MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

BOTTLE BROOK BRIDGE
STATE ROUTE 16 OVER BOTTLE BROOK
KINGSBURY PLANTATION, MAINE

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Piscataquis County
WIN 19179.00

Soils Report No. 2014-01
Bridge No. 6467

January 13, 2014

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Appendices

GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of twin corrugated steel pipe culverts which carry State Route 16 over Bottle Brook in Kingsbury Plantation, Maine with the new Bottle Brook Bridge. The existing twin 4-foot diameter steel pipes are approximately 43 feet long and of unknown age. The proposed replacement structure will be a 20-foot span by 6-foot rise, approximately 80-foot long, precast concrete box culvert. The new box culvert will be constructed with a 24 degree skew to be better aligned with the existing stream channel. 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 supplier-designed in accordance with Special Provision 534 - Precast Concrete Arches, Box Culverts, Frames and AASHTO LRFD Bridge Design Specifications, 6th Edition, 2012 (LRFD). The loading specified for the structure should be Modified HL-93 Strength 1 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 proposed box culvert will have 1-foot tall precast headwalls. The box will be embedded approximately 2 feet into the streambed and 2 feet of special fill will be placed inside the bottom of the culvert to create a natural streambed crossing. The proposed box culvert will be bedded on a 1-foot thick layer of granular borrow.

Precast Concrete Flared Inlet and Outlet Walls – The box culvert's inlet and outlet walls will slope-tapered to match the 2:1 sideslopes. The walls will also be flared out at approximately a 4:1 taper ratio to approximately twice the bankfull width. The bottom slabs connecting the left and right walls at each end of the box culvert shall include toe walls to prevent undermining. Each toe wall 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 state 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 walls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil.

Bearing Resistance - For a precast box with a base width of 22 feet, the applied bearing stress at the strength limit state shall not exceed the calculated factored bearing resistance of 10.6 kips per square foot (ksf). A factored bearing resistance of 6 ksf should be used to control settlement when analyzing the service limit state. In no instance shall be bearing stress exceed the nominal structural resistance of the structural concrete which may be taken as $0.3f'c$.

Settlement – No settlement issues are anticipated at the site. The cohesionless glacial till soils at the anticipated foundation elevation for the precast box are dense in consistency and the cohesive glacial till soils encountered are stiff and heavily preconsolidated. There is no plan to change in the horizontal alignment or vertical profile from the existing.

Frost Protection – Foundations placed on soil should be founded a minimum of 7.2 feet below finished exterior grade for frost protection.

Scour and Riprap – The box culvert will be constructed with integral concrete headwalls and sloped tapered inlet and outlet walls to retain riprap slopes. The sloped, flared walls at the inlet and outlet will share the same base slab. These base slabs shall be fabricated with cutoff walls that extend a minimum of 1 foot 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. Riprap aprons will be installed at both ends of the culvert.

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.

Construction Considerations – The box culvert soil envelope 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 thick loose measure and compacted to the manufacturer’s specifications. To control future settlement, in no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

The proposed box culvert will be bedded on a 1-foot thick layer of granular borrow. Based on the soils encountered in the borings, silty glacial till may be encountered at this elevation. The Contractor shall minimize disturbance to the silty till soils and all subgrade surfaces should be protected from any unnecessary construction traffic.

Earthwork and excavations will result in the exposure of silty glacial till. These soils may be susceptible to disturbance and rutting as a result of exposure to water or construction traffic. If disturbance and rutting occur, we recommend that the Contractor remove and replace the disturbed materials with ¾-inch stone or compacted MaineDOT Standard Specification 703.20, Gravel Borrow. Cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow or ¾-inch stone.

Staged construction will require temporary earth support systems. Cobbles and boulders were encountered in the explorations and these obstructions may impede driving sheet piles that may be required for temporary earth support.

Glacial till subunits encountered have a significant percentage of fine material passing the #200 sieve. These soils may become saturated and water seepage may be encountered during construction. There may be localized sloughing and instability in some excavations and cut slopes. The Contractor should control groundwater, surface water infiltration and soil erosion.

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of twin steel pipes which carry State Route 16 over Bottle Brook in Kingsbury Plantation, Maine. The new structure will be called Bottle Brook Bridge. A subsurface investigation has been completed. The purpose of the investigation was to explore subsurface conditions at the site in order to develop geotechnical recommendations for the new box culvert construction. This report presents the subsurface information obtained at the site during the subsurface investigation, foundation design recommendations and geotechnical design parameters.

It is unknown when the existing twin pipes were constructed. The existing structure consists of twin 4-foot diameter steel pipes. The pipes are approximately 43 feet long on an approximately 12 degree skew. The pipes are in poor condition, misaligned with the upstream channel flow and are failing. There are potholes and cracks in the overlying roadway indicating water is infiltrating between the pipes and washing out the roadbase.

The Maine Department of Transportation (MaineDOT) Bridge Program considered rehabilitation but the existing pipes are too small and in too poor condition for rehabilitation. It has been determined that the poor condition of the steel pipes warrants replacement in conjunction with staged construction to allow alternating one-way traffic to be maintained along State Route 16.

The proposed replacement structure will be a 20-foot span by 6-foot rise, approximately 80-foot long, precast concrete box culvert. Due to the migration of the stream to the west, the new culvert will be constructed with a 24 degree skew to be better aligned with the existing stream channel. The box culvert will have 1-foot tall precast headwalls. The proposed box will have inlet and outlet toe walls and slope-tapered, flared walls at both the upstream and downstream ends. The invert of the box culvert will be embedded approximately 2 feet into the streambed and 2 feet of special fill will be placed inside the bottom of the culvert to create a natural stream crossing. The culvert will have sediment sills spaced at 8 feet maximum along the inside culvert length. The new bridge will be located on the same horizontal alignment as the existing bridge. The finished grade over the proposed precast box culvert will match the existing.

2.0 GEOLOGIC SETTING

The twin pipes to be replaced carry State Route 16 over Bottle Brook approximately 5 miles east of the Mayfield/Kingsbury Plantation town line, as shown on Sheet 1 – Location Map, found at the end of this report.

The Maine Geologic Survey (MGS) Surficial Geology of the Kingsbury Quadrangle Open File No. 86-33 (1986) indicates the surficial soils in the vicinity of the bridge project consist of glacial till. Glacial till is typically comprised of heterogeneous mixtures of sand, silt, clay and stones. Basal till is fine-grained and compact. Ablation till is loose, sandy and stoney. Glacial till generally overlies bedrock.

The Bedrock Geologic Map of Maine, MGS, (1985), cites the bedrock at the bridge site as metamorphic pelite of the Carrabassett Formation.

3.0 SUBSURFACE INVESTIGATION

Subsurface conditions at the site were explored by drilling three (3) test borings. Test borings BB-KING-101 and BB-KING-101A were drilled in the westbound shoulder of State Route 16, approximately 15 feet west of the existing pipe culverts. Test boring BB-KING-102 was drilled in the eastbound shoulder of State Route 16, approximately 5 feet outside of the existing pipe culverts. The boring locations are shown on Sheet 2 - Boring Location Plan and Interpretive Subsurface Profile found at the end of this report.

Borings BB-KING-101A and BB-KING-102 were terminated at depths of approximately 22 and 23 feet below the roadway surface, respectively. Boring BB-KING-101 was drilled to a depth of approximately 6.5 feet below the roadway surface, without sampling, and abandoned due to damaged drill casing. The borings were drilled on August 19, 2013 by MaineDOT Drill Crew. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring log provided in Appendix A – Boring Logs and on Sheet 3 - Boring Logs found at the end of this report.

The borings were drilled using solid stem auger and cased wash boring techniques. Soil samples 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 dill 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 2013 and was found to deliver approximately 43 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 of 0.867 to the raw field N-values. This hammer efficiency factor (0.867) and both the raw field N-value and corrected N-value (N_{60}) are shown on the boring logs.

