

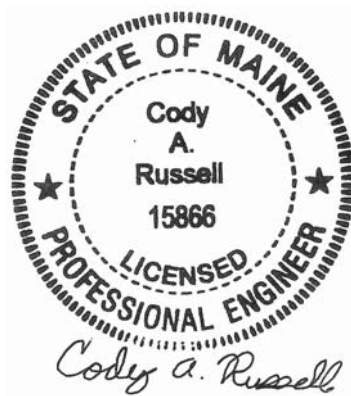
**MAINE DEPARTMENT OF TRANSPORTATION  
HIGHWAY PROGRAM  
GEOTECHNICAL SECTION  
AUGUSTA, MAINE**

**GEOTECHNICAL DESIGN REPORT**

*For the Construction of:*

**EAST BRIDGE  
TUTTLE ROAD  
CUMBERLAND, MAINE**

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Cumberland County  
WIN 22668.00

June 17, 2020

Soils Report 2020-19  
Bridge No. 6553

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## **1.0 INTRODUCTION**

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of an existing large culvert (#46210) on Tuttle Road in Cumberland, Maine. A subsurface investigation has been completed at the site to evaluate subsurface conditions and to develop geotechnical design and construction recommendations for the replacement structure. This report presents the subsurface information obtained during the subsurface investigation and soil laboratory testing programs and provides design and construction recommendations and geotechnical design parameters for the culvert replacement.

The existing structure is an approximately 56-foot long, 72-inch diameter corrugated metal pipe (CMP) culvert. The CMP is failing and is in need of replacement. Tuttle Road is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 128-inch span by 83-inch rise by 96-foot long polymer-coated steel pipe arch culvert on a skew of approximately 26 degrees to the roadway centerline. The invert of the proposed culvert is approximately 11 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.

## **2.0 GEOLOGIC SETTING**

The existing culvert carries an unnamed stream under Tuttle Road in Cumberland and is located approximately 1.93 miles southeast of Route 9 as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Surficial Geology Yarmouth Quadrangle, Maine, Open File 99-105 (1999) the surficial soils at the site consist of Stream Alluvium. Stream Alluvium consists of sand, silt, and minor amounts of gravel.

According to the map titled Bedrock Geologic Map of Maine (1985) published by the MGS, the bedrock in the vicinity of the site consists of calcareous sandstone and/or interbedded sandstone and impure limestone of the Vassalboro Formation.

## **3.0 SUBSURFACE INVESTIGATION**

One (1) boring (HB-CLD-101) and one (1) probe (HB-CLD-102) were drilled for this project on November 9, 2016 by New England Boring Contractors (NEBC) using a trailer mounted drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the Boring Log in Appendix A.

Boring HB-CLD-101 was drilled using hollow stem auger drilling techniques. Soil samples were obtained in boring HB-CLD-101 at 5-foot intervals using Standard Penetration Test (SPT) methods. The NEBC drill rig is equipped with a manually operated hammer to drive the split

spoon. Probe HB-CLD-102 was drilled using solid stem auger techniques. No soil samples were obtained in the probe.

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. An experienced geotechnical engineer 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.

#### 4.0 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 five (5) standard grain size analyses with natural water content and three (3) grain size analyses with hydrometer and natural water content. The results of the laboratory testing program are discussed in the following section and are included in Appendix B – Laboratory Test Results. Laboratory test information is also shown on the Boring Logs in Appendix A.

#### 5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test boring and probe generally consisted of fill consisting of sand, silt and a thin layer of wood, overlying layers of native sandy silt, silty clay, and sand. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile.

Boring HB-CLD-101 was drilled to a depth of approximately 32.0 feet below ground surface (bgs) and did not encounter a refusal surface. Probe HB-CLD-102 was drilled to a depth of approximately 35.0 feet bgs without encountering a refusal surface.

