117.30	78.81	78.81	78.81	450.72	85.79
5.58	704.38	0.03	3.45	1.32	765.10	15.00	85.79	140.06	78.81	78.81	77.82	445.08	85.79
6.70	633.92	0.07	3.50	1.23	935.33	15.00	85.79	162.82	78.81	78.81	75.13	429.71	85.79
7.82	401.08	0.16	3.56	1.17	757.12	15.00	85.79	185.58	78.81	78.81	64.50	368.90	85.79
8.93	281.64	0.32	3.60	1.11	711.87	15.00	85.79	208.33	78.81	78.81	57.33	327.89	85.79
10.05	281.19	0.62	3.65	1.06	986.61	15.00	85.79	231.09	78.81	78.81	57.30	327.72	85.79
11.17	147.55	1.10	3.69	1.02	693.83	15.00	85.79	253.85	78.81	78.81	46.22	264.33	85.79
12.28	116.49	1.88	3.72	0.99	751.34	15.00	85.79	276.61	78.81	78.81	42.71	244.30	85.79
13.40	116.49	3.06	3.75	0.95	1015.99	15.00	85.79	299.37	78.81	78.81	42.71	244.30	85.79
14.52	116.49	4.81	3.79	0.93	1350.18	15.00	85.79	322.12	78.81	78.81	42.71	244.30	85.79
15.64	116.49	7.32	3.81	0.90	1766.81	15.00	85.79	344.88	78.81	78.81	42.71	244.30	85.79
16.75	116.49	10.84	3.84	0.88	2280.30	15.00	85.79	367.64	78.81	78.81	42.71	244.30	85.79
17.87	116.49	15.68	3.87	0.85	2906.72	15.00	85.79	390.40	78.81	78.81	42.71	244.30	85.79
18.99	116.49	22.20	3.89	0.83	3663.83	15.00	85.79	413.16	78.81	78.81	42.71	244.30	85.79
20.10	116.49	30.85	3.92	0.82	4571.26	15.00	85.79	435.91	78.81	78.81	42.71	244.30	85.79
21.22	116.49	42.15	3.94	0.80	5650.52	15.00	85.79	458.67	78.81	78.81	42.71	244.30	85.79
22.34	72.59	56.71	3.96	0.78	4781.18	15.00	85.79	481.43	78.81	78.81	36.48	208.67	85.79
23.45	18.55	75.25	3.98	0.77	2051.91	15.00	85.79	504.19	78.81	78.81	23.15	132.42	85.79
24.57	0.00	98.59	4.00	0.75	0.00	0.00	0.00	526.95	78.81	78.81	0.00	0.00	0.00
25.69	0.00	127.69	4.02	0.74	0.00	0.00	0.00	549.70	78.81	78.81	0.00	0.00	0.00
26.80	0.00	163.63	4.04	0.73	0.00	0.00	0.00	572.46	78.81	78.81	0.00	0.00	0.00
27.92	0.00	207.65	4.05	0.72	0.00	0.00	0.00	595.22	78.81	78.81	0.00	0.00	0.00


1000yr Return Period Free-Field Ground Displacement Results
Lateral Displacement (in)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
285.0
275.9
266.8
257.7
248.6
239.5
230.4
221.3
212.2
203.1
194.0
Elevation (ft)
Pier 3 Top Cap
Pier 3 Btm Cap
Max Lateral Displacement over Cap ≅ 50 in
Min Lateral Displacement over Cap ≅ 39 in
Average Displacement


1000yr Return Period Mobilized Soil Reaction
Mobilized Soil Reaction per Foundation Element (lbf/in)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
285.0
275.9
266.8
257.7
248.6
239.5
230.4
221.3
212.2
203.1
194.0
Elevation (ft)
Pier 3 Top Cap
Pier 3 Btm Cap
Soil Reaction
Simplified Soil Reaction


1000yr Return Period Mobilized Soil Reaction
Mobilized Soil Reaction per Cap Width (lbf/ft)
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
10000.0
285.0
275.9
266.8
257.7
248.6
239.5
230.4
221.3
212.2
203.1
194.0
Elevation (ft)
Pier 3 Top Cap
Pier 3 Btm Cap
Idealized Soil Reaction

Calculated By: SKB Date: 02/12/2026
Checked By: BAR Date: 02/12/2026

LATERAL LOADS APPLIED TO PILE CAP DUE TO FLOW LIQUEFACTION

Inputs

$W_t := 54\ ft$ (Transverse Width of Pile Cap)

$W_l := 36\ ft$ (Longitudinal Length of Pile Cap)

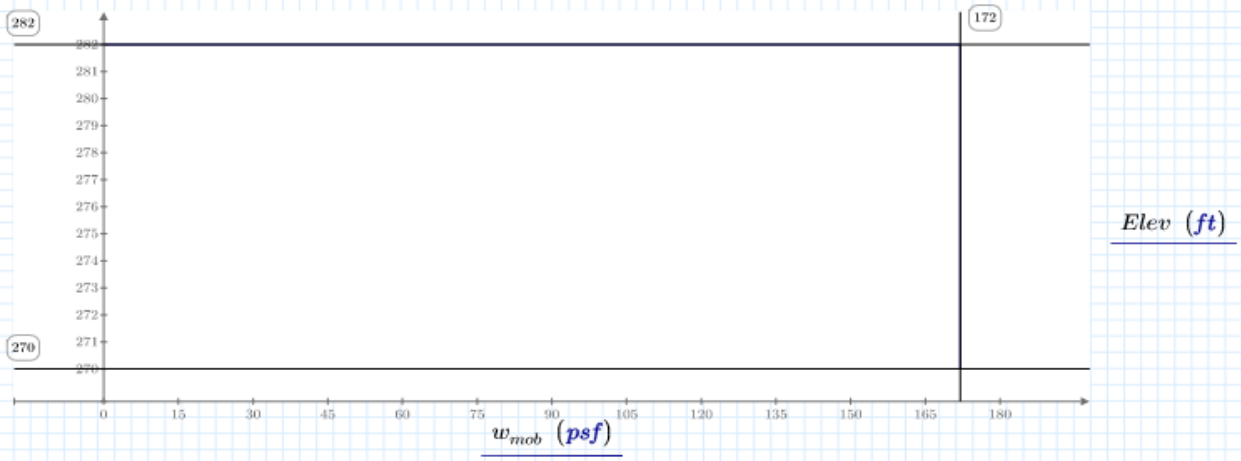
$\alpha := 0.5$ (Adhesion Factor, See MTD 20-15 Attachment 1)

$S_R := 100\ psf$ (Residual Shear Strength, See Seismic Soil Profile)

Plot of Mobilized Pressures (See Excel Spreadsheet)

(Table of Mobilized Soil Pressures at Respective Cap Elevations)

w_{mob} (psf)	$Elev$ (ft)
0	282
172	282
172	270
0	270



Resultant Forces

$h_1 := Elev_1 - Elev_2 = 12\ ft$

$P_1 := w_{mob_2} \cdot h_1 \cdot W_t = 111.456\ kip$

$P_{sides} := 2 \cdot \alpha \cdot S_R \cdot W_l \cdot \left(Elev_0 - Elev_3\right) = 43.2\ kip$

Total Force due to Flow Liquefaction

$F_{ULT} := P_1 + P_{sides} = 154.656\ kip$

PIER 8

100-YR RETURN PERIOD

ROLLINS LIQUEFIED SAND P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

p-multiplier to take diameter effect into account, p_d: **7.90** kN/m

MATLOCK SOFT CLAY P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

Strain at 1/2 max difference in principal stresses[1], ε_{50}:	0.02			
Average submerged unit weight to desired depth, γ':	47.6	(pcf) ⟷	7.5	kN/m^3
Residual shear strength, S_r:	100	(psf) ⟷	4.8	kPa
Pile displacement at 1/2 ult. Soil resistance, y_{50}:	3.6	(in) ⟷	91.4	mm

[1] ε_{50} for the Hybrid Liquefied Sand P-Y Model should be between 0.0005 and 0.05. See FBMP Manual for equation with $(N_1)_{60\text{-}cs}$

FREE-FIELD GROUND DISPLACEMENTS

Elev (ft)	Depth (ft)	Lat. Displ. (ft)	Lat. Displ. (in)
282.0	0	1.2	14.8
278.1	3.9	0.9	11.0
274.2	7.8	0.9	10.7
270.2	11.8	0.1	1.0
266.3	15.7	0.1	0.8
262.4	19.6	0.0	0.0

ROLLINS LIQUEFIED SAND P-Y MODEL

Depth (m)	LD (mm)	A	B	C	$p_{0.3m}$ (kN/m)	p (kN/m)	p (lbf/in)
0.00	374.66	0.00	2.80	2.85	121.35	15.00	85.79
1.20	279.45	0.00	3.05	2.06	39.32	15.00	85.79
2.39	272.10	0.00	3.20	1.73	58.20	15.00	85.79
3.59	25.44	0.00	3.31	1.53	2.62	15.00	85.79
4.78	20.48	0.01	3.40	1.39	4.42	15.00	85.79
5.98	0.32	0.04	3.47	1.28	0.04	0.34	1.94

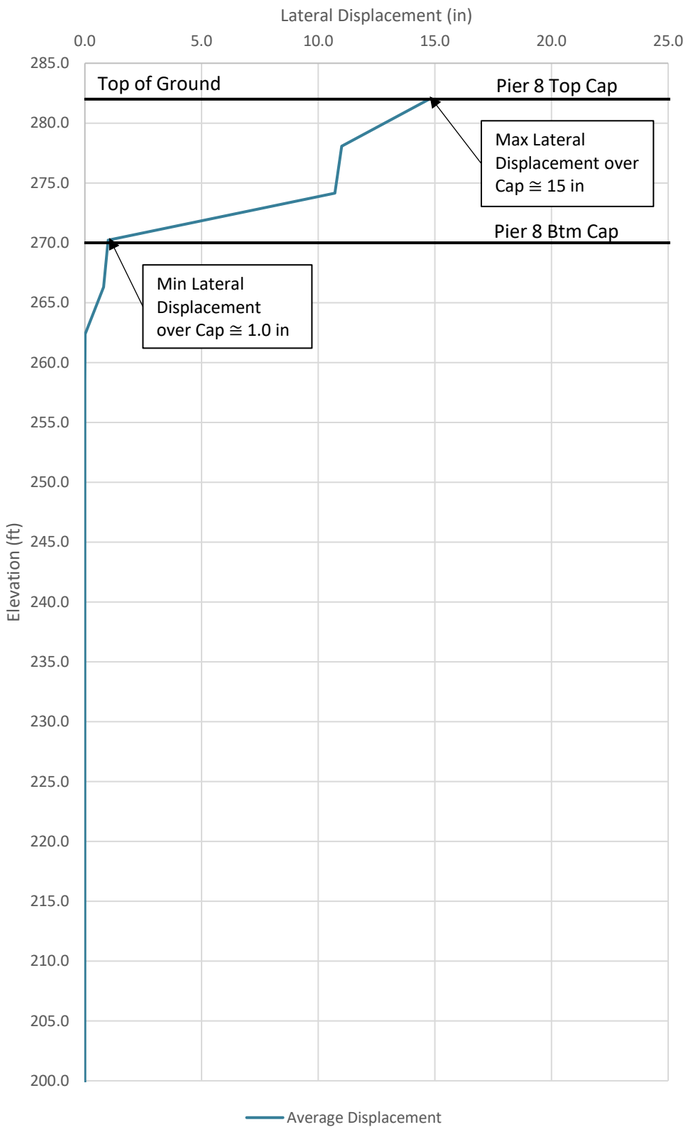
MATLOCK SOFT CLAY P-Y MODEL

p_{u1} (kN/m)	p_{u2} (kN/m)	p_u (kN/m)	p (kN/m)	p (lbf/in)
26.32	78.81	26.32	21.06	120.43
45.49	78.81	45.49	33.01	188.77
64.71	78.81	64.71	46.54	266.15
83.93	78.81	78.81	25.72	147.12
103.14	78.81	78.81	23.93	136.86
122.36	78.81	78.81	5.95	34.05

