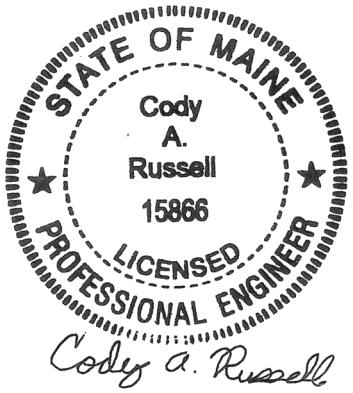
MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of

LARGE CULVERT #269786
ROUTE 24
GARDINER, MAINE

Prepared by:
Yueh-Ti Lee
Assistant Geotechnical Engineer



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

Kennebec County
WIN 27136.00

Soils Report 2025-10
February 18, 2025

PROJECT DETAILS

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical design and construction recommendations for the replacement of an existing large culvert (#269786) consisting of an approximately 5-foot span by 4-foot rise by 80-foot-long precast concrete box culvert with corrugated metal pipe (CMP) extensions on each end on Route 24 in Gardiner. The existing culvert is in poor condition and needs replacement both from an infrastructure and environmental standpoint. The culvert is located approximately 0.12 of a mile southwest of Costello Road as shown in the attached Location Map. Route 24 is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 48-inch diameter, approximately 100-foot-long reinforced concrete pipe culvert. The invert of the proposed culvert is approximately 17.7 feet below the existing road grade at the roadway centerline. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V to protect against erosion.

SUBSURFACE INVESTIGATION

One (1) boring (HB-GAR-101) and one (1) probe (HB-GAR-102) were drilled for this project on August 14, 2023 by the MaineDOT drill crew using a trailer mounted drill rig. Exploration locations are shown on the attached 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 attached Boring Logs.

Boring HB-GAR-101 was drilled using solid stem auger, cased wash boring, and rock core drilling techniques. Soil samples were obtained in the boring 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 51 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 0.906 to the raw field N-values. The bedrock was cored in boring HB-GAR-101 using an NQ 2-inch core barrel. Probe HB-GAR-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 Northeast Transportation Training and Certification Program (NETTCP) certified subsurface inspector logged the subsurface conditions encountered. The boring and probes were located in the field by taping to surveyed site features after completion of the drilling program.

LABORATORY TESTING

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. Laboratory testing consisted of one (1) standard grain size analyses with natural water content, three (3) standard grain size analyses

with hydrometer and natural water content, and one (1) Atterberg Limits tests. The results of the laboratory testing program are discussed in the following section and are shown in the attached Boring Logs, Laboratory Testing Summary Sheet, Grain Size Distribution Curve Sheet, and Atterberg Limits Plots.

SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test boring and probe generally consisted of fill consisting of sand and silt underlain by native silt underlain by bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on the attached Boring Location Plan & Interpretive Subsurface Profile with Boring Logs.

Boring HB-GAR-101 was drilled to refusal at a depth of approximately 19.4 feet below ground surface (bgs). Bedrock was cored in the boring for a total boring depth of approximately 24.4 feet bgs. Probe HB-GAR-102 was drilled to refusal at a depth of approximately 20.2 feet bgs. The exact nature of the refusal surface was not determined in the probe.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 0.8	HMA Pavement	--	--	--
0.8 – 15.0	Fill: Dark brown, moist, fine to coarse sand, some gravel, little silt. Olive and grey, moist to wet, silt, little to some clay, trace to some fine to coarse sand, trace gravel.	A-1-b A-4	SM CL	2.4 14.4 to 18.4
15.0 – 19.4	Grey, wet, silt, little clay, little gravel, trace fine to coarse sand, occasional cobbles.	A-4	CL	19.7
19.4 – 24.4	Bedrock: Mafic to felsic volcanic rocks of the Cushing Formation.	--	--	--

[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-value obtained in the sand fill was 35 blows per foot (bpf), indicating that the sand fill is dense in consistency. Two (2) N-values obtained in the silt fill were 6 bpf and 8 bpf, indicating that the silt fill is medium stiff in consistency. One (1) N-value obtained in the native silt was 98 bpf, indicating that the silt is hard in consistency. The Rock Quality Designation (RQD) of the bedrock was determined to be 37 percent in boring HB-GAR-101 which correlates to a Rock Mass Quality of Poor.

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

Boring No. and Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-GAR-101 4D	19.7	30	20	10	-0.03

Interpretation of these results indicate that the silt has low plasticity. The silt in sample 4D from boring HB-GAR-101 is some to heavily overconsolidated.

Groundwater was recorded at depth 10.0 feet bgs in boring HB-GAR-101. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following sections discuss geotechnical recommendations for the design and construction of the proposed reinforced concrete pipe culvert, and oversteepened slope at approximate Station 14+50.

Reinforced Concrete Pipe Culvert Design and Construction – The proposed replacement structure will consist of a 48-inch diameter, approximately 100-foot-long reinforced concrete pipe culvert. The proposed structure inlet and outlet slopes shall be riprapped with slopes no steeper than 2H:1V to protect against erosion. The proposed reinforced concrete pipe culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 603. The invert of the proposed reinforced concrete pipe culvert ranges from approximately 92.86 feet at the inlet end to approximately 89.82 feet at the outlet end with a slope of approximately 3.0%.

