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BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE**

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

**EDDY FLATS BRIDGE
US ROUTE 302 OVER THE SACO RIVER OVERFLOW
FRYEBURG, MAINE**

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1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and provide geotechnical design recommendations for the replacement of Eddy Flats Bridge which carries US Route 302 over the Saco River Overflow in Fryeburg, Maine. This report presents the subsurface information obtained at the site during the subsurface investigations, geotechnical recommendations, and geotechnical design parameters for the design of the new substructures.

The existing Eddy Flats Bridge is a 33-foot long, single span bridge built in 1931. The existing bridge is skewed 45 degrees. The superstructure consists of a concrete slab and the substructures consist of mass concrete abutments and wingwalls supported on timber piles. The 2017 Maine Department of Transportation (MaineDOT) Bridge Inspection Report rates the superstructure and substructures as poor and fair condition, respectively. There is heavy scaling beneath the flow line at the northwest wingwall, minor cracking and staining damage at the breast walls of the abutments, and the Abutment No. 1 footing is exposed approximately 35 percent of its length. There is also active scour damage evidence along the abutment footings. The existing bridge has a Federal Highway Administration sufficiency rating of 32.6 and is classified as structurally deficient.

The proposed replacement bridge will be a 58-foot single span integral bridge consisting of precast concrete NEXT F double tee beams on pile-supported integral abutments. The proposed vertical alignment will require a raise in the profile grade on the order of 5 feet. The proposed bridge alignment will be shifted 5 feet upstream (to the north) resulting in significant new fills on the left side of each bridge approach. The existing abutments will be removed and approaches widened and reconstructed with 1H:2V (horizontal:vertical) riprap slopes.

The bridge replacement will be completed by using staged construction. Traffic will first be shifted to the south side of the existing bridge and the north side replaced. Then traffic will be shifted to onto the newly constructed north side, and the south side demolished and reconstructed.

2.0 GEOLOGIC SETTING

The existing structure carries US Route 302 over Saco River Overflow as shown on Sheet 1 – Location Map.

The Maine Geological Survey (MGS) Surficial Geology Map of the Fryeburg Quadrangle, Maine, Open-file No. 14-29 (2014), indicates the surficial soils in the vicinity of the bridge project consist of stream alluvium deposits. This unit consists of sand, silt, gravel, and organic material deposited on the flood plains of modern streams. The unit includes large swampy areas on the Saco River floodplain near the project site. Glacial lacustrine deposits associated with Lake Pigwacket are also mapped in the area. These deposits consist of silt, clay, and sand which were deposited during late-glacial to postglacial time.

The Bedrock Geology Map of Maine, MGS (1985), cites the bedrock as intrusive Carboniferous muscovite-biotite granite.

3.0 SUBSURFACE INVESTIGATION

Seven test borings were drilled at the site. Borings BB-FSRO-101, BB-FSRO-101A and BB-FSRO-101B were drilled behind the existing west abutment and BB-FSRO-102 was drilled behind south abutment. Borings BB-FSRO-201, BB-FSRO-202 and BB-FSRO-203 were drilled in the shoulder of the eastbound lane of Route 302 along the western bridge approach to determine subsurface conditions for a possible retaining wall.

The MaineDOT Drill Crew drilled the 100-series test borings in March and April 2011. 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 Sheets 4 and 5 – Boring Logs.

The 200-series borings were drilled by GZA GeoEnvironmental, Inc., (GZA) in March 2018. A summary of the subsurface conditions encountered in the 200-series borings is provided in Appendix D.

Borings were performed by using a combination of solid stem auger, cased wash boring and rock coring techniques. Soil samples were typically obtained in 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6-inch interval of penetration are recorded. The sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated per ASTM D4633 “Standard Test Method for Energy Measurement for Dynamic Penetrometers” prior to the test borings in March and April 2011. All N-values discussed in this report are corrected values computed by applying an average energy transfer of 0.840 for both borings. The hammer efficiency factor (0.840) and both the raw field N-value and corrected N-value (N_{60}) are shown on the boring logs.

Bedrock was cored using an NQ-2” core barrel and the Rock Quality Designation (RQD) of the core calculated. A Northeast Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions encountered. The MaineDOT geotechnical engineer selected the boring location and drilling methods, designated type and depth of sampling techniques, reviewed boring log and identified field testing requirements. The borings were located in the field using taped measurements at the completion of the drilling program.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected soil samples recovered from the test borings to assist in soil classification, evaluation of engineering properties of the soils, and geologic assessment of the project site. Laboratory testing consisted of: nineteen (19)

standard grain size analyses with natural water contents, and eleven (11) standard grain size analyses with hydrometer and natural water contents. The results of soil tests are included as Appendix B – Laboratory Test Results. Moisture content information and other soil test results are also shown on the boring logs provided in Appendix A – Boring Logs.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test borings generally consisted of miscellaneous fill, underlain by stream alluvium, glaciolacustrine deposits, and glacial till, all underlain by igneous bedrock. The boring logs are provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs. A generalized subsurface profile is shown on Sheet 3 – Interpretive Subsurface Profile and Sheet 4 – Interpretive Subsurface Profile (11.0 feet Rt). The following paragraphs discuss the general subsurface conditions encountered:

5.1 Miscellaneous Fill

A layer of fill was encountered in the borings. The thickness of the fill unit encountered ranged from approximately 13 to 22 feet thick and generally consisted of:