Proactive by Design

GEOTECHNICAL DESIGN REPORT
REPLACEMENT OF CAPE NEDDICK BRIDGE
MAINE DOT WIN 21709.00
YORK, MAINE

Prepared for:
Maine Department of Transportation
Augusta, Maine

June 2018
09.0025930.00

Prepared by:
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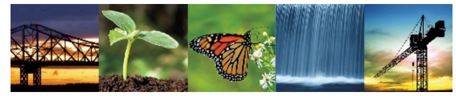

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VIA EMAIL

June 29, 2018
File No. 09.0025930.00

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

Re: Geotechnical Design Report
Replacement of Cape Neddick Bridge #2127
Maine Department of Transportation WIN 21709.00
York, Maine

Dear Laura:

We are pleased to provide this Geotechnical Design Report (GDR) for Maine Department of Transportation (MaineDOT) Bridge No. 2127 over the Cape Neddick River in York, Maine. Our work was completed in accordance with the Multi-PIN Project Contract Number 20150608000000000793 between MaineDOT and GZA GeoEnvironmental, Inc. (GZA) dated July 22, 2015, which incorporates GZA's proposal No. 09.P000070.17, dated February 22, 2017, and the *Limitations* included in **Appendix A** of this report.

It has been a pleasure serving MaineDOT on this phase of the project, and we look forward to our continued work with you through project completion. If you have any questions regarding the report, or if we can provide further assistance, please do not hesitate to contact the undersigned.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Blaine Cardali, E.I.T
Project Engineer

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1.0 INTRODUCTION

This report presents the results of GZA's geotechnical evaluation for the replacement of the Cape Neddick Bridge. Our services are subject to the *Limitations* contained in **Appendix A** of this report.

1.1 BACKGROUND

The existing Cape Neddick Bridge #2127 carries Route 1 over Cape Neddick River in York, at the location shown on **Figure 1**. The existing bridge was constructed in 1928 and consists of a 15-foot single-span bridge with a cast-in-place concrete superstructure and deck. The bridge is supported by spread footings bearing on or near the top of rock. The abutments consist of cast-in-place concrete back walls. We understand the bridge is in need of replacement due primarily to the superstructure's poor condition with significant section loss and the deteriorating condition of the concrete substructure units.

HNTB is the engineer preparing the Design-Detail contract package for the replacement bridge. The replacement bridge is proposed to be constructed on the existing alignment. It is anticipated that the bridge will consist of a buried arch structure supported on spread footing foundations that bear on fill concrete and bedrock. The proposed construction sequencing includes two phases, the first to maintain a single lane of traffic on the right side of the existing structure while constructing the left two-thirds of the proposed structure, and the second phase would move traffic to the new lanes on the left side of the proposed structure and reconstruct the right third.

1.2 OBJECTIVES AND SCOPE OF SERVICES

The objective of this GDR is to provide geotechnical evaluations and engineering recommendations for the proposed bridge to be used by HNTB for development of the Design-Detail contract package. To meet these objectives, GZA completed the following Scope of Services:

- Conducted site visits to observe surficial conditions, traffic and boring access;
- Coordinated and observed a preliminary subsurface exploration program, consisting of six (6) test borings to evaluate subsurface conditions;
- Conducted a laboratory testing program to evaluate engineering properties of the site soils and bedrock;
- Conducted geotechnical engineering analyses to evaluate spread footings bearing on rock, design parameters, and seismic design considerations for the proposed bridge;
- Developed geotechnical engineering recommendations; and
- Prepared this report summarizing our findings and design recommendations.

2.0 SUBSURFACE EXPLORATIONS

GZA completed a subsurface exploration program consisting of six (6) test borings (BB-YCN-101 through BB-YCN-104, BB-YCN-101A, and BB-YCN-104A). The borings were drilled in the northbound and southbound lanes behind each existing abutment. The borings were drilled using a truck-mounted drill rig and backfilled with cuttings, crushed stone, and asphalt cold patch. The approximate as-drilled boring locations were located by GZA using taped ties to existing bridge structure components and nearby sign structures, and later surveyed by MaineDOT surveyors. MaineDOT provided the as-drilled locations and elevations to GZA with the exception of boring BB-YCN-104, which was estimated by GZA using an offset from BB-YCN-104A. See **Figure 2** for the as-drilled boring location plan. Elevations referenced in this report are in feet and refer to the National American Vertical Datum of 1988 (NAVD88).

The borings were drilled to depths of approximately 7.5 to 37 feet below ground surface. Two of the six borings (BB-YCN-101A and -104A) were cored approximately 10 to 17 feet into bedrock. The remaining borings were terminated after refusal with the split-spoon or casing, and where feasible, roller bit advancement to evaluate top of rock. New England Boring Contractors of Hermon, Maine provided drilling services and coordinated utility clearance. The drilling was completed between March 6 and March 8, 2017. GZA personnel monitored the drilling work and prepared logs of each boring that are included in **Appendix B**.

The borings were drilled using 3- and 4-inch driven or spun casing and drive-and-wash drilling techniques. Standard penetration testing (SPT) and split-spoon sampling were performed at 5-foot typical intervals in the overburden using a 24-inch-long, 1-3/8-inch inside-diameter sampler, driven with a 140-lb safety hammer with a 30-inch drop, and a rope-and-cathead. Bedrock cores were obtained using NX2 coring equipment.

3.0 LABORATORY TESTING

GZA retained Thielsch Engineering's Geotechnical Laboratory in Cranston, Rhode Island to complete the soil testing program to assess the gradation and engineering characteristics of the soil; and GeoTesting of Acton, Massachusetts to perform the bedrock testing to evaluate the strength of the bedrock. The programs included: six (6) gradation analysis / AASHTO Classification / Unified Soil Classification System / Frost Classifications, and six (6) moisture content tests on soils, and two (2) unconfined compressive strength / secant modulus tests on bedrock core samples. Results of the testing are included in **Appendix C**.

4.0 SUBSURFACE CONDITIONS

4.1 SURFICIAL AND BEDROCK GEOLOGY

Based on available literature[1], surficial geologic units mapped in the area include fine to coarse sand, marine sands, silts, and clays (Presumpscot formation), and gravelly sand Glacial Till deposits.

[1] O'Toole, Patrick, Clinch, J. Michael and Cameron, Cornelia C., 1999, Surficial geology of the York Beach quadrangle, Maine: Maine Geological Survey, Open-File Map 99-106, map, scale 1:24,000. *Maine Geological Survey Maps*. 1009. http://digitalmaine.com/mgs_maps/1009

The site is mapped near the contact between two bedrock units, based on the Bedrock Geologic Map of Maine (Osberg et al, 1985; on-line GIS version). The bedrock beneath the existing bridge is mapped as quartz syenite, an igneous rock similar to granite. Immediately east of the bridge, the rock is mapped as alkali feldspar granite. About 1/3-mile northeast of the existing bridge, the rock is mapped as the Kittery formation of the Merrimack group, consisting of metasandstone and phyllite.

4.2 SUBSURFACE PROFILE

Three soil units were encountered beneath surficial pavement in the test borings: Fill, Glacial Till, and Cobbles/Boulders. Approximately 13 inches of asphalt pavement and 6 inches of a concrete were encountered in the borings drilled through the approaches. The approximate thicknesses and generalized descriptions of the subsurface units are presented in the following table, in descending order from existing ground surface. Detailed descriptions of the materials encountered at specific locations are provided in the boring logs in **Appendix B**. The subsurface conditions are also shown in relation to the bridge alignment on **Figure 2**.

GENERALIZED SUBSURFACE CONDITIONS		
Subsurface Unit	**Approximate Encountered Thickness (ft)**	**Generalized Description**
Fill	6 to 12	Variable ranging from: Brown, loose to dense, fine to coarse SAND, little Gravel, little to some Silt to: Brown, loose to dense sandy GRAVEL, little to some Silt (USCS: SW-SM, SP-SM, SM, SP, or GP). • MaineDOT Frost Classification = I-II • Encountered in all borings • Probable cobbles and boulders throughout
Glacial Till	3 to 10	Brown, medium dense to very dense, gravelly fine to coarse SAND, some Silt to: Brown, medium dense to very dense, sandy GRAVEL, little Silt (USCS: SM or GM). • MaineDOT Frost Classification = I-II • Encountered in all borings, except for BB-YCN-104 (which met refusal in Fill) • Probable cobbles and boulders throughout
Encountered Top of Bedrock Elevation	Abutment 1: Approx. El. 7.9 to El. 10.2 Abutment 2: Approx. El. 13.3 to El. 15.3	

4.2.1 Bedrock

GZA evaluated the top of bedrock elevation based on split spoon refusals, drilling conditions, and/or rock coring results. Depending on the drilling method and observation made by GZA's field engineer, the top of bedrock was defined using the criteria of split-spoon refusal prior to identification of bedrock by roller bit, casing refusal, auger advancement or rock coring.

Bedrock was cored in two (2) test borings and was described as hard, fresh, aphanitic to medium grained, and tan to gray Granite and Granodiorite. The joints were typically very close to moderately spaced, low angle to moderately dipping with few high angle joints, undulating, rough, fresh to discolored and partially open to open. The Rock Quality Designation (RQD) ranged from 10 to 96 percent, with an average RQD of 49 percent, indicating poor quality rock.

Unconfined compressive strength (UCS) testing was conducted on two samples of fresh rock, the results of which are summarized in the following table.

SUMMARY OF BEDROCK STRENGTH TEST RESULTS							
Boring	**Depth below Existing Grade (ft)**	**Depth below Top of Rock (ft)**	**Elevation (ft NAVD 88)**	**Unconfined Compressive Strength (psi)**	**Secant Modulus @ 50% of Failure Stress (ksi)**	**Unit Weight (pcf)**	**Rock Type**
BB-YCN-104A	16.0	0.7	14.6	33,150	9,130	168	GRANODIORITE
BB-YCN-104A	19.1	3.8	11.5	34,110	10,200	166	GRANITE

4.2.2 Groundwater

Groundwater was encountered at depths of approximately 10.6 to 15.5 feet below ground surface in the test borings. These depths correspond to approximately El. 20 to 15 feet. Water levels were generally measured in completed boreholes within about 30 minutes of completion of drilling. The groundwater observations were made at the times and under the conditions stated in the borings logs. Refer to the table in the subsequent section for observed groundwater depths and elevations. Fluctuations in groundwater levels will occur due to season, precipitation, construction activity, river level and other factors. Consequently, water levels during and after construction are likely to vary from those encountered in the borings at the time the observations were made.

5.0 ENGINEERING EVALUATIONS

5.1 GENERAL

GZA has conducted geotechnical engineering evaluations in accordance with 2017 AASHTO LRFD Bridge Design Specifications, 8th Edition, with Interims (herein known as AASHTO) and the MaineDOT Bridge Design Guide, 2014 Edition (MaineDOT BDG). Supporting calculations developed by GZA for the project are attached in **Appendix E** of this report.

5.2 APPROACH EMBANKMENTS

The replacement bridge is proposed to be constructed on or close to the existing horizontal and vertical alignments. Grading within the limits of the existing roadway will be limited to minor cuts and fills on the order of 1 foot or less. The extent of necessary side slope widening has yet to be determined.

The subsurface conditions beneath the approaches include fill and glacial till over bedrock. Therefore, it is our judgment that embankment settlement and global stability are not significant concerns for the project.

5.3 SEISMIC DESIGN CONSIDERATIONS

Seismic site class was evaluated in accordance with the 2014 AASHTO LRFD, along with consideration of the 2011 AASHTO Guide Specifications for LRFD Bridge Design (Seismic Guide Specification).

As described previously, the anticipated foundation type consists of spread footings bearing on bedrock. Commentary Article C3.4.2.2 of the Seismic Guide Specification indicates that the ground motion at the abutment controls transfer of earthquake motion to relatively short bridges, and the site classification should be determined at the base of the approach fill. For this project, the approach fills are generally bearing directly on bedrock. Considering the extremely high strength of the rock and our experience with rock types in the York-Kittery area, we anticipate that the shear wave velocity of rock that will support the bridge exceeds 5,000 feet per second. Therefore, the bridge should be assigned to Site Class A.

5.4 FOUNDATION EVALUATION

5.4.1 Foundation Type Assessment

Assessment of the foundation types was influenced by several geotechnical factors, primarily thickness and strength of soil, and depth to and strength of the bedrock. Subsurface conditions and water levels relevant to foundation type considerations are summarized in the table below.

Boring	Approximate Top of Rock Depth (ft)	Approximate Top of Rock Elevation (ft)	Approximate Groundwater Depth (ft)	Approximate Groundwater Elevation (ft)	Substructure
BB-YCN-101	19.2	10.2	13.5	15.9	Abutment 1
BB-YCN-101A	19.8	9.7	13.2	16.3	Abutment 1
BB-YCN-102	22.7	7.9	15.5	15.1	Abutment 1
BB-YCN-103	16.1	13.3	12.7	16.7	Abutment 2
BB-YCN-104	NE	NE	NE	NE	Abutment 2
BB-YCN-104A	15.3	15.3	10.6	20.0	Abutment 2

Several foundation types were considered for support of the proposed bridge during preliminary design, including: driven piles, spun pipe piles, micropiles, rock socketed H-Piles, and spread footings. Spread footings were selected by HNTB as preferred foundation type for final design.

5.4.2 Spread Footings Bearing on Rock

The proposed bridge may be supported on spread footing foundations bearing directly on intact bedrock free of all loose soil and rock material. Nominal and factored bearing resistances were calculated for the abutment footings using the Rock Mass Rating (RMR)-based empirical correlation presented in "Foundations on Rock," by Duncan Wyllie. RMR was evaluated in accordance with Table 10.4.6.4-1 of the 2012 AASHTO LRFD Bridge Design Specifications, 6th Edition (AASHTO). The current (8th Edition) of the AASHTO Design Specifications does not include the Rock Mass Rating (RMR) formulation included in the 6th Edition. However, Articles C10.4.6.4 and 10.6.2.6.2 of the 8th Edition allow for RMR-based design procedures for footings on rock, so the 6th Edition methodology was followed.

