S.W.COLE ENGINEERING, INC.

GEOTECHNICAL DESIGN REPORT

20-1403

June 7, 2024

Geotechnical Engineering Services

WIN 026168.00
Route 105 (Razorville Road) over Davis Stream
Farrar Bridge #3929
Washington, Maine

Prepared For:
Maine Department of Transportation
Attention: Laura Krusinski, P.E.
State House Station 16
Augusta, ME 04333-0016

Prepared By:
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26 Coles Crossing Drive
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Attention: Laura Krusinski, P.E.
State House Station 16
Augusta, ME 04333-0016

Subject: Geotechnical Engineering Services
WIN 026168.00
Route 105 (Razorville Road) over Davis Stream
Farrar Bridge #3929 Replacement
Washington, Maine

Dear Laura:

In accordance with our Proposal, dated October 13, 2023, and project specific Assignment Letter #13, dated October 17, 2023, we have completed explorations and geotechnical engineering services for the subject project. The purpose of our services was to obtain subsurface information and provide geotechnical recommendations for foundations and earthwork associated with the proposed bridge replacement. Our scope of services included subsurface explorations, soils laboratory testing, geotechnical analyses of the subsurface findings, and preparation of this report.

The services provided by S. W. Cole Engineering, Inc. (S.W.COLE) were conducted in accordance with our Multi-PIN Agreement with the Maine Department of Transportation (MaineDOT), No. 20200623000000000765, dated June 22, 2020. The contents of this report are subject to the limitations set forth in Appendix A.

1.0 INTRODUCTION

1.1 Site Conditions

The site is Farrar Bridge (MaineDOT Bridge #3929) carrying Route 105 (Razorville Road) over Davis Stream in Washington, Maine. The site location is shown on the “Site Location Map” attached in Appendix B. Based on the provided information, we understand the existing structure was constructed in 1947 and consist of a ±20-foot-span by ±8-foot-rise steel-plate arch structure on concrete footings with a 15-degree-skew in a NW-SE orientation. We understand the structure is currently in poor condition with grout bags placed to protect undermining of the concrete footings in 1995 and repaired in 2012. Historic Plans indicate the structure prior to replacement in 1947 consisted of a timber superstructure supported by dry-laid stone abutments. We understand portions of the dry-laid stone structure may be present at the site.

1.2 Proposed Construction

We understand the existing structure will be replaced with a new single, precast concrete box culvert with a 24-foot-span by 9-foot-rise. We understand the proposed replacement structure will be 72 feet long (±50-foot-long box section plus tapered inlet and outlet sections) and have an 8-degree-skew. We understand the replacement structure will be rotated to realign with the flow of Davis Stream. We understand there will be minimal changes to the horizontal alignment of Route 105 (Razorville Road) and vertical grades of the roadway approaches. We anticipate the slopes on the inlet and outlet ends of the culvert shall have 1.75:1(H:V) or flatter riprap slopes. We understand the invert of the box culvert will be recessed approximately 3 feet into the stream.

2.0 EXPLORATIONS AND TESTING

2.1 Explorations

Two test borings (BB-WDS-101 and -102) and one test probe (BP-WDS-103) were made at the site between December 12 and December 13, 2023, by Seaboard Drilling, LLC (Seaboard) using a track-mounted Diedrich D-50 drill rig. The exploration locations were selected and established in the field by S.W.COLE using taped measurements from existing site features. The "as-drilled" exploration locations are shown on the "Boring Location Plan & Interpretive Subsurface Profile" attached in Appendix B. Logs of these test borings and a Key to Soil and Rock Descriptions and Terms used on the logs are attached as Appendix C.

2.2 Testing

The test borings were drilled using a combination of solid-stem auger, cased wash boring, and NQ2 rock core drilling techniques. The soils in the test borings were sampled at approximate 5-foot intervals using a split-spoon sampler and Standard Penetration Test (SPT) methods using a calibrated automatic hammer. Soil sampling was not performed in the test probe. Upon encountering refusal, borings BB-WDS-101 and BB-WDS-102 were advanced ±10 feet into bedrock using NQ2 rock coring.

The Seaboard drill rig was equipped with an automatic hammer to drive the split-spoon sampler. The hammer was calibrated per ASTM D4633-10 "Standard Test Method for Energy Measurement for Dynamic Penetrometers." Corrected N-values discussed in this report were computed by applying the corresponding average energy transfer factor of 1.087 to the raw field N-values. The hammer efficiency factor (1.087), uncorrected SPT blow counts, uncorrected and corrected SPT N-values, rock core intervals, and Rock Quality Designation (RQD) are shown on the boring logs provided in Appendix C.

Laboratory testing was performed on disturbed SPT samples obtained during the explorations. Laboratory testing was performed by S.W.COLE following applicable American Association of

State Highway and Transportation Officials (AASHTO) testing procedures. Laboratory testing included three natural water content tests, three grain size analyses (without hydrometer), and two unconfined rock core compressive strength tests. Moisture content and rock core compressive strength test results are shown on the boring logs in Appendix C. Results of the laboratory testing is provided in Appendix D.

3.0 SUBSURFACE CONDITIONS

3.1 Surficial and Bedrock Geology

According to the Maine Geological Survey's (MGS's) mapping of the Razorville Quadrangle, Maine (Open-File Map 86-66)[1], surficial geologic units mapped within the site vicinity consists of glacial stream deposits and glacial till. The geologic units encountered at the site generally consisted of fill from previous site development.

According to the MGS Bedrock Geology of the Razorville Quadrangle, Maine[2], bedrock in the site vicinity is mapped as Cape Elizabeth Formation. The bedrock recovered from the test borings is generally consistent with the mapped bedrock geology.

3.2 Soil and Bedrock

Subsurface conditions at the project site were explored by drilling two test borings and one test probe. The test borings encountered a soils profile generally consisted of fill overlying bedrock. The principal strata encountered in the explorations are summarized below. An Interpretive Subsurface Profile is attached in Appendix B. Refer to the boring logs in Appendix C for more detailed descriptions of the subsurface findings at the exploration locations.

Surficial: The test borings made within the roadway encountered a 10-inch-thick surficial layer of pavement.

Fill: Below the pavement, fill was encountered in each test boring extending to depths of about 14.1 to 15.8 feet below ground surface (bgs), corresponding to Elevation (El.) 271.2 to 269.2 feet. Where sampled, the fill generally consisted of:

- Brown, SAND, some to little gravel, some to little silt, and
- Brown, Gravelly SAND, little silt.

The fill was generally loose to very dense with SPT N_{60} values ranging from 9 to 72 blows per foot (bpf). In boring BB-WDS-101, a concrete mass was encountered at a depth of 10.2 feet bgs and a 3.9-foot length of concrete was cored prior to encountering bedrock.

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[1] Smith, Geoffrey W., and Thompson, Woodrow B., 1986, Reconnaissance surficial geology of the Razorville quadrangle, Maine: Maine Geological Survey, Open-File Map 86-66, map, scale 1:24,000.
[2] West, David P., Jr., and Peterman, Emily M., 2004, Bedrock geology of the Razorville quadrangle, Maine: Maine Geological Survey, Open-File Map 04-29, color map, scale 1:24,000.

Bedrock: Bedrock was encountered and sampled in borings BB-WDS-101 and BB-WDS-102. The top of intact bedrock varied from about 14.1 to 15.8 feet bgs (El. 271.2 to 269.2 feet). The bedrock generally consisted of grey, hard, quartz-biotite Schist of the Cape Elizabeth Formation. Joints were generally low angle to moderately dipping, very close to close, and tight to open.

The following table summarizes the approximate depths to bedrock, corresponding top of bedrock elevations and Rock Quality Designation (RQD) where encountered.