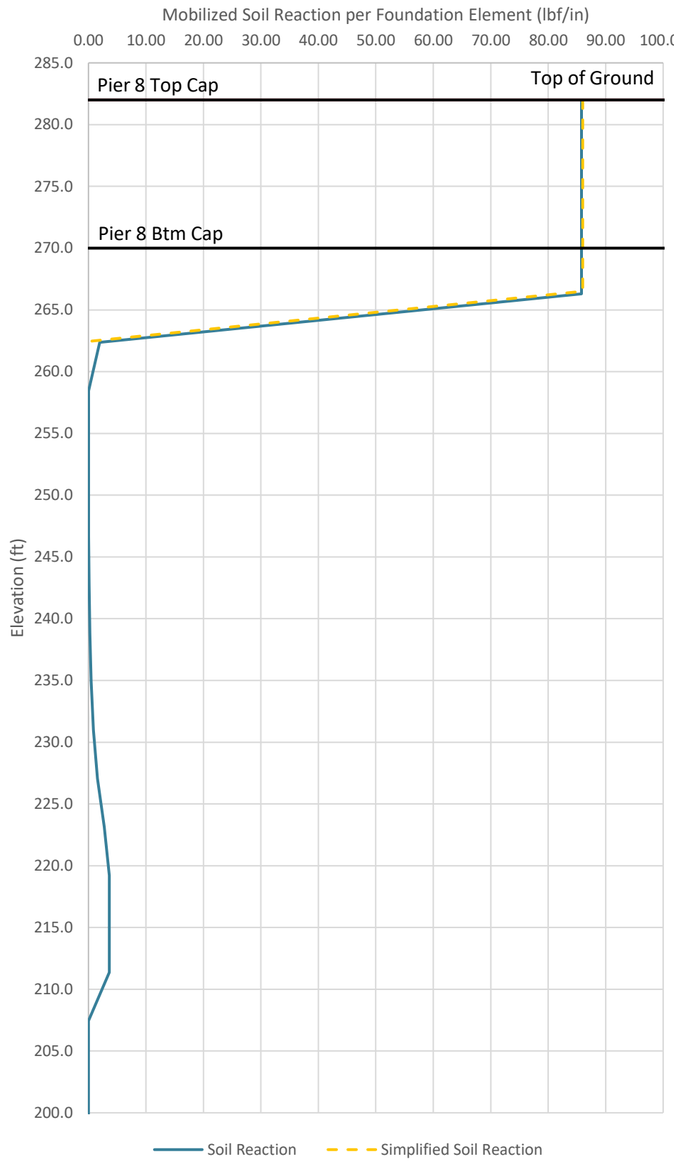
MIN P

p (lbf/in)
85.79
85.79
85.79
85.79
85.79
1.94

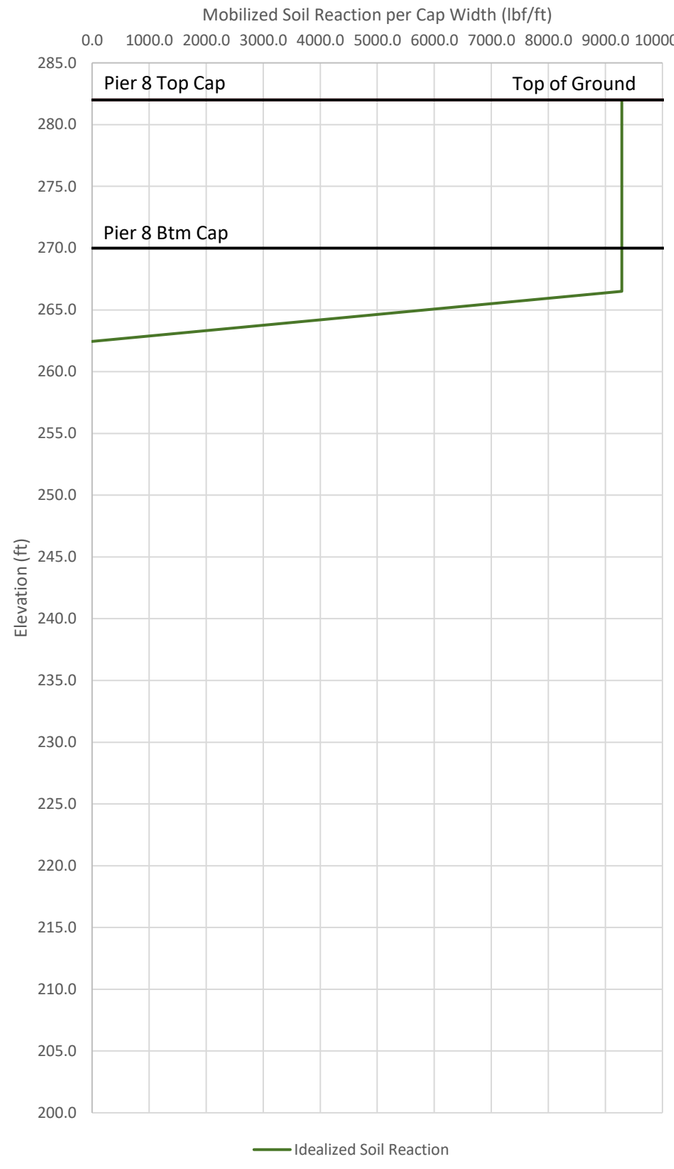
100yr Return Period Free-Field Ground Displacement Results



100yr Return Period Mobilized Soil Reaction



100yr Return Period Mobilized Soil Reaction



Calculated By: SKB Date: 02/13/2026
Checked By: BAR Date: 02/13/2026

LATERAL LOADS APPLIED TO PILE CAP DUE TO FLOW LIQUEFACTION

Inputs

$W_t := 54\ ft$ (Transverse Width of Pile Cap)

$W_l := 36\ ft$ (Longitudinal Length of Pile Cap)

$\alpha := 0.5$ (Adhesion Factor, See MTD 20-15 Attachment 1)

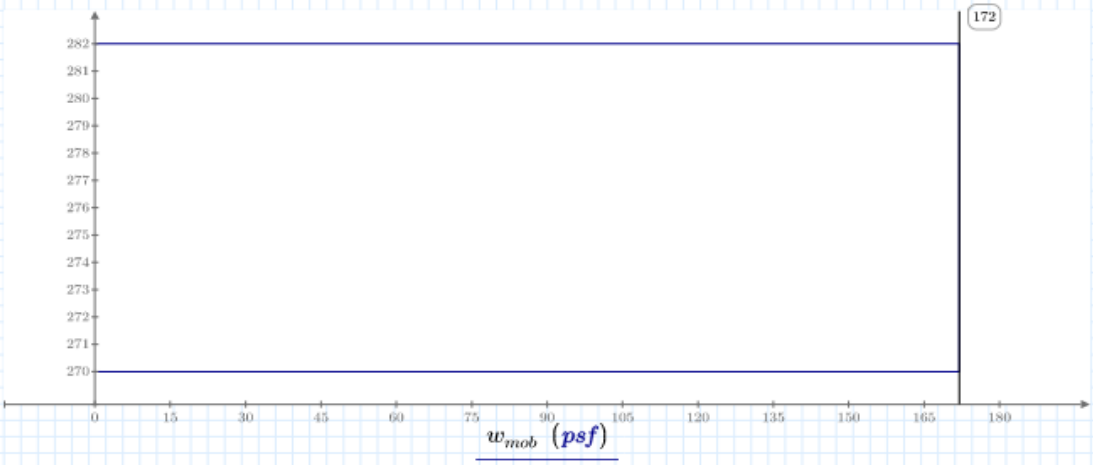
$S_R := 100\ psf$ (Residual Shear Strength, See Seismic Soil Profile)

Plot of Mobilized Pressures (See Excel Spreadsheet)

(Table of Mobilized Soil Pressures and Cap Elevations)

w_{mob} (psf)	$Elev$ (ft)
0	282
172	282
172	270
0	270

(Horizontal and Vertical Markers Are Not Automatic)



Resultant Forces

$h_1 := Elev_1 - Elev_2 = 12\ ft$

$P_1 := w_{mob_2} \cdot h_1 \cdot W_t = 111.456\ kip$

$P_{sides} := 2 \cdot \alpha \cdot S_R \cdot W_l \cdot \left(Elev_0 - Elev_3\right) = 43.2\ kip$

Total Force due to Flow Liquefaction

$F_{ULT} := P_1 + P_{sides} = 154.656\ kip$

1,000-YR RETURN PERIOD

ROLLINS LIQUEFIED SAND P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

p-multiplier to take diameter effect into account, p_d: **7.90** kN/m

MATLOCK SOFT CLAY P-Y MODEL INPUTS (IDEALIZED FOR FOUNDATION DIAM.)

(Please Refer to the FB-Multipier Help Manual for Additional Guidance on Parameters)

Strain at 1/2 max difference in principal stresses[1], ε_{50}: **0.02**

Average submerged unit weight to desired depth, γ': **47.6** (pcf) ⟷ **7.5** kN/m^3

Residual shear strength, S_r: **50** (psf) ⟷ **2.4** kPa

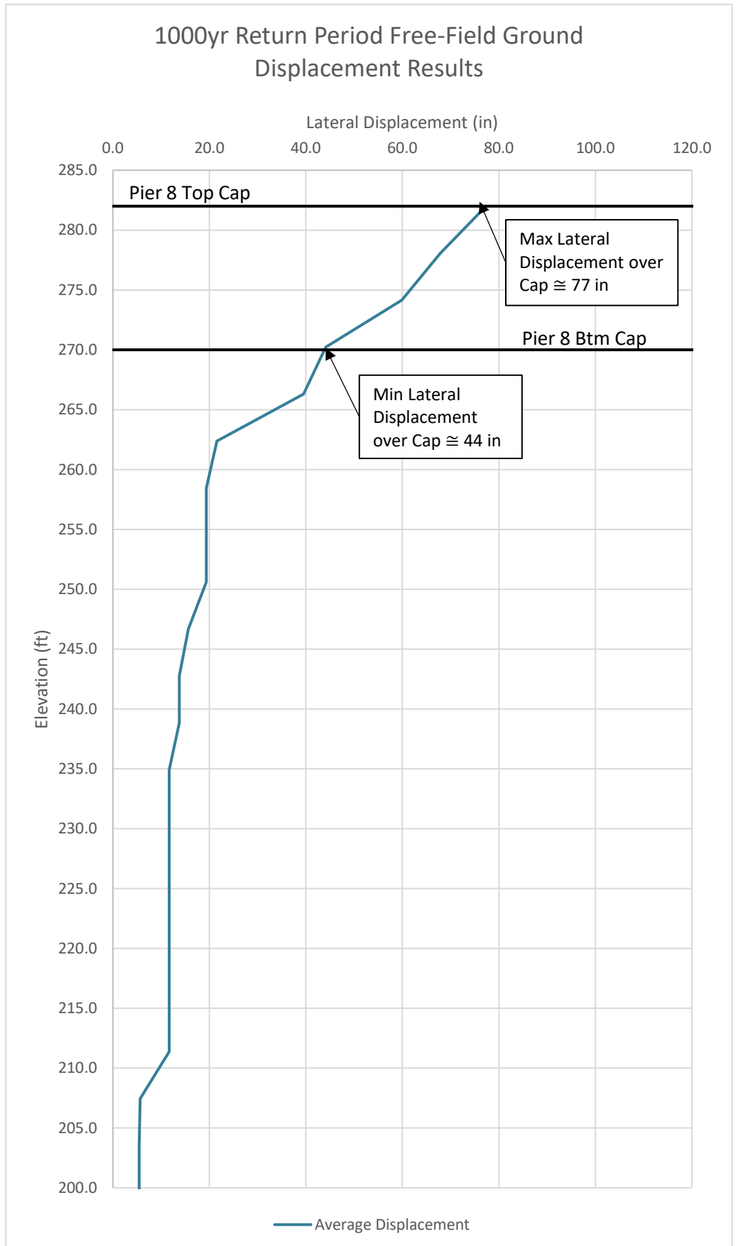
Pile displacement at 1/2 ult. Soil resistance, y_{50}: **3.6** (in) ⟷ **91.4** mm

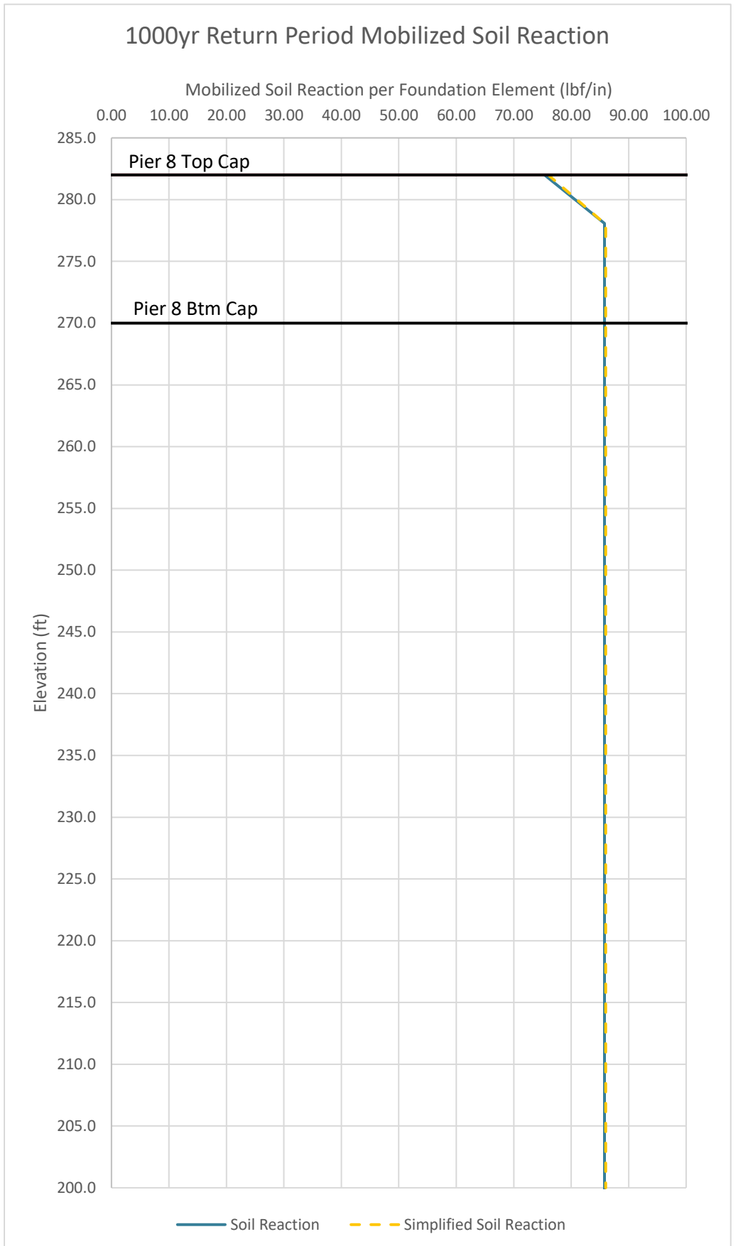
[1] ε_{50} for the Hybrid Liquefied Sand P-Y Model should be between 0.0005 and 0.05. See FBMP Manual for equation with $(N_1)_{60\text{-}cs}$

