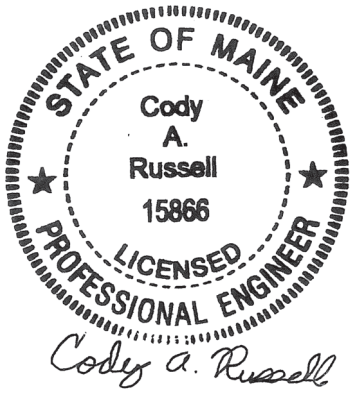
MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of

STAGE ROAD BRIDGE
ROUTE 2
ETNA, MAINE

Prepared by:
Yueh-Ti Lee
Assistant Geotechnical Engineer



Reviewed by:
Cody Russell, P.E.
Senior Geotechnical Engineer

Penobscot County
WIN 24279.00

Soils Report 2024-37
Bridge No. 6722

November 18, 2024

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Appendices

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 (#47394) on Route 2 in Etna. 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 consists of a 5-foot span by 4-foot rise by 45-foot-long concrete box culvert. The existing culvert is in poor condition and needs replacement both from an infrastructure and environmental standpoint. Route 2 is a Highway Corridor Priority 3 road.

The proposed replacement structure will be an approximately 128-inch span by 83-inch rise by 100-foot-long corrugated metal pipe (CMP) arch culvert on a skew of approximately 30 degrees. The invert of the proposed culvert is approximately 12 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 Route 2 in Etna and is located approximately 0.73 of a mile east of West Etna Road as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Reconnaissance Surficial Geology of the Stetson Quadrangle, Maine, Open File 86-39 (1986) the surficial soils at the site consist of Till. Till consists of silt, clay, and sand.

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 interbedded sandstone and impure limestone of the Vassalboro Formation.

3.0 SUBSURFACE INVESTIGATION

One (1) boring (HB-ETA-101) and one (1) probe (HB-ETA-102) were drilled for this project on February 20, 2020 by the MaineDOT drill crew using a trailer-mounted drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile with Boring Logs. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the Boring Logs in Appendix A.

Boring HB-ETA-101 was drilled using solid stem auger, cased wash boring, and open hole drilling techniques. Soil samples were obtained in boring HB-ETA-101 at 5-foot intervals using Standard Penetration Test (SPT) methods. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The MaineDOT calibrated automatic hammer delivers approximately 48

percent more energy 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 0.886 to the raw field N-values. Probe HB-ETA-102 was drilled using solid stem drilling 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. 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.

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 four (4) standard grain size analyses with natural water content and one (1) 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 generally consisted of fill consisting of gravelly sand and gravel underlain by glacial till consisting of sandy gravel and silt. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile with Boring Logs.

Boring HB-ETA-101 was drilled to a depth of approximately 22.0 feet below ground surface (bgs) and did not encounter a refusal surface. Probe HB-ETA-102 was drilled to a depth of approximately 20.0 feet bgs and did not encounter a refusal surface.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 0.3	HMA Pavement	--	--	--
0.3 – 9.0	Fill: Brown, damp to wet, gravelly fine to coarse sand, trace to some silt. Brown, moist, gravel, some fine to coarse sand, little silt, occasional cobbles.	A-1-b	SM or GM	7.3 to 16.5
9.0 – 22.0	Glacial Till:	A-1-a	GM	11.0

	Grey-brown, wet, fine to coarse sandy gravel, little silt. Grey, wet, silt, some fine to coarse sand, trace to little clay, little gravel.	or A-4	or CL	to 20.6

[1]BGS = below ground surface
[2]AASHTO = American Association of State Highway and Transportation Officials
[3]USCS = Unified Soil Classification System
[4]WC% = Water content in percent

One (1) N_{60}-value obtained in the fill was 92 blows per foot (bpf) indicating that the fill is very dense in consistency. Two (2) N_{60}-values obtained in the silt glacial till were 55 bpf and 69 bpf, indicating that the glacial till is hard in consistency.

Groundwater was recorded at depth 10.0 feet bgs in boring HB-ETA-101. 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 following sections discuss geotechnical recommendations for the design and construction of the proposed culvert.

