MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

MEETING HOUSE BRIDGE
OVER MESERVEY BROOK
STATE ROUTE 173
LINCOLNVILLE, MAINE

Prepared by:
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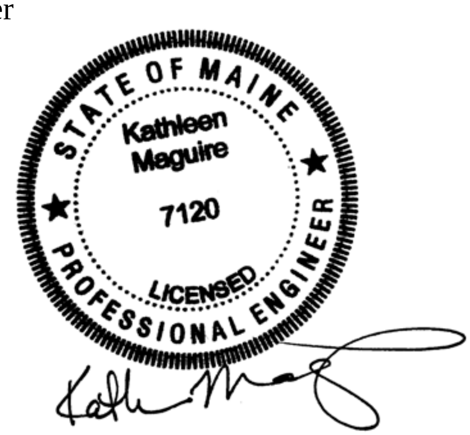
Geotechnical Engineer



Reviewed by:
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Senior Geotechnical Engineer

Waldo County
WIN 20488.00

Soils Report No. 2014-03
Bridge No. 3994

Fed. No. STP-2048(800)
January 7, 2014

Table of Contents

Tables

Sheets

Appendices

GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of Meeting House Bridge which carries State Route 173 over Meservey Brook in Lincolnville, Maine. The proposed replacement structure will be a precast concrete box culvert with a 5 degree skew. The following design recommendations are discussed in detail in Section 7.0 of this report.

Precast Concrete Box Culvert Design and Construction– The precast concrete box culvert shall be designed by the Manufacturer in accordance with Special Provision 534 and AASHTO LRFD Bridge Design Specifications 6^{th} Edition 2012 (LRFD) specifications. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The precast concrete box culvert shall be designed for all relevant strength and service limit states and load combinations. The box culverts shall be constructed with concrete inlet and outlet toe walls.

Precast Concrete Box Culvert Headwall Design – Concrete headwalls should be specified to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A minimum 1 foot by 1 foot concrete headwall is recommended.

Precast Concrete Inlet and Outlet Walls and Toe Walls - Precast concrete box culvert inlet and outlet walls will be slope-tapered to match the 2:1 side slopes. The bottom slabs connecting the left and right walls at each end of the box culvert shall include toe walls to prevent undermining. Toe walls should extend a minimum of 1 foot below the maximum depth of scour.

The sloped inlet and outlet walls are essentially retaining walls and shall be designed for all relevant strength and service limit states and load combinations specified in LRFD. The walls shall be designed to resist lateral earth pressures, vehicular loads, creep and temperature and shrinkage deformations of the concrete box culvert. The wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil.

Bearing Resistance - The factored bearing stress for the strength limit state for the box culvert on compacted fill shall not exceed the calculated factored bearing resistance of 16 ksf, however, the service limit state will control. A factored bearing resistance of 5 ksf shall be used to control settlement when analyzing the service limit state. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$.

Scour and Riprap – The box culvert shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway and with inlet and outlet cutoff walls that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface.

Settlement - No settlement issues are anticipated at the site. The installation of the proposed box culvert will result in a net unloading of the site soils at the structure location. Placement of fill soils at the location of the existing structure is not anticipated to exceed the past loading condition of the site soils.

Frost Protection - Any foundation placed on granular subgrade soils should be founded a minimum of 5.3 feet below finished exterior grade for frost protection.

Seismic Design Considerations – 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.

Construction Considerations – The box culvert will be bedded on a 1-foot thick layer of granular fill. The soil envelop and backfill shall consist of Standard Specification 703.19 - Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The granular borrow backfill should be placed in lifts of 6 to 8 inches loose measure and compacted with to the manufacturer's specifications. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

Construction of the proposed precast concrete box culverts will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow or ¾ inch stone. Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow or ¾ inch stone.

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.

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of Meeting House Bridge which carries State Route 173 over Meservey Brook in Lincolnville, Maine. A subsurface investigation has been completed at the site. The purpose of the investigation was to explore subsurface conditions at the site in order to develop geotechnical recommendations for the bridge replacement. This report presents the soils information obtained at the site during the subsurface investigation, foundation design recommendations and geotechnical design parameters for the bridge replacement.

Meeting House Bridge was built in 1948 and consists of two (2) steel plate pipes (each 8 foot- 9 inches in diameter) with very little cover. Maine Department of Transportation (MaineDOT) Bridge Maintenance inspection report for the bridge indicates the both pipes are in serious condition with heavy rusting, scattered holes and continuous areas of cracking at the spring line. The 2012 MaineDOT Bridge Maintenance inspection reports assign the culverts a condition rating of 3 – excessive damage and the channel a rating of 6 – bank slumping. The structure has a scour critical rating of 8 – stable above footing meaning the culverts have been determined to be stable for the assessed or the calculated scour condition. The bridge has a Bridge Sufficiency Rating of 52.2.

The proposed replacement structure will be a 20-foot span by 9 foot rise, approximately 74-foot long precast concrete box culvert skewed at approximately 5 degrees. The proposed box culvert will have inlet and outlet toe walls with slope-tapered inlet and outlet walls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The existing roadway horizontal profile will be maintained in the replacement. The vertical profile at the bridge will be raised less than 1 foot at the highest point. Route 173 will be closed to traffic for 14 days for the construction of the replacement of the structure.

2.0 GEOLOGIC SETTING

Meeting House Bridge is located on State Route 173 in Lincolnville, Maine and crosses Meservey Brook approximately 0.2 miles northwest of the junction with State Route 52 as shown on Sheet 1 - Location Map found end of this report.

According to the Surficial Geology Map of the Lincolnville Quadrangle, Maine Open File No. 13-7 2013 published by the Maine Geological Survey the surficial soils in the vicinity of the Meeting House Bridge site consist of wetland deposits and till. The wetland deposits consist of peat, muck, silt ad clay in poorly drained areas and may also include some alluvial sediments along stream valleys. The till deposits consist of sand, silt and gravel size rock debris deposited by glacial ice.

According to the Bedrock Geologic Map of Maine, Maine Geologic Survey, 1985, the site is underlain by Ordovician-Cambrian sulfidic/carboniferous pelite of the Penobscot Formation.

3.0 SUBSURFACE INVESTIGATION

Subsurface conditions at the site were explored by drilling two (2) test borings. Test borings BB-LMB-101 and BB-LMB-102 were drilled on either side of the existing structure. The borings were drilled on September 6, 2013 by the MaineDOT drill crew. The boring locations are shown on Sheet 2 - Boring Location Plan & Interpretive Subsurface Profile found at the end of this report. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A - Boring Logs and on Sheet 3 - Boring Logs found end of this report.

The borings were drilled using solid stem auger and cased wash boring techniques. Soil samples were typically obtained at 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6 inch interval of penetration are recorded. The sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated per ASTM D4633-05 “Standard Test Method for Energy Measurement for Dynamic Penetrometers” in July of 2013 and was found to deliver approximately 44.5 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values computed by applying an average energy transfer factor of 0.867 to the raw field N-values. This hammer efficiency factor, 0.867, and both the raw field N-value and the corrected N-value are shown on the boring logs. The bedrock was cored in both borings using an NQ-2 inch core barrel and the Rock Quality Designation (RQD) of the core was calculated for the NQ cores.

The MaineDOT Geotechnical Team member selected the boring locations and drilling methods, designated type and depth of sampling techniques, reviewed field logs for accuracy and identified field and laboratory testing requirements. A New England Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions encountered. The borings were located in the field by taping to site features after completion of the drilling program.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected soil samples obtained in the test borings 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, five (5) grain size analyses with hydrometer and natural water content and two (2) Atterberg Limits tests. The results of laboratory tests are included as Appendix B - Laboratory Test Results found at the end of this report. Laboratory test information is also shown on the boring logs provided in Appendix A – Boring Logs and on Sheet 3 – Boring Logs found at the end of this report.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test borings generally consisted of sands underlain by silt which is underlain by bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy across the site is shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile found at the end of this report. The boring logs are provided in Appendix A – Boring Logs and Sheet 3 – Boring Logs found at the end of this report. A brief summary description of the strata encountered follows:

5.1 Sand

A layer of sand was encountered below the pavement in both of the borings. The layer ranged from approximately 14.0 feet to 18.5 feet thick at the boring locations. The deposit generally consisted of brown to grey, moist, fine to coarse sand, little to some silt, trace clay, little to trace gravel, and trace wood. Within the sand, an isolated boulder was encountered in boring BB-LMB-102 at a depth of approximately 7.4 to 8.9 feet below ground surface (bgs).

Corrected SPT N-values in the sand ranged from 6 to 19 blows per foot (bpf), indicating a soil that is loose to medium dense in consistency. Grain size analyses were conducted on three (3) samples from the sand. Grain size analyses resulted in the soil being classified as an A-4, A-1-b or A-2-4 under the AASHTO Soil Classification System and an SC-SM or SM under the Unified Soil Classification System. The measured natural water contents of the samples tested ranged from approximately 6 to 27 percent.

5.2 Silt

A layer of silt was encountered below the sand in both borings. The silt ranged from approximately 9.3 to 11.8 feet thick at the boring locations. The silt consisted of grey, wet, silt, some sand, little to some clay, little gravel, trace organics.

Corrected SPT N-values in the silt ranged from 4 to 7 bpf indicating a soil that is soft to medium stiff in consistency. Grain size analyses conducted on three (3) samples from the silt resulted in the soil being classified as an A-4 under the AASHTO Soil Classification System and a CL-ML under the Unified Soil Classification System. The measured natural water contents of samples tested ranged from approximately 12 to 25 percent.

Table 5-1, below, summarizes the results of the Atterberg Limits tests from samples of the silt:

Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
BB-LMB-101 4D	25.2	25	19	6	1.03
BB-LMB-102 5D	12.5	18	13	5	-0.10

Table 5-1 Summary of Atterberg Limits Testing Results for Silt Samples

Interpretation of these results indicates that the silt sample from BB-LMB-101 is normally consolidated (water content is close to liquid limit) while the silt sample from BB-LMB-102 is to some to heavily over consolidated (water content is close to plastic limit).

5.3 Bedrock

The bedrock at the site is identified as dark blue to purplish, banded, metamorphosed pelite transitioning to pegmatite with quartz, feldspar, garnet, muscovite amphibole and pyrite, steeply dipping joints at 60 to 70 degrees with limonite staining. Joint orientations are subvertical with wavy and slightly rough surface. The RQD of the bedrock was determined to range from 30 to 48 percent correlating to a rock mass quality of poor to fair.

Table 5-2 summarizes approximate top of bedrock elevations at the exploration locations.

Boring	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock Surface (feet)
BB-LMB-101	30.3	136.1
BB-LMB-102	23.3	145.0

Table 5-2 Approximate Depth to Bedrock and Elevation of Bedrock Surface at Exploration Locations

5.4 Groundwater

The measured groundwater level in the borings was approximately 8.0 feet bgs in both borings. The water levels measured upon completion of drilling are indicated on the boring logs in Appendix A. Note that water was introduced into the boreholes during the drilling operations. It is likely that the water levels indicated on the boring logs do not represent stabilized groundwater conditions. Groundwater levels will fluctuate with seasonal changes, runoff and adjacent construction activities.