The bearing resistance is based on the bedrock classification and descriptions provided on the test boring logs, and the results of the unconfined compression testing completed on the bedrock. As previously noted, the tested Granite / Granodiorite samples had an unconfined compressive strength of 33.1 ksi. Based on the available data and the stated methodology, the calculated nominal bearing resistance is over 500 kips per square foot (ksf). From a practical standpoint, we recommend that the footings have a minimum width of 3 feet and that the nominal bearing resistance be limited to 90 ksf. This will provide a factored bearing resistance of 40 ksf for the strength loading condition.

5.4.3 Load and Resistance Factors

AASHTO LRFD load factors should be applied to horizontal earth pressure (EH), vertical earth pressure (EV), earth surcharge (ES), live load surcharge (LS) loads, and components and attachments (DC) loads using the load factors for permanent loads (γ_p) provided in LRFD Table 3.4.1-2 for strength limit state foundation design.

SUMMARY OF LOAD FACTORS – STRENGTH I		
Horizontal Load Factor Type	**Load Factor Symbol**	**Load Factor**
Earth Pressure from Retained Backfill – Active	γ_{EHMAX}	1.5
Max Earth Pressure from Road Base	γ_{ESMAX}	1.5
Min Earth Pressure from Road Base	γ_{ESMIN}	0.75
Live Load – Roadway	γ_{Ls}	1.75
Live Load – Superstructure	γ_{LL}	1.75

Recommended LRFD resistance factors for strength limit state design of the bedrock-bearing foundations were derived from LRFD Tables 10.5.5.2.2-1 and 11.5.7-1, and are presented in the following table.

RESISTANCE FACTORS – STRENGTH I		
Foundation Resistance Type	**Method/Condition**	**Resistance Factor (ϕ)**
Bearing	Footing on Rock	0.45
Sliding	Tremie Concrete on Rock	0.8

Resistance factors for service and extreme limit state design should be taken as 1.0.

5.4.4 Frost Penetration

Fill soils are anticipated to be present at the abutments, either as existing fill or imported backfill. Based on the MaineDOT BDG, Section 5.2.1, the Freezing Index for the site is 1,100, and with low to moderate moisture content (±5 percent) soils, the estimated depth of frost penetration is 5.8 feet.

6.0 RECOMMENDATIONS

6.1 SEISMIC DESIGN

Seismic site class was evaluated in accordance with the 2017 AASHTO LRFD, along with consideration of the 2011 AASHTO Guide Specifications for LRFD Bridge Design (Seismic Guide Specification).

As described previously, the anticipated foundation type consists of spread footings bearing on bedrock. Commentary Article C3.4.2.2 of the Seismic Guide Specification indicates that the ground motion at the abutment controls transfer of earthquake motion to relatively short bridges, and the site classification should be determined at the base of the approach fill. For this project, the approach fills are generally bearing directly on bedrock. Considering the extremely high strength of the rock and our experience with rock types in the York-Kittery area, we anticipate that the shear wave velocity of rock that will support the bridge exceeds 5,000 feet per second. Therefore, the bridge should be assigned to Site Class A.

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

SITE CLASS B SEISMIC DESIGN PARAMETERS	
Parameter	**Design Value**
Fpga	0.8
Fa	0.8
Fv	0.8
As (Period = 0.0 sec)	0.077 g
SDs (Period = 0.2 sec)	0.148 g
SD1 (Period = 1.0 sec)	0.035 g

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

6.2 ABUTMENT AND WINGWALL DESIGN

- Backfill between new abutments and a 1.5H:1V plane extending up from the bottom of the abutment to the pavement subgrade should consist of Maine DOT 703.19 Granular Borrow for Underwater Backfill, BDG Type 4 soil. Recommended soil properties for Type 4 soils to be used as backfill are as follows:
  - Internal Friction Angle of Soil = 32°
  - Soil Total Unit Weight = 125 pcf
  - Coefficient of Passive Earth Pressure, K_p= 6.73 (use for design of backwalls and wingwalls)

- Live load surcharge should be applied as a uniform lateral surcharge pressure using the equivalent fill height (Heq) values developed in accordance with AASHTO Article 3.11.6.4, based on the abutment/wingwall height and distance from the wall backface to the edge of traffic.
- Foundation drainage should be provided in accordance with Section 5.4.1.9 of the BDG.
  - We recommend the use of French drains on the uphill side of abutments and wing walls to prevent buildup of differential hydrostatic pressure. Foundation drains should be sloped to drain by gravity and should daylight through weep holes in the abutments.

6.3 SPREAD FOOTINGS

The replacement bridge may be supported on spread footing foundations bearing on fill concrete that bears directly on intact bedrock free of all loose soil and rock material. We recommend a nominal bearing resistance of 90 ksf. This will provide a factored bearing resistance of 40 ksf for the strength loading condition.

LRFD Article 10.6.2.4.4 indicates that footings bearing on rock with an RMR-based rock quality of Fair or better and designed using LRFD methods are generally anticipated to experience ½ inch or less of elastic settlement.

If the exposed bedrock surface is steeper than 4 horizontal to 1 vertical (4H:1V), then anchoring, doweling, benching or other means should be employed to improve sliding resistance.

For proposed foundations bearing on bedrock, we recommend that sliding resistance be assessed using a nominal sliding resistance coefficient (C tan ϕ_f) equal to 0.7 for cast-in-place concrete on sound rock, a resistance factor (ϕ_τ) of 0.8, and a factored sliding resistance coefficient is 0.56 for the Strength Limit State.

7.0 CONSTRUCTION CONSIDERATIONS

Construction considerations are intended to identify geotechnical-related issues that have the potential to impact design and cost considerations for bridge construction. These items are provided in the bullets that follow.

- Bedrock Excavation: In general, the bedrock surface should be exposed and all loose material removed using pressurized air and water, under the observation of the Geotechnical Engineer. If a footing subgrade slope exceeds 4H:1V, then additional measures such as benching, doweling or keying into the rock should be considered to increase lateral resistance.
- Support of Excavation: We anticipate that temporary support of excavation may be necessary to maintain portions of the roadway in a two-phased construction approach. Given the irregular surface of the bedrock and the lack of potential toe-in, we anticipate that braced steel sheeting or drilled soldier beam and lagging systems are technically feasible for this project. A sheet pile cofferdam system would probably require two levels of bracing, or wales and tiebacks to enhance lateral resistance. A drilled soldier beam system could consist of micropiles drilled and grouted into

the bedrock. The need for tiebacks with this type of system would need to be assessed by the designer of the support of excavation system.

- Obstructions: Remains of previous structures, cobbles and boulders are anticipated to be present in the overburden soils and could impact installation of support of excavation systems, and preparation of bearing subgrades. It may be necessary to pre-excavate a trench, remove obstructions and backfill the trench with crushed stone in order to expedite installation of the excavation support system.

TABLES

TABLE 1 - SUMMARY OF SUBSURFACE CONDITIONS
Cape Neddick Bridge
York, Maine
GZA Project No. 09.0025930.00

Boring Designation	Northing (2)	Easting (2)	Approx. Ground Surface Elevation (2)	Soil and Groundwater Conditions (1,3,4)									Bottom of Exploration	
				Pavement Thickness	Depth to top of FILL		Depth to Top of Glacial Till		Depth to Top of Rock		Depth to Groundwater (4)			
				BGS	BGS	ELEV	BGS	ELEV	BGS	ELEV	BGS	ELEV	BGS	ELEV
BB-YCN-101	**130976.6**	**918950.7**	29.4	1.8	1.8	27.6	13.5	15.9	19.2	10.2	13.5	15.9	19.2	10.2
BB-YCN-101A	**130972.4**	**918952.5**	29.5	1.8	NM	--	NM	--	19.8	9.7	13.2	16.3	36.5	-7.0
BB-YCN-102	**130981.5**	**918969.8**	30.6	1.8	1.8	28.8	13.0	17.6	22.7	7.9	15.5	15.1	24.0	6.6
BB-YCN-103	**131008.8**	**918940.3**	29.4	1.8	7.8	21.6	7.8	21.6	16.1	13.3	12.7	16.7	17.3	12.1
BB-YCN-104	**131016.7**	**918958.9**	30.6	1.8	1.8	28.8	NE	--	NE	--	NE	--	7.5	23.1
BB-YCN-104A	**131023.4**	**918956.9**	30.6	1.8	1.8	28.8	12.0	18.6	15.3	15.3	10.6	20.0	25.4	5.2

NOTES:

1. All depths are measured in feet below ground surface (bgs). Depths were estimated to the nearest 0.1 feet during drilling as presented on the boring logs. The accuracy of these values depends on drilling conditions and sample recovery and is on the order of ±1 foot.
2. Boring locations were provided by the Client on March 10, 2017 in a file titled "borings(03-10-17).csv." These data are understood to consist of as-drilled locations and GS elevations except for BB-YCN-104 which was estimated by GZA using an offset of BB-YCN-104A.
3. "NE" indicates stratum or groundwater not encountered in exploration, "NM" indicates strata thicknesses were not measured in re-located boring.
4. Groundwater measurements were taken 15 to 30 minutes after completion of drilling as documented on the boring logs.

Table 2 - Summary of Bedrock Data
Cape Neddick Bridge
York, Maine

Boring	Run	GS Elevation	Depth of Core Run below GS (ft)			Depth to Rock (ft)	Depth (ft) Below Top of Rock			Length of Core Run (ft)	Rec (in)	Rec (%)	RQD (in)	RQD %	Joint Spacing Desc.	Corr. Spacing (in)	Aperture Desc.	Corr. Aperture (in)	Joint Weathering	Rock Type
			Top		Bottom		Top		Bottom											
BB-YCN-101A	R1	29.5	20.0	-	21.5	19.8	0.2	-	1.7	1.5	17	94%	4	24%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh	GRANITE/GRANODIORITE
BB-YCN-101A	R2	29.5	21.5	-	26.5	19.8	1.7	-	6.7	5.0	58	97%	28	47%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE
BB-YCN-101A	R3	29.5	26.5	-	30.0	19.8	6.7	-	10.2	3.5	42	100%	4	10%	Extremely Close to Close	<0.75-8	Tight to Partially Open	0.004-0.1	Fresh	GRANODIORITE
BB-YCN-101A	R4	29.5	30.0	-	33.0	19.8	10.2	-	13.2	3.0	36	100%	10	28%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE
BB-YCN-101A	R5	29.5	33.0	-	36.5	19.8	13.2	-	16.7	3.5	42	100%	25	60%	Very Close to Moderate	0.75-24	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE
BB-YCN-104A	R1	30.6	15.4	-	17.3	15.3	0.1	-	2.0	1.9	20	87%	12	52%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE
BB-YCN-104A	R2	30.6	17.3	-	20.9	15.3	2.0	-	5.6	3.6	40	93%	32	74%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE
BB-YCN-104A	R3	30.6	20.9	-	25.4	15.3	5.6	-	10.1	4.5	60	111%	52	96%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored	GRANITE/GRANODIORITE

