MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of

PRESTILE HILL BRIDGE
ROUTE 164
CARIBOU, MAINE

Prepared by:
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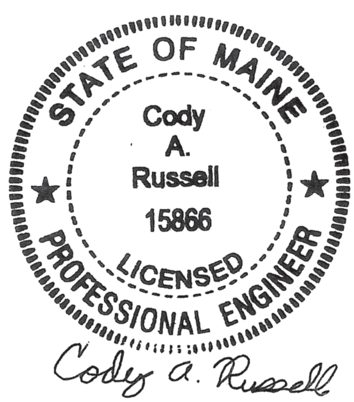
Assistant Geotechnical Engineer



Reviewed by:
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Aroostook County
WIN 22845.10

Soils Report 2026-05
Bridge No. 6599

January 22, 2026

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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 (#931080) on Route 164 in Caribou, 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 consists of an approximately 90-inch span by 96-inch rise by 120-foot-long precast concrete box culvert. The box culvert is in poor condition and needs replacement both from an infrastructure and environmental standpoint. Route 164 is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 30-foot span by 16-foot, 1.5-inch rise by 96-foot-long precast concrete arch culvert founded on stem walls founded on a mat foundation. The invert of the proposed culvert is approximately 40.4 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 164 in Caribou and is located approximately 1.10 of a mile north of Route 1 as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Reconnaissance Surficial Geology of the Caribou Quadrangle, Maine, Open File 86-59 (1986) the surficial soils at the site consist of Till. Till consists of sand, silt, and clay.

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 interbedded pelite, limestone, and dolostone of the Carys Mills Formation.

3.0 SUBSURFACE INVESTIGATION

One (1) boring (HB-CARI-101) and one (1) probe (HB-CARI-102) were drilled near the proposed structure on October 18, 2017 by the MaineDOT drill crew using a trailer mounted drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan. 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-CARI-101 was drilled using solid stem auger, cased wash boring, and roller cone drilling techniques. Soil samples were obtained in boring HB-CARI-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 42 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 0.854 to the raw field N-values. Probe HB-CARI-102 was drilled using solid stem auger, cased wash boring, and roller coned 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 in the boring and probe. 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 nine (9) standard grain size analyses with 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 in the test boring and probe generally consisted of sand and silty sand fill underlain by glacial till consisting of sand, sandy silt, silt, and gravelly sand. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 3 – Interpretive Subsurface Profile.

Boring HB-CARI-101 was drilled to depth of approximately 47.0 feet below ground surface (bgs) without encountering a refusal surface. Probe HB-CARI-102 was drilled to depth of approximately 45.0 feet bgs without encountering a refusal surface.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 18.5	Fill: Brown, moist to wet, fine to coarse sand, some gravel, some silt. Brown, moist, silty fine to coarse sand, some gravel.	A-1-b or A-2-4 A-4	SM SM	8.9 to 21.7 16.0
18.5 – 47.0	Till:			

	Grey, wet, fine to coarse sand, some silt, some gravel. Grey-brown, wet, fine to coarse sandy silt, some gravel. Grey-brown and grey, wet, silt, some fine to coarse sand, some gravel. Brown and grey-brown, wet, gravelly fine to coarse sand, some silt. Cobbles from 39.5-39.9 feet bgs.	A-2-4, A-4, or A-1-b	SM	8.7 to 20.8

[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

Three (3) N_{60}-values obtained in the fill ranged from 9 blows per foot (bpf) to 11 bpf and 14 bpf, indicating that the sand fill is loose to medium dense in consistency. Three (3) N_{60}-values obtained in the sand and gravelly sand till ranged from 19 bpf and 63 bpf, indicating that the sand and gravelly sand till are medium dense to very dense in consistency. Three (3) N_{60}-values obtained in the sandy silt and silt till ranged from 21 bpf to 91 bpf, indicating that the sandy silt and silt till are very stiff to hard in consistency

5.1 Groundwater

Groundwater was recorded at depth 4.0 feet bgs in boring HB-CARI-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 Precast Concrete Arch Culvert Design and Construction

The proposed replacement structure will consist of a 30-foot span by 16-foot 1.5-inch rise by 96-foot-long precast concrete arch culvert founded on stem walls founded on a mat foundation. The approximate top-of-footing elevation of the proposed precast concrete arch culvert will be set at an elevation of 463.83 feet. The proposed precast concrete arch culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 534.

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 ¾-Inch. Any disturbed soils at the bedding elevation resulting from excavation activities should be removed by hand prior to placement of the bedding material. 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 1.5-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.

6.2 Settlement

No settlement issues are anticipated at the site. The precast concrete 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 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 10th Edition 2024 (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	14.0

6.4 Modulus of Subgrade Reaction

A modulus of subgrade reaction (k_s) equal to 175 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.

