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MEMORANDUM

To: David Burhans, T.Y. Lin, David.Burhans@tylin.com

From: Jason Keohane, Jason.Keohane@gza.com
Andrew Blaisdell, P.E., andrew.blaisdell@gza.com
Michael Smith, P.E., Michael.smith@gza.com

Date: August 21, 2026

File No.: 09.0026331.00

Re: Mast Arm Design Memorandum
Elm Street Mast Arms (WIN 25653.00)
Biddeford, Maine



GZA GeoEnvironmental, Inc. (GZA) is pleased to provide this design memorandum to T. Y. Lin International (TYLin, Client) summarizing the exploration program, laboratory testing and geotechnical design of mast arms for the subject project. The work was completed in accordance with GZA's subconsultant agreement with TYLin dated April 15, 2026 and the change order dated May 26, 2026. Calculations included herein are in accordance with AASHTO LRFD 10th Edition. This memorandum is subject to the limitations attached in **Appendix A**.

The project is composed of an approximately 600-foot-long section of Elm Street (Route 1) which includes the intersections with Lincoln Street to the south and Diamond Street/Upper Falls Road to the north (the Site). Four mast arm foundations are proposed, with three at the Diamond Street/Upper Falls intersection and one at the Lincoln Street intersection.

SUBSURFACE EXPLORATIONS

GZA visited the Site on April 27, 2026, to mark proposed boring locations for utility clearance. Proposed boring locations were adjusted to reduce potential conflicts with overhead utilities and previously marked underground utilities. Our drilling subcontractor, Seaboard Drilling, LLC of Bangor, Maine (Seaboard), then submitted a DigSafe ticket at least three business days prior to drilling and hired a private utility locator.

Seaboard mobilized to the Site on May 4, 2026, along with their vacuum excavator subcontractor to pre-excavate the four (4) test borings, HB-BES-101 to HB-BES-104, using vacuum excavation methods. The vacuum excavations extended to a desired depth of about 4 to 5 feet below ground surface (bgs) which encountered frequent angular gravel and cobbles (apparent blast rock fill). The vacuum excavations were backfilled with the spoils upon completion.

Seaboard drilled the test borings between May 4 and May 5, 2026, at the locations shown in **Figures 1 and 2**. The test borings were drilled using a Diedrich D-50 ATV rig to depths ranging



from approximately 16.5 to 21.5 feet bgs. GZA observed and logged the vacuum excavation and drilling and prepared logs of the test borings which are included in **Appendix B**.

The borings were drilled using a combination of hollow stem augers and 4-inch driven casing and drive and wash drilling techniques. Standard penetration testing (SPT) and split-spoon sampling were performed nearly continuously in the upper 12 feet, then at typical 5-foot intervals thereafter. Sampling was completed using a 24-inch-long, 1-3/8-inch inside-diameter sampler. SPTs were conducted using automatic hammer Seaboard SN 202102 which had a rated hammer energy transfer ratio of 1.009 at the time of drilling.

In three borings, approximately 5 feet of rock core was taken using NQ (2.0-inch diameter) coring equipment. A photographic log of recovered rock cores is provided in **Appendix C**. Test boring HB-BES-102 was terminated after encountering top of weathered rock at 16.5 feet bgs. At the completion of drilling, the borings were backfilled with cuttings and sand, then cold patched.

LABORATORY TESTING

GZA retained Thielsch Engineering's Geotechnical Laboratory in Cranston, Rhode Island to complete laboratory testing to assess the gradation and index properties of the soil, as well as two rock core compressive strength tests. The testing program is summarized in the table below:

COMPLETED LABORATORY TESTS		
Laboratory Test	ASTM Standard	Number of Tests
Grain Size Analysis	D6913	11
Atterberg Limits	D4318	2
Moisture Content	D2216	5
Organic Content	D2974	4
Compressive Strength of Rock	D7012	2

Results of the testing were used to review soil descriptions in the boring logs and to develop engineering properties for soil and bedrock and are included in **Appendix D**.

SUBSURFACE CONDITIONS

In general, two typical subsurface profiles were identified for use in engineering evaluations, which are summarized below.

Profile 1 (HB-BES-101 and -102): About 16 to 17 feet of primarily loose to medium dense granular soil overlying bedrock. The overburden had energy corrected SPT values (N_{60} values) ranging from 3 to 72 blows per foot (bpf), with increasing density with depth in HB-BES-101 and generally a loose consistency throughout in HB-BES-102. The overburden profile consisted of about 5 to 8 feet of fill (fine to coarse SAND, little to some gravel, trace silt, with angular cobbles), overlying 1 to 2 feet of relic topsoil with organics (silty fine to medium SAND, trace gravel, with organics), overlying approximately 2 to 7 feet of alluvium (very loose to medium dense SILT to fine SAND), overlying marine sand in HB-BES-102 only (very dense, sandy GRAVEL to gravelly SAND, little to some silt). Test boring HB-BES-102 encountered top of weathered rock at 16.5 feet bgs with no rock coring performed. Test boring HB-BES-101 encountered Phyllite bedrock at 16.3 feet bgs and collected one rock core which had a Rock Quality Designation (RQD) of 55 percent.



Profile 2 (HB-BES-103 and -104): About 11 to 14 feet of soil consisting mostly of granular fill overlying bedrock. The overburden consisted of about 10 feet of granular fill with all refusal N-values (less than 2 to 3 inches for 50 blows) and varied from SAND to GRAVEL. The material was difficult to sample with a split spoon due to the angular cobbles and boulders encountered, which were likely blasted rock fragments used as fill. Therefore, the N-values may not be representative of the density of the sandy soils in between the rock fragments. Test boring HB-BES-103 encountered weathered rock underlying fill, while test boring HB-BES-104 encountered 2 feet of relic topsoil and 1 foot of marine sand between fill and weathered rock. Both borings encountered approximately 1 foot of weathered rock, followed by Phyllite bedrock which was cored in both borings with RQDs between 33 and 47 percent.

For both profiles, water level readings taken immediately upon completion of drilling with no stabilization time ranged from 8 to 10 feet bgs. Groundwater observations have been made at the times and under the conditions stated in the test borings logs. Groundwater measurements made during drilling may not represent stabilized groundwater conditions. Fluctuations in groundwater levels will occur due to variations in seasonal influences, precipitation amounts, and other factors different from those existing at the time the observations were made.

MAST ARM DESIGN

Each subsurface profile was developed into a model and analyzed using the design software FB-MultiPier software (by BSI) to assess the lateral performance of drilled shaft foundations. TYLin calculated three load cases for each mast arm which included axial, shear, moment and torsional forces applied at the top of drilled shaft. Therefore, six load cases were used for each model. GZA evaluated a range of shaft diameters and required embedment depths as needed based on a maximum lateral movement of 0.5 inches for the unfactored Service loads at the top of the drilled shaft along with confirmation that the lengths were not marginal relative to potential excessive deformation.

Profile 1 was modeled entirely as loose sand, assuming that bedrock would not be encountered. Profile 2 was modeled as dense sand overlying bedrock assuming that a rock socket would be needed. The overburden soils were modeled as “Reese Sand” with strength properties including stiffness coefficient (k), friction angle, and shear modulus calculated based on empirical correlations with N_{60} values. Visual descriptions and lab gradations of soil were used to estimate effective unit weight and Poisson’s ratio. Ultimate unit skin friction in sand was calculated using the beta method, which is a function of vertical effective stress and the interface friction angle. Additional details of our assumptions and inputs are included in **Appendix E**.

For bedrock properties, the effective unit weight and Poisson’s ratio were taken directly from laboratory test results on the two intact rock samples. The initial modulus of rock mass and shear modulus input into the model are both based off of the design basis equivalent rock modulus; The design modulus is calculated in accordance with AASHTO LRFD Section 10.4.6.4 which utilizes elastic secant modulus of intact rock (from lab testing) and rock quality of cores using the geologic strength index (GSI). Although the laboratory results show a higher unconfined compressive strength (UCS) of intact rock, the UCS input was limited to 2,000 psi due to the calibration of the “weak rock” p-y curve model used. Ultimate unit skin friction in rock was calculated in accordance with empirical correlations presented in AASHTO Section 10.8.3.5. Additional details of our assumptions and inputs are included in **Appendix E**.

The calculations and proposed drilled shaft properties have been included in **Appendix E**. A drilled shaft diameter of 3 feet was selected for all four drilled shafts. TYLin Mast Arms #1, #3 and #4 will have a minimum overburden embedment of 15 feet with no rock socket required. Mast Arm #2 will have an overburden embedment of 13 feet or less, with a 2.5-foot-diameter rock socket embedded at least 2 feet into bedrock. Reinforcement requirements developed from our calculations are presented on the drilled shaft foundation design plans, **Figures 1 and 2**. A summary of the results of the FB-MultiPier analyses is presented in the following table.



SUMMARY OF FB-MULTIPLIER RESULTS		
Parameter	Profile 1 Result	Profile 2 Result
Maximum Lateral Displacement, Service	0.1 inch	0.02 in
Maximum Moment, Strength	70 kip-ft	27 kip-ft
Demand/Capacity Ratio, Strength	0.09	0.03
Maximum Moment, Extreme	136 kip-ft	64 kip-ft
Demand/Capacity Ratio, Extreme	0.18	0.08

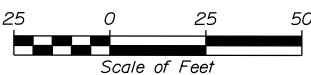
CLOSING

We trust this provides the information you need at this time. Please contact Jason Keohane at 207-358-5125 if you have any questions.

Attachments: Figures 1 and 2 – Foundation Design Plans (by TYLin)
Appendix A – Limitations
Appendix B – Test Boring Logs
Appendix C – Rock Core Photographic Log
Appendix D – Laboratory Test Results
Appendix E – Mast Arm Design Calculations



Figures 1 and 2 – Foundation Design Plans (by TYLin)



Approximate location and designation of 100-Series cased wash borings by GZA

1. All reinforcing steel is to be grade 60 and conform to MaineDOT Standard Specification requirements along with any project specific Supplementals or Special Provisions.

2. All rebar shall have 6" cover unless otherwise noted.

3. Should there be a discrepancy between these Details and actual observed field conditions report it to the Resident immediately.

4. Do not proceed with dependent work until any such discrepancy is resolved to the satisfaction of the Resident.

5. Concrete to be Class LP with $f'_c = 5,000$ PSI.

6. Item 626.44 (36" Diameter Foundation) shall be 15' long, unless competent rock is encountered at 13' below top of shaft or less, in which case a rock socket shall be provided in accordance with the dimensions provided in the summary table.

7. Foundation sizes are designed based on estimated loading conditions and are subject to change based on the design of the above-ground components and the actual loading conditions at the top of each foundation submitted by the Contractor in accordance with Standard Specification Section 62d.034. Any increase in foundation size based on the submitted loading conditions shall be paid for at the unit price bid by the Contractor. Any reduction in foundation size shall be to the benefit of the Department at the unit price bid by the Contractor.

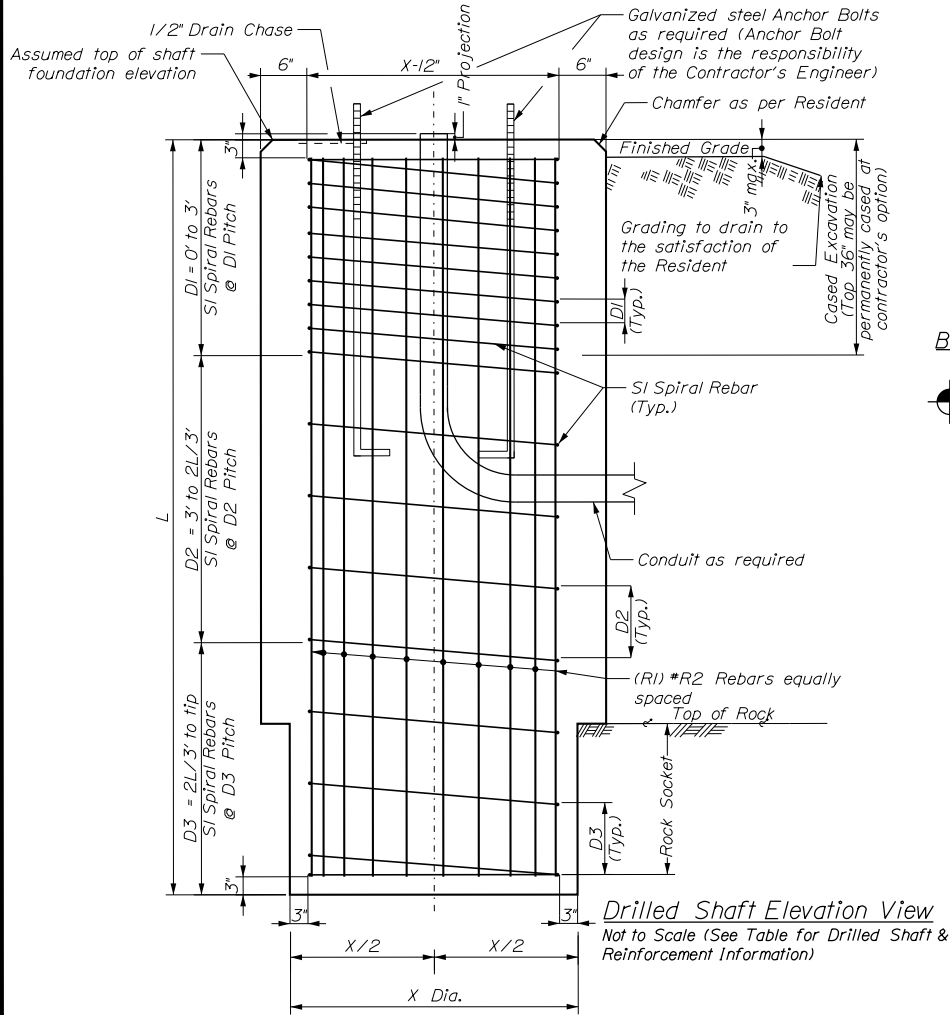
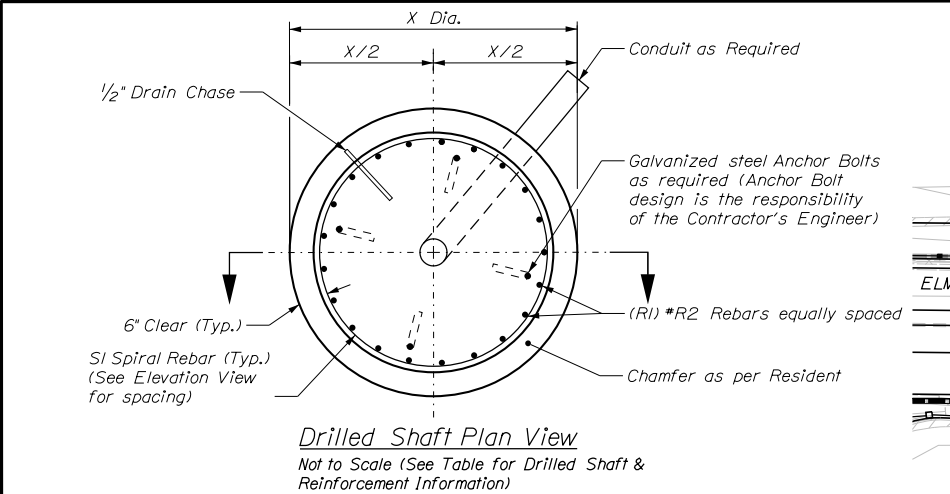
Page 1 of 1
Boring No.: HE-BES-102

Page 1 of 1
Boring No.: HB-BES-103

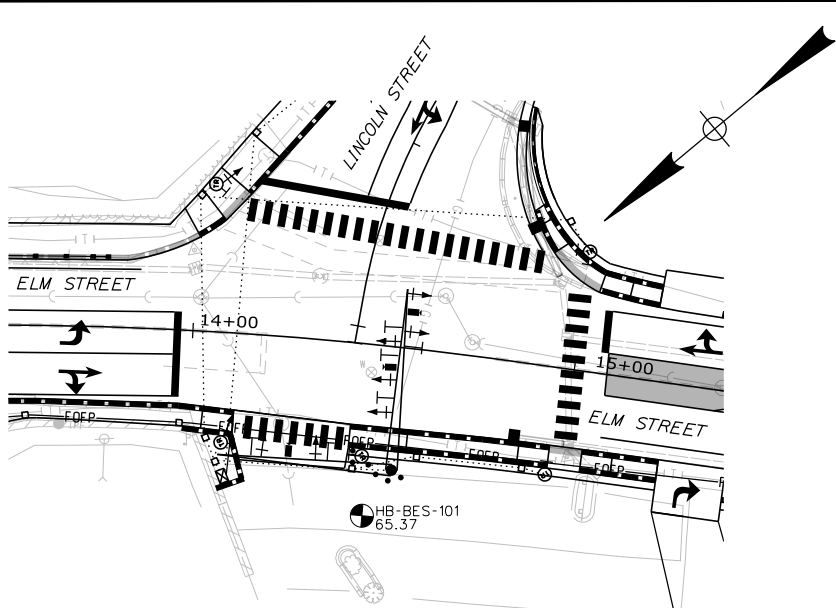
Page 1 of 1
Boring No.: HB-BES-104

FOUNDATION DESIGN PLANS

PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED BY: T.Y. LIN INTERNATIONAL	
PROJ MGR:	JLK	REVIEWED BY:	ARB
DESIGNED BY:	---	DRAWN BY:	---
DATE: AUGUST 2026	PROJECT NO. 09.0026331.00	CHECKED BY:	MPS
		SCALE:	AS SHOWN
		REVISION NO.	0
		SHEET NO: 1 OF 2	



MAST ARM FOUNDATION
LINCOLN / ELM STREET



BORING LOCATION PLAN LEGEND

HB-BES-101 Approximate location and designation of 100-Series cased wash borings by GZA

NOTES:

1. All reinforcing steel is to be grade 60 and conform to MaineDOT Standard Specification requirements along with any project specific Supplementals or Special Provisions.
2. All rebar shall have 6" cover unless otherwise noted.
3. Should there be a discrepancy between these Details and actual observed field conditions report it to the Resident immediately.
4. Do not proceed with dependent work until any such discrepancy is resolved to the satisfaction of the Resident.
5. Concrete to be Class LP with $f'c = 5,000$ PSI.
6. Foundation sizes are designed based on estimated loading conditions and are subject to change based on the design of the above-ground components and the actual loading conditions at the top of each foundation submitted by the Contractor in accordance with Standard Specification Section 62d.034. Any increase in foundation size based on the submitted loading conditions shall be paid for at the unit price bid by the Contractor. Any reduction in foundation size shall be to the benefit of the Department at the unit price bid by the Contractor.