Boring Number (Substructure)	Approximate Depth to Bedrock (feet)	Approximate Bedrock Elevation (feet)	RQD (Rock Quality)
BB-WDS-101	14.1	271.2	R2: 32% (Poor) R3: 8% (Very Poor)
BB-WDS-102	15.8	269.2	R1: 33% (Poor) R2: 75% (Fair)

RQD values for the bedrock cores generally ranged from 8 to 75 percent corresponding to a Rock Quality of very poor to fair. Detailed descriptions of the rock core and RQD values for each core run are shown on the exploration logs in Appendix C. Rock core photographs are shown in Appendix C.

3.3 Groundwater

The water level was measured in borings BB-WDS-101 and BB-WDS-102 at depths of 10.1 and 10.5 feet bgs, respectively, after drilling. It should be noted that water was introduced during drilling; therefore, water levels indicated may not represent stabilized groundwater conditions. Long term groundwater information is not available but can be expected to be influenced by the water level of the Davis Stream. It should be anticipated that groundwater levels will fluctuate seasonally, particularly in response to periods of snowmelt and precipitation, changes in site use and the water level of Davis Stream.

4.0 GEOTECHNICAL EVALUATIONS

S.W.COLE conducted geotechnical engineering evaluations in accordance with 2020 AASHTO LRFD Bridge Design Specifications, 9th Edition (LRFD) and the MaineDOT Bridge Design Guide, 2003 Edition with revisions through June 2018 (MaineDOT BDG). Geotechnical engineering calculations and reference documents used to support the recommendations within this report are provided in Appendix E.

4.1 Precast Concrete Box Culvert

The proposed replacement structure will consist of a 24-foot-span by 9-foot-rise precast concrete box culvert (box culvert) with slope-tapered inlet and outlet walls. We understand the box culvert will be 72 feet long (±50 feet of box sections plus tapered inlet and outlet sections) with an 8-degree skew. We understand the slopes on the inlet and outlet ends of the culvert shall have 1.75:1(H:V) or flatter riprap slopes. We understand the invert of the box culvert will be recessed approximately 3 feet into the streambed.

Based on the MaineDOT BDG Section 8.3.1, the precast box culvert shall include toe walls at the inlet and outlet ends to prevent undermining. The toe walls should extend at least 1 foot below the maximum scour depth.

We anticipate the subgrade soils for the proposed box culvert will generally consist of bedrock. Based on the anticipated bearing strata, the box culvert shall be founded on a minimum 1-foot-thick mat of MaineDOT Standard Specification 703.19 Granular Borrow for Underwater Backfill modified with a maximum particle size of 4 inches (Modified Granular Borrow).

We anticipate bedrock removal will be needed to achieve proposed bearing elevation. Placing the precast box on dissimilar materials is to be avoided. Isolated points of contact of the bottom slab and bedrock can create localized bearing stress. To mitigate these concerns, high points in the bedrock surface should be excavated down to allow for all box segments to be installed on a minimum 12-inch-thick mat of bedding material.

4.2 Bearing Resistance

The bearing elevation of the box culvert bearing mat will be approximately El. 269 feet. The majority of subgrade at this elevation is expected to consist of bedrock. Based on these subgrade conditions, bedrock shall be removed and the box culvert installed on a 1-foot-thick layer of compacted, Modified Granular Borrow overlying a prepared bedrock surface.

The factored bearing resistance for a precast box culvert strength and service limit states based on LRFD Section 10.6.3.1.2a shall not exceed the factored bearing resistances shown in the following table.

Overall Foundation Width (feet)	Factored Bearing Resistance (ksf)	
	Strength Limit State	Service Limit State
26	13.7	8

Due to the size of the box culvert, the service limit state may govern the design. The bearing stress shall not exceed the nominal structural resistance of the structural concrete of 0.3×f'c.

4.3 Frost Protection

Based on the MaineDOT BDG Figure 5-1, the design freezing index for the Washington, Maine area is approximately 1,425 freezing degree-days. Based on MaineDOT BDG Section 5.2.1 and foundation subgrade soils with an average water content of about 10%, the maximum seasonal frost penetration is estimated to be on the order of about 6.7 feet. Considering this, we recommend foundations should have at least 6.7 feet of soil cover to provide frost protection.

Riprap is not to be considered as contributing to the overall thickness of soils required for frost protection.

4.4 Seismic Design Considerations

In accordance with LRFD Article 3.10.1, seismic analysis is not required for buried structures, except where they cross active faults. There are no known active faults in Maine; therefore, further seismic evaluation is not required.

4.5 Scour Protection

The box culvert shall be constructed with inlet and outlet toe walls that extend a minimum of 1 foot below the maximum depth of scour. Inlet and outlet toe walls will be protected by streambed armoring consisting of plain riprap aprons (MaineDOT Standard Specification 703.26 Plain Riprap). The riprap side slopes shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface. Riprap side slopes shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of Granular Borrow for Underwater Backfill bedding material in accordance with MaineDOT Standard Detail 610(02).

4.6 Construction Considerations

Construction of the new structure will include earth and rock excavation to achieve the proposed subgrade elevation as well as removal of the existing structure. Construction phase dewatering is recommended to allow for the bearing pad construction in the dry.

The box culvert will be constructed on a minimum 1-foot-thick layer of compacted Modified Granular Borrow. We anticipate bedrock excavation will be needed to allow for installation of the bedding material. The nature, slope, and degree of fracturing in the bedrock will not be evident until the entire foundation excavation is made. The soil envelope and box culvert backfill shall consist Modified Granular Borrow. The Granular Borrow backfill should be placed in maximum 8-inch lifts (loose measure) and compacted to at least 92 percent of the AASHTO T-180 maximum dry density. The precast concrete box culvert shall be installed in conformance with MaineDOT BDG Section 8 and MaineDOT Standard Specification Section 534.

Saturated soils and water seepage will be encountered during construction and in excavations. There may be localized sloughing and instability of excavations and cut slopes. The Contractor should control groundwater and surface water infiltration using temporary ditches, sump pumps, granular drainage blankets, stone ditch protection, or hand-laid riprap with geotextile underlayment to divert groundwater and surface water. The design and planning of excavations, excavation support systems, and dewatering is the responsibility of the contractor.

5.0 CLOSURE

It has been a pleasure to be of assistance to you with this phase of your project. We look forward to working with you during the construction phase of the project.

Sincerely,

S. W. Cole Engineering, Inc.

2024.06.07 11:28:36 -04'00'

STATE OF MAINE
MICHAEL A. ST. PIERRE
No. 12519
LICENSED
PROFESSIONAL ENGINEER

Michael St. Pierre, P.E.
Principal Geotechnical Engineer

Robert E. Chaput, Jr.

Robert E. Chaput, Jr., P.E.
Principal Geotechnical Engineer

MAS:rec

APPENDIX A
Limitations

This report has been prepared for the exclusive use of Maine Department of Transportation for specific application to the Farrar Bridge #3929 Replacement (WIN 026168.00) carrying Route 105 (Razorville Road) over Davis Stream in Washington, Maine. S. W. Cole Engineering, Inc. (S.W.COLE) has endeavored to conduct our services in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made.

The soil profiles described in the report are intended to convey general trends in subsurface conditions. The boundaries between strata are approximate and are based upon interpretation of exploration data and samples.

The analyses performed during this investigation and recommendations presented in this report are based in part upon the data obtained from subsurface explorations made at the site. Variations in subsurface conditions may occur between explorations and may not become evident until construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and to review the recommendations of this report.

Observations have been made during exploration work to assess site groundwater levels. Fluctuations in water levels will occur due to variations in rainfall, temperature, and other factors.