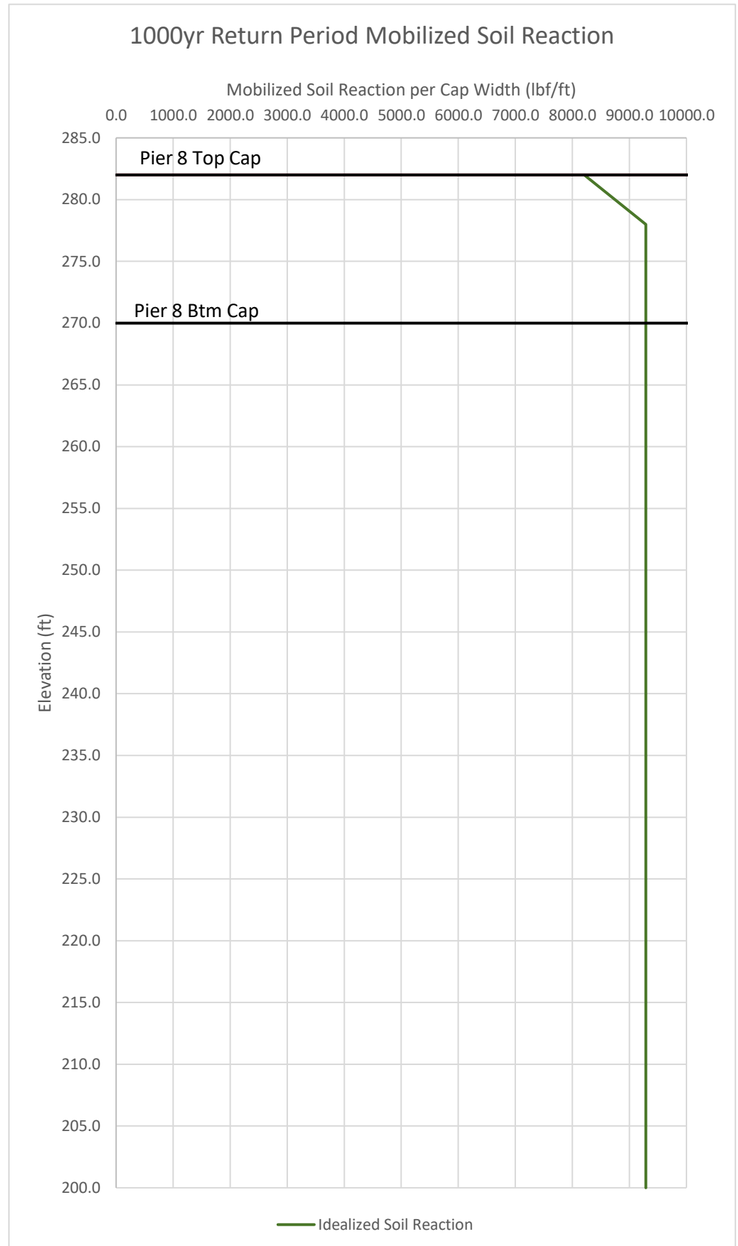
FREE-FIELD GROUND DISPLACEMENTS

Elev (ft)	Depth (ft)	Lat. Displ. (ft)	Lat. Displ. (in)
282.0	0	6.4	77.3
278.1	3.9	5.7	67.9
274.2	7.8	5.0	59.9
270.2	11.8	3.7	44.1
266.3	15.7	3.3	39.5
262.4	19.6	1.8	21.5
258.5	23.5	1.6	19.4
254.5	27.5	1.6	19.4
250.6	31.4	1.6	19.4
246.7	35.3	1.3	15.6
242.8	39.2	1.1	13.8
238.8	43.2	1.1	13.8
234.9	47.1	1.0	11.7
231.0	51.0	1.0	11.7
227.1	54.9	1.0	11.7
223.1	58.9	1.0	11.7
219.2	62.8	1.0	11.7
215.3	66.7	1.0	11.7
211.4	70.6	1.0	11.7
207.4	74.6	0.5	5.6
203.5	78.5	0.5	5.5
199.6	82.4	0.5	5.5
195.7	86.3	0.5	5.5
191.7	90.3	0.5	5.5
187.8	94.2	0.0	0.0
183.9	98.1	0.0	0.0

ROLLINS LIQUEFIED SAND P-Y MODEL								MATLOCK SOFT CLAY P-Y MODEL					MIN P
Depth (m)	LD (mm)	A	B	C	$p_{0.3m}$ (kN/m)	p (kN/m)	p (lbf/in)	p_{u1} (kN/m)	p_{u2} (kN/m)	p_u (kN/m)	p (kN/m)	p (lbf/in)	p (lbf/in)
0.00	1963.98	0.00	2.80	2.85	13554.34	15.00	85.79	13.18	39.40	13.18	13.18	75.38	75.38
1.20	1723.63	0.00	3.05	2.06	1681.41	15.00	85.79	30.92	39.40	30.92	30.92	176.85	85.79
2.39	1520.25	0.00	3.20	1.73	1136.38	15.00	85.79	48.71	39.40	39.40	39.40	225.36	85.79
3.59	1121.25	0.00	3.31	1.53	846.32	15.00	85.79	66.50	39.40	39.40	39.40	225.36	85.79
4.78	1003.60	0.01	3.40	1.39	979.86	15.00	85.79	84.28	39.40	39.40	39.40	225.36	85.79
5.98	547.31	0.04	3.47	1.28	623.16	15.00	85.79	102.07	39.40	39.40	35.77	204.59	85.79
7.18	491.61	0.10	3.53	1.20	791.87	15.00	85.79	119.86	39.40	39.40	34.51	197.40	85.79
8.37	491.61	0.23	3.58	1.14	1128.39	15.00	85.79	137.65	39.40	39.40	34.51	197.40	85.79
9.57	491.61	0.47	3.63	1.08	1572.80	15.00	85.79	155.43	39.40	39.40	34.51	197.40	85.79
10.76	397.18	0.90	3.67	1.04	1721.98	15.00	85.79	173.22	39.40	39.40	32.15	183.85	85.79
11.96	349.75	1.62	3.71	1.00	2052.34	15.00	85.79	191.01	39.40	39.40	30.81	176.22	85.79
13.16	349.75	2.76	3.75	0.96	2741.03	15.00	85.79	208.79	39.40	39.40	30.81	176.22	85.79
14.35	296.00	4.50	3.78	0.93	3084.51	15.00	85.79	226.58	39.40	39.40	29.14	166.69	85.79
15.55	296.00	7.09	3.81	0.90	4014.57	15.00	85.79	244.37	39.40	39.40	29.14	166.69	85.79
16.74	296.00	10.81	3.84	0.88	5155.40	15.00	85.79	262.16	39.40	39.40	29.14	166.69	85.79
17.94	296.00	16.05	3.87	0.85	6540.78	15.00	85.79	279.94	39.40	39.40	29.14	166.69	85.79
19.14	296.00	23.24	3.90	0.83	8207.98	15.00	85.79	297.73	39.40	39.40	29.14	166.69	85.79
20.33	296.00	32.95	3.92	0.81	10197.88	15.00	85.79	315.52	39.40	39.40	29.14	166.69	85.79
21.53	296.00	45.83	3.94	0.79	12555.23	15.00	85.79	333.30	39.40	39.40	29.14	166.69	85.79
22.72	143.44	62.67	3.97	0.78	8724.10	15.00	85.79	351.09	39.40	39.40	22.89	130.93	85.79
23.92	138.77	84.39	3.99	0.76	10422.55	15.00	85.79	368.88	39.40	39.40	22.64	129.49	85.79
25.12	138.77	112.07	4.01	0.75	12676.56	15.00	85.79	386.67	39.40	39.40	22.64	129.49	85.79
26.31	138.77	146.94	4.03	0.73	15306.27	15.00	85.79	404.45	39.40	39.40	22.64	129.49	85.79
27.51	138.77	190.43	4.05	0.72	18357.40	15.00	85.79	422.24	39.40	39.40	22.64	129.49	85.79
28.70	0.00	244.19	4.07	0.71	0.00	0.00	0.00	440.03	39.40	39.40	0.00	0.00	0.00
29.90	0.00	310.06	4.08	0.70	0.00	0.00	0.00	457.82	39.40	39.40	0.00	0.00	0.00


1000yr Return Period Free-Field Ground Displacement Results
Lateral Displacement (in)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Pier 8 Top Cap
Pier 8 Btm Cap
Max Lateral Displacement over Cap ≅ 77 in
Min Lateral Displacement over Cap ≅ 44 in
Elevation (ft)
285.0
280.0
275.0
270.0
265.0
260.0
255.0
250.0
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Average Displacement


1000yr Return Period Mobilized Soil Reaction
Mobilized Soil Reaction per Foundation Element (lbf/in)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Pier 8 Top Cap
Pier 8 Btm Cap
Elevation (ft)
285.0
280.0
275.0
270.0
265.0
260.0
255.0
250.0
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Soil Reaction
Simplified Soil Reaction


1000yr Return Period Mobilized Soil Reaction
Mobilized Soil Reaction per Cap Width (lbf/ft)
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
10000.0
Pier 8 Top Cap
Pier 8 Btm Cap
Elevation (ft)
285.0
280.0
275.0
270.0
265.0
260.0
255.0
250.0
245.0
240.0
235.0
230.0
225.0
220.0
215.0
210.0
205.0
200.0
Idealized Soil Reaction

Calculated By: SKB Date: 02/18/2026
Checked By: BAR Date: 02/18/2026

LATERAL LOADS APPLIED TO PILE CAP DUE TO FLOW LIQUEFACTION

Inputs

$W_t := 54\ ft$ (Transverse Width of Pile Cap)

$W_l := 36\ ft$ (Longitudinal Length of Pile Cap)

$\alpha := 0.5$ (Adhesion Factor, See MTD 20-15 Attachment 1)

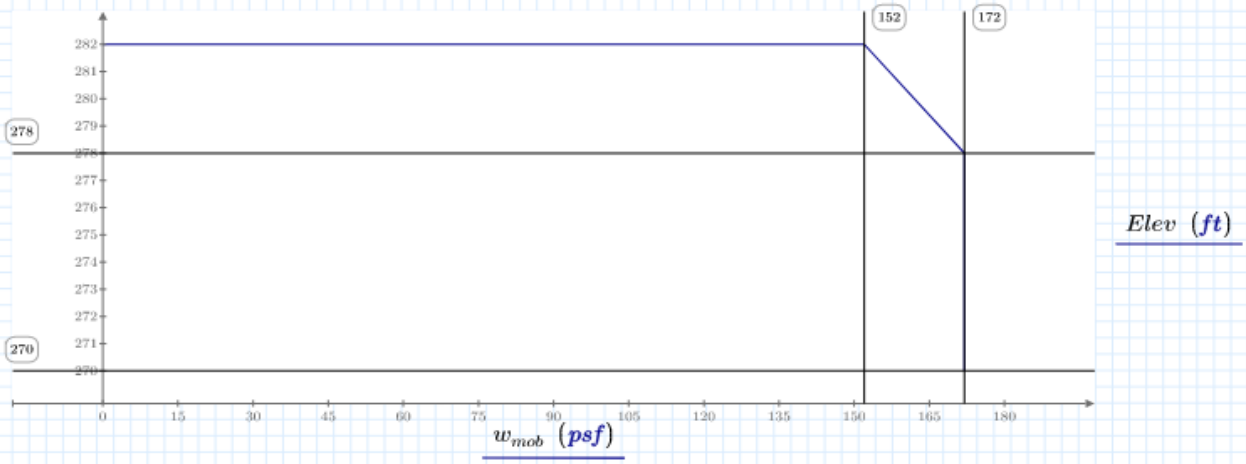
$S_R := 50\ psf$ (Residual Shear Strength, See Seismic Soil Profile)