Maine Department of Transportation				Project: Elm Street Mast Arms		Boring No.: HB-BES-101	
SoilBorC Exploration Log				Location: Biddeford, Maine		WIN: 28114.00	
US CUSTOMARY UNITS							
Driller:	SoilBorC Drilling	Elevation (ft.):	65.4	Auger ID/OD:	2.25/4.25"		
Operator:	J. Woodhull	Datum:	NAVD88	Sampler:	Splintpost		
Logged By:	S. Miller	Rig Type:	Duick D-50	Hammer Wt./Fall:	1800/30"		
Core Start/Finish:	8/20/2025 - 8/20/2025	Drilling Method:	SSA	Core Barrel:	N2		
Boring Location:	N241703.8, E902529.5	Casing ID/OD:	N/A	Water Level:	N/A		
Hammer Efficiency Factor:	1.02	Hammer Type:	Automatic D	Hydraulic C	Ropecl Collared C		
Notes:				Notes:			
D1 = Split Spoon Sample				R1 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				T2 = Pusher Torque (lb-ft)			
L1 = Thin Wall Tube Sample				H1 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H2 = Hardness			
R1 = Hardness				H3 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H4 = Hardness			
L1 = Thin Wall Tube Sample				H5 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H6 = Hardness			
R1 = Hardness				H7 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H8 = Hardness			
L1 = Thin Wall Tube Sample				H9 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H10 = Hardness			
R1 = Hardness				H11 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H12 = Hardness			
L1 = Thin Wall Tube Sample				H13 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H14 = Hardness			
R1 = Hardness				H15 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H16 = Hardness			
L1 = Thin Wall Tube Sample				H17 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H18 = Hardness			
R1 = Hardness				H19 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H20 = Hardness			
L1 = Thin Wall Tube Sample				H21 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H22 = Hardness			
R1 = Hardness				H23 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H24 = Hardness			
L1 = Thin Wall Tube Sample				H25 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H26 = Hardness			
R1 = Hardness				H27 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H28 = Hardness			
L1 = Thin Wall Tube Sample				H29 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H30 = Hardness			
R1 = Hardness				H31 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H32 = Hardness			
L1 = Thin Wall Tube Sample				H33 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H34 = Hardness			
R1 = Hardness				H35 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H36 = Hardness			
L1 = Thin Wall Tube Sample				H37 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H38 = Hardness			
R1 = Hardness				H39 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H40 = Hardness			
L1 = Thin Wall Tube Sample				H41 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H42 = Hardness			
R1 = Hardness				H43 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H44 = Hardness			
L1 = Thin Wall Tube Sample				H45 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H46 = Hardness			
R1 = Hardness				H47 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H48 = Hardness			
L1 = Thin Wall Tube Sample				H49 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H50 = Hardness			
R1 = Hardness				H51 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H52 = Hardness			
L1 = Thin Wall Tube Sample				H53 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H54 = Hardness			
R1 = Hardness				H55 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H56 = Hardness			
L1 = Thin Wall Tube Sample				H57 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H58 = Hardness			
R1 = Hardness				H59 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H60 = Hardness			
L1 = Thin Wall Tube Sample				H61 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H62 = Hardness			
R1 = Hardness				H63 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H64 = Hardness			
L1 = Thin Wall Tube Sample				H65 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H66 = Hardness			
R1 = Hardness				H67 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H68 = Hardness			
L1 = Thin Wall Tube Sample				H69 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H70 = Hardness			
R1 = Hardness				H71 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H72 = Hardness			
L1 = Thin Wall Tube Sample				H73 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H74 = Hardness			
R1 = Hardness				H75 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H76 = Hardness			
L1 = Thin Wall Tube Sample				H77 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H78 = Hardness			
R1 = Hardness				H79 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H80 = Hardness			
L1 = Thin Wall Tube Sample				H81 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H82 = Hardness			
R1 = Hardness				H83 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H84 = Hardness			
L1 = Thin Wall Tube Sample				H85 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H86 = Hardness			
R1 = Hardness				H87 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H88 = Hardness			
L1 = Thin Wall Tube Sample				H89 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H90 = Hardness			
R1 = Hardness				H91 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H92 = Hardness			
L1 = Thin Wall Tube Sample				H93 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H94 = Hardness			
R1 = Hardness				H95 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H96 = Hardness			
L1 = Thin Wall Tube Sample				H97 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H98 = Hardness			
R1 = Hardness				H99 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H100 = Hardness			
L1 = Thin Wall Tube Sample				H101 = Hardness			
M1 = Unconsolidated Thin Wall Tube Sample attempt				H102 = Hardness			
R1 = Hardness				H103 = Hardness			
M2 = Unconsolidated Split Spoon Sample attempt				H104 = Hardness			
L1 = Thin Wall Tube Sample				H105 = Hardness			

Visual Description and Remarks		Laboratory Testing Results	
		ASTM D1586	
		Unified Class	



Appendix A – 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

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Location: Biddeford, Maine

WIN: 28114.00

Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐

Corrected C = Consolidation Test

Remarks:

1. Automatic hammer Seaboard Drilling #367, energy transfer ratio = 1.022.
2. Used vacuum excavation techniques to advance the borehole from ground surface to approximately 5 feet below ground surface (bgs) on May 4, 2026. Upon completion of the vacuum excavation, the borehole was backfilled with sand then drilling resumed on May 6, 2026.
3. Fine grained soil descriptions on this log are based on plasticity estimated using visual classification techniques or laboratory Atterberg Limit Test if available, rather than the MaineDOT standard based percentages passing specific grain sizes.
4. Water level measured with augers in place immediately after boring completion.

Page 1 of 1
Boring No.: HB-BES-101

* 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.

[illegible]



Appendix C – Rock Core Photographic Log



Elm Street Mast Arms
MaineDOT WIN 25653.00
Biddeford, ME
Rock Core Photographic Log

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type	Box Row
HB-BES-103	R1	11.5 - 16.8	60	100	28	47	PHYLLITE	1
HB-BES-104	R1	4.5 - 8.5	16	33	N/A	N/A	BOULDER (Fill)	2
HB-BES-104	R2	14.0 - 19.0	60	100	20	33	PHYLLITE	3
HB-BES-101	R1	16.5 - 21.5	60	100	33	55	PHYLLITE	4



- Notes:**
1. Box row corresponds to the core box section in which the rock core sample is contained; Row 1=Top, Row 4=Bottom.
 2. Top photo is dry, bottom photo is wet.



Appendix D – Laboratory Test Results

 Thielsch DIVISION OF THE RISE GROUP	195 Frances Avenue Cranston RI, 02910 Phone: (401)-467-6454 Fax: (401)-467-2398 cts.thielsch.com <i>Let's Build a Solid Foundation</i>	Client Information: GZA GeoEnvironmental, Inc. Portland, ME (207) 879-9190 Project Contact: Jason Keohane Collected By: S. Miller	Project Information: Elm Street Biddeford Mast Arms Biddeford, ME Project Number: 09.0026331.00 Task 3 Summary Page: 1 of 2 Report Date: 5/28/2026
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LABORATORY TESTING DATA SHEET, Report No.: 26E175

Boring No.	Sample ID	Depth	Laboratory No.	Identification Tests									Compaction		CBR					Permeability	Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	OD LL	Gravel %	Sand %	Fines %	Org. %	pH	9 _d MAX (pcf) W _{opt} (%)	9 _d MAX (pcf) W _{opt} (%) (Corr.)	Dry unit wt. (pcf)	Test Moisture Content %	Target Test Setup as % of Proctor	CBR @ 0.1"	CBR @ 0.2"	Permeability cm/sec	
				D2216	D4318		D6913			D2974	D4792	D698/D1557		D1883					D2434/D5084		
HB-BES-101	1D (Top 5")	5.0-5.4'	26-S-1720	10.8				29.0	61.1	9.9											Brown f-c SAND, some fine Gravel, trace Silt
HB-BES-101	1D (Bottom 7")	5.4-7.0'	26-S-1721	80.7	NV	NP		5.5	61.7	32.8	16.4										Dark Brown Organic f-m SAND, some Silt, trace fine Gravel
HB-BES-101	2D (Bottom 13")	7.4-9.0'	26-S-1722					1.3	24.2	74.5											Grey SILT, some fine Sand, trace fine Gravel
HB-BES-101	3D (Bottom 11")	10.2-12.0'	26-S-1723					38.8	38.0	23.2											Grey f-c GRAVEL and f-c SAND, some Silt
HB-BES-101	4D	15.0-16.3'	26-S-1724					38.2	50.0	11.8											Grey f-c SAND and f-c GRAVEL, little Silt
HB-BES-102	1D	5.0-7.0'	26-S-1725					13.3	79.6	7.1											Brown f-m SAND, little fine Gravel, trace Silt
HB-BES-102	2D (Bottom 4")	7.9-9.0'	26-S-1726	53.4	NV	NP		5.4	57.5	37.1	11.4										Brown f-m Organic SAND and SILT, trace fine Gravel
HB-BES-102	3D (Bottom 16")	10.3-12.0'	26-S-1727					0.0	94.5	5.5											Brown fine SAND, trace Silt
HB-BES-102	4D (6-19")	15.5-16.5'	26-S-1728	39.4				3.2	56.3	40.5	2.9										Dark Brown f-m SAND and Clayey SILT, trace fine Gravel
HB-BES-103	1D	5.0-6.3'	26-S-1729					53.7	33.6	12.7											Brown f-c GRAVEL, some f-c Sand, little Silt
HB-BES-104	GS-1	0.3-3.0'	26-S-1730					17.2	71.0	11.8											Dark Brown f-c SAND, little fine Gravel, little Silt
ASTM D2974 Organic Content performed by MS 05-20-26.																					

ASTM D2974 Organic Content performed by MS 05-20-26.

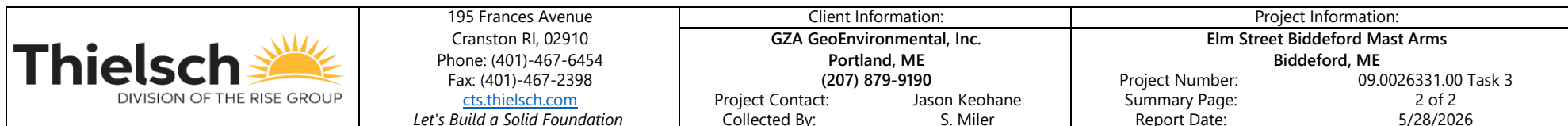
Date Received: 5/18/2026

Reviewed By: 

Date Reviewed: 5/28/2026

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Let's Build a Solid Foundation

Client Information:
GZA GeoEnvironmental, Inc.
Portland, ME
(207) 879-9190

Project Contact: Jason Keohane
Collected By: S. Miler

Project Information:	
Elm Street Biddeford Mast Arms	
Biddeford, ME	
Project Number:	09.0026331.00 Task 3
Summary Page:	2 of 2
Report Date:	5/28/2026

LABORATORY TESTING DATA SHEET, Report No.: 26E175

Date Received: 5/18/2026

Reviewed By:

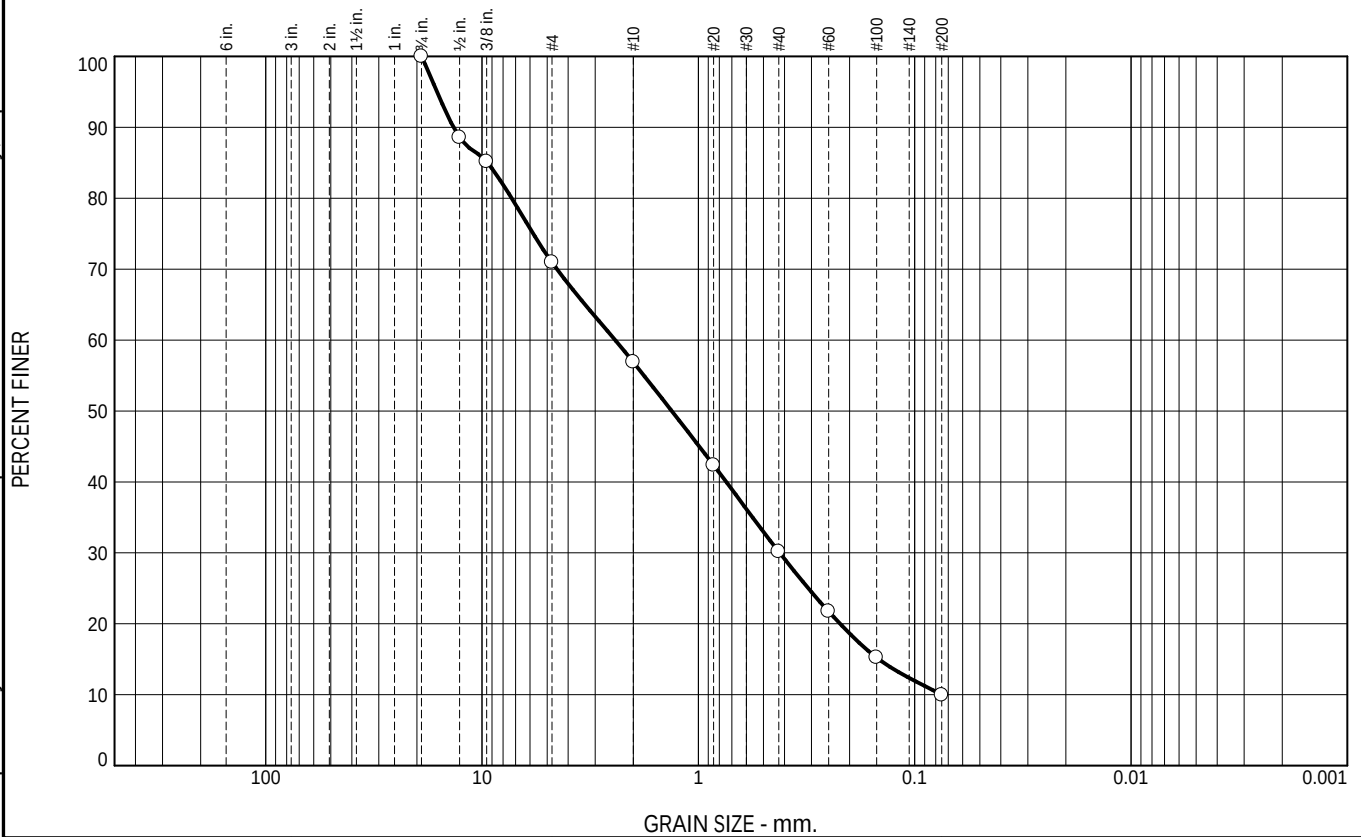
Date Reviewed: 5/28/2026

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	29.0	14.1	26.7	20.3	9.9	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	88.6		
3/8"	85.2		
#4	71.0		
#10	56.9		
#20	42.4		
#40	30.2		
#60	21.7		
#100	15.2		
#200	9.9		

* (no specification provided)

Soil Description
Brown f-c SAND, some fine Gravel, trace Silt

PL= NP Atterberg Limits LL= NV PI= NP
Coefficients
D₉₀= 13.5417 D₈₅= 9.4343 D₆₀= 2.4243
D₅₀= 1.3272 D₃₀= 0.4209 D₁₅= 0.1467
D₁₀= 0.0756 C_u= 32.08 C_c= 0.97

USCS= SP-SM Classification AASHTO= A-1-b
Remarks

Source of Sample: Test Boring Depth: 5.0-5.4'
Sample Number: HB-BES-101, 1D T 5"

Date: 05-27-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

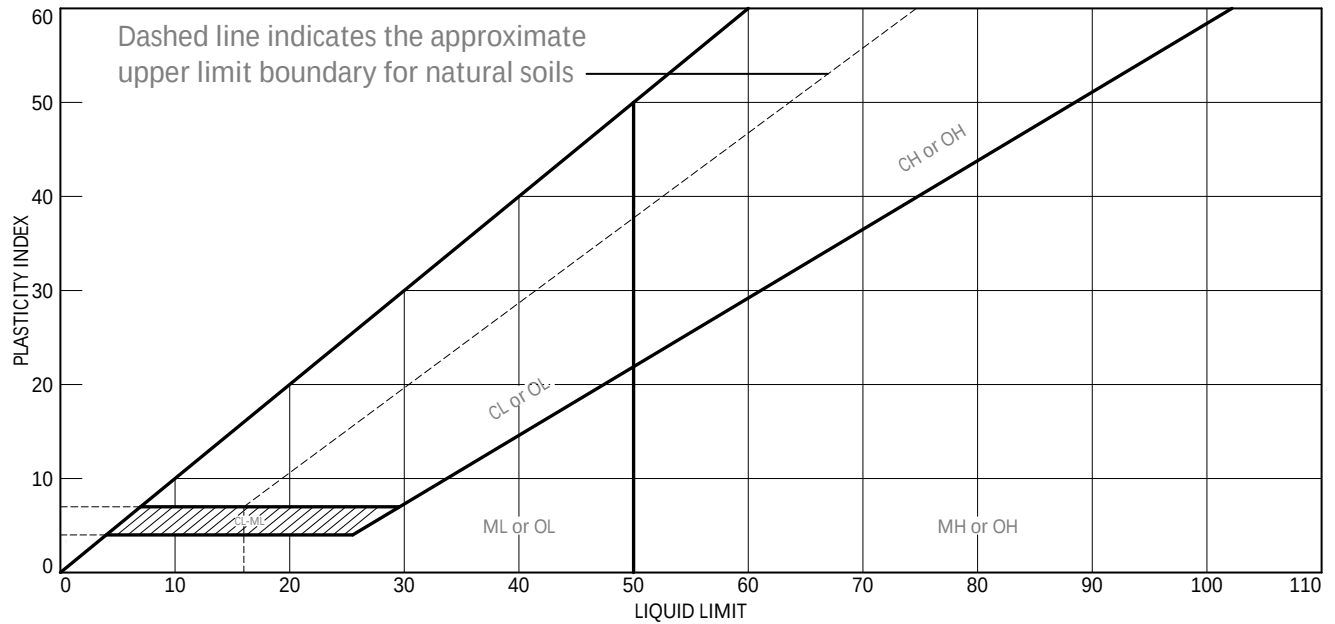
Figure S-1720

Tested By: MS/BR/AB

Checked By: Andrew Vanasse

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LIQUID AND PLASTIC LIMITS TEST REPORT



MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
Dark Brown Organic f-m SAND, some Silt, trace fine Gravel	NV	NP	NP	62.1	32.8	SM

Project No. 09.0026331.00 Task 3 Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME
Source of Sample: Test Boring Depth: 5.4-7.0'
Sample Number: HB-BES-101, 1D B 7"

Thielsch Engineering Inc.

Cranston, RI

Remarks:

- Sample classified as non-plastic and non-viscous. Sample could not roll past 1/4" and could not achieve more than 25 blows.

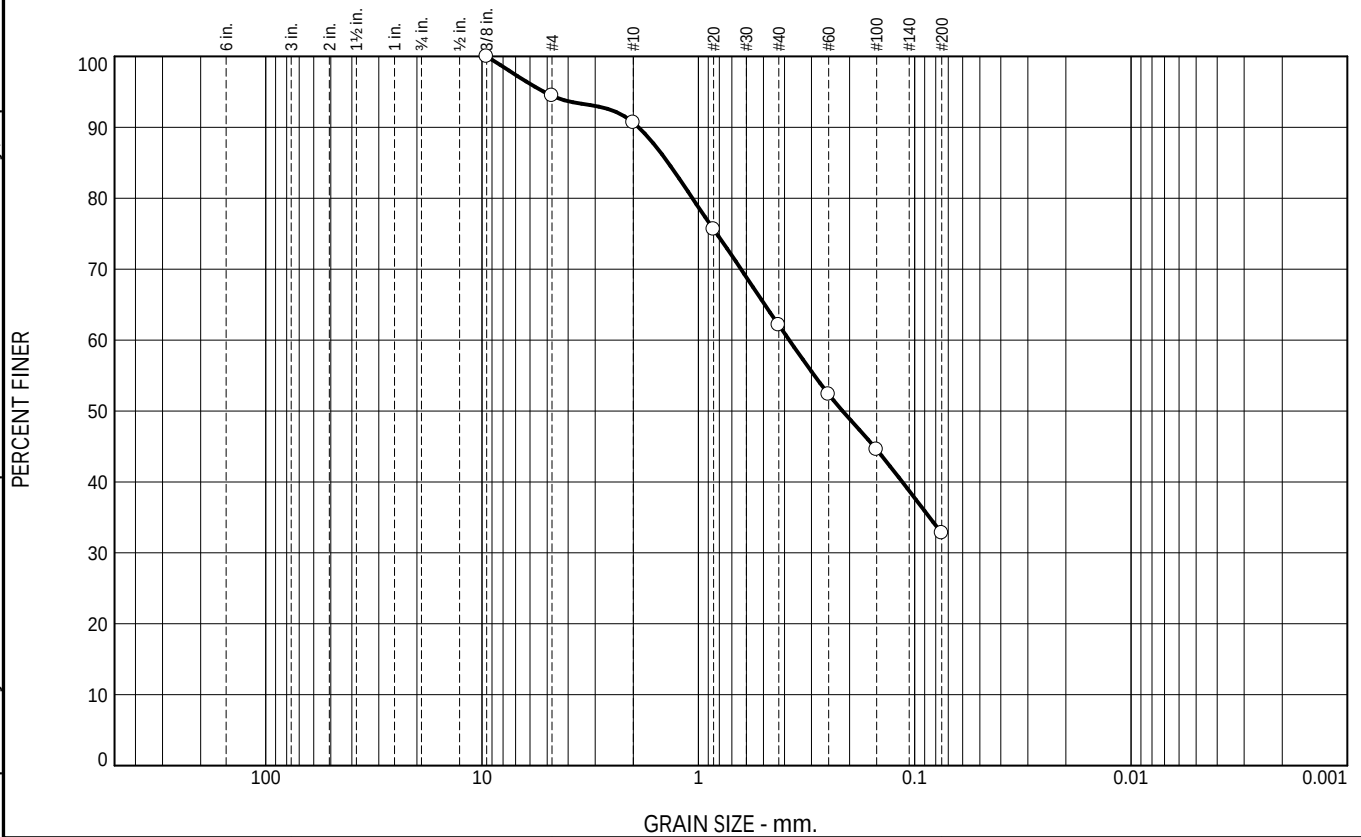
Figure S-1721

Tested By: SF

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.5	3.8	28.6	29.3	32.8	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	94.5		
#10	90.7		
#20	75.6		
#40	62.1		
#60	52.4		
#100	44.6		
#200	32.8		

* (no specification provided)

Soil Description
Dark Brown Organic f-m SAND, some Silt, trace fine Gravel

PL= NP **Atterberg Limits** LL= NV PI= NP
D₉₀= 1.8877 D₈₅= 1.3780 D₆₀= 0.3802
D₅₀= 0.2155 D₃₀= D₁₅=
D₁₀= C_u= C_c=

