GOLDER
MEMBER OF WSP

Supplemental Geotechnical Design Report - Part II

I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22)

FREEPORT, MAINE

MAINEDOT WIN 021726.00

Submitted to:

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APPENDICES

1.0 INTRODUCTION

This Supplemental Geotechnical Design Report (SGDR) summarizes the results of Golder Associates Inc.'s, a member of WSP, (Golder's) supplemental geotechnical design recommendations for the replacement of the Mallet Drive Bridge #5721 over I-295 in Freeport, Maine at Exit 22 (formerly Approach Road, see Sheet 1 for the site location). This is the second of two supplemental reports associated with the geotechnical design at the site, and specifically pertains to the geotechnical design of the drilled shaft foundations for the traffic mast arms and high mast lighting tower in the project development area.

Our design calculations and references are made in conjunction with the HNTB 98% Design Plans[1]. Golder had previously submitted the Preliminary Geotechnical Design Report (PGDR)[2] on December 21, 2020 which summarized our field activities, field and laboratory data collection, subsurface interpretations, and preliminary geotechnical design for the bridge foundations and embankments. The PGDR[2] serves as the basis for this report. Our work presented herein was completed in accordance with Golder's proposed scope of work[3] for supplemental design and Golder's General Consultant Agreement (GCA) dated June 15, 2020.

Golder's supplemental geotechnical design work is being completed in two stages, and each stage will be documented in a separate report as follows:

- Part I pertains to the supplemental geotechnical subsurface investigation and supplemental design of the bridge abutments, their foundations, and the approach embankments. This is the subject of a separate report[4].
- Part II pertains to geotechnical foundation designs and recommendations for traffic mast arms and light standards and luminaires within the project development area. It includes a supplemental subsurface investigation to identify the soil at the traffic mast arm and light standard locations. This is the subject of this report.

1.1 Project Background

The existing Mallet Drive Bridge (formerly Approach Road) at I-295 Exit 22 was originally constructed in 1957. The bridge will be replaced with a two span integral abutment bridge that will increase bridge clearance over I-295 to the 16 foot minimum standard. The proposed abutments will be moved away from I-295 back into the existing embankment, and will be lengthened to the south of the present Mallet Drive centerline to accommodate widening of Mallet Drive. These alignment modifications will impact approach embankment configurations and loadings.

Golder's PGDR details the historical geotechnical investigation findings and Golder's geotechnical subsurface investigation that included in-situ and laboratory testing; presents recommended geotechnical parameters for design and construction; and provides preliminary geotechnical designs for the bridge foundations and approach embankments. The PGDR describes shallow and sloping bedrock encountered at the abutment locations and

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1. HNTB, July 16, 2021, Freeport, Cumberland County, Approach Road Bridge over Interstate 295 and Signalized Intersections Exit 22 Interchange: 98% Plans, Filename: WIN 20021726.00_Freeport_Exit 2022_Plans 20.
2. Golder Associates, Inc., December 21, 2020, Preliminary Geotechnical Design Report, I-295 Mallet Drive Bridge Replacement #5721 (Exit 22), Freeport, Maine, MaineDOT WIN 021726.00.
3. Golder Associates, Inc., April 9, 2021, Proposal for Phase II Supplemental Geotechnical Design and Analysis: I-295 Mallet Drive Bridge Replacement #5721 (Exit 21), Freeport, Maine, MaineDOT WIN 021726.00.
4. Golder Associates, Inc., August 20, 2021, Supplemental Geotechnical Design Report Part I, I-295 Mallet Drive Bridge Replacement #5721 (Exit 22), Freeport, Maine, MaineDOT WIN 021726.00.

recommends additional probes to establish the bedrock surface along the proposed abutment centerline. The PGDR additionally recommends abutment pile design, downdrag mitigation strategies for the piles, and engineering analysis and design be performed during final design after the bedrock elevations at the proposed abutment centerlines, specifically Abutment No. 2 with shallow bedrock, are better defined. These recommendations are the basis for the supplemental geotechnical analyses provided in SGDR Part I[4].

Additional site development includes installation of four (4) traffic mast arm structures and one (1) high mast lighting structure to support traffic safety improvements at the site. These structures require geotechnical foundation design to support the axial, shear, moment, and torsional loading imposed on them. Foundation design and recommendations for these structures are discussed in this report.

1.2 Scope of Geotechnical Work

In accordance with the scope of work described in our proposal dated April 9, 2021 and referenced in our Project Contract with MaineDOT dated April 22, 2021, Golder performed the following work for the SGDR Part II:

- Planned, coordinated, and monitored a geotechnical field program to establish the soil properties at or near the proposed locations of the traffic mast arms and high mast lighting towers.
- Performed geotechnical drilled shaft foundation design of four (4) highway sign mast arm foundations and one (1) high mast light standard foundation using the loading and minimum drilled shaft diameters provided by HNTB[5].

2.0 GEOLOGIC SETTING

2.1 Regional Surficial Geology

The proposed bridge replacement site is located in southern-central Maine within the Seaboard Lowland Section of the New England Physiographic Province.[6] Regional surficial geologic mapping indicates the surficial soils consist of Holocene (Recent) wetland/saltwater marsh deposits overlying Pleistocene Presumpscot Formation fine grained sediments, which overlie Pleistocene glacial till deposits. The wetland/saltwater marsh deposits consist of peat, clay, silt, and sand deposited in low-lying areas adjacent to tidal inlets, tidal channels, and tidal flats. The Presumpscot Formation consists of fine-grained marine mud (silt and clay with local sandy beds and lenses), locally with marine fossils and dropstones, deposited in deeper, quieter water during marine submergence of the coastal lowland. The till consists of a light to dark gray, heterogeneous, non-sorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders, rarely stratified and deposited directly by glacial ice. The till consists of two varieties: a basal (or lodgment) till, fine grained and very dense; and an overlying ablation (or melt-

5 Hodgdon, Steven (HNTB). "Freeport - Lighting and Signal Foundation Locations and Design Loads " Message to Melissa Landon (Golder Associates). June 29, 2021. E-mail

6 Fenneman, N.M., and Johnson, D.W., 1946. Physiographic Divisions of the Conterminous U.S., U.S. Geological Survey, 1 sheet, scale 1:7,000,000.

out) till, coarser grained, stony, and relatively loose.[7,8,9] Regional mapping indicates the overburden thickness ranges between 5 feet and 200 feet below ground surface in the Yarmouth-Freeport area.[10]

2.2 Regional Bedrock Geology

Regional bedrock geologic mapping indicates the bedrock beneath the site consists of the Silurian-Ordovician Vassalboro Group, undifferentiated, previously mapped as the Hutchins Corner Formation.[11,12,13] The lithology consists of light to medium gray, fine- to medium-grained, plagioclase-quartz-biotite granofels and gneiss, interlayered with subordinate amounts of greenish gray, fine-grained, calc-silicate granofels or medium gray, medium-grained biotite schist. Layer thickness ranges from 1 to 4 inches, and pegmatite lenses, boudins and sills are common. This formation is interpreted to have been initially deposited as sediments within a marine basin, which subsequently underwent diagenesis to form sedimentary rocks. This formation was then metamorphosed by heat and pressure under miles of younger rocks, forming a layered foliation, and then underwent ductile deformation by several tectonic events dating back to at least Devonian time starting with the Acadian orogeny. This compressional stress created additional foliation textures (low greenschist to upper amphibolite facies), and at least three-fold sets. This in turn was followed by post-metamorphic brittle deformation forming numerous northeast trending thrust faults and joints, with the emplacement of non-metamorphosed discordant pegmatite dikes and layer diabase dikes during the Mesozoic Era.[7,8] Within the Yarmouth-Freeport area, metamorphic compositional layering within the Vassalboro Group strikes northeast-southwest, and dips gently to the southeast.

3.0 SUBSURFACE INVESTIGATIONS

3.1 Preliminary Geotechnical Investigation

Golder performed the preliminary geotechnical subsurface investigation as described in in the PGDR[2]. The subsurface investigation included 6 (six) borings with two borings each near the proposed abutment locations and pier location. For the abutment locations, one boring was performed in the westbound lane of Mallet Drive and one boring was performed south of the existing embankment to provide information for the proposed bridge shift to the south. For the pier location, one boring was performed in the westbound lane of Mallet Drive and one boring was performed eastbound lane of Mallet Drive. These borings were performed in existing fills from the original roadway embankment construction through the in situ glaciomarine and sand and gravel layers to bedrock. Each boring had 10 feet of rock core drilled. The locations of these 100-series borings (BB-FMD-1XX) are shown on Sheet 3 of this report. Refer to the PGDR[2] for the methods used, boring logs, and interpreted subsurface

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7 Retelle, M.J., 1999. Surficial Geology of the Yarmouth Quadrangle, Maine. Maine Geological Survey, Open-File No. 99-105, 1 sheet, scale 1:24,000.

8 Retelle, M.J., 1999. Surficial Geology of the Yarmouth 7.5-minute Quadrangle, Cumberland County, Maine. Maine Geological Survey Open-File 99-136, 8 p.

9 Prescott, G.C., Jr., 1977. Ground-Water Favorability and Surficial Geology of the Windham-Freeport Area, Maine. U.S. Geological Survey, Hydrologic Investigations Atlas HA-564, 1 sheet, scale 1:62,500.

10 Tolman, S.S., 2010. Overburden Thickness in the Portland 30x60-minute Quadrangle, Maine. Maine Geological Survey, Open-File No. 10-65, 1 sheet, scale 1:125,000.

11 Berry, H.N., IV, and Hussey, A.M., II, 1998. Bedrock Geology of the Portland 1:100,000 Quadrangle, Maine and New Hampshire. Maine Geological Survey, Open-File No. 98-1, 1 sheet, scale 1:100,000.

12 Hussey, A.M., II, 1985. The Bedrock Geology of the Bath and Portland 2° Map Sheets, Maine. Maine Geological Survey, Open-File No. 85-87, 82 p., 2 sheets, scale 1:250,000.

13 West, D.P., Jr. and Hussey, A.M., II, 2017. Bedrock Geology of the Yarmouth Quadrangle, Maine. Maine Geological Survey, Open-File No. 17-11, 1 sheet, scale 1:24,000.

stratigraphy. This information forms the basis of the interpretive subsurface profiles provided in Sheet 5 of this report.

3.2 Supplemental Geotechnical Investigation

Golder completed nine (9) test borings (BB-FMD-201 through BB-FMD-203 and BB-FMD-205 through BB-FMD-210) between May 22 and June 10, 2021 along Mallet Drive between the I-295 southbound and northbound entrance/exit ramp intersections and at the base of the south embankment of existing Abutment No. 2. BB-FMD-204 was originally planned for the south embankment of existing Abutment No. 1 however, the location was inaccessible to a geotechnical track-rig because the slope location was prohibitive for access due to a vegetated steep slope and the need to remove guardrail and guardrail posts. The field program included Standard Penetration Test (SPT) sampling of coarse-grained and fine-grained materials. Golder geotechnical engineers or geologists monitored drilling activities, selected sampling intervals, logged subsurface conditions encountered, and obtained soil samples and rock core for use in visual description and subsequent laboratory testing and classification. The as-drilled boring locations were surveyed by MaineDOT following completion of the drilling program. Boring location coordinates and ground surface elevations are summarized in Table 1. Boring locations with respect to existing site features are illustrated in Sheet 2, Sheet 3, and Sheet 4.

Borings were completed by S.W. Cole Explorations, LLC (S.W.COLEx) of Bangor, Maine using a Diedrich D-50 truck-mounted rig (BB-FMD-201, -202, -203, -205, -206, -207, -208, -209, -210). S.W.COLEx drilled the borings using solid-stem augers from the ground surface, followed by the cased and washed methods in which the boring was advanced by driving 5.5 inch diameter casing in 5-foot lengths, and the soil in the casing was washed out with a roller bit and water to the depth where samples were subsequently collected. All borings were advanced to at least a depth of 20 feet before termination, or, if bedrock was encountered shallower than 20 feet, to refusal at the bedrock surface after which 5 feet of rock core was collected.

Standard Penetration Testing (SPT) was performed using a calibrated automatic hammer system and a standard 2-inch split spoon sampler in accordance with American Society for Testing and Materials (ASTM) D1586 for all borings. Sampling was conducted continuously between the ground surface and 12 feet depth, and then at 5-foot intervals from 15 feet depth to boring termination for all borings. Split spoons were driven 24 inches by a 140-pound hammer dropped 30 inches, and the number of hammer blows required to advance the split spoon sampler through each 6-inch increment was recorded. Soil samples were collected and stored in jars for subsequent characterization and laboratory testing. Measured, uncorrected N-values, calculated as the sum of the hammer blows to advance the sampler during the 6-inch to 18-inch interval, are provided in the boring logs in Appendix A. A hammer efficiency factor of 0.974 provided by S.W.COLEx was used to convert the measured N-values to N_{60} values, which are also provided in the boring logs in Appendix A.

For each boring, 5 feet of rock core was collected using NQ-size (1-⅞ inch inside diameter) diamond-tipped core barrels in all borings following refusal of either the casing or rollercone bit to advance. Rock core samples were placed in wooden boxes and transported to the Golder office. Total Core Recovery (TCR), calculated Rock Quality Designation (RQD), and coring rates were recorded for each core run and are provided in the boring logs in Appendix A. A detailed summary of rock quality parameters for the recovered rock core is presented in Table 2, and photographs of the rock core are presented in Appendix B.

Details of the sampling methods used, field data obtained, and soil and rock conditions encountered during the investigation are presented on the boring logs provided in Appendix A. Soils were field characterized in accordance with ASTM D2488. Bedrock lithology was field characterized and the descriptions were revised in the office. A description of the boring log symbols and terms used for the soil and rock descriptions is also provided in Appendix A.

3.3 Supplementary Rock Probes

Golder completed four (4) rock probes on June 9 and June 22, 2021 on Mallet Drive near the proposed abutment locations: RP-FMD-204 was performed at proposed Abutment No. 1 and RP-FMD-207, RP-FMD-208 and RP-FMD-209 were performed at proposed Abutment No. 2. Rock probes were completed by Maine Drilling and Blasting (MD&B) of Gardiner, Maine using an Atlas Copco D 755 track-mounted rig. MD&B drilled the borings using hollow piping advanced by air hammering, with 12-foot sections in length of pipe added as needed from a rotary pipe holder attached to the rig. Golder geotechnical engineers or geologists monitored drilling activities and logged the depth at which bedrock was encountered by the drilling. The as-drilled rock probe locations were surveyed by MaineDOT following completion of the drilling program. Rock probe location coordinates and ground surface elevations are summarized in Table 1, and rock probe locations with respect to existing site features are illustrated in Sheet 3. Rock probes were used to develop Interpretive Subsurface Cross Section B-B' at Abutment No. 2 shown in Sheet 6. A detailed description of the rock probe field activities is provided in Golder's Supplemental Geotechnical Design Report Part I[4].

4.0 LABORATORY TESTING PROGRAM

Laboratory testing of soil samples was performed by GeoTesting Express (GTX) of Acton, Massachusetts in accordance with applicable American Society for Testing Materials (ASTM) and American Association of State Highway Transportation Officials (AASHTO) testing procedures. Geotechnical laboratory tests were performed on SPT split spoon soil samples representative of each soil type collected from the borings to assist in soil classification. The types and numbers of each of the laboratory tests conducted on soil samples are summarized in Table 4-1. Measured index and classification test results from soil samples are summarized in Table 3. Soil testing results are also included on the boring logs in Appendix A. Complete laboratory testing results are provided in Appendix C.

Table 4-1: Laboratory Testing of Soils

Soil Laboratory Test	Test Standard	No. Tests Completed
Grainsize (sieve)	ASTM D6913 AASHTO T 88	18
Water Content	ASTM D2216 AASHTO T 265	26
Atterberg Limits with Natural Water Content	ASTM D4318 AASHTO T 89/90	6

5.0 SUBSURFACE CONDITIONS

Soils encountered at the borings were found to generally include fill materials placed during construction of the bridge and roadway, naturally occurring silt and clay associated with the glaciomarine Presumpscot Formation, and sand and gravel interpreted as glacial till over bedrock. Detailed descriptions of the soil and bedrock conditions encountered at the borings are provided on the boring logs in Appendix A. The following descriptions summarize the major stratigraphic units from the existing ground surface to depth.

Asphalt Pavement: Asphalt pavement thickness observed in borings BB-FMD-202, BB-FMD-203, BB-FMD-207, BB-FMF-208, BB-FMD-209 and BB-FMD-210 ranged from 8 inches to 12 inches.

Fill: Fill was encountered in borings BB-FMD-201, -202, -203, -205, -206, -207, -208, -209 and -210. The layer was observed to be between 4.7 feet and 20.7 feet thick and start between elevation 142.3 feet and 161.1 feet. The fill consisted of fine to coarse SAND with "trace" gravel fractions and silt fractions ranging from "silty" to "trace" and sandy SILT with "trace" gravel fractions. Laboratory classifications generally described the layer as SM, SC, GM, ML or SP-SM (USCS classification) and A-2-4, A-3, A-4, A-1-a or A-1-b (AASHTO classification). N_{60}-values for the fill, corrected for hammer efficiency, ranged from 0 to refusal, where N_{60}-values generally decreased with increasing depth within the fill. The fill layer transitions to the Presumpscot Formation sandy silty or sandy clay and silt at 8.0 feet, 11.0 feet, 7.0 feet, 20.7 feet and15.9 below ground surface (bgs) for borings BB-FMD-201, -202, -203, -207 and -209, respectively, and to bedrock at 4.7 feet, 17.5 feet and 18.5 feet bgs for borings BB-FMD-205, -206 and -208 respectively.

Glaciomarine: Presumpscot silty or sandy clay was encountered in borings BB-FMD-201, -202, -203, -207 and -209. It was not encountered in BB-FMD-205, -206 and -208 because native soil was likely removed for placement of the pier foundations on bedrock. The layer starts between elevation 143.6 feet and 156.5 feet. The Presumpscot silty or sandy clay and silt consists of clay with up to "trace" gravel fractions, sand fractions ranging from "sandy" to "trace", and silt fractions ranging from "silty" to "trace". Laboratory classifications generally described the layer as ML or CL (USCS classification) and A-4 or A-6 (AASHTO classification). SPT N_{60}-values ranged from 5 to 81 (soft to hard). The clay and silt layer transitions to sand and gravel at 15.9 feet bgs in BB-FMD-209.

Sand and Gravel: Sand and gravel (glacial till) was encountered in borings BB-FMD-208, -209, and -210 and was observed to be 9.7 feet thick. The glacial till consists of fine to coarse sand with up to "some" gravel fractions and silt fractions ranging from "little" to "trace" and gravel with sand fractions ranging from "sandy" to "some" and "trace" silt. Laboratory classifications generally described the layer as SM or GW (USCS classification) and A-1-b or A-1-a (AASHTO classification). SPT N_{60}-values ranged from 39 to 104. The sand and gravel layer transitions to bedrock at 18.5 feet for BB-FDR-208.

Bedrock: The bedrock surface was encountered in BB-FMD-205, -206 and -208. The bedrock surface elevation varied approximately 9 feet across the site and generally slopes down from the northeast (El. 151.6 at BB-FMD-206) to southwest (El. 142.3 at BB-FMD-205). Borings BB-FMD-205, -206 and -208 were drilled to refusal with 5 feet of rock core obtained. The predominant bedrock lithology encountered was blue/gray, coarse-grained, strongly foliated, fresh to moderately weathered gneiss, interpreted to be part of the Vassalboro Formation. The RQD (rock quality designation) ranged from very poor (14%) to good (76%), and the estimated RMR (rock mass rating) ranged from 57 to 67. Table 2 provides detailed information about the recovery, rock quality designation (RQD), rock mass rating (RMR), and descriptions of lithology, rock mass and discontinuities.

Groundwater: Groundwater level measurements in BB-FMD-201, -202, -203, -206, -207, -208, -209 and -210 were measured upon completion of the boreholes and prior to removal of the casing. Groundwater elevations measured in the borings were between 135.6 feet and 154.8 feet. Groundwater levels shown on the Interpretive Subsurface Profile A-A' (Sheet 5) were interpreted based on these water level meter measurements from the PGDR[2].

6.0 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

Golder used the geotechnical data collected during the supplemental and preliminary geotechnical investigations to develop design parameters for the traffic mast arm and high mast lighting structure drilled shaft foundations. These parameters were based on correlations with SPT N_{60} values and engineering judgement and were used for subsequent geotechnical design.

HNTB[5] provided Golder with stationing and offset locations, design loads, and minimum foundation diameters for four (4) mast arm structures and one (1) high mast lighting structure. Table 6-1 provides information related to the design of the mast arm and high mast lighting. Sheet 2 through Sheet 4 show the locations of each of these structures with respect to site features and BB-FMD-200 series borings.

Table 6-1: Mast Arm and High Mast Light Parameters for Foundation Design

Structure[1]	Loading Description[2]	Minimum Foundation Diameter[2] (in)	Station[1]	Offset[1]	Proposed Ground Elevation[1] (ft)	Existing Ground Elevation[1] (ft)
Traffic Mast Arm M1 (35' & 30' mast arms)	Dual Mast Arm	36	34+80.2	38.3 feet RT	175.0	166.5
Traffic Mast Arm M2 (30' mast arm)	50 foot Mast Arm	36	33+85.1	29.9 feet LT	169.5	169.5
Traffic Mast Arm M3 (30' & 45' mast arms)	Dual Mast Arm	36	27+30.8	21.1 feet LT	156.0	156.0
Traffic Mast Arm M4 (50' mast arm)	50 foot Mast Arm	36	28+04.3	73.0 feet RT	158.0	155.2
High Mast Lighting (HML) (90' high mast pole)		48	33+75.0	51.0 feet LT	167.2	168.0

1. From HNTB 98% Design Plans[1].
2. Based on mast arm and high mast lighting load scenario information[5] provided to Golder by HNTB.

Golder evaluated the subsurface profiles at or nearby each of the mast arm and high mast lighting structures. Rather than perform separate foundation analyses for each structure, we aggregated this information into two design profiles based on soil layering (material type and thickness) and soil engineering properties relevant to the foundation design. Appendix D summarizes the subsurface characteristics and interpreted engineering parameters for each of the five (5) locations as well as the two (2) design subsurface profiles for design of the mast arm or high mast lighting foundations. Golder chose the two (2) design subsurface layering and material properties profiles in order to provide a uniform drilled shaft foundation design for four (4) mast arm structures and a specific foundation design for the single high mast lighting structure. The design subsurface profiles incorporated cohesionless soils (proposed and in situ fills and sand/gravel above bedrock) and the Presumpscot glaciomarine clay.

Golder evaluated drilled shaft lengths assuming the top of shaft is at the proposed ground surface, ignoring any reveal height above the ground surface. We assumed the upper 2 feet of soil does not contribute to soil-shaft frictional interaction in the analyses that are subsequently discussed: axial resistance (Section 6.2), uplift evaluation (Section 6.3), and torsion evaluation (Section 6.5). The upper 2 feet of soil is incorporated into the lateral resistance and pushover evaluations (Section 6.4).

6.1 Drilled Shaft Foundation Settlement and Downdrag Loading

AASHTO LRFD[14] Article 3.11.8 indicates that downdrag on drilled shafts can be assumed to fully develop in soil layers where settlement is equal to or greater than 0.4 inches. We evaluated the settlement (immediate for cohesionless soils, consolidation for fine-grained glaciomarine soil) for the foundation in response to the embankment fills, where appropriate, along with foundation self-weight and applied axial load.

For the scenario where a drilled shaft is founded in the stratigraphy of cohesionless soils above glaciomarine clay, we estimated consolidation settlement of the drilled shaft to estimate downdrag loading. The loads imposed by the proposed embankment fill, shaft self-weight, and the structural axial component were distributed through the subsurface soils using Boussinesq stress distribution theory. The subsurface soils were then discretized into layers less than 10 feet thick, and the effective stress, imposed stresses, and other soil parameters were used to evaluate consolidation settlement within each layer using one-dimensional consolidation theory for cohesive soil. Golder used our knowledge of the Presumpscot Formation soil properties from southern coastal Maine and engineering judgement to estimate compressibility and coefficient of consolidation parameters used in the analysis as undisturbed samples were not collected for subsequent laboratory testing because of high soil stiffness.

For the analyses performed, the estimated consolidation settlement for the design stratigraphy with the glaciomarine layer was less than 0.4 inches. Thus, downdrag loading was assumed to be negligible and was not included in the geotechnical analysis. Where the design stratigraphy included only cohesionless soils over a similar depth, we assumed immediate settlement of the foundation was smaller than consolidation settlement. Thus, downdrag loading was assumed to be negligible and was not included in the geotechnical analysis. The full analysis methodology and calculations are provided in Appendix E.

6.2 Drilled Shaft Axial Resistance

In accordance with the MaineDOT Bridge Design Guide[15] Section 5.8, the design methods in AASHTO LRFD[14] and FHWA GEC 10[16] were used to evaluate geotechnical resistance for axial compression loads through a combination of side friction and end bearing tip resistance. The nominal axial geotechnical resistance was calculated for a single vertical drilled shaft at each design profile location. Contributions from side resistance of the soils in the top two feet of each shaft were neglected in the analysis to account for the effects of seasonal moisture changes, disturbance during construction, cyclic lateral loading, and low lateral stresses from freshly placed concrete. Below this depth, side and tip resistance were evaluated in accordance with AASHTO LRFD Article 10.8.3.5 for both cohesionless and cohesive soils. Resistance factors of 0.55 and 0.45 were applied to side resistance in cohesionless and cohesive soils, respectively. Resistance factors of 0.50 and 0.40 were applied to

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[14] AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020.

[15] Guertin Elkerton & Associates for Maine Department of Transportation. Bridge Design Guide. Dated August 2003 with 2018 updates.

[16] FHWA. Drilled Shafts: Construction Procedures and Design Methods. Publication No. FHWA-NHI 18-024 and FHWA GEC 010. September 2018.

tip resistance in cohesionless and cohesive soils, respectively. Table 6-2 presents our recommended values of factored geotechnical axial compression resistance for each design profile analyzed. The full analysis methodology and calculations are provided in Appendix E.

6.3 Drilled Shaft Uplift Resistance

Although it is our understanding uplift loads will not be applied to the drilled shafts, uplift resistance will be provided by side friction acting along the perimeter of the shaft. Based on side friction resistance determined per AASHTO LRFD[14] guidance, and resistance factors of 0.45 and 0.35 for uplift in cohesionless and cohesive soils, respectively (as per AASHTO LRFD Table 10.5.5.2.4-1), recommended factored geotechnical uplift resistances for each design profile are provided in Table 6-2.

6.4 Drilled Shaft Lateral Resistance

The computer program LPile[17] was used to evaluate the lateral geotechnical resistance of the drilled shaft for each design profile. A summary of the input soil and rock parameters and p-y lateral models used in the LPile analyses is provided in Appendix D.

A pushover analysis was performed with LPile to evaluate lateral geotechnical resistance at the Strength I and Extreme I limit states for each design profile. The shaft was modeled as a simple linear elastic beam with an elastic modulus equal to that of concrete and a moment of inertia equal to that of the uncracked circular cross section. Shaft head deflection was computed for a constant factored axial design load and various multiples of the factored shear and moment design loads, up to 1/φ times the factored shear and moment design loads. A resistance factor (φ) of 0.67 was used for Strength I loads and a resistance factor of 0.8 was used for Extreme I loads. In accordance with FHWA GEC 10[16] Section 9.3.3.3.1, the drilled shaft design was considered stable if the analyses each converged to a solution with a computed head deflection no larger than 10% of the shaft diameter. Furthermore, Golder designed the mast arm foundations so that total drilled shaft rotation at the end of the pushover analysis would result in an estimated vertical movement at the tip of the mast arm of less than 6 inches.

Lateral geotechnical resistance at the Service I limit state was evaluated for each design profile by modeling the shaft as a nonlinear reinforced concrete shaft in flexure. In accordance with FHWA GEC 10, a limiting requirement of 0.5 inches was used for the shaft head deflection under Service I loads. Table 6-2 presents the computed head deflections under Service I loads for each design profile analyzed. In support of HNTB's structural design, the maximum bending moment in the drilled shaft for each of the design profiles at the Strength I, Extreme I, and Service I limits states is provided in Table 6-3. The full analysis methodology and calculations are provided in Appendix E.

6.5 Drilled Shaft Torsional Resistance

The design method in Florida Department of Transportation (FDOT) Modifications to LRFD[18] was used to evaluate torsional resistance of the drilled shaft for the Mast Arm design profiles. Torsional resistance was not evaluated for the High Mast Lighting design profile, since based on the factored design loads provided by HNTB[5] the High Mast Lighting will experience no appreciable torsional loading. In accordance with the FDOT method, the drilled shaft was assumed to be installed entirely within cohesionless soil for the torsional calculation. We

[17] Ensoft, Inc. LPile software package, version 2019.11.05, release date 03/05/20.

[18] Florida Department of Transportation. FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (LRFDLTS-1). Structures Manual, Volume 3. January 2021.

assumed that the drilled shaft circumference is in contact with soil and determined torsional resistance assuming no casing is in place. The nominal torsional resistance was calculated for a single vertical drilled shaft at each design profile location. Contributions from skin friction resistance of the soils in the top two feet of each shaft were neglected in the analysis to account for the effects of seasonal moisture changes, disturbance during construction, cyclic lateral loading, and low lateral stresses from freshly placed concrete. A resistance factor of 1.0 was applied to torsional resistance for mast arm structures. For the Mast Arms analyzed, shaft length was controlled by the torsional resistance, and a torsion demand capacity ratio of 0.89 was calculated under the Extreme I load case. Table 6-2 presents our recommended values of factored torsional resistance for each design profile analyzed. The full analysis methodology and calculations are provided in Appendix E.

6.6 Drilled Shaft Summary

Table 6-2 presents the factored geotechnical resistance values and lateral deflection for the governing drilled shaft lengths and diameters we analyzed for each for the design soil profiles chosen, as previously discussed. As discussed, the design soil profiles were chosen based on our interpretation of the subsurface layering and material properties that include fill and in situ cohesionless soils and glaciomarine clay when present. Table 6-3 presents the maximum bending moments at the various limit states derived from the lateral analyses for the design profiles and drilled shafts. Table 6-4 presents Golder's recommended foundation dimensions for each of the traffic mast arms and the high mast light pole, which were determined based on our engineering judgment, evaluation of design loading scenarios, and comparison of the actual subsurface soil conditions with the design soil profiles conditions.

Table 6-2: Factored Geotechnical Resistance and Lateral Deflection for Drilled Shaft Design Scenarios

Design Soil Profile	Shaft Diameter[1] (in)	Shaft Length[1,2] (ft)	Factored Axial Compression Resistance (kips)	Factored Uplift Resistance (kips)	Lateral Shaft Head Deflection[3] (in)	Factored Torsional Resistance (kip-ft)
High Mast Lighting	48	10	397	41	0.14	N/A
Mast arm (based on M3)	36	12	53	33	0.19	159

1. The drilled shaft diameters and lengths are adequate for the Strength I, Extreme I, Service I, and Service II limit load cases, considering axial, shear, moment, and torsion loading provide by HNTB. See Appendix E – Drilled Shaft Design Calculations, for details.
2. Shaft length assumes the top of the shaft is at the proposed final grade. This length ignores the maximum 3 inches of reveal above ground level allowable in certain conditions noted in MaineDOT Standard Specification Section 626.034 and in MaineDOT Standard Details 626(01) and 626(02).If the location of the shaft allows for HNTB to specify a reveal above the ground surface, we recommend the shaft length be increased by 0.5 feet.
3. At the governing Service Limit State.

Table 6-3: Maximum Bending Moments for Drilled Shaft Design Scenarios

Design Soil Profile	Shaft Diameter[1] (in)	Shaft Length[1,2] (ft)	Load Cases		
			Strength I M_{max} (kip-ft)	Extreme I M_{max} (kip-ft)	Service I M_{max} (kip-ft)
High Mast Lighting	48	10	0	251	93
Mast arm (based on M3)	36	12	148	213	141

1. The drilled shaft diameters and lengths are adequate for the Strength I, Extreme I, Service I, and Service II limit load cases, considering axial, shear, moment, and torsion loading provide by HNTB. See Appendix E – Drilled Shaft Design Calculations, for details.
2. Shaft length assumes the top of the shaft is at the proposed final grade. This length ignores the maximum 3 inches of reveal above ground level allowable in certain conditions noted in MaineDOT Standard Specification Section 626.034 and in MaineDOT Standard Details 626(01) and 626(02).If the location of the shaft allows for HNTB to specify a reveal above the ground surface, we recommend the shaft length be increased by 0.5 feet.
3. The drilled shaft was modeled as a simple linear elastic beam with an elastic modulus equal to that of concrete and a moment of inertia equal to that of the uncracked circular cross section.