Plot of Mobilized Pressures (See Excel Spreadsheet)

(Table of Mobilized Soil Pressures and Cap Elevations)

w_{mob} (psf)	$Elev$ (ft)
0	282
152	282
172	278
172	270

(Horizontal and Vertical Markers Are Not Automatic)



Resultant Forces

$h_1 := Elev_1 - Elev_2 = 4\ ft$

$h_2 := Elev_2 - Elev_3 = 8\ ft$

$P_1 := w_{mob_1} \cdot h_1 \cdot W_t = 32.832\ kip$

$P_2 := \frac{1}{2} \cdot \left(w_{mob_2} - w_{mob_1}\right) \cdot h_1 \cdot W_t = 2.16\ kip$

$P_3 := w_{mob_2} \cdot h_2 \cdot W_t = 74.304\ kip$

$P_{sides} := 2 \cdot \alpha \cdot S_R \cdot W_l \cdot \left(Elev_0 - Elev_3\right) = 21.6\ kip$

Total Force due to Flow Liquefaction

$F_{ULT} := P_1 + P_2 + P_3 + P_{sides} = 130.896\ kip$

MINIMUM PILE LENGTH EVALUATION - WITHOUT CONSTRICTOR PLATE

Calculated By: SKB Date: 04/29/2026
Checked By: MJS Date: 05/08/2026

Main Span Pile Length Evaluation for Load Test Program

Strength Limit State Analysis Input Information

$\Sigma\gamma_{STR}Q_{STR} := 4375\ kip$ [Factored Structural Load @ Strength-I Limit State]

$\phi_{STR} := 0.8$ [Resistance Factor for Strength-I Limit State]

Extreme Event Limit State Analysis Input Information

$\Sigma\gamma_{EEII}Q_{EEII} := 3281\ kip$ [Factored Structural Load @ EE-II Limit State]

$\Sigma\gamma_{EEI}Q_{EEI} := 5375\ kip$ [Factored Structural Load @ EE-I Limit State]

$\gamma_p DD := 658\ kip$ [Factored Downdrag Load @ EE-I Limit State]

$R_{sLIQ} := 658\ kip$ [Loss of Skin Resistance due to Liquefaction]

$\phi_{EE} := 1.0$ [Resistance Factor for Extreme Event Limit State]

Nominal Required Resistance Calculation for STR Limit State

$R_{str} := \frac{\Sigma\gamma_{STR}Q_{STR}}{\phi_{STR}} = 5468.75\ kip$ [Nominal Bearing Resistance @ STR-I]

Nominal Required Resistance Calculation for EE-II Limit State

$R_{eeII} := \frac{\Sigma\gamma_{EEII}Q_{EEII}}{\phi_{EE}} = 3281\ kip$ [Nominal Bearing Resistance @ EE-II]

Nominal Required Resistance Calculation for EE-I Limit State

$R_{eeI} := \frac{\Sigma\gamma_{EEI}Q_{EEI}}{\phi_{EE}} + \frac{\gamma_p DD}{\phi_{EE}} + R_{sLIQ} = 6691\ kip$ [Nominal Bearing Resistance @ EE-I]

Foundation Layout Information

$BPC := 270\ ft$ [Bottom of Pile Cap Elevation]

$D_{nr} := 12.3\ ft$ [Unreinforced Pile Length]

Estimated Pile Penetration & Total Pile Length

$D_{STR} := 135\ ft$ [Estimated Pile Penetration Length @ STR]

$D_{EEII} := 97\ ft$ [Estimated Pile Penetration Length @ EEII]

$D_{EEI} := 153\ ft$ [Estimated Pile Penetration Length @ EEI]

Estimated Pile Penetration & Total Pile Length (Cont.)

$L_{STR} := D_{nr} + D_{STR} = 147.3\ ft$ [Total Pile Length @ STR Limit State]

$L_{EEII} := D_{nr} + D_{EEII} = 109.3\ ft$ [Total Pile Length @ EE-II Limit State]

$L_{EEI} := D_{nr} + D_{EEI} = 165.3\ ft$ [Total Pile Length @ EE-I Limit State]

Governing Total Pile Length & Tip Elevation

$D := \max\left(D_{STR}, D_{EEII}, D_{EEI}\right) = 153\ ft$ [Governing Pile Penetration Length]

$L := D_{nr} + D = 165.3\ ft$ [Total Pile Length]

$PTE := \text{round}\left(\frac{BPC - L}{ft}\right) \cdot ft = 105\ ft$ [Pile Tip Elevation]

MINIMUM PILE LENGTH EVALUATION - WITH CONSTRICTOR PLATE

Main Span Pile Length Evaluation (with Constrictor Plate) for Load Test Program

Strength Limit State Analysis Input Information

$\Sigma\gamma_{STR}Q_{STR} := 4375\ kip$ [Factored Structural Load @ Strength-I Limit State]

$\phi_{STR} := 0.8$ [Resistance Factor for Strength-I Limit State]

Extreme Event Limit State Analysis Input Information

$\Sigma\gamma_{EEII}Q_{EEII} := 3281\ kip$ [Factored Structural Load @ EE-II Limit State]

$\Sigma\gamma_{EEI}Q_{EEI} := 5375\ kip$ [Factored Structural Load @ EE-I Limit State]

$\gamma_p DD := 658\ kip$ [Factored Downdrag Load @ EE-I Limit State]

$R_{sLIQ} := 658\ kip$ [Loss of Skin Resistance @ EE-I Limit State]

$\phi_{EE} := 1.0$ [Resistance Factor for Extreme Event Limit State]

Nominal Required Resistance Calculation for STR Limit State

$$R_{str} := \frac{\Sigma\gamma_{STR}Q_{STR}}{\phi_{STR}} = 5468.75\ kip$$ [Nominal Bearing Resistance @ STR-I]

Nominal Required Resistance Calculation for EE-II Limit State

$$R_{eeII} := \frac{\Sigma\gamma_{EEII}Q_{EEII}}{\phi_{EE}} = 3281\ kip$$ [Nominal Bearing Resistance @ EE-II]

Nominal Required Resistance Calculation for EE-I Limit State

$$R_{eeI} := \frac{\Sigma\gamma_{EEI}Q_{EEI}}{\phi_{EE}} + \frac{\gamma_p DD}{\phi_{EE}} + R_{sLIQ} = 6691\ kip$$ [Nominal Bearing Resistance @ EE-I]

Foundation Layout Information

$BPC := 270\ ft$ [Bottom of Pile Cap Elevation]

$D_{nr} := 12.3\ ft$ [Unreinforced Pile Length]

Estimated Pile Penetration & Total Pile Length

$D_{STR} := 89\ ft$ [Estimated Pile Penetration Length @ STR]

$D_{EEII} := 82\ ft$ [Estimated Pile Penetration Length @ EEII]

$D_{EEI} := 92\ ft$ [Estimated Pile Penetration Length @ EEI]

Estimated Pile Penetration & Total Pile Length (Cont.)

$L_{STR} := D_{nr} + D_{STR} = 101.3\ ft$ [Total Pile Length @ STR Limit State]

$L_{EEII} := D_{nr} + D_{EEII} = 94.3\ ft$ [Total Pile Length @ EE-II Limit State]

$L_{EEI} := D_{nr} + D_{EEI} = 104.3\ ft$ [Total Pile Length @ EE-I Limit State]

Governing Total Pile Length & Tip Elevation

$D := \max\left(D_{STR}, D_{EEII}, D_{EEI}\right) = 92\ ft$ [Governing Pile Penetration Length]

$L := D_{nr} + D = 104.3\ ft$ [Total Pile Length]

$PTE := \text{round}\left(\frac{BPC - L}{ft}\right) \cdot ft = 166\ ft$ [Pile Tip Elevation]

Extended Drive Total Pile Length & Tip Elevation

$D_{ext} := 15\ ft$ [Extended Penetration Length for Plug Development]

$L_{ext} := L + D_{ext} = 119.3\ ft$ [Total Pile Length after Extended Drive]

$PTE_{ext} := \text{round}\left(\frac{BPC - L_{ext}}{ft}\right) \cdot ft = 151\ ft$ [Pile Tip Elevation after Extended Drive]

SPECIAL NOTE PILE PROPERTIES TABLE

Pile Properties and Testing Assignments

Test Pile No.	Location	Pile Type[1,5,6]	Pile Size (in.)[3]	Nominal Wall (in.)[7]	Order Length (ft)	Qty	Initial Driving Criteria[9]		Extended Driving Criteria[9]		Testing Assignment			
							Estimated Pile Tip Elevation (ft)	Target Nominal Axial Resistance[4] (kip)	Approximate Pile Tip Elevation (ft)	Approximate Nominal Axial Resistance[4] (kip)	Dynamic	Static[8]	Pseudo-Static	
													Axial	Lateral
PT-2	Main Span (River)	LDOEPP[2]	72	1.5	175	1	165	7500	150	8500	X		X	X
PT-3	Main Span (River)	LDOEPP	72	1.5	220	1	105	7500	--	--	X		X	

Notes:

[1.] All piles are Large Diameter Open-End Pipe Piles (LDOEPP).

[2.] Testing including a Constrictor Plate.

[3.] Pipe pile sizes are based on outside diameter.

[4.] Target and Approximate Nominal Axial Resistances are based on plugged conditions and are anticipated after setup, not during initial driving.

[5.] Pile yield stress for US-51 Bridge Replacement Project (pipe piles) is 50 ksi.

[6.] Steel for pipe piles shall conform to ASTM A252, Grade 3 (F_y = 50 ksi), for welded or seamless steel pipe piles.

[7.] The wall thickness at any point shall not be more than 12.5% under the specified nominal wall thickness. The nominal thickness of ordered piles shall match this table. Oversized nominal wall thickness is not permitted.

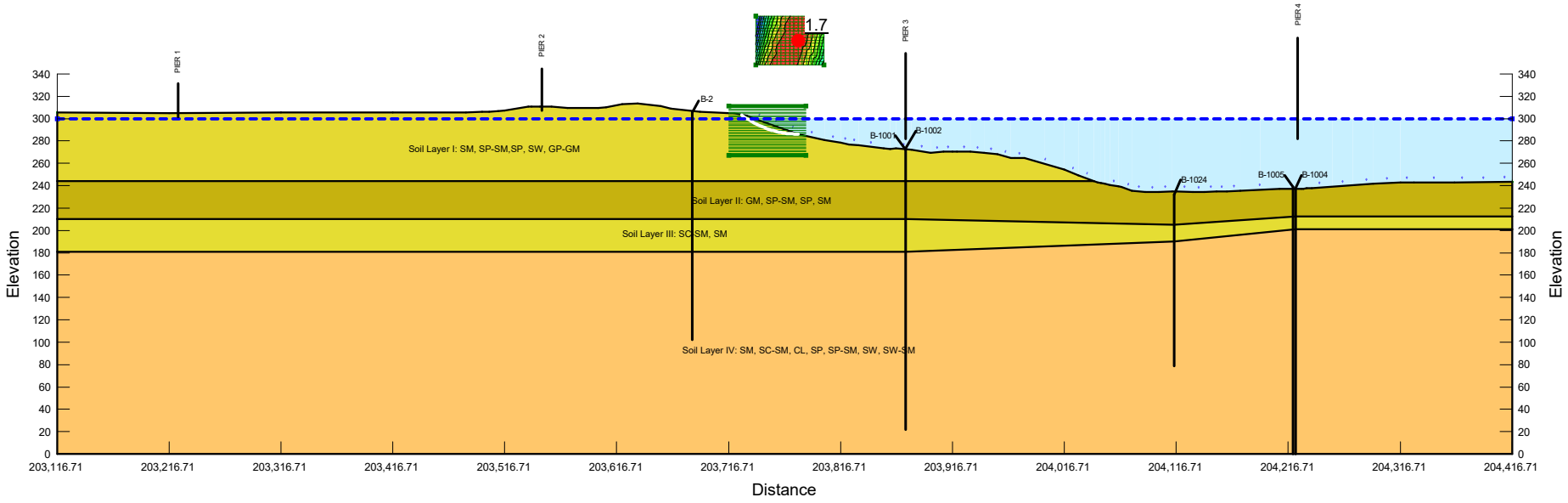
[8.] Per ASTM D1143, the load test apparatus for static load tests shall be designed to safely apply a test load of at least 120% of the Target Nominal Axial Resistance.

[9.] Pile points and cutting shoes conforming to AASHTO M-103 or ASTM A-148 may be required.