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-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.

Bedrock Removal and Subgrade Preparation – The approximate invert of the proposed culvert ranges from an elevation of 92.86 feet at the inlet to 89.82 feet at the outlet. Constructing the culvert at this elevation may require removal of bedrock. The need for and depth of weathered bedrock removal will vary over the length of the proposed reinforced concrete pipe culvert. The bottom elevation of the excavation shall take into account the wall thickness of the culvert bottom and the required 1-foot layer of bedding material. The boring indicates that the Rock Quality of the bedrock is poor with an RQD of approximately 37 percent.

The bedrock surface shall be prepared in accordance with MaineDOT standard practices. The nature, slope, and degree of fracturing in the bedrock bearing surfaces will not be evident until the excavation from the reinforced concrete pipe culvert is made. Construction activities should not be permitted to create any open fissures in the bedrock to remain. Any irregularities in the existing bedrock surface or irregularities created during the excavation process should be backfilled with crushed stone to the bottom of the required bedding material.

The Contractor shall remove any overburden soil and weathered bedrock that can be removed using ordinary excavation equipment to expose competent bedrock at the required elevation. In accordance with MaineDOT standard practices, the bedrock shall be clean and free of debris, soil, and loose rock. The cleanliness and condition of the bedrock surface should be confirmed and accepted by the Resident prior to placing the cast-in-place concrete pedestal footings. If soil is encountered at bedding material subgrade it shall be overexcavated to expose the underlying bedrock surface.

Blasting shall be conducted in accordance with Section 105.2.7 and Section 203.042 of the MaineDOT Standard Specifications. It is also recommended that the Contractor conduct pre- and post-blast surveys, as well as blast vibration monitoring at nearby structures in accordance with the MaineDOT Standard Specifications and industry standards at the time of the blast. The Contractor's blasting submittals shall address blasting procedures adjacent to an active roadway, including flyrock controls.

It is anticipated that there will be seepage of water from fractures and joints exposed in the bedrock surface. Water should be controlled by pumping from sumps. The Contractor should maintain the excavation so that all work is completed in the dry.

Settlement – No settlement issues are anticipated at the site. No changes to the existing vertical or horizontal alignment are currently planned for this project. The reinforced concrete culvert is larger than the existing culvert and will result in a net unloading of the site soils at the structure location. Any settlement due to elastic compression of the bedrock, subgrade soils, and bedding material will be immediate and negligible.

Scour and Riprap – Both the inlet and outlet of the reinforced concrete pipe 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.

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.

Oversteepened Slope at approximate Station 14+50 – A 1.5H:1V slope is proposed at approximate Station 14+50. In accordance with AASHTO LRFD Bridge Design Specifications 9th Edition 2020 (LRFD) Article 11.6.3.7 evaluation of earth slopes where geotechnical parameters are well-defined shall achieve a factor of safety of 1.3 (equivalent to a resistance factor of 0.75). Analysis of the proposed 1.5H:1V slopes using Geostudio Slope/W software determined that riprap armor was necessary for the slopes to achieve a factor of safety of 1.3 or greater. The critical slope was analyzed assuming 3.6-feet of plain riprap will armor the full height of the slope. The analysis of the proposed slope resulted in an acceptable factor of safety of approximately 1.3. Attached Slope Stability Analyses presents the stability results from this analysis. The stability analyses were based on subsurface conditions encountered in a boring drilled in the vicinity of the slope.

The slope shall be armored with 3 feet of riprap conforming to MaineDOT Standard Specification Section 703.26 Plain Riprap and Hand Laid Riprap underlain by a 1-foot layer of protective aggregate cushion conforming to MaineDOT Standard Specification 703.19 Granular Borrow Material for Underwater Backfill that is underlain by a non-woven Class 1 erosion control geotextile that meets the requirements for MaineDOT Standard Specification 722.03.

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 proposed reinforced concrete pipe will require deep soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is possible that the use of complex (four-sided) braced excavations with dewatering will be necessary due to maintenance of traffic and the depth of the excavation. If this is the case, adequate embedment 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 soils as backfill around the culvert or as roadway base material shall not be permitted. The excavated soils may only be used as common borrow in accordance with MaineDOT Standard Specifications 203 and 703.