Table 6-4: Mast Arm and High Mast Light Recommended Foundations

Structure	Loading Description[1]	Shaft Diameter[1,2] (in)	Shaft Length[2,3] (ft)	Station[4]	Offset[4]	Proposed Ground Elevation[4] (ft)	Expected Soil[5]
M1	Dual Mast Arm	36	12	34+80.2	38.3 feet RT	172.0	F/S&G
M2	50 foot Mast Arm	36	12	33+85.1	29.9 feet LT	169.5	F/BR
M3	Dual Mast Arm	36	12	27+30.8	21.1 feet LT	156.0	F/G
M4	50 foot Mast Arm	36	12	28+04.3	73.0 feet RT	158.0	F/G
High Mast Pole	High Mast Lighting	48	10	33+75.0	51.0 feet LT	167.2	F/BR

1. Based on mast arm and high mast lighting load scenario information[5] provided to Golder by HNTB.
2. The final concrete dimensions and reinforcing steel design for the spread footings are the responsibility of the project structural engineer.
3. Shaft length assumes the top of the shaft is at the proposed final grade. This length ignores the maximum 3 inches of reveal above ground level allowable in certain conditions noted in MaineDOT Standard Specification Section 626.034 and in MaineDOT Standard Details 626(01) and 626(02).If the location of the shaft allows for HNTB to specify a reveal above the ground surface, we recommend the shaft length be increased by 0.5 feet.
4. From HNTB 98% Design Plans[1].
5. Soil types: F = fill, G = glaciomarine, S&G = sand and gravel, BR = bedrock. Symbols are listed left to right from shallowest to deepest.

7.0 CONSTRUCTION CONSIDERATIONS

Drilled shaft foundations should be constructed in accordance with MaineDOT Standard Specification Section 626.034. Foundations should be cast-in-place using temporary casing, if necessary, with no more than 2 feet of permanent casing (e.g., tubular form) below the ground surface. We recommend the drilled shaft foundation locations be cleared, grubbed, and stripped of existing vegetation, pavement, and topsoil, and any unsuitable materials exposed at the subgrade level, such as wood, logs, tree stumps, organic silt, peat, soft clay, debris fill, or other materials that may compress, decay or collapse should be removed prior to start of foundation construction. We recommend unsuitable soils be replaced with Granular Borrow materials and placement methods in accordance with MaineDOT Standard Specifications. We recommend concrete for drilled shafts be placed (via tremie methods) as soon after excavation as practicable to prevent debris from collecting in the excavated area. The Contractor should provide temporary dewatering of excavations for foundations such that concrete is placed in the dry. The concrete for drilled shafts shall be placed in accordance with Section 502.10 as temporary casing is withdrawn to prevent debris from contaminating the foundation and to ensure concrete is cast against the surrounding soil. The level of the concrete inside the temporary casing should be above the bottom of the casing throughout concrete placement.

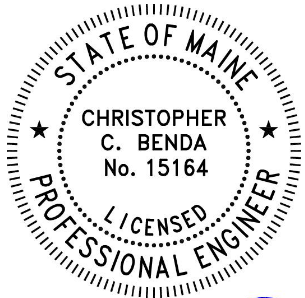
8.0 REPORT AND EXPLORATION LIMITATIONS

This Supplemental Geotechnical Design Report was prepared for the exclusive use of MaineDOT and HNTB for specific application to the proposed Mallet Drive bridge replacement at I-295 Exit 22 in Freeport, Maine. We conducted our evaluations and compiled our recommendations in accordance with generally accepted soil and foundation engineering practices in this geographical area and under similar time and financial constraints. Golder makes no other warranty, either express or implied. If changes in the nature, design, or location of the proposed project are planned, Golder should be notified to review the appropriateness of our conclusions and recommendations, and to modify the recommendations as appropriate to reflect the changes in design. In addition, Golder should review the final plans and specifications to evaluate compliance with these recommendations.

Our analyses and recommendations are based, in part, on information obtained from the referenced subsurface explorations completed at the discrete locations described in the report. Variations in the nature and extent of subsurface conditions between explorations should be expected. Golder should be notified if conditions encountered during construction vary from those described in this report so that we may re-evaluate, and if necessary, revise the recommendations made in this report.

The professional services provided by Golder for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

Signature Page



Golder Associates Inc.

Melissa E Landon, PhD, PE
Senior Project Engineer

Christopher C. Benda, PE
Practice Leader

MEL/CCB/RAW

https://golderassociates.sharepoint.com/sites/139982/project files/6 deliverables/sgdr part ii 21450910/final/sgdr part 2 final - freeport bridge 5721 win 021726.00 - golder 21450910.docx

Tables

Table 1: Subsurface Exploration Locations
Supplemental Geotechnical Design Report
I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Freeport, Maine
MaineDOT WIN 021726.00

Test Boring Designation[1]	As-Drilled Locations[2,3]		Existing Ground Surface Elevation[3] (feet)	Boring Depth[4] (feet)	Comments[4,5]
	Northing (feet)	Easting (feet)			
BB-FMD-201	376178.1	1054356.0	154.8	27.0	-
BB-FMD-202	376214.2	1054444.5	156.2	27.0	-
BB-FMD-203	376097.4	1054412.2	155.6	27.0	-
BB-FMD-205	375781.5	1054716.6	147.0	9.7	Bedrock at 142.3 ft elevation (4.7 ft bgs)
BB-FMD-206	375746.3	1054891.8	169.1	22.5	Bedrock at 151.6 ft elevation (17.5 ft bgs)
BB-FMD-207	375713.0	1054910.1	169.6	25.5	Bedrock at 144.1 ft elevation (25.5 ft bgs)
BB-FMD-208	375857.1	1054762.8	166.0	23.5	Bedrock at 147.5 ft elevation (18.5 ft bgs)
BB-FMD-209	375630.8	1054958.7	172.3	20.8	-
BB-FMD-210	375658.2	1054898.2	171.0	25.4	-
RP-FMD-204	376009.5	1054581.0	160.8	33.0	-
RP-FMD-209	375850.1	1054756.0	166.4	16.0	Bedrock at 150.4 ft elevation (16.0 ft bgs)
RP-FMD-210	375833.4	1054756.0	166.7	15.0	Bedrock at 151.7 ft elevation (15.0 ft bgs)
RP-FMD-211	375825.2	1054747.0	166.2	15.5	Bedrock at 150.7 ft elevation (15.5 ft bgs)

Notes:

1. Boring BB-FMD-2XX were performed by S.W. Cole from June 6 to June 10, 2021. Rock probes RP-FMD-2XX were performed by Maine Drilling and Blasting on June 9 and June 23, 2021.
2. All test boring (BB-FMD-XXX) and rock probe (RP-FMD-XXX) locations are illustrated in Sheet 2 entitled "Boring Location Plan".
3. As-drilled locations and elevations for BB-FMD-2XX and RP-FMD-2XX are derived from survey files within the emails titled "FW: Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
4. Boring logs for BB-FMD-20X are presented in Appendix A
5. bgs = below ground surface

Prepared By: BK
Checked By: HTV
Reviewed By: CCB

Table 2: Summary of Rock Core Quality
Supplemental Geotechnical Design Report
I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Freeport, Maine
MaineDOT WIN 021726.00

Test Boring Designation	Core Size	Existing Ground Surface Elevation[1]	Run						TCR[2]		RQD[3]			Physical Rock Parameters			Lithologic, Rock Mass and Discontinuity Description[6]
			No.	Midpoint Depth Below Bedrock Surface	Depth Below Ground Surface (ft)			Length	Length		Length		Designation	Weathering[4]	Estimated Field Strength[4]	Rock Mass Rating [RMR][5]	
(-)	(in)	(ft)	(-)	(ft)	Start	End	Midpoint	(ft)	(ft)	%	(ft)	%	(-)	(-)	(-)	(-)	
BB-FMD-205	NX (2.875)	147.031	R1	2.7	4.7	9.7	7.2	5.0	5.0	100%	2.1	41%	Poor	Fresh to slightly weathered (W1 to W2)	Very Strong (R5)	60	4.7-9.7 ft: Grey, fine grained, strongly foliated, SCHIST, very strong (R5), fresh to slightly weathered (W1 to W2), discontinuities low angle to vertical (5°-90°),very closely to closely spaced (0.2-0.8 ft) [VASSALBORO FORMATION].
BB-FMD-206	NX (2.875)	169.1	R1	2.5	17.5	22.5	20.0	5.0	3.7	74%	0.7	14%	Very Poor	Moderately weathered (W3)	Extremely Strong (R6)	57	17.5-22.5 ft: Dark grey, fine grained, SCHIST, extremely strong (R6), moderately weathered (W3), discontinuities horizontal to moderately dipping (0°-40°), very closely to closely spaced (0.05-0.3 ft) [VASSALBORO FORMATION].
BB-FMD-208	NX (2.875)	166.0	R1	2.5	18.5	23.5	21.0	5.0	4.7	94%	3.8	76%	Good	Slightly to moderately weathered (W2 to W3)	Strong to very strong (R4 to R5)	67	18.5-23.5 ft: Grey, fine grained, strongly foliated, SCHIST, strong to very strong (R4 to R5), slightly to moderately weathered (W2 to W3), discontinuities low to moderately dipping (5°-35°), very closely to closely spaced (0.05- 0.6 ft) [VASSALBORO FORMATION].

Notes:

1. As-drilled elevations for are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
2. TCR = total core recovery. Total core recovery is the length of core recovered divided by the length of the run.
3. RQD = rock quality designation. RQD is the total length of intact, full diameter core pieces recovered with a length greater than or equal to 4 inches measured along the core axis. The percent RQD is the total length of RQD measured versus the run length. Note that vertical discontinuities are not included in determination of RQD.
4. Weathering and Estimated Field Strength based on Tables II.4 and II.3 (respectively) in Willey, 2004 (based on ISRM, 1981).
5. Rock Mass Rating (RMR) System (Bieniawski, 1989) assigns numerical ratings to six parameters, including the strength of the intact rock, the RQD, the discontinuity spacing, groundwater conditions, and orientation of discontinuities. These ratings are summed to give the RMR value. The rating adjustment for joint orientation was assigned a value of 0; correlation of geologic field mapping data of exposed rock outcrops with the rock core samples and proposed foundation type may allow for a different rating adjustment for joint orientation, and thus a modification to the RMR value shown on this table.
6. Mapped bedrock formation taken from: Berry & Hussey, 1998; Hussey, 1985; and West & Hussey, 2017.
7. ft = feet, in = inches

Prepared by: BK
Checked by: KAR/HTV
Reviewed by: JRS

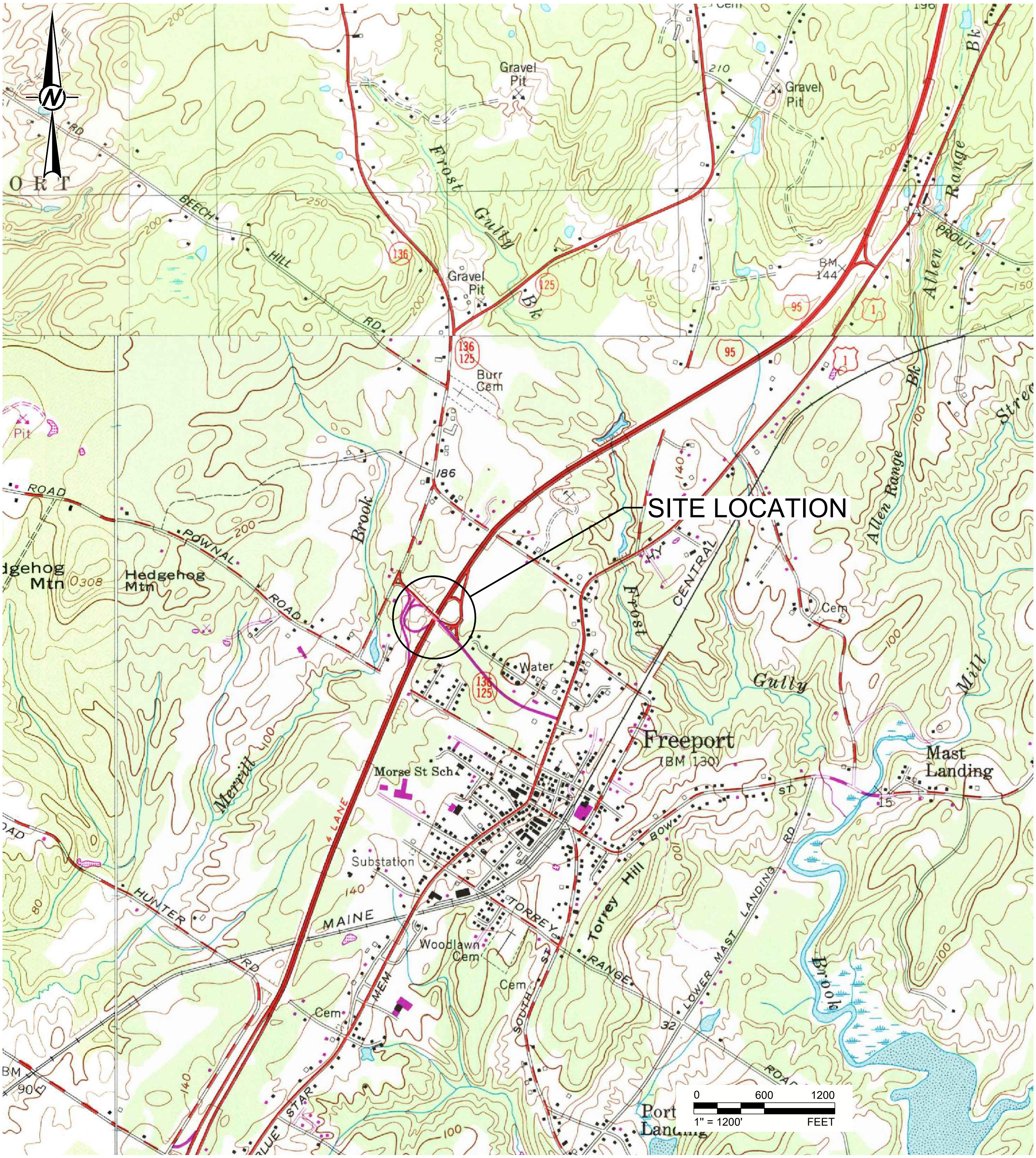
Table 3: Summary of Laboratory Soil Index and Classification Testing Results
Supplemental Geotechnical Design Report
I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Freeport, Maine
MaineDOT WIN 023626.00

Test Boring Designation[1]	Ground Surface Elevation[2] (feet)	Sample Number[3]	Sample Depth Below Ground Surface (feet)	Approximate Sample Elevation (feet)	Laboratory Testing[4]						Soil Classification[5]	
					Sieve Minus No. 200 (%)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	AASHTO	USCS
BB-FMD-201	154.8	3D	4.0 - 6.0	150.8 - 148.8	-	4.5	-	-	-	-	-	-
BB-FMD-201	154.8	5DA	8.0 - 8.6	146.8 - 146.2	58.0	21.3	-	-	-	-	A-4	ML
BB-FMD-201	154.8	6D	10.0 - 12.0	144.8 - 142.8	-	31.1	-	-	-	-	-	-
BB-FMD-201	154.8	7D	15.0 - 17.0	139.8 - 137.8	-	23.9	41	20	21	0.2	-	-
BB-FMD-202	156.2	4D	8.0 - 10.0	146.8 - 144.8	27.0	13.3	-	-	-	-	A-2-4	SM
BB-FMD-202	156.2	5DA	10.0 - 10.9	146.2 - 145.3	22.0	8.1	-	-	-	-	A-2-4	SM
BB-FMD-202	156.2	6D	15.0 - 17.0	141.2 - 139.2	93.0	27.5	36	19	17	0.5	A-6	CL
BB-FMD-203	155.6	3D	5.0 - 7.0	151.2 - 149.2	18.0	8.1	-	-	-	-	A-2-4	SC
BB-FMD-203	155.6	5D	9.0 - 11.0	146.6 - 144.6	-	12.4	-	-	-	-	-	-
BB-FMD-203	155.6	8D	20.0 - 22.0	135.6 - 133.6	87.0	29.3	29	18	11	1.0	A-6	CL
BB-FMD-205	147.0	2D	2.0 4.0	153.6 - 151.6	27.0	14.0	-	-	-	-	A-2-4	SM
BB-FMD-206	169.1	3D	4.0 - 6.0	151.6 - 149.6	10.0	7.0	-	-	-	-	A-1-a	GM
BB-FMD-206	169.1	5D	8.0 - 10.0	147.6 - 145.6	9.3	5.4	-	-	-	-	A-3	SP-SM
BB-FMD-206	169.1	7DA	15.0 - 15.5	154.1 - 153.6	18.0	13.0	-	-	-	-	A-1-b	SC
BB-FMD-207	169.6	3D	4.8 - 6.8	164.3 - 162.3	8.0	4.2	-	-	-	-	A-3	SP-SM
BB-FMD-207	169.6	6D	10.8 - 12.8	158.8 - 156.8	9.4	6.9	-	-	-	-	A-3	SP-SM
BB-FMD-207	169.6	8DB	20.6 - 21.0	149.0 - 148.6	72.0	26.5	-	-	-	-	A-4	ML
BB-FMD-208	166.0	4D	6.8 - 8.8	162.8 - 160.8	-	6.2	-	-	-	-	-	-
BB-FMD-208	166.0	6D	10.8 - 12.8	158.8 - 156.8	16.0	6.3	-	-	-	-	A-1-b	SM
BB-FMD-208	166.0	7D	15.0 - 17.0	151.0 - 149.0	1.7	6.3	-	-	-	-	A-1-a	GW
BB-FMD-209	172.3	3D	4.7 - 6.7	161.3 - 159.3	14.0	2.8	-	-	-	-	A-2-4	SM
BB-FMD-209	172.3	5D	8.7 - 10.7	157.3 - 155.3	-	5.8	-	-	-	-	-	-
BB-FMD-209	172.3	7DB	15.3 - 16.2	150.7 - 149.8	81.0	27.3	25	17	8	1.3	A-4	CL
BB-FMD-210	171.0	6D	10.0 - 12.0	156.0 - 154.0	-	9.8	-	-	-	-	-	-
BB-FMD-210	171.0	7DA	15.0 - 15.5	151.0 - 150.5	27.0	10.4	-	-	-	-	A-2-4	SM
BB-FMD-210	171.0	8D	20.0 - 20.3	146.0 - 145.6	-	15.9	-	-	-	-	-	-

Notes:
1. All test boring (BB-FMD-XXX) locations are illustrated in Sheets 2 through Sheets 4 entitled "Boring Location Plan".
2. As-drilled elevations for are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT
3. Laboratory testing was performed by GeoTesting Express, Inc.
4. Atterberg Limits ASTM D4318; Particle Size ASTM D6913; Moisture Content ASTM D2216
5. AASHTO and USCS symbols assigned based on interpreted laboratory test results provided by GeoTesting Express, Inc. on June 29, 2021.
6. Complete laboratory soil test results are provided in Appendix C.

Prepared By: BK
Checked By: HTV
Reviewed By: CCB

Sheets



REFERENCE(S)

BASE MAP TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLE OF FREEPORT, MAINE DATED 1957

STATE OF MAINE
CHRISTOPHER C. BENDA
No. 15164
LICENSED
PROFESSIONAL ENGINEER

CLIENT	PROJECT
MAINE DEPARTMENT OF TRANSPORTATION 16 STATE HOUSE STATION AUGUSTA, MAINE 04333	I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22) FREEPORT, MAINE MAINEDOT WIN 021726.00

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-08-20
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	MEL
APPROVED	CCB

TITLE

SITE LOCATION PLAN

PROJECT NO.	SUBTITLE	REV.	SHEET
21450910	A	0	1 OF 6

Last Edited By: azumbado Date: 2021-08-13 Time:3:13:25 PM | Printed By: AZumbado Date: 2021-08-20 Time:2:09:25 PM
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 1 in

LEGEND

⊙	PROPOSED HIGH MAST LIGHTING (SEE SHEET 3)
●	PROPOSED MAST ARM FOUNDATION
BB-FDR-102 TOB 130.1	COMPLETED 100 SERIES BORINGS (SEE SHEET 3)
BB-FDR-202 TOB 156.2	COMPLETED 200 SERIES BORINGS
TOB XXX.X	ELEVATION OF TOP OF BORING

NOTE(S)

1. AS DRILLED BORING LOCATION PLAN FOR 100-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "BOR12-18-19edit.csv" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 01/06/2020. AS DRILLED BORING LOCATION PLAN FOR 200-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "21726 Exit22 - 200 Series Borings Compiled" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 06/24/2021.

REFERENCE(S)

1. BASEMAP ELEMENTS TAKEN FROM MAINE DOT IN FILE NAMED "3DTopo_2019-11-18.dgn" RECIEVED ON JANUARY 2, 2020.
2. SURVEY DATA PROVIDED TO GOLDER ON JANUARY 2, 2020 BY MAINE DOT IN FILE "FREEPORT 21726.00 SURVEY DATA 2019-11-18.zip".
3. PROPOSED STATIONING PROVIDED TO GOLDER BY HNTB FOR A SOUTHERN SHIFT OF THE BRIDGE.
4. LOCATIONS FOR MAST ARM FOUNDATIONS AND LIGHT STANDARD FOUNDATIONS DERIVED FROM ELECTRONIC FILE NAME: "Foundation Location Tables.pdf" PROVIDED BY HNTB ON JUNE 29, 2021.
5. GOLDER ASSOCIATES, INC., DECEMBER 21, 2020, PRELIMINARY GEOTECHNICAL DESIGN REPORT, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
6. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part I, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
6. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part II, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
7. EXIT RAMP ALIGNMENTS PROVIDED TO GOLDER BY HNTB ON JULY 14, 2021.

0 25 50
1" = 25' FEET

GOLDER
MEMBER OF WSP

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021726.00

WIN 021726.00

Bridge No. 5721

BRIDGE PLANS

STATE OF MAINE · CHRISTOPHER C. BENDA · No. 15164 · LICENSED · PROFESSIONAL ENGINEER

	MEL	BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	MEL	AAZ	2021-08-20
CHECKED-REVIEWED	CCB	AAZ	2021/08/20
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

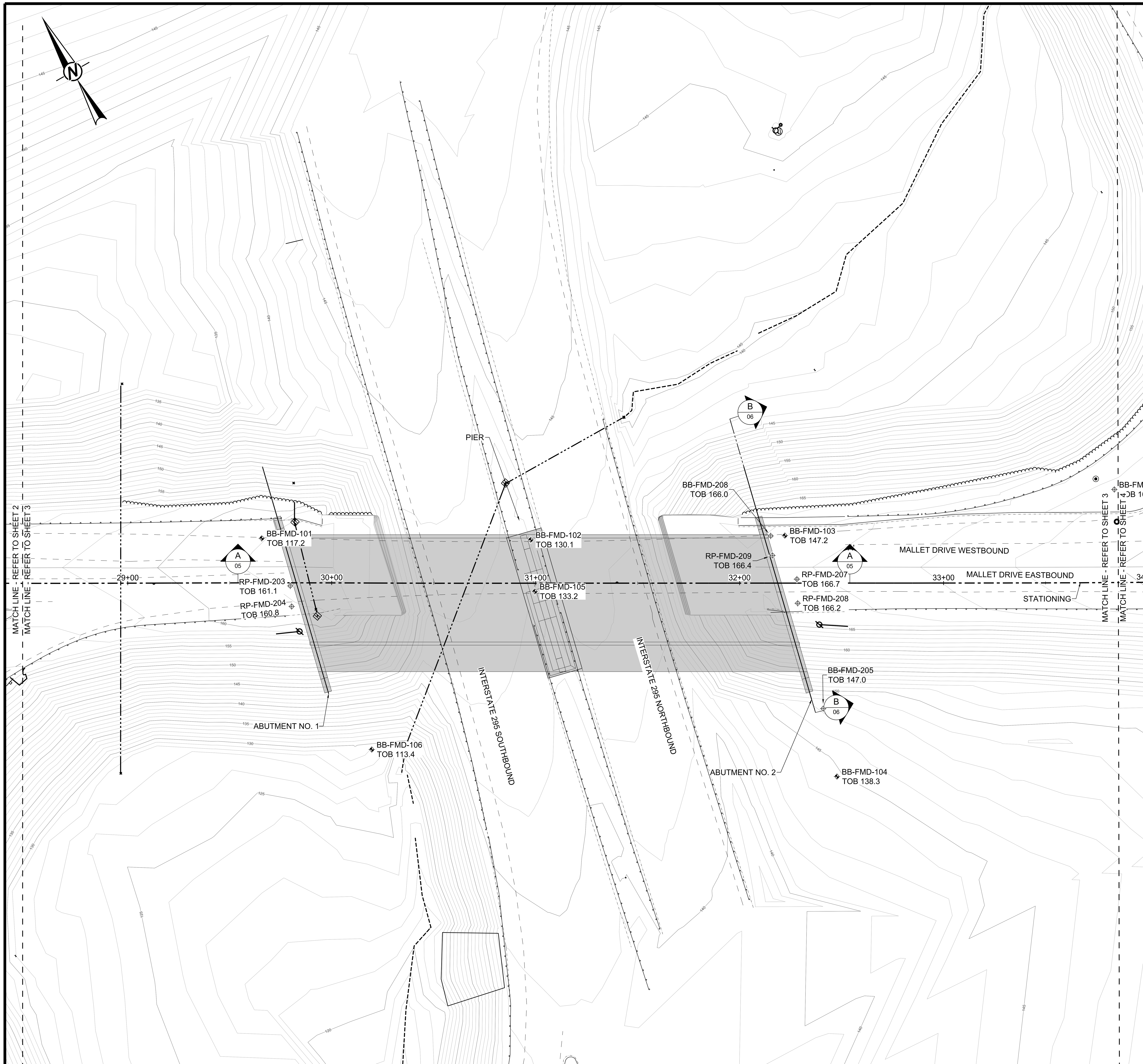
P.E. NUMBER

DATE

APPROACH ROAD BRIDGE
INTERSTATE 295
FREEPORT CUMBERLAND

BORING LOCATION PLAN

SHEET NUMBER
2
OF 6



LEGEND

RP-FDR-201	COMPLETED ROCK PROBES
	PROPOSED HIGH MAST LIGHTING
	PROPOSED MAST ARM FOUNDATION
BB-FDR-102 TOB 130.1	COMPLETED 100 SERIES BORINGS (SEE SHEET 3)
BB-FDR-202 TOB 156.2	COMPLETED 200 SERIES BORINGS
TOB XXX.X	ELEVATION OF TOP OF BORING OR ROCK PROBE

NOTE(S)

1. AS DRILLED BORING LOCATION PLAN FOR 100-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "BOR12-18-19edit.csv" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 01/06/2020. AS DRILLED BORING LOCATION PLAN FOR 200-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "21726 Exit22 - 200 Series Borings Compiled" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 06/24/2021.

REFERENCE(S)

1. BASEMAP ELEMENTS TAKEN FROM MAINE DOT IN FILE NAMED "3DTopo_2019-11-18.dgn" RECEIVED ON JANUARY 2, 2020.
2. SURVEY DATA PROVIDED TO GOLDER ON JANUARY 2, 2020 BY MAINE DOT IN FILE "FREEPORT 21726.00 SURVEY DATA 2019-11-18.zip".
3. PROPOSED STATIONING PROVIDED TO GOLDER BY HNTB FOR A SOUTHERN SHIFT OF THE BRIDGE.
4. LOCATIONS FOR MAST ARM FOUNDATIONS AND LIGHT STANDARD FOUNDATIONS DERIVED FROM ELECTRONIC FILE NAME: "Foundation Location Tables.pdf" PROVIDED BY HNTB ON JUNE 29, 2021.
5. GOLDER ASSOCIATES, INC., DECEMBER 21, 2020, PRELIMINARY GEOTECHNICAL DESIGN REPORT, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
6. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part I, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
7. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part II, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
8. EXIT RAMP ALIGNMENTS PROVIDED TO GOLDER BY HNTB ON JULY 14, 2021.
9. DETAILS OF BRIDGE AND FOUNDATION ELEMENTS TAKEN FROM HNTB, APPROACH ROAD BRIDGE OVER INTERSTATE 295 AND SIGNALIZED INTERSECTIONS, EXIT 22 INTERCHANGE: 98% PS&E, DATED JULY 16, 2021.

0 25 50
1" = 25' FEET

GOLDER
MEMBER OF WSP

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021726.00

WIN 021726.00

BRIDGE PLANS

Bridge No. 5721

STATE OF MAINE ★ CHRISTOPHER C. BENDA No. 15164 LICENSED PROFESSIONAL ENGINEER

		BY	DATE
PROJ. MANAGER	MEL		
DESIGN-DETAILED	MEL	AAZ	2021-08-20
CHECKED-REVIEWED	CCB	AAZ	2021/08/20
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

APPROACH ROAD BRIDGE
INTERSTATE 295
FREEPORT CUMBERLAND

BORING LOCATION PLAN

SHEET NUMBER

3

OF 6

Date:2021-07-02

Username:

Division:

Filename: 21450910_0002_003.dwg

LEGEND

(symbol)	PROPOSED HIGH MAST LIGHTING
(symbol)	PROPOSED MAST ARM FOUNDATION
BB-FDR-102 TOB 130.1	COMPLETED 100 SERIES BORINGS (SEE SHEET 3)
BB-FDR-202 TOB 156.2	COMPLETED 200 SERIES BORINGS
TOB XXX.X	ELEVATION OF TOP OF BORING

NOTE(S)

1. AS DRILLED BORING LOCATION PLAN FOR 100-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "BOR12-18-19edit.csv" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 01/06/2020. AS DRILLED BORING LOCATION PLAN FOR 200-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "21726 Exit22 - 200 Series Borings Compiled" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 06/24/2021.

REFERENCE(S)

1. BASEMAP ELEMENTS TAKEN FROM MAINE DOT IN FILE NAMED "3DTopo_2019-11-18.dgn" RECEIVED ON JANUARY 2, 2020.
2. SURVEY DATA PROVIDED TO GOLDER ON JANUARY 2, 2020 BY MAINE DOT IN FILE "FREEPORT 21726.00 SURVEY DATA 2019-11-18.zip".
3. PROPOSED STATIONING PROVIDED TO GOLDER BY HNTB FOR A SOUTHERN SHIFT OF THE BRIDGE.
4. LOCATIONS FOR MAST ARM FOUNDATIONS AND LIGHT STANDARD FOUNDATIONS DERIVED FROM ELECTRONIC FILE NAME: "Foundation Location Tables.pdf" PROVIDED BY HNTB ON JUNE 29, 2021.
5. GOLDER ASSOCIATES, INC., DECEMBER 21, 2020, PRELIMINARY GEOTECHNICAL DESIGN REPORT, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
6. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part I, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
7. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part II, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
8. EXIT RAMP ALIGNMENTS PROVIDED TO GOLDER BY HNTB ON JULY 14, 2021.

