MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

STEEP FALLS BRIDGE
OVER SACO RIVER
STATE ROUTE 11
LIMINGTON AND STANDISH, MAINE

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GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of Steep Falls Bridge which carries State Route 11 over the Saco River on the Limington-Standish town line. The proposed bridge superstructure will be a 190 foot long single span, steel girder superstructure founded on cast-in-place, cantilever, reinforced concrete abutments on spread footings on bedrock. The following design recommendations are discussed in detail in the attached report:

General - Spread Footings on Bedrock- The proposed abutments will be founded on spread footings on bedrock or concrete seals constructed on bedrock, if needed. The abutments will be constructed in moderately shallow excavations possibly requiring cofferdams and temporary support systems. Suitable bedrock with a minimum RQD of 67 percent will be likely encountered at the bedrock surface. The bedrock surface shall be cleared of all weathered, loose and potentially erodible or scourable rock prior to construction.

Abutment and Wingwall Design - Abutments and wingwalls shall be designed for all applicable load combinations and shall be designed for all relevant strength, extreme and service limit states. The design of project abutments and wingwalls founded on spread footings at the strength limit state shall consider bearing resistance, eccentricity (overturning), failure by sliding and reinforced concrete structural failure. Extreme limit state design checks for abutments shall include bearing resistance, eccentricity, failure by sliding and structural failure with respect to extreme event load combinations relating to certain hydraulic events and ice. Additional lateral earth pressure due to construction surcharge or live load surcharge is required. Abutment and wingwall designs shall include a drainage system to intercept any groundwater. Anchorage of footings to seals or of seals to bedrock may be required by the MaineDOT Bridge Design Guide.

Bedrock Removal - Construction activities should not be permitted to disturb the bedrock mass or to create any rock falls or any open fissures. Any irregularities in the existing bedrock surface or irregularities created during the excavation process should be backfilled with unreinforced concrete to the bearing elevation. Footings may be stepped for varying depths to bedrock along the centerline of bearing. The bottom of footing elevation may vary based on the presence of fractured bedrock. The bedrock surface shall be cleared of all loose fractured bedrock, loose decomposed bedrock and soil. The bedrock surface slope shall be less than 4 horizontal to 1 vertical (4H:1V) or it shall be benched in level steps or excavated to be completely level. Anchors or dowels may also be designed and employed to improve sliding resistance where the prepared bedrock surface is steeper than 4H:1V in any direction. For footings or seals constructed in the dry, the final bearing surface shall be washed with high pressure water and air prior to concrete being placed for the footing.

Bearing Resistance – When analyzing the service limit state load combination, a factored bearing resistance of 20 ksf may be used and for preliminary footing sizing, and to control settlements. The bearing resistance for abutment and wingwall foundations founded on competent, sound bedrock shall be investigated at the strength limit state using factored loads

and a factored bearing resistance of 34 ksf. For extreme limit state load combinations a factored bearing resistance of 60 ksf may be used for gravity and semi-gravity abutments and 75 ksf may be used for cantilever type abutments.

Cast-in-place Cantilever Type Retaining Wall – A cast-in-place, cantilever type retaining wall founded on bedrock is proposed at the northeast corner of Abutment No. 2. The design of the retaining wall founded on a spread footing on bedrock at the strength limit state shall consider nominal bearing resistance, overturning (eccentricity), lateral sliding and structural failure. Strength limit state design shall also consider foundation resistance after scour due to the design flood. The cast-in-place retaining wall shall be designed as unrestrained meaning free to rotate at the top in an active state of earth pressure. Bearing resistance for the proposed cast-in-place retaining wall founded on bedrock shall be investigated at the service limit state using factored loads and a factored bearing resistance of 20 ksf. The bearing resistance for cast-in-place retaining wall foundations founded on competent, sound bedrock shall be investigated at the strength limit state using factored loads and a factored bearing resistance of 34 ksf. For extreme limit state load combinations a factored bearing resistance of 60 ksf may be used for gravity and semi-gravity walls and 75 ksf may be used for cantilever type walls.

Scour and Riprap - The consequences of changes in foundation conditions resulting from the design flood for scour shall be considered for any foundation constructed on granular soils at the strength and service limit states. These changes in foundation conditions shall be investigated at the abutments and wingwalls should they be designed to bear on soil. For scour protection, any footings for wingwalls, which are constructed on granular deposits, should be embedded a minimum of 3 feet below the design scour depth and armored with 3 feet of riprap. Bridge approach slopes, slopes at wingwalls and slopes at the toes of any footings on granular soils shall be armored with 3 feet of riprap. Stone riprap shall be placed at a maximum slope of 1.75H:1V. The toe of the riprap section shall be constructed 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material and Class “1” Erosion Control Geotextile.

Settlement - The proposed approach embankments at the bridge approaches will be constructed on granular soils. Placement of the necessary fill will result in negligible densification of the underlying soils and minimal settlement of the embankments. Any settlement will occur during and immediately after construction of the widened embankments. Post-construction settlement will be minimal. Any settlement of bridge abutments will be due to elastic compression of the bedrock mass, and is anticipated to be less than 0.5 inch.

Frost Protection - It is anticipated that the abutment and wingwall spread footings will be founded directly on bedrock. For foundations on bedrock, heave due to frost is not a design issue and no requirements for minimum depth of embedment are necessary. Any foundation placed on granular soils should be founded a minimum of 6.0 feet below finished exterior grade for frost protection.

Seismic Design Considerations - Seismic analysis is not required for single-span bridges regardless of seismic zone. Steep Falls Bridge is not on the National Highway System. The bridge is not classified as a major structure. These criteria eliminate the MaineDOT requirement to design the foundations for seismic earth loads. However, superstructure connections and minimum support length requirements shall be designed per AASHTO LRFD Bridge Design Specifications 6th Edition 2012.

Construction Considerations - Construction activities may include construction of cofferdams and earth support systems to support the approach fills and control stream flow during construction of seals and footings for abutments and wingwalls. Construction activities will also include common earth and rock excavation and structural earth and rock excavation for major structures.

The nature, slope and degree of fracturing in the bedrock bearing surfaces will not be evident until the foundation excavations are made. The bedrock surface shall be cleared of all loose fractured bedrock, loose decomposed bedrock and soil. The final bearing surface shall be solid. The bedrock surface slope shall be less than 4 horizontal to 1 vertical (4H:1V) or it shall be benched in level steps or excavated to be completely level. Anchoring, doweling or other means of improving sliding resistance may also be employed where the prepared bedrock surface is steeper than 4H:1V in any direction.

Where foundations are constructed in the dry, the final bearing surface shall be washed with high pressure water and air prior to concrete being placed for the footing. In-the-dry or underwater excavation of highly sloped and loose fractured bedrock material may be done using conventional excavation methods, but may require drilling and blasting techniques. Blasting should be conducted in accordance with Section 105.2.6 of the MaineDOT Standard Specifications. It is also recommended that the contractor conduct pre-and post-blast surveys, as well as blast vibration monitoring at nearby residences and bridge structures in accordance with industry standards at the time of the blast.

The cleanliness and condition of the bedrock surface shall be approved by the Resident prior to placement of the footing concrete or seal concrete.

1.0 INTRODUCTION

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of Steep Falls Bridge which carries State Route 11 over the Saco River on the Limington-Standish town line. This report presents the soils information obtained at the site during the subsurface investigation, foundation recommendations and geotechnical design parameters for bridge replacement.

The existing Steep Falls Bridge was built in 1936 and is an approximately 220 foot long, single span riveted steel through truss founded on reinforced concrete abutments founded on spread footings on bedrock. Year 2010 Maine Department of Transportation (MaineDOT) Bridge Maintenance inspection reports assign the existing substructures a condition rating of 4 – poor with a Bridge Sufficiency Rating of 44.1. The Inspection Notes state that the bridge is in poor condition with heavy rusting and section loss. The abutments have spalling and exposed rebar in the bearing areas and cracking with efflorescence throughout the wingwalls.

The proposed bridge will be a single span, steel plate girder superstructure founded on cast-in-place reinforced concrete abutments on spread footings on bedrock or concrete seals, if needed. The proposed bridge will have a span length of approximately 190 feet on the existing alignment. Proposed Abutment No. 1 will be constructed in front of the existing Abutment No. 1 and proposed Abutment No. 2 will be constructed at the location of existing Abutment No. 2 resulting in a shorten bridge span. The vertical alignment will be raised at the north abutment and lowered at the south abutment in order to improve sight distance and provide a positive grade across the bridge.

2.0 GEOLOGIC SETTING

The Steep Falls Bridge on State Route 11 at the Limington-Standish town line crosses the Saco River 0.4 miles south of the junction with State Route 113 as shown on Sheet 1 - Location Map presented at the end of this report. The Saco River flows southeast into Casco Bay at Saco, Maine.

According to the Steep Falls Quadrangle, Maine Surficial Geologic map published by the Maine Geological Survey Open File No. 02-231 (1999) the surficial soils in the vicinity of the site consist of stream terrace deposits. These deposits generally consist of sand and gravel and erosion surfaces on former flood plains of the Saco River and were formed when the river flowed at higher levels than present.

According to Maine Geologic Survey map titled the Bedrock Geology of Portland 1:100,000 Quadrangle, Maine and New Hampshire Open-File No. 98-1 (1998) the bedrock at the site is part of the Sebago Lake Sequence specifically the Steep Falls Formation. The bedrock is identified as quartz-feldspar-biotite granofels interlayered with variable proportions of diopside calc-silicate granofels and thin muscovite schist layers.

3.0 SUBSURFACE INVESTIGATION

Subsurface conditions at the site were explored by drilling six (6) test borings at the site. Test borings BB-LSSR-101 and BB-LSSR-102 were drilled through the existing bridge deck at the location of the proposed south abutment (Abutment No. 1). Test borings BB-LSSR-103, BB-LSSR-104A and BB-LSSR-104 were drilled near the location of the proposed north abutment (Abutment No. 2). Test boring BB-LSSR-105 was drilled near the location of a proposed retaining wall to the east of proposed Abutment No. 2. Boring BB-LSSR-104A encountered a shallow refusal surface and was abandoned. These boring locations are shown in Sheet 2 - Boring Location Plan found at the end of this report. The borings were drilled between September 12 and 19, 2013 by the MaineDOT Materials Testing and Exploration drill crew using a trailer mounted drill rig. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A - Boring Logs and graphically on Sheet 3 - Interpretive Subsurface Profile found at the end of this report.

All the borings were drilled using solid stem auger and cased wash boring techniques. Soil samples were obtained, where possible, 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 standard penetration resistance, N-value, is the sum of the blows for the second and third intervals. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated in July of 2013 and was found to deliver approximately 44.5 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values computed by applying the corresponding average energy transfer factor of 0.867 to the raw field N-values. The hammer efficiency factor (0.867) and both the raw field N-values and the corrected N-values are shown on the boring logs.

Where possible the borings were advanced to bedrock and were terminated with bedrock cores. The bedrock was cored using an NQ-2" core barrel and the Rock Quality Designation (RQD) of the core was calculated. The MaineDOT Geotechnical Team member selected the boring locations and drilling methods, designated type and depth of sampling techniques, and identified field and laboratory testing requirements. The MaineDOT Subsurface Inspector certified by the Northeast Transportation Technical Certification Program (NETTCP) and a consultant geotechnical engineer logged the subsurface conditions encountered at the borings. The borings were located in the field by a MaineDOT survey crew after completion of the drilling program.

Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A – Boring Logs and on Sheet 4 – Boring Logs found at the end of this report.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected samples recovered from 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 twelve (12) standard washed grain size analyses with natural moisture content. The tests were performed in the MaineDOT Materials and Testing Laboratory in Bangor, Maine. The results of this laboratory testing are provided in Appendix B - Laboratory Data at the end of this report. Moisture content information is also shown on the Boring Logs in Appendix A and on Sheet 4 - Boring Logs found at the end of this report.

5.0 SUBSURFACE CONDITIONS

The general soil stratigraphy encountered at proposed Abutment No. 1 consisted of a thin layer of sand overlying bedrock. The general soil stratigraphy encountered at proposed Abutment No. 2 consisted of fill materials overlying bedrock. An interpretive subsurface profile depicting the detailed soil stratigraphy across the site is show on Sheet 3 - Interpretive Subsurface Profile found at the end of this report. A brief summary description of the strata encountered is as follows:

5.1 Abutment No. 1

A thin layer of native sand was encountered overlying bedrock in borings BB-LSSR-101 and BB-LSSR-102. The native sand was made up of brown, damp to moist, fine to coarse sand with trace to some gravel, trace silt and trace wood. One corrected SPT N-value in the native sand layer was 13 blows per foot (bpf) indicating that the soil is medium dense in consistency. Two (2) water contents from samples obtained within the native sand were approximately 9%. Two (2) grain size analyses conducted on samples of native sand indicated that the soil is classified as an A-1-a or A-1-b under the AASHTO Soil Classification System and as an SW-SM under the Unified Soil Classification System. Laboratory test results can be found in Appendix B - Laboratory Data.

5.2 Abutment No. 2

A series of fill materials were encountered overlying bedrock in borings BB-LSSR-103, BB-LSSR-104A and BB-LSSR-104. Boring BB-LSSR-104A encountered a shallow refusal surface and was abandoned. The fill materials consisted of sand fill, boulder/rubble fill and concrete.