USCS= SM **Classification** AASHTO= A-2-4(0)

Remarks

Source of Sample: Test Boring Depth: 5.4-7.0'
Sample Number: HB-BES-101, 1D B 7"

Date: 05-27-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

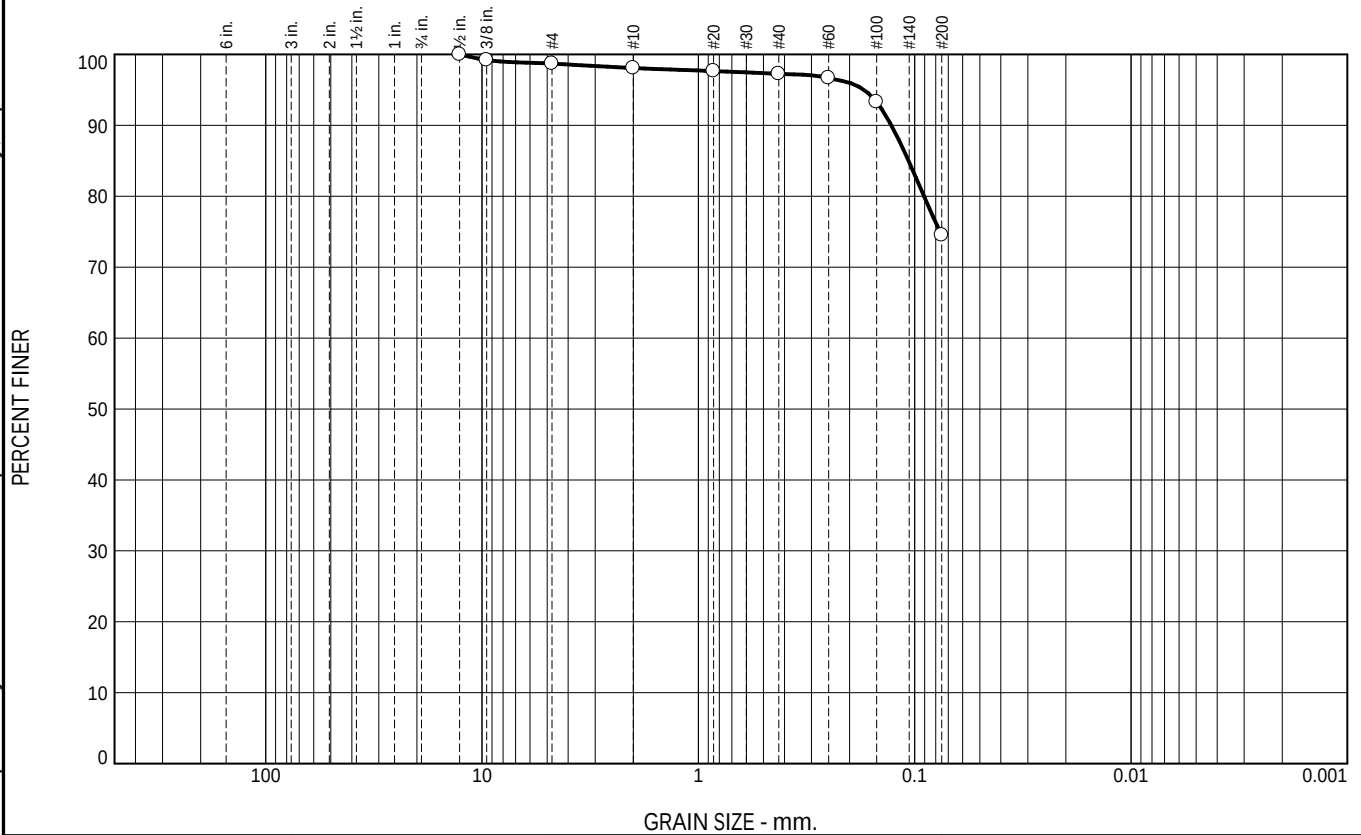
Figure S-1721

Tested By: AB/RB

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.3	0.6	0.8	22.8	74.5	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	99.2		
#4	98.7		
#10	98.1		
#20	97.7		
#40	97.3		
#60	96.7		
#100	93.3		
#200	74.5		

* (no specification provided)

Soil Description
Grey SILT, some fine Sand, trace fine Gravel

PL= NP **Atterberg Limits** LL= NV PI= NP

Coefficients
D₉₀= 0.1282 D₈₅= 0.1068 D₆₀=
D₅₀= D₃₀= D₁₅=
D₁₀= C_u= C_c=

USCS= ML **Classification** AASHTO= A-4(0)

Remarks
Sample visually classified as non-plastic. Sample could not be rolled to 1/4".

Source of Sample: Test Boring Depth: 7.4-9.0'
Sample Number: HB-BES-101, 2D B 13"

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

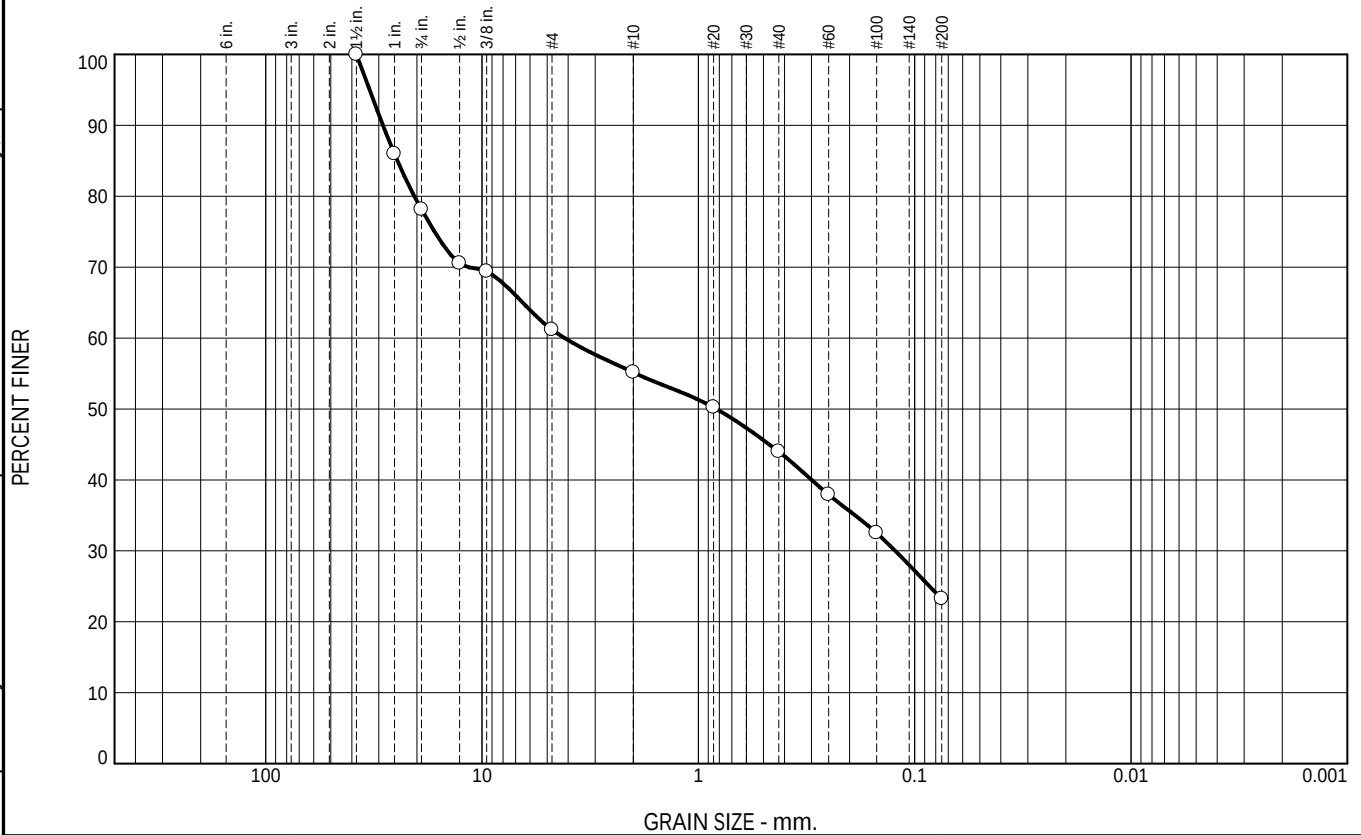
Figure S-1722

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	21.9	16.9	6.0	11.2	20.8	23.2	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	86.0		
3/4"	78.1		
1/2"	70.6		
3/8"	69.4		
#4	61.2		
#10	55.2		
#20	50.2		
#40	44.0		
#60	37.9		
#100	32.5		
#200	23.2		

* (no specification provided)

Soil Description
Grey f-c GRAVEL and f-c SAND, some Silt

PL= NP Atterberg Limits LL= NV PI= NP

Coefficients
D₉₀= 28.7097 D₈₅= 24.5963 D₆₀= 4.1484
D₅₀= 0.8249 D₃₀= 0.1230 D₁₅=
D₁₀= C_u= C_c=

Classification
USCS= GM AASHTO= A-1-b

Remarks

Source of Sample: Test Boring Depth: 10.2-12.0'
Sample Number: HB-BES-101, 3D B 11"

Date: 05-21-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

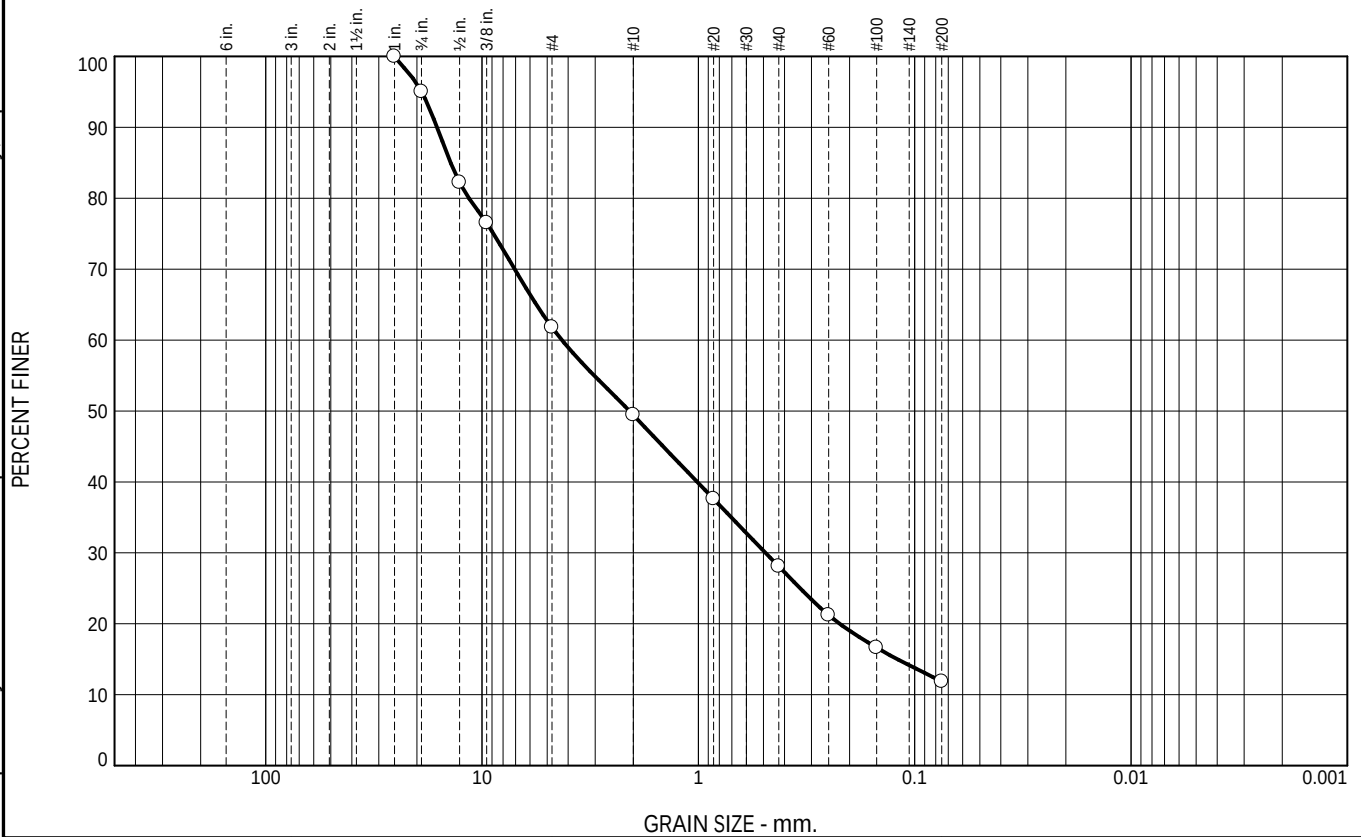
Figure S-1723

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspected and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	5.0	33.2	12.4	21.3	16.3	11.8	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	95.0		
1/2"	82.2		
3/8"	76.5		
#4	61.8		
#10	49.4		
#20	37.6		
#40	28.1		
#60	21.2		
#100	16.6		
#200	11.8		

* (no specification provided)

Soil Description
Grey f-c SAND and f-c GRAVEL, little Silt

PL= NP Atterberg Limits LL= NV PI= NP
Coefficients
D₉₀= 16.1496 D₈₅= 13.9569 D₆₀= 4.2711
D₅₀= 2.0824 D₃₀= 0.4898 D₁₅= 0.1202
D₁₀= C_u= C_c=

Classification
USCS= SP-SM AASHTO= A-1-a
Remarks

Source of Sample: Test Boring Depth: 15.0-16.3'
Sample Number: HB-BES-101, 4D

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

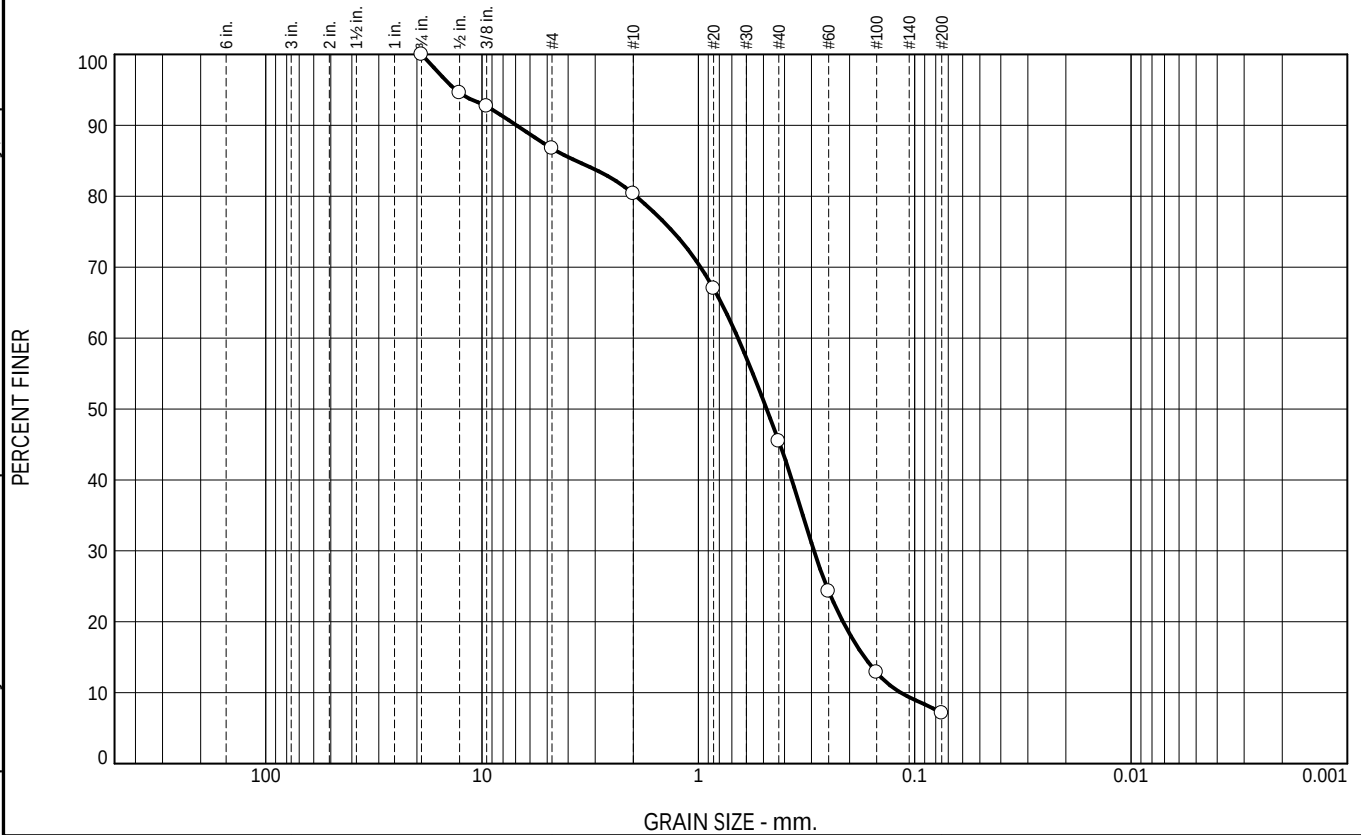
Figure S-1724

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	13.3	6.3	34.9	38.4	7.1	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	94.6		
3/8"	92.7		
#4	86.7		
#10	80.4		
#20	67.0		
#40	45.5		
#60	24.3		
#100	12.8		
#200	7.1		

* (no specification provided)

Soil Description
Brown f-m SAND, little fine Gravel, trace Silt

PL= NP Atterberg Limits LL= NV PI= NP

Coefficients
D₉₀= 6.9191 D₈₅= 3.6752 D₆₀= 0.6561
D₅₀= 0.4836 D₃₀= 0.2923 D₁₅= 0.1705
D₁₀= 0.1161 C_u= 5.65 C_c= 1.12

Classification
USCS= SP-SM AASHTO= A-1-b

Remarks

Source of Sample: Test Boring Depth: 5.0-7.0'
Sample Number: HB-BES-102, 1D

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

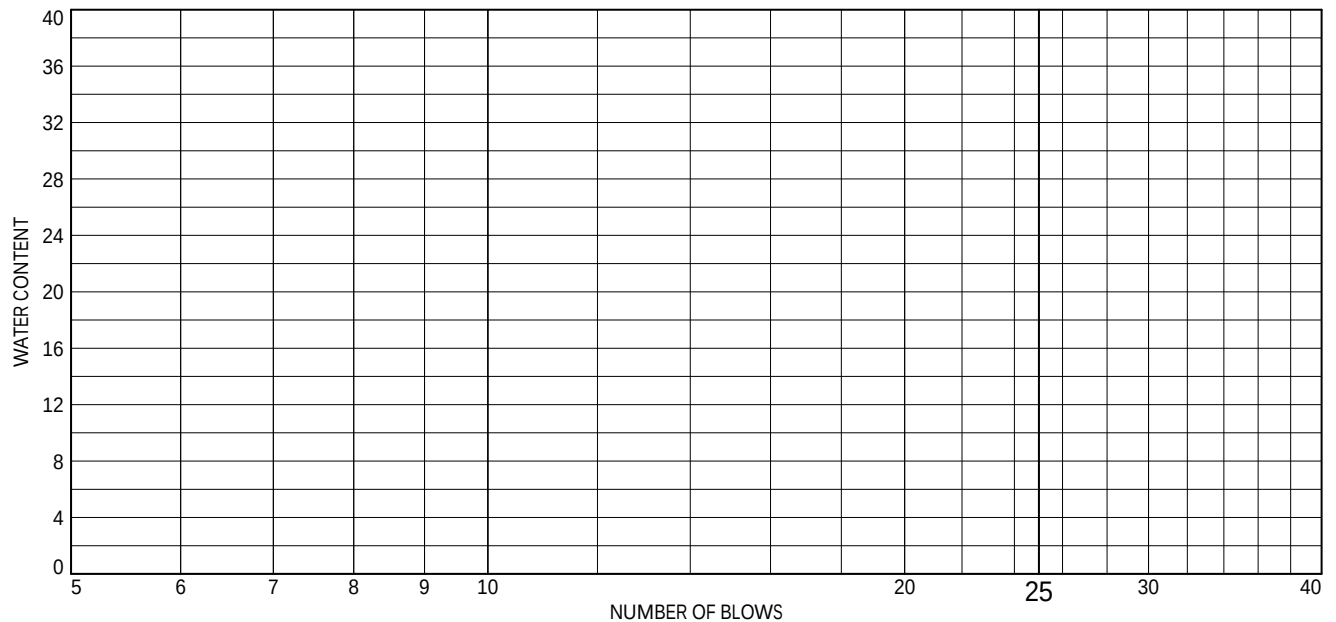
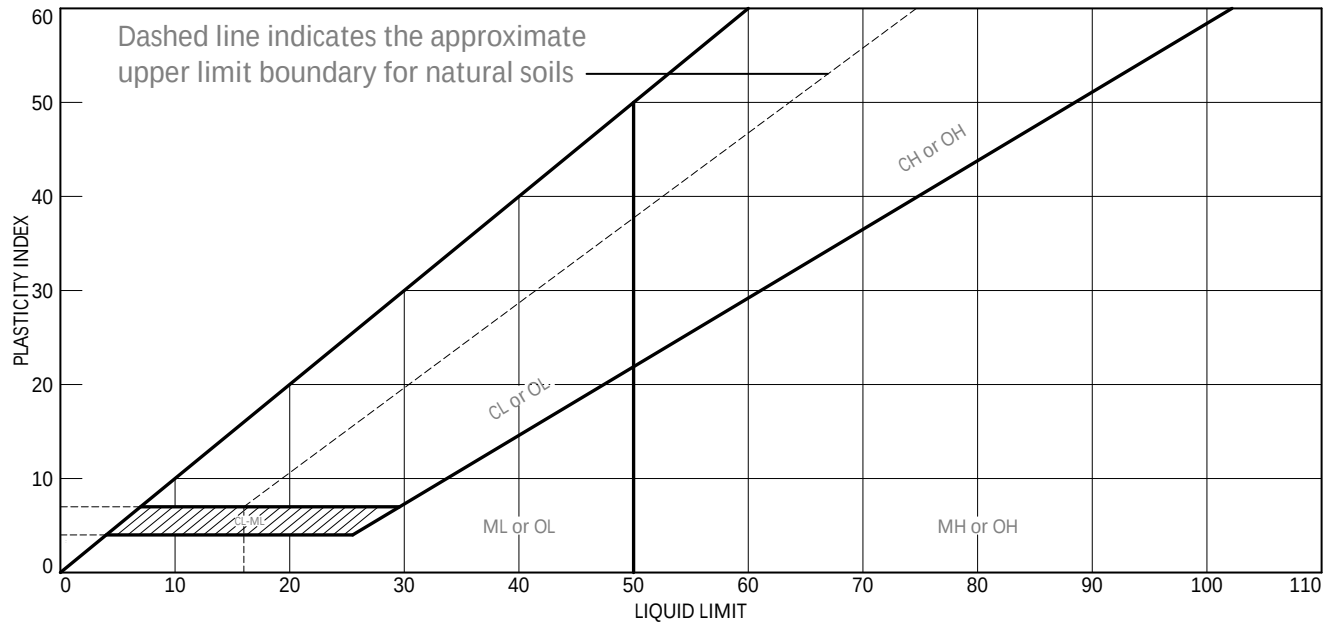
Figure S-1725

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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LIQUID AND PLASTIC LIMITS TEST REPORT



MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
Brown f-m Organic SAND and SILT, trace fine Gravel	NV	NP	NP	69.1	37.1	SM

Project No. 09.0026331.00 Task 3 Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME
Source of Sample: Test Boring Depth: 7.9-9.0'
Sample Number: HB-BES-102, 2D B 4"

Thielsch Engineering Inc.