0 25 50
1" = 25' FEET

GOLDER
MEMBER OF WSP

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021726.00

WIN 021726.00
BRIDGE PLANS
Bridge No. 5721

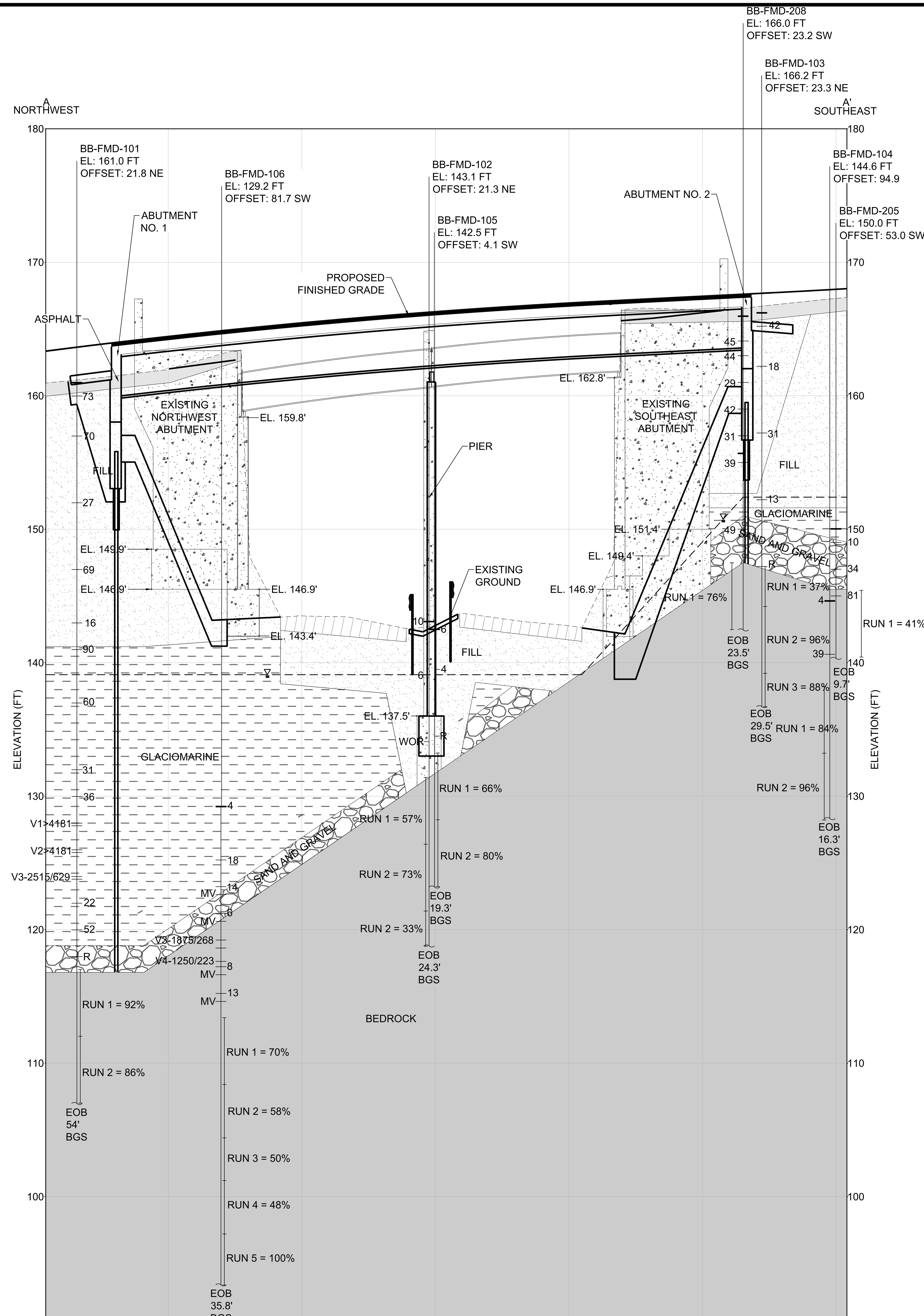
	MEL	BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	MEL	AAZ	2021-08-20
CHECKED-REVIEWED	CCB	AAZ	2021/08/20
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE
P.E. NUMBER
DATE

APPROACH ROAD BRIDGE
INTERSTATE 295
FREEPORT CUMBERLAND

BORING LOCATION PLAN

SHEET NUMBER
4
OF 6



LEGEND

BB-FMD-101 / EL: 161.0 FT / OFFSET: 14.4 N	BORING LOCATION I.D. / ELEVATION / OFFSET (FT) FROM SECTION LINE
(TOB)	TOP OF BORING ORPROBE
30	SPT: N60 - VALUE (CORRECTED FOR HAMMER EFFICIENCY)
V1 - 2515/629	FIELD VANE SHEAR TEST LOCATION AND UNDRAINED SHEAR STRENGTH (PSF) (PEAK/REMOLDED)
WOR	WEIGHT OF ROD
MV	MISSED VANE
R	REFUSAL
RUN1 - 92%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 54' BGS	END OF BORING DEPTH FEET BELOW GROUND SURFACE (BGS)
	ASPHALT
	EXISTING ABUTMENT AND FOUNDATION ELEMENTS
	PROPOSED ABUTMENT ELEMENTS
	BROWN TO GRAY, LOOSE TO MEDIUM DENSE, SILTY FINE TO COARSE SAND AND GRAVEL (FILL)
	GRAY, VERY SOFT TO VERY STIFF, LOW PLASTICITY SILTY CLAY (GLACIOMARINE)
	BROWN, MEDIUM DENSE TO VERY DENSE, FINE TO COARSE SAND, SOME SILT, TRACE GRAVEL (SAND AND GRAVEL)
	LIGHT GRAY, COARSE-GRAINED GNEISS, EXTREMELY STRONG, FRESH TO SLIGHTLY WEATHERED (BEDROCK)
	INTERPRETED GROUNDWATER SURFACE
	EXISTING GROUND SURFACE

NOTES:

1. AS DRILLED BORING LOCATION PLAN FOR 100-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "BOR12-18-19edit.csv" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 01/06/2020. AS DRILLED BORING LOCATION PLAN FOR 200-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "21726 Exit22 - 200 Series Borings Compiled" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 06/24/2021.
2. FOR DETAILED LITHOLOGIC DESCRIPTIONS SEE BORING LOGS IN NOTE 8, APPENDIX A (100-SERIES BORINGS) AND NOTE 9, APPENDIX A (200-SERIES BORINGS).
3. FOR COMPLETE LABORATORY DATA SEE LABORATORY REPORTS IN NOTE 8 (100-SERIES BORINGS) AND NOTE 9 (200-SERIES BORINGS).
4. GROUNDWATER SURFACE IS INTERPRETED FROM LOCALIZED SURFACE WATER LEVELS AND MEASUREMENTS TAKEN DURING THE SUBSURFACE EXPLORATION PROGRAMS. FOR DETAILS ON THE SUBSURFACE EXPLORATION PROGRAMS, SEE NOTE 8 (100-SERIES BORINGS) AND NOTE 9 (200-SERIES BORINGS).
5. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION, REFER TO BORING LOGS IN NOTE 8, APPENDIX A (100-SERIES BORINGS) AND NOTE 9, APPENDIX A (200-SERIES BORINGS).
6. ABUTMENT AND PIER DETAILS INTERPRETED FROM ELECTRONIC FILE NAME "5721 FREEPORT 1956" PROVIDED TO GOLDER ON 8/22/2019 AND "Mallett Dr Profile1to1.dgn" PROVIDED TO GOLDER BY HNTB ON MAY 27, 2021.
7. FOR SOIL STRATA ANALYSIS THE ASPHALT LAYER AND ROADFILL LAYER ARE COMBINED FOR A LAYER THICKNESS OF FIVE FEET.
8. GOLDER ASSOCIATES, INC., DECEMBER 21, 2020, PRELIMINARY GEOTECHNICAL DESIGN REPORT, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
9. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part I, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
10. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part II, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.

0 5 10 — 1" = 5' FEET

0 25 50 — 1" = 25' FEET

GOLDER MEMBER OF WSP

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021726.00

WIN 021726.00

BRIDGE PLANS

Bridge No. 5721

	BY	DATE
PROJ. MANAGER	MEL	
DESIGN-DETAILED	AAZ	2021-08-20
CHECKED-REVIEWED	CCB	2021/08/20
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

APPROACH ROAD BRIDGE
INTERSTATE 295
FREEPORT CUMBERLAND

INTERPRETIVE SUBSURFACE PROFILE A-A'

SHEET NUMBER

5

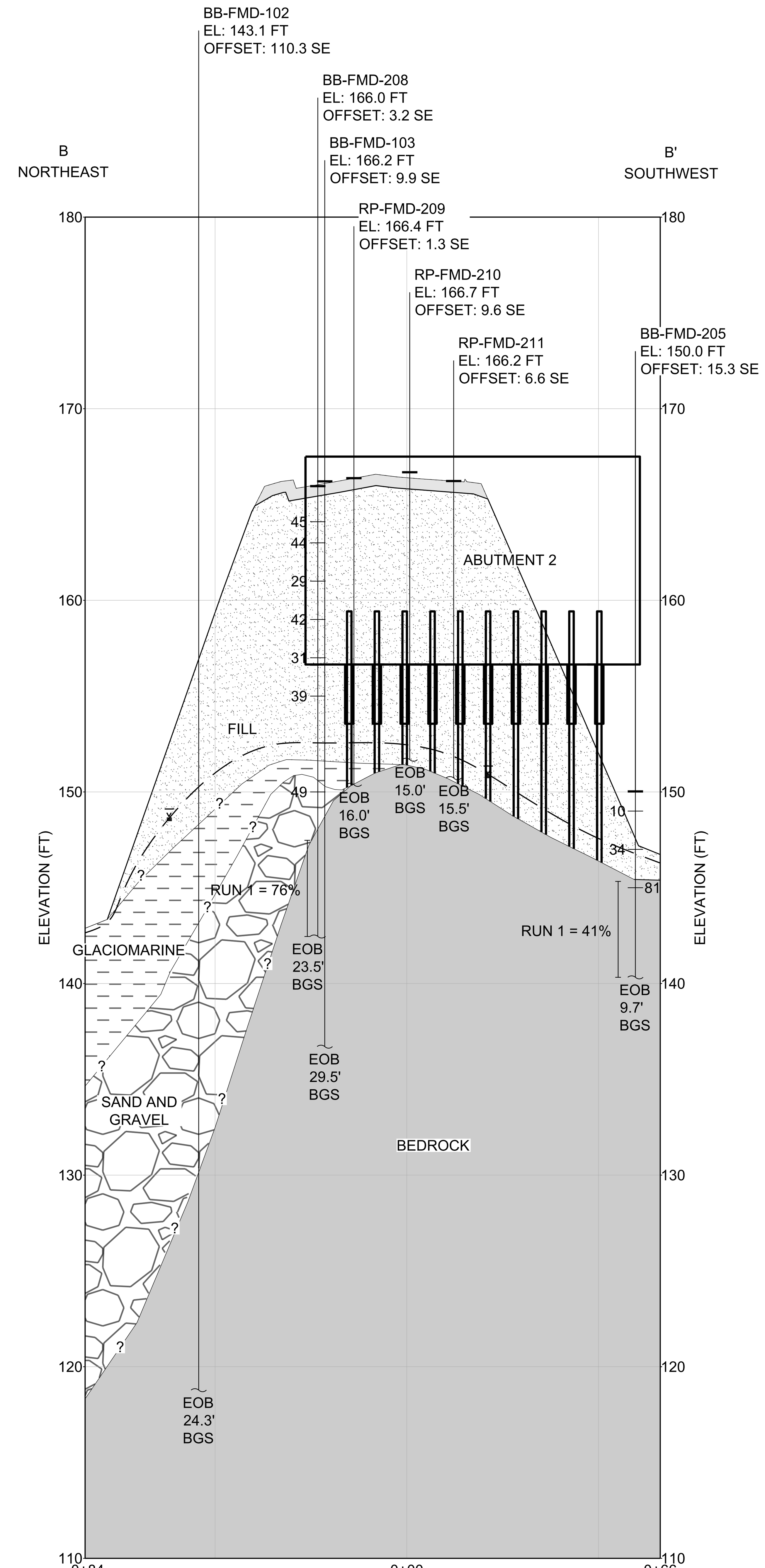
OF 6

Filename: 21450910_0002_004

Division:

Username:

Date:2021-07-02



LEGEND

RP-FMD-210	ROCK PROBE LOCATION I.D.
BB-FMD-101	BORING LOCATION I.D.
EL: 161.0 FT	ELEVATION
OFFSET: 14.4 N	OFFSET (FT) FROM SECTION LINE
(TOB)	TOP OF BORING OR PROBE
30	SPT: N60 - VALUE (CORRECTED FOR HAMMER EFFICIENCY)
V1 - 2515/629	FIELD VANE SHEAR TEST LOCATION AND UNDRAINED SHEAR STRENGTH (PSF) (PEAK/REMOLDED)
WOR	WEIGHT OF ROD
MV	MISSED VANE
R	REFUSAL
RUN1 - 92%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 54' BGS	END OF BORING OR ROCK PROBE DEPTH FEET BELOW GROUND SURFACE (BGS)

- ASPHALT
- PROPOSED ABUTMENT ELEMENTS
- BROWN TO GRAY, LOOSE TO MEDIUM DENSE, SILTY FINE TO COARSE SAND AND GRAVEL (FILL)
- GRAY, VERY SOFT TO VERY STIFF, LOW PLASTICITY SILTY CLAY (GLACIOMARINE)
- BROWN, MEDIUM DENSE TO VERY DENSE, FINE TO COARSE SAND, SOME SILT, TRACE GRAVEL (SAND AND GRAVEL)
- LIGHT GRAY, COARSE-GRAINED GNEISS, EXTREMELY STRONG, FRESH TO SLIGHTLY WEATHERED (BEDROCK)
- INTERPRETED GROUNDWATER SURFACE
- EXISTING GROUND SURFACE

NOTES:

1. AS DRILLED BORING LOCATION PLAN FOR 100-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "BOR12-18-19edit.csv" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 01/06/2020. AS DRILLED BORING LOCATION PLAN FOR 200-SERIES BORINGS DERIVED FROM ELECTRONIC FILE NAME: "21726 Exit22 - 200 Series Borings Compiled" PROVIDED TO GOLDER BY MAINE DEPARTMENT OF TRANSPORTATION ON 06/24/2021.
2. FOR DETAILED LITHOLOGIC DESCRIPTIONS SEE BORING LOGS IN NOTE 8, APPENDIX A (100-SERIES BORINGS) AND NOTE 9, APPENDIX A (200-SERIES BORINGS).
3. FOR COMPLETE LABORATORY DATA SEE LABORATORY REPORTS IN NOTE 8 (100-SERIES BORINGS) AND NOTE 9 (200-SERIES BORINGS).
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5. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION, REFER TO BORING LOGS IN NOTE 8, APPENDIX A (100-SERIES BORINGS) AND NOTE 9, APPENDIX A (200-SERIES BORINGS).
6. ABUTMENT AND PIER DETAILS INTERPRETED FROM ELECTRONIC FILE NAME "5721 FREEPORT 1956" PROVIDED TO GOLDER ON 8/22/2019 AND "Mallett Dr Profile1to1.dgn" PROVIDED TO GOLDER BY HNTB ON MAY 27, 2021.
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9. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part I, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.
10. GOLDER ASSOCIATES, INC., AUGUST 20, 2021, SUPPLEMENTAL BRIDGE GEOTECHNICAL DESIGN REPORT Part II, I-295 MALLET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22), FREEPORT, MAINE, MAINEDOT WIN 021726.00.

VERTICAL SCALE: 0 5 10; 1" = 5' FEET

HORIZONTAL SCALE: 0 25 50; 1" = 25' FEET

GOLDER
MEMBER OF WSP

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021726.00

WIN 021726.00

BRIDGE PLANS

Bridge No. 5721

STATE OF MAINE CHRISTOPHER C. BENDA No. 15164 LICENSED PROFESSIONAL ENGINEER

SIGNATURE

P.E. NUMBER

DATE

	MEL	BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	KAR	AAZ	2021-08-20
CHECKED-REVIEWED	CCB	AAZ	2021/08/20
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

APPROACH ROAD BRIDGE
INTERSTATE 295
FREEPORT CUMBERLAND

INTERPRETIVE SUBSURFACE CROSS SECTION B-B'

SHEET NUMBER
6
OF 6

APPENDIX A

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, if applicable):

Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
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.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

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

MODIFIED BURMISTER SYSTEM

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

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. Density is rated according to standard penetration resistance (N-value).

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 undrained 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 (%) = sum of the lengths of intact pieces of core* > 4 inches / 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, if applicable):

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, 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 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
-spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
-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: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

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

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22) Location: Freeport, Maine	Boring No.: BB-FMD-201 WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	154.8 ft	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	C. Battistella	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	05/27/21 (22:10);05/27/21 (23:55)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376178.07 ft, E 1054356.023 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	19.2 ft
Hammer Efficiency Factor: 0.974		**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane 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	1D	24/14	0.00 - 2.00	3/5/7/10	12	19	PUSH			Brown, damp, medium dense, fine to coarse SAND, some fine gravel, well-graded (FILL)	
	2D	24/16	2.00 - 4.00	10/8/9/7	17	28	34			Brown, damp, medium dense, fine to coarse SAND, little fine gravel, well-graded (FILL)	
							45				
	3D	24/16	4.00 - 6.00	10/12/14/12	26	42	85			Brown, damp, dense, fine to coarse SAND, some fine gravel, trace silt, well-graded (FILL)	WC = 4.5%
5							53				
	4D	24/15	6.00 - 8.00	6/10/7/5	17	28	24			Brown, damp, medium dense, fine to coarse SAND, little fine gravel, trace silt, well-graded (FILL)	
							17				
	5D	24/15	8.00 - 10.00	6/6/5/3	11	18	15			5DA, Top 10 in: Dark brown, damp, very stiff, fine to medium Sandy SILT, trace gravel, q_p=1 ksf, non-plastic (FILL)	
							18				5DA: GTX #621778 WC = 21.3% Fines = 58.2% A-4, ML
10	6D	24/24	10.00 - 12.00	4/4/4/4	8	13	23	144.8		5DB, Bottom 5 in: Brown, wet, medium dense, fine to coarse Silty SAND, trace gravel, well-graded (FILL) 10.0	
							21			6D: Brown to grey, damp, stiff, Silty CLAY, T_V=4000 psf, q_p=3.5 ksf, slightly to moderately plastic (GLACIOMARINE) 10 to 14 ft bgs casing blows done with 300lb/30in.	
							20				
							20				6D: WC = 31.1%
							40				
15	7D	24/19	15.00 - 17.00	4/5/10/11	15	24	OPEN			Clay in wash 15 ft bgs. Brown to grey, damp, very stiff, Silty CLAY, T_V=13000 psf, q_p=5.1 ksf, slightly plastic (GLACIOMARINE)	GTX #621760 WC = 23.9% LL = 41 PL = 20 PI = 21 LI = 0.2
20	8D	24/24	20.00 - 22.00	6/8/10/14	18	29				Brown to grey, damp, very stiff, Silty CLAY, T_V=13000 psf, q_p= 6.2 ksf, slightly to moderately plastic, iron staining (GLACIOMARINE)	
25											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-201
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	154.8 ft	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	C. Battistella	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	05/27/21 (22:10);05/27/21 (23:55)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376178.07 ft, E 1054356.023 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	19.2 ft
Hammer Efficiency Factor:	0.974	**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	9D	24/24	25.00 - 27.00	4/5/6/7	11	18				Brown, moist, very stiff, Silty CLAY, T_v=15000 psf, q_p=3.6 ksf, moderately plastic (GLACIOMARINE)	
								127.8		27.0	
										Bottom of Exploration at 27.0 feet below ground surface. Boring backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-202
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	156.2	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/01/21 (20:04);06/01/21 (22:10)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376214.198 ft, E 1054444.482 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	6.6 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	1D	24/16	0.70 - 2.70	19/19/17/16	36	58	PUSH	155.5		Asphalt thickness of 8 in (ASPHALT) 0.7	
										Light brown and tan, dry, very dense, fine to coarse SAND, little gravel, well-graded (FILL)	
	2D	24/18	4.00 - 6.00	12/13/15/16	28	45	V			Light brown and tan, dry, dense, fine to medium SAND, trace silt, poorly-graded (FILL)	
5							34				
	3D	24/23	6.00 - 8.00	4/3/6/10	9	15	62			Light brown, damp, medium dense, fine SAND, trace gravel, trace coarse sand, trace silt, poorly-graded (FILL)	
							83				
	4D	24/22	8.00 - 10.00	10/8/11/9	19	31	56			Light brown, damp, dense, fine to medium SAND, some silt, trace gravel, well-graded (FILL)	4D: GTX #621761 WC = 13.3% Fines = 27.3% A-2-4(0), SM
							63				
10	5D	24/23	10.00 - 12.00	12/9/6/7	15	24	39			5DA, Top 11 in: Light brown, damp, medium dense, fine to medium SAND, some silt, little gravel, well-graded (FILL)	5DA: GTX #621762, 621755 WC = 8.1% Fines = 21.6% Non-plastic A-2-4(0), SM
							73 OPEN	145.3		10.9 5DB, Bottom 12 in: Grey, damp, stiff, Silty CLAY, T_v=13000 psf, q_p=5.1 ksf, slightly plastic (GLACIOMARINE)	
15	6D	24/16	15.00 - 17.00	5/5/6/4	11	18				Grey, wet, very stiff, Silty CLAY, trace sand, T_v=13000 psf, q_p=5.1 ksf, slightly plastic (GLACIOMARINE)	6D: GTX #621763, 621756 WC = 27.5% Fines = 93.2% LL = 36 PL = 19 PI = 17 LI = 0.5 A-6, CL
20	7D	24/19	20.00 - 22.00	4/3/4/3	7	11				Grey, wet, stiff, Silty CLAY, T_v=13000 psf, q_p=3.1 ksf, slightly plastic (GLACIOMARINE)	
25											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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:** I-295 Mallet Drive Bridge Replacement #5721 (Exit 22) **Location:** Freeport, Maine	**Boring No.:** BB-FMD-202 **WIN:** 021726.00

Driller:	SW Cole	**Elevation (ft.)**	156.2	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/01/21 (20:04);06/01/21 (22:10)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376214.198 ft, E 1054444.482 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	6.6 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane 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	8D	24/24	25.00 - 27.00	4/5/11/17	16	26				Grey, wet, very stiff, Silty CLAY, T_V=13000 psf, q_p=5.1 ksf, slightly to moderately plastic (GLACIOMARINE)	
								129.2		27.0	
										Bottom of Exploration at 27.0 feet below ground surface. Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-203
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	155.6	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/01/21 (23:15);06/02/21 (01:55)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376097.401 ft, E 1054412.229 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	8 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
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V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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							PUSH			Asphalt thickness 12 in (ASPHALT)	
	1D	24/19	1.00 - 3.00	12/16/20/16	36	58		154.6		1.0 Tan, damp, very dense, fine to coarse SAND, some gravel, well-graded (FILL)	
	2D	24/19	3.00 - 5.00	14/14/16/12	30	49				Tan and light brown, damp, dense, fine to medium SAND, trace gravel, poorly-graded (FILL)	
5	3D	24/18	5.00 - 7.00	5/6/6/7	12	19				Tan, damp, medium dense, fine to medium SAND, little clay/silt, trace gravel, well-graded (FILL)	GTX #621764 WC = 8.1% Fines = 18.3% A-2-4(0), SC
	4D	24/17	7.00 - 9.00	10/9/7/6	16	26				Tan, damp, medium dense, Clayey fine SAND, trace coarse sand, poorly-graded (FILL)	
	5D	24/13	9.00 - 11.00	5/7/5/5	12	19				Tan, damp, medium dense, Clayey fine SAND, trace coarse sand, poorly-graded (FILL)	WC = 12.4%
10											
	6D	24/19	11.00 - 13.00	3/3/4/4	7	11		143.6		6DA, Top 12 in: Tan, damp, medium dense, fine to medium SAND, little clay, trace coarse sand, poorly-graded (FILL) 12.0 6DB, Bottom 7 in: Light brown and grey, damp, stiff, Sandy CLAY, moderately plastic (GLACIOMARINE)	
15	7D	24/14	15.00 - 17.00	3/2/1/3	3	5				Grey, wet, medium stiff, Silty CLAY, little sand, trace gravel (from wash), T_v=4100 psf, q_p=2.1 ksf, slightly plastic (GLACIOMARINE)	
20	8D	24/13	20.00 - 22.00	WOH/WOH/4/4	4	6				Grey, wet, medium stiff, Silty CLAY, little sand, T_v=4100 psf, q_p=2.1 ksf, slightly plastic (GLACIOMARINE)	GTX #621765, 621757 WC = 29.3% Fines = 87.1% LL = 29 PL = 18 PI = 11 LI = 1 A-6, CL
25											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-203
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	155.6	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/01/21 (23:15);06/02/21 (01:55)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 376097.401 ft, E 1054412.229 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	8 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	9D	24/22	25.00 - 27.00	1/2/2/2	4	6				Grey, wet, medium stiff, Silty CLAY, T_v=13000 psf, q_p=3.1 ksf, slightly to moderately plastic (GLACIOMARINE)	
								128.6		27.0	
										Bottom of Exploration at 27.0 feet below ground surface. Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-205
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	147.0	**Auger ID/OD:**	2.5 in
Operator:	S. Shaw	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	J. Sedam	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/10/21 (08:30);06/10/21 (09:30)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375781.491 ft, E 1054716.636 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	No measurement
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

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MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	1D	24/7	0.00 - 2.00	3/2/4/6	6	10				1DA, Top 2 in: Brown, dry, loose, fine to medium SAND, trace gravel, trace silt, trace organics, poorly-graded (FILL)	
										1DB, Bottom 5 in: Reddish brown, dry, loose, fine to medium SAND, some silt, little gravel, trace organics, well-graded (FILL)	GTX #621776 WC = 14% Fines = 27.1% A-2-4(0), SM
	2D	24/23	2.00 - 4.00	6/7/14/21	21	34				2D: Reddish brown, dry to damp, dense, fine to medium SAND, some silt, little gravel, trace organics, well-graded (FILL)	
	3D	7.2/9.6	4.00 - 4.60	34/50(1")	50	81	NQ			3DA, Top 5 in: Brown, damp, very dense, fine to medium SAND, some silt, little gravel, trace organics, well-graded (FILL)	
5	~~R1~~	~~60/25~~	~~4.70 - 9.70~~	~~RQD = 41%~~				142.3		3DB, Bottom 5 in: Reddish brown, damp, very dense, fine to coarse SAND, some gravel, some silt, well-graded (FILL) Top of bedrock at elev. 142.3 ft.	
										4.7 Grey, fine grained, strongly foliated, SCHIST, very strong (R5), fresh to slightly weathered (W1 to W2). Discontinuities low angle to vertical (5-90 deg) and very closely to closely spaced (0.2-2 ft). [VASSALBORO FORMATION] Rock Mass Quality: POOR Rock Core Rate (min:sec) 4.7-5.7 ft (2:21) 5.7-6.7 ft (2:19) 6.7-7.7 ft (2:15) 7.7-8.7 ft (1:49) 8.7-9.7 ft (2:39) 100% Recovery	
10								137.0		10.0 **Bottom of Exploration at 10.0 feet below ground surface.** Backfilled with gravel and topped with cold patch.	
15											
20											
25											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.

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Boring No.: BB-FMD-205

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-206
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	169.1	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/03/21 (02:40);06/07/21 (22:08)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375746.32 ft, E 1054891.826 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	14.3 ft
Hammer Efficiency Factor: 0.974		**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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 Information: 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	1D	24/16	0.00 - 2.00	7/11/13/15	24	39				White and light brown, damp, dense, Gravelly fine to coarse SAND, little silt, trace organics, well-graded (FILL)	
	2D	24/15	2.00 - 4.00	16/22/15/11	37	60				White and tan, dry, very dense, fine to coarse Sandy GRAVEL, little silt, trace organics, well-graded (FILL)	
	3D	24/11	4.00 - 6.00	12/10/28/22	38	62				Brown, damp, very dense, fine to coarse Sandy GRAVEL, little silt, well-graded (FILL)	GTX #621766 WC = 7.0% Fines = 10.4% A-1-a, GM
5							31				
	4D	24/16	6.00 - 8.00	7/5/9/8	14	23	27			4DA, Top 4 in: Dark brown, damp, medium dense, fine to coarse SAND, little gravel, little silt, well-graded (FILL)	
							31			4DB, Bottom 12 in: Tan, damp, medium dense, fine to medium SAND, some silt, trace gravel, poorly-graded (FILL)	
	5D	24/3	8.00 - 10.00	12/12/15/8	27	44	42			5D: Brown, damp, dense, fine to medium SAND, trace silt, poorly-graded (FILL)	GTX #621767 WC = 5.4% Fines = 9.3% A-3, SP-SM
							36				
10	6D	24/9	10.00 - 12.00	8/4/6/4	10	16				6D: Greyish tan, moist, medium dense, fine to coarse SAND, little silt, trace gravel, well-graded (FILL)	
15	7D	24/10	15.00 - 17.00	7/29/20/9	49	80	17			7DA, Top 6 in: Grey, moist, very dense, Gravelly SAND, little clay/ silt, well-graded (FILL)	GTX #621768 WC = 13.0% Fines = 18.4% A-1-b, SC
							21			7DB, Bottom 4 in: Orange brown, moist, very dense, Gravelly fine to medium SAND, little silt, poorly-graded (FILL)	
	R1	60/44	17.50 - 22.50	RQD = 14%			12 NQ	151.6		Top of bedrock at elev. 151.6 ft. 17.5	
										Dark grey, fine grained, SCHIST, extremely strong (R6), moderately weathered (W3), discontinuities horizontal to moderately dipping (0-40 deg), close to very closely spaced (0.05-0.3 ft). [VASSALBORO FORMATION]	
										Rock Mass Quality: VERY POOR	
20										Rock Core Rate (min:sec)	
										17.5-18.5 ft (2:02)	
								146.6		18.5-19.5 ft (1:53)	
										19.5-20.5 ft (1:40)	
										20.5-21.5 ft (1:07)	
25										21.5-22.5 ft (1:15)	

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-206
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	169.1	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/03/21 (02:40);06/07/21 (22:08)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375746.32 ft, E 1054891.826 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	14.3 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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SSA = Solid Stem Auger
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RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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										73% Recovery	
										22.5	
										Bottom of Exploration at 22.5 feet below ground surface. Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-207
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	169.6	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/07/21 (22:11);06/08/21 (00:37)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375712.979 ft, E 1054910.126 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	16.3 ft
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	1D	24/18	0.80 - 2.80	14/16/16/17	32	52		168.8	Asphalt thickness of 10 in (ASPHALT) ——— 0.8 Tan, damp, very dense, fine to coarse SAND, some gravel, trace silt, well-graded (FILL)	
	2D	24/17	2.80 - 4.80	12/11/9/6	20	32			Tan, damp, dense, fine to coarse SAND, little gravel, well-graded (FILL)	
	3D	24/10	4.80 - 6.80	8/9/9/7	18	29				
5									Tan, damp, medium dense, fine to medium SAND, trace gravel, trace silt, well-graded (FILL)	GTX #621769 WC = 4.2% Fines = 8.0% A-3, SP-SM
	4D	24/16	6.80 - 8.80	6/4/4/4	8	13				
									Tan, damp, medium dense, fine SAND, trace gravel, trace coarse sand, trace silt, poorly-graded (FILL)	
	5D	24/21	8.80 - 10.80	6/8/9/15	16	26				
									Tan, damp, medium dense, fine SAND, little clay, trace silt, poorly-graded (FILL)	
10	6D	24/20	10.80 - 12.80	11/11/10/15	21	34				
									Tan, damp, dense, fine to medium SAND, trace silt, poorly-graded (FILL)	GTX #621770 WC = 6.9% Fines = 9.4% A-3, SP-SM
							15			
							52			
15	7D	6/6	15.00 - 15.50	50(6")	50	81	21		Brown, damp, very dense, fine to medium SAND, trace gravel, trace silt, rock chips in shoe, well-graded (FILL) Driller notes boulder from 15.5 to 16.7 ft bgs	
							16			
							11			
							13			
							39			
20	8D	10/6	20.50 - 21.33	13/50(4")	50	81		148.9	8DA, Top 2 in: Brown and grey, moist, very dense, Sandy GRAVEL, little silt, well-graded (FILL) ——— 20.7 8DB, Bottom 4 in: Tan, moist, hard, SILT, some sand, trace gravel, non-plastic (GLACIOMARINE)	8DB: GTX #621771, 621758 WC = 26.5% Fines = 71.5% Non-plastic A-4, ML
25										

Remarks:

Hammer calibration obtained from SW Cole calibration report.
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22) Location: Freeport, Maine	Boring No.: BB-FMD-207 WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	169.6	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/07/21 (22:11);06/08/21 (00:37)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375712.979 ft, E 1054910.126 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	16.3 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