The sand and gravel fill materials ranged from approximately 15.8 feet thick in boring BB-LSSR-103 to approximately 21.7 feet thick in boring BB-LSSR-104. The sand fill soils generally consisted of brown and light brown, damp to wet, fine to coarse sand, with trace to little silt and trace to some gravel; and brown, moist, gravelly fine to coarse sand, with little silt. Corrected SPT N-values in the sand fill ranged from 7 to 58 blows per foot (bpf)

indicating that the layer is loose to very dense in consistency. Eight (8) water contents from sand fill samples obtained within the layer ranged from approximately 4% to 17%. Eight (8) grain size analyses conducted on sand fill samples indicated that the soil is classified as an A-2-4, A-1-b or A-3 under the AASHTO Soil Classification System and as an SM, SW-SM or SP-SM under the Unified Soil Classification System. Laboratory test results can be found in Appendix B - Laboratory Data. This testing information is also shown on the boring logs in Appendix A and on Sheet 4 - Boring Logs found at the end of this report.

Boulder/rubble fill was encountered in boring BB-LSSR-103 and was found to be approximately 12.8 feet thick. The boulder/rubble fill was comprised of granite, biotite, granofels, schist and pegmatite boulders and rock fill.

The concrete fill encountered was assumed to be part of the existing abutment footing. The thickness of the concrete ranged from approximately 3.4 feet in boring BB-LSSR-103 to approximately 4.8 feet in boring BB-LSSR-104.

5.3 Northeast Retaining Wall

A layer of sand was encountered overlying bedrock in boring BB-LSSR-105 which was taken at the end of the proposed northeast retaining wall. The sand was approximately 15.2 feet thick in boring BB-LSSR-105. The sand was made up of brown, moist, fine to coarse sand with little to some silt and trace to some gravel. Cobbles were encountered within the bottom 5 feet of the boring. Corrected SPT N-values in the sand ranged from 16 to 42 bpf indicating that the soil is medium dense to dense in consistency.

Two (2) water contents from samples obtained within the sand ranged from approximately 10 to 11%. Two (2) grain size analyses conducted on samples of sand indicated that the soil is classified as an A-2-4 under the AASHTO Soil Classification System and as an SM under the Unified Soil Classification System. Laboratory test results can be found in Appendix B - Laboratory Data.

5.4 Bedrock

The bedrock was cored in five (5) out of the six (6) borings conducted at the site. Table 1 summarizes approximate depths to bedrock, corresponding top of bedrock elevations and RQD at the boring locations:

Boring Number Substructure	Depth to Bedrock	Bedrock Elevation	RQD
BB-LSSR-101 Abutment No. 1 west	1.2 feet	255.1 feet	70 to 90%
BB-LSSR-102 Abutment No. 1 east	5.8 feet	250.3 feet	75%
BB-LSSR-103 Abutment No. 2 west	32.0 feet	244.4 feet	89%
BB-LSSR-104 Abutment No. 2 east	26.5 feet	250.0 feet	55 to 100%
BB-LSSR-105 Retaining Wall	15.2 feet	261.8 feet	90%

Table 1 – Summary of Bedrock Depths, Bedrock Elevations and RQD

The bedrock in borings BB-LSSR-101, BB-LSSR-102, BB-LSSR-103 and BB-LSSR-105 is identified as grey-white and black, fine to coarse grained, pegmatite, hard, fresh to slightly weathered, joints dipping at low to moderate angles with secondary steep angles, very close to close, planar to undulating, rough, tight to open with slight oxidized joint surfaces.

The upper portion of the bedrock cored in boring BB-LSSR-104 is identified as grey-white, fine to medium grained biotite schist with coarse grained pegmatite intrusions, moderately hard to hard, fresh to slightly weathered, joints dipping at low to moderate angles, very close to moderately close, planar to undulating, rough, tight to open. The lower portion of the bedrock in boring BB-LSSR-104 is identified as grey, aphanitic to fine grained biotite granofels with schist zones, moderately hard to hard, fresh to slightly weathered, low to moderately dipping joints, very close to moderately close, planar to undulating, rough, tight to open, with slight oxidation, occasional pitting and occasional quartz veins and intrusions. The RQD of the bedrock ranged from 55 to 100% indicating a Rock Mass Quality of fair to excellent.

5.5 Groundwater

Groundwater was not observed in the borings. Groundwater levels will fluctuate with precipitation, seasonal changes, runoff and construction activity.

6.0 FOUNDATION ALTERNATIVES

Assessment of subsurface conditions indicates that due to the presence of shallow bedrock the most effective foundation type for this site is full height, cast-in-place, cantilever-type abutments and wingwalls on spread footings founded directly on bedrock or on seals constructed on bedrock.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

The following subsections will discuss the foundation considerations and recommendations for full height, cast-in-place, cantilever-type abutments founded on bedrock or on seals constructed on bedrock.

7.1 General - Spread Footings on Bedrock

Bedrock was encountered at approximate elevation 255.1 and 250.3 feet in the vicinity of proposed Abutment No. 1 and at approximate elevation 244.4 and 250.0 feet in the vicinity of Abutment No. 2. Spread footings or seals, if required, could be practically and economically constructed to bear on bedrock within moderately shallow excavations possibly requiring cofferdams and temporary support systems.

The borings indicate that suitable bedrock with a minimum RQD of 67 percent will be encountered at the bedrock surface; however, the bedrock surface shall be cleared of all loose bedrock and highly fractured bedrock. Based on borings conducted at the site and top of bedrock elevations encountered in those borings, the bottom of footing or bottom of seal elevations are presented in Table 2 below:

Substructure	Estimated Bottom of Footing or Seal Elevation
Abutment No. 1	249.6 feet
Abutment No. 2	245.0 feet

Table 2 – Estimated Bottom of Footing or Seal Elevations for Abutments

These bottom of footing elevations are estimated based on a proposed bridge location at the time this report was published. Any realignment of the roadway and/or bridge structure will require a reevaluation of the bottom of footing elevations.

7.2 Abutment and Wingwall Design

Abutments and wingwalls shall be proportioned for all applicable load combinations specified in AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) Articles 3.4.1 and 11.5.5 and shall be designed for all relevant strength, extreme and service limit states. The design of project abutments and wingwalls founded on spread footings at the strength limit state shall consider bearing resistance, eccentricity (overturning), failure by sliding and reinforced concrete structural failure.

For scour protection of abutment and wingwall footings, construct the footings directly on bedrock surfaces cleaned of all weathered, loose and potentially erodible or scourable rock. Strength and extreme limit state designs do not need to consider foundation resistance after the design or check floods for scour.

Extreme limit state design checks for abutments shall include bearing resistance, eccentricity, failure by sliding and structural failure with respect to extreme event load conditions relating to certain hydraulic events and ice (if warranted by ice history or stream constriction by the abutments). Resistance factors, φ, for the extreme limit state shall be taken as 1.0 with the exception of bearing for which a resistance factor of 0.8 shall be used.

For the service limit state, a resistance factor, φ, of 1.0 shall be used to assess spread footing design for settlement, horizontal movement, bearing resistance, sliding and eccentricity. The overall stability of foundations are typically investigated at the Service I Load Combination and a resistance factor, φ, of 0.65. Shear failure along adversely oriented joint surfaces in the rock mass below the foundations is not anticipated, therefore, a global stability evaluation may be waived.

For footings or concrete seals on bedrock, the eccentricity of loading at the strength limit state, based on factored loads, shall not exceed 0.45 of the footing dimensions in either direction. The eccentricity corresponds to the resultant of reaction forces falling within the middle nine-tenths (9/10) of the base width.

For sliding analyses, a sliding resistance factor, φ_τ, of 0.80 shall be applied to the nominal sliding resistance of abutments and wingwalls founded on concrete seals on bedrock assuming the bedrock subgrade will be prepared in-the-wet and some amount of sediment will remain on the bedrock surface. If the bedrock subgrade is prepared in-the-dry and cleaned with high pressure water and air prior to placing seal concrete a sliding resistance factor, φ_τ, of 0.90 may be used. LRFD Table 11.5.7-1 allows a sliding resistance factor, φ_τ, of 1.0 for gravity and semigravity retaining walls regardless of subgrade material.

Assuming that the rock subgrade will be prepared in-the-wet, some amount of sediment is expected to remain on the rock surface and the sliding computations for resistance of abutment and wingwall footings to lateral loads shall assume a maximum friction coefficient of 0.60 at the bedrock-seal concrete interface. If the bedrock subgrade is prepared in-the-dry and cleaned with high pressure water and air prior to placing seal concrete, sliding computations for resistance of abutment and wingwall footings to lateral loads shall assume a maximum frictional coefficient of 0.70 at the bedrock-seal concrete interface.

Anchorage of the footing to the seal is required by the MaineDOT Bridge Design Guide (BDG). The dowels should be drilled and grouted into the seal concrete after dewatering and prior to placing the footing concrete. Anchorage of seals to bedrock may also be required to resist sliding forces and improve stability. If bedrock is observed to slope steeper than 4H:1V at the subgrade elevation, the bedrock should be benched to create level steps or excavated to be completely level.

Cantilever-type abutments should be designed for active earth pressure over the abutment height. In designing for active pressure, a Rankine active earth pressure coefficient, K_a, of 0.31 is recommended (assuming a level backfill). Earth loads for wingwalls shall also be calculated using an active earth pressure coefficient, K_a, of 0.31 (assuming a level backfill), calculated using Rankine Theory. After evaluation of the anticipated magnitude of lateral

movement of the abutment, the designer may elect to use at-rest earth pressures. An at-rest earth pressure coefficient, K_o, of 0.47 is recommended. This recommendation assumes the granular soil behind abutments and wingwalls will be drained and no unbalanced hydrostatic pressures will develop behind abutments and wingwalls. The earth pressure coefficients will need to be recalculated if there is a sloping backfill surface behind the abutments or wingwalls. See Appendix C – Calculations at the end of this report for supporting documentation.

The designer may assume Soil Type 4 (MaineDOT BDG Section 3.6.1) for backfill material soil properties. The backfill properties are as follows: ϕ = 32 degrees, γ = 125 pcf.

Additional lateral earth pressure due to construction surcharge or live load surcharge is required per Section 3.6.8 of the MaineDOT BDG for the abutments and wingwalls if an approach slab is not specified. When a structural approach slab is specified, reduction, not elimination of the surcharge loads is permitted per LRFD Article 3.11.6.5. The live load surcharge on walls may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) of 2.0 feet, per LRFD Table 3.11.6.4-2. The live load surcharge on abutments may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from the Table 3 below:

Abutment Height (feet)	h_{eq} (feet)
5	4.0
10	3.0
≥20	2.0

Table 3 - Equivalent Height of Soil for Estimating Live Load Surcharge

Abutment and wingwall designs shall include a drainage system to intercept any groundwater. Drainage behind the structure shall be in accordance with Section 5.4.1.4 Drainage, of the MaineDOT BDG.

Backfill within 10 feet of the abutments and wingwalls and side slope fill shall conform to Granular Borrow for Underwater Backfill - MaineDOT Specification 709.19. This gradation specifies 10 percent or less of the material passing the No. 200 sieve. This material is specified in order to reduce the amount of fines and to minimize frost action behind the structure.

Slopes above the wingwalls should be constructed with riprap and not exceed 1.75H:1V.

7.3 Bedrock Removal and Bedrock Subgrade Preparation

Construction activities should not be permitted to disturb the bedrock mass or to create any rockfalls or any open fissures. Any irregularities in the existing bedrock surface or irregularities created during the excavation process should be backfilled with unreinforced

concrete to the bearing elevation. Footings may be stepped for varying depths to bedrock along the centerline of bearing. The bottom of footing elevation may vary based on the presence of fractured bedrock.

The nature, slope and degree of fracturing in the bedrock bearing surfaces will not be evident until the foundation excavations for the abutments and pier are made. The bedrock surface shall be cleared of all loose fractured bedrock, loose decomposed bedrock and soil. The final bearing surface shall be solid. The bedrock surface slope shall be less than 4H:1V or it shall be benched in level steps or excavated to be completely level. Anchors or dowels may also be designed and employed to improve sliding resistance where the prepared bedrock surface is steeper than 4H:1V in any direction.

The contractor should maintain the abutment and wingwall excavations so that the foundations can be constructed in the dry. The cleanliness and condition of the bedrock surface should be confirmed by the Resident prior to placing concrete. The final bedrock surface shall be approved by the Resident prior to placement of the footing concrete or seal concrete.

Where foundations are constructed in the dry, the final bearing surface shall be washed with high pressure water and air prior to concrete being placed for the footing. In-the-dry or underwater excavation of highly sloped and loose fractured bedrock material may be done using conventional excavation methods, but may require drilling and blasting techniques. Blasting should be conducted in accordance with Section 105.2.6 of the MaineDOT Standard Specifications. It is also recommended that the contractor conduct pre-and post-blast surveys, as well as blast vibration monitoring at nearby structures in accordance with industry standards at the time of the blast.

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

7.4 Bearing Resistance

Substructure spread footings shall be proportioned to provide stability against bearing capacity failure. Application of permanent and transient loads are specified in LRFD Article 11.5.5. The stress distribution may be assumed to be a triangular or trapezoidal distribution over the effective base as shown in LRFD Figure 11.6.3.2-2.