6.0 FOUNDATION ALTERNATIVES

Based on the subsurface conditions encountered at the site the following alternatives for rehabilitation and replacement of the existing structure were identified:

- Rehabilitation by invert lining with fish weirs,
- Replacement with a 20-foot span by 9-foot rise precast concrete box culvert, and
- Replacement with two (2), 12 foot-10 inch span by 8 foot-4 inch rise steel plate arches.

The Preliminary Design Report (PDR) for this project recommends that the replacement structure be a precast concrete box culvert skewed at approximately 5 degrees. The proposed box culvert will have inlet and outlet toe walls with slope-tapered inlet and outlet walls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

The proposed replacement structure will consist of a 20-foot span by 9-foot rise precast concrete box culvert on a 5 degree skew. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The following sections will discuss geotechnical design recommendations for design of a precast concrete box culvert.

7.1 Precast Concrete Box Culvert Design and Construction

Precast concrete box culverts are typically detailed on the contract plans with only the basic layout and required hydraulic opening so that the Contractor may choose the appropriate structure. The manufacturer is responsible for the design of the structure including determination of the wall thickness, haunch thickness and reinforcement in accordance with Special Provision 534 Precast Concrete Arches, Box Culverts, which is included in Appendix C of this report. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The designer should use Soil Type 4 as presented in the MaineDOT Bridge Design Guide (BDG) Section 3.6 to design earth loads from the soil envelope. The backfill properties are as follows: ϕ = 32 degrees, γ = 125 pcf.

The precast concrete box shall include accommodations for toe walls at both the inlet and outlet ends to prevent undermining per MaineDOT BDG Section 8.3.1. The toe walls should extend a minimum of 1 foot below the maximum depth of scour.

The precast concrete box culvert will be supplier-designed in accordance with AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) specifications. The precast concrete box culvert shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Article 3.4.1 and LRFD Section 12. The precast concrete box culvert shall be constructed in conformance with MaineDOT BDG Section 8 and Special Provision 534.

The box culvert will be bedded on a 1-foot thick layer of granular fill. The soil envelop and backfill shall consist of Standard Specification 703.19 - Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The granular borrow backfill should be placed in lifts of 6 to 8 inches loose measure and compacted with to the manufacturer's specifications. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

7.2 Precast Concrete Box Culvert Headwall Design

Concrete headwalls should be included in the culvert design to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A nominal 1 foot by 1 foot concrete headwall is recommended.

7.3 Precast Concrete Inlet and Outlet Walls and Toe Walls

Precast concrete box culvert inlet and outlet will be slope-tapered to match the 2:1 side slopes. The left and right inlet and outlet walls will share the same precast base slab or will be cast separately and joined at the site. The sloped inlet and outlet walls are essentially retaining walls and shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Articles 3.4.1, 11.5.5 and 11.6. The walls shall be designed to resist lateral earth pressures, vehicular loads, creep and temperature and shrinkage deformations of the concrete box culvert. The wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) of 2.0 feet per LRFD Article 3.11.6.4.

Culvert inlet and outlet walls that are fixed to the box culvert should be designed to resist movement using an at-rest earth pressure coefficient, K_o, of 0.47 assuming a level backslope. The at-rest earth pressure coefficient will change if the backslope conditions are different. Wingwalls sections that are independent of the box culvert should be designed using the Rankine active earth pressure coefficient, K_a, of 0.52 assuming a 2H:1V backslope. The active earth pressure coefficient will also change if the backslope conditions are different. See Appendix D – Calculations for supporting documentation.

The bottom slabs connecting the left and right wingwalls at each end of the box culvert shall include toe walls to prevent undermining per MaineDOT BDG Section 8.3.1. The toe walls should extend a minimum of 1 foot below the maximum depth of scour.

7.4 Bearing Resistance

The factored bearing pressure for at the strength limit state for the box culvert on compacted fill shall not exceed the calculated factored bearing resistance of 16 kips per square foot (ksf), however, the service limit state bearing resistance will govern. A factored bearing resistance of 5 ksf shall be used to control settlement when analyzing the service limit state as allowed in LRFD C10.6.2.6.1. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$. See Appendix D - Calculations for supporting documentation.

7.5 Scour and Riprap

The box culverts shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. Inlet and outlet cutoff walls will be provided that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap conforming to MaineDOT Supplemental Specification Section 703.26 Plain and Hand Laid Riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material conforming to MaineDOT Standard Specification 703.19 Granular Borrow Material for Underwater Backfill. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes should also be constructed in accordance with MaineDOT Supplemental Specification Section 610 – Stone Fill, Riprap, Stone Blanket and

Stone Ditch Protection and shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface. Riprap aprons will be installed at both ends of the box culvert.

7.6 Settlement

No settlement issues are anticipated at the location of the replacement structure. The installation of the proposed box culvert will result in a net unloading of the site soils at the structure location. Placement of fill soils at the location of the existing structure is not anticipated to exceed the past loading condition of the site soils.

7.7 Frost Protection

Any foundation placed on granular subgrade soils should be designed with an appropriate embedment for frost protection. Based on the State of Maine frost depth map found in Maine DOT BDG (Figure 5-1), the site has an air design-freezing index of approximately 1300 F-degree days. Considering the site soils and natural water contents determined in the laboratory, this correlates to a frost depth of approximately 5.3 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 5.3 feet below finished exterior grade for frost protection. See Appendix D- Calculations at the end of this report for supporting documentation.

Riprap is not to be considered as contributing to the overall of thickness of soils required for frost protection.

7.8 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.

7.9 Construction Considerations

The box culvert will be bedded on a 1-foot thick layer of granular fill. The soil envelop and backfill shall consist of Standard Specification 703.19 - Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The granular borrow backfill should be placed in lifts of 6 to 8 inches loose measure and compacted with to the manufacturer’s specifications. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

Construction of the proposed precast concrete box culverts will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow.

Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow or ¾ inch stone.

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.

8.0 CLOSURE

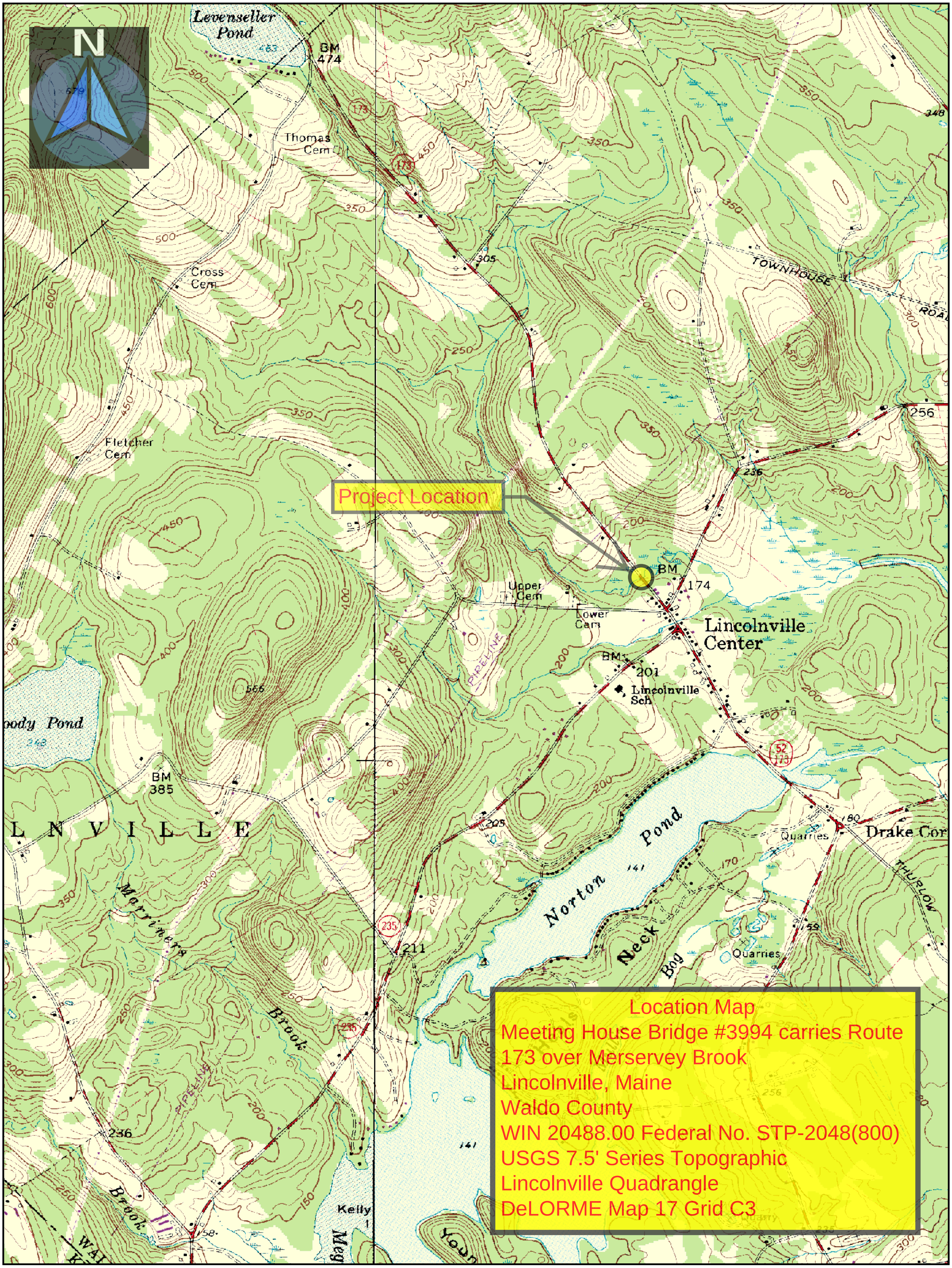
This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Meeting House Bridge on State Route 173 in Lincolnville, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use 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. Further, the analyses and recommendations are based in part upon limited soil explorations at discrete locations 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.