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S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
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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								144.1		25.5 **Bottom of Exploration at 25.5 feet below ground surface.** Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-208
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	166.0	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/02/21 (21:12);06/03/21 (02:22)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375857.054 ft, E 1054762.839 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	13.6 ft
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
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WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
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$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane 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	1D	24/18	0.80 - 2.80	17/13/15/17	28	45		165.2		Asphalt thickness of 10 in (ASPHALT) ——0.8	
										Tan, dry, dense, fine to coarse SAND, some gravel, trace silt, well-graded (FILL)	
	2D	24/24	2.80 - 4.80	12/14/13/10	27	44					
										Tan, dry, dense, fine to coarse SAND, some gravel, trace silt, well-graded (FILL)	
	3D	24/18	4.80 - 6.80	10/10/8/11	18	29	44				
5							89			Tan, dry, medium dense, fine to coarse SAND, little gravel, trace silt, well-graded (FILL)	
	4D	24/17	6.80 - 8.80	8/13/13/14	26	42	107				
							54			Tan, dry, dense, fine to coarse SAND, trace gravel, trace silt, poorly-graded (FILL)	WC = 6.2%
	5D	24/19	8.80 - 10.80	7/8/11/17	19	31	78	157.2		——8.8	
							162			Tan, damp, dense, fine to coarse SAND, some gravel, little silt, well-graded (SAND AND GRAVEL)	
10	6D	24/16	10.80 - 12.80	10/11/13/11	24	39					
										Tan and white, damp, dense, fine to coarse SAND, some gravel, little silt, well-graded (SAND AND GRAVEL)	6D: GTX #621772 WC = 6.3% Fines = 15.9% A-1-b, SM
15	7D	24/8	15.00 - 17.00	5/15/15/12	30	49				Greyish tan, damp, dense, GRAVEL, some fine to coarse sand, trace silt, well-graded (SAND AND GRAVEL)	7D: GTX #621773 WC = 6.3% Fines = 1.7% A-1-a, GW
							22				
	R1	60/56	18.50 - 23.50	RQD = 76%			137 NQ	147.5		Top of bedrock at elev. 147.5 ft. ——18.5	
20										Grey, fine grained, strongly foliated, SCHIST, strong to very strong (R4 to R5), slightly to moderately weathered (W2 to W3). Discontinuities low to moderately dipping (5-35 deg) and very closely to closely spaced (<0.05-0.6 ft). [VASSALBORO FORMATION] Rock Mass Quality: GOOD Rock Core Rate (min:sec) 18.5-19.5 ft (5:12) 19.5-20.5 ft (4:15) 20.5-21.5 ft (1:50) 21.5-22.5 ft (2:48)	
								142.5			
25											

Remarks:

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Boring No.: BB-FMD-208

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-208
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	166.0	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/02/21 (21:12);06/03/21 (02:22)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375857.054 ft, E 1054762.839 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	13.6 ft
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N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
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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										22.5-23.5 ft (2:37) 93% Recovery	
										23.5	
										Bottom of Exploration at 23.5 feet below ground surface. Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-209
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	172.3	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/08/21 (00:43);06/08/21 (21:52)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375630.836 ft, E 1054958.721 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	DRY at 20.8 ft
Hammer Efficiency Factor: 0.974		**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	1D	24/17	0.70 - 2.70	10/11/14/17	25	41		171.6		Asphalt thickness of 8 in (ASPHALT) 0.7	
										Tan, dry, dense, fine to coarse SAND, some gravel, trace silt, rock chips in shoe, well-graded (FILL)	
	2D	24/19	2.70 - 4.70	15/11/17/15	28	45				Tan, dry, dense, fine to coarse SAND, some fine gravel, trace silt, well-graded (FILL)	
	3D	24/9	4.70 - 6.70	5/5/12/8	17	28				Greyish tan, dry, medium dense, fine to coarse SAND, little silt, trace gravel, well-graded (FILL)	GTX #621774 WC = 2.8% Fines = 13.9% A-2-4(0), SM
5											
	4D	24/21	6.70 - 8.70	6/6/5/4	11	18				Tan, dry, medium dense, fine to medium SAND, little gravel, little silt, well-graded (FILL)	
	5D	24/24	8.70 - 10.70	7/6/8/8	14	23				Tan, damp, medium dense, gravelly fine to medium SAND, trace silt, well-graded (FILL)	WC = 5.8%
10	6D	24/16	10.70 - 12.70	8/14/13/10	27	44	32			6DA, Top 6 in: Brown, damp, dense, fine to coarse SAND, little gravel, trace silt, well-graded (FILL)	
							24	161.1		11.2	
							28			6DB, Bottom 10 in: Tan, damp, dense, Silty SAND, trace gravel (SAND AND GRAVEL)	
							101				
							65				
15	7D	18/17	15.00 - 16.50	6/14/50(6")	64	104	19	156.5		7DA, Top 3 in: Tan, damp, very dense, fine to medium SAND, trace silt, poorly-graded (SAND AND GRAVEL) 15.9	
							117	156.2		7DB, Middle 11 in: Grey, moist, hard, Silty CLAY, little sand, trace gravel, T_v=13000 psf, q_p=5.1 ksf, slightly plastic (GLACIOMARINE)	7DB: GTX #621775, 621759 WC = 27.3% Fines = 81% LL = 25 PL = 17 PI = 8 LI = 1.3 A-4, CL
										16.2	
										7DC, Bottom 4 in: Grey and black, dry, very dense, Sandy GRAVEL, trace silt, well-graded (SAND AND GRAVEL) Driller notes boulder from 18.9 to 20 ft bgs	
								152.3		20.0	
20	8D	8/7	20.00 - 20.67	62/50(2")	50	81		151.5		8DA, Top 2 in: Dark grey, moist, very dense, Sandy GRAVEL, trace silt, well-graded (SAND AND GRAVEL)	
										8DB, Bottom 5 in: Tan and orange, wet, very dense, Sandy GRAVEL, trace silt, well-graded (SAND AND GRAVEL)	
										Fractured rock from 20 to 20.7 ft bgs. Production ceased at 20.8 ft bgs due to water loss in this formation.	
25										20.8	

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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:	I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)			**Boring No.:**	BB-FMD-209
Location:	Freeport, Maine			**WIN:**	021726.00
Driller:	SW Cole	**Elevation (ft.)**	172.3	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/08/21 (00:43);06/08/21 (21:52)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375630.836 ft, E 1054958.721 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	DRY at 20.8 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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										**Bottom of Exploration at 20.8 feet below ground surface.** Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-210
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	171.1	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/08/21 (22:44);06/09/21 (04:52)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375658.207 ft, E 1054898.191 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	18.3 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	1D	8/8	0.90 - 1.57	19/50(2")	50	81				Asphalt thickness of 11 in (ASPHALT)	
								170.2		0.9 — Tan and white, dry, very dense, fine to coarse SAND, little gravel, well-graded (FILL)	
	2D	24/20	2.00 - 4.00	5/11/12/9	23	37				Tan, dry, dense, fine to coarse SAND, little gravel, trace silt, well-graded (FILL)	
	3D	24/17	4.00 - 6.00	2/3/6/7	9	15				Tan, dry, medium dense, fine to coarse SAND, trace silt, well-graded (FILL)	
5											
	4D	24/14	6.00 - 8.00	4/4/5/4	9	15				Tan, dry, medium dense, fine to coarse SAND, trace gravel, trace silt, well-graded (FILL)	
	5D	24/12	8.00 - 10.00	5/5/8/8	13	21				Tan, damp, medium dense, fine to coarse SAND, little gravel, trace silt, well-graded (FILL)	
10	6D	24/18	10.00 - 12.00	8/6/14/10	20	32				Tan, damp, dense, fine to coarse SAND, some gravel, trace silt, well-graded (FILL)	WC = 9.8%
15	7D	24/14	15.00 - 17.00	18/16/8/46	24	39	34	155.6		7DA, Top 6 in: Tan, damp, dense, fine to coarse SAND, some silt, trace gravel, well-graded (FILL)	7DA: GTX #6217977 WC = 10.4% Fines = 26.8% A-2-4(0), SM
							72			15.5 — 7DB, Bottom 8 in: Grey and black, damp, dense, Sandy GRAVEL, well-graded (SAND AND GRAVEL) Driller Notes: multiple boulders (approx. 1 ft thick) between 17 and 25 ft bgs.	
							354				
							251				
							157				
20	8D	4/4	20.00 - 20.33	50(4")	50	81				Tan and grey, wet, very dense, coarse SAND, little gravel, little silt, well- graded (SAND AND GRAVEL)	WC = 15.9%
25											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: I-295 Mallet Drive Bridge Replacement #5721 (Exit 22)
Location: Freeport, Maine

Boring No.: BB-FMD-210
WIN: 021726.00

Driller:	SW Cole	**Elevation (ft.)**	171.1	**Auger ID/OD:**	2.5 in
Operator:	J. Layfield	**Datum:**	NAD83 (2011) Maine 2000 West	**Sampler:**	Standard Split Spoon
Logged By:	B. Kurtoglu	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140 lbs/30 in
Date Start/Finish:	06/08/21 (22:44);06/09/21 (04:52)	**Drilling Method:**	Pin Auger / Cased Wash	**Core Barrel:**	NQ
Boring Location:	N 375658.207 ft, E 1054898.191 ft	**Casing ID/OD:**	5.5 in	**Water Level*:**	18.3 ft
Hammer Efficiency Factor:	0.974	**Hammer Type:**	Automatic ☐ Hydraulic ☒ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	9D	4/5	25.00 - 25.33	50(5")	50	81		145.7		Dark grey, moist, very dense, Silty fine to coarse SAND, little gravel, well-graded (SAND AND GRAVEL) —25.4	
										Bottom of Exploration at 25.4 feet below ground surface. Backfilled with gravel and topped with cold patch.	
30											
35											
40											
45											
50											

Remarks:

Hammer calibration obtained from SW Cole calibration report.
As-drilled elevations are derived from survey files within the emails titled "FW Exit 20 and 22 Borings and Probes Freeport" received by Golder on June 11 and June 28, 2021 from MaineDOT.
Water level was measured 15 minutes after the completion of the drilling while casing was still in the hole.

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APPENDIX B

Rock Core Photographs

APPENDIX B
Rock Core Photos
I-295 MALET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22)
FREEPORT, MAINE
MAINEDOT WIN 012726.00

Boring	Date Cored	Run	Depth Below Surface feet	Recovery		RQD	
				Feet	%	Feet	%
BB-FMD-208	6/2/2021	R1	18.5 - 23.5	4.7 / 5.0	94	3.8 / 5.0	76
BB-FMD-206	6/7/2021	R1	17.5 - 22.5	3.7 / 5.0	74	0.7 / 5.0	14

From top to bottom of photo:
Row 1 = BB-FMD-208 Run 1: 18.5 - 23.5 ft bgs
Row 2 = BB-FMD-206 Run 1: 17.5 - 22.5 ft bgs

GOLDER
MEMBER OF WSP

APPENDIX B
Rock Core Photos
I-295 MALET DRIVE BRIDGE REPLACEMENT #5721 (EXIT 22)
FREEPORT, MAINE
MAINEDOT WIN 012726.00

Boring	Date Cored	Run	Depth Below Surface feet	Recovery		RQD	
				Feet	%	Feet	%
BB-FMD-205	6/10/2021	R1	4.7 - 9.7	5.0 / 5.0	100	2.1 / 5.0	41

From top to bottom of photo:
Row 1 = BB-FMD-205 Run 1: 4.7 - 9.7 ft bgs

GOLDER
MEMBER OF WSP

APPENDIX C

Laboratory Test Results

Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	---	Sample Type:	---	Tested By:	GA
Sample ID:	---	Test Date:	06/25/21	Checked By:	bfs
Depth :	---	Test Id:	621799		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-FMD-201	3D	4-6 ft	Moist, light olive brown sand with clay and gravel	4.5
BB-FMD-201	5DA	8-10 ft	Moist, dark grayish brown sandy clay	21.3
BB-FMD-201	6D	10-12 ft	Moist, olive gray clay	31.1
BB-FMD-201	7D	15-17 ft	Moist, olive gray clay	23.9
BB-FMD-203	5D	9-11 ft	Moist, light olive brown clayey sand	12.4
BB-FMD-205	2D	2-4 ft	Moist, dark yellowish brown clayey sand	14.0
BB-FMD-208	6D	10-12 ft	Moist, dark grayish brown clayey sand with gravel	6.3
BB-FMD-208	7D	15-17 ft	Moist, dark grayish brown gravel with sand	6.3
BB-FMD-208	4D	6-8 ft	Moist, light yellowish brown sand with silt	6.2

Notes: Temperature of Drying : 110º Celsius

Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	---	Sample Type:	---	Tested By:	GA
Sample ID:	---	Test Date:	06/25/21	Checked By:	bfs
Depth :	---	Test Id:	621797		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-FMD-209	3D	4-6 ft	Moist, light olive brown silty sand	2.8
BB-FMD-209	7DB	15-16.5 ft	Moist, dark gray clay with sand	27.3
BB-FMD-209	5D	8-10 ft	Moist, light olive brown sand with silt	5.8
BB-FMD-210	7DA	15-17 ft	Moist, olive brown clayey sand	10.4
BB-FMD-210	6D	10-12 ft	Moist, light olive brown clayey sand	9.8
BB-FMD-210	8D	20-20.3 ft	Moist, dark grayish brown gravel with sand and clay	15.9

Notes: Temperature of Drying : 110º Celsius

GeoTesting EXPRESS

Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: ---	Sample Type: ---	Tested By:	GA
Sample ID: ---	Test Date: 06/25/21	Checked By:	bfs
Depth : ---	Test Id: 621783		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BR-FMD-202	4D	8-10 ft	Moist, olive brown clayey sand	13.3
BR-FMD-202	5DA	10-11 ft	Moist, brown silty sand	8.1
BR-FMD-202	6D	15-17 ft	Moist, dark gray clay	27.5
BR-FMD-203	3D	5-7 ft	Moist, light olive brown clayey sand	8.1
BR-FMD-203	8D	20-22 ft	Moist, dark gray clay	29.3

Notes: Temperature of Drying : 110º Celsius

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GeoTesting EXPRESS

Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	---	Sample Type:	---	Tested By:	GA
Sample ID:	---	Test Date:	06/25/21	Checked By:	bfs
Depth :	---	Test Id:	621789		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BR-FMD-206	3D	4-6 ft	Moist, dark brown gravel with clay and sand	7.0
BR-FMD-206	5D	8-10 ft	Moist, light olive brown sand with silt	5.4
BR-FMD-206	7DA	15-17 ft	Moist, grayish brown clayey sand with gravel	13.0
BR-FMD-207	3D	4-6 ft	Moist, light olive brown sand with silt	4.2
BR-FMD-207	6D	10-12 ft	Moist, light olive brown sand with clay	6.9
BR-FMD-207	8DB	20-21.3 ft	Moist, dark yellowish brown silt with sand	26.5

Notes: Temperature of Drying : 110º Celsius

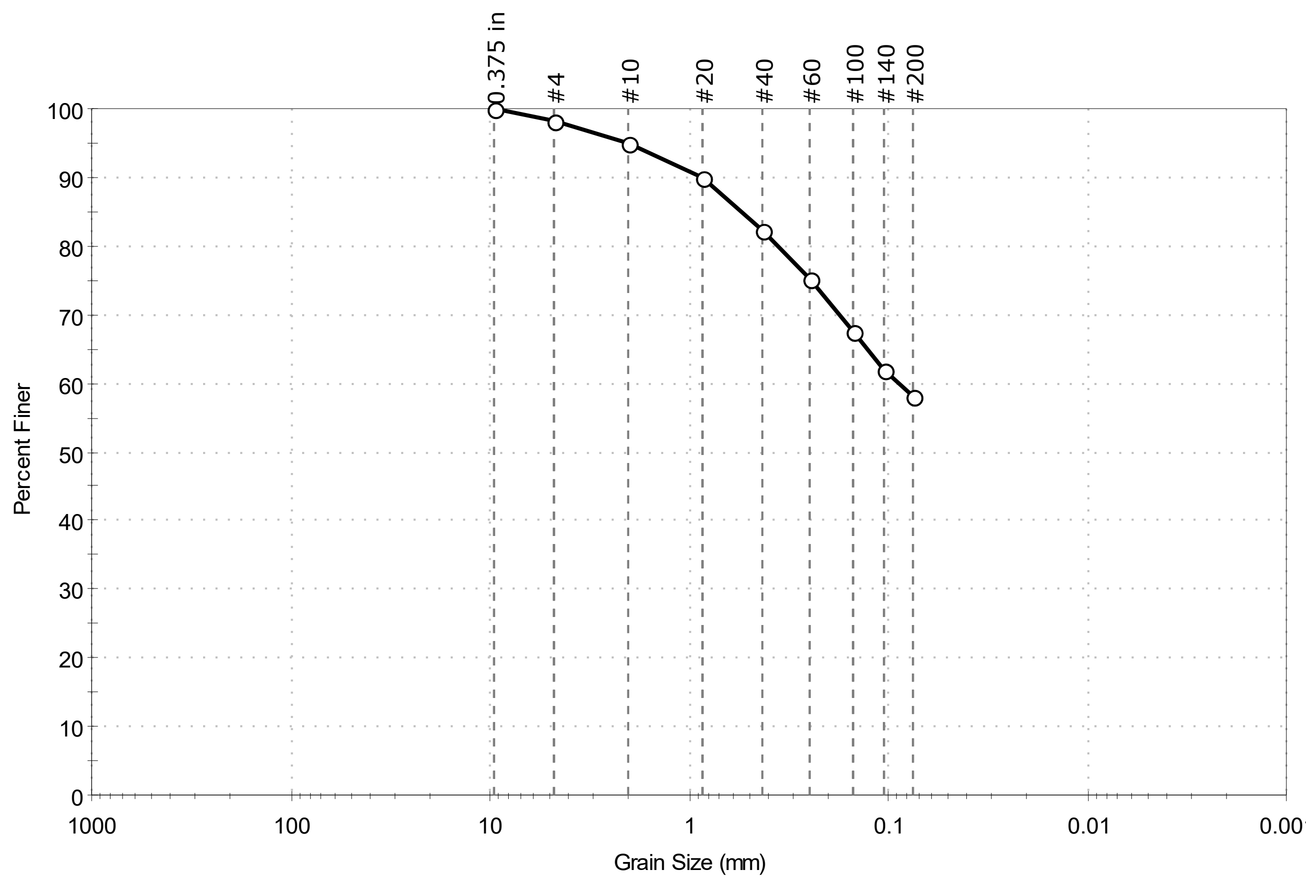
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BB-FMD-201	Sample Type: jar	Tested By:	GA
Sample ID: 5DA	Test Date: 06/25/21	Checked By:	bfs
Depth : 8-10 ft	Test Id: 621778		

Test Comment: ---

Visual Description: Moist, dark grayish brown sandy clay

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.8	40.0	58.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	98		
#10	2.00	95		
#20	0.85	90		
#40	0.42	82		
#60	0.25	75		
#100	0.15	68		
#140	0.11	62		
#200	0.075	58		

Coefficients

D_{85} =0.5397 mm D_{30} =N/A

D_{60} =0.0887 mm D_{15} =N/A

D_{50} =N/A D_{10} =N/A

C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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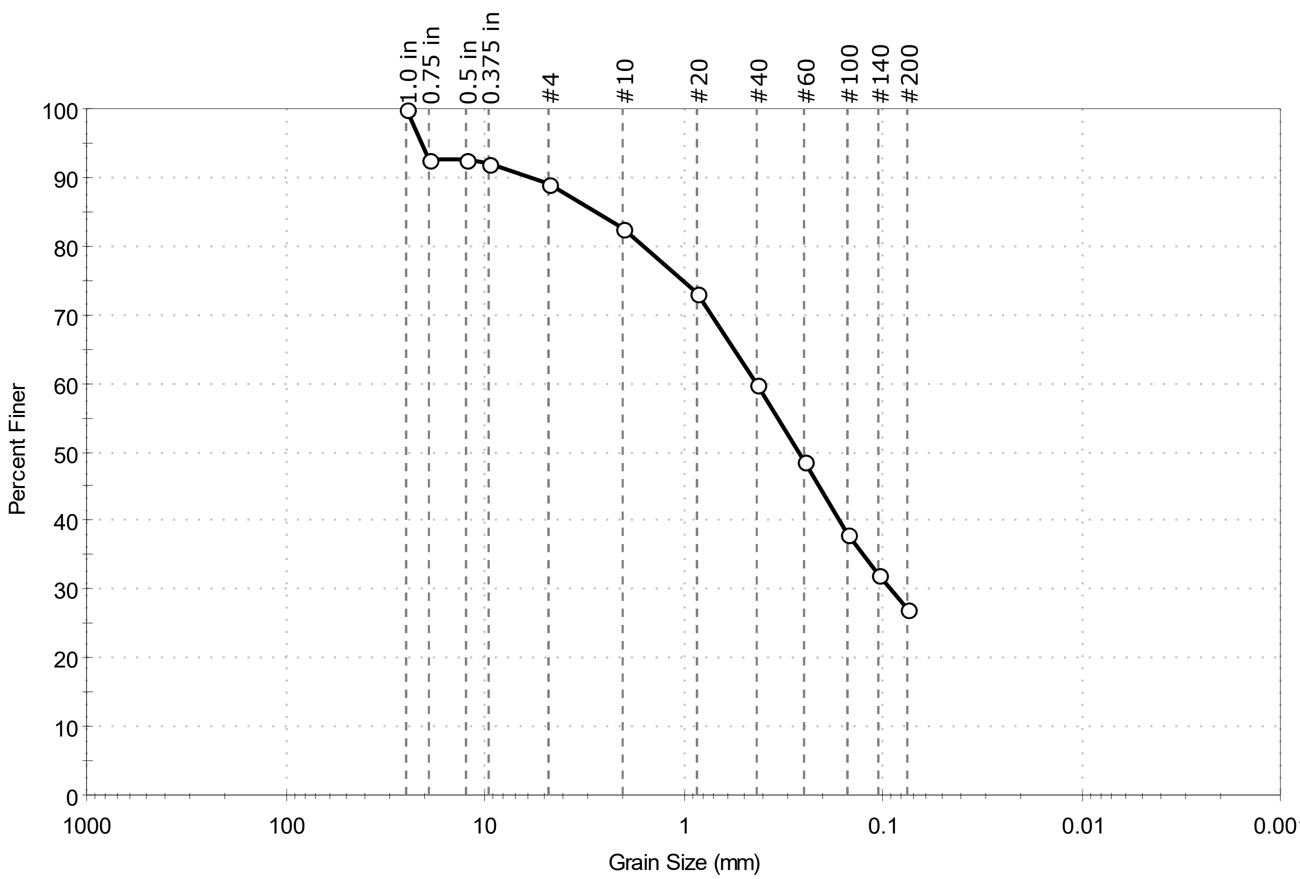
Client: Golder Associates
Project: Freeport Mallet Dr Bridge Ex 22
Location: Freeport, ME
Project No: GTX-313826
Boring ID: BB-FMD-205
Sample Type: jar
Tested By: GA
Sample ID: 2D
Test Date: 06/25/21
Checked By: bfs
Depth : 2-4 ft
Test Id: 621776
Test Comment: ---
Visual Description: Moist, dark yellowish brown clayey sand
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	10.9	62.0	27.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.0 in	25.00	100		
0.75 in	19.00	93		
0.5 in	12.50	93		
0.375 in	9.50	92		
#4	4.75	89		
#10	2.00	82		
#20	0.85	73		
#40	0.42	60		
#60	0.25	49		
#100	0.15	38		
#140	0.11	32		
#200	0.075	27		

Coefficients

D_{85} =2.7804 mm
D_{30} =0.0911 mm
D_{60} =0.4287 mm
D_{15} =N/A
D_{50} =0.2653 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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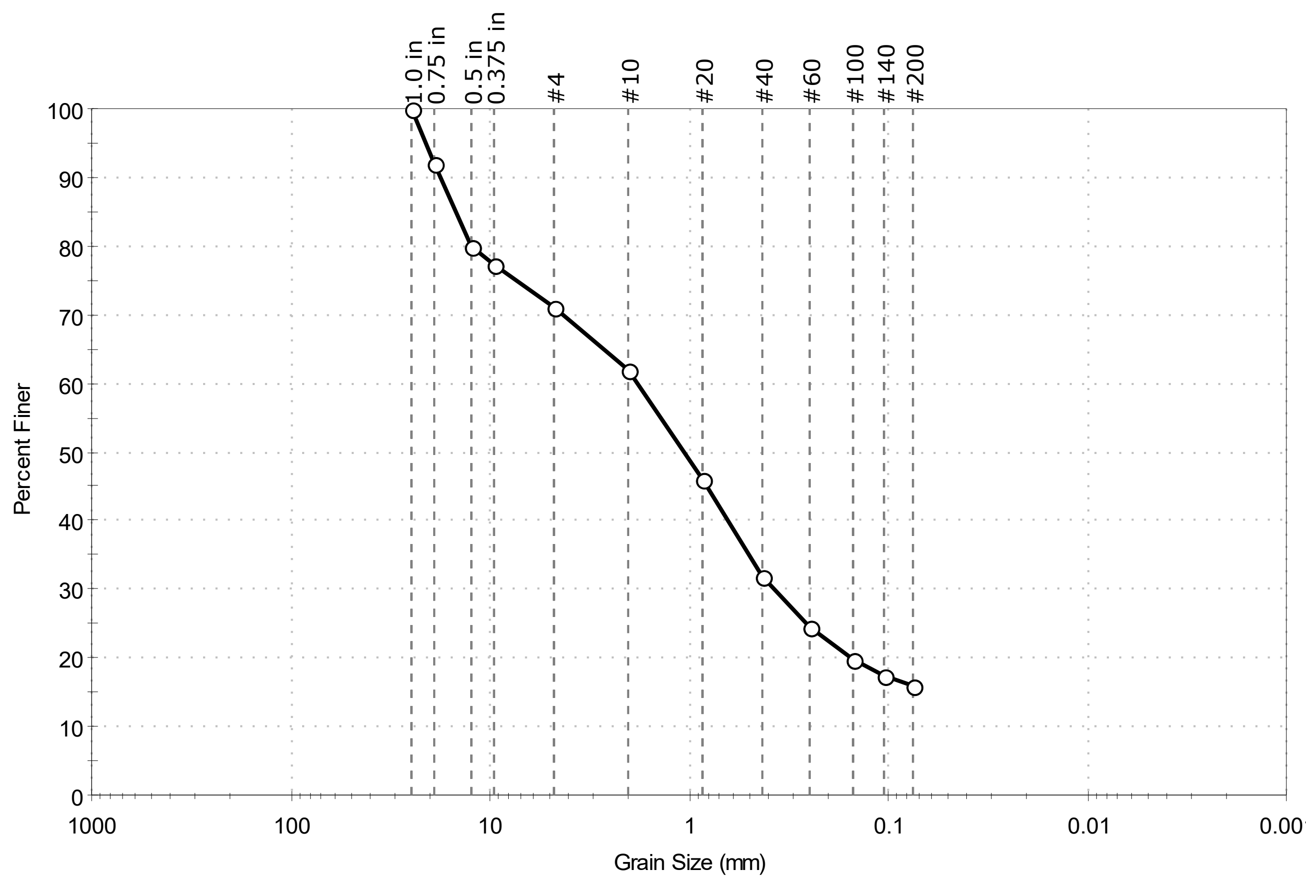
GeoTesting EXPRESS

Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	BB-FMD-208	Sample Type:	jar	Tested By:	GA
Sample ID:	6D	Test Date:	06/25/21	Checked By:	bfs
Depth :	10-12 ft	Test Id:	621772		

Test Comment: ---
Visual Description: Moist, dark grayish brown clayey sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	28.9	55.2	15.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.0 in	25.00	100		
0.75 in	19.00	92		
0.5 in	12.50	80		
0.375 in	9.50	77		
#4	4.75	71		
#10	2.00	62		
#20	0.85	46		
#40	0.42	32		
#60	0.25	24		
#100	0.15	20		
#140	0.11	18		
#200	0.075	16		

Coefficients

D_{85} =14.9236 mm D_{30} =0.3736 mm
D_{60} =1.8027 mm D_{15} =N/A
D_{50} =1.0586 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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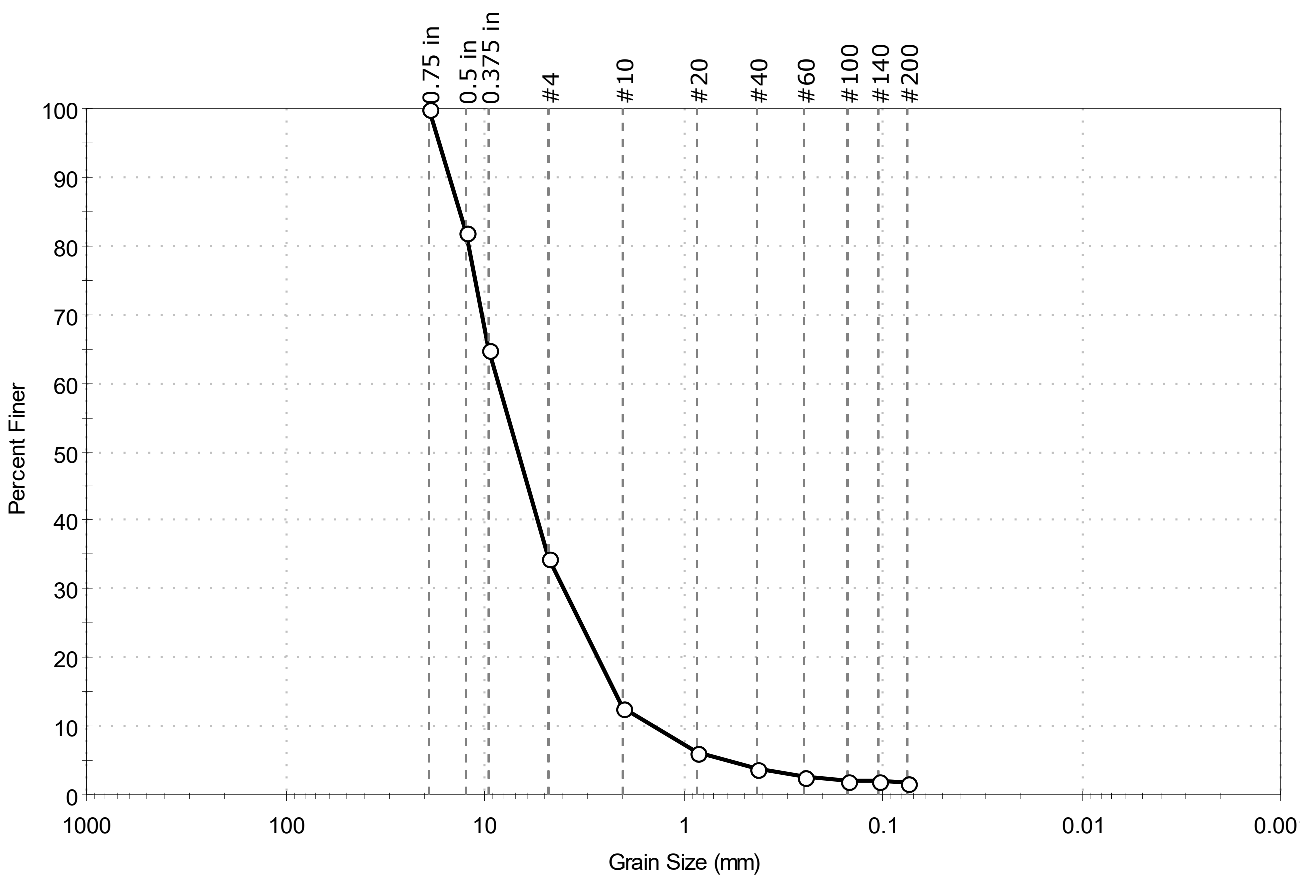
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID:	BB-FMD-208	Sample Type: jar	Tested By: GA
Sample ID:	7D	Test Date: 06/25/21	Checked By: bfs
Depth :	15-17 ft	Test Id: 621773	
Test Comment:	---		
Visual Description:	Moist, dark grayish brown gravel with sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	65.4	32.9	1.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	82		
0.375 in	9.50	65		
#4	4.75	35		
#10	2.00	13		
#20	0.85	6		
#40	0.42	4		
#60	0.25	3		
#100	0.15	2		
#140	0.11	2		
#200	0.075	1.7		