Appendix G – Global Stability Analysis

Cairo Bridge - West Riverbank, IL
Static Analysis: Top Slope
GWT: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date:02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

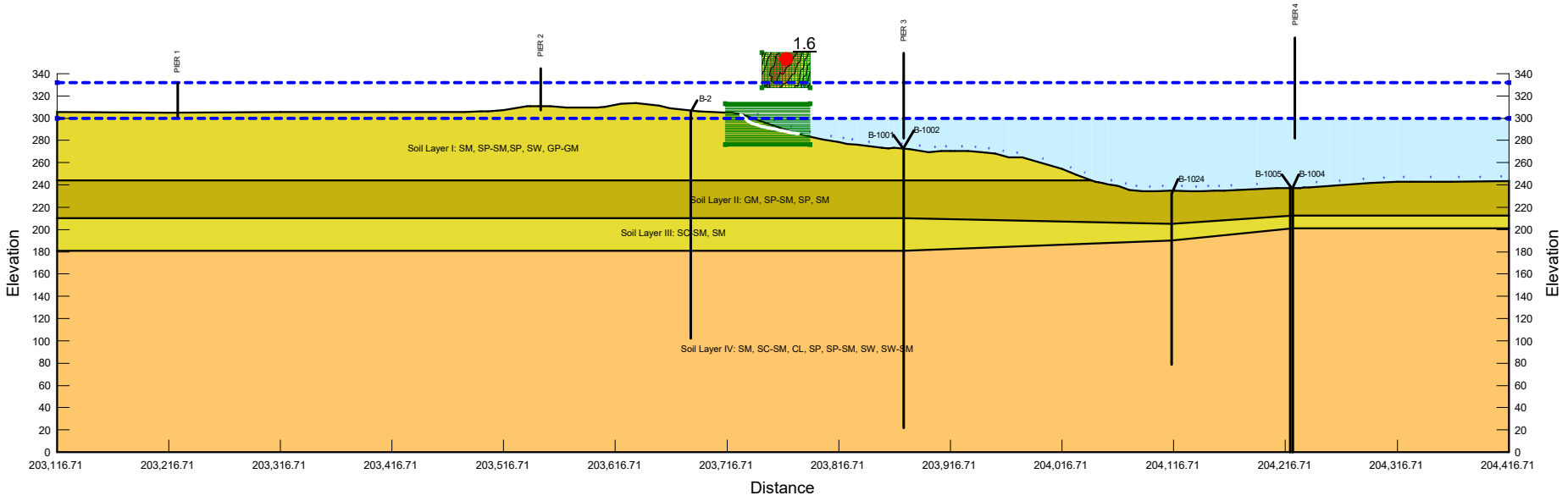
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL
Static Analysis: Rapid Drawdown (100 YR Event, Top Slope)
Piezometric Surface 1: 331.92 ft
Piezometric Surface 2: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date: 02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

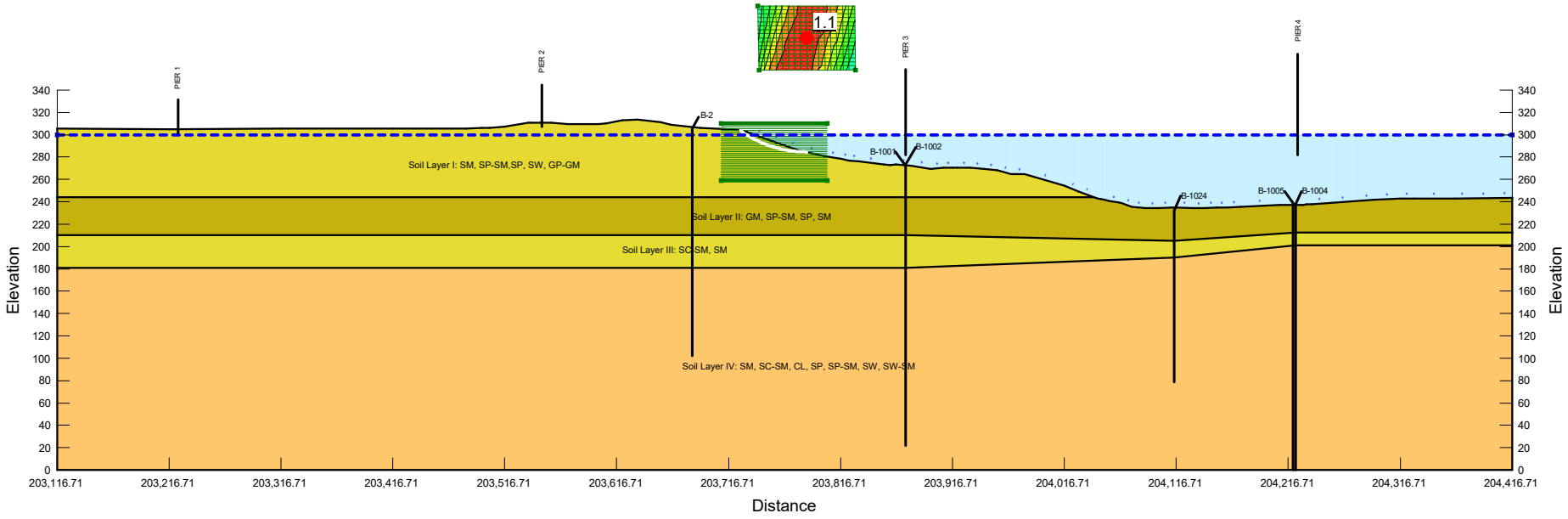
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion R (psf)	Phi R (°)	Piezometric Surface	Piezometric Surface After Drawdown
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30	0	30	1	2
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36	0	36	1	2
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31	0	31	1	2
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36	0.1	35.9	1	2



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL
Seismic Analysis: Top Slope, 100 YR
GWT: 300 ft
Horizontal Seismic Coefficient: 0.08
Created By: Lambert, Samuel Date: 02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

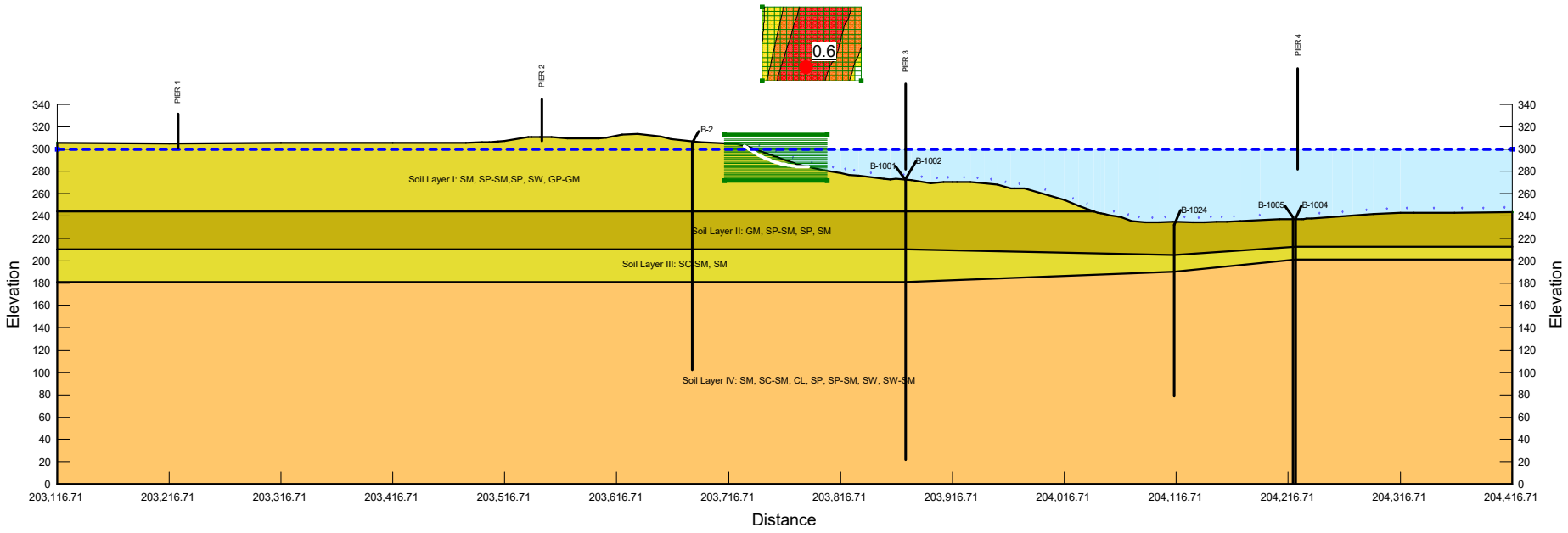
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL
Seismic Analysis: Top Slope, 1000 YR
GWT: 300 ft
Horizontal Seismic Coefficient: 0.265
Created By: Lambert, Samuel Date: 02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

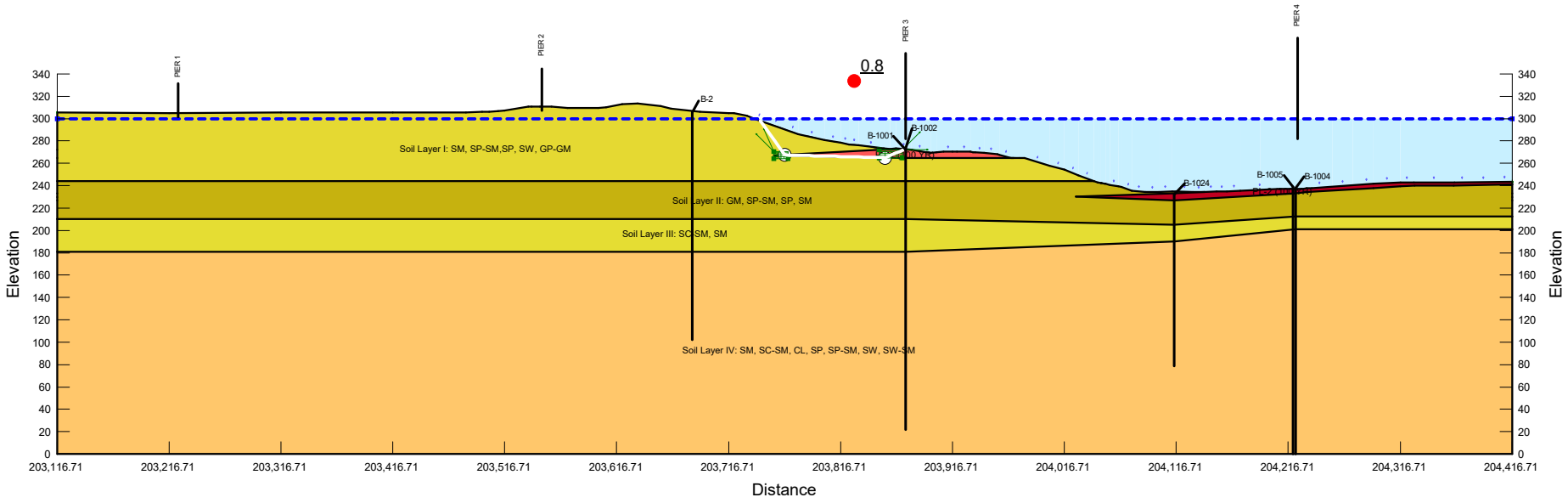
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL - Liquefaction (100 YR)
Seismic Analysis: Wedge Case I - PL-1
GWT: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date:02/25/2026
Revised By: Borders, Stephen Date: 02/25/2026

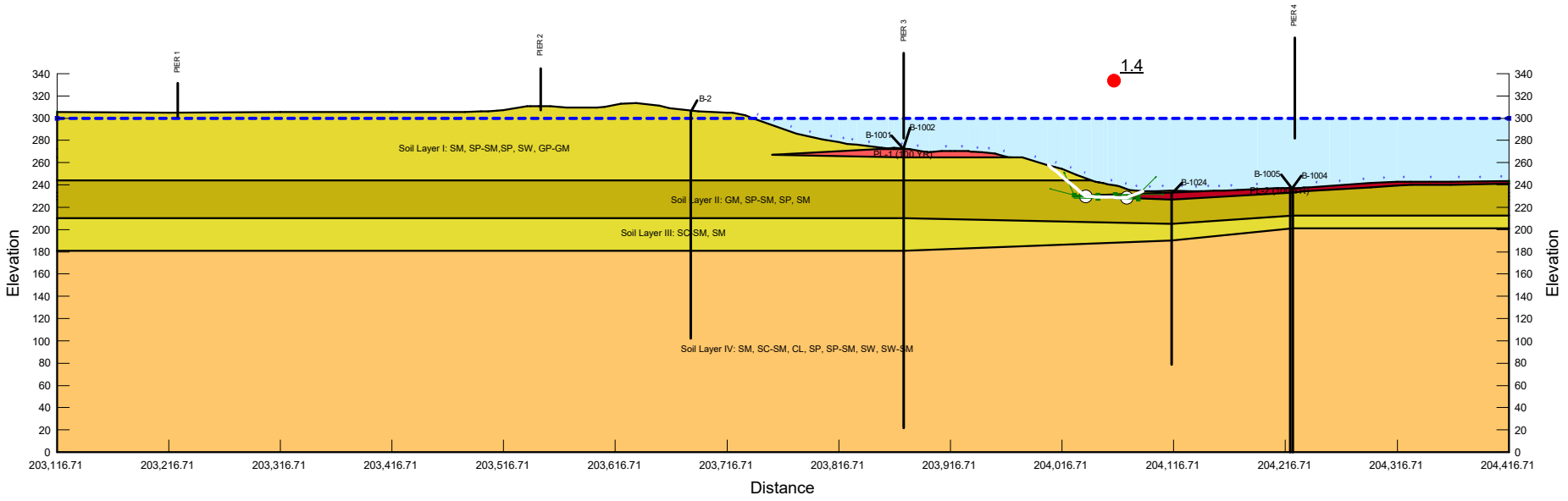
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	PL-1 (100 YR)	Mohr-Coulomb	125	35	0
	PL-2 (100 YR)	Mohr-Coulomb	130	100	0
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL - Liquefaction (100 YR)
Seismic Analysis: Wedge Case I - PL2
GWT: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date:02/25/2026
Revised By: Borders, Stephen Date: 02/25/2026