Cranston, RI

Remarks:

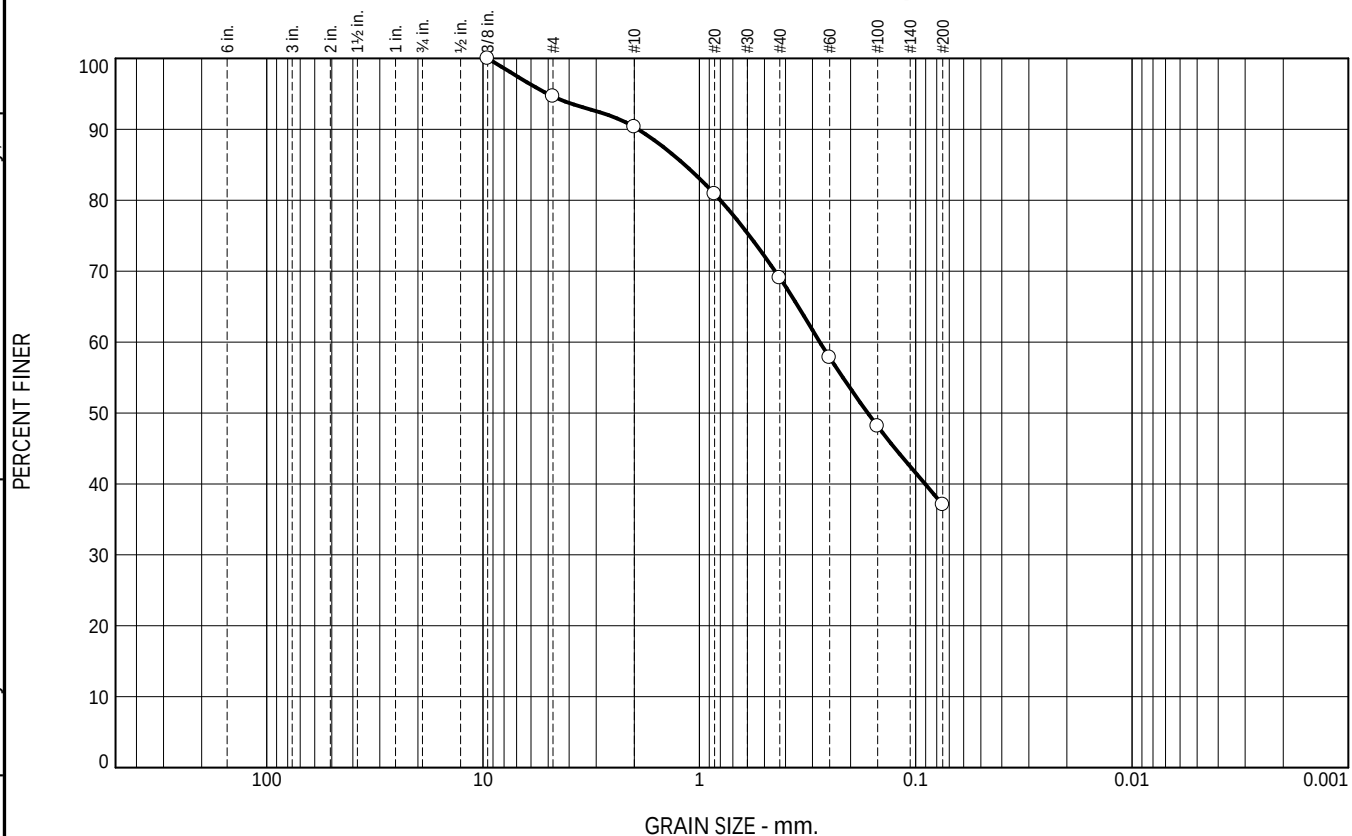
Figure S-1726

Tested By: SF

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.4	4.3	21.2	32.0	37.1	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	94.6		
#10	90.3		
#20	80.9		
#40	69.1		
#60	57.8		
#100	48.1		
#200	37.1		

* (no specification provided)

Soil Description
Brown f-m Organic SAND and SILT, trace fine Gravel

PL= NP Atterberg Limits LL= NV PI= NP
D₉₀= 1.9193 D₈₅= 1.1683 D₆₀= 0.2777
D₅₀= 0.1666 D₃₀= D₁₅=
D₁₀= C_u= C_c=

USCS= SM Classification AASHTO= A-4(0)
Remarks

Source of Sample: Test Boring Depth: 7.9-9.0'
Sample Number: HB-BES-102, 2D B 4"

Date: 05-27-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

Figure S-1726

Tested By: AB/RB

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.3	5.8	88.4	5.5	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.7		
#20	98.4		
#40	93.9		
#60	46.6		
#100	16.0		
#200	5.5		

* (no specification provided)

Soil Description
Brown fine SAND, trace Silt

PL= NP Atterberg Limits LL= NV PI= NP

Coefficients
D₉₀= 0.3887 D₈₅= 0.3641 D₆₀= 0.2879
D₅₀= 0.2606 D₃₀= 0.1970 D₁₅= 0.1460
D₁₀= 0.1176 C_u= 2.45 C_c= 1.15

Classification
USCS= SP-SM AASHTO= A-3

Remarks

Source of Sample: Test Boring Depth: 10.3-12.0'
Sample Number: HB-BES-102, 3D B 16"

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

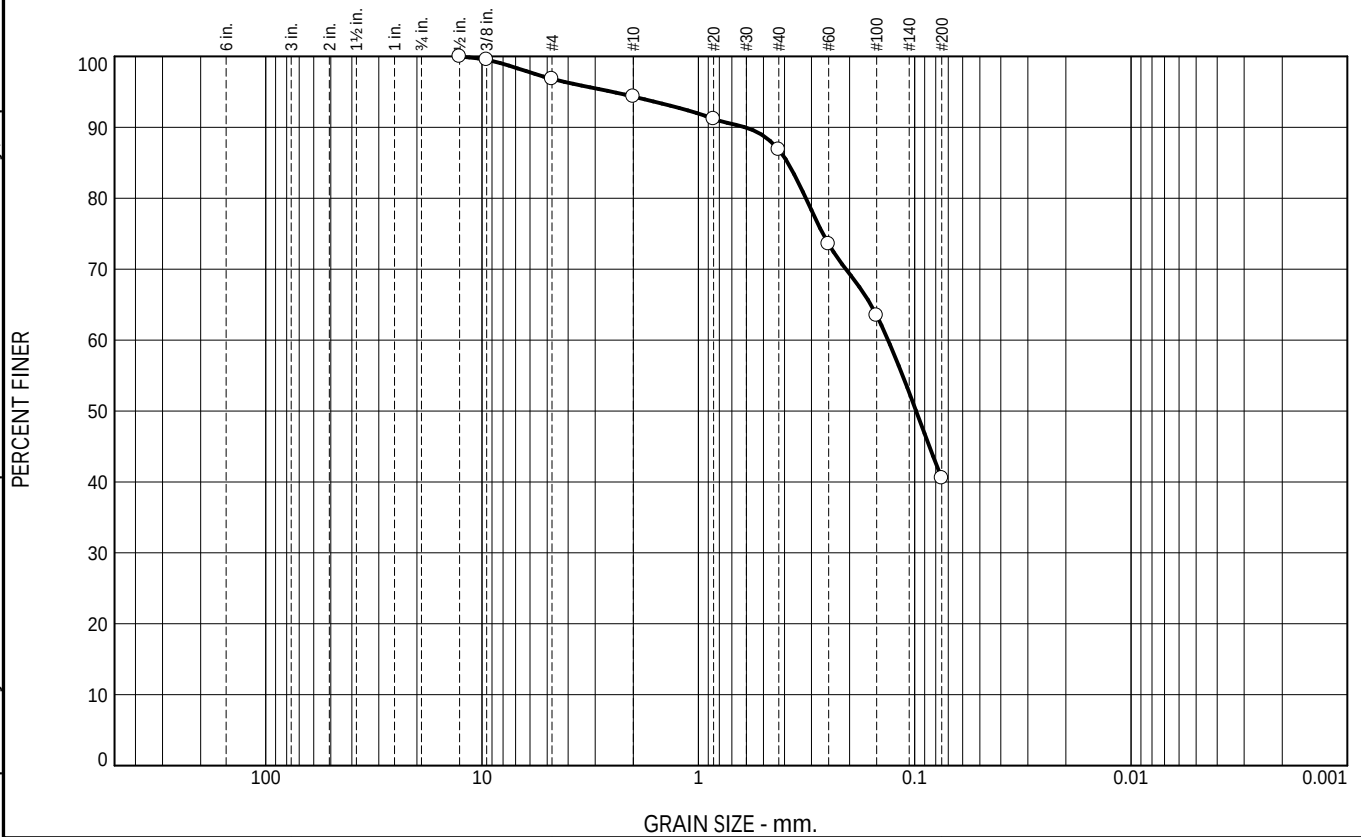
Figure S-1727

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.2	2.5	7.4	46.4	40.5	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	99.5		
#4	96.8		
#10	94.3		
#20	91.2		
#40	86.9		
#60	73.5		
#100	63.5		
#200	40.5		

* (no specification provided)

Soil Description
Dark Brown f-m SAND and Clayey SILT, trace fine Gravel

PL= NP **Atterberg Limits** LL= NV PI= NP
Coefficients
D₉₀= 0.6076 D₈₅= 0.3858 D₆₀= 0.1328
D₅₀= 0.0985 D₃₀= D₁₅=
D₁₀= C_u= C_c=

Classification
USCS= SM AASHTO= A-4(0)

Remarks
Sample visually classified as plastic. Sample rolled to 1/4".

Source of Sample: Test Boring Depth: 15.5-16.5'
Sample Number: HB-BES-102, 4D 6-19"

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

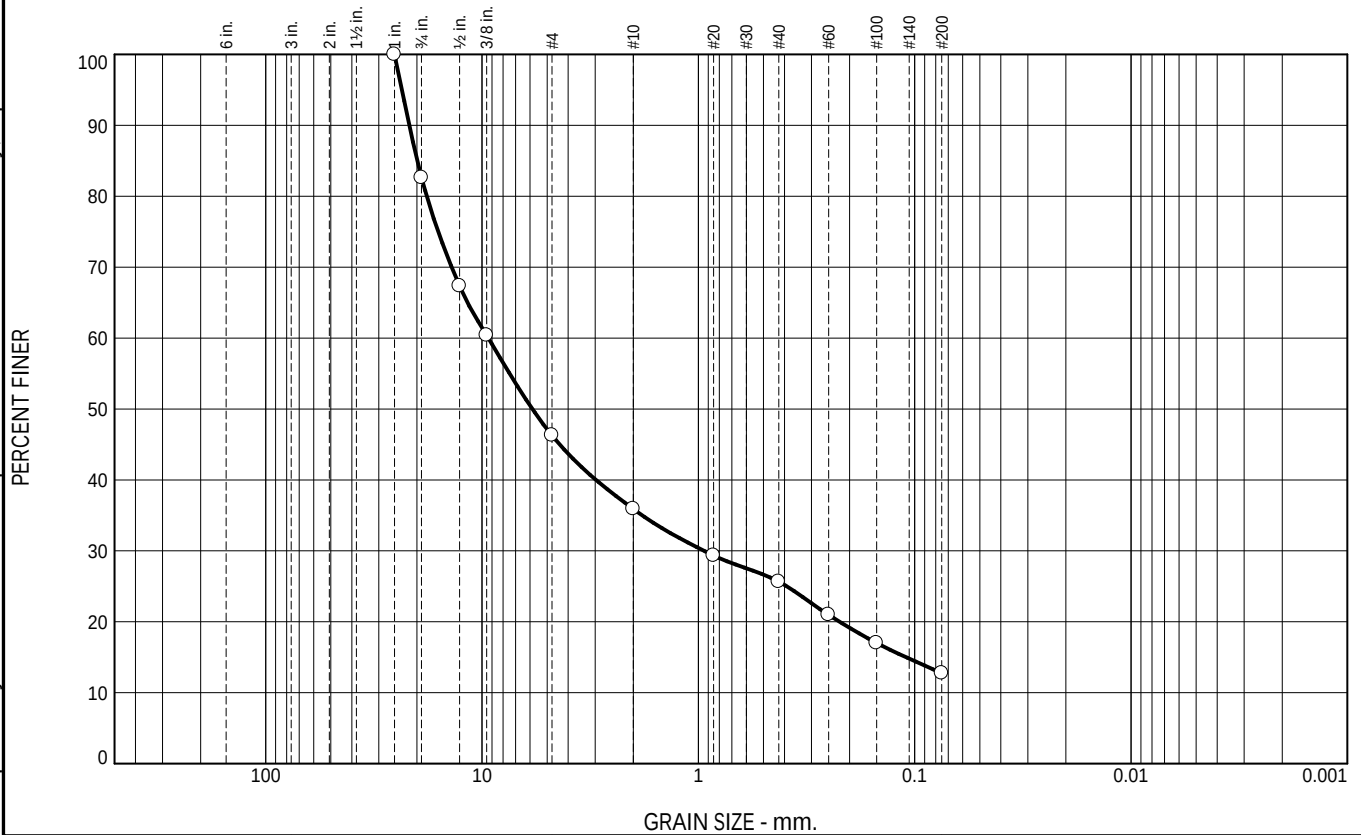
Figure S-1728

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	17.4	36.3	10.4	10.2	13.0	12.7	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	82.6		
1/2"	67.4		
3/8"	60.4		
#4	46.3		
#10	35.9		
#20	29.3		
#40	25.7		
#60	21.0		
#100	17.0		
#200	12.7		

* (no specification provided)

Soil Description		
Brown f-c GRAVEL, some f-c Sand, little Silt		
PL= NP	Atterberg Limits LL= NV	PI= NP
D ₉₀ = 21.6851	Coefficients D ₈₅ = 19.9370	D ₆₀ = 9.3566
D ₅₀ = 5.8516	D ₃₀ = 0.9401	D ₁₅ = 0.1097
D ₁₀ =	C _u =	C _c =
USCS= GM	Classification AASHTO=	A-1-a
Remarks		

Source of Sample: Test Boring Depth: 5.0-6.3'
Sample Number: HB-BES-103, 1D

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

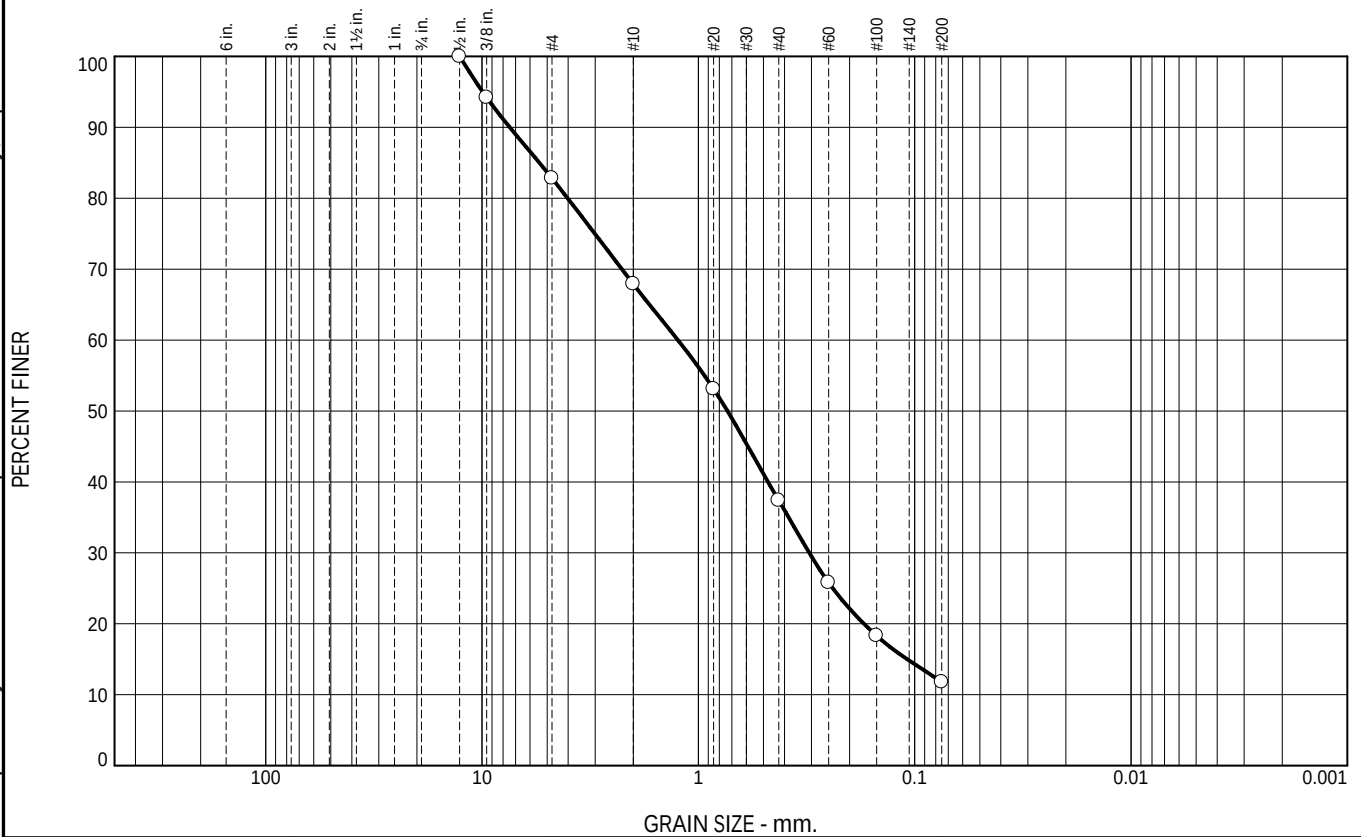
Figure S-1729

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	17.2	14.9	30.5	25.6	11.8	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	94.2		
#4	82.8		
#10	67.9		
#20	53.1		
#40	37.4		
#60	25.8		
#100	18.3		
#200	11.8		