6.1 Corrugated Metal Pipe Arch Culvert Design and Construction

The proposed replacement structure will be a 128-inch span by 83-inch rise by 100-foot-long corrugated metal pipe arch culvert on a skew of approximately 29 degrees. The proposed corrugated metal pipe arch culvert shall be furnished and installed in accordance with MaineDOT Standard Specification 509.

The invert of the proposed corrugated metal pipe arch culvert ranges from approximately 335.15 feet at the inlet end to approximately 334.15 feet at the outlet end with a 1.1% slope.

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.

6.2 Settlement

No settlement issues are anticipated at the site. The proposed corrugated metal pipe arch culvert will be constructed at a new location east (up station) of the existing culvert. The proposed corrugated metal pipe arch culvert is larger than the existing culvert and will result in a net unloading of the site soils at the proposed 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 bedding material will be immediate and negligible.

6.3 Scour and Riprap

Both the inlet and outlet of the corrugated metal 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 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 corrugated metal pipe arch 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.

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 (#47394) under Route 2 in Etna, 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.

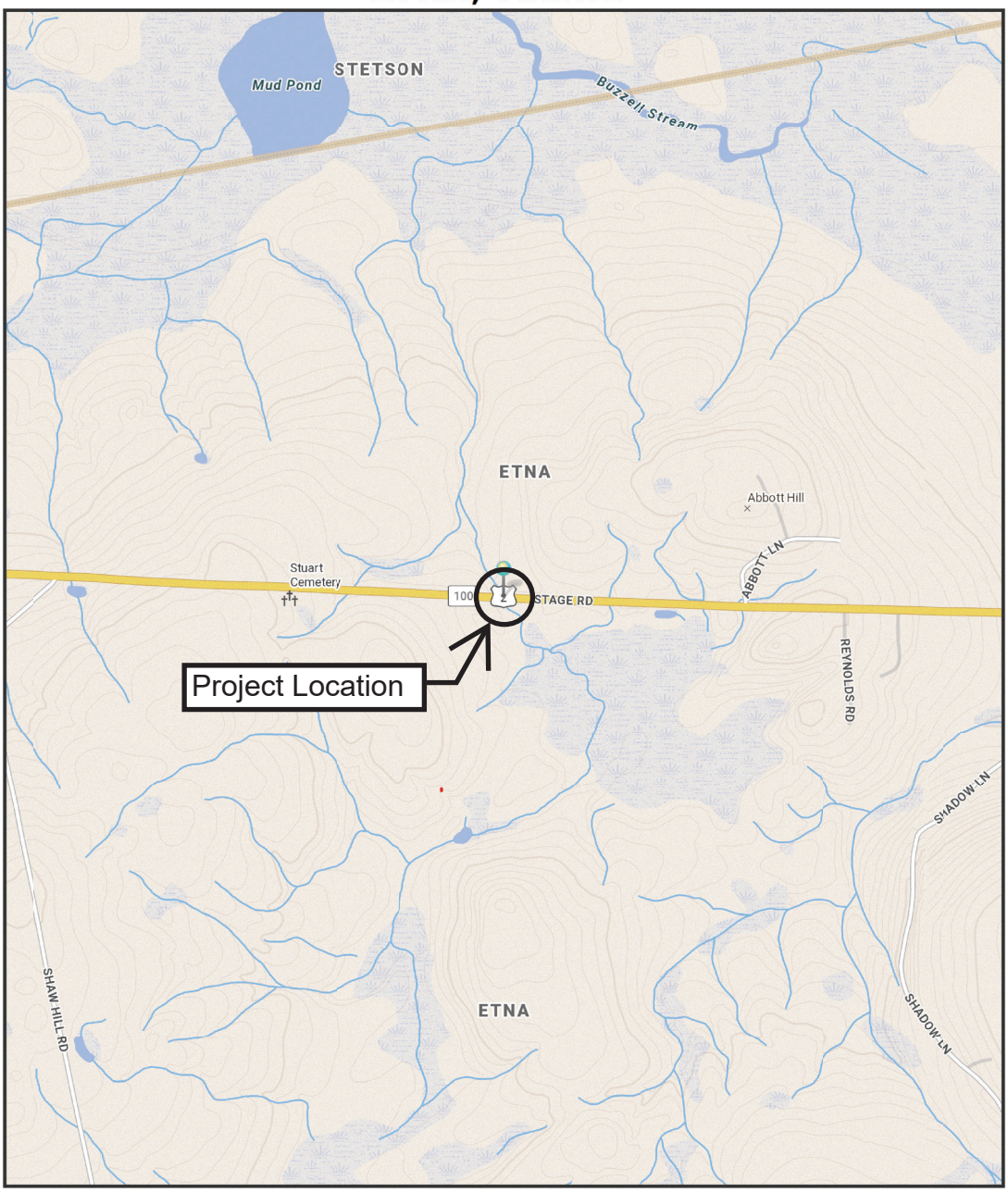
Sheets

Date:10/10/2024

Division: GEOTECH

Username: Terry.White

ETNA, MAINE

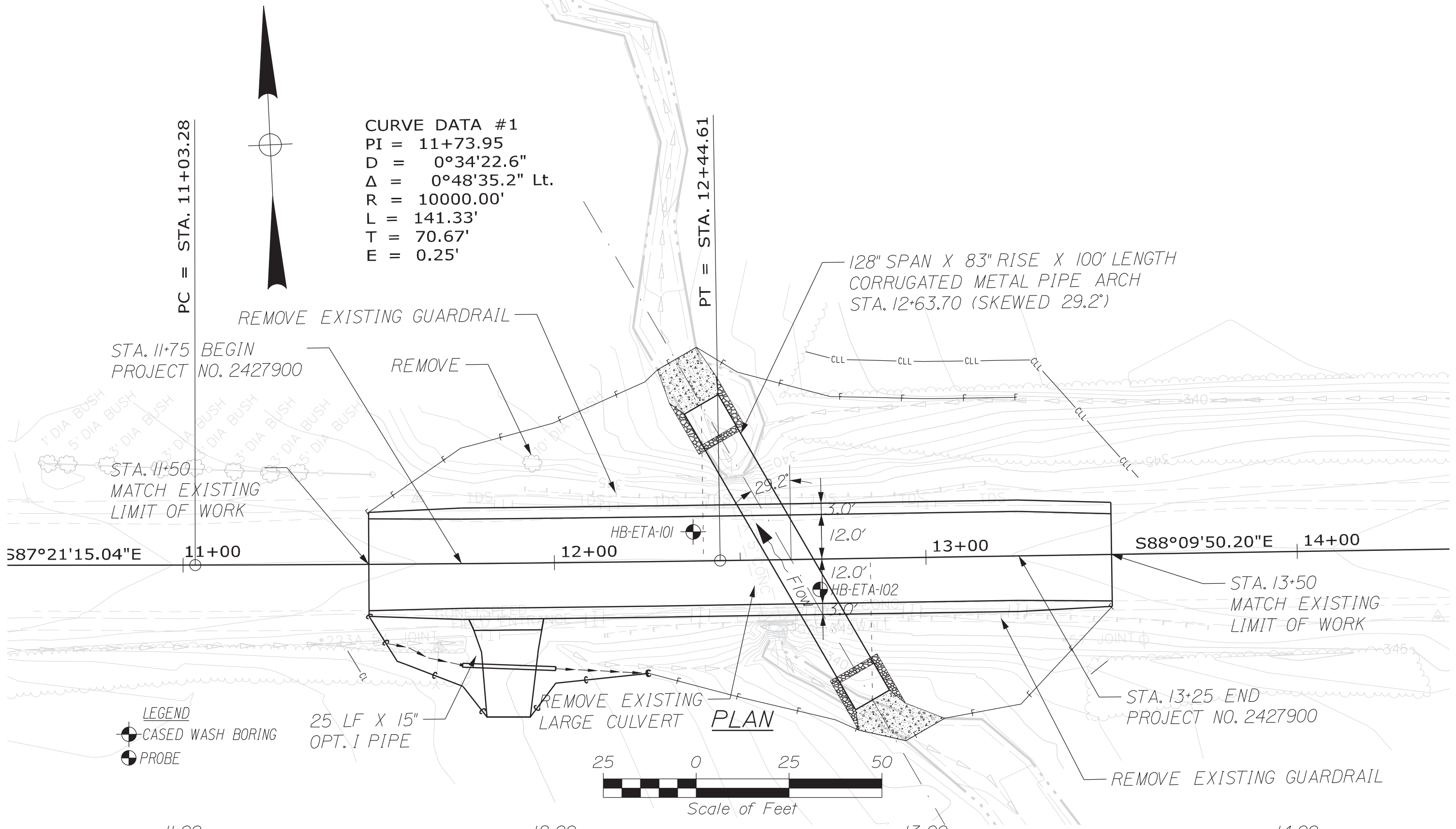


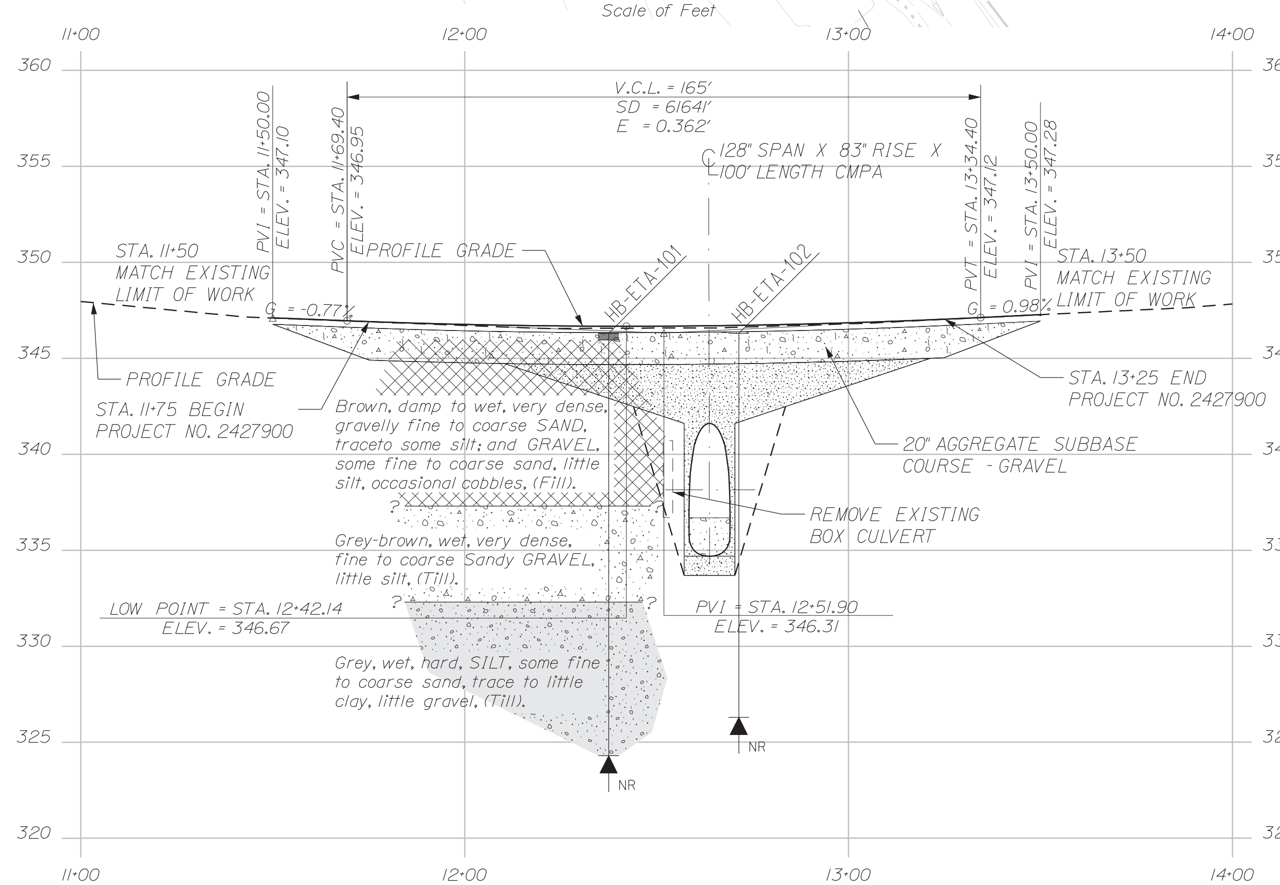
0.25 Miles

1 inch = 0.28 miles

Date: 10/10/2024
Time: 9:59:06 AM

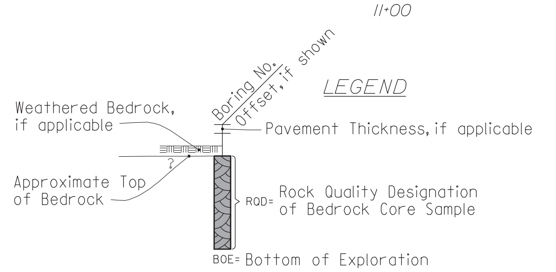
SHEET NUMBER 1 OF 2	ETNA ROUTE 2 LOCATION MAP	STATE OF MAINE DEPARTMENT OF TRANSPORTATION 2427900 WIN 24279.00 HIGHWAY PLANS





PROFILE

HORIZ 25 0 25 50
VERT 5 0 5 10
SCALE



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.