6.5 Scour and Riprap

Both the inlet and outlet of the precast concrete arch 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.

6.6 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.

6.7 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 precast concrete 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 soil or bedrock 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 (#931080) under Route 164 in Caribou, 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.

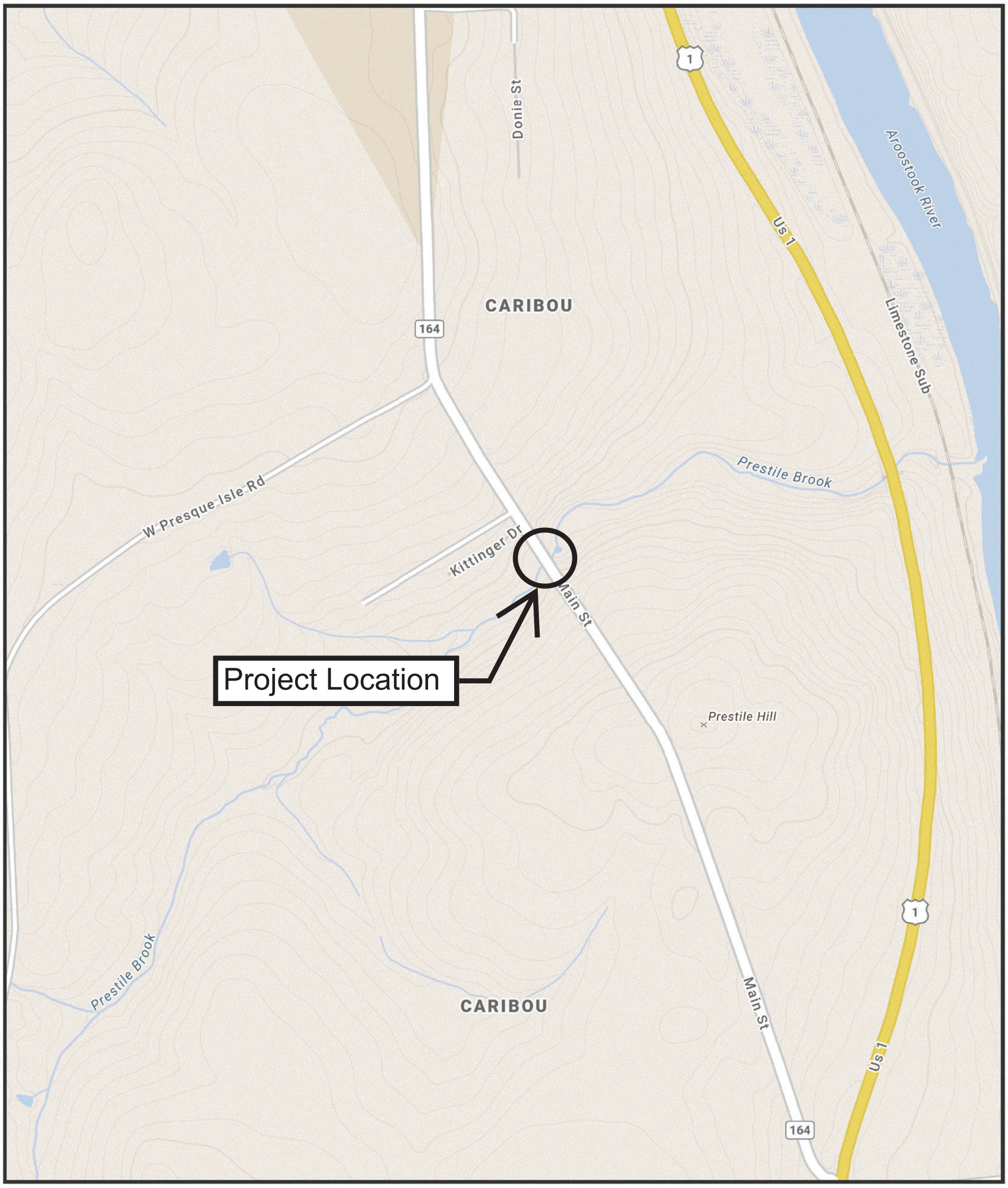
Sheets

Date:1/27/2026

Division:

Username: Cody.A.Russell

CARIBOU, MAINE



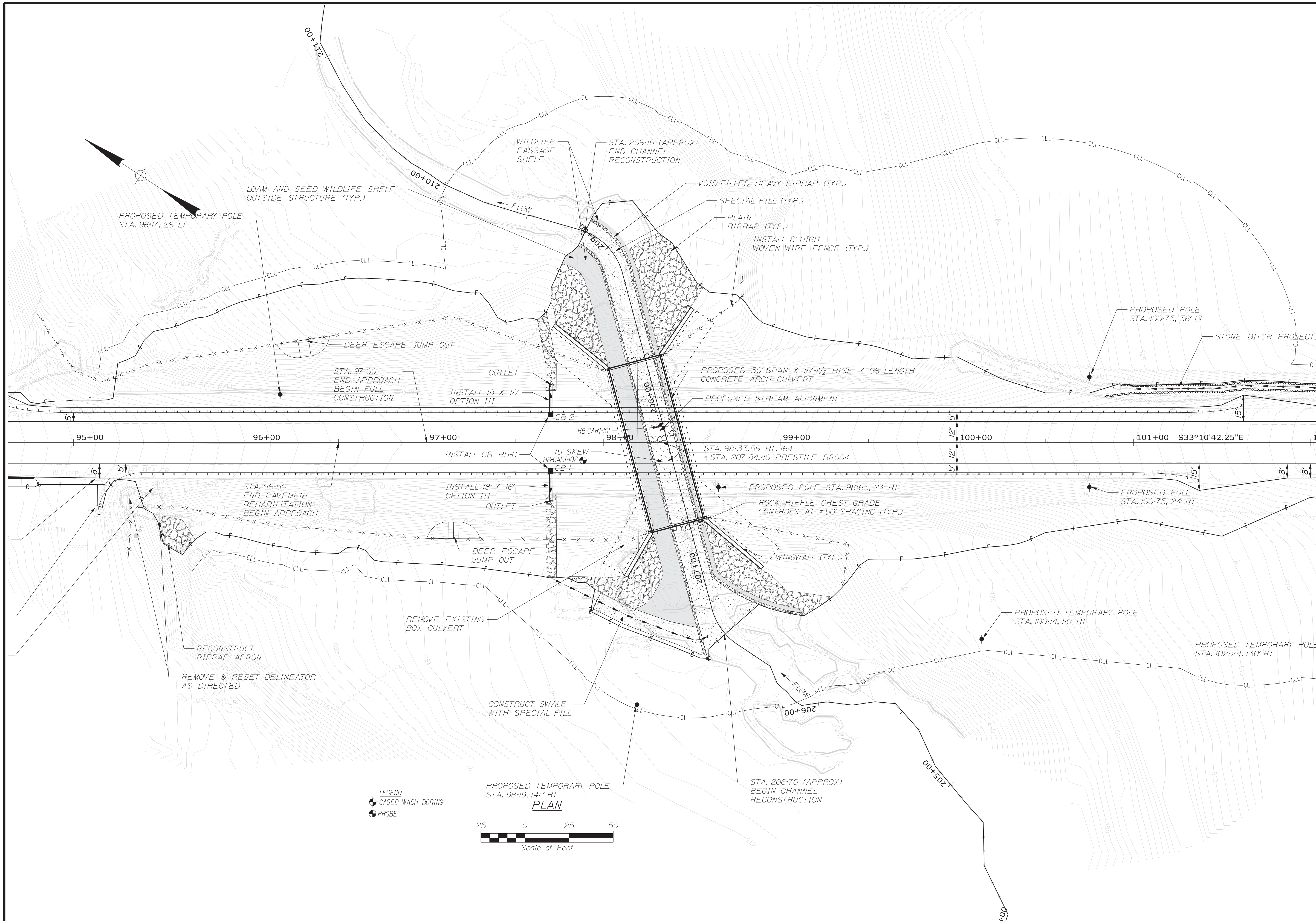
The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information.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

0.25 Miles

1 inch =0.28 miles

Date: 1/7/2026
Time: 11:12:06 AM

SHEET NUMBER	CARIBOU ROUTE 164	STATE OF MAINE DEPARTMENT OF TRANSPORTATION
1		2284510
OF 3	LOCATION MAP	WIN 22845.10 HIGHWAY PLANS



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2284510

WIN 22845.10

HIGHWAY PLANS

	BY	DATE	SIGNATURE
PROJ. MANAGER	R.SOUCY		
DESIGN-DETAILED			
CHECKED-REVIEWED			
DESIGN2-DETAILED2	T.LEE		
DESIGN3-DETAILED3	T.WHITE	JAN 2026	
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

P.E. NUMBER

DATE

CARIBOU
PRESTILE HILL BRIDGE

BORING LOCATION PLAN

SHEET NUMBER

2

OF 3

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Username: Cody.A.Russell Date:1/29/2026