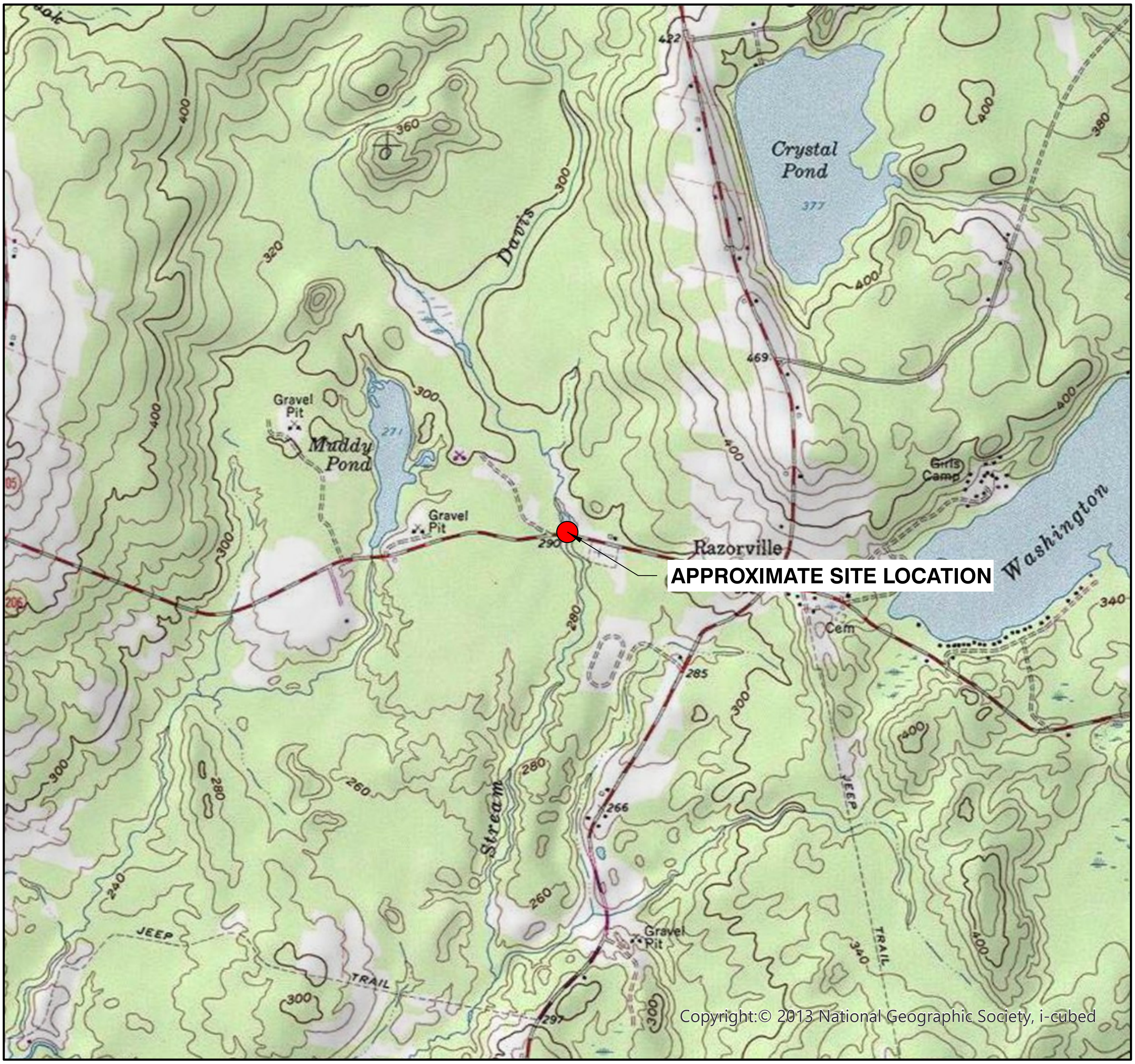
S.W.COLE's scope of services has not included the investigation, detection, or prevention of any Biological Pollutants at the project site or in any existing or proposed structure at the site. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

Recommendations contained in this report are based substantially upon information provided by others regarding the proposed project. In the event that any changes are made in the design, nature, or location of the proposed project, S.W.COLE should review such changes as they relate to analyses associated with this report. Recommendations contained in this report shall not be considered valid unless the changes are reviewed by S.W.COLE.

S.W.COLE ENGINEERING, INC.

APPENDIX B

Figures



N
W E
S

2,000 0 2,000 4,000

Scale in Feet

S.W.COLE ENGINEERING, INC.