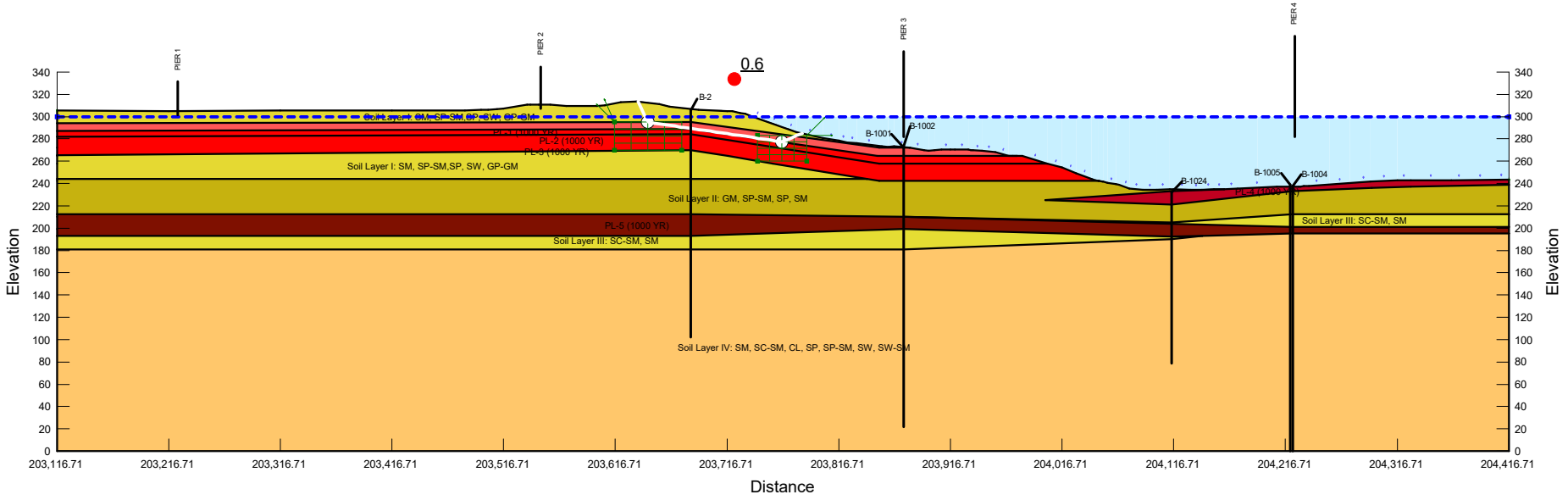
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	PL-1 (100 YR)	Mohr-Coulomb	125	35	0
	PL-2 (100 YR)	Mohr-Coulomb	130	100	0
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL - Liquefaction (1000 YR)
Seismic Analysis: Wedge Case I - PL-1 through 3
GWT: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date:02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

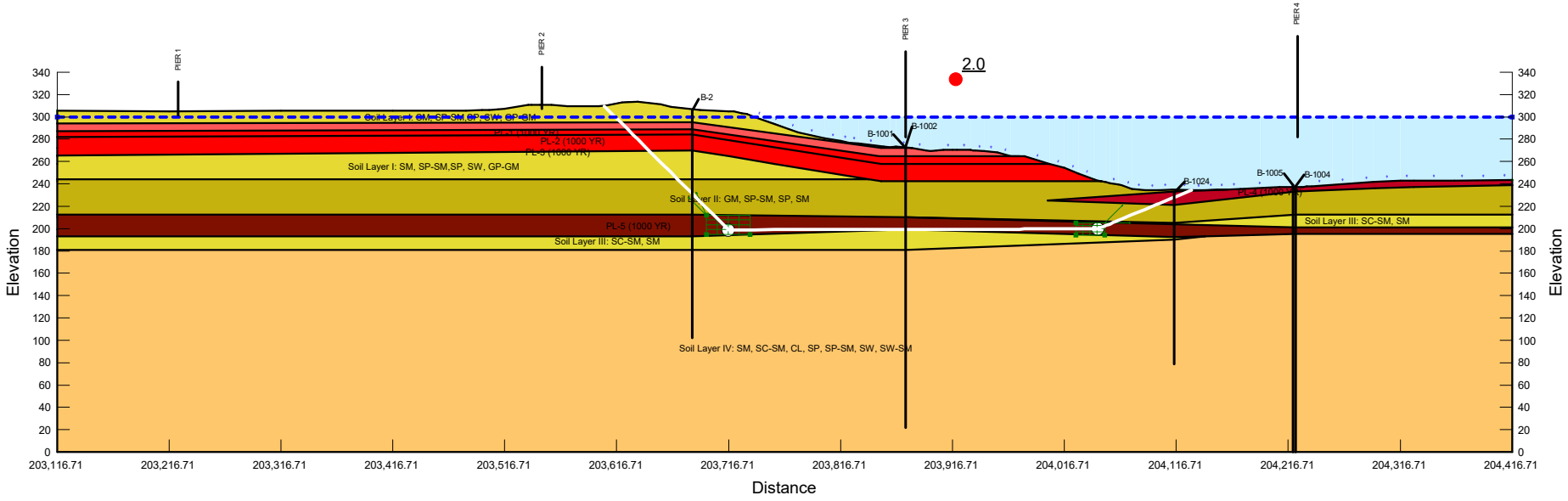
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	PL-1 (1000 YR)	Mohr-Coulomb	125	100	0
	PL-2 (1000 YR)	Mohr-Coulomb	125	300	0
	PL-3 (1000 YR)	Mohr-Coulomb	125	500	0
	PL-4 (1000 YR)	Mohr-Coulomb	130	235	0
	PL-5 (1000 YR)	Mohr-Coulomb	130	1,000	0
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - West Riverbank, IL - Liquefaction (1000 YR)
Seismic Analysis: Wedge Case I - PL-5
GWT: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Lambert, Samuel Date:02/24/2026
Revised By: Borders, Stephen Date: 02/24/2026

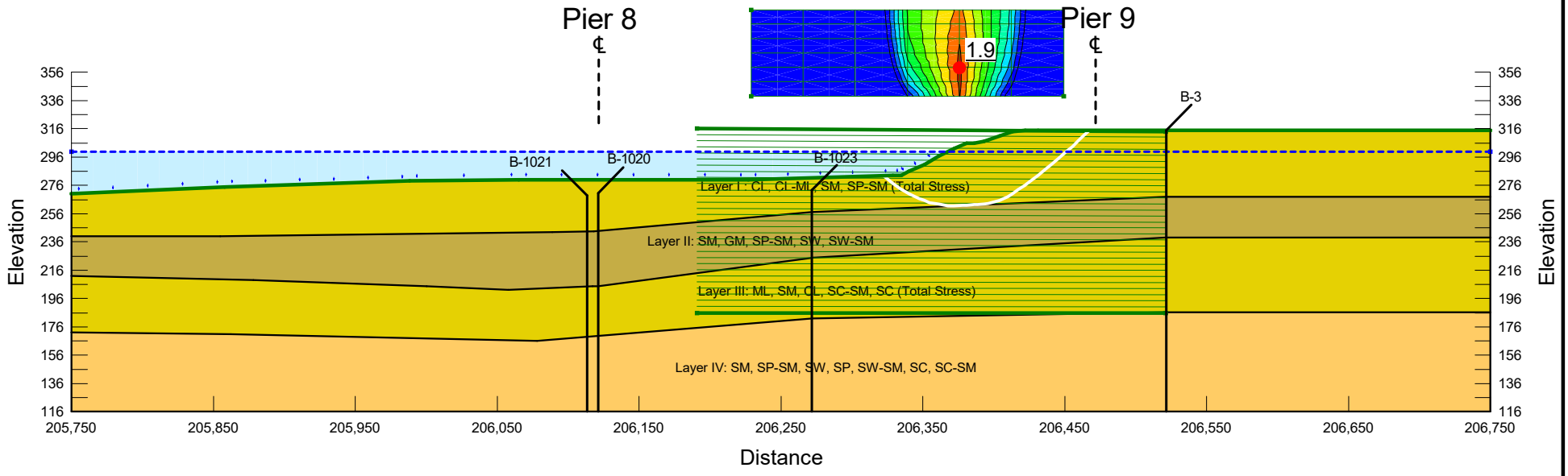
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	PL-1 (1000 YR)	Mohr-Coulomb	125	100	0
	PL-2 (1000 YR)	Mohr-Coulomb	125	300	0
	PL-3 (1000 YR)	Mohr-Coulomb	125	500	0
	PL-4 (1000 YR)	Mohr-Coulomb	130	235	0
	PL-5 (1000 YR)	Mohr-Coulomb	130	1,000	0
	Soil Layer I: SM, SP-SM,SP, SW, GP-GM	Mohr-Coulomb	125	0	30
	Soil Layer II: GM, SP-SM, SP, SM	Mohr-Coulomb	130	0	36
	Soil Layer III: SC-SM, SM	Mohr-Coulomb	125	0	31
	Soil Layer IV: SM, SC-SM, CL, SP, SP-SM, SW, SW-SM	Mohr-Coulomb	140	0	36



US-51 Bridge
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1001, B-1002, B-1024

Cairo Bridge - East Riverbank, KY
Static Analysis : Short-Term
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

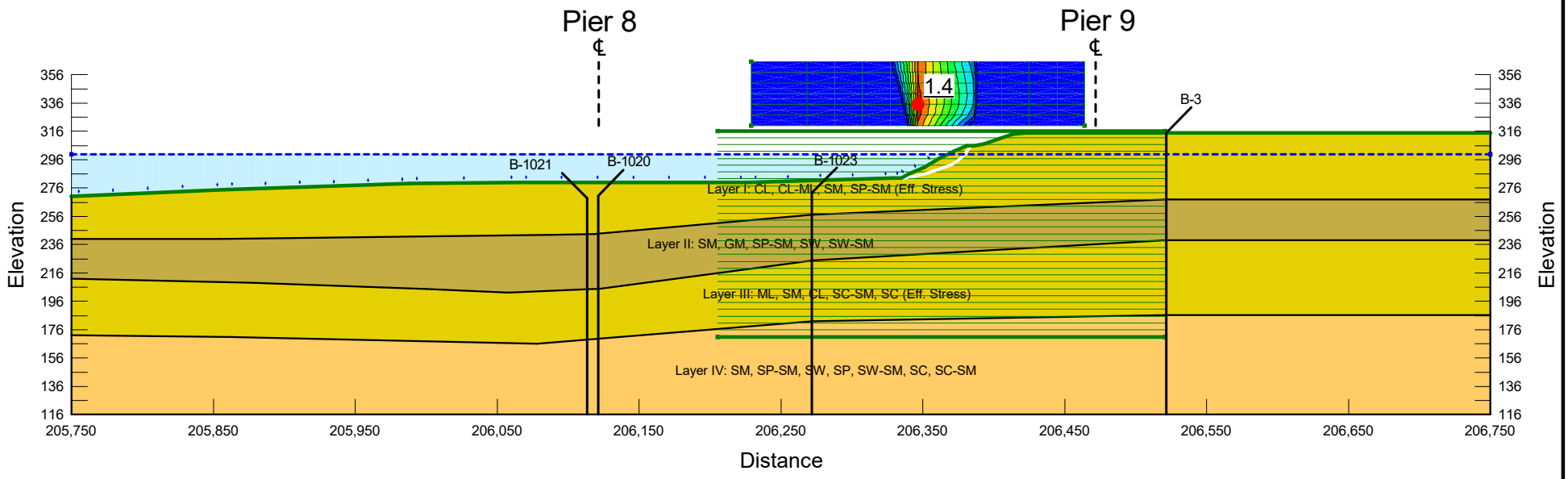
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Undrained Shear Strength (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115			850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125			1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36	



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY
Static Analysis : Long-Term
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