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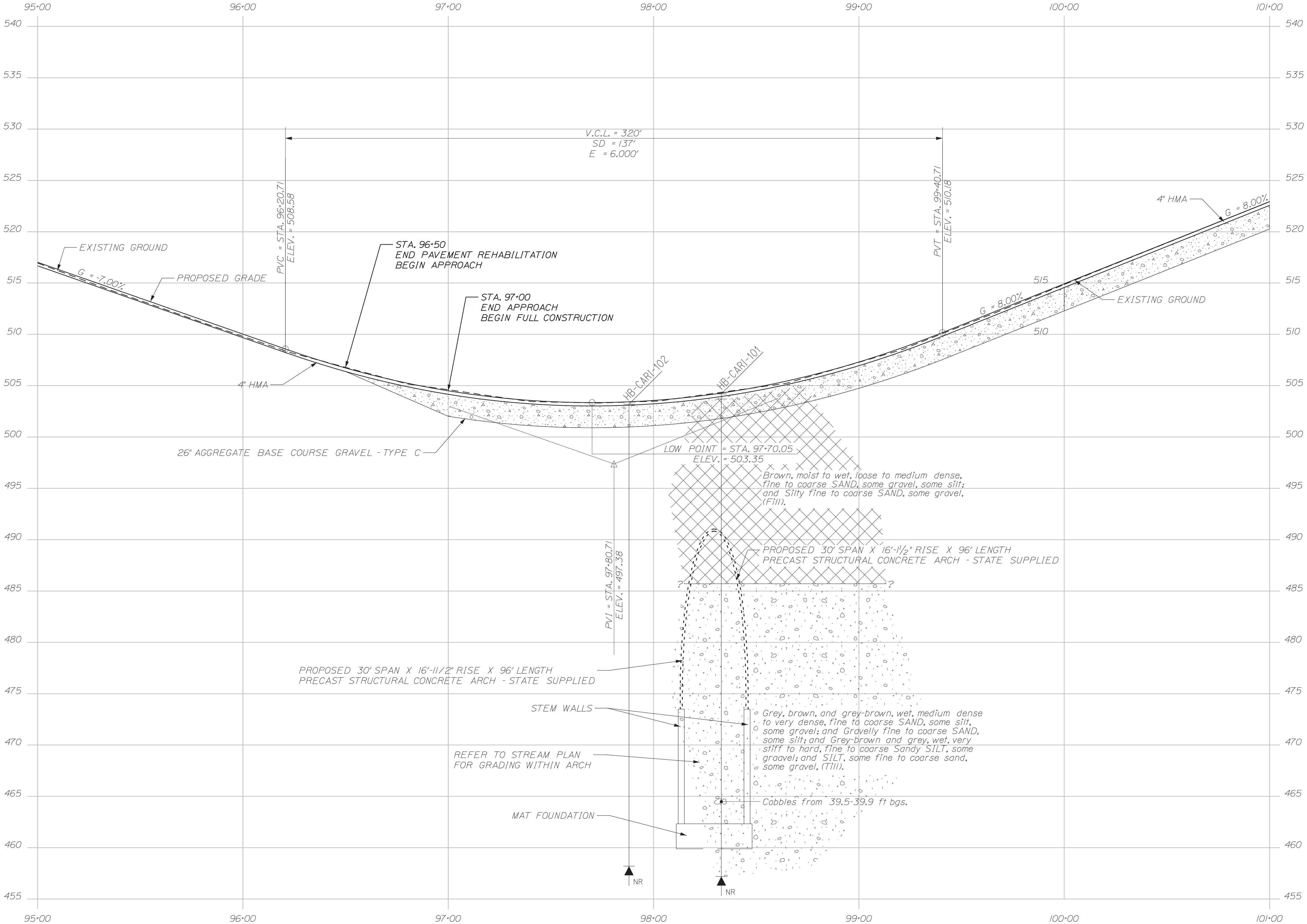
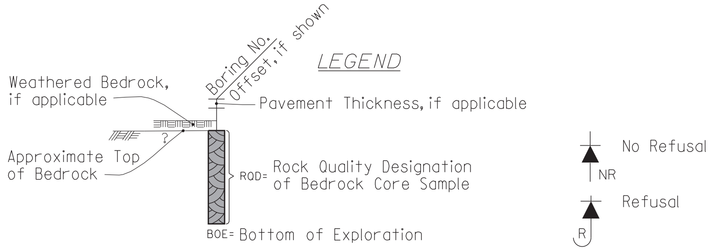
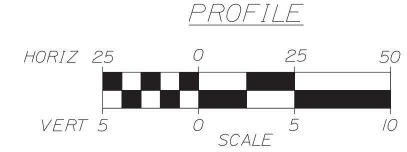


LEGEND



PROFILE



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

2284510

WIN 22845.10

HIGHWAY PLANS

		BY	DATE
PROJ. MANAGER	R.SOUCY		
DESIGN-DETAILED			
CHECKED-REVIEWED			
DESIGN2-DETAILED2	YT LEE	T.WHITE	JAN 2026
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

CARIBOU
PRESTILE HILL BRIDGE
INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 3

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):

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

*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: Route 164 Large Culvert Replacement
Location: Caribou, Maine

