

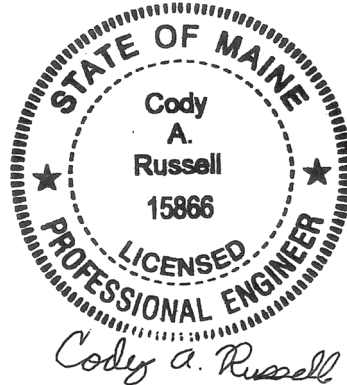
**MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE**

GEOTECHNICAL DESIGN REPORT

For the Replacement of

**CROSS CULVERTS XC-921882 & XC-921883
ROUTE 16
COPLIN PLANTATION, MAINE**

Prepared by:
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Senior Geotechnical Engineer

Franklin County
WIN 23263.00

Soils Report 2024-08
March 11, 2024

PROJECT DETAILS

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical design and construction recommendations for the replacement of two cross culverts consisting of an 6.5-foot span by 4.5-foot rise by 28-foot long concrete box culvert with 48-inch diameter corrugated metal pipe (CMP) extensions that bring the total length to 55 feet (XC-921882) and an approximately 30-inch diameter, 60-foot long CMP (XC-921883) on Route 16 in Coplin Plantation. The existing culverts are in poor condition. The culverts are located approximately 0.14 of a mile westerly of the Eustis / Coplin Plantation town line as shown in the attached Location Map. Route 16 is a Highway Corridor Priority 4 road.

The proposed replacement structure will be an 8-foot span by 7-foot rise by 116-foot long precast concrete box culvert on a skew of approximately 37 degrees to the roadway centerline. The invert of the proposed culvert is approximately 9.8 feet below the existing road grade at the roadway centerline. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V to protect against erosion.

SUBSURFACE INVESTIGATION

Two (2) borings (HB-COP-101 and HB-COP-102) and two (2) probes (HB-COP-101A and HB-COP-101B) were drilled for this project on May 29, 2018 by the MaineDOT drill crew using a trailer-mounted drill rig. One (1) additional probe (HB-COP-201) and one (1) additional boring (HB-COP-202) were drilled on February 12, 2024 by an S.W. Cole track mounted drill rig. Exploration locations are shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are shown on the attached Boring Logs.

The borings were drilled using solid stem auger, cased wash boring, and rock core drilling techniques. Soil samples were obtained in the borings at 5-foot intervals using Standard Penetration Test (SPT) methods. The MaineDOT and S.W. Cole drill rigs are equipped with automatic hammers to drive the split spoon. The MaineDOT and S.W. Cole calibrated automatic hammer delivers approximately 55 percent and 81 percent more energy, respectively, during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values (N_{60}) computed by applying an average energy transfer factor of 0.928 and 1.087 to the raw MaineDOT and S.W. Cole field N-values, respectively. Bedrock was cored in borings HB-COP-102 and HB-COP-202 using an NQ-2 core barrel and the Rock Quality Designation (RQD) of the core was calculated. The probes were drilled using solid stem auger drilling techniques. No soil samples were obtained in the probes.

The MaineDOT Geotechnical Team member selected the boring and probe locations, drilling methods, designated type and depth of sampling, reviewed field logs for accuracy and identified field and laboratory testing requirements. A NorthEast Transportation Training and Certification (NETTCP) certified Subsurface Investigator logged the subsurface conditions encountered. The boring and probe were located in the field by taping to surveyed site features after completion of the drilling program.

LABORATORY TESTING

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. Laboratory testing consisted of four (4) standard grain size analyses with natural water content. The results of the laboratory testing program are discussed in the following section and are shown on the attached Boring Logs, Laboratory Testing Summary Sheet, and Grain Size Distribution Curve sheet.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test borings generally consisted of fill underlain by native sand and glacial till underlain by bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring locations is shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet. The approximate exploration depths are shown on the attached Boring Logs.

Pavement and Fill Soils – Borings HB-COP-101 and HB-COP-202 were drilled in the gravel shoulder and did not encounter pavement. Boring HB-COP-102 was drilled in the paved shoulder and encountered approximately 5.0 inches of pavement. All borings encountered a layer of fill soils consisting of:

- Brown, damp, fine to coarse sand, little to some gravel, trace to little silt, occasional cobble, occasional wood.
- Grey-brown, wet, silty fine to coarse sand, little gravel.

The thickness of the fill ranged from approximately 8.5 to 8.6 feet in the borings. SPT N_{60} -values obtained in the fill ranged from 12 to 71 blows per foot (bpf) indicating that the fill is medium dense to very dense in consistency.

Water contents from two (2) samples obtained within the fill ranged from approximately 9.5% to 12.7%. Grain size analyses conducted on two (2) samples of the fill resulted in the soil being classified as an A-1-b under the AASHTO Soil Classification System and an SW-SM or SM under the Unified Soil Classification System.

Native Sand – In borings HB-COP-102 and HB-COP-202 the fill was underlain by a layer of native sand consisting of:

- Brown, wet, fine to coarse sand, little to some silt, trace to little gravel.

The thickness of the native sand ranged from approximately 5.0 to 6.5 feet. SPT N_{60} -values obtained in the native sand ranged from 43 to 53 bpf, indicating that the native sand is dense to very dense in consistency.

Water contents from one (1) obtained within the native sand was 13.5%. Grain size analyses conducted on one (1) sample of the native sand resulted in the soil being classified as an A-1-b

under the AASHTO Soil Classification System and an SM under the Unified Soil Classification System.

Glacial Till – In boring HB-COP-102 the native sand was underlain by a layer of glacial till consisting of:

- Brown, wet, silt, some fine to coarse sand, some gravel.

The thickness of the glacial till ranged was approximately 3.1 feet. No SPT N₆₀-values were obtained in the glacial till, but it took 40 blows to drive the split spoon 1.2 inches, indicating that the glacial till is very dense in consistency.