The table below summarizes the field and laboratory information obtained in boring HB-CLD-101:

Approx. Depth BGS <sup>1</sup> (feet)	Soil Description	AASHTO <sup>2</sup> Classification	USCS <sup>3</sup>	WC% <sup>4</sup>
0.0 – 0.7	Pavement	--	--	--
0.7 – 12.0	Fill – Interbedded layers of light brown, brown and grey, damp to moist, fine to coarse sand, little to some gravel, trace to little silt and grey, moist, silt, little fine to medium sand, little clay.	A-1-b	SW-SM or SW	3.6 to 2.7
	2" Wood layer	A-4	CL	29.0

12.0 – 20.6	Interbedded layers of brownish grey to grey, wet, fine to medium Sandy silt, trace clay, trace wood and organics and brown, fine to coarse sand, some silt, little gravel.	A-4	CL	27.7
20.6 – 30.0	Olive brown to grey, wet, silty clay, trace fine to medium sand.	A-6	CL	37.8 to 31.0
30.0 – 32.0	Brownish-grey, wet, fine to coarse sand, little silt, trace gravel, with layer of fine sandy silt.	A-2-4	SM	18.8

<sup>1</sup>BGS = below ground surface

<sup>2</sup>AASHTO = American Association of State Highway and Transportation Officials

<sup>3</sup>USCS = Unified Soil Classification System

<sup>4</sup>WC% = Water content in percent

Two (2) N-values obtained in the sand fill were 7 blows per foot (bpf) and 63 bpf indicating that the fill is loose to very dense in consistency. One (1) N-value obtained in the silt fill was 4 bpf indicating that the silt fill is soft in consistency. One (1) N-value obtained in the native sandy silt was 4 bpf indicating that the sandy silt is soft in consistency. One (1) N-value obtained in the silty clay was 6 bpf indicating that the silty clay is medium stiff in consistency. One (1) N-value obtained in the native sand was 21 bpf indicating that the sand is medium dense in consistency.

Vane shear testing conducted in the silty clay layer showed measured undrained shear strengths ranging from approximately 491 to 804 pounds per square foot (psf) with remolded shear strengths ranging from 67 to 112 psf. Based on the ratio of undrained to remolded shear strength from the vane shear tests, the silty clay was determined to have a sensitivity of approximately 7.0 to 8.0 and are classified as sensitive.

The following table summarizes the results of Atterberg Limits tests done on one (1) sample of the native silty clay:

Boring No. and Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-CLD-101 6D	31.0	28	18	10	1.30

Interpretation of these results indicate that the silty clay has medium plasticity and is on the verge of being a viscous liquid if disturbed. Overburden pressure and interparticle cementation is providing stability to keep the soil in its current state, but the slightest disturbance causing remolding could convert the soil into a viscous fluid.

Groundwater was observed in boring HB-CLD-101 at a depth of approximately 10.6 feet bgs. Groundwater was not observed in the probe. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

## **6.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS**

The proposed replacement structure will consist of a 128-inch span by 83-inch rise by 96-foot long polymer-coated steel pipe arch culvert on a skew of approximately 26 degrees to the roadway centerline. The proposed structure inlet and outlet slopes shall be riprapped with slopes no steeper than 2H:1V to protect against erosion. The following sections discuss geotechnical recommendations for the design and construction of the proposed culvert.

### **6.1 Polymer-Coated Steel Pipe Arch Culvert Design and Construction**

The proposed replacement structure will consist of a 128-inch span by 83-inch rise by 96-foot long polymer-coated steel pipe arch culvert on a skew of approximately 26 degrees to the roadway centerline. The proposed polymer-coated steel pipe arch shall be designed and constructed in accordance with MaineDOT Standard Specification 603. The inverts of the proposed polymer-coated steel pipe arch range from approximate elevation 47.3 feet at the inlet to approximate elevation 46.9 at the outlet with a 0.36 percent slope.

The full nature of the culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders in excess of 6 inches encountered at the bedding elevation shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone  $\frac{3}{4}$ -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. A 2-inch layer of wood was encountered at the approximate proposed culvert bedding elevation. Any wood, loose soils, or soft or unsuitable materials encountered in the culvert excavation shall be removed and replaced with Granular Borrow Material for Underwater Backfill (MaineDOT 703.19) or Crushed Stone  $\frac{3}{4}$ -Inch (MaineDOT 703.13).

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.

### **6.2 Settlement**

No settlement issues are anticipated at the site. The proposed polymer-coated steel pipe arch culvert is larger than the existing culvert 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.

### **6.3 Scour and Riprap**

Both the inlet and outlet of the polymer-coated steel pipe arch culvert shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. Slopes 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 non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03 that is underlain by a 1-foot layer of protective aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19). The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

### **6.4 Seismic Design Considerations**

In conformance 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, seismic analysis is not required.

### **6.5 Construction Considerations**

Construction activities may 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 proposed polymer-coated steel pipe arch culvert will require deep 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.

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.