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

Project: Rout 2 Large Culvert
Location: Etna, Maine
Boring No.: HB-ETA-101
WIN: 24279.00

Driller:	MaineDOT	Elevation (ft.)	346.3	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Westrack	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B.Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/20/2020; 08:00-12:00	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	12+37.5, 7.8 ft Lt.	Casing ID/OD:	NW-3"	Water Level*:	10.0 ft bgs.
Hammer Efficiency Factor: 0.886		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	346.0	4" HMA. (0.3)	
									Brown, damp, Gravelly fine to coarse SAND, trace silt, (Fill). (Off Auger) (1.5)	
								344.8 / 344.3	Concrete. (2.0)	
	1D	24/15	2.00 - 4.00	30/38/24/28	62	92			Brown, wet (frozen), very dense, Gravelly fine to coarse SAND, some silt, (Fill). FROST depth at 3.0 ft bgs.	G#340697 A-1-b, SM WC=16.5%
5	2D	15.6/12	5.00 - 6.30	15/30/50(3.6")	---				Brown, moist, very dense, GRAVEL, some fine to coarse sand, little silt, occasional cobbles, (Fill). Cobble from 6.3-6.6 ft bgs. Cobble from 7.6-7.9 ft bgs. Cobble from 8.0-8.6 ft bgs. (9.0)	G#340698 A-1-b, GM WC=7.3%
10	3D	12/9	10.00 - 11.00	38/50	---		85	337.3	Grey brown, wet, very dense, fine to coarse Sandy GRAVEL, little silt, (Till). Cobble from 11.0-11.6 ft bgs. Roller Coned ahead to 15.0 ft bgs. (14.0)	G#340699 A-1-a, GM WC=17.6%
							OPEN HOLE	332.3		
15	4D	24/20	15.00 - 17.00	10/21/26/24	47	69			Grey, wet, hard, SILT, some fine to coarse sand, little clay, little gravel, (Till).	G#340700 A-4, CL WC=11.0%
20	5D	24/22	20.00 - 22.00	19/18/19/25	37	55			Grey, wet, hard, SILT, some fine to coarse sand, (Till). (22.0)	G#340701 A-4, CL WC=20.6%
								324.3	Bottom of Exploration at 22.0 feet below ground surface. NO REFUSAL	
25										

Remarks:

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

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-ETA-101

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

Project: Rout 2 Large Culvert
Location: Etna, Maine
Boring No.: HB-ETA-102
WIN: 24279.00

Drilling Contractor:	MaineDOT	Elevation (ft.)	346.3	Auger ID/OD:	5" Dia.
Operator:	Daggett/Westrack	Datum:	NAVD88	Sampler:	N/A
Logged By:	B.Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	N/A
Date Start/Finish:	2/20/2020; 08:00-12:00	Drilling Method:	Solid Stem Auger	Core Barrel:	N/A
Boring Location:	12+71.4, 8.2 ft Rt.	Casing ID/OD:	N/A	Water Level*:	None Observed

Definitions: D = Split 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; 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-value	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0						SSA		Probe, no material samples taken.	
5									
10									
15									
20							326.3	Bottom of Exploration at 20.0 feet below ground surface. NO REFUSAL (20.0)	
25									

Remarks:

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

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 — Boring No.: HB-ETA-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
2427900
WIN 24279.00
HIGHWAY PLANS

SIGNATURE
P.E. NUMBER
DATE

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	T.LEE	
DESIGN3-DETAILED3	T.WHITE	NOV 2024
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

ETNA
ROUTE 2
BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE WITH BORING LOGS

SHEET NUMBER
2
OF 2

Filename: ...\MSTA\002_BLP&ISP_WBL1.dgn Division: GEOTECH Username: Yueh-Ti.Lee Date:11/19/2024