MAINEDOT

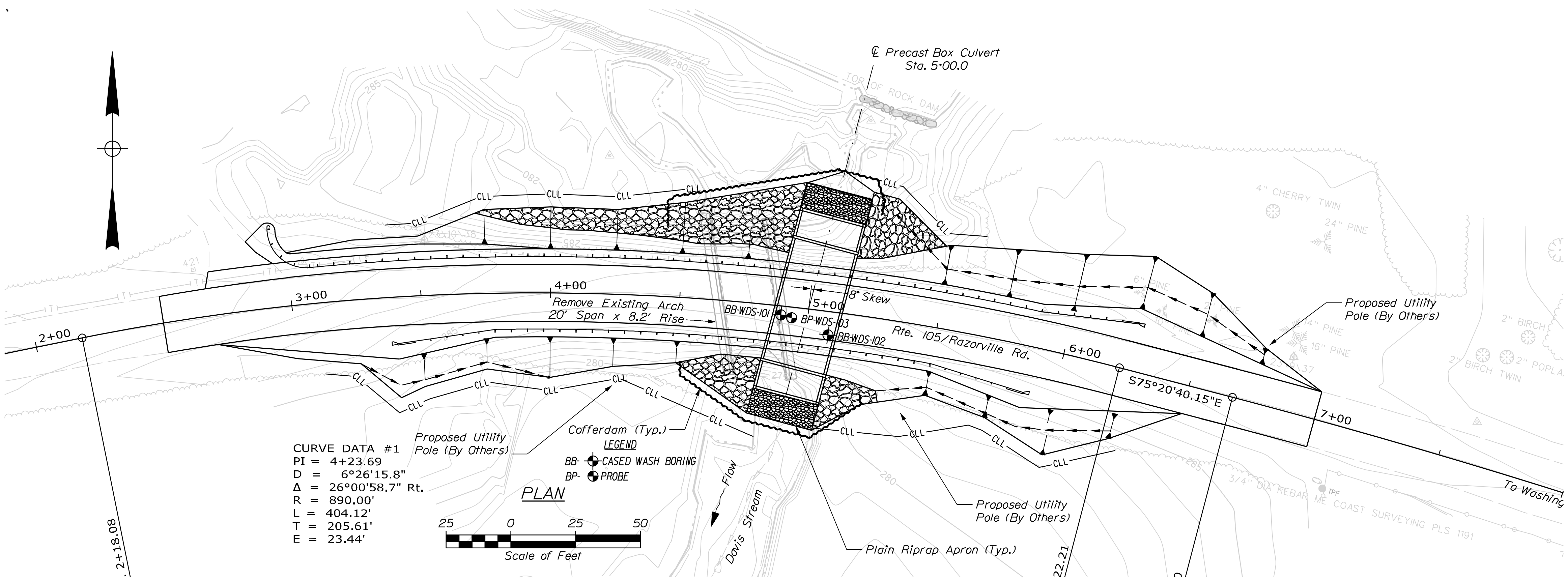
SITE LOCATION MAP

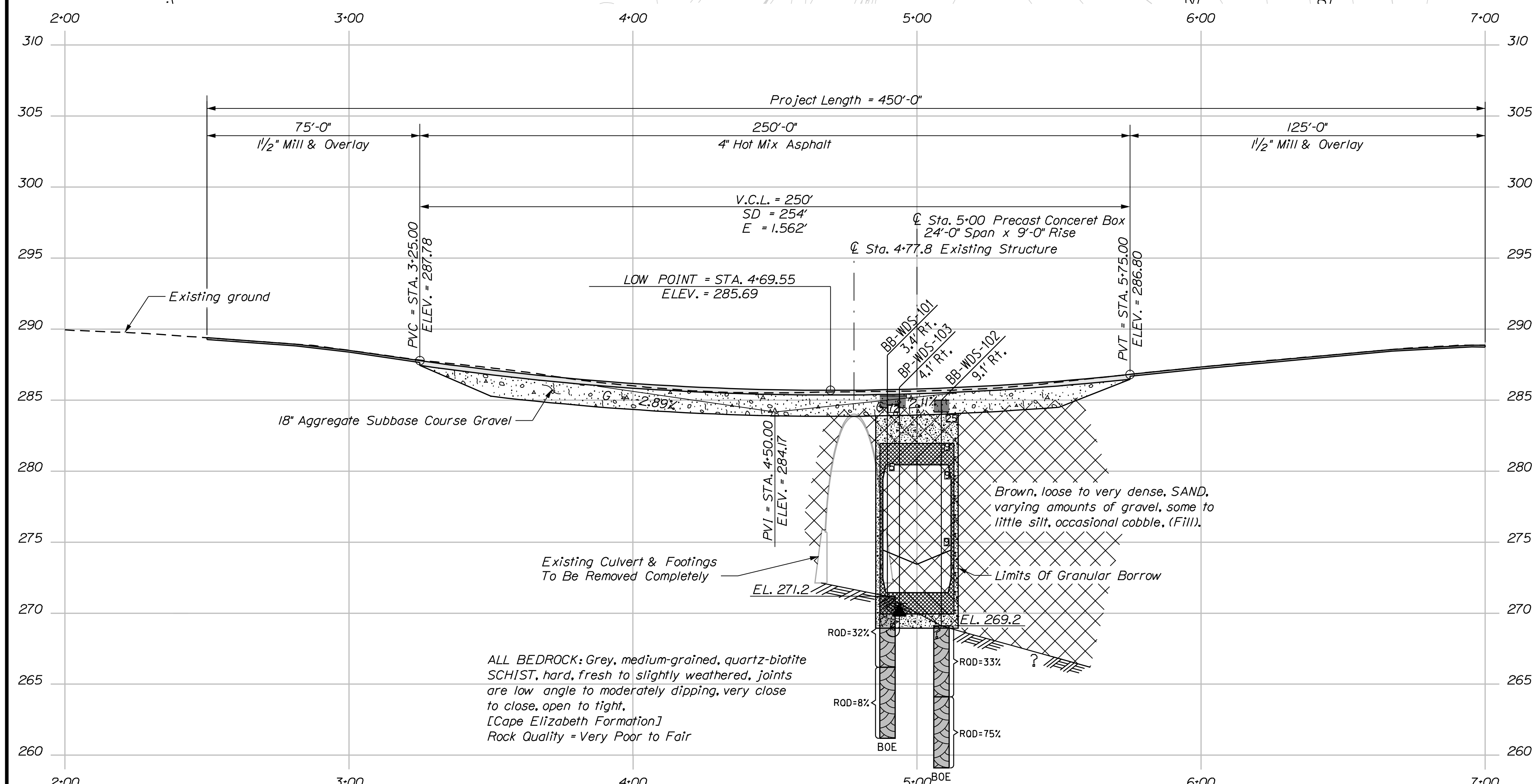
FARRAR BRIDGE #3929 REPLACEMENT
ROUTE 105 (RAZORVILLE ROAD) OVER DAVIS STREAM
WASHINGTON, MAINE
WIN 026168.00

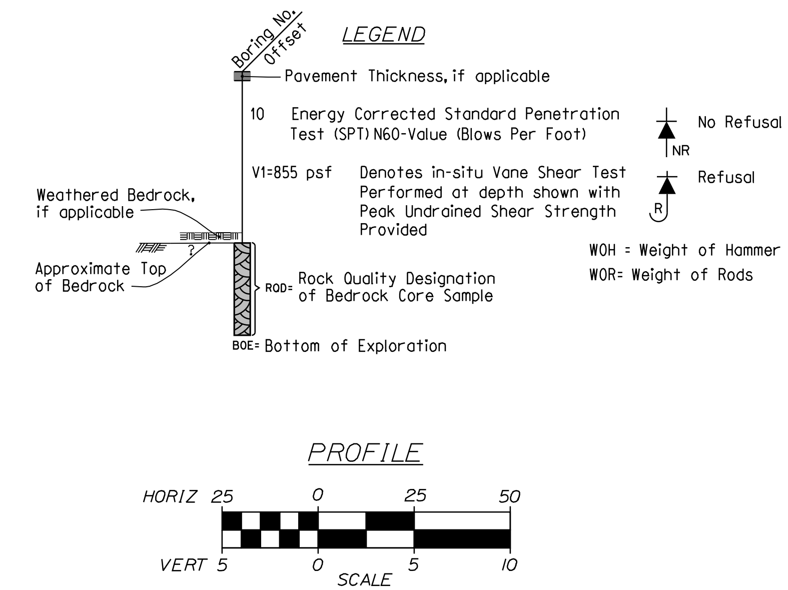
Job No.	20-1403-026168	Scale	1" = 2000'
Date:	04/16/2024	Sheet	1

NOTE:
SITE LOCATION MAP PREPARED FROM ESRI ArcGIS ONLINE AND DATA PARTNERS INCLUDING USGS AND © 2007 NATIONAL GEOGRAPHIC SOCIETY.

R:\2020\20-1403\ArcProject\20-1403.aprx, 4/15/2024 9:07 PM, 1:24,000, Filename: ...\GEOTECH\MSTA\006_BLP&SP1.dgn   Division: GEOTECH   Username: Terry.White   Date:6/3/2024







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

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2616800

BRIDGE NO. 3929   WIN 26168.00   BRIDGE PLANS

PROJ. MANAGER	B. Nichols	BY	DATE
DESIGN-DETAILED	T. Aguilar	MRP	Jan\2023
CHECKED-REVIEWED	------	------	------
DESIGN2-DETAILED2	M.ST.PIERRE	T.WHITE	APR 2024
DESIGN3-DETAILED3	------	------	------
REVISIONS 1	------		------
REVISIONS 2	------		------
REVISIONS 3	------		------
REVISIONS 4	------		------
FIELD CHANGES	------		------

SIGNATURE

P.E. NUMBER

DATE

FARRAR BRIDGE
DAVIS STREAM
WASHINGTON   KNOX COUNTY

BORING LOCATION PLAN &
INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
2
OF 3

S.W.COLE
ENGINEERING, INC.

APPENDIX C

Boring Logs,
Key to Soil and Rock Descriptions and Terms &
Rock Core Photos

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations (in this order, if applicable):
Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
Name (Sand, Silty Sand, Clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

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

MODIFIED BURMISTER SYSTEM

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

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) Silty or Clayey gravels; and (3) Silty, Clayey or Gravelly sands. Density is rated according to standard penetration resistance (N-value).

Density of Cohesionless Soils	Standard Penetration Resistance N_{60}-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

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

Consistency of Cohesive soils	SPT N_{60}-Value (blows per foot)	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD\ (\%) = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

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

Rock Quality Based on RQD

Rock Quality	RQD (%)
Very Poor	≤25
Poor	26 - 50
Fair	51 - 75
Good	76 - 90
Excellent	91 - 100

Desired Rock Observations (in this order, if applicable):
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -tightness (tight, open, or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream
Location: Washington, ME