## 7.0 CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed replacement of an existing large culvert (#46210) under Tuttle Road in Cumberland, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

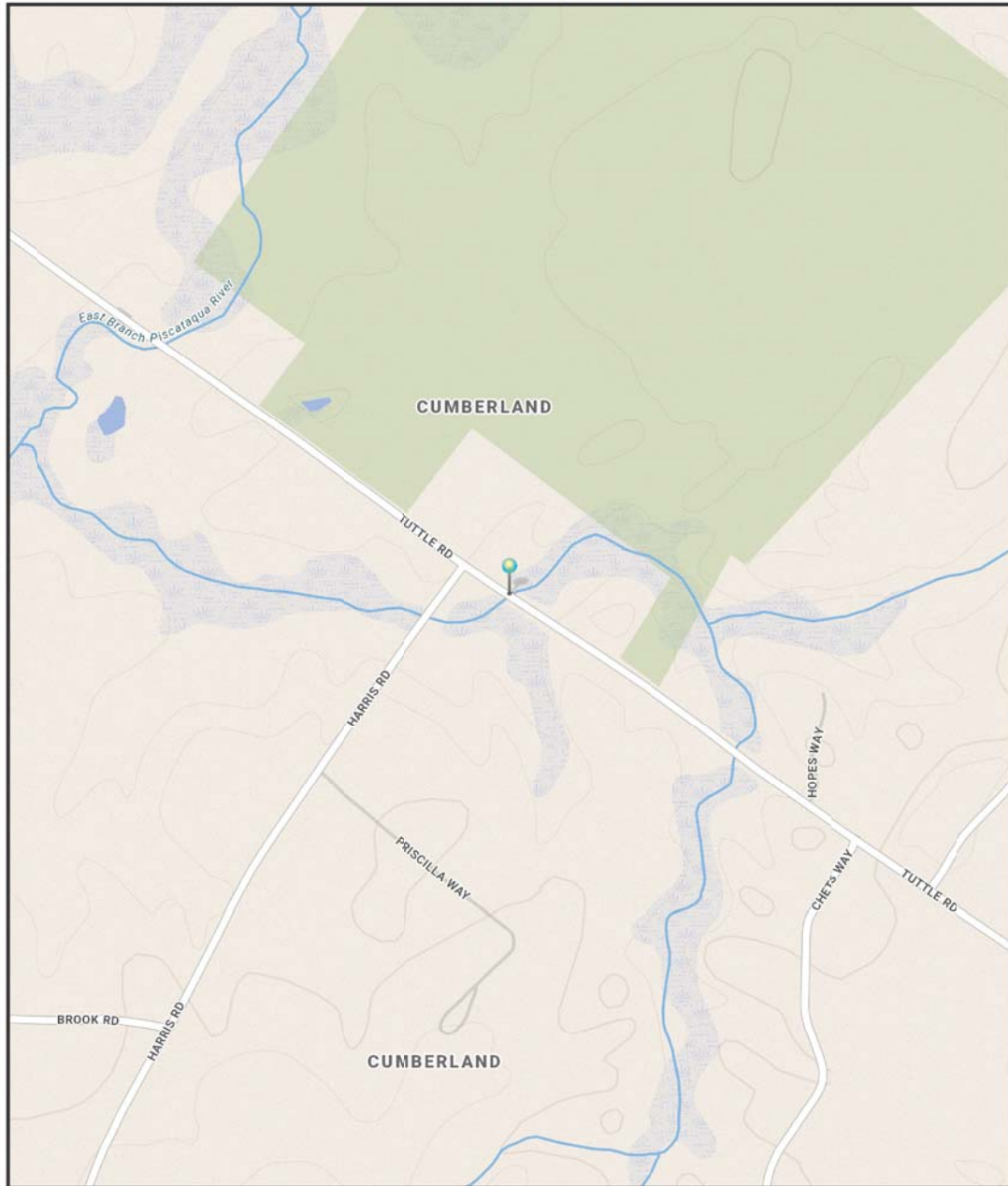
In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes 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.