A factored bearing resistance of 20 ksf may be used and for preliminary footing sizing, and to control settlements when analyzing the service limit state load combination. The bearing resistance for abutment and wingwall footings founded on competent, sound bedrock shall be investigated at the strength limit state using factored loads and a factored bearing resistance of 34 ksf. This assumes a bearing resistance factor, φ_b, for spread footings on bedrock of 0.45, based on bearing resistance evaluation using semi-empirical methods. For extreme limit state load combinations a factored bearing resistance of 60 ksf may be used for gravity and semi-gravity walls and 75 ksf may be used for cantilever type walls. This assumes a bearing

resistance factor of 0.8 in accordance with LRFD Article C11.5.8. See Appendix C – Calculations at the end of this report for supporting documentation.

In no instance shall the factored bearing stress exceed the factored compressive resistance of the footing concrete, which may be taken as 0.3*f'c*. No footing shall be less than 2 feet wide regardless of the applied bearing pressure or bearing material.

7.5 Cast-in-Place Cantilever Type Retaining Wall

A cast-in-place, cantilever type retaining wall founded on bedrock is proposed at the northeast corner of Abutment No. 2. The design of the retaining wall founded on a spread footing on bedrock at the strength limit state shall consider nominal bearing resistance, overturning (eccentricity), lateral sliding and structural failure. Strength and extreme limit state designs do not need to consider foundation resistance after the design or check floods for scour. The cast-in-place retaining wall shall be designed as unrestrained meaning free to rotate at the top in an active state of earth pressure. Earth loads shall be calculated using as active earth pressure coefficient, K_a, calculated using Rankine Theory for cantilever walls ($K_a = 0.31$) and Coulomb Theory for gravity shaped structures ($K_a = 0.28$). These earth pressure coefficients are calculated assuming a level backfill slope. The earth pressure coefficients will need to be recalculated if there is a sloping backfill surface behind the retaining wall.

Bearing resistance for the proposed cast-in-place retaining wall founded on bedrock shall be investigated at the service limit state using factored loads and a factored bearing resistance of 20 ksf. Resistance factors for the service limit state shall be taken as 1.0. A factored bearing resistance of 20 ksf may be used to control settlement when analyzing the service limit state and for preliminary footing sizing as allowed in LRFD C10.6.2.1. The bearing resistance for the proposed cast-in-place retaining wall founded on competent, sound bedrock shall be investigated at the strength limit state using factored loads and a factored bearing resistance of 34 ksf. This assumes a bearing resistance factor, φ_b, for spread footings on bedrock of 0.45. For extreme limit state load combinations a factored bearing resistance of 60 ksf may be used for gravity and semi-gravity walls and 75 ksf may be used for cantilever type walls. This assumes a bearing resistance factor of 0.8 in accordance with LRFD Article C11.5.8. See Appendix C – Calculations at the end of this report for supporting documentation.

The vertical stress shall be calculated assuming a triangular or trapezoidal distribution over an effective base area as shown in LRFD Figure 11.6.3.2-2. For footings on rock, the location of the resultant of the reaction forces shall be within the middle nine-tenths (9/10) of the base width. See Appendix C - Calculations at the end of this report for supporting documentation. In no instance shall the factored bearing stress exceed the nominal resistance of the footing concrete, which is taken as 0.3*f'c*. No footing shall be less than 2 feet wide regardless of the applied bearing pressure.

The Designer may assume Soil Type 4 (MaineDOT BDG Section 3.6.1) for backfill material soil properties. The backfill properties are as follows: $\phi = 32$ degrees, $\gamma = 125$ pcf.

Assuming that the rock subgrade will be prepared in-the-wet, some amount of sediment is expected to remain on the rock surface and the sliding computations for resistance to lateral loads shall assume a maximum friction coefficient of 0.60 at the bedrock-concrete interface. If the bedrock subgrade is prepared in-the-dry and cleaned with high pressure water and air prior to placing seal concrete, sliding computations for resistance to lateral loads shall assume a maximum frictional coefficient of 0.70 at the bedrock-concrete interface. A sliding resistance factor of ϕ_τ=0.80 shall be applied to the nominal sliding resistance of walls founded on spread footings on bedrock.

7.6 Scour and Riprap

For scour protection of abutment and wingwall footings, place the bottom of seals or footings directly on bedrock surfaces cleaned of all weathered, loose and potentially erodible or scourable rock.

The consequences of changes in foundation conditions resulting from the design flood for scour shall be considered for any foundation constructed on granular soils at the strength and service limit states. These changes in foundation conditions shall be investigated at the abutments and wingwalls should they be designed to bear on soil. For scour protection, any footings for wingwalls, which are constructed on granular deposits, should be embedded a minimum of 3 feet below the design scour depth and armored with 3 feet of riprap. Refer to MaineDOT BDG Section 2.3.11 for information regarding scour design.

Bridge approach slopes, slopes at wingwalls and slopes at the toes of any footings on granular soils shall be armored with 3 feet of riprap. Stone riprap shall conform to item number 703.26 of MaineDOT Special Provision 703 and shall be placed at a maximum slope of 1.75H:1V. The toe of the riprap section shall be constructed 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material conforming to item number 703.19 of the Standard Specification and Class “1” Erosion Control Geotextile per Standard Details 610(02) through 610(04).

7.7 Settlement

The proposed approach embankments at the bridge approaches will be constructed on granular soils. Placement of the necessary fill will result in negligible densification of the underlying soils and minimal settlement of the embankments. Any settlement will occur during and immediately after construction of the widened embankments. Post-construction settlement will be minimal.

Any settlement of bridge abutments will be due to elastic compression of the bedrock mass, and is anticipated to be less than 0.5 inch.

7.8 Frost Protection

It is anticipated that the abutment and wingwall spread footings will be founded directly on bedrock. For foundations on bedrock, heave due to frost is not a design issue and no requirements for minimum depth of embedment are necessary.

In the event that any foundation is placed on granular subgrade soils, it should be designed with an appropriate embedment for frost protection. According to the Modberg Software by the US Army Cold Regions Research and Engineering Laboratory the site has an air design-freezing index of approximately 1492 F-degree days. In a granular soil with a water content of approximately 10%, this correlates to a frost depth of approximately 6.0 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 6.0 feet below finished exterior grade for frost protection. This minimum embedment depth applies only to foundations placed on granular soils and not those founded on bedrock. See Appendix C - Calculations at the end of this report for supporting documentation.

7.9 Seismic Design Considerations

The following parameters were determined for the site from the USGS Seismic Parameters CD provided with the LRFD Manual and LRFD Articles 3.10.3.1 and 3.10.6:

- Peak ground acceleration coefficient (PGA) = 0.095g
- Design spectral acceleration coefficient at 0.2-second period, S_{DS} = 0.186g
- Design spectral acceleration coefficient at 1.0-second period, S_{D1} = 0.047g
- Site Class B (Rock with 2,500 ft/s < v_s < 5,000 ft/s)
- Seismic Zone 1, based on a S_{D1} < 0.15g

In conformance with LRFD Table 4.7.4.2 seismic analysis is not required for single-span bridges regardless of seismic zone. According to Figure 2-2 of the MaineDOT BDG, the Steep Falls Bridge is not on the National Highway System (NHS). The bridge is not classified as a major structure since the construction costs will not exceed $10 million. These criteria eliminate the MaineDOT BDG requirement to design the foundations for seismic earth loads. However, superstructure connections and minimum support length requirements shall be designed per LRFD Articles 3.10.9 and 4.7.4.4, respectively.

See Appendix C – Calculations at the end of this report for supporting documentation.

7.10 Construction Considerations

Construction activities may include construction of cofferdams and earth support systems to support the approach fills and control stream flow during construction of seals and footings for abutments and wingwalls. Construction activities will also include common earth and rock excavation and structural earth and rock excavation for major structures.

The nature, slope and degree of fracturing in the bedrock bearing surfaces will not be evident until the foundation excavations are made. The bedrock surface shall be cleared of all loose fractured bedrock, loose decomposed bedrock and soil. The final bearing surface shall be solid. The bedrock surface slope shall be less than 4 horizontal to 1 vertical (4H:1V) or it shall be benched in level steps or excavated to be completely level. Anchoring, doweling or other means of improving sliding resistance may also be employed where the prepared bedrock surface is steeper than 4H:1V in any direction.

Where foundations are constructed in the dry, the final bearing surface shall be washed with high pressure water and air prior to concrete being placed for the footing. In-the-dry or underwater excavation of highly sloped and loose fractured bedrock material may be done using conventional excavation methods, but may require drilling and blasting techniques. Blasting should be conducted in accordance with Section 105.2.6 of the MaineDOT Standard Specifications. It is also recommended that the contractor conduct pre-and post-blast surveys, as well as blast vibration monitoring at nearby residences and bridge structures in accordance with industry standards at the time of the blast.

The cleanliness and condition of the bedrock surface shall be approved by the Resident prior to placement of the footing concrete or seal concrete.

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

Using the excavated native soils as structural backfill should not be permitted. The native soils may only be used as common borrow in accordance with MaineDOT Standard Specifications 203 and 703.

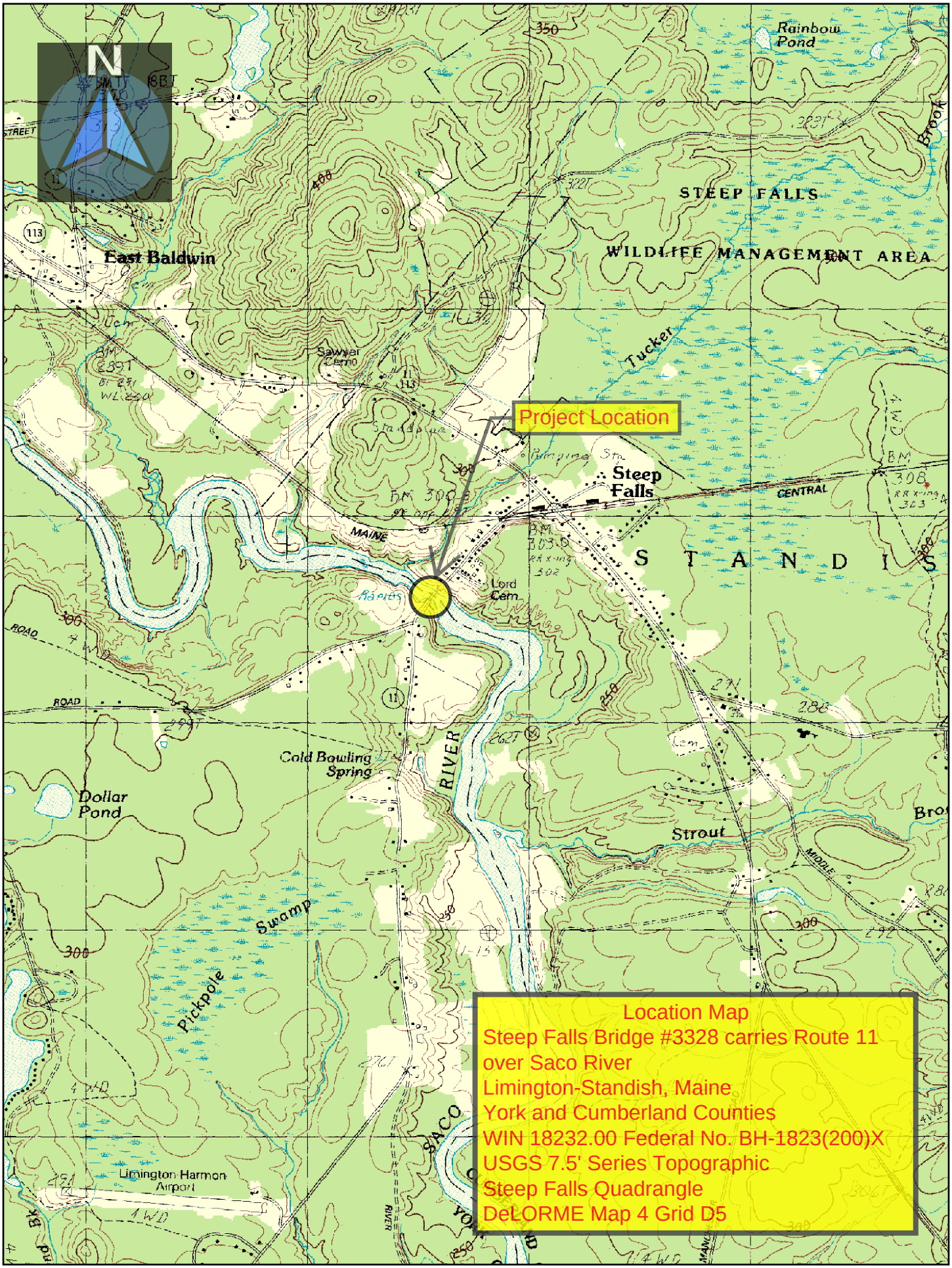
The Contractor will have to excavate the existing subbase and subgrade fill soils in the bridge approaches. These materials should not be used to re-base the new bridge approaches. Excavated subbase sand and gravel may be used as fill below subgrade level in fill areas provided all other requirements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

8.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Steep Falls Bridge in Limington and Standish, 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.