A Northeast Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions encountered. The MaineDOT geotechnical engineer selected the boring locations and drilling methods, designated type and depth of sampling techniques, reviewed draft boring logs and identified field and laboratory testing requirements. The borings were located in the field using taped measurements at the completion of the drilling program.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected soil samples recovered from 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 three (3) standard grain size analyses, one (1) grain size analysis with hydrometer, and four (4) natural water content tests. The results of laboratory tests are included as Appendix B – Laboratory Test Results found at the end 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 in the test borings generally consisted of granular fill underlain by glacial till with frequent cobbles and boulders. The boring logs are provided in Appendix A – Boring Logs and on Sheet 3 – Boring Logs found at the end of this report. A generalized subsurface profile is shown on Sheet 2 – Boring Location Plan and Interpretive Subsurface Profile found at the end of this report. A brief summary description of the strata encountered follows:

5.1 Fill Soils

A layer of granular fill was encountered in the borings. The encountered thickness ranged from approximately 8 feet to 9 feet. The miscellaneous fill subunits encountered consisted of:

- Grey-brown and brown, damp, gravelly, fine to coarse sand, little silt;
- Brown, moist, fine to coarse sand, some silt, little gravel, trace roots and wood fragments; and
- Brown, damp, fine to coarse sand, some silt, trace gravel.

Cobbles were encountered in the fill unit between approximately 6.7 and 8.8 feet below the ground surface (bgs) in BB-KING-101A. SPT N-values in the fill unit ranged from 6 to 77 blows per foot (bpf), indicating the fill is loose to very dense in consistency.

One (1) grain size analysis conducted indicated that the fill soil is classified as A-1-b by the AASHTO Classification System and SM by the Unified Soil Classification System. The water content from one sample obtained within the layer was approximately 12 percent.

5.2 Glacial Till

A layer of glacial till was encountered below the fill materials

Boring BB-KING-101A was terminated approximately 13 feet into the glacial till at a depth of 22 feet bgs. No refusal surface was encountered in the boring.

Boring BB-KING-102 was terminated approximately 15 feet into the glacial till at a depth of 23 feet bgs. No refusal surface was encountered in the boring.

The glacial till deposit consisted of:

- Brown, moist, sandy, silt, little gravel;
- Olive, moist, silt, some sand, little gravel, occasional cobbles;
- Olive, wet, silty sand, little gravel, occasional cobbles;
- Grey, wet, sandy silt, little to some gravel, occasional cobbles; and
- Grey, moist, sand, some silt, little gravel, little clay.

Cobbles and boulders were encountered in the glacial till in BB-KING-101A between approximately 16.5 to 17.7 feet bgs and approximately 18 to 18.5 feet bgs. Cobbles were also encountered in BB-KING-102 from approximately 12.1 to 12.9 feet bgs, approximately 16.2 to 17.0 feet bgs and approximately 21.5 to 21.8 feet bgs.

SPT N-values ranged from 39 to 176 bpf in the cohesionless glacial till layers, indicating the soil is dense to very dense. SPT N-values in the silty till deposits ranged from 19 to 134 bpf indicated the deposit is very stiff to hard in consistency.

Three (3) grain size analyses conducted indicate that the glacial till is classified as A-4 by the AASHTO Classification System and ML, SC-SM and SM by the Unified Soil Classification System. The measured water contents of samples tested ranged from approximately 8 to 11 percent.

5.3 Groundwater

Groundwater was observed in boring BB-KING-101A at a depth of approximately 6.5 feet bgs. The water level is indicated on the boring log in Appendix A found at the end of this report. Note that water was introduced into the borehole during drilling operations. It is likely that the water level measured does not represent stabilized groundwater conditions. Groundwater levels will fluctuate with seasonal changes, precipitation, runoff, river levels and construction activities.

6.0 FOUNDATION ALTERNATIVES

Box culverts with several hydraulic openings were considered for replacement of the existing twin pipes. A precast box with a 20-foot span and a 6-foot rise was found to meet the site hydraulic conditions as well as fish passage width recommendations and was the selected alternative. A 6-foot rise avoids raising the roadway elevation while still allowing for 2 feet of fill below the roadway. The length of the box will be approximately 80 feet with a 24 degree skew to improve alignment with the stream.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

7.1 Precast Concrete Box Culvert Design and Construction

The proposed replacement structure will consist of a 20-foot span by 6-foot rise precast concrete box culvert. The proposed box culvert will have 1-foot tall precast headwalls with slope-tapered, flared inlet and outlet walls. Sideslopes will be repaired to 2H:1V side slopes. The box will be embedded approximately 2 feet into the streambed and 2 feet of special fill will be placed inside the bottom of the culvert to create a natural streambed. The fill soils will be retained in the box with sediment traps placed at 8-foot spacing.

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.

Precast concrete box culverts are typically detailed on the contract plans with only basic layout and required hydraulic opening. The manufacturer selected by the Contractor is responsible for the design of the structure including determination of wall thickness, haunch thickness and reinforcement in accordance with Special Provision 534 - Precast Concrete Arches, Box Culverts, Frames which is included in Appendix D of this report. The loading specified for the structure should be Modified HL-93 Strength 1 in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The design 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: $\phi = 32°$, $\gamma = 125$ pcf.

The precast concrete box culvert will be supplier-designed in accordance with AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD). 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 envelope 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 thick loose measure and compacted 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 Headwalls

Concrete headwalls will be included in the culvert design to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. Nominal 1 foot by 1 foot concrete headwalls are recommended.

7.3 Precast Concrete Flared Inlet and Outlet Walls and Toe Walls

The box culvert's inlet and outlet will be slope-tapered to match the 2:1 sideslopes. The inlet and outlets will also be flared out approximated at a 4:1 taper ratio to approximately twice the bankfull width. 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 C – 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 glacial till soils at the anticipated foundation elevation for the precast box are hard to very dense in consistency. These soils are characterized as having adequate bearing resistance.

For a precast box culvert with a base width of 22 feet, the factoring bearing stress at the strength limit state shall not exceed the calculated factored bearing resistance at the strength limit state of 10.6 kips per square foot (ksf). To control settlement, the factored bearing stress at the service limit state shall not exceed the calculated, factored bearing resistance of 6 ksf. The strength limit state bearing resistance may govern the design. In no instance shall be bearing stress exceed the nominal structural resistance of the structural concrete which may be taken as 0.3*f'c*. See Appendix C – Calculations for supporting calculations.

7.5 Settlement

No settlement issues are anticipated at the location of the replacement culvert. The glacial till deposit at the anticipated foundation elevation for the precast box culvert is dense in consistency. The soils are heavily preconsolidated and are not expected to consolidate, even if a load greater that the existing overburden pressure is applied. There is no plan to change the horizontal alignment or vertical profile from the existing.

The soil envelope and backfill for the precast box 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 thick loose measure and compacted to the manufacturer's specifications. To control future settlement, the envelope and backfill soil shall be compacted to no less than 92 percent of the AASHTO T-180 maximum dry density. Remove any cobbles or boulders (in excess of 6 inches) encountered at the bearing elevation and replace with compacted granular borrow or ¾ inch stone.

7.6 Frost Protection

Foundations placed on the native soils should be designed with an appropriate embedment for frost protection. According to BDG Figure 5-1, Maine Design Freezing Index Map, Kingsbury Plantation has a design freezing index (DFI) of approximately 2100 F-degree days. Based on soil laboratory test results, a water content of 10% was used for coarse-grained soils at the potential elevation of a precast box foundation. These components correlate to a frost depth of 8.1 feet. A similar analysis was performed using Modberg software by the US Army Cold Regions Research and Engineering Laboratory (CRREL). For the Modberg analysis, Kingsbury Plantation was assigned a DFI from the database of approximately 2048 F-degree days for Millinocket which lies on a DFI contour similar to Kingsbury Plantation. A water content of 10% was used. These components correlate to a frost depth of approximately 7.2 feet.

We recommend that foundations be designed with a minimum embedment of 7.2 feet for frost protection. See Appendix C – Calculations for supporting calculations.

