Proactive by Design

GEOTECHNICAL DESIGN REPORT CROCKETT BRIDGE NO. 2199 OVER THE MUDDY RIVER

MAINE DOT WIN 20466.00
NAPLES, MAINE

Prepared for:
Maine Department of Transportation
Augusta, Maine

March 2016
09.0025899.00

Prepared by:
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VIA EMAIL

March 23, 2016
File No. 09.0025899.00

Ms. Laura Krusinski
Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016

Re: Final Geotechnical Design Report
Crockett Bridge No. 2199 Over the Muddy River
MaineDOT WIN 20466.00
Naples, Maine

Dear Laura:

We are pleased to provide this Final Geotechnical Design Report for MaineDOT Bridge No. 2199 over Muddy River in Naples, Maine. Our work was completed in accordance with Assignment Letter No. 1, dated October 14, 2015, issued under Multi-PIN Project Contract Number 20150608000000000793 between Maine Department of Transportation and GZA GeoEnvironmental, Inc. (GZA) dated July 22, 2015, which incorporates GZA's proposal No. 09.P000046.16, dated October 1, 2015, and the attached Limitations included in Appendix A of this report.

It has been a pleasure serving the Maine Department of Transportation team on this project. If you have any questions regarding the report, or if we can provide further assistance, please do not hesitate to contact the undersigned.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

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1.0 INTRODUCTION

This report presents the results of the geotechnical evaluation completed by GZA GeoEnvironmental, Inc. (GZA) for the proposed replacement of Maine Department of Transportation (MaineDOT) Bridge No. 2199 over the Muddy River. Our services were provided in accordance with Assignment Letter No. 1, dated October 14, 2015, issued under Multi-PIN Project Contract Number 20150608000000000793 between MaineDOT and GZA dated July 22, 2015, which incorporates GZA's proposal No. 09.P000046.16, dated October 1, 2015, and the attached *Limitations* included in **Appendix A**.

1.1 BACKGROUND

Crockett Bridge (#2199) carries Route 11/114 (Sebago Road) over the Muddy River at the location shown on **Figure 1, Locus Plan**. The existing bridge was constructed in 1930 and consists of a single-span, cast-in-place concrete rigid frame with a clear span of 20 feet. The existing bridge deck is approximately level at El. 276 to El. 277. The southwest abutment is supported by a spread footing bearing on bedrock and the northeast abutment is supported on timber piles. The approach embankments are generally riprap covered and have slope inclinations generally ranging from 1.5 horizontal to 1 vertical (1.5H:1V) to 2H:1V, but are locally as steep as 1H:1V.

MaineDOT plans[1] show that the replacement bridge will consist of an 80-foot-long, single-span bridge, extending from approximately Sta. 114+70 to Sta. 115+50, as shown on **Figure 2, Boring Location Plan**. The new bridge is proposed to include a superstructure consisting of four precast NEXT 36 F beams with integral abutment substructures, supported by spun pipe piles, defined and discussed further herein. MaineDOT provided an estimated thermal deformation of the bridge superstructure of 0.88 inches, which would result in approximately 0.44 inches of pile head translation at each abutment, as well as a live load-induced pile head rotation of 0.00245 inches/inch in the direction opposite of the imposed lateral load.

The total length of the project is about 675 feet (Sta. 112+25 to 119+00). The horizontal alignment of the roadway and bridge in the project area will not be significantly modified as part of the project. The approach roadway will be up to 2 feet below existing grades to the southwest of the bridge and up to 3 feet above existing grades northeast of the existing bridge, respectively. Approach embankment modifications will include placing additional fill and riprap along the northwest (upstream) sides of the approach embankments to provide a slope inclination ranging from 1.75H:1V to 2.5H:1V, with plain riprap protection. Fill and riprap will also be placed in front of each abutment at an inclination of 1.75H:1V.

The project plans call for the bridge to be constructed in the fall of 2016 using Accelerated Bridge Construction (ABC) inside of a 26-day road closure, during which traffic will be detoured. All of the bridge demolition activities must be completed within this window, and at least one lane must be re-opened to traffic at completion of the closure.

The project also includes reconstruction of the existing slope on the Right (southeast) side of the road between approximately Sta. 116+75 and 118+25. The roadway will be reconstructed and widened up to approximately Sta. 118+00 as part of this work. GZA is providing geotechnical recommendations for the slope modification in a separate design memorandum.

[1] Plans reviewed during preparation of this report consisted of a "Semi-Final" set provided by MaineDOT dated March 14, 2016.

1.2 OBJECTIVES AND SCOPE OF SERVICES

The objectives of our work were to evaluate subsurface conditions and to provide final geotechnical engineering recommendations for the proposed Crockett Bridge No. 2199 replacement. To meet these objectives, GZA completed the following Scope of Services:

- Conducted site visits to observe surficial conditions and reviewed mapped surficial and bedrock geology of the site;
- Visited the MaineDOT soil and rock storage facility in Bangor to review and obtain samples of rock core;
- Conducted a site visit to observe and log supplemental subsurface investigations;
- Developed the interpretive subsurface profile based on the evaluation of the subsurface conditions;
- Conducted geotechnical engineering analyses to evaluate axial and lateral foundation design for the replacement bridge, embankment design considerations, and seismic design considerations;
- Developed geotechnical design parameters and recommendations for spun pipe pile foundations, lateral earth pressures, and seismic design parameters; and
- Prepared this final report summarizing our findings and design recommendations.

2.0 SUBSURFACE EXPLORATIONS

Prior to GZA's engagement in the project, an exploration program was completed by MaineDOT in May 2015. A supplemental exploration program was completed by MaineDOT at GZA's request in December 2015. Details of these programs are described below.

2.1 TEST BORINGS

MaineDOT/Northern Test Boring drilled five test borings, including BB-NMR-101, -102, and -102A on May 5 and 6, 2015, and BB-NMR-201 and -202 on December 10 and 28, 2015. MaineDOT logged all of the borings except for BB-NMR-201, which was logged by a GZA engineer.

Borings BB-NMR-101, -201, and -202 were drilled through the southwest approach (adjacent to Abutment 1), while BB-NMR-102 and BB-NMR-102A were drilled through the northeast approach (adjacent to Abutment 2) as shown on the Boring Location Plan (prepared by MaineDOT), **Figure 2**. The as-drilled boring locations and elevations were surveyed and provided by MaineDOT (in station/offset format for the locations) and are included on the logs in **Appendix B**.

Three test borings (BB-NMR-101, -102A and -202) were drilled through the overburden soil and terminated approximately 7 to 9 feet into bedrock. Borings BB-NMR-102 and -201 were terminated in soil due to casing damage during drilling. Depths of borings ranged from approximately 25.5 to 49.6 feet below ground surface (bgs). The borings were drilled using 3- and 4-inch driven casing and drive-and-wash drilling techniques. Standard penetration testing (SPT) and split-spoon sampling were performed at 5-foot typical intervals in the overburden portion of the 100-series borings using a 24-inch-long, 1-3/8-inch inside diameter sampler. Soil samples were not collected in the 200-series borings. Bedrock cores were obtained using NQ2 wire-line coring equipment in borings

BB-NMR-101, -102A and -202. The borings were backfilled with soil cuttings and/or sand, and were patched with cold patch.

Drafts of the logs were prepared in Logdraft by MaineDOT or GZA. GZA subsequently reviewed the logs and made edits in GeoSystem Logdraft to reflect laboratory soil test results and our analysis of stratification. The final logs are provided in **Appendix B**.

2.2 REVIEW OF ROCK CORE

GZA requested access to the rock core samples in order to make an independent assessment of the rock type and characteristics. After receiving approval from the MaineDOT Geotechnical Group, a GZA engineer visited MaineDOT's laboratory in Bangor, reviewed the available rock core specimens, and prepared descriptions for core samples from borings BB-NMR-101, -102A, and -202. The GZA observations are provided on the logs in **Appendix B**. GZA also took wet and dry photographs of the rock core specimens, which are presented in **Appendix C**.

3.0 LABORATORY TESTING

Laboratory testing was conducted by MaineDOT on split-spoon soil samples retrieved from the 100-series borings. The testing program consisted of gradation analysis / AASHTO Classification / Frost Classification assessments and water content of eight samples, hydrometer testing of one sample and specific gravity of two samples.

GZA retained Thielsch Engineering's Geotechnical Laboratory in Cranston, Rhode Island to complete a bedrock testing program to assess the strength characteristics of the bedrock, consisting of unconfined compression strength tests with axial and lateral strain measurements on two bedrock samples.

Results of the laboratory testing are included in **Appendix D.**

4.0 SUBSURFACE CONDITIONS

4.1 SURFICIAL AND BEDROCK GEOLOGY

Based on available literature, surficial geologic units in the site vicinity are mapped as Glacial Lake Sebago Bottom Deposit (massive to stratified and cross-stratified sand, generally fine to medium, and massive to laminated silt and silty clay, may contain boulders and gravel) varying in thickness from 1 to 60 feet. The bridge approach embankments are mapped as Artificial Fill.

Bedrock at the site is mapped as the Sebago pluton. The Sebago pluton in the site vicinity is described as medium-grained equigranular, biotitic-muscovite Granite, white to pale pink, locally pegmatitic. Two intrusive dikes are also mapped in the immediate site vicinity, including a mafic dike (reddish-brown weathering, black basaltic dikes) and a trachyte dike (dark gray weathering, chocolate-brown feldspar-bearing dikes).

4.2 SUBSURFACE PROFILE

Four soil units: Fill, Gravelly Sand, Silt, and Gravel were encountered below pavement and above bedrock in the test borings. The encountered thicknesses and generalized descriptions are presented in the following table, in descending order from existing ground surface. Detailed descriptions of the materials encountered at specific locations are provided in the boring logs in **Appendix B**. An interpretive subsurface profile based on the test boring results is presented as **Figure 3, Interpretive Subsurface Profile**.

Soil Unit	Approx. Encountered Thickness (ft)	Generalized Description
Fill	7 to 15	Brown, loose to dense, fine to coarse SAND, little to some silt, trace to some gravel. (USCS: SM) Occasional cobbles. MaineDOT Frost Classification = II.
Gravelly Sand	12 to 15	Brown-gray, medium dense to dense, gravelly SAND to sandy GRAVEL, little to trace silt. (USCS: SW-SM, GW-GM, SP, SM) Occasional cobbles. MaineDOT Frost Classification = 0-II.
Silt	3 to 4	Gray, medium stiff to stiff, clayey SILT to SILT, trace sand, trace gravel. (USCS: ML). MaineDOT Frost Classification = IV.
Gravel	3 to 10	Brown, medium dense to very dense GRAVEL, some sand to fine to coarse SAND, some gravel, little silt. (USCS: GP, GP-GM, SP-SM) Cobbles and boulders encountered near bottom of stratum. MaineDOT Frost Classification = 0.
Top of Bedrock Elevation	Abutment 1: El. 250.2 (BB-NMR-101) to El. 255.3 (BB-NMR-202) Abutment 2: El. 234.4 (BB-NMR-102A)	

GZA did not observe the soil samples during our work. Generalized descriptions for the soil units are based on field classifications by MaineDOT, modified for consistency with laboratory test results.

4.2.1 Bedrock

Bedrock encountered in the borings consisted of Granite with Trachyte dikes in BB-NMR-101 and Granite in BB-NMR-102A and BB-NMR-202. Granite was generally described as very hard to hard, fresh, medium grained, and white/gray/black. Trachyte was encountered from the top of rock (26 feet bgs) to 29.3 feet bgs and from 33.5 to 34.8 feet bgs in BB-NMR-101 and was generally described as very hard, fresh, aphanitic and red-brown. Joints were very close to moderately spaced, horizontal to moderately dipping, undulating, rough, fresh to discolored, and tight to open. The RQD ranged from 23 to 100 percent. The bedrock is sloping down toward the north and west based on the encountered top of rock elevations in the borings at average inclinations ranging from 2H:1V to 4H:1V.

Two laboratory unconfined compressive strength tests with strain measurements were conducted on bedrock core samples (one on Trachyte from BB-NMR-101 and one on Granite from BB-NMR-102A). The test results are included in **Appendix D.** The Trachyte had an unconfined compressive strength of 34.3 kips per square inch (ksi), a Young's modulus of 4,580 ksi and a Poisson's ratio of 1.38. The Granite had an unconfined compressive strength of 14.9 kips ksi, a Young's modulus of 3,230 ksi and a Poisson's ratio of 0.94.

4.2.2 Groundwater

Groundwater was not measured in the boreholes. We estimate that the groundwater is roughly 9 feet bgs for all borings, corresponding to El. 267, based on the relative moisture in the sample descriptions. Groundwater levels fluctuate due to changes in river level, season, precipitation, infiltration and construction activity in the area. Therefore, groundwater levels during and after construction are likely to vary from those estimated based on the results of the test borings.

5.0 ENGINEERING EVALUATIONS

5.1 GENERAL

GZA has conducted geotechnical engineering evaluations in accordance with 2014 AASHTO LRFD Bridge Design Specifications, 7th Edition, with Interims (herein known as AASHTO) and the MaineDOT Bridge Design Guide, 2014 Edition (MaineDOT BDG). The sections that follow describe the evaluations and the geotechnical basis for each element. Supporting calculations developed by GZA for the project are attached in **Appendix E** of this report.

5.2 APPROACH EMBANKMENTS

The proposed approach embankments will vary between 2 feet below and 3 feet above existing grades, but the embankments will be widened by 6 to 8 feet in the vicinity of the bridge. Proposed slopes inclination at both approaches will be flattened to range between 1.75H:1V and 2.5H:1V. As a result of these modifications, fill placement will be required at both approaches. The maximum new fill thickness over the existing slopes will be approximately 9 feet, including riprap.

The embankments will be constructed over primarily medium dense to dense sand and gravel, with only thin layers of silt. In our experience, total settlement will likely be on the order of ½ to 1 inch or less and will occur rapidly during embankment construction. Therefore, we do not anticipate that settlement will be observed in the paved approaches, and downdrag loading is not anticipated on the piles.

The proposed embankment slopes at the approach to Abutment 1 will be flatter than the existing slopes, will have a maximum height of 12 feet, and will bear on either medium stiff to stiff Silt or medium dense to dense Gravelly Sand. The proposed embankment slopes at the approach to Abutment 2 will also be flatter than the existing slopes, will have a maximum height of 20 feet, and they will bear on dense Gravelly Sand. Based on these proposed geometries and anticipated subsurface conditions, it is our opinion that the potential for global instability of the proposed embankments is low.

5.3 SEISMIC DESIGN CONSIDERATIONS

The subsurface profile for seismic design includes the approach fills (including backfill behind abutments) and underlying Gravelly Sand, Silt and Gravel overlying bedrock. Seismic site class was determined in general accordance with LRFD Table C3.10.3.1, considering the average SPT N-value of granular soils encountered in the borings. The SPT N-value used to determine the site class was evaluated by including only the soil profile, resulting in an effective profile thickness ranging from 26 to 39 feet.

The average SPT N-value for encountered granular soils is between 15 and 50 blows per foot. Therefore, the bridge is assigned to Site Class D.

The available subsurface data indicates that the natural materials encountered at the site are sufficiently stiff or dense that the potential for liquefaction is low.

5.4 EVALUATION OF FOUNDATIONS

5.4.1 Foundation Type Assessment

Based on constructability and cost considerations, MaineDOT selected an integral abutment bridge for the project. Three foundation types were considered during preliminary design for support of the proposed integral abutment bridge: driven H-piles, conventional micropiles (with rock sockets and central steel threadbars), and spun pipe piles (without sockets or threadbars). Geotechnical considerations for each foundation alternative are described below.

- Driven Piles: At this site, driven piles would likely be driven to refusal on rock due to the relatively thin soil profile, especially at Abutment 1. Integral abutment support with driven H-piles relies on a thick enough soil profile to develop fixity, or at least a pinned end condition. The subsurface data at Abutment 1 indicates that the depth from bottom of integral abutment to top of rock may be as little as 10 feet, and the rock surface is sloping. Preliminary lateral pile evaluations were conducted for H-piles assuming a 10-foot-thick soil profile, and the results indicated the piles would not achieve a pinned condition under the imposed thermal deflection. In addition, piles could potentially “walk” when driven to sloping rock, which would induce additional stress, and is a concern given the tight tolerance for location and inclination of integral abutment piles. H-piles would be feasible at Abutment 2, but considering the planned ABC, it was not desirable to mobilize two different foundation operations. Therefore, driven piles were not considered further.
- Micropiles: Micropiles are considered a feasible foundation type for the subsurface conditions encountered at Crockett Bridge. Micropile casing is typically advanced through the overburden and into bedrock using an air percussive hammer. An air hammer with a smaller bit is conventionally used to drill a rock socket below the bottom of the casing. For a conventional micropile, a threadbar or inner hollow casing is used to transmit vertical loads to the socket, and the micropile gains axial compression resistance primarily through friction along the grout-rock interface. The outer casing is typically advanced a moderate distance into bedrock to promote fixity under lateral loading, thereby eliminating the “walking pile” effect associated with driven pile. Preliminary lateral pile evaluations indicated that micropiles could achieve adequate fixity with a casing embedment depth into rock of 3 feet, regardless of whether internal reinforcing extended into bedrock.
- Spun Pipe Piles: Spun pipe piles are a concept that was developed by the MaineDOT design team for this project. A spun pipe pile is essentially a micropile with no central reinforcement and where the bottom of the casing sits on the bottom of the rock socket. The spun pipe pile gains axial compressive resistance through end bearing on the rock surface at the bottom of the casing, which requires that the casing be filled with grout to provide end bearing resistance over the entire tip area, similar to a rock-socketed drilled shaft. The primary advantage of the spun pipe pile over conventional micropile is reduced construction time since a second stage of drilling and internal reinforcement installation is not required. In addition, the spun pipe pile can be designed using resistance factors appropriate for end-bearing drilled shafts as discussed further herein, which eliminates the requirement for testing and saves more time in the schedule.

Based primarily on schedule considerations, the project team selected spun pipe piles over conventional micropiles as the preferred pile type for the project. Preliminary lateral pile evaluations were conducted for two readily-available N80 9-5/8-inch-outside diameter pipe sections, including wall thicknesses of 0.472 inches and 0.545 inches. The results indicated the maximum stress in the 9-5/8x0.472 and 9-5/8x0.545 spun pipe pile sections would be between 77 ksi and 72 ksi, respectively, under combined bending. Based on these results, the

MaineDOT designer selected a 9-5/8x0.545 pile section, which would have a maximum stress level of 90 percent of yield stress under combined loading, as the preferred pile type for the project.

Due to the significant reliance on bedrock resistance for the spun pipe pile, we recommend an additional 2 feet of advancement into rock to improve the reliability of the assumed conditions. However, the analyses presented herein only rely on 3 feet of embedment.

5.4.2 Pile Design Considerations and Load and Resistance Factors

Evaluations were conducted for axial compressive geotechnical resistance of the piles. The geotechnical static resistance of spun pipe piles was calculated using the drilled shaft tip resistance on rock methodology in accordance with AASHTO LRFD Article 10.8. Side friction was not assumed to provide any resistance to axial compressive loads. Axial tensile geotechnical (uplift) resistance was not evaluated because the integral abutment configuration will not impose uplift loading on the piles.

By utilizing steel pipe piles supported in bedrock, total and differential settlement will be limited to elastic compression of the piles and should be less than ½ inch.

The piles will be installed on land through the approach embankments and will not be subject to a saline environment. Therefore, corrosion was not considered in the design.

As discussed in Section 5.2, we conclude the potential for measurable post-construction settlement of the soil adjacent to the piles is low. Therefore, downdrag loading was not included in the pile design.

Pile design recommendations are presented in **Section 6.4** of this report.

5.4.3 Load and Resistance Factors

Structural resistance of the spun pipe piles at the strength limit state should be based on a resistance factor of 0.75 for axial compression resistance per AASHTO LRFD Table 10.5.5.2.5-2. The piles should be designed at the strength limit state considering geotechnical resistance of the piles using a resistance factor of 0.50, for tip resistance on rock, per AASHTO Table 10.5.5.2.5-1. The resistance factor for tip resistance on rock does not require pile load testing.

AASHTO LRFD load factors should be applied to horizontal earth pressure (EH), vertical earth pressure (EV), earth surcharge (ES), and live load surcharge (LS) loads using the load factors for permanent loads (γ_p) provided in AASHTO Table 3.4.1-2 for strength and extreme limit state design. A load factor of 1.5 may be applied to the passive pressure used to design the integral backwall (end diaphragm) to account for deformation of the backwall into the soil as a result of thermal expansion of the integral bridge deck.

5.4.4 Pile Type and Loading Data

The abutments are planned to be supported on American Petroleum Institute (API) 5CT N80 steel pipe with a minimum yield strength (fy) of 80 ksi. Each abutment will include a single row of five, 9.625x0.545 pipes. The maximum factored axial load for the strength condition provided by MaineDOT is 365 kips per pile. Considering the resistance factor of 0.50 for tip resistance in rock, the required nominal pile resistance is 730 kips.

5.4.5 Axial Pile Resistance

Spun pipe piles will gain axial compressive resistance through end bearing in bedrock. The nominal tip resistance was estimated using procedures described in AASHTO Article 10.9.3.5.3, which references Article 10.8.3.5.4c for tip resistance on competent rock.

The primary input parameters used to calculate tip resistance on rock in accordance with 2014 AASHTO LRFD include the Geologic Strength Index (GSI), unconfined compressive strength (q_u) and the rock group constant (m_i). Based on the results of the borings, we conclude the spun pipe piles could bear in either the encountered trachyte or granite. Therefore, we evaluated tip resistance for both rock types. The bedrock input parameters selected for our evaluation are summarized in the table below.

BEDROCK PROPERTIES FOR TIP RESISTANCE EVALUATION				
Parameter Description	**Parameter Symbol (units)**	**Value for Granite**	**Value for Trachyte**	**Reference**
Unconfined Compressive Strength, Intact Rock	q_u (psi)	14,930	34,300	Laboratory test data
Geologic Strength Index	GSI	60	60	AASHTO Figure 10.4.6.4-1
Rock Group Constant	m_i	32	25	AASHTO Table 10.4.6.4-1

GZA calculated nominal and factored axial tip resistance for the strength and extreme limit states, which are presented in the table below.

AXIAL SPUN PILE TIP RESISTANCE			
Rock Type	**Nominal Unit Tip Resistance (ksf)**	**Nominal Geotechnical Resistance (kips)**	**Factored Geotechnical Resistance, Strength (ksf)**
Granite	2,553	1,290	645
Trachyte	4,806	2,428	1,214

The controlling tip resistance value is for end bearing on granite. Since the controlling factored tip resistance (645 kips) is greater than the maximum factored load (365 kips), we conclude end bearing resistance on rock is suitable to support the design loads.

5.4.6 Lateral Pile Analysis

The subsurface strata encountered near the top of the piles included primarily Gravelly Sand at Abutment 1 and a combination of Sand (Possible Fill) and Gravelly Sand at Abutment 2. The following soil profiles were developed for lateral pile evaluations at each abutment. The overburden thickness at Abutment 1 was assumed to be consistent with the shallower depth encountered at the borings (BB-NMR-202).

L-PILE® INPUT PARAMETERS ABUTMENT 1, PILE LENGTH = 13' (BORINGS BB-NMR-101 and BB-NMR-202)						
Stratum	**Soil Model**	**Top of Layer Elevation (ft-NAVD 88)**	**Layer Thickness (ft)**	**k (pci) / E50**	**ϕ' (deg)/ Su (psf) / qu Rock (psi)**	**γ_e (pcf)**
Gravelly Sand	Reese Sand	266.0	9.0	100	38	67
Silt/Clay	Stiff Clay	257.0	3.5	E_{50} = 0.01	1,000 psf	57
Gravel (Possible Till)	Reese Sand	253.5	3.5	125	40	72
Rock	Weak Rock	250.0	3.0	krm = 0.0005	2,000 psi	102

L-PILE® INPUT PARAMETERS ABUTMENT 2, PILE LENGTH = 44' (BORING BB-NMR-102/102A)						
Stratum	**Soil Model**	**Top of Layer Elevation (ft-NAVD 88)**	**Layer Thickness (ft)**	**k (pci) / E50**	**ϕ' (deg)/ Su (psf) / qu Rock (psi)**	**γ_e (pcf)**
Sand (Possible Fill)	Reese Sand	277.0	11.0	130	35	125
Sand (Possible Fill)	Reese Sand	266.0	3.5	80	35	63
Gravelly Sand	Reese Sand	262.5	14.5	100	38	67
Silt/Clay	Stiff Clay	248.0	3.0	E_{50} = 0.01	1,000 psf	57
Lower Sand	Reese Sand	245.0	5.0	60	34	63
Gravel (Possible Till)	Reese Sand	240.0	4.0	125	40	73
Rock	Weak Rock	236.0	3.0	krm = 0.0005	2,000 psi	102

GZA conducted lateral pile analyses using L-PILE 2015® based on a maximum thermal deflection of 0.44 inches, as provided by MaineDOT. A slope of 0.00245 in/in, induced by the live load, was applied at pile head in the direction opposite of imposed lateral deflection. The assumed axial load was 365 kips, representing the maximum factored axial load at the time of our evaluation. The planned spun pile section was analyzed assuming: 1) empty casing and 2) casing with grout infill with a compressive strength of 6 ksi. This grout compressive strength was recommended by the MaineDOT designer to model grout that achieves a higher unconfined compressive strength than the design value, which is intended to model the upper-bound bending stiffness. Our results are summarized in the table below.

L-PILE® RESULTS							
Location	**Pile Type and Size**	**Axial Load (kips)**	**Shear Force for Lateral deflection of 0.44 in. (kips)**	**Moment at Pile Head (ft-kips)**	**Total Stress at Pile Head (ksi)**	**Bending Stress at Pile Head (ksi)**	**Axial Stress at Pile Head (ksi)**
Abutment 1	9-5/8x0.545 (Empty Casing)	365	32.6	-1569.8	70.5	47.0	23.5
Abutment 1	9-5/8x0.545 (6 ksi Grout Infill)	365	36.0	-1787.1	60.1 / 5.94	--	--
Abutment 2	9-5/8x0.545 (Empty Casing)	365	34.1	-1618.3	71.9	48.4	23.5
Abutment 2	9-5/8x0.545 (6 ksi Grout Infill)	365	37.4	-1823.8	61.5 / 5.96	--	--

The total stress for the grout filled casings includes stress in the steel (first value) and grout (second value). Bending and axial stress are not reported separately for a combined steel and grout section in L-PILE®. L-PILE 2015 models the combined steel and grout section using a cracked grout section when the bending stress exceeds 75 percent of the unconfined compressive stress, resulting in a reduced composite section bending stiffness. This condition occurred in approximately the upper 3 feet of the pile based on our evaluation, and it would occur over a longer distance for lower strength grout.

5.4.7 Lateral Earth Pressure

Thermal expansion of the bridge will cause the backwalls and wingwalls of the integral abutment to move toward the backfill, which will result in earth pressures approaching passive earth pressure. The material properties will be controlled by the backfill material, which is proposed to consist of BDG Type 4 soil. Soil properties for Type 4 soil are provided in **Section 6.3** of this report.

Based on the estimated thermal bridge expansion of 0.44 inches and the maximum abutment height of 11.75 feet, the calculated abutment rotation is 0.0031 inch/inch. In accordance with the requirements of the BDG Section 5.4.2.11, integral abutment reinforcement is to be designed for full Coloumb passive pressure if the wall rotation is greater than 0.005 feet/foot. Considering that the anticipated rotation is only about 60 percent of the value that triggers full Coloumb, we conclude that Rankine passive earth pressure may be used for design.

Lateral earth pressure evaluations for abutments are based on the BDG summarized below:

- Passive earth pressure coefficients were developed using Rankine theory for Type 4 soil.
- AASHTO Commentary C3.10.9.1 specifies that single-span bridges are not required to include acceleration-augmented (earthquake-induced) soil pressures for design.

Design lateral earth pressure recommendations are provided in **Section 6.3** of this report.

5.4.8 Frost Penetration

Fill soils are anticipated to be present at the abutments, either as existing fill or imported backfill. Based on the MaineDOT BDG, Section 5.2.1, the Freezing Index for the site is 1,345, and with low to moderate moisture content (±15 percent) soils, the estimated depth of frost penetration is 6.5 feet.

6.0 RECOMMENDATIONS

6.1 SEISMIC DESIGN

The United States Geological Survey online Design Maps Tool was used to develop parameters for bridge design. Based on the site coordinates, the software provided the recommended AASHTO Response Spectra (Site Class D) for a 7 percent probability of exceedance in 75 years. These results are summarized for the site as follows:

SITE CLASS D SEISMIC DESIGN PARAMETERS	
Parameter	**Design Value**
Fpga	1.6
Fa	1.6
Fv	2.4
As (Period = 0.0 sec)	0.154 g
SDs (Period = 0.2 sec)	0.302 g
SD1 (Period = 1.0 sec)	0.114 g

Per AASHTO Article 4.7.4.2, single span bridges need not be analyzed for seismic loads, but the minimum requirements for superstructure connections and support lengths as specified in AASHTO Articles 4.7.4.4 and 3.10.9 apply.

6.2 EMBANKMENT DESIGN

Widened embankment should be constructed in accordance with MaineDOT Standard Details, including the following:

- Fill slopes that are not riprap-covered should be constructed with an inclination no steeper than 2H:1V.
- Fill slopes with inclinations ranging from 1.75H:1V to 2H:1V should be covered by a minimum of 3 feet of plain riprap, which should be underlain by a minimum 12-inch-thick protective aggregate cushion consisting of MaineDOT 703.19, Granular Borrow for Underwater Backfill, underlain by a loosely placed, non-woven erosion control geotextile meeting the requirements of Standard Specification 722.03.

All fill placed below the water level should consist of Maine DOT 703.19 Granular Borrow for Underwater Backfill, or a coarser material such as MaineDOT 703.20 Gravel Borrow, 703.12 Aggregate for Crushed Stone Surfaces, 703.31 Crushed Stone, or well-graded blasted rock fill.

If the mudline outside of the existing embankment is found to be underlain by weak organic soil, this material should be assumed to consist of “Muck” and should be fully removed in accordance with the MaineDOT Standard Specifications, Section 203.05 to expose suitable, inorganic soil as confirmed by the Resident and/or Engineer. We recommend that a pay item be included for Muck removal in the bid documents. Additional construction considerations are presented in **Section 7.3**.

6.3 ABUTMENT AND WINGWALL DESIGN

- Backfill behind abutments should consist of Maine DOT 703.19 Granular Borrow for Underwater Backfill, BDG Type 4 soil. Recommended soil properties for Type 4 soils to be used as backfill are as follows:
  - Internal Friction Angle of Soil = 32°
  - Soil Total Unit Weight = 125 pcf
  - Rankine Coefficient of Passive Earth Pressure, K_p= 3.25 (use for design of backwalls and wingwalls)
- Live load surcharge should be applied as a uniform lateral surcharge pressure using the equivalent fill height (Heq) values developed in accordance with AASHTO Article 3.11.6.4 based on the abutment/wingwall height and distance from the wall backface to the edge of traffic.
- Foundation drainage should be provided in accordance with Section 5.4.1.9 of the BDG.
  - We recommend the use of French drains and/or geocomposite drainage boards on the uphill side of abutments and wing walls to prevent buildup of differential hydrostatic pressure. Foundation drains should be sloped to drain by gravity and should daylight through weep holes in the abutments.

6.4 SPUN PIPE PILE DESIGN

- The proposed abutments may be supported on 9.625x0.545 spun pipe piles (80 ksi yield stress) infilled with grout with a 28-day compressive strength of 4 ksi.
- Steel pipe for the spun piles should conform to API 5CT N80 or ASTM A252 Grade 3 Modified with a Fy of 80 ksi, and shall be straight-seamed.
- The spun pipe piles may be designed using a nominal resistance of 730 kips, calculated by dividing the maximum factored pile load of 365 kips by a resistance factor of 0.50. The required maximum factored load is less than the factored geotechnical pile resistance.
- The spun pipe piles should be advanced to a minimum depth of 5 feet below the top of rock elevation encountered at each location.
- The pile tip elevations used in the drawings should be a minimum of 5 feet below the bedrock elevations encountered in the borings (see below), plus or minus 5 feet at Abutment 1 and plus or minus 10 feet at Abutment 2, to account for potential variability in the top of rock surface:
  - Abutment 1 Top of Rock: El. 250.2 (BB-NMR-101) and El. 255.3 (BB-NMR-202)
  - Abutment 2 Top of Rock: El. 234.4 (BB-NMR-102A)
- Piles should be spliced in accordance with ASTM A148/A148M, Grade 725-585 (Grade 105-85) and using special welding procedures suitable for API N80 pipe in accordance with American Welding Society (AWS) D1.1, "Structural Welding Code – Steel." Strength of the splices shall equal or exceed that of the intact section.
- The structural engineer should complete structural evaluation of the piles using the bending stress results from the LPile analyses summarized in **Section 5.4.5** (output provided in **Appendix E**) in accordance with the design steps listed in BDG Section 5.4.2.4.C. The structural design should satisfy the results of the empty casing analysis presented herein.

7.0 CONSTRUCTION CONSIDERATIONS

This section provides guidance regarding quality control during pile installation, excavation, dewatering, and foundation subgrade preparation and protection. These items are given in the paragraphs that follow.

7.1 PILE INSTALLATION AND GROUT INFILL

Spun pipe piles should be installed in accordance with the requirements of Special Provision Section 501, Foundation Piles (Spun Pipe Piles).

We anticipate that spun pipe piles will be installed using the same methods used to install permanent micropile casing. This procedure typically involves the use of an under-reamer bit when it is necessary to socket the pipe into bedrock. Using this procedure, a down-the-hole hammer is used and the pipe and inner rods are advanced in the duplex drilling method with internal flush.

At the completion of drilling, the holes should be thoroughly cleaned under air or water to provide a clean end bearing surface. The depth and soundness of the hole should be assessed using a weighted tape prior to grouting.

In order to maintain a clean rock socket, it will be necessary to achieve a seal in rock. If soil is observed in the casing following drilling and cleaning, additional measures will be required to achieve a seal before grouting. This could include advancing the casing further into rock, and/or retracting the casing, grouting the area just above and within the socket, and re-drilling to rock, below the original socket depth.

The drill holes should be tremie grouted from the bottom up. A plug should be placed in the tremie pipe prior to insertion into the pile to prevent water entry into the pipe. The tremie pipe should remain at least 5 feet below the top of grout level throughout the grout placement, if it is pulled during grouting.

Because load testing is not planned, the presence of a Geotechnical Engineer is strongly recommended throughout advancement of steel pipes, final cleaning, bar placement and grout placement to ensure that the intent of the design and special provisions are met. The Geotechnical Engineer should observe and assess the following portions of the work: depth to top of rock, embedment in the rock, bottom cleanliness, depth of hole, length of casing installed, and grout volumes.

7.2 PILE OBSTRUCTIONS

Cobbles, boulders, riprap and/or rock fill may be encountered by the spun pipe piles in the overburden. We anticipate that the spun pipe pile installation method will be capable of advancing through possible obstructions.

7.3 EMBANKMENT CONSTRUCTION

Fill placement could be completed in-the-dry inside of a cofferdam. If embankment construction in-the-wet is considered, permitting considerations for work in the river should be addressed, which we anticipate would include the use of a silt curtain at a minimum. We recommend that fill placed in the wet consist of angular shot rock or a similar material.

The widened approach embankments and new fill at the toe of the abutment backwalls will require fill placement below the water level (estimated at El. 265 to El. 267). Embankment fill will be placed as low as approximately El. 261 along much of the upstream embankment, and riprap will extend as low as El. 254. We anticipate that fill placement at these elevations would need to be conducted either inside of a cofferdam to be placed in-the-dry or will be conducted in-the-wet. Embankment construction in the wet should address permitting considerations for work in the river, which we anticipate would include the use of a silt curtain at a minimum.