FIGURES

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

CAPE NEDDICK BRIDGE #2127 OVER CAPE NEDDICK RIVER
YORK, MAINE
WIN 21709.00

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

PREPARED FOR:
MAINE DEPARTMENT
OF TRANSPORTATION

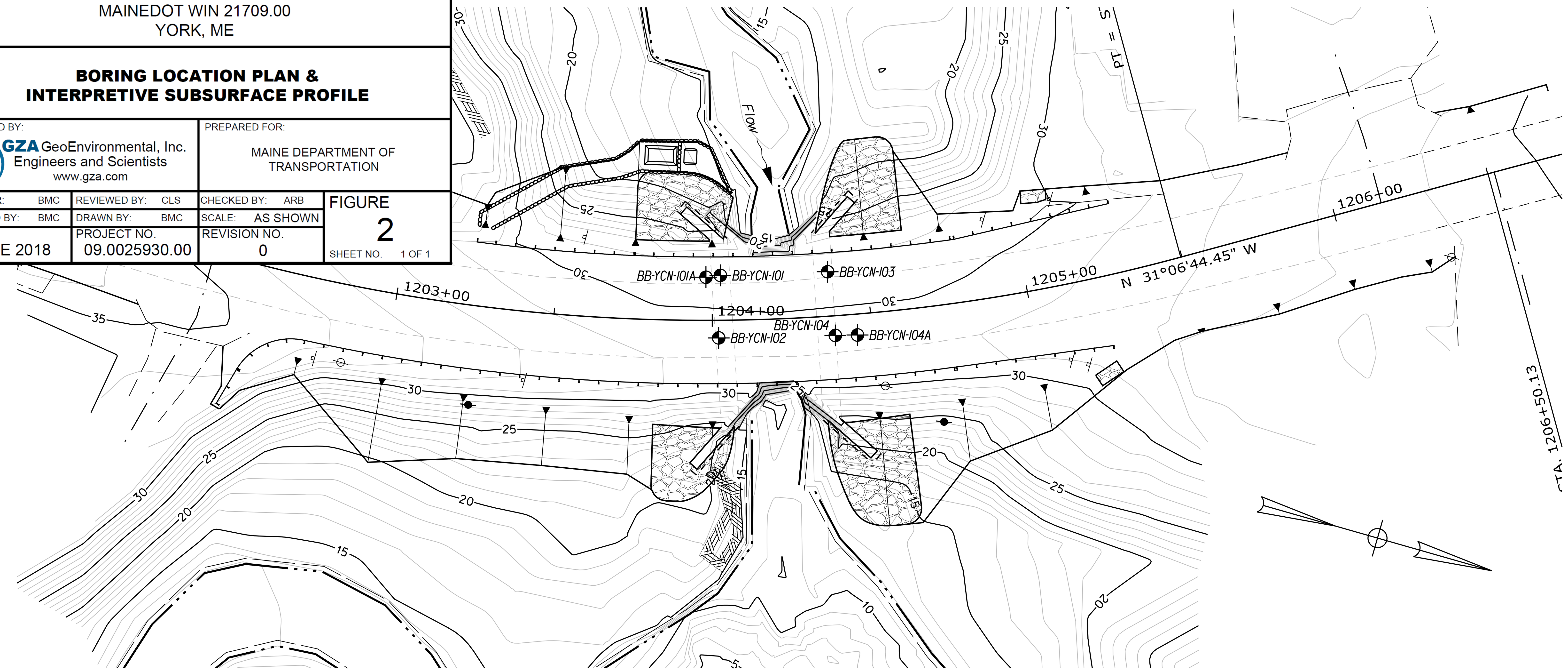
LOCUS PLAN

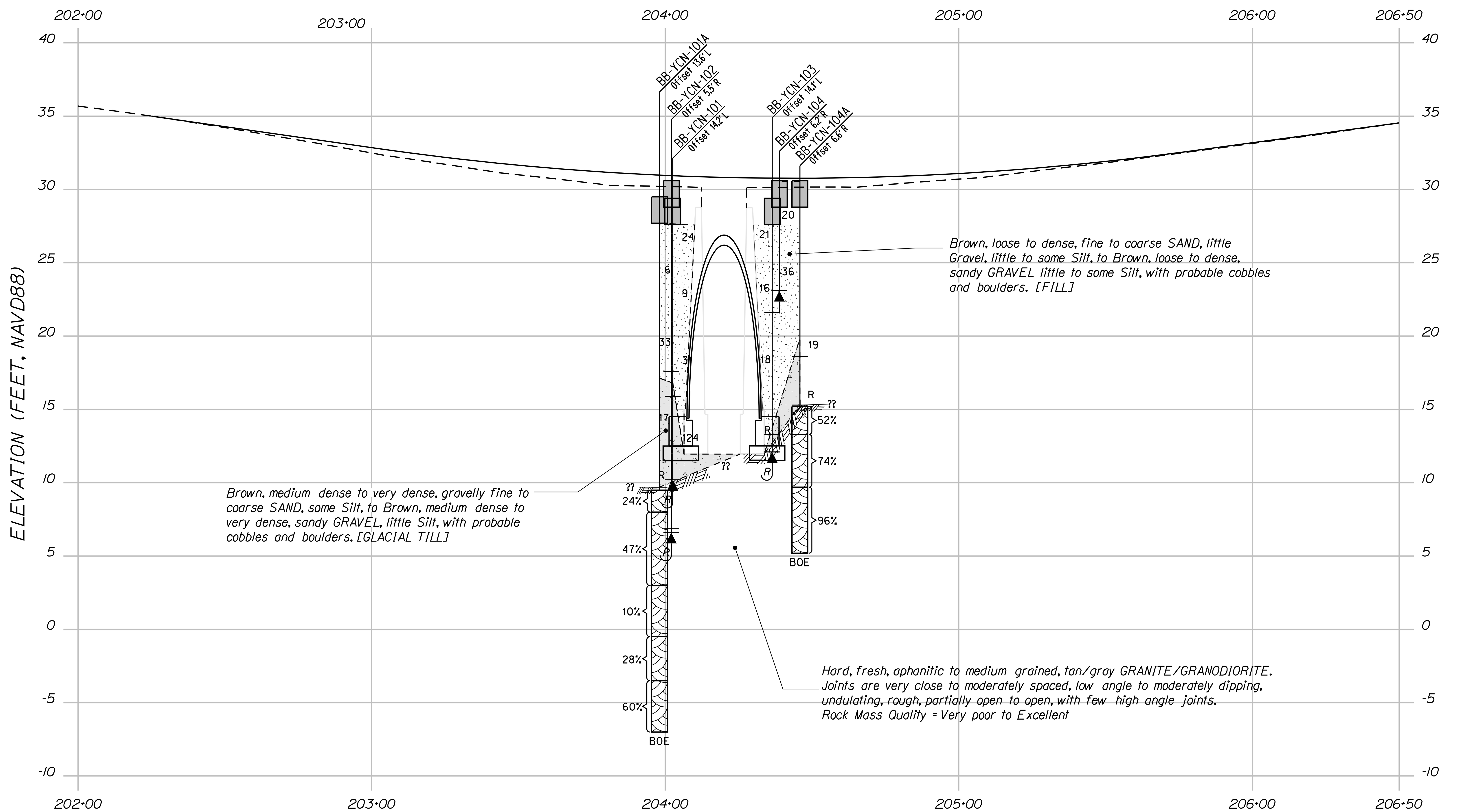
PROJ MGR: BMC	REVIEWED BY: CLS	CHECKED BY: ARB	FIGURE
DESIGNED BY: BMC	DRAWN BY: ADM	SCALE: 1 in = 2,000 ft	1
DATE: MARCH 2017	PROJECT NO. 09.0025930.00	REVISION NO.	

CAPE NEDDICK BRIDGE NO. 2127
MAINEDOT WIN 21709.00
YORK, ME

BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MAINE DEPARTMENT OF TRANSPORTATION	FIGURE 2
PROJ MGR: BMC	REVIEWED BY: CLS	CHECKED BY: ARB	
DESIGNED BY: BMC	DRAWN BY: BMC	SCALE: AS SHOWN	
DATE: JUNE 2018	PROJECT NO. 09.0025930.00	REVISION NO. 0	SHEET NO. 1 OF 1





NOTES

1) Base map developed from electronic files provided by MaineDOT on March 15, 2017 (Files included BDPLAN.dgn, Contours.dgn, Points.dgn, RWPLAN.dgn, Text.dgn, topo.dgn and wetlands.dgn).

2) Profile developed from electronic files provided by HNTB on March 17, 2016 (Files included Profile.dgn and z_Bridge Elevation.dgn).

3) The as-drilled locations of the test borings were surveyed by a MaineDOT survey crew and supplied to GZA except for BB-YCN-104 which was determined using offset from BB-YCN-104A.

4) BB-YCN-100 series bridge borings were performed by New England Boring Contractors and observed by GZA personnel between March 6 and March 8, 2017.

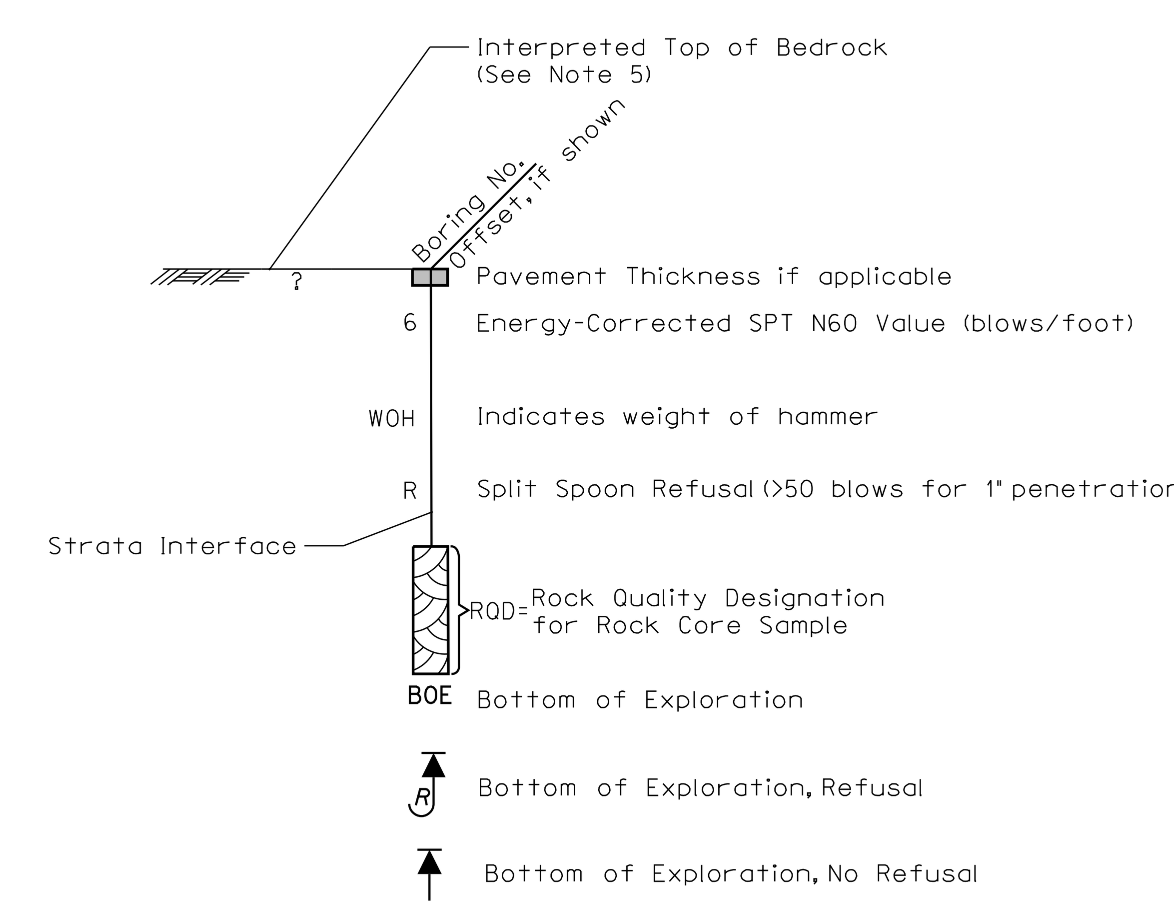
5) Interpreted top of rock considers general trend of ledge lines between borings BB-YCN-101A and -104A.

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

BORING LOCATION PLAN LEGEND

BB-YCN-104 Location and designation of cased wash boring

INTERPRETIVE SUBSURFACE PROFILE LEGEND



PLAN

25 0 25 50
Scale

PROFILE

Horiz. 25 0 25 50
Vert. 5 0 5 10
SCALE

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS
WIN 21709.00
BRIDGE NO. 2127

SIGNATURE
P.E. NUMBER
DATE

	XXXX	BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	BMC	BMC	APR 2017
CHECKED-REVIEWED	CLS	ARB	APR 2017
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

CAPE NEDDICK BRIDGE
ROUTE 1 OVER CAPE NEDDICK RIVER
YORK YORK COUNTY

BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

PREPARED BY: GZA

SHEET NUMBER
6
OF 28

Filename: ...\Geotech\MSTA\BLP\002_BLP.dgn Division: HIGHWAY Username: common Date:6/22/2018

Date:5/17/2018

Username:

Division:

Filename: 006_Boring Logs 1.dgn

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-101
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	29.4	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/7/17 - 3/7/17	Drilling Method:	SSA/Drive & Wash	Core Barrel:	-
Boring Location:	N130976.6, E918950.7	Casing ID/OD:	4"/3"	Water Level *:	13.5'
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								28.1	1.3 -CONCRETE-	
								27.6	1.8	
	1D	24/3	2.0 - 4.0	16-16-8-6	24	24			Brown, dry, medium dense, fine to coarse SAND, some Gravel, little Silt, with probable cobbles and boulders. -FILL- (SW-SM)	
5	2D	24/1	5.0 - 7.0	14-3-6-4	9	9			Brown, dry, loose, fine to coarse SAND, some Gravel, some Silt, with probable cobbles and boulders. -FILL- (SM)	
10	3D	24/9	10.0 - 12.0	9-14-17-21	31	31	89		Brown, moist, dense, fine to coarse SAND, some Gravel, some Silt, with probable cobbles and boulders. -FILL- (SM)	G#1 A-2-4, SM wc=14.6
							61			
							70			
							58	15.9	13.5	
							50			
15	4D	24/7	15.0 - 17.0	10-99-25-18	124	124	128		Brown, wet, very dense, sandy GRAVEL, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (GM)	G#2 A-1-a, GM wc=14.3
							117			
							136			
							66			
							22/2"	10.2	Broke NW casing. Moved to BB-YCN-101A. 19.2 Bottom of Exploration at 19.20 feet below ground surface.	
20										
25										

Remarks:

1. Water level measured 15 minutes after completion of drilling.
2. Cobbles and boulders throughout fill, based on casing and roller cone advancement.
3. 4" casing met refusal at 19.2' bgs; then 3" casing broke while setting up to core. Bottom 10.0' of casing remained in borehole.

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.

Page 1 of 2 Boring No.: BB-YCN-101

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-101A
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	29.5	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/8/17 - 3/8/17	Drilling Method:	SSA/Spin & Wash	Core Barrel:	NX2
Boring Location:	N130972.4, E918952.5	Casing ID/OD:	3"	Water Level *:	13.2'
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Sample Information

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							SPUN		Refer to Boring BB-YCN-101. Moved approximately 4.5' south of boring BB-YCN-101 and spun 3" casing to rock. No sampling in overburden materials.	
5										
10										
15										
								9.7	19.8	
20	R1	18/17	20.0 - 21.5	RQD = 24%			NX2		Spun casing to 19.8' bgs then roller cone to 20.0' bgs and set up to core. R1: Hard, fresh, fine to medium grained, gray/tan, GRANITE/GRANODIORITE. Joints are very close to close, low angle, rough, undulating, fresh, partially open to open. Rock Mass Quality = Very Poor Rock Core Times (min/ft): 2.75, 2.5/6" Recovery = 94%	
	R2	60/58	21.5 - 26.5	RQD = 47%					R2: Hard, fresh, fine to medium grained, gray/tan, GRANITE/GRANODIORITE. Primary joints are very close to close, low angle, rough, undulating, fresh, partially open to open. Secondary joints are moderately spaced, moderate to high angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Poor Rock Core Times (min/ft): 3.5, 2.75, 3.5, 3.0, 3.75 Recovery = 97%	
25	R3	42/42	26.5 - 30.0	RQD = 10%					R3: Hard, fresh, aphanitic, gray, GRANODIORITE with calcite stringers. Joints are extremely close to close, low angle, rough, undulating, fresh to discolored, partially open to open. Two high angle joints. Rock Mass Quality = Very Poor Rock Core Times (min/ft): 3.0, 3.25, 3.0, 2.75/6" Recovery = 100%	
30	R4	36/36	30.0 - 33.0	RQD = 28%					R4: Hard, fresh, fine to medium grained, tan/gray, GRANITE/GRANODIORITE. Joints are very close to close, low angle, rough, undulating, fresh to discolored, tight to open. Rock Mass Quality = Poor Rock Core Times (min/ft): 1.5, 2.5, 3.0 Recovery = 100%	
	R5	42/42	33.0 - 36.5	RQD = 60%					R5: Hard, fresh, coarse grained, tan/gray, GRANITE/GRANODIORITE. Joints are very close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Fair Rock Core Times (min/ft): 3.0, 2.75, 2.0, 1.25/6" Recovery = 100%	
35								-7.0	36.5 Bottom of Exploration at 36.50 feet below ground surface.	
40										
45										
50										

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.