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

7.7 Scour and Riprap

The box culvert shall be constructed with integral concrete headwalls and wingwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. Inlet and outlet toe walls shall be provided that extend a minimum of 1-foot 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 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 culvert.

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 proposed box culvert will be bedded on a 1-foot thick layer of granular borrow. Based on the soils encountered in the borings, dense granular glacial till and a stiff, fine-grained silty till will be encountered at this elevation. The Contractor shall minimize disturbance to the silty till soils and all subgrade surfaces should be protected from any unnecessary construction traffic.

Earthwork and excavations will result in the exposure of silty glacial till soils. The silty till may be susceptible to disturbance and rutting as a result of exposure to water or construction traffic. If disturbance and rutting occur, we recommend that the Contractor remove and replace the disturbed materials with ¾-inch stone or compacted MaineDOT Standard Specification 703.20, Gravel Borrow. Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow

Staged construction will require temporary earth support systems. Cobbles and boulders were encountered in the explorations and these obstructions may impede driving sheet piles that may be required for temporary earth support. Cobbles and boulders in the excavation shall be removed and replaced with compacted gravel borrow or ¾-inch stone.

The silty glacial till has a significant percentage of fine material passing the #200 sieve. These soils may become saturated and water seepage may be encountered during construction and in excavations. There may be localized sloughing and instability in some excavations and cut slopes. The Contractor should control groundwater, surface water infiltration using temporary ditches, sump pumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water.

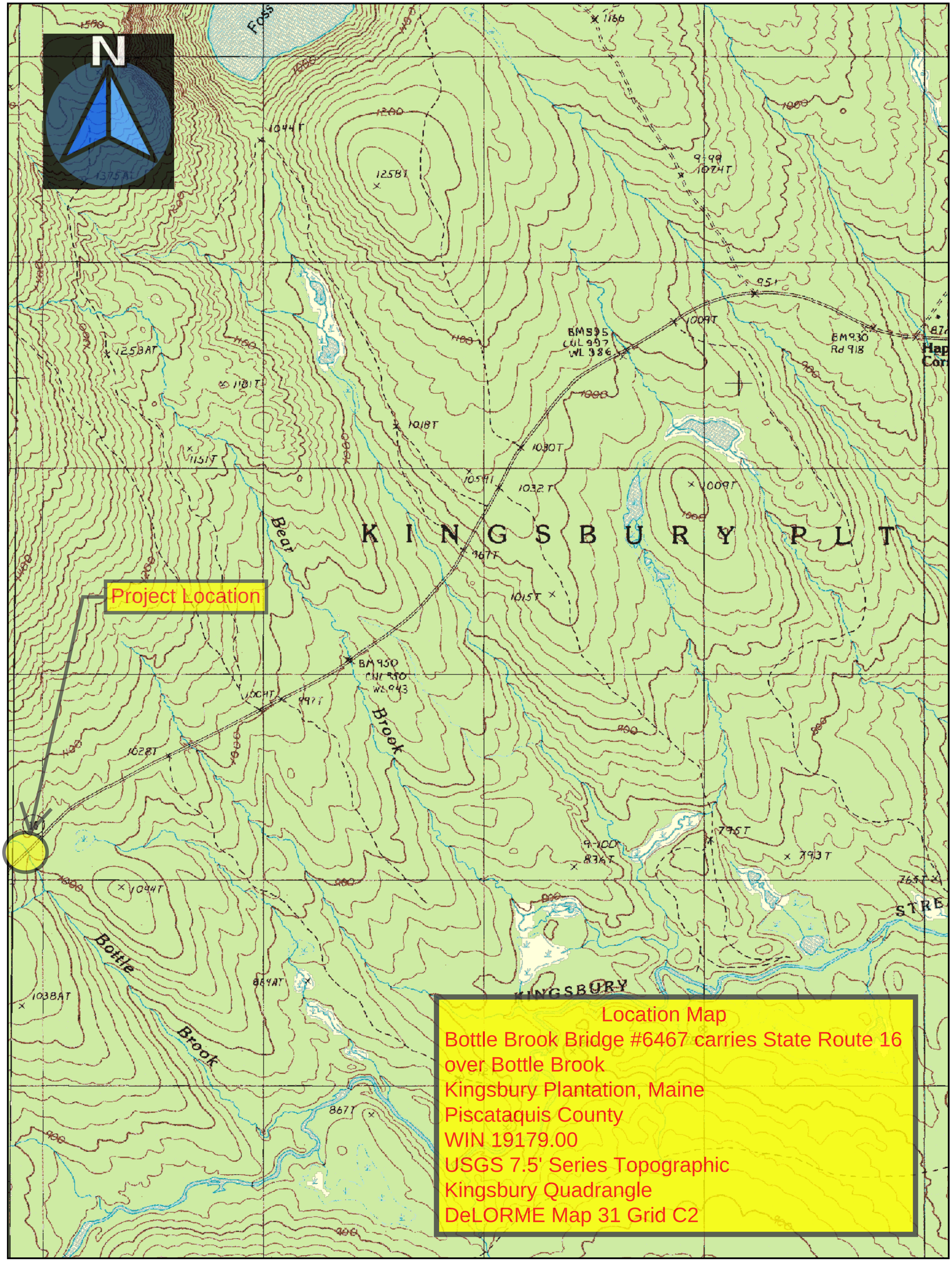
8.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed construction of Bottle Brook Bridge on State Route 16 in Kingsbury Plantation, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is implied.

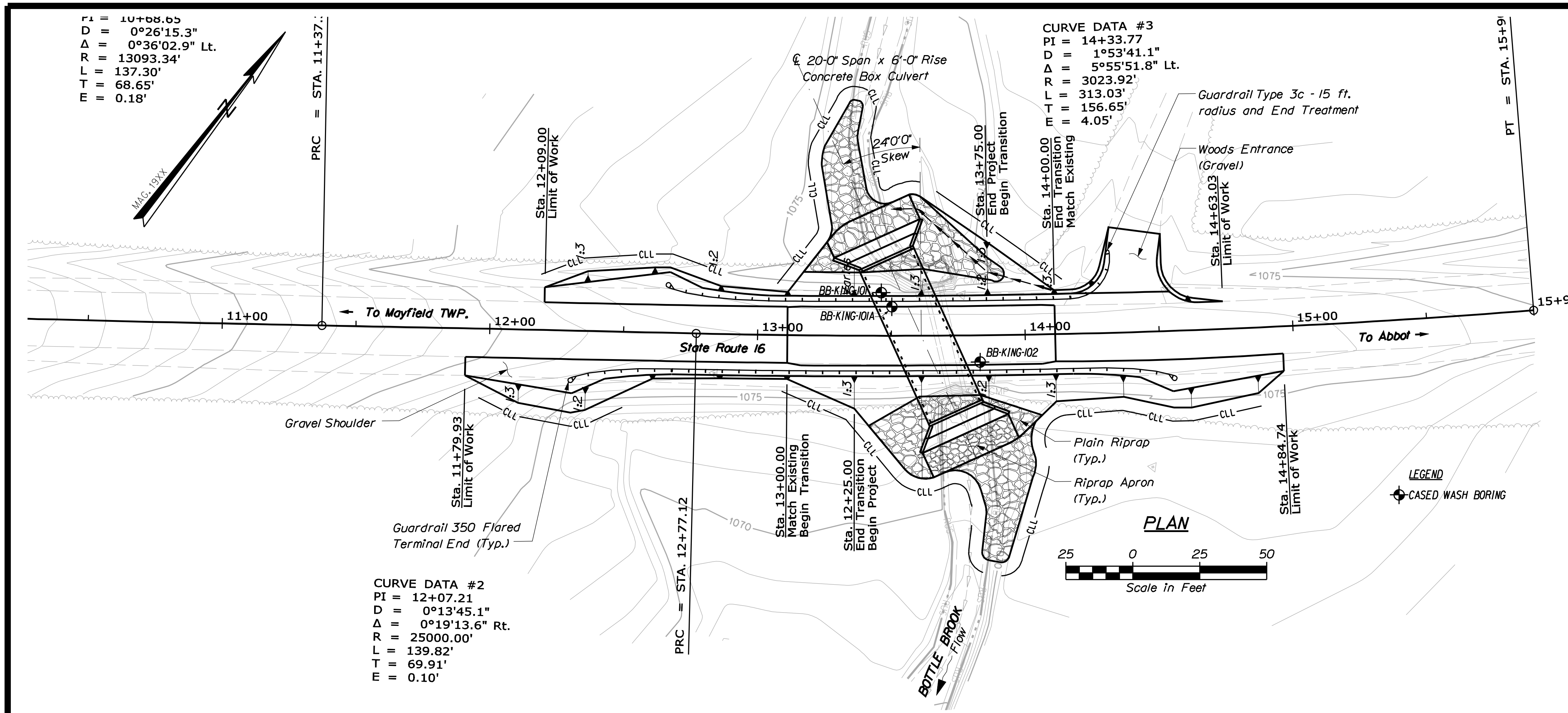
In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes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