Coefficients

D_{85} =13.3811 mm D_{30} =3.9631 mm

D_{60} =8.4859 mm D_{15} =2.1943 mm

D_{50} =6.7531 mm D_{10} =1.4156 mm

C_u =5.995 C_c =1.307

Classification

ASTM Well-graded GRAVEL with Sand (GW)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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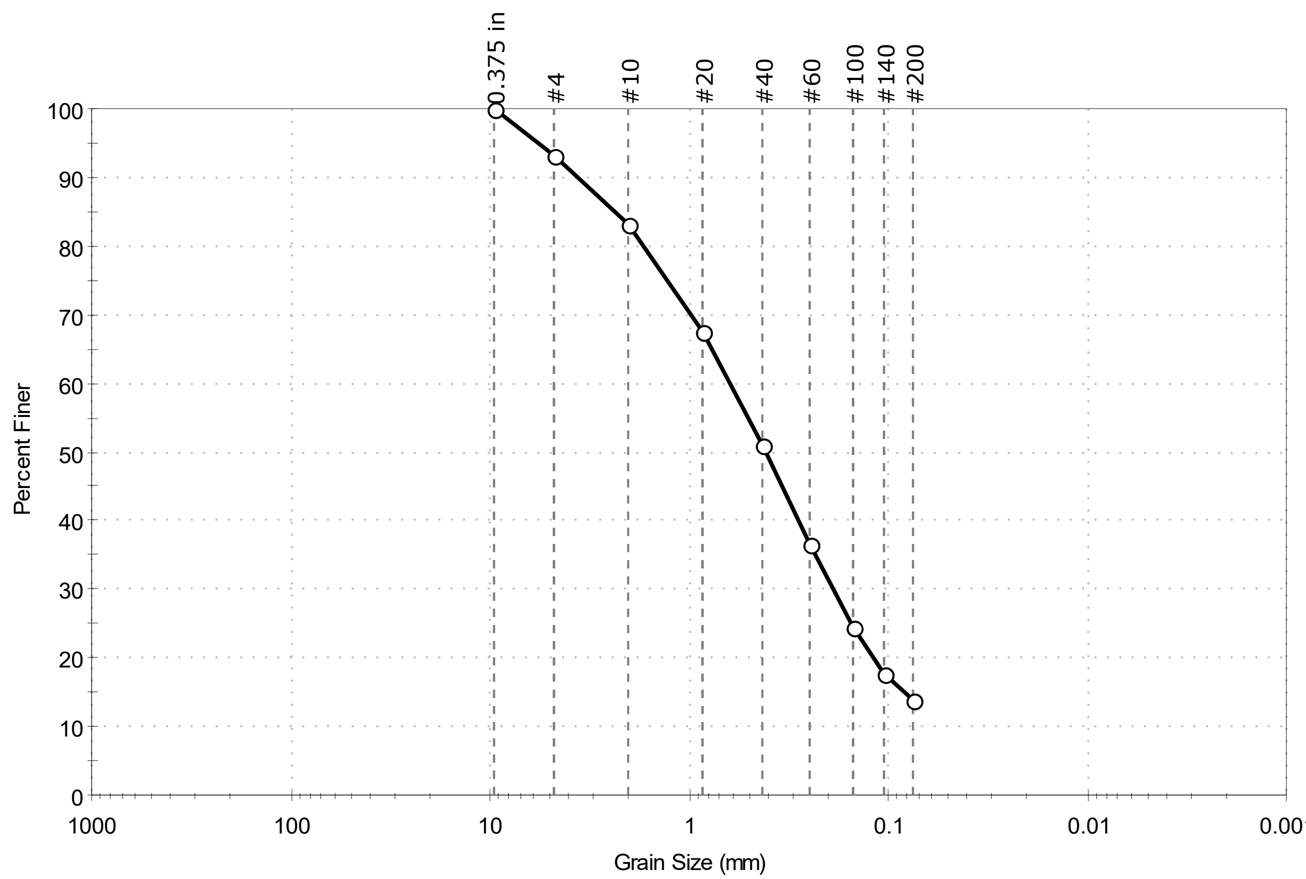
Client:	Golder Associates			
Project:	Freeport Mallet Dr Bridge Ex 22			
Location:	Freeport, ME		Project No:	GTX-313826
Boring ID:	BB-FMD-209	Sample Type: jar	Tested By:	GA
Sample ID:	3D	Test Date: 06/25/21	Checked By:	bfs
Depth :	4-6 ft	Test Id: 621774		

Test Comment: ---
Visual Description: Moist, light olive brown silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	6.8	79.3	13.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	93		
#10	2.00	83		
#20	0.85	68		
#40	0.42	51		
#60	0.25	36		
#100	0.15	24		
#140	0.11	18		
#200	0.075	14		

Coefficients

D_{85} =2.3578 mm　D_{30} =0.1901 mm
D_{60} =0.6172 mm　D_{15} =0.0832 mm
D_{50} =0.4087 mm　D_{10} =N/A
C_u =N/A　C_c =N/A

Classification

ASTM　N/A

AASHTO　Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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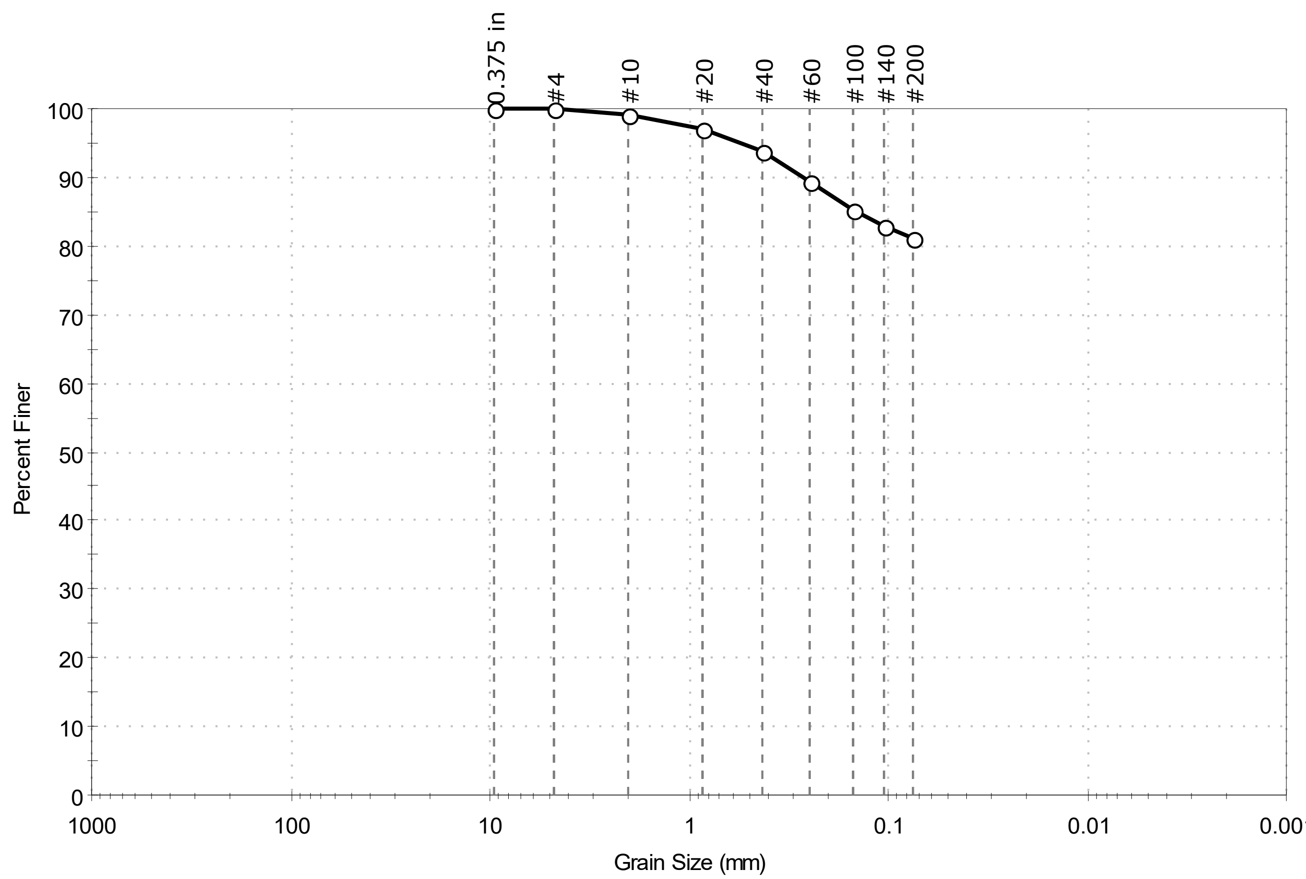
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BB-FMD-209
Sample Type:	jar
Tested By:	GA
Sample ID:	7DB
Test Date:	06/25/21
Checked By:	bfs
Depth :	15-16.5 ft
Test Id:	621775
Test Comment:	---
Visual Description:	Moist, dark gray clay with sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.1	18.9	81.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	97		
#40	0.42	94		
#60	0.25	89		
#100	0.15	85		
#140	0.11	83		
#200	0.075	81		

Coefficients

D_{85} =0.1457 mm
D_{30} =N/A
D_{60} =N/A
D_{15} =N/A
D_{50} =N/A
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM Lean CLAY with Sand (CL)

AASHTO Silty Soils (A-4 (4))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME

Project No: GTX-313826

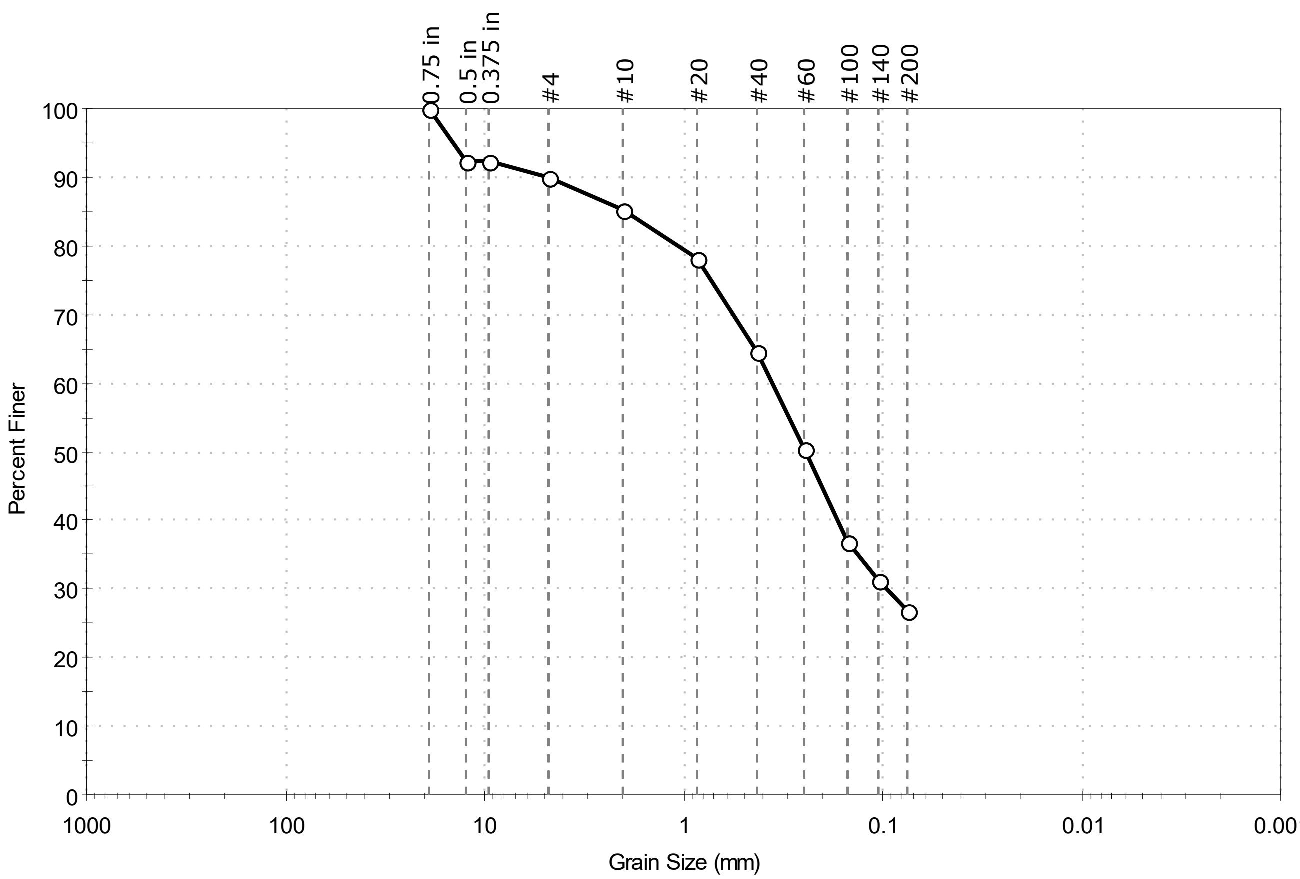
Boring ID:	BB-FMD-210	Sample Type:	jar	Tested By:	GA
Sample ID:	7DA	Test Date:	06/25/21	Checked By:	bfs
Depth :	15-17 ft	Test Id:	621777		

Test Comment: ---

Visual Description: Moist, olive brown clayey sand

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	10.0	63.2	26.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	92		
0.375 in	9.50	92		
#4	4.75	90		
#10	2.00	85		
#20	0.85	78		
#40	0.42	65		
#60	0.25	50		
#100	0.15	37		
#140	0.11	31		
#200	0.075	27		

Coefficients

D_{85} =1.9305 mm
D_{30} =0.0965 mm
D_{60} =0.3590 mm
D_{15} =N/A
D_{50} =0.2471 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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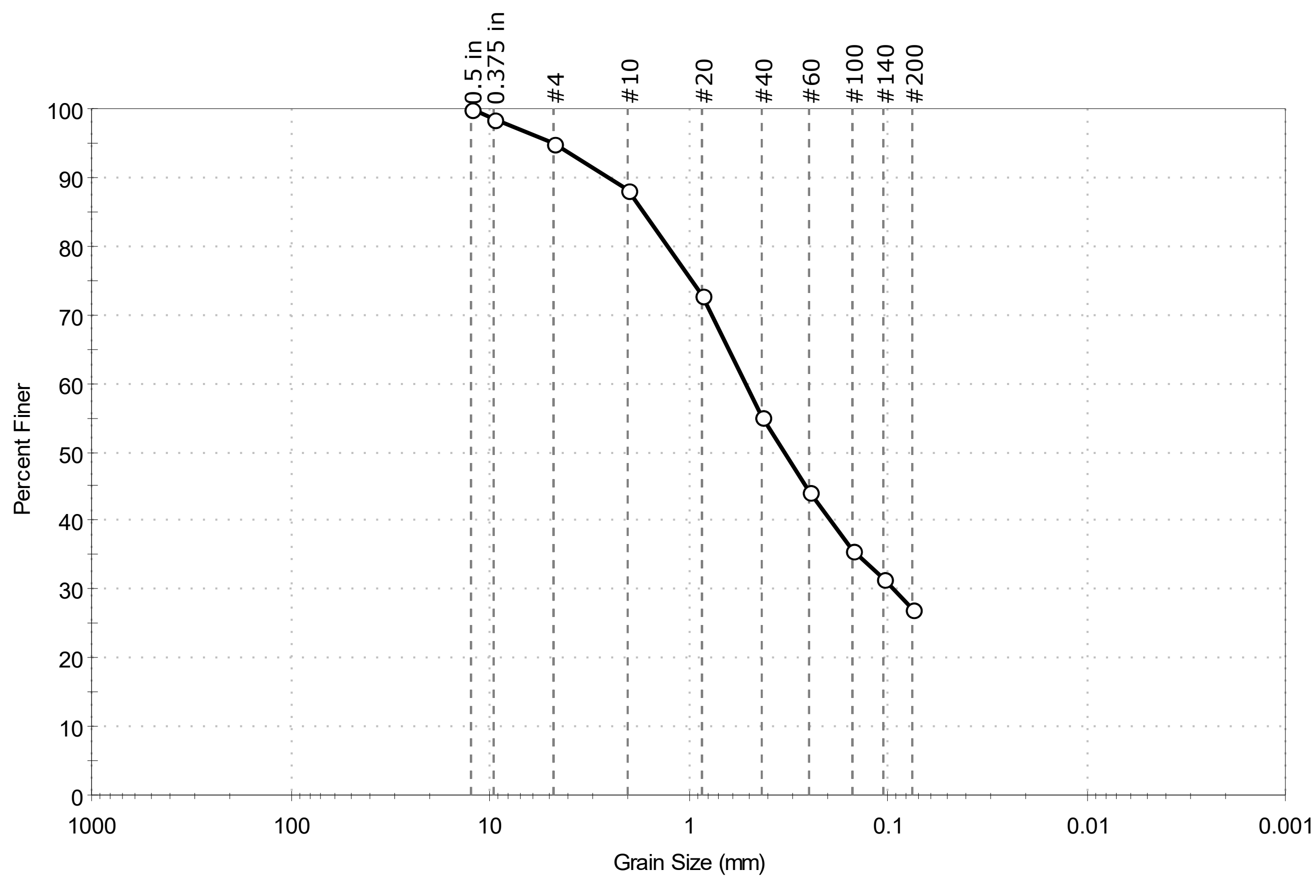
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BR-FMD-202
Sample Type:	jar
Tested By:	GA
Sample ID:	4D
Test Date:	06/25/21
Checked By:	bfs
Depth :	8-10 ft
Test Id:	621761
Test Comment:	---
Visual Description:	Moist, olive brown clayey sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	5.0	67.7	27.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	98		
#4	4.75	95		
#10	2.00	88		
#20	0.85	73		
#40	0.42	55		
#60	0.25	44		
#100	0.15	36		
#140	0.11	32		
#200	0.075	27		

Coefficients

D_{85} =1.6662 mm

D_{30} =0.0935 mm

D_{60} =0.5143 mm

D_{15} =N/A

D_{50} =0.3316 mm

D_{10} =N/A

C_u =N/A

C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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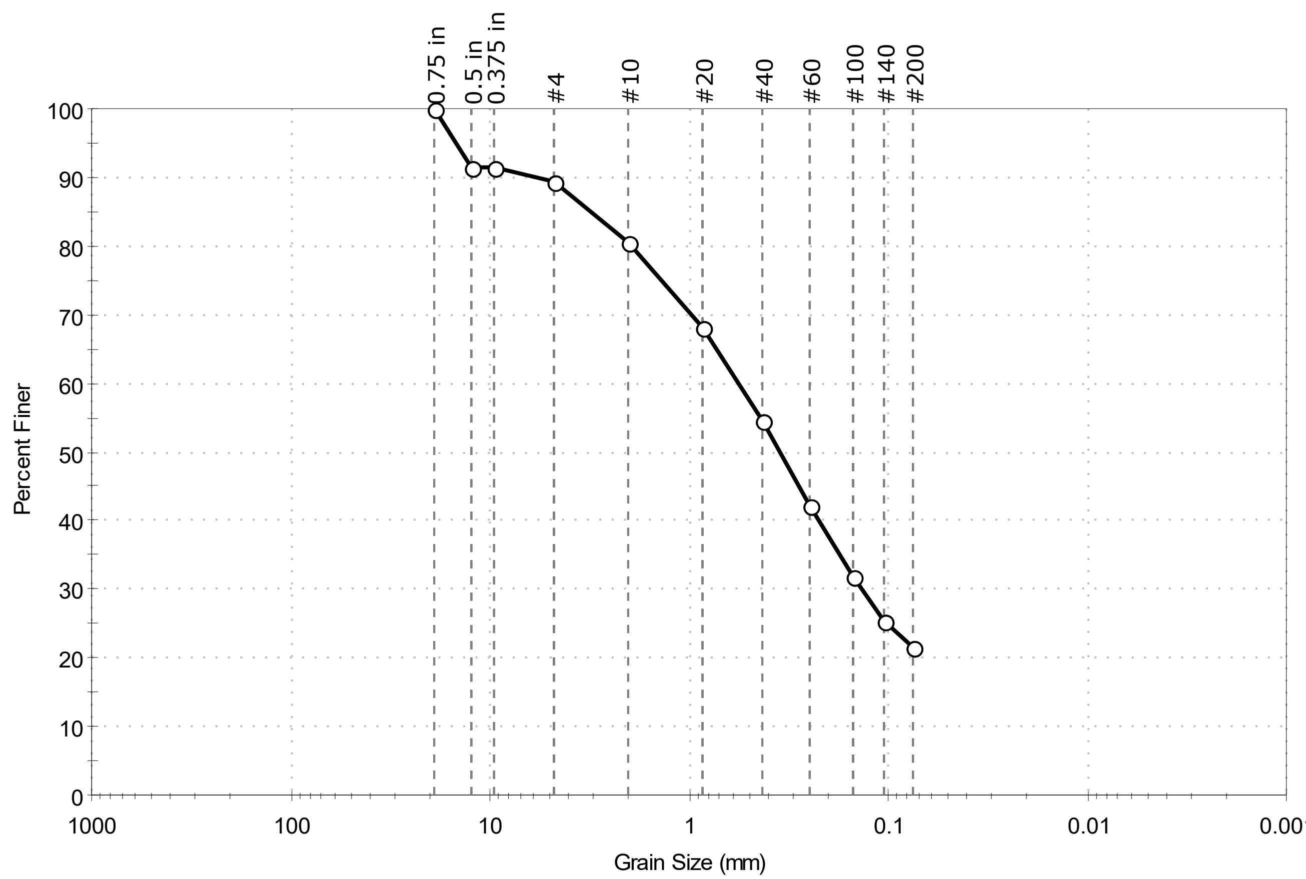
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BR-FMD-202
Sample ID:	5DA
Depth :	10-11 ft
Sample Type:	jar
Test Date:	06/25/21
Test Id:	621762
Tested By:	GA
Checked By:	bfs
Test Comment:	---
Visual Description:	Moist, brown clayey sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	10.6	67.8	21.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	92		
0.375 in	9.50	92		
#4	4.75	89		
#10	2.00	81		
#20	0.85	68		
#40	0.42	54		
#60	0.25	42		
#100	0.15	32		
#140	0.11	25		
#200	0.075	22		

Coefficients

D_{85} =3.0598 mm
D_{30} =0.1354 mm
D_{60} =0.5613 mm
D_{15} =N/A
D_{50} =0.3508 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM Silty SAND (SM)

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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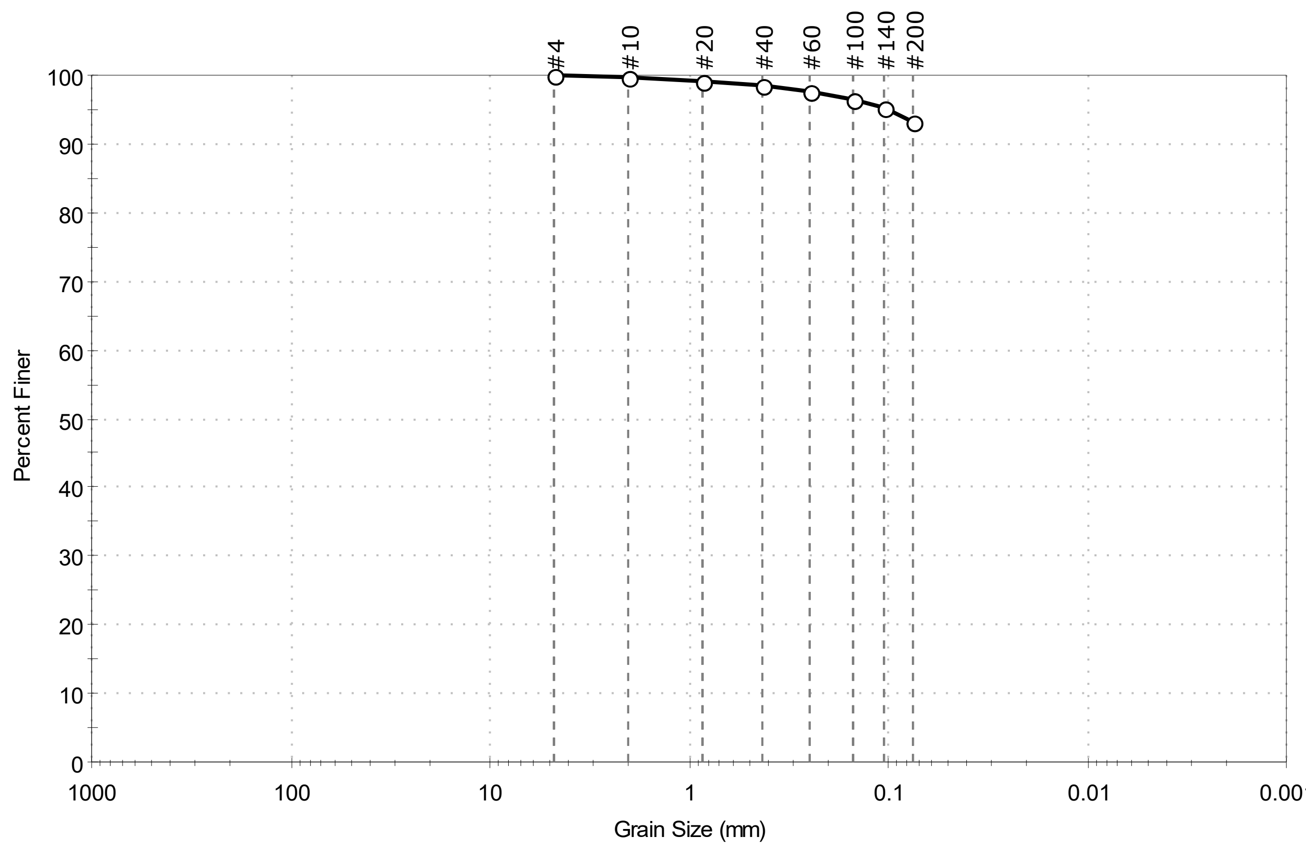
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BR-FMD-202	Sample Type: jar	Tested By:	GA
Sample ID: 6D	Test Date: 06/25/21	Checked By:	bfs
Depth : 15-17 ft	Test Id: 621763		

Test Comment: ---
Visual Description: Moist, dark gray clay
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	6.8	93.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	98		
#60	0.25	98		
#100	0.15	97		
#140	0.11	95		
#200	0.075	93		

Coefficients

D_{85} =N/A
D_{30} =N/A
D_{60} =N/A
D_{15} =N/A
D_{50} =N/A
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (16))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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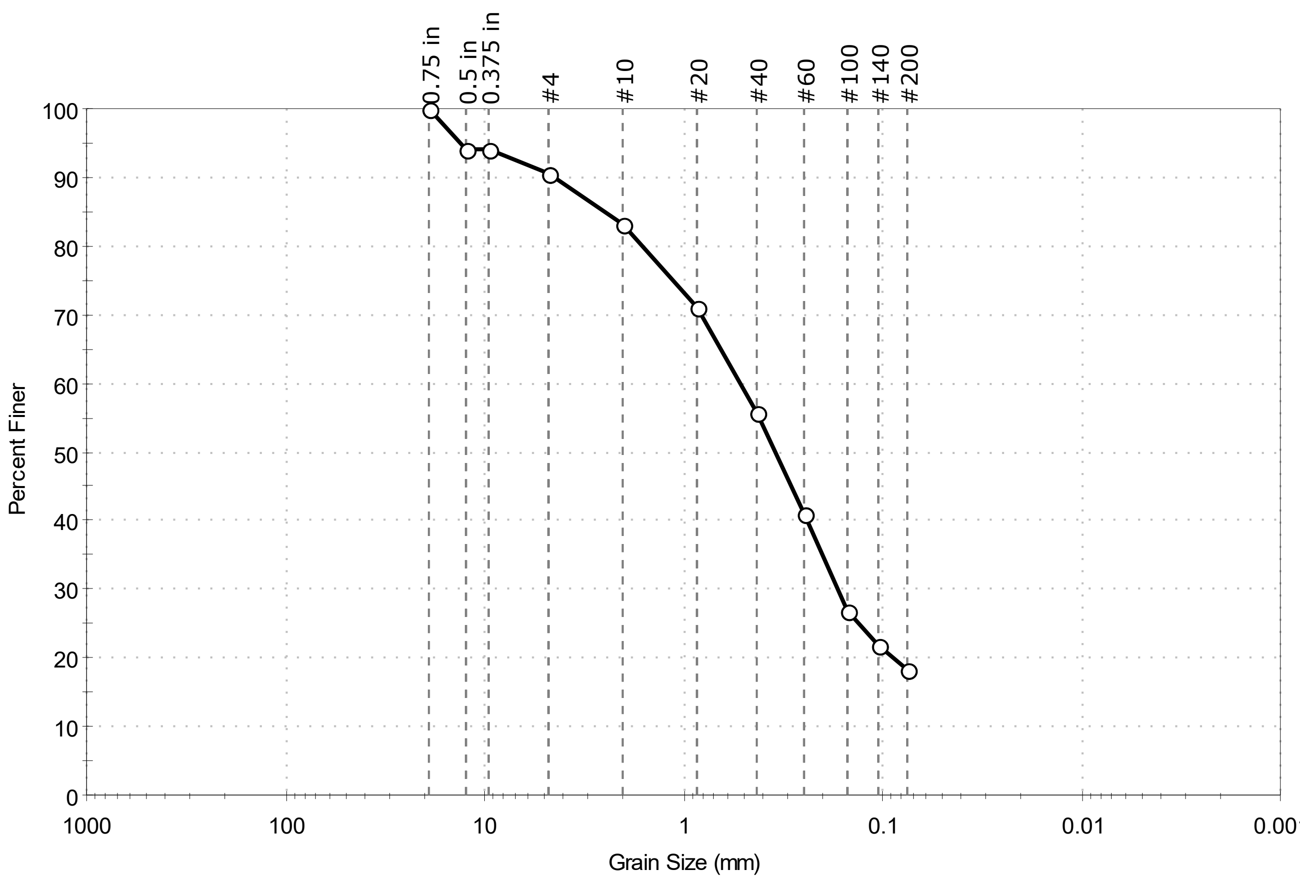
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BR-FMD-203	Sample Type: jar	Tested By:	GA
Sample ID: 3D	Test Date: 06/25/21	Checked By:	bfs
Depth : 5-7 ft	Test Id: 621764		

Test Comment: ---

Visual Description: Moist, light olive brown clayey sand

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	9.4	72.3	18.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	94		
0.375 in	9.50	94		
#4	4.75	91		
#10	2.00	83		
#20	0.85	71		
#40	0.42	56		
#60	0.25	41		
#100	0.15	27		
#140	0.11	22		
#200	0.075	18		

Coefficients

D_{85} =2.4574 mm D_{30} =0.1676 mm

D_{60} =0.5178 mm D_{15} =N/A

D_{50} =0.3467 mm D_{10} =N/A

C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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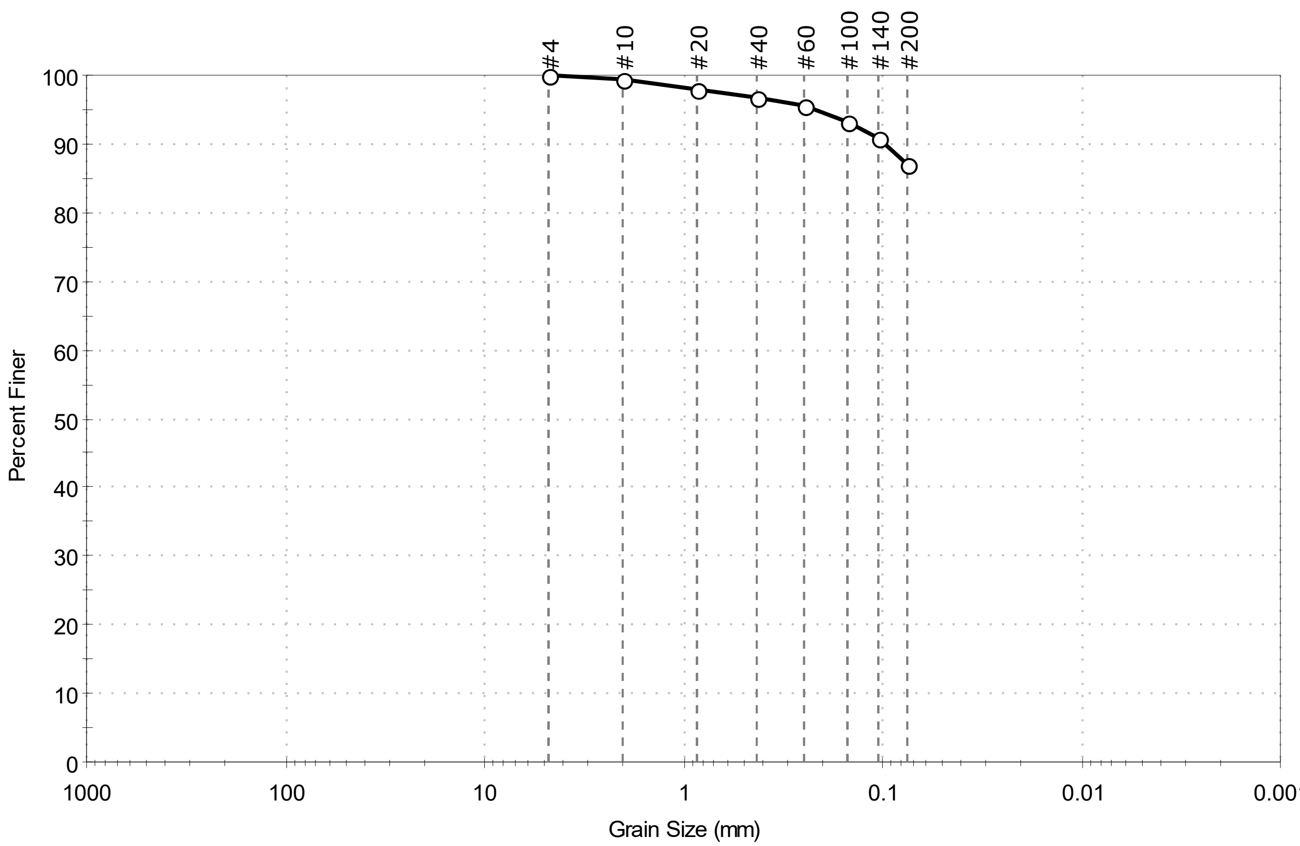
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BR-FMD-203	Sample Type: jar	Tested By:	GA
Sample ID: 8D	Test Date: 06/25/21	Checked By:	bfs
Depth : 20-22 ft	Test Id: 621765		
Test Comment:	---		
Visual Description:	Moist, dark gray clay		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	12.9	87.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	99		
#20	0.85	98		
#40	0.42	97		
#60	0.25	95		
#100	0.15	93		
#140	0.11	91		
#200	0.075	87		