Boring No.: BB-WDS-101
WIN: 26168.00

Driller:	Seaboard Drilling	**Elevation (ft.)**	285.3	**Auger ID/OD:**	5" Solid Stem
Operator:	R. Hackett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Celamy	**Rig Type:**	Track-mounted Diedrich D-50	**Hammer Wt./Fall:**	140 lb / 30"
Date Start/Finish:	12-13-2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2 2"
Boring Location:	Sta. 4+89.6, 3.4 ft Rt.	**Casing ID/OD:**	HW 4"/4.5"	**Water Level*:**	10.1 ft (after drilling)
Hammer Efficiency Factor:	1.087	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/15	0.90 - 2.90	23-20-20-20	40	72	SSA	284.5		10" of Pavement. (0.8) Brown, moist, very dense, SAND, some gravel, little silt, (Fill).	15404A A-1-b, SM WC=5.8%
5	2D	24/5	5.00 - 7.00	2-1-2-3	3	5				Brown, moist, loose, SAND, some silt, little gravel, (Fill).	
10	MD	2/0	10.00 - 10.17	50/2"	- -		75	275.1		No recovery. (10.2)	
	R1	47/35	10.20 - 14.12				NQ2			R1 Core: Concrete.	
	R2	60/48	14.12 - 19.12	RQD = 32%			NQ2	271.2		(14.1) Top of Bedrock at Elev. 271.2 ft. R2: Bedrock: Grey, medium-grained, quartz-biotite SCHIST, hard, fresh to very slight weathering, joints are low angle to modeately dipping, very close to close, open to tight, (Cape Elizabeth Formation). Rock Quality = Poor R2: Core Times (min:sec) 14.1-15.1 ft (3:40) 15.1-16.1 ft (4:06) 16.1-17.1 ft (3:13) 17.1-18.1 ft (4:36) 18.1-19.1 ft (4:00) 80% Recovery	15405A qp=10,040psi UW=170.6pcf
15											
20	R3	60/60	19.12 - 24.12	RQD = 8%				261.2		R3: Bedrock: Similar to R2. Rock Quality = Very Poor R3: Core Times (min:sec) 19.1-20.1 ft (4:06) 20.1-21.1 ft (4:50) 21.1-22.1 ft (4:48) 22.1-23.1 ft (3:10) 23.1-24.1 ft (4:36) 100% Recovery (24.1)	
25											

Remarks:

Autohammer SN 362; Calibrated 11/03/2023.

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: Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream
Location: Washington, ME

Boring No.: BB-WDS-101
WIN: 26168.00

Driller:	Seaboard Drilling	**Elevation (ft.)**	285.3	**Auger ID/OD:**	5" Solid Stem
Operator:	R. Hackett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Celamy	**Rig Type:**	Track-mounted Diedrich D-50	**Hammer Wt./Fall:**	140 lb / 30"
Date Start/Finish:	12-13-2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2 2"
Boring Location:	Sta. 4+89.6, 3.4 ft Rt.	**Casing ID/OD:**	HW 4"/4.5"	**Water Level*:**	10.1 ft (after drilling)
Hammer Efficiency Factor:	1.087	**Hammer Type:**	Automatic ☒	Hydraulic ☐	Rope & Cathead ☐

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										**Bottom of Exploration at 24.1 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Autohammer SN 362; Calibrated 11/03/2023.

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream **Location:** Washington, ME	**Boring No.:** BB-WDS-102 **WIN:** 26168.00

Driller:	Seaboard Drilling	**Elevation (ft.)**	285.0	**Auger ID/OD:**	5" Solid Stem
Operator:	R. Hackett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Celamy	**Rig Type:**	Track-mounted Diedrich D-50	**Hammer Wt./Fall:**	140 lb / 30"
Date Start/Finish:	12-12-2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2 2"
Boring Location:	Sta. 5+08.6, 9.1 ft Rt.	**Casing ID/OD:**	HW 4"/4.5"	**Water Level*:**	10.5 ft (after drilling)
Hammer Efficiency Factor:	1.087	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	284.2		10" of Pavement. 0.8	
	1D	24/10	1.30 - 3.30	8-8-6-5	14	25				Brown, moist, medium dense, SAND, some gravel, little silt, (Fill).	
	2D	24/10	3.30 - 5.30	4-2-3-3	5	9				Similar to above, except loose.	15406A A-1-b, SM WC=14.1%
5	3D	24/6	5.30 - 7.30	2-2-3-1	5	9				Brown, wet, loose, SAND, some silt, little gravel, (Fill).	
10	4D	24/17	10.00 - 12.00	2-2-3-1	5	9	97			Brown, wet, loose, Gravelly SAND, little silt, (Fill)	15407A A-1-b, SM WC=9.3%
							165				
							365				
							210				
							55				
15	5D	8/5	15.00 - 15.67	23-50/2"	- -		168			Similar to above.	
	R1	60/60	15.90 - 20.90	RQD = 33%			NQ2	269.2		15.8 Top of Bedrock at Elev 269.2 ft. R1: Bedrock: Grey, medium-grained, quartz-biotite SCHIST, hard, fresh to very slight weathering, joints are low angle to modeately dipping, very close to close, open to tight, (Cape Elizabeth Formation). Rock Quality = Poor R1: Core Times (min:sec) 15.9-16.9 ft (4:35) 16.9-17.9 ft (4:40) 17.9-18.9 ft (3:42) 18.9-19.9 ft (5:10) 19.9-20.9 ft (4:30) 100% Recovery	
20	R2	60/56	20.90 - 25.90	RQD = 75%						R2: Similar to R1. Rock Quality = Fair R2: Core Times (min:sec) 20.9-21.9 ft (4:30) 21.9-22.9 ft (4:00) 22.9-23.9 ft (5:00)	15408A qp=8,750psi UW=171.2pcf
25											

Remarks:

Autohammer SN 362; Calibrated 11/03/2023.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream
Location: Washington, ME

Boring No.: BB-WDS-102

WIN: 26168.00

Driller:	Seaboard Drilling	**Elevation (ft.)**	285.0	**Auger ID/OD:**	5" Solid Stem
Operator:	R. Hackett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Celamy	**Rig Type:**	Track-mounted Diedrich D-50	**Hammer Wt./Fall:**	140 lb / 30"
Date Start/Finish:	12-12-2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2 2"
Boring Location:	Sta. 5+08.6, 9.1 ft Rt.	**Casing ID/OD:**	HW 4"/4.5"	**Water Level*:**	10.5 ft (after drilling)
Hammer Efficiency Factor:	1.087	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25								259.1		23.9-24.9 ft (4:30) 24.9-25.9 ft (4:45) 93% Recovery 25.9 **Bottom of Exploration at 25.9 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Autohammer SN 362; Calibrated 11/03/2023.

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* 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: Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream
Location: Washington, ME

Boring No.: BP-WDS-103
WIN: 26168.00

Driller:	Seaboard Drilling	**Elevation (ft.)**	285.3	**Auger ID/OD:**	5" Solid Stem
Operator:	R. Hackett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Celamy	**Rig Type:**	Track-mounted Diedrich D-50	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	12-12-2023	**Drilling Method:**	Solid-Stem Auger	**Core Barrel:**	N/A
Boring Location:	Sta. 4+93.8, 4.1 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	Not observed
Hammer Efficiency Factor: N/A		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			10" of Pavement.	
								284.5		0.8 Probable Fill	
5											
								276.3		9.0 Probable granular soil with cobbles based on drilling action.	
10											
								270.7		14.6 **Bottom of Exploration at 14.6 feet below ground surface.** Auger Refusal.	
15											
20											
25											

Remarks:

Auger probe; No sampling.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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MaineDOT

Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream

Washington, Maine

Rock Core Photograph

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-WDS-102	R1	15.9 – 20.9	60	100%	20	33%	SCHIST	1
BB-WDS-102	R2	20.9 – 25.9	56	93%	45	75%	SCHIST	2
BB-WDS-101	R1	10.2 – 14.1	35	74%	N/A	N/A	CONCRETE	4

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Transition between core runs within box row is marked by wood separators.

MaineDOT

Farrar Bridge #3929 carries Route 105 (Razorville Road) over Davis Stream

Washington, Maine

Rock Core Photograph

Boring No.	Run	Depth (ft)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-WDS-101	R2	14.1 – 19.1	48	80%	19	32%	SCHIST	1
BB-WDS-101	R3	19.1 – 24.1	60	100%	5	8%	SCHIST	2

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Transition between core runs within box row is marked by wood separators.