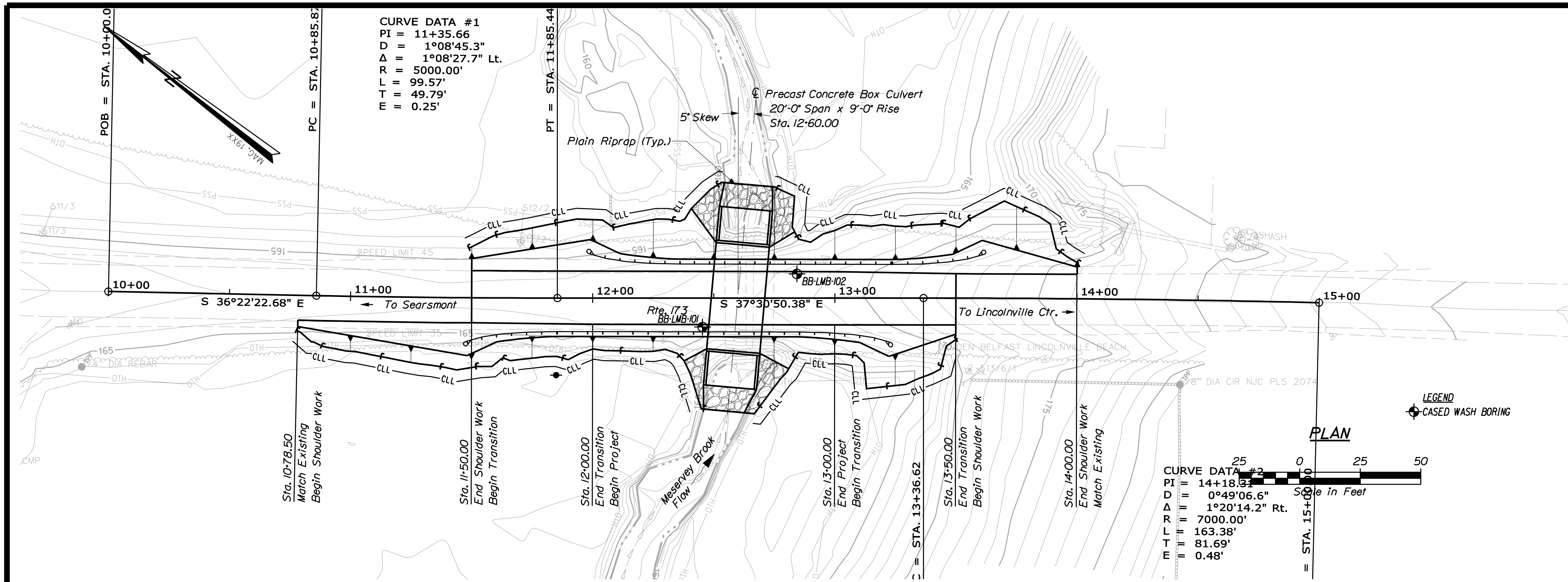
It is also recommend that the geotechnical designer be provided the opportunity for a general review of the final design plans and specifications in order to verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design.

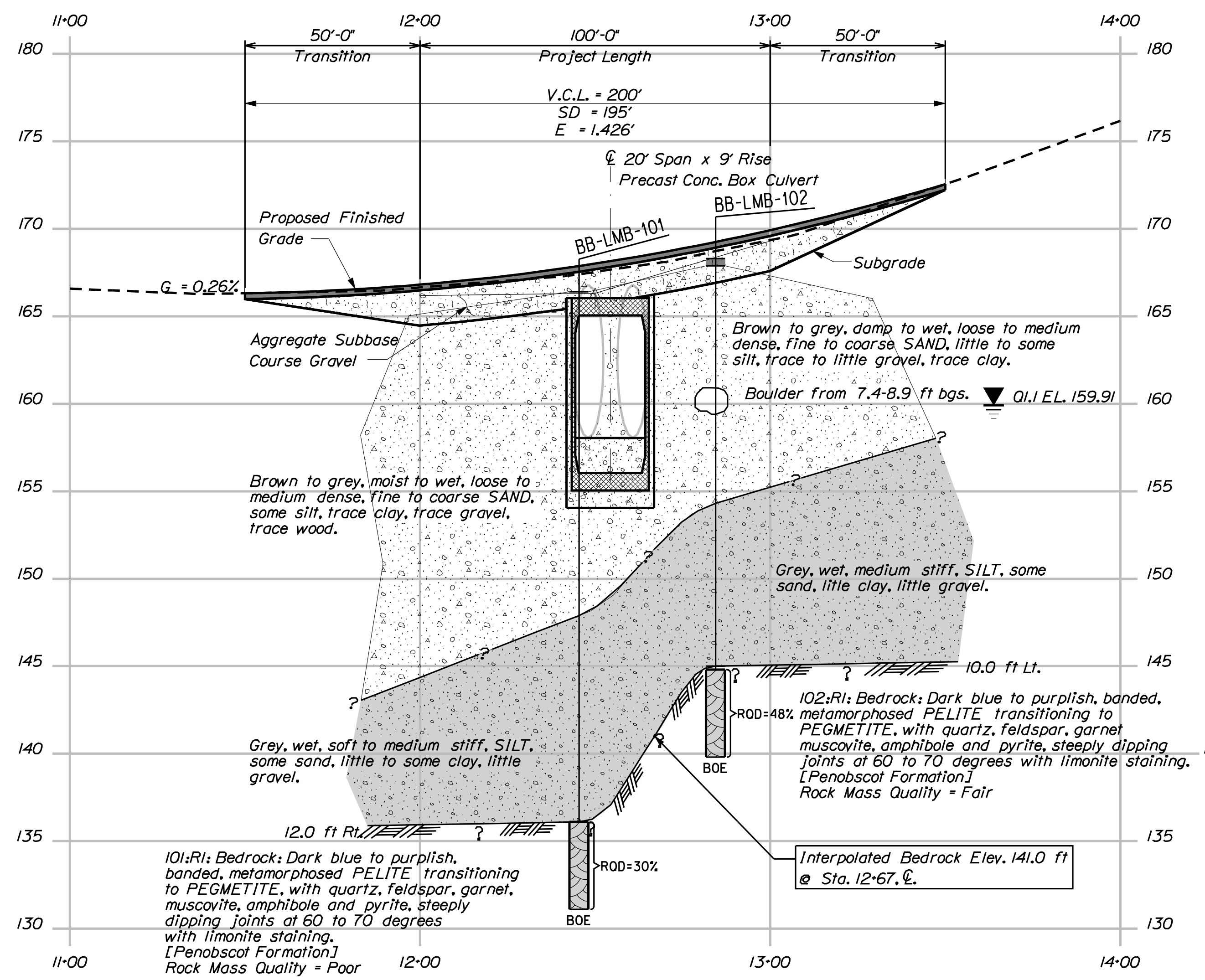
Sheets

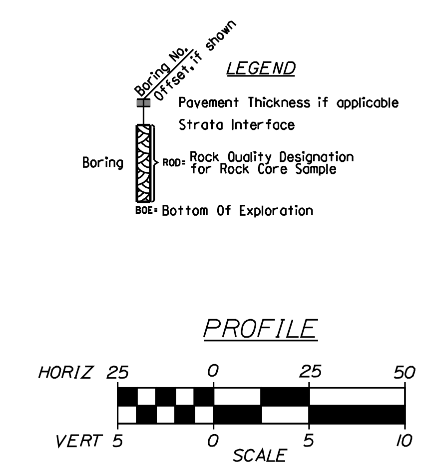
Sheet 1



Map Scale 1:24000







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 transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2048(800)

WIN 20488.00

BRIDGE PLANS

BRIDGE NO. 3994

	NDB	BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	BJN		
CHECKED-REVIEWED	BJN	BJN	
DESIGN2-DETAILED2	K.MAGUIRE	T.WHITE	DEC 2013
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

MEETING HOUSE BRIDGE
MESERVEY BROOK
LINCOLNVILLE WALDO COUNTY

BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

2

OF 3

Filename: ...\GEOTECH\MSTA\004_BLP&SP1.dgn Division: GEOTECH Username: terry.white Date:1/7/2014

Filename: ...\msta\005_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:1/7/2014

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Meeting House Bridge #3994 carries Route 173 over Merservey
Location: Lincolnville, Maine

Boring No.: BB-LMB-101
WIN: 20488.00

Driller:	MaineDOT	Elevation (ft.)	166.4	Auger ID/OD:	5" Solid Stem
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	12+45.4, 12.0 ft Rt.	Casing ID/OD:	NW	Water Level*:	8.0 ft bgs.
Hammer Efficiency Factor: 0.867		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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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				
5	1D	24/16	5.00 - 7.00	2/2/2/2	4	6				Brown, moist, loose, fine to coarse SAND, some silt, trace clay, trace gravel.	G#266650 A-4, SC-SM WC=21.4%
10	2D	24/12	10.00 - 12.00	3/4/4/5	8	12	13			Brown, wet, medium dense, fine to coarse SAND, some silt, trace gravel, trace clay, with wood.	
							17				
							17				
							17				
							21				
15	3D	24/7	15.00 - 17.00	8/8/5/8	13	19	18			Grey, wet, medium dense, fine to coarse SAND, some silt, trace gravel, trace clay.	
							30				
							16				
							12	147.90		18.50	
							11				
20	4D	24/20	20.00 - 22.00	2/1/2/2	3	4	10			Grey, wet, soft, SILT, some fine to medium sand, some clay.	G#243085 A-4, CL-ML WC=25.2% LL=25 PL=19 PI=6
							13				
							13				
							12				
							14				
25	5D	24/16	25.00 - 27.00	2/2/2/2	4	6	12			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel.	G#243086 A-4, CL-ML WC=12.9%
							14				
							23				
							24				
							310			a80 blows for 0.3 ft.	
30	R1	60/60	30.30 - 35.30	RQD = 30%			a80 NQ-2	136.10		30.30 Top of Bedrock at Elev. 136.1 ft. R1:Bedrock: Dark blue to purplish, banded, metamorphosed PELITE transitioning to PEGMETITE, with quartz, feldspar, garnet, muscovite, amphibole and pyrite, steeply dipping joints at 60 to 70 degrees with limonite staining. [Penobscot Formation] Rock Mass Quality = Poor. R1:Core Times (min:sec) 30.3-31.3 ft (6:40) 31.3-32.3 ft (5:14) 32.3-33.3 ft (5:00) 33.3-34.3 ft (5:30) 34.3-35.3 ft (6:00) 100% Recovery	
35								131.10		35.30 Bottom of Exploration at 35.30 feet below ground surface.	
40											
45											
50											

Remarks:

300 lbs. down pressure on Core Barrel.

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.: BB-LMB-101

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Meeting House Bridge #3994 carries Route 173 over Merservey
Location: Lincolnville, Maine

Boring No.: BB-LMB-102
WIN: 20488.00

Driller:	MaineDOT	Elevation (ft.)	168.3	Auger ID/OD:	5" Solid Stem
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	12+84.4, 10.0 ft Lt.	Casing ID/OD:	HW & NW	Water Level*:	8.0 ft bgs.
Hammer Efficiency Factor: 0.867		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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	167.88		5" Pavement 0.42	
	1D	24/13	1.00 - 3.00	5/5/2/2	7	10				Brown, damp, loose, fine to coarse SAND, little silt, trace gravel, trace clay .	G#243087 A-1-b, SC-SM WC=5.8%
5	2D	24/12	5.00 - 7.00	3/2/3/2	5	7	10			Similar to above.	
							16				
							300			Roller Coned ahead from 7.4-10.0 ft bgs. Boulder from 7.4-8.9 ft bgs.	
							88				
							43			Set in NW Casing at 8.9 ft bgs, after drilling through with Roller Cone.	
10	3D	24/14	10.00 - 12.00	3/5/8/9	13	19	55			Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel.	G#243088 A-2-4, SM WC=27.2%
							40				
							48				
							46				
							32	154.30		14.00	
15	4D	24/7	15.00 - 17.00	5/3/2/7	5	7	12			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel, trace organics.	
							17				
							28				
							34				
							32				
20	5D	24/18	20.00 - 22.00	2/2/3/2	5	7	22			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel.	G#243089 A-4, CL-ML WC=12.5% LL=18 PL=13 PI=5
							25				
							33			a50 blows for 0.3 ft.	
	R1	60/56	23.50 - 28.50	RQD = 48%			a50 NQ	145.00		Roller Coned ahead to 23.5 ft bgs. 23.30 Top of Bedrock at Elev. 145.0 ft. R1:Bedrock: Dark blue to purplish, banded, metamorphosed PELITE transitioning to PEGMETITE, with quartz, feldspar, garnet, muscovite, amphibole and pyrite, steeply dipping joints at 60 to 70 degrees with limonite staining. [Penobscot Formation] Rock Mass Quality = Fair. R1:Core Times (min:sec) 23.5-24.5 ft (6:00) 24.5-25.5 ft (3:35) 25.5-26.5 ft (3:25) 26.5-27.5 ft (4:25) 27.5-28.5 ft (5:45) 93% Recovery	
25											
								139.80		28.50 Bottom of Exploration at 28.50 feet below ground surface.	
30											
35											
40											
45											
50											

Remarks:

300 lbs. down pressure on Core Barrel.