Water contents from one (1) obtained within the glacial till was 13.4%. Grain size analyses conducted on one (1) sample of the glacial till resulted in the soil being classified as an A-4 under the AASHTO Soil Classification System and an SM under the Unified Soil Classification System.

Bedrock – Bedrock or a refusal surface was encountered at elevations ranging from approximately 1179.8 feet to 1191.6 feet in the vicinity of the proposed box culvert. The approximate elevations of the top of bedrock or the refusal surface encountered at the boring and probe locations are presented on the attached Boring Logs. Bedrock was cored in borings HB-COP-102 and HB-COP 202. A rock core was attempted in boring HB-COP-101, but the core bit broke after advancing 0.8 feet and the boring was abandoned without determining the exact nature of the refusal surface. The exact nature of the refusal surface was not determined in the probes.

The bedrock consists of intrusive Devonian gabbro, diorite, and ultramafic rocks. The Rock Quality Designation (RQD) of the bedrock was determined range from 0% to 70%, correlating to a Rock Quality of Very Poor to Fair.

Groundwater – Groundwater was recorded at a depths of approximately 5.5 and 5.0 feet bgs in boring HB-COP-102 and HB-COP-202, respectively. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

Precast Concrete Box Culvert Construction – The proposed replacement structure will be an 8-foot span by 7-foot rise by 116-foot long precast concrete box culvert on a skew of approximately 37 degrees to the roadway centerline. The proposed precast concrete box culvert shall be furnished and installed in accordance with MaineDOT Standard Specification 534.

The invert of the proposed precast concrete box culvert ranges from approximately 1188.45 feet at the inlet end to approximately 1187.58 feet at the outlet end with a 0.75% slope. To facilitate fish passage, habitat connectivity design elements will be used inside the precast concrete box culvert as shown on the Streambed Details Sheet in the Plans.

The full nature of the proposed culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders encountered in excess of 6 inches shall be removed

and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone ¾-Inch. The prepared subgrade shall be proof-rolled using a static roller to visually confirm the prepared subgrade is firm and stable. The exposed subgrade shall be free of ponded water so that bedding material placement and compaction can be completed in the dry.

The proposed structure shall be bedded on a 1-foot thick layer of Granular Borrow, Material for Underwater Backfill meeting the requirements of MaineDOT Standard Specification 703.19. The soil envelope and backfill shall consist of Standard Specification 703.19 - Granular Borrow with a maximum particle size of 4 inches. The granular borrow bedding and backfill material shall be placed in lifts of 6 to 8 inches loose measure and compacted to the manufacturer’s specifications or, in the absence of manufacturer’s specifications. The bedding and backfill soil shall be compacted to at least 92 percent of the AASHTO T-180 maximum dry density. All subgrade surfaces should be protected from construction traffic in order to limit disturbance.

Settlement – No settlement issues are anticipated at the site. No changes to the existing vertical or horizontal alignment are currently planned for this project. The proposed precast concrete box culvert is larger than the existing culverts and will result in a net unloading of the site soils at the structure location. Placement of fill soils at the location of the existing structure is not anticipated to exceed the past loading condition of the site soils. Any settlement due to elastic compression of the subgrade soils and bedding material will be immediate and negligible.

Bearing Resistance – The factored bearing resistances for the precast concrete box culvert bearing on compacted granular bedding material placed on native soils at the service and strength limit states are presented in the table below. Supporting calculations in accordance with AASHTO LRFD Bridge Design Specifications 9th Edition 2020 (LRFD) are provided in Appendix C – Calculations.

Limit State	Resistance Factor ϕ_b	AASHTO LRFD Reference	Factored Bearing Resistance (ksf)
Service	1.0	Article 10.5.5.1	6.0
Strength	0.45	Table 10.5.5.2.2-1	6.0

Modulus of Subgrade Reaction – A modulus of subgrade reaction (k_s) equal to 210 pounds per cubic inch shall be used for the structural design of the box culvert’s base slab. Calculations are included in Appendix C – Calculations.

Scour and Riprap – Both the inlet and outlet of the precast concrete box culvert shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V. No specific scour protection recommendations are needed other than armoring with riprap. The riprap on the slopes shall be underlain by a 1-foot layer of protective aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19) that is underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03. The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

Construction Considerations – Construction activities will include construction of cofferdams and earth support systems to control stream flow during construction. Construction activities will also include common earth excavation. Construction of the precast concrete box culvert will require soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is likely that the use of complex (four-sided) braced excavations with dewatering will be necessary due to the depth of the excavation. If this is the case, adequate embedment into the native soils will be necessary to allow for the excavation and maintenance of a stable excavation bottom. All earth support systems shall be designed by a Professional Engineer licensed in the State of Maine. Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill (MaineDOT 703.19) or Crushed Stone ¾-Inch (MaineDOT 703.13). All subgrade surfaces shall be proof-rolled using a static roller to provide a firm and stable surface and protected from any unnecessary construction equipment or traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted Granular Borrow for Underwater Backfill (703.19) or Crushed Stone ¾-Inch (703.13).

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water as needed to maintain a stable excavation and allow work in the dry.

Using the excavated native soils as backfill around the culvert shall not be permitted. The native soils may only be used as Common Borrow in accordance with MaineDOT Standard Specifications 203 and 703.

The Contractor will have to excavate the existing subbase and subgrade fill soils in the vicinity of the culvert. These materials should not be used to re-base the roadway. Excavated subbase sand and gravel may be used as fill below roadway subgrade level in fill areas provided all other requirements of MaineDOT Standard Specifications 203 and 703 are met.

CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program and their project design consultant for specific application to the proposed replacement of two (2) cross culverts (XC-921882 and XC-921883) under Route 16 in Coplin Plantation, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes in design. These analyses and recommendations are based in part upon a limited subsurface investigation at discrete exploratory location completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also

become necessary to re-evaluate the recommendations made in this report.

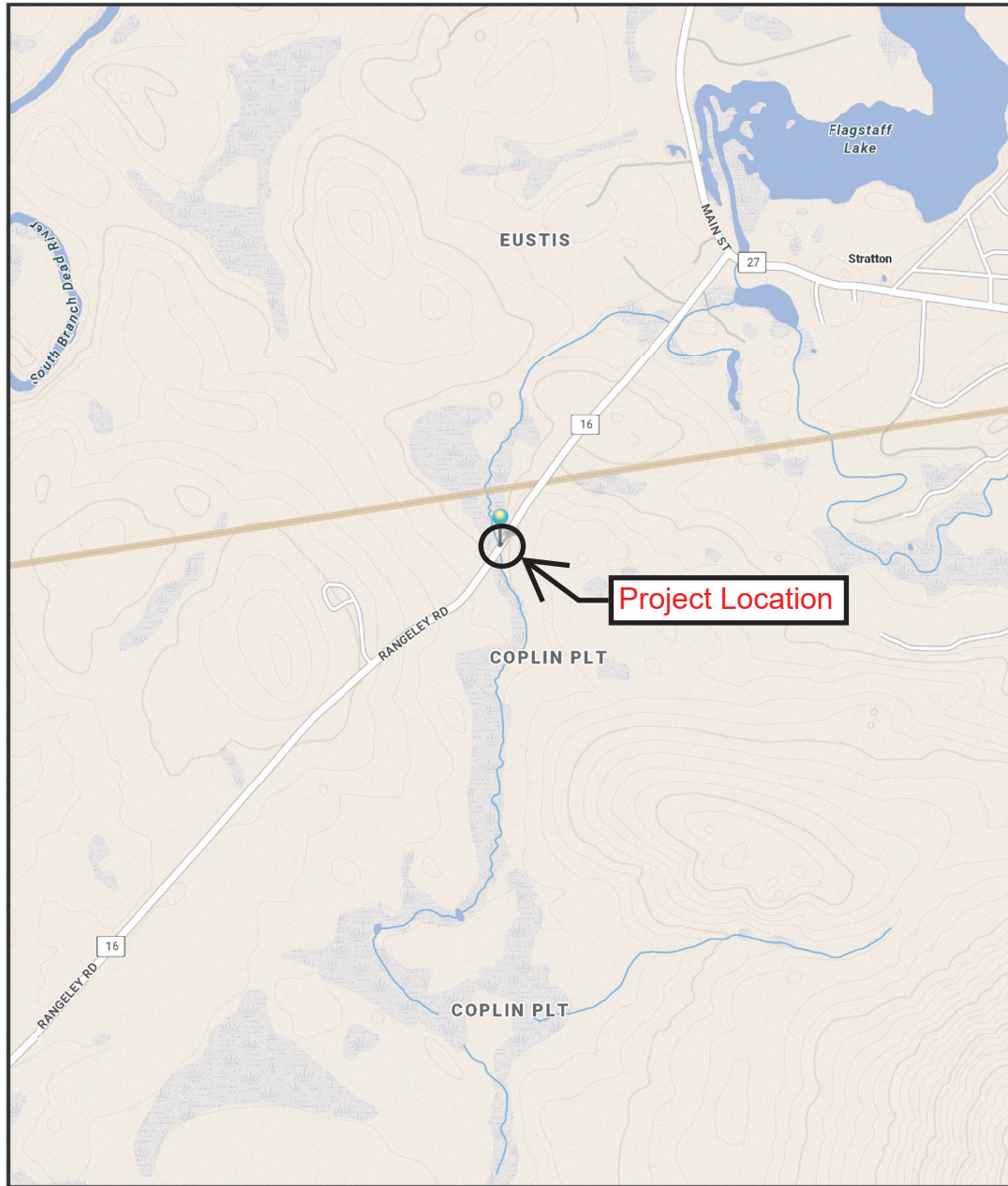
It is recommended that a geotechnical engineer be provided the opportunity for a review of the design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.

Attachments:

Location Map
Boring Location Plan & Interpretive Subsurface Profile
Key to Soil and Rock Descriptions and Terms
Boring Logs
Laboratory Testing Summary Sheet
Grain Size Distribution Curves
Calculations