APPENDIX D

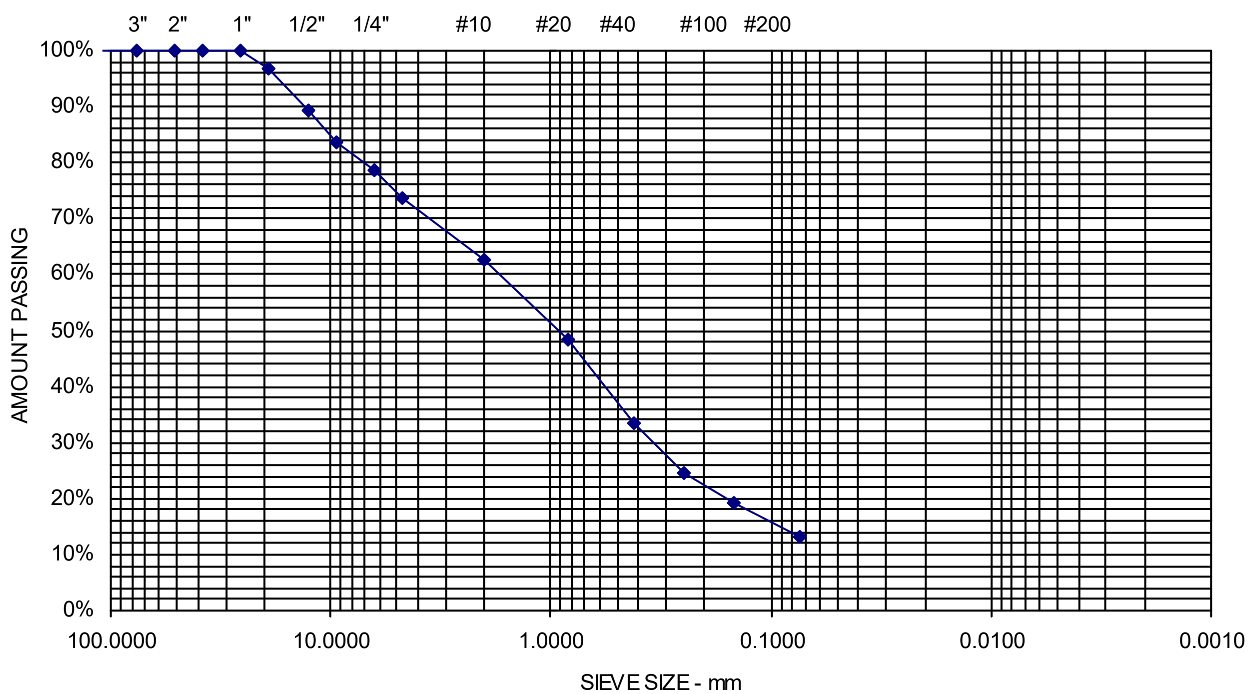
Laboratory Test Results

Report of Gradation

ASTM C-117 & C-136

Project Name	VARIOUS ME - STATEWIDE BRIDGE PROJECTS (20200623000000000765) - GEOTECHNICAL INVESTIGATIONS AND	Project Number	20-1403
Client	STATE OF MAINE DEPARTMENT OF TRANSPORTATION	Lab ID	15404A
Exploration	**BB-WDS-101**	Date Received	2/16/2024
Material Source	**BB-WDS-101, 1D, 0.9 FT**	Date Completed	2/19/2024
		Tested By	BRANDON CHAPUT

STANDARD DESIGNATION (mm/µm)	SIEVE SIZE	AMOUNT PASSING (%)	
150 mm	**6"**	**100**	
100 mm	**4"**	**100**	
75 mm	**3"**	**100**	
50 mm	**2"**	**100**	
38.1 mm	**1-1/2"**	**100**	
25.0 mm	**1"**	**100**	
19.0 mm	**3/4"**	**97**	
12.5 mm	**1/2"**	**89**	
9.5 mm	**3/8"**	**84**	
6.3 mm	**1/4"**	**79**	
4.75 mm	**No. 4**	**74**	26.3% Gravel
2.00 mm	**No. 10**	**63**	
850 um	**No. 20**	**48**	
425 um	**No. 40**	**33**	60.6% Sand
250 um	**No. 60**	**25**	
150 um	**No. 100**	**19**	
75 um	**No. 200**	**13.1**	13.1% Fines



Comments: Moisture Content: 5.8%

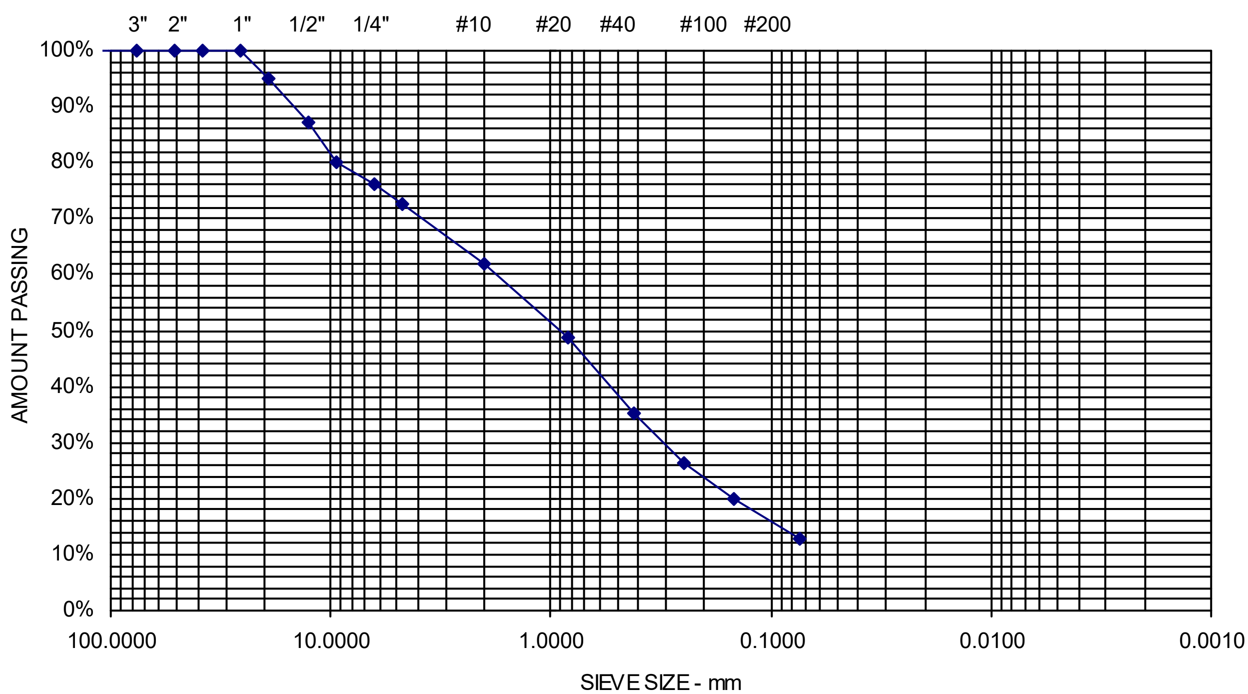
Sheet 1

Report of Gradation

ASTM C-117 & C-136

Project Name	VARIOUS ME - STATEWIDE BRIDGE PROJECTS (20200623000000000765) - GEOTECHNICAL INVESTIGATIONS AND	Project Number	20-1403
Client	STATE OF MAINE DEPARTMENT OF TRANSPORTATION	Lab ID	15406A
Exploration	**BB-WDS-102**	Date Received	2/16/2024
Material Source	**BB-WDS-102, 2D, 3.3 FT**	Date Completed	2/19/2024
		Tested By	BRANDON CHAPUT

STANDARD DESIGNATION (mm/µm)	SIEVE SIZE	AMOUNT PASSING (%)	
150 mm	**6"**	**100**	
100 mm	**4"**	**100**	
75 mm	**3"**	**100**	
50 mm	**2"**	**100**	
38.1 mm	**1-1/2"**	**100**	
25.0 mm	**1"**	**100**	
19.0 mm	**3/4"**	**95**	
12.5 mm	**1/2"**	**87**	
9.5 mm	**3/8"**	**80**	
6.3 mm	**1/4"**	**76**	
4.75 mm	**No. 4**	**73**	27.2% Gravel
2.00 mm	**No. 10**	**62**	
850 um	**No. 20**	**49**	
425 um	**No. 40**	**35**	59.9% Sand
250 um	**No. 60**	**26**	
150 um	**No. 100**	**20**	
75 um	**No. 200**	**12.8**	12.8% Fines