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.: BB-LMB-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2048(800)

BRIDGE PLANS

WIN 20488.00

BRIDGE NO. 3994

		BY	DATE
PROJ. MANAGER			
DESIGN-DETAILED	BJN	BJN	
CHECKED-REVIEWED			
DESIGN2-DETAILED2	K.MAGUIRE	T.WHITE	OCT 2013
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

MEETING HOUSE BRIDGE
MESERVEY BROOK
LINCOLNVILLE WALDO COUNTY

BORING LOGS

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)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
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., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

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. Consistency is rated according to standard penetration resistance.

Modified Burmister System

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

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 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):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, 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, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

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

Sample Container Labeling Requirements:

PIN
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: Meeting House Bridge #3994 carries Route 173 over Merservey Brook
Location: Lincolnville, Maine

Boring No.: BB-LMB-101
WIN: 20488.00

Driller:	MaineDOT	**Elevation (ft.)**	166.4	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	12+45.4, 12.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.867	**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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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				
5	1D	24/16	5.00 - 7.00	2/2/2/2	4	6				Brown, moist, loose, fine to coarse SAND, some silt, trace clay, trace gravel.	G#266650 A-4, SC-SM WC=21.4%
10	2D	24/12	10.00 - 12.00	3/4/4/5	8	12	13			Brown, wet, medium dense, fine to coarse SAND, some silt, trace gravel, trace clay, with wood.	
							17				
							17				
							17				
							21				
15	3D	24/7	15.00 - 17.00	8/8/5/8	13	19	18			Grey, wet, medium dense, fine to coarse SAND, some silt, trace gravel, trace clay.	
							30				
							16				
							12	147.90		18.50	
							11				
20	4D	24/20	20.00 - 22.00	2/1/2/2	3	4	10			Grey, wet, soft, SILT, some fine to medium sand, some clay.	G#243085 A-4, CL-ML WC=25.2% LL=25 PL=19 PI=6
							13				
							13				
							12				
25							14				

Remarks:

300 lbs. down pressure on Core Barrel.

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: Meeting House Bridge #3994 carries Route 173 over Merservey Brook
Location: Lincolnville, Maine

Boring No.: BB-LMB-101
WIN: 20488.00

Driller:	MaineDOT	**Elevation (ft.)**	166.4	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	12+45.4, 12.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	8.0 ft bgs.

Hammer Efficiency Factor: 0.867 **Hammer Type:** Automatic ☒ Hydraulic ☐ Rope & Cathead ☐

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SSA = Solid Stem Auger
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RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	24/16	25.00 - 27.00	2/2/2/2	4	6	12			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel.	G#243086 A-4, CL-ML WC=12.9%
							14				
							23				
							24				
							310				
30	R1	60/60	30.30 - 35.30	RQD = 30%			a80	136.10		a80 blows for 0.3 ft.	
							NQ-2			30.30 Top of Bedrock at Elev. 136.1 ft. R1:Bedrock: Dark blue to purplish, banded, metamorphosed PELITE transitioning to PEGMETITE, with quartz, feldspar, garnet, muscovite, amphibole and pyrite, steeply dipping joints at 60 to 70 degrees with limonite staining. [Penobscot Formation] Rock Mass Quality = Poor. R1:Core Times (min:sec) 30.3-31.3 ft (6:40) 31.3-32.3 ft (5:14) 32.3-33.3 ft (5:00) 33.3-34.3 ft (5:30) 34.3-35.3 ft (6:00) 100% Recovery	
35								131.10			
										35.30 **Bottom of Exploration at 35.30 feet below ground surface.**	
40											
45											
50											

Remarks:

300 lbs. down pressure on Core Barrel.

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

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Meeting House Bridge #3994 carries Route 173 over Merservey Brook **Location:** Lincolnville, Maine	**Boring No.:** BB-LMB-102 **WIN:** 20488.00

Driller:	MaineDOT	**Elevation (ft.)**	168.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	12+84.4, 10.0 ft Lt.	**Casing ID/OD:**	HW & NW	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.867	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
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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	167.88		5" Pavement — 0.42	
	1D	24/13	1.00 - 3.00	5/5/2/2	7	10				Brown, damp, loose, fine to coarse SAND, little silt, trace gravel, trace clay .	G#243087 A-1-b, SC-SM WC=5.8%
5	2D	24/12	5.00 - 7.00	3/2/3/2	5	7	10			Similar to above.	
							16				
							300			Roller Coned ahead from 7.4-10.0 ft bgs. Boulder from 7.4-8.9 ft bgs.	
							88				
							43			Set in NW Casing at 8.9 ft bgs, after drilling through with Roller Cone.	
10	3D	24/14	10.00 - 12.00	3/5/8/9	13	19	55			Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel.	G#243088 A-2-4, SM WC=27.2%
							40				
							48				
							46	154.30		14.00	
							32				
15	4D	24/7	15.00 - 17.00	5/3/2/7	5	7	12			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel, trace organics.	
							17				
							28				
							34				
							32				
20	5D	24/18	20.00 - 22.00	2/2/3/2	5	7	22			Grey, wet, medium stiff, SILT, some sand, little clay, little gravel.	G#243089 A-4, CL-ML WC=12.5% LL=18 PL=13 PI=5
							25				
							33				
	R1	60/56	23.50 - 28.50	RQD = 48%			a50 NQ	145.00		a50 blows for 0.3 ft. Roller Coned ahead to 23.5 ft bgs. — 23.30	
25										Top of Bedrock at Elev. 145.0 ft. R1:Bedrock: Dark blue to purplish, banded, metamorphosed PELITE	

Remarks:

300 lbs. down pressure on Core Barrel.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Meeting House Bridge #3994 carries Route 173 over Merservey Brook
Location: Lincolnville, Maine

Boring No.: BB-LMB-102
WIN: 20488.00

Driller:	MaineDOT	**Elevation (ft.)**	168.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/6/2013-9/6/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
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Hammer Efficiency Factor:	0.867	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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N-uncorrected = Raw field SPT N-value
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N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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										transitioning to PEGMETITE, with quartz, feldspar, garnet, muscovite, amphibole and pyrite, steeply dipping joints at 60 to 70 degrees with limonite staining. [Penobscot Formation] Rock Mass Quality = Fair. R1:Core Times (min:sec) 23.5-24.5 ft (6:00) 24.5-25.5 ft (3:35) 25.5-26.5 ft (3:25) 26.5-27.5 ft (4:25) 27.5-28.5 ft (5:45) 93% Recovery	
								139.80		28.50	
30										**Bottom of Exploration at 28.50 feet below ground surface.**	
35											
40											
45											
50											

Remarks:

300 lbs. down pressure on Core Barrel.

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): Lincolnville Work Number: 20488.00

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
BB-LMB-101, 1D	12+45.4	12.0 Rt.	5.0-7.0	266650	1	21.4			SC-SM	A-4	III
BB-LMB-101, 4D	12+45.4	12.0 Rt.	20.0-22.0	243085	1	25.2	25	6	CL-ML	A-4	IV
BB-LMB-101, 5D	12+45.4	12.0 Rt.	25.0-27.0	243086	1	12.9			CL-ML	A-4	IV
BB-LMB-102, 1D	12+84.4	10.0 Lt.	1.0-3.0	243087	1	5.8			SC-SM	A-1-b	II
BB-LMB-102, 3D	12+84.4	10.0 Lt.	10.0-12.0	243088	1	27.2			SM	A-2-4	II
BB-LMB-102, 5D	12+84.4	10.0 Lt.	20.0-22.0	243089	1	12.5	18	5	CL-ML	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.

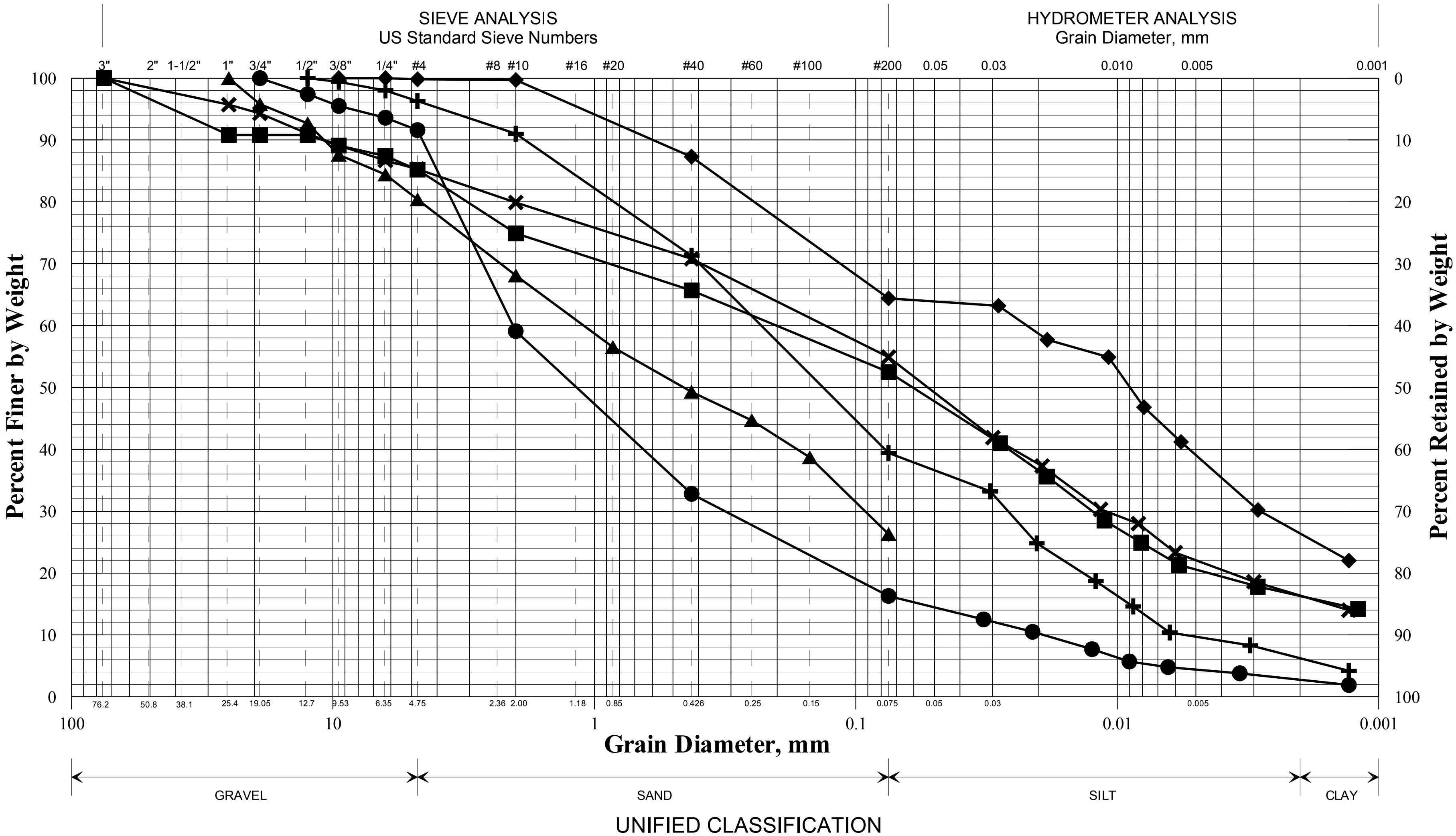
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