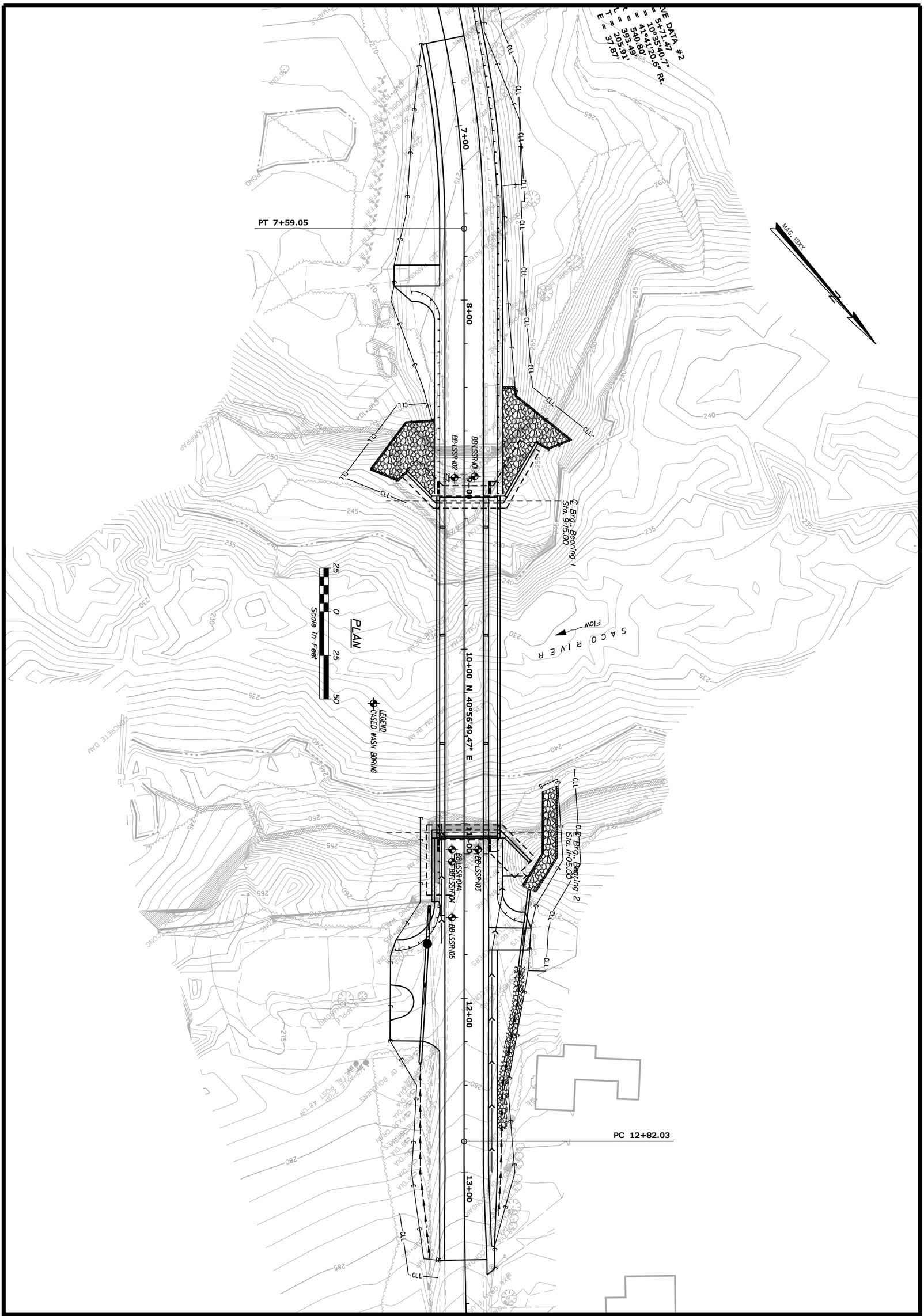
We also recommend that we be provided the opportunity for a general review of the final design and specifications in order that the earthwork and foundation recommendations may be properly interpreted and implemented in the design.

Sheets



Map Scale 1:24000

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



STEEP FALLS BRIDGE SACO RIVER LIMINGTON-STANDISH CUMBERLAND CNTY	PROJ. MANAGER	BY	DATE
	DESIGN-DETAILED		
	CHECKED-REVIEWED		
	DESIGN2-DETAILED2	K.MAGUIRE	T.WHITE	SEPT 2013
	DESIGN3-DETAILED3		
	REVISIONS 1		
	REVISIONS 2		
	REVISIONS 3		
	REVISIONS 4		
	FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BH-1823(200)X

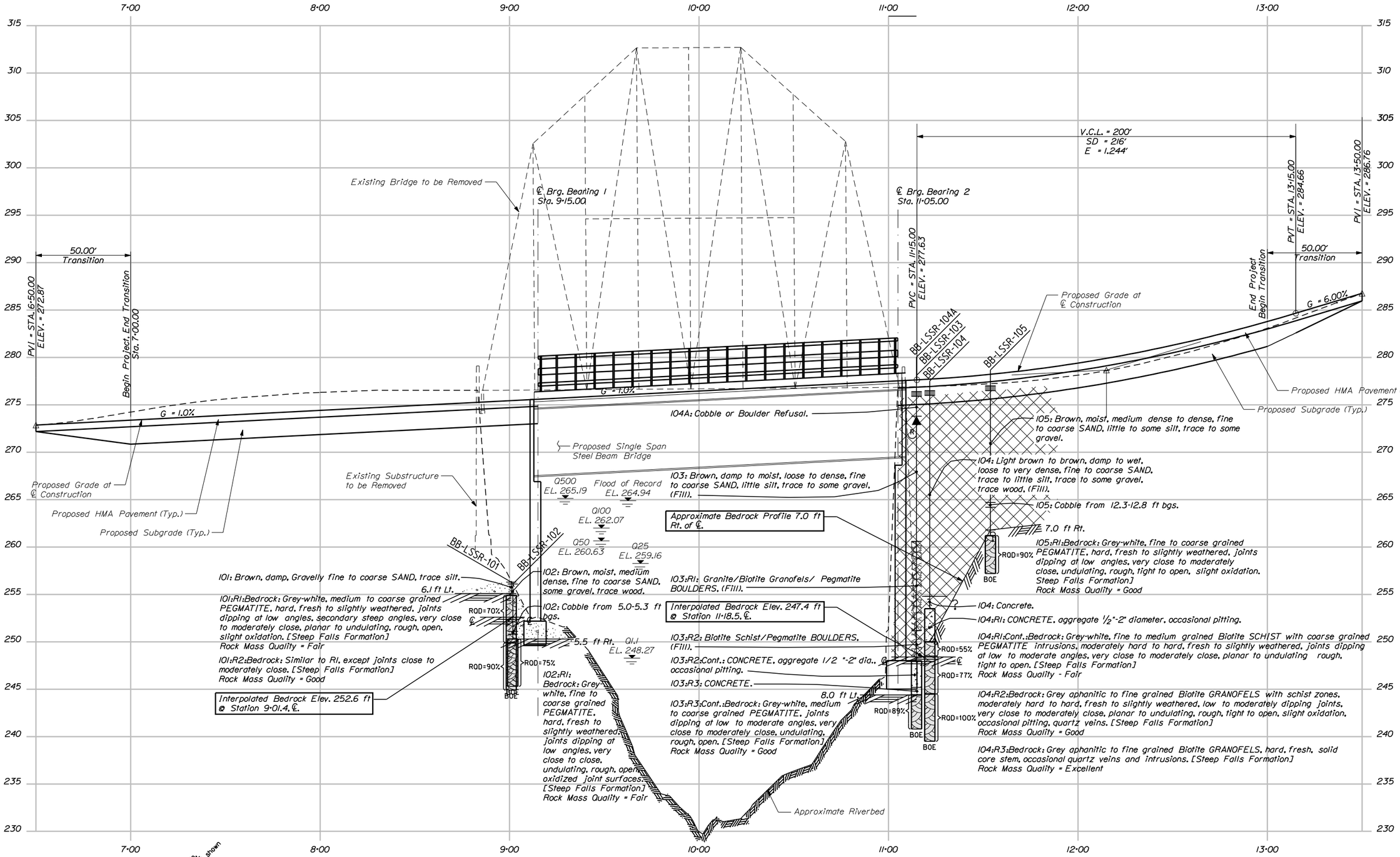
WIN 18232.00

BRIDGE NO. 3328

BRIDGE PLANS

BORING LOCATION PLAN

SHEET NUMBER 2 OF 4



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

BH-1823(200)X

WIN 18232.00

BRIDGE NO. 3328

BRIDGE PLANS

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

SIGNATURE

P.E. NUMBER

DATE

STEEP FALLS BRIDGE
SACO RIVER
LIMINGTON-STANDISH CUMBERLAND CNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 4

Filename: ...\00\geotech\msta\007_ISP1.dgn Division: GEOTECH Username: terry.white Date:12/9/2013

Filename: ...\msta\008_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:12/9/2013

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-101   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	256.3	Auger ID/OD:	N/A
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/12/2013; 07:00-10:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	9+00.9, 6.1 ft Lt.	Casing ID/OD:	NW	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	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	1D	13.2/9	0.00 - 1.10	2/7/30(12")	---		SPUN CASE		Brown, damp, Gravelly fine to coarse SAND, trace silt. Spun Casing ahead to 1.4 ft bgs.	G#243090 A-1-a, SW-SM WC=9.4%
1.20	R1	60/60	1.40 - 6.40	RQD = 70%			NQ-2	255.10	Top of Bedrock at Elev. 255.1 ft. R1:Bedrock: Grey-white, medium to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, secondary steep angles, very close to moderately close, planar to undulating, rough, open, slight oxidation. [Steep Falls Formation] Rock Mass Quality = Fair R1:Core Times (min:sec) 1.4-2.4 ft (4:52) 2.4-3.4 ft (4:19) 3.4-4.4 ft (4:40) 4.4-5.4 ft (4:20) 5.4-6.4 ft (5:20) 100% Recovery	
	R2	60/60	6.40 - 11.40	RQD = 90%					R2:Bedrock: Similar to R1, except joints close to moderately close. [Steep Falls Formation] Rock Mass Quality = Good R2:Core Times (min:sec) 6.4-7.4 ft (4:55) 7.4-8.4 ft (5:58) 8.4-9.4 ft (5:58) 9.4-10.4 ft (6:00) 10.4-11.4 ft (6:00) 100% Recovery	
11.40								244.90	Bottom of Exploration at 11.40 feet below ground surface.	

Remarks:
Bridge Deck (0.8 ft Concrete)
19.9 ft from Bridge Deck to Ground.
300-400 lbs down pressure on Core Barrel.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1   Boring No.: BB-LSSR-101

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-102   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	256.1	Auger ID/OD:	N/A
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/19/2013; 07:00-11:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	9+01.7, 5.5 ft Rt.	Casing ID/OD:	NW	Water Level*:	None Observed
Hammer Efficiency Factor: 0.867		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	1D	24/16	0.00 - 2.00	6/5/4/8	9	13	15		Brown, moist, medium dense, fine to coarse SAND, some gravel, trace silt, trace wood.	G#243091 A-1-b, SW-SM WC=8.7%
							12			
							38			
							56			
							90			
5	2D R1	3.6/3 60/60	5.50 - 5.80 5.80 - 10.80	30(3.6") RQD = 75%	---		NQ-2	250.30	Cobble from 5.0-5.3 ft bgs. Roller Coned ahead to 5.5 ft bgs. Similar to above.	
5.80									Top of Bedrock at Elev. 250.3 ft. R1:Bedrock: Grey-white, fine to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, very close to close, undulating, rough, open, oxidized joint surfaces. [Steep Falls Formation] Rock Mass Quality = Fair R1:Core Times (min:sec) 5.8-6.8 ft (4:29) 6.8-7.8 ft (4:54) 7.8-8.8 ft (4:50) 8.8-9.8 ft (5:50) 9.8-10.8 ft (5:00) 100% Recovery	
10.80								245.30	Bottom of Exploration at 10.80 feet below ground surface.	