## **Sheets**



# CUMBERLAND, MAINE

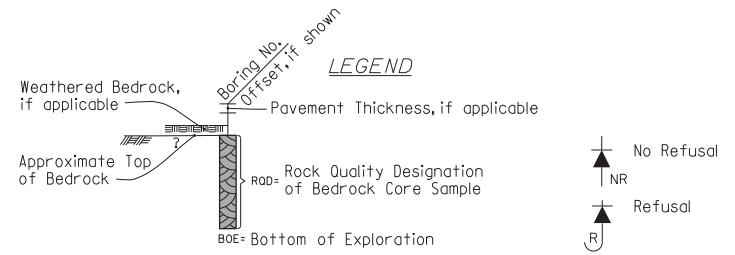
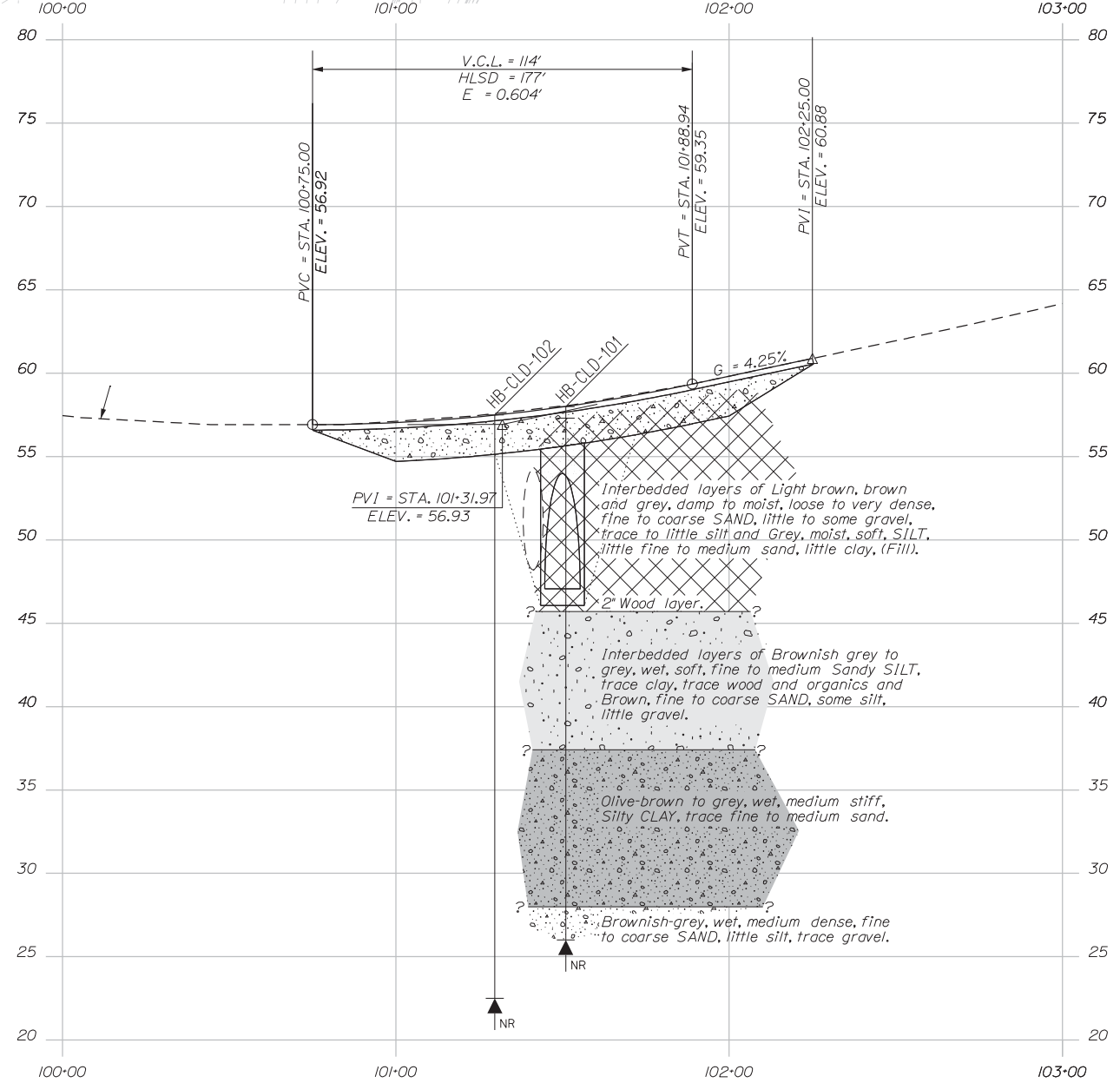
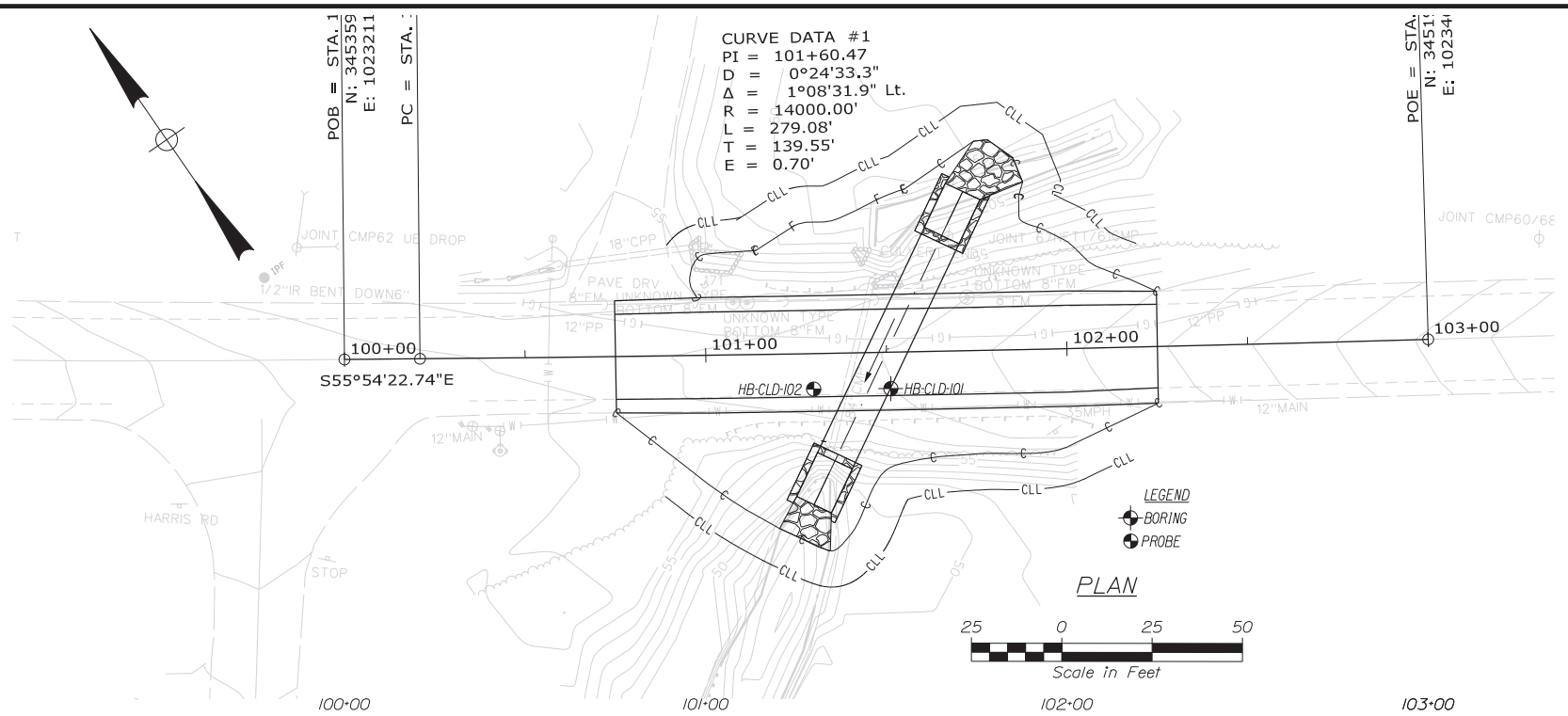