Boring No.: HB-CARI-101
WIN: 22845.10

Driller:	MaineDOT	**Elevation (ft.)**	504.2	**Auger ID/OD:**	5" Dia. Solid Stem
Operator:	Travis/Tyson	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	10/18/2017; 07:30-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	98+33, 9.4 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	4.0 ft bgs.
Hammer Efficiency Factor:	0.854	**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	503.7		6" HMA. 0.5	
5	1D	24/14	5.00 - 7.00	3/5/5/5	10	14				Brown, moist, medium dense, fine to coarse SAND, some gravel, some silt, (Fill).	G#302644 A-1-b, SM WC=8.9%
10	2D	24/12	10.00 - 12.00	3/3/3/4	6	9	6			Brown, moist, loose, Silty fine to coarse SAND, some gravel, (Fill).	G#302645 A-4, SM WC=16.0%
							12				
							14				
							18				
							21				
15	3D	24/8	15.00 - 17.00	6/4/4/8	8	11	13			Brown, wet, medium dense, fine to coarse SAND, some gravel, some silt, (Fill).	G#302646 A-2-4, SM WC=21.7%
							16				
							37				
							40	485.7		18.5	
							48				
20	4D	24/16	20.00 - 22.00	5/7/6/10	13	19	31			Grey, wet, medium dense, fine to coarse SAND, some silt, some gravel, (Till).	G#302647 A-2-4, SM WC=12.2%
							24				
							27				
							39				
25							77	480.2		24.0	

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.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Route 164 Large Culvert Replacement			**Boring No.:**	HB-CARI-101
Location:	Caribou, Maine			**WIN:**	22845.10
Driller:	MaineDOT	**Elevation (ft.)**	504.2	**Auger ID/OD:**	5" Dia. Solid Stem
Operator:	Travis/Tyson	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	10/18/2017; 07:30-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	98+33, 9.4 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	4.0 ft bgs.
Hammer Efficiency Factor:	0.854	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	5D	24/15	25.00 - 27.00	7/8/7/8	15	21	37			Grey-brown, wet, very stiff, fine to coarse Sandy SILT, some gravel, (Till).	G#302648 A-4, SM WC=20.8%
							32				
							49				
							54	475.7		28.5	
							53				
30	6D	24/17	30.00 - 32.00	5/6/13/10	19	27	22			Grey-brown, wet, very stiff, SILT, some fine to coarse sand, some gravel, (Till).	G#302649 A-4, SM WC=14.1%
							32				
							40				
							67	470.7		33.5	
							59				
35	7D	24/11	35.00 - 37.00	4/3/20/45	23	33	27			Brown, wet, dense, Gravelly fine to coarse SAND, some silt, (Till).	G#302650 A-1-b, SM WC=18.1%
							32				
							48			Roller Coned ahead to 40.0 ft bgs.	
							93				
							165			Cobbles from 39.5-39.9 ft bgs.	
40	8D	24/15	40.00 - 42.00	7/19/25/34	44	63	47			Grey-brown, wet, very dense, Gravelly fine to coarse SAND, some silt, (Till).	G#303026 A-1-b, SM WC=10.0%
							97				
							114	461.2		43.0	
							88				
							114				
45	9D	24/18	45.00 - 47.00	14/36/28/31	64	91				Grey, wet, hard, SILT, some fine to coarse sand, some gravel, (Till).	G#303027 A-4, SM WC=8.7%
								457.2		47.0 **Bottom of Exploration at 47.0 feet below ground surface.** NO REFUSAL	
50											

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.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 164 Large Culvert Replacement
Location: Caribou, Maine

Boring No.: HB-CARI-102
WIN: 22845.10

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	503.2	**Auger ID/OD:**	5" Dia. Solid Stem
Operator:	Travis/Tyson	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	10/18/2017; 12:30-14:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	97+88.2, 10.0 ft Rt.	**Casing ID/OD:**	NW-3"	**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 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										
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.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Route 164 Large Culvert Replacement			**Boring No.:**	HB-CARI-102
Location:	Caribou, Maine			**WIN:**	22845.10
Drilling Contractor:	MaineDOT	**Elevation (ft.)**	503.2	**Auger ID/OD:**	5" Dia. Solid Stem
Operator:	Travis/Tyson	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	10/18/2017; 12:30-14:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	97+88.2, 10.0 ft Rt.	**Casing ID/OD:**	NW-3"	**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 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.
25						RCA			Set in NW Casing at 25.0 ft bgs, then Roller Coned ahead to 45.0 ft bgs.	
30										
35										
40										
45							458.2		45.0 **Bottom of Exploration at 45.0 feet below ground surface.** NO REFUSAL	
50										

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-CARI-102

<u>Appendix B</u>

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Caribou Work Number: 22845.00