* (no specification provided)

Soil Description
Dark Brown f-c SAND, little fine Gravel, little Silt

PL= NP Atterberg Limits LL= NV PI= NP
Coefficients
D₉₀= 7.4433 D₈₅= 5.4258 D₆₀= 1.2429
D₅₀= 0.7335 D₃₀= 0.3073 D₁₅= 0.1084
D₁₀= C_u= C_c=

USCS= SW-SM Classification AASHTO= A-1-b
Remarks

Source of Sample: Test Boring Depth: 0.3-3.0'
Sample Number: HB-BES-104, GS-1

Date: 05-22-26

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Elm Street Biddeford Mast Arms
Biddeford, ME

Project No: 09.0026331.00 Task 3

Figure S-1730

Tested By: AB/BR/MS

Checked By: Andrew Vanasse

	195 Frances Avenue Cranston RI, 02910 Phone: (401)-467-6454 Fax: (401)-467-2398 thielsch.com <i>Let's Build a Solid Foundation</i>	Client Information:	Project Information:
		GZA GeoEnvironmental, Inc. Portland, ME (207) 879-9190 Project Contact: Jason Keohane Collected By: S. Miller	Elm Street Biddeford Mast Arms Biddeford, ME Project Number: 09.0026331.00 Task 3 Summary Page: 1 of 1 Report Date: 6/2/2026

LABORATORY TESTING DATA SHEET, Report No.: 26E176

Material Source / Boring No.	Sample No.	Depth	Laboratory No.	Specimen Data						Compressive Strength Tests								Rock Formation or Description or Remarks	
				Mohs Hard-ness	Diameter (in)	Length (in)	(1) Unit Weight (PCF)	(2) Wet Density (PCF)	Bulk G _s	(3) Other Tests	(4) Strength PSI	(5) Strain %	(6) E sec PSI EE+06	(7) Poisson's Ratio	st PSI	Is ₅₀ PSI	(8) s _c PSI		
HB-BES-101	R1	20.0-20.6'	26-S-1732		1.975	4.456	169.3				3174	0.079	3.60E+06	0.18				Grey Metasandstone	
Fresh Break																			
HB-BES-103	R1	15.4-16.2'	26-S-1733		1.992	4.436	173.0				4992	0.170	5.88E+06	0.79				Grey Metasandstone	
Break partially along weathered plane																			
(1) Volume Determined By Measuring Dimensions					Notes	(3) PLD=Point Load (diametrical),					Notes	(5) Strain at Peak Deviator Stress							
(2) Determined by Measuring Dimensions and						PLA= Point Load (Axial) ST= Splitting Tensile						(6) Represents Secant Modulus at 50% of Total Failure Stress							
Weight of Saturated Sample						U= Unconfined Compressive Strength						(7) Represents Secant Poisson's Ratio at 50% of Total Failure Stress							
						(4) Taken at Peak Deviator Stress						(8) Estimated UCS from Table 1 of ASTM D5731 for NX cores (Is x 24)							

Date Received:

5/18/2026

Reviewed By:



Date Reviewed:

6/2/2026

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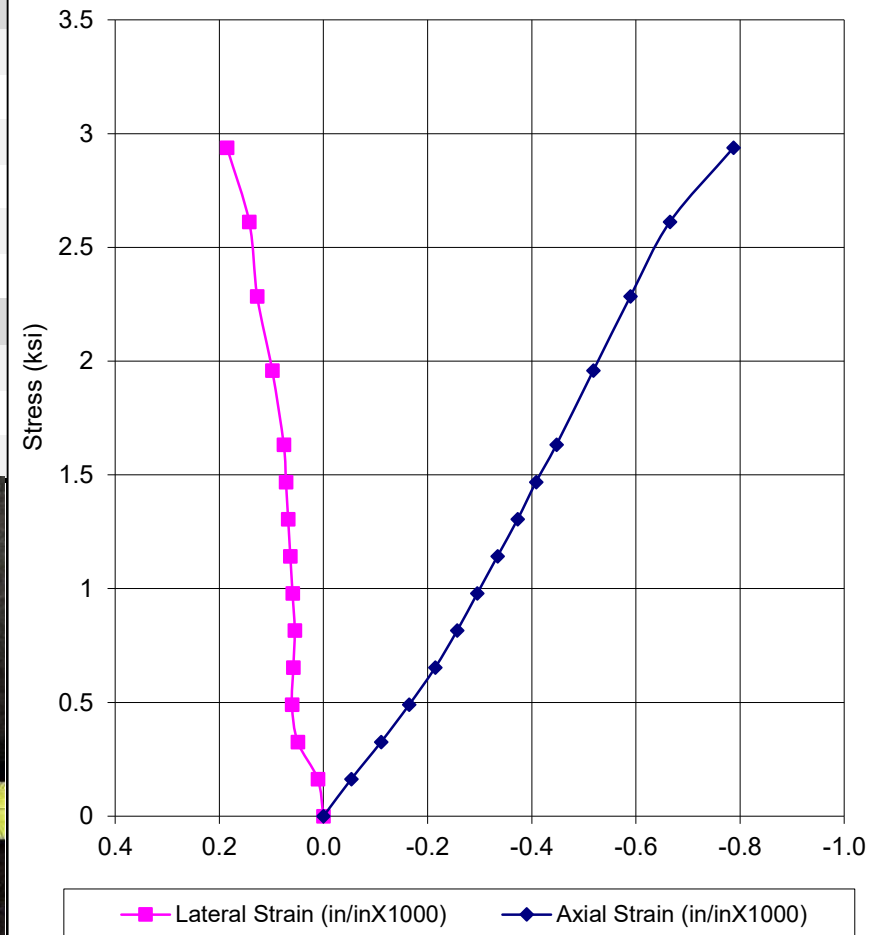
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Client Information:
GZA GeoEnvironmental
S. Portland, ME
Project Manager: Jason Keohane
Assigned by: Jason Keohane
Collected by: S. Miller

Project Information:
Elm Street Biddeford Mast Arms
Biddeford, ME
Project Number: 09.0026331.00 Task 3
Technician: BR
Report Date: 5/29/2026

ASTM D7012 Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Sample Information		Compressive Test Information	
Boring ID:	HB-BES-101	Unit Weight (pcf):	169.3
Sample #:	R1	Failure Stress (psi):	3,174
Depth (ft):	20.0-20.6	Failure Mode:	Fresh Break
Tested Depth (ft):	20.06-20.43	Time to Failure (min)	2.15
Rock Type:	Grey Metasandstone		
Features:	Fresh Break		
Test Specimen Information		Elastic Moduli Test Information	
Diameter, D (in):	1.975	Poisson's Ratio @ 50%:	0.18
Length, L (in):	4.456	Strain %:	0.079
L:D Ratio:	2.26	E sec PSI @ 50%:	3.60E+06



Testing Notes:



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Client Information:
GZA GeoEnvironmental
Biddeford, ME
Project Manager: Jason Keohane
Assigned by: Jason Keohane
Collected by: S. Miller

Project Information:
Elm Street Biddeford Mast Arms
Biddeford, ME
Project Number: 09.0026331.00 Task 3
Technician: BR
Report Date: 5/29/2026

ASTM D7012 Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

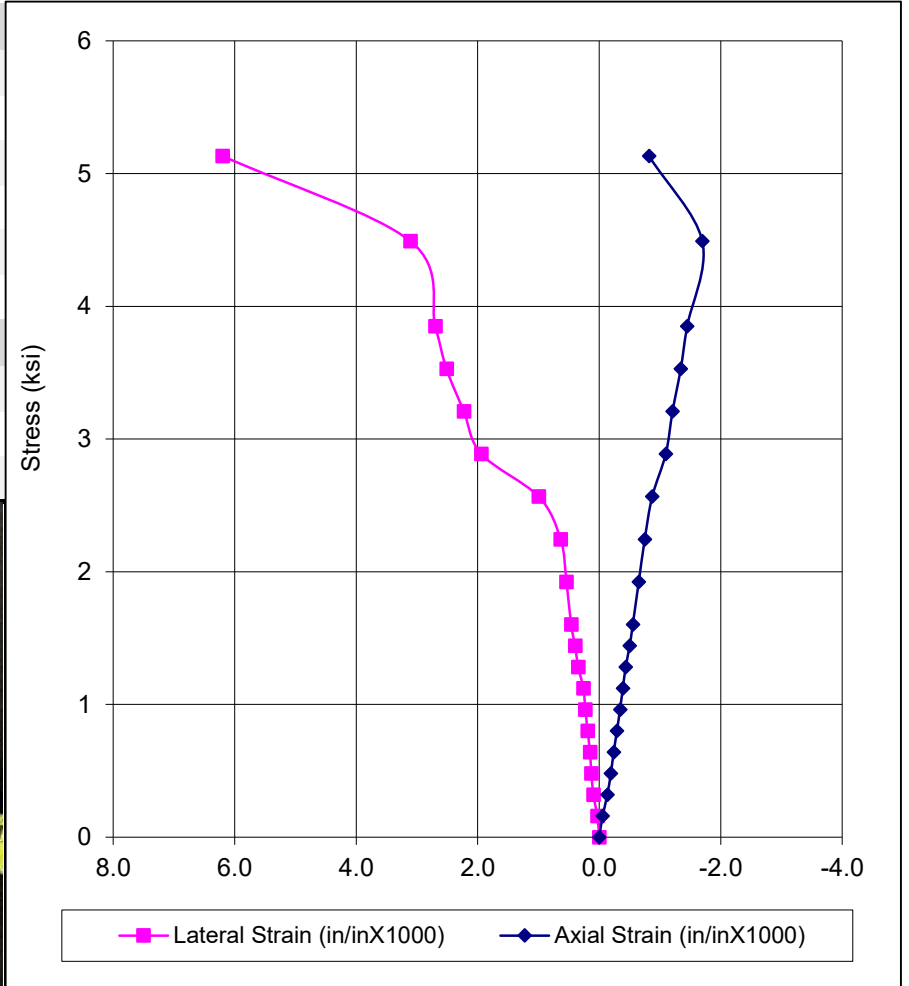
Sample Information		Compressive Test Information	
Boring ID:	HB-BES-103	Unit Weight (pcf):	173.0
Sample #:	R1	Failure Stress (psi):	4,992
Depth (ft):	15.4-16.2	Failure Mode:	Weathered plane
Tested Depth (ft):	15.70-16.07	Time to Failure (min)	3.28
Rock Type:	Grey Metasandstone		
Features:	Break partially along weathered plane.		
Test Specimen Information		Elastic Moduli Test Information	
Diameter, D (in):	1.992	Poisson's Ratio @ 50%:	0.79
Length, L (in):	4.436	Strain %:	0.170
L:D Ratio:	2.23	E sec PSI @ 50%:	5.88E+06



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Collected by: S. Miller

Project Information:
Elm Street Biddeford Mast Arms
Biddeford, ME
Project Number: 09.0026331.00 Task 3
Technician: BR

Sample Information:
Boring Number: HB-BES-103
Sample Number: R1
Depth: 15.4-16.2'
TEI Sample Number: UCS-1733



Testing Notes: Initial break at approx. 2570 psi (8000 lbs force)



Appendix E – Mast Arm Design Calculations



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*Engineers and
Scientists*

JOB: 09.0026331.00 Biddeford Mast Arms
SUBJECT: Drilled Shaft Design
SHEET: 1 OF 3
CALCULATED BY N. Williams/E.Tome
07/29/2026
REVIEWED BY A.Blaissdell 07/31/2026

Objective

Design of the proposed Mast Arm drilled shaft foundations based on load cases provided by TYLin. GZA evaluated and developed generalized subsurface profiles for each foundation location based on the borings performed by Seaboard and observed by GZA. GZA evaluated a range of drilled shaft diameters and shaft lengths. GZA evaluated the shaft diameter and required embedment depths and rock socket lengths as needed based on a maximum lateral movement of 0.5 inches for the unfactored Service loads at the top of the drilled shaft along with confirmation that the lengths were not marginal relative to potential excessive deformation (i. e. shaft "tipping").

Methodology

1. Develop anticipated subsurface profiles and parameters for each mast arm location.
2. Complete lateral pile analyses based on the loading provided by TYLin.

1. Soil Properties

GZA developed soil parameters for two subsurface profiles which are presented on Page 4 based on measured field data and laboratory results. The profiles were based on borings HB-BES-101 through -104. The soil parameters were used to develop soil property inputs for FBPIer to conduct the lateral pile analyses. The soil layer elevations are based on the closest boring(s).

The general basis for each profile is presented below:

Loose Soil Profile

- Profile 1 was developed based on borings HB-BES-101 and -102. Soil properties were averaged for each boring and modeled as a loose sand soil profile overlying weak rock.

Shallow Rock Profile

- Profile 2 was developed based on borings HB-BES-103 and -104. Soil properties were averaged for each boring and modeled as medium dense sand overlying weak rock.



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*Engineers and
Scientists*

JOB: 09.0026331.00 Biddeford Mast Arms
SUBJECT: Drilled Shaft Design
SHEET: 2 OF 3
CALCULATED BY N. Williams/E.Tome
07/29/2026
REVIEWED BY A.Blaissdell 07/31/2026

2. Loading Configuration(s) Provided by TYLin

GZA applied the load cases shown below to the top of the drilled shaft for the mast arm drilled shaft foundations using the FBPIer software. Updated loading provided by TYLin on August 11, 2026.

Basic wind speeds base 700 Year-MRI for Extreme Event 1.

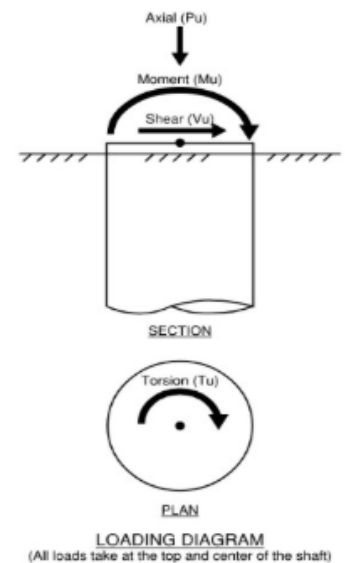
Basic Wind Speed: 120 mph

1 - Mast Arm for Route 1 Northbound/Elm Street at Upper Falls Road				
	Axial (Pu)	Shear (Vu)	Moment (Mu)	Torsion (Tu)
Service I -	2.50 kips	1.50 kips	30.00 kip-ft	21.00 kip-ft
Strength I -	3.00 kips	0.00 kips	26.50 kip-ft	0.00 kip-ft
Extreme I -	3.00 kips	3.00 kips	56.50 kip-ft	51.50 kip-ft

2 - Mast Arm for Upper Falls Road at Route 1 / Elm Street				
	Axial (Pu)	Shear (Vu)	Moment (Mu)	Torsion (Tu)
Service I -	4.50 kips	1.50 kips	27.00 kip-ft	17.00 kip-ft
Strength I -	5.50 kips	0.00 kips	23.00 kip-ft	0.00 kip-ft
Extreme I -	5.00 kips	3.00 kips	53.00 kip-ft	41.50 kip-ft

3 - Dual Mast Arms - Route 1 Southbound & Diamond Street at Upper Falls Road				
	Axial (Pu)	Shear (Vu)	Moment (Mu)	Torsion (Tu)
Service I -	7.00 kips	1.50 kips	44.00 kip-ft	18.00 kip-ft
Strength I -	9.00 kips	0.00 kips	31.50 kip-ft	0.00 kip-ft
Extreme I -	8.00 kips	3.00 kips	78.00 kip-ft	43.50 kip-ft

4 - Dual Mast Arms - Rt. 1/Elm Street S-BND & N-BND at Lincoln St. and Lincoln Street at Rt. 1/Elm Street				
	Axial (Pu)	Shear (Vu)	Moment (Mu)	Torsion (Tu)
Service I -	7.00 kips	1.50 kips	81.50 kip-ft	47.00 kip-ft
Strength I -	9.00 kips	0.00 kips	70.00 kip-ft	0.00 kip-ft
Extreme I -	8.00 kips	4.00 kips	128.50 kip-ft	116.50 kip-ft





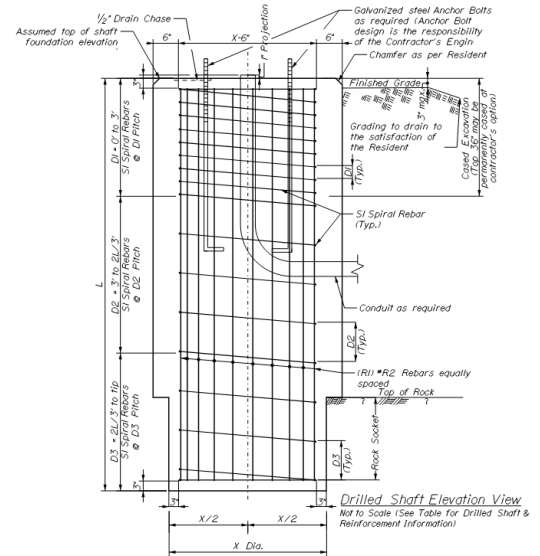
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Engineers and
Scientists

JOB: 09.0026331.00 Biddeford Mast Arms
SUBJECT: Drilled Shaft Design
SHEET: 3 OF 3
CALCULATED BY N. Williams/E.Tome
07/29/2026
REVIEWED BY A.Blaissdell 07/31/2026

3. Results

GZA considered a range of drilled shaft diameters (3 to 5 feet) and lengths based on shaft toe stability and a maximum lateral displacement of 0.5 inches for the unfactored Service loads and the soil properties and depths for Soil Profiles 1 and 2. Depending on depth to rock, sockets were required to limit the displacement at the top and to prevent the drilled shaft from tipping. Based on the loading provided, see the table below summarizing the minimum shaft dimensions and reinforcement.



TYLin Mast Arm #	Location	Drilled Shaft Dimensions				Reinforcing Steel			Spiral Bar Spacing		
		X _{ob}	X _{rs}	L _{ob}	L _{rs}	R1	R2	S1	D1 (in)	D2 (in)	D3 (in)
		Diameter Overburden (feet)	Diameter Rock Socket (feet)	Length Overburden (feet)	Length Rock Socket (feet)	Longitudinal Rebars Quantity	Longitudinal Rebars Size	Spiral Rebars Size	0 to 3 ft	3 ft to 2L/3 ft	2L/3 ft to tip
1	Route 1 NB/Elm Street at Upper Falls Road	3.0	N/A	15.0	N/A	12	#9	#5	4	4	12
2	Upper Falls Road at Route 1/Elm Street	3.0	2.5	Less than 13	2.0	12	#9	#5	4	4	12
4	Route 1 SB & Diamond Street at Upper Falls Road	3.0	N/A	15.0	N/A	12	#9	#5	4	4	12

TYLin Mast Arm #	Location	Drilled Shaft Dimensions				Reinforcing Steel			Spiral Bar Spacing		
		X _{ob}	X _{rs}	L _{ob}	L _{rs}	R1	R2	S1	D1 (in)	D2 (in)	D3 (in)
		Diameter Overburden (feet)	Diameter Rock Socket (feet)	Length Overburden (feet)	Length Rock Socket (feet)	Longitudinal Rebars Quantity	Longitudinal Rebars Size	Spiral Rebars Size	0 to 3 ft	3 ft to 2L/3 ft	2L/3 ft to tip
3	Route 1 SB & NB and Lincoln Street at Lincoln Street	3.0	N/A	15.0	N/A	12	#9	#5	4	4	12

4. Attachments

The attachments are described as follows:

- **Bedrock Parameters & Axial Resistance**
- **Mast Arm Lateral Pile Parameters**
- **Mast Arm Drilled Shaft Calculations:**

FBPier Results - 3.0' Shaft with no rock socket - Profile 1 (Intersections of Route 1 Northbound/Elm Street at Upper Falls Road and of Upper Falls Road at Route 1/Elm Street)

FBPier Results - 3.0' Shaft with 2.5' rock socket - Profile 2 (Intersections of Route 1 Southbound & Northbound and Lincoln Street at Lincoln Street and of Route 1 Southbound & Diamond Street at Upper Falls Road.)



Drilled Shaft Design Parameters in Bedrock

Project: Elm Street Mast Arm Foundations

Project No.: 09.0026331.00

Location: Biddeford, ME

Calculated By: E. Tome

Date: 7/29/2026

Checked By: N. Williams / A. Blaisdell

Date: 7/31/2026

Objective: Develop foundation design parameters for drilled shafts in bedrock using AASHTO methodology for support of the mast arms.