Coefficients

D_{85} =N/A | D_{30} =N/A

D_{60} =N/A | D_{15} =N/A

D_{50} =N/A | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (8))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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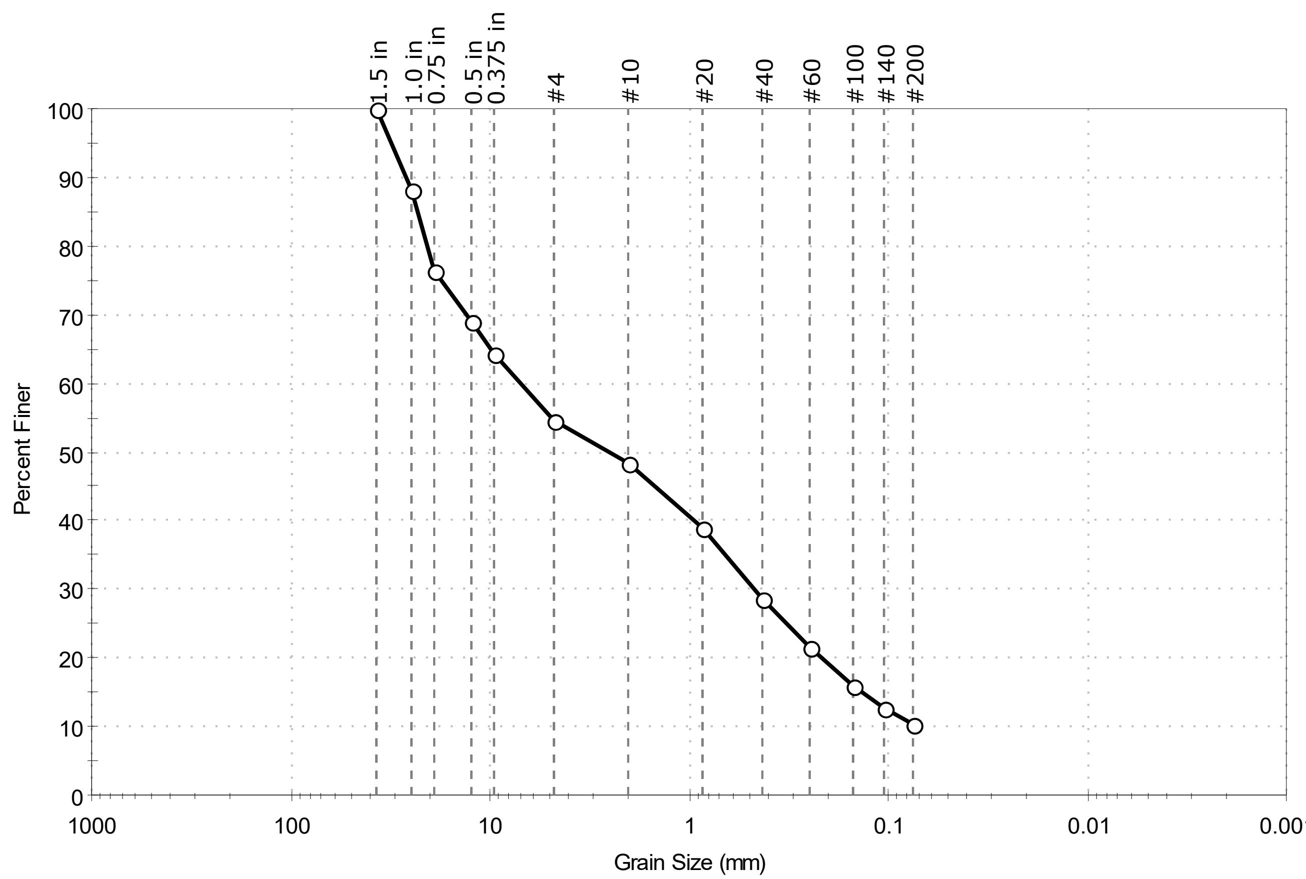
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BR-FMD-206
Sample Type:	jar
Tested By:	GA
Sample ID:	3D
Test Date:	06/25/21
Checked By:	bfs
Depth :	4-6 ft
Test Id:	621766
Test Comment:	---
Visual Description:	Moist, dark brown gravel with clay and sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	45.3	44.3	10.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1.0 in	25.00	88		
0.75 in	19.00	77		
0.5 in	12.50	69		
0.375 in	9.50	64		
#4	4.75	55		
#10	2.00	48		
#20	0.85	39		
#40	0.42	29		
#60	0.25	22		
#100	0.15	16		
#140	0.11	13		
#200	0.075	10		

Coefficients

D_{85} =23.1870 mm
D_{30} =0.4625 mm
D_{60} =6.9712 mm
D_{15} =0.1355 mm
D_{50} =2.5111 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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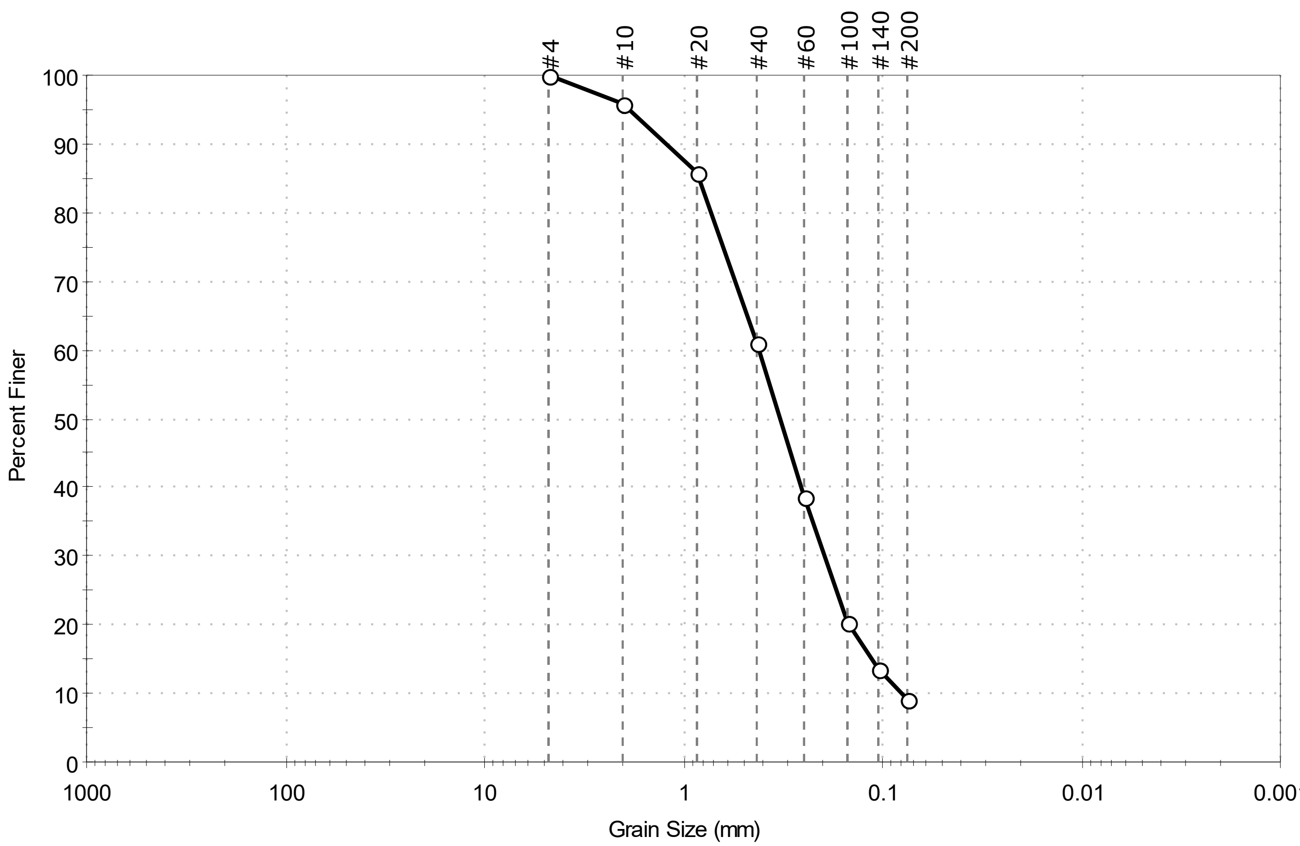
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BR-FMD-206	Sample Type: jar	Tested By:	GA
Sample ID: 5D	Test Date: 06/25/21	Checked By:	bfs
Depth : 8-10 ft	Test Id: 621767		

Test Comment: ---

Visual Description: Moist, light olive brown sand with silt

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	90.7	9.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	96		
#20	0.85	86		
#40	0.42	61		
#60	0.25	39		
#100	0.15	20		
#140	0.11	14		
#200	0.075	9.3		

Coefficients

D_{85} =0.8315 mm D_{30} =0.1962 mm

D_{60} =0.4137 mm D_{15} =0.1140 mm

D_{50} =0.3268 mm D_{10} =0.0795 mm

C_u =5.204 C_c =1.170

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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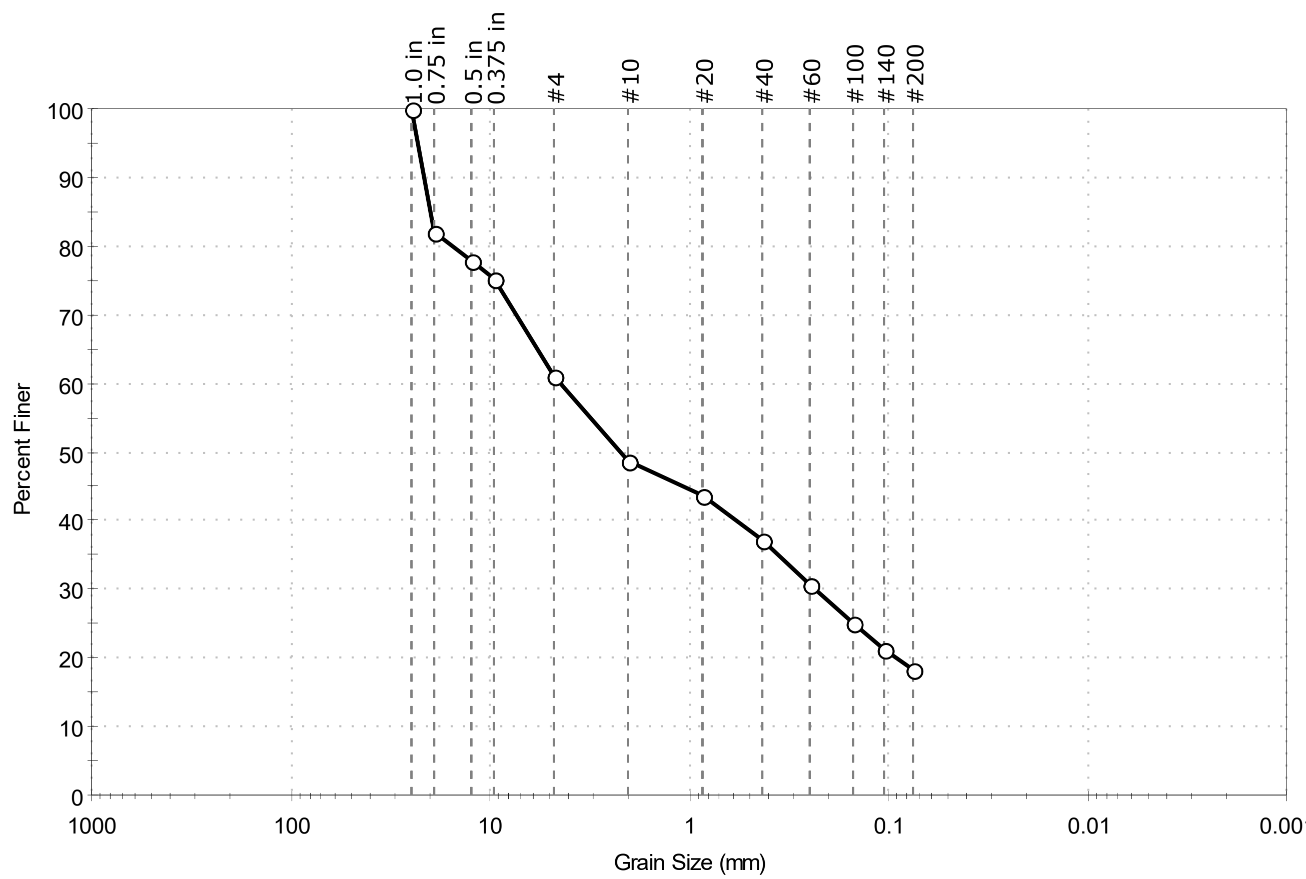
Client:	Golder Associates			
Project:	Freeport Mallet Dr Bridge Ex 22			
Location:	Freeport, ME		Project No:	GTX-313826
Boring ID:	BR-FMD-206	Sample Type: jar	Tested By:	GA
Sample ID:	7DA	Test Date: 06/25/21	Checked By:	bfs
Depth :	15-17 ft	Test Id: 621768		

Test Comment: ---

Visual Description: Moist, grayish brown clayey sand with gravel

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	39.0	42.6	18.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.0 in	25.00	100		
0.75 in	19.00	82		
0.5 in	12.50	78		
0.375 in	9.50	75		
#4	4.75	61		
#10	2.00	49		
#20	0.85	44		
#40	0.42	37		
#60	0.25	31		
#100	0.15	25		
#140	0.11	21		
#200	0.075	18		

Coefficients

D_{85} =19.8550 mm | D_{30} =0.2370 mm

D_{60} =4.4213 mm | D_{15} =N/A

D_{50} =2.1805 mm | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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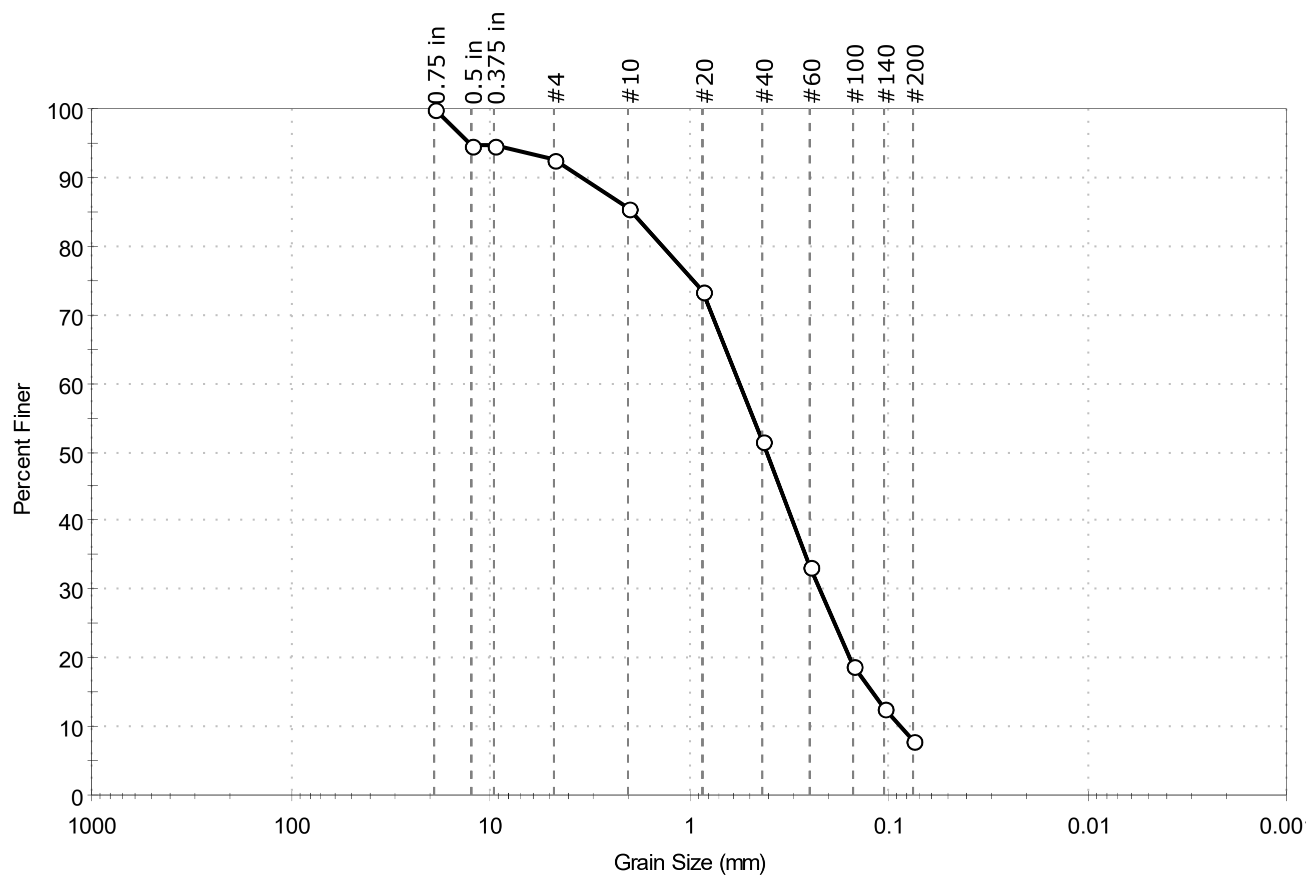
Client: Golder Associates			
Project: Freeport Mallet Dr Bridge Ex 22			
Location: Freeport, ME		Project No:	GTX-313826
Boring ID: BR-FMD-207	Sample Type: jar	Tested By:	GA
Sample ID: 3D	Test Date: 06/25/21	Checked By:	bfs
Depth : 4-6 ft	Test Id: 621769		
Test Comment: ---			
Visual Description: Moist, light olive brown sand with silt			
Sample Comment: ---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	7.4	84.6	8.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	95		
0.375 in	9.50	95		
#4	4.75	93		
#10	2.00	86		
#20	0.85	74		
#40	0.42	52		
#60	0.25	33		
#100	0.15	19		
#140	0.11	13		
#200	0.075	8.0		

Coefficients

D_{85} =1.9235 mm | D_{30} =0.2218 mm

D_{60} =0.5536 mm | D_{15} =0.1211 mm

D_{50} =0.4051 mm | D_{10} =0.0873 mm

C_u =6.341 | C_c =1.018

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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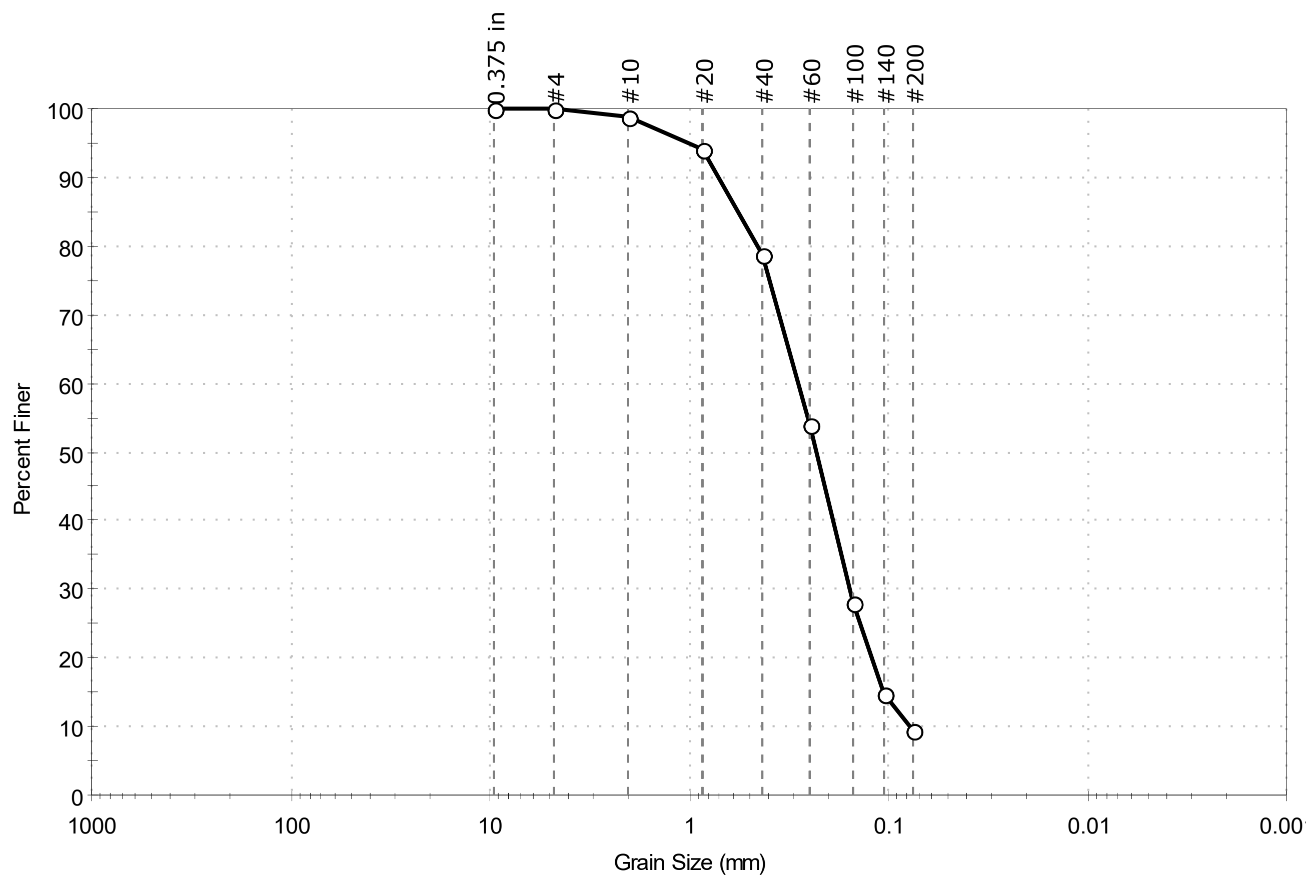
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BR-FMD-207
Sample Type:	jar
Tested By:	GA
Sample ID:	6D
Test Date:	06/25/21
Checked By:	bfs
Depth :	10-12 ft
Test Id:	621770
Test Comment:	---
Visual Description:	Moist, light olive brown sand with clay
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.2	90.4	9.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	94		
#40	0.42	79		
#60	0.25	54		
#100	0.15	28		
#140	0.11	15		
#200	0.075	9.4		

Coefficients

D_{85} =0.5635 mm
D_{30} =0.1556 mm
D_{60} =0.2847 mm
D_{15} =0.1065 mm
D_{50} =0.2313 mm
D_{10} =0.0777 mm
C_u =3.664
C_c =1.094

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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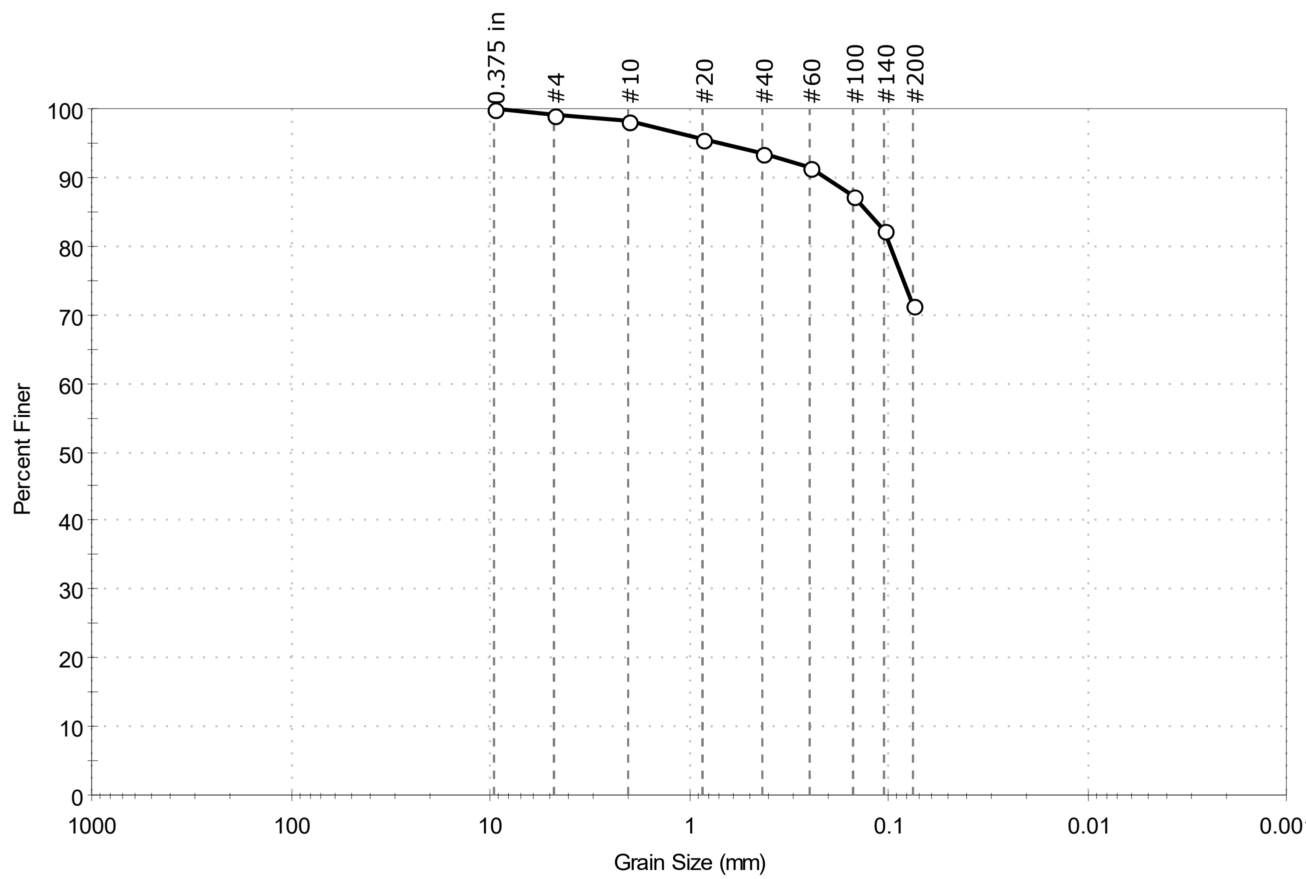
Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID:	BR-FMD-207	Sample Type: jar	Tested By: GA
Sample ID:	8DB	Test Date: 06/25/21	Checked By: bfs
Depth :	20-21.3 ft	Test Id: 621771	

Test Comment: ---

Visual Description: Moist, dark yellowish brown silt with sand

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.9	27.6	71.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	99		
#10	2.00	98		
#20	0.85	96		
#40	0.42	93		
#60	0.25	91		
#100	0.15	87		
#140	0.11	82		
#200	0.075	72		

Coefficients

D_{85} =0.1278 mm | D_{30} =N/A

D_{60} =N/A | D_{15} =N/A

D_{50} =N/A | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM SILT with Sand (ML)

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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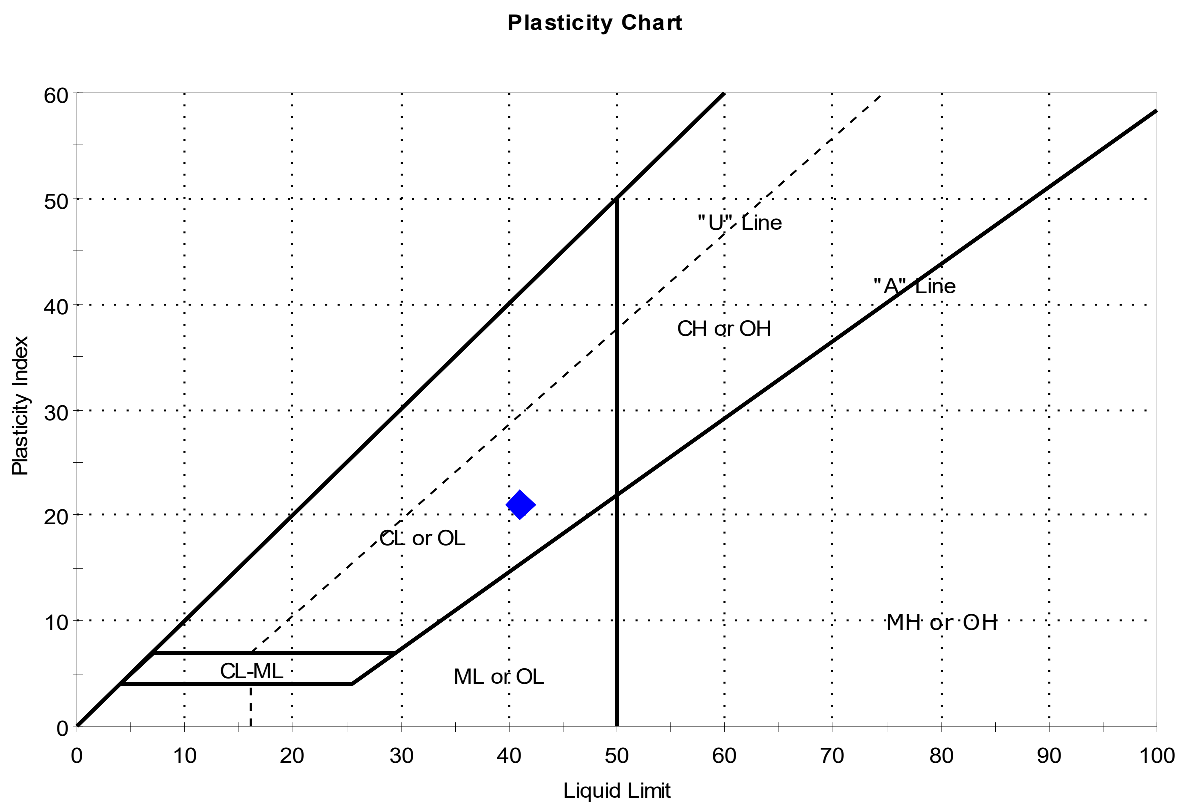
Client:	Golder Associates
Project:	Freeport Mallet Dr Bridge Ex 22
Location:	Freeport, ME
Project No:	GTX-313826
Boring ID:	BB-FMD-201
Sample Type:	jar
Tested By:	GA
Sample ID:	7D
Test Date:	06/25/21
Checked By:	bfs
Depth :	15-17 ft
Test Id:	621760
Test Comment:	---
Visual Description:	Moist, olive gray clay
Sample Comment:	---