Remarks:
20.2 ft from Bridge Deck to Ground.
Ledge Outcrop 3.0 ft South of Boring
300-400 lbs down pressure on Core Barrel.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1   Boring No.: BB-LSSR-102

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-103   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	276.4	Auger ID/OD:	5" Solid Stem
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/12,16/2013	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	11+14.8, 8.0 ft Lt.	Casing ID/OD:	NW	Water Level*:	None Observed
Hammer Efficiency Factor: 0.867		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	275.90	6" Pavement (0.50)	
	1D	24/20	1.50 - 3.50	11/8/8/7	16	23			Brown, damp, medium dense, fine to coarse SAND, little silt, trace gravel, (Fill).	G#243092 A-2-4, SM WC=4.3%
5	2D	24/18	5.00 - 7.00	3/4/4/4	8	12			Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#243093 A-1-b, SM WC=8.1%
10	3D	24/17	10.00 - 12.00	3/3/3/5	6	9	15		Brown, moist, loose, fine to coarse SAND, little gravel, little silt, (Fill).	G#243094 A-1-b, SM WC=9.9%
							19			
							16			
							19			
	4D	21.6/13	14.00 - 15.80	7/12/12/30(3.6")	24	35			Brown, moist, dense, Gravelly fine to coarse SAND, little silt, (Fill).	G#243095 A-1-b, SM WC=10.8%
15.80	R1	112.8/60	15.80 - 25.20				NQ-2	260.60	R1: Granite/Biotite Granofels/Pegmatite BOULDERS, (Fill). R1:Core Times (min:sec) 15.8-16.8 ft (4:10) 16.8-17.8 ft (3:00) 17.8-18.8 ft (1:00) 18.8-19.8 ft (0:30) 19.8-20.8 ft (1:00) 20.8-21.8 ft (0:30) 21.8-22.8 ft (0:30) 22.8-23.8 ft (2:00) 23.8-24.8 ft (1:00) 24.8-25.3 ft (0:45) 53% Recovery Core Barrel Full	
25	R2	72/60	25.20 - 31.20						R2: Biotite Schist/Pegmatite BOULDERS. R2:Core Times (min:sec) 25.2-26.2 ft (3:10) 26.2-27.2 ft (3:37) 27.2-28.2 ft (2:30) 5" Drop 28.2-29.2 ft (2:15) 5" Drop	
28.60								247.80	R2:Cont.: CONCRETE, aggregate .5"-2" diameter, occasional pitting. 29.2-30.2 ft (4:40) 30.2-31.2 ft (3:45) 83% Recovery	
	R3	54/54	31.20 - 35.70						R3: CONCRETE. R3: Core Times (min:sec) 31.2-32.2 ft (3:15)	
32.00				RQD = 89%				244.40	Top of Bedrock at Elev. 244.4 ft. R3:Cont.:Bedrock: Grey-white, medium to coarse grained PEGMATITE, joints dipping at low to moderate angles, very close to moderately close, undulating, rough, open. [Steep Falls Formation] Rock Mass Quality = Good 32.2-33.2 ft (5:17) 33.2-34.2 ft (6:58) 34.2-35.2 ft (11:20) 35.2-35.7 ft (9:00) 100% Recovery	
35.70								240.70	Bottom of Exploration at 35.70 feet below ground surface.	

Remarks:
300-400 lbs down pressure on Core Barrel.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1   Boring No.: BB-LSSR-103

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-104   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	276.5	Auger ID/OD:	5" Solid Stem
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/18/2013; 07:30-12:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	11+21.8, 7.0 ft Rt.	Casing ID/OD:	NW	Water Level*:	None Observed
Hammer Efficiency Factor: 0.867		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	276.00	6" Pavement (0.50)	
5	1D	24/13	5.00 - 7.00	3/5/3/3	8	12			Light brown, damp, medium dense, fine to coarse SAND, little silt, little gravel, (Fill).	G#243096 A-2-4, SM WC=7.3%
10	2D	24/14	10.00 - 12.00	3/3/4/4	7	10	6		Brown, wet, loose, fine to coarse SAND, little silt, trace gravel, trace wood, (Fill).	G#243097 A-1-b, SM WC=9.5%
							7			
							18			
							17			
							10			
15	3D	24/11	15.00 - 17.00	2/3/2/5	5	7	4		Brown, wet, loose, fine to coarse SAND, some gravel, trace silt, (Fill).	G#243098 A-1-b, SW-SM WC=17.1%
							5			
							12			
							12			
							31			
20	4D	20.4/14	20.00 - 21.70	12/21/19/25(2.4)	40	58			Brown, wet, very dense, fine to coarse SAND, trace silt, trace gravel, (Fill).	G#243099 A-3, SP-SM WC=16.3%
21.70								254.80	Roller Coned ahead to 23.0 ft bgs., in Concrete.	
	R1	60/54	23.00 - 28.00				NQ-2		R1: CONCRETE, aggregate .5"-2" diameter, frequent pitting. R1:Core Times (min:sec) 23.0-24.0 ft (8:05) 24.0-25.0 ft (10:24) No water return 25.0-26.0 ft (7:23)	
26.50				RQD = ᵃ55%				250.00	Top of Bedrock at Elev. 250.0 ft. R1:Cont.:Bedrock: Grey-white, fine to medium grained biotite SCHIST with coarse grained PEGMATITE intrusions, moderately hard to hard, fresh to slightly weathered, joints dipping at low to moderate angles, very close to moderately close, planar to undulating rough, tight to open. [Steep Falls Formation] Rock Mass Quality - Fair ᵃRQD based on Bedrock portion of run only. 26.0-27.0 ft (7:20) 27.0-28.0 ft (7:00) 90% Recovery	
	R2	48/48	28.00 - 32.00	RQD = 77%					R2:Bedrock: Grey aphanitic to fine grained biotite GRANOFELS with schist zones, moderately hard to hard, fresh to slightly weathered, low to moderately dipping joints, very close to moderately close, planar to undulating, rough, tight to open, slight oxidation, occasional pitting, quartz veins [Steep Falls Formation] Rock Mass Quality = Good R2:Core Times (min:sec) 28.0-29.0 ft (4:40) No water return 29.0-30.0 ft (4:00) 30.0-31.0 ft (6:10) 31.0-32.0 ft (6:20) 100% Recovery Core Blocked	
	R3	60/60	32.00 - 37.00	RQD = 100%					R3:Bedrock: Grey aphanitic to fine grained biotite GRANOFELS, hard, fresh, solid core stem, occasional quartz veins and intrusions. [Steep Falls Formation] Rock Mass Quality = Excellent R3:Core Times (min:sec) 32.0-33.0 ft (6:00) 33.0-34.0 ft (3:50) 34.0-35.0 ft (5:25) 35.0-36.0 ft (6:15) 36.0-37.0 ft (7:00) 100% Recovery	
37.00								239.50	Bottom of Exploration at 37.00 feet below ground surface.	

Remarks:
300-400 lbs down pressure on Core Barrel.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1   Boring No.: BB-LSSR-104

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-104A   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	276.5	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:	9/18/2013; 07:00-07:30	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	11+14.8, 7.0 ft Rt.	Casing ID/OD:	N/A	Water Level*:	None Observed
Hammer Efficiency Factor:		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA		Cobble or Boulder at 2.6 ft bgs.	
2.60								273.90	Bottom of Exploration at 2.60 feet below ground surface. Cobble or Boulder REFUSAL	

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-LSSR-104A

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

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-105   WIN: 18232.00

Driller:	MaineDOT	Elevation (ft.)	277.0	Auger ID/OD:	5" Solid Stem
Operator:	Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	9/18/2013; 12:30-16:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	11+53.8, 7.0 ft Rt.	Casing ID/OD:	NW	Water Level*:	None Observed
Hammer Efficiency Factor: 0.867		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	276.50	6" Pavement (0.50)	
5	1D	24/18	5.00 - 7.00	5/6/5/6	11	16			Brown, moist, medium dense, fine to coarse SAND, little silt, trace gravel.	G#243100 A-2-4, SM WC=11.4%
10	2D	24/19	10.00 - 12.00	5/5/24/31	29	42	28		Brown, moist, dense, fine to coarse SAND, some silt, some gravel.	G#243051 A-2-4, SM WC=10.0%
							150		Cobble from 12.3-12.8 ft bgs.	
							16			
							35			
							140			
15.20	R1	48/45	15.80 - 19.80	RQD = 90%			NQ-2	261.80	Top of Bedrock at Elev. 261.8 ft. Roller Coned ahead to 15.8 ft bgs. R1:Bedrock: Grey-white, fine to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, very close to moderately close, undulating, rough, tight to open, slight oxidation. [Steep Falls Formation] Rock Mass Quality = Good R1:Core Times (min:sec) 15.8-16.8 ft (14:46) 16.8-17.8 ft (14:16) 17.8-18.8 ft (14:52) 18.8-19.8 ft (24:22) 94% Recovery 3" core left in bottom of boring.	
19.80								257.20	Bottom of Exploration at 19.80 feet below ground surface.	

Remarks:
400-600 lbs down pressure on Core Barrel.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1   Boring No.: BB-LSSR-105

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
BH-1823(200)X
BRIDGE PLANS
WIN 18232.00
BRIDGE NO. 3328

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

SIGNATURE
P.E. NUMBER
DATE

STEEP FALLS BRIDGE
SACO RIVER
LIMINGTON-STANDISH CUMBERLAND CNTY

BORING LOGS

SHEET NUMBER
4
OF 4

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 thumbnai
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

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

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

Correlation of RQD to Rock Mass Quality

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

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

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

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

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-101
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	256.3	**Auger ID/OD:**	N/A
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/12/2013; 07:00-10:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	9+00.9, 6.1 ft Lt.	**Casing ID/OD:**	NW	**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

Sample Information

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	1D	13.2/9	0.00 - 1.10	2/7/30(12")	---		SPUN CASE			Brown, damp, Gravelly fine to coarse SAND, trace silt. Spun Casing ahead to 1.4 ft bgs.	G#243090 A-1-a, SW-SM WC=9.4%
	R1	60/60	1.40 - 6.40	RQD = 70%			NQ-2	255.10		1.20 Top of Bedrock at Elev. 255.1 ft. R1:Bedrock: Grey-white, medium to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, secondary steep angles, very close to moderately close, planar to undulating, rough, open, slight oxidation. [Steep Falls Formation] Rock Mass Quality = Fair R1:Core Times (min:sec) 1.4-2.4 ft (4:52) 2.4-3.4 ft (4:19) 3.4-4.4 ft (4:40) 4.4-5.4 ft (4:20) 5.4-6.4 ft (5:20) 100% Recovery	
5	R2	60/60	6.40 - 11.40	RQD = 90%						R2:Bedrock: Similar to R1, except joints close to moderately close. [Steep Falls Formation] Rock Mass Quality = Good R2:Core Times (min:sec) 6.4-7.4 ft (4:55) 7.4-8.4 ft (5:58) 8.4-9.4 ft (5:58) 9.4-10.4 ft (6:00) 10.4-11.4 ft (6:00) 100% Recovery	
10								244.90		11.40 **Bottom of Exploration at 11.40 feet below ground surface.**	
15											
20											
25											

Remarks:

Bridge Deck (0.8 ft Concrete)
19.9 ft from Bridge Deck to Ground.
300-400 lbs down pressure on Core Barrel.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-102
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	256.1	**Auger ID/OD:**	N/A
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/2013; 07:00-11:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	9+01.7, 5.5 ft Rt.	**Casing ID/OD:**	NW	**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

Sample Information

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	1D	24/16	0.00 - 2.00	6/5/4/8	9	13	15			Brown, moist, medium dense, fine to coarse SAND, some gravel, trace silt, trace wood.	G#243091 A-1-b, SW-SM WC=8.7%
							12				
							38				
							56				
							90				
5	2D	3.6/3	5.50 - 5.80	30(3.6")	---		NQ-2			Cobble from 5.0-5.3 ft bgs. Roller Coned ahead to 5.5 ft bgs. Similar to above.	
	R1	60/60	5.80 - 10.80	RQD = 75%				250.30		5.80	
										Top of Bedrock at Elev. 250.3 ft. R1:Bedrock: Grey-white, fine to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, very close to close, undulating, rough, open, oxidized joint surfaces. [Steep Falls Formation] Rock Mass Quality = Fair R1:Core Times (min:sec) 5.8-6.8 ft (4:29) 6.8-7.8 ft (4:54) 7.8-8.8 ft (4:50) 8.8-9.8 ft (5:50) 9.8-10.8 ft (5:00) 100% Recovery	
10								245.30		10.80	
15											
20											
25											

Bottom of Exploration at 10.80 feet below ground surface.

Remarks:

20.2 ft from Bridge Deck to Ground.
Ledge Outcrop 3.0 ft South of Boring
300-400 lbs down pressure on Core Barrel.