Appendix A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations (in this order, if applicable):

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

MODIFIED BURMISTER SYSTEM

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

TERMS DESCRIBING DENSITY/CONSISTENCY

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

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

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

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

Rock Quality Designation (RQD):

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

*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))

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

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: Rout 2 Large Culvert
Location: Etna, Maine

Boring No.: HB-ETA-101
WIN: 24279.00

Driller:	MaineDOT	**Elevation (ft.)**	346.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Westrack	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B.Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/20/2020; 08:00-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	12+37.5, 7.8 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor: 0.886		**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	346.0		4" HMA.	
										0.3	
								344.8		Brown, damp, Gravelly fine to coarse SAND, trace silt, (Fill). (Off Auger)	
								344.3		1.5	
	1D	24/15	2.00 - 4.00	30/38/24/28	62	92				Concrete.	G#340697 A-1-b, SM WC=16.5%
										2.0	
										Brown, wet (frozen), very dense, Gravelly fine to coarse SAND, some silt, (Fill). FROST depth at 3.0 ft bgs.	
5	2D	15.6/12	5.00 - 6.30	15/30/50(3.6")	---					Brown, moist, very dense, GRAVEL, some fine to coarse sand, little silt, occasional cobbles, (Fill).	G#340698 A-1-b, GM WC=7.3%
										Cobble from 6.3-6.6 ft bgs.	
										Cobble from 7.6-7.9 ft bgs. Cobble from 8.0-8.6 ft bgs.	
								337.3		9.0	
10	3D	12/9	10.00 - 11.00	38/50	---		85			Grey brown, wet, very dense, fine to coarse Sandy GRAVEL, little silt, (Till).	G#340699 A-1-a, GM WC=17.6%
							OPEN HOLE			Cobble from 11.0-11.6 ft bgs. Roller Coned ahead to 15.0 ft bgs.	
								332.3		14.0	
15	4D	24/20	15.00 - 17.00	10/21/26/24	47	69				Grey, wet, hard, SILT, some fine to coarse sand, little clay, little gravel, (Till).	G#340700 A-4, CL WC=11.0%
20	5D	24/22	20.00 - 22.00	19/18/19/25	37	55				Grey, wet, hard, SILT, some fine to coarse sand, (Till).	G#340701 A-4, CL WC=20.6%
								324.3		22.0	
										Bottom of Exploration at 22.0 feet below ground surface. NO REFUSAL	
25											

Remarks:

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

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-ETA-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Rout 2 Large Culvert
Location: Etna, Maine

Boring No.: HB-ETA-102
WIN: 24279.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	346.3	**Auger ID/OD:**	5" Dia.
Operator:	Daggett/Westrack	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B.Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	2/20/2020; 08:00-12:00	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	12+71.4, 8.2 ft Rt.	**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

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-value	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0						SSA			Probe, no material samples taken.	
5										
10										
15										
20							326.3		20.0 **Bottom of Exploration at 20.0 feet below ground surface.** NO REFUSAL	
25										

Remarks:

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.

Appendix B

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Etna Work Number: 24279.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
HB-ETA-101, 1D	12+37.5	7.8 Lt.	2.0-4.0	340697	1	16.5			SM	A-1-b	II
HB-ETA-101, 2D	12+37.5	7.8 Lt.	5.0-6.3	340698	1	7.3			GM	A-1-b	I
HB-ETA-101, 3D	12+37.5	7.8 Lt.	10.0-11.0	340699	1	17.6			GM	A-1-a	I
HB-ETA-101, 4D	12+37.5	7.8 Lt.	15.0-17.0	340700	1	11.0			CL	A-4	IV
HB-ETA-101, 5D	12+37.5	7.8 Lt.	20.0-22.0	340701	1	20.6			CL	A-4	IV