COPLIN PLANTATION, MAINE

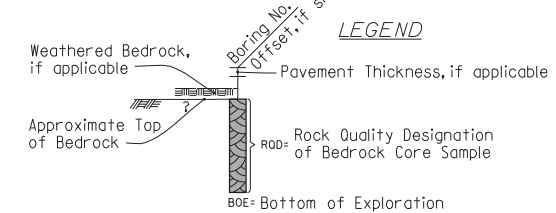
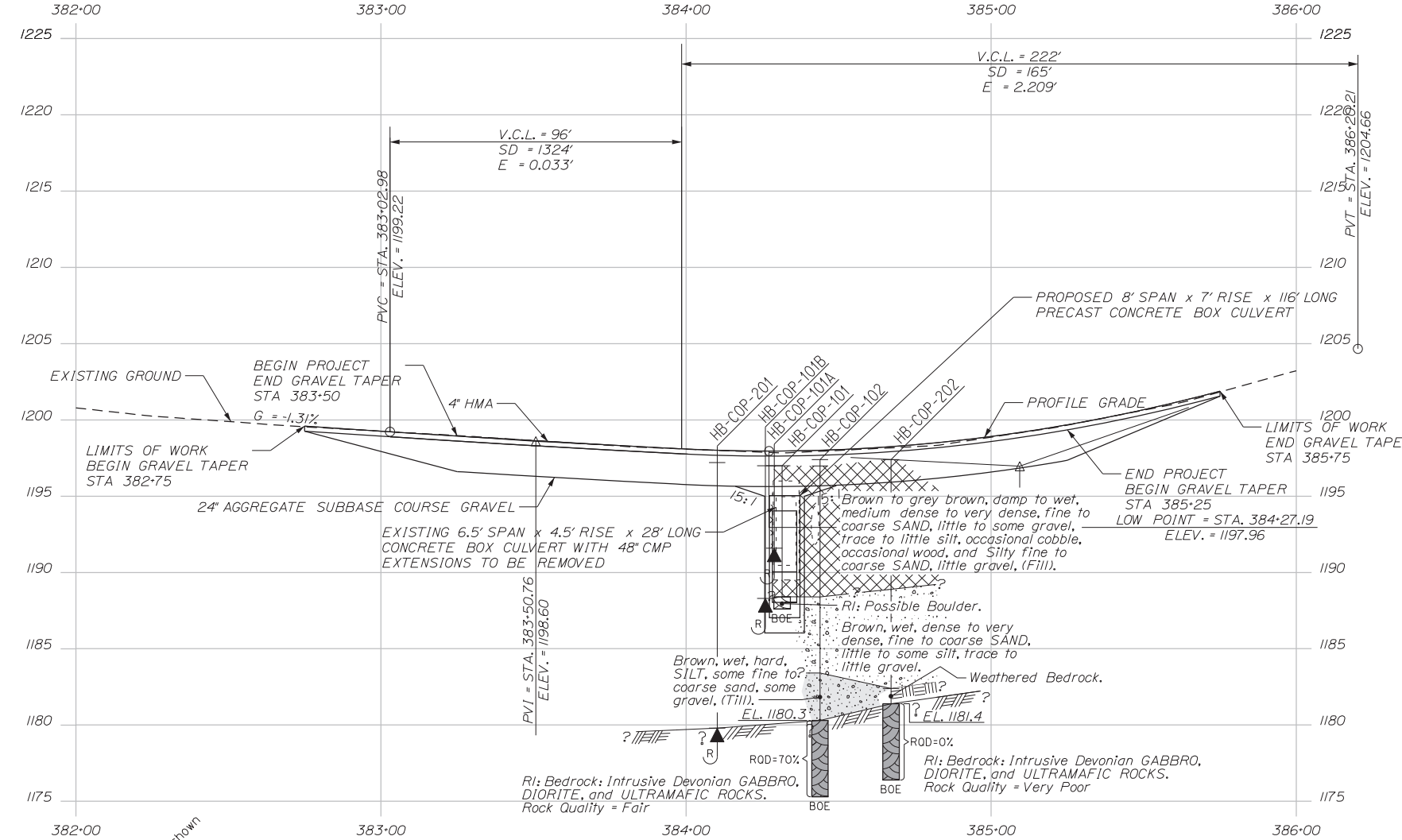
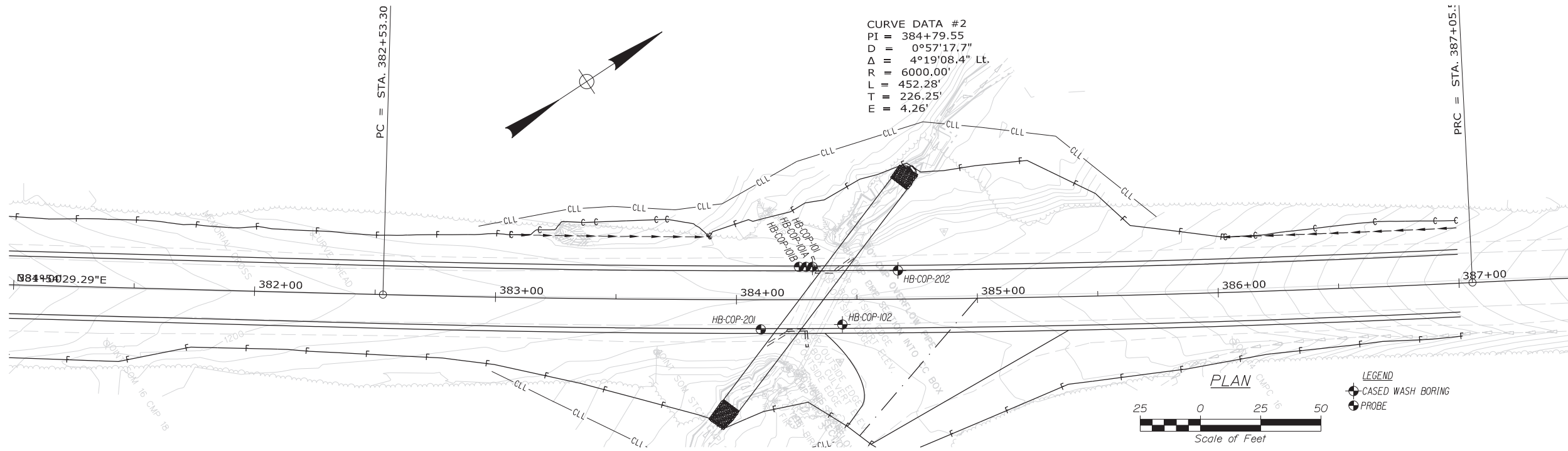


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0.3 Miles
1 inch = 0.32 miles

Date: 2/29/2024
Time: 7:17:28 AM

SHEET NUMBER 1 OF 2	COPLIN PLANTATION	STATE OF MAINE DEPARTMENT OF TRANSPORTATION
	ROUTE 16	23263.00
	LOCATION MAP	WIN 23263.00 HIGHWAY PLANS



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.