Atterberg Limits - ASTM D4318



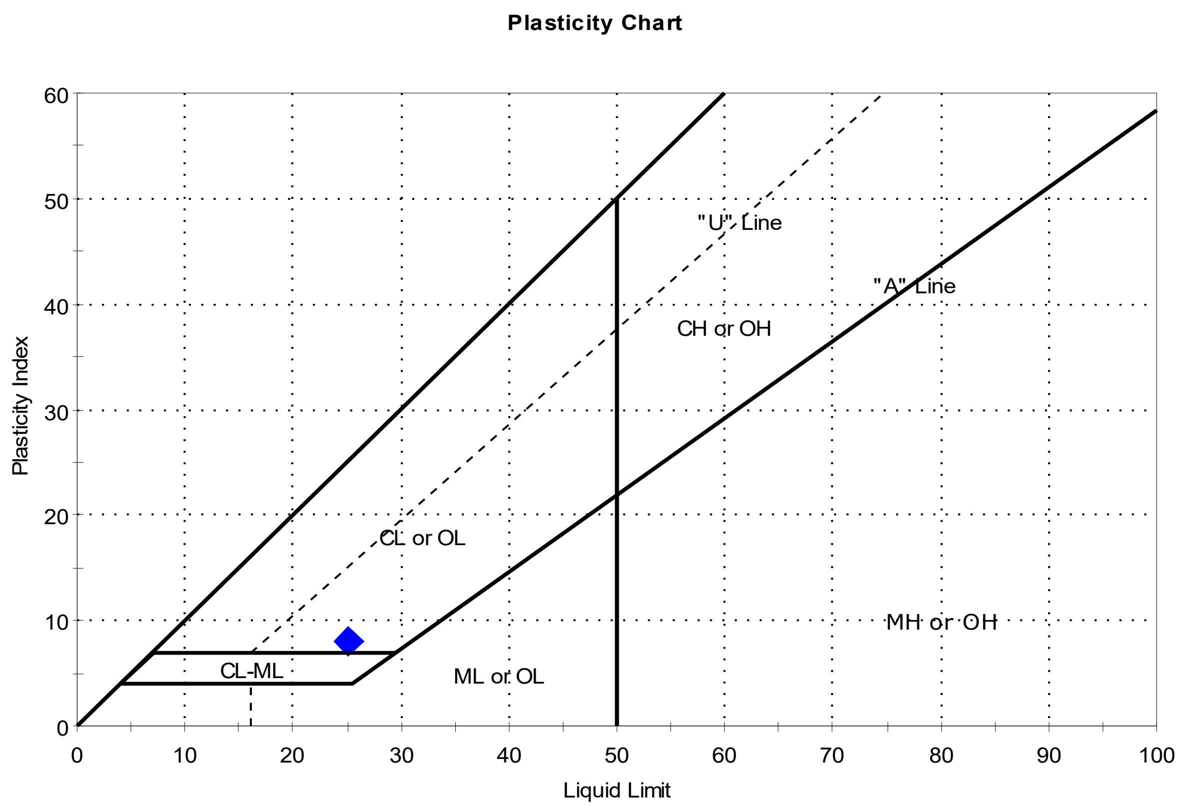
Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	7D	B-FMD-20	15-17 ft	24	41	20	21	0.2	

Sample Prepared using the WET method

Dry Strength: VERY HIGH
Dilatancy: NONE
Toughness: MEDIUM

Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BB-FMD-209	Sample Type: jar	Tested By:	GA
Sample ID: 7DB	Test Date: 06/25/21	Checked By:	bfs
Depth : 15-16.5 ft	Test Id: 621759		
Test Comment:	---		
Visual Description:	Moist, dark gray clay with sand		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	7DB	B-FMD-20	15-16.5 ft	27	25	17	8	1.3	Lean CLAY with Sand (CL)

Sample Prepared using the WET method

6% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826

Boring ID:	BR-FMD-202	Sample Type:	jar	Tested By:	GA
Sample ID:	5DA	Test Date:	06/25/21	Checked By:	bfs
Depth :	10-11 ft	Test Id:	621755		

Test Comment:	---
Visual Description:	Moist, brown silty sand
Sample Comment:	---

Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	5DA	R-FMD-20	10-11 ft	8	n/a	n/a	n/a	n/a	Silty SAND (SM)

46% Retained on #40 Sieve

Dry Strength: NONE

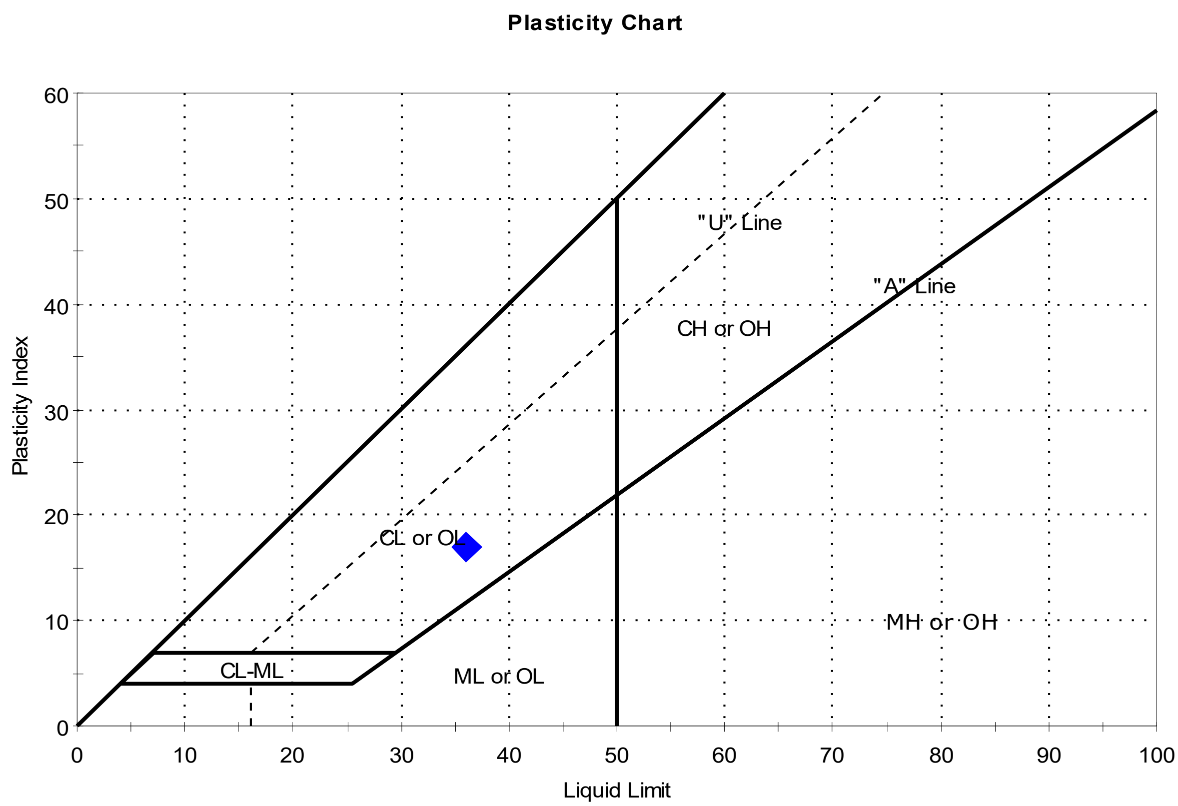
Dilatancy: RAPID

Toughness: n/a

The sample was determined to be Non-Plastic

Client:	Golder Associates		
Project:	Freeport Mallet Dr Bridge Ex 22		
Location:	Freeport, ME	Project No:	GTX-313826
Boring ID: BR-FMD-202	Sample Type: jar	Tested By:	GA
Sample ID: 6D	Test Date: 06/25/21	Checked By:	bfs
Depth : 15-17 ft	Test Id: 621756		
Test Comment:	---		
Visual Description:	Moist, dark gray clay		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	6D	R-FMD-20	15-17 ft	27	36	19	17	0.5	Lean CLAY (CL)

Sample Prepared using the WET method

2% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilatancy: NONE

Toughness: MEDIUM

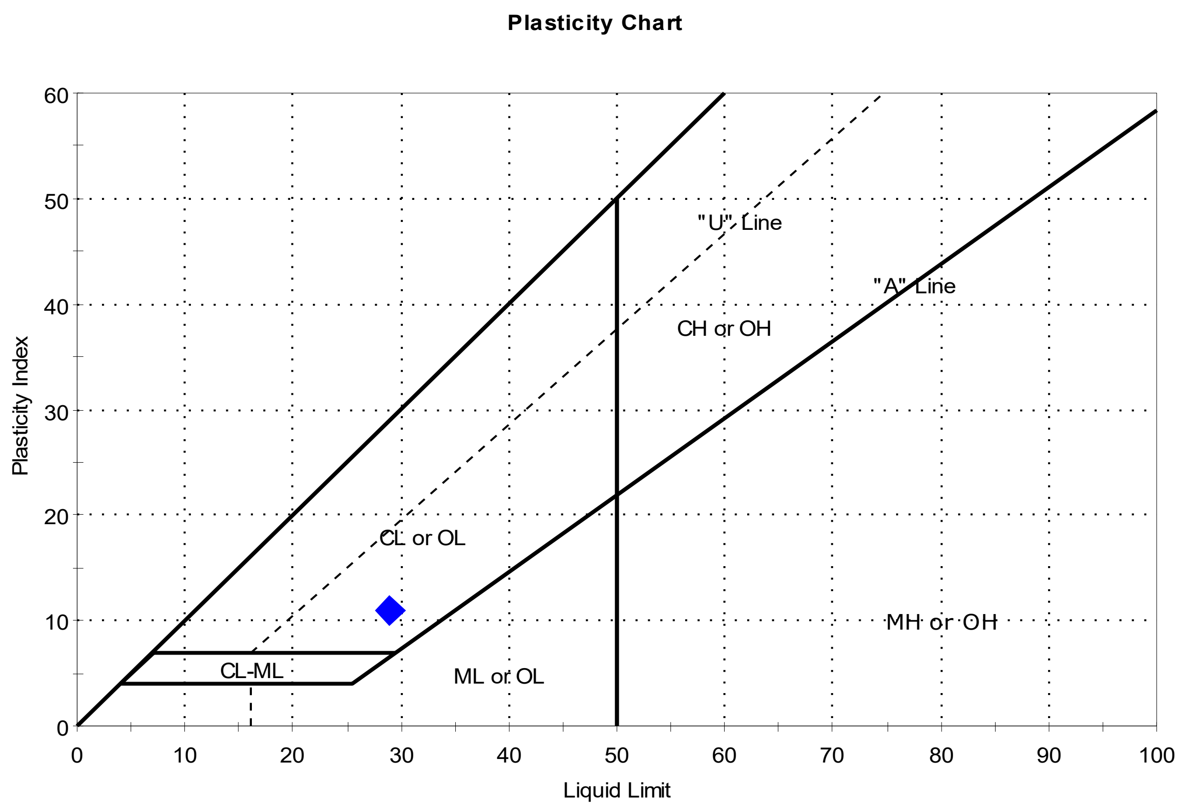
Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	BR-FMD-203	Sample Type:	jar	Tested By:	GA
Sample ID:	8D	Test Date:	06/25/21	Checked By:	bfs
Depth :	20-22 ft	Test Id:	621757		

Test Comment: ---

Visual Description: Moist, dark gray clay

Sample Comment: ---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	8D	R-FMD-20	20-22 ft	29	29	18	11	1	Lean CLAY (CL)

Sample Prepared using the WET method

3% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

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Client:	Golder Associates				
Project:	Freeport Mallet Dr Bridge Ex 22				
Location:	Freeport, ME			Project No:	GTX-313826
Boring ID:	BR-FMD-207	Sample Type:	jar	Tested By:	GA
Sample ID:	8DB	Test Date:	06/25/21	Checked By:	bfs
Depth :	20-21.3 ft	Test Id:	621758		

Test Comment: ---

Visual Description: Moist, dark yellowish brown silt with sand

Sample Comment: ---

Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	8DB	R-FMD-20	20-21.3 ft	27	n/a	n/a	n/a	n/a	SILT with Sand (ML)

7% Retained on #40 Sieve

Dry Strength: NONE

Dilatancy: RAPID

Toughness: n/a

The sample was determined to be Non-Plastic

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APPENDIX D

Subsurface Layering and Engineering Properties for Drilled Shaft Design

GOLDER
MEMBER OF WSP

Date: August 4, 2021
Project No.: 21450910
Subject: Subsurface Layering and Engineering Properties for Mast Arm and High Mast Lighting Foundations
Project Title: MaineDOT I-295 Exit 22 Mallet Bridge Replacement No. 5721 - SGDR Part II

Made by: BK
Checked by: MEL
Reviewed by: CCB

Layering						Lateral Model[1]	Below GW table[2]?	Effective Unit Weight (pcf)[3]	Undrained Shear Strength[4] (psf)	Friction Angle[4] (°)	Subgrade Modulus[5] (pci)	Major Principal Strain at 50% (ε_{50})[5]	UCS[3] (psi)	Design Note
Soil Type	Depth (ft bgs) Start	Depth (ft bgs) End	Elevation (ft) Start	Elevation (ft) End	Thickness (ft)									
M1: 30' and 35' mast arms, dual mast arm loading scenario, Station 34+80.17, Offset 38.3' RT, Layering[7]														
Granular Borrow	0.0	5.5	172.0	166.5	5.5	Sand (Reese)	N	125	-	32	88	-	-	Drilled shaft
Granular Borrow Replacement[6]	5.5	6.5	166.5	165.5	1.0	Sand (Reese)	N	125	-	32	88	-	-	
Fill	6.5	16.4	165.5	155.6	9.9	Sand (Reese)	N	125	-	34	127	-	-	
Sand/Gravel	16.4	19.2	155.6	152.8	2.8	Sand (Reese)	N	125	-	38	209	-	-	
Sand/Gravel	19.2	-	152.8	-	-	Sand (Reese)	Y	62.6	-	38	124	-	-	
M2: 30' mast arm, 50 foot mast arm loading scenario, Station 33+85.05, Offset 29.9' LT, Layering[8]														
Granular Borrow Replacement[6]	0.0	1.0	169.5	168.5	1.0	Sand (Reese)	N	125	-	32	88	-	-	Drilled shaft
Fill	1.0	14.7	168.5	154.8	13.7	Sand (Reese)	N	125	-	40	253	-	-	
Fill	14.7	17.9	154.8	151.6	3.2	Sand (Reese)	Y	62.6	-	40	148	-	-	
Bedrock	17.9	-	151.6	-	-	Strong Rock	Y	106.6	-	-	-	-	2486	
MA3: 30' and 45' mast arms, dual mast arm loading scenario, Station 27+30.77, Offset 21.1' LT, Layering[9]														
Granular Borrow Replacement[6]	0.0	1.0	156.0	155.0	1.0	Sand (Reese)	N	125	-	32	88	-	-	Drilled shaft
Fill	1.0	6.4	155.0	149.6	5.4	Sand (Reese)	N	125	-	37	187	-	-	
Fill	6.4	10.7	149.6	145.3	4.3	Sand (Reese)	Y	62.6	-	37	112	-	-	
Glaciomarine	10.7	-	145.3	-	-	Stiff Clay w/o Free Water (Reese)	Y	56.6	2141	-	500	0.005	-	

GOLDER
MEMBER OF WSP

Date: August 4, 2021
Project No.: 21450910
Subject: Subsurface Layering and Engineering Properties for Mast Arm and High Mast Lighting Foundations
Project Title: MaineDOT I-295 Exit 22 Mallet Bridge Replacement No. 5721 - SGDR Part II

Made by: BK
Checked by: MEL
Reviewed by: CCB

Layering														
	Depth (ft bgs)		Elevation (ft)		Thickness		Below GW	Effective Unit Weight	Undrained Shear	Friction	Subgrade	Major Principal Strain at 50%		
Soil Type	Start	End	Start	End	(ft)	Lateral Model[1]	table[2]?	(pcf)[3]	Strength[4] (psf)	Angle[4] (°)	Modulus[5] (pci)	(ε_{50})[5]	UCS[3] (psi)	Design Note
M4: 50' mast arm, 50-foot mast arm loading scenario, Station 28+04.33, Offset 73.0 RT, Layering[10]														
Granular Borrow	0.0	2.8	158.0	155.2	2.8	-	N	125	-	32	88	-	-	Drilled shaft
Granular Borrow Replacement[6]	2.8	3.8	155.2	154.2	1.0	Sand (Reese)	N	125	-	32	88	-	-	
Fill	3.8	10.4	154.2	147.6	6.6	Sand (Reese)	N	125	-	37	187	-	-	
Fill	10.4	14.4	147.6	143.6	4.0	Sand (Reese)	Y	62.6	-	37	112	-	-	
Glaciomarine	14.4	-	143.6	-	-	Stiff Clay w/o Free Water (Reese)	Y	56.6	693.0	-	-	0.01	-	
HML: 90' high mast pole, high mast lighting load scenario, Station 33+75 Offset 51.0' LT, Layering[11]														
Granular Borrow Replacement[6]	0.0	1.0	167.2	166.2	1.0	Sand (Reese)	N	125	-	32	88	-	-	Drilled shaft
Fill (above GW)	1.0	12.4	166.2	154.8	11.4	Sand (Reese)	N	125	-	40	253	-	-	
Fill (below GW)	12.4	15.6	154.8	151.6	3.2	Sand (Reese)	Y	62.6	-	40	148	-	-	
Bedrock	15.6	-	151.6	-	-	Strong Rock	Y	106.6	-	-	-	-	2486	
Design basis for mast arms (based on M3 soil profile)														
Granular Borrow Replacement[6]	0.0	1.0	156.0	155.0	1.0	Sand (Reese)	N	125	-	32	88	-	-	Friction angle, subgrade modulus, and shear strength (and related ε_{50}) reduced based on engineering judgement.
Fill	1.0	6.4	155.0	149.6	5.4	Sand (Reese)	N	125	-	34	127	-	-	
Fill	6.4	10.7	149.6	145.3	4.3	Sand (Reese)	Y	62.6	-	34	77	-	-	
Glaciomarine	10.7	-	145.3	-	-	Stiff Clay w/o Free Water (Reese)	Y	56.6	690	-	-	0.010	-	

GOLDER
MEMBER OF WSP

Date: August 4, 2021
Project No.: 21450910
Subject: Subsurface Layering and Engineering Properties for Mast Arm and High Mast Lighting Foundations
Project Title: MaineDOT I-295 Exit 22 Mallet Bridge Replacement No. 5721 - SGDR Part II

Made by: BK
Checked by: MEL
Reviewed by: CCB

Soil Type	Layering: Depth (ft bgs) Start	Layering: Depth (ft bgs) End	Layering: Elevation (ft) Start	Layering: Elevation (ft) End	Layering: Thickness (ft)	Lateral Model[1]	Below GW table[2]?	Effective Unit Weight (pcf)[3]	Undrained Shear Strength[4] (psf)	Friction Angle[4] (°)	Subgrade Modulus[5] (pci)	Major Principal Strain at 50% (ε_{50})[5]	UCS[3] (psi)	Design Note
Design basis for high mast lighting (based on HML)														
Granular Borrow Replacement[6]	0.0	1.0	167.2	166.2	1.0	Sand (Reese)	N	125	-	32	88	-	-	Friction angle and subgrade modulus reduced based on engineering judgement
Fill (above GW)	1.0	12.4	166.2	154.8	11.4	Sand (Reese)	N	125	-	34	127	-	-	
Fill (below GW)	12.4	15.6	154.8	151.6	3.2	Sand (Reese)	Y	62.6	-	34	77	-	-	
Bedrock	15.6	-	151.6	-	-	Strong Rock	Y	106.6	-	-	-	-	2486	

Notes:

1. Lateral model: Isenhower, W.M., Wang, S.T., and Vasquez, L.G. LPILE v2019 Technical Manual: A Program for the Analysis of Deep Foundations Under Lateral Loading. Ensoft, Inc. Release: March 2020.
2. Water table determined based on boring log stratigraphy(Appendix A, SGDR Part II)
3. Soil properties determined based on the PGDR (Golder Associates, Inc., December 21, 2020, Preliminary Geotechnical Design Report, I-295 Mallet Drive Bridge Replacement #5721 (Exit 22), Freeport, Maine, MaineDOT WIN 021726.00)
4. Soil properties correlated from SPT N_{60} values
5. Bridge Software Institute. FB-MultiPier Soil Parameter Table (US Customary Units). Accessed 7/2021. https://bsi.ce.ufl.edu/downloads/files/MultiPier_Soil_Table.pdf
6. We propose to remove and replace the upper 1 foot of existing soil with new Gravel Borrow to remove organics.
7. Layering determined from stratigraphy from BB-FMD-210 for in situ soils; Stating elevation for Granular Borrow is the proposed elevation at Sta. 34+75 from HNTB 98% plans; Starting elevation for Granular Borrow Replacement is the existing ground surface from the HNTB 98% plans for the actual location.
8. Layering determined from stratigraphy from BB-FMD-206 for in situ soils; Stating elevation for Granular Borrow Replacement is the proposed elevation at Sta. 34+00 from HNTB 98% plans; Starting elevation for Granular Borrow Replacement is the existing ground surface from the HNTB 98% plans for the actual location.
9. Layering determined from stratigraphy from BB-FMD-202 for in situ soils; Stating elevation for Granular Borrow Replacement is the proposed elevation at Sta. 27+25 from HNTB 98% plans; Starting elevation for Granular Borrow Replacement is the existing ground surface from the HNTB 98% plans for the actual location.
10. Layering determined from stratigraphy from BB-FMD-203 for in situ soils; Stating elevation for Granular Borrow is the proposed elevation at Sta. 28+00 from HNTB 98% plans; Starting elevation for Granular Borrow Replacement is the existing ground surface from the HNTB 98% plans for the actual location.
11. Layering determined from stratigraphy from BB-FMD-206 for in situ soils; Stating elevation for Granular Borrow is the proposed elevation at Sta. 33+75 from HNTB 98% plans, which is below the existing groundsurface elevatoion of 168.0 ft.

APPENDIX E

Drilled Shaft Design Calculations

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	8/6/2021	**Made by:**	KAR / BK
Project No.:	21450910	**Checked by:**	MSG
Subject:	Drilled Shaft Design for Mast Arms M1 through M4	**Reviewed by:**	CCB
Project Title:	MaineDOT Mallet Drive Bridge 5721 Freeport (Exit 22) Phase 2		

OBJECTIVE
Determine if the proposed drilled shaft foundation will provide adequate support for Mast Arms M1 through M4 at Exit 22 based on the final design loads provided by HNTB.

METHOD
As per the MaineDOT Bridge Design Guide Section 5.8 (Ref. 2), use the procedure outlined in AASHTO LRFD Article 10.8 (Ref. 1) and FHWA GEC-10 (Ref. 4).

REFERENCES

1. AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020.
2. Guertin Elkerton & Associates for Maine Department of Transportation. Bridge Design Guide. Dated August 2003 with 2018 updates.
3. AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Ed. 2015 with 2017, 2018, and 2020 Interim Revisions.
4. FHWA. Drilled Shafts: Construction Procedures and Design Methods. Publication No. FHWA-NHI 18-024 and FHWA GEC 010. September 2018.
5. Golder geotechnical test boring logs for 200-series borings.
6. Golder geotechnical test boring logs for 100-series borings (Appendix A, Preliminary Geotechnical Design Report, dated December 21, 2020).
7. Bridge Software Institute. FB-MultiPier Soil Parameter Table (US Customary Units). Accessed July 2021. https://bsi.ce.ufl.edu/downloads/files/MultiPier_Soil_Table.pdf
8. Email communication between Golder and HNTB, subject "Freeport - Lighting and Signal Foundation Locations and Design Loads", dated June 29, 2021.
9. GeoTesting Express laboratory testing results, dated February 4, 2020 (Appendix C, Preliminary Geotechnical Design Report, dated December 21, 2020).
10. HNTB for State of Maine Department of Transportation. Approach Road Bridge over Interstate 295 and Signalized Intersections, Exit 22 Interchange: 98% PS&E, dated July 16, 2021.
11. Holtz, R.D. and Kovacs, W.D. 1981. An Introduction to Geotechnical Engineering, 1st ed. Prentice Hall, Englewood Cliffs, NJ.
12. FHWA. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054. September 2002.
13. MaineDOT. Standard Details. March 2020.
14. VTrans. Materials & Research Engineering Instructions MREI 10-01. March 9, 2010.
15. Rodriguez, C.M., et al. Final Report: State of Practice and Literature Review on Foundations for Coastal Traffic Signal Mast Arm Structures. State of North Carolina Department of Transportation Research & Development, Report No. FHWA/NC/2018-17. May 14, 2020.
16. Florida Department of Transportation. FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (LRFDLTS-1). Structures Manual, Volume 3. January 2021.

ASSUMPTIONS
1. The drilled shafts are assumed to be installed either open hole or with temporary casing that is removed after construction. It is assumed that permanent casing will not be used, and the effect of permanent casing is not included in the analysis of nominal side resistance.
2. The topmost 1 foot of existing soil is removed and replaced by granular borrow at the drilled shaft location.
3. Typical steel reinforcement details are assumed for the purpose of the serviceability limit state lateral geotechnical analysis. Full steel reinforcement design and structural analysis will be performed by a non-Golder structural engineer.
4. Shaft head deflection is limited to 0.5 inches under Service loads and less than 10% of the shaft diameter under a "pushover" analysis (step 6). Furthermore, total shaft rotation at the end of the pushover analysis is limited so that the estimated vertical movement at the tip of the mast arm will not exceed 6 inches.

5. The glaciomarine silty clay is asssumed to be sufficiently overconsolidated such that it will experience only recompression settlement after loading (based on Golder's local engineering experience).
6. The glaciomarine silty clay is assumed to be undrained, and thus total stress analysis is used in calculating nominal shaft resistance via the alpha method as per Ref. 1 Article C10.8.3.5.1b and Ref. 4 page 10-18.

ATTACHMENTS
1. LPile analysis output for Strength I, Extreme I, and Service I (nonlinear model)

CALCULATION

Summary of calculation steps:
1. Define subsurface profile for analysis.
2. Select trial shaft diameter, shaft length, and shaft reinforcement for evaluation.
3. Calculate settlement and resulting downdrag loading at the drilled shaft location.
4. Define the factored design loads for the analysis.
5. Check geotechnical axial compression resistance of the shaft at the Strength I limit state.
6. Check lateral geotechnical resistance of the shaft at the Strength I and Extreme I limit states.
7. Check horizontal movement at the top of the shaft at the Service I limit state.
8. Check embedment length to resist torsion loading demand at the Extreme I limit state.
9. Check estimated vertical movement at the tip of the mast arm during the pushover analysis.

1. Define subsurface profile for analysis.

The soil stratigraphy encountered in boring BB-FMD-202 near Mast Arm 3 is used for the combined mast arm analysis, since the presence of glaciomarine silty clay makes this soil profile the weakest.

Proposed top of drilled shaft elevation =	156.0	ft	(Ref. 10, Sheet 32, Station 27+25.00)
Existing ground surface elevation =	156.0	ft	(Ref. 10, Sheet 32, Station 27+25.00)
Elevation to which remove/replace soil =	155.0	ft	(Assumption 2)
Groundwater (GW) elevation in BB-FMD-202 =	149.6	ft	(Ref. 5)

Layer	Depth below top of shaft[1]	Lateral Model	Effective Unit Weight (pcf)[2]	Average N_{60} Value[1]	Design Friction Angle (°)[2]	Undrained Shear Strength (psf)[2]	Subgrade Modulus (pci)[3]	Major Principal Strain at 50%[3]	UCS (psi)
Granular Borrow Replacement	0 - 1 ft	Sand (Reese)	125	-	32	-	88	-	-
Existing Fill (above GW)	1 - 6.4 ft	Sand (Reese)	125	35	34	-	127	-	-
Existing Fill (below GW)	6.4 - 10.7 ft	Sand (Reese)	62.6	35	34	-	77	-	-
Glaciomarine Silty Clay	> 10.7 ft	Stiff Clay w/o Free Water (Reese)	56.6	18	-	690	-	0.01	-

1) Ref. 5

2) Proposed soils: Ref. 2, Table 3-3. Existing soils: correlation to average N_{60} value for each layer, Ref. 5.
3) Ref. 7. Interpolation based on friction angle for cohesionless layers and on undrained shear strength for cohesive layers.

Clay consolidation parameters for the Glaciomarine Silty Clay layer are based on Golder's local engineering experience ($C_{c\varepsilon}$, $C_{r\varepsilon}$, c_v) and calculated (e_0) from soil moisture contents determined in laboratory testing (Reference 9).

$C_{c\varepsilon}$ =	0.25	
$C_{r\varepsilon}$ =	0.02	
e_0 =	1.00	
c_v =	120	ft^2/yr

2. Select trial shaft diameter, shaft length, and shaft reinforcement for evaluation.

The analysis will be evaluated with the minimum shaft diameter to accommodate poles and anchorages as provided by HNTB (Reference 8):

Shaft diameter for Traffic Signals =	36	inches	=	3.0	feet
which corresponds to shaft circumference =	113	inches	=	9.4	feet
and shaft base area =	1018	in^2	=	7.1	ft^2

The analysis was initially evaluated with a shaft length of 7 feet, which is the shaft length specified for larger shaft diameters in the MaineDOT Standard Details (Ref. 13, page 626(02)). However, the LPile analysis with a 7-foot shaft length resulted in excessive lateral deflection at the shaft head for both the pushover analysis (Step 6) and the Service I limit state (Step 7). Thus the analysis will be evaluated with the shaft length necessary to meet the lateral deflection requirements in Steps 6 and 7 and the torsional resistance requirement in Step 8.

Shaft length = 12 feet

Ref. 3 Article 13.6.2.1 requires a minimum concrete cover of 3 inches over steel reinforcement (to protect against corrosion). Ref. 4 Section 12.4 recommends a minimum concrete cover of 4 inches for shaft diameters greater than 3 feet and smaller than 5 feet.

Concrete cover to edge of bar =	3	in	(Ref. 3, Article 13.6.2.1)
Concrete compressive strength, f'_c =	5	ksi	(Ref. 1, Article C5.6.4.2)

Ref. 1 Article 5.6.4.2 and Ref. 4 Section 12.3.1 recommend a steel longitudinal reinforcement area of 1% to 1.5% of the gross area of the section and require a minimum of six bars in a circular arrangement plus a minimum #5 bar size. The MaineDOT Standard Details (Ref. 13, pg. 626(01) and 626(02)) specify six #6-size bars for an 18-inch diameter shaft and eight #6-size bars for a 24-inch diameter shaft, corresponding to 1.04% and 0.78% steel area, respectively.

This analysis will be evaluated with twelve Grade 60 #6-size bars, arranged in a symmetrical circular pattern with single-bar bundles, for the purpose of geotechnical design only.

Steel reinforcement area per bar =	0.44	in^2		(Ref. 4, Table 6-2, #14-size)	
Number of bars =	12				
Steel reinforcement area per shaft =	5.28	in^2	=	0.52%	of total shaft area
Steel yield strength, F_y =	60	ksi		(Ref. 4, Section 12.2.2)	
Steel elastic modulus, E =	29,000	ksi		(Ref. 4, Section 12.2.2)	

As per Assumption 3, steel transverse reinforcement for structural design purposes is not analyzed. Tie hoop reinforcement will be assumed for constructability purposes, as per Ref. 4 Section 6.1. Assume #3-size ties (based on Ref. 13 page 626(02)) spaced a maximum of 12 inches apart (based on Ref. 1 Article 5.7.2.6), resulting in 12 ties for a shaft length of 12 feet.

Steel reinforcement area per tie, A_v =	0.11	in^2	(Ref. 4, Table 6-2, #3-size)
Steel yield strength for ties =	60	ksi	(Ref. 4, Section 12.2.2)
Spacing of the ties, s =	12	in	(Ref. 1, Article 5.7.2.6)
Number of ties =	12		

3. Calculate settlement and resulting downdrag loading at the drilled shaft location.

Ref. 1 Article 3.11.8 indicates that downdrag on drilled shafts can be assumed to fully develop in soil layers where settlement is equal to or greater than 0.4 inches. Calculate the estimated settlement due to embankment construction at the drilled shaft location and due to axial load on the drilled shaft in order to determine the potential for downdrag loading.

3a. Settlement due to embankment construction, calculated for soil below the base of the Granular Borrow Replacement:

Begin by determining the change in effective stress state within the soil at the proposed drilled shaft location to identify if settlement or heave will occur. The change in effective stress state due to change in stratigraphy is determined at an elevation of 155.0 ft (elevation of the base of the remove/replace soil at the drilled shaft location). Calculate the vertical stress increase from the proposed embankment loading.

Existing Conditions (Ref. 10, Sheet 32, Station 27+25.00):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Stress Contribution of Layer (psf)
		Top	Bottom		
Existing Fill	125	156.0	155.0	1.0	125

After Construction (Ref. 10, Sheet 32, Station 27+25.00):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Stress Contribution of Layer (psf)
		Top	Bottom		
Granular Borrow Replacement	125	156.0	155.0	1.0	125

Calculate the increase or decrease in effective stress as a result of construction.

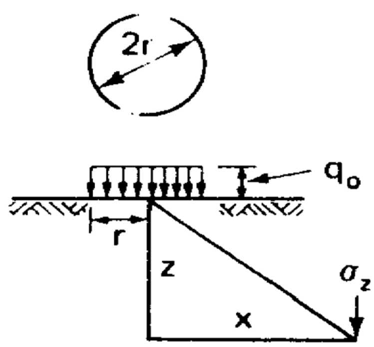
	σ'_v at Elev. 155.0 ft (psf)	$\Delta\sigma'_v$ at Elev. 155.0 ft (psf)	Result
Existing Conditions	125	0	No change
After Construction	125		

No settlement is expected to occur due to embankment construction at the drilled shaft location.