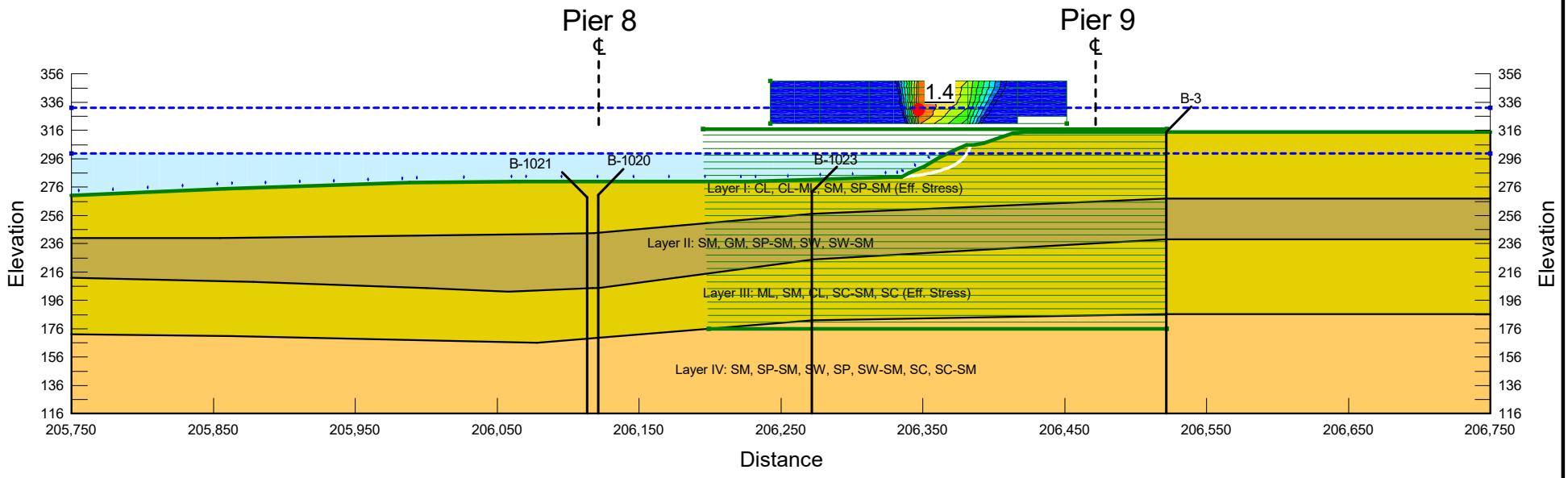
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Layer I: CL, CL-ML, SM, SP-SM (Eff. Stress)	Mohr-Coulomb	115	50	28
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32
	Layer III: ML, SM, CL, SC-SM, SC (Eff. Stress)	Mohr-Coulomb	125	50	29
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY
Static Analysis: Rapid Drawdown
Rapid Drawdown (100 YR Event)
Piezometric Surface 1:331.92 ft
Piezometric Surface 2:300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

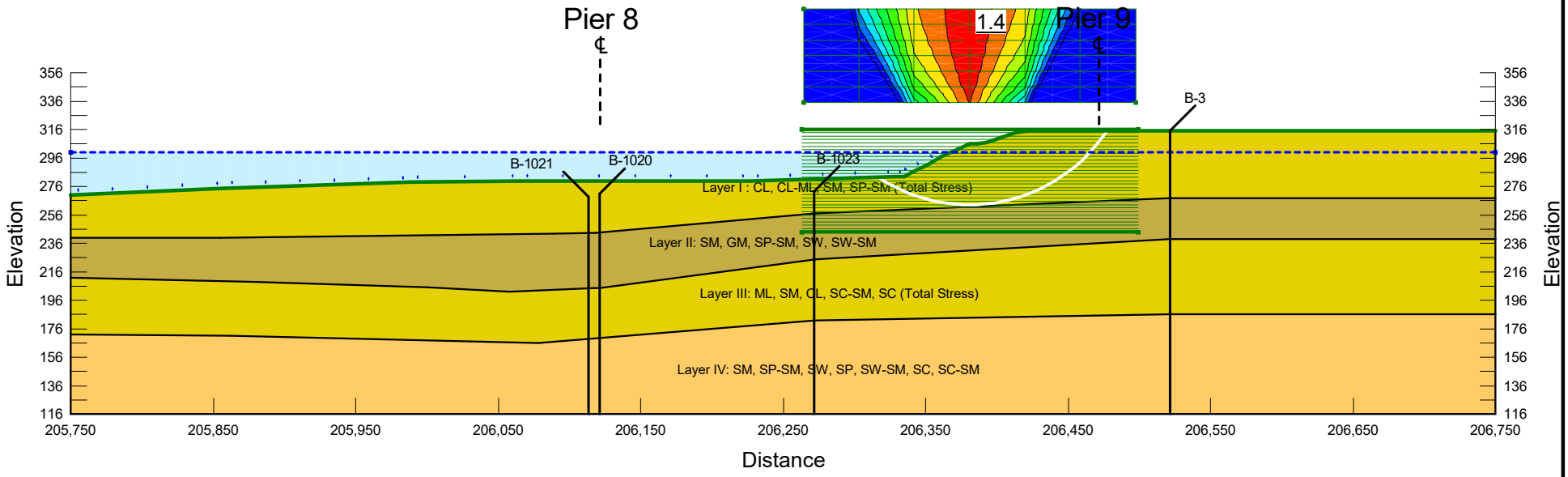
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion R (psf)	Phi R (°)
	Layer I: CL, CL-ML, SM, SP-SM (Eff. Stress)	Mohr-Coulomb	115	50	28	850	0
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32	0	0
	Layer III: ML, SM, CL, SC-SM, SC (Eff. Stress)	Mohr-Coulomb	125	50	29	1,600	0
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36	0	0



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY
Pseudo-Static Analysis : 100 YR PGA
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0.075
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

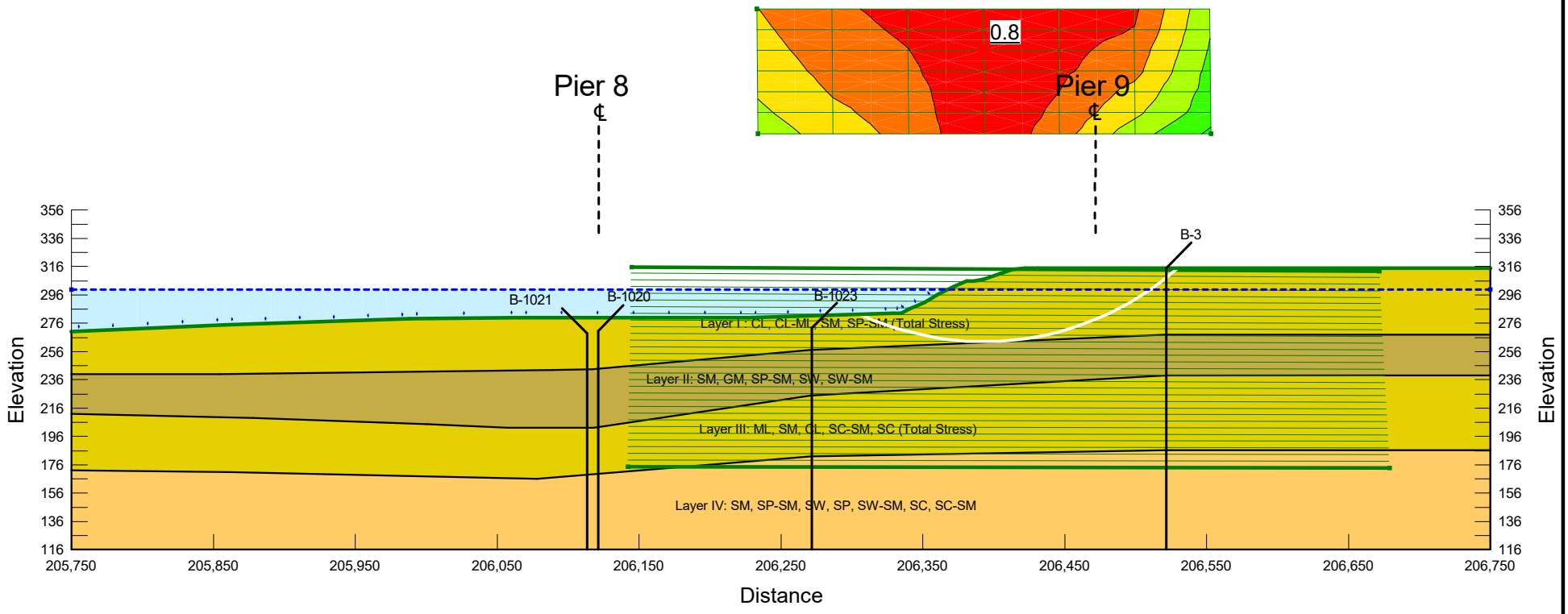
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Undrained Shear Strength (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115			850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125			1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36	



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY
Pseudo-Static Analysis : 1/2 1000 YR PGA
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0.265
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

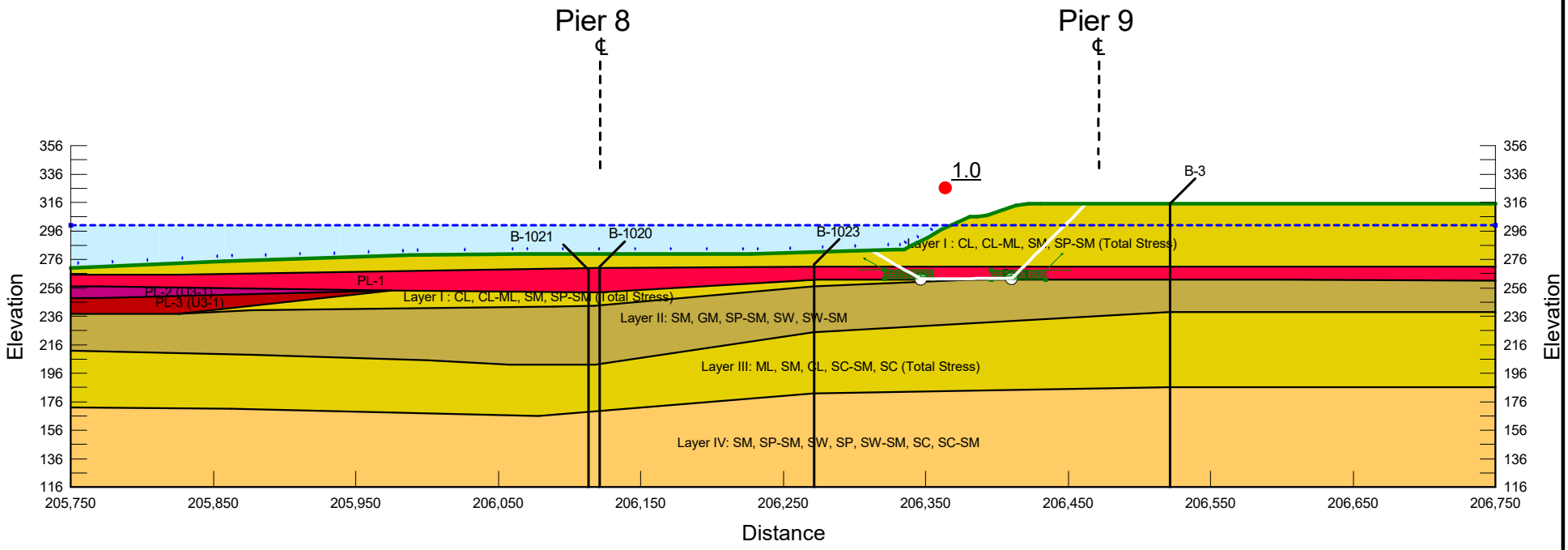
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Undrained Shear Strength (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115			850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125			1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36	



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY - Liquefaction (100 YR)
Seismic Analysis: Wedge Case I, PL-1
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 01/05/2026
Revised By:Schuster, Matthew Date: 12/04/2025