PROJ. MANAGER	BY	DATE	SIGNATURE	P.E. NUMBER	DATE
DESIGN-DETAILED					
CHECKED-REVIEWED					
DESIGN-DETAILED	C. RUSSELL	MAR 2024			
DESIGN-DETAILED	T. WHITE				
REVISIONS 1					
REVISIONS 2					
REVISIONS 3					
REVISIONS 4					
FIELD CHANGES					

COPLIN PLANTATION
 ROUTE 16
 BORING LOCATION PLAN &
 INTERPRETIVE SUBSURFACE PROFILE

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Route 16 Large Culvert Replacement Location: Coplin Plantation, Maine	Boring No.: HB-COP-101 WIN: 23263.00
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Driller: MaineDOT	Elevation (ft.): 1197.0	Auger ID/OD: 5" Solid Stem
Operator: Daggett/Niles	Datum: NAVD88	Sampler: Standard Split Spoon
Logged By: B. Wilder	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"
Date Start/Finish: 5/29/2018; 09:00-10:30	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"
Boring Location: 384+31.5, 13.6 ft Lt. in-Shoulder	Casing ID/OD: NW-3"	Water Level*: None Observed

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>	
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt	R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person	S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _{u(lab)} = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected
T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test		

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0	1D	24/17	0.00 - 2.00	3/4/4/12	8	12	SSA			Brown, damp, medium dense, fine to coarse SAND, little gravel, little silt, (Fill).	G#296342 A-1-b, SM WC=9.5%	
5	2D	24/16	5.00 - 7.00	22/19/17/32	36	56	129			Brown, wet, very dense, fine to coarse SAND, some gravel, trace silt, wood.	G#296343 A-1-b, SW-SM WC=12.7%	
							158					
							150					
	R1	9,6/9,6	8.60 - 9.40				a100 NQ-2	1188.4		aRoller coned ahead to 8.6 ft bgs., 100 blows for 0.6 ft.		
								1187.6		R1: Possible boulder. Broke Core Bit		
10										Bottom of Exploration at 9.4 feet below ground surface.		
15												
20												
25												

Remarks:

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Route 16 Large Culvert Replacement Location: Coplin Plantation, Maine	Boring No.: HB-COP-101A WIN: 23263.00
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Drilling Contractor: MaineDOT	Elevation (ft.): 1197.0	Auger ID/OD: 5" Dia.
Operator: Daggett/Niles	Datum: NAVD88	Sampler: N/A
Logged By: B. Wilder	Rig Type: CME 45C	Hammer Wt./Fall: N/A
Date Start/Finish: 5/29/2018-5/29/2018	Drilling Method: Solid Stem Auger	Core Barrel: N/A
Boring Location: 384+28.9, 13.6 ft Lt.	Casing ID/OD: N/A	Water Level*: None Observed

Definitions: D = Spilt Spoon Sample S = Sample off Auger Flights B = Bucket Sample off Auger Flights MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MV = Unsuccessful Field Vane Shear Test Attempt V = Field Vane Shear Test, PP= Pocket Penetrometer	MU = Unsuccessful Thin Wall Tube Sample 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 1 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-value = Raw Field SPT N-value T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent ≡ = Similar or Equal too LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test
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Depth (ft.)	Sample Information								Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-value	Casing Blows	Elevation (ft.)	Graphic Log		
0						SSA			Probe, no material descriptions given.	
5						↙	1191.6		Bottom of Exploration at 5.4 feet below ground surface. REFUSAL, possible Boulder?	5.4
10										
15										
20										
25										

Remarks:

Driller: MaineDOT	Elevation (ft.): 1197.4	Auger ID/OD: 5" Solid Stem
Operator: Daggett/Niles	Datum: NAVD88	Sampler: Standard Split Spoon
Logged By: B. Wilder	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"
Date Start/Finish: 5/29/2018; 10:30-	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"
Boring Location: 384+43.9, 10.4 ft Rt.	Casing ID/OD: NW-3"	Water Level*: 5.5 ft bgs.

Hammer Efficiency Factor: 0.928 **Hammer Type:** Automatic Hydraulic Rope & Cathead

Definitions: R = Rock Core Sample S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf)
 D = Split Spoon Sample SSA = Solid Stem Auger S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) WC = Water Content, percent
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q_p = Unconfined Compressive Strength (ksf) LL = Liquid Limit
 U = Thin Wall Tube Sample RC = Roller Cone N-uncorrected = Raw Field SPT N-value PL = Plasticity Limit
 MU = Unsuccessful Thin Wall Tube Sample Attempt WOH = Weight of 140lb. Hammer Hammer Efficiency Factor = Rig Specific Annual Calibration Value PI = Plasticity Index
 V = Field Vane Shear Test, PP = Pocket Penetrometer WOR/C = Weight of Rods or Casing N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency G = Grain Size Analysis
 MV = Unsuccessful Field Vane Shear Test Attempt WO1P = Weight of One Person N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected C = Consolidation Test

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0								SSA	1197.0	5" HMA.		
										Similar soils as HB-COP-101.		
5										Cobble from 5.5-6.1 ft bgs.		
										Cobble from 7.0-7.4 ft bgs.		
10	1D	24/17	10.00 - 12.00	10/15/19/33	34	53			1188.4	Brown, wet, very dense, fine to coarse SAND, little silt, trace gravel.	G#296344 A-1-b, SM WC=13.5%	
15	2D	7.2/6	15.00 - 15.60	20/40(1.2")	---				1183.4	Brown, wet, hard, SILT, some fine to coarse sand, some gravel, (Till). Cobble from 15.6-15.8 ft bgs. Roller Coned ahead to 17.1 ft bgs.	G#296345 A-4, SM WC=13.4%	
	R1	60/50	17.10 - 22.10	RQD = 70%					1180.3	Top of Bedrock at Elev. 1180.3 ft. R1: Bedrock: Intrusive Devonian GABBRO, DIORITE, and ULTRAMAFIC ROCKS. Rock Quality = Fair R1: Core Times (min:sec) 17.1-18.1 ft (2:00) 18.1-19.1 ft (1:45) 19.1-20.1 ft (1:38) 20.1-21.1 ft (1:30) 21.1-22.1 ft (1:20) 83% Recovery		
20									1175.3	Bottom of Exploration at 22.1 feet below ground surface.		
25												