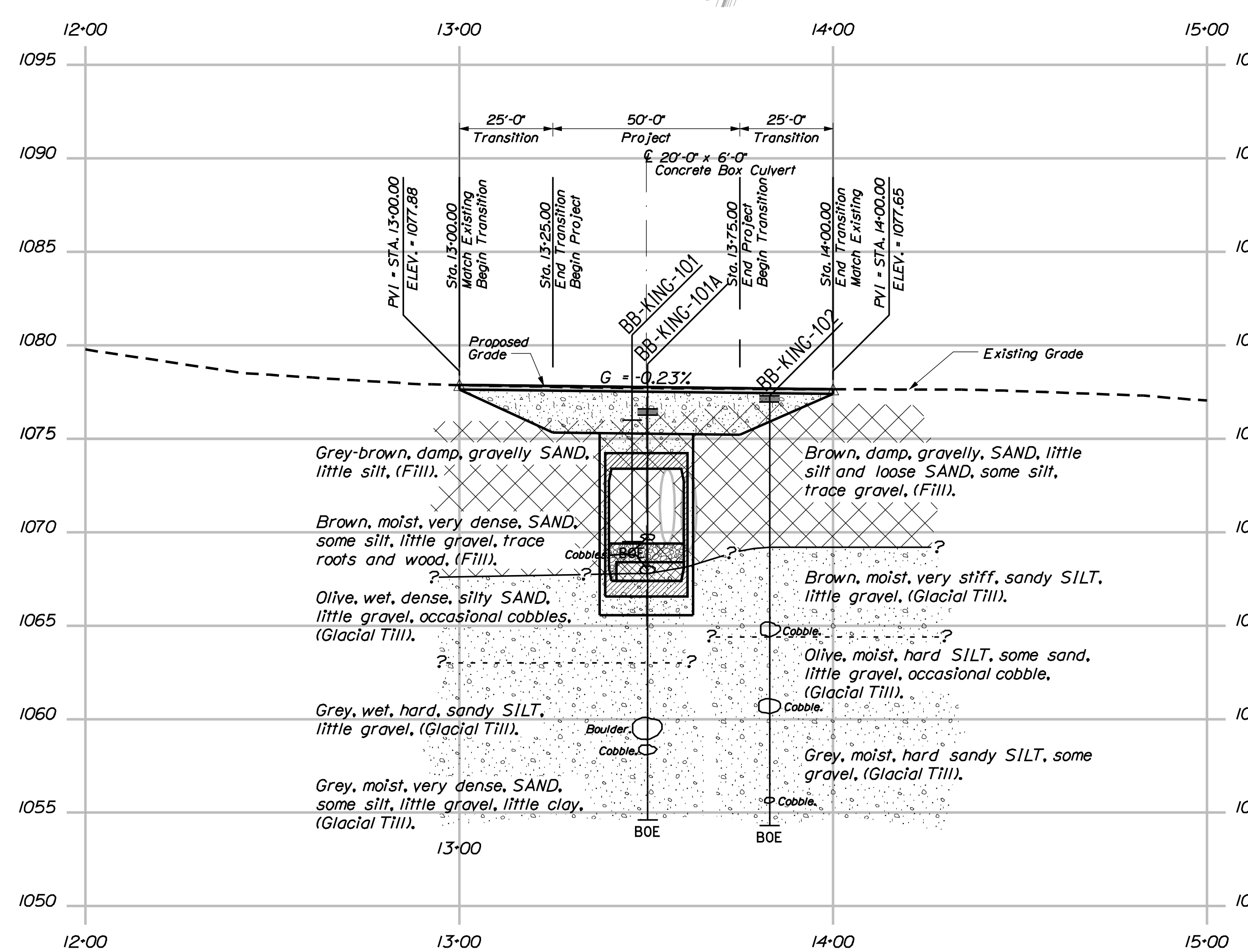
We also recommend that we be provided the opportunity for a general review of the final design and specifications in order that the earthwork and foundation recommendations may be properly interpreted and implemented in the design.

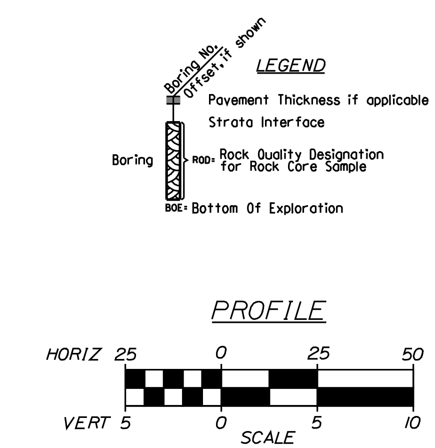
Sheets



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

19179.00

BRIDGE PLANS
WIN 19179.00
BRIDGE NO. 6467

PROJ. MANAGER	S. Bodge		
DESIGN-DETAILED	J. Buck	D. Sullivan	
CHECKED-REVIEWED	L. KRUSINSKI	T. WHITE	JAN 2014
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

BY DATE SIGNATURE P.E. NUMBER DATE

BOTTLE BROOK BRIDGE
BOTTLE BROOK
KINGSBURY PISCATAQUIS COUNTY
BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
2
OF 3

Filename: ...\GEOTECH\MSTA\006_BLP&ISP1.dgn Division: GEOTECH Username: terry.white Date:1/14/2014

Filename: ...\msta\007_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:1/14/2014

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bottle Brook Bridge, #6467	Location: Kingsbury Plt, Maine	Boring No.: BB-KING-101	WIN: 19179.00
Driller: MaineDOT	Elevation (ft.) 1076.0	Auger ID/OD: 5" Solid Stem	
Operator: Giles/Daggett	Datum: NAVD88	Sampler: N/A	
Logged By: B. Wilder	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"	
Date Start/Finish: 8/19/2013; 07:00-07:30	Drilling Method: Cased Wash Boring	Core Barrel: N/A	
Boring Location: 13+46.2, 16.1 ft Lt.	Casing ID/OD: HW	Water Level*: None Observed	
Hammer Efficiency Factor:	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	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA			No descriptions given.	
6.50								1069.50		Bottom of Exploration at 6.50 feet below ground surface. Bent HW Casing, moved to BB-KING-101A.	