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

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Boring No.: BB-LSSR-102

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-103
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	276.4	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/12,16/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	11+14.8, 8.0 ft Lt.	**Casing ID/OD:**	NW	**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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	275.90	6" Pavement — 0.50	
	1D	24/20	1.50 - 3.50	11/8/8/7	16	23			Brown, damp, medium dense, fine to coarse SAND, little silt, trace gravel, (Fill).	G#243092 A-2-4, SM WC=4.3%
5	2D	24/18	5.00 - 7.00	3/4/4/4	8	12			Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#243093 A-1-b, SM WC=8.1%
10	3D	24/17	10.00 - 12.00	3/3/3/5	6	9	15		Brown, moist, loose, fine to coarse SAND, little gravel, little silt, (Fill).	G#243094 A-1-b, SM WC=9.9%
							19			
							16			
							19			
	4D	21.6/13	14.00 - 15.80	7/12/12/30(3.6")	24	35			Brown, moist, dense, Gravelly fine to coarse SAND, little silt, (Fill).	G#243095 A-1-b, SM WC=10.8%
15	R1	112.8/60	15.80 - 25.20				NQ-2	260.60	15.80 — R1: Granite/Biotite Granofels/Pegmatite BOULDERS, (Fill). R1:Core Times (min:sec) 15.8-16.8 ft (4:10) 16.8-17.8 ft (3:00) 17.8-18.8 ft (1:00) 18.8-19.8 ft (0:30) 19.8-20.8 ft (1:00) 20.8-21.8 ft (0:30) 21.8-22.8 ft (0:30) 22.8-23.8 ft (2:00) 23.8-24.8 ft (1:00) 24.8-25.3 ft (0:45) 53% Recovery Core Barrel Full	
20										
25										

Remarks:

300-400 lbs down pressure on Core Barrel.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-103
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	276.4	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/12,16/2013	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	11+14.8, 8.0 ft Lt.	**Casing ID/OD:**	NW	**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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	R2	72/60	25.20 - 31.20							R2: Biotite Schist/Pegmatite BOULDERS. R2:Core Times (min:sec) 25.2-26.2 ft (3:10) 26.2-27.2 ft (3:37) 27.2-28.2 ft (2:30) 5" Drop 28.2-29.2 ft (2:15) 5" Drop	
								247.80		28.60 R2:Cont.: CONCRETE, aggregate ½"-2" diameter, occasional pitting. 29.2-30.2 ft (4:40) 30.2-31.2 ft (3:45) 83% Recovery	
30											
	R3	54/54	31.20 - 35.70							R3: CONCRETE. R3: Core Times (min:sec) 31.2-32.2 ft (3:15)	
				RQD = 89%				244.40		32.00 Top of Bedrock at Elev. 244.4 ft. R3:Cont.:Bedrock: Grey-white, medium to coarse grained PEGMATITE, joints dipping at low to moderate angles, very close to moderately close, undulating, rough, open. [Steep Falls Formation] Rock Mass Quality = Good 32.2-33.2 ft (5:17) 33.2-34.2 ft (6:58) 34.2-35.2 ft (11:20) 35.2-35.7 ft (9:00) 100% Recovery	
35								240.70		35.70 **Bottom of Exploration at 35.70 feet below ground surface.**	
40											
45											
50											

Remarks:

300-400 lbs down pressure on Core Barrel.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-104A
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	276.5	**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:	9/18/2013; 07:00-07:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+14.8, 7.0 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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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			Cobble or Boulder at 2.6 ft bgs.	
								273.90		2.60	
										Bottom of Exploration at 2.60 feet below ground surface. Cobble or Boulder REFUSAL	
5											
10											
15											
20											
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-104
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/18/2013; 07:30-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	11+21.8, 7.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.867	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
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RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
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PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	276.00	6" Pavement — 0.50	
5	1D	24/13	5.00 - 7.00	3/5/3/3	8	12			Light brown, damp, medium dense, fine to coarse SAND, little silt, little gravel, (Fill).	G#243096 A-2-4, SM WC=7.3%
10	2D	24/14	10.00 - 12.00	3/3/4/4	7	10	6		Brown, wet, loose, fine to coarse SAND, little silt, trace gravel, trace wood, (Fill).	G#243097 A-1-b, SM WC=9.5%
							7			
							18			
							17			
							10			
15	3D	24/11	15.00 - 17.00	2/3/2/5	5	7	4		Brown, wet, loose, fine to coarse SAND, some gravel, trace silt, (Fill).	G#243098 A-1-b, SW-SM WC=17.1%
							5			
							12			
							12			
							31			
20	4D	20.4/14	20.00 - 21.70	12/21/19/25(2.4)	40	58			Brown, wet, very dense, fine to coarse SAND, trace silt, trace gravel, (Fill).	G#243099 A-3, SP-SM WC=16.3%
								254.80	21.70	
									Roller Coned ahead to 23.0 ft bgs., in Concrete.	
	R1	60/54	23.00 - 28.00				NQ-2		R1: CONCRETE, aggregate ½"-2" diameter, frequent pitting. R1:Core Times (min:sec) 23.0-24.0 ft (8:05) 24.0-25.0 ft (10:24) No water return	
25										

Remarks:

300-400 lbs down pressure on Core Barrel.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-104
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	276.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/18/2013; 07:30-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	11+21.8, 7.0 ft Rt.	**Casing ID/OD:**	NW	**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
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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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										25.0-26.0 ft (7:23)	
				RQD = [a]55%				250.00		26.50	
										Top of Bedrock at Elev. 250.0 ft. R1:Cont.:Bedrock: Grey-white, fine to medium grained biotite SCHIST with coarse grained PEGMATITE intrusions, moderately hard to hard, fresh to slightly weathered, joints dipping at low to moderate angles, very close to moderately close, planar to undulating rough, tight to open. [Steep Falls Formation] Rock Mass Quality - Fair [a]RQD based on Bedrock portion of run only. 26.0-27.0 ft (7:20) 27.0-28.0 ft (7:00) 90% Recovery	
	R2	48/48	28.00 - 32.00	RQD = 77%							
30											
	R3	60/60	32.00 - 37.00	RQD = 100%						R2:Bedrock: Grey aphanitic to fine grained biotite GRANOFELS with schist zones, moderately hard to hard, fresh to slightly weathered, low to moderately dipping joints, very close to moderately close, planar to undulating, rough, tight to open, slight oxidation, occasional pitting, quartz veins [Steep Falls Formation] Rock Mass Quality = Good R2:Core Times (min:sec) 28.0-29.0 ft (4:40) No water return 29.0-30.0 ft (4:00) 30.0-31.0 ft (6:10) 31.0-32.0 ft (6:20) 100% Recovery Core Blocked	
35								239.50		R3:Bedrock: Grey aphanitic to fine grained biotite GRANOFELS, hard, fresh, solid core stem, occasional quartz veins and intrusions. [Steep Falls Formation] Rock Mass Quality = Excellent R3:Core Times (min:sec) 32.0-33.0 ft (6:00) 33.0-34.0 ft (3:50) 34.0-35.0 ft (5:25) 35.0-36.0 ft (6:15) 36.0-37.0 ft (7:00) 100% Recovery	
40										37.00 **Bottom of Exploration at 37.00 feet below ground surface.**	
45											
50											

Remarks:

300-400 lbs down pressure on Core Barrel.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Steep Falls Bridge #3328 carries Route 11 over Saco River
Location: Limington-Standish, Maine

Boring No.: BB-LSSR-105
WIN: 18232.00

Driller:	MaineDOT	**Elevation (ft.)**	277.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/18/2013; 12:30-16:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	11+53.8, 7.0 ft Rt.	**Casing ID/OD:**	NW	**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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	276.50	6" Pavement — 0.50	
5	1D	24/18	5.00 - 7.00	5/6/5/6	11	16			Brown, moist, medium dense, fine to coarse SAND, little silt, trace gravel.	G#243100 A-2-4, SM WC=11.4%
10	2D	24/19	10.00 - 12.00	5/5/24/31	29	42	28		Brown, moist, dense, fine to coarse SAND, some silt, some gravel.	G#243051 A-2-4, SM WC=10.0%
							150			
							16		Cobble from 12.3-12.8 ft bgs.	
							35			
							140			
15	R1	48/45	15.80 - 19.80	RQD = 90%			NQ-2	261.80	15.20 — Top of Bedrock at Elev. 261.8 ft. Roller Coned ahead to 15.8 ft bgs. R1:Bedrock: Grey-white, fine to coarse grained PEGMATITE, hard, fresh to slightly weathered, joints dipping at low angles, very close to moderately close, undulating, rough, tight to open, slight oxidation. [Steep Falls Formation] Rock Mass Quality = Good R1:Core Times (min:sec) 15.8-16.8 ft (14:46) 16.8-17.8 ft (14:16) 17.8-18.8 ft (14:52) 18.8-19.8 ft (24:22) 94% Recovery 3" core left in bottom of boring.	
20								257.20	19.80 — **Bottom of Exploration at 19.80 feet below ground surface.**	
25										

Remarks:

400-600 lbs down pressure on Core Barrel.

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

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

Appendix B

Laboratory Data

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Limington-Standish Work Number: 18232.00

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-LSSR-101, 1D	9+00.9	6.1 Lt.	0.0-1.1	243090	1	9.4			SW-SM	A-1-a	0
BB-LSSR-102, 1D	9+01.7	5.5 Rt.	0.0-2.0	243091	1	8.7			SW-SM	A-1-b	0
BB-LSSR-103, 1D	11+14.8	8.0 Lt.	1.5-3.5	243092	2	4.3			SM	A-2-4	II
BB-LSSR-103, 2D	11+14.8	8.0 Lt.	5.0-7.0	243093	2	8.1			SM	A-1-b	II
BB-LSSR-103, 3D	11+14.8	8.0 Lt.	10.0-12.0	243094	2	9.9			SM	A-1-b	II
BB-LSSR-103, 4D	11+14.8	8.0 Lt.	14.0-15.8	243095	2	10.8			SM	A-1-b	II
BB-LSSR-104, 1D	11+21.8	7.0 Rt.	5.0-7.0	243096	3	7.3			SM	A-2-4	II
BB-LSSR-104, 2D	11+21.8	7.0 Rt.	10.0-12.0	243097	3	9.5			SM	A-1-b	II
BB-LSSR-104, 3D	11+21.8	7.0 Rt.	15.0-17.0	243098	3	17.1			SW-SM	A-1-b	0
BB-LSSR-104, 4D	11+21.8	7.0 Rt.	20.0-21.7	243099	3	16.3			SP-SM	A-3	0
BB-LSSR-105, 1D	11+53.8	7.0 Rt.	5.0-7.0	243100	4	11.4			SM	A-2-4	II
BB-LSSR-105, 2D	11+53.8	7.0 Rt.	10.0-12.0	243051	4	10.0			SM	A-2-4	II

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.

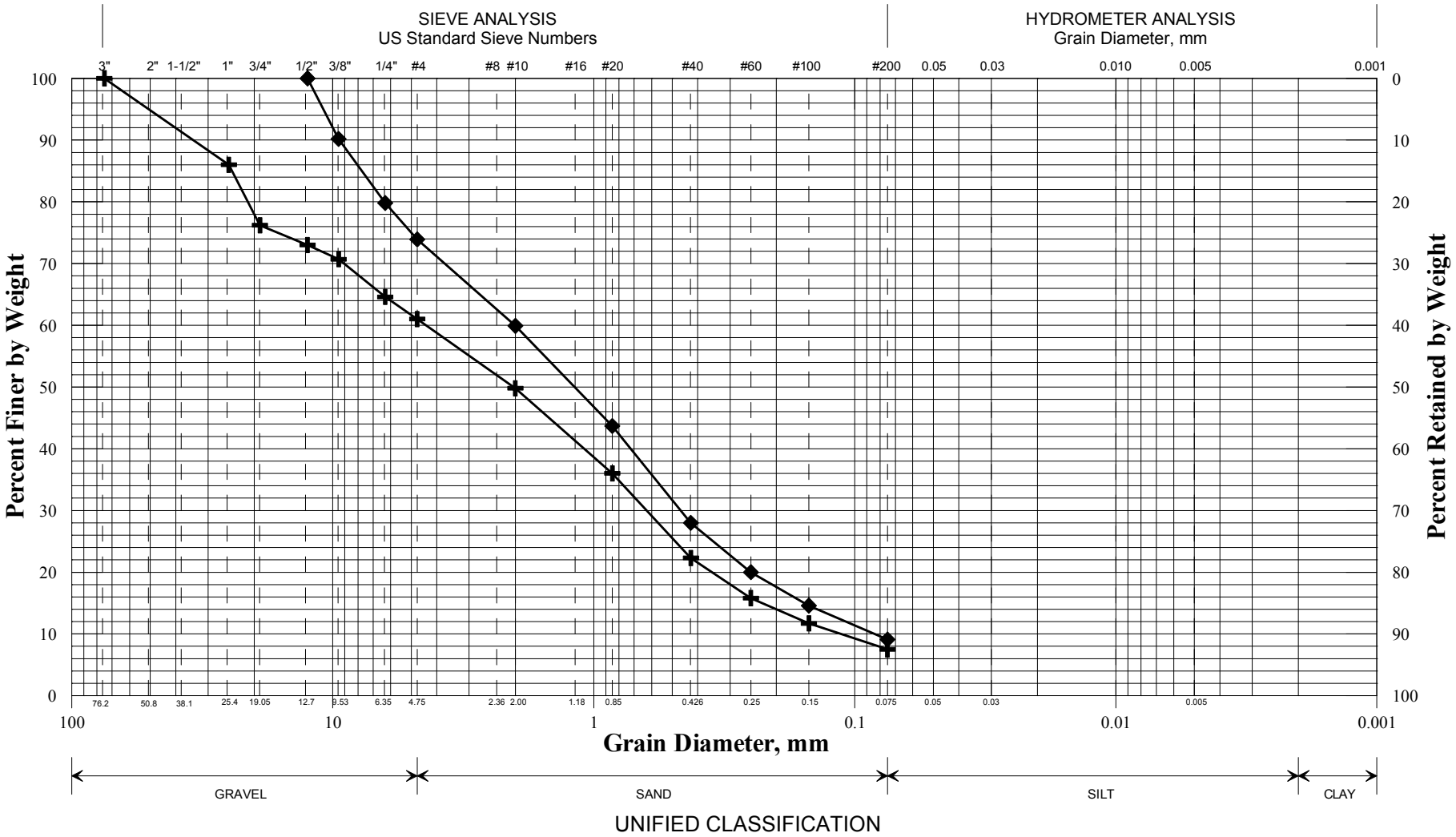
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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