The subgrade material beneath the widened embankments is anticipated to consist of riprap over portions of the existing embankment, or up to a few feet of existing Sand, underlain by Gravelly Sand. However, explorations were not conducted within the river, so the potential for weak river/lake bottom deposits has not been explored. In the absence of weak organic soil, conventional embankment construction procedures should be suitable, provided the work is completed in-the-dry. If necessary, an initial layer of separation geotextile beneath coarse aggregate or choked riprap may be appropriate to provide a stable subgrade for subsequent filling conducted partially in-the-wet.

7.4 EXCAVATION, TEMPORARY LATERAL SUPPORT AND DEWATERING

Excavations for abutment foundations are anticipated to range from 9 to 12 feet below existing pavement grades. It is our understanding that Route 11/114 (Sebago Road) will be out of service during construction of the new bridge. In areas where sufficient space is available and water conditions permit, the excavation slopes may consist of sloped, open cuts. In all cases, temporary excavations should comply with Occupational Safety and Health Administration (OSHA) excavation safety requirements.

Considering the proximity of the required abutment excavations to the river water level, management of water will be related to river/lake water levels at the time of construction. Considering the deepest excavation level at approximately El. 265 and Q50 at El. 267, typical water levels will be near the bottom of excavation level. It may be desirable to over-excavate and place an 8- to 12-inch thick crushed stone working mat to improve accessibility and allow dewatering.

We anticipate that the inflow of groundwater or surface water to excavations can be handled by open pumping from sumps installed at the bottom of excavations if cofferdams are installed. Stacked sand bags or a porta-dam type system may be sufficient to limit inflow of surface water in lieu of a sheet pile cofferdam, given the relatively small anticipated head. The contractor should be responsible for controlling groundwater, surface runoff, tidal inflow, infiltration and water from all other sources by methods which preserve the undisturbed condition of the subgrade and permit foundation construction in-the-dry. Discharge of pumped groundwater and river water should comply with all local, State, and federal regulations.

7.5 REUSE OF ON-SITE MATERIALS

Based on the test boring results, 3 of the 4 fill samples tested had less than 20 percent passing the No. 200 sieve, and 1 out of 4 had 7 percent passing the No. 200 sieve. Therefore, most of the excavated fill is likely to meet MaineDOT specifications for Granular Borrow, but unlikely to meet the specifications for Granular Borrow for Underwater Backfill. Any remaining material exceeding 20 percent passing the No. 200 sieve is considered suitable for use as Common Borrow.

If the contractor wishes to reuse excavated material as embankment fill or in other areas, we recommend that the proposed material be stockpiled and tested for grain size distribution. Stockpiled materials meeting the appropriate MaineDOT specifications may be reused on the project.

FIGURES

SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS

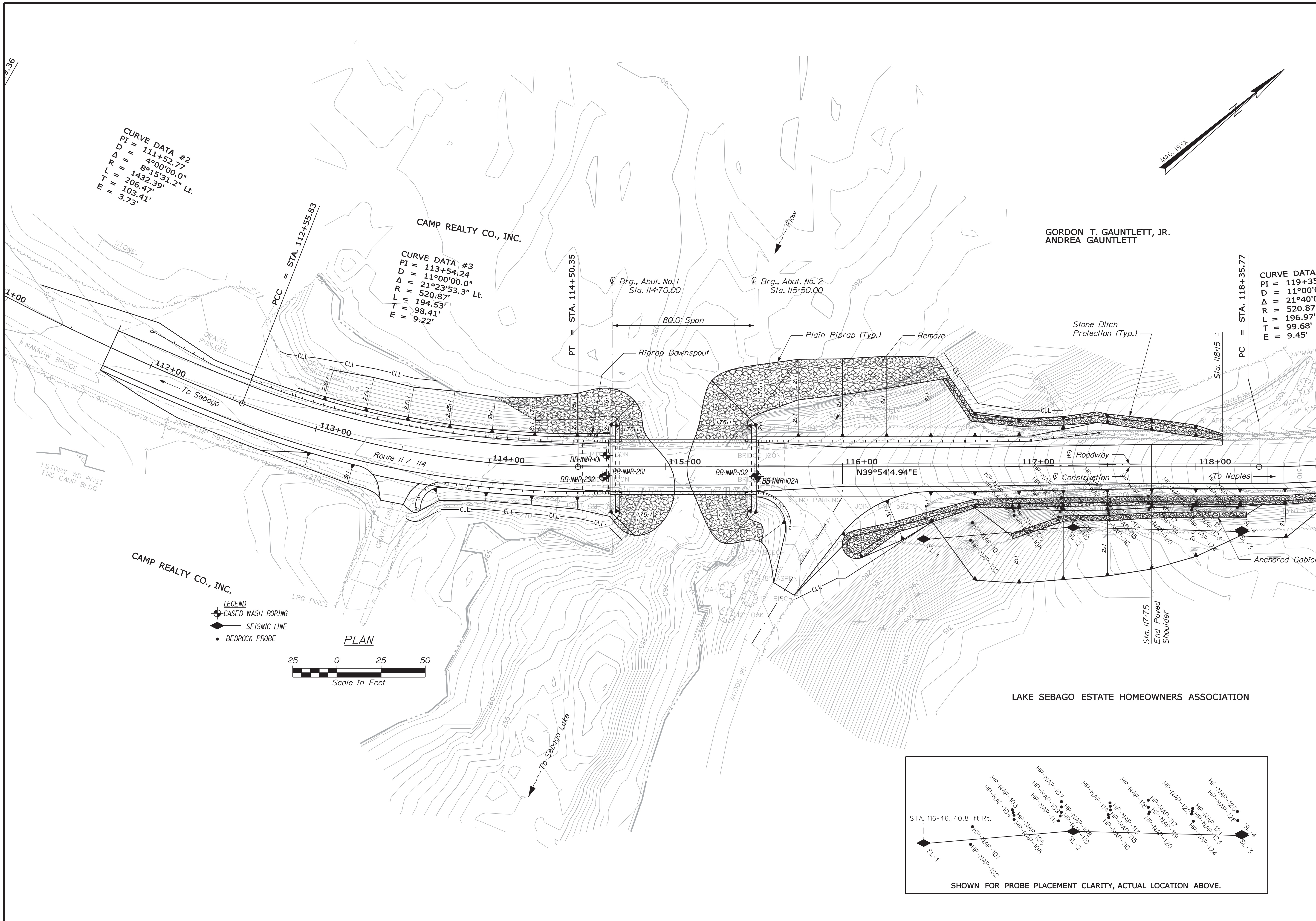
CROCKETT BRIDGE NO. 2199
OVER MUDDY RIVER
NAPLES, MAINE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
MAINEDOT

LOCUS PLAN

PROJ MGR: ARB	REVIEWED BY: CLS	CHECKED BY: RJM	FIGURE
DESIGNED BY: ARB	DRAWN BY: ADM	SCALE: 1 in = 2,000 ft	1
DATE: 3/15/2016	PROJECT NO. 09.0025899.00	REVISION NO.	



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN 20466.00

BRIDGE NO. 2199

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	M. Parlin	
DESIGN-DETAILED	G. Gustafson	D. Damren
CHECKED-REVIEWED	GZA	T. WHITE	MAR 2016
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

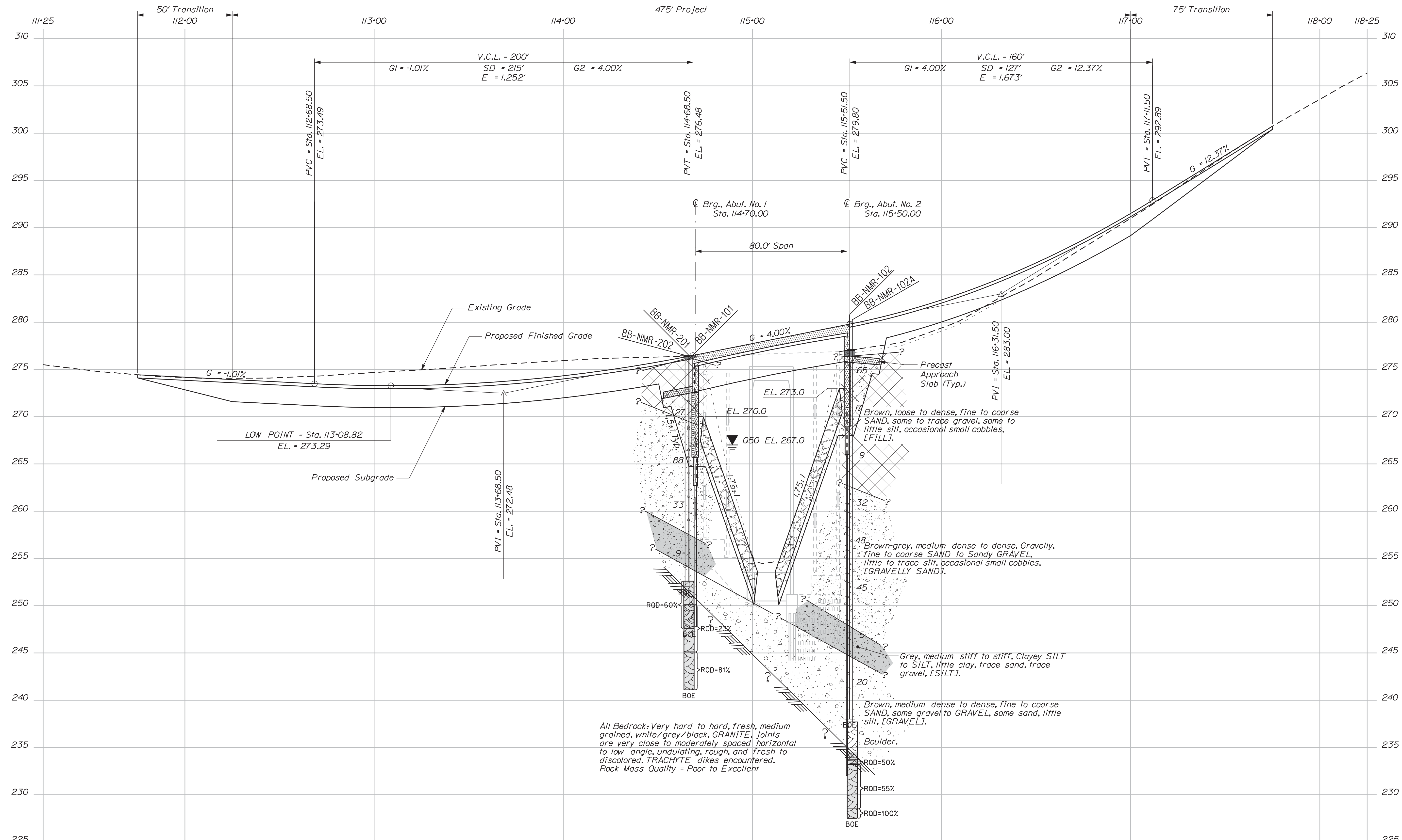
BORING LOCATION PLAN

SHEET NUMBER

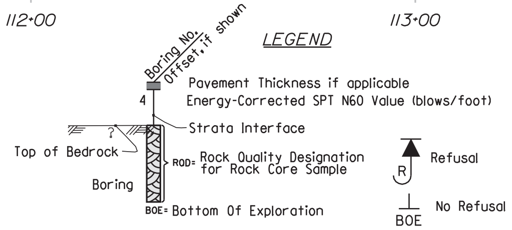
2

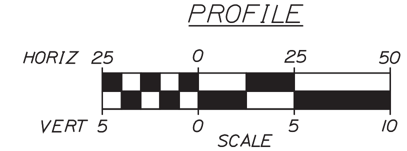
Filename: ...\00\GEOTECH\MSTA\006_BLP1.dgn Division: GEOTECH Username: Laura.Krusinski Date:3/15/2016

Filename: ...\00\GEOTECH\MSTA\007_ISP1.dgn Division: GEOTECH Username: terry.white Date:3/21/2016



PROFILE





Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2046(600)

WIN 20466.00

BRIDGE PLANS

BRIDGE NO. 2199

		BY	DATE
PROJ. MANAGER	M. Porin		
DESIGN-DETAILED	G. Gustafson	D. Damren	
CHECKED-REVIEWED	GZA	T. WHITE	MAR 2016
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

CROCKETT BRIDGE
MUDDY RIVER
NAPLES CUMBERLAND COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3

APPENDIX A – LIMITATIONS

GEOTECHNICAL LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions .

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

Subsurface Conditions

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have

been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

8. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

9. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

Compliance with Codes and Regulations

10. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

Cost Estimates

11. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

12. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

APPENDIX B – TEST BORING LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly-graded sands, gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations: (in this order)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
Name (sand, silty sand, clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) silty or clayey gravels; and (3) silty, clayey or gravelly sands. Consistency is rated according to standard penetration resistance.

Modified Burmister System

Descriptive Term	Portion of Total
trace	0% - 10%
little	11% - 20%
some	21% - 35%
adjective (e.g. sandy, clayey)	36% - 50%

Density of Cohesionless Soils	Standard Penetration Resistance N-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) gravelly, sandy or silty clays; and (3) clayey silts. Consistency is rated according to shear strength as indicated.

Consistency of Cohesive soils	SPT N-Value blows per foot	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily Penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
-dip (horiz - 0-5, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
-spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
-tightness (tight, open or healed)
-infilling (grain size, color, etc.)
Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

Sample Container Labeling Requirements:

PIN	Blow Counts
Bridge Name / Town	Sample Recovery
Boring Number	Date
Sample Number	Personnel Initials
Sample Depth	

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-101
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	276.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2015; 10:30-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	114+65.6, 5.0 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	275.6		7" Pavement ——0.6	
5	1D	24/14	5.0 - 7.0	5/9/9/10	18	27	15			Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, occasional small cobbles. -FILL- (SM)	G#263325 A-1-b, SM WC=7.7%
							23				
							45	269.2		——7.0	
							47				
							29				
10	2D	24/4	10.0 - 12.0	10/47/11/6	58	88	10			Brown, wet, dense, gravelly, fine to coarse SAND, trace silt, occasional small cobbles. -GRAVELLY SAND- (SP)	
							51				
							52				
							124	262.7		– – –13.5	
	3D	24/10	14.0 - 16.0	6/9/13/10	22	33	34			Brown, wet, medium dense, sandy GRAVEL, trace silt. -GRAVELLY SAND- (GW-GM)	G#263374 A-1-a, GW-GM WC=19.3%
15							62				
							66				
							72				
							59				
	4D	24/17	19.0 - 21.0	5/3/3/4	6	9	29	257.2		——19.0 Grey, wet, medium stiff to stiff, SILT, little clay, trace sand, trace gravel. -SILT- (ML)	G#263375 A-4, ML WC=27.2%
20							31				
							41				
							102	253.7		——22.5	
							137				
	5D	9.6/9.6	24.0 - 24.8	34/50(3.6")	---		180			Brown, wet, very dense, GRAVEL, some fine to coarse cobbles.	
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-101
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	276.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2015; 10:30-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	114+65.6, 5.0 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25							150			Roller Coned ahead to 26.0 ft bgs. -GRAVEL- (GP)	
								250.2		26.0	
	R1	60/57	26.0 - 31.0	RQD = 23%			NQ-2			Top of Bedrock at Elev. 250.2 ft. R1: 26.0'-29.3': Very hard, fresh, aphanitic, red/brown, TRACHYTE. Primary joints are very close to close, low angle to moderately dipping, undulating, rough, discolored, tight to open. Secondary joints are moderately spaced, high angle, undulating, rough, discolored, tight. Rock Mass Quality = Very Poor R 1:Core Times (min:sec/ft): 2:57, 3:3 5:38, 3:33, 7:35 95% Recovery No water return.	
								246.9			
30											R#1 q_p=4,940 ksf
										29.3	
	R2	48/48	31.0 - 35.0	RQD = 81%						29.3'-31.0': Very hard, fresh, medium grained, white/ gray/black, GRANITE. R2: 31.0'-33.5': Very hard, fresh, medium grained, white/ gray/black, GRANITE. Joints are very close to moderately spaced, undulating, rough, fresh to discolored, tight to partially open. Rock Mass Quality = Good R2:Core Times (min:sec) 31.0-32.0 ft (4:47) 32.0-33.0 ft (6:33) 33.0-34.0 ft (9:54) 34.0-35.0 ft (7:18) 100% Recovery	
								242.7		33.5	
35								241.4 241.2		33.5'-34.8': Very hard, fresh, aphanitic, red/brown, TRACHYTE.	
										34.8	
										34.8'-35.0': Very hard, fresh, medium grained, white/ gray/black, GRANITE.	
										35.0	
40										**Bottom of Exploration at 35.00 feet below ground surface.**	
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-102
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	277.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/5/2015-5/6/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	115+51.4, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	276.4	7" Pavement ——— 0.6	
	1D	24/14	1.0 - 3.0	9/19/24/11	43	65			Brown, damp, dense, fine to coarse SAND, little gravel, little silt, occasional small cobble. -FILL- (SM)	G#263400 A-1-b, SM WC=5.0%
								273.0	——— 4.0	
5	2D	24/12	5.0 - 7.0	6/6/5/5	11	17	9		Brown, moist, medium dense, fine to coarse SAND, some silt, trace gravel. -POSSIBLE FILL- (SM)	G#263913 A-2-4, SM WC=7.9%
							19			
							33			
							27			
							20			
10	3D	24/4	10.0 - 12.0	3/3/3/6	6	9	8		Light brown, wet, loose, fine to coarse SAND, some silt, trace gravel. -POSSIBLE FILL- (SM)	
							9			
							29			
							35			
							140	262.5	——— 14.5	
15	4D	24/8	15.0 - 17.0	18/10/11/10	21	32	36		Brown, wet, medium dense, Gravelly, fine to coarse SAND, little silt. -GRAVELLY SAND- (SM)	G#263914 A-1-b, SM WC=13.4%
							43			
							58			
							99			
	5D	24/9	19.0 - 21.0	10/22/10/6	32	48	18		Grey, wet, dense, Gravelly, fine to coarse SAND, little silt, with granite cobble. -GRAVELLY SAND- (SM) Roller Coned ahead to 24.0 ft bgs.	
20							26			
							16			
							20			
							28			
	6D	24/13	24.0 - 26.0	6/17/13/13	30	45	21		Grey, wet, dense, Gravelly, fine to coarse SAND, trace Silt.	G#263915 A-1-b, SW-SM
25										

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-102
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	277.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/5/2015-5/6/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	115+51.4, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25							55			-GRAVELLY SAND- (SW-SM)	WC=10.3%
							46				
							28				
							33				
	7D	24/3	29.0 - 31.0	2/1/2/1	3	5	30	248.0		29.0 Grey, wet, medium stiff, Clayey SILT, trace fine sand. -SILT- (ML)	G#263916 Insufficient material
30							29				
							29				
							32	245.0		32.0	
							39				
	8D	24/9	34.0 - 36.0	5/7/6/6	13	20	29			Brown, wet, medium dense, fine to coarse SAND, some gravel, little silt. -GRAVEL- (SP-SM)	G#263917 A-1-b, SP-SM WC=12.8%
35							42				
							37				
							138				
							157				
								238.0		39.0 **Bottom of Exploration at 39.00 feet below ground surface.** BROKE NW CASING, left in 25.0 in bore hole. Moved to BB-NMR-102A. NO REFUSAL	
40											
45											
50											

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-102A
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	277.1	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/5/2015-5/6/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	115+52.8, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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WOH = weight of 140lb. hammer
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S_u = Insitu Field Vane Shear Strength (psf)
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N-uncorrected = Raw field SPT N-value
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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Started BB-NMR-102A at 39.0 ft bgs.	
5											
10							DROVE NW			Drove NW Casing to 39.0 ft bgs.	
15											
20											
25											

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Maine Department of Transportation

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Location: Naples, Maine

Boring No.: BB-NMR-102A
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Driller:	MaineDOT	**Elevation (ft.)**	277.1	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/5/2015-5/6/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	115+52.8, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										Drove NW Casing to 39.0 ft bgs.	
30											
35											
	1D	4.8/4.8	39.0 - 39.4	50(4.8")	---		a70	237.7		Very dense, GRAVEL, some sand, little silt. (GP-GM) 39.4	G#263918 A-1-a, GP-GM WC=5.0%
40	R1	54/27	39.4 - 43.9	RQD = 50%			NQ-2			R1: 39.4'-40.5': Boulder, then drop to 42.7' (TOR). Boulder from 39.4'-40.5', then drop from 41.5'-42.3'. Apparent top of rock at 42.7' bgs.	
								234.4		42.7 R1:(Bedrock):42.7'-43.4': Very hard, fresh, medium grained, white/black, GRANITE. Joints are close, low angle to moderately dipping, undulating, rough, fresh to discolored, open. Rock Mass Quality = Fair R 1:Core Times (min:sec/ft): 7:02, 2:1 1:29, 2:00	R#2 q_p=2, 150 ksf
	R2	56.4/45	43.9 - 48.6	RQD = 55%						R2: Very hard, fresh, medium grained, white/black, GRANITE. Joints are close to moderately spaced, low angle, undulating, rough, fresh, tight to open. Rock Mass Quality = Fair R 2:Core Times (min:sec/ft): 2:50, 2:4 3:29, 4:15, 5:12/ 0.9' 80% Recovery Core Blocked	
45											
	R3	12/12	48.6 - 49.6	RQD = 100%				227.5		R3: Very hard, fresh, medium grained, white/black,	
50											

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-102A
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	277.1	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/5/2015-5/6/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	115+52.8, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.908	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50										GRANITE. No joints. Rock Mass Quality = Excellent R3:Core Times (min:sec/ft): 7:50 100% Recovery Core Blocked 49.6 **Bottom of Exploration at 49.60 feet below ground surface.**	
55											
60											
65											
70											
75											

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-201
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	B. Wilder	**Datum:**	NAVD 88	**Sampler:**	--
Logged By:	E. Lonstein	**Rig Type:**	CME Trailer Rig	**Hammer Wt./Fall:**	--
Date Start/Finish:	12/10/2015-12/10/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	--
Boring Location:	114+66.4, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	Not measured
Hammer Efficiency Factor:	--	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Augered to 20.0' bgs; set NW casing. Drove casing to 19.7' bgs.	
										3.5'-4.3': Apparent cobbles based on drill action.	
5											
10											
15										15.7'-16.2': Apparent cobbles based on drill action.	
							RC				
20										Advanced roller cone below casing through soil from 19.7'-25.5' bgs. Drove casing to 21.0' bgs. Driller indicated drive shoe was damaged; abandoned boring.	
25											

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US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-201
PIN: 20466.00

Driller:	MaineDOT	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	B. Wilder	**Datum:**	NAVD 88	**Sampler:**	--
Logged By:	E. Lonstein	**Rig Type:**	CME Trailer Rig	**Hammer Wt./Fall:**	--
Date Start/Finish:	12/10/2015-12/10/2015	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	--
Boring Location:	114+66.4, 4.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	Not measured
Hammer Efficiency Factor: --		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

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q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25								251.0		25.5 **Bottom of Exploration at 25.50 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: BB-NMR-201

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-202
PIN: 20466.00

Driller:	Northern Test Boring	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	M. Nadeau	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/28/15-12/28/15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	114+64.4, 5.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	Not measured
Hammer Efficiency Factor: --		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0										Augered to 20.0' bgs; set HW casing. Drove casing to 20.9' bgs.	
5											
10											
15											
20											
	R1	60/36	23.9 - 28.9	RQD = 60%				252.6		23.9	
25										Increased resistance encountered at 20.9' bgs; roller coned from 20.9'-23.9' bgs through possible rock.	

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Crockett Bridge #2199 carries Routes 11 & 114 over Muddy River
Location: Naples, Maine

Boring No.: BB-NMR-202
PIN: 20466.00

Driller:	Northern Test Boring	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	M. Nadeau	**Datum:**	NAVD 88	**Sampler:**	Standard Split
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/28/15-12/28/15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	114+64.4, 5.8 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	Not measured
Hammer Efficiency Factor: --		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										R1: Very hard to hard, fresh, medium grained, white/gray/black, GRANITE. Joints are very close to moderately spaced, horizontal to low angle, undulating, rough, fresh to discolored. Rock Mass Quality = Good R1: Core Times (min:sec/ft): 2:30, 1:45, 1:40, 4:10, 4:15 100% Recovery.	
								247.6		28.9	
										Bottom of Exploration at 28.90 feet below ground surface.	
30											
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

APPENDIX C – ROCK CORE PHOTOGRAPHS

Crockett Bridge Muddy River – Naples, ME

Photos of Rock Core Boxes

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type
BB-NMR-102A	R1	39.4 - 43.9	27	50	27	50	GRANITE
BB-NMR-102A	R2	43.9 - 48.6	45	80	31	55	GRANITE
BB-NMR-102A	R3	48.6 - 49.6	12	100	12	100	GRANITE
BB-NMR-101	R1	26.0 - 31.0	57	95	14	23	TRACHYTE-GRANITE
BB-NMR-101	R2	31.0 - 35.0	48	100	39	81	GRANITE-TRACHYTE-GRANITE

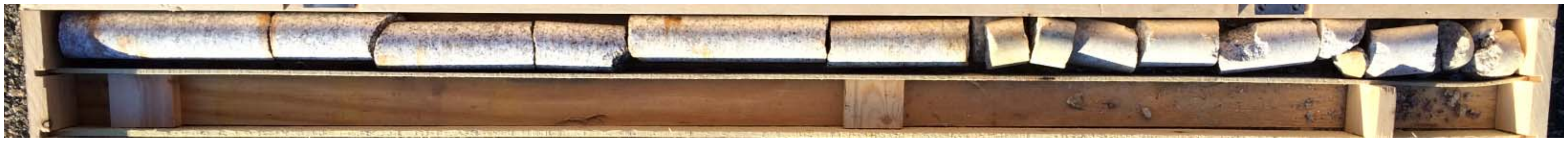
Row 1 (top): BB-NMR-102A (R1-R2), Row 2: BB-NMR-102A (R2-R3), Row 3: BB-NMR-101 (R1), Row 4 (bottom): BB-NMR-101 (R2) dry

Row 1 (top): BB-NMR-102A (R1-R2), Row 2: BB-NMR-102A (R2-R3), Row 3: BB-NMR-101 (R1), Row 4 (bottom): BB-NMR-101 (R2) wet

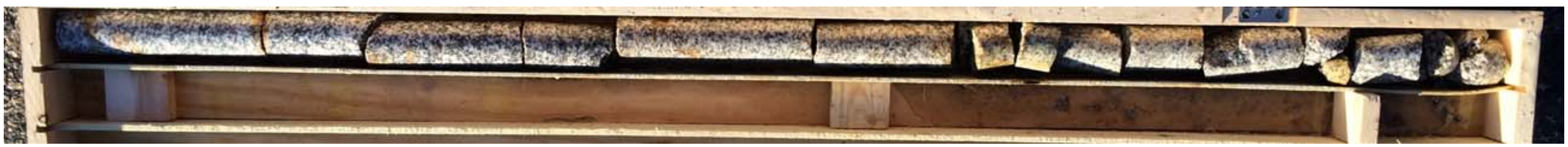
Crockett Bridge Muddy River – Naples, ME

Photos of Rock Core Boxes

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type
BB-NMR-202	R1	23.9 - 28.9	60	100	36	60	GRANITE



BB-NMR-202 (R1) dry



BB-NMR-202 (R1) wet

APPENDIX D – LABORATORY TESTING RESULTS

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Naples   Work Number: 20466.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
BB-NMR-101, 1D	114+65.6	5.0 Lt.	5.0-7.0	263325	1	7.7			SM	A-1-b	II
BB-NMR-101, 3D	114+65.6	5.0 Lt.	14.0-16.0	263374	1	19.3			GW-GM	A-1-a	0
BB-NMR-101, 4D	114+65.6	5.0 Lt.	19.0-21.0	263375	1	27.2			CL	A-4	IV
BB-NMR-102, 1D	115+51.4	4.8 Rt.	1.0-3.0	263400	2	5.0			SM	A-1-b	II
BB-NMR-102, 2D	115+51.4	4.8 Rt.	5.0-7.0	263913	2	7.9			SM	A-2-4	II
BB-NMR-102, 4D	115+51.4	4.8 Rt.	15.0-17.0	263914	2	13.4			SM	A-1-b	II
BB-NMR-102, 6D	115+51.4	4.8 Rt.	24.0-26.0	263915	2	10.3			SW-SM	A-1-b	0
BB-NMR-102, 7D	115+51.4	4.8 Rt.	29.0-31.0	263916	---	Insufficient material to run hydro.					
BB-NMR-102, 8D	115+51.4	4.8 Rt.	34.0-36.0	263917	2	12.8			SP-SM	A-1-b	0
BB-NMR-102A, 1D	115+52.8	4.8 Rt.	39.0-39.4	263918	3	5.0			GP-GM	A-1-a	0

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

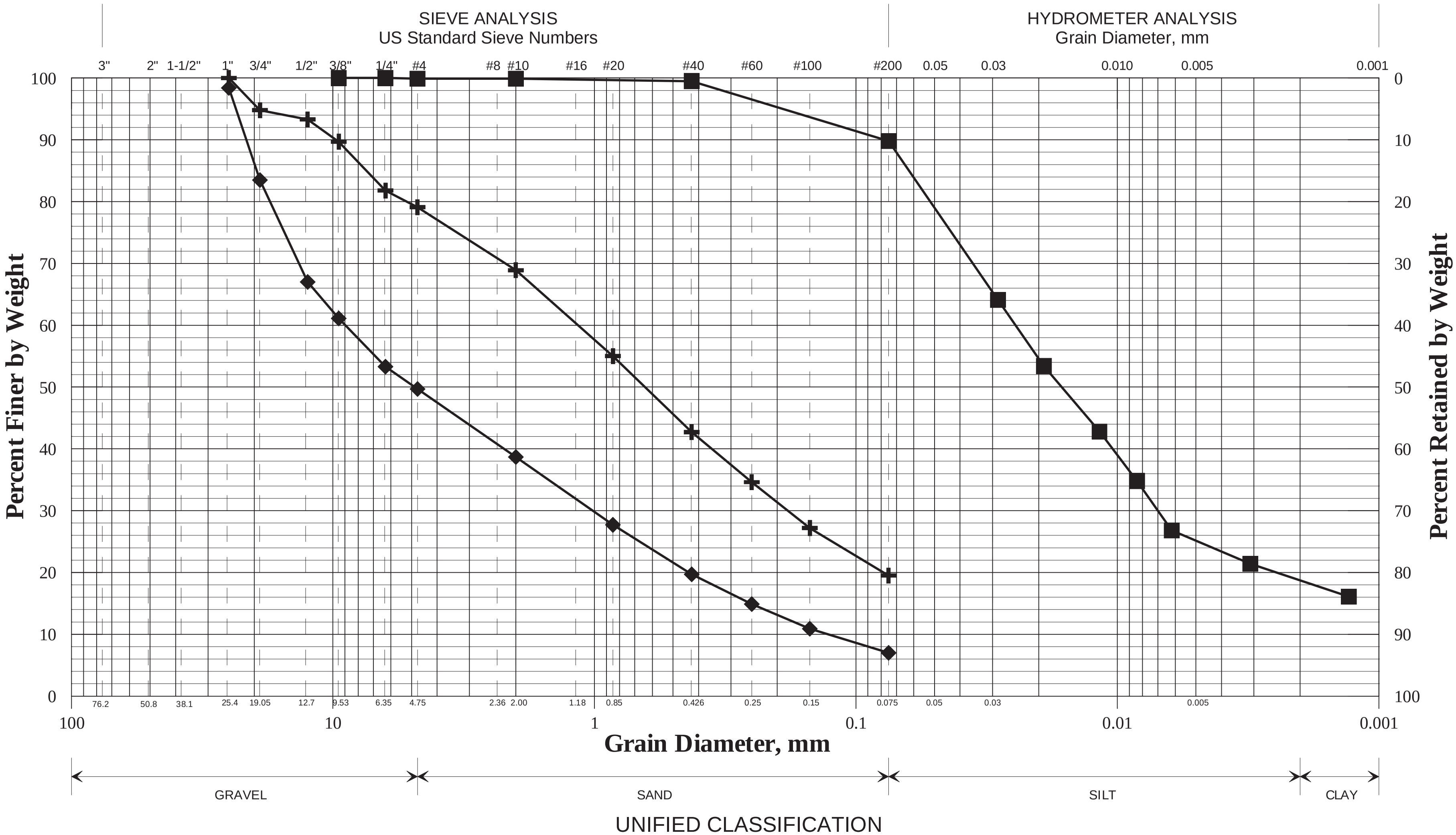
WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98   NP = Non Plastic

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

State of Maine Department of Transportation

GRAIN SIZE DISTRIBUTION CURVE

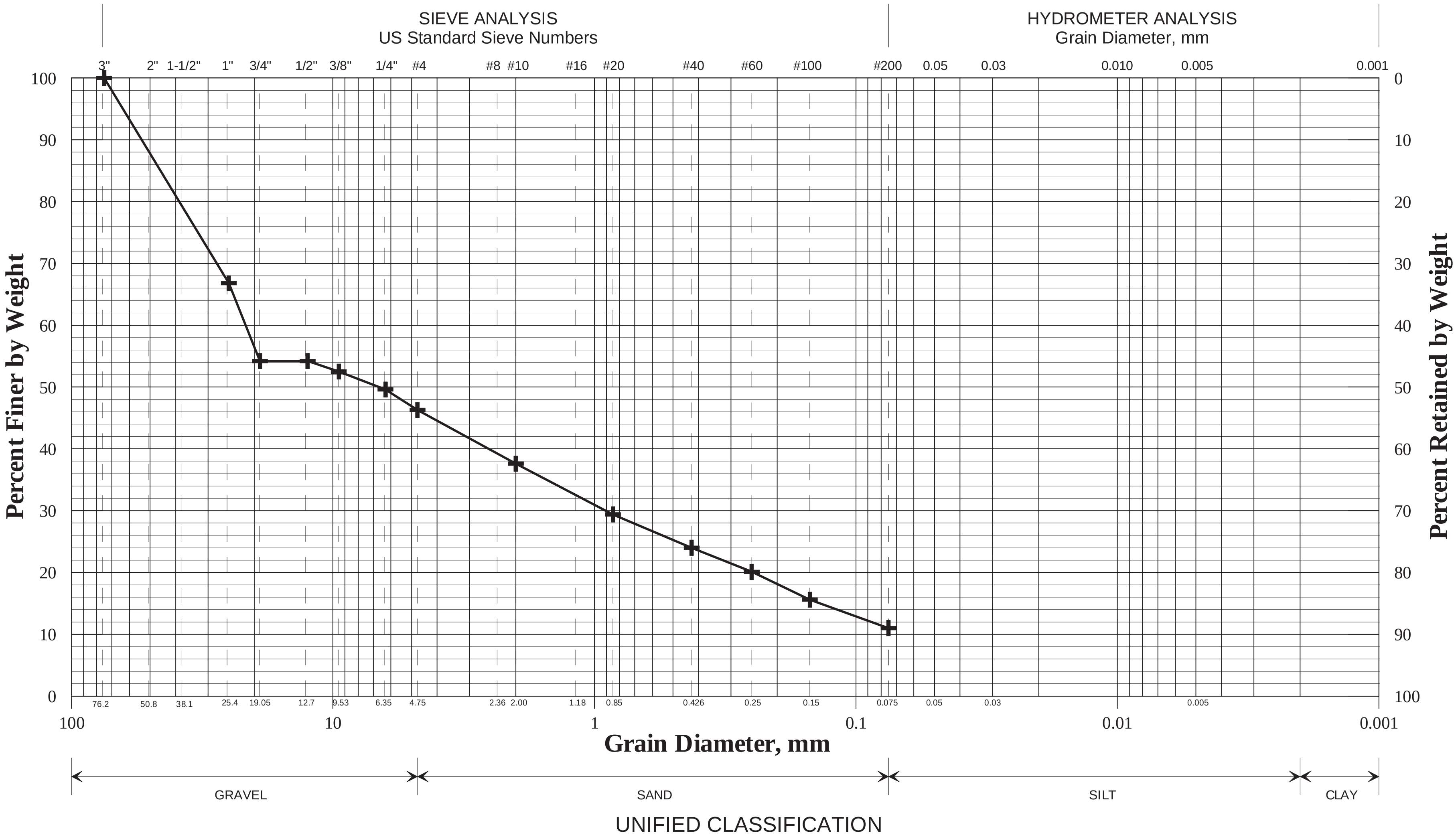


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-NMR-101/1D	114+65.6	5.0 LT	5.0-7.0	SAND, some gravel, little silt.	7.7			
◆	BB-NMR-101/3D	114+65.6	5.0 LT	14.0-16.0	Sandy GRAVEL, trace silt.	19.3			
■	BB-NMR-101/4D	114+65.6	5.0 LT	19.0-21.0	SILT, little clay, trace sand, trace gravel.	27.2			
●									
▲									
✖									