Comments: Moisture Content: 14.1%

Sheet 2

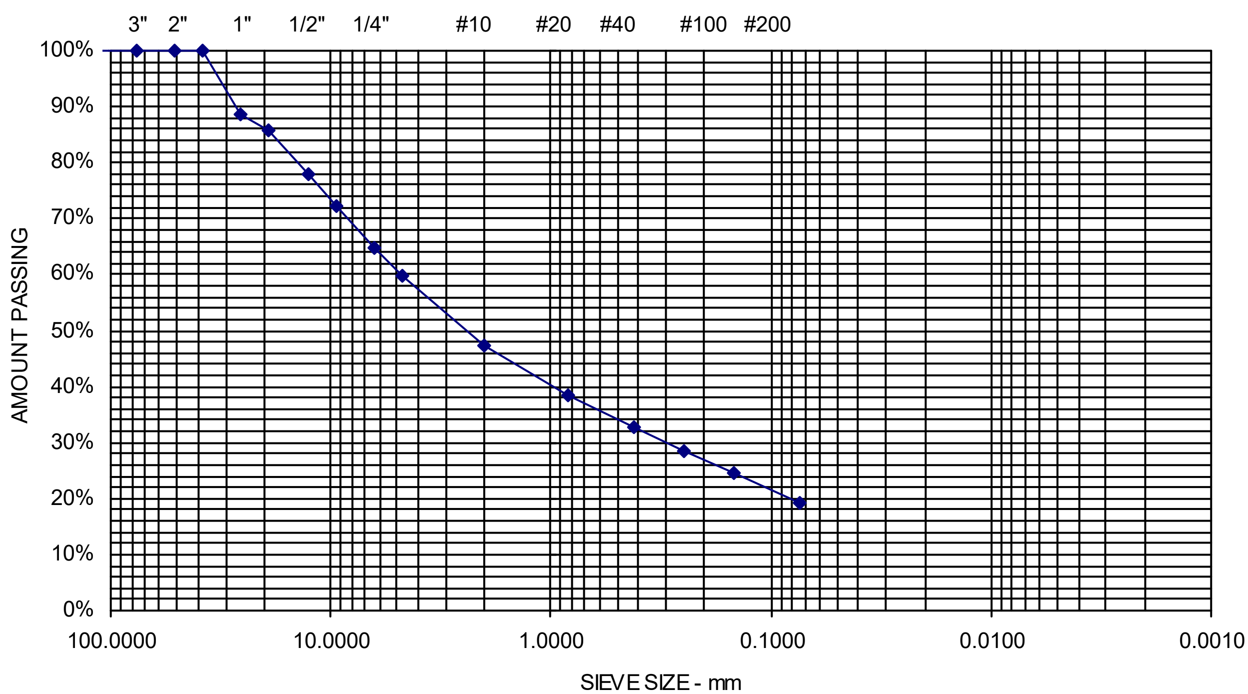
Report of Gradation

ASTM C-117 & C-136

S.W.COLE ENGINEERING, INC.

Project Name	VARIOUS ME - STATEWIDE BRIDGE PROJECTS (20200623000000000765) - GEOTECHNICAL INVESTIGATIONS AND	Project Number	20-1403
Client	STATE OF MAINE DEPARTMENT OF TRANSPORTATION	Lab ID	15407A
Exploration	**BB-WDS-102**	Date Received	2/16/2024
Material Source	**BB-WDS-102, 4D, 10 FT**	Date Completed	2/19/2024
		Tested By	BRANDON CHAPUT

STANDARD DESIGNATION (mm/µm)	SIEVE SIZE	AMOUNT PASSING (%)	
150 mm	**6"**	**100**	
100 mm	**4"**	**100**	
75 mm	**3"**	**100**	
50 mm	**2"**	**100**	
38.1 mm	**1-1/2"**	**100**	
25.0 mm	**1"**	**89**	
19.0 mm	**3/4"**	**86**	
12.5 mm	**1/2"**	**78**	
9.5 mm	**3/8"**	**72**	
6.3 mm	**1/4"**	**65**	
4.75 mm	**No. 4**	**60**	40.3% Gravel
2.00 mm	**No. 10**	**47**	
850 um	**No. 20**	**39**	
425 um	**No. 40**	**33**	40.3% Sand
250 um	**No. 60**	**28**	
150 um	**No. 100**	**25**	
75 um	**No. 200**	**19.4**	19.4% Fines



Comments: Moisture Content: 9.3%

Sheet 3

S.W.COLE ENGINEERING, INC.

APPENDIX E

Calculations

BEARING RESISTANCE OF PRECAST BOX CULVERT

Foundation Soil Parameters: compacted Granular Borrow (sand with gravel - SW, SP) on bedrock

$\gamma_f := 125\ pcf$ Total Moist Unit Weight of Bearing Soil

$\phi := 32\ deg$ Undrained Friction Angle of Bearing Soil

$c_s := 0\ psf$ Undrained Shear Strength of Bearing Soil

$\gamma_q := 125\ pcf$ Total Moist Unit Weight of Foundation Backfill

Foundation Parameters:

$B := 26\ ft$ Overall Foundation Width

$D_f := 4\ ft$ Embedment Depth + Bearing Pad

$D_w := 0\ ft$ Depth of Water Below Foundation

Nominal Bearing Resistance - Service Limit State

Table C10.6.2.5.1-1—Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State Modified after U.S. Department of the Navy (1982)

Type of Bearing Material	Consistency in Place	Bearing Resistance (ksf) Ordinary Range	Bearing Resistance (ksf) Recommended Value of Use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks)	Very hard, sound rock	120–200	160
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks)	Hard sound rock	60–80	70
Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities	Hard sound rock	30–50	40
Weathered or broken bedrock of any kind, except highly argillaceous rock (shale)	Medium hard rock	16–24	20
Compaction shale or other highly argillaceous rock in sound condition	Medium hard rock	16–24	20
Well-graded mixture of fine- and coarse-grained soil: glacial till, hardpan, boulder clay (GW-GC, GC, SC)	Very dense	16–24	20
Gravel, gravel-sand mixture, boulder-gravel mixtures (GW, GP, SW, SP)	Very dense Medium dense to dense Loose	12–20 8–14 4–12	14 10 6
Coarse to medium sand, and with little gravel (SW, SP)	Very dense Medium dense to dense Loose	8–12 4–8 2–6	8 6 3
Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC)	Very dense Medium dense to dense Loose	6–10 4–8 2–4	6 5 3
Fine sand, silty or clayey medium to fine sand (SP, SM, SC)	Very dense Medium dense to dense Loose	6–10 4–8 2–4	6 5 3
Homogeneous inorganic clay, sandy or silty clay (CL, CH)	Very dense Medium dense to dense Loose	6–12 2–6 1–2	8 4 1
Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML, MH)	Very stiff to hard Medium stiff to stiff Soft	4–8 2–6 1–2	6 3 1

From 2020 AASHTO LRFD Table C10.6.2.5.1-1 for compacted (dense) Granular Borrow on bedrock, recommend Service Limit Nominal Bearing Resistance = 8 ksf

Calculated by / Date: MAS / June 2024
Checked by: NDS

Nominal Bearing Resistance - Strength Limit State

From AASHTO LRFD Section 10.6.3.1.2a

$$q_n = c_s \cdot N_{cm} + \gamma_q \cdot D_f \cdot N_{qm} \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B \cdot N_{\gamma m} \cdot C_{w\gamma}$$