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

CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed replacement of an existing large culvert (#269786) under Route 24 in Gardiner, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

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

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

Attachments

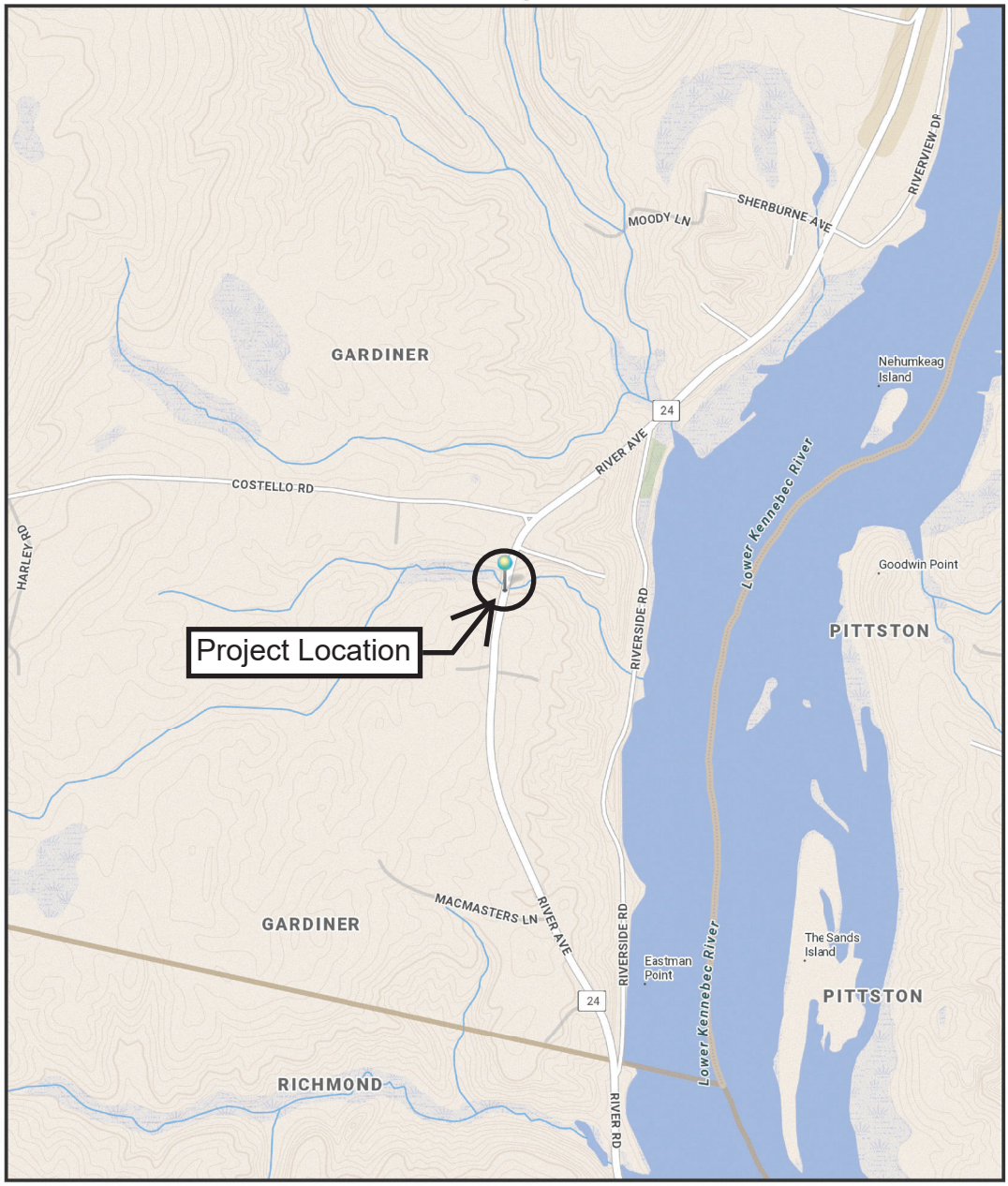
Location Map
Boring Location Plan & Interpretive Subsurface Profile with Boring Logs
Key to Soil and Rock Descriptions and Terms
Boring Logs
Laboratory Testing Summary Sheet
Grain Size Distribution Curves
Atterberg Limits Plots
Slope Stability Analyses