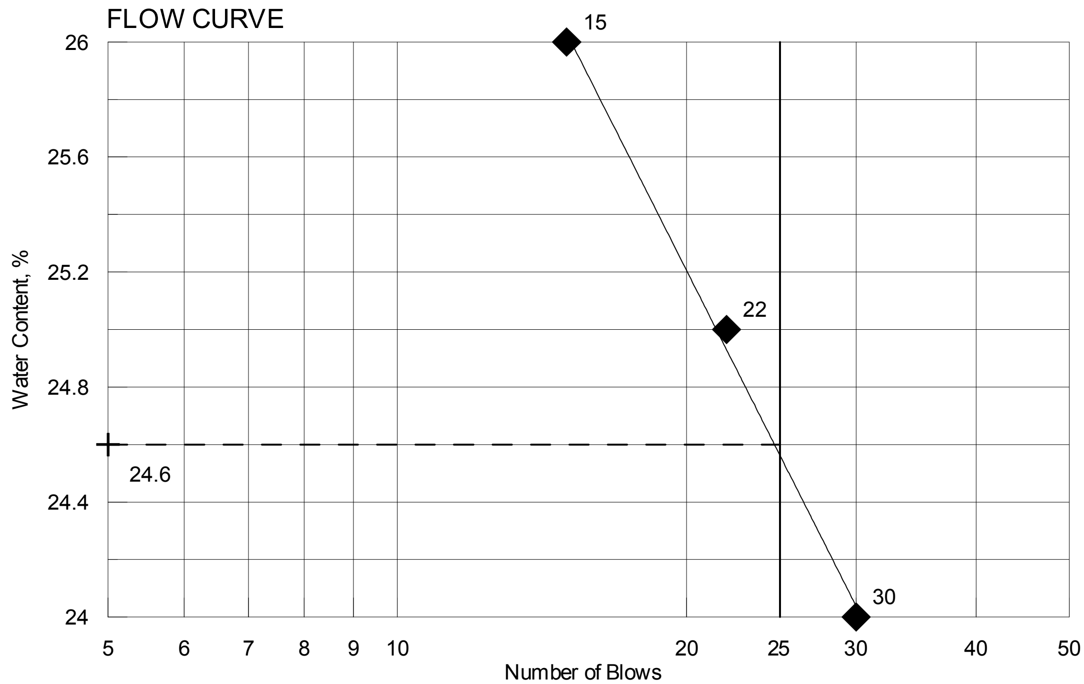


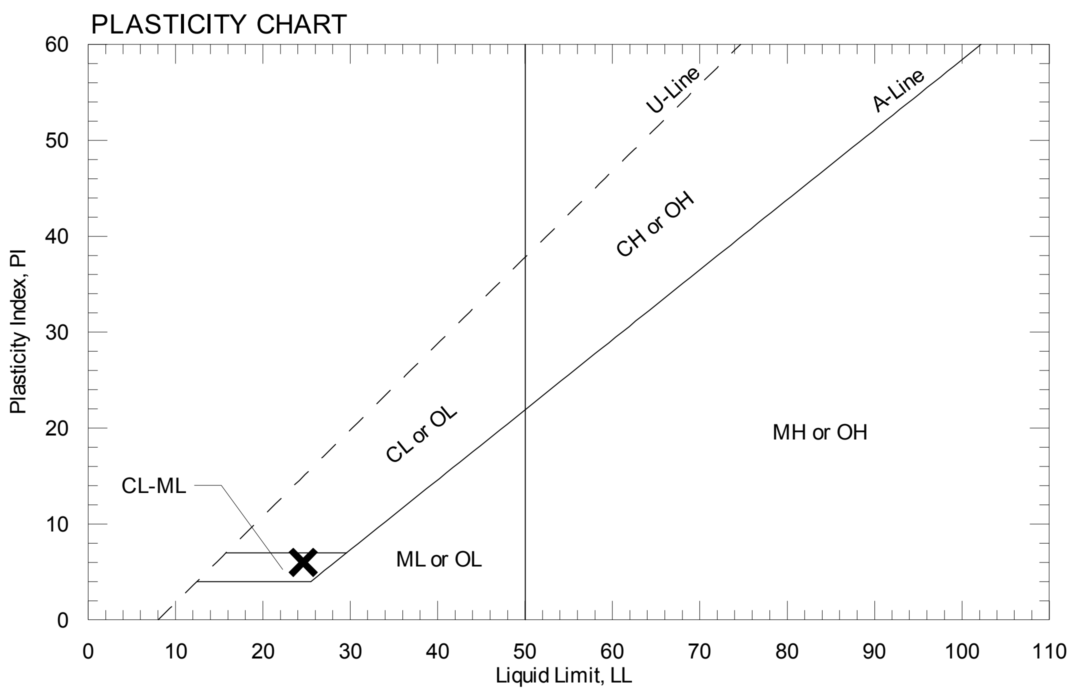
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-LMB-101/1D	12+45.4	12.0 RT	5.0-7.0	SAND, some silt, trace clay, trace gravel.	21.4			
◆	BB-LMB-101/4D	12+45.4	12.0 RT	20.0-22.0	SILT, some sand, some clay.	25.2	25	19	6
■	BB-LMB-101/5D	12+45.4	12.0 RT	25.0-27.0	SILT, some sand, little clay, little gravel.	12.9			
●	BB-LMB-102/1D	12+84.4	10.0 LT	1.0-3.0	SAND, little silt, trace gravel, trace clay.	5.8			
▲	BB-LMB-102/3D	12+84.4	10.0 LT	10.0-12.0	SAND, some silt, little gravel.	27.2			
✖	BB-LMB-102/5D	12+84.4	10.0 LT	20.0-22.0	SILT, some sand, little clay, little gravel.	12.5	18	13	5

WIN	
020488.00	
Town	
Lincolnville	
Reported by/Date	
WHITE, TERRY A	10/10/2013

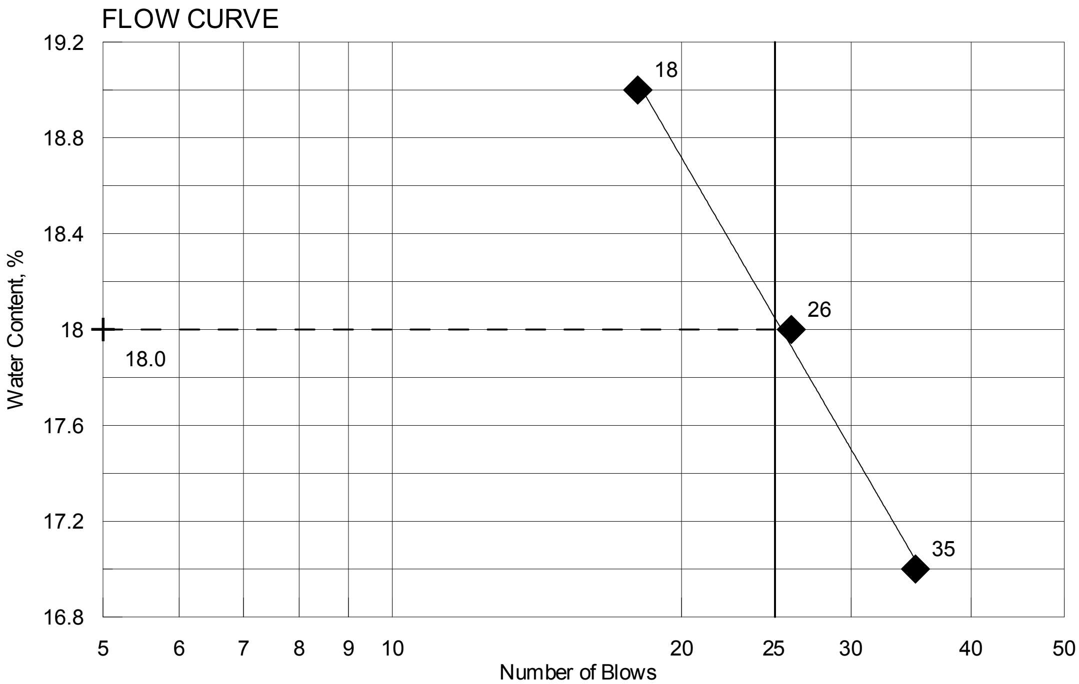
SHEET 1

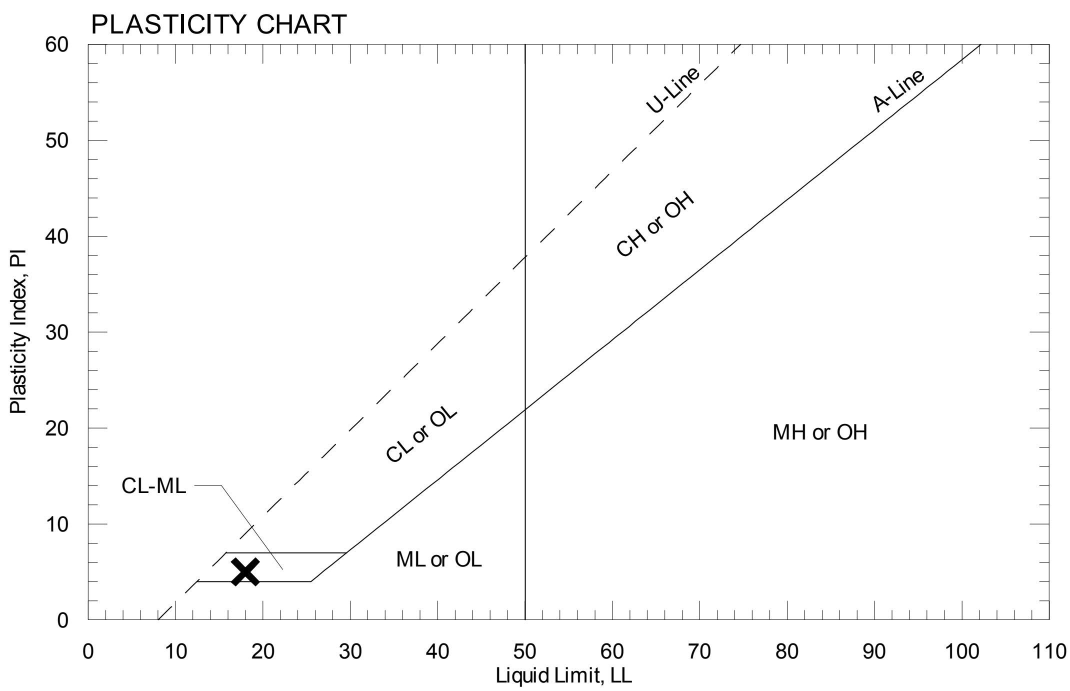
TOWN	Lincolnville	Reference No.	243085
WIN	020488.00	Water Content, %	25.2
Sampled	9/4/2013	Liquid Limit @ 25 blows (T 89), %	25
Boring No./Sample No.	BB-LMB-101/4D	Plastic Limit (T 90), %	19
Station	12+45.4	Plasticity Index (T 90), %	6
Depth	20.0-22.0	Tested By	BBURR





TOWN	Lincolnville	Reference No.	243089
WIN	020488.00	Water Content, %	12.5
Sampled	9/4/2013	Liquid Limit @ 25 blows (T 89), %	18
Boring No./Sample No.	BB-LMB-102/5D	Plastic Limit (T 90), %	13
Station	12+84.4	Plasticity Index (T 90), %	5
Depth	20.0-22.0	Tested By	BBURR





Appendix C

Special Provisions

SECTION 534 - PRECAST STRUCTURAL CONCRETE

534.01 Description The Contractor shall design, manufacture, furnish, and install precast structural concrete arches, box culverts or three sided frames and associated wingwalls, headwalls, toe walls, cut-off walls and appurtenances, in accordance with the Contract Documents.