WIN	
020466.00	
Town	
Naples	
Reported by/Date	
WHITE, TERRY A	7/1/2015

SHEET 1

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

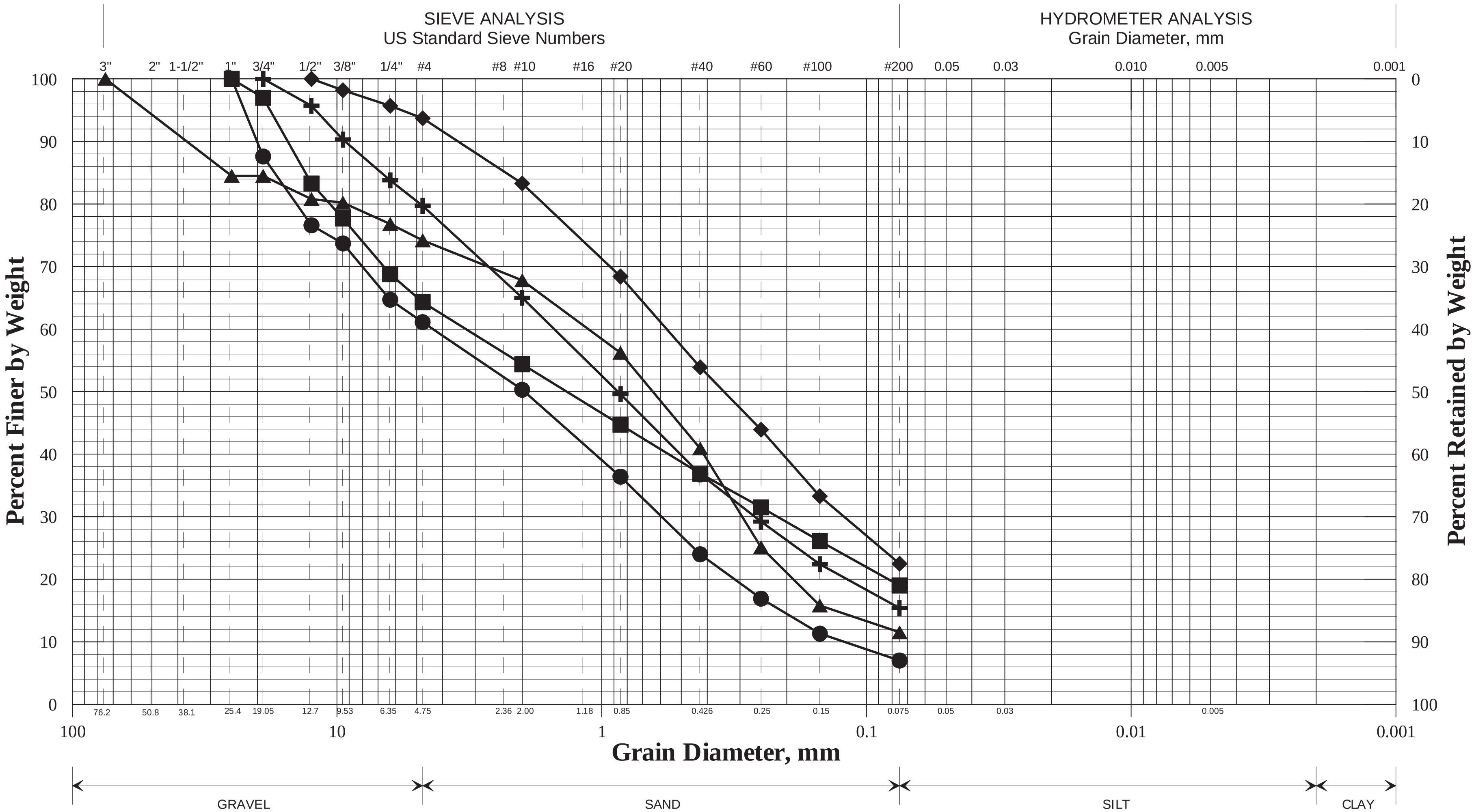


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-NMR-102A/1D	115+52.8	4.8 RT	39.0-39.4	GRAVEL, some sand, little silt.	5.0			
◆									
■									
●									
▲									
✖									

WIN	
020466.00	
Town	
Naples	
Reported by/Date	
WHITE, TERRY A	7/1/2015

SHEET 3

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-NMR-102/1D	115+51.4	4.8 RT	1.0-3.0	SAND, little gravel, little silt.	5.0			
◆	BB-NMR-102/2D	115+51.4	4.8 RT	5.0-7.0	SAND, some silt, trace gravel.	7.9			
■	BB-NMR-102/4D	115+51.4	4.8 RT	15.0-17.0	Gravelly SAND, little silt.	13.4			
●	BB-NMR-102/6D	115+51.4	4.8 RT	24.0-26.0	Gravelly SAND, trace silt.	10.3			
▲	BB-NMR-102/8D	115+51.4	4.8 RT	34.0-36.0	SAND, some gravel, little silt.	12.8			
✖									

WIN	
020466.00	
Town	
Naples	
Reported by/Date	
WHITE, TERRY A	7/1/2015

SHEET 2

MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263325	**BB-NMR-101/1D**	**GEOTECHNICAL (DISTURBED)**	**5/6/2015**	**6/16/2015**

Sample Type: **GEOTECHNICAL** Location: Station: **114+65.6** Offset, ft: **5.0** **LT** Dbfg, ft: **5.0-7.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	**100.0**
¾ in. [19.0 mm]	**94.8**
½ in. [12.5 mm]	**93.3**
⅜ in. [9.5 mm]	**89.7**
¼ in. [6.3 mm]	**81.8**
No. 4 [4.75 mm]	**79.1**
No. 10 [2.00 mm]	**68.9**
No. 20 [0.850 mm]	**55.0**
No. 40 [0.425 mm]	**42.7**
No. 60 [0.250 mm]	**34.6**
No. 100 [0.150 mm]	**27.2**
No. 200 [0.075 mm]	**19.5**

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	**7.7**

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/25/2015**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263374	BB-NMR-101/3D	GEOTECHNICAL (DISTURBED)	5/6/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **114+65.6** Offset, ft: **5.0 LT** Dbfg, ft: **14.0-16.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	98.4
¾ in. [19.0 mm]	83.5
½ in. [12.5 mm]	67.0
⅜ in. [9.5 mm]	61.1
¼ in. [6.3 mm]	53.3
No. 4 [4.75 mm]	49.7
No. 10 [2.00 mm]	38.7
No. 20 [0.850 mm]	27.7
No. 40 [0.425 mm]	19.7
No. 60 [0.250 mm]	14.9
No. 100 [0.150 mm]	10.9
No. 200 [0.075 mm]	7.0

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	19.3

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263375	BB-NMR-101/4D	GEOTECHNICAL (DISTURBED)	5/6/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **114+65.6** Offset, ft: **5.0** **LT** Dbfg, ft: **19.0-21.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	100.0
¼ in. [6.3 mm]	100.0
No. 4 [4.75 mm]	99.9
No. 10 [2.00 mm]	99.9
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	99.5
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	89.8
[0.0286 mm]	64.1
[0.0191 mm]	53.4
[0.0117 mm]	42.8
[0.0084 mm]	34.8
[0.0062 mm]	26.8
[0.0031 mm]	21.4
[0.0013 mm]	16.1

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	2.67
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	27.2

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/24/2015**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263400	BB-NMR-102/1D	GEOTECHNICAL (DISTURBED)	5/5/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **1.0-3.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**95.7**
⅜ in. [9.5 mm]	**90.3**
¼ in. [6.3 mm]	**83.8**
No. 4 [4.75 mm]	**79.7**
No. 10 [2.00 mm]	**65.0**
No. 20 [0.850 mm]	**49.6**
No. 40 [0.425 mm]	**36.8**
No. 60 [0.250 mm]	**29.2**
No. 100 [0.150 mm]	**22.4**
No. 200 [0.075 mm]	**15.4**

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	**5.0**

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263913	BB-NMR-102/2D	GEOTECHNICAL (DISTURBED)	5/5/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **5.0-7.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	100.0
⅜ in. [9.5 mm]	98.2
¼ in. [6.3 mm]	95.7
No. 4 [4.75 mm]	93.7
No. 10 [2.00 mm]	83.3
No. 20 [0.850 mm]	68.4
No. 40 [0.425 mm]	53.9
No. 60 [0.250 mm]	43.9
No. 100 [0.150 mm]	33.3
No. 200 [0.075 mm]	22.5

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	7.9

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

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MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263914	**BB-NMR-102/4D**	**GEOTECHNICAL (DISTURBED)**	**5/5/2015**	**6/16/2015**

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **15.0-17.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	**100.0**
¾ in. [19.0 mm]	**97.0**
½ in. [12.5 mm]	**83.3**
⅜ in. [9.5 mm]	**77.7**
¼ in. [6.3 mm]	**68.8**
No. 4 [4.75 mm]	**64.3**
No. 10 [2.00 mm]	**54.4**
No. 20 [0.850 mm]	**44.7**
No. 40 [0.425 mm]	**36.9**
No. 60 [0.250 mm]	**31.5**
No. 100 [0.150 mm]	**26.1**
No. 200 [0.075 mm]	**19.0**

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	**13.4**

Consolidation (T 216)

Trimmings, Water Content, %	

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

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Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263915	BB-NMR-102/6D	GEOTECHNICAL (DISTURBED)	5/5/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **24.0-26.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	100.0
¾ in. [19.0 mm]	87.6
½ in. [12.5 mm]	76.6
⅜ in. [9.5 mm]	73.7
¼ in. [6.3 mm]	64.7
No. 4 [4.75 mm]	61.1
No. 10 [2.00 mm]	50.3
No. 20 [0.850 mm]	36.4
No. 40 [0.425 mm]	24.0
No. 60 [0.250 mm]	16.9
No. 100 [0.150 mm]	11.3
No. 200 [0.075 mm]	7.0

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	10.3

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263916	**BB-NMR-102/7D**	**GEOTECHNICAL (DISTURBED)**	**5/5/2015**	**6/16/2015**

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **29.0-31.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	
[mm]	

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	**2.68**
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

Testing canceled. Insufficient amount of material available to run Hydro.

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/24/2015**

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MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263917	BB-NMR-102/8D	GEOTECHNICAL (DISTURBED)	5/5/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **115+51.4** Offset, ft: **4.8** **RT** Dbfg, ft: **34.0-36.0**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	100.0
1 in. [25.0 mm]	84.5
¾ in. [19.0 mm]	84.5
½ in. [12.5 mm]	80.8
⅜ in. [9.5 mm]	80.2
¼ in. [6.3 mm]	76.8
No. 4 [4.75 mm]	74.2
No. 10 [2.00 mm]	67.8
No. 20 [0.850 mm]	56.2
No. 40 [0.425 mm]	40.9
No. 60 [0.250 mm]	25.1
No. 100 [0.150 mm]	15.8
No. 200 [0.075 mm]	11.5

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	12.8

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
263918	BB-NMR-102A/1D	GEOTECHNICAL (DISTURBED)	5/5/2015	6/16/2015

Sample Type: **GEOTECHNICAL** Location: Station: **115+52.8** Offset, ft: **4.8** **RT** Dbfg, ft: **39.0-39.4**

WIN/Town **020466.00 - NAPLES** Sampler: **BRUCE WILDER**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method: Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	100.0
1 in. [25.0 mm]	66.8
¾ in. [19.0 mm]	54.2
½ in. [12.5 mm]	54.2
⅜ in. [9.5 mm]	52.5
¼ in. [6.3 mm]	49.6
No. 4 [4.75 mm]	46.3
No. 10 [2.00 mm]	37.6
No. 20 [0.850 mm]	29.4
No. 40 [0.425 mm]	24.0
No. 60 [0.250 mm]	20.1
No. 100 [0.150 mm]	15.6
No. 200 [0.075 mm]	11.0

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition (T 267)	
Loss, %	
H2O, %	
Water Content (T 265), %	5.0

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **6/23/2015**

Paper Copy: Lab File; Project File; Geotech File

LABORATORY TESTING DATA SHEET

Project Name: Crockett Bridge #2199 over Muddy River, WIN 20466.00
Project No.: 09.0025899.00
Project Manager: A. Blaisdell

Location: Naples, ME
Assigned By: A. Blaisdell
Report Date: 12/10/2015

Reviewed By: [signature]
Date Reviewed: 12/10/2015

Boring No.	Sample No.	Depth Ft.	Lab No.	Sample Data: Moh's Hard-ness	Do in.	L in.	(1) Unit Wt. PCF	(2) Wet Density PCF	Bulk Gs.	Compression Tests: (3) Other Tests	(4) Strength PSI	(5) Strain %	(6) Conf. Stress	(7) E sec PSI EE+06	(8) Poisson's Ratio	στ PSI	Is_{50} KSI	Rock Formation or Description or Remarks
BB-NMR-101	R2	34.0-34.4	1		1.967	4.776	161.9			U	34,300	0.64		4.58	0.94			Trachyte
BB-NMR-102A	R2	45.1-45.5	2		1.968	4.634	163.4			U	14,930	0.39		3.23	1.38			Granite

(1) Volume Determined By Measuring Dimensions
(2) Determined by Measuring Dimensions and Weight of Saturated Sample

(3) P=Petrographic PLD=Point Load (diametrical), PLA= Point Load (Axial) RST= Splitting Tensile U= Unconfined Compressive Strength
(4) Taken at Peak Deviator Stress

(5) Strain at Peak Deviator Stress
(6) Represents Confining Stress on Triaxial Tests
(7) Represents Secant Modulus at 50% of Total Failure Stress
(8) Represents Secant Poisson's Ratio at 50% of Total Failure Stress

THIELSCH ENGINEERING
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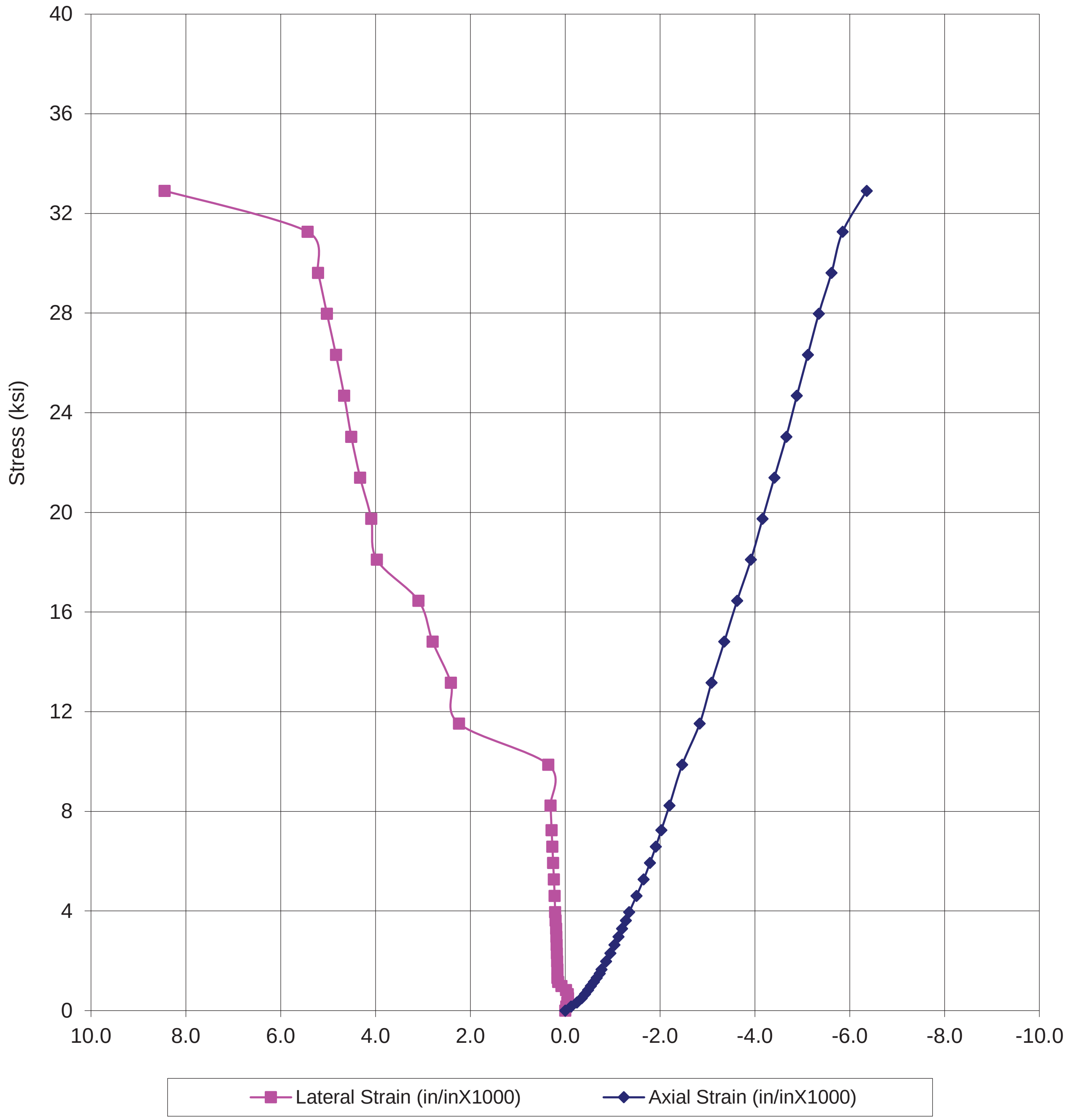
Crockett Bridge #2199 over Muddy River, WIN 20466.00
Naples, ME



Rock Unconfined Compression Testing - ASTM D7012

Boring No. BB-NMR-101
Sample No. R2
Depth: 34.0-34.4'

File No. 09.0025899.00
Date: 12/09/15
Test No. U 1

THIELSCH ENGINEERING

Crockett Bridge #2199
over Muddy River
Naples, ME

GZA Project # 09.0025899.00

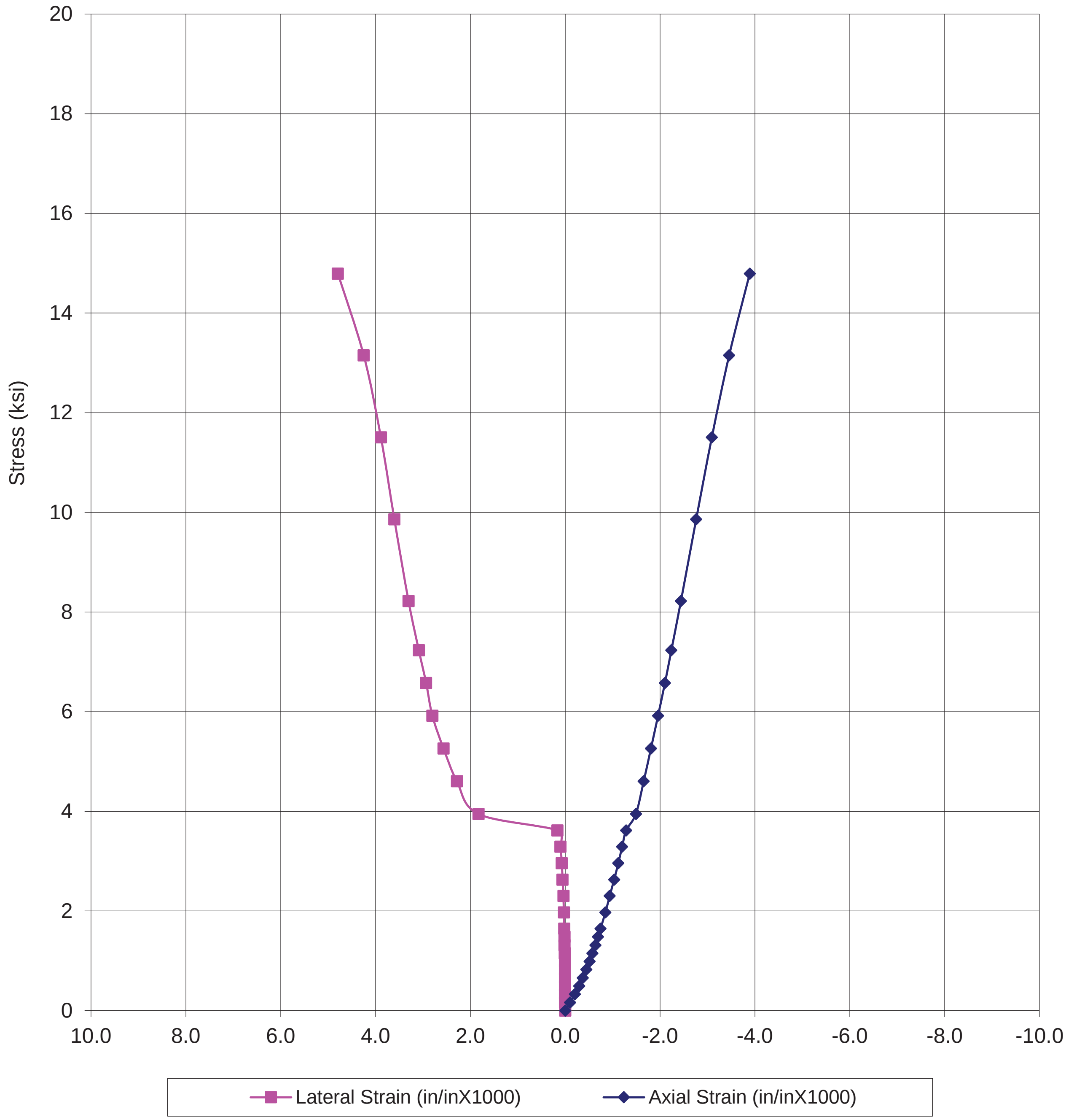
BORING NO.	SAMPLE NO.	DEPTH
BB-NMR-101	R-2	34.0 – 34.4'

Crockett Bridge #2199
over Muddy River
Naples, ME

GZA Project # 09.0025899.00

BORING NO.	SAMPLE NO.	DEPTH
BB-NMR-101	R-2	34.0 – 34.4’

Crockett Bridge #2199 over Muddy River, WIN 20466.00
Naples, ME



Rock Unconfined Compression Testing - ASTM D7012

Boring No. BB-NMR-102A
Sample No. R2
Depth:45.1-45.5'

File No. 09.0025899.00
Date: 12/09/15
Test No. U 2

THIELSCH ENGINEERING

Crockett Bridge #2199
over Muddy River
Naples, ME

GZA Project # 09.0025899.00

BORING NO.	SAMPLE NO.	DEPTH
BB-NMR-102A	R-2	45.1 - 45.5'

Crockett Bridge #2199
over Muddy River
Naples, ME

GZA Project # 09.0025899.00

BORING NO.	SAMPLE NO.	DEPTH
BB-NMR-102A	R-2	45.1 - 45.5'

APPENDIX E – GEOTECHNICAL ENGINEERING CALCULATIONS

Spun Pile End Bearing Calculation
Crockett Bridge - Naples, ME
Job #: 09.0025899.00

Calc by: N. Williams, 2/12/16
Reviewed by: A. Blaisdell, 2/13/16 and C. Snow, 2/16/16

Pile Section: 9.625" OD Pipe

Assumptions: 1) Pile will be filled with grout or concrete to achieve end bearing resistance across the entire tip area.
2) End bearing resistance is calculated in accordance with drilled shaft tip resistance on rock methodology, AASHTO LRFD Section 10.8

Parameter Description	Parameter Symbol	Values			
		Granite		Trachyte	Reference
Unconfined compressive strength of intact rock	q_u (psi)	14930		34300	Lab data
Nominal Shaft Tip Resistance, Intact Rock	$q_{p\ intact}$ (ksf)	5374.8		12348	AASHTO Eq. 10.8.3.5.4C-1
Geological Strength Index	GSI	60		60	AASHTO FIG 10.4.6.4-1
Hoek - Brown 2002	D	0		0	Hoek - Brown 2002
Empirically determined rock mass parameter	s	0.012		0.012	AASHTO Eq. 10.4.6.4-2
Empirically determined rock mass parameter	a	0.50		0.50	AASHTO Eq. 10.4.6.4-3
Rock group constant	m_i	32		25	AASHTO TABLE 10.4.6.4-1
Empirically determined rock mass parameter	m_b	7.7		6.0	AASHTO Eq. 10.4.6.4-4
Vertical effective stress at the socket bearing elevation	$\sigma'_{v,b}$ (psf)	2329.1		2329.1	Vertical effective stress, shallowest anticipated socket bearing elevation
	$\sigma'_{v,b}$ (psi)	16.2		16.2	
Fracturing coefficient	A	2107		4108	AASHTO Eq. 10.8.3.5.4C-3 (Turner and Ramey, 2010)
Nominal Shaft Tip Resistance, Jointed Rock Mass	$q_{p\ jointed}$ (ksf)	2553		4806	AASHTO Eq. 10.8.3.5.4C-2
Nominal Shaft Tip Resistance, Jointed Rock Mass	$q_{p\ jointed}$ (psi)	17730		33374	
Ratio of Jointed Tip Resistance / Intact Tip Resistance	$q_{p\ jointed} / q_{p\ intact}$	0.48		0.39	
Ratio of Jointed Tip Resistance / UCS	$q_{p\ jointed} / q_u$	1.19		0.97	
Area of Pile Tip	A_p (ft^2)	0.51		0.51	
Nominal Tip Resistance, Intact Rock	$R_{p,i}$ (kips)	2716		6239	
Nominal Tip Resistance, Jointed Rock Mass	$R_{p,j}$ (kips)	1290		2428	AASHTO Eq. 10.8.3.5-2
Resistance Factor	ϕ_{qp}	0.5		0.5	AASHTO TABLE 10.5.5.2.5-1
Factored Tip Resistance, Intact Rock	$R_{R,i}$ (kips)	1358		3120	
Factored Tip Resistance, Jointed Rock Mass	$R_{R,j}$ (kips)	645		1214	AASHTO Eq. 10.8.3.5-1

Result:
End bearing resistance on Granite Controls. Nominal and factored geotechnical resistance of spun pile are 1290 kips and 645 kips, respectively.

Table 10.5.5.2.5-1—Resistance Factors for Geotechnical Resistance of Axially Loaded Micropiles

Limit State	Method/ Ground Condition	Resistance Factor
Compression Resistance of Single Micropile, ϕ_{stat}	Side Resistance (Bond Resistance): Presumptive Values	0.55[(1)]
	Tip Resistance on Rock O'Neill and Reese (1999)	0.50
	Side Resistance and Tip Resistance Load Test	Values in Table 10.5.5.2.3-1, but no greater than 0.70
Block Failure, ϕ_{bl}	Clay	0.60
Uplift Resistance of Single Micropile, ϕ_{up}	Presumptive Values	0.55[(1)]
	Tension Load Test	Values in Table 10.5.5.2.3-1, but no greater than 0.70
Group Uplift Resistance, ϕ_{ug}	Sand & Clay	0.50

Resistance Factor for End Bearing on Rock

[(1)] Apply to presumptive grout-to-ground bond values for preliminary design only in Article C10.9.3.5.2.

Table 10.5.5.2.5-2—Resistance Factors for Structural Resistance of Axially Loaded Micropiles

Section / Loading Condition		Resistance Factor
Pile Cased Length	Tension, φ_{TC}	0.80
	Compression, φ_{CC}	0.75
Pile Uncased Length	Tension, φ_{TU}	0.80
	Compression, φ_{CU}	0.75

Table 10.4.6.4-1—Values of the Constant m_i by Rock Group (after Marinos and Hoek 2000; with updated values from Rocscience, Inc., 2007)

Rock type	Class	Group	Texture: Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Granite

Trachyte

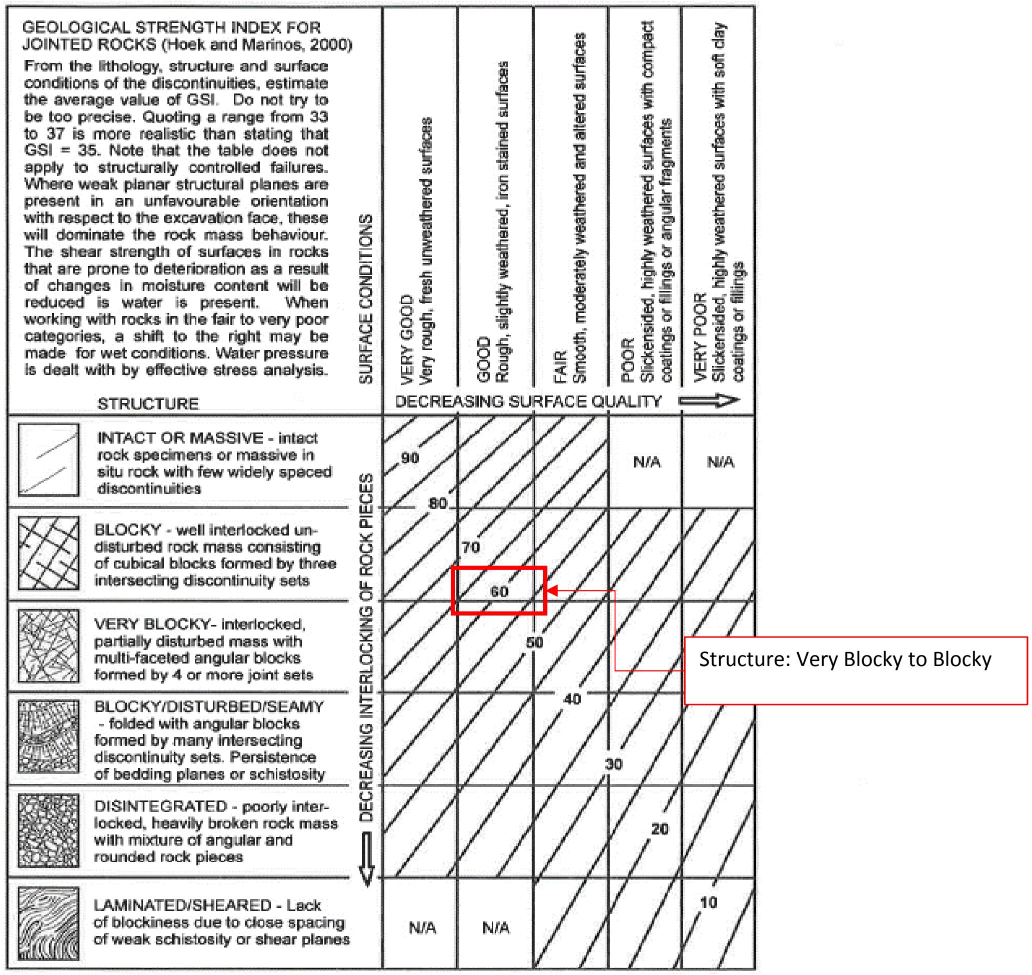


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

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JOB 09.0025899.00 Crockett Bridge
SHEET NO 1 OF 3
Calculated By NVV Date 2/15/16
Checked By CLS Date 2/16/16
Scale N/A

End-bearing of 9 5/8" OD micropile on GRANITE

Unconfined compressive strength of Granite, q_u (psi) = 14930 (lab data)

Nominal shaft Tip Resistance of intact rock $q_{p(intact)} = 2.5 q_u$

$$q_{p(intact)} = 2.5(14930\ lb/in^2) = 37{,}325\ lb/in^2 \checkmark$$
$$= 5{,}374.8\ kip/ft^2 \checkmark$$

Geologic Strength Index (GSI) From Fig. 10.4.6.4-1 AASHTO
GSI = 60 Structure: very blocky to blocky ✓
Surface Condition: Good

The disturbance factor, D = 0 ✓ (Hoek et al 2002)
No Blasting / Disturbance

Empirically determined rock mass parameter, s,

$$s = e^{\left(\frac{GSI-100}{9-3D}\right)} = e^{\frac{60-100}{9-3(0)}} = .0117 \checkmark$$

Empirically determined rock mass parameter, a

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-\frac{GSI}{15}} - e^{-20/3}\right) = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-60}{15}} - e^{-\frac{20}{3}}\right)$$
$$= 0.503 \checkmark$$

Rock Group constant, m_i
for Granite, $m_i = 32$ ✓

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Engineers and Scientists

JOB 09.0025899.00 Crockett Bridge
SHEET NO 2 OF 3
Calculated By NVW Date 2/5/16
Checked By CWS Date 2/16/16
Scale N/A

Empirically determined Rock mass parameter, m_b

$$m_b = m_i e^{\frac{GSI-100}{28-14D}} = 32 e^{\frac{60-100}{28-14(0)}} = 7.67$$

Vertical effective stress at the socket bearing elevation, $\sigma'_{v,b}$

water level @ El. 267.0

Pile located @ location BB-NMR-101

$$\sigma'_{v,b} = (125\ lb/ft^3 \times 7\ ft) + (130\ lb/ft^3 \times 3\ ft) + [(130\ lb/ft^3 - 62.4\ lb/ft^3) \times 9] + [(170\ lb/ft^3 - 62.4\ lb/ft^3) \times 3.5\ ft] + [(135\ lb/ft^3 - 62.4\ lb/ft^3) \times 3.5\ ft]$$

$$= 2329.1\ lb/ft^2$$

$$= 16.2\ lb/in^2$$

Fracturing coefficient, A

$$A = \sigma'_{v,b} + q_u \left[m_b \frac{\sigma'_{v,b}}{q_u} + s \right]^a = 16.2\ lb/in^2 + 14930\ lb/in^2 \left[7.67 \frac{16.2\ lb/in^2}{14930\ lb/in^2} + .0117 \right]^{0.503}$$

$$= 2104.2\ lb/in^2$$

Nominal shaft tip resistance, jointed rock mass, $q_{p(jointed)}$

$$q_{p(jointed)} = A + q_u \left[m_b \left(\frac{A}{q_u} \right) + s \right]^a = 2104.2 + 14930\ lb/in^2 \left[7.67 \frac{2104.2}{14930} + .0117 \right]^{0.503}$$

$$= 17715.0\ lb/in^2$$

$$= 2551.0\ kip/ft^2$$

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Fax (207) 879-0099
http://www.gza.com

Engineers and Scientists

JOB 09.0025899.00 Crockett Bridge
SHEET NO 3 OF 3
Calculated By MW Date 2/15/16
Checked By CLS Date 2/16/16
Scale N/A

Area of Pile Tip, A_p

OD = $9\frac{5}{8}$" $A_p = \frac{\pi}{4} d^2 = \frac{\pi}{4}(9\frac{5}{8}")^2$
$= 72.7 \text{ in}^2$
$= 0.505 \text{ ft}^2$ ✓

Nominal Tip Resistance Intact Rock, $R_{p,i}$

$R_{p,i} = A_p (q_{p(intact)}) = 0.505 \text{ ft}^2 \times 5{,}374.8 \text{ kip/ft}^2$
$= 2714.2 \text{ kips}$ ✓

Nominal Tip Resistance Jointed Rock, $R_{p,j}$

$R_{p,j} = A_p (q_{p(jointed)}) = 0.505 \text{ ft}^2 \times 2551 \text{ kip/ft}^2$
$= 1288.2 \text{ kips}$ ✓

Resistance Factor, ϕ_{qp} AASHTO table 10.5.5.2.5-1

$\phi_{qp} = 0.5$

Factored tip resistance, Intact Rock, $R_{R,i}$

$R_{R,i} = \phi_{qp} \times R_{p,i} = 0.5 \times 2714.2 \text{ kips}$
$= 1357.1 \text{ kips}$ ✓

Factored tip resistance, Jointed Rock Mass, $R_{R,j}$

$R_{R,j} = \phi_{qp} \times R_{p,j} = 0.5 \times 1288.2 \text{ kips}$
$= 644.1 \text{ kips}$ ✓

Tabel 1- LPile Input Parameters
Crockett Bridge #2199 Over Muddy River, Naples, ME
GZA GeoEnvironmental, Inc.