Date:3/31/2025

Division: GEOTECH

Username: Yueh-Ti.Lee

GARDINER, MAINE



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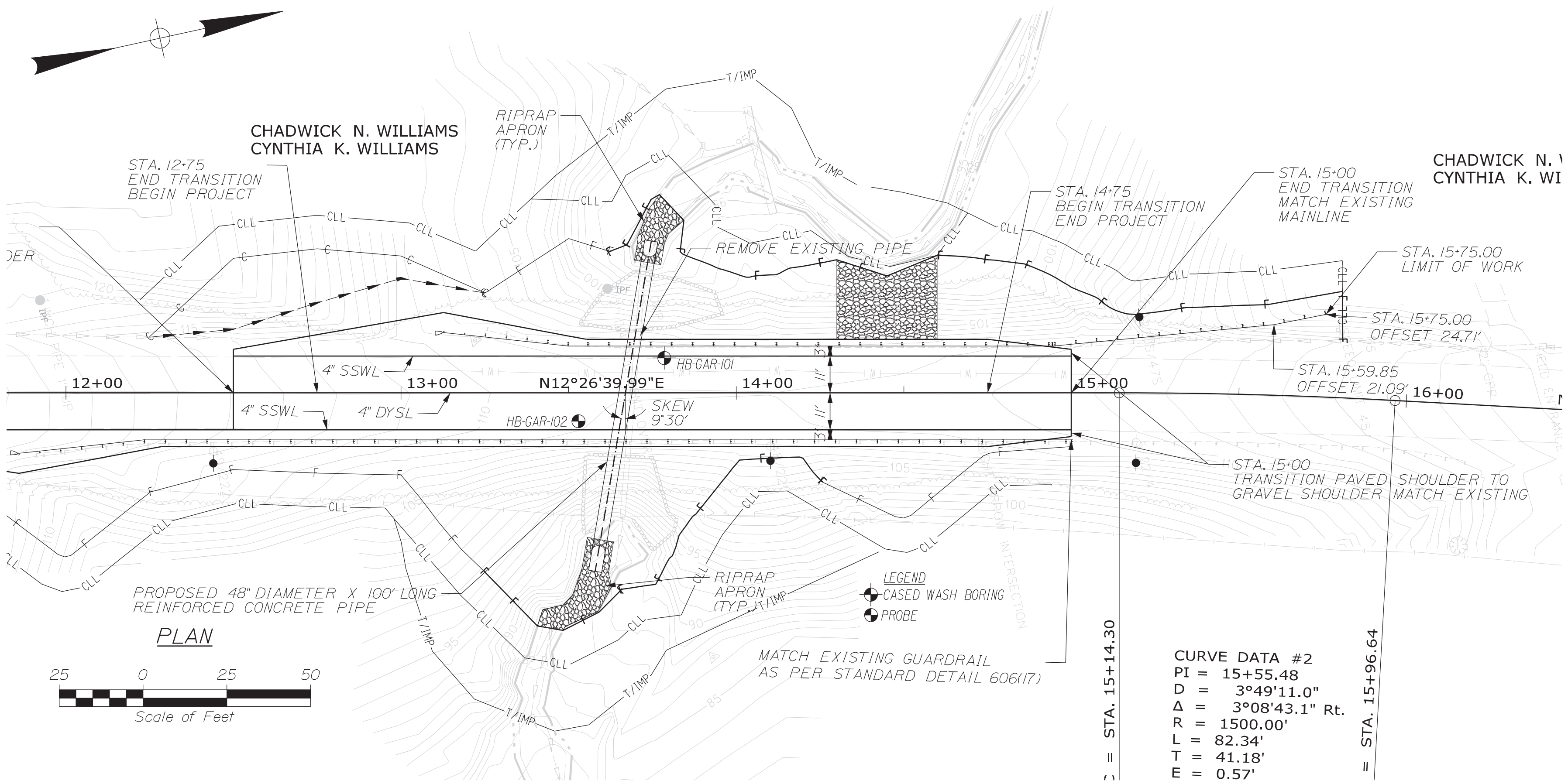
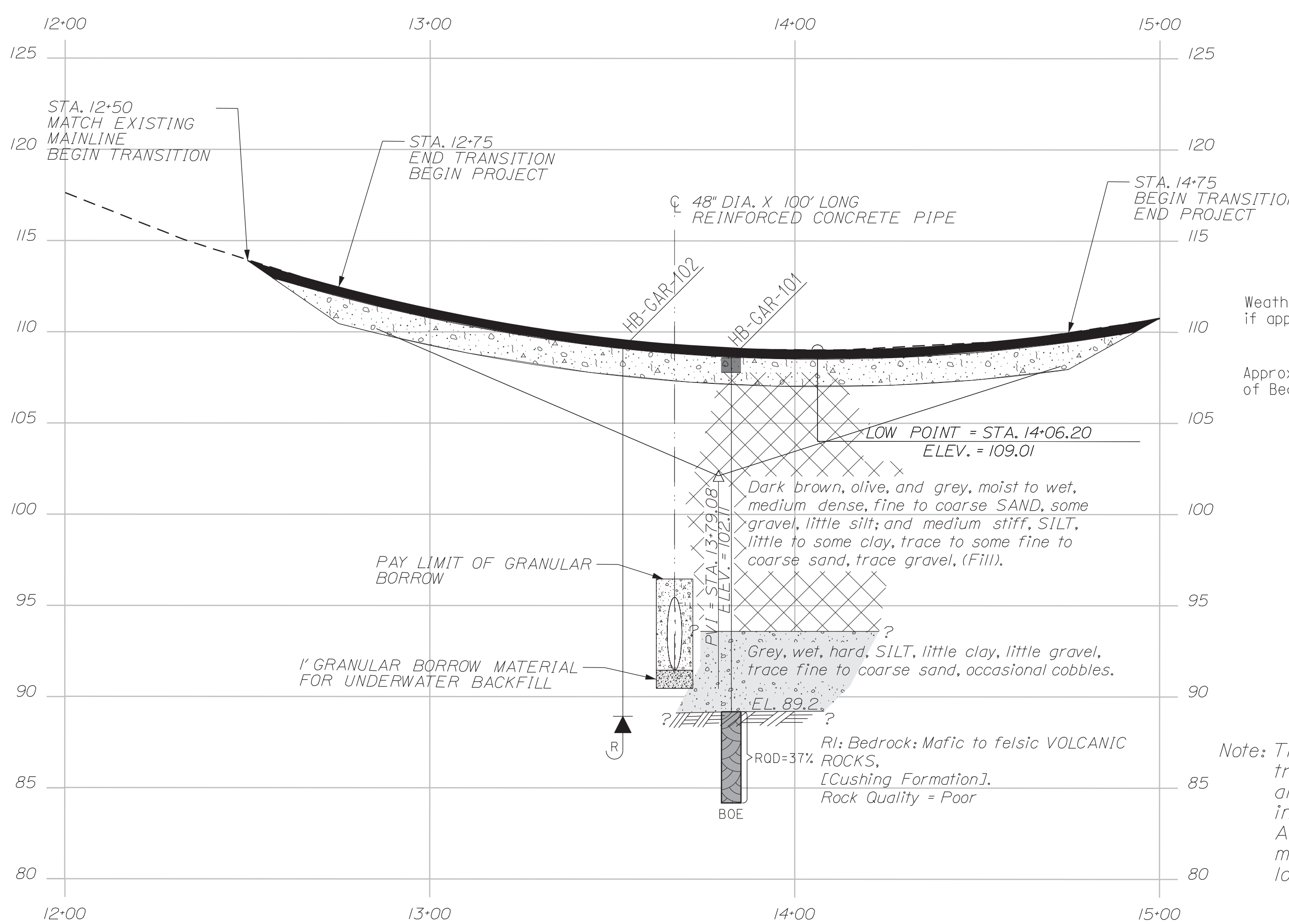
0.25 Miles