ALL REQUIREMENTS IN THIS SPECIFICATION ARE THE RESPONSIBILITY OF THE CONTRACTOR, UNLESS NOTED OTHERWISE.

534.02 Materials Structural precast elements for the arch, box culvert, or three sided frame and associated precast elements shall meet the requirements of the following Standard Specification Subsection, except as noted otherwise in this specification:

Structural Precast Concrete Units	712.061

Where there is a conflict between this Section and Section 712.061, the requirements of this Section 534 shall take precedence.

New concrete mix designs and mix designs not previously approved by the Fabrication Engineer shall be qualified by trial batches prepared in accordance with AASHTO T 126 (ASTM C 192). The test results shall demonstrate that the concrete meets the requirements of the Contract Documents.

Grout, concrete patching material, and geotextiles shall be one of the products listed on the Department's Qualified Products List (QPL), unless otherwise approved by the Department.

Bedding and backfill material shall conform to the requirements of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, with the additional requirement that the maximum particle size shall be limited to 4 inches, or as shown on the Plans.

534.03 Drawings Prepare shop detail, erection and other necessary Working Drawings in accordance with Standard Specification Section 105.7, Working Drawings. The Department will review the drawings in accordance with the applicable requirements of Section 105.7, Working Drawings. Changes and revisions to the reviewed Working Drawings shall require further review by the Fabrication Engineer. Working Drawings shall include the following minimum details:

1. Fully dimensioned views showing the geometry of the units, including all projections, recesses, notches, openings, block outs, keyways and chamfers.
2. Details and bending schedules of reinforcing steel including the size, spacing, and location. Reinforcing provided under lifting devices shall be shown in detail.
3. Details and locations of all items to be embedded.
4. Total weight of each unit.

Concrete mix designs shall be part of the Working Drawing submittal. Include aggregate specific gravity, absorption, percent fracture, fineness modulus and gradation as part of the mix design. Provide the mix design calculations demonstrating how the batch weights, water-cement ratio and admixture dosage rate were determined.

534.04 Design Requirements The Contractor shall design the precast structural concrete structure in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition. The HL-93 live load specified in the AASHTO LRFD Bridge Design Specifications shall be used for all limit states, except for Strength I. The live load used for the Strength I limit state shall be the Maine Modified live load, which consists of the standard HL-93 Live Load with a 25 percent increase in the Design Truck only. (Wheel loads based on the Design Truck shall be increased 25 percent). Additionally, if the governing load rating factor based on the HL-93 live load is equal to or less than 1.10 and the span is 14 feet, or greater, then a load rating based on the Maine legal truck (Configuration #6) shall also be checked to insure the rating factor is equal to, or greater than, 1.0.

The live load deflection check, per AASHTO LRFD Bridge Design Specifications, for the top slab of box culverts and frames with clear spans of 15 feet, or greater, and cover depths of 4 feet, or less, is mandatory. The live load deflection check shall be documented in the design computations submittal.

Design calculations that consist of computer program generated output shall be supplemented with at least one hand calculation and graphics demonstrating the design methodology used. The hand calculation shall document, at a minimum, the Strength I load case flexural design check of the top slab positive moment reinforcing steel. Design calculations shall provide thorough documentation of the sources of equations used and material properties.

The design shall be load rated in accordance with the AASHTO Manual for Bridge Evaluation, latest edition, by the LRFR method and in accordance with the MaineDOT Load Rating Guide.

The Contractor shall submit design calculations and load rating, if applicable, for the precast structure to the Department for review. A Registered Professional Engineer, licensed in accordance with State of Maine laws, shall sign and seal all design calculations and drawings.

The Contractor shall submit the following items for review by the Department, at least forty-five (45) Working Days prior to production:

A. The name and location of the manufacturer.
B. Method of manufacture and material certificates.
C. Description of method of handling, storing, transporting, and erecting the units.
D. Design computations (bound and indexed)
E. Load rating computations and completed load rating form (bound and indexed)

534.05 Facilities for Inspection Provide a private office at the fabrication plant for the Department's inspection personnel, or Quality Assurance Inspectors (QAI's). The office shall be in close proximity to the Work. The office shall be climate controlled to maintain the temperature between 68° F and 75° F and have the exit(s) closed by a door(s) equipped with a lock and 2 keys which shall be furnished to the QAI's.

The QAI's office shall meet the following minimum requirements:

Description	Quantity
Office area (minimum ft^2)	100
Drafting table surface (ft^2)	35
Drafting stools-each	1
Office desk	1
Ergonomic swivel chairs	1
Folding chairs	2
High-speed internet connection (ports)	1
Fluorescent Lighting of 100 ft-candles minimum for all work areas	2
110 Volt 60 cycle electric wall outlets	3
Wall closet	1
Plan Rack	1
Waste Basket with trash bags	1
Two-drawer file cabinet (locking)	1
Broom	1
Dustpan	1
Water Cooler	1
Cleaning materials- floor, surfaces, windows, for duration of the project	

The Contractor will be responsible for disposing of trash and supplying commercially bottled water for the water cooler.

The QAI will have the option to reject any furniture or supplies provided to the QAI's office, based on general poor condition.

Provide parking space for the QAI(s) in close proximity to the entrance to the QAI's office. Maintain the pathway between the parking area and the QAI's office so that it is free of obstacles, debris, snow and ice.

The facilities and all furnishings shall remain the property of the Contractor upon completion of the Work. Payment for the facilities, heating, lighting, internet connection and monthly internet charges and all furnishings shall be incidental to the Contract.

Failure to comply with the above requirements will be considered denial of access to the Work for the purpose of inspection. The Department will reject all Work done when access for inspection is denied.

534.06 Notice of Beginning Work Give the Department a minimum of two weeks notice for in-Maine work and three weeks notice for out-of-Maine work prior to beginning production. If the production schedule changes, notify the Fabrication Engineer no less than 3 working days prior to the initial start-up date. Any Work done without the QAI present will be rejected. Advise the Fabrication Engineer of the production schedule and any changes to it. If Work is suspended on a project, the Fabrication Engineer will require 72 hours notice prior to the resumption of Work.

534.07 Quality Control Quality Control (QC) is the responsibility of the Contractor.

Provide a copy of the Quality System Manual (QSM) to the Fabrication Engineer, if requested.

Inspect all aspects of the Work in accordance with the Contractor's QSM. Reject materials and workmanship that do not meet Contract requirements.

Record measurements and test results on the appropriate forms from APPENDIX E of Precast/Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Structural Precast Concrete Products (MNL 116), or an equivalent form prepared by the user. Provide copies of measurements and test results to the QAI as follows:

Type of Report	**When Provided to QAI***
Aggregate gradations-fine aggregate and coarse aggregate	Prior to beginning work and at least once a week thereafter
Material certifications /calibration certifications	Prior to beginning work (anticipate adequate time for review by QAI)
Pre-placement inspection report	Prior to the concrete placement
Concrete batch slips	The morning of the next work day
Results of concrete testing	The morning of the next work day
Concrete temperature records	Provide with compressive strength testing
Nonconformance reports/repair procedures	Within 24 hours of discovery
Results of compressive strength testing (for design strength)	Prior to stopping curing/Prior to final acceptance
Post-placement inspection report	Prior to final acceptance

* The Contractor and QAI may, by mutual agreement, modify any part of the schedule; however, failure to provide the documentation when required by the Fabrication Engineer will result in the product being deemed unacceptable. The Contractor may perform testing in addition to the minimum required. The results of all testing shall be made available to the Department.

534.08 Quality Assurance Quality Assurance (QA) is the prerogative of the Department.

The QAI will witness or review documentation, workmanship and testing to assure the Work is being performed in accordance with the Contract Documents.

The QAI has the authority to reject materials and products that do not meet the Contract requirements, including Work rejected due to denial of access or the lack of adequate notice of the beginning of production. The acceptance of material or workmanship by the QAI will not prevent subsequent rejection, if found unacceptable by the Department, at a later date.

<u>534.09 Nonconforming Work</u> Correct or replace nonconforming material and/or workmanship. Generate a nonconformance report (NCR) describing the nonconformance and the proposed corrective action; provide a copy to the QAI and forward a copy to the Fabrication Engineer for review.

In the event that an item does not meet the Contract requirements but is deemed suitable for use by the Department, said item may be accepted in accordance with Section 106.8, Non-Conforming Work, of the Standard Specifications.

<u>534.10 Forms</u> Construct forms in accordance with the Working Drawings. The forms shall be well constructed, carefully aligned and sufficiently tight to prevent leakage of mortar. Reject forms that do not maintain the dimensions shown on the Working Drawings.

Seal wooden forms to prevent absorption of water. Apply and cure the sealer in accordance with the manufacturer's product data sheet.

Remove all paint, adherent material, foreign matter and debris prior to placing concrete.

Apply a non-staining bond-breaking compound to the forms in accordance with the manufacturer's product data sheet. Solvent clean reinforcing steel and welded steel wire fabric contaminated with the bond-breaking compound.

<u>534.11 Reinforcing Steel and Welded Steel Wire Fabric</u> Fabricate, package, handle, store, place, splice and repair reinforcing steel and welded steel wire fabric in accordance with Section 503 of the Standard Specifications, unless otherwise specified in this specification.

Accurately locate and securely anchor the reinforcing steel and welded steel wire fabric to prevent displacement during concrete placement. Install and secure all reinforcing steel and welded steel wire fabric prior to beginning the concrete placement.

The concrete cover shown on the reviewed Working Drawings, or as specified in this specification, shall be the minimum allowable cover. Use sufficient supports and spacers to maintain the minimum concrete cover. The supports and spacers shall be made of a dielectric material or other material approved by the Fabrication Engineer.

<u>534.12 Inserts</u> Recess inserts, ties or other steel items a minimum of 1 inch from the surface unless noted otherwise on the Plans. Any recess shall be filled with a product from the Department's QPL. The QAI is not responsible for verifying the location of inserts or other hardware installed for the convenience of the Contractor.

534.13 Concrete Placement Do not batch or place concrete until all the form(s) for any continuous placement have been inspected and accepted by the QCI, and the QAI concurs.