Inputs: Rock core data from borings HB-BES-101 through 104, including rock type and RQD, and laboratory test data including unit weight, unconfined compressive strength, secant modulus of elasticity and Poisson's ratio for specimens, were assessed as follows:

1. Rock was primarily classified as Phyllite across the site.
2. Design Unconfined Compressive Strength, RQD, Secant Modulus, and Poisson's Ratio values for competent Phyllite bedrock were averaged from laboratory test results.

Approach:

1. Evaluate Geologic Strength Index (GSI), rock mass parameters, and equivalent rock mass modulus in accordance with AASHTO LRFD Article 10.4.6.
2. Develop LPILE/FBPier inputs for Weak Rock model based on bedrock structure characterization and laboratory test results. See red text on page 2. Choose initial modulus of rock mass as 1/100th of the equivalent rock mass based on research by KSDOT.

Calculation: Rock Socket Lateral Parameters - Typical Rock

References: 1) AASHTO LRFD Bridge Design Specifications, 10th Ed. (2024)

Parameter Description	Parameter Symbol	Design Values	Reference
Rock Type		Phyllite	Rock ID per boring logs/geologic mapping
Comparable Rock Type/Texture		Phyllite	AASHTO Table 10.4.6.4-1
Unconfined compressive strength of intact rock	q_u (psi)	4,083	Average of samples
Elastic Secant Modulus of Intact Rock	E_i (ksi)	4,740	Average of samples
Poisson's Ratio of Intact Rock	ν	0.49	Average of samples
LPILE Input Unconfined compressive strength	$q_{u-LPILE}$ (psi)	2,000	Limit UCS to 2,000 psi for LPILE
Design Strain Factor	krm	0.0005	Use krm value from Lpile manual
Rock Total Unit Weight	γ' (psf)	171	Average value from lab UCS tests
Rock Effective Unit Weight	γ' (psf)	108.6	
Geological Strength Index	GSI	60	AASHTO FIG 10.4.6.4-1
Hoek - Brown 2002	D	0	Hoek - Brown 2002
Rock Quality Designation	RQD (%)	45	Average RQD
Empirically determined rock mass parameter	s	0.011749	AASHTO Eq. 10.4.6.4-2
Empirically determined rock mass parameter	a	0.503	AASHTO Eq. 10.4.6.4-3
Rock group constant	m_i	7	AASHTO Table 10.4.6.4-1
Empirically determined rock mass parameter	m_b	1.68	AASHTO Eq. 10.4.6.4-4
Equivalent Rock Mass Modulus, Hoek & Brown	E_{m1} (ksi)	1,368	AASHTO Table 10.4.6.5-1 - eq. from table
Equivalent Rock Mass Modulus, Yang	E_{m2} (ksi)	753	AASHTO Table 10.4.6.5-1 - eq. from table
Design Basis Equivalent Rock Modulus	E_m (ksi)	1,061	Calculated as the average of E_{m1} and E_{m2} above
Initial Modulus of Rock Mass, Lpile K_{ir} Value	K_{ir} (ksi)	10.61	Calculated as 1/100th of the calculated Design basis equivalent Rock Modulus, based on the KSDOT research.
Shear Modulus	G (ksi)	355.9	Calculated as $G = E_m / (2 * (1 + \nu))$

Notes:

1. Yellow cell is user input, white is calculated.
2. Red text are input values for LPILE/FBPier Weak Rock model.
3. A reduced modulus for use in LPILE was based on research by Kansas Department of Transportation (KSDOT) presented in a paper entitled " Lateral Capacity of Rock Sockets in Limestone Under Cyclic and Repeated Loading" dated August 2010.

Elm Street Mast Arm Foundations
 Biddeford, ME
 09.0026331.00

Calculated by E. Tome
 Checked by N. Williams / A. Blaisdell

Date: 7/29/2026
 Date: 7/31/2026

Calculation: Drilled Shaft Side Resistance in Rock

References: 1) AASHTO LRFD Bridge Design Specifications, 10th Ed. (2024)

Parameter Description	Parameter Symbol	Values	Reference
Method 1: Kulhawy et al 2005 (Rock w/o caving)			
Unconfined compressive strength of intact rock	q_u (psi)	4,000	Maximum value is concrete unconfined compressive strength
Regression Coefficient	C	1	AASHTO 10.8.3.5.4b
Nominal Unit Side Resistance (Method 1)	$qs1$ (ksf)	34.9	AASHTO Eq. 10.8.3.5.4b-1
Method 2: O'Neill and Reese 1999, Brown et al 2010 (Temporary casing required for socket support during installation)			
Joint Modification Factor	a_E	0.600	AASHTO 10.8.3.5.4b, based on RQD
Nominal Unit Side Resistance (Method 2)	$qs2$ (ksf)	13.6	AASHTO Eq. 10.8.3.5.4b-2
Side Resistance Design Parameters			
Nominal Side Resistance	qs (ksf)	24.3	Average of Methods 1 and 2 (Conservative, sidewalls expected to stand in excavations)

Table 10.5.5.2.4-1—Resistance Factors for Geotechnical Resistance of Drilled Shafts

Method/Soil/Condition			Resistance Factor
Nominal Axial Compressive Resistance of Single-Drilled Shafts, ϕ_{axial}	Side resistance in clay	α -method (Brown et al., 2010)	0.45
	Tip resistance in clay	Total Stress (Brown et al., 2010)	0.40
	Side resistance in sand	β -method (Brown et al., 2010)	0.55
	Tip resistance in sand	Brown et al. (2010)	0.50
	Side resistance in cohesive IGMs	Brown et al. (2010)	0.60
	Tip resistance in cohesive IGMs	Brown et al. (2010)	0.55
	Side resistance in rock	Kulhawy et al. (2005) Brown et al. (2010)	0.55
	Side resistance in rock	Carter and Kulhawy (1988)	0.50
	Tip resistance in rock	Canadian Geotechnical Society (1985) Pressuremeter Method (Canadian Geotechnical Society, 1985) Brown et al. (2010)	0.50
Block Failure, ϕ_{B}	Clay		0.55
Uplift Resistance of Single-Drilled Shafts, ϕ_{up}	Clay	α -method (Brown et al., 2010)	0.35
	Sand	β -method (Brown et al., 2010)	0.45
	Rock	Kulhawy et al. (2005) Brown et al. (2010)	0.40
Group Uplift Resistance, ϕ_{upg}	Sand and clay		0.45
Horizontal Geotechnical Resistance of Single Shaft or Shaft Group	All materials		1.0
Static Load Test (compression), ϕ_{load}	All Materials		0.70
Static Load Test (uplift), ϕ_{upload}	All Materials		0.60

10.5.5.3.3—Other Extreme Limit States

Resistance factors for extreme limit state, including the design of foundations to resist earthquake, ice, vehicle or vessel impact loads, shall be taken as 1.0. For uplift resistance of piles and shafts, the resistance factor shall be taken as 0.80 or less.

Table 1: Guidelines for estimating disturbance factor D From Hoek et al., 2002

Appearance of rock mass	Description of rock mass	Suggested value of D
	Excellent quality controlled blasting or excavation by Tunnel Boring Machine results in minimal disturbance to the confined rock mass surrounding a tunnel. No Blasting, No Disturbance	$D = 0$
	Mechanical or hand excavation in poor quality rock masses (no blasting) results in minimal disturbance to the surrounding rock mass. Where squeezing problems result in significant floor heave, disturbance can be severe unless a temporary invert, as shown in the photograph, is placed.	$D = 0$ $D = 0.5$ No invert
	Very poor quality blasting in a hard rock tunnel results in severe local damage, extending 2 or 3 m, in the surrounding rock mass.	$D = 0.8$
	Small scale blasting in civil engineering slopes results in modest rock mass damage, particularly if controlled blasting is used as shown on the left hand side of the photograph. However, stress relief results in some disturbance.	$D = 0.7$ Good blasting $D = 1.0$ Poor blasting
	Very large open pit mine slopes suffer significant disturbance due to heavy production blasting and also due to stress relief from overburden removal. In some softer rocks excavation can be carried out by ripping and dozing and the degree of damage to the slopes is less.	$D = 1.0$ Production blasting $D = 0.7$ Mechanical excavation

GEOLOGICAL STRENGTH INDEX FOR JOINTED ROCKS (Hoek and Marinos, 2000) From the lithology, structure and surface conditions of the discontinuities, estimate the average value of GSI. Do not try to be too precise. Quoting a range from 33 to 37 is more realistic than stating that GSI = 35. Note that the table does not apply to structurally controlled failures. Where weak planar structural planes are present in an unfavourable orientation with respect to the excavation face, these will dominate the rock mass behaviour. The shear strength of surfaces in rocks that are prone to deterioration as a result of changes in moisture content will be reduced if water is present. When working with rocks in the fair to very poor categories, a shift to the right may be made for wet conditions. Water pressure is dealt with by effective stress analysis.		SURFACE CONDITIONS				
STRUCTURE		DECREASING SURFACE QUALITY →				
 INTACT OR MASSIVE - intact rock specimens or massive in situ rock with few widely spaced discontinuities  BLOCKY - well interlocked un-disturbed rock mass consisting of cubical blocks formed by three intersecting discontinuity sets  VERY BLOCKY- interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets  BLOCKY/DISTURBED/SEAMY - folded with angular blocks formed by many intersecting discontinuity sets. Persistence of bedding planes or schistosity  DISINTEGRATED - poorly interlocked, heavily broken rock mass with mixture of angular and rounded rock pieces  LAMINATED/SHEARED - Lack of blockiness due to close spacing of weak schistosity or shear planes		DECREASING INTERLOCKING OF ROCK PIECES ↓				
		VERY GOOD Very rough, fresh unweathered surfaces	GOOD Rough, slightly weathered, iron stained surfaces	FAIR Smooth, moderately weathered and altered surfaces	POOR Slackensided, highly weathered surfaces with compact coatings or fillings or angular fragments	VERY POOR Slackensided, highly weathered surfaces with soft clay coatings or fillings
		90	80	70	N/A	N/A
		80	70	60	N/A	N/A
		70	60	50	40	30
		60	50	40	30	20
		50	40	30	20	10
		40	30	20	10	N/A
		30	20	10	N/A	N/A
		20	10	N/A	N/A	N/A
		10	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A	N/A

Best Estimate
 Structure: Blocky
 Surface Conditions: Very good to Good
 Select GSI=60

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

Table 10.4.6.4-1—Values of the Constant m , 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)	Sandstone 17 ± 4	Siltstone 7 ± 2	Claystone 4 ± 2
			Breccia (19 ± 5)		Greywacke (18 ± 3)	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	Diorite 25 ± 5 Granodiorite (29 ± 3)		
		Dark	Gabbro 27 ± 3	Dolerite (16 ± 5) Norite 20 ± 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)	

Phyllite,
use mean value



FB Pier Input Parameters for Mast Arm Drilled Shaft Foundations
Elm Street Improvements
Biddeford, Maine

GZA FILE NO. 09.0026331.00

CALCULATED BY E. Tome

CHECKED BY N. Williams/A. Blaisdell

Objective: To estimate the horizontal modulus of subgrade reaction (k) or E50 of subsurface strata for use in lateral analyses. K values are estimated using strata internal friction angles (ϕ') or shear strength.

Methods Correlations between the horizontal modulus of subgrade reaction and the soil internal friction angle of a given stratum are based on Figure 3-34 presented in the 2022 LPile Technical Manual.

Given Information: Masst arm locations and design loading provided by TYLin.

Design Profile 1 (Loose)											
Stratum	Soil Model	Top of Layer Elevation (NAVD88 ft)	k (pci) / E50	ϕ' (deg)/ Su (psf)	γ_e (pcf)	β	Representative SPT N_{60} -value ⁶	Poisson's Ratio, n	Shear Modulus, G (ksi) ⁹	Ultimate Unit Skin Friction ^{8,9} (psf)	Torsional Shear Stress ^{8,9} (psf)
Fine to Coarse Sand	Reese Sand	57	48	30	120	1.20	5	0.3	0.73	648	648
Fine to Coarse Sand*	Reese Sand	48	35	30	57.6	1.20	5	0.3	0.73	890	890
Rock	Weak Rock, Reduced E	41	--	--	108.6	--	--	0.49	10.6	24300	24300

Design Profile 2 (Dense, Shallow Rock)											
Stratum	Soil Model	Top of Layer Elevation (NAVD88 ft)	k (pci) / E50	ϕ' (deg)/ Su (psf)	γ_e (pcf)	β	Representative SPT N_{60} -value ⁶	Poisson's Ratio, n	Shear Modulus, G (ksi) ⁹	Ultimate Unit Skin Friction ^{8,9} (psf)	Torsional Shear Stress ^{8,9} (psf)
Fine to Coarse Sand	Reese Sand	58	164	36	130	1.20	47	0.3	3.33	624	624
Fine to Coarse Sand*	Reese Sand	50	97	36	67.6	1.20	47	0.3	3.33	746	746
Rock	Weak Rock, Reduced E	47	--	--	108.6	--	--	0.49	10.6	24300	24300

Notes: 1. pci = pounds per cubic inch, deg = degrees, psi = pounds per square inch, γ_e = effective unit weight, pcf = pounds per square foot.

2. * indicates the top of layer is the approximate ground water elevation based on the boring logs.

3. Weak Rock Input Parameters:

Unit Weight = 171 pcf, Unconfined Compressive Strength = 2,000 psi (maximum recommended for lateral analysis), RQD = 45%, krm = 0.0005 (Lpile Manual 2022), Shear Strength = 1,000 psi (half of UCS)

4. Elevations are in feet and reference the North American Vertical Datum of 1988 (NAVD 88).

5. Lateral model parameters for soil, axial model parameters for soil and rock, and torsional model parameters for soil and rock interpolated from default inputs for BSI "Parameters of Soil Models for Studying Soil-Pile Interaction Analysis Using FB-MultiPier", dated May 2011.

6. Representative N_{60} values based average SPT-N values from boring logs.

7. Ultimate unit end bearing is assumed to be zero based on the assumptions made for shaft design for consideration of strain compatibility.

8. Ultimate unit skin friction and torsional shear resistance for rock corresponds to nominal side friction resistance values given for similar rock types.

9. Equations:

Shear Modulus, Sand (BSI FBPIer Parameters, May 2011): $G_s(ksf) = 35 * (N_{60})^{0.68}$

Torsional Shear Stress, Sand: (using same as Ultimate Skin Friction)

Torsional Shear Stress in rock taken as the same as Ultimate Unit Skin Friction in rock.

Shear Mass Modulus taken as 1/100th of the design values presented in the BSI properties table based on KSDOT research.

Ultimate unit skin friction in sand estimated using the β method (BSI FBPIer Axial Soil Resistance): $\beta = 1.5 - 0.135(z)^{0.5}$, $0.25 \leq \beta \leq 1.2$

Drilled Shaft Reinforcement Plan Sections 1, 2, and 3

Section List

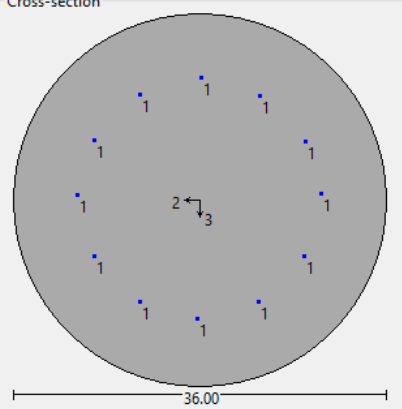
Segment 1

Pile Type

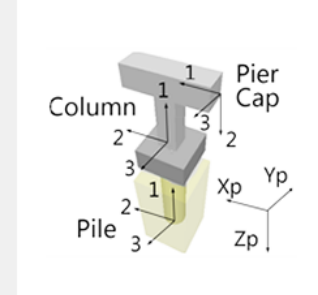
Type 1

☒ Show Bar Group Numbers

Cross-section



Orientation



Bar Group Properties

Group	# Bars	Area (in^2)	Diameter (in.)	Spacing (in.)	Coord-2 (in.)	Coord-3 (in.)	Orientation	Prestressed (ksi)
1	12	1.000000	24.000	6.283	N/A	N/A	Circular	0.00

Material Properties

Concrete	Concrete	Mild Steel	Mild Steel	Prestressed	Prestressed	H-Pile	H-Pile	Pipe/Casing	Pipe/Casing
f'c (ksi)	Ec (ksi)	fy (ksi)	Es (ksi)	fps (ksi)	Eps (ksi)	fhp (ksi)	Ehp (ksi)	fsh (ksi)	Esh (ksi)
5.0	4031.0	60.0	29000.0						

Full Cross-Section Pile Properties

Pile Type Info

Pile Type

Type 1

Add

Del

Pile Segments (Head to Tip)

Custom

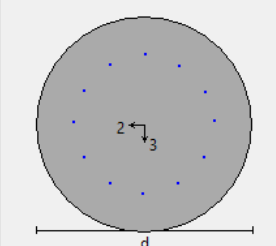
Custom

Custom

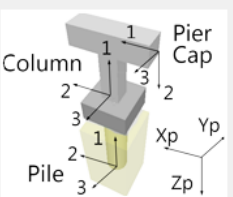
Add

Del

Segment Cross-section



Orientation



Database Section Selection

☐ Use Database Section

☒ Customize Current Section

Custom

Retrieve Section

Add To Database

Delete Section

Section Type

☒ Circular

☐ Pipe Pile

☐ Rectangular

☐ Pipe Pile (Concrete Filled)

☐ H-Pile

Edit Section Contents

Section Constitutive Properties

☒ Default Stress-Strain Curves

☐ User-Defined Stress-Strain Curves

Edit Properties

Plot Stress-Strain

Section Dimensions

Diameter (d)

36

in

Unit Weight

150

pcf

Length

3

ft

Cross-Section Details

OK

Cancel

Notes >>

OK

Cancel

Excel

Drilled Shaft Reinforcement Plan Section 3 (Rock Socket as needed)

Section List

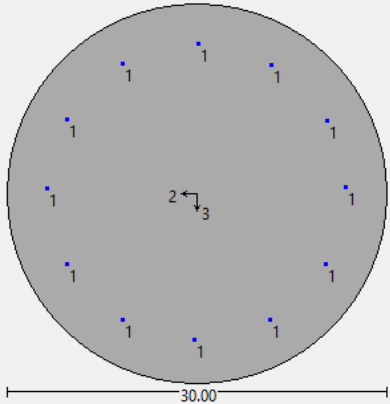
Segment 3

Pile Type

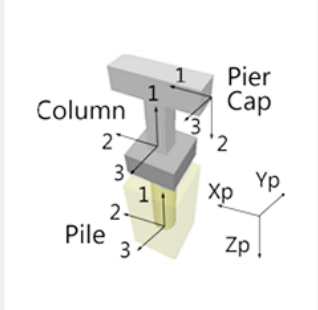
Type 1

☒ Show Bar Group Numbers

Cross-section



Orientation



Bar Group Properties

Group	# Bars	Area (in^2)	Diameter (in.)	Spacing (in.)	Coord-2 (in.)	Coord-3 (in.)	Orientation	Prestressed (ksi)
1	12	1.000000	24.000	6.283	N/A	N/A	Circular	0.00

Material Properties

Concrete	Concrete	Mild Steel	Mild Steel	Prestressed	Prestressed	H-Pile	H-Pile	Pipe/Casing	Pipe/Casing
f'c	Ec	fy	Es	fps	Eps	fhp	Ehp	fsh	Esh
(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)
5.0	4031.0	60.0	29000.0						

Full Cross-Section Pile Properties

Pile Type Info

Pile Type

Type 1

Add

Del

Pile Segments (Head to Tip)

Custom

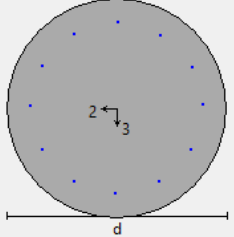
Custom

Custom

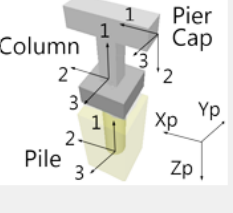
Add

Del

Segment Cross-section



Orientation



Database Section Selection

☐ Use Database Section

☒ Customize Current Section

Custom

Retrieve Section

Add To Database

Delete Section

Section Type

☒ Circular

☐ Rectangular

☐ H-Pile

☐ Pipe Pile

☐ Pipe Pile (Concrete Filled)

Edit Section Contents

Section Constitutive Properties

☒ Default Stress-Strain Curves

☐ User-Defined Stress-Strain Curves

Edit Properties

Plot Stress-Strain

Section Dimensions

Diameter (d)

30

in

Unit Weight

150

pcf

Length

2

ft

OK

Cancel

Notes >>

Cross-Section Details

OK

Cancel

Excel

Sections 1 and 2 Transverse Reinforcement

Confined Concrete

☐ Unconfined

☒ Shear Reinforcement

☐ Shear Reinforcement and Casing

☐ Shear Reinforcement and Confine-Only Casing

Yield Stress 60 ksi

Shear Spacing 4 in

Bar Diameter 0.625 in

Notes

1. 'Confine-Only' indicates that the casing is capable of confining the section concrete and the casing contribution to stiffness, bending, and axial resistance of the section is neglected.