Remarks:

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

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

Page 1 of 1

Boring No.: BB-KING-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bottle Brook Bridge, #6467	Location: Kingsbury Plt, Maine	Boring No.: BB-KING-101A	WIN: 19179.00
Driller: MaineDOT	Elevation (ft.) 1076.6	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: 8/19/2013; 07:30-14:00	Drilling Method: Cased Wash Boring	Core Barrel: N/A	
Boring Location: 13+50.4, 10.8 ft Lt.	Casing ID/OD: HW	Water Level*: 6.5 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	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	1076.27		4" PAVEMENT. (0.33)	
	S1		1.50 - 3.50							Grey-brown, damp, gravelly, fine to coarse SAND, little silt, (Fill).	
5	1D	24/13	5.00 - 7.00	10/36/17/53	53	77				Brown, moist, very dense, fine to coarse SAND, some silt, little gravel, trace roots and wood fragments, (Fill). Cobble from 6.7-7.0 ft bgs. Cobble from 8.4-8.8 ft bgs.	G#243301 A-1-b, SM WC=11.9%
9.00								1067.60			
10	2D	24/16	10.00 - 12.00	3/11/16/16	27	39	51			Olive, wet, dense, silty, fine to coarse SAND, little gravel, occasional cobbles, (Glacial Till).	
							81				
							101				
13.50							189	1063.10			
							OPEN HOLE				
15	3D	18/12	15.00 - 16.50	12/19/50	69	100				Grey, wet, hard, sandy SILT, little gravel, occasional cobbles, (Glacial Till). Roller Coned ahead to 20.0 ft bgs. Boulder from 16.5-17.7 ft bgs. Cobble from 18.0-18.5 ft bgs.	
20	4D	24/18	20.00 - 22.00	15/77/45/56	122	176				Grey, moist, very dense, SAND, some silt, little gravel, little clay, (Glacial Till).	G#243302 A-4, SC-SM WC=7.6%
22.00								1054.60		Bottom of Exploration at 22.00 feet below ground surface. NO REFUSAL	

Remarks:

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

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Page 1 of 1

Boring No.: BB-KING-101A

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bottle Brook Bridge, #6467	Location: Kingsbury Plt, Maine	Boring No.: BB-KING-102	WIN: 19179.00
Driller: MaineDOT	Elevation (ft.) 1077.3	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: 8/19/2013; 07:30-14:00	Drilling Method: Cased Wash Boring	Core Barrel: N/A	
Boring Location: 13+83, 10.0 ft Rt.	Casing ID/OD: HW	Water Level*: None Observed	
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	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	1076.97		4" PAVEMENT. (0.33) Brown, damp, gravelly, fine to coarse SAND, little silt, (Fill).	
5	1D	24/12	5.00 - 7.00	2/2/2/4	4	6				Brown, damp, loose, fine to coarse SAND, some silt, trace gravel, (Fill).	
8.00								1069.30			
10	2D	24/18	10.00 - 12.00	3/5/8/17	13	19	25			Brown, moist, very stiff, sandy SILT, little gravel, (Weathered Glacial Till).	G#243303 A-4, SM WC=9.0%
							56			Large Cobble from 12.1-12.9 ft bgs.	
							88				
13.00							167	1064.30			
							172				
15	3D	14.4/13	15.00 - 16.20	11/12/25(2.4")	---		OPEN HOLE			Olive, moist, hard, SILT, some fine to coarse SAND, little gravel, occasional cobbles, (Glacial Till). Roller Coned ahead to 20.0 ft bgs. Cobble from 16.2-17.0 ft bgs.	G#243304 A-4, ML WC=10.7%
20	4D	18/16	20.00 - 21.50	24/28/65	93	134				Grey, moist, hard, fine to coarse sandy SILT, some gravel, occasional cobbles, (Glacial Till). Cobble from 21.5-21.8 ft bgs. Roller Coned ahead to 23.0 ft bgs.	
23.00								1054.30		Bottom of Exploration at 23.00 feet below ground surface. NO REFUSAL	

Remarks:

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

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Page 1 of 1

Boring No.: BB-KING-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19179.00

BRIDGE NO. 6467 | WIN 19179.00 | BRIDGE PLANS

PROJ. MANAGER	S. Bodge	BY	DATE
DESIGN-DETAILED	J. Buck	D. Sullivan	------
CHECKED-REVIEWED	------	------	------
DESIGN2-DETAILED2	L.KRUSINSKI	T.WHITE	JAN 2014
DESIGN3-DETAILED3	------	------	------
REVISIONS 1	------		------
REVISIONS 2	------		------
REVISIONS 3	------		------
REVISIONS 4	------		------
FIELD CHANGES	------		------

SIGNATURE
P.E. NUMBER
DATE

BOTTLE BROOK BRIDGE
BOTTLE BROOK
KINGSBURY   PISCATAQUIS 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

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
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Bottle Brook Bridge, #6467			**Boring No.:**	BB-KING-101
Location:	Kingsbury Plt, Maine			**PIN:**	19179.00
Driller:	MaineDOT	**Elevation (ft.)**	1076.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	8/19/2013; 07:00-07:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+46.2, 16.1 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**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			No descriptions given.	
5											
6.50								1069.50		**Bottom of Exploration at 6.50 feet below ground surface.** Bent HW Casing, moved to BB-KING-101A.	
10											
15											
20											
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bottle Brook Bridge, #6467
Location: Kingsbury Plt, Maine

Boring No.: BB-KING-101A
PIN: 19179.00

Driller:	MaineDOT	**Elevation (ft.)**	1076.6	**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:	8/19/2013; 07:30-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+50.4, 10.8 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	6.5 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
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WOR/C = weight of rods or casing
WO1P = Weight of one person
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T_v = Pocket Torvane Shear Strength (psf)
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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	1076.27		4" PAVEMENT. 0.33	
	S1		1.50 - 3.50							Grey-brown, damp, gravelly, fine to coarse SAND, little silt, (Fill).	
5	1D	24/13	5.00 - 7.00	10/36/17/53	53	77				Brown, moist, very dense, fine to coarse SAND, some silt, little gravel, trace roots and wood fragments, (Fill).	G#243301 A-1-b, SM WC=11.9%
										Cobble from 6.7-7.0 ft bgs.	
										Cobble from 8.4-8.8 ft bgs.	
								1067.60		9.00	
10	2D	24/16	10.00 - 12.00	3/11/16/16	27	39	51			Olive, wet, dense, silty, fine to coarse SAND, little gravel, occasional cobbles, (Glacial Till).	
							81				
							101				
							189	1063.10		13.50	
							OPEN HOLE				
15	3D	18/12	15.00 - 16.50	12/19/50	69	100				Grey, wet, hard, sandy SILT, little gravel, occasional cobbles, (Glacial Till). Roller Coned ahead to 20.0 ft bgs. Boulder from 16.5-17.7 ft bgs.	
										Cobble from 18.0-18.5 ft bgs.	
20	4D	24/18	20.00 - 22.00	15/77/45/56	122	176				Grey, moist, very dense, SAND, some silt, little gravel, little clay, (Glacial Till).	G#243302 A-4, SC-SM WC=7.6%
								1054.60		22.00 **Bottom of Exploration at 22.00 feet below ground surface.** NO REFUSAL	
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bottle Brook Bridge, #6467
Location: Kingsbury Plt, Maine
Boring No.: BB-KING-102
PIN: 19179.00

Driller:	MaineDOT	**Elevation (ft.)**	1077.3	**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:	8/19/2013; 07:30-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+83, 10.0 ft Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.867	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
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MU = Unsuccessful Thin Wall Tube Sample attempt
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SSA = Solid Stem Auger
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T_v = Pocket Torvane Shear Strength (psf)
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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.
0							SSA	1076.97		4" PAVEMENT. (0.33)	
										Brown, damp, gravelly, fine to coarse SAND, little silt, (Fill).	
5	1D	24/12	5.00 - 7.00	2/2/2/4	4	6				Brown, damp, loose, fine to coarse SAND, some silt, trace gravel, (Fill).	
								1069.30		(8.00)	
10	2D	24/18	10.00 - 12.00	3/5/8/17	13	19	25			Brown, moist, very stiff, sandy SILT, little gravel, (Weathered Glacial Till).	G#243303 A-4, SM WC=9.0%
							56				
							88			Large Cobble from 12.1-12.9 ft bgs.	
							167	1064.30		(13.00)	
							172				
15	3D	14.4/13	15.00 - 16.20	11/12/25(2.4")	---		OPEN HOLE			Olive, moist, hard, SILT, some fine to coarse SAND, little gravel, occasional cobbles, (Glacial Till). Roller Coned ahead to 20.0 ft bgs.	G#243304 A-4, ML WC=10.7%
										Cobble from 16.2-17.0 ft bgs.	
20	4D	18/16	20.00 - 21.50	24/28/65	93	134				Grey, moist, hard, fine to coarse sandy SILT, some gravel, occasional cobbles, (Glacial Till).	
										Cobble from 21.5-21.8 ft bgs. Roller Coned ahead to 23.0 ft bgs.	
								1054.30		(23.00) **Bottom of Exploration at 23.00 feet below ground surface.** NO REFUSAL	
25											