Test concrete in accordance with the following Standards:

AASHTO T23 (ASTM C 31) Practice for Making and Curing Concrete Test Specimens in Field
AASHTO T 22 (ASTM C 39) Test Method for Compressive Strength of Cylindrical Concrete Specimens
AASHTO T119 (ASTM C 143) Test Method for Slump of Hydraulic Cement Concrete
AASHTO T141 (ASTM C 172) Practice for Sampling Freshly Mixed Concrete
AASHTO T152 (ASTM C 231) Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 1064 Test Method for Temperature of Freshly mixed Portland Cement Concrete
ASTM C 1611 Standard Test Method for Slump Flow of Self-Consolidating Concrete

Test the first two loads of concrete for temperature, air entrainment and slump, or slump flow for Self-Consolidating Concrete (SCC). If the first load is unacceptable, test the second load as the first. Continue this process until two consecutive loads are acceptable. After two consecutive loads are acceptable, the frequency of testing shall be at the discretion of the QAI.

Test the concrete for temperature, air entrainment and slump, or slump flow for SCC, if there is a change in the dosage rate of any admixture, a change of three inches or more in slump or a change of more than 5° F in mix temperature.

Test every load of 1 cubic yard, or less, from a stationary mixer or 2 cubic yards, or less, from a transit mixer for temperature, air entrainment and slump, or slump flow for SCC, prior to placing the concrete in the forms.

Perform all testing in the presence of the QAI. The QAI will designate the loads to be tested. Make cylinders used to determine stripping strength during the last 1/3 of the placement.

Place the concrete as nearly as possible to its final location. Control the depth of each lift in order to minimize entrapped air voids. The maximum depth of an unconsolidated lift shall be 18 inches. Vibrate the concrete with internal or internal and external vibrators. Do not use external vibrators, only. Insert internal vibrators vertically and penetrate the lower layer of concrete by at least 4 inches. Insert the vibrators in the concrete to assure that the radii of action of the vibrators overlap. Hold the vibrators in position from 5 to 15 seconds; vibration time shall be reduced by 50 percent when placing SCC. Do not use vibrators to move concrete horizontally. Each lift of concrete shall have sufficient plasticity to be consolidated with subsequent lifts.

Do not re-temper the concrete with water after discharging has begun. The Contractor may add High Range, Water Reducing, admixture to the concrete after batching if that practice conforms to the manufacturer's product data sheet. Discard concrete that becomes unworkable.

Do not use water or water-based products to aid in finishing fresh concrete.

After the concrete has been placed and finished and before the forms are covered, remove all concrete from projecting reinforcing steel.

534.14 Process Control Test Cylinders The Contractor shall cast a minimum of 8 concrete test cylinders for each continuous concrete placement, for QC purposes; 2 cylinders shall be cured in accordance with AASHTO T23 and 6 of the cylinders shall be cured under the same conditions as the units. Unit identification, entrained air content, water-cement ratio, slump, and temperature of the sampled concrete shall be recorded at the time of cylinder casting. The Contractor shall perform all testing in the presence of the QAI. The QAI will designate the loads to be tested.

At least once per week, the Contractor shall make 2 concrete cylinders (6 cylinders when the Contract includes permeability requirements) for use by the Department, Cylinders shall be cured in accordance with AASHTO T23 (ASTM C31).

If the Contractor fails to make enough cylinders to demonstrate that the product meets the Contract requirements, the product will be considered unacceptable.

The compressive strength of the concrete will be determined by averaging the compressive strength of two test cylinders made from the same sample. For the purpose of determining design strength, the average of two cylinders shall meet or exceed the design strength, and the difference in strength between the two shall be no more than 10 percent of the higher strength cylinder.

Perform compressive strength testing to determine transfer and design strength in the presence of the QAI. Cylinder tests not witnessed by the QAI will not be acceptable.

534.15 Manufacture of Precast Units Unless otherwise noted on the Working Drawings, the concrete cover over the outside circumferential reinforcement shall be 2 inches, minimum, and the concrete cover over the inside reinforcement shall be 1½ inches, minimum. The clear distance of the end of circumferential wires shall not be less than 1 inch or more than 2 inches from the end of the units. Reinforcement shall be single or multiple layers of welded wire fabric or a single layer of deformed billet steel bars.

Welded steel wire fabric shall meet the space requirements and contain sufficient longitudinal wires extending through the unit to maintain the shape and position of the reinforcement. Longitudinal distribution reinforcement may be welded steel wire fabric or deformed steel bars which meet the spacing requirements. The ends of the longitudinal distribution reinforcement shall not be more than 3 inches from the ends of the units.

Do not use more than three layers of reinforcing to form a single mat. If reinforcing steel is cut to install lifting devices, install additional reinforcing adjacent to the cut steel, as shown on the Working Drawings.

Tension splices in the reinforcement will not be permitted. For splices other than tension splices, the overlap shall be a minimum of 12 inches for welded steel wire fabric and as specified in Standard Specification Section 503 for deformed steel bars. The center-to-center wire spacing in wire fabric sheets shall not be less than 2 inches, or more than 4 inches, for the circumferential wires, and shall not be more than eight inches for the longitudinal wires. The center-to-center spacing of the longitudinal distribution steel for either line of reinforcing in the top slab shall not be more than 15 inches.

The units shall be free of fractures. The ends of the units shall be normal to the walls and centerline of the unit, within the limits of variation provided, except where beveled ends are specified. The surfaces of the units shall be a smooth steel form or troweled surface finish, unless a form liner is specified. The ends and interior of the assembled structure shall make a continuous line of units with a smooth interior surface.

Defects which may cause rejection of precast units include, but are not limited to, the following:

A. Any discontinuity (crack, rock pocket, etc.) of the concrete which could allow moisture to reach the reinforcing steel.
B. Rock pockets or honeycomb over 6 square inches in area or over 1 inch deep.
C. Edge or corner breakage exceeding 12 inches in length or 1 inch in depth.
D. Any other defect that clearly and substantially impacts the quality, durability, or maintainability of the structure, as determined by the Fabrication Engineer.

The manufacturer of the units shall sequentially number and shop fit each adjacent unit to ensure that they fit together in the field. This fit up shall be witnessed by the QAI. Any non-fitting units shall be corrected or replaced at no cost to the Department.

The manufacturer of the units shall keep accurate records of aggregate gradations, concrete batching, testing, curing, and inspection activities to verify that forms, reinforcing and unit dimensions conform to these requirements. Copies of reports shall be furnished to the Resident when requested.

534.16 Tolerances Dimensional tolerances shall be in conformance with the following:

A. The internal dimensions shall not vary by more than 1 percent from the design dimensions or 1½ inches, whichever is less, with the exception of the cross diagonal dimension which shall not vary by more than one-half inch from the design dimension.
B. The haunch dimensions shall not vary by more than three-quarter inch from the design dimension.
C. The dimension of the legs shall not vary by more than one-quarter inch from the dimension shown on the reviewed Working Drawings.

D. The slab and wall thickness shall not be less than the design thickness by more than one-quarter inch. A thickness greater than the design thickness shall not be cause for rejection.
E. Variations in laying lengths of two opposite surfaces shall not be more than five-eighth inch in any unit, except where beveled ends for laying of curves are specified.
F. The under-run in length of any unit shall not be more than one-half inch.

534.17 Finishing Concrete Products shall be finished to meet the ordinary finish requirements of Standard Specification Section 502. Units or portions of units that will be exposed to view in their final location shall receive a rubbed finish, per Section 502. The Contractor may use alternative methods of achieving an acceptable finish on exposed units if approved by the Fabrication Engineer.

Marking: The date of manufacture, the production lot number, and the type of unit shall be clearly and indelibly scribed on a rear, unexposed portion of each unit.

534.18 Repairing Defects Defects requiring repair will be considered either non-structural or structural.

Non-Structural Defects: Exposed surfaces shall be of uniform appearance; only minor repairs to remove and blend fins, patch minor spalls and to repair small, entrapped air pockets, shall be permitted. Repair honeycombing, ragged or irregular edges and other non-structural or cosmetic defects using a patching material from the MaineDOT QPL. The repair, including preparation of the repair area, mixing and application and curing of the patching material, shall be in accordance with the manufacturer's product data sheet. Corners not exposed in the final product may be ground smooth with no further repair necessary, if the depth of the defect does not exceed one-half inch. Remove form ties and other hardware to a depth of not less than one inch from the face of the concrete and patch the holes using a patching material from the MaineDOT QPL.

Structural Defects: Repair structural defects only with the approval of the Fabrication Engineer. Submit a nonconformance report (NCR) to the Fabrication Engineer with a proposed repair procedure. Do not perform structural repairs without an NCR that has been reviewed by the Fabrication Engineer. Structural defects include, but are not be limited to, exposed reinforcing steel or strand, cracks in bearing areas, through cracks and cracks 0.013 inch in width that extend more than 12 inches in length in any direction. Give the QAI adequate notice prior to beginning any structural repairs.

534.19 Handling, Storage and Transportation Handle, store and transport units in a manner as to eliminate the danger of chipping, cracks, fracture, and excessive bending stresses. Any units found damaged upon delivery, or damaged after delivery, shall be subject to rejection.

Do not place precast units in an upright position until a compressive strength of at least 4,000 psi is attained. Precast units may be handled and moved, but not transported, until the 28 day design strength has been attained.

Support stored precast units above the ground on dunnage in a manner to prevent twisting or distortion. Protect the units from discoloration and damage.

Set precast units on one-half inch thick neoprene pads during shipment to prevent damage to the unit legs. The Contractor shall repair any damage to precast units resulting from shipping or handling; this shall be accomplished by saw cutting a minimum of one-half inch deep around the perimeter of the damaged area, removing any loose concrete out to the sawcut perimeter and installing a polymer-modified cementitious patching material, from the Department's QPL, per the manufacturer's product data sheet.

534.20 Installation of Precast Units When footings are required, install the precast units on concrete footings that have reached a compressive strength of at least 3,000 psi. Construct the completed footing surface to the lines and grades shown on the Plans. When checked with a 10 foot straightedge, the surface shall not vary more than one-quarter inch in 10 feet. The footing keyway shall be filled with a Department-approved non-shrink flowable cementitious grout with a design compressive strength of at least 5,000 psi.

Three sided frame and box culvert joints shall be sealed with a Department-approved flexible joint sealant in accordance AASHTO M 198 (ASTM C 990). Joints shall be closed tight. Culvert units shall be equipped with joint closure mechanisms to draw units together and close joints to the required opening.

Completely fill the exterior face of joints between precast units with a material from the MaineDOT QPL and cover with a minimum 12 inch wide joint wrap. The surface shall be free of dirt and deleterious materials before applying the filler material and joint wrap. Install the external wrap in one continuous piece over each unit joint, taking care to keep the joint wrap in place during backfilling.

Seal the joints between the end unit and attached elements with a non-woven geotextile. Install and tighten the bolts fastening the connection plate(s) between the elements that are designed to be fastened together as designated by the manufacturer.

Fill holes that were cast in the units for handling with either Portland cement mortar or with precast plugs secured with Portland cement mortar or other approved adhesive.