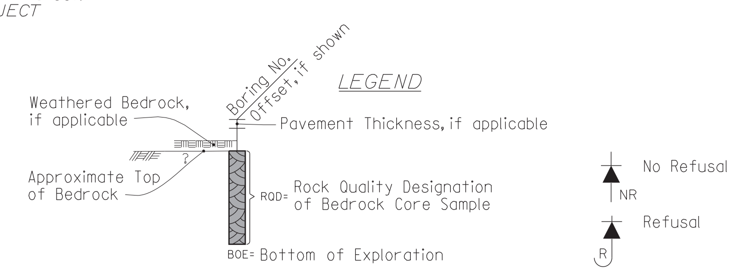
1 inch = 0.28 miles

Date: 2/18/2025
Time: 7:07:46 AM

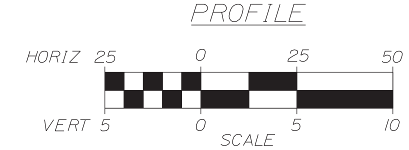
SHEET NUMBER 1 OF 2	GARDINER ROUTE 24 LOCATION MAP	STATE OF MAINE DEPARTMENT OF TRANSPORTATION 27136.00 WIN 27136.00 HIGHWAY PLANS







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.

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Large Culvert Replacement on Route 24
Location: Gardiner, Maine

Boring No.: HB-GAR-101
WIN: 27136.00

Driller: MaineDOT	Elevation (ft.) 108.6	Auger ID/OD: 5" Solid Stem
Operator: Daggett/Eric	Datum: NAVD88	Sampler: Standard Split Spoon
Logged By: C. Russell	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"
Date Start/Finish: 8/14/2023; 09:00-11:15	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"
Boring Location: 13+78.6, 10.5 ft Lt.	Casing ID/OD: NW-3"	Water Level*: 10.0 ft bgs.
Hammer Efficiency Factor: 0.906	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)
T_v = Pocket Torvane 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
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	107.9		9" HMA. 0.8	
	1D	24/18	1.00 - 3.00	4/6/17/6	23	35				Dark brown, moist, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#379634 A-1-b, SM WC=2.4%
5	2D	24/13	5.00 - 7.00	2/2/3/3	5	8	10			Olive, moist, medium stiff, SILT, some fine to coarse sand, little clay, trace gravel, (Fill).	G#379635 A-4, CL WC=14.4%
							12				
							20				
							20				
							23				
10	3D	24/18	10.00 - 12.00	2/2/2/3	4	6	19			Grey, wet, medium stiff, SILT, some clay, trace fine to coarse sand, trace gravel, (Fill).	G#379636 A-4, CL WC=18.4%
							25				
							35				
							36				
							48	93.6		15.0	
15	4D MV	24/16	15.00 - 17.00 15.63 - 15.63	WOH/38/27/19 Would Not Push	65	98	24			Grey, wet, hard, SILT, little clay, little gravel, trace fine to coarse sand. Cobble in tip of spoon. Failed 55x110 mm vane attempt.	G#379637 A-4, CL WC=19.7% LL=30 PL=20 PI=10
							88				
							144				
							128			a100 blows for 4.8". 19.4	
	R1	60/60	19.40 - 24.40	RQD = 37%			a100 NQ-2	89.2		Top of Bedrock at Elev. 89.2 ft. Casing REFUSAL at 19.4 ft bgs. R1: Bedrock: Mafic to felsic VOLCANIC ROCKS, [Cushing Formation]. Rock Quality = Poor R1: Core Times (min:sec) 19.4-20.4 ft (2:05) 20.4-21.4 ft (3:14) 21.4-22.4 ft (3:22) 22.4-23.4 ft (4:48) 23.4-24.4 ft (2:42) 100% Recovery	
20											
25								84.2		Bottom of Exploration at 24.4 feet below ground surface. 24.4	

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.