Remarks:

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

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Route 16 Large Culvert Replacement Location: Coplin Plantation, Maine	Boring No.: HB-COP-201 WIN: 23263.00
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Drilling Contractor: S.W. Cole	Elevation (ft.): 1197.2	Auger ID/OD: 5" Dia.
Operator: Daggett & SW Cole	Datum: NAVD88	Sampler: N/A
Logged By: B. Wilder	Rig Type: Diedrick D-50 Track	Hammer Wt./Fall: N/A
Date Start/Finish: 2/12/2024-2/12/2024	Drilling Method: Solid Stem Auger	Core Barrel: N/A
Boring Location: 384+10.2, 12.3 ft Rt.	Casing ID/OD: N/A	Water Level*: None Observed

Definitions: D = Spilt Spoon Sample MU = Unsuccessful Thin Wall Tube Sample Attempt WO1P = Weight of 1 Person
 S = Sample off Auger Flights R = Rock Core Sample S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
 B = Bucket Sample off Auger Flights SSA = Solid Stem Auger S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) LL = Liquid Limit
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q_p = Unconfined Compressive Strength (ksf) PL = Plastic Limit
 U = Thin Wall Tube Sample RC = Roller Cone N-value = Raw Field SPT N-value G = Grain Size Analysis
 MV = Unsuccessful Field Vane Shear Test Attempt WOH = Weight of 140lb. Hammer T_v = Pocket Torvane Shear Strength (psf)
 V = Field Vane Shear Test. PP = Pocket Penetrometer WOR/C = Weight of Rods or Casing WC = Water Content, percent ≡ = Similar or Equal too C = Consolidation Test

Depth (ft.)	Sample Information									Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-value	Casing Blows	Elevation (ft.)	Graphic Log			
0									SSA	Probe, no material descriptions given.	
5											
10											
15											
17.4								1179.8		Bottom of Exploration at 17.4 feet below ground surface. REFUSAL	
20											
25											

Remarks:

Driller: S.W. Cole	Elevation (ft.): 1197.4	Auger ID/OD: 5" Solid Stem
Operator: Daggett & SW Cole	Datum: NAVD88	Sampler: Standard Split Spoon
Logged By: B. Wilder	Rig Type: Diedrick D-50 Track	Hammer Wt./Fall: 140#/30"
Date Start/Finish: 5/29/2018; 10:30-	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"
Boring Location: 384+67.2, 11.9 ft Lt.	Casing ID/OD: NW-3"	Water Level*: 5.0 ft bgs.

Hammer Efficiency Factor: 1.087 **Hammer Type:** Automatic Hydraulic Rope & Cathead

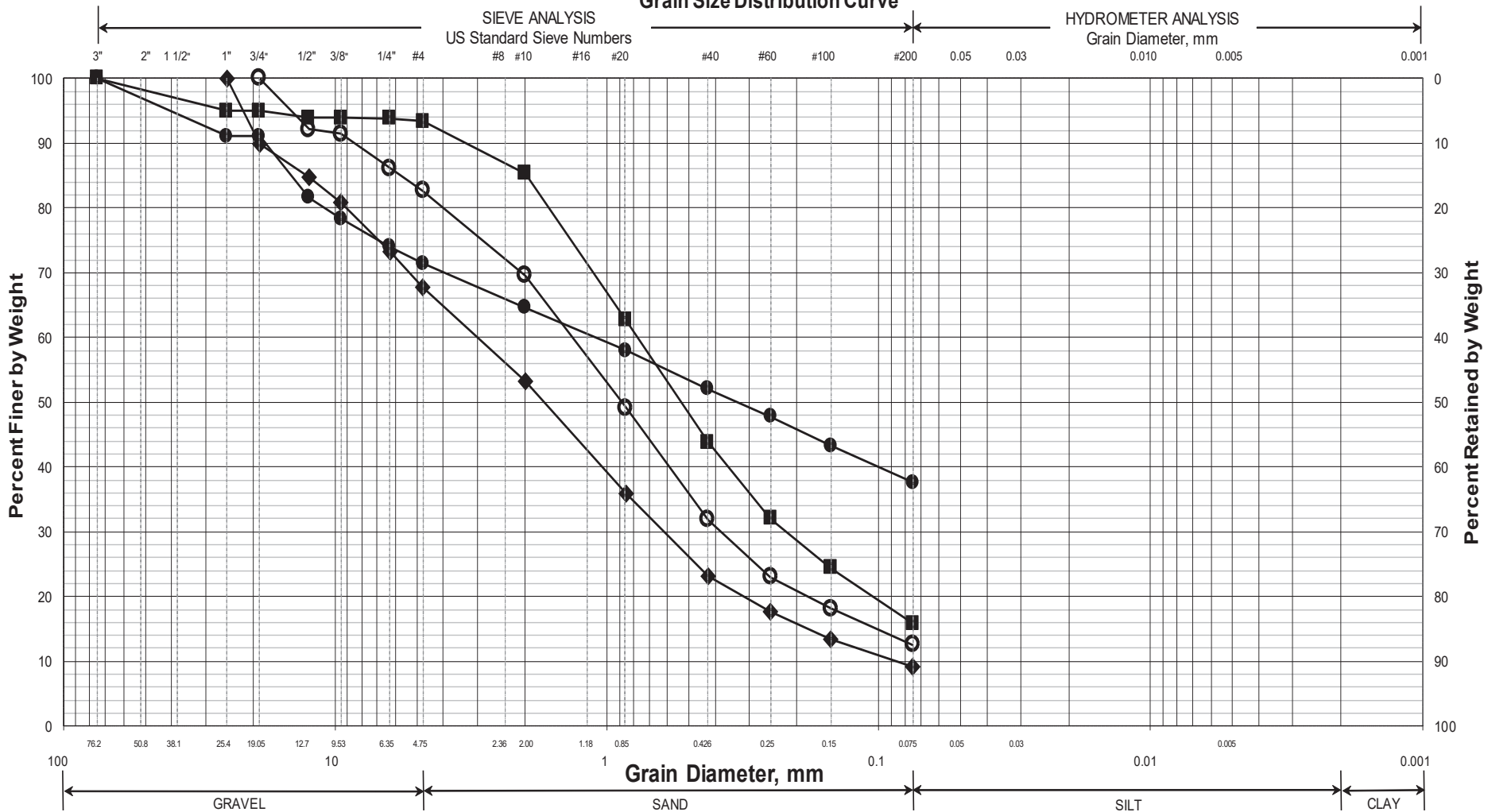
Definitions: R = Rock Core Sample S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf)
 D = Split Spoon Sample SSA = Solid Stem Auger S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) WC = Water Content, percent
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q_p = Unconfined Compressive Strength (ksf) LL = Liquid Limit
 U = Thin Wall Tube Sample RC = Roller Cone N-uncorrected = Raw Field SPT N-value PL = Plastic Limit
 MU = Unsuccessful Thin Wall Tube Sample Attempt WOH = Weight of 140lb. Hammer Hammer Efficiency Factor = Rig Specific Annual Calibration Value PI = Plasticity Index
 V = Field Vane Shear Test, PP = Pocket Penetrometer WOR/C = Weight of Rods or Casing N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency G = Grain Size Analysis
 MV = Unsuccessful Field Vane Shear Test Attempt WO1P = Weight of One Person N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected C = Consolidation Test