Place and compact the bedding material as shown on the Plans prior to lifting and setting the culvert units. Backfilling of the structure shall be done in accordance with the manufacturer's instructions and the Contract Documents. Uniformly distribute backfill material in layers of not more than 8 inches in depth, loose measure, and thoroughly compact each layer using approved compactors before successive layers are placed. Compact the Granular Borrow bedding and backfill in accordance with Section 203.12, Construction of Earth Embankment with Moisture and Density Control, except that the minimum required compaction shall be 92 percent of maximum density, as determined by AASHTO T-180, Method C or D. Place and compact the backfill without disturbance or displacement of the structure, keeping the fill at approximately the same elevation on both sides of the structure. Whenever a compaction test fails, the Contractor shall not place additional backfill over the area until the lift is re-compacted and a passing test achieved.

Use hand-operated compactors within five feet of the precast structure as well as over the top until it is covered with at least 12 inches of backfill. Take appropriate precautions to protect the top of the culvert from damage during backfilling and/or paving operations. Any damage to the top of the precast structure shall be repaired, or units replaced, at no cost to the Department.

534.21 Method of Measurement Precast Structural Concrete Arches, including three-sided frames, and Precast Concrete Box Culverts will be measured as one lump sum, complete, in place and accepted.

534.22 Basis of Payment The accepted Precast Structural Concrete Arches, including three-sided frames, or Precast Concrete Box Culverts will be paid for at the respective Contract lump sum price. The lump sum price shall include associated wingwalls, headwalls, toe walls, cut-off walls and appurtenances, and shall be full compensation for all labor, equipment, materials, professional services, and incidentals necessary for designing, manufacturing, furnishing and installing the precast concrete elements and accessories. Falsework, reinforcing steel, welded steel wire fabric, jointing tape, geotextile, grout, cast-in-place concrete fill or grout fill for anchorage of precast wings and/or other appurtenances will not be measured and paid for separately, but will be incidental to the lump sum pay item. Cast-in-place concrete, reinforcing steel in cast-in-place elements and membrane waterproofing will be measured and paid for separately, under the provided Contract Pay Items. Pay adjustments for quality level will not be made for precast concrete.

Excavation for precast structural concrete structures, including excavation below culverts for bedding and backfilling, will be measured and paid for as provide in Section 206, Structural Excavation.

When the minimum cover material extends above the subgrade line, the removal of the cover material necessary to complete the work will not be paid for directly, but shall be considered incidental to the precast structural concrete lump sum pay item.

Payment will be made under:

Pay Item	Pay Unit
534.70 Precast Structural Concrete Arch	Lump Sum
534.71 Precast Concrete Box Culvert	Lump Sum

Appendix D

Calculations

LIQUIDITY INDEX (LI):

$$\text{Liquidity Index} = \frac{\text{natural water content - Plastic Limit}}{\text{Liquid Limit -Plastic Limit}}$$

wc is close to LL	Soil is normally consolidated
wc is close to PL	Soil is some-to-heavily over consolidated
wc is intermediate	Soil is over consolidated
wc is greater than LL	Soil is on the verge of being a viscous liquid when remolded

Sample	Soil	WC	LL	PL	PI	LI	Plasticity	
BB-LMB-101, 4D	Silt	25.2	25	19	6	1.03	low plasticity	normally consolidated
BB-LMB-102, 5D	Silt	12.5	18	13	5	-0.10	low plasticity	some to heavily overconsolidated

At-Rest and Active Earth Pressure:

At-Rest Lateral Earth Pressure
from LRFD Article 3.11.5.2 pg 3-71

Effective friction angle of soil $\phi_f := 32 \cdot deg$

$K_o := 1 - \sin(\phi_f)$ $K_o = 0.47$

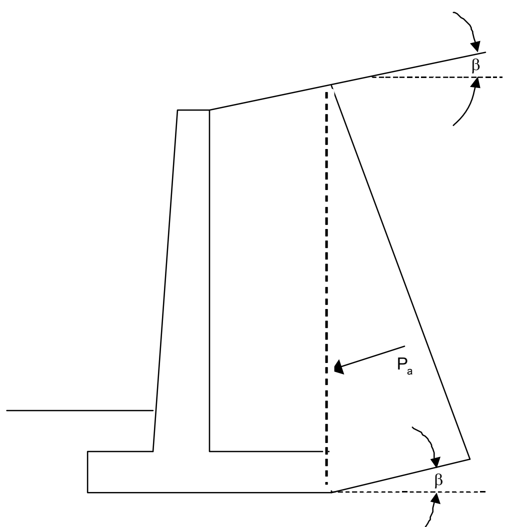
Active Earth Pressure - Rankine Theory
from MaineDOT Bridge Design Guide Section 3.6.5.2 pg 3-7

Soil Type 4 Properties from MaineDOT Bridge Design Guide (BDG)

unit weight: $\gamma_{type4} := 125 \cdot pcf$

Internal Friction Angle: $\phi_{type4} := 32 \cdot deg$

Cohesion: $c_{sand} := 0 \cdot psf$



Generally use Rankine for long heeled cantilever walls where the failure surface is un interrupted by the top of the wall system. The earth pressure is applied to a plane extending vertically up from the heel of the wall base and the weight of the soil on the inside of the vertical plane is considered as part of the wall weight. The failure sliding surface is not restricted by the top of the wall or the backface of the wall.

For cantilever walls with sloped backfill surface:

β = Angel of fill slope to the horizontal

$\beta := 26.56 \cdot deg$ assume 2H:1V sloping backfill surface

$$K_{a\_rankine\_slope} := \frac{\cos(\beta) - \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}}{\cos(\beta) + \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}} \qquad K_{a\_rankine\_slope} = 0.52$$

Pa is oriented at an angle of β to the vertical plane.

Bearing Resistance - Native Granular Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - box culvert on granular soils

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 6th Edition 2012
Table C10.6.2.6.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Fine to coarse sand (SM)

Based on N-values ranging from 12 to 19 - Soils are medium dense at bearing elevation

Consistency In Place: medium dense

Bearing Resistance: Ordinary Range (ksf) 4 to 8

Recommended Value of Use: 5 ksf

$$tsf := g\cdot\left(\frac{ton}{ft^2}\right)$$

Recommended Value: $5\cdot ksf = 2.5\cdot tsf$

Therefore: $q_{nom} := 2.5\cdot tsf$

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1)

$q_{factored\_bc} := 2.5tsf$ or $q_{factored\_bc} = 5\cdot ksf$

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

Part 2 - Strength Limit State

Nominal and factored Bearing Resistance - box culvert on native soils

Reference: Foundation Engineering and Design by JE Bowles Fifth Edition

Assumptions:

1. The box culvert and bedding will be founded at ~ Elev 154.5

   Top of fill within the box ~ Elev. 158.5

   Bottom of Construction will be 4 feet below this. $D_{box} := 4.0\cdot ft$

2. Assumed parameters for fill soils: (Ref: Bowles 5th Ed Table 3-4)

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

   Dry unit weight: $\gamma_d := 120\cdot pcf$

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

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

3. Use Terzaghi strip equations as L>B

4. Effective stress analysis footing on ϕ-c soil (Bowles 5th Ed. Example 4-1 pg 231)

Depth the water table: $D_w := 0\cdot ft$

Unit Weight of water: $\gamma_w := 62.4\cdot pcf$

Effective stress at box bearing level:

$$q_{eff} := D_w \cdot \gamma_s + \left(D_{box} - D_w\right) \cdot \left(\gamma_s - \gamma_w\right) \qquad q_{eff} = 0.25 \cdot ksf$$

Look at 4 widths: $B := \begin{pmatrix} 18 \\ 20 \\ 22 \\ 24 \end{pmatrix} \cdot ft$

Terzaghi Shape factors from Table 4-1 For a strip footing: $s_c := 1.0$ $s_\gamma := 1.0$

Meyerhof Bearing Capacity Factors - Bowles 5th Ed. table 4-4 pg 223

For ϕ=32 deg $N_c := 35.47$ $N_q := 23.2$ $N_\gamma := 22$

Nominal Bearing Resistance per Terzaghi equation (Bowles 5th Ed. Table 4-1 pg 220)

$$q_{nominal} := c_{ns} \cdot N_c \cdot s_c + q_{eff} \cdot N_q + 0.5\left(\gamma_s\right) B \cdot N_\gamma \cdot s_\gamma$$

$$q_{nominal} = \begin{pmatrix} 30.6 \\ 33.3 \\ 36.1 \\ 38.8 \end{pmatrix} \cdot ksf$$

Factored Bearing Resistance for Strength Limit State

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

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

$$q_{factored} = \begin{pmatrix} 13.8 \\ 15 \\ 16.2 \\ 17.5 \end{pmatrix} \cdot ksf \qquad B = \begin{pmatrix} 18 \\ 20 \\ 22 \\ 24 \end{pmatrix} \cdot ft$$

Recommend a limiting factored bearing resistance of 16 ksf for box culvert with a 20 foot opening and 1 foot thick walls (B=22 feet)

Factored Bearing Resistance for Service and Extreme Limit States

Resistance Factor: $\phi_b := 1.0$ AASHTO LRFD Table 10.5.5.2.2-1

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

$$q_{factored} = \begin{pmatrix} 30.6 \\ 33.3 \\ 36.1 \\ 38.8 \end{pmatrix} \cdot ksf \qquad B = \begin{pmatrix} 18 \\ 20 \\ 22 \\ 24 \end{pmatrix} \cdot ft$$

Recommend a limiting factored bearing resistance of 36 ksf for box culvert with a 20 foot opening and 1 foot thick walls (B=22 feet)

Frost Protection:

Method 1 - MaineDOT Design Freezing Index (DFI) Map and Depth of Frost Penetration Table are in BDG Section 5.2.1.

From the Design Freezing Index Map:
Lincolnville, Maine
DFI = 1300 degree-days

From the lab testing: soils are coarse grained with a water content = ~20%

From Table 5-1 MaineDOT BDG for Design Freezing Index of 1300 and wc =20%
Frost Penetration = 70.2 inches

$\text{Frost\_depth} := 63\text{in}$ $\qquad$ $\text{Frost\_depth} = 5.3 \cdot \text{ft}$

Method 2 - Check Frost Depth using Modberg Software

Closest Station is Belfast

--- ModBerg Results ---

Project Location: Belfast, Maine

Air Design Freezing Index	=	1188 F-days
N-Factor	=	0.80
Surface Design Freezing Index	=	950 F-days
Mean Annual Temperature	=	45.5 deg F
Design Length of Freezing Season	=	118 days

Layer #:Type	t	w%	d	Cf	Cu	Kf	Ku	L
1-Coarse	63.6	20.0	120.0	32	44	3.2	1.7	3,456

t = Layer thickness, in inches.
w% = Moisture content, in percentage of dry density.
d = Dry density, in lbs/cubic ft.
Cf = Heat Capacity of frozen phase, in BTU/(cubic ft degree F).
Cu = Heat Capacity of thawed phase, in BTU/(cubic ft degree F).
Kf = Thermal conductivity in frozen phase, in BTU/(ft hr degree).
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).
L = Latent heat of fusion, in BTU / cubic ft.

****
Total Depth of Frost Penetration = 5.30 ft = 63.6 in.
****

$\text{Frost\_depth}_{\text{modberg}} := 63.6 \cdot \text{in}$

$\text{Frost\_depth}_{\text{modberg}} = 5.3 \cdot \text{ft}$ $\qquad$ Use Frost Depth = 5.3 feet for design