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-CARI-101, 1D	98+33	9.2 Lt.	5.0-7.0	302644	1	8.9			SM	A-1-b	II
HB-CARI-101, 2D	98+33	9.2 Lt.	10.0-12.0	302645	1	16.0			SM	A-4	III
HB-CARI-101, 3D	98+33	9.2 Lt.	15.0-17.0	302646	1	21.7			SM	A-2-4	II
HB-CARI-101, 4D	98+33	9.2 Lt.	20.0-22.0	302647	1	12.2			SM	A-2-4	II
HB-CARI-101, 5D	98+33	9.2 Lt.	25.0-27.0	302648	1	20.8			SM	A-4	III
HB-CARI-101, 6D	98+33	9.2 Lt.	30.0-32.0	302649	2	14.1			SM	A-4	III
HB-CARI-101, 7D	98+33	9.2 Lt.	35.0-37.0	302650	2	18.1			SM	A-1-b	II
HB-CARI-101, 8D	98+33	9.2 Lt.	40.0-42.0	303026	2	10.0			SM	A-1-b	II
HB-CARI-101, 9D	98+33	9.2 Lt.	45.0-47.0	303027	2	8.7			SM	A-4	III

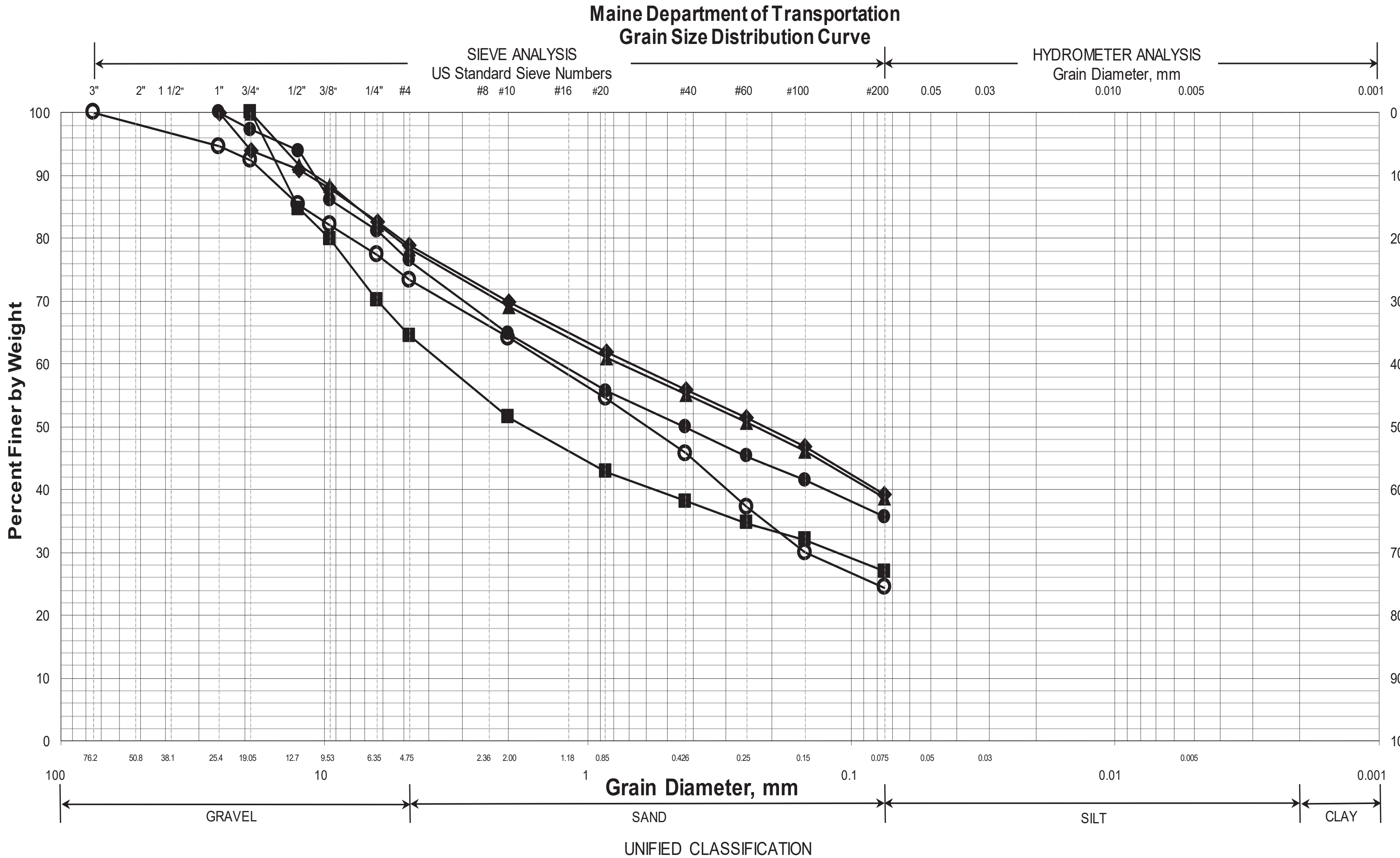
Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT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