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.

Page 2 of 2 Boring No.: BB-YCN-101A

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-102
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	30.6	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/6/17 - 3/6/17	Drilling Method:	SSA/Drive & Wash	Core Barrel:	-
Boring Location:	N130981.5, E918969.8	Casing ID/OD:	3"	Water Level *:	15.5'
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								29.3	1.3 -CONCRETE-	
								28.8	1.8	
	1D	10/10	2.0 - 2.8	19-100/4"					Brown/gray, dry, sandy GRAVEL, little Silt, with probable cobbles and boulders. -FILL- (GP-GM)	
5	2D	24/10	5.0 - 7.0	2-4-2-4	6	6			Brown, dry, loose, fine to coarse SAND, some Silt, little Gravel, with probable cobbles and boulders. -FILL- (SM)	G#3 A-2-4, SM wc=10.4
10	3D	24/3	10.0 - 12.0	3-20-13-8	33	33			Brown, dry, dense, fine to coarse SAND, some Silt, little Gravel, with probable cobbles and boulders. -FILL- (SM)	
							33			
							47			
							24	17.6	13.0	
							20			
15	4D	24/7	15.0 - 17.0	5-4-13-15	17	17	14		Brown, wet, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM)	
							33			
							37			
							110			
							79	10.4	No recovery.	
20	5D	2/0	20.0 - 20.2	60/2"	R		RC		20.2 -POSSIBLE BOULDER-	
								8.6	22.0 -POSSIBLE GLACIAL TILL-	
								7.9	22.7 -POSSIBLE BEDROCK-	
								6.6	24.0 Bottom of Exploration at 24.00 feet below ground surface.	
25										

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.
3. Cobbles and boulders throughout Fill, based on casing and roller cone advancement.
4. Split spoon refusal at 20.2' bgs, roller cone from 20.2'-24.0' with approximately 1000 psi pressure 750 rpm, intermediate resistance from 20.2'-22.0' bgs, then minimal resistance from 22.0'-22.7' bgs, then increased resistance (approximately 5 min/ft) from 22.7'-24.0' bgs.

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.

Page 1 of 1 Boring No.: BB-YCN-102

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-103
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	29.4	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/7/17 - 3/7/17	Drilling Method:	SSA/Spin & Wash	Core Barrel:	-
Boring Location:	N131008.8, E918940.3	Casing ID/OD:	3"	Water Level *:	12.7'
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								27.9	1.5 -CONCRETE-	
								27.6	1.8	
	1D	24/8	2.0 - 4.0	12-10-11-27	21	21			Brown, moist, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -FILL- (SM)	
5	2D	24/0	5.0 - 7.0	14-8-8-8	16	16	SPUN		No recovery.	
							/ RC			
								21.6	7.8	
10	3D	24/6	10.0 - 12.0	4-7-11-17	18	18			Brown, moist, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM)	G#4 A-1-a, SM wc=13.8
15								13.3	Split spoon refusal at 16.1' bgs. No recovery.	
	4D	1/0	16.0 - 16.1	50/1"	R		RC		16.1 -POSSIBLE BEDROCK-	
								12.1	17.3 Bottom of Exploration at 17.30 feet below ground surface.	
20										
25										

Remarks:

1. From 2.0'-6.0' bgs encountered probable cobbles throughout, based on casing and roller cone advancement.
2. Roller cone advancement with approximately 1,000 psi 750 RPM, from 16.1'-17.3' bgs, advancement greater than 5 min/ft.
3. Water level measured 30 minutes after completion of drilling.

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.

Page 1 of 1 Boring No.: BB-YCN-103

CAPE NEDDICK BRIDGE NO. 2127
MAINEDOT WIN 21709.00
YORK, ME

BORING LOGS SHEET 1

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MAINE DEPARTMENT OF TRANSPORTATION	
PROJ MGR: BMC	REVIEWED BY: CLS	CHECKED BY: ARB	FIGURE 3
DESIGNED BY: BMC	DRAWN BY: BMC	SCALE: AS SHOWN	
DATE: JUNE 2018	PROJECT NO. 09.0025930.00	REVISION NO. 0	SHEET NO. 1 OF 1

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2170(900)X

WIN 21709.00

BRIDGE NO. 2127

BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	Devon Eaton		
DESIGN-DETAILED	E. Forgacs	C. Helmick	5\18
CHECKED-REVIEWED	L. Driscoll	R. Hanf	5\18
DESIGN2-DETAILED2	-	-	-
DESIGN3-DETAILED3	-	-	-
REVISIONS 1	-		-
REVISIONS 2	-		-
REVISIONS 3	-		-
REVISIONS 4	-		-
FIELD CHANGES	-		-

SIGNATURE

P.E. NUMBER

DATE

CAPE NEDDICK BRIDGE
CAPE NEDDICK RIVER
YORK COUNTY
YORK

BORING LOGS 1

SHEET NUMBER 6 OF 28

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-104
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	30.6	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/6/17 - 3/6/17	Drilling Method:	SSA/Drive & Wash	Core Barrel:	NX2
Boring Location:	N131016.7, E918958.9	Casing ID/OD:	4"	Water Level *:	-
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								29.4	-CONCRETE- (1.2)	
	1D	24/10	1.8 - 3.8	21-12-8-9	20	20		28.8	(1.8) Brown/gray, dry, medium dense, GRAVEL, some fine to coarse Sand, trace Silt, with probable cobbles and boulders. -FILL- (GP-GM)	G*5 A-1-a, GP-GM wc=2.8
5	2D	24/9	5.0 - 7.0	25-21-15-14	36	36			Dark brown, moist, dense, fine to coarse SAND, some Gravel, little Silt, with probable cobbles and boulders,. -FILL- (SM)	
								23.1	No refusal; SSA kicked and could not advance casing, probable boulder; pulled, and moved approximately 7.0' north. (7.5)	
									Bottom of Exploration at 7.50 feet below ground surface.	
10										
15										
20										
25										

Remarks:

1. Boulders/cobbles throughout Fill, based on casing and roller cone advancement.

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.

Page 1 of 2

Boring No.: BB-YCN-104

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project:	Cape Neddick Bridge 09.0025930.00	Location:	Route 1 Over Cape Neddick River York, Maine	Boring No.:	BB-YCN-104A
				PIN:	21709.00
Driller:	New England Boring	Elevation (ft.)	30.6	Auger ID/OD:	4.25" OD
Operator:	Brad Enos	Datum:	NAVD 88	Sampler:	Split Spoon
Logged By:	Blaine Cardali	Rig Type:	Truck - Mobile Drill	Hammer Wt./Fall:	140/30
Date Start/Finish:	3/6/17 - 3/6/17	Drilling Method:	SSA/Drive & Wash	Core Barrel:	NX2
Boring Location:	N131023.4, E918956.9	Casing ID/OD:	4"/3"	Water Level *:	10.6'
Hammer Efficiency Factor:	0.6	Hammer Type:	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								29.4	-CONCRETE- (1.2)	
								28.8	(1.8) Refer to Boring BB-YCN-104 for soil description. Moved approximately 7.0' north, advanced boring to 10.0' and started sampling.	
5										
								23.1	(7.5)	
10	3D	24/12	10.0 - 12.0	21-11-8-34	19	19	65		Brown, moist, medium dense, fine to coarse SAND, some Silt, trace Gravel, with probable cobbles and boulders. -FILL- (SM)	G*6 A-2-4, SM wc=15.2
							47			
							309	18.6	(12.0)	
							118			
							48			
15	4D R1	4/1 23/20	15.0 - 15.3 15.4 - 17.3	100/4" RQD = 52%	R		RC NX2	15.3	Brown, wet, fine to medium SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM) (15.3)	
									Split spoon refusal at 15.3' bgs, roller cone to 15.4' and set up to core. R1: Hard, fresh, fine to medium grained, gray, GRANODIORITE/GRANITE. Joints are close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Fair Rock Core Times (min/ft): 1.5, 1.75/.9' Recovery = 87%	q_p=4774 ksf
	R2	43/40	17.3 - 20.9	RQD = 74%					R2: Hard, fresh, fine to medium grained, gray, GRANODIORITE/GRANITE. Joints are close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. One high angle joint. Rock Mass Quality = Fair Rock Core Times (min/ft): 2.5, 2.0, 2.5, 1.5/0.6' Recovery = 93%	q_p=4912 ksf
20	R3	54/60	20.9 - 25.4	RQD = 96%					R3: Hard, fresh, fine to coarse grained, gray, GRANODIORITE/GRANITE. Joints are close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Excellent Rock Core Times (min/ft): 2.0, 3.5, 3.0, 2.75, 2.5/0.5' Recovery = 111%	
25								5.2	(25.4) Bottom of Exploration at 25.40 feet below ground surface.	
30										
35										
40										
45										
50										

Remarks:

1. 4" casing to 15.0' bgs then 3" to 15.4' bgs.
2. Water level taken approximately 15 minutes after completion of drilling.
3. Boulders/cobbles throughout Fill, based on casing and roller cone advancement.

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.

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Boring No.: BB-YCN-104A

CAPE NEDDICK BRIDGE NO. 2127
MAINEDOT WIN 21709.00
YORK, ME

BORING LOGS SHEET 2

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MAINE DEPARTMENT OF TRANSPORTATION	
PROJ MGR: BMC	REVIEWED BY: CLS	CHECKED BY: ARB	FIGURE 4
DESIGNED BY: BMC	DRAWN BY: BMC	SCALE: AS SHOWN	
DATE: JUNE 2018	PROJECT NO. 09.0025930.00	REVISION NO. 0	SHEET NO. 1 OF 1

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2170(900)X

BRIDGE NO. 2127 | **WIN 21709.00** | BRIDGE PLANS

PROJ. MANAGER	Devon Eaton	BY	DATE
DESIGN-DETAILED	E. Forgacs	C. Helmick	5\18
CHECKED-REVIEWED	L. Driscoll	R. Hanf	5\18
DESIGN2-DETAILED2	-	-	-
DESIGN3-DETAILED3	-	-	-
REVISIONS 1	-		-
REVISIONS 2	-		-
REVISIONS 3	-		-
REVISIONS 4	-		-
FIELD CHANGES	-		-

SIGNATURE

P.E. NUMBER

DATE

CAPE NEDDICK BRIDGE
CAPE NEDDICK RIVER
YORK COUNTY
YORK

BORING LOGS 2

SHEET NUMBER
7
OF 28

Date:5/17/2018

Username:

Division:

Filename: 007_Boring Logs 2.dgn

APPENDIX A – LIMITATIONS

GEOTECHNICAL LIMITATIONS

Use of Report

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

Standard of Care

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

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

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

Subsurface Conditions

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

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

7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

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

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

Compliance with Codes and Regulations

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

Cost Estimates

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

Additional Services

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

APPENDIX B – TEST BORING LOGS

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Cape Neddick Bridge 09.0025930.00 **Location:** Route 1 Over Cape Neddick River York, Maine	**Boring No.:** BB-YCN-101 **PIN:** 21709.00

Driller:	New England Boring	**Elevation (ft.)**	29.4	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/7/17 - 3/7/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	-
Boring Location:	N130976.6, E918950.7	**Casing ID/OD:**	4"/3"	**Water Level*:**	13.5'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			-ASPHALT-	
								28.1 27.6		1.3 -CONCRETE- 1.8	
	1D	24/3	2.0 - 4.0	16-16-8-6	24	24				Brown, dry, medium dense, fine to coarse SAND, some Gravel, little Silt, with probable cobbles and boulders. -FILL- (SW-SM)	
5	2D	24/1	5.0 - 7.0	14-3-6-4	9	9				Brown, dry, loose, fine to coarse SAND, some Gravel, some Silt, with probable cobbles and boulders. -FILL- (SM)	
10	3D	24/9	10.0 - 12.0	9-14-17-21	31	31	89			Brown, moist, dense, fine to coarse SAND, some Gravel, some Silt, with probable cobbles and boulders. -FILL- (SM)	G#1 A-2-4, SM wc=14.6
							61				
							70				
							58	15.9		13.5	
							50				
15	4D	24/7	15.0 - 17.0	10-99-25-18	124	124	128			Brown, wet, very dense, sandy GRAVEL, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (GM)	G#2 A-1-a, GM wc=14.3
							117				
							136				
							66				
							22/2"	10.2		Broke NW casing. Moved to BB-YCN-101A. 19.2 **Bottom of Exploration at 19.20 feet below ground surface.**	
20											
25											

Remarks:

1. Water level measured 15 minutes after completion of drilling.
2. Cobbles and boulders throughout fill, based on casing and roller cone advancement.
3. 4" casing met refusal at 19.2' bgs; then 3" casing broke while setting up to core. Bottom 10.0' of casing remained in borehole.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-101A
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	29.5	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/8/17 - 3/8/17	**Drilling Method:**	SSA/Spin & Wash	**Core Barrel:**	NX2
Boring Location:	N130972.4, E918952.5	**Casing ID/OD:**	3"	**Water Level*:**	13.2'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SPUN			Refer to Boring BB-YCN-101. Moved approximately 4.5' south of boring BB-YCN-101 and spun 3" casing to rock. No sampling in overburden materials.	
5											
10											
15											
								9.7		19.8	
20	R1	18/17	20.0 - 21.5	RQD = 24%			NX2			Spun casing to 19.8' bgs then roller cone to 20.0' bgs and set up to core. R1: Hard, fresh, fine to medium grained, gray/tan, GRANITE/GRANODIORITE. Joints are very close to close, low angle, rough, undulating, fresh, partially open to open. Rock Mass Quality = Very Poor Rock Core Times (min/ft): 2.75, 2.5/6" Recovery = 94%	
	R2	60/58	21.5 - 26.5	RQD = 47%						R2: Hard, fresh, fine to medium grained, gray/tan,	
25											