3b. Settlement due to axial load on the drilled shaft, calculated for soil below the base of the shaft:

Base of shaft elevation =	144.0	ft	(From Steps 1 and 2)
Axial load on drilled shaft =	12	kips	(Strength I, Ref. 8; see Step 4)
Shaft area =	7.1	ft^2	(From Step 2)
Stress increase due to axial load =	1698	psf	
Shaft length =	12	ft	
Total shaft volume =	85	ft^3	
$\gamma_{concrete}$ =	140	pcf	
γ_{steel} =	490	pcf	
Shaft weight =	12	kips	
Total stress increase due to axial load and shaft weight =	3399	psf	

Subdivide the subsurface soils into layers no larger than 10 feet thick and to a depth of either three times the footing width (shaft diameter) or to bedrock. Calculate the vertical stress increase at each layer, assuming the Boussinesq stress distribution method for stress under a uniformly loaded circular area (Ref. 11, Figure 8.22).



$$\sigma_z = \frac{I \times q_o}{100}$$ (Ref. 11, Figure 8.22)

where:

- σ_z = Vertical stress increase (psf)
- I = influence value from Ref. 11, Figure 8.22
- z = Depth to midpoint of layer (ft)

q_0 = stress increase due to axial load =	3399	psf	(From above)
r = radius of uniformly loaded circular area =	1.5	ft	(Half of shaft diameter from Step 2)
x = offset distance to settlement location =	0	ft	(Calculate settlement below shaft center)

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Layer	Depth below footing (ft)	Layer Thickness (ft)	z (ft)	x/r	z/r	I	Stress Increase σ_z (psf)
Glaciomarine	0-9	9.0	4.5	0.0	3.0	13.4	456
Total depth (ft) =	9.0	(three times shaft diameter)					

Determine σ'_{v0} at layer midpoint for in situ existing soil. Use consolidation theory to estimate settlement of the Glaciomarine Silty Clay.

Stress due to existing soil above footing	σ'_{v0} (psf)
	1143

Layer	Layer Thickness (ft)	Effective Unit Weight of Layer (pcf)	σ'_{v0} at layer midpoint (psf)
Glaciomarine	9.0	56.6	1397

Consolidation theory general equation (Ref. 11, Eq. 8-11, 8-16, and 8-18b):

$$\Delta H_i = C_c \frac{H_0}{1+e_0} \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$ for normally consolidated clay

$$\Delta H_i = C_r \frac{H_0}{1+e_0} \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$ for overconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v \le \sigma'_p$

$$\Delta H_i = C_r \frac{H_0}{1+e_0} \log \frac{\sigma'_p}{\sigma'_{v0}} + C_c \frac{H_0}{1+e_0} \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_p}$$ for overconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v > \sigma'_p$

where:

H_0	initial height of layer i, ft		9.0
$\Delta\sigma_v$	surcharge load, psf		456
σ'_{v0}	in situ vertical effective stress, psf		1397
$\sigma'_{v0} + \Delta\sigma_v$	psf		1853
σ'_p	preconsolidated stress, psf		N/A
C_c	compression index, $C_c = C_{c\varepsilon}(1+e_0)$		0.50
C_r	recompression index, $C_r = C_{r\varepsilon}(1+e_0)$		0.04
e_0	initial void ratio		1.00
	Use equation (Assumption 3):		8-16
	Total Settlement, ΔH_i	ft	0.022
		in	0.26

Since the estimated settlement in the soil layer is less than 0.4 inches, as per Ref. 1 Article 3.11.8 downdrag loading will be assumed to be negligible for this analysis.

4. Define the factored design loads for the analysis.

The factored design loads at the top of the shaft were provided by HNTB (Ref. 8). The loads below represent the maximum loads between the dual mast arm and 50-foot mast arm loading scenarios.

		Factored Design Forces (Dual Mast Arm)				Factored Design Forces (50' Mast Arm)			
Load	Units	Strength I	Extreme I	Service I	Service II	Strength I	Extreme I	Service I	Service II
Axial	kip	12	11	10	10	11	10	9	9
Moment	kip-ft	115	206	137	92	148	176	129	119
Shear	kip	0	4	2	0	0	5	3	0
Torsion	kip-ft	0	127	49	0	0	142	62	0

Factored Design Forces for Combined Analysis					
Load	Units	Strength I	Extreme I	Service I	Service II
Axial	kip	12	11	10	10
Moment	kip-ft	148	206	137	119
Shear	kip	0	5	3	0
Torsion	kip-ft	0	142	62	0

As per Step 3, no downdrag loading will be added.

5. Check geotechnical axial compression resistance of the shaft at the Strength I limit state.

Compute nominal side resistance for all layers through which the shaft extends and nominal tip resistance for the layer at the tip elevation. Select appropriate resistance factors and calculate factored resistances.

Note that as per Ref. 14 page 5, a minimum of the upper 2 feet of soil should be neglected for contributions to skin friction resistance. As per Ref. 1 Article C10.8.3.5.1b, for cohesive soils at least the top 5 feet of any shaft should not be taken to contribute to the development of resistance through skin friction, to account for the effects of seasonal moisture changes, disturbance during construction, cyclic lateral loading, and low lateral stresses from freshly placed concrete.

The factored resistance of the drilled shaft, R_R, shall be taken as:

$$R_R = \varphi R_n = \varphi_{qp} R_p + \varphi_{qs} R_s \qquad \text{(Ref. 1, Eq. 10.8.3.5-1)}$$

consisting of the nominal shaft tip resistance, R_p:

$$R_p = q_p A_p \qquad \text{(Ref. 1, Eq. 10.8.3.5-2)}$$

and the nominal shaft side resistance, R_s:

$$R_s = q_s A_s \qquad \text{(Ref. 1, Eq. 10.8.3.5-3)}$$

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Calculate the unit side resistance q_s at the midpoint of the Existing Fill layer. Use the beta method for cohesionless soils (Ref. 1, Article 10.8.3.5.2b).

$$q_s = \beta\sigma'_v$$ (Ref. 1, Eq. 10.8.3.5.2b-1)

$$\beta = (1-\sin\phi'_f)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin\phi'_f}\tan\phi'_f$$ (Ref. 1, Eq. 10.8.3.5.2b-2)

For sands: $$\frac{\sigma'_p}{p_a} = 0.47(N_{60})^m$$ (Ref. 1, Eq. 10.8.3.5.2b-4)

For gravelly soils: $$\frac{\sigma'_p}{p_a} = 0.15(N_{60})$$ (Ref. 1, Eq. 10.8.3.5.2b-5)

where:

Depth below top of shaft to midpoint of layer =	5.9	ft		
Vertical effective stress at midpoint, σ'_v =	0.738	ksf		
Friction angle for layer, ϕ'_f =	34	deg	= 0.59 rad	(From Step 1)
Average N_{60} value for layer =	35		(From Step 1)	
Atmospheric pressure, p_a =	2.12	ksf	(Ref. 1, Article 10.8.3.5.2b)	
Sand constant, m =	0.6	for clean quartzitic sands (Ref. 1, Article 10.8.3.5.2b)		
Preconsolidation stress, σ'_p =	8.41	ksf	(Ref. 1, Eq. 10.8.3.5.2b-4)	

β =	1.16	
Existing Fill q_s =	0.86	ksf

Calculate the unit side resistance q_s at the midpoint of the Glaciomarine Silty Clay layer. Use the alpha method for cohesive soils (Ref. 1, Article 10.8.3.5.1b).

$$q_s = \alpha S_u$$ (Ref. 1, Eq. 10.8.3.5.1b-1)

$$\alpha = 0.55 \text{ for } \frac{S_u}{p_a} \leq 1.5$$ (Ref. 1, Eq. 10.8.3.5.1b-2)

$$\alpha = 0.55 - 0.1\left(\frac{S_u}{p_a} - 1.5\right) \text{ for } 1.5 \leq \frac{S_u}{p_a} \leq 2.5$$ (Ref. 1, Eq. 10.8.3.5.1b-3)

where:

Undrained shear strength for layer, S_u =	0.690	ksf	(From Step 1)
Atmospheric pressure, p_a =	2.12	ksf	(Ref. 1, Article 10.8.3.5.1b)
S_u / p_a =	0.33		
Adhesion factor, α =	0.55		(Ref. 1, Eq. 10.8.3.5.1b-2)

Glaciomarine q_s =	0.38	ksf

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Based on the shaft length selected in Step 2, the drilled shaft will terminate in the Glaciomarine Silty Clay layer. Calculate the unit tip resistance q_p for the Glaciomarine Silty Clay layer. Use the cohesive soil method (Ref. 1, Article 10.8.3.5.1c). Note that as per Ref. 1 Article 10.8.3.5.1c, if the soil within two diameters of the tip has S_u < 0.5 ksf, the value of N_c should be multiplied by 0.67.

$$q_p = N_c S_u \leq 80.0 \text{ ksf}$$ (Ref. 1, Eq. 10.8.3.5.1c-1)

$$N_c = 6\left[1 + 0.2\left(\frac{Z}{D}\right)\right] \leq 9$$ (Ref. 1, Eq. 10.8.3.5.1c-2)

where:

Undrained shear strength for layer, S_u = 0.690 ksf (From Step 1)
Diameter of drilled shaft, D = 3.0 ft (From Step 2)
Penetration of drilled shaft into layer, Z = 1.3 ft

N_c = 6.52
Glaciomarine q_p = 4.50 ksf

Compute nominal and factored side and tip resistances for all layers.

	q_s (ksf)	Shaft circumference (ft)	Length of shaft* (ft)	A_s (ft^2)	R_s (kips)	φ_{qs}**	$R_{R,s}$ (kips)
Existing Fill	0.86	9.4	8.7	82.0	70.1	0.55	38.6
Glaciomarine	0.38	9.4	1.3	12.3	4.6	0.45	2.1

* neglecting top 2 feet of shaft for Existing Fill length as per Ref. 14, page 5
** Ref. 1, Table 10.5.5.2.4-1

	q_p (ksf)	A_p (ft^2)	R_p (kips)	φ_{qp}*	$R_{R,p}$ (kips)
Glaciomarine	4.50	7.1	31.8	0.40	12.7

* Ref. 1, Table 10.5.5.2.4-1

Factored geotechnical axial compression resistance of the drilled shaft:

$R_R = R_{R,s} + R_{R,p}$ = 53 kips

Check against Strength I factored axial design load:

Strength I factored axial design load:		Factored geotechnical axial compression resistance:	
12 kips	<	53 kips	OK

Demand capacity ratio = 0.22

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6. Check lateral geotechnical resistance of the shaft at the Strength I and Extreme I limit states.

Perform a pushover analysis using LPile to compute shaft head deflection at various multiples of the factored shear and moment design loads, up to 1/φ times the factored shear and moment design loads. As per Ref. 4 Section 9.3.3.3.1, for a stable condition the analyses should each converge to a solution with a computed deflection no larger than 10% of the shaft diameter. For the pushover analysis the shaft should be modeled as a simple linear elastic beam rather than a nonlinear stress-strain model (Ref. 4, Section 9.3.3.3.1).

Elastic modulus for linear model = 4,000,000 psi (Ref. 4, page 9-21)
Moment of inertia for linear model, I = 82,448 in^4 (Ref. 4, page 9-21: $I = \pi D^4/64$)

Recommended resistance factor φ for lateral geotechnical resistance (Ref. 4, Table 9-1):

Limit State	φ	1/φ
Strength I	0.67	1.5
Extreme I	0.8	1.25

Computed shaft deflection at each load multiple analyzed with LPile:

Limit State	LPile Load Case	Multiple of Factored Design Loads	Loads Applied in LPile			Computed Lateral Head Deflection from LPile (in)	Deflection < 10% of Shaft Diameter?
			Axial (kips)	Moment (kip-ft)	Shear (kips)		
Strength I	1	0.25	12	37	0	0.03	Yes
	2	0.50	12	74	0	0.07	Yes
	3	0.75	12	111	0	0.12	Yes
	4	1.00	12	148	0	0.17	Yes
	5	1.25	12	185	0	0.24	Yes
	6	1.50	12	222	0	0.33	Yes
Extreme I	7	0.25	11	52	1	0.06	Yes
	8	0.50	11	103	3	0.14	Yes
	9	0.75	11	155	4	0.24	Yes
	10	1.00	11	206	5	0.41	Yes
	11	1.25	11	258	6	0.74	Yes
					maximum =	0.74	

The trial shaft length of 12 feet exhibits stable behavior up through 1/φ times the factored design loads, and the maximum computed deflection of 0.74 inches is less than 10% of the shaft diameter (10% of 36 inches = 3.6 inches). Thus, based on the pushover analysis, the trial shaft length of 12 feet satisfies the lateral geotechnical criterion at the Strength I and Extreme I limit states.

7. Check horizontal movement at the top of the shaft at the Service I limit state.

Use LPile to compute shaft head deflection at the Service I factored design loads. As per Ref. 4 page 9-27 and Ref. 14 page 3, deflection due to combined loading on the structure should be limited to 0.5 inches at the top of the shaft. For the serviceability analysis the shaft should be modeled as a nonlinear reinforced concrete shaft in flexure (Ref. 4, Section 9.3.3.3.3).

Computed shaft deflection analyzed with LPile:

Limit State	LPile Load Case	Multiple of Factored Design Loads	Loads Applied in LPile			Computed Lateral Head Deflection from LPile (in)	Deflection < 0.5 Inches?
			Axial (kips)	Moment (kip-ft)	Shear (kips)		
Service I	12	1.00	10	137	3	0.19	Yes

The computed deflection of 0.19 inches is less than the required limit of 0.5 inches. Thus the trial shaft length of 12 feet satisfies the lateral criterion at the Service I limit state. The LPile analysis output for factored design loads at the Service I limit state is included as Attachment 1.

8. Check embedment length to resist torsion loading demand at the Extreme I limit state.

Compute nominal and factored torsion resistance of the drilled shaft. Due to the limitations of the method in Ref. 15 Section 4.2.2 and Ref. 16 Section 13.6.1.1, assume the drilled shaft is installed entirely within cohesionless soil.

$$T_u \leq \phi_{tor} \cdot T_n$$ (Ref. 16, Section 13.6.1.1)

$$T_n = \pi D L F_s \left(\frac{D}{2}\right)$$ (Ref. 16, Section 13.6.1.1)

$$F_s = \sigma'_v \omega_{fdot}$$ (Ref. 16, Section 13.6.1.1)

where:

Factored torsional loading demand, T_u =	142	kip-ft	(From Step 4 - Extreme I)
Resistance factor for torsion, ϕ_{tor} =	1.0	for mast arm structures (Ref. 16, Section 13.6.1.1)	
Shaft diameter, D =	3.0	ft	(From Step 2)
Shaft length =	12	ft	(From Step 2)
Midpoint of shaft =	6	ft	
Vertical effective stress at midpoint, σ'_v =	0.750	ksf	
Load transfer ratio, ω_{fdot} =	1.5		(Ref. 16, Section 13.6.1.1, for uncorrected N-values of 15 or greater)
Unit skin friction, F_s =	1.13	ksf	
Shaft length contributing to resistance, L =	10	ft	(neglecting top 2 feet as per Ref. 14, page 5)
Nominal torsion resistance, T_n =	159	kip-ft	
Factored torsion resistance, T_r =	159	kip-ft	

Check against Extreme I factored torsion design load:

Extreme I factored torsion design load:		Factored torsion resistance:	
142 kip-ft	<	159 kip-ft	OK

Demand capacity ratio = 0.89

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9. Check estimated vertical movement at the tip of the mast arm during the pushover analysis.

Computed maximum shaft head deflection =	0.74	in	(From LPile, Extreme I factored load × 1.25)			
Computed maximum shaft tip deflection =	0.45	in	(From LPile, Extreme I factored load × 1.25)			
Total shaft deflection =	1.19	in				
Shaft length =	12	ft	=	144	in	(From Step 2)
Total shaft rotation = deflection ÷ length =	0.01	rad				
Maximum mast arm length for M1 to M4 =	50	ft	=	600	in	(Ref. 8)
Vertical movement at tip of mast arm = shaft rotation × mast arm length =	4.96	in				

The estimated vertical movement of 4.96 inches at the tip of the mast arm during the pushover analysis is less than the required limit of 6 inches (Assumption 4). Thus the total shaft rotation will be considered sufficiently small.

CONCLUSIONS

The results of the analysis indicate that the proposed drilled shaft foundation with a shaft diameter of 36 inches and a shaft length of 12 feet will provide adequate support for Mast Arms M1 through M4 at Exit 22 based on the final design loads provided by HNTB. A maximum lateral deflection of 0.19 inches occurs at the top of the shaft under the Service I load case, satisfying the limiting requirement of 0.5 inches.The shaft length is controlled by the torsional resistance, and a torsion demand capacity ratio of 0.89 was calculated under the Extreme I load case. Although reinforcement consisting of twelve Grade 60 #6 bars arranged in a circular pattern was used in Golder's modeling, it is understood that HNTB will perform the final structural check and generate the required reinforcement pattern.

Attachment 1

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OBJECTIVE

Determine if the proposed drilled shaft foundation will provide adequate support for the High Mast Lighting location at Exit 22 based on the final design loads provided by HNTB.

METHOD

As per the MaineDOT Bridge Design Guide Section 5.8 (Ref. 2), use the procedure outlined in AASHTO LRFD Article 10.8 (Ref. 1) and FHWA GEC-10 (Ref. 4).

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14. VTrans. Materials & Research Engineering Instructions MREI 10-01. March 9, 2010.
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ASSUMPTIONS

1. The drilled shafts are assumed to be installed either open hole or with temporary casing that is removed after construction. It is assumed that permanent casing will not be used, and the effect of permanent casing is not included in the analysis of nominal side resistance.
2. The topmost 1 foot of existing soil is removed and replaced by granular borrow at the drilled shaft location.
3. Typical steel reinforcement details are assumed for the purpose of the serviceability limit state lateral geotechnical analysis. Full steel reinforcement design and structural analysis will be performed by a non-Golder structural engineer.
4. Shaft head deflection is limited to 0.5 inches under Service loads and less than 10% of the shaft diameter under a "pushover" analysis (step 5). Furthermore, total shaft rotation at the end of the pushover analysis is limited so that the estimated vertical movement at the tip of the mast arm will not exceed 6 inches.

5. The immediate settlement of the cohesionless soils is assumed to be sufficiently small that downdrag loading will be negligible.

ATTACHMENTS

1. LPile analysis output for Strength I, Extreme I, and Service I (nonlinear model)

CALCULATION

Summary of calculation steps:

1. Define subsurface profile for analysis.
2. Select trial shaft diameter, shaft length, and shaft reinforcement for evaluation.
3. Define the factored design loads for the analysis.
4. Check geotechnical axial compression resistance of the shaft at the Strength I limit state.
5. Check lateral geotechnical resistance of the shaft at the Strength I and Extreme I limit states.
6. Check horizontal movement at the top of the shaft at the Service I limit state.

1. Define subsurface profile for analysis.

The soil stratigraphy encountered in nearby boring BB-FMD-206 is used for the analysis at the High Mast Lighting location.

Proposed top of drilled shaft elevation =	167.2	ft	(Ref. 10, Sheet 44, Station 33+75.00)
Existing ground surface elevation =	168.0	ft	(Ref. 10, Sheet 44, Station 33+75.00)
Elevation to which remove/replace soil =	166.2	ft	(Assumption 2)
Groundwater (GW) elevation in BB-FMD-206 =	154.8	ft	(Ref. 5)

Layer	Depth below top of shaft[1]	Lateral Model	Effective Unit Weight (pcf)[2]	Average N_{60} Value[1]	Design Friction Angle (°)[2]	Undrained Shear Strength (psf)[2]	Subgrade Modulus (pci)[3]	Major Principal Strain at 50%[3]	UCS (psi)[4]
Granular Borrow Replacement	0 - 1 ft	Sand (Reese)	125	-	32	-	88	-	-
Existing Fill (above GW)	1 - 12.4 ft	Sand (Reese)	125	46	34	-	127	-	-
Existing Fill (below GW)	12.4 - 15.6 ft	Sand (Reese)	62.6	46	34	-	77	-	-
Bedrock	> 15.6 ft	Strong Rock (Vuggy Limestone)	106.6	-	-	-	-	-	2486

1) Ref. 5
2) Proposed soils: Ref. 2, Table 3-3. Existing soils: correlation to average N_{60} value for each layer, Ref. 5.
3) Ref. 7. Interpolation based on friction angle for cohesionless layers and on undrained shear strength for cohesive layers.
4) Ref. 6. Using lowest UCS value from laboratory test results due to low RQD encountered in boring BB-FMD-103 on southeastern side of bridge.

2. Select trial shaft diameter, shaft length, and shaft reinforcement for evaluation.

The analysis will be evaluated with the minimum shaft diameter to accommodate poles and anchorages as provided by HNTB (Reference 8):

Shaft diameter for High Mast Lighting =	48	inches	=	4.0	feet
which corresponds to shaft circumference =	151	inches	=	12.6	feet
and shaft base area =	1810	in^2	=	12.6	ft^2

The analysis was initially evaluated with a shaft length of 7 feet, which is the shaft length specified for larger shaft diameters in the MaineDOT Standard Details (Ref. 13, page 626(02)). However, the LPile analysis with a 7-foot shaft length resulted in excessive lateral deflection at the shaft head for both the pushover analysis (Step 5) and the Service I limit state (Step 6). Thus the analysis will be evaluated with the shaft length necessary to meet the lateral deflection requirements in Steps 5 and 6.

Shaft length =	10	feet

Ref. 3 Article 13.6.2.1 requires a minimum concrete cover of 3 inches over steel reinforcement (to protect against corrosion). Ref. 4 Section 12.4 recommends a minimum concrete cover of 4 inches for shaft diameters greater than 3 feet and smaller than 5 feet.

Concrete cover to edge of bar =	4	in	(Ref. 4, Section 12.4)
Concrete compressive strength, f'_c =	5	ksi	(Ref. 1, Article C5.6.4.2)

Ref. 1 Article 5.6.4.2 and Ref. 4 Section 12.3.1 recommend a steel longitudinal reinforcement area of 1% to 1.5% of the gross area of the section and require a minimum of six bars in a circular arrangement plus a minimum #5 bar size. The MaineDOT Standard Details (Ref. 13, pg. 626(01) and 626(02)) specify six #6-size bars for an 18-inch diameter shaft and eight #6-size bars for a 24-inch diameter shaft, corresponding to 1.04% and 0.78% steel area, respectively.

This analysis will be evaluated with sixteen Grade 60 #6-size bars, arranged in a symmetrical circular pattern with single-bar bundles, for the purpose of geotechnical design only.

Steel reinforcement area per bar =	0.44	in^2		(Ref. 4, Table 6-2, #6-size)	
Number of bars =	16				
Steel reinforcement area per shaft =	7.04	in^2	=	0.39%	of total shaft area
Steel yield strength, F_y =	60	ksi		(Ref. 4, Section 12.2.2)	
Steel elastic modulus, E =	29,000	ksi		(Ref. 4, Section 12.2.2)	

As per Assumption 3, steel transverse reinforcement for structural design purposes is not analyzed. Tie hoop reinforcement will be assumed for constructability purposes, as per Ref. 4 Section 6.1. Assume #3-size ties (based on Ref. 13 page 626(02)) spaced a maximum of 12 inches apart (based on Ref. 1 Article 5.7.2.6), resulting in 10 ties for a shaft length of 10 feet.

Steel reinforcement area per tie, A_v =	0.11	in^2	(Ref. 4, Table 6-2, #3-size)
Steel yield strength for ties =	60	ksi	(Ref. 4, Section 12.2.2)
Spacing of the ties, s =	12	in	(Ref. 1, Article 5.7.2.6)
Number of ties =	10		

3. Define the factored design loads for the analysis.

The factored design loads at the top of the shaft were provided by HNTB (Ref. 8). The loads corresponding to High Mast Lighting were selected.

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Subject:	Drilled Shaft Design for High Mast Lighting at Station 33+75.00	**Reviewed by:**	CCB
Project Title:	MaineDOT Mallet Drive Bridge 5721 Freeport (Exit 22) Phase 2		

Factored Design Forces (High Mast Lighting)					
Load	Units	Strength I	Extreme I	Service I	Service II
Axial	kip	9	8	7.5	7.5
Moment	kip-ft	0	245	90.5	0
Shear	kip	0	5	2	0
Torsion	kip-ft	0	0	0	0

As per Assumption 5, no downdrag loading will be added.

4. Check geotechnical axial compression resistance of the shaft at the Strength I limit state.

Compute nominal side resistance for all layers through which the shaft extends and nominal tip resistance for the layer at the tip elevation. Select appropriate resistance factors and calculate factored resistances.

Note that as per Ref. 14 page 5, a minimum of the upper 2 feet of soil should be neglected for contributions to skin friction resistance. As per Ref. 1 Article C10.8.3.5.1b, for cohesive soils at least the top 5 feet of any shaft should not be taken to contribute to the development of resistance through skin friction, to account for the effects of seasonal moisture changes, disturbance during construction, cyclic lateral loading, and low lateral stresses from freshly placed concrete.

The factored resistance of the drilled shaft, R_R, shall be taken as:

$$R_R = \varphi R_n = \varphi_{qp} R_p + \varphi_{qs} R_s \quad \text{(Ref. 1, Eq. 10.8.3.5-1)}$$

consisting of the nominal shaft tip resistance, R_p:

$$R_p = q_p A_p \quad \text{(Ref. 1, Eq. 10.8.3.5-2)}$$

and the nominal shaft side resistance, R_s:

$$R_s = q_s A_s \quad \text{(Ref. 1, Eq. 10.8.3.5-3)}$$

Calculate the unit side resistance q_s at the midpoint of the Existing Fill layer. Use the beta method for cohesionless soils (Ref. 1, Article 10.8.3.5.2b).

$$q_s = \beta \sigma'_v \quad \text{(Ref. 1, Eq. 10.8.3.5.2b-1)}$$

$$\beta = (1 - \sin \phi'_f)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin \phi'_f} \tan \phi'_f \quad \text{(Ref. 1, Eq. 10.8.3.5.2b-2)}$$

For sands: $$\frac{\sigma'_p}{p_a} = 0.47(N_{60})^m \quad \text{(Ref. 1, Eq. 10.8.3.5.2b-4)}$$

For gravelly soils: $$\frac{\sigma'_p}{p_a} = 0.15(N_{60}) \quad \text{(Ref. 1, Eq. 10.8.3.5.2b-5)}$$

where:

Depth below top of shaft to midpoint of layer =	5.5	ft
Vertical effective stress at midpoint, σ'_v =	0.688	ksf

Friction angle for layer, ϕ'_f = 34 deg = 0.59 rad (From Step 1)
Average N_{60} value for layer = 46 (From Step 1)
Atmospheric pressure, p_a = 2.12 ksf (Ref. 1, Article 10.8.3.5.2b)
Sand constant, m = 0.6 for clean quartzitic sands (Ref. 1, Article 10.8.3.5.2b)
Preconsolidation stress, σ'_p = 9.91 ksf (Ref. 1, Eq. 10.8.3.5.2b-4)

β = 1.32
Existing Fill q_s = 0.91 ksf

Based on the shaft length selected in Step 2, the drilled shaft will terminate in the Existing Fill layer. Calculate the unit tip resistance q_p for the Existing Fill layer. Use the cohesionless soil method (Ref. 1, Article 10.8.3.5.2c). Note that as per Ref. 1 Article 10.8.3.5.2c, the value of q_p should be limited to 60 ksf unless greater values can be justified through load test data.

$$\text{If } N_{60} \leq 50, \text{then } q_p = 1.2N_{60} \leq 60 \text{ ksf}$$ (Ref. 1, Eq. 10.8.3.5.2c-1)

where:

Average N_{60} value for layer = 46 (From Step 1)

Existing Fill q_p = 55.2 ksf

Compute nominal and factored side and tip resistances for all layers.

	q_s (ksf)	Shaft circumference (ft)	Length of shaft* (ft)	A_s (ft^2)	R_s (kips)	φ_{qs}**	$R_{R,s}$ (kips)
Existing Fill	0.91	12.6	8.0	100.5	91.4	0.55	50.3

* neglecting top 2 feet of shaft for Existing Fill length as per Ref. 14, page 5
** Ref. 1, Table 10.5.5.2.4-1

	q_p (ksf)	A_p (ft^2)	R_p (kips)	φ_{qp}*	$R_{R,p}$ (kips)
Existing Fill	55.2	12.6	693.7	0.50	346.8

* Ref. 1, Table 10.5.5.2.4-1

Factored geotechnical axial compression resistance of the drilled shaft:

$R_R = R_{R,s} + R_{R,p}$ = 397 kips

Check against Strength I factored axial design load:

Strength I factored axial design load: 9 kips < Factored geotechnical axial compression resistance: 397 kips OK

Demand capacity ratio = 0.02

5. Check lateral geotechnical resistance of the shaft at the Strength I and Extreme I limit states.

Perform a pushover analysis using LPile to compute shaft head deflection at various multiples of the factored shear and moment design loads, up to 1/φ times the factored shear and moment design loads. As per Ref. 4 Section 9.3.3.3.1, for a stable condition the analyses should each converge to a solution with a computed deflection no larger than 10% of the shaft diameter. For the pushover analysis the shaft should be modeled as a simple linear elastic beam rather than a nonlinear stress-strain model (Ref. 4, Section 9.3.3.3.1).

Elastic modulus for linear model =	4,000,000	psi	(Ref. 4, page 9-21)
Moment of inertia for linear model, I =	260,576	in^4	(Ref. 4, page 9-21: $I = \pi D^4/64$)

Recommended resistance factor φ for lateral geotechnical resistance (Ref. 4, Table 9-1):

Limit State	φ	1/φ
Strength I	0.67	1.5
Extreme I	0.8	1.25

Computed shaft deflection at each load multiple analyzed with LPile:

Limit State	LPile Load Case	Multiple of Factored Design Loads	Loads Applied in LPile			Computed Lateral Head Deflection from LPile (in)	Deflection < 10% of Shaft Diameter?
			Axial (kips)	Moment (kip-ft)	Shear (kips)		
Strength I	1	0.25	9	0	0	0.00	Yes
	2	0.50	9	0	0	0.00	Yes
	3	0.75	9	0	0	0.00	Yes
	4	1.00	9	0	0	0.00	Yes
	5	1.25	9	0	0	0.00	Yes
	6	1.50	9	0	0	0.00	Yes
Extreme I	7	0.25	8	61	1	0.09	Yes
	8	0.50	8	123	3	0.20	Yes
	9	0.75	8	184	4	0.35	Yes
	10	1.00	8	245	5	0.64	Yes
	11	1.25	8	306	6	1.19	Yes
					maximum =	1.19	

The trial shaft length of 10 feet exhibits stable behavior up through 1/φ times the factored design loads, and the maximum computed deflection of 1.19 inches is less than 10% of the shaft diameter (10% of 48 inches = 4.8 inches). Thus, based on the pushover analysis, the trial shaft length of 10 feet satisfies the lateral geotechnical criterion at the Strength I and Extreme I limit states.

6. Check horizontal movement at the top of the shaft at the Service I limit state.

Use LPile to compute shaft head deflection at the Service I factored design loads. As per Ref. 4 page 9-27 and Ref. 14 page 3, deflection due to combined loading on the structure should be limited to 0.5 inches at the top of the shaft. For the serviceability analysis the shaft should be modeled as a nonlinear reinforced concrete shaft in flexure (Ref. 4, Section 9.3.3.3.3).

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CALCULATIONS

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Computed shaft deflection analyzed with LPile:

Limit State	LPile Load Case	Multiple of Factored Design Loads	Loads Applied in LPile			Computed Lateral Head Deflection from LPile (in)	Deflection < 0.5 Inches?
			Axial (kips)	Moment (kip-ft)	Shear (kips)		
Service I	12	1.00	7.5	90.5	2	0.14	Yes

The computed deflection of 0.14 inches is less than the required limit of 0.5 inches. Thus the trial shaft length of 10 feet satisfies the lateral criterion at the Service I limit state. The LPile analysis output for factored design loads at the Service I limit state is included as Attachment 1.

CONCLUSIONS

The results of the analysis indicate that the proposed drilled shaft foundation with a shaft diameter of 48 inches and a shaft length of 10 feet will provide adequate support for the High Mast Lighting location at Exit 22 based on the final design loads provided by HNTB. A maximum lateral deflection of 0.14 inches occurs at the top of the shaft under the Service I load case, satisfying the limiting requirement of 0.5 inches. Although reinforcement consisting of sixteen Grade 60 #6 bars arranged in a circular pattern was used in Golder's modeling, it is understood that HNTB will perform the final structural check and generate the required reinforcement pattern.

Attachment 1

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