GZA FILE NO. 09.0025899.00
CALCULATED BY E. Lonstein
CHECKED BY A. Blaisdell
DATE 1/13/2016

Abutment 1 (Boring: BB-NMR-101)						
Stratum	**Soil Model**	**Top of Layer Elevation (ft)**	**Layer Thickness (ft)**	**k (pci) / E50 / krm**	**ϕ' (deg)/ Su (psf)/ UCS (psi)**	**γ_e (pcf)**
Gravelly Sand	Reese Sand	266.0	9.0	100	38	67
Silt/Clay	Stiff Clay	257.0	3.5	E_{50} = 0.01	1000 psf	57
Gravel (Possible Till)	Reese Sand	253.5	3.5	125	40	72
Rock	Weak Rock	250.0	3.0	krm = 0.0005	1000 psi	102

Notes:
1. Abutment 1 layering is based on stratification of boring BB-NMR-101.
2. Additional parameters for Weak Rock include: Modulus of 50 ksi and RQD of 20%.
- Initial Modulus, E_{ir}=50 ksi
-Strain Constant, ε_{rm}=0.0005

Abutment 2 (Borings: BB-NMR-102 and BB-NMR-102A)						
Stratum	**Soil Model**	**Top of Layer Elevation (ft)**	**Layer Thickness (ft)**	**k (pci) / E50**	**ϕ' (deg)/ Su (psf)**	**γ_e (pcf)**
Sand (Possible Fill)	Reese Sand	277.0	11	130	35	125
Sand (Possible Fill)	Reese Sand	266.0	3.5	80	35	63
Gravelly Sand	Reese Sand	262.5	14.5	100	38	67
Silt/Clay	Stiff Clay	248.0	3	E_{50} = 0.01	1000 psf	57
Lower Sand	Reese Sand	245.0	5	60	34	63
Gravel (Possible Till)	Reese Sand	240.0	4	125	40	73
Rock	Weak Rock	236.0	3.0	krm = 0.0005	1000 psi	102

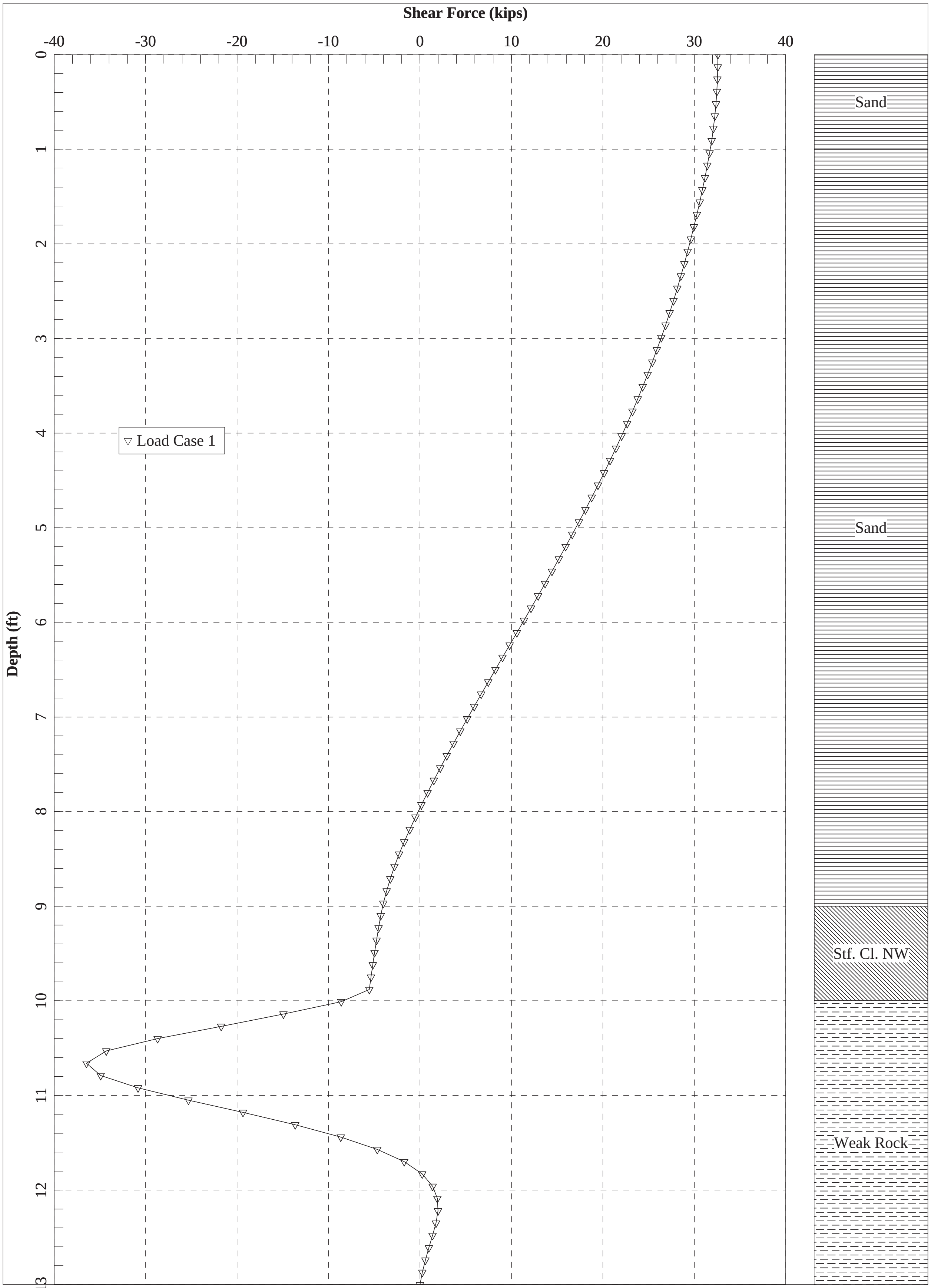
Notes:
1. Abutment 2 layering is based primarily on stratification of BB-NMR-102 and BB-NMR-102A.
The bottom of the till should be considered as the maximum pile length.
2. Additional parameters for Weak Rock include: Modulus of 50 ksi and RQD of 20%.
- Initial Modulus, E_{ir}=50 ksi
-Strain Constant, ε_{rm}=0.0005

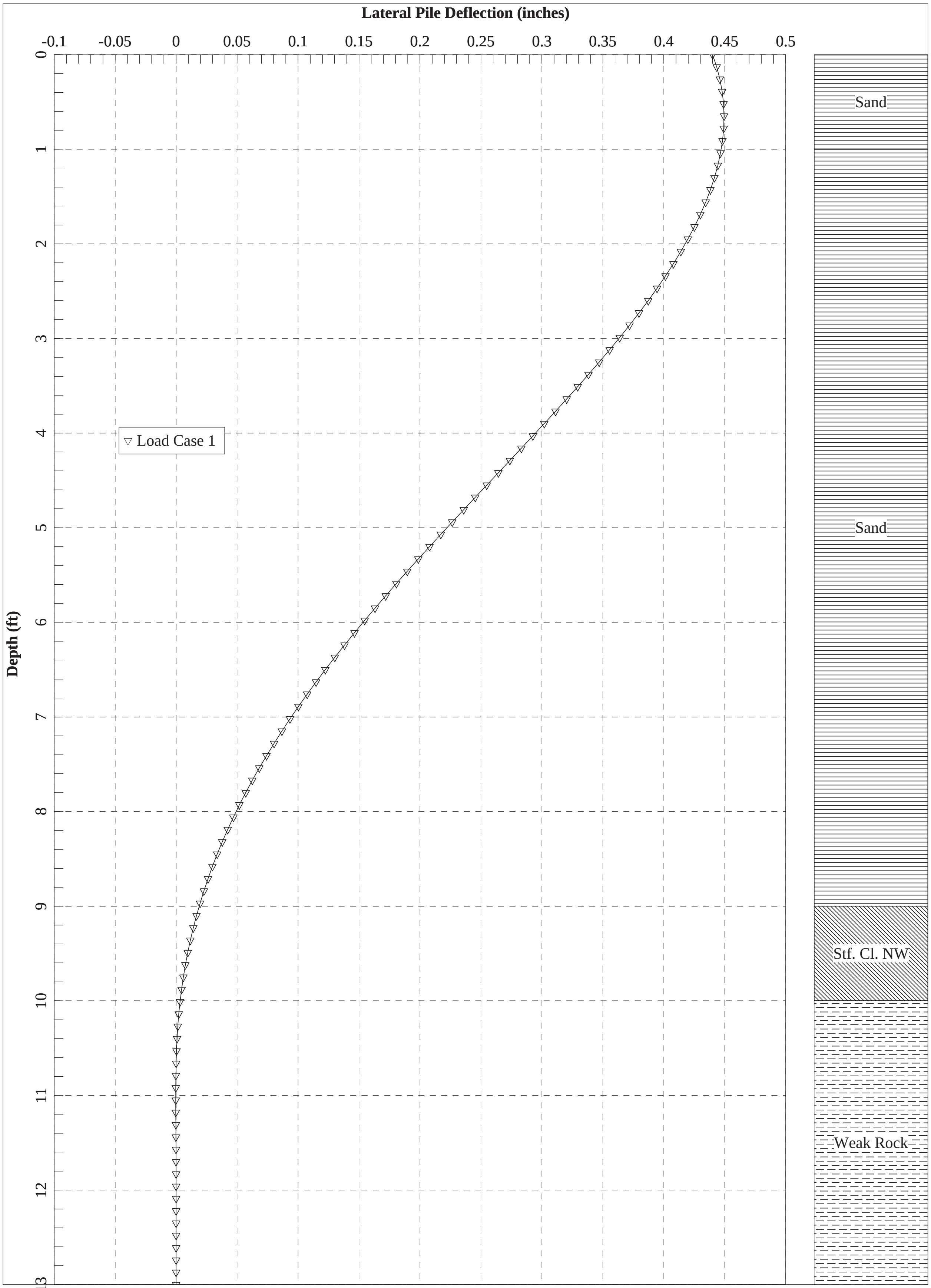
Table 2 - Updated LPILE Result Summary
Crockett Bridge #2199 Over Muddy River, Naples, ME
GZA GeoEnvironmental, Inc.

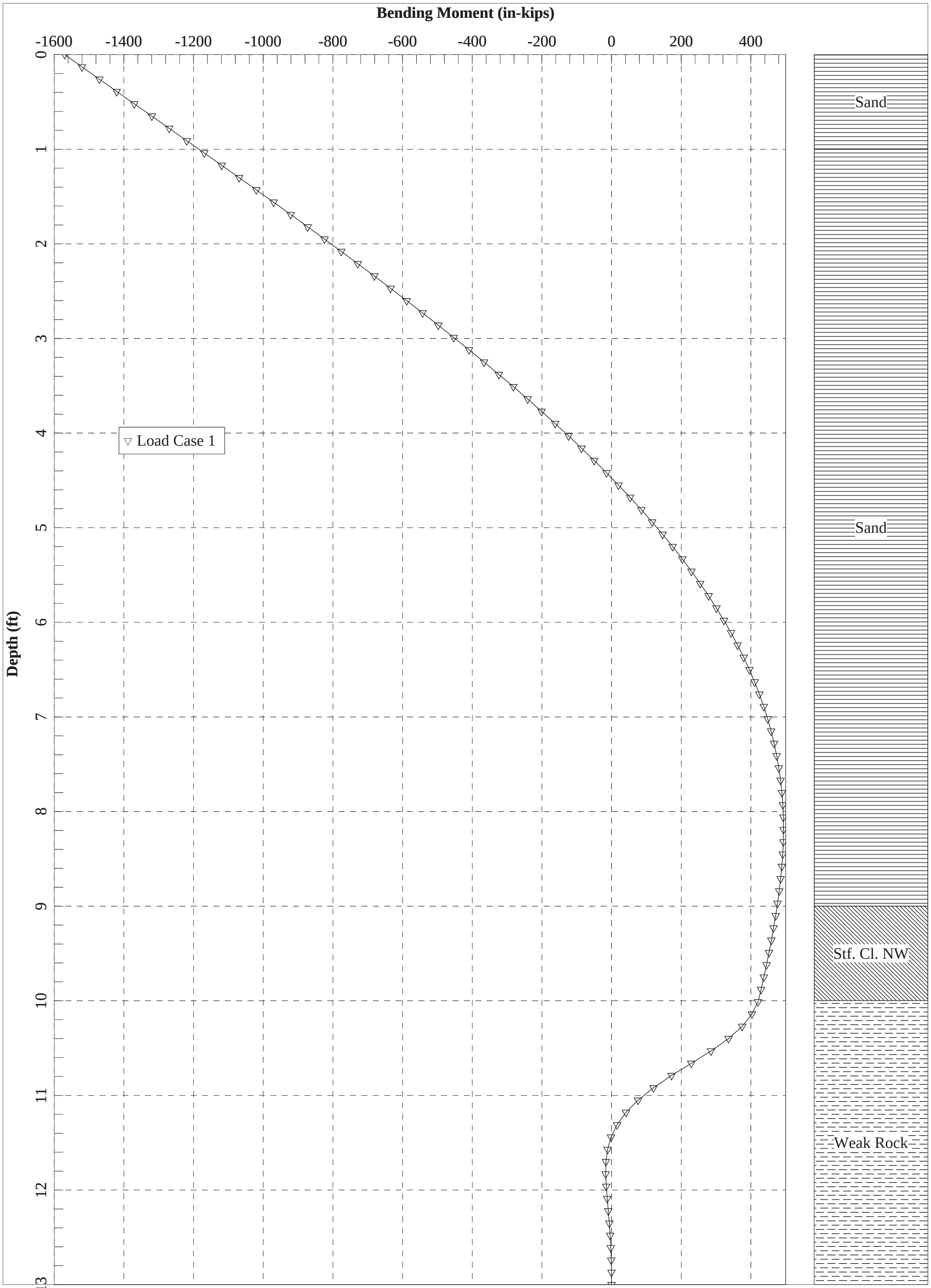
GZA FILE NO. 09.0025899.00
CALCULATED BY B.Cardali
CHECKED BY A. Blaisdell
DATE 3/23/2016

Lpile Summary Table							
Location	**Pile Type and Size**	**Axial Load (kips)**	**Shear Force for Lateral deflection of 0.44 in. (kips)**	**Moment at Pile Head (in-kips)**	**Total Stress at Pile Head (ksi)**	**Bending Stress at Pile Head (ksi)**	**Axial Stress at Pile Head (ksi)**
Abutment 1	Empty Casing (.545" Wall Thickness)	365	32.6	-1569.8	70.5	47.0	23.5
Abutment 1	Concrete Filled Casing (6 ksi/ .545" Wall Thickness)	365	36.0	-1787.1	60.1 / 5.94*	--	--
Abutment 2	Empty Casing (.545" Wall Thickness)	365	34.1	-1618.3	71.9	48.4	23.5
Abutment 2	Concrete Filled Casing (6 ksi/ .545" Wall Thickness)	365	37.4	-1823.8	61.5 / 5.96*	--	--

Notes:
1. Slope of 0.00245 in/in was applied at pile head in direction opposite of imposed lateral deflection .
2. The axial load is the maximum Factored Axial Load provided by Garrett Gustafson (MaineDOT) via email on 1/5/16.
3. The casing sections are 9-5/8" diameter pile with stated wall thicknesses
4. Abutment 1 Pile Length = 13 feet (3 feet embedment in rock).
5. Abutment 2 Pile Length = 44 feet (3 feet embedment in rock).
6. For grouted casing analyses, second number in Total Stress at Pile Head columns is the concrete stress.


Shear Force (kips)
-40
-30
-20
-10
0
10
20
30
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock


Bending Moment (in-kips)
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock

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

                    LPile for Windows, Version 2015-08.003

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

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

Path to file locations:
\09 Jobs\0025800s\09.0025899.00 - MDOT Naples\Work\Calcs\LPile\

Name of input data file:
Crockett Bridge Abutment 1 9in diam piles not concrete filled 10 feet thick pipe.lp8d

Name of output report file:
Crockett Bridge Abutment 1 9in diam piles not concrete filled 10 feet thick pipe.lp8o

Name of plot output file:
Crockett Bridge Abutment 1 9in diam piles not concrete filled 10 feet thick pipe.lp8p

Name of runtime message file:
Crockett Bridge Abutment 1 9in diam piles not concrete filled 10 feet thick pipe.lp8r


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

               Date:  January 12, 2016     Time:  15:06:03
```



```
--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Crockett Bridge #2199 Muddy River, Naples, ME


Job Number: 09.0025899.00


Client: MaineDOT


Engineer:


Description:




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
```

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 13.00 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point	Depth X ft	Pile Diameter in
1	0.00000	9.62500000
2	13.0000000	9.62500000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Steel Pipe Pile
Section Length	= 13.000000 ft
Pile Diameter	= 9.625000 in
Shear Capacity of Section	= 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 0.0000 ft
Distance from top of pile to bottom of layer	= 1.000000 ft
Effective unit weight at top of layer	= 130.000000 pcf
Effective unit weight at bottom of layer	= 130.000000 pcf
Friction angle at top of layer	= 38.000000 deg.
Friction angle at bottom of layer	= 38.000000 deg.
Subgrade k at top of layer	= 160.000000 pci
Subgrade k at bottom of layer	= 160.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 1.000000 ft
Distance from top of pile to bottom of layer	= 9.000000 ft
Effective unit weight at top of layer	= 67.000000 pcf
Effective unit weight at bottom of layer	= 67.000000 pcf
Friction angle at top of layer	= 38.000000 deg.
Friction angle at bottom of layer	= 38.000000 deg.
Subgrade k at top of layer	= 100.000000 pci
Subgrade k at bottom of layer	= 100.000000 pci

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	= 9.000000 ft
Distance from top of pile to bottom of layer	= 10.000000 ft
Effective unit weight at top of layer	= 57.000000 pcf
Effective unit weight at bottom of layer	= 57.000000 pcf
Undrained cohesion at top of layer	= 1000.000000 psf
Undrained cohesion at bottom of layer	= 1000.000000 psf
Epsilon-50 at top of layer	= 0.010000
Epsilon-50 at bottom of layer	= 0.010000

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

Distance from top of pile to top of layer	= 10.000000 ft
Distance from top of pile to bottom of layer	= 13.000000 ft
Effective unit weight at top of layer	= 102.000000 pcf

```
Effective unit weight at bottom of layer          =   102.000000 pcf
Uniaxial compressive strength at top of layer     =  1000.000000 psi
Uniaxial compressive strength at bottom of layer  =  1000.000000 psi
Initial modulus of rock at top of layer           =       50000. psi
Initial modulus of rock at bottom of layer        =       50000. psi
RQD of rock at top of layer                       =    20.000000 %
RQD of rock at bottom of layer                    =    20.000000 %
k rm of rock at top of layer                      =       0.0000
k rm of rock at bottom of layer                   =       0.0000
```

(Depth of lowest soil layer extends 0.00 ft below pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	130.0000	--	38.0000	--	--	--	160.0000	--
	(Reese, et al.)	1.0000	130.0000	--	38.0000	--	--	--	160.0000	--
2	Sand	1.0000	67.0000	--	38.0000	--	--	--	100.0000	--
	(Reese, et al.)	9.0000	67.0000	--	38.0000	--	--	--	100.0000	--
3	Stiff Clay	9.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
	w/o Free Water	10.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
4	Weak	10.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.
	Rock	13.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.440000 in	S = 0.002450 in/in	365000.	N.A.

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading.
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

```
Length of Section                                =    13.000000 ft
Outer Diameter of Pipe                           =     9.625000in
Pipe Wall Thickness                              =     0.545000in
Yield Stress of Pipe                             =    80.000000ksi
Elastic Modulus                                  =       29000.ksi
Cross-sectional Area                             =    15.546485sq. in.
Moment of Inertia                                =   160.796181in^4
Elastic Bending Stiffness                        =     4663089. kip-in^2
Plastic Modulus, Z                               =    44.987248in^3
Plastic Moment Capacity = Fy Z                   =        3599.in-kip
```

Axial Structural Capacities:

```
Nom. Axial Structural Capacity = Fy As           =     1243.719 kips
Nominal Axial Tensile Capacity                   =    -1243.719 kips
```

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

Number	Axial Thrust Force kips
1	365.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 365.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Run Msg
0.00001008	46.9970366	4663282.	85.1436192	24.8704357	
0.00002016	93.9940732	4663282.	44.9780596	26.2628951	
0.00003023	140.9911099	4663282.	31.5895397	27.6553554	
0.00004031	187.9881465	4663282.	24.8952798	29.0478157	
0.00005039	234.9851831	4663282.	20.8787238	30.4402762	
0.00006047	281.9822197	4663282.	18.2010199	31.8327361	
0.00007055	328.9792563	4663282.	16.2883742	33.2251962	
0.00008062	375.9762930	4663282.	14.8538899	34.6176564	
0.00009070	422.9733296	4663282.	13.7381799	36.0101165	
0.0001008	469.9703662	4663282.	12.8456119	37.4025766	
0.0001109	516.9674028	4663282.	12.1153290	38.7950367	
0.0001209	563.9644394	4663282.	11.5067599	40.1874969	
0.0001310	610.9614760	4663282.	10.9918169	41.5799569	
0.0001411	657.9585127	4663282.	10.5504371	42.9724172	
0.0001512	704.9555493	4663282.	10.1679079	44.3648773	
0.0001612	751.9525859	4663282.	9.8331949	45.7573375	
0.0001713	798.9496225	4663282.	9.5378600	47.1497975	
0.0001814	845.9466591	4663282.	9.2753400	48.5422577	
0.0001915	892.9436958	4663282.	9.0404536	49.9347178	
0.0002016	939.9407324	4663282.	8.8290560	51.3271779	
0.0002116	986.9377690	4663282.	8.6377914	52.7196381	
0.0002217	1034.	4663282.	8.4639145	54.1120982	
0.0002318	1081.	4663282.	8.3051574	55.5045583	
0.0002419	1128.	4663282.	8.1596300	56.8970185	
0.0002520	1175.	4663282.	8.0257448	58.2894786	
0.0002620	1222.	4663282.	7.9021584	59.6819387	
0.0002721	1269.	4663282.	7.7877266	61.0743989	
0.0002822	1316.	4663282.	7.6814685	62.4668590	
0.0002923	1363.	4663282.	7.5825386	63.8593191	
0.0003023	1410.	4663282.	7.4902040	65.2517792	

Crockett Bridge Abutment 1 9in diam piles not concrete filled 10 feet thick pipe.lp8o

0.0003124	1457.	4663282.	7.4038264	66.6442394	
0.0003225	1504.	4663282.	7.3228475	68.0366995	
0.0003326	1551.	4663282.	7.2467763	69.4291596	
0.0003427	1598.	4663282.	7.1751800	70.8216198	
0.0003527	1645.	4663282.	7.1076748	72.2140799	
0.0003628	1692.	4663282.	7.0439200	73.6065400	
0.0003729	1739.	4663282.	6.9836113	74.9990002	
0.0003830	1786.	4663282.	6.9264768	76.3914603	
0.0003930	1833.	4663282.	6.8722723	77.7839204	
0.0004132	1927.	4662467.	6.7721746	80.0000000	Y
0.0004334	2015.	4650186.	6.6868742	80.0000000	Y
0.0004535	2094.	4617411.	6.6198204	80.0000000	Y
0.0004737	2162.	4564515.	6.5702787	80.0000000	Y
0.0004938	2223.	4501394.	6.5326082	80.0000000	Y
0.0005140	2278.	4432424.	6.5039536	80.0000000	Y
0.0005341	2329.	4360117.	6.4824500	80.0000000	Y
0.0005543	2376.	4286107.	6.4667333	80.0000000	Y
0.0005745	2419.	4211106.	6.4560187	80.0000000	Y
0.0005946	2460.	4136412.	6.4491575	80.0000000	Y
0.0006148	2497.	4062416.	6.4455821	80.0000000	Y
0.0006349	2533.	3989310.	6.4448991	80.0000000	Y
0.0006551	2566.	3917576.	6.4465149	80.0000000	Y
0.0006752	2598.	3847409.	6.4500573	80.0000000	Y
0.0006954	2628.	3778616.	6.4554625	80.0000000	Y
0.0007155	2656.	3711611.	6.4622173	80.0000000	Y
0.0007357	2683.	3646377.	6.4701478	80.0000000	Y
0.0007559	2708.	3582895.	6.4790996	80.0000000	Y
0.0007760	2732.	3521139.	6.4889355	80.0000000	Y
0.0007962	2756.	3461045.	6.4995653	80.0000000	Y
0.0008163	2778.	3402650.	6.5108195	80.0000000	Y
0.0008365	2799.	3345938.	6.5225820	80.0000000	Y
0.0008566	2819.	3290796.	6.5348362	80.0000000	Y
0.0008768	2838.	3237223.	6.5474709	80.0000000	Y
0.0008970	2857.	3185189.	6.5604061	80.0000000	Y
0.0009171	2875.	3134661.	6.5735715	80.0000000	Y
0.0009373	2892.	3085208.	6.5862568	80.0000000	Y
0.0009574	2908.	3037189.	6.5989959	80.0000000	Y
0.0009776	2923.	2989793.	6.6107428	80.0000000	Y
0.0009977	2937.	2943725.	6.6227161	80.0000000	Y
0.0010179	2950.	2898345.	6.6332965	80.0000000	Y
0.0010380	2963.	2854275.	6.6438682	80.0000000	Y
0.0010582	2974.	2810794.	6.6535631	80.0000000	Y
0.0010784	2985.	2768461.	6.6626275	80.0000000	Y
0.0010985	2996.	2727074.	6.6714901	80.0000000	Y
0.0011187	3005.	2686288.	6.6789227	80.0000000	Y
0.0011388	3014.	2646715.	6.6864783	80.0000000	Y
0.0011590	3022.	2607744.	6.6929406	80.0000000	Y
0.0011791	3030.	2569647.	6.6986999	80.0000000	Y
0.0011993	3037.	2532626.	6.7046701	80.0000000	Y
0.0012799	3062.	2392491.	6.7227354	80.0000000	Y
0.0013605	3082.	2265306.	6.7371943	80.0000000	Y
0.0014412	3098.	2149949.	6.7486797	80.0000000	Y

0.0015218	3112.	2045021.	6.7580309	80.0000000	Y
0.0016024	3124.	1949302.	6.7659146	80.0000000	Y
0.0016830	3133.	1861749.	6.7728369	80.0000000	Y
0.0017637	3142.	1781348.	6.7784690	80.0000000	Y
0.0018443	3149.	1707367.	6.7831404	80.0000000	Y
0.0019249	3155.	1639218.	6.7875124	80.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	365.0000000000	3155.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.440000 inches
Rotation of pile head = 2.450E-03 radians
Axial load on pile head = 365000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4400	-1569847.	32585.	0.00245	70462.	4.66E+09	0.00	0.00	0.00
0.1300	0.4434	-1520277.	32563.	0.00193	68979.	4.66E+09	-14.0946	49.5873	0.00
0.2600	0.4460	-1470451.	32528.	0.00143	67487.	4.66E+09	-30.7010	107.3772	0.00
0.3900	0.4479	-1420420.	32466.	9.49E-04	65990.	4.66E+09	-49.3368	171.8428	0.00

0.5200	0.4490	-1370238.	32373.	4.83E-04	64488.	4.66E+09	-69.3461	240.9389	0.00
0.6500	0.4494	-1319964.	32249.	3.26E-05	62983.	4.66E+09	-90.2692	313.3590	0.00
0.7800	0.4491	-1269659.	32091.	-4.01E-04	61478.	4.66E+09	-111.6071	387.6842	0.00
0.9100	0.4481	-1219383.	31901.	-8.17E-04	59973.	4.66E+09	-133.2054	463.6966	0.00
1.0400	0.4465	-1169199.	31678.	-0.00122	58471.	4.66E+09	-152.3393	532.1940	0.00
1.1700	0.4443	-1119163.	31432.	-0.00160	56974.	4.66E+09	-163.1814	572.8967	0.00
1.3000	0.4416	-1069311.	31168.	-0.00197	55482.	4.66E+09	-174.5463	616.6637	0.00
1.4300	0.4382	-1019680.	30888.	-0.00231	53996.	4.66E+09	-185.3695	659.9002	0.00
1.5600	0.4343	-970306.	30591.	-0.00265	52518.	4.66E+09	-195.0004	700.3819	0.00
1.6900	0.4300	-921221.	30279.	-0.00296	51049.	4.66E+09	-204.2131	740.9486	0.00
1.8200	0.4251	-872458.	29954.	-0.00326	49590.	4.66E+09	-212.5014	779.8435	0.00
1.9500	0.4198	-824046.	29618.	-0.00355	48141.	4.66E+09	-219.3073	815.0185	0.00
2.0800	0.4140	-776011.	29269.	-0.00382	46703.	4.66E+09	-227.4748	857.1110	0.00
2.2100	0.4079	-728382.	28907.	-0.00407	45278.	4.66E+09	-236.4258	904.2799	0.00
2.3400	0.4013	-681189.	28532.	-0.00430	43865.	4.66E+09	-244.2937	949.5867	0.00
2.4700	0.3944	-634461.	28143.	-0.00452	42467.	4.66E+09	-254.7066	1007.	0.00
2.6000	0.3872	-588232.	27735.	-0.00473	41083.	4.66E+09	-268.0046	1080.	0.00
2.7300	0.3797	-542543.	27307.	-0.00492	39716.	4.66E+09	-281.0322	1155.	0.00
2.8600	0.3719	-497435.	26859.	-0.00509	38366.	4.66E+09	-293.7327	1232.	0.00
2.9900	0.3638	-452947.	26391.	-0.00525	37034.	4.66E+09	-306.0493	1312.	0.00
3.1200	0.3555	-409117.	25907.	-0.00539	35723.	4.66E+09	-314.4646	1380.	0.00
3.2500	0.3470	-365975.	25410.	-0.00552	34431.	4.66E+09	-322.7692	1451.	0.00
3.3800	0.3383	-323548.	24896.	-0.00564	33162.	4.66E+09	-335.6958	1548.	0.00
3.5100	0.3294	-281877.	24363.	-0.00574	31914.	4.66E+09	-348.1197	1649.	0.00
3.6400	0.3204	-240999.	23811.	-0.00583	30691.	4.66E+09	-359.9801	1753.	0.00
3.7700	0.3112	-200952.	23240.	-0.00590	29492.	4.66E+09	-371.2178	1861.	0.00
3.9000	0.3020	-161769.	22653.	-0.00596	28320.	4.66E+09	-381.7759	1972.	0.00
4.0300	0.2926	-123485.	22049.	-0.00601	27174.	4.66E+09	-391.9720	2090.	0.00
4.1600	0.2832	-86131.	21429.	-0.00604	26056.	4.66E+09	-403.1656	2221.	0.00
4.2900	0.2737	-49742.	20792.	-0.00607	24967.	4.66E+09	-413.8343	2358.	0.00
4.4200	0.2643	-14351.	20139.	-0.00608	23907.	4.66E+09	-423.9534	2503.	0.00
4.5500	0.2548	20012.	19470.	-0.00608	24077.	4.66E+09	-433.5015	2654.	0.00
4.6800	0.2453	53315.	18786.	-0.00606	25074.	4.66E+09	-442.4608	2814.	0.00
4.8100	0.2359	85532.	18090.	-0.00604	26038.	4.66E+09	-450.8168	2982.	0.00
4.9400	0.2265	116635.	17380.	-0.00601	26969.	4.66E+09	-458.5587	3159.	0.00
5.0700	0.2171	146600.	16659.	-0.00596	27866.	4.66E+09	-465.6792	3346.	0.00
5.2000	0.2079	175404.	15928.	-0.00591	28728.	4.66E+09	-472.1747	3544.	0.00
5.3300	0.1987	203026.	15187.	-0.00585	29554.	4.66E+09	-478.0452	3754.	0.00
5.4600	0.1896	229445.	14437.	-0.00577	30345.	4.66E+09	-483.2944	3976.	0.00
5.5900	0.1807	254645.	13679.	-0.00569	31099.	4.66E+09	-487.9296	4213.	0.00
5.7200	0.1718	278608.	12915.	-0.00560	31817.	4.66E+09	-491.9617	4466.	0.00
5.8500	0.1632	301322.	12145.	-0.00551	32496.	4.66E+09	-495.4050	4736.	0.00
5.9800	0.1547	322772.	11370.	-0.00540	33138.	4.66E+09	-498.1980	5025.	0.00
6.1100	0.1463	342948.	10591.	-0.00529	33742.	4.66E+09	-500.0925	5332.	0.00
6.2400	0.1382	361843.	9810.	-0.00517	34308.	4.66E+09	-501.0500	5658.	0.00
6.3700	0.1302	379448.	9029.	-0.00505	34835.	4.66E+09	-501.0512	6004.	0.00
6.5000	0.1224	395762.	8248.	-0.00492	35323.	4.66E+09	-500.0793	6373.	0.00
6.6300	0.1148	410784.	7469.	-0.00478	35772.	4.66E+09	-498.1196	6767.	0.00
6.7600	0.1075	424516.	6694.	-0.00465	36183.	4.66E+09	-495.1596	7187.	0.00
6.8900	0.1003	436961.	5925.	-0.00450	36556.	4.66E+09	-491.1897	7637.	0.00
7.0200	0.09343	448128.	5163.	-0.00435	36890.	4.66E+09	-486.2022	8118.	0.00
7.1500	0.08676	458026.	4409.	-0.00420	37186.	4.66E+09	-480.1925	8634.	0.00

7.2800	0.08032	466668.	3665.	-0.00405	37445.	4.66E+09	-473.1582	9189.	0.00
7.4100	0.07413	474071.	2934.	-0.00389	37667.	4.66E+09	-465.0998	9787.	0.00
7.5400	0.06819	480250.	2215.	-0.00373	37851.	4.66E+09	-456.0205	10433.	0.00
7.6700	0.06250	485229.	1512.	-0.00357	38000.	4.66E+09	-445.9262	11131.	0.00
7.8000	0.05706	489030.	824.5477	-0.00341	38114.	4.66E+09	-434.8259	11889.	0.00
7.9300	0.05187	491680.	155.6531	-0.00324	38194.	4.66E+09	-422.7312	12714.	0.00
8.0600	0.04694	493207.	-493.6096	-0.00308	38239.	4.66E+09	-409.6570	13614.	0.00
8.1900	0.04227	493643.	-1122.	-0.00291	38252.	4.66E+09	-395.6212	14600.	0.00
8.3200	0.03786	493023.	-1725.	-0.00275	38234.	4.66E+09	-378.1991	15584.	0.00
8.4500	0.03370	491388.	-2287.	-0.00258	38185.	4.66E+09	-341.9398	15828.	0.00
8.5800	0.02980	488827.	-2793.	-0.00242	38108.	4.66E+09	-307.0258	16071.	0.00
8.7100	0.02616	485427.	-3246.	-0.00225	38006.	4.66E+09	-273.5628	16314.	0.00
8.8400	0.02277	481268.	-3648.	-0.00209	37882.	4.66E+09	-241.6517	16558.	0.00
8.9700	0.01963	476429.	-4001.	-0.00193	37737.	4.66E+09	-211.3874	16801.	0.00
9.1000	0.01674	470985.	-4287.	-0.00177	37574.	4.66E+09	-154.5043	14401.	0.00
9.2300	0.01409	465075.	-4523.	-0.00162	37397.	4.66E+09	-148.0044	16385.	0.00
9.3600	0.01169	458717.	-4748.	-0.00146	37207.	4.66E+09	-141.2517	18853.	0.00
9.4900	0.00952	451927.	-4963.	-0.00131	37004.	4.66E+09	-134.2124	21982.	0.00
9.6200	0.00760	444725.	-5167.	-0.00116	36788.	4.66E+09	-126.8441	26045.	0.00
9.7500	0.00590	437129.	-5359.	-0.00101	36561.	4.66E+09	-119.0932	31479.	0.00
9.8800	0.00443	429161.	-5538.	-8.69E-04	36322.	4.66E+09	-110.8914	39009.	0.00
10.0100	0.00319	420840.	-8614.	-7.27E-04	36073.	4.66E+09	-3832.	1873383.	0.00
10.1400	0.00217	403113.	-14923.	-5.89E-04	35543.	4.66E+09	-4256.	3062984.	0.00
10.2700	0.00135	374952.	-21733.	-4.59E-04	34700.	4.66E+09	-4475.	5155218.	0.00
10.4000	7.37E-04	335830.	-28685.	-3.40E-04	33529.	4.66E+09	-4438.	9400992.	0.00
10.5300	2.94E-04	285841.	-34305.	-2.36E-04	32033.	4.66E+09	-2766.	1.47E+07	0.00
10.6600	8.40E-07	229067.	-36469.	-1.50E-04	30334.	4.66E+09	-8.8088	1.64E+07	0.00
10.7900	-1.73E-04	172228.	-34916.	-8.25E-05	28633.	4.66E+09	1999.	1.80E+07	0.00
10.9200	-2.57E-04	120222.	-30825.	-3.36E-05	27076.	4.66E+09	3246.	1.97E+07	0.00
11.0500	-2.78E-04	76094.	-25318.	-7.93E-07	25755.	4.66E+09	3813.	2.14E+07	0.00
11.1800	-2.59E-04	41231.	-19350.	1.88E-05	24712.	4.66E+09	3838.	2.31E+07	0.00
11.3100	-2.19E-04	15700.	-13642.	2.84E-05	23948.	4.66E+09	3480.	2.48E+07	0.00
11.4400	-1.71E-04	-1365.	-8668.	3.08E-05	23519.	4.66E+09	2897.	2.65E+07	0.00
11.5700	-1.23E-04	-11379.	-4676.	2.86E-05	23819.	4.66E+09	2222.	2.82E+07	0.00
11.7000	-8.14E-05	-15985.	-1728.	2.40E-05	23956.	4.66E+09	1557.	2.98E+07	0.00
11.8300	-4.81E-05	-16797.	245.0280	1.86E-05	23981.	4.66E+09	971.7131	3.15E+07	0.00
11.9600	-2.35E-05	-15242.	1393.	1.32E-05	23934.	4.66E+09	500.5402	3.32E+07	0.00
12.0900	-6.89E-06	-12465.	1904.	8.57E-06	23851.	4.66E+09	154.2133	3.49E+07	0.00
12.2200	3.22E-06	-9311.	1966.	4.92E-06	23757.	4.66E+09	-75.4671	3.66E+07	0.00
12.3500	8.47E-06	-6338.	1745.	2.31E-06	23668.	4.66E+09	-207.7984	3.83E+07	0.00
12.4800	1.04E-05	-3870.	1379.	5.99E-07	23594.	4.66E+09	-260.3773	3.90E+07	0.00
12.6100	1.03E-05	-2035.	974.6640	-3.88E-07	23539.	4.66E+09	-258.5036	3.90E+07	0.00
12.7400	9.20E-06	-828.7685	593.5699	-8.67E-07	23503.	4.66E+09	-230.0786	3.90E+07	0.00
12.8700	7.63E-06	-182.1863	265.2526	-1.04E-06	23483.	4.66E+09	-190.8410	3.90E+07	0.00
13.0000	5.97E-06	0.00	0.00	-1.07E-06	23478.	4.66E+09	-149.2264	1.95E+07	0.00

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

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.44000000 inches
Computed slope at pile head     =     0.00244171 radians
Maximum bending moment          =      -1569847. inch-lbs
Maximum shear force             =        -36469. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =    10.66000000 feet below pile head
Number of iterations            =              9
Number of zero deflection points =             2
```