2. As an exception, if 'Linear Analysis' and 'Transformed Section' are applicable for this section, then the casing stiffness is included in the stiffness, bending, and axial resistance calculations.

OK Cancel

Section 3 Transverse Reinforcement

Confined Concrete

☐ Unconfined

☒ Shear Reinforcement

☐ Shear Reinforcement and Casing

☐ Shear Reinforcement and Confine-Only Casing

Yield Stress 60 ksi

Shear Spacing 12 in

Bar Diameter 0.625 in

Notes

1. 'Confine-Only' indicates that the casing is capable of confining the section concrete and the casing contribution to stiffness, bending, and axial resistance of the section is neglected.

2. As an exception, if 'Linear Analysis' and 'Transformed Section' are applicable for this section, then the casing stiffness is included in the stiffness, bending, and axial resistance calculations.

OK Cancel

PROFILE 1

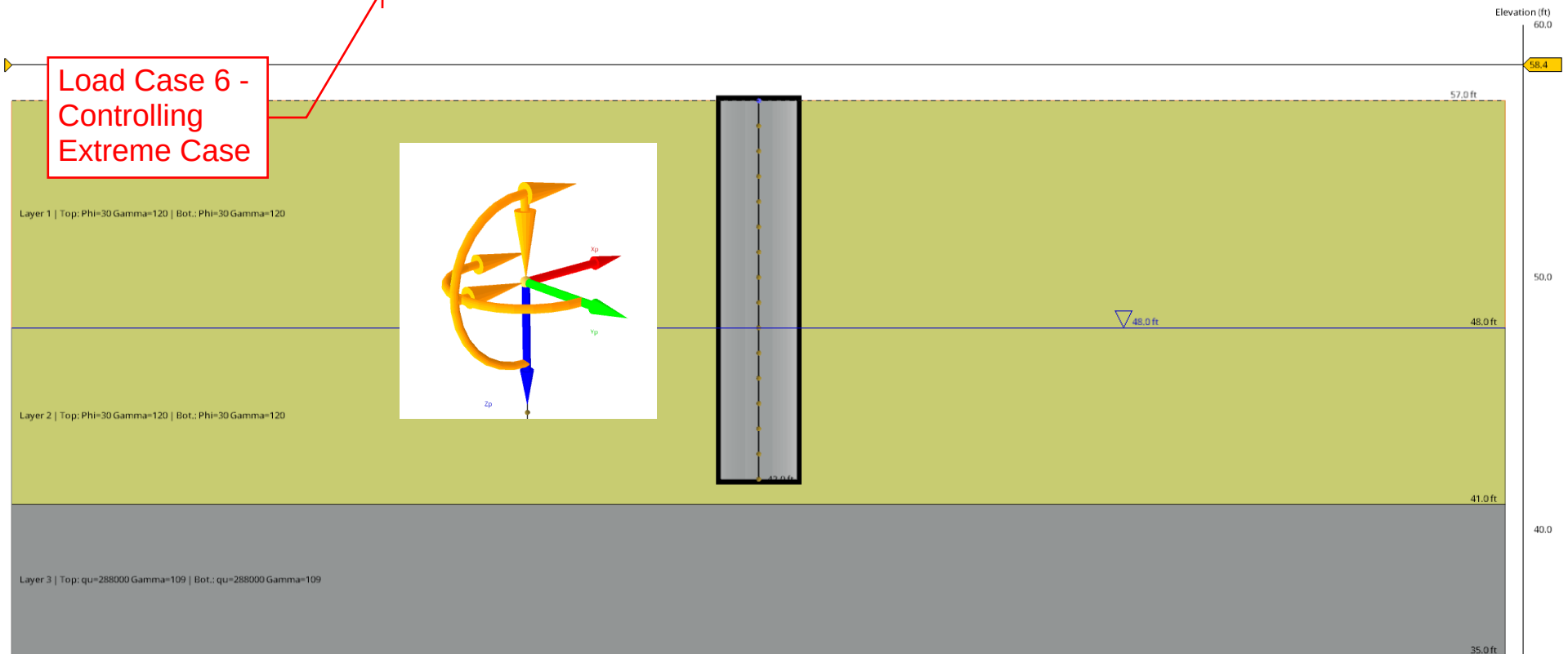
Load Table - Substructure 1

Load Case	Node	Force Xp	Force Yp	Force Zp	Moment Xp	Moment Yp	Moment Zp	Displacement?
PreLoad	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
1	1	1.5000	0.0000	7.0000	0.0000	-44.0000	18.0000	No
2	1	0.0000	0.0000	9.0000	0.0000	-31.5000	0.0000	No
3	1	3.0000	0.0000	8.0000	0.0000	-78.0000	43.5000	No
4	1	1.5000	0.0000	7.0000	0.0000	-81.5000	47.0000	No
5	1	0.0000	0.0000	9.0000	0.0000	-70.0000	0.0000	No
6	1	4.0000	0.0000	8.0000	0.0000	-128.5000	116.5000	No

Load Case 4 -
Controlling
Service Case

Load Case 5 -
Controlling
Strength Case

Load Case 6 -
Controlling
Extreme Case



Soil Inputs, Page 1 of 3

Global Lateral Axial Torsional Tip

Soil Set Table

		Water Table	Cyclic		Delete
Soil Set	Soil Layers	(ft)	Loading	Use SPT 'N' Values	Soil Set
1	3	48.00	☐	SPT	Delete
Add Set					

Notes

1. Enter number of soil sets and soil layers in Soil Set Table.
2. Enter layer elevations, select soil models, etc, in Soil Layer Table.
3. Enter soil properties appropriate to each model on Lateral, Axial, Torsional, and Tip pages.
4. The 'Add Layer' button adds a layer to the soil set above the button.
5. When a layer elevation is changed, all affected layers will have their elevations automatically adjusted.
6. API soils are designed specifically for steel pipe piles.
7. If 'Specify Top & Bottom Properties' is not checked, the 'Unit Weight (Top)' will apply to both the top and bottom of the layer.

Soil Layer Table

			Top	Bottom					Unit	Unit	Specify	
			Layer	Layer					Weight	Weight	Top &	
Soil	Soil	Soil	Elevation	Elevation	Lateral	Axial	Torsional	Tip	(Top)	(Bottom)	Bottom	Del
Set	Layer	Type	(ft)	(ft)	Model	Model	Model	Model	(pcf)	(pcf)	Properties	La
1	1	Cohesionless	57.00	48.00	Sand (Reese)	Drilled Shaft Sand	Hyperbolic	Drilled Shaft Sand	120.000		☐	Del
1	2	Cohesionless	48.00	41.00	Sand (Reese)	Drilled Shaft Sand	Hyperbolic	Drilled Shaft Sand	120.000		☐	Del
1	3	Rock	41.00	35.00	Weak Rock (Reese)	Drilled Shaft Limestone (McVay)	Hyperbolic	Drilled Shaft Sand	171.000		☐	Del
Add Layer												

Global Lateral Axial Torsional Tip

Notes

1. Only the soil properties relevant to the currently selected model are enabled.
2. To enter 'Custom P-Y' data, select 'Custom P-Y' as Lateral model, then right click the cell.
3. API soils are designed specifically for steel pipe piles.
4. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Lateral Model Table

			Internal				Undrained	Major	Major	Average			
			Friction	Subgrade	Mass	Stiffness	Shear	Principal	Principal	Undrained	Unconfined		
Soil	Soil	Lateral	Angle	Modulus	Modulus	Constant	Strength	Strain	Strain	Strength	Strength	RQD	Poisson's
Set	Layer	Model	(deg)	(lb/in^3)	(ksi)	krm	(psf)	@50%	@100%	(psf)	(psf)	%	Ratio
1	1	Sand (Reese)	30.0000	48.0000									
1	2	Sand (Reese)	30.0000	35.0000									
1	3	Weak Rock (Reese)			10.6000	0.0005					288000.0000	45.0000	

Soil Inputs, Page 2 of 3

Global	Lateral	Axial	Torsional	Tip
--------	---------	-------	-----------	-----

Notes

1. Only the soil properties relevant to the currently selected model are enabled.
2. To enter 'Custom T-Z' data, select 'Custom T-Z' as Axial model, then right click the cell.
3. API soils are designed specifically for steel pipe piles. The API method 'API RP 2A-LRFD (1993)' requires 'Internal Friction Angle' and 'Coefficient of Lateral Earth Pressure'. The API method 'API RP 2GEO (2021)' requires 'Nominal Unit Side Friction' and 'Disp. at Nominal Unit Side Friction'.
4. If the Axial model Driven Pile (McVay) is selected for any layer in a soil set, it must be used for all layers in the soil set.
5. The Driven Pile (McVay) model recommends using Small Strain Shear Modulus. See the Help Manual for more details.
6. Drilled Shaft IGM (Cohesive) only allows one input each for Pile Concrete, Unit Weight, and Slump.
7. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

			Small								Shaft		Nominal	
		Internal	Strain		Undrained	Unconfined	Mass			Split	Concrete		Unit	Coefficien
		Friction	Shear		Shear	Compressive	Modulus	Modulus		Tensile	Unit		Side	of Lateral
Axial	API	Angle	Modulus	Poisson's	Strength	Strength	(Em)	Ratio		Strength	Weight	Slump	Friction	Earth
Model	Method	(deg)	(ksi)	Ratio	(psf)	(psf)	(ksi)	(Em/Ei)	Surface	(psf)	(pcf)	(in)	(psf)	Pressure
Drilled Shaft Sand ▼														
Drilled Shaft Sand ▼														
Drilled Shaft Limestone (McVay) ▼													24300.00	

Global

Lateral

Axial

Torsional

Tip

Notes

1. Only the soil properties relevant to the currently selected model are enabled.

2. To enter 'Custom T-0' data, select 'Custom T-0' as Torsional model, then right click the cell.

3. The foundation type should be considered when selecting a representative Shear Modulus. See the Help Manual for more details.

4. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Torsional Model Table

				Torsional
			Shear	Shear
Soil	Soil	Torsional	Modulus	Stress
Set	Layer	Model	(ksi)	(psf)
1	1	Hyperbolic	0.73	648.00
1	2	Hyperbolic	0.73	890.00
1	3	Hyperbolic	10.60	24300.00

Global

Lateral

Axial

Torsional

Tip

Notes

1. Only the soil properties relevant to the currently selected model are enabled.

2. Only the 'Tip' layer for each soil set is shown on this page.

3. Tip properties can be distinct from properties for other soil models. For example, internal friction angle can have different values for the tip and lateral models.

4. API soils are designed specifically for steel pipe piles. The API method 'API RP 2A-LRFD (1993)' requires 'Internal Friction Angle'. The API method 'API RP 2GEO (2021)' requires 'Nominal Unit End Bearing' and 'Bearing Capacity I

5. The Driven Pile (McVay) model recommends using Small Strain Shear Modulus. See the Help Manual for more details.

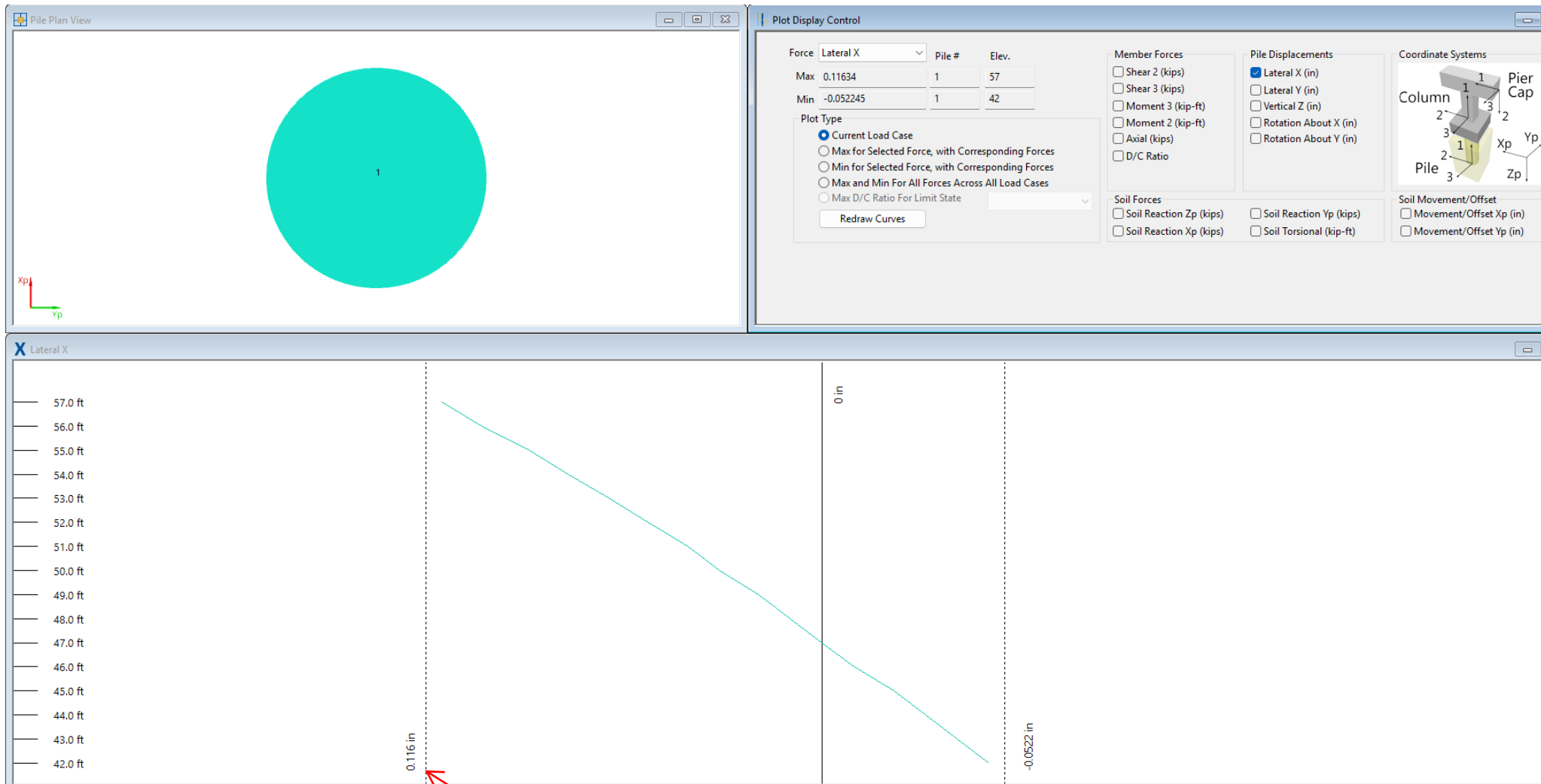
6. To enter 'Custom Q-Z' data, select 'Custom Q-Z' as Tip model, then right click the cell.

7. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Tip Model Table

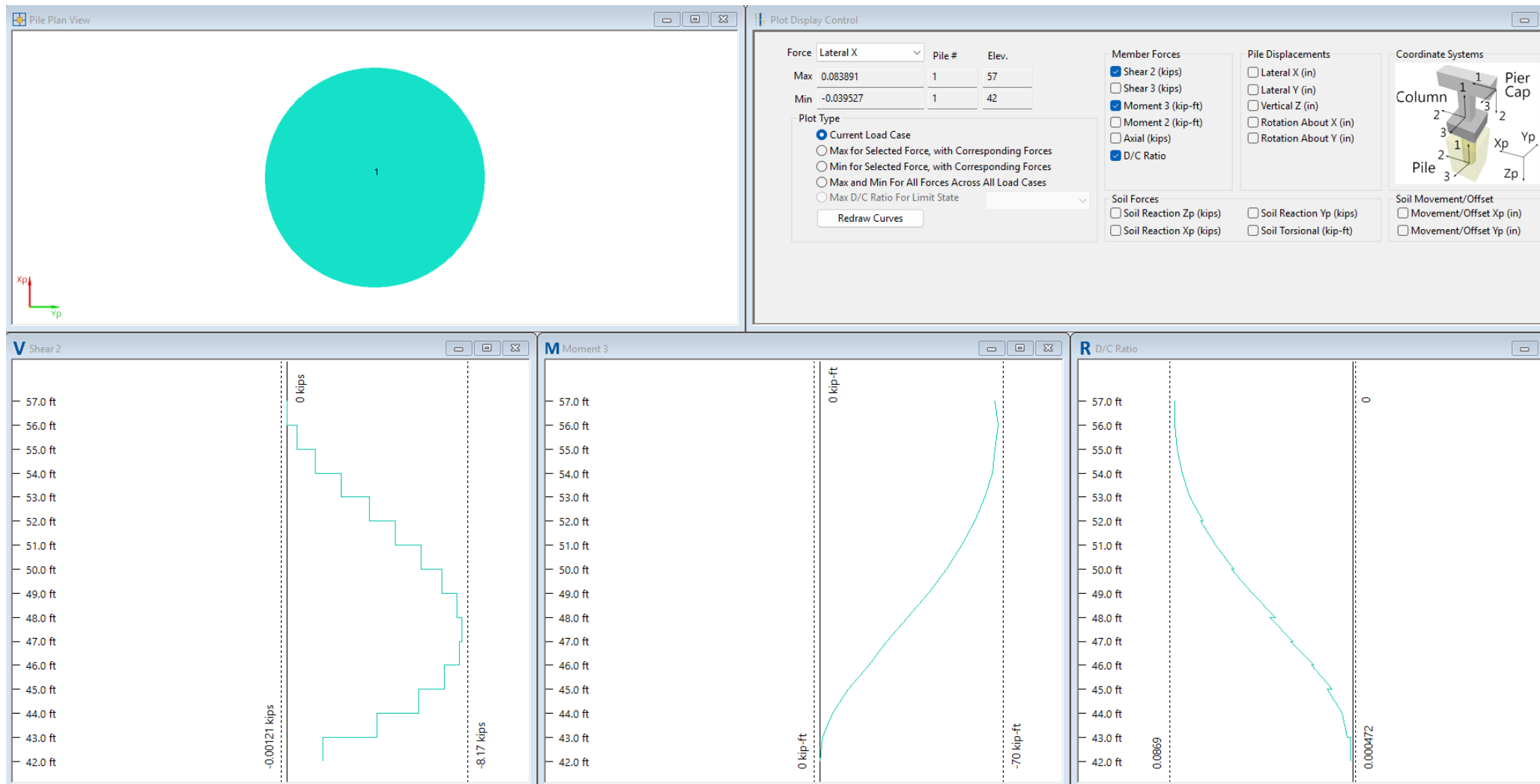
					Small							
				Internal	Strain		Nominal		Undrained	IGM	Nominal	
				Friction	Shear		Tip	Uncorrected	Shear	Mass	Unit End	
Soil	Soil	Tip	API	Angle	Modulus	Poisson's	Resistance	SPT	Strength	Modulus	Bearing	End
Set	Layer	Model	Method	(deg)	(ksi)	Ratio	(kips)	(blows/ft)	(psf)	(ksi)	(ksi)	Condition
1	Tip	Drilled Shaft Sand ▾						5.0000				