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-101A

PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	29.5	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/8/17 - 3/8/17	**Drilling Method:**	SSA/Spin & Wash	**Core Barrel:**	NX2
Boring Location:	N130972.4, E918952.5	**Casing ID/OD:**	3"	**Water Level*:**	13.2'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										GRANITE/GRANODIORITE. Primary joints are very close to close, low angle, rough, undulating, fresh, partially open to open. Secondary joints are moderately spaced, moderate to high angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Poor Rock Core Times (min/ft): 3.5, 2.75, 3.5, 3.0, 3.75 Recovery = 97%	
	R3	42/42	26.5 - 30.0	RQD = 10%						R3: Hard, fresh, aphanitic, gray, GRANODIORITE with calcite stringers. Joints are extremely close to close, low angle, rough, undulating, fresh to discolored, partially open to open. Two high angle joints. Rock Mass Quality = Very Poor Rock Core Times (min/ft): 3.0, 3.25, 3.0, 2.75/6" Recovery = 100%	
30	R4	36/36	30.0 - 33.0	RQD = 28%						R4: Hard, fresh, fine to medium grained, tan/gray, GRANITE/GRANODIORITE. Joints are very close to close, low angle, rough, undulating, fresh to discolored, tight to open. Rock Mass Quality = Poor Rock Core Times (min/ft): 1.5, 2.5, 3.0 Recovery = 100%	
	R5	42/42	33.0 - 36.5	RQD = 60%						R5: Hard, fresh, coarse grained, tan/gray, GRANITE/GRANODIORITE. Joints are very close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Fair Rock Core Times (min/ft): 3.0, 2.75, 2.0, 1.25/6" Recovery = 100%	
35								-7.0		36.5	
										Bottom of Exploration at 36.50 feet below ground surface.	
40											
45											
50											

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-102
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	30.6	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/6/17 - 3/6/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	-
Boring Location:	N130981.5, E918969.8	**Casing ID/OD:**	3"	**Water Level*:**	15.5'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
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MV = Unsuccessful Insitu 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 = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA		-ASPHALT-	
								29.3	1.3	
								28.8	-CONCRETE- 1.8	
	1D	10/10	2.0 - 2.8	19-100/4"					Brown/gray, dry, sandy GRAVEL, little Silt, with probable cobbles and boulders. -FILL- (GP-GM)	
5	2D	24/10	5.0 - 7.0	2-4-2-4	6	6			Brown, dry, loose, fine to coarse SAND, some Silt, little Gravel, with probable cobbles and boulders. -FILL- (SM)	G#3 A-2-4, SM wc=10.4
10	3D	24/3	10.0 - 12.0	3-20-13-8	33	33			Brown, dry, dense, fine to coarse SAND, some Silt, little Gravel, with probable cobbles and boulders. -FILL- (SM)	
							33			
							47			
							24	17.6	13.0	
							20			
15	4D	24/7	15.0 - 17.0	5-4-13-15	17	17	14		Brown, wet, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM)	
							33			
							37			
							110			
							79			
20	5D	2/0	20.0 - 20.2	60/2"	R		RC	10.4	No recovery. 20.2	
									-POSSIBLE BOULDER-	
								8.6	22.0 -POSSIBLE GLACIAL TILL-	
								7.9	22.7 -POSSIBLE BEDROCK-	
								6.6	24.0	
25									**Bottom of Exploration at 24.00 feet below ground**	

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.
3. Cobbles and boulders throughout Fill, based on casing and roller cone advancement.
4. Split spoon refusal at 20.2' bgs, roller cone from 20.2'-24.0' with approximately 1000 psi pressure 750 rpm, intermediate resistance from 20.2'-22.0' bgs, then minimal resistance from 22.0'-22.7' bgs, then increased resistance (approximately 5 min/ft) from 22.7'-24.0' bgs.

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

Boring No.: BB-YCN-102

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Cape Neddick Bridge
09.0025930.00
Location: Route 1 Over Cape Neddick River
York, Maine

Boring No.: BB-YCN-102

PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	30.6	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/6/17 - 3/6/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	-
Boring Location:	N130981.5, E918969.8	**Casing ID/OD:**	3"	**Water Level*:**	15.5'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample 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.
25										**surface.**	
30											
35											
40											
45											
50											

Remarks:

1. 3" casing to 20' bgs.
2. Water level measured 20 minutes after completion of drilling.
3. Cobbles and boulders throughout Fill, based on casing and roller cone advancement.
4. Split spoon refusal at 20.2' bgs, roller cone from 20.2'-24.0' with approximately 1000 psi pressure 750 rpm, intermediate resistance from 20.2'-22.0' bgs, then minimal resistance from 22.0'-22.7' bgs, then increased resistance (approximately 5 min/ft) from 22.7'-24.0' bgs.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-103
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	29.4	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/7/17 - 3/7/17	**Drilling Method:**	SSA/Spin & Wash	**Core Barrel:**	-
Boring Location:	N131008.8, E918940.3	**Casing ID/OD:**	3"	**Water Level*:**	12.7'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			-ASPHALT-	
								27.9		1.5	
								27.6		-CONCRETE- 1.8	
	1D	24/8	2.0 - 4.0	12-10-11-27	21	21				Brown, moist, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -FILL- (SM)	
5	2D	24/0	5.0 - 7.0	14-8-8-8	16	16	SPUN / RC			No recovery.	
								21.6		7.8	
10	3D	24/6	10.0 - 12.0	4-7-11-17	18	18				Brown, moist, medium dense, gravelly fine to coarse SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM)	G#4 A-1-a, SM wc=13.8
15											
	4D	1/0	16.0 - 16.1	50/1"	R		RC	13.3		Split spoon refusal at 16.1' bgs. No recovery. 16.1	
								12.1		-POSSIBLE BEDROCK- 17.3	
										Bottom of Exploration at 17.30 feet below ground surface.	
20											
25											

Remarks:

1. From 2.0'-6.0' bgs encountered probable cobbles throughout, based on casing and roller cone advancement.
2. Roller cone advancement with approximately 1,000 psi 750 RPM, from 16.1'-17.3' bgs, advancement greater than 5 min/ft.
3. Water level measured 30 minutes after completion of drilling.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-104
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	30.6	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/6/17 - 3/6/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	NX2
Boring Location:	N131016.7, E918958.9	**Casing ID/OD:**	4"	**Water Level*:**	-
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			-ASPHALT-	
	1D	24/10	1.8 - 3.8	21-12-8-9	20	20		29.4		1.2	
								28.8		-CONCRETE- 1.8	G#5 A-1-a, GP-GM wc=2.8
										Brown/gray, dry, medium dense, GRAVEL, some fine to coarse Sand, trace Silt, with probable cobbles and boulders. -FILL- (GP-GM)	
5	2D	24/9	5.0 - 7.0	25-21-15-14	36	36				Dark brown, moist, dense, fine to coarse SAND, some Gravel, little Silt, with probable cobbles and boulders,. -FILL- (SM)	
								23.1		No refusal; SSA kicked and could not advance casing, probable boulder; pulled, and moved approximately 7.0' north. 7.5	
										Bottom of Exploration at 7.50 feet below ground surface.	
10											
15											
20											
25											

Remarks:

1. Boulders/cobbles throughout Fill, based on casing and roller cone advancement.

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

Boring No.: BB-YCN-104

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-104A
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	30.6	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/6/17 - 3/6/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	NX2
Boring Location:	N131023.4, E918956.9	**Casing ID/OD:**	4"/3"	**Water Level*:**	10.6'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			-ASPHALT-	
								29.4		1.2	
								28.8		-CONCRETE- 1.8	
										Refer to Boring BB-YCN-104 for soil description. Moved approximately 7.0' north, advanced boring to 10.0' and started sampling.	
5											
								23.1		7.5	
10	3D	24/12	10.0 - 12.0	21-11-8-34	19	19	65			Brown, moist, medium dense, fine to coarse SAND, some Silt, trace Gravel, with probable cobbles and boulders. -FILL- (SM)	G#6 A-2-4, SM wc=15.2
							47				
							309	18.6		12.0	
							118				
							48				
15	4D	4/1	15.0 - 15.3	100/4"	R		RC	15.3		Brown, wet, fine to medium SAND, little Silt, with probable cobbles and boulders. -GLACIAL TILL- (SM) 15.3	
	R1	23/20	15.4 - 17.3	RQD = 52%			NX2			Split spoon refusal at 15.3' bgs, roller cone to 15.4' and set up to core. R1: Hard, fresh, fine to medium grained, gray, GRANODIORITE/GRANITE. Joints are close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Fair Rock Core Times (min/ft): 1.5, 1.75/.9' Recovery = 87%	q_p=4774 ksf
	R2	43/40	17.3 - 20.9	RQD = 74%						R2: Hard, fresh, fine to medium grained, gray, GRANODIORITE/GRANITE. Joints are close to moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. One high angle joint. Rock Mass Quality = Fair Rock Core Times (min/ft): 2.5, 2.0, 2.5, 1.5/0.6' Recovery = 93%	q_p=4912 ksf
20	R3	54/60	20.9 - 25.4	RQD = 96%						R3: Hard, fresh, fine to coarse grained, gray, GRANODIORITE/GRANITE. Joints are close to	
25											

Remarks:

1. 4" casing to 15.0' bgs then 3" to 15.4' bgs.
2. Water level taken approximately 15 minutes after completion of drilling.
3. Boulders/cobbles throughout Fill, based on casing and roller cone advancement.

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: Cape Neddick Bridge 09.0025930.00
Location: Route 1 Over Cape Neddick River York, Maine

Boring No.: BB-YCN-104A
PIN: 21709.00

Driller:	New England Boring	**Elevation (ft.)**	30.6	**Auger ID/OD:**	4.25" OD
Operator:	Brad Enos	**Datum:**	NAVD 88	**Sampler:**	Split Spoon
Logged By:	Blaine Cardali	**Rig Type:**	Truck - Mobile Drill	**Hammer Wt./Fall:**	140/30
Date Start/Finish:	3/6/17 - 3/6/17	**Drilling Method:**	SSA/Drive & Wash	**Core Barrel:**	NX2
Boring Location:	N131023.4, E918956.9	**Casing ID/OD:**	4"/3"	**Water Level*:**	10.6'
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25							V	5.2		moderately spaced, low angle, rough, undulating, fresh to discolored, partially open to open. Rock Mass Quality = Excellent Rock Core Times (min/ft): 2.0, 3.5, 3.0, 2.75, 2.5/0.5' Recovery = 111% 25.4 **Bottom of Exploration at 25.40 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

1. 4" casing to 15.0' bgs then 3" to 15.4' bgs.
2. Water level taken approximately 15 minutes after completion of drilling.
3. Boulders/cobbles throughout Fill, based on casing and roller cone advancement.

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

Boring No.: BB-YCN-104A

APPENDIX C – LABORATORY TESTING RESULTS

THIELSCH ENGINEERING

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Cape Neddick Bridge

Town(s): York, Maine

MDOT Project Number:

GZA Project Number: 09.0025930.00

Boring & Sample Identification Number	Station (Feet)	Sample No.	Depth (Feet)	Lab Number	Organic %	W.C.	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
BB-YCN-101		3D	10-12	G 1		14.6			SM	A-2-4	II
BB-YCN-101		4D	15-17	G 2		14.3			GM	A-1-a	I
BB-YCN-102		2D	5-7	G 3		10.4			SM	A-2-4	II
BB-YCN-103		3D	10-12	G 4		13.8			SM	A-1-a	II
BB-YCN-104		1D	2-4	G 5		2.8			GP-GM	A-1-a	I
BB-YCN-104		3D	10-12	G 6		15.2			SM	A-2-4	I

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

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

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

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

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

LABORATORY TESTING DATA SHEET

Project Name **Cape Neddick Bridge** Location York, Maine Reviewed By [signature]

Project No. **09.0025930.00** Assigned By B. Cardali

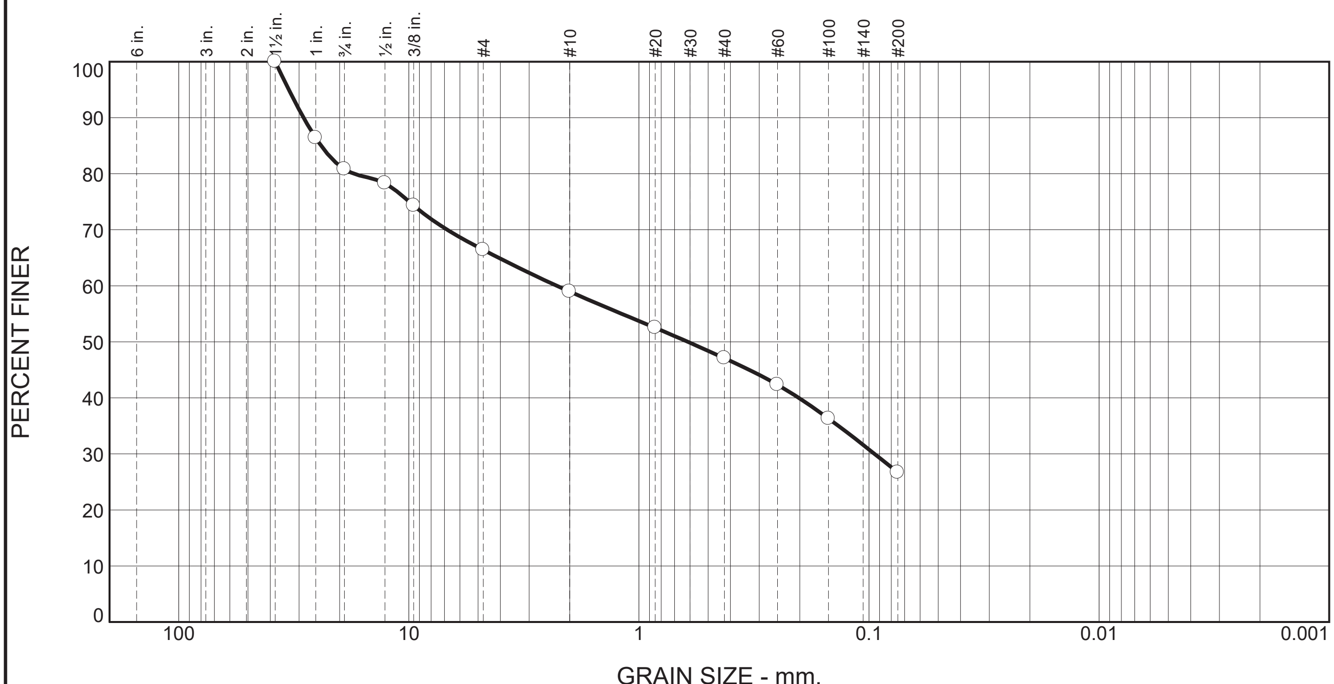
Project Manager B. Cardali Report Date 03.21.17 Date Reviewed *03.22.17*