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

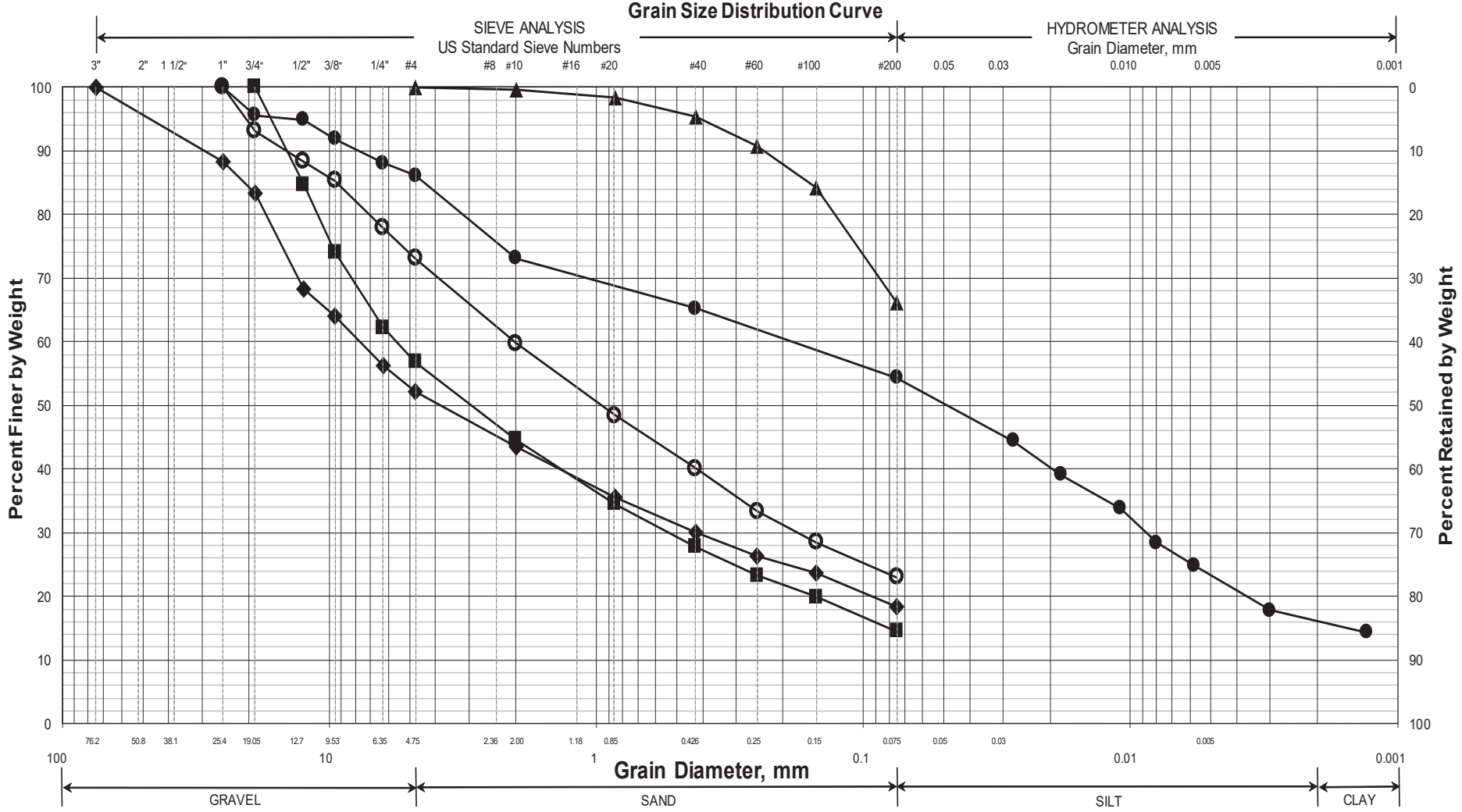
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

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

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

Maine Department of Transportation
Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-ETA-101/1D	12+37.5	7.8 LT	2.0-4.0	Gravelly SAND, some silt.	16.5			
◆	HB-ETA-101/2D	12+37.5	7.8 LT	5.0-6.3	GRAVEL, some sand, little silt.	7.3			
■	HB-ETA-101/3D	12+37.5	7.8 LT	10.0-11.0	Sandy GRAVEL, little silt.	17.6			
●	HB-ETA-101/4D	12+37.5	7.8 LT	15.0-17.0	SILT, some sand, little clay, little gravel.	11.0			
▲	HB-ETA-101/5D	12+37.5	7.8 LT	20.0-22.0	SILT, some sand.	20.6			
×									

WIN
024279.00
Town
Etna
Reported by/Date
WHITE, TERRY A 10/9/2024