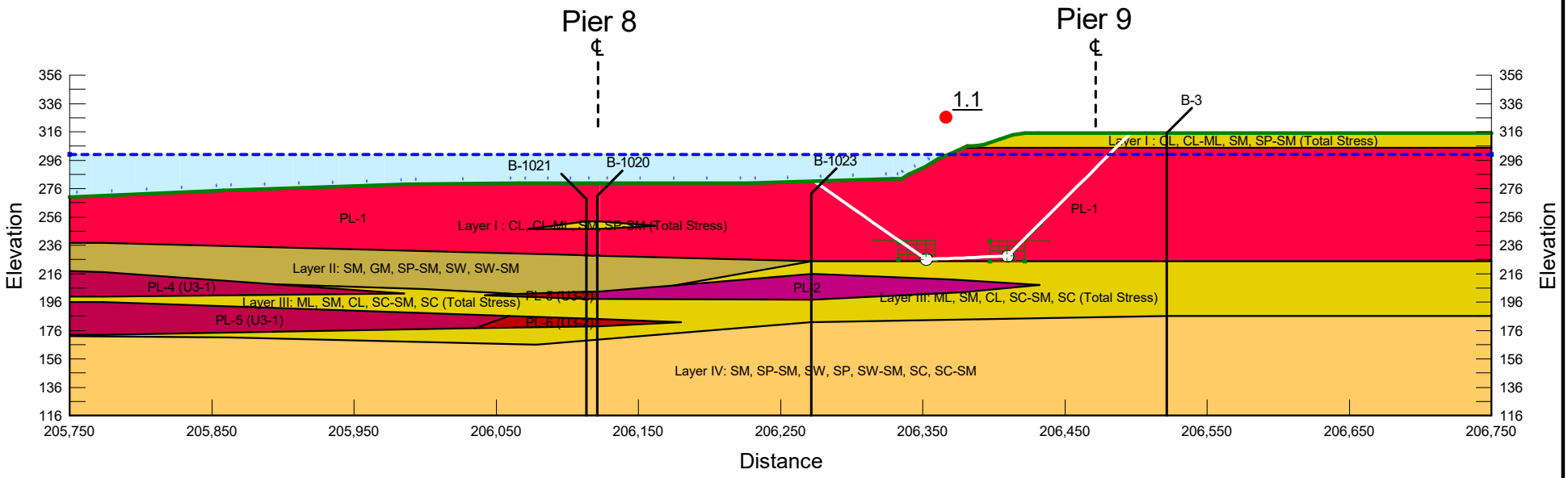
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Undrained Shear Strength (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115			850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125	0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125			1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135	0	36	
	PL-1	Undrained (Phi=0)	120			100
	PL-2 (Pier 7)	Undrained (Phi=0)	120			175
	PL-3 (Pier 7)	Undrained (Phi=0)	120			250



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY- Liquefaction (1000 YR)
Seismic Analysis : Wedge Case I, PL-1
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 12/17/2025
Revised By:Schuster, Matthew Date: 12/04/2025

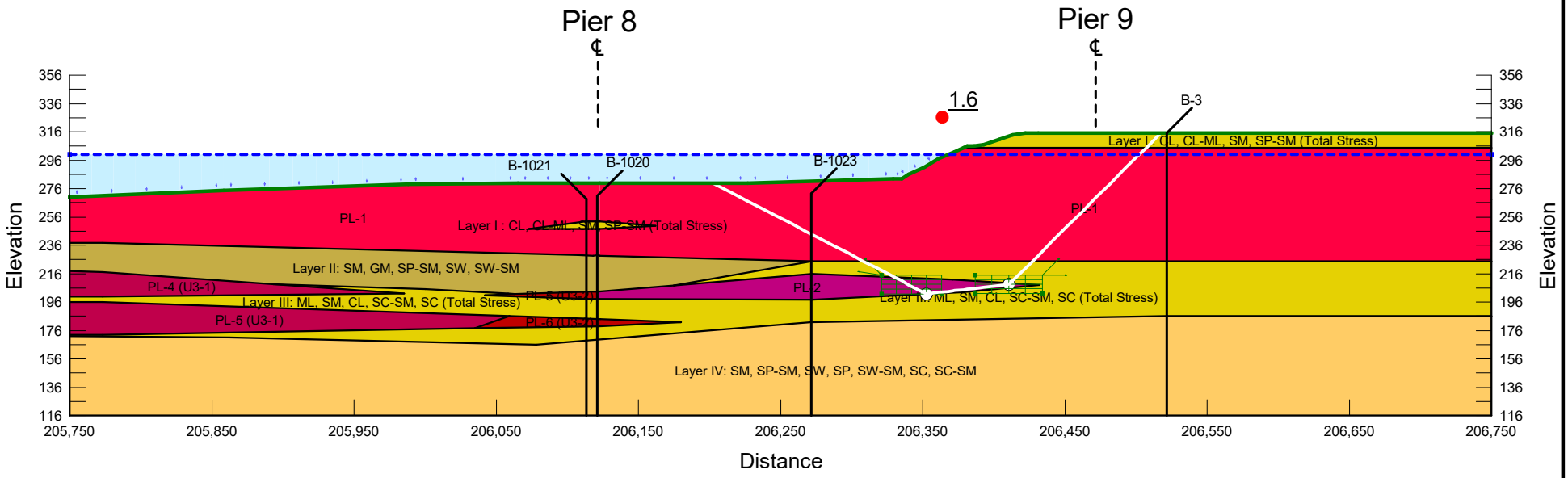
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Minimum Strength (psf)	Undrained Shear Strength vs Vertical Effective Stress Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Total Cohesion (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115					850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125			0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125					1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135			0	36	
	PL-1	SHANSEP	120	0	Shansep-I			
	PL-2	Undrained (Phi=0)	120					1,000
	PL-4 (Pier 7)	Undrained (Phi=0)	120					700
	PL-5 (Pier 7)	Undrained (Phi=0)	125					1,000
	PL-5 (Pier 8)	Undrained (Phi=0)	125					350
	PL-6 (Pier 8)	Undrained (Phi=0)	125					400



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Cairo Bridge - East Riverbank, KY - Liquefaction (1000 YR)
Seismic Analysis : Wedge Case I, PL-2
GWT Elevation: 300 ft
Horizontal Seismic Coefficient: 0
Created By: Pineda, Raydel Date: 12/17/2025
Revised By:Schuster, Matthew Date: 12/04/2025

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Minimum Strength (psf)	Undrained Shear Strength vs Vertical Effective Stress Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Total Cohesion (psf)
	Layer I : CL, CL-ML, SM, SP-SM (Total Stress)	Undrained (Phi=0)	115					850
	Layer II: SM, GM, SP-SM, SW, SW-SM	Mohr-Coulomb	125			0	32	
	Layer III: ML, SM, CL, SC-SM, SC (Total Stress)	Undrained (Phi=0)	125					1,600
	Layer IV: SM, SP-SM, SW, SP, SW-SM, SC, SC-SM	Mohr-Coulomb	135			0	36	
	PL-1	SHANSEP	120	0	Shansep-I			
	PL-2	Undrained (Phi=0)	120					1,000
	PL-4 (Pier 7)	Undrained (Phi=0)	120					700
	PL-5 (Pier 7)	Undrained (Phi=0)	125					1,000
	PL-5 (Pier 8)	Undrained (Phi=0)	125					350
	PL-6 (Pier 8)	Undrained (Phi=0)	125					400



US-51 Bridge Replacement Project
Alexander County, IL and Ballard County, KY
Analysis Type: Spencer
Critical Borings: B-1023 and B-3

Appendix H – Report Figures During Drilling Program

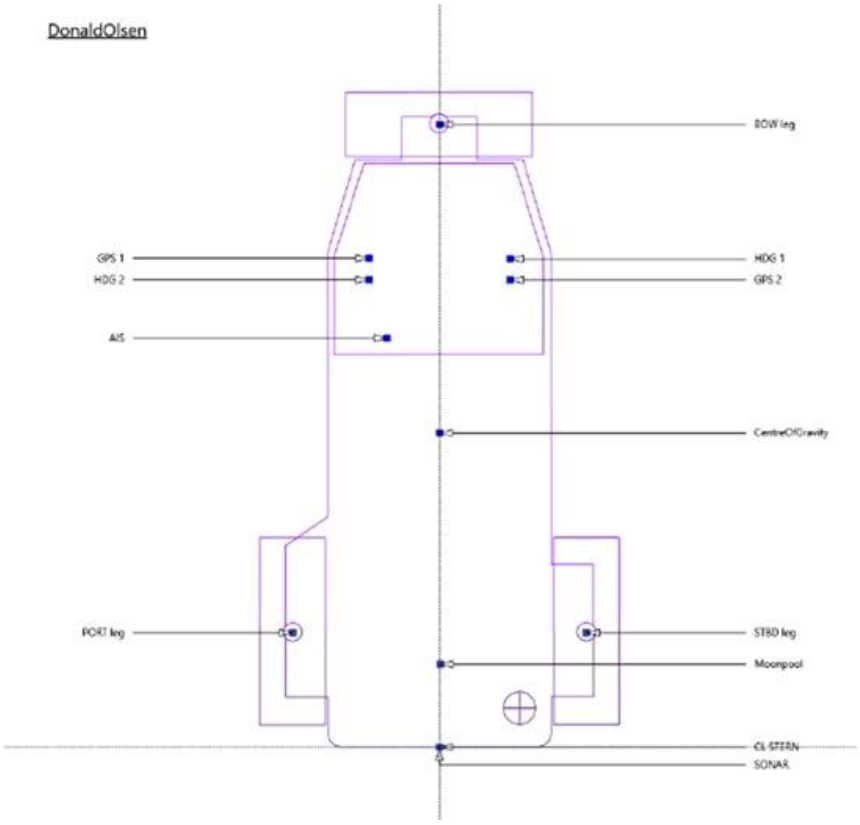


Figure 1. Donald Olson GNSS Positioning System



Figure 2. Funnel Cloud during Subsurface Investigation

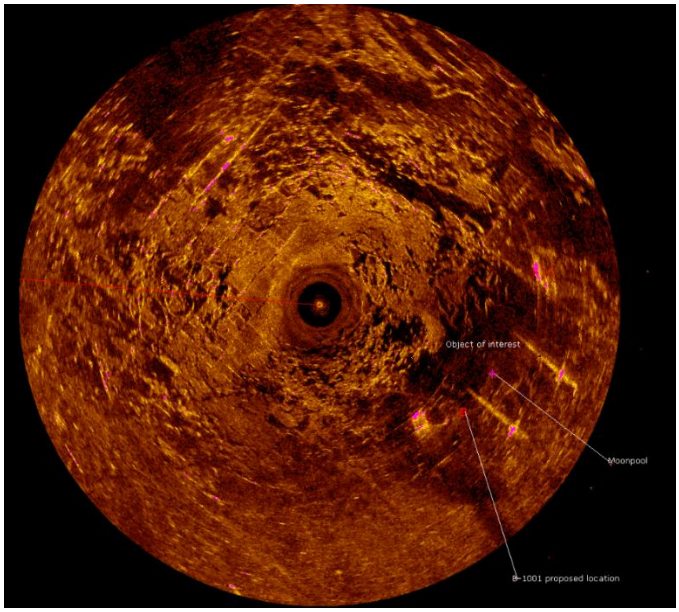


Figure 3. Sonar Image of B1001 Location



Figure 4. Wood Debris within C1003



Figure 5. Receding River Levels resulting in termination of SCPTu



Figure 6. Cable in Liftboat Propeller



Figure 7. Wood Fragments in B1002



Figure 8. Aluminum Cable in B1002

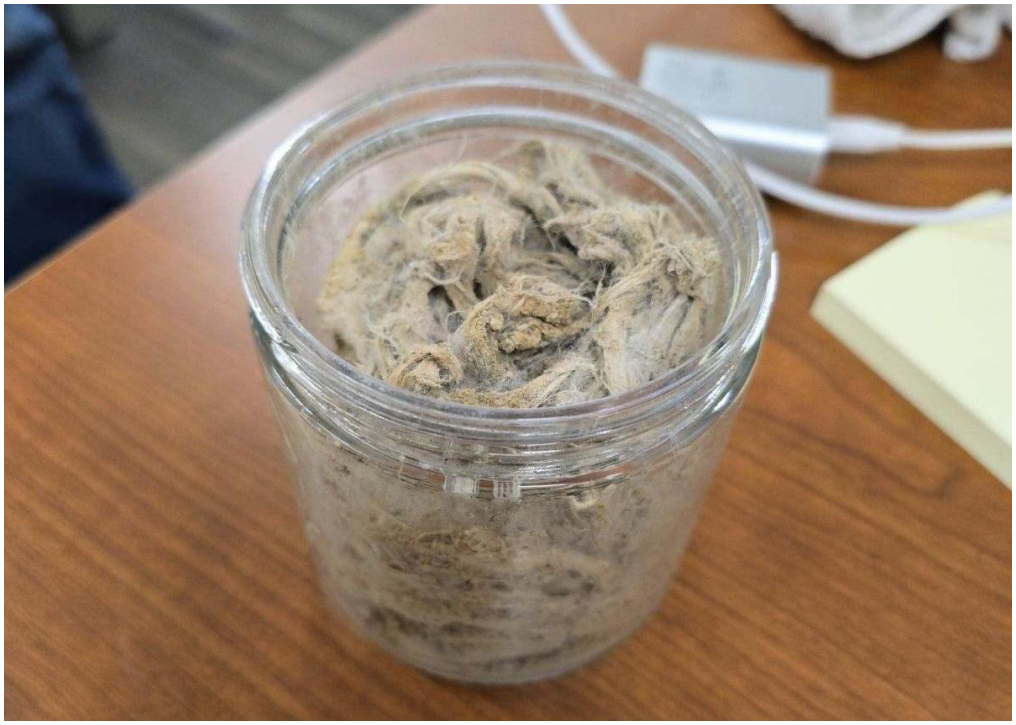


Figure 9. Apparent Synthetic Manmade Fibers



Figure 10. Apparent Porters Creek Formation (~385 ft below mudline)



Figure 11. Apparent Chert Cobble from B-1008 (~313 ft below mudline)