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests: Water Content %	LL %	PL %	Gravel %	Sand %	Fines (<#200) %	Corrosivity: pH	Sulfate (mg/kg)	Chloride (mg/kg)	Resistivity (Mohms-cm)	GTL Resist	Laboratory Log and Soil Description
BB-YCN-101	3D	10-12	G1	14.6			33.6	39.7	26.7						Light Brown f-c SAND, some f-c Gravel, some Silt
BB-YCN-101	4D	15-17	G2	14.3			45.3	42.4	12.3						Light Brown f-c GRAVEL and f-c SAND, little Silt
BB-YCN-102	2D	5-7	G3	10.4			13.9	56.5	29.6						Brown f-c SAND, some Silt, little f-c Gravel
BB-YCN-103	3D	10-12	G4	13.8			38.4	47.3	14.3						Brown f-c SAND and f-c GRAVEL, little Silt
BB-YCN-104	1D	2-4	G5	2.8			64.8	27.6	7.6						Light Grey f-c GRAVEL, some f-c Sand, trace Silt
BB-YCN-104	3D	10-12	G6	15.2			7.2	66.0	26.8						Brown f-c SAND, some Silt, trace fine Gravel

THIELSCH ENGINEERING

195 Frances Avenue
Cranston, RI 02910 401-467-6454

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	19.2	14.4	7.4	11.9	20.4	26.7	

TEST RESULTS (D6913)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	86.4		
.75	80.8		
0.5	78.3		
.375	74.3		
#4	66.4		
#10	59.0		
#20	52.5		
#40	47.1		
#60	42.3		
#100	36.3		
#200	26.7		

* (no specification provided)

Material Description

Light Brown f-c SAND, some f-c Gravel, some Silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 28.6812 D_{85}= 24.0598 D_{60}= 2.2733
D_{50}= 0.6129 D_{30}= 0.0946 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 03.13.17 **Date Tested:** 03.16.17
Tested By: IA
Checked By: Matthew Colman, P.E.
Title: Laboratory Manager

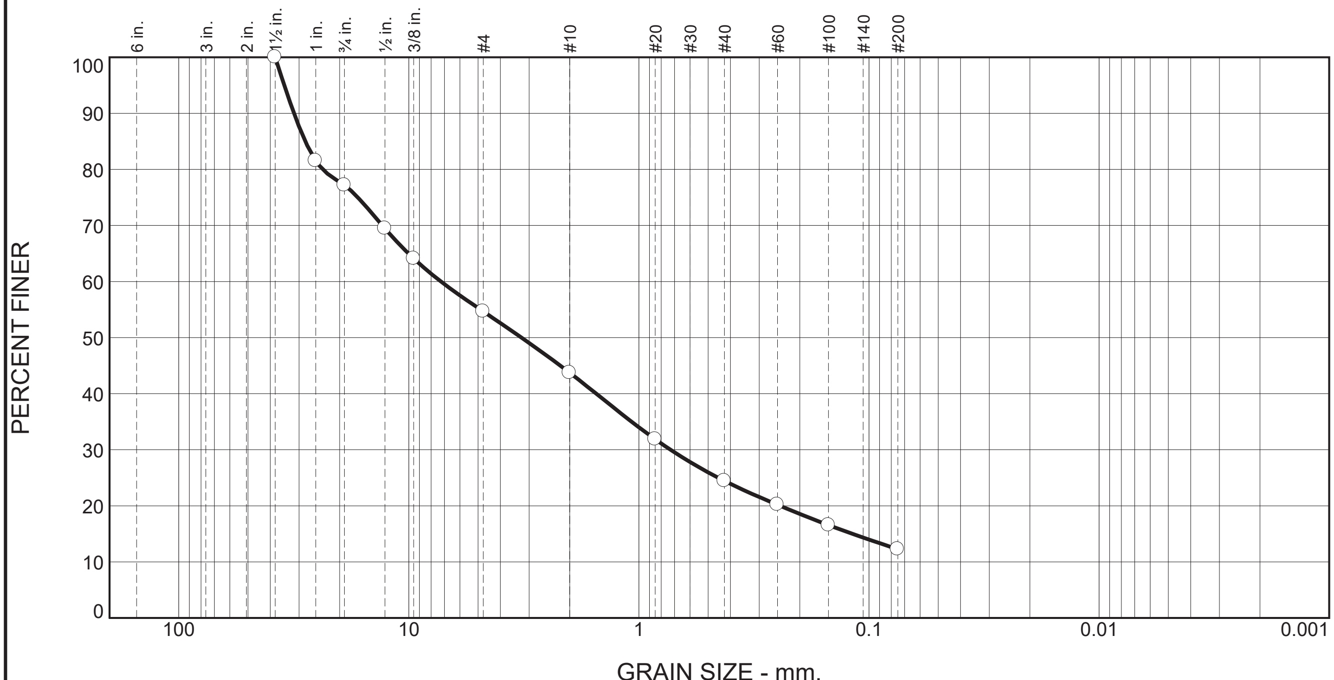
Source of Sample: Borings **Depth:** 10-12'
Sample Number: BB-YCN-101 / 3D
Date Sampled:

Thielsch Engineering Inc.

Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	22.8	22.5	11.0	19.3	12.1	12.3	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	81.5		
.75	77.2		
0.5	69.4		
.375	64.1		
#4	54.7		
#10	43.7		
#20	31.9		
#40	24.4		
#60	20.2		
#100	16.6		
#200	12.3		

* (no specification provided)

Material Description

Light Brown f-c GRAVEL and f-c SAND, little Silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 31.5568 D_{85}= 28.2022 D_{60}= 7.2512
D_{50}= 3.2388 D_{30}= 0.7284 D_{15}= 0.1178
D_{10}= C_u= C_c=

Remarks

Date Received: 03.13.17 **Date Tested:** 03.16.17
Tested By: IA
Checked By: Matthew Colman, P.E.
Title: Laboratory Manager

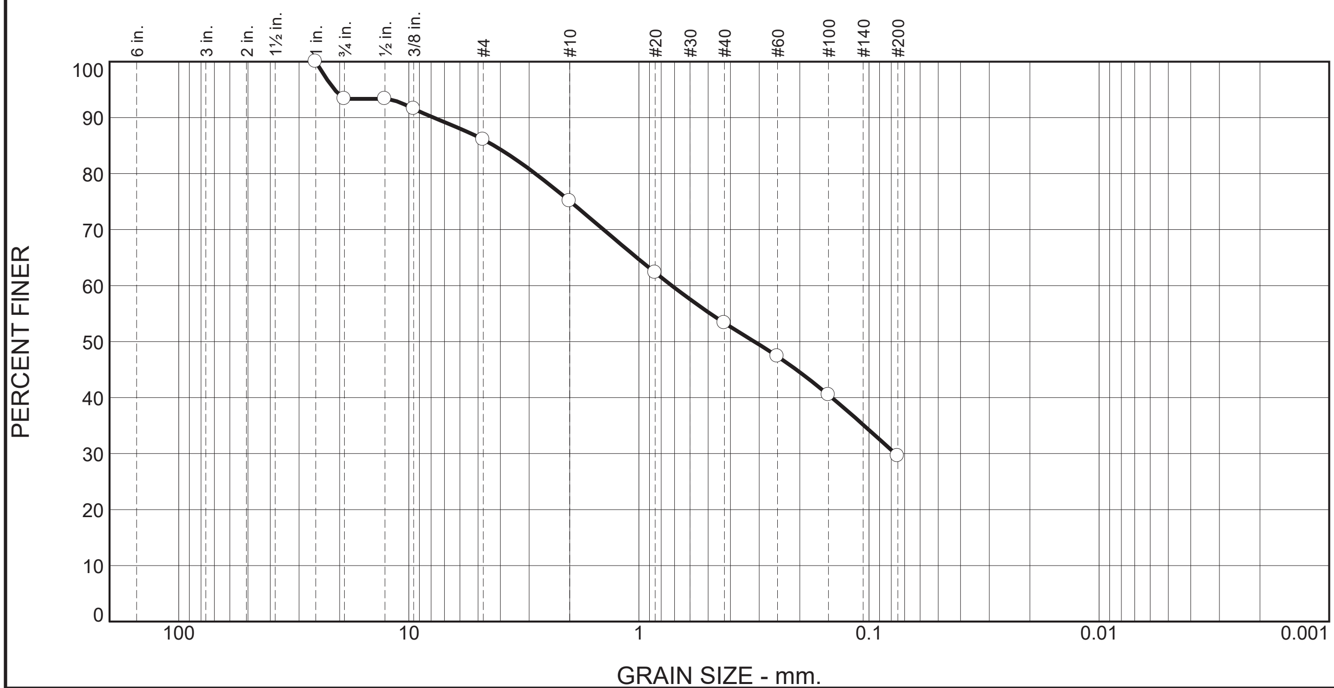
Source of Sample: Borings **Depth:** 15-17'
Sample Number: BB-YCN-101 / 4D
Date Sampled:

Thielsch Engineering Inc.

Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-2

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.6	7.3	11.0	21.8	23.7	29.6	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	93.4		
0.5	93.4		
.375	91.6		
#4	86.1		
#10	75.1		
#20	62.3		
#40	53.3		
#60	47.4		
#100	40.5		
#200	29.6		

* (no specification provided)

Material Description

Brown f-c SAND, some Silt, little f-c Gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 7.7966 D_{85}= 4.2593 D_{60}= 0.7197
D_{50}= 0.3150 D_{30}= 0.0770 D_{15}=
D_{10}= C_u= C_c=

Remarks

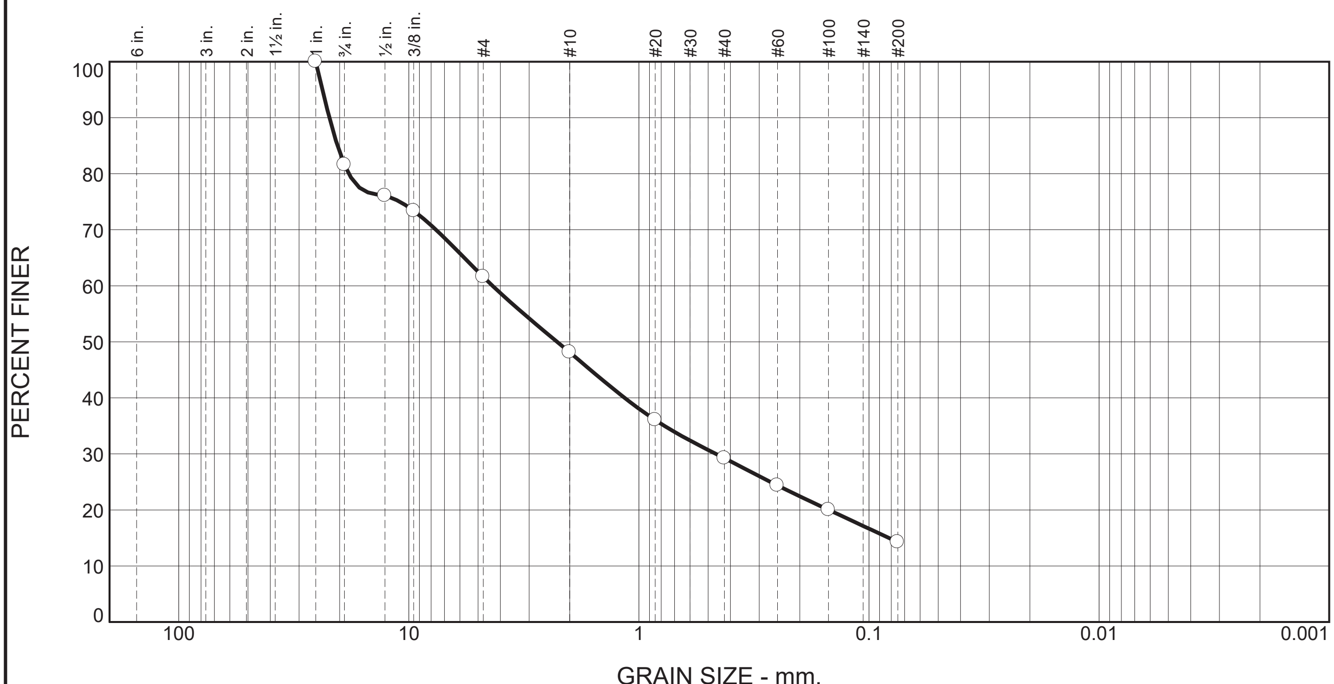
Date Received: 03.13.17 **Date Tested:** 03.16.17
Tested By: IA
Checked By: Matthew Colman, P.E.
Title: Laboratory Manager

Source of Sample: Borings **Depth:** 5-7'
Sample Number: BB-YCN-102 / 2D
Date Sampled:

Thielsch Engineering Inc.
Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-3

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	18.4	20.0	13.5	18.9	14.9	14.3	

TEST RESULTS (D6913)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	81.6		
0.5	76.1		
.375	73.4		
#4	61.6		
#10	48.1		
#20	36.1		
#40	29.2		
#60	24.4		
#100	20.0		
#200	14.3		

* (no specification provided)

Material Description

Brown f-c SAND and f-c GRAVEL, little Silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 22.1292 D_{85}= 20.4178 D_{60}= 4.3244
D_{50}= 2.2685 D_{30}= 0.4627 D_{15}= 0.0819
D_{10}= C_u= C_c=

Remarks

Date Received: 03.13.17 **Date Tested:** 03.16.17
Tested By: IA
Checked By: Matthew Colman, P.E.
Title: Laboratory Manager