From Table 10.6.3.1.2a-1 for $\phi = 32\ deg$ $c_s = 0\ psf$

$N_c := 35.5$ $N_q := 23.2$ $N_\gamma := 30.2$

From Table 10.6.3.1.2a-2, for Dw = Df

$C_{wq} := 0.5$ $C_{w\gamma} := 0.5$

LRFD Eqn 10.6.3.1.2a-1

$$q_n := c_s \cdot N_c + \gamma_q \cdot D_f \cdot N_q \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B \cdot N_\gamma \cdot C_{w\gamma}$$

$q_n = 30.3\ ksf$ for $B = 26\ ft$

Factored Bearing Resistance - Strength Limit State

From AASHTO LRFD Table 10.5.5.2.2-1, Resistance Factor for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

$\varphi_b := 0.45$

$q_r := \varphi_b \cdot q_n = 13.7\ ksf$ for $B = 26\ ft$

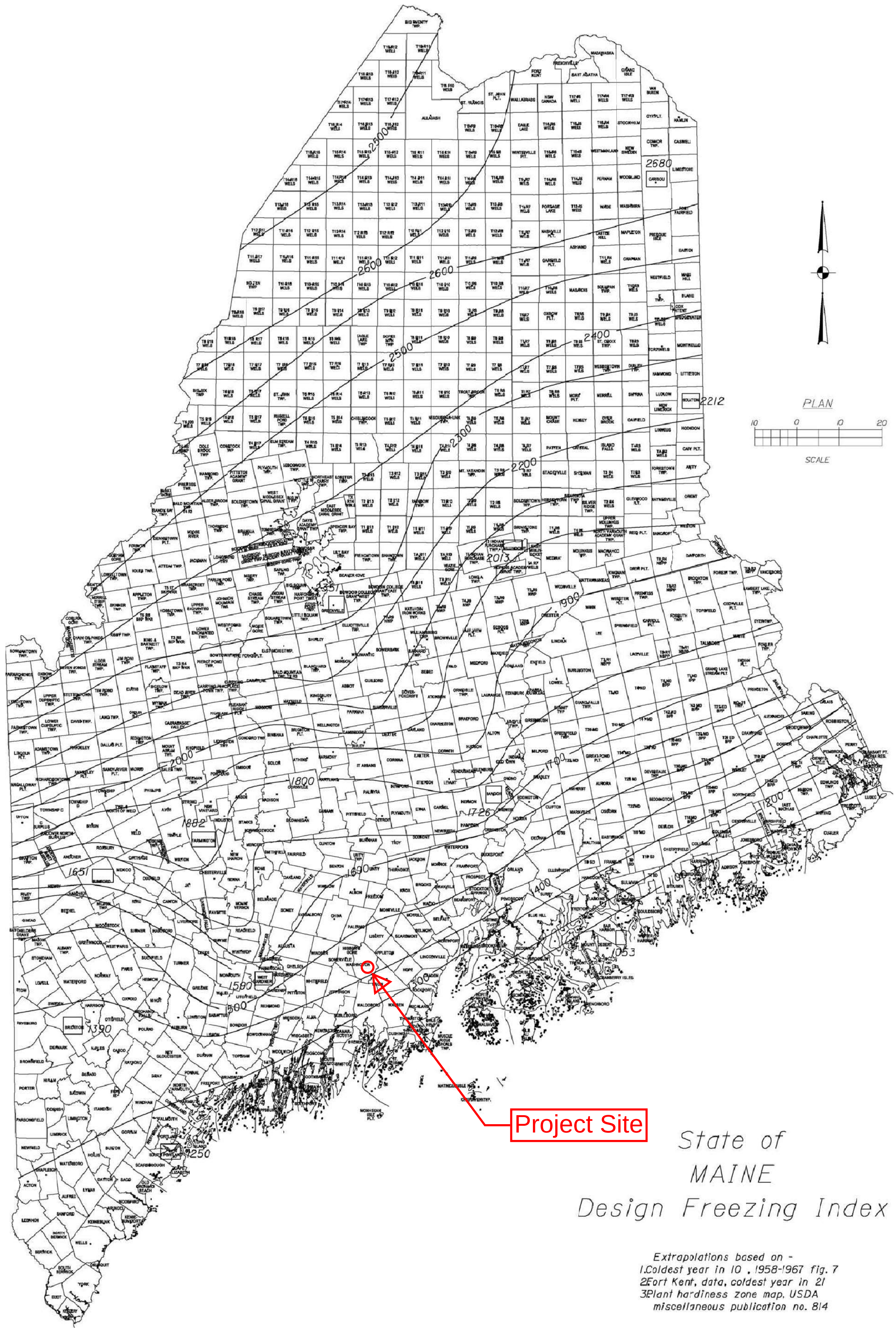


Figure 5-1 Maine Design Freezing Index Map

5.2 General

5.2.1 Frost

Any foundation placed on seasonally frozen soils must be embedded below the depth of frost penetration to provide adequate frost protection and to minimize the potential for freeze/thaw movements. Fine-grained soils with low cohesion tend to be most frost susceptible. Soils containing a high percentage of particles smaller than the No. 200 sieve also tend to promote frost penetration.

In order to estimate the depth of frost penetration at a site, Table 5-1 has been developed using the Modified Berggren equation and Figure 5-1 Maine Design Freezing Index Map. The use of Table 5-1 assumes site specific, uniform soil conditions where the Geotechnical Designer has evaluated subsurface conditions. Coarse-grained soils are defined as soils with sand as the major constituent. Fine-grained soils are those having silt and/or clay as the major constituent. If the make-up of the soil is not easily discerned, consult the Geotechnical Designer for assistance. In the event that specific site soil conditions vary, the depth of frost penetration should be calculated by the Geotechnical Designer.

Table 5-1 Depth of Frost Penetration

Design Freezing Index	Frost Penetration (in)					
	Coarse Grained			Fine Grained		
	w=10%	w=20%	w=30%	w=10%	w=20%	w=30%
1000	66.3	55.0	47.5	47.1	40.7	36.9
1100	69.8	57.8	49.8	49.6	42.7	38.7
1200	73.1	60.4	52.0	51.9	44.7	40.5
1300	76.3	63.0	54.3	54.2	46.6	42.2
1400	79.2	65.5	56.4	56.3	48.5	43.9
1500	82.1	67.9	58.4	58.3	50.2	45.4
1600	84.8	70.2	60.3	60.2	51.9	46.9
1700	87.5	72.4	62.2	62.2	53.5	48.4
1800	90.1	74.5	64.0	64.0	55.1	49.8
1900	92.6	76.6	65.7	65.8	56.7	51.1
2000	95.1	78.7	67.5	67.6	58.2	52.5
2100	97.6	80.7	69.2	69.3	59.7	53.8
2200	100.0	82.6	70.8	71.0	61.1	55.1
2300	102.3	84.5	72.4	72.7	62.5	56.4
2400	104.6	86.4	74.0	74.3	63.9	57.6
2500	106.9	88.2	75.6	75.9	65.2	58.8
2600	109.1	89.9	77.1	77.5	66.5	60.0

S.W.COLE ENGINEERING, INC.

Estimated Frost Depth Penetration

Based on MaineDOT Bridge Design Guide Section 5.2.1

Site Location: Washington, ME

Soil Conditions: ASSUMED, Gravelly SAND, little silt (Fill)
(Coarse Grained)

Step 1 From BDG Figure 5-1 Design Freezing Index = ±1450 freezing degree-days

Step 2 From laboratory test results...
soils water content (WC): 5.8 to 14.1%, avg = 9.8%
Use WC = 10%

Step 3 From BDG Table 5-1, interpolate frost penetration for WC = 10%

$$DFI := 1425$$

$$DFI_1 := 1400 \qquad d_1 := 79.2\ in$$

$$DFI_2 := 1500 \qquad d_2 := 82.1\ in$$

$$d_{frost} := d_1 + (d_2 - d_1) \cdot \left(\frac{DFI - DFI_1}{DFI_2 - DFI_1} \right) = 79.9\ in$$

$$d_{frost} = 6.7\ ft$$

Calculated by / Date: MAS / June 2024
Checked by: NDS