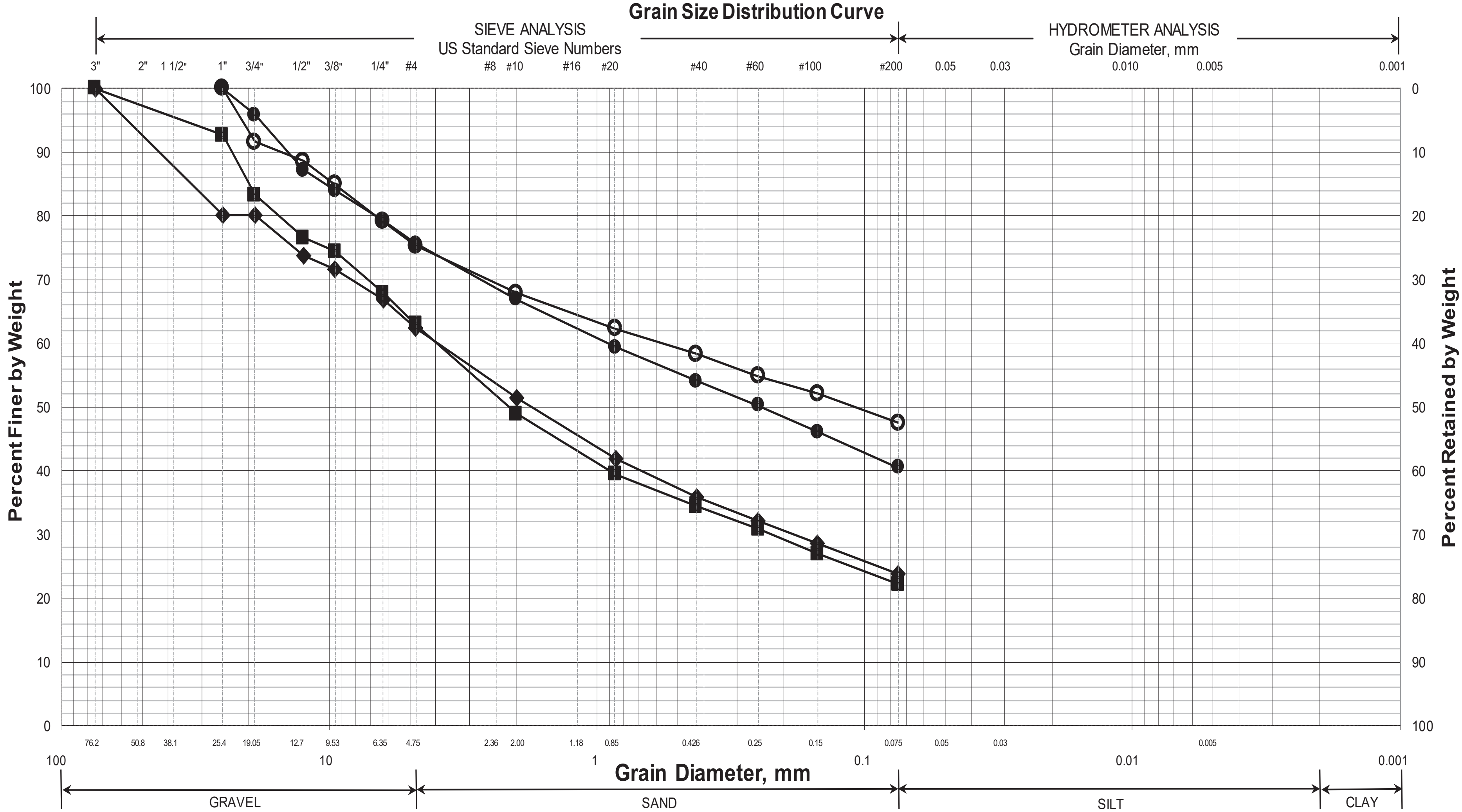


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-CARI-101/1D	98+33	9.2 LT	5.0-7.0	SAND, some gravel, some silt.	8.9			
◆	HB-CARI-101/2D	98+33	9.2 LT	10.0-12.0	Silty SAND, some gravel.	16.0			
■	HB-CARI-101/3D	98+33	9.2 LT	15.0-17.0	SAND, some gravel, some silt.	21.7			
●	HB-CARI-101/4D	98+33	9.2 LT	20.0-22.0	SAND, some silt, some gravel.	12.2			
▲	HB-CARI-101/5D	98+33	9.2 LT	25.0-27.0	Sandy SILT, some gravel.	20.8			
×									