Summary of Pile-head Responses for Conventional Analyses

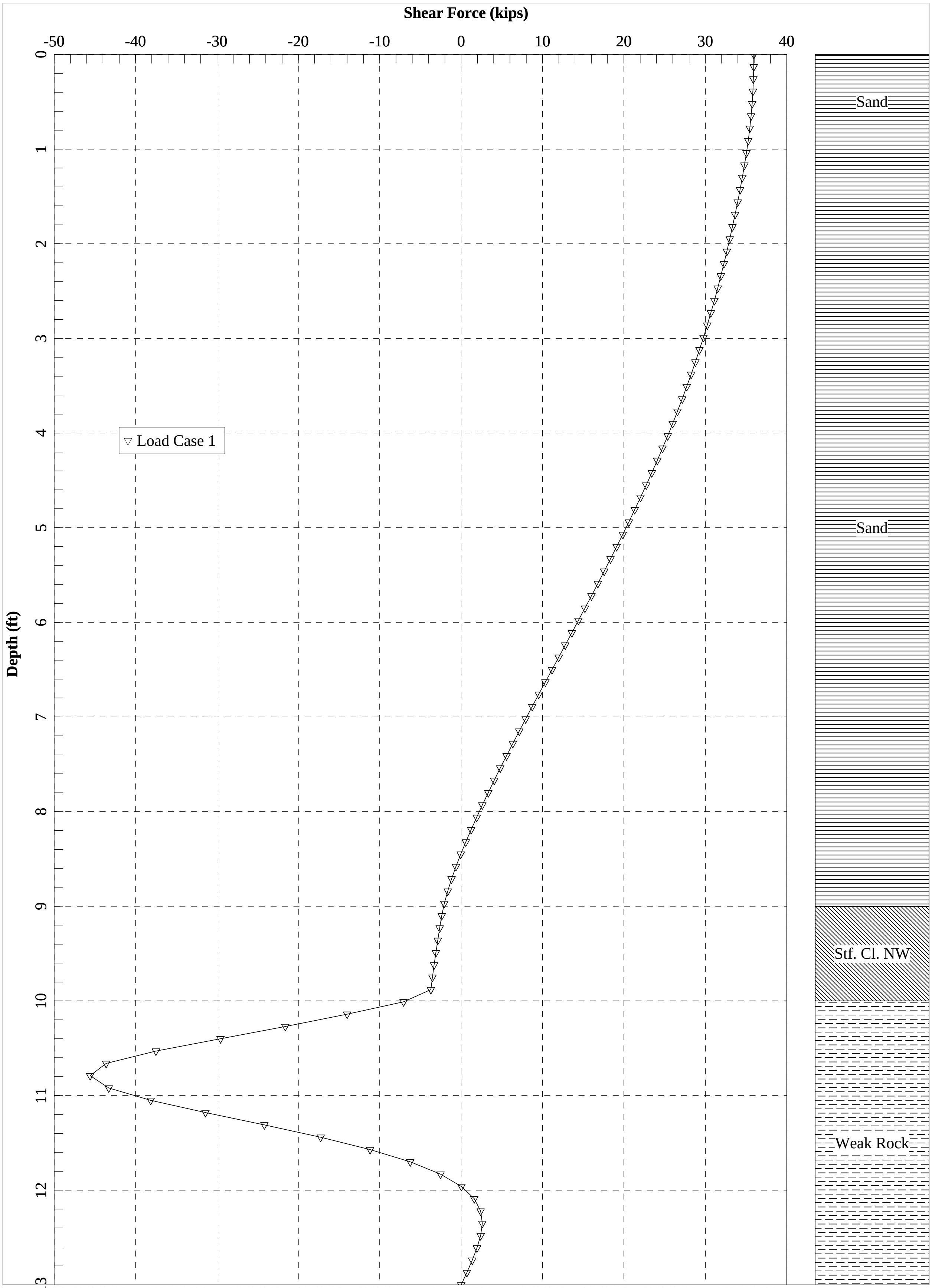
Definitions of Pile-head Loading Conditions:

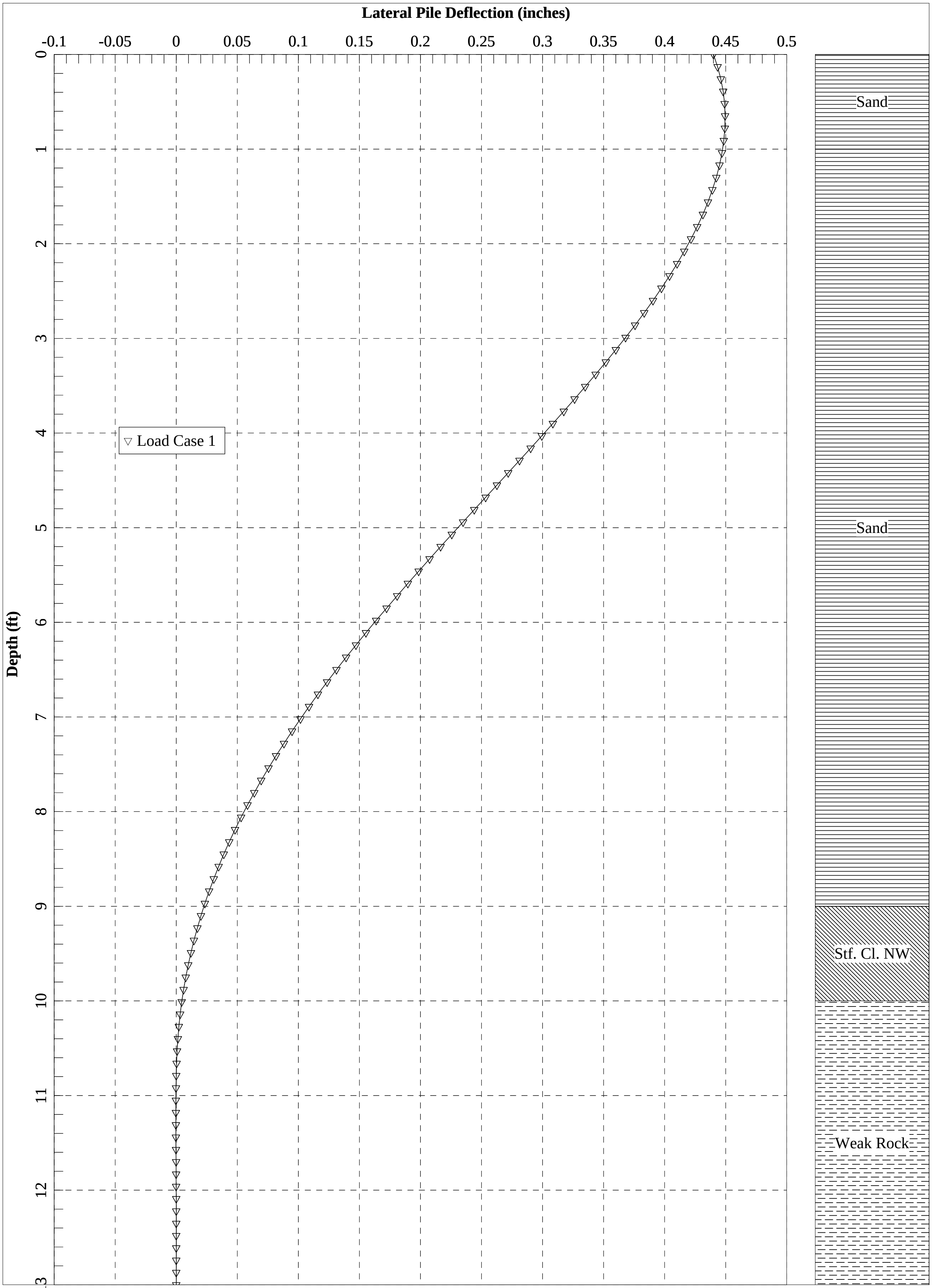
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

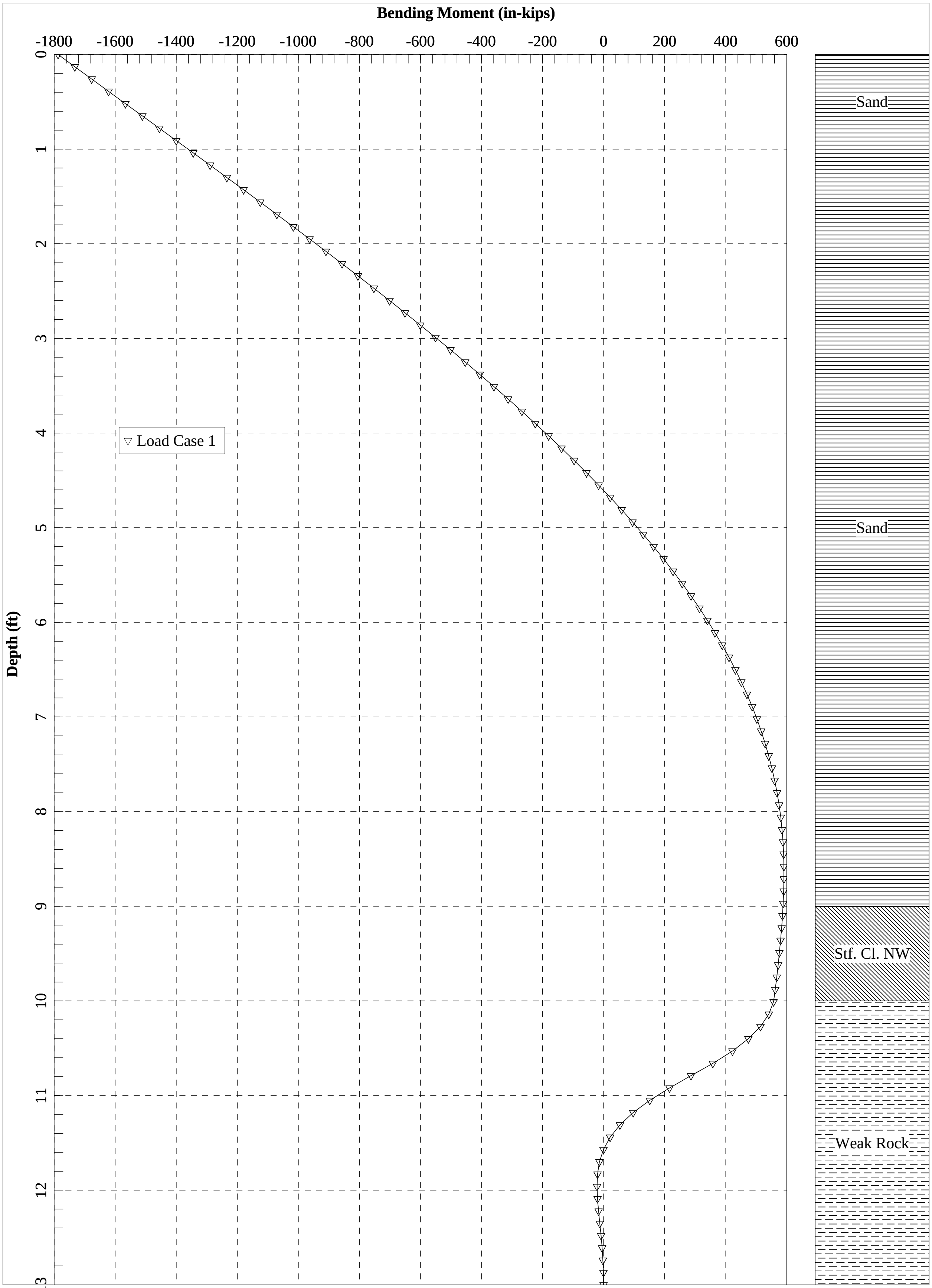
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4400	S, rad	0.00245	365000.	0.4400	0.00244	-36469.	-1569847.

Maximum pile-head deflection = 0.440000000 inches
Maximum pile-head rotation = 0.002441709 radians

The analysis ended normally.


Shear Force (kips)
-50
-40
-30
-20
-10
0
10
20
30
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock


Bending Moment (in-kips)
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Load Case 1
Sand
Sand
Stf. Cl. NW
Weak Rock

Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8o

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

                    LPile for Windows, Version 2015-08.003

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

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

Path to file locations:
\09 Jobs\0025800s\09.0025899.00 - MDOT Naples\Work\Calcs\LPile\

Name of input data file:
Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8d

Name of output report file:
Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8o

Name of plot output file:
Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8p

Name of runtime message file:
Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8r


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

               Date:  March 2, 2016     Time:  10:28:39
```



```
------------------------------------------------------------------------------
                                  Problem Title
------------------------------------------------------------------------------

Project Name: Crockett Bridge #2199 Muddy River, Naples, ME


Job Number: 09.0025899.00


Client: MaineDOT


Engineer:


Description:




------------------------------------------------------------------------------
                          Program Options and Settings
------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
```

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 13.00 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point	Depth X ft	Pile Diameter in
1	0.00000	9.62500000
2	13.0000000	9.62500000

Input Structural Properties:

Pile Section No. 1:

Section Type = Drilled Shaft with Casing
Section Length = 13.000000 ft
Section Diameter = 9.625000 in
Shear Capacity of Section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 0.0000 ft
Distance from top of pile to bottom of layer = 1.000000 ft
Effective unit weight at top of layer = 130.000000 pcf
Effective unit weight at bottom of layer = 130.000000 pcf
Friction angle at top of layer = 38.000000 deg.
Friction angle at bottom of layer = 38.000000 deg.
Subgrade k at top of layer = 160.000000 pci
Subgrade k at bottom of layer = 160.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 1.000000 ft
Distance from top of pile to bottom of layer = 9.000000 ft
Effective unit weight at top of layer = 67.000000 pcf
Effective unit weight at bottom of layer = 67.000000 pcf
Friction angle at top of layer = 38.000000 deg.
Friction angle at bottom of layer = 38.000000 deg.
Subgrade k at top of layer = 100.000000 pci
Subgrade k at bottom of layer = 100.000000 pci

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer = 9.000000 ft
Distance from top of pile to bottom of layer = 10.000000 ft
Effective unit weight at top of layer = 57.000000 pcf
Effective unit weight at bottom of layer = 57.000000 pcf
Undrained cohesion at top of layer = 1000.000000 psf
Undrained cohesion at bottom of layer = 1000.000000 psf
Epsilon-50 at top of layer = 0.010000
Epsilon-50 at bottom of layer = 0.010000

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

Distance from top of pile to top of layer = 10.000000 ft
Distance from top of pile to bottom of layer = 13.000000 ft
Effective unit weight at top of layer = 102.000000 pcf

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Effective unit weight at bottom of layer	=	102.000000 pcf
Uniaxial compressive strength at top of layer	=	1000.000000 psi
Uniaxial compressive strength at bottom of layer	=	1000.000000 psi
Initial modulus of rock at top of layer	=	50000. psi
Initial modulus of rock at bottom of layer	=	50000. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k rm of rock at top of layer	=	0.0000
k rm of rock at bottom of layer	=	0.0000

(Depth of lowest soil layer extends 0.00 ft below pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	130.0000	--	38.0000	--	--	--	160.0000	--
	(Reese, et al.)	1.0000	130.0000	--	38.0000	--	--	--	160.0000	--
2	Sand	1.0000	67.0000	--	38.0000	--	--	--	100.0000	--
	(Reese, et al.)	9.0000	67.0000	--	38.0000	--	--	--	100.0000	--
3	Stiff Clay	9.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
	w/o Free Water	10.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
4	Weak	10.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.
	Rock	13.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.

Static Loading Type

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

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Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.440000 in	S = 0.002450 in/in	365000.	N.A.

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading.
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	13.000000 ft
Outer Diameter of Casing	=	9.625000in
Casing Wall Thickness	=	0.545000in
Moment of Inertia of Steel Casing	=	160.796181in^4
Yield Stress of Casing	=	80000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Area of Single Reinforcing Bar	=	0.0000sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000in
Yield Stress of Reinforcing Bars	=	0.0000 psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000 psi
Gross Area of Pile	=	72.759777sq. in.
Area of Concrete	=	57.213291sq. in.
Cross-sectional Area of Steel Casing	=	15.546485sq. in.
Area of All Steel (Casing and Bars)	=	15.546485sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.37 percent

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Axial Structural Capacities:

```
Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =     1535.507 kips
Tensile Load for Cracking of Concrete                  =      -80.679 kips
Nominal Axial Tensile Capacity                         =    -1243.719 kips
```

Concrete Properties:

```
Compressive Strength of Concrete                       =        6000. psi
Modulus of Elasticity of Concrete                      =     4415201. psi
Modulus of Rupture of Concrete                         =  -580.947489 psi
Compression Strain at Peak Stress                      =     0.002310
Tensile Strain at Fracture of Concrete                 =   -0.0001147
Maximum Coarse Aggregate Size                          =       0.0000 in
```

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

Number	Axial Thrust Force kips
1	365.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

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

Axial Thrust Force =   365.000 kips

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Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	7.1470166	5717613.	413.0853832	0.0005164	0.0005043	2.3821523	0.00000	14.9726006
0.00000250	14.2940304	5717612.	208.9497464	0.0005224	0.0004983	2.4061418	0.00000	15.1453676
0.00000375	21.4410382	5717610.	140.9048918	0.0005284	0.0004923	2.4300569	0.00000	15.3181734
0.00000500	28.5880371	5717607.	106.8827328	0.0005344	0.0004863	2.4538976	0.00000	15.4910181
0.00000625	35.7350243	5717604.	86.4696520	0.0005404	0.0004803	2.4776637	0.00000	15.6639018
0.00000750	42.8819968	5717600.	72.8611103	0.0005465	0.0004743	2.5013552	0.00000	15.8368243
0.00000875	50.0289515	5717594.	63.1408766	0.0005525	0.0004683	2.5249721	0.00000	16.0097857
0.00001000	57.1758857	5717589.	55.8508355	0.0005585	0.0004623	2.5485142	0.00000	16.1827861
0.00001125	64.3227963	5717582.	50.1809228	0.0005645	0.0004563	2.5719817	0.00000	16.3558253
0.00001250	71.4696803	5717574.	45.6450999	0.0005706	0.0004503	2.5953743	0.00000	16.5289035
0.00001375	78.6165349	5717566.	41.9340697	0.0005766	0.0004442	2.6186921	0.00000	16.7020205
0.00001500	85.7633571	5717557.	38.8416339	0.0005826	0.0004382	2.6419349	0.00000	16.8751764
0.00001625	92.9101439	5717547.	36.2250400	0.0005887	0.0004323	2.6651028	0.00000	17.0483712
0.00001750	100.0568924	5717537.	33.9823219	0.0005947	0.0004263	2.6881957	0.00000	17.2216050
0.00001875	107.2035997	5717525.	32.0387044	0.0006007	0.0004203	2.7112134	0.00000	17.3948776
0.00002000	114.3502627	5717513.	30.3381062	0.0006068	0.0004143	2.7341561	0.00000	17.5681892
0.00002125	121.4968787	5717500.	28.8376415	0.0006128	0.0004083	2.7570236	0.00000	17.7415396
0.00002250	128.6434445	5717486.	27.5039547	0.0006188	0.0004023	2.7798158	0.00000	17.9149289
0.00002375	135.7899573	5717472.	26.3107125	0.0006249	0.0003963	2.8025328	0.00000	18.0883572
0.00002500	142.9364141	5717457.	25.2368481	0.0006309	0.0003903	2.8251744	0.00000	18.2618243
0.00002625	150.0828119	5717440.	24.2653077	0.0006370	0.0003843	2.8477406	0.00000	18.4353304
0.00002750	157.2291479	5717424.	23.3821379	0.0006430	0.0003783	2.8702314	0.00000	18.6088753
0.00002875	164.3754191	5717406.	22.5758121	0.0006491	0.0003723	2.8926466	0.00000	18.7824592
0.00003000	171.5216224	5717387.	21.8367248	0.0006551	0.0003664	2.9149863	0.00000	18.9560820

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0.00003125	178.6677551	5717368.	21.1568075	0.0006612	0.0003604	2.9372504	0.00000	19.1297436
0.00003250	185.8138141	5717348.	20.5292328	0.0006672	0.0003544	2.9594388	0.00000	19.3034442
0.00003375	192.9597964	5717327.	19.9481849	0.0006733	0.0003484	2.9815515	0.00000	19.4771837
0.00003500	200.1056992	5717306.	19.4086787	0.0006793	0.0003424	3.0035884	0.00000	19.6509621
0.00003625	207.2515195	5717283.	18.9064168	0.0006854	0.0003365	3.0255495	0.00000	19.8247794
0.00003750	214.3972543	5717260.	18.4376749	0.0006914	0.0003305	3.0474347	0.00000	19.9986356
0.00003875	221.5429007	5717236.	17.9992090	0.0006975	0.0003245	3.0692440	0.00000	20.1725307
0.00004000	228.6884558	5717211.	17.5881807	0.0007035	0.0003185	3.0909772	0.00000	20.3464648
0.00004125	235.8339165	5717186.	17.2020958	0.0007096	0.0003126	3.1126344	0.00000	20.5204377
0.00004250	242.9792800	5717160.	16.8387534	0.0007156	0.0003066	3.1342156	0.00000	20.6944496
0.00004375	250.1245444	5717132.	16.4962040	0.0007217	0.0003006	3.1557204	0.00000	20.8684992
0.00004500	257.2697045	5717105.	16.1727150	0.0007278	0.0002946	3.1771491	0.00000	21.0425889
0.00004625	264.4147585	5717076.	15.8667409	0.0007338	0.0002887	3.1985016	0.00000	21.2167175
0.00004750	271.5597035	5717046.	15.5768989	0.0007399	0.0002827	3.2197778	0.00000	21.3908851
0.00004875	278.7045365	5717016.	15.3019482	0.0007460	0.0002768	3.2409776	0.00000	21.5650916
0.00005125	292.9938547	5716953.	14.7923620	0.0007581	0.0002648	3.2831478	0.00000	21.9136213
0.00005375	307.2826894	5716887.	14.3302790	0.0007703	0.0002529	3.3250119	0.00000	22.2623067
0.00005625	321.5710172	5716818.	13.9093655	0.0007824	0.0002410	3.3665695	0.00000	22.6111478
0.00005875	335.8588144	5716746.	13.5243659	0.0007946	0.0002291	3.4078200	0.00000	22.9601446
0.00006125	350.1460574	5716670.	13.1708824	0.0008067	0.0002172	3.4487631	0.00000	23.3092972
0.00006375	364.4327226	5716592.	12.8452074	0.0008189	0.0002053	3.4893983	0.00000	23.6586054
0.00006625	378.7187864	5716510.	12.5441927	0.0008311	0.0001934	3.5297252	0.00000	24.0080695
0.00006875	393.0042251	5716425.	12.2651481	0.0008432	0.0001815	3.5697433	0.00000	24.3576892
0.00007125	407.2890153	5716337.	12.0057610	0.0008554	0.0001696	3.6094523	0.00000	24.7074648
0.00007375	421.5731331	5716246.	11.7640322	0.0008676	0.0001578	3.6488516	0.00000	25.0573961
0.00007625	435.8565551	5716152.	11.5382250	0.0008798	0.0001459	3.6879409	0.00000	25.4074832

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	0.00007875	450.1392576	5716054.	11.3268230	0.0008920	0.0001340	3.7267197	0.00000	25.7577262
	0.00008125	464.4212169	5715953.	11.1284965	0.0009042	0.0001222	3.7651875	0.00000	26.1081249
	0.00008375	478.7024095	5715850.	10.9420745	0.0009164	0.0001103	3.8033440	0.00000	26.4586795
	0.00008625	492.9828117	5715743.	10.7665219	0.0009286	0.00009846	3.8411887	0.00000	26.8093900
	0.00008875	507.2623999	5715633.	10.6009202	0.0009408	0.00008661	3.8787212	0.00000	27.1602563
	0.00009125	521.5411503	5715519.	10.4444514	0.0009531	0.00007477	3.9159409	0.00000	27.5112785
	0.00009375	535.8190395	5715403.	10.2963850	0.0009653	0.00006294	3.9528476	0.00000	27.8624567
	0.00009625	550.0960436	5715284.	10.1560662	0.0009775	0.00005112	3.9894407	0.00000	28.2137907
	0.00009875	564.3721391	5715161.	10.0229066	0.0009898	0.00003929	4.0257198	0.00000	28.5652807
	0.0001013	578.6473023	5715035.	9.8963759	0.0010020	0.00002748	4.0616845	0.00000	28.9169267
	0.0001038	592.9215095	5714906.	9.7759949	0.0010143	0.00001567	4.0973344	0.00000	29.2687286
	0.0001063	607.1947371	5714774.	9.6613296	0.0010265	0.00000386	4.1326689	0.00000	29.6206865
	0.0001088	621.4669613	5714639.	9.5519856	0.0010388	-0.00000794	4.1676877	0.00000	29.9728005
	0.0001113	635.7381579	5714500.	9.4476044	0.0010510	-0.00001974	4.2023903	0.00000	30.3250708
	0.0001138	650.0083045	5714359.	9.3478587	0.0010633	-0.00003152	4.2367763	0.00000	30.6774968
	0.0001163	664.2773766	5714214.	9.2524494	0.0010756	-0.00004331	4.2708453	0.00000	31.0300789
	0.0001188	678.5453507	5714066.	9.1611027	0.0010879	-0.00005509	4.3045967	0.00000	31.3828171
	0.0001213	692.8122015	5713915.	9.0735672	0.0011002	-0.00006686	4.3380302	0.00000	31.7357115
	0.0001238	707.0778709	5713761.	8.9896119	0.0011125	-0.00007863	4.3711454	0.00000	32.0887616
	0.0001263	721.3421422	5713601.	8.9090236	0.0011248	-0.00009039	4.4039414	0.00000	32.4419655
	0.0001288	735.6046994	5713435.	8.8316053	0.0011371	-0.0001021	4.4364177	0.00000	32.7953201
	0.0001313	749.8651782	5713259.	8.7571750	0.0011494	-0.0001139	4.4685736	0.00000	33.1488218
	0.0001338	763.7002212	5709908.	8.6843993	0.0011615	-0.0001258	4.5000038	0.00000	33.4979522
C	0.0001363	777.7511034	5708265.	8.6149086	0.0011738	-0.0001376	4.5313228	0.00000	33.8495040
C	0.0001388	791.7335200	5706188.	8.5477675	0.0011860	-0.0001495	4.5622571	0.00000	34.2004368
C	0.0001413	805.6752124	5703895.	8.4829263	0.0011982	-0.0001613	4.5928348	0.00000	34.5510553
C									

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0.0001438	819.5812197	5701435.	8.4202791	0.0012104	-0.0001732	4.6230619	0.00000	34.9014179	C
0.0001463	833.4152369	5698566.	8.3596064	0.0012226	-0.0001851	4.6529007	0.00000	35.2510709	C
0.0001488	847.2161152	5695571.	8.3009158	0.0012348	-0.0001970	4.6823918	0.00000	35.6004769	C
0.0001588	901.9588331	5681630.	8.0837197	0.0012833	-0.0002447	4.7967530	0.00000	36.9938695	C
0.0001688	956.0478508	5665469.	7.8910128	0.0013316	-0.0002926	4.9054545	0.00000	38.3811327	C
0.0001788	1010.	5647898.	7.7187956	0.0013797	-0.0003407	5.0086062	0.00000	39.7628392	C
0.0001888	1063.	5629551.	7.5639392	0.0014277	-0.0003890	5.1063182	0.00000	41.1396888	C
0.0001988	1115.	5610700.	7.4238331	0.0014755	-0.0004375	5.1986477	0.00000	42.5117379	C
0.0002088	1167.	5591854.	7.2965505	0.0015232	-0.0004861	5.2857199	0.00000	43.8801567	C
0.0002188	1219.	5573197.	7.1804015	0.0015707	-0.0005348	5.3675999	0.00000	45.2453795	C
0.0002288	1271.	5554816.	7.0739604	0.0016182	-0.0005836	5.4443352	0.00000	46.6076361	C
0.0002388	1322.	5536783.	6.9760434	0.0016655	-0.0006324	5.5159709	0.00000	47.9671758	C
0.0002488	1373.	5519201.	6.8856967	0.0017128	-0.0006814	5.5825619	0.00000	49.3245335	C
0.0002588	1424.	5502074.	6.8020591	0.0017600	-0.0007304	5.6441373	0.00000	50.6798340	C
0.0002688	1474.	5485461.	6.7244442	0.0018072	-0.0007795	5.7007391	0.00000	52.0335639	C
0.0002788	1525.	5469391.	6.6522578	0.0018543	-0.0008287	5.7524002	0.00000	53.3861597	C
0.0002888	1575.	5453885.	6.5849921	0.0019014	-0.0008778	5.7991482	0.00000	54.7380915	C
0.0002988	1625.	5438777.	6.5220449	0.0019485	-0.0009270	5.8409631	0.00000	56.0884248	C
0.0003088	1675.	5424181.	6.4631194	0.0019955	-0.0009762	5.8778903	0.00000	57.4382573	C
0.0003188	1724.	5410112.	6.4078945	0.0020425	-0.0010255	5.9099469	0.00000	58.7881206	C
0.0003288	1774.	5396380.	6.3558835	0.0020895	-0.0010747	5.9371065	0.00000	60.1365933	C
0.0003388	1824.	5383200.	6.3070454	0.0021365	-0.0011240	5.9594193	0.00000	61.4860698	C
0.0003488	1873.	5370290.	6.2608547	0.0021835	-0.0011732	5.9768462	0.00000	62.8339962	C
0.0003588	1922.	5357881.	6.2173609	0.0022305	-0.0012225	5.9894250	0.00000	64.1831895	C
0.0003688	1971.	5345754.	6.1761393	0.0022775	-0.0012718	5.9971335	0.00000	65.5314536	C
0.0003788	2020.	5334020.	6.1371644	0.0023245	-0.0013210	5.9999822	0.00000	66.8804877	C

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0.0003888	2069.	5322634.	6.1002407	0.0023715	-0.0013703	5.9988289	0.00000	68.2300406	C
0.0003988	2118.	5311497.	6.0651228	0.0024185	-0.0014195	5.9992364	0.00000	69.5790594	C
0.0004088	2167.	5300723.	6.0318451	0.0024655	-0.0014687	5.9994695	0.00000	70.9295229	C
0.0004188	2215.	5290204.	6.0001646	0.0025126	-0.0015179	5.9995809	0.00000	72.2800822	C
0.0004288	2264.	5279915.	5.9699674	0.0025596	-0.0015671	5.9996021	0.00000	73.6307092	C
0.0004388	2312.	5269904.	5.9412697	0.0026067	-0.0016162	5.9995417	0.00000	74.9829009	C
0.0004488	2360.	5260110.	5.9139385	0.0026539	-0.0016653	5.9993816	0.00000	76.3362311	C
0.0004588	2409.	5250439.	5.8877697	0.0027010	-0.0017145	5.9990768	0.00000	77.6891751	C
0.0004688	2457.	5240990.	5.8628394	0.0027482	-0.0017635	5.9985652	0.00000	79.0437747	C
0.0004788	2504.	5231270.	5.8392545	0.0027955	-0.0018124	5.9990904	0.00000	80.0000000	CY
0.0004888	2551.	5219732.	5.8174937	0.0028433	-0.0018609	5.9999301	0.00000	80.0000000	CY
0.0004988	2596.	5205456.	5.7977902	0.0028916	-0.0019088	5.9996106	0.00000	80.0000000	CY
0.0005088	2639.	5188093.	5.7803995	0.0029408	-0.0019559	5.9989556	0.00000	80.0000000	CY
0.0005188	2681.	5167399.	5.7653957	0.0029908	-0.0020022	5.9978842	0.00000	80.0000000	CY
0.0005288	2719.	5143219.	5.7528243	0.0030418	-0.0020474	5.9999549	0.00000	80.0000000	CY
0.0005388	2756.	5115467.	5.7427115	0.0030939	-0.0020916	5.9995475	0.00000	80.0000000	CY
0.0005488	2791.	5085269.	5.7345514	0.0031468	-0.0021349	5.9986347	0.00000	80.0000000	CY
0.0006088	2971.	4881166.	5.7124464	0.0034775	-0.0023818	5.9987089	0.00000	80.0000000	CY
0.0006688	3119.	4663747.	5.7211722	0.0038260	-0.0026107	5.9980642	0.00000	80.0000000	CY

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	365.000	2687.603	0.00300000

Page 12

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

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

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

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	2688.	237.249991	1747.	5403889.
1	0.70	2688.	255.499996	1881.	5368165.
1	0.75	2688.	273.750000	2016.	5335111.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.440000 inches
Rotation of pile head = 2.450E-03 radians
Axial load on pile head = 365000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4400	-1787073.	35961.	0.00245	0.00	5.39E+09	0.00	0.00	0.00
0.1300	0.4434	-1732238.	35939.	0.00194	0.00	5.39E+09	-14.0946	49.5866	0.00
0.2600	0.4461	-1677153.	35904.	0.00145	0.00	5.42E+09	-30.7010	107.3713	0.00
0.3900	0.4479	-1621867.	35842.	9.75E-04	0.00	5.44E+09	-49.3368	171.8208	0.00
0.5200	0.4491	-1566436.	35749.	5.19E-04	0.00	5.46E+09	-69.3461	240.8820	0.00
0.6500	0.4496	-1510920.	35625.	7.97E-05	0.00	5.47E+09	-90.2692	313.2398	0.00
0.7800	0.4493	-1455377.	35467.	-3.42E-04	0.00	5.49E+09	-111.6071	387.4658	0.00
0.9100	0.4485	-1399871.	35277.	-7.47E-04	0.00	5.51E+09	-133.2054	463.3319	0.00
1.0400	0.4470	-1344464.	35054.	-0.00114	0.00	5.53E+09	-152.3393	531.6337	0.00
1.1700	0.4450	-1289211.	34808.	-0.00151	0.00	5.55E+09	-163.1814	572.1155	0.00
1.3000	0.4423	-1234149.	34544.	-0.00186	0.00	5.57E+09	-174.5462	615.6021	0.00

Crockett Bridge Abutment 1 9in diam piles 6 ksi concrete filled 10 feet thick pipe.lp8o

1.4300	0.4391	-1179315.	34264.	-0.00220	0.00	5.59E+09	-185.3694	658.4955	0.00
1.5600	0.4355	-1124744.	33967.	-0.00252	0.00	5.61E+09	-195.0003	698.5700	0.00
1.6900	0.4313	-1070470.	33655.	-0.00282	0.00	5.63E+09	-204.2130	738.6524	0.00
1.8200	0.4267	-1016524.	33330.	-0.00311	0.00	5.65E+09	-212.5013	776.9842	0.00
1.9500	0.4216	-962935.	32994.	-0.00339	0.00	5.66E+09	-219.3071	811.5208	0.00
2.0800	0.4161	-909728.	32645.	-0.00364	0.00	5.68E+09	-227.4746	852.8463	0.00
2.2100	0.4102	-856933.	32283.	-0.00389	0.00	5.69E+09	-236.4256	899.1071	0.00
2.3400	0.4040	-804580.	31908.	-0.00411	0.00	5.70E+09	-244.2935	943.3888	0.00
2.4700	0.3974	-752696.	31519.	-0.00433	0.00	5.71E+09	-254.7063	999.9061	0.00
2.6000	0.3905	-701314.	31111.	-0.00452	0.00	5.71E+09	-268.0042	1071.	0.00
2.7300	0.3833	-650476.	30683.	-0.00471	0.00	5.71E+09	-281.0318	1144.	0.00
2.8600	0.3758	-600221.	30235.	-0.00488	0.00	5.71E+09	-293.7322	1219.	0.00
2.9900	0.3680	-550587.	29767.	-0.00504	0.00	5.72E+09	-306.0487	1297.	0.00
3.1200	0.3601	-501612.	29281.	-0.00518	0.00	5.72E+09	-317.3683	1375.	0.00
3.2500	0.3519	-453332.	28779.	-0.00531	0.00	5.72E+09	-326.1142	1446.	0.00
3.3800	0.3435	-405775.	28260.	-0.00543	0.00	5.72E+09	-339.5115	1542.	0.00
3.5100	0.3349	-358981.	27720.	-0.00553	0.00	5.72E+09	-352.4437	1642.	0.00
3.6400	0.3262	-312989.	27160.	-0.00562	0.00	5.72E+09	-364.8497	1745.	0.00
3.7700	0.3174	-267836.	26582.	-0.00570	0.00	5.72E+09	-376.6699	1851.	0.00
3.9000	0.3084	-223559.	25986.	-0.00577	0.00	5.72E+09	-387.8462	1962.	0.00
4.0300	0.2994	-180190.	25372.	-0.00583	0.00	5.72E+09	-398.6897	2077.	0.00
4.1600	0.2903	-137764.	24741.	-0.00587	0.00	5.72E+09	-410.5369	2206.	0.00
4.2900	0.2811	-96315.	24092.	-0.00590	0.00	5.72E+09	-421.8843	2341.	0.00
4.4200	0.2719	-55879.	23425.	-0.00592	0.00	5.72E+09	-432.7044	2483.	0.00
4.5500	0.2626	-16486.	22742.	-0.00593	0.00	5.72E+09	-442.9729	2631.	0.00
4.6800	0.2534	21831.	22043.	-0.00593	0.00	5.72E+09	-452.6687	2787.	0.00
4.8100	0.2441	59043.	21330.	-0.00592	0.00	5.72E+09	-461.7736	2951.	0.00
4.9400	0.2349	95122.	20603.	-0.00590	0.00	5.72E+09	-470.2730	3123.	0.00
5.0700	0.2257	130042.	19863.	-0.00587	0.00	5.72E+09	-478.1556	3305.	0.00
5.2000	0.2166	163778.	19112.	-0.00583	0.00	5.72E+09	-485.4133	3496.	0.00
5.3300	0.2075	196307.	18349.	-0.00578	0.00	5.72E+09	-492.0417	3699.	0.00
5.4600	0.1986	227608.	17577.	-0.00572	0.00	5.72E+09	-498.0397	3913.	0.00
5.5900	0.1897	257662.	16796.	-0.00565	0.00	5.72E+09	-503.4097	4140.	0.00
5.7200	0.1809	286451.	16007.	-0.00558	0.00	5.72E+09	-508.1575	4382.	0.00
5.8500	0.1723	313959.	15211.	-0.00550	0.00	5.72E+09	-512.2924	4639.	0.00
5.9800	0.1638	340171.	14409.	-0.00541	0.00	5.72E+09	-515.8272	4914.	0.00
6.1100	0.1554	365075.	13602.	-0.00531	0.00	5.72E+09	-518.7150	5207.	0.00
6.2400	0.1472	388660.	12791.	-0.00521	0.00	5.72E+09	-520.7006	5519.	0.00
6.3700	0.1391	410917.	11978.	-0.00510	0.00	5.72E+09	-521.7346	5850.	0.00
6.5000	0.1313	431841.	11164.	-0.00499	0.00	5.72E+09	-521.7956	6201.	0.00
6.6300	0.1236	451428.	10351.	-0.00487	0.00	5.72E+09	-520.8643	6575.	0.00
6.7600	0.1161	469677.	9540.	-0.00474	0.00	5.72E+09	-518.9234	6973.	0.00
6.8900	0.1088	486590.	8733.	-0.00461	0.00	5.72E+09	-515.9578	7398.	0.00
7.0200	0.1017	502172.	7931.	-0.00447	0.00	5.72E+09	-511.9547	7852.	0.00
7.1500	0.09484	516430.	7136.	-0.00433	0.00	5.72E+09	-506.9033	8338.	0.00
7.2800	0.08819	529374.	6350.	-0.00419	0.00	5.72E+09	-500.7956	8859.	0.00
7.4100	0.08176	541017.	5575.	-0.00405	0.00	5.72E+09	-493.6257	9419.	0.00
7.5400	0.07556	551375.	4811.	-0.00390	0.00	5.72E+09	-485.3904	10021.	0.00
7.6700	0.06960	560466.	4061.	-0.00375	0.00	5.72E+09	-476.0891	10671.	0.00
7.8000	0.06388	568311.	3327.	-0.00359	0.00	5.72E+09	-465.7240	11374.	0.00
7.9300	0.05840	574935.	2609.	-0.00344	0.00	5.72E+09	-454.2998	12136.	0.00
8.0600	0.05316	580363.	1910.	-0.00328	0.00	5.72E+09	-441.8245	12966.	0.00

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8.1900	0.04817	584626.	1231.	-0.00312	0.00	5.71E+09	-428.3089	13871.	0.00
8.3200	0.04343	587756.	574.4411	-0.00296	0.00	5.71E+09	-413.7671	14863.	0.00
8.4500	0.03894	589788.	-56.4489	-0.00280	0.00	5.71E+09	-395.0662	15828.	0.00
8.5800	0.03470	590766.	-643.4275	-0.00264	0.00	5.71E+09	-357.4704	16071.	0.00
8.7100	0.03071	590783.	-1173.	-0.00248	0.00	5.71E+09	-321.1828	16314.	0.00
8.8400	0.02698	589926.	-1647.	-0.00231	0.00	5.71E+09	-286.3212	16558.	0.00
8.9700	0.02349	588281.	-2067.	-0.00215	0.00	5.71E+09	-252.9996	16801.	0.00
9.1000	0.02026	585929.	-2391.	-0.00199	0.00	5.71E+09	-162.0415	12479.	0.00
9.2300	0.01727	583091.	-2639.	-0.00183	0.00	5.71E+09	-155.7142	14064.	0.00
9.3600	0.01454	579784.	-2877.	-0.00167	0.00	5.72E+09	-149.1457	16006.	0.00
9.4900	0.01205	576023.	-3104.	-0.00152	0.00	5.72E+09	-142.3070	18428.	0.00
9.6200	0.00980	571827.	-3320.	-0.00136	0.00	5.72E+09	-135.1628	21511.	0.00
9.7500	0.00780	567213.	-3525.	-0.00121	0.00	5.72E+09	-127.6698	25529.	0.00
9.8800	0.00604	562200.	-3718.	-0.00105	0.00	5.72E+09	-119.7753	30923.	0.00
10.0100	0.00452	556808.	-7072.	-8.98E-04	0.00	5.72E+09	-4180.	1441820.	0.00
10.1400	0.00324	541158.	-14001.	-7.48E-04	0.00	5.72E+09	-4704.	2264812.	0.00
10.2700	0.00219	513976.	-21603.	-6.04E-04	0.00	5.72E+09	-5042.	3595556.	0.00
10.4000	0.00135	474445.	-29563.	-4.70E-04	0.00	5.72E+09	-5163.	5948271.	0.00
10.5300	7.23E-04	422275.	-37493.	-3.47E-04	0.00	5.72E+09	-5005.	1.08E+07	0.00
10.6600	2.71E-04	357860.	-43613.	-2.41E-04	0.00	5.72E+09	-2841.	1.64E+07	0.00
10.7900	-2.84E-05	286477.	-45572.	-1.53E-04	0.00	5.72E+09	328.9694	1.80E+07	0.00
10.9200	-2.06E-04	215850.	-43285.	-8.43E-05	0.00	5.72E+09	2603.	1.97E+07	0.00
11.0500	-2.91E-04	151525.	-38135.	-3.41E-05	0.00	5.72E+09	4000.	2.14E+07	0.00
11.1800	-3.12E-04	96909.	-31407.	-2.56E-07	0.00	5.72E+09	4626.	2.31E+07	0.00
11.3100	-2.92E-04	53536.	-24178.	2.03E-05	0.00	5.72E+09	4642.	2.48E+07	0.00
11.4400	-2.49E-04	21451.	-17260.	3.05E-05	0.00	5.72E+09	4228.	2.65E+07	0.00
11.5700	-1.97E-04	-349.3913	-11189.	3.34E-05	0.00	5.72E+09	3556.	2.82E+07	0.00
11.7000	-1.45E-04	-13496.	-6251.	3.15E-05	0.00	5.72E+09	2774.	2.98E+07	0.00
11.8300	-9.88E-05	-19889.	-2531.	2.69E-05	0.00	5.72E+09	1996.	3.15E+07	0.00
11.9600	-6.10E-05	-21422.	39.1113	2.13E-05	0.00	5.72E+09	1298.	3.32E+07	0.00
12.0900	-3.23E-05	-19791.	1616.	1.57E-05	0.00	5.72E+09	722.9714	3.49E+07	0.00
12.2200	-1.21E-05	-16399.	2401.	1.07E-05	0.00	5.72E+09	283.1939	3.66E+07	0.00
12.3500	1.19E-06	-12314.	2599.	6.82E-06	0.00	5.72E+09	-29.0952	3.83E+07	0.00
12.4800	9.21E-06	-8298.	2397.	4.01E-06	0.00	5.72E+09	-230.1567	3.90E+07	0.00
12.6100	1.37E-05	-4841.	1950.	2.22E-06	0.00	5.72E+09	-342.3641	3.90E+07	0.00
12.7400	1.61E-05	-2217.	1369.	1.25E-06	0.00	5.72E+09	-403.0563	3.90E+07	0.00
12.8700	1.76E-05	-572.8641	710.8355	8.73E-07	0.00	5.72E+09	-440.1599	3.90E+07	0.00
13.0000	1.88E-05	0.00	0.00	7.95E-07	0.00	5.72E+09	-471.1677	1.95E+07	0.00

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

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.44000000 inches
Computed slope at pile head     =     0.00244207 radians
Maximum bending moment          =      -1787073. inch-lbs
```



```
Maximum shear force             =        -45572. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =    10.79000000 feet below pile head
Number of iterations            =             10
Number of zero deflection points =             2
```

Summary of Pile-head Responses for Conventional Analyses

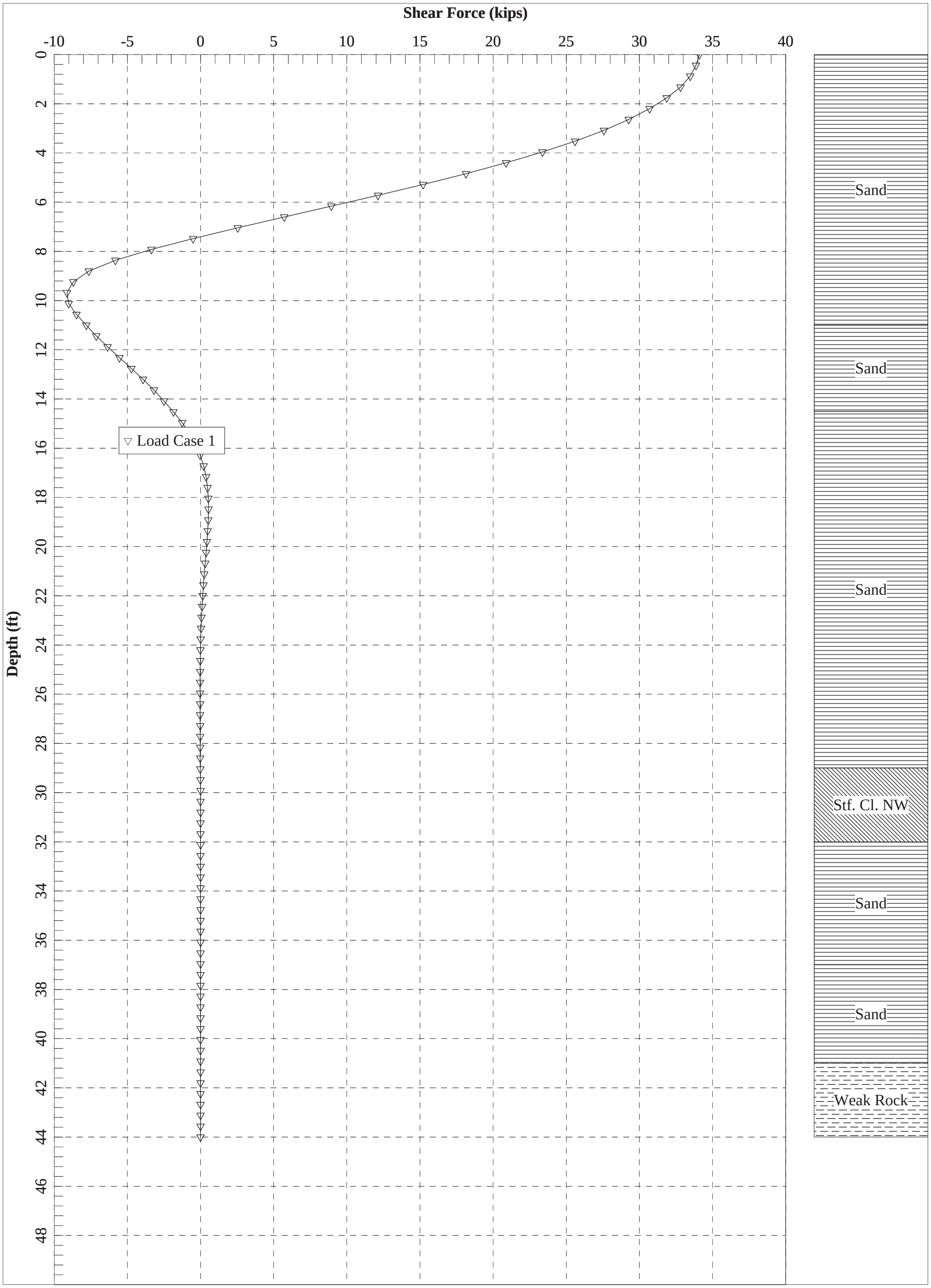
Definitions of Pile-head Loading Conditions:

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

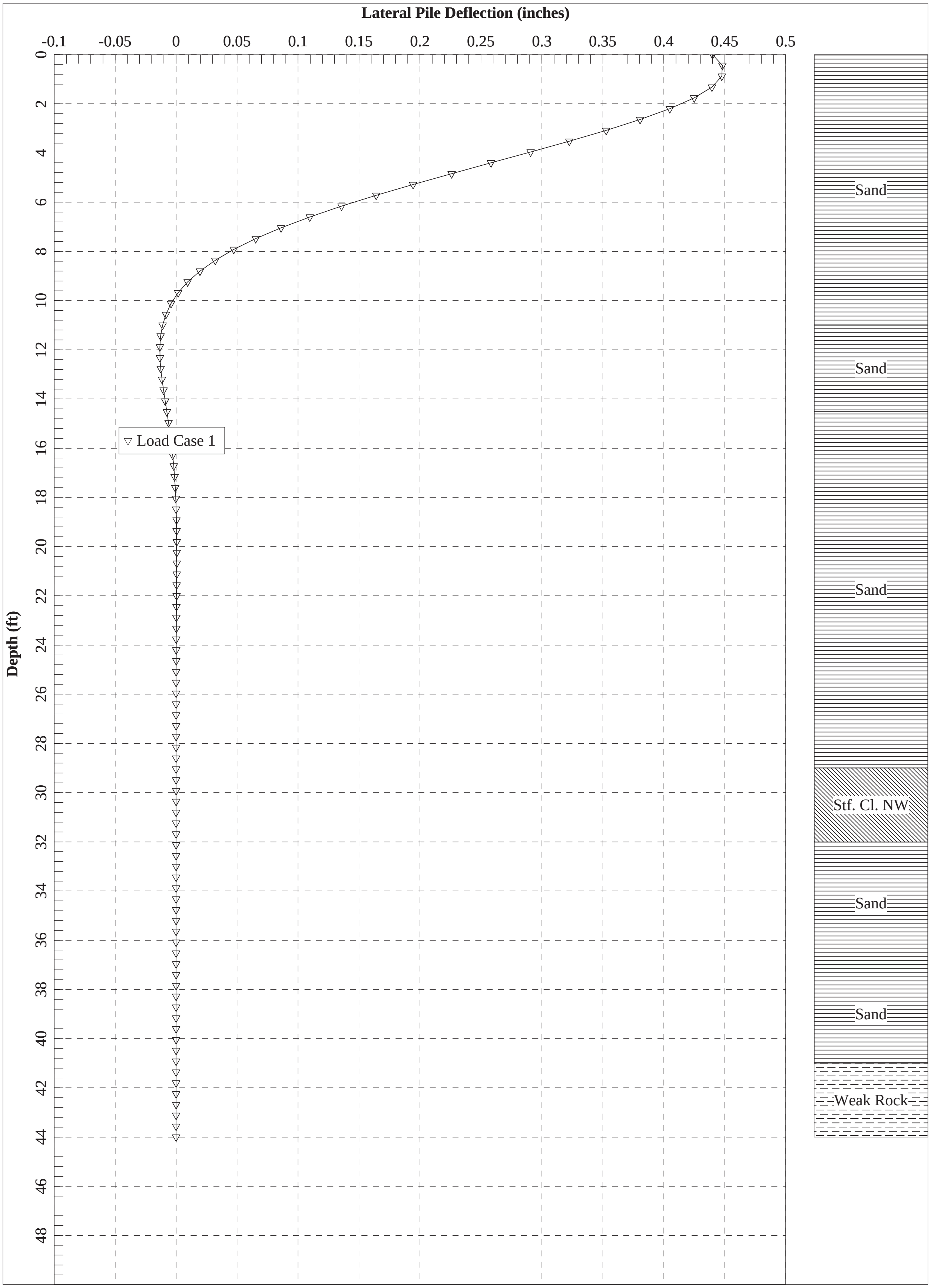
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4400	S, rad	0.00245	365000.	0.4400	0.00244	-45572.	-1787073.

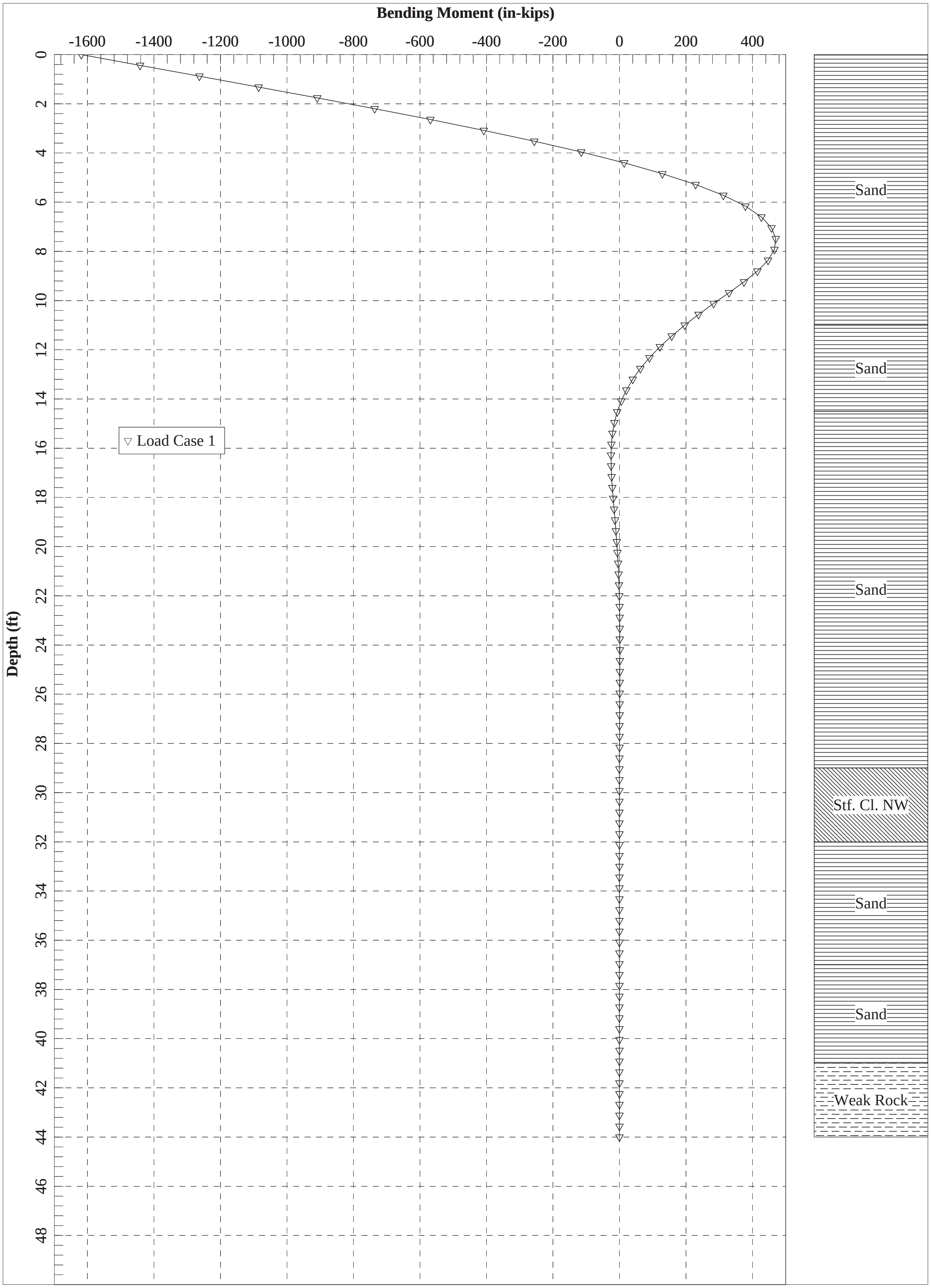
```
Maximum pile-head deflection =     0.440000000 inches
Maximum pile-head rotation   =     0.002442069 radians
```

The analysis ended normally.


Shear Force (kips)
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Sand
Sand
Sand
Stf. Cl. NW
Sand
Sand
Weak Rock

Abutment 2 - Empty Casing (.545" Wall Thickness)




Bending Moment (in-kips)
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Sand
Sand
Sand
Stf. Cl. NW
Sand
Sand
Weak Rock

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

                    LPile for Windows, Version 2015-08.003

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

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

Path to file locations:
\09 Jobs\0025800s\09.0025899.00 - MDOT Naples\Work\Calcs\LPile\

Name of input data file:
Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8d

Name of output report file:
Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8o

Name of plot output file:
Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8p

Name of runtime message file:
Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8r


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

               Date:  January 12, 2016     Time:  15:29:15
```



```
-------------------------------------------------------------------------------
                                 Problem Title
-------------------------------------------------------------------------------

Project Name: Crockett Bridge #2199 Muddy River, Naples, ME


Job Number: 09.0025899.00


Client: MaineDOT


Engineer:


Description:




-------------------------------------------------------------------------------
                          Program Options and Settings
-------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
```

```
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Total number of pile sections                          =          1

Total length of pile                                   =        44.00 ft

Depth of ground surface below top of pile              =         0.00 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point         Depth            Pile
                X            Diameter
               ft               in
-----       ---------       -----------
  1          0.00000        9.62500000
  2       44.0000000        9.62500000


Input Structural Properties:
----------------------------

Pile Section No. 1:

   Section Type                                        = Steel Pipe Pile
   Section Length                                      =    44.000000 ft
   Pile Diameter                                       =     9.625000 in
   Shear Capacity of Section                           =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians
```



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Pile Batter Angle                                      =        0.000 degrees
                                                       =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =       0.0000 ft
   Distance from top of pile to bottom of layer        =    11.000000 ft
   Effective unit weight at top of layer               =   125.000000 pcf
   Effective unit weight at bottom of layer            =   125.000000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =   130.000000 pci
   Subgrade k at bottom of layer                       =   130.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    11.000000 ft
   Distance from top of pile to bottom of layer        =    14.500000 ft
   Effective unit weight at top of layer               =    63.000000 pcf
   Effective unit weight at bottom of layer            =    63.000000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    80.000000 pci
   Subgrade k at bottom of layer                       =    80.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    14.500000 ft
   Distance from top of pile to bottom of layer        =    29.000000 ft
   Effective unit weight at top of layer               =    67.000000 pcf
   Effective unit weight at bottom of layer            =    67.000000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =   100.000000 pci
   Subgrade k at bottom of layer                       =   100.000000 pci


Layer 4 is stiff clay without free water

   Distance from top of pile to top of layer           =    29.000000 ft
   Distance from top of pile to bottom of layer        =    32.000000 ft
   Effective unit weight at top of layer               =    57.000000 pcf
```

Effective unit weight at bottom of layer = 57.000000 pcf
Undrained cohesion at top of layer = 1000.000000 psf
Undrained cohesion at bottom of layer = 1000.000000 psf
Epsilon-50 at top of layer = 0.010000
Epsilon-50 at bottom of layer = 0.010000

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 32.000000 ft
Distance from top of pile to bottom of layer = 37.000000 ft
Effective unit weight at top of layer = 63.000000 pcf
Effective unit weight at bottom of layer = 63.000000 pcf
Friction angle at top of layer = 34.000000 deg.
Friction angle at bottom of layer = 34.000000 deg.
Subgrade k at top of layer = 60.000000 pci
Subgrade k at bottom of layer = 60.000000 pci

Layer 6 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 37.000000 ft
Distance from top of pile to bottom of layer = 41.000000 ft
Effective unit weight at top of layer = 73.000000 pcf
Effective unit weight at bottom of layer = 73.000000 pcf
Friction angle at top of layer = 40.000000 deg.
Friction angle at bottom of layer = 40.000000 deg.
Subgrade k at top of layer = 125.000000 pci
Subgrade k at bottom of layer = 125.000000 pci

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

Distance from top of pile to top of layer = 41.000000 ft
Distance from top of pile to bottom of layer = 44.000000 ft
Effective unit weight at top of layer = 102.000000 pcf
Effective unit weight at bottom of layer = 102.000000 pcf
Uniaxial compressive strength at top of layer = 1000.000000 psi
Uniaxial compressive strength at bottom of layer = 1000.000000 psi
Initial modulus of rock at top of layer = 50000. psi
Initial modulus of rock at bottom of layer = 50000. psi
RQD of rock at top of layer = 20.000000 %
RQD of rock at bottom of layer = 20.000000 %
k rm of rock at top of layer = 0.0000
k rm of rock at bottom of layer = 0.0000

(Depth of lowest soil layer extends 0.00 ft below pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	Layer kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	35.0000	--	--	--	130.0000	--
	(Reese, et al.)	11.0000	125.0000	--	35.0000	--	--	--	130.0000	--
2	Sand	11.0000	63.0000	--	35.0000	--	--	--	80.0000	--
	(Reese, et al.)	14.5000	63.0000	--	35.0000	--	--	--	80.0000	--
3	Sand	14.5000	67.0000	--	38.0000	--	--	--	100.0000	--
	(Reese, et al.)	29.0000	67.0000	--	38.0000	--	--	--	100.0000	--
4	Stiff Clay	29.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
	w/o Free Water	32.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
5	Sand	32.0000	63.0000	--	34.0000	--	--	--	60.0000	--
	(Reese, et al.)	37.0000	63.0000	--	34.0000	--	--	--	60.0000	--
6	Sand	37.0000	73.0000	--	40.0000	--	--	--	125.0000	--
	(Reese, et al.)	41.0000	73.0000	--	40.0000	--	--	--	125.0000	--
7	Weak	41.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.
	Rock	44.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8o

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.440000 in	S = 0.002450 in/in	365000.	N.A.