Remarks:

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

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

Appendix B

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Kingsbury Work Number: 19179.00

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-KING-101A, 1D	13+50.4	10.8 Lt.	5.0-7.0	243301	1	11.9			SM	A-1-b	II
BB-KING-101A, 4D	13+50.4	10.8 Lt.	20.0-22.0	243302	1	7.6			SC-SM	A-4	III
BB-KING-102, 2D	13+83	10.0 Rt.	10.0-12.0	243303	1	9.0			SM	A-4	III
BB-KING-102, 3D	13+83	10.0 Rt.	15.0-16.2	243304	1	10.7			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)

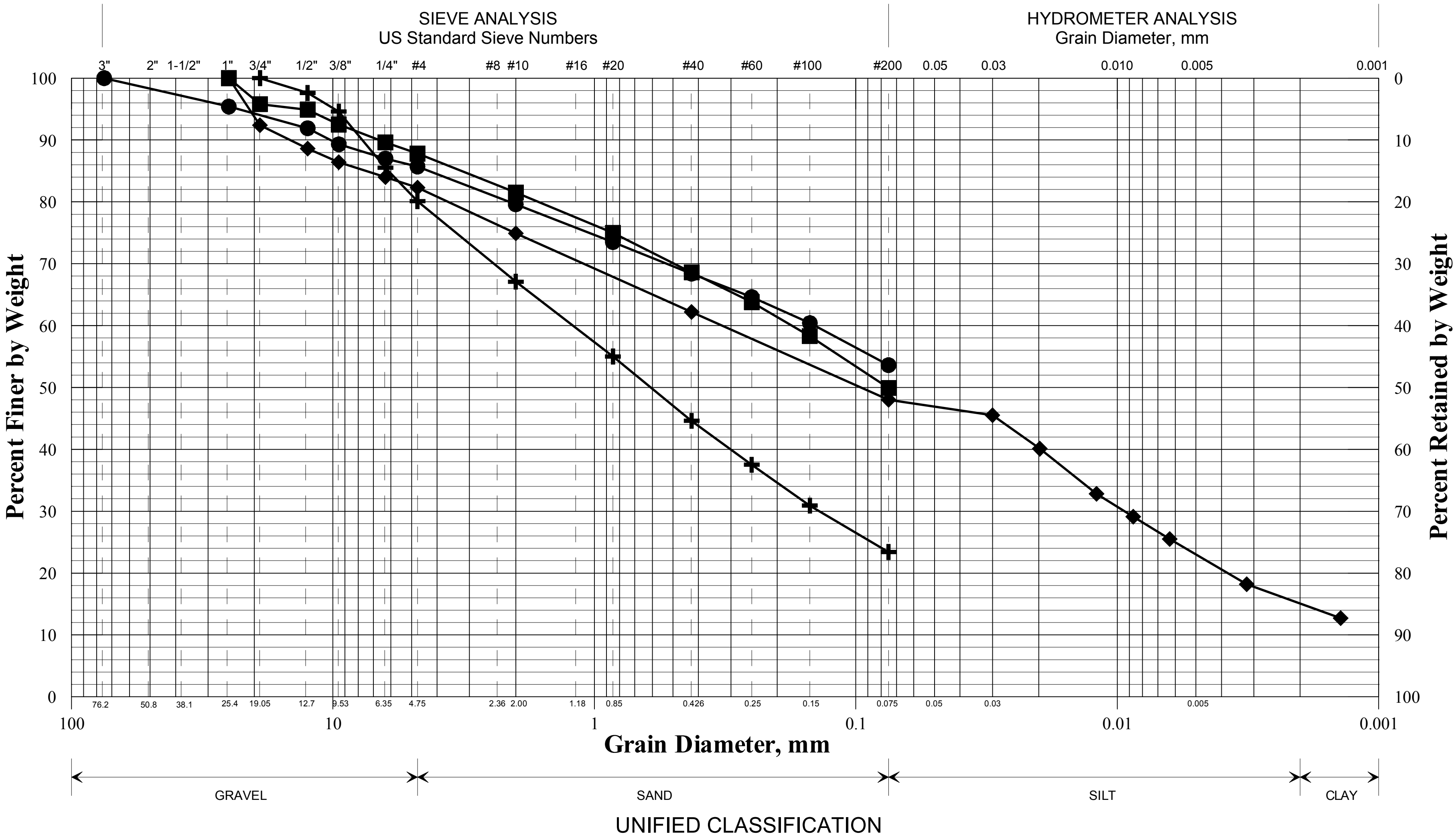
WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

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-KING-101A/1D	13+50.4	10.8 LT	5.0-7.0	SAND, some silt, little gravel.	11.9			
◆	BB-KING-101A/4D	13+50.4	10.8 LT	20.0-22.0	SAND, some silt, little gravel, little clay.	7.6			
■	BB-KING-102/2D	13+83	10.0 RT	10.0-12.0	Sandy SILT, little gravel.	9.0			
●	BB-KING-102/3D	13+83	10.0 RT	15.0+16.2	SILT, some sand, little gravel.	10.7			
▲									
✖									

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Town
Kingsbury Plt
Reported by/Date
WHITE, TERRY A 12/4/2013

SHEET 1

Appendix C

Calculations

Backfill engineering strength parameters

Soil Type 4 Properties from Bridge Design Guide (BDG)

Unit weight	$\gamma_1 := 125 \cdot \text{pcf}$
Internal friction angle	$\phi_1 := 32 \cdot \text{deg}$
Cohesion	$c_1 := 0 \cdot \text{psf}$

Active Earth Pressure

Rankine Theory

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 back face of wall.

- For cantilever walls with horizontal backslope

$$K_a := \tan\left(45 \cdot \text{deg} - \frac{\phi_1}{2}\right)^2 \qquad K_a = 0.307$$

- For a sloped backfill

β = Angle of fill slope to the horizontal (this case, 1V:2H slope)

$\beta := 26.56 \cdot \text{deg}$

$$K_{aslope} := \frac{\cos(\beta) - \sqrt{\cos(\beta)^2 - \cos(\phi_1)^2}}{\cos(\beta) + \sqrt{\cos(\beta)^2 - \cos(\phi_1)^2}} \qquad K_{aslope} = 0.517$$

β = Angle of fill slope to the horizontal (this case, 1V:1.75 slope)

$\beta := 29.75 \cdot \text{deg}$

$$K_{aslope} := \frac{\cos(\beta) - \sqrt{\cos(\beta)^2 - \cos(\phi_1)^2}}{\cos(\beta) + \sqrt{\cos(\beta)^2 - \cos(\phi_1)^2}} \qquad K_{aslope} = 0.647$$

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

At-rest Earth Pressure

Reference LRFD Article 3.11.5.2

There is no estimation of at-rest earth pressure which considers sloped backfill.