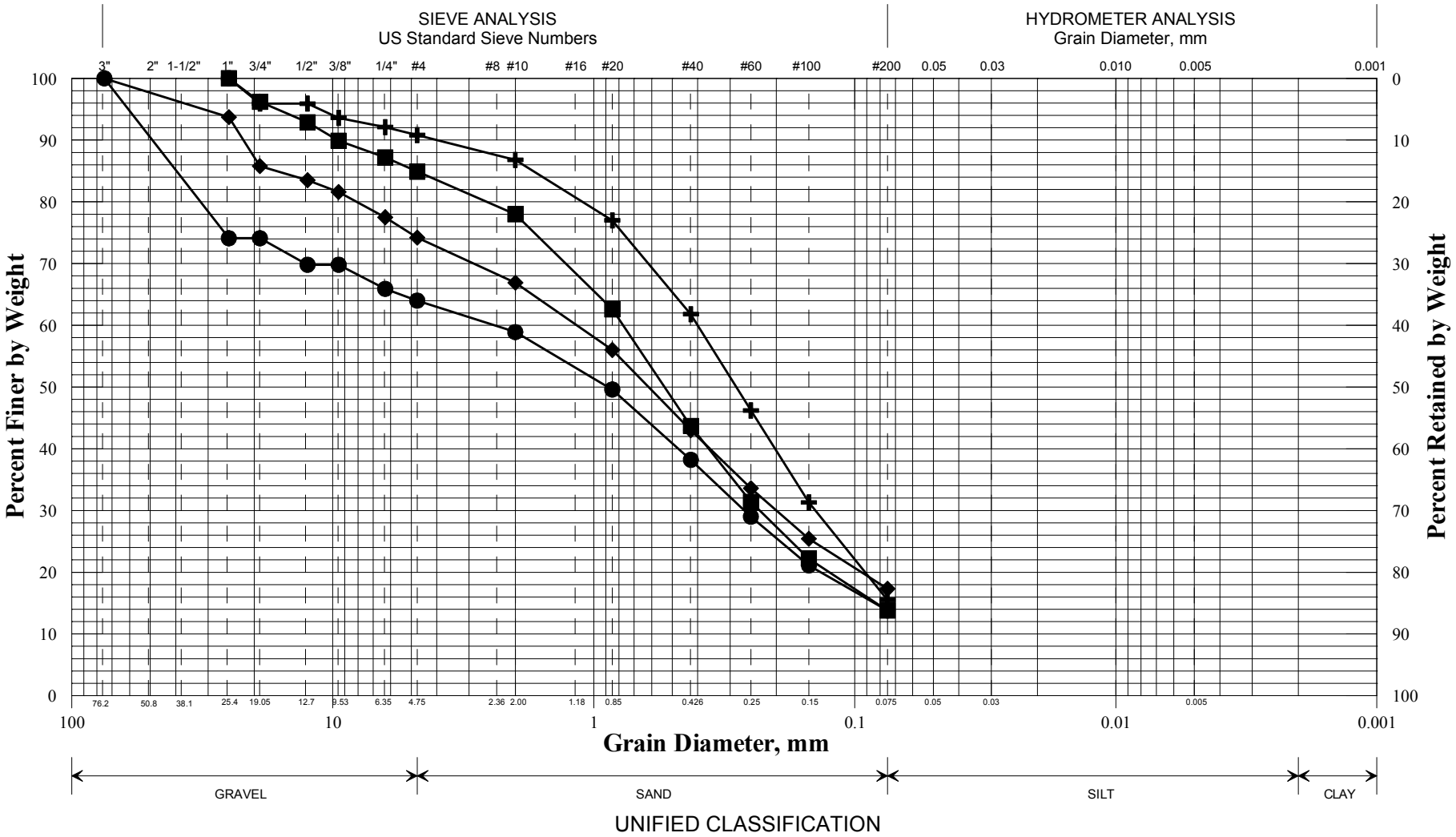
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-LSSR-101/1D	9+00.9	6.1 LT	0.0-1.1	Gravelly SAND, trace silt.	9.4			
◆	BB-LSSR-102/1D	9+01.7	5.5 RT	0.0-2.0	SAND, some gravel, trace silt.	8.7			
■									
●									
▲									
✖									

WIN
018232.00
Town
Standish
Reported by/Date
WHITE, TERRY A 10/8/2013

SHEET 1

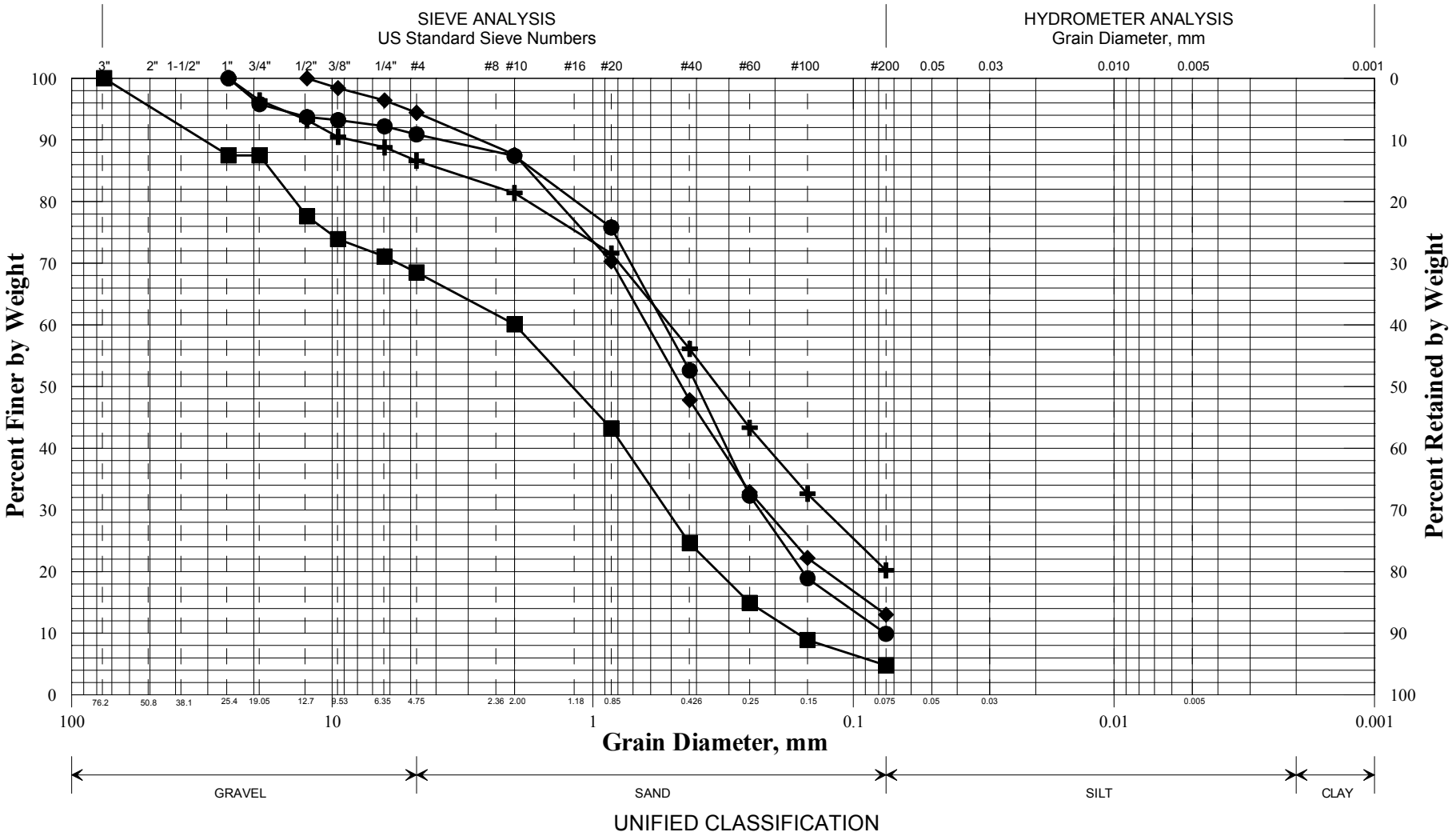
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-LSSR-103/1D	11+14.8	8.0 LT	1.5-3.5	SAND, little silt, trace gravel.	4.3			
◆	BB-LSSR-103/2D	11+14.8	8.0 LT	5.0-7.0	SAND, some gravel, little silt.	8.1			
■	BB-LSSR-103/3D	11+14.8	8.0 LT	10.0-12.0	SAND, little gravel, little silt.	9.9			
●	BB-LSSR-103/4D	11+14.8	8.0 LT	14.0-15.8	Gravelly SAND, little silt.	10.8			
▲									
✖									

WIN
018232.00
Town
Standish
Reported by/Date
WHITE, TERRY A 10/8/2013

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

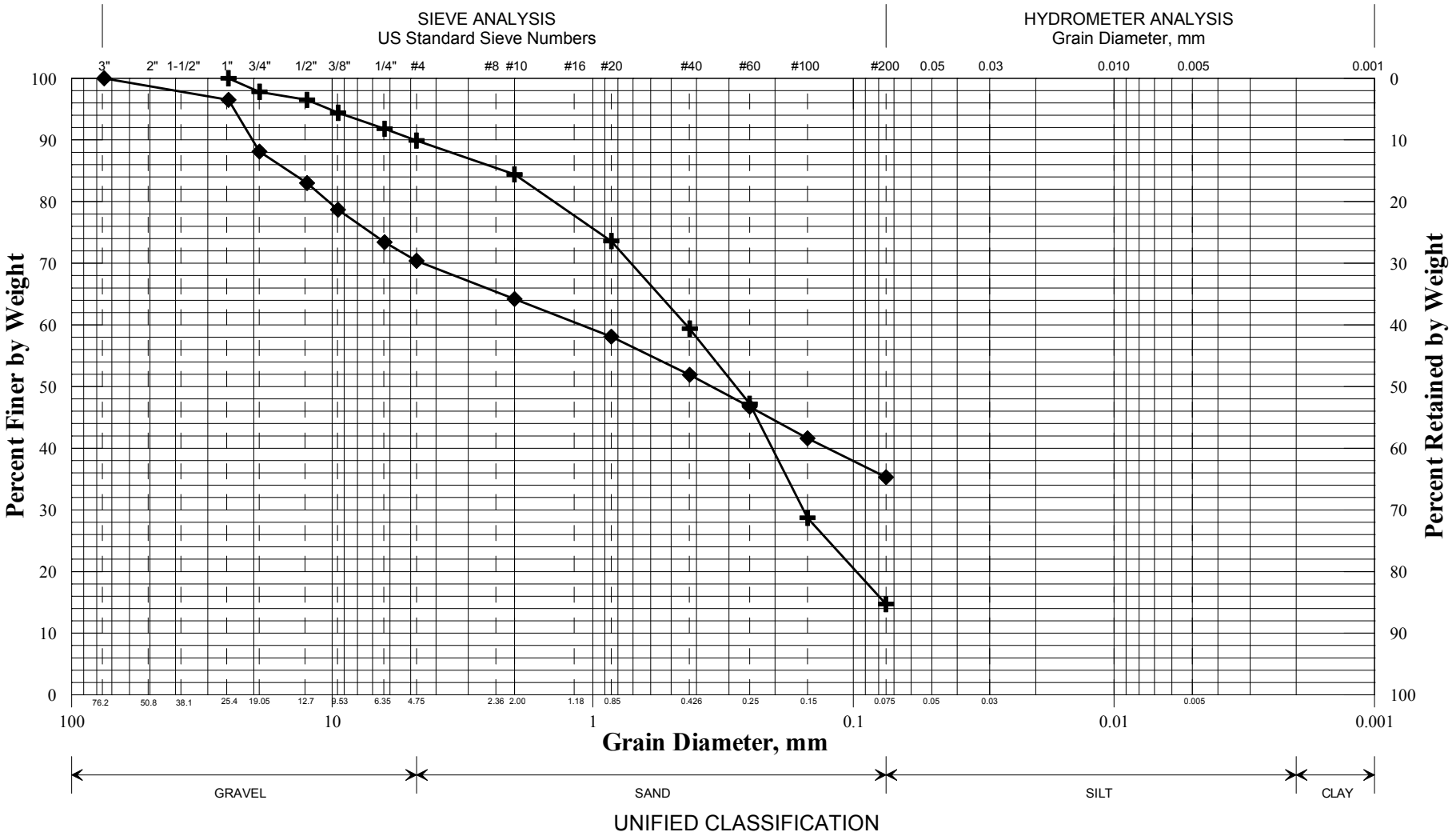


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-LSSR-104/1D	11+21.8	7.0 RT	5.0-7.0	SAND, little silt, little gravel.	7.3			
◆	BB-LSSR-104/2D	11+21.8	7.0 RT	10.0-12.0	SAND, little silt, trace gravel.	9.5			
■	BB-LSSR-104/3D	11+21.8	7.0 RT	15.0-17.0	SAND, some gravel, trace silt.	17.1			
●	BB-LSSR-104/4D	11+21.8	7.0 RT	20.0-21.7.	SAND, trace silt, trace gravel.	16.3			
▲									
✖									

WIN
018232.00
Town
Standish
Reported by/Date
WHITE, TERRY A 10/8/2013

SHEET 3

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-LSSR-105/1D	11+53.8	7.0 RT	5.0-7.0	SAND, little silt, trace gravel.	11.4			
◆	BB-LSSR-105/2D	11+53.8	7.0 RT	10.0-12.0	SAND, some silt, some gravel.	10.0			
■									
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▲									
✖									