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0							SSA					
	1D	24/11	2.00 - 4.00	3/4/35/41	39	71				Brown, wet, very dense, fine to coarse SAND, some gravel, trace silt, occasional cobble, (Fill).		
5												
	2D	24/9	5.00 - 7.00	2/3/4/6	7	13				Grey-brown, wet, medium dense, Silty fine to coarse SAND, little gravel.		
								1188.9			8.5	
10												
	3D	24/13	10.00 - 12.00	10/11/13/21	24	43	20			Brown, wet, dense, fine to coarse SAND, some silt, little gravel.		
							31					
							92					
							90					
							183					
15								1182.4		Weathered ROCK.	15.0	
	4D	4/3	15.00 - 15.33	50(4")	---		150			Roller Coned ahead to 16.0 ft bgs.		
								1181.4			16.0	
	R1	60/14	16.00 - 21.00	RQD = 0%			NQ-2			Top of Bedrock at Elev. 1181.4 R1: Bedrock: Intrusive Devonian GABBRO, DIORITE, and ULTRAMAFIC ROCKS. Rock Quality = Very Poor R1: Core Times (min:sec) 16.0-17.0 ft (1:37) 17.0-18.0 ft (1:25) 18.0-19.0 ft (1:37) 19.0-20.0 ft (1:21) 20.1-21.0 ft (2:12) 23% Recovery		
20								1176.4			21.0	
										Bottom of Exploration at 21.0 feet below ground surface.		
25												

Remarks:

Auto Hammer #362

Maine Department of Transportation Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-COP-101/1D	384+31.5	13.6 LT	0.0-2.0	SAND, little gravel, little silt.	9.5			
◆	HB-COP-101/2D	384+31.5	13.6 LT	5.0-7.0	SAND, some gravel, trace silt.	12.7			
■	HB-COP-102/1D	384+43.9	10.4 RT	10.0-12.0	SAND, little silt, trace gravel.	13.5			
●	HB-COP-102/2D	384+43.9	10.4 RT	15.0-15.6	SILT, some sand, some gravel.	13.4			
▲									
X									

WIN
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Town
Coplin Pit
Reported by/Date
WHITE, TERRY A 2/28/2024

Bearing Resistance - Existing Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - Box Culvert on Sand

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 9th Edition 2020
Table C10.6.2.6.1-1 Presumptive Bearing Resistances for Spread Footings at the
Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Sand (SM)

Based on N-values, soils are dense to very dense near the bearing elevation

Density In Place: very dense

Bearing Resistance: Ordinary Range (ksf) 6 to 10

Recommended Value of Use: $q_{nom} := 6 \cdot ksf$

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1) $\phi_{service_bc} := 1.0$

$q_{factored_service_bc} := q_{nom} \cdot \phi_{service_bc}$ $q_{factored_service_bc} = 6 \cdot ksf$

Note: This bearing resistance is settlement limited (1 inch) and applies only at the service limit state.