- For vertical walls with level backslope

$K_o := 1 - \sin(\phi_1)$ $K_o = 0.47$

Analysis : Bearing Resistance of Box Culvert on Dense or Stiff Glacial Till Deposit

Assumptions:

1. Box bottom is embedded 2 feet below the streambed with 2 feet of fill placed inside. Bottom of box is at approx. Elev. 1066.5 feet

2. Both fine grained and coarse grained glacial till soils at the bottom of the box. Assumed parameters for a stiff silty Glacial Till are:
Tested soil samples - A-4, ML, SM and SC-SM
Saturated unit weight = 121 pcf
Average wet unit weight = 121 pcf
ϕ = 30-35 degrees, dense Silt or sandy Silt, consolidated & drained (ref: Bowles, 5th Ed., Table 2-6)
ϕ = 30-34 degrees, Dense Silt (nonplastic) (ref: Lambe and Whitman, Table 11.3).
Su = undrained shear strength, c = 0 psf

3. Method used: Terzaghi, use strip equations since L>B

Foundation Widths and Depth

$$B := \begin{pmatrix} 16 \\ 18 \\ 20 \\ 22 \end{pmatrix} \cdot ft$$

$$D_f := 2.0 \cdot ft$$

$$D_w := 0 \cdot ft$$

$$\gamma_w := 62.4 \cdot pcf$$

Foundation soils:

Samples of the glacial till are stiff to hard silt.

$$\gamma 1_{sat} := 121 \cdot pcf$$

$$\gamma 1_d := 118 \cdot pcf$$

$$\phi := 34 \cdot deg$$

$$c := 0 \cdot psf$$

Nominal Bearing Resistance - For Service Limit State

Method: LRFD Table C10.6.2.6.1-1, Presumptive Bearing Resistance for Spread Footings at the Service Limit State, based on *NavFac DM 7.2, May 1983, Foundations and Earth Structures*, Table 1, 7.2-142, "Presumptive Values of Allowable Bearing Pressures for Spread Foundations".

Samples of the fine grained glacial till are all A-4 and ML, SC-SM or SM

Bearing Material:	Consistency in Place	Bearing Pressure Range (ksf)	AASHTO Recommended Value (ksf)
Fine to medium sand, silty or clayey medium to coarse sand, (SW, SM, SC)	medium dense to dense	4-8 ksf	5 ksf
Inorganic silt, sandy or clayey silt (ML, MH)	medium stiff to stiff	2-6 ksf	3 ksf

Glacial Till deposit is dense where cohesionless and stiff to hard where fine-grained. Recommend the upper limit of the AASHTO Recommended Range: 6 ksf, to limit settlement to 1.0 inch for Service Limit State Loads

Nominal Bearing Resistance for Strength Limit States: Terzaghi Method - ϕ and c soil.

Shape Factors for strip footing (Bowles 5th Ed., pg 220)

$s_\gamma := 1.0$ $\quad$ $s_c := 1.0$

Meyerhof Bearing Capacity Factors - (Ref: Bowles Table 4-4, 5th Ed. pg 223) for stiff, silty glacial till, ϕ = 34 degrees

$N_c := 42.14$ $\quad$ $N_q := 29.4$ $\quad$ $N_\gamma := 31.1$

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

$$q := D_f \cdot (\gamma1_{sat} - \gamma_w) - D_w \cdot (\gamma_w) \qquad q = 0.117 \cdot ksf$$

$$q_n := c \cdot N_c \cdot s_c + q \cdot N_q + 0.5 \cdot (\gamma1_{sat} - \gamma_w) \cdot B \cdot N_\gamma \cdot s_\gamma$$

$$q_n = \begin{pmatrix} 18 \\ 19.8 \\ 21.7 \\ 23.5 \end{pmatrix} \cdot ksf$$

Factored Bearing Resistance for strength limit state

Use a resistance factor per AASHTO LRFD Table 10.5.5.2.2-1

$\varphi_b := 0.45$

$q_r := q_n \cdot \varphi_b$

$q_r = \begin{pmatrix} 8.1 \\ 8.9 \\ 9.8 \\ 10.6 \end{pmatrix} \cdot ksf$ for $B = \begin{pmatrix} 16 \\ 18 \\ 20 \\ 22 \end{pmatrix} \cdot ft$

10.6 ksf for strength limit state design for a 22-foot wide precast box foundation slab.

Factored Bearing Resistance for extreme limit state

Use a resistance factor per AASHTO LRFD Table 10.5.5.2.2-1

$\varphi_b := 1.0$

$q_r := q_n \cdot \varphi_b$

$q_r = \begin{pmatrix} 18 \\ 19.8 \\ 21.7 \\ 23.5 \end{pmatrix} \cdot ksf$ **for** $B = \begin{pmatrix} 16 \\ 18 \\ 20 \\ 22 \end{pmatrix} \cdot ft$

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

From Design Freezing Index Map: **Kingsbury PLT, Maine**
DFI = 2100 degree-days.

Case 1 - both fine and coarse grained soils at footing of culvert headwalls, water contents range from 9 to 12% . Assume coarse grained and wc = 10%.

Depth of Frost Penetration =

$$d := 97.6 \cdot in \qquad d = 8.133 \cdot ft$$

Method 2 - ModBerg Software

Examine potential precast box or walls placed on coarse grained soils; use
ModBerg weather database information for Millinocket which is on a DFI contour similar to Kingsbury Plt.

```
                  ------------------------
                  --- ModBerg Results ---
                  -----------------------
Project Location: Millinocket, Maine

Air Design Freezing Index       =  2048 F-days
N-Factor                        =  0.80
Surface Design Freezing Index   =  1638 F-days
Mean Annual Temperature         =  41.4 deg F
Design Length of Freezing Season =  142 days
---------------------------------------------------------
Layer
#:Type          t    w%    d    Cf  Cu   Kf   Ku    L
---------------------------------------------------------
1-Coarse       86.3 10.0 120.0  26  32   1.7  1.5  1,728
---------------------------------------------------------

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 = 7.19 ft = 86.3 in.
*********************************************************
```

Recommendation: 7.2 feet for design of foundations constructed on soil

Appendix D

Special Provisions

SPECIAL PROVISION 534
PRECAST STRUCTURAL CONCRETE
(Precast Structural Concrete Arches, Box Culverts, Frames)

The following replaces Section 534 in the Standard Specifications in its entirety:

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

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

Structural Precast Concrete Units	712.061

New concrete mix designs and mix designs not previously approved by the Fabrication Engineer, including Self-Consolidating Concrete (SCC) mixes, 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 Plans and this Specification. If accelerated curing is to be used in production, the test specimens shall be similarly cured.

Grout, concrete patching material, and geotextiles shall be one of the products listed on the Department's list of prequalified materials, unless otherwise approved by the Department.

Bedding and backfill material shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, with the additional requirement that the maximum particle size 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 Section 100 of the Standard Specifications. The Department will review and approve the drawings in accordance with the applicable requirements of Section 100 of the Standard Specifications. Changes and revisions to the approved Working Drawings shall require further approval by the Fabrication Engineer.

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% increase in the Design Truck. (Wheel loads based on the Design Truck shall be increased 25%). In addition, if the governing load rating factor based on the HL-93 live load is equal to or less than 1.10 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 Section 2.5.2.6.2 for the top slab of box culverts and frames with clear spans 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 graphic 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, load rating if applicable and working/shop drawings for the precast structure to the Department for approval. A Licensed Professional Engineer, licensed in accordance with State of Maine laws, shall sign and seal all design calculations and drawings. Drawings shall conform with Section 105.7 - Working Drawings.

The Contractor shall submit the following items for review by the Resident 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 members.
D) Design computations (bound and indexed)
E) Load rating computations and completed load rating form (bound and indexed)
F) Shop Drawings with the following minimum details:

1) Fully dimensioned views showing the geometry of the members, including all projections, recesses, notches, openings, block outs, and keyways.
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 member.

<u>534.05 Facilities for Inspection</u> 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
QAI's office (minimum ft^2)	100
Drafting Table Surface (ft^2)	35
Drafting stools-each	1
Office Desk	1
Ergonomic Swivel Chairs	1
Folding Chairs	2
Cordless telephone	1
Answering machine	1
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
Cleaning Materials	1
Water Cooler	1

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, telephone installation, internet connection, basic monthly telephone and 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-state work and three weeks notice for out-of-state work prior to beginning production. If the production schedule changes, notify the Fabrication Engineer no less than three (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 / stressing calculations / calibration certifications	Prior to beginning work (anticipate adequate time for review by QAI)
Pre-pour 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 testing (for release)
Non-conformance reports/repair procedures	Within 24 hours of discovery
Results of compressive testing (for design strength)	Prior to stopping curing / Prior to final acceptance
Post-pour 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, testing and assure the Work is being performed in accordance with the QSM.