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Boring No.: HB-GAR-101

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Large Culvert Replacement on Route 24
Location: Gardiner, Maine

Boring No.: HB-GAR-102
WIN: 27136.00

Drilling Contractor: MaineDOT	Elevation (ft.) 109.1	Auger ID/OD: 5" Dia.
Operator: Daggett/Eric	Datum: NAVD88	Sampler: N/A
Logged By: C. Russell	Rig Type: CME 45C	Hammer Wt./Fall: N/A
Date Start/Finish: 8/14/2023; 11:30-12:00	Drilling Method: Solid Stem Auger	Core Barrel: N/A
Boring Location: 13+52.8, 8.5 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.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0						SSA			Probe, no material samples taken.	
5										
10										
15										
20							88.9		Bottom of Exploration at 20.2 feet below ground surface. Auger REFUSAL 20.2	
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.

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Boring No.: HB-GAR-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

27136.00

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HIGHWAY PLANS

PROJ. MANAGER	M. ROONEY		
DESIGN-DETAILED			
CHECKED-REVIEWED			
DESIGN2-DETAILED2	YT LEE		
DESIGN3-DETAILED3			
REVISIONS 1	PAPER SIZE CORRECTED	T. WHITE	FEB 2025
REVISIONS 2			APR 2025
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

BY | DATE | SIGNATURE | P.E. NUMBER | DATE

GARDINER
ROUTE 24

BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE WITH BORING LOGS

SHEET NUMBER
2
OF 2

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

MODIFIED BURMISTER SYSTEM

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

TERMS DESCRIBING DENSITY/CONSISTENCY

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

Density of Cohesionless Soils	Standard Penetration Resistance N-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))

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Large Culvert Replacement on Route 24

Location: Gardiner, Maine

Boring No.: HB-GAR-101

WIN: 27136.00

Driller:	MaineDOT	**Elevation (ft.)**	108.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Eric	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	C. Russell	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	8/14/2023; 09:00-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+78.6, 10.5 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor: 0.906		**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	107.9		9" HMA.	
										0.8	
	1D	24/18	1.00 - 3.00	4/6/17/6	23	35				Dark brown, moist, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#379634 A-1-b, SM WC=2.4%
5	2D	24/13	5.00 - 7.00	2/2/3/3	5	8	10			Olive, moist, medium stiff, SILT, some fine to coarse sand, little clay, trace gravel, (Fill).	G#379635 A-4, CL WC=14.4%
							12				
							20				
							20				
							23				
10	3D	24/18	10.00 - 12.00	2/2/2/3	4	6	19			Grey, wet, medium stiff, SILT, some clay, trace fine to coarse sand, trace gravel, (Fill).	G#379636 A-4, CL WC=18.4%
							25				
							35				
							36				
							48				
15	4D MV	24/16	15.00 - 17.00 15.63 - 15.63	WOH/38/27/19 Would Not Push	65	98	24	93.6		15.0 Grey, wet, hard, SILT, little clay, little gravel, trace fine to coarse sand. Cobble in tip of spoon. Failed 55x110 mm vane attempt.	G#379637 A-4, CL WC=19.7% LL=30 PL=20 PI=10
							88				
							144				
							128				
	R1	60/60	19.40 - 24.40	RQD = 37%			[a]100 NQ-2	89.2		[a]100 blows for 4.8". 19.4	
20										Top of Bedrock at Elev. 89.2 ft. Casing REFUSAL at 19.4 ft bgs. R1: Bedrock: Mafic to felsic VOLCANIC ROCKS, [Cushing Formation]. Rock Quality = Poor R1: Core Times (min:sec) 19.4-20.4 ft (2:05) 20.4-21.4 ft (3:14) 21.4-22.4 ft (3:22) 22.4-23.4 ft (4:48) 23.4-24.4 ft (2:42)	
25								84.2			

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: Large Culvert Replacement on Route 24

Location: Gardiner, Maine

Boring No.: HB-GAR-101

WIN: 27136.00

Driller:	MaineDOT	**Elevation (ft.)**	108.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Eric	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	C. Russell	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	8/14/2023; 09:00-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+78.6, 10.5 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor: 0.906		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample Information: 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										100% Recovery	
										24.4	
										Bottom of Exploration at 24.4 feet below ground surface.	
30											
35											
40											
45											
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: Large Culvert Replacement on Route 24
Location: Gardiner, Maine

Boring No.: HB-GAR-102
WIN: 27136.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	109.1	**Auger ID/OD:**	5" Dia.
Operator:	Daggett/Eric	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	C. Russell	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	8/14/2023; 11:30-12:00	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	13+52.8, 8.5 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							88.9		20.2 **Bottom of Exploration at 20.2 feet below ground surface.** Auger 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.