WIN
018232.00
Town
Standish
Reported by/Date
WHITE, TERRY A 10/8/2013

Appendix C

Calculations

Earth Pressure:

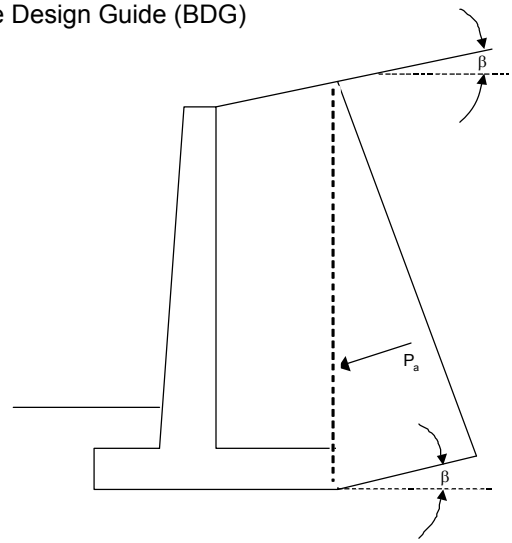
Active Earth Pressure - Rankine Theory
from MaineDOT Bridge Design Guide Section 3.6.5.2 pg 3-7

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

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

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

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



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

For cantilever walls with sloped backfill surface:

β = Angel of fill slope to the horizontal

$\beta := 0 \cdot deg$ assume horizontal backfill surface

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

$K_{a\_rankine\_slope} = 0.31$

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

At-Rest Earth Pressure
from Principles of Foundation Engineering, BM Das, 4th Edition
Eq. 6.3

$K_o := 1 - \sin(\phi_{type4})$ $K_o = 0.47$

<u>Active Earth Pressure</u> - Coulomb Theory
from MaineDOT Bridge Design Guide Section 3.6.5.2 pg 3-5

For cases where the backface of the wall interferes with the development of a full sliding surface in the backfill use Coulomb Theory.

- Coulomb Theory applies for gravity, semi-gravity, and prefab modular walls with steep back faces
- Coulomb Theory applies to concrete cantilever wall with short heels where the sliding surface is restricted by the top of the wall - the wedge of soil does not move.
- Inter face friction is considered in Coulomb Theory

Angle of backface of wall to the horizontal: $\alpha := 90 \cdot deg$

Choosing Friction Angle between fill and wall:

i.) From LRFD Table 3.11.5.3-1 range from 17 to 22 - choose δ = 20 degrees
ii.) From MaineDOT BDG Table 3-3 δ = 24 degrees
iii.) From LRFD Figure C3.11.5.3-1 - δ = 1/3 to 2/3 * Internal Friction Angle = 21.33 degrees

Use Friction Angle between fill and wall = $\delta := 20 \cdot deg$

β = Angel of fill slope to the horizontal $\beta := 0 \cdot deg$

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

$$K_{a\_coulomb} := \frac{\sin(\alpha + \phi_{type4})^2}{\sin(\alpha)^2 \cdot \sin(\alpha - \delta) \cdot \left(1 + \sqrt{\frac{\sin(\phi_{type4} + \delta) \cdot \sin(\phi_{type4} - \beta)}{\sin(\alpha - \delta) \cdot \sin(\beta + \alpha)}}\right)^2}$$

$K_{a\_coulomb} = 0.28$

Orientation of Coulomb Pa :

- In the case of gravity shaped walls and prefab walls - Pa is oriented δ degrees up from a perpendicular line to the backface.
- In the case of short heeled cantilever walls where the top of the wall interferes with the failure surface - Pa is oriented at an angle of 1/3 to 2/3 Φ to the normal of a vertical line extending up from the heel of the wall.

Bearing Resistance for Abutments, Wingwalls and Cast-in-Place Retaining Wall on Bedrock:

SERVICE LIMIT STATE

Presumptive Bearing Resistance for Service Limit State ONLY

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

For Broken Rock of any kind:

Type of Bearing Material: Weathered or broken rock of any kind

Consistency In Place: medium hard rock

Bearing Resistance: Ordinary Range (ksf) 16 to 24

Recommended Value of Use: 20 ksf

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

$q_{factored\_bc} := 20 \cdot ksf$

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

STRENGTH LIMIT STATE

Determine Bearing Resistance using RMR Method

From AASHTO LRFD Bridge Design Specifications
Section 10.4.6.4 Rock Mass Strength

Bedrock at the site is Pegmatite,Schist and Granofels which was found to be "fair to excellent" in quality.
RQD ranged from 55 to 100%. (Average 81% - good)

Determine RMR from Table 10.4.6.4-1 Geomechanics Classification of Rock Mass

From AASHTO - RMR is determined as the sum of the five relative ratings listed in Table 10.4.6.4-1

1. Strength of intact rock

From Standard Specifications for Highway Bridges 17th Edition - 2002
Table 4.4.8.1.2B uniaxial compressive strength for Granite = 2,100 to 49,000 psi = 300 to 7,000 ksf

Use: $q_u := 2000 \cdot ksf$ $q_u = 13889 \cdot psi$

From Table 10.4.6.4.-1:
For Uniaxial Compressive Strength = 1080 to 2160 ksf: Relative Rating = 7

2. Drill Core Quality

Bedrock RQD = Average 81% (good) From Table 10.4.6.4.-1: RQD 75% to 90%: Relative Rating = 17

3. Spacing of joints

Assume Spacing of 2 inches to 1 foot From Table 10.4.6.4.-1: Relative Rating = 10

4. Condition of joints

Assume slightly rough surfaces <0.05 in, hard joint wall rock From Table 10.4.6.4.-1: Relative Rating = 20

5. Groundwater conditions

General Conditions = Water under moderate pressure From Table 10.4.6.4.-1: Relative Rating = 4

Raw RMR = 58

Adjustment to RMR for joint Orientations from Table 10.4.6.4-2

Assume Strike and Dip Orientations of Joints = Fair For Foundations: Rating = -7

Adjusted RMR = 51 $RMR := 51$

Determine Rock Mass Class from Adjusted RMR Rating

For Adjusted RMR = 51 From LRFD Table 10.4.6.4.-3: Class No. = III - Fair Rock

Determine Rock Type from LRFD Table 10.4.6.4.-4

Rock Type E - Granite

Determine Rock Property constants *m* and *s:*

Reference: The Hoek and Brown Failure Criterion - a 1988 Update,
15th Canadian Rock Mechanics Symposium

m/m_i= exp ((RMR-100)/14) Eq 18 - for disturbed rock masses

where m_i = m for intact rock $m_i := 25$ From LRFD Table 10.4.6.4-4

$$m_{Efair} := m_i \cdot \exp\left(\frac{RMR - 100}{14}\right) \qquad m_{Efair} = 0.755$$

s = exp ((RMR-100)/6) Eq 19 - for disturbed rock masses

$$s_{Efair} := \exp\left(\frac{RMR - 100}{6}\right) \qquad s_{Efair} = 0.00028$$

<u>Determine nominal and factored bearing resistance of Bedrock:</u>

Foundation Shape correction factor:

$C_{f1} := 1.0$ From Foundations on Rock, Wyllie, Table 5.4 pg 138

Uniaxial Compressive Strength - Granite

$$q_{uc} := \begin{pmatrix} 2100 \\ 4000 \\ 14000 \\ 49000 \end{pmatrix} \cdot psi$$

Upper and lower bounds from from Standard Specifications for Highway Bridges 17th Edition - 2002 Table 4.4.8.1.2B

Determine Nominal Bearing Resistance:

From Foundations on Rock, Wyllie, Table 5.4 pg 138

$$q_{nom} := C_{f1} \cdot \sqrt{s_{Efair}} \cdot q_{uc} \cdot \left[1 + \sqrt{m_{Efair} \cdot \left(s_{Efair}^{\frac{-1}{2}}\right) + 1}\right] \qquad q_{nom} = \begin{pmatrix} 40 \\ 75 \\ 264 \\ 924 \end{pmatrix} \cdot ksf$$

Determine Factored Bearing Resistance at the Strength Limit State:

From Table 10.5.5.2.2-1 Resistance factor for footing on rock $\phi_b := 0.45$

The factored resistance $q_R = \phi_b \times q_n$ equation 10.6.3.1.1-1 AASHTO LRFD

$$q_R := \phi_b \cdot q_{nom} \qquad q_R = \begin{pmatrix} 18 \\ 34 \\ 119 \\ 416 \end{pmatrix} \cdot ksf$$

Recommend 34 ksf for Strength Limit State

Determine Factored Bearing Resistance at the Extreme Limit State:

Use a bearing resistance factor of 0.8 for Extreme Limit State for gravity and semigravity walls per LRFD Article C11.5.8. Use for piers for consistency with the theory of preventing collapse for the Extreme Event.

Resistance factor - $\phi_{bc} := 0.8$

$$q_{rEE} := \phi_{bc} \cdot q_{nom} \qquad q_{rEE} = \begin{pmatrix} 32 \\ 60 \\ 211 \\ 739 \end{pmatrix} \cdot ksf$$

For Gravity and Semigravity Walls

Recommend 60 ksf for Extreme Limit State

Resistance factor - $\phi_{bc} := 1.0$

$$q_{rEE} := \phi_{bc} \cdot q_{nom} \qquad q_{rEE} = \begin{pmatrix} 40 \\ 75 \\ 264 \\ 924 \end{pmatrix} \cdot ksf$$

For Cantilever Type Abutments and Retaining Walls

Recommend 75 ksf for Extreme Limit State

Frost Protection:

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

From the Design Freezing Index Map:
Limington/Standish, Maine
DFI = 1320 degree-days

From the lab testing: soils are coarse grained with a water content = ~10%

From Table 5-1 MaineDOT BDG for Design Freezing Index of 1320 and wc =10%
Frost Penetration = 76.9 inches (by interpolation)

$Frost\_depth := 76.9in$ $\quad$ $Frost\_depth = 6.4 \cdot ft$

Method 2 - Check Frost Depth using Modberg Software

Closest Station is West Buxton

ModBerg Results

Project Location: West Buxton 2 NNW, Maine

Air Design Freezing Index	=	1492 F-days
N-Factor	=	0.80
Surface Design Freezing Index	=	1194 F-days
Mean Annual Temperature	=	43.9 deg F
Design Length of Freezing Season	=	132 days

Layer #:Type	t	w%	d	Cf	Cu	Kf	Ku	L
1-Coarse	69.2	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 = 5.77 ft = 69.2 in.
****

$Frost\_depth_{modberg} := 69.2 \cdot in$

$Frost\_depth_{modberg} = 5.767 \cdot ft$ $\quad$ Use Frost Depth = 6.0 feet for design

Seismic:

18232.00 Limington - Standish Steep Falls Bridge

LIMINGTON:

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
State - Maine
Zip Code - 04049
Zip Code Latitude = 43.701900
Zip Code Longitude = -070.660000
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.098	PGA - Site Class B
0.2	0.190	Ss - Site Class B
1.0	0.047	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
State - Maine
Zip Code - 04049
Zip Code Latitude = 43.701900
Zip Code Longitude = -070.660000
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.098	As - Site Class B
0.2	0.190	SDs - Site Class B
1.0	0.047	SD1 - Site Class B

18232.00 Limington - Standish Steep Falls Bridge

STANDISH:

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
State - Maine
Zip Code - 04084
Zip Code Latitude = 43.787000
Zip Code Longitude = -070.547600
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.095	PGA - Site Class B
0.2	0.186	Ss - Site Class B
1.0	0.047	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
State - Maine
Zip Code - 04084
Zip Code Latitude = 43.787000
Zip Code Longitude = -070.547600
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.095	As - Site Class B
0.2	0.186	SDs - Site Class B
1.0	0.047	SD1 - Site Class B

Seismic Design Parameters for
2007 AASHTO Seismic Design Guidelines

Purpose - The ground motion parameters obtained in this analysis are for use with the design procedures described in AASHTO Guidelines for the Seismic Design of Highway Bridges (2007) The user may calculate seismic design parameters and response spectra (both for period and displacement), for Site Class A through E.

Description - This program allows the user to obtain seismic design parameters for sites in the 50 states of the United States, Puerto Rico and the U.S. Virgin Islands. In most cases the user may perform an analysis for a site by specifying location by either latitude-longitude (recommended) or zip code. However, locations in Puerto and the Virgin Islands may only be specified by latitude-longitude.

Ground motion maps are included in PDF format. These maps may be opened using a map viewer that is part of the software package.

Data - The 2007 AASHTO maps are based on 5% in 50 year probabilistic data from the U.S. Geological Survey data sets for the following regions: 48 conterminous states (2002), Alaska (2006), Hawaii (1998), Puerto Rico and the Virgin Islands (2003). These were the most recent data available at the time of preparation of the AASHTO maps. The AASHTO maps are labelled with a probability of exceedance of 7% in 75 years which is approximately equal to the 5% in 50 year data.

Disclaimer - Correct application of the data obtained from the use of this program and/or maps is the responsibility of the user. This software is not a substitute for technical knowledge of seismic design and/or analysis.