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading.
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	44.000000 ft
Outer Diameter of Pipe	=	9.625000in
Pipe Wall Thickness	=	0.545000in
Yield Stress of Pipe	=	80.000000ksi
Elastic Modulus	=	29000.ksi
Cross-sectional Area	=	15.546485sq. in.
Moment of Inertia	=	160.796181in^4
Elastic Bending Stiffness	=	4663089. kip-in^2
Plastic Modulus, Z	=	44.987248in^3
Plastic Moment Capacity = Fy Z	=	3599.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1243.719 kips
Nominal Axial Tensile Capacity	=	-1243.719 kips

Crockett Bridge Abutment 2 9in diam piles not concrete filled thick pipe.lp8o

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

Number	Axial Thrust Force kips
1	365.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 365.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Run Msg
0.00001008	46.9970366	4663282.	85.1436192	24.8704357	
0.00002016	93.9940732	4663282.	44.9780596	26.2628951	
0.00003023	140.9911099	4663282.	31.5895397	27.6553554	
0.00004031	187.9881465	4663282.	24.8952798	29.0478157	
0.00005039	234.9851831	4663282.	20.8787238	30.4402762	
0.00006047	281.9822197	4663282.	18.2010199	31.8327361	
0.00007055	328.9792563	4663282.	16.2883742	33.2251962	
0.00008062	375.9762930	4663282.	14.8538899	34.6176564	
0.00009070	422.9733296	4663282.	13.7381799	36.0101165	
0.0001008	469.9703662	4663282.	12.8456119	37.4025766	
0.0001109	516.9674028	4663282.	12.1153290	38.7950367	
0.0001209	563.9644394	4663282.	11.5067599	40.1874969	
0.0001310	610.9614760	4663282.	10.9918169	41.5799569	
0.0001411	657.9585127	4663282.	10.5504371	42.9724172	
0.0001512	704.9555493	4663282.	10.1679079	44.3648773	
0.0001612	751.9525859	4663282.	9.8331949	45.7573375	
0.0001713	798.9496225	4663282.	9.5378600	47.1497975	
0.0001814	845.9466591	4663282.	9.2753400	48.5422577	
0.0001915	892.9436958	4663282.	9.0404536	49.9347178	
0.0002016	939.9407324	4663282.	8.8290560	51.3271779	
0.0002116	986.9377690	4663282.	8.6377914	52.7196381	
0.0002217	1034.	4663282.	8.4639145	54.1120982	
0.0002318	1081.	4663282.	8.3051574	55.5045583	
0.0002419	1128.	4663282.	8.1596300	56.8970185	
0.0002520	1175.	4663282.	8.0257448	58.2894786	
0.0002620	1222.	4663282.	7.9021584	59.6819387	
0.0002721	1269.	4663282.	7.7877266	61.0743989	
0.0002822	1316.	4663282.	7.6814685	62.4668590	
0.0002923	1363.	4663282.	7.5825386	63.8593191	
0.0003023	1410.	4663282.	7.4902040	65.2517792	
0.0003124	1457.	4663282.	7.4038264	66.6442394	
0.0003225	1504.	4663282.	7.3228475	68.0366995	
0.0003326	1551.	4663282.	7.2467763	69.4291596	
0.0003427	1598.	4663282.	7.1751800	70.8216198	

0.0003527	1645.	4663282.	7.1076748	72.2140799	
0.0003628	1692.	4663282.	7.0439200	73.6065400	
0.0003729	1739.	4663282.	6.9836113	74.9990002	
0.0003830	1786.	4663282.	6.9264768	76.3914603	
0.0003930	1833.	4663282.	6.8722723	77.7839204	
0.0004132	1927.	4662467.	6.7721746	80.0000000	Y
0.0004334	2015.	4650186.	6.6868742	80.0000000	Y
0.0004535	2094.	4617411.	6.6198204	80.0000000	Y
0.0004737	2162.	4564515.	6.5702787	80.0000000	Y
0.0004938	2223.	4501394.	6.5326082	80.0000000	Y
0.0005140	2278.	4432424.	6.5039536	80.0000000	Y
0.0005341	2329.	4360117.	6.4824500	80.0000000	Y
0.0005543	2376.	4286107.	6.4667333	80.0000000	Y
0.0005745	2419.	4211106.	6.4560187	80.0000000	Y
0.0005946	2460.	4136412.	6.4491575	80.0000000	Y
0.0006148	2497.	4062416.	6.4455821	80.0000000	Y
0.0006349	2533.	3989310.	6.4448991	80.0000000	Y
0.0006551	2566.	3917576.	6.4465149	80.0000000	Y
0.0006752	2598.	3847409.	6.4500573	80.0000000	Y
0.0006954	2628.	3778616.	6.4554625	80.0000000	Y
0.0007155	2656.	3711611.	6.4622173	80.0000000	Y
0.0007357	2683.	3646377.	6.4701478	80.0000000	Y
0.0007559	2708.	3582895.	6.4790996	80.0000000	Y
0.0007760	2732.	3521139.	6.4889355	80.0000000	Y
0.0007962	2756.	3461045.	6.4995653	80.0000000	Y
0.0008163	2778.	3402650.	6.5108195	80.0000000	Y
0.0008365	2799.	3345938.	6.5225820	80.0000000	Y
0.0008566	2819.	3290796.	6.5348362	80.0000000	Y
0.0008768	2838.	3237223.	6.5474709	80.0000000	Y
0.0008970	2857.	3185189.	6.5604061	80.0000000	Y
0.0009171	2875.	3134661.	6.5735715	80.0000000	Y
0.0009373	2892.	3085208.	6.5862568	80.0000000	Y
0.0009574	2908.	3037189.	6.5989959	80.0000000	Y
0.0009776	2923.	2989793.	6.6107428	80.0000000	Y
0.0009977	2937.	2943725.	6.6227161	80.0000000	Y
0.0010179	2950.	2898345.	6.6332965	80.0000000	Y
0.0010380	2963.	2854275.	6.6438682	80.0000000	Y
0.0010582	2974.	2810794.	6.6535631	80.0000000	Y
0.0010784	2985.	2768461.	6.6626275	80.0000000	Y
0.0010985	2996.	2727074.	6.6714901	80.0000000	Y
0.0011187	3005.	2686288.	6.6789227	80.0000000	Y
0.0011388	3014.	2646715.	6.6864783	80.0000000	Y
0.0011590	3022.	2607744.	6.6929406	80.0000000	Y
0.0011791	3030.	2569647.	6.6986999	80.0000000	Y
0.0011993	3037.	2532626.	6.7046701	80.0000000	Y
0.0012799	3062.	2392491.	6.7227354	80.0000000	Y
0.0013605	3082.	2265306.	6.7371943	80.0000000	Y
0.0014412	3098.	2149949.	6.7486797	80.0000000	Y
0.0015218	3112.	2045021.	6.7580309	80.0000000	Y
0.0016024	3124.	1949302.	6.7659146	80.0000000	Y
0.0016830	3133.	1861749.	6.7728369	80.0000000	Y
0.0017637	3142.	1781348.	6.7784690	80.0000000	Y

0.0018443	3149.	1707367.	6.7831404	80.0000000	Y
0.0019249	3155.	1639218.	6.7875124	80.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	365.0000000000	3155.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.440000 inches
Rotation of pile head = 2.450E-03 radians
Axial load on pile head = 365000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4400	-1618348.	34102.	0.00245	71914.	4.66E+09	0.00	0.00	0.00
0.4400	0.4481	-1441879.	33862.	7.18E-04	66632.	4.66E+09	-45.3618	534.5041	0.00
0.8800	0.4476	-1263529.	33478.	-8.14E-04	61294.	4.66E+09	-100.2641	1183.	0.00
1.3200	0.4395	-1085217.	32807.	-0.00214	55958.	4.66E+09	-153.7796	1847.	0.00
1.7600	0.4249	-908823.	31868.	-0.00327	50678.	4.66E+09	-202.0706	2511.	0.00
2.2000	0.4049	-736081.	30690.	-0.00420	45508.	4.66E+09	-243.9539	3181.	0.00
2.6400	0.3805	-568533.	29267.	-0.00494	40494.	4.66E+09	-294.9662	4093.	0.00
3.0800	0.3528	-407967.	27571.	-0.00550	35688.	4.66E+09	-347.4200	5200.	0.00

3.5200	0.3225	-256197.	25606.	-0.00587	31146.	4.66E+09	-397.1200	6501.	0.00
3.9600	0.2908	-114939.	23375.	-0.00608	26918.	4.66E+09	-447.8474	8133.	0.00
4.4000	0.2583	14084.	20881.	-0.00614	23900.	4.66E+09	-496.8028	10155.	0.00
4.8400	0.2259	129227.	18148.	-0.00606	27346.	4.66E+09	-538.7102	12590.	0.00
5.2800	0.1943	229069.	15216.	-0.00585	30334.	4.66E+09	-571.8694	15538.	0.00
5.7200	0.1641	312469.	12132.	-0.00555	32830.	4.66E+09	-596.1188	19180.	0.00
6.1600	0.1357	378568.	8948.	-0.00516	34808.	4.66E+09	-609.8858	23722.	0.00
6.6000	0.1097	426839.	5729.	-0.00470	36253.	4.66E+09	-609.5572	29352.	0.00
7.0400	0.08611	457184.	2551.	-0.00420	37161.	4.66E+09	-594.1634	36434.	0.00
7.4800	0.06530	469968.	-503.9326	-0.00368	37544.	4.66E+09	-563.0446	45529.	0.00
7.9200	0.04729	466029.	-3352.	-0.00315	37426.	4.66E+09	-515.6683	57569.	0.00
8.3600	0.03208	446697.	-5818.	-0.00263	36847.	4.66E+09	-418.3708	68860.	0.00
8.8000	0.01954	414727.	-7630.	-0.00214	35890.	4.66E+09	-268.1775	72484.	0.00
9.2400	0.00947	374376.	-8698.	-0.00169	34683.	4.66E+09	-136.5013	76108.	0.00
9.6800	0.00164	329403.	-9124.	-0.00130	33337.	4.66E+09	-24.8049	79732.	0.00
10.1200	-0.00422	283019.	-9014.	-9.49E-04	31949.	4.66E+09	66.5474	83356.	0.00
10.5600	-0.00838	237873.	-8474.	-6.54E-04	30597.	4.66E+09	138.0687	86981.	0.00
11.0000	-0.01113	196057.	-7800.	-4.09E-04	29346.	4.66E+09	117.3326	55686.	0.00
11.4400	-0.01270	157084.	-7122.	-2.09E-04	28179.	4.66E+09	139.2729	57917.	0.00
11.8800	-0.01333	121651.	-6354.	-5.10E-05	27119.	4.66E+09	151.8434	60147.	0.00
12.3200	-0.01323	90185.	-5540.	6.90E-05	26177.	4.66E+09	156.3566	62377.	0.00
12.7600	-0.01260	62882.	-4720.	1.56E-04	25360.	4.66E+09	154.1926	64608.	0.00
13.2000	-0.01159	39741.	-3926.	2.14E-04	24667.	4.66E+09	146.7346	66838.	0.00
13.6400	-0.01034	20603.	-3181.	2.48E-04	24095.	4.66E+09	135.3158	69068.	0.00
14.0800	-0.00897	5193.	-2504.	2.62E-04	23633.	4.66E+09	121.1800	71298.	0.00
14.5200	-0.00757	-6850.	-1856.	2.62E-04	23683.	4.66E+09	124.2759	86652.	0.00
14.9600	-0.00621	-15414.	-1250.	2.49E-04	23939.	4.66E+09	105.2282	89440.	0.00
15.4000	-0.00494	-21010.	-744.2770	2.28E-04	24107.	4.66E+09	86.3535	92228.	0.00
15.8400	-0.00380	-24154.	-335.7288	2.03E-04	24201.	4.66E+09	68.3997	95016.	0.00
16.2800	-0.00280	-25337.	-18.1012	1.75E-04	24236.	4.66E+09	51.9138	97804.	0.00
16.7200	-0.00196	-25018.	217.3165	1.46E-04	24227.	4.66E+09	37.2595	100591.	0.00
17.1600	-0.00126	-23606.	380.7293	1.19E-04	24184.	4.66E+09	24.6393	103379.	0.00
17.6000	-7.02E-04	-21455.	483.0548	9.32E-05	24120.	4.66E+09	14.1203	106167.	0.00
18.0400	-2.74E-04	-18864.	535.2771	7.04E-05	24043.	4.66E+09	5.6608	108955.	0.00
18.4800	4.08E-05	-16074.	547.9412	5.06E-05	23959.	4.66E+09	-0.8639	111743.	0.00
18.9200	2.60E-04	-13273.	530.7791	3.40E-05	23875.	4.66E+09	-5.6369	114531.	0.00
19.3600	4.00E-04	-10600.	492.4591	2.05E-05	23795.	4.66E+09	-8.8782	117318.	0.00
19.8000	4.76E-04	-8151.	440.4409	9.84E-06	23722.	4.66E+09	-10.8256	120106.	0.00
20.2400	5.04E-04	-5987.	380.9221	1.84E-06	23657.	4.66E+09	-11.7194	122894.	0.00
20.6800	4.95E-04	-4136.	318.8562	-3.89E-06	23602.	4.66E+09	-11.7904	125682.	0.00
21.1200	4.62E-04	-2605.	258.0266	-7.71E-06	23556.	4.66E+09	-11.2512	128470.	0.00
21.5600	4.14E-04	-1381.	201.1577	-9.96E-06	23519.	4.66E+09	-10.2901	131258.	0.00
22.0000	3.57E-04	-441.9154	150.0518	-1.10E-05	23491.	4.66E+09	-9.0682	134045.	0.00
22.4400	2.98E-04	245.6291	105.7366	-1.11E-05	23485.	4.66E+09	-7.7179	136833.	0.00
22.8800	2.40E-04	717.4751	68.6139	-1.06E-05	23499.	4.66E+09	-6.3437	139621.	0.00
23.3200	1.86E-04	1011.	38.6028	-9.58E-06	23508.	4.66E+09	-5.0241	142409.	0.00
23.7600	1.39E-04	1162.	15.2702	-8.35E-06	23513.	4.66E+09	-3.8140	145197.	0.00
24.2000	9.81E-05	1204.	-2.0547	-7.01E-06	23514.	4.66E+09	-2.7484	147985.	0.00
24.6400	6.46E-05	1167.	-14.1827	-5.67E-06	23513.	4.66E+09	-1.8455	150772.	0.00
25.0800	3.82E-05	1076.	-21.9859	-4.40E-06	23510.	4.66E+09	-1.1103	153560.	0.00
25.5200	1.82E-05	952.1886	-26.3364	-3.25E-06	23506.	4.66E+09	-0.5376	156348.	0.00
25.9600	3.83E-06	810.8674	-28.0605	-2.25E-06	23502.	4.66E+09	-0.1154	159136.	0.00

26.4000	-5.65E-06	664.5585	-27.9080	-1.42E-06	23498.	4.66E+09	0.1732	161924.	0.00
26.8400	-1.12E-05	521.6285	-26.5321	-7.47E-07	23494.	4.66E+09	0.3480	164712.	0.00
27.2800	-1.35E-05	387.2606	-24.4794	-2.33E-07	23490.	4.66E+09	0.4296	167500.	0.00
27.7200	-1.36E-05	264.0234	-22.1863	1.36E-07	23486.	4.66E+09	0.4390	170287.	0.00
28.1600	-1.21E-05	152.4501	-19.9795	3.72E-07	23483.	4.66E+09	0.3969	173075.	0.00
28.6000	-9.69E-06	51.6079	-18.0798	4.87E-07	23480.	4.66E+09	0.3227	175863.	0.00
29.0400	-6.96E-06	-40.3499	-12.3973	4.93E-07	23479.	4.66E+09	1.8297	1387479.	0.00
29.4800	-4.48E-06	-81.2093	-4.4602	4.25E-07	23480.	4.66E+09	1.1767	1387479.	0.00
29.9200	-2.48E-06	-89.0861	0.3658	3.28E-07	23481.	4.66E+09	0.6513	1387479.	0.00
30.3600	-1.01E-06	-78.6113	2.7870	2.33E-07	23480.	4.66E+09	0.2658	1387479.	0.00
30.8000	-1.46E-08	-60.5543	3.4989	1.55E-07	23480.	4.66E+09	0.00383	1387479.	0.00
31.2400	6.20E-07	-42.2583	3.0787	9.63E-08	23479.	4.66E+09	-0.1630	1387479.	0.00
31.6800	1.00E-06	-28.4149	1.9527	5.63E-08	23479.	4.66E+09	-0.2635	1387479.	0.00
32.1200	1.22E-06	-21.8552	1.1796	2.79E-08	23479.	4.66E+09	-0.02933	127458.	0.00
32.5600	1.30E-06	-16.0656	1.0184	6.40E-09	23478.	4.66E+09	-0.03172	129130.	0.00
33.0000	1.28E-06	-11.1252	0.8508	-9.00E-09	23478.	4.66E+09	-0.03178	130803.	0.00
33.4400	1.20E-06	-7.0465	0.6873	-1.93E-08	23478.	4.66E+09	-0.03016	132476.	0.00
33.8800	1.08E-06	-3.7931	0.5353	-2.54E-08	23478.	4.66E+09	-0.02742	134149.	0.00
34.3200	9.34E-07	-1.2958	0.3995	-2.83E-08	23478.	4.66E+09	-0.02401	135821.	0.00
34.7600	7.80E-07	0.5349	0.2825	-2.87E-08	23478.	4.66E+09	-0.02032	137494.	0.00
35.2000	6.30E-07	1.7980	0.1850	-2.74E-08	23478.	4.66E+09	-0.01661	139167.	0.00
35.6400	4.91E-07	2.5941	0.1066	-2.49E-08	23478.	4.66E+09	-0.01309	140839.	0.00
36.0800	3.67E-07	3.0197	0.04588	-2.17E-08	23478.	4.66E+09	-0.00990	142512.	0.00
36.5200	2.61E-07	3.1625	9.10E-04	-1.82E-08	23478.	4.66E+09	-0.00713	144185.	0.00
36.9600	1.74E-07	3.0996	-0.03062	-1.47E-08	23478.	4.66E+09	-0.00481	145857.	0.00
37.4000	1.06E-07	2.8958	-0.05426	-1.13E-08	23478.	4.66E+09	-0.00414	206421.	0.00
37.8400	5.49E-08	2.5702	-0.07095	-8.21E-09	23478.	4.66E+09	-0.00218	209906.	0.00
38.2800	1.92E-08	2.1782	-0.07875	-5.52E-09	23478.	4.66E+09	-7.75E-04	213391.	0.00
38.7200	-3.48E-09	1.7598	-0.08042	-3.30E-09	23478.	4.66E+09	1.43E-04	216876.	0.00
39.1600	-1.56E-08	1.3416	-0.07832	-1.54E-09	23478.	4.66E+09	6.52E-04	220360.	0.00
39.6000	-1.97E-08	0.9387	-0.07439	-2.48E-10	23478.	4.66E+09	8.37E-04	223845.	0.00
40.0400	-1.82E-08	0.5570	-0.07011	5.99E-10	23478.	4.66E+09	7.85E-04	227330.	0.00
40.4800	-1.34E-08	0.1960	-0.06649	1.02E-09	23478.	4.66E+09	5.86E-04	230815.	0.00
40.9200	-7.42E-09	-0.1490	-0.06407	1.05E-09	23478.	4.66E+09	3.29E-04	234300.	0.00
41.3600	-2.31E-09	-0.4846	-0.01440	6.93E-10	23478.	4.66E+09	0.01848	4.22E+07	0.00
41.8000	-1.03E-10	-0.3038	0.03757	2.46E-10	23478.	4.66E+09	0.00120	6.15E+07	0.00
42.2400	2.90E-10	-0.08876	0.02905	2.42E-11	23478.	4.66E+09	-0.00444	8.08E+07	0.00
42.6800	1.52E-10	0.00282	0.00971	-2.44E-11	23478.	4.66E+09	-0.00289	1.00E+08	0.00
43.1200	3.17E-11	0.01388	1.92E-04	-1.50E-11	23478.	4.66E+09	-7.18E-04	1.19E+08	0.00
43.5600	-5.85E-12	0.00491	-0.00132	-4.34E-12	23478.	4.66E+09	1.46E-04	1.32E+08	0.00
44.0000	-1.41E-11	0.00	0.00	-1.56E-12	23478.	4.66E+09	3.52E-04	6.60E+07	0.00

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

Output Summary for Load Case No. 1:

```
Pile-head deflection              =     0.44000000 inches
Computed slope at pile head       =     0.00235010 radians
Maximum bending moment            =      -1618348. inch-lbs
Maximum shear force               =         34102. lbs
Depth of maximum bending moment   =       0.000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =              7
Number of zero deflection points  =              7
```

Summary of Pile-head Responses for Conventional Analyses

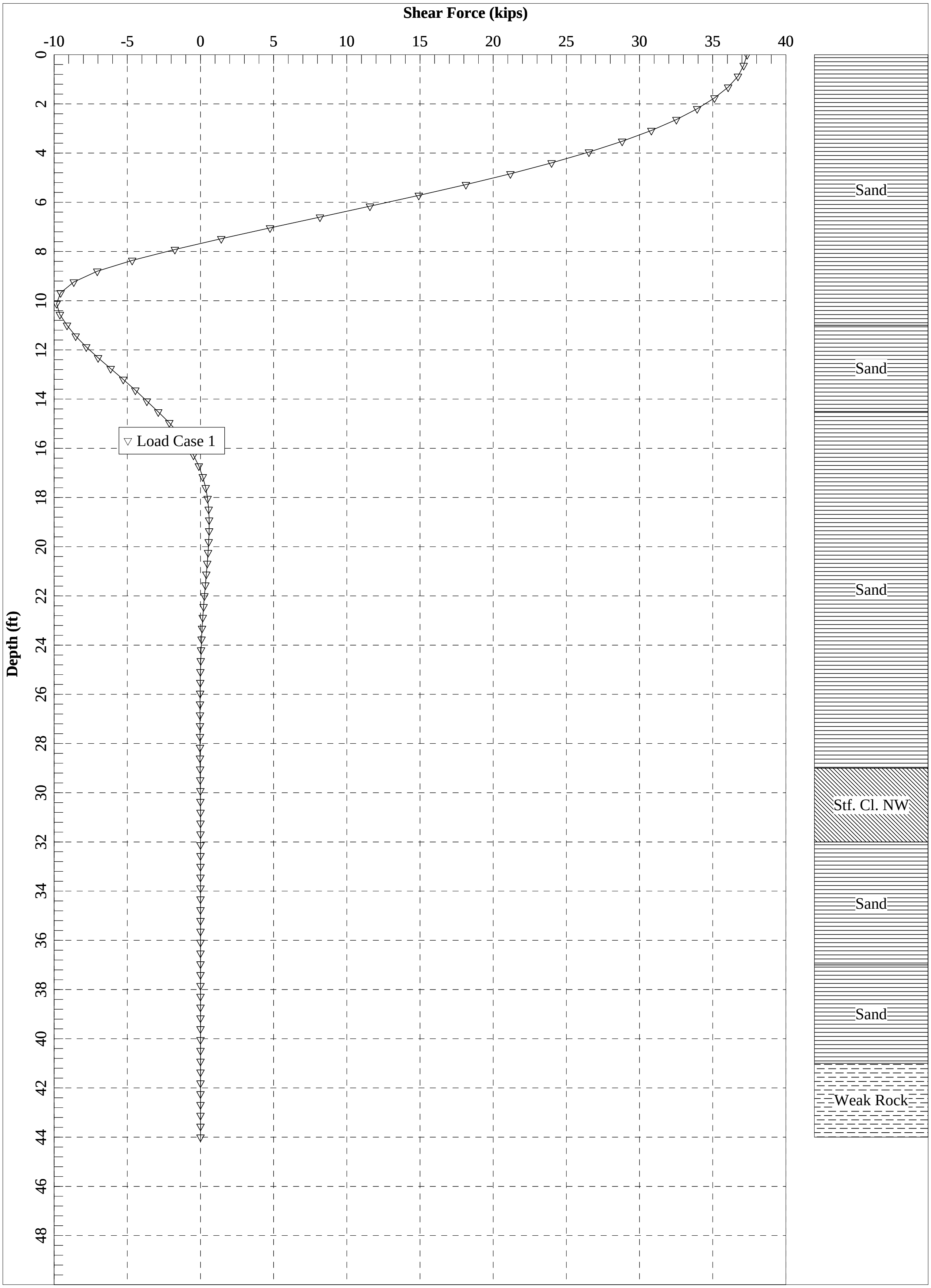
Definitions of Pile-head Loading Conditions:

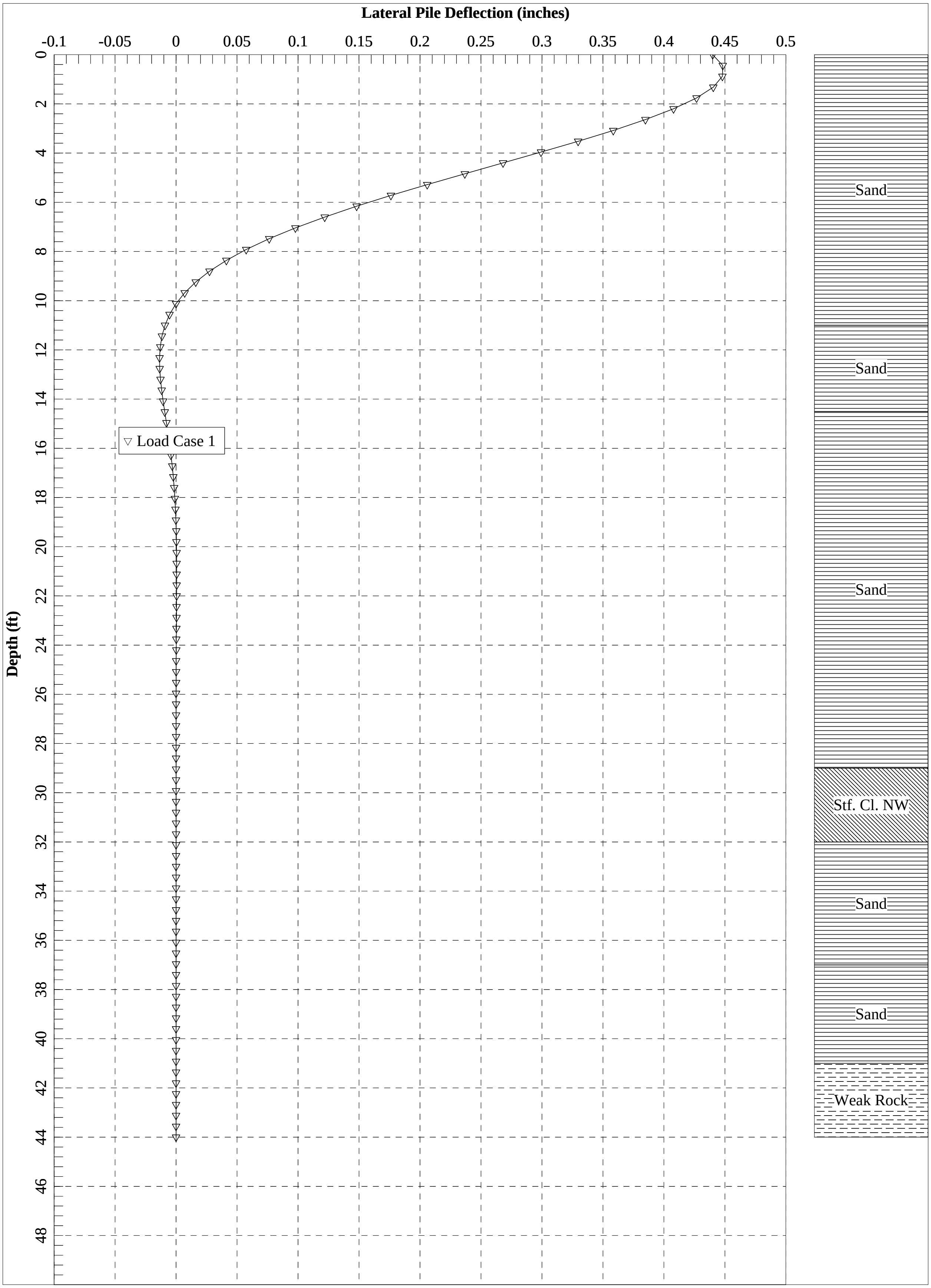
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

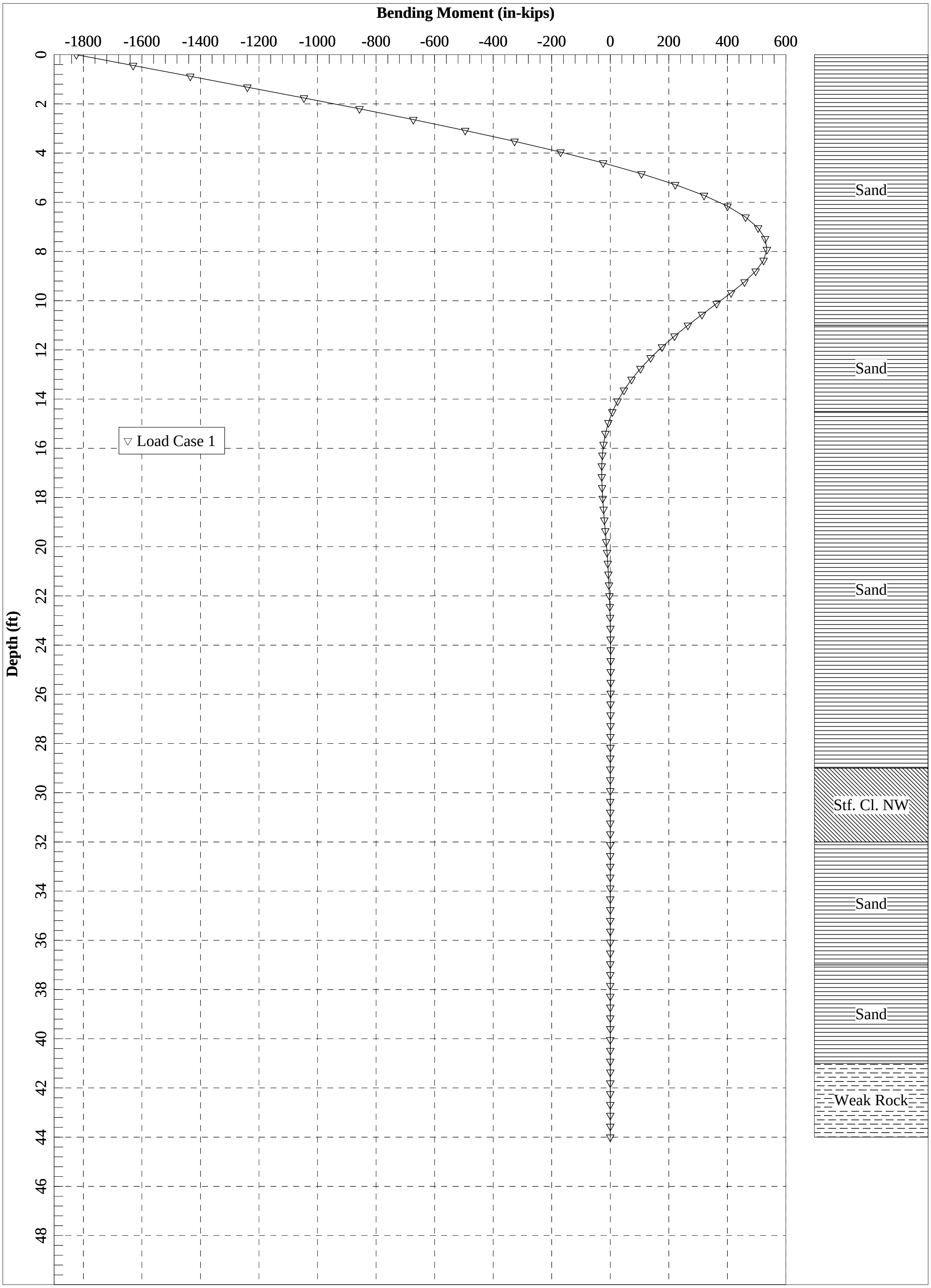
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4400	S, rad	0.00245	365000.	0.4400	0.00235	34102.	-1618348.

Maximum pile-head deflection = 0.440000000 inches
Maximum pile-head rotation = 0.002350097 radians

The analysis ended normally.


Shear Force (kips)
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Sand
Sand
Sand
Stf. Cl. NW
Sand
Sand
Weak Rock


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Sand
Sand
Sand
Stf. Cl. NW
Sand
Sand
Weak Rock


Bending Moment (in-kips)
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Sand
Sand
Sand
Stf. Cl. NW
Sand
Sand
Weak Rock

```
                       Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o
================================================================================

                       LPile for Windows, Version 2015-08.003

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

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

Path to file locations:
\09 Jobs\0025800s\09.0025899.00 - MDOT Naples\Work\Calcs\LPile\

Name of input data file:
Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8d

Name of output report file:
Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o

Name of plot output file:
Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8p

Name of runtime message file:
Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8r



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

               Date:  March 2, 2016     Time:  10:52:50



--------------------------------------------------------------------------------
                                                             Page 1
```

```
                       Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Crockett Bridge #2199 Muddy River, Naples, ME


Job Number: 09.0025899.00


Client: MaineDOT


Engineer:


Description:





--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats
                                                             Page 2
```

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 44.00 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameters used for p-y curve computations are defined using 2 points.

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

Point	Depth X ft	Pile Diameter in
1	0.00000	9.62500000
2	44.0000000	9.62500000

Input Structural Properties:

Pile Section No. 1:

Section Type = Drilled Shaft with Casing
Section Length = 44.000000 ft
Section Diameter = 9.625000 in
Shear Capacity of Section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o

The soil profile is modelled using 7 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 0.0000 ft
Distance from top of pile to bottom of layer = 11.000000 ft
Effective unit weight at top of layer = 125.000000 pcf
Effective unit weight at bottom of layer = 125.000000 pcf
Friction angle at top of layer = 35.000000 deg.
Friction angle at bottom of layer = 35.000000 deg.
Subgrade k at top of layer = 130.000000 pci
Subgrade k at bottom of layer = 130.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 11.000000 ft
Distance from top of pile to bottom of layer = 14.500000 ft
Effective unit weight at top of layer = 63.000000 pcf
Effective unit weight at bottom of layer = 63.000000 pcf
Friction angle at top of layer = 35.000000 deg.
Friction angle at bottom of layer = 35.000000 deg.
Subgrade k at top of layer = 80.000000 pci
Subgrade k at bottom of layer = 80.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 14.500000 ft
Distance from top of pile to bottom of layer = 29.000000 ft
Effective unit weight at top of layer = 67.000000 pcf
Effective unit weight at bottom of layer = 67.000000 pcf
Friction angle at top of layer = 38.000000 deg.
Friction angle at bottom of layer = 38.000000 deg.
Subgrade k at top of layer = 100.000000 pci
Subgrade k at bottom of layer = 100.000000 pci

Layer 4 is stiff clay without free water

Distance from top of pile to top of layer = 29.000000 ft
Distance from top of pile to bottom of layer = 32.000000 ft
Effective unit weight at top of layer = 57.000000 pcf
Effective unit weight at bottom of layer = 57.000000 pcf
Undrained cohesion at top of layer = 1000.000000 psf
Undrained cohesion at bottom of layer = 1000.000000 psf
Epsilon-50 at top of layer = 0.010000
Epsilon-50 at bottom of layer = 0.010000

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 32.000000 ft
Distance from top of pile to bottom of layer = 37.000000 ft
Effective unit weight at top of layer = 63.000000 pcf

```
   Effective unit weight at bottom of layer          =    63.000000 pcf
   Friction angle at top of layer                    =    34.000000 deg.
   Friction angle at bottom of layer                 =    34.000000 deg.
   Subgrade k at top of layer                        =    60.000000 pci
   Subgrade k at bottom of layer                     =    60.000000 pci
```

Layer 6 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer         =    37.000000 ft
   Distance from top of pile to bottom of layer      =    41.000000 ft
   Effective unit weight at top of layer             =    73.000000 pcf
   Effective unit weight at bottom of layer          =    73.000000 pcf
   Friction angle at top of layer                    =    40.000000 deg.
   Friction angle at bottom of layer                 =    40.000000 deg.
   Subgrade k at top of layer                        =   125.000000 pci
   Subgrade k at bottom of layer                     =   125.000000 pci
```

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