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Gardiner Work Number: 27136.00

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-GAR-101, 1D	13+78.6	10.5 Lt.	1.0-3.0	379634	1	2.4			SM	A-1-b	II
HB-GAR-101, 2D	13+78.6	10.5 Lt.	5.0-7.0	379635	1	14.4			CL	A-4	IV
HB-GAR-101, 3D	13+78.6	10.5 Lt.	10.0-12.0	379636	1	18.4			CL	A-4	IV
HB-GAR-101, 4D	13+78.6	10.5 Lt.	15.0-17.0	379637	1	19.7	30	10	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.

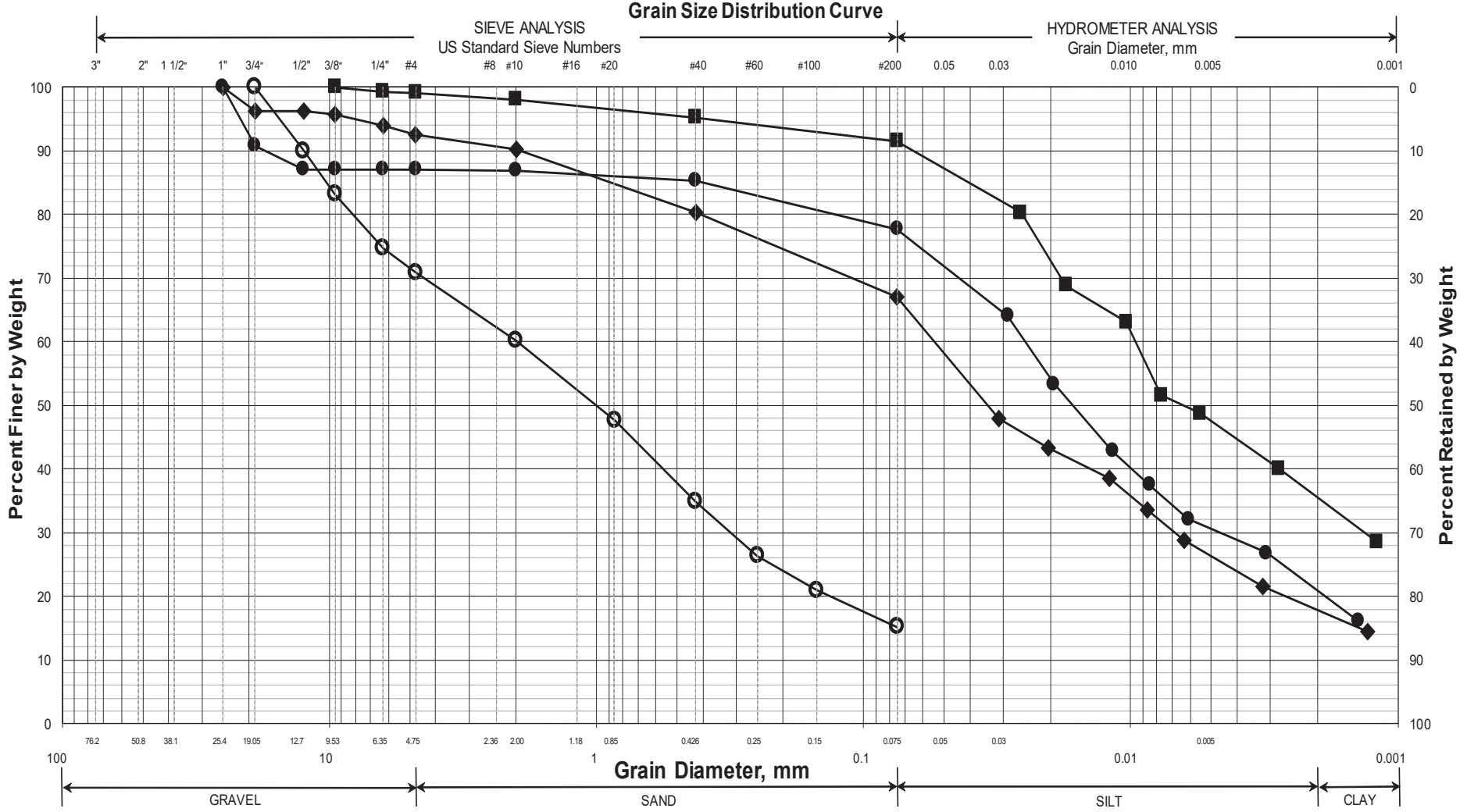
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