WIN	
022845.00	
Town	
Caribou	
Reported by/Date	
WHITE, TERRY A	1/6/2026

SHEET 1

Maine Department of Transportation
Grain Size Distribution Curve



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-CARI-101/6D	98+33	9.2 LT	30.0-32.0	SILT, some sand, some gravel.	14.1			
◆	HB-CARI-101/7D	98+33	9.2 LT	35.0-37.0	Gravelly SAND, some silt.	18.1			
■	HB-CARI-101/8D	98+33	9.2 LT	40.0-42.0	Gravelly SAND, some silt.	10.0			
●	HB-CARI-101/9D	98+33	9.2 LT	45.0-47.0	SILT, some sand, some gravel.	8.7			
▲									
×									

WIN	
022845.00	
Town	
Caribou	
Reported by/Date	
WHITE, TERRY A	1/6/2026

SHEET 2

Appendix C

Calculations

Bearing Resistance - Existing Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - Precast Concrete Mat Foundation on Silt

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 10th Edition 2024
Table C10.6.2.5.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Silt (Till)

Based on N-values, soils are hard at the bearing elevation

Density In Place: hard

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 - Precast Concrete Mat Foundation on Silt

Reference: AASHTO LRFD Bridge Design Specifications 10th Edition 2024 - Article 10.6.3.1

Assumptions:

1. The box will be founded at ~ Elev 463.83 feet

   Bottom of Construction will be 3 feet below box invert $D_{footing} := 3.0 \cdot ft$

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 $B_{box} := 30 \cdot ft$

   Length of box culvert, L $L_{box} := 96 \cdot ft$

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 ϕ=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 ϕ=32 degrees

$$s_c := 1 + \left(\frac{B_{box}}{L_{box}}\right)\left(\frac{N_q}{N_c}\right) \qquad s_c = 1.2$$

$$s_\gamma := 1 - 0.4\left(\frac{B_{box}}{L_{box}}\right) \qquad s_\gamma = 0.875$$

$$s_q := 1 + \left(\frac{B_{box}}{L_{box}} \cdot \tan(\phi_{ns})\right) \qquad s_q = 1.2$$

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 LRFD Table 10.6.3.1.2a-4

$\frac{D_{footing}}{B_{box}} = 0.1$ for ϕ=32 degrees $d_q := 1.2$

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 42.75$ LRFD Eq. 10.6.3.1.2a-2

$N_{qm} := N_q \cdot s_q \cdot d_q \cdot i_q$ $N_{qm} = 33.28$ LRFD Eq. 10.6.3.1.2a-3

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 26.43$ LRFD Eq. 10.6.3.1.2a-4

Coefficients for Groundwater Depths LRFD Table 10.6.3.1.2a-2

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

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

$q_{nominal} = 31 \cdot ksf$

Factored Bearing Resistance for Strength Limit State

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

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

$q_{factored} = 14 \cdot ksf$

Recommend a limiting factored bearing resistance of 14.0 ksf for the Strength Limit State.

Modulus of Subgrade Reaction:

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

Width of culvert, B $B_{box} := 30 \cdot ft$

Length of culvert, L $L_{box} := 96 \cdot ft$

Thickness of culvert, t $t_{box} := 12 \cdot in$ assumed

Depth of culvert, D $D_{box} := 40 \cdot ft$

Bearing Resistance: $q_{factored\_service\_bc} = 6 \cdot ksf$ Calculated above

Modulus of Elasticity:
Site soils at bearing elevation are Silt (Till)
Use Glacial Till values
From Bowles Table 2-8 Modulus Es for Glacial Till, dense ranges from 3133 - 15038 ksf

Use: Modulus of Elasticity, Es $E_s := 3500 \cdot ksf$

Poisson's Ratio:
Site soils are Silt (Till)
From Bowles Table 2-7 Poisson's Ration μ for Silt/Till ranges from 0.3 - 0.35

Use: Possion's Ratio, μ $\mu := 0.3$

$$E_{prime\_s} := \frac{1 - \mu^2}{E_s} \qquad E_{prime\_s} = 0.00026 \cdot \frac{ft^2}{kip}$$

Analyze corner:

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

$$H_{inf} := \frac{5 \cdot B_{box}}{B_{box}} \qquad H_{inf} = 5$$ N in Table 5-2

$$\frac{L_{box}}{B_{box}} = 3.2$$ M in Table 5-2

From Table 5-2 for N=5 and M=3.2

$I_1 := 0.553$

$I_2 := 0.083$

by interpolation

Determine Steinbrenner influence factor - Bowles Section 5-6:

$$I_s := I_1 + \left[\frac{1 - (2 \cdot \mu)}{1 - \mu}\right] \cdot I_2 \qquad I_s = 0.6004$$

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

Depth ratio: $\frac{D_{box}}{B_{box}} = 1.3333$ $\frac{L_{box}}{B_{box}} = 3.2$ $\mu = 0.3$ $I_F := 0.70$

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

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

$$k_s = 177 \cdot pci$$

Recommend Modulus of Subgrade Reaction of 175 pci