Load Case 4 - Controlling Service Case

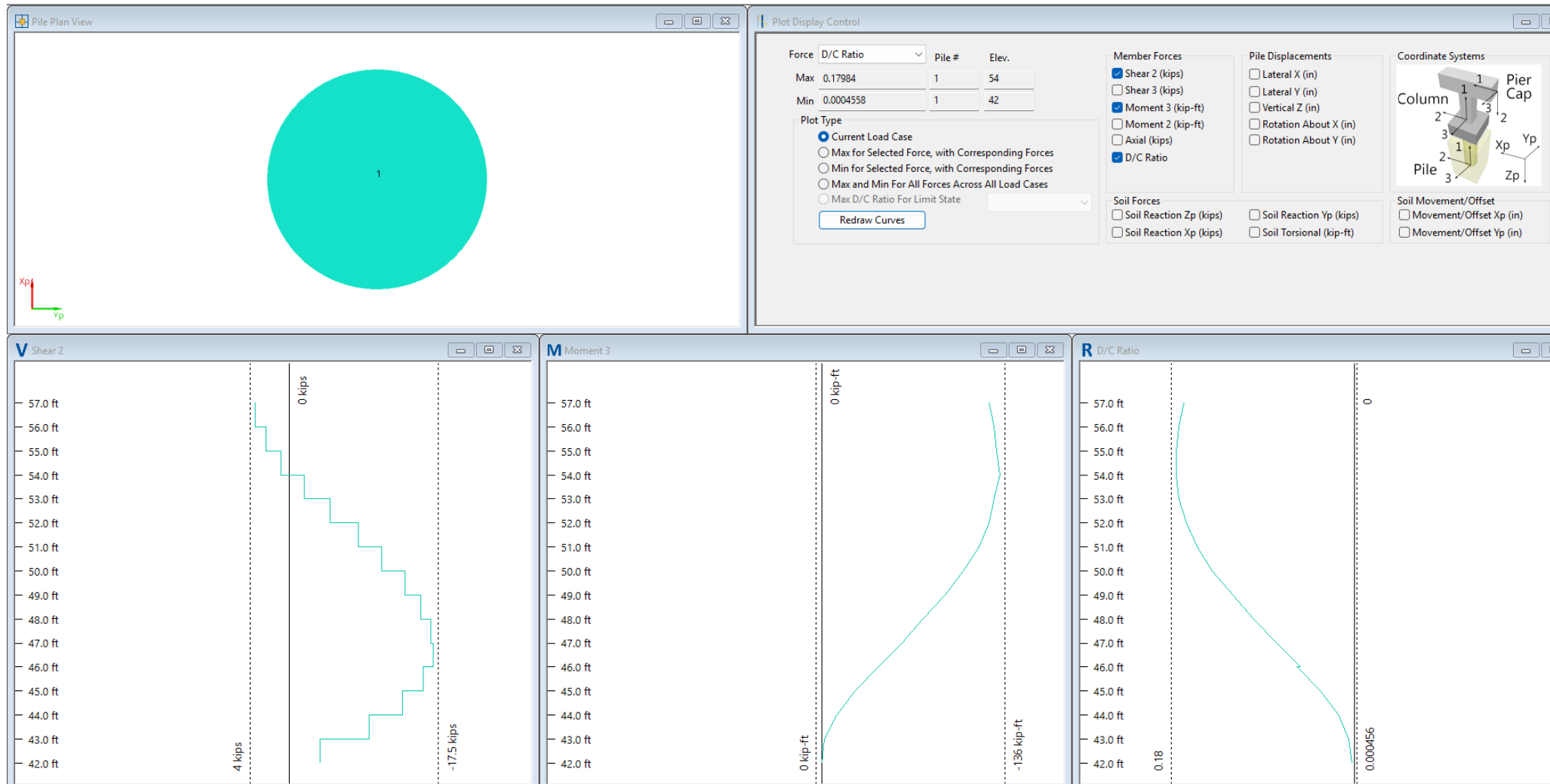


Displacement
at Top of
Shaft = 0.1 in

Load Case 5 - Controlling Strength Case



Load Case 6 - Controlling Extreme Case



PROFILE 2

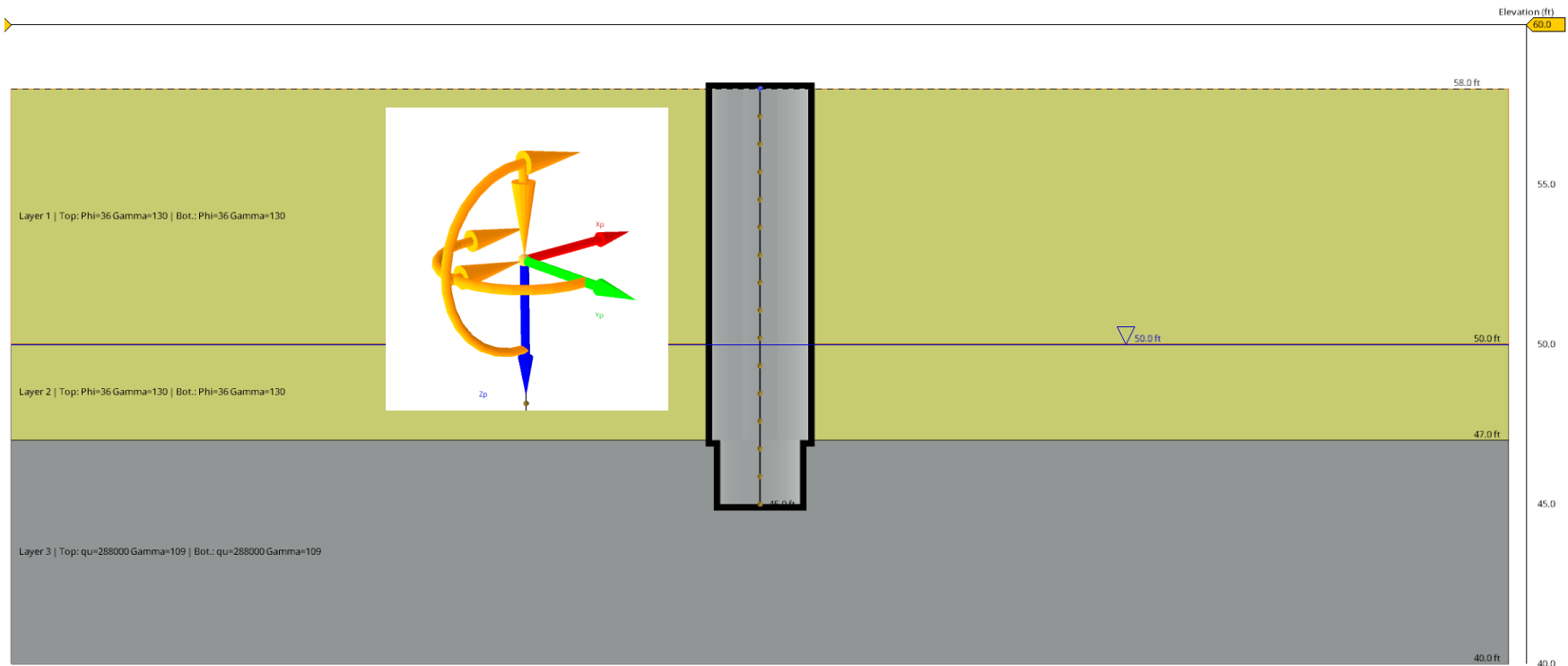
Load Case 1 -
Controlling
Service Case

Load Case 2 -
Controlling
Strength Case

Load Case 3 -
Controlling
Extreme Case

Load Table - Substructure 1

Load Case	Node	Force Xp	Force Yp	Force Zp	Moment Xp	Moment Yp	Moment Zp	Displacement?
PreLoad	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
1	1	1.5000	0.0000	2.5000	0.0000	-30.0000	21.0000	No
2	1	0.0000	0.0000	3.0000	0.0000	-26.5000	0.0000	No
3	1	3.0000	0.0000	3.0000	0.0000	-56.5000	51.5000	No
4	1	1.5000	0.0000	4.5000	0.0000	-27.0000	17.0000	No
5	1	0.0000	0.0000	5.5000	0.0000	-23.0000	0.0000	No
6	1	3.0000	0.0000	5.0000	0.0000	-53.0000	41.5000	No



Soil Inputs, Page 1 of 3

Global Lateral Axial Torsional Tip

Soil Set Table

Soil Set	Soil Layers	Water Table (ft)	Cyclic Loading	Use SPT 'N' Values	Soil Set
1	3	50.00	☐	SPT	Delete
Add Set					

- Notes
1. Enter number of soil sets and soil layers in Soil Set Table.
 2. Enter layer elevations, select soil models, etc, in Soil Layer Table.
 3. Enter soil properties appropriate to each model on Lateral, Axial, Torsional, and Tip pages.
 4. The 'Add Layer' button adds a layer to the soil set above the button.
 5. When a layer elevation is changed, all affected layers will have their elevations automatically adjusted.
 6. API soils are designed specifically for steel pipe piles.
 7. If 'Specify Top & Bottom Properties' is not checked, the 'Unit Weight (Top)' will apply to both the top and bottom of the layer.

Soil Layer Table

Soil Set	Soil Layer	Soil Type	Top Layer Elevation (ft)	Bottom Layer Elevation (ft)	Lateral Model	Axial Model	Torsional Model	Tip Model	Unit Weight (Top) (pcf)	Unit Weight (Bottom) (pcf)	Specify Top & Bottom Properties
1	1	Cohesionless	58.00	50.00	Sand (Reese)	Drilled Shaft Sand	Hyperbolic	Drilled Shaft Clay	130.000		☐
1	2	Cohesionless	50.00	47.00	Sand (Reese)	Drilled Shaft Sand	Hyperbolic	Drilled Shaft Clay	130.000		☐
1	3	Rock	47.00	40.00	Weak Rock (Reese)	Drilled Shaft Limestone (McVay)	Hyperbolic	Drilled Shaft Clay	171.000		☐

Global Lateral Axial Torsional Tip

- Notes
1. Only the soil properties relevant to the currently selected model are enabled.
 2. To enter 'Custom P-Y' data, select 'Custom P-Y' as Lateral model, then right click the cell.
 3. API soils are designed specifically for steel pipe piles.
 4. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Lateral Model Table

Soil Set	Soil Layer	Lateral Model	Internal Friction Angle (deg)	Subgrade Modulus (lb/in^3)	Mass Modulus (ksi)	Stiffness Constant krm	Undrained Shear Strength (psf)	Major Principal Strain @50%	Major Principal Strain @100%	Average Undrained Shear Strength (psf)	Unconfined Compressive Strength (psf)	RQD %	Poisson's Ratio	Residual Strength (psi)
1	1	Sand (Reese)	36.0000	164.0000										
1	2	Sand (Reese)	36.0000	97.0000										
1	3	Weak Rock (Reese)			10.6000	0.0005					288000.0000	45.0000		

Soil Inputs, Page 2 of 3

Global Lateral Axial Torsional Tip

- Notes
1. Only the soil properties relevant to the currently selected model are enabled.
 2. To enter 'Custom T-Z' data, select 'Custom T-Z' as Axial model, then right click the cell.
 3. API soils are designed specifically for steel pipe piles. The API method 'API RP 2A-LRFD (1993)' requires 'Internal Friction Angle' and 'Coefficient of Lateral Earth Pressure'. The API method 'API RP 2GEO (2021)' requires 'Nominal Unit Side Friction' and 'Disp. at Nominal Unit Side Friction'.
 4. If the Axial model Driven Pile (McVay) is selected for any layer in a soil set, it must be used for all layers in the soil set.
 5. The Driven Pile (McVay) model recommends using Small Strain Shear Modulus. See the Help Manual for more details.
 6. Drilled Shaft IGM (Cohesive) only allows one input each for Pile Concrete, Unit Weight, and Slump.
 7. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Axial Model Table

			Small								Shaft		Nominal	
		Internal	Strain		Undrained	Unconfined	Mass			Split	Concrete		Unit	Coefficient
		Friction	Shear		Shear	Compressive	Modulus	Modulus		Tensile	Unit		Side	of Lateral
Axial	API	Angle	Modulus	Poisson's	Strength	Strength	(Em)	Ratio		Strength	Weight	Slump	Friction	Earth
Model	Method	(deg)	(ksi)	Ratio	(psf)	(psf)	(ksi)	(Em/Ei)	Surface	(psf)	(pcf)	(in)	(psf)	Pressure
Drilled Shaft Sand														
Drilled Shaft Sand														
Drilled Shaft Limestone (McVay)													24300.00	

Global Lateral Axial Torsional Tip

- Notes
1. Only the soil properties relevant to the currently selected model are enabled.
 2. To enter 'Custom T-0' data, select 'Custom T-0' as Torsional model, then right click the cell.
 3. The foundation type should be considered when selecting a representative Shear Modulus. See the Help Manual for more details.
 4. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Torsional Model Table

				Torsional	
				Shear	
Soil	Soil	Torsional		Modulus	Stress
Set	Layer	Model		(ksi)	(psf)
1	1	Hyperbolic	3.33		624.00
1	2	Hyperbolic	3.33		746.00
1	3	Hyperbolic	10.60		24300.00

Soil Table

GlobalLateralAxialTorsionalTip

Notes

1. Only the soil properties relevant to the currently selected model are enabled.

2. Only the 'Tip' layer for each soil set is shown on this page.

3. Tip properties can be distinct from properties for other soil models. For example, internal friction angle can have different values for the tip and lateral models.

4. API soils are designed specifically for steel pipe piles. The API method 'API RP 2A-LRFD (1993)' requires 'Internal Friction Angle'. The API method 'API RP 2GEO (2021)' requires 'Nominal Unit End Bearing' and 'Bearing Capacity Factor'.

5. The Driven Pile (McVay) model recommends using Small Strain Shear Modulus. See the Help Manual for more details.

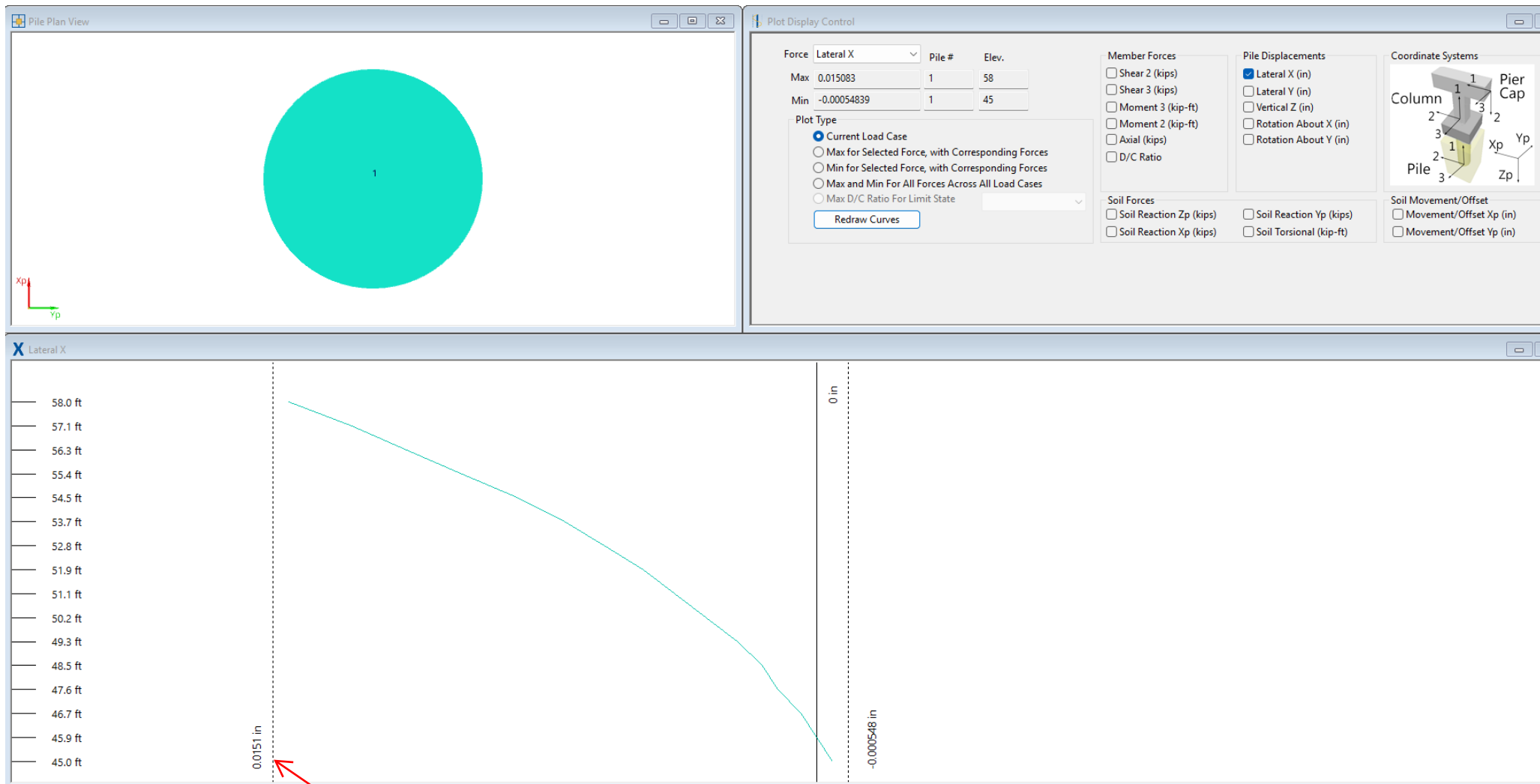
6. To enter 'Custom Q-Z' data, select 'Custom Q-Z' as Tip model, then right click the cell.

7. The 'Print' button prints the table data for the current page. Landscape orientation is recommended.

Tip Model Table

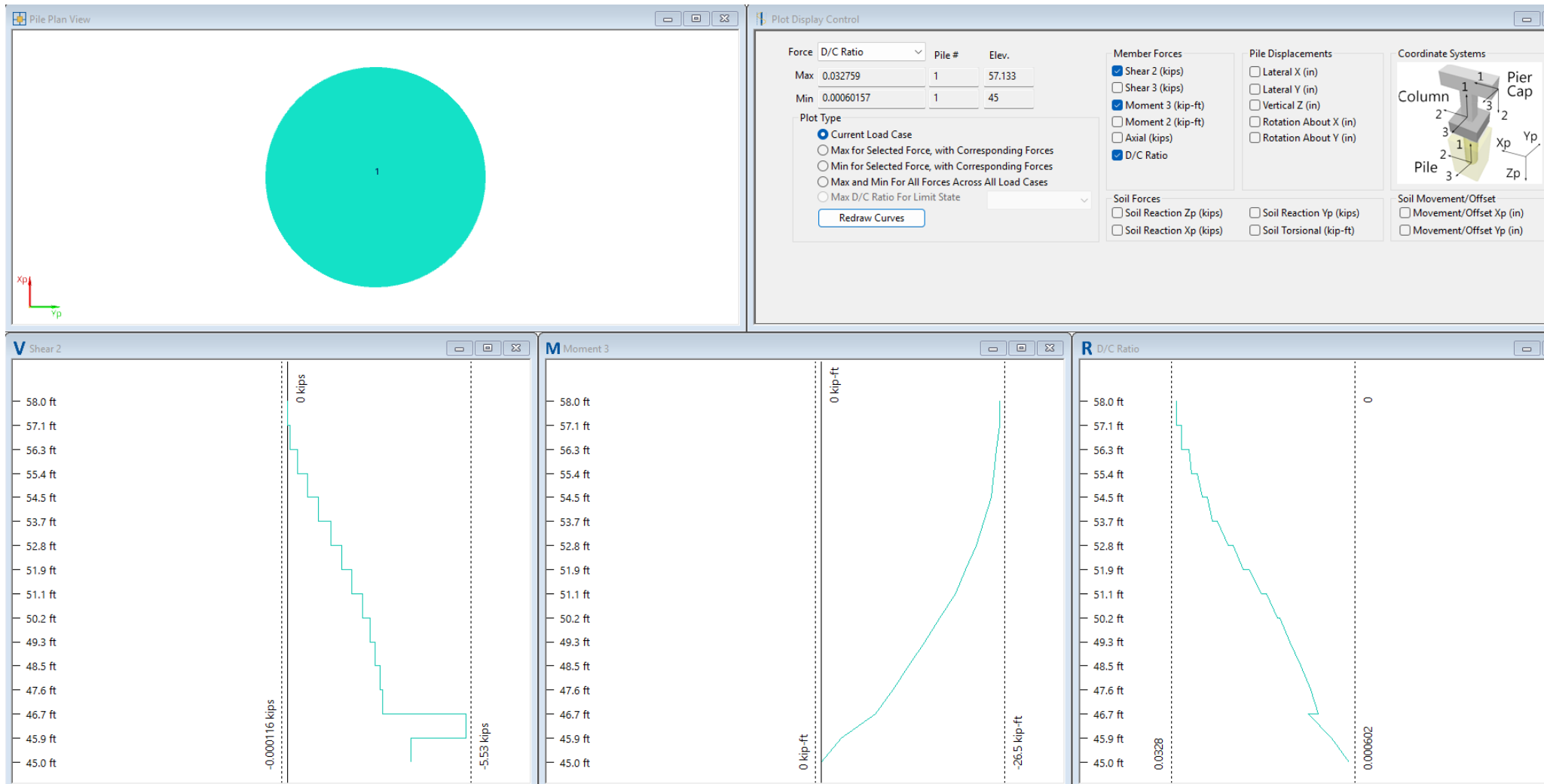
					Small							
				Internal	Strain		Nominal		Undrained	IGM	Nominal	
				Friction	Shear		Tip	Uncorrected	Shear	Mass	Unit End	
Soil	Soil	Tip	API	Angle	Modulus	Poisson's	Resistance	SPT	Strength	Modulus	Bearing	End
Set	Layer	Model	Method	(deg)	(ksi)	Ratio	(kips)	(blows/ft)	(psf)	(ksi)	(ksi)	Condition
1	Tip	Drilled Shaft Clay							144000.0000			

Load Case 1 - Controlling Service Case



Displacement
at Top of
Shaft = 0.02 in

Load Case 2 - Controlling Strength Case



Load Case 3 - Controlling Extreme Case