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 the Work is unacceptable.

534.09 Rejections Correct or replace rejected material and/or workmanship. Generate a non-conformance report (NCR); provide a copy to the QAI and forward a copy to the Fabrication Engineer for determination of corrective action.

In the event that an item fabricated under this Specification does not meet the Contract requirements but is deemed suitable for use by the Department, said item may be accepted in accordance with Section 100 of the Standard Specifications (see 106.8).

534.10 Forms and Casting Beds Construct forms to conform to 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 Plan dimensions. Inspect the bulkheads after each cast and repair or replace worn or damaged pieces.

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.

534.11 Reinforcing Steel Fabricate, package, handle, store, place, splice and repair reinforcing steel in accordance with Section 503 of the Standard Specifications.

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

The concrete cover shown on the approved Working Drawings shall be the minimum allowable cover. Use sufficient bar supports and spacers to maintain the minimum concrete cover. The bar supports and spacers shall be made of a dielectric material or other material approved by the Fabrication Engineer.

If reinforcing steel is not noted on the plans or drawings, the minimum amount of steel required shall be the area of steel equal to a grid of No. 4 bars at 18 inches in both directions, horizontally and vertically. Only one mat of steel is required for concrete thickness of 7 inches or less; two mats, one each face is required for thickness greater than 7 inches.

534.12 Voids and Inserts Voids shall be non-absorbent. The out-to-out dimensions of the voids shall be within 2% of Plan dimensions. Repair damaged voids in a manner acceptable to the Fabrication Engineer. Store, handle and place voids in a manner that prevents damage.

Accurately locate and securely anchor, securely cap and vent the voids in the form. Any portion of a void that is displaced beyond the allowable dimensional tolerances shall be cause for rejection of the slab or beam.

Open the void drains immediately upon removing the product from the form.

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 Qualified Products List. 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/C 1611M-05-Standard Test Method for Slump Flow of Self-Consolidating Concrete

Test the first two loads of concrete for temperature, air entrainment and slump, or spread for 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 cylinders are acceptable, the frequency of testing shall be at the discretion of the QAI.

Test the concrete for temperature, air entrainment and slump, or spread 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 spread 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 alone. 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. 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 HRWR 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

<u>534.14 Process Control Test Cylinders</u> Make concrete test cylinders for each day’s casting. Cylinders tested to determine stripping strength and early design strength shall be field cured in accordance with AASHTO T23 (ASTM C 31). 28 day cylinders shall be standard cured. Record unit identification, entrained air content, water-cement ratio, slump and temperature of the sampled concrete at the time of cylinder casting. Once a week, make four cylinders for use by the Department. They shall be standard cured in accordance with AASHTO T23 (ASTM C 31).

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, neither cylinder shall have a compressive strength less than 90% of design strength.

Perform compressive 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 The cover of concrete over the outside circumferential reinforcement shall be 2 inches minimum. The concrete cover over the inside reinforcement shall be 1 ½ 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 sections. 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 section 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 be not more than 3 inches from the ends of the sections.

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.

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 or deformed steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches or more than 4 inches. For the wire fabric, the spacing center to center of the longitudinal wires shall not be more than 8 inches. The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall not be more than 15 inches.

The members shall be free of fractures. The ends of the members shall be normal to the walls and centerline of the section, within the limits of variation provided, except where beveled ends are specified. The surfaces of the members 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 members with a smooth interior surface.

Defects which may cause rejection of precast units include the following:

1) Any discontinuity (crack or rock pocket etc.) of the concrete which could allow moisture to reach the reinforcing steel.
2) Rock pockets or honeycomb over 6 square inches in area or over 1 inch deep.
3) Edge or corner breakage exceeding 12 inches in length or 1 inch in depth.
4) Extensive fine hair cracks or checks.
5) Any other defect that clearly and substantially impacts the quality, durability, or maintainability of the structure as measured by accepted industry standards.

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

Documentation The producer of the structural precast 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 applicable reference specification or the established industry standards for the product being produced. The internal dimensions shall not vary by more than 1 percent from the design dimensions or 1 ½ inches, whichever is less with the exception of the cross diagonal dimension which shall not vary by more than ½ inch from the design dimension. The haunch dimensions shall not vary by more than ¾ inch from the design dimension. The dimension of the legs shall not vary by more than ¼ inch from the dimension shown on the approved shop drawings.

The slab and wall thickness shall not be less than the design thickness by more than ¼ inch. A thickness greater than the design thickness shall not be cause for rejection.

Variations in laying lengths of two opposite surfaces shall not be more than ⅝ inch in any section, except where beveled ends for laying of curves are specified.

The under-run in length of any section shall not be more than ½ in.

534.17 Finishing Concrete Products shall meet ordinary finish requirements per subsection 502.14. Fascia members shall receive a rubbed finish per subsection 502.14. The Contractor may use alternative methods of achieving an acceptable finish on fascia members 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.

543.18 Repairing 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. Units that are cracked or require surface repairs larger than 2 in^2 or an accumulated repair area greater than 10% of the surface being repaired may be rejected.

Repair honeycombing, ragged or irregular edges and other cosmetic defects using a patching material from the MaineDOT Qualified Products List. 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 ½ inch. Remove form ties and other hardware to a depth of not less than 1 inch from the face of the concrete and patch the holes using a patching material from the MaineDOT Qualified Products List.

Repair structural defects only with the approval of the Fabrication Engineer. Submit a non-conformance report (NCR) to the Fabrication Engineer with a proposed repair procedure. Do not perform structural repairs without an approved NCR. 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 structural repairs.

<u>534.19 Handling, Storage and Transportation</u> Handle store and transport members 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 members in an upright position until a compressive strength of at least 4350 psi is attained. Precast products a may be handled and moved, but do not transport products until the 28 day design strength has been attained.

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

<u>534.20 Installation of Precast Units</u> Do not ship precast members until sufficient strength has been attained to withstand shipping, handling and erection stresses without cracking, deformation, or spalling. A minimum strength of 4350 psi shall be attained prior to shipping in all cases.

Set precast members on ½ inch neoprene pads during shipment to prevent damage to the section legs. The Contractor shall repair any damage to precast members resulting from shipping or handling by saw cutting a minimum of ½ inch deep around the perimeter of the damaged area and placing a polymer-modified cementitious patching material.

When footings are required, install the precast members on concrete footings that have reached a compressive strength of at least 2900 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 ¼ inch in 10 feet. The footing keyway shall be filled with a non-shrink flowable cementitious grout with a design compressive strength of at least 5000 psi.

Box culvert joints shall be sealed with an approved flexible joint sealant in accordance AASHTO M 198 (ASTM C 990). Joints shall be closed tight to within 0.625 inches ±0.125 inch. Culvert sections shall be equipped with joint closure mechanisms to draw sections together and close joints to the required opening.

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. Completely fill the exterior face of joints between precast members with an approved material 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 member 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.

Place and compact the bedding material as shown on the plans prior to lifting and setting the culvert sections. Backfill the structure 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 5 feet of the precast structure as well as over the top until it is covered with at least 12 inches of backfill. The Contractor shall take adequate precautions to protect the top of the culvert from damage during backfilling and/or paving operations. Any damage to the top of the culvert shall be repaired or members replaced at no cost to the Department.

<u>534.21 Method of Measurement</u> The Department will measure Precast Structural Concrete Arch, Box Culvert or three sided Frames for payment per Lump Sum each, complete in place and accepted.

<u>534.22 Basis of Payment</u> The Department will pay for the accepted quantity of Precast Structural Concrete Arch (Including Frames) or Precast Concrete Box Culvert at the Contract Lump Sum price, such payment being full compensation for all labor, equipment, materials, professional services, and incidentals for 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 is 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.

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