The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch.

0.1 Miles  
1 inch = 0.13 miles

Date: 5/7/2020  
Time: 10:38:02 AM

SHEET NUMBER  <b>1</b>  OF 2	CUMBERLAND TUTTLE ROAD	STATE OF MAINE DEPARTMENT OF TRANSPORTATION	
		CAPITAL PROJECTS	
	LOCATION MAP	WIN <b>22668.00</b>	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.

STATE OF MAINE		DEPARTMENT OF TRANSPORTATION	
022668.00		WIN 22668.00	
HIGHWAY PLANS		SHEET NUMBER	
CUMBERLAND TUTTLE ROAD		BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE	
PROJ. MANAGER	DATE	BY	DATE
C. RUSSELL	MAY 2020	T. WHITE	MAY 2020
CHECKED-REVIEWED	SIGNATURE		
DESIGNS-DETAILED	P.E. NUMBER		
DESIGNS-DETAILED	DATE		
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			
2		OF 2	

## **Appendix A**

Boring Logs



<b>Maine Department of Transportation</b> Soil/Rock Exploration Log US CUSTOMARY UNITS	<b>Project:</b> Large Culvert #46210 Replacement on Tuttle Road <b>Location:</b> Cumberland, Maine	<b>Boring No.:</b> HB-CLD-101 <b>WIN:</b> 22668.00
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<b>Drilling Contractor:</b> New England Boring	<b>Elevation (ft.):</b> 58.0	<b>Auger ID/OD:</b> 2.25-5.0"
<b>Operator:</b> Dupuis/Maynard	<b>Datum:</b> NAVD88	<b>Sampler:</b> Standard Split Spoon
<b>Logged By:</b> Be Schonewald	<b>Rig Type:</b> Mobile Drill B-51 Trailer	<b>Hammer Wt./Fall:</b> 140#30"
<b>Date Start/Finish:</b> 11/9/2016; 10:20-13:30	<b>Drilling Method:</b> Hollow Stem Auger	<b>Core Barrel:</b> N/A
<b>Boring Location:</b> 101+51, 10.0 ft Rt.	<b>Casing ID/OD:</b> N/A	<b>Water Level*:</b> 10.6 ft bgs inside augers

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<sub>u</sub> = Peak/Remolded Field Vane Undrained Shear Strength (psf)  
 B = Bucket Sample off Auger Flights SSA = Solid Stem Auger S<sub>u(lab)</sub> = Lab Vane Undrained Shear Strength (psf) LL = Liquid Limit  
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q<sub>p</sub> = Unconfined Compressive Strength (ksf) PL = Plastic Limit  
 U = Thin Wall Tube Sample RC = Roller Cone N-value = Raw Field SPT N-value PI = Plasticity Index  
 MV = Unsuccessful Field Vane Shear Test Attempt WOH = Weight of 140lb. Hammer T<sub>v</sub> = Pocket Torvane Shear Strength (psf) G = Grain Size Analysis  
 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							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-value	Casing Blows					
0							57.3		0.7 ft HMA.		
	1D	24/14	1.50 - 3.50	21/42/21/22	63				Brown, damp, very dense, fine to coarse SAND, some gravel, trace silt, (Fill).	G#304332 A-1-b, SW-SM WC=3.6%	
5											
	2D	24/13	5.00 - 7.00	5/3/4/5	7				Light brown, damp, loose, fine to coarse SAND, little gravel, trace silt, (Fill).	G#304333 A-1-b, SW WC=2.7%	
10											
	3D	24/16	10.00 - 12.00	1/2/2/2	4				Grey, moist, soft, SILT, little fine to medium sand, little clay, with pieces debris; disturbed.	G#304334 A-4, CL WC=29.0%	
	3D-A						46.0		3D-A (11.7-12.0 ft) A 2-inch layer Wood, possible pressure treated, underlain by Grey, fine to medium SAND, little silt, (Fill).		
15											
	4D	24/17	15.30 - 17.30	2/1/3/3	4				Brownish grey to grey, wet, soft, fine to medium Sandy SILT, trace clay, with pieces of wood and organics that decrease with depth.	G#304335 A-4, CL WC=27.7%	
20											
	5D	24/20	20.00 - 22.00	2/3/3/2	6		37.4		Brown, fine to coarse SAND, some silt, little gravel.		
									5D (20.6-22.0) Olive-brown to grey, wet, medium stiff, Silty CLAY, trace fine to medium sand.	G#304336 A-6, CL WC=37.8%	
	V1		22.63 - 23.00	Su=491/67 psf					55x110 mm vane raw torque readings: V1: 11.0/1.5 ft-lbs		
	V2		23.63 - 24.00	Su=625/89 psf					V2: 14.0/2.0 ft-lbs		
25											