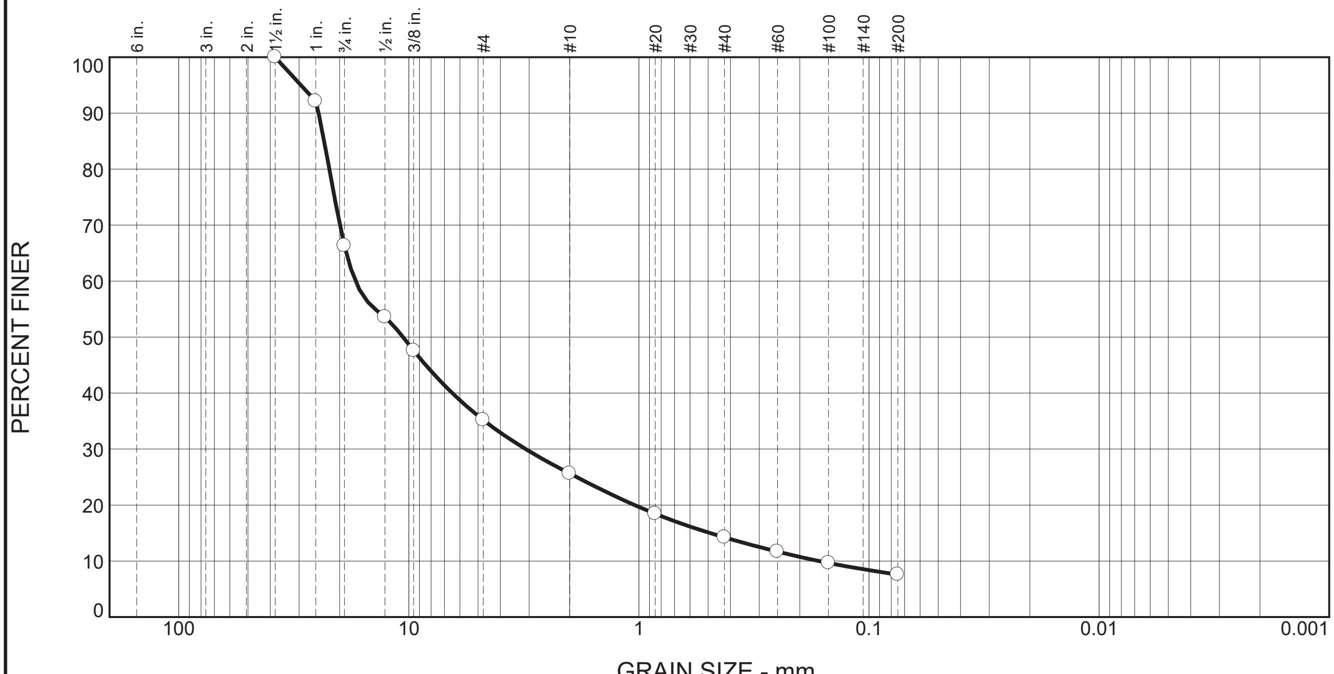
Source of Sample: Borings **Depth:** 10-12'
Sample Number: BB-YCN-103 / 3D
Date Sampled:

Thielsch Engineering Inc.

Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-4

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	33.7	31.1	9.6	11.4	6.6	7.6	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	92.1		
.75	66.3		
0.5	53.6		
.375	47.6		
#4	35.2		
#10	25.6		
#20	18.5		
#40	14.2		
#60	11.7		
#100	9.7		
#200	7.6		

* (no specification provided)

Material Description

Light Grey f-c GRAVEL, some f-c Sand, trace Silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 24.6935 D_{85}= 23.3181 D_{60}= 17.0603
D_{50}= 10.6049 D_{30}= 3.1037 D_{15}= 0.4897
D_{10}= 0.1646 C_u= 103.67 C_c= 3.43

Remarks

Date Received: 03.13.17 **Date Tested:** 03.16.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Borings **Depth:** 2-4'
Sample Number: BB-YCN-104 / 1D

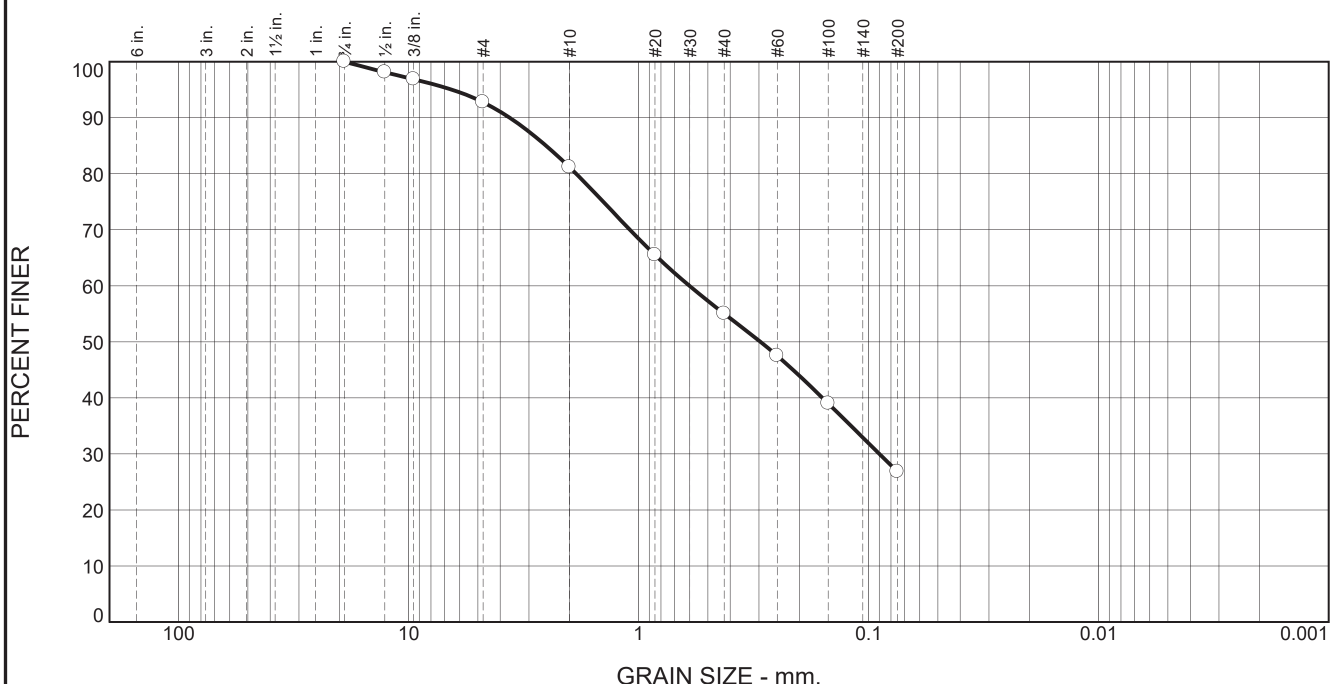
Date Sampled:

Thielsch Engineering Inc.

Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-5

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.2	11.6	26.2	28.2	26.8	

TEST RESULTS (D6913)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
0.5	98.1		
.375	96.9		
#4	92.8		
#10	81.2		
#20	65.5		
#40	55.0		
#60	47.5		
#100	39.0		
#200	26.8		

* (no specification provided)

Material Description

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

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 3.6382 D_{85}= 2.5271 D_{60}= 0.6015
D_{50}= 0.2956 D_{30}= 0.0898 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 03.13.17 **Date Tested:** 03.16.17
Tested By: IA
Checked By: Matthew Colman, P.E.
Title: Laboratory Manager

Source of Sample: Borings **Depth:** 10-12'
Sample Number: BB-YCN-104 / 3D
Date Sampled:

Thielsch Engineering Inc.

Cranston, RI

Client: Maine Department of Transportation
Project: Cape Neddick Bridge
York, Maine
Project No: 09.0025930.00 **Figure** S-6

APPENDIX D – ROCK CORE PHOTOGRAPHS

Cape Neddick Bridge Replacement
York, ME
Rock Core Photographs

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-YCN-104A	R1	15.4 - 17.3	20	88	12	52	GRANODIORITE	1
BB-YCN-104A	R2	17.3 - 20.9	40	93	32	74	GRANITE/GRANODIORITE	1
BB-YCN-104A	R3	20.9 - 25.4	60	111	52	96	GRANITE/GRANODIORITE	2
BB-YCN-101A	R1	20.0 - 21.5	17	94	4	24	GRANITE/GRANODIORITE	3
BB-YCN-101A	R2	21.5 - 26.5	58	97	28	47	GRANITE/GRANODIORITE	3,4
BB-YCN-101A	R3	26.5 - 30.0	42	100	4	10	GRANODIORITE	4

Notes: 1. Box row corresponds to the core box section in which the rock core sample is contained; Row 1=Top, Row 3=Bottom.
2. Top photo is dry, bottom photo is wet.

Cape Neddick Bridge Replacement
York, ME
Rock Core Photographs

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-YCN-101A	R4	30.0 - 33.0	36	100	10	28	GRANITE/GRANODIORITE	1
BB-YCN-101A	R5	33.0 - 36.5	42	100	25	60	GRANITE/GRANODIORITE	2

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

APPENDIX E – CALCULATIONS

Objective

Assess nominal and factored bearing resistance of a foundation on rock based on support in GRANITE/GRANODIORITE from borings BB-YCN-101A, and -104A.

Methodology

Use data from test borings and evaluate the nominal bearing resistance as follows:

1. Bedrock Properties From Test Borings
2. Calculation Of Rock Mass Rating
3. Determine Rock Property Constants s and m
4. Calculate Nominal Bearing Resistance of Bedrock q_n

References

1. American Association of State Highway and Transportation Officials, AASHTO LRFD Bridge Design Specifications: Customary U.S. Units, 6th edition, 2012. (AASHTO LRFD).

   Note: AASHTO 7th Edition is now in effect, but the coefficients used in the bedrock bearing evaluations are understood to be correlated relative to the older Hoek and Brown 1988 methodology. Therefore, RMR is used for the evaluation per LRFD 6th Edition rather than GSI per LRFD 7th Edition.

2. Wyllie, Duncan C., "Foundations on Rock", Second edition, 1992.

1. Rock Properties

Bedrock properties were obtained from rock core specimens and logs completed for the Cape Neddick Bridge Project in York, ME. This calculation is based on the data from borings BB-YCN-101A, and -104A.

Bedrock Quality

Boring	Run	Length of Core Run (ft)	Rec (%)	RQD %	Joint Spacing Desc.	Corr. Spacing (in)	Aperture Desc.	Corr. Aperture (in)	Joint Weathering
BB-YCN-101A	R1	1.5	94%	24%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh
BB-YCN-101A	R2	5.0	97%	47%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh to discolored
BB-YCN-101A	R3	3.5	100%	10%	Extremely Close to Close	<0.75-8	Tight to Partially Open	0.004-0.1	Fresh
BB-YCN-101A	R4	3.0	100%	28%	Very Close to Close	0.75-8	Partially Open to open	0.01-0.1	Fresh to discolored
BB-YCN-101A	R5	3.5	100%	60%	Very Close to Moderate	0.75-24	Partially Open to open	0.01-0.1	Fresh to discolored
BB-YCN-104A	R1	1.9	88%	52%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored
BB-YCN-104A	R2	3.6	93%	74%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored
BB-YCN-104A	R3	4.5	111%	96%	Close to Moderate	2.5-24	Partially Open to open	0.01-0.1	Fresh to discolored
			Avg RQD	49%					
			St. Dev RQD	18%					

RQD between 31 and 67% representative of rock for BB-YCN-101A, and -104 (mean-1 std deviation to mean).

Bedrock Strength

Boring	Run	LAB						Rock Type
		Depth of Sample (ft)	Depth of Sample into Rock (ft)	Elev Top of Sample (ft)	UCS (psi)	Modulus (ksi)	Unit Wt (pcf)	
BB-YCN-104A	R1	15.7	0.4	14.9	33,156	9,130	168	GRANODIORITE
BB-YCN-104A	R2	19	3.7	11.6	34,109	10,200	166	GRANITE

Select lowest strength rock encountered at BB-YCN-104A, 33,100 psi.

2. Calculation of Rock Mass Rating (RMR)

From AASHTO LRFD 6th Ed. Table 10.4.6.4-1, determine the RMR.

Parameter 1- Uniaxial Compressive Strength

$\sigma_{u.r} := 33.1\text{ksi} = 4766.4\cdot\text{ksf}$ Representative unconfined compressive strength of rock at BB-YCN-104.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_1 := 15$ for $\sigma_{u.r}$=>4320 ksf

Parameter 2- Drill Core Quality

Representative RQD from table above: 37-67%

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_2 := 8$

Parameter 3- Spacing of Joints

From Boring Logs, generally very close to moderately spaced =<.75 in to 2 feet, Typical spacing was 8 in. to 16 in.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating

$RR_3 := 10$

Parameter 4- Condition of Joints

From boring logs, hard joint walls and rough surface, with joint seperation less than 0.05 in., and described fresh to discolored.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_4 := 20$

Parameter 5- Ground Water Conditions

Hydrostatic Conditions- Water under moderate pressure

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_5 := 4$

Parameter 6-Adjustment for joint orientation

The joint sets are generally moderately dipping and generally rough and open. Therefore the joint orientation is considered Fair.

From AASHTO LRFD Table 10.4.6.4-2

Relative Rating $RR_6 := -7$

Total RMR Rating

$$RMR := RR_1 + RR_2 + RR_3 + RR_4 + RR_5 + RR_6$$

$$RMR = 50$$

From AASHTO LRFD Table 10.4.6.4-3 RMR= 41 to 60 is indicative of Fair Rock Quality

3. Determine Rock Property Constants s and m

Use AASHTO LRFD 6th Ed. Table 10.4.6.4-4 to develop empirircal rock property constants

Granite/Granodiorite is categorized as rock type E, coarse grained polymineralic igneous & metamorphic crystalline rocks, RMR=50, using s and m values interpolated from the logarithmic trend of plotted values from AASHTO Table 10.4.6.4-4 (plots on sheet 8).