```
   Distance from top of pile to top of layer         =    41.000000 ft
   Distance from top of pile to bottom of layer      =    44.000000 ft
   Effective unit weight at top of layer             =   102.000000 pcf
   Effective unit weight at bottom of layer          =   102.000000 pcf
   Uniaxial compressive strength at top of layer     =  1000.000000 psi
   Uniaxial compressive strength at bottom of layer  =  1000.000000 psi
   Initial modulus of rock at top of layer           =       50000. psi
   Initial modulus of rock at bottom of layer        =       50000. psi
   RQD of rock at top of layer                       =    20.000000 %
   RQD of rock at bottom of layer                    =    20.000000 %
   k rm of rock at top of layer                      =       0.0000
   k rm of rock at bottom of layer                   =       0.0000
```

(Depth of lowest soil layer extends   0.00 ft below pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	35.0000	--	--	--	130.0000	--
	(Reese, et al.)	11.0000	125.0000	--	35.0000	--	--	--	130.0000	--

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
2	Sand	11.0000	63.0000	--	35.0000	--	--	--	80.0000	--
	(Reese, et al.)	14.5000	63.0000	--	35.0000	--	--	--	80.0000	--
3	Sand	14.5000	67.0000	--	38.0000	--	--	--	100.0000	--
	(Reese, et al.)	29.0000	67.0000	--	38.0000	--	--	--	100.0000	--
4	Stiff Clay	29.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
	w/o Free Water	32.0000	57.0000	1000.0000	--	--	--	0.01000	--	--
5	Sand	32.0000	63.0000	--	34.0000	--	--	--	60.0000	--
	(Reese, et al.)	37.0000	63.0000	--	34.0000	--	--	--	60.0000	--
6	Sand	37.0000	73.0000	--	40.0000	--	--	--	125.0000	--
	(Reese, et al.)	41.0000	73.0000	--	40.0000	--	--	--	125.0000	--
7	Weak	41.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.
	Rock	44.0000	102.0000	--	--	1000.0000	20.0000	--	--	50000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.440000 in	S = 0.002450 in/in	365000.	N.A.

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading.
Axial thrust is assumed to be acting axially for all pile batter angles.

Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	44.000000 ft
Outer Diameter of Casing	=	9.625000in
Casing Wall Thickness	=	0.545000in
Moment of Inertia of Steel Casing	=	160.796181in^4
Yield Stress of Casing	=	80000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Area of Single Reinforcing Bar	=	0.0000sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000in
Yield Stress of Reinforcing Bars	=	0.0000 psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000 psi
Gross Area of Pile	=	72.759777sq. in.
Area of Concrete	=	57.213291sq. in.
Cross-sectional Area of Steel Casing	=	15.546485sq. in.
Area of All Steel (Casing and Bars)	=	15.546485sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.37 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1535.507 kips
Tensile Load for Cracking of Concrete	=	-80.679 kips
Nominal Axial Tensile Capacity	=	-1243.719 kips

Concrete Properties:

Compressive Strength of Concrete	=	6000. psi
Modulus of Elasticity of Concrete	=	4415201. psi
Modulus of Rupture of Concrete	=	-580.947489 psi
Compression Strain at Peak Stress	=	0.002310
Tensile Strain at Fracture of Concrete	=	-0.0001147
Maximum Coarse Aggregate Size	=	0.0000 in

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

Number	Axial Thrust Force kips
1	365.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

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

Axial Thrust Force = 365.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg	Run Msg
0.00000125	7.1470166	5717613.	413.0853832	0.0005164	0.0005043	2.3821523	0.00000	14.9726006	
0.00000250	14.2940304	5717612.	208.9497464	0.0005224	0.0004983	2.4061418	0.00000	15.1453676	
0.00000375	21.4410382	5717610.	140.9048918	0.0005284	0.0004923	2.4300569	0.00000	15.3181734	
0.00000500	28.5880371	5717607.	106.8827328	0.0005344	0.0004863	2.4538976	0.00000	15.4910181	
0.00000625	35.7350243	5717604.	86.4696520	0.0005404	0.0004803	2.4776637	0.00000	15.6639018	
0.00000750	42.8819968	5717600.	72.8611103	0.0005465	0.0004743	2.5013552	0.00000	15.8368243	
0.00000875	50.0289515	5717594.	63.1408766	0.0005525	0.0004683	2.5249721	0.00000	16.0097857	
0.00001000	57.1758857	5717589.	55.8508355	0.0005585	0.0004623	2.5485142	0.00000	16.1827861	
0.00001125	64.3227963	5717582.	50.1809228	0.0005645	0.0004563	2.5719817	0.00000	16.3558253	
0.00001250	71.4696803	5717574.	45.6450999	0.0005706	0.0004503	2.5953743	0.00000	16.5289035	
0.00001375	78.6165349	5717566.	41.9340697	0.0005766	0.0004442	2.6186921	0.00000	16.7020205	
0.00001500	85.7633571	5717557.	38.8416339	0.0005826	0.0004382	2.6419349	0.00000	16.8751764	

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0.00001625	92.9101439	5717547.	36.2250400	0.0005887	0.0004323	2.6651028	0.00000	17.0483712
0.00001750	100.0568924	5717537.	33.9823219	0.0005947	0.0004263	2.6881957	0.00000	17.2216050
0.00001875	107.2035997	5717525.	32.0387044	0.0006007	0.0004203	2.7112134	0.00000	17.3948776
0.00002000	114.3502627	5717513.	30.3381062	0.0006068	0.0004143	2.7341561	0.00000	17.5681892
0.00002125	121.4968787	5717500.	28.8376415	0.0006128	0.0004083	2.7570236	0.00000	17.7415396
0.00002250	128.6434445	5717486.	27.5039547	0.0006188	0.0004023	2.7798158	0.00000	17.9149289
0.00002375	135.7899573	5717472.	26.3107125	0.0006249	0.0003963	2.8025328	0.00000	18.0883572
0.00002500	142.9364141	5717457.	25.2368481	0.0006309	0.0003903	2.8251744	0.00000	18.2618243
0.00002625	150.0828119	5717440.	24.2653077	0.0006370	0.0003843	2.8477406	0.00000	18.4353304
0.00002750	157.2291479	5717424.	23.3821379	0.0006430	0.0003783	2.8702314	0.00000	18.6088753
0.00002875	164.3754191	5717406.	22.5758121	0.0006491	0.0003723	2.8926466	0.00000	18.7824592
0.00003000	171.5216224	5717387.	21.8367248	0.0006551	0.0003664	2.9149863	0.00000	18.9560820
0.00003125	178.6677551	5717368.	21.1568075	0.0006612	0.0003604	2.9372504	0.00000	19.1297436
0.00003250	185.8138141	5717348.	20.5292328	0.0006672	0.0003544	2.9594388	0.00000	19.3034442
0.00003375	192.9597964	5717327.	19.9481849	0.0006733	0.0003484	2.9815515	0.00000	19.4771837
0.00003500	200.1056992	5717306.	19.4086787	0.0006793	0.0003424	3.0035884	0.00000	19.6509621
0.00003625	207.2515195	5717283.	18.9064168	0.0006854	0.0003365	3.0255495	0.00000	19.8247794
0.00003750	214.3972543	5717260.	18.4376749	0.0006914	0.0003305	3.0474347	0.00000	19.9986356
0.00003875	221.5429007	5717236.	17.9992090	0.0006975	0.0003245	3.0692440	0.00000	20.1725307
0.00004000	228.6884558	5717211.	17.5881807	0.0007035	0.0003185	3.0909772	0.00000	20.3464648
0.00004125	235.8339165	5717186.	17.2020958	0.0007096	0.0003126	3.1126344	0.00000	20.5204377
0.00004250	242.9792800	5717160.	16.8387534	0.0007156	0.0003066	3.1342156	0.00000	20.6944496
0.00004375	250.1245444	5717132.	16.4962040	0.0007217	0.0003006	3.1557204	0.00000	20.8684992
0.00004500	257.2697045	5717105.	16.1727150	0.0007278	0.0002946	3.1771491	0.00000	21.0425889
0.00004625	264.4147585	5717076.	15.8667409	0.0007338	0.0002887	3.1985016	0.00000	21.2167175
0.00004750	271.5597035	5717046.	15.5768989	0.0007399	0.0002827	3.2197778	0.00000	21.3908851
0.00004875	278.7045365	5717016.	15.3019482	0.0007460	0.0002768	3.2409776	0.00000	21.5650916
0.00005125	292.9938547	5716953.	14.7923620	0.0007581	0.0002648	3.2831478	0.00000	21.9136213

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0.00005375	307.2826894	5716887.	14.3302790	0.0007703	0.0002529	3.3250119	0.00000	22.2623067
0.00005625	321.5710172	5716818.	13.9093655	0.0007824	0.0002410	3.3665695	0.00000	22.6111478
0.00005875	335.8588144	5716746.	13.5243659	0.0007946	0.0002291	3.4078200	0.00000	22.9601446
0.00006125	350.1460574	5716670.	13.1708824	0.0008067	0.0002172	3.4487631	0.00000	23.3092972
0.00006375	364.4327226	5716592.	12.8452074	0.0008189	0.0002053	3.4893983	0.00000	23.6586054
0.00006625	378.7187864	5716510.	12.5441927	0.0008311	0.0001934	3.5297252	0.00000	24.0080695
0.00006875	393.0042251	5716425.	12.2651481	0.0008432	0.0001815	3.5697433	0.00000	24.3576892
0.00007125	407.2890153	5716337.	12.0057610	0.0008554	0.0001696	3.6094523	0.00000	24.7074648
0.00007375	421.5731331	5716246.	11.7640322	0.0008676	0.0001578	3.6488516	0.00000	25.0573961
0.00007625	435.8565551	5716152.	11.5382250	0.0008798	0.0001459	3.6879409	0.00000	25.4074832
0.00007875	450.1392576	5716054.	11.3268230	0.0008920	0.0001340	3.7267197	0.00000	25.7577262
0.00008125	464.4212169	5715953.	11.1284965	0.0009042	0.0001222	3.7651875	0.00000	26.1081249
0.00008375	478.7024095	5715850.	10.9420745	0.0009164	0.0001103	3.8033440	0.00000	26.4586795
0.00008625	492.9828117	5715743.	10.7665219	0.0009286	0.00009846	3.8411887	0.00000	26.8093900
0.00008875	507.2623999	5715633.	10.6009202	0.0009408	0.00008661	3.8787212	0.00000	27.1602563
0.00009125	521.5411503	5715519.	10.4444514	0.0009531	0.00007477	3.9159409	0.00000	27.5112785
0.00009375	535.8190395	5715403.	10.2963850	0.0009653	0.00006294	3.9528476	0.00000	27.8624567
0.00009625	550.0960436	5715284.	10.1560662	0.0009775	0.00005112	3.9894407	0.00000	28.2137907
0.00009875	564.3721391	5715161.	10.0229066	0.0009898	0.00003929	4.0257198	0.00000	28.5652807
0.0001013	578.6473023	5715035.	9.8963759	0.0010020	0.00002748	4.0616845	0.00000	28.9169267
0.0001038	592.9215095	5714906.	9.7759949	0.0010143	0.00001567	4.0973344	0.00000	29.2687286
0.0001063	607.1947371	5714774.	9.6613296	0.0010265	0.00000386	4.1326689	0.00000	29.6206865
0.0001088	621.4669613	5714639.	9.5519856	0.0010388	-0.00000794	4.1676877	0.00000	29.9728005
0.0001113	635.7381579	5714500.	9.4476044	0.0010510	-0.00001974	4.2023903	0.00000	30.3250708
0.0001138	650.0083045	5714359.	9.3478587	0.0010633	-0.00003152	4.2367763	0.00000	30.6774968
0.0001163	664.2773766	5714214.	9.2524494	0.0010756	-0.00004331	4.2708453	0.00000	31.0300789
0.0001188	678.5453507	5714066.	9.1611027	0.0010879	-0.00005509	4.3045967	0.00000	31.3828171

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0.0001213	692.8122015	5713915.	9.0735672	0.0011002	-0.00006686	4.3380302	0.00000	31.7357115	
0.0001238	707.0778709	5713761.	8.9896119	0.0011125	-0.00007863	4.3711454	0.00000	32.0887616	
0.0001263	721.3421422	5713601.	8.9090236	0.0011248	-0.00009039	4.4039414	0.00000	32.4419655	
0.0001288	735.6046994	5713435.	8.8316053	0.0011371	-0.0001021	4.4364177	0.00000	32.7953201	
0.0001313	749.8651782	5713259.	8.7571750	0.0011494	-0.0001139	4.4685736	0.00000	33.1488218	
0.0001338	763.7002212	5709908.	8.6843993	0.0011615	-0.0001258	4.5000038	0.00000	33.4979522	C
0.0001363	777.7511034	5708265.	8.6149086	0.0011738	-0.0001376	4.5313228	0.00000	33.8495040	C
0.0001388	791.7335200	5706188.	8.5477675	0.0011860	-0.0001495	4.5622571	0.00000	34.2004368	C
0.0001413	805.6752124	5703895.	8.4829263	0.0011982	-0.0001613	4.5928348	0.00000	34.5510553	C
0.0001438	819.5812197	5701435.	8.4202791	0.0012104	-0.0001732	4.6230619	0.00000	34.9014179	C
0.0001463	833.4152369	5698566.	8.3596064	0.0012226	-0.0001851	4.6529007	0.00000	35.2510709	C
0.0001488	847.2161152	5695571.	8.3009158	0.0012348	-0.0001970	4.6823918	0.00000	35.6004769	C
0.0001588	901.9588331	5681630.	8.0837197	0.0012833	-0.0002447	4.7967530	0.00000	36.9938695	C
0.0001688	956.0478508	5665469.	7.8910128	0.0013316	-0.0002926	4.9054545	0.00000	38.3811327	C
0.0001788	1010.	5647898.	7.7187956	0.0013797	-0.0003407	5.0086062	0.00000	39.7628392	C
0.0001888	1063.	5629551.	7.5639392	0.0014277	-0.0003890	5.1063182	0.00000	41.1396888	C
0.0001988	1115.	5610700.	7.4238331	0.0014755	-0.0004375	5.1986477	0.00000	42.5117379	C
0.0002088	1167.	5591854.	7.2965505	0.0015232	-0.0004861	5.2857199	0.00000	43.8801567	C
0.0002188	1219.	5573197.	7.1804015	0.0015707	-0.0005348	5.3675999	0.00000	45.2453795	C
0.0002288	1271.	5554816.	7.0739604	0.0016182	-0.0005836	5.4443352	0.00000	46.6076361	C
0.0002388	1322.	5536783.	6.9760434	0.0016655	-0.0006324	5.5159709	0.00000	47.9671758	C
0.0002488	1373.	5519201.	6.8856967	0.0017128	-0.0006814	5.5825619	0.00000	49.3245335	C
0.0002588	1424.	5502074.	6.8020591	0.0017600	-0.0007304	5.6441373	0.00000	50.6798340	C
0.0002688	1474.	5485461.	6.7244442	0.0018072	-0.0007795	5.7007391	0.00000	52.0335639	C
0.0002788	1525.	5469391.	6.6522578	0.0018543	-0.0008287	5.7524002	0.00000	53.3861597	C
0.0002888	1575.	5453885.	6.5849921	0.0019014	-0.0008778	5.7991482	0.00000	54.7380915	C
0.0002988	1625.	5438777.	6.5220449	0.0019485	-0.0009270	5.8409631	0.00000	56.0884248	C
0.0003088	1675.	5424181.	6.4631194	0.0019955	-0.0009762	5.8778903	0.00000	57.4382573	C

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0.0003188	1724.	5410112.	6.4078945	0.0020425	-0.0010255	5.9099469	0.00000	58.7881206	C
0.0003288	1774.	5396380.	6.3558835	0.0020895	-0.0010747	5.9371065	0.00000	60.1365933	C
0.0003388	1824.	5383200.	6.3070454	0.0021365	-0.0011240	5.9594193	0.00000	61.4860698	C
0.0003488	1873.	5370290.	6.2608547	0.0021835	-0.0011732	5.9768462	0.00000	62.8339962	C
0.0003588	1922.	5357881.	6.2173609	0.0022305	-0.0012225	5.9894250	0.00000	64.1831895	C
0.0003688	1971.	5345754.	6.1761393	0.0022775	-0.0012718	5.9971335	0.00000	65.5314536	C
0.0003788	2020.	5334020.	6.1371644	0.0023245	-0.0013210	5.9999822	0.00000	66.8804877	C
0.0003888	2069.	5322634.	6.1002407	0.0023715	-0.0013703	5.9988289	0.00000	68.2300406	C
0.0003988	2118.	5311497.	6.0651228	0.0024185	-0.0014195	5.9992364	0.00000	69.5790594	C
0.0004088	2167.	5300723.	6.0318451	0.0024655	-0.0014687	5.9994695	0.00000	70.9295229	C
0.0004188	2215.	5290204.	6.0001646	0.0025126	-0.0015179	5.9995809	0.00000	72.2800822	C
0.0004288	2264.	5279915.	5.9699674	0.0025596	-0.0015671	5.9996021	0.00000	73.6307092	C
0.0004388	2312.	5269904.	5.9412697	0.0026067	-0.0016162	5.9995417	0.00000	74.9829009	C
0.0004488	2360.	5260110.	5.9139385	0.0026539	-0.0016653	5.9993816	0.00000	76.3362311	C
0.0004588	2409.	5250439.	5.8877697	0.0027010	-0.0017145	5.9990768	0.00000	77.6891751	C
0.0004688	2457.	5240990.	5.8628394	0.0027482	-0.0017635	5.9985652	0.00000	79.0437747	C
0.0004788	2504.	5231270.	5.8392545	0.0027955	-0.0018124	5.9990904	0.00000	80.0000000	CY
0.0004888	2551.	5219732.	5.8174937	0.0028433	-0.0018609	5.9999301	0.00000	80.0000000	CY
0.0004988	2596.	5205456.	5.7977902	0.0028916	-0.0019088	5.9996106	0.00000	80.0000000	CY
0.0005088	2639.	5188093.	5.7803995	0.0029408	-0.0019559	5.9989556	0.00000	80.0000000	CY
0.0005188	2681.	5167399.	5.7653957	0.0029908	-0.0020022	5.9978842	0.00000	80.0000000	CY
0.0005288	2719.	5143219.	5.7528243	0.0030418	-0.0020474	5.9999549	0.00000	80.0000000	CY
0.0005388	2756.	5115467.	5.7427115	0.0030939	-0.0020916	5.9995475	0.00000	80.0000000	CY
0.0005488	2791.	5085269.	5.7345514	0.0031468	-0.0021349	5.9986347	0.00000	80.0000000	CY
0.0006088	2971.	4881166.	5.7124464	0.0034775	-0.0023818	5.9987089	0.00000	80.0000000	CY
0.0006688	3119.	4663747.	5.7211722	0.0038260	-0.0026107	5.9980642	0.00000	80.0000000	CY

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Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	365.000	2687.603	0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

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

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	2688.	237.249991	1747.	5403889.
1	0.70	2688.	255.499996	1881.	5368165.
1	0.75	2688.	273.750000	2016.	5335111.

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

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.440000 inches
Rotation of pile head = 2.450E-03 radians
Axial load on pile head = 365000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4400	-1823797.	37351.	0.00245	0.00	5.38E+09	0.00	0.00	0.00
0.4400	0.4482	-1630216.	37111.	7.56E-04	0.00	5.38E+09	-45.3618	534.3672	0.00

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0.8800	0.4480	-1434817.	36727.	-7.32E-04	0.00	5.50E+09	-100.2642	1182.	0.00
1.3200	0.4405	-1239559.	36056.	-0.00201	0.00	5.57E+09	-153.7797	1843.	0.00
1.7600	0.4268	-1046322.	35117.	-0.00309	0.00	5.63E+09	-202.0710	2500.	0.00
2.2000	0.4079	-856828.	33939.	-0.00397	0.00	5.69E+09	-243.9545	3158.	0.00
2.6400	0.3848	-672604.	32516.	-0.00468	0.00	5.71E+09	-294.9671	4047.	0.00
3.0800	0.3584	-495406.	30810.	-0.00522	0.00	5.72E+09	-351.3795	5176.	0.00
3.5200	0.3296	-327121.	28817.	-0.00560	0.00	5.72E+09	-403.5486	6464.	0.00
3.9600	0.2993	-169505.	26544.	-0.00583	0.00	5.72E+09	-457.4829	8072.	0.00
4.4000	0.2681	-24341.	23989.	-0.00592	0.00	5.72E+09	-510.2068	10050.	0.00
4.8400	0.2367	106643.	21173.	-0.00588	0.00	5.72E+09	-556.3827	12409.	0.00
5.2800	0.2059	221926.	18136.	-0.00573	0.00	5.72E+09	-594.1425	15234.	0.00
5.7200	0.1762	320251.	14922.	-0.00548	0.00	5.72E+09	-623.0852	18671.	0.00
6.1600	0.1480	400634.	11580.	-0.00515	0.00	5.72E+09	-642.9155	22929.	0.00
6.6000	0.1218	462381.	8167.	-0.00475	0.00	5.72E+09	-649.9064	28164.	0.00
7.0400	0.09789	505187.	4756.	-0.00430	0.00	5.72E+09	-642.3517	34647.	0.00
7.4800	0.07640	529185.	1424.	-0.00383	0.00	5.72E+09	-619.4748	42811.	0.00
7.9200	0.05750	534971.	-1744.	-0.00333	0.00	5.72E+09	-580.6968	53326.	0.00
8.3600	0.04120	523616.	-4664.	-0.00284	0.00	5.72E+09	-525.4380	67337.	0.00
8.8000	0.02746	496681.	-7047.	-0.00237	0.00	5.72E+09	-376.9439	72484.	0.00
9.2400	0.01614	458352.	-8656.	-0.00193	0.00	5.72E+09	-232.6242	76108.	0.00
9.6800	0.00705	412722.	-9551.	-0.00153	0.00	5.72E+09	-106.5227	79732.	0.00
10.1200	-1.73E-05	363388.	-9832.	-0.00117	0.00	5.72E+09	0.2724	83356.	0.00
10.5600	-0.00532	313415.	-9600.	-8.59E-04	0.00	5.72E+09	87.5813	86981.	0.00
11.0000	-0.00909	265326.	-9116.	-5.92E-04	0.00	5.72E+09	95.8408	55686.	0.00
11.4400	-0.01156	219436.	-8528.	-3.68E-04	0.00	5.72E+09	126.8499	57917.	0.00
11.8800	-0.01297	176692.	-7803.	-1.85E-04	0.00	5.72E+09	147.7625	60147.	0.00
12.3200	-0.01352	137753.	-6991.	-3.97E-05	0.00	5.72E+09	159.6854	62377.	0.00
12.7600	-0.01339	103020.	-6137.	7.15E-05	0.00	5.72E+09	163.8501	64608.	0.00
13.2000	-0.01276	72672.	-5278.	1.53E-04	0.00	5.72E+09	161.5495	66838.	0.00
13.6400	-0.01178	46698.	-4445.	2.08E-04	0.00	5.72E+09	154.0827	69068.	0.00
14.0800	-0.01057	24937.	-3661.	2.41E-04	0.00	5.72E+09	142.7108	71298.	0.00
14.5200	-0.00924	7110.	-2884.	2.56E-04	0.00	5.72E+09	151.5798	86652.	0.00
14.9600	-0.00787	-6503.	-2132.	2.56E-04	0.00	5.72E+09	133.3027	89440.	0.00
15.4000	-0.00653	-16389.	-1479.	2.45E-04	0.00	5.72E+09	114.1360	92228.	0.00
15.8400	-0.00528	-23064.	-926.6107	2.27E-04	0.00	5.72E+09	94.9976	95016.	0.00
16.2800	-0.00414	-27050.	-473.5492	2.04E-04	0.00	5.72E+09	76.6166	97804.	0.00
16.7200	-0.00313	-28851.	-114.0912	1.78E-04	0.00	5.72E+09	59.5417	100591.	0.00
17.1600	-0.00226	-28941.	159.6640	1.51E-04	0.00	5.72E+09	44.1535	103379.	0.00
17.6000	-0.00153	-27749.	357.2343	1.25E-04	0.00	5.72E+09	30.6838	106167.	0.00
18.0400	-9.32E-04	-25651.	489.0227	1.01E-04	0.00	5.72E+09	19.2361	108955.	0.00
18.4800	-4.63E-04	-22972.	565.6998	7.82E-05	0.00	5.72E+09	9.8083	111743.	0.00
18.9200	-1.07E-04	-19979.	597.7059	5.83E-05	0.00	5.72E+09	2.3152	114531.	0.00
19.3600	1.53E-04	-16885.	594.8683	4.13E-05	0.00	5.72E+09	-3.3901	117318.	0.00
19.8000	3.30E-04	-13856.	566.1282	2.71E-05	0.00	5.72E+09	-7.4963	120106.	0.00
20.2400	4.39E-04	-11012.	519.3650	1.56E-05	0.00	5.72E+09	-10.2170	122894.	0.00
20.6800	4.95E-04	-8432.	461.3061	6.66E-06	0.00	5.72E+09	-11.7751	125682.	0.00
21.1200	5.09E-04	-6166.	397.5058	-8.06E-08	0.00	5.72E+09	-12.3917	128470.	0.00
21.5600	4.94E-04	-4234.	332.3824	-4.88E-06	0.00	5.72E+09	-12.2763	131258.	0.00
22.0000	4.58E-04	-2637.	269.2950	-8.06E-06	0.00	5.72E+09	-11.6205	134045.	0.00
22.4400	4.09E-04	-1359.	210.6507	-9.90E-06	0.00	5.72E+09	-10.5933	136833.	0.00
22.8800	3.53E-04	-374.5573	158.0293	-1.07E-05	0.00	5.72E+09	-9.3391	139621.	0.00
23.3200	2.96E-04	350.6152	112.3150	-1.07E-05	0.00	5.72E+09	-7.9770	142409.	0.00
23.7600	2.40E-04	852.7790	73.8287	-1.02E-05	0.00	5.72E+09	-6.6012	145197.	0.00
24.2000	1.88E-04	1169.	42.4540	-9.22E-06	0.00	5.72E+09	-5.2831	147985.	0.00
24.6400	1.43E-04	1337.	17.7525	-8.07E-06	0.00	5.72E+09	-4.0735	150772.	0.00

Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o

25.0800	1.03E-04	1388.	-0.9346	-6.81E-06	0.00	5.72E+09	-3.0049	153560.	0.00
25.5200	7.08E-05	1353.	-14.3992	-5.54E-06	0.00	5.72E+09	-2.0953	156348.	0.00
25.9600	4.48E-05	1257.	-23.4948	-4.34E-06	0.00	5.72E+09	-1.3501	159136.	0.00
26.4000	2.50E-05	1122.	-29.0796	-3.24E-06	0.00	5.72E+09	-0.7654	161924.	0.00
26.8400	1.06E-05	962.6610	-31.9726	-2.28E-06	0.00	5.72E+09	-0.3304	164712.	0.00
27.2800	9.19E-07	792.7701	-32.9220	-1.47E-06	0.00	5.72E+09	-0.02917	167500.	0.00
27.7200	-4.89E-06	620.6552	-32.5828	-8.13E-07	0.00	5.72E+09	0.1576	170287.	0.00
28.1600	-7.67E-06	451.8301	-31.5031	-3.18E-07	0.00	5.72E+09	0.2514	173075.	0.00
28.6000	-8.25E-06	289.2086	-30.1144	2.41E-08	0.00	5.72E+09	0.2747	175863.	0.00
29.0400	-7.41E-06	133.7295	-24.2460	2.19E-07	0.00	5.72E+09	1.9482	1387479.	0.00
29.4800	-5.93E-06	32.3252	-14.9893	2.96E-07	0.00	5.72E+09	1.5581	1387479.	0.00
29.9200	-4.29E-06	-25.6985	-7.9015	2.99E-07	0.00	5.72E+09	1.1266	1387479.	0.00
30.3600	-2.77E-06	-52.2679	-3.0051	2.63E-07	0.00	5.72E+09	0.7281	1387479.	0.00
30.8000	-1.51E-06	-58.4470	-0.03639	2.12E-07	0.00	5.72E+09	0.3965	1387479.	0.00
31.2400	-5.32E-07	-53.4693	1.3792	1.60E-07	0.00	5.72E+09	0.1398	1387479.	0.00
31.6800	1.84E-07	-44.5004	1.6203	1.15E-07	0.00	5.72E+09	-0.04845	1387479.	0.00
32.1200	6.84E-07	-36.8029	1.4488	7.76E-08	0.00	5.72E+09	-0.01650	127458.	0.00
32.5600	1.00E-06	-29.5000	1.3404	4.69E-08	0.00	5.72E+09	-0.02454	129130.	0.00
33.0000	1.18E-06	-22.8287	1.1985	2.28E-08	0.00	5.72E+09	-0.02921	130803.	0.00
33.4400	1.24E-06	-16.9312	1.0390	4.42E-09	0.00	5.72E+09	-0.03121	132476.	0.00
33.8800	1.23E-06	-11.8737	0.8744	-8.88E-09	0.00	5.72E+09	-0.03115	134149.	0.00
34.3200	1.15E-06	-7.6634	0.7141	-1.79E-08	0.00	5.72E+09	-0.02959	135821.	0.00
34.7600	1.04E-06	-4.2643	0.5647	-2.34E-08	0.00	5.72E+09	-0.02700	137494.	0.00
35.2000	9.03E-07	-1.6104	0.4305	-2.61E-08	0.00	5.72E+09	-0.02380	139167.	0.00
35.6400	7.61E-07	0.3829	0.3141	-2.67E-08	0.00	5.72E+09	-0.02030	140839.	0.00
36.0800	6.21E-07	1.8095	0.2163	-2.57E-08	0.00	5.72E+09	-0.01677	142512.	0.00
36.5200	4.90E-07	2.7655	0.1367	-2.36E-08	0.00	5.72E+09	-0.01338	144185.	0.00
36.9600	3.72E-07	3.3435	0.07418	-2.07E-08	0.00	5.72E+09	-0.01029	145857.	0.00
37.4000	2.71E-07	3.6288	0.01906	-1.75E-08	0.00	5.72E+09	-0.01059	206421.	0.00
37.8400	1.87E-07	3.6123	-0.02857	-1.42E-08	0.00	5.72E+09	-0.00745	209906.	0.00
38.2800	1.21E-07	3.3818	-0.06116	-1.09E-08	0.00	5.72E+09	-0.00490	213391.	0.00
38.7200	7.17E-08	3.0087	-0.08188	-8.00E-09	0.00	5.72E+09	-0.00294	216876.	0.00
39.1600	3.68E-08	2.5480	-0.09371	-5.43E-09	0.00	5.72E+09	-0.00154	220360.	0.00
39.6000	1.43E-08	2.0401	-0.09937	-3.31E-09	0.00	5.72E+09	-6.08E-04	223845.	0.00
40.0400	1.81E-09	1.5115	-0.1012	-1.67E-09	0.00	5.72E+09	-7.78E-05	227330.	0.00
40.4800	-3.35E-09	0.9781	-0.1010	-5.25E-10	0.00	5.72E+09	1.46E-04	230815.	0.00
40.9200	-3.73E-09	0.4470	-0.1002	1.33E-10	0.00	5.72E+09	1.66E-04	234300.	0.00
41.3600	-1.94E-09	-0.08020	-0.05885	3.03E-10	0.00	5.72E+09	0.01549	4.22E+07	0.00
41.8000	-5.34E-10	-0.1756	-0.00155	1.85E-10	0.00	5.72E+09	0.00622	6.15E+07	0.00
42.2400	1.35E-11	-0.09724	0.01433	5.88E-11	0.00	5.72E+09	-2.07E-04	8.08E+07	0.00
42.6800	8.68E-11	-0.02447	0.00944	2.59E-12	0.00	5.72E+09	-0.00165	1.00E+08	0.00
43.1200	4.09E-11	0.00242	0.00265	-7.59E-12	0.00	5.72E+09	-9.24E-04	1.19E+08	0.00
43.5600	6.69E-12	0.00355	-2.31E-04	-4.83E-12	0.00	5.72E+09	-1.67E-04	1.32E+08	0.00
44.0000	-1.02E-11	0.00	0.00	-3.20E-12	0.00	5.72E+09	2.55E-04	6.60E+07	0.00

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

Output Summary for Load Case No. 1:

Crockett Bridge Abutment 2 9in diam piles 6 ksi concrete filled thick pipe.lp8o

```
Pile-head deflection            =     0.44000000 inches
Computed slope at pile head     =     0.00235506 radians
Maximum bending moment          =      -1823797. inch-lbs
Maximum shear force             =         37351. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              7
Number of zero deflection points =             7
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4400	S, rad	0.00245	365000.	0.4400	0.00236	37351.	-1823797.

Maximum pile-head deflection = 0.440000000 inches
Maximum pile-head rotation = 0.002355064 radians

The analysis ended normally.

USGS Design Maps Detailed Report

2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (43.92593°N, 70.61586°W)

Site Class D – "Stiff Soil"

Article 3.4.1 — Design Spectra Based on General Procedure

Note: Maps in the 2009 AASHTO Specifications are provided by AASHTO for Site Class B. Adjustments for other Site Classes are made, as needed, in Article 3.4.2.3.

From Figure 3.4.1-2 [1]	PGA = 0.096 g
From Figure 3.4.1-3 [2]	S_S = 0.189 g
From Figure 3.4.1-4 [3]	S_1 = 0.048 g

Article 3.4.2.1 — Site Class Definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Article 3.4.2.

Table 3.4.2.1–1 Site Class Definitions

SITE CLASS	SOIL PROFILE NAME	Soil shear wave velocity, $\overline{v}_S$, (ft/s)	Standard penetration resistance, $\overline{N}$	Soil undrained shear strength, $\overline{s}_u$, (psf)
A	Hard rock	$\overline{v}_S > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \overline{v}_S \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \overline{v}_S \leq 2{,}500$	$\overline{N} > 50$	>2,000 psf
D	Stiff soil profile	$600 \leq \overline{v}_S < 1{,}200$	$15 \leq \overline{N} \leq 50$	1,000 to 2,000 psf
E	Stiff soil profile	$\overline{v}_S < 600$	$\overline{N} < 15$	<1,000 psf
E	—	Any profile with more than 10 ft of soil having the characteristics: 1. Plasticity index *PI* > 20, 2. Moisture content *w* ≥ 40%, and 3. Undrained shear strength $\overline{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays (*H* > 10 feet of peat and/or highly organic clay where *H* = thickness of soil) 3. Very high plasticity clays (*H* > 25 feet with plasticity index *PI* > 75) 4. Very thick soft/medium stiff clays (*H* > 120 feet)		

For SI: 1ft/s = 0.3048 m/s 1lb/ft^2 = 0.0479 kN/m^2

Article 3.4.2.3 — Site Coefficients

Table 3.4.2.3-1 (for F_{pga})—Values of F_{pga} as a Function of Site Class and Mapped Peak Ground Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.096 g, F_{PGA} = 1.600

Table 3.4.2.3-1 (for F_a)—Values of F_a as a Function of Site Class and Mapped Short-Period Spectral Acceleration Coefficient

Site Class	Spectral Response Acceleration Parameter at Short Periods				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.189 g, F_a = 1.600

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_1

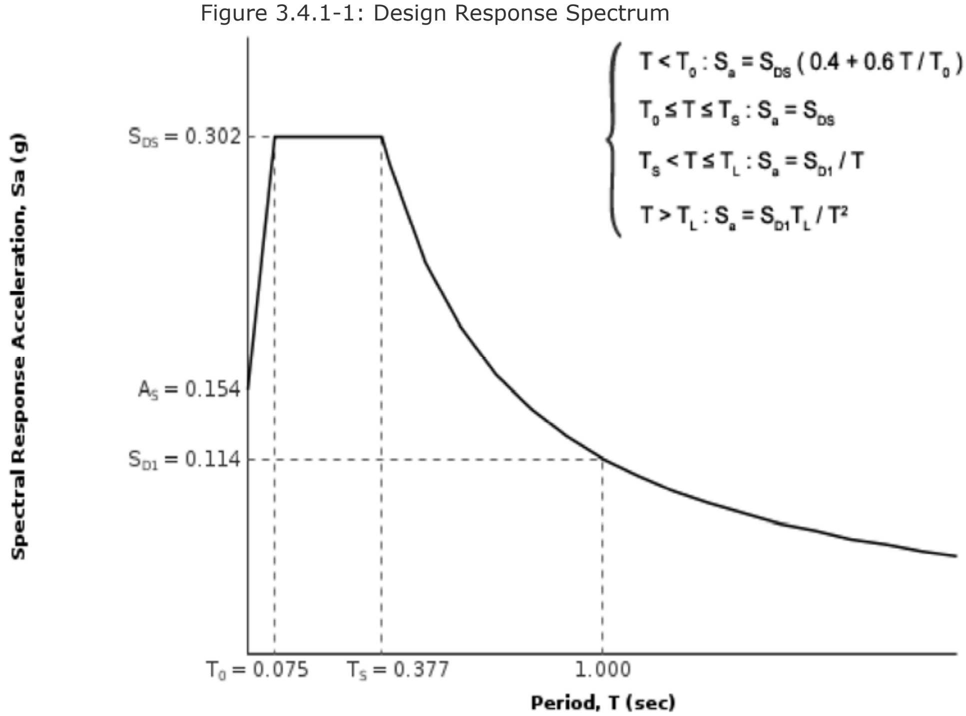
For Site Class = D and S_1 = 0.048 g, F_v = 2.400

Equation (3.4.1-1): $A_S = F_{PGA}\,PGA = 1.600 \times 0.096 = 0.154$ g

Equation (3.4.1-2): $S_{DS} = F_a\,S_S = 1.600 \times 0.189 = 0.302$ g

Equation (3.4.1-3): $S_{D1} = F_v\,S_1 = 2.400 \times 0.048 = 0.114$ g

Figure 3.4.1-1: Design Response Spectrum



Article 3.5 - Selection of Seismic Design Category (SDC)

Table 3.5-1—Partitions for Seismic Design Categories A, B, C, and D

VALUE OF S_{D1}	SDC
$S_{D1} < 0.15g$	A
$0.15g \le S_{D1} < 0.30g$	B
$0.30g \le S_{D1} < 0.50g$	C
$0.50g \le S_{D1}$	D

For S_{D1} = 0.114 g, Seismic Design Category = A

Seismic Design Category ≡ "the design category in accordance with Table 3.5-1" = A

References

1. *Figure 3.4.1-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-2.pdf
2. *Figure 3.4.1-3*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-3.pdf
3. *Figure 3.4.1-4*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-4.pdf