**Remarks:**





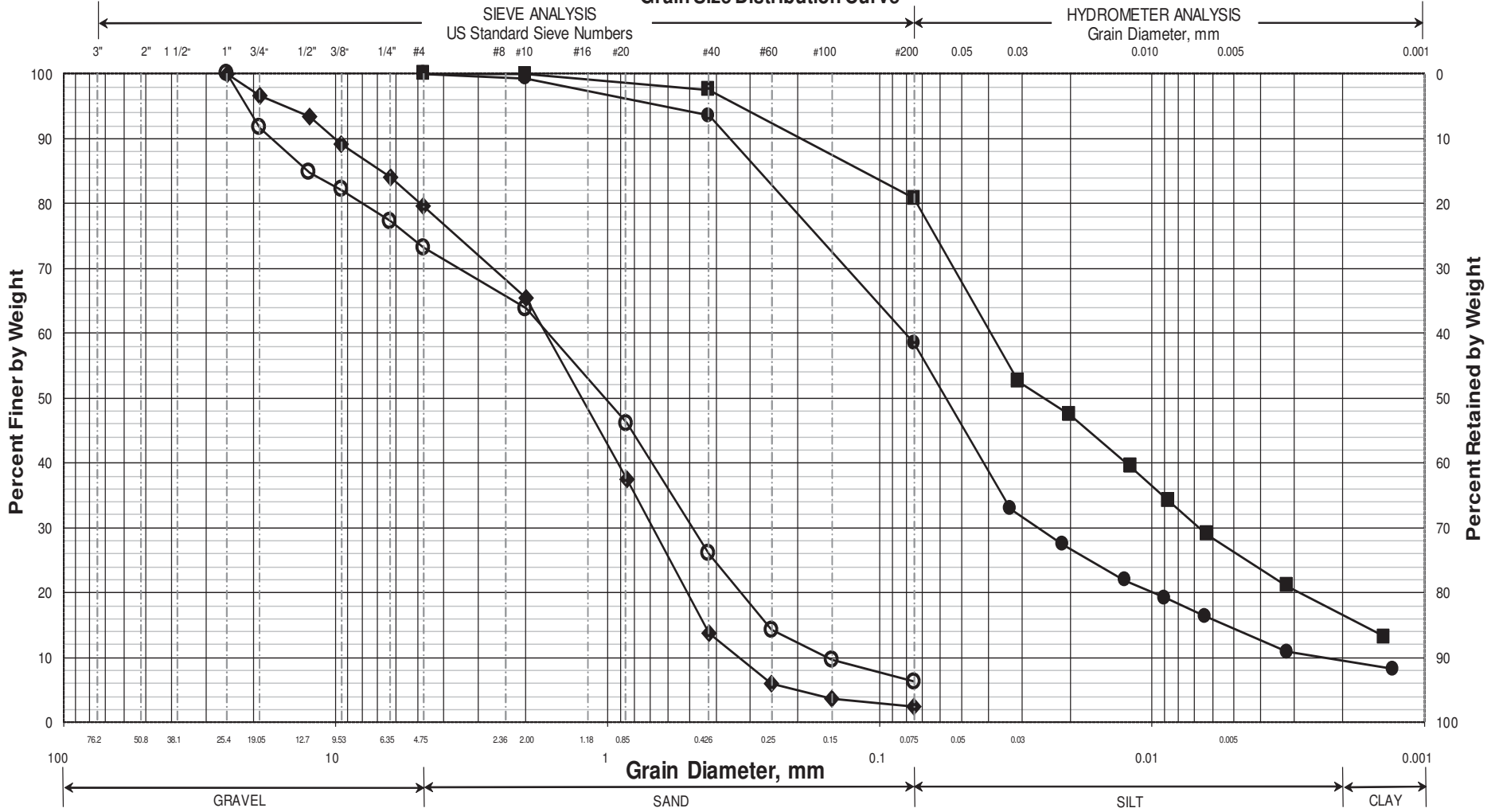


## **Appendix B**

Laboratory Test Results



## Maine Department of Transportation Grain Size Distribution Curve

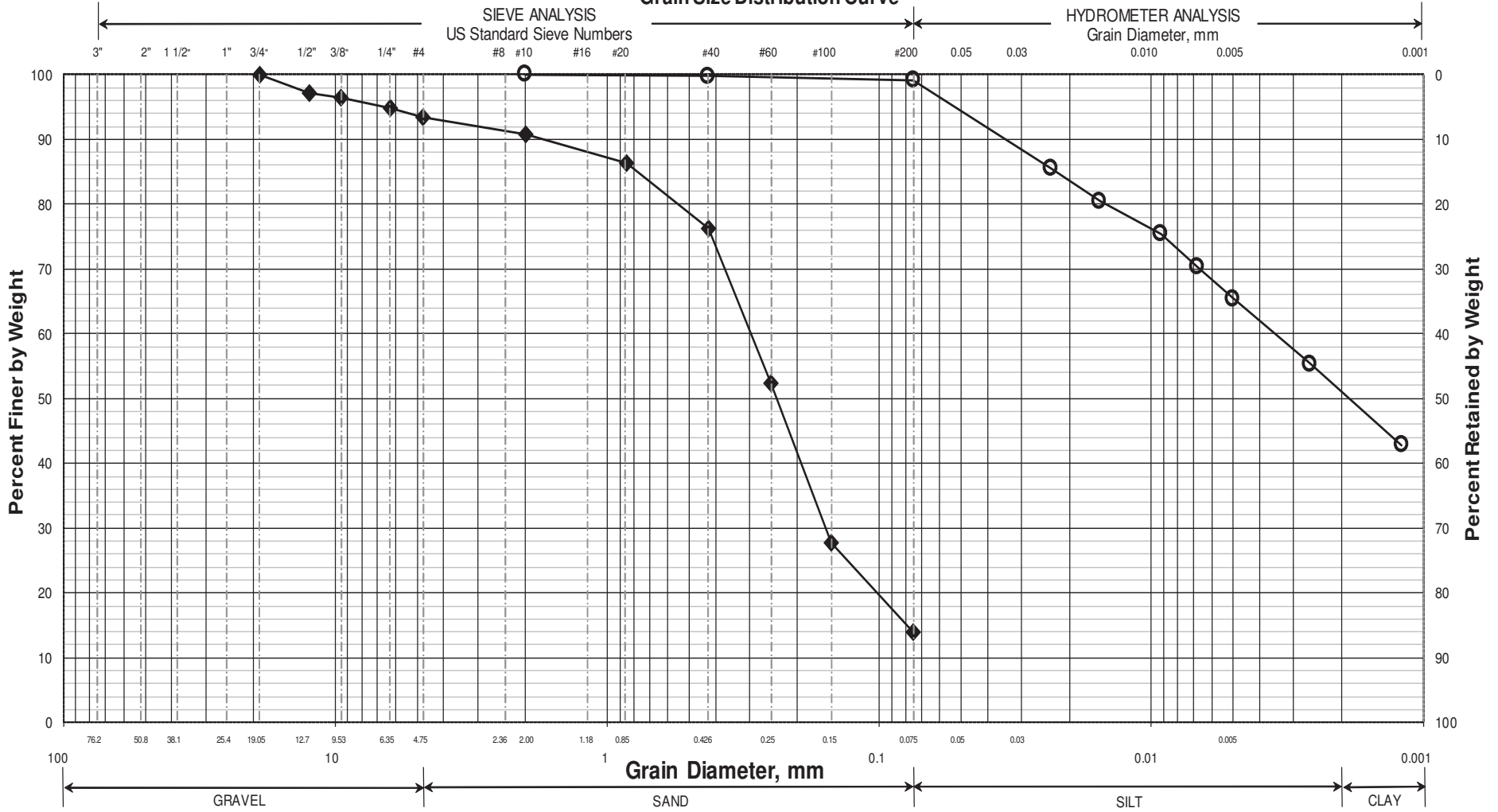


UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-CLD-101/1D	101+51	10.0 RT	1.5-3.5	SAND, some gravel, trace silt.	3.6			
◆	HB-CLD-101/2D	101+51	10.0 RT	5.0-7.0	SAND, little gravel, trace silt.	2.7			
■	HB-CLD-101/3D	101+51	10.0 RT	10.0-11.7	SILT, little sand, little clay.	29.0			
●	HB-CLD-101/4D	101+51	10.0 RT	15.3-17.3	Sandy SILT, trace clay.	27.7			
▲									
X									

WIN
022668.00
Town
Cumberland
Reported by/Date
WHITE, TERRY A 5/7/2020

### Maine Department of Transportation Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-CLD-101/5D	101+51	10.0 RT	20.6-22.0	Silty CLAY, trace sand.	37.8			
◆	HB-CLD-101/7D	101+51	10.0 RT	30.0-32.0	SAND, little silt, trace gravel.	18.8			
■									
●									
▲									
×									

WIN
022668.00
Town
Cumberland
Reported by/Date
WHITE, TERRY A      5/7/2020

TOWN	Cumberland	Reference No.	304337
WIN	022668.00	Water Content, %	31
Sampled	11/9/2016	Liquid Limit @ 25 blows (T 89), %	28
Boring No./Sample No.	HB-CLD-101/6D	Plastic Limit (T 90), %	18
Station	101+51	Plasticity Index (T 90), %	10
Depth	25.0-27.0	Tested By	BBURR