Part 2 - Strength Limit State

Nominal and factored Bearing Resistance - Box Culvert on Sandy Gravel

Reference: AASHTO LRFD Bridge Design Specifications 9th Edition 2020 - Article 10.6.3.1

Assumptions:

1. The box will be founded at ~ Elev 1188.0 feet

Bottom of Construction will be 2 feet below box invert $D_{footing} := 2.0 \cdot ft$

2. Assumed parameters for fill soils:

Saturated unit weight: $\gamma_s := 125 \cdot pcf$

Internal friction angle: $\phi_{ns} := 32 \cdot deg$

Undrained shear strength: $c_{ns} := 0 \cdot psf$

3. Box Culvert parameters

Width of box culvert, B $B_{box} := 8 \cdot ft$

Length of box culvert, L $L_{box} := 116 \cdot ft$

Nominal Bearing Resistance per LRFD Equation 10.6.3.1.2a-1

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$$

Bearing Capacity Factors - LRFD Table 10.6.3.1.2a-1

For $\phi=32$ deg $N_c := 35.5$ $N_q := 23.2$ $N_\gamma := 30.2$

Shape Correction Factors LRFD Table 10.6.3.1.2a-3

for $\phi=32$ degrees

$$s_c := 1 + \left(\frac{B_{\text{box}}}{L_{\text{box}}} \right) \left(\frac{N_q}{N_c} \right) \quad s_c = 1.05$$

$$s_\gamma := 1 - 0.4 \left(\frac{B_{\text{box}}}{L_{\text{box}}} \right) \quad s_\gamma = 0.9724$$

$$s_q := 1 + \left(\frac{B_{\text{box}}}{L_{\text{box}}} \cdot \tan(\phi_{ns}) \right) \quad s_q = 1.04$$

Load Inclination Factors:

Assume all are 1.0 (LRFD Article C10.6.3.1.2a)

$i_c := 1.0$ $i_q := 1.0$ $i_\gamma := 1.0$

Depth Correction Factor

$$d_q := 1 + 2 \cdot \tan(\phi_{ns}) \cdot (1 - \sin(\phi_{ns}))^2 \cdot \tan\left(\frac{D_{\text{footing}}}{B_{\text{box}}}\right)^{-1} \quad d_q = 2.0815$$

LRFD Eq. 10.6.3.1.2a-10

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 37.1$ LRFD Eq. 10.6.3.1.2a-2

$N_{qm} := N_q \cdot s_q \cdot d_q \cdot i_q$ $N_{qm} = 50.37$ LRFD Eq. 10.6.3.1.2a-3

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 29.37$ LRFD Eq. 10.6.3.1.2a-4

Coefficients for Groundwater Depths LRFD Table 10.6.3.1.2a-2

Depth the water table: $D_w := 0 \cdot \text{ft}$ $C_{wq} := 0.5$ $C_{w\gamma} := 0.5$

$$q_{\text{nominal}} := c_{ns} \cdot N_{cm} + \gamma_s \cdot D_{\text{footing}} \cdot N_{qm} \cdot C_{wq} + 0.5(\gamma_s) B_{\text{box}} \cdot N_{\gamma m} \cdot C_{w\gamma}$$

$q_{\text{nominal}} = 13.6 \cdot \text{ksf}$

Factored Bearing Resistance for Strength Limit State

Resistance Factor: $\phi_b := 0.45$ LRFD Table 10.5.5.2.2-1

$q_{\text{factored}} := q_{\text{nominal}} \cdot \phi_b$

$q_{\text{factored}} = 6.1 \cdot \text{ksf}$

Recommend a limiting factored bearing resistance of 6.0 ksf for the Strength Limit State.

Modulus of Subgrade Reaction:

Reference: Foundation Analysis and Design 5th Edition JE Bowles Section 9-6

Width of box culvert, B $B_{\text{box}} = 8 \text{ ft}$
 Length of box culvert, L $L_{\text{box}} = 116 \text{ ft}$
 Thickness of box culvert, t $t_{\text{box}} := 12 \cdot \text{in}$ assumed
 Depth of box, D $D_{\text{box}} := 9.8 \cdot \text{ft}$
 Bearing Resistance: $q_{\text{factored_service_bc}} = 6 \cdot \text{ksf}$ Calculated above
 Modulus of Elasticity: Site soils at bearing elevation are Sand. Use values for Sand (dense)
 From Bowles Table 2-8 Modulus E_s for Sand, dense ranges from 1000 - 1700 ksf

 Use Modulus of Elasticity, E_s $E_s := 1200 \cdot \text{ksf}$
 Poisson's Ratio: Site conditions at bearing elevation are Sand. Use values for Sand, gravelly sand.
 From Bowles Table 2-7 Poisson's Ratio μ for Sand, gravelly sand ranges from 0.3 - 0.4

 Use Poisson's Ratio, μ $\mu := 0.35$

$$E_{\text{prime_s}} := \frac{1 - \mu^2}{E_s} \quad E_{\text{prime_s}} = 0.000731 \cdot \frac{\text{ft}^2}{\text{kip}}$$

Analyze corner:

Take H as 5*B as recommended in Bowles Chapter 5

$$H_{\text{inf}} := \frac{5 \cdot B_{\text{box}}}{B_{\text{box}}} \quad H_{\text{inf}} = 5 \quad \text{N in Table 5-2} \quad \text{From Table 5-2 for N=5 and M=14.5}$$

$$\frac{L_{\text{box}}}{B_{\text{box}}} = 14.5 \quad \text{M in Table 5-2} \quad I_1 := 0.530$$

$$I_2 := 0.144 \quad \text{by interpolation}$$

Determine Steinbrenner influence factor - Bowles Section 5-6:

$$I_s := I_1 + \left[\frac{1 - (2 \cdot \mu)}{1 - \mu} \right] \cdot I_2 \quad I_s = 0.5965$$

Determine Influence factor for footing depth - Bowles Figure 5-7

Depth ratio: $\frac{D_{\text{box}}}{B_{\text{box}}} = 1.225$ $\frac{L_{\text{box}}}{B_{\text{box}}} = 14.5$ $\mu = 0.35$ $I_F := 0.80$

Calculate modulus of subgrade reaction - Bowles Eq. 9-7

$$k_s := \frac{1}{B_{\text{box}} \cdot E_{\text{prime_s}} \cdot I_s \cdot I_F} \quad \text{Bowles Eq. 9-7}$$

$$k_s = 207 \cdot \text{pci}$$

Recommend Modulus of Subgrade Reaction of 210 pci