$m := 0.71$

$s := 0.00025$

4. Calculate Nominal and Factored Bearing Resistance of Bedrock q_n and q_R

From Wyllie "Foundations on Rock"

Eq. 5.4 Pg.138

$$q_n := C_{f1}\cdot\sqrt{s}\cdot\sigma_{u.r}\cdot\left[1+\sqrt{m\cdot\left(s^{-\frac{1}{2}}\right)+1}\right]$$

Where

$C_{f1} := 1.0$ From Wyllie Table 5.4 Pg. 138 Correction factor for foundation shape for rectangular foundation:

$s = 0.00025$ For L/B>6, use factor C_{fl}=1.0,

$m = 0.71$ For L/B=1, use factor C_{fl}=1.12, therefore,

$\sigma_{u.r} = 33.1\cdot ksi$ For conservatism, assume long strip, lowest $C_{fl.}$

Nominal Bearing Resistance

$$q_n := C_{f1}\cdot\sqrt{s}\cdot\sigma_{u.r}\cdot\left[1+\sqrt{m\cdot\left(s^{-\frac{1}{2}}\right)+1}\right]$$

$q_n = 586\cdot ksf$ Say 90 ksf

Presumptive (allowable) values for massive igneous rock range from 12 ksf (IBC) to 120 ksf (DM7.2-142), implying q_n of 24 to 240 ksf. Assume for practical purposes q_n = 90 ksf. q_R = (0.45)(90 ksf) = 40 ksf

Factored Bearing Resistance for Strength Condition

Bearing Resistance Factor is specified in Table 10.5.5.2.2-1

$\phi_b := 0.45$ Footing on rock

$q_R := \phi_b\cdot q_n$

$q_R = 263.7\cdot ksf$ Say 40 ksf

→ Reference:I:\Mathcad\units.xmcd

10-22 **AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS**

Table 10.4.6.4-1 Geomechanics Classification of Rock Masses.

<table>
<tr><th colspan="3">Parameter</th><th colspan="7">Ranges of Values</th></tr>
<tr><td rowspan="3">1</td><td rowspan="2">Strength of intact rock material</td><td>Point load strength index</td><td>>175 ksf</td><td>85–175 ksf</td><td>45–85 ksf</td><td>20–45 ksf</td><td colspan="3">For this low range, uniaxial compressive test is preferred</td></tr>
<tr><td>Uniaxial compressive strength</td><td>>4320 ksf</td><td>2160–4320 ksf</td><td>1080–2160 ksf</td><td>520–1080 ksf</td><td>215–520 ksf</td><td>70–215 ksf</td><td>20–70 ksf</td></tr>
<tr><td colspan="2">Relative Rating</td><td>15</td><td>12</td><td>7</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">Drill core quality RQD</td><td colspan="2">90% to 100%</td><td>75% to 90%</td><td>50% to 75%</td><td colspan="2">25% to 50%</td><td><25%</td></tr>
<tr><td colspan="2">Relative Rating</td><td colspan="2">20</td><td>17</td><td>13</td><td colspan="2">8</td><td>3</td></tr>
<tr><td rowspan="2">3</td><td colspan="2">Spacing of joints</td><td colspan="2">>10 ft.</td><td>3–10 ft.</td><td>1–3 ft.</td><td colspan="2">2 in.–1 ft.</td><td><2 in.</td></tr>
<tr><td colspan="2">Relative Rating</td><td colspan="2">30</td><td>25</td><td>20</td><td colspan="2">10</td><td>5</td></tr>
<tr><td rowspan="2">4</td><td colspan="2">Condition of joints</td><td colspan="2">• Very rough surfaces
• Not continuous
• No separation
• Hard joint wall rock</td><td>• Slightly rough surfaces
• Separation <0.05 in.
• Hard joint wall rock</td><td>• Slightly rough surfaces
• Separation <0.05 in.
• Soft joint wall rock</td><td colspan="2">• Slicken-sided surfaces
or
• Gouge <0.2 in. thick
or
• Joints open 0.05–0.2 in.
• Continuous joints</td><td>• Soft gouge >0.2 in. thick
or
• Joints open >0.2 in.
• Continuous joints</td></tr>
<tr><td colspan="2">Relative Rating</td><td colspan="2">25</td><td>20</td><td>12</td><td colspan="2">6</td><td>0</td></tr>
<tr><td rowspan="4">5</td><td rowspan="3">Ground water conditions (use one of the three evaluation criteria as appropriate to the method of exploration)</td><td>Inflow per 30 ft. tunnel length</td><td colspan="2">None</td><td colspan="2"><400 gal./hr.</td><td colspan="2">400–2000 gal./hr.</td><td>>2000 gal./hr.</td></tr>
<tr><td>Ratio = joint water pressure/ major principal stress</td><td colspan="2">0</td><td colspan="2">0.0–0.2</td><td colspan="2">0.2–0.5</td><td>>0.5</td></tr>
<tr><td>General Conditions</td><td colspan="2">Completely Dry</td><td colspan="2">Moist only (interstitial water)</td><td colspan="2">Water under moderate pressure</td><td>Severe water problems</td></tr>
<tr><td colspan="2">Relative Rating</td><td colspan="2">10</td><td colspan="2">7</td><td colspan="2">4</td><td>0</td></tr>
</table>

Table 10.4.6.4-2 Geomechanics Rating Adjustment for Joint Orientations.

Strike and Dip Orientations of Joints		Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Ratings	Tunnels	0	–2	–5	–10	–12
	Foundations	0	–2	–7	–15	–25
	Slopes	0	–5	–25	–50	–60

Table 10.4.6.4-3 Geomechanics Rock Mass Classes Determined From Total Ratings.

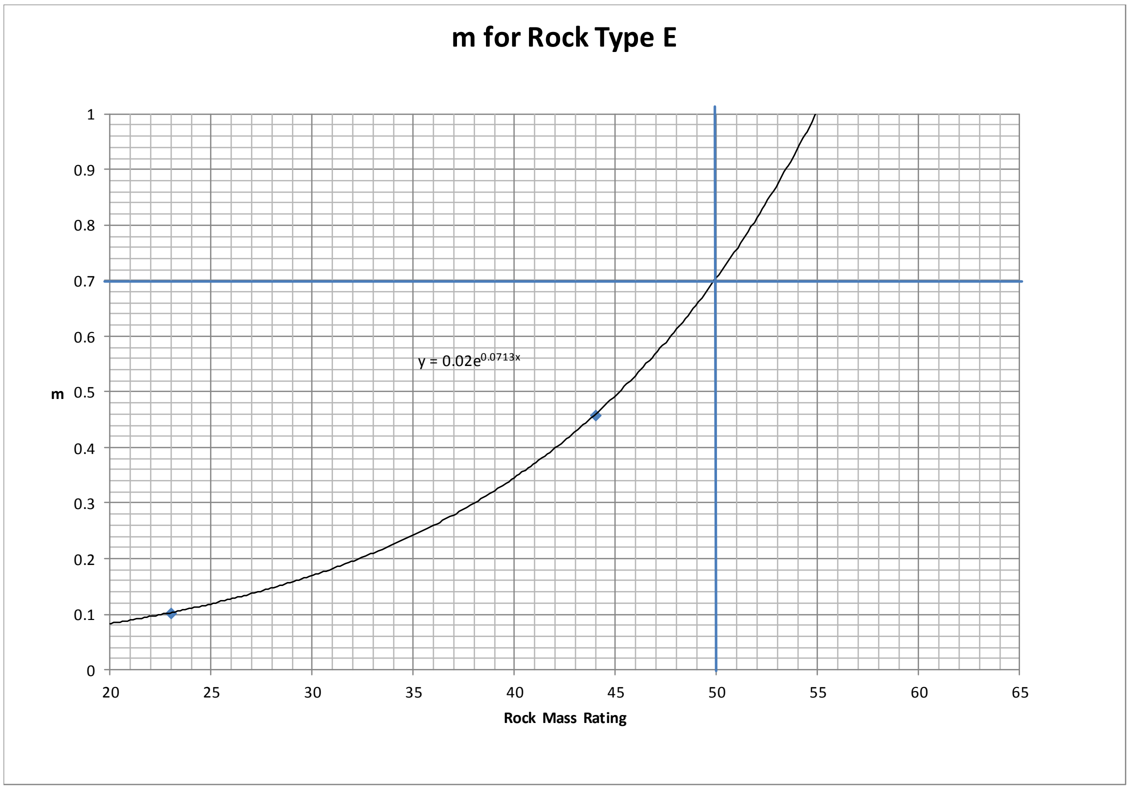
RMR Rating	100–81	80–61	60–41	40–21	<20
Class No.	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

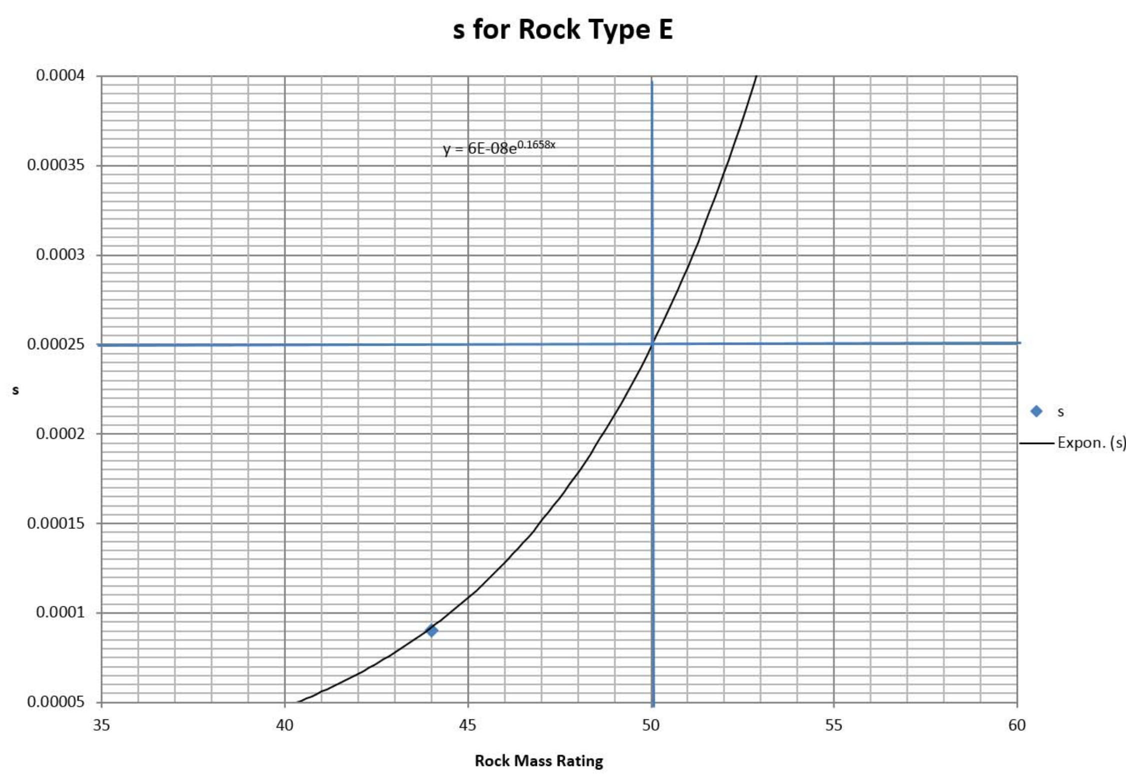
Table 10.4.6.4-4 Approximate relationship between rock-mass quality and material constants used in defining nonlinear strength (*Hoek and Brown, 1988*)

Rock Type:

A = Carbonate rocks with well developed crystal cleavage—*dolomite, limestone and marble*
B = Lithified argrillaceous rocks—*mudstone, siltstone, shale and slate (normal to cleavage)*
C = Arenaceous rocks with strong crystals and poorly developed crystal cleavage—*sandstone and quartzite*
D = Fine grained polyminerallic igneous crystalline rocks—*andesite, dolerite, diabase and rhyolite*
E = Coarse grained polyminerallic igneous & metamorphic crystalline rocks—*amphibolite, gabbro gneiss, granite, norite, quartz-diorite*

Rock Quality	Constants	A	B	C	D	E
INTACT ROCK SAMPLES Laboratory size specimens free from discontinuities CSIR rating: *RMR* = 100	*m* *s*	7.00 1.00	10.00 1.00	15.00 1.00	17.00 1.00	25.00 1.00
VERY GOOD QUALITY ROCK MASS Tightly interlocking undisturbed rock with unweathered joints at 3–10 ft. CSIR rating: *RMR* = 85	*m* *s*	2.40 0.082	3.43 0.082	5.14 0.082	5.82 0.082	8.567 0.082
GOOD QUALITY ROCK MASS Fresh to slightly weathered rock, slightly disturbed with joints at 3–10 ft. CSIR rating: *RMR* = 65	*m* *s*	0.575 0.00293	0.821 0.00293	1.231 0.00293	1.395 0.00293	2.052 0.00293
FAIR QUALITY ROCK MASS Several sets of moderately weathered joints spaced at 1–3 ft. CSIR rating: *RMR* = 44	*m* *s*	0.128 0.00009	0.183 0.00009	0.275 0.00009	0.311 0.00009	0.458 0.00009
POOR QUALITY ROCK MASS Numerous weathered joints at 2 to 12 in.; some gouge. Clean compacted waste rock. CSIR rating: *RMR* = 23	*m* *s*	0.029 3×10^{-6}	0.041 3×10^{-6}	0.061 3×10^{-6}	0.069 3×10^{-6}	0.102 3×10^{-6}
VERY POOR QUALITY ROCK MASS Numerous heavily weathered joints spaced <2 in. with gouge. Waste rock with fines. CSIR rating: *RMR* = 3	*m* *s*	0.007 1×10^{-7}	0.010 1×10^{-7}	0.015 1×10^{-7}	0.017 1×10^{-7}	0.025 1×10^{-7}


m for Rock Type E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
m
y = 0.02e^0.0713x
20
25
30
35
40
45
50
55
60
65
Rock Mass Rating


s for Rock Type E
0.0004
0.00035
0.0003
0.00025
0.0002
0.00015
0.0001
0.00005
s
y = 6E-08e^0.1658x
35
40
45
50
55
60
Rock Mass Rating
s
Expon. (s)