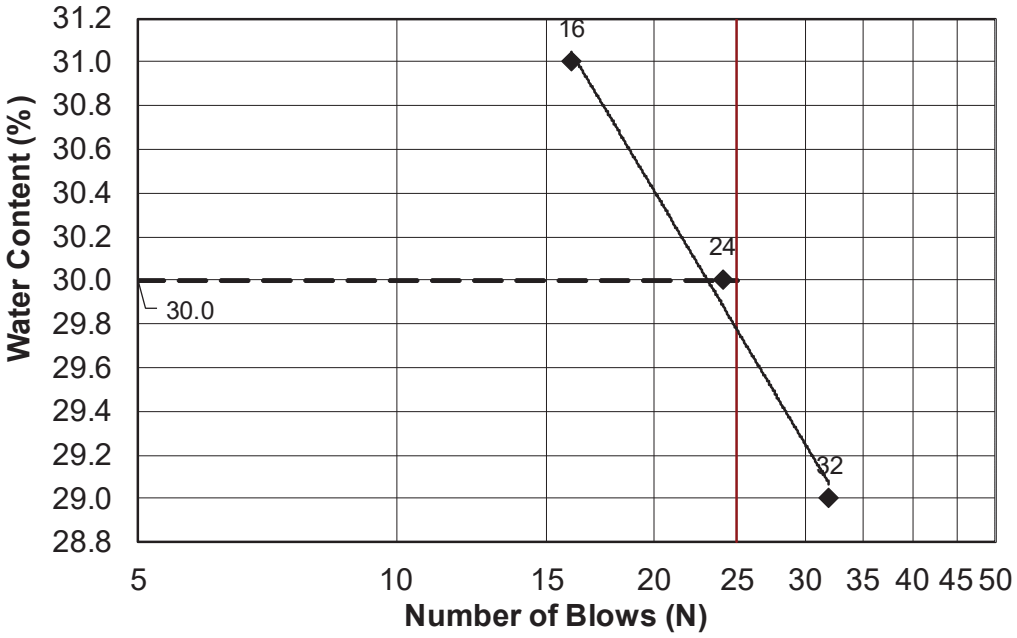


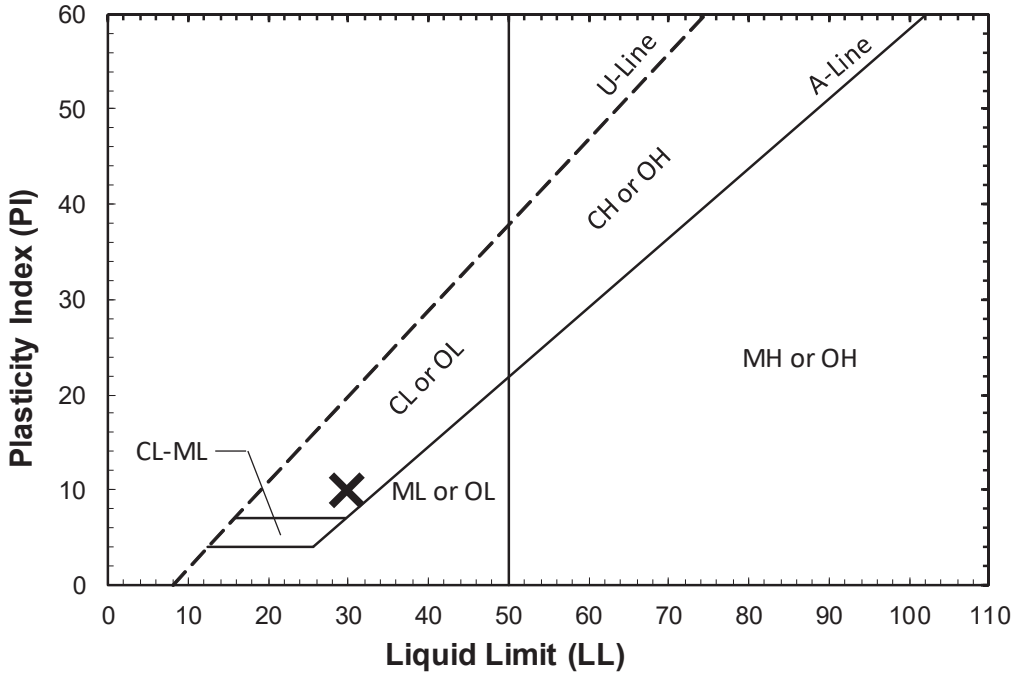
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-GAR-101/1D	13+78.6	10.5 LT	1.0-3.0	SAND, some gravel, little silt.	2.4			
◆	HB-GAR-101/2D	13+78.6	10.5 LT	5.0-7.0	SILT, some sand, little clay, trace gravel.	14.4			
■	HB-GAR-101/3D	13+78.6	10.5 LT	10.0-12.0	SILT, some clay, trace sand, trace gravel.	18.4			
●	HB-GAR-101/4D	13+78.6	10.5 LT	15.0-17.0	SILT, little clay, little gravel, trace sand.	19.7	30	20	10
▲									
×									

WIN
027136.00
Town
Gardiner
Reported by/Date
WHITE, TERRY A 2/14/2025

TOWN	Gardiner	Reference No.	379637
WIN	027136.00	Water Content, %	19.7
Sampled	8/14/2023	Liquid Limit @ 25 blows (T 89), %	30
Boring No./Sample No.	HB-GAR-101/4D	Plastic Limit (T 90), %	20
Station	13+78.6	Plasticity Index (T 90), %	10
Depth	15.0-17.0	Tested By	BBURR





14+50 Proposed Slope

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	Native Silt	Mohr-Coulomb	120	675	0
	Riprap	Mohr-Coulomb	140	0	42
	Sand Fill	Mohr-Coulomb	125	0	34
	Silt Fill	Mohr-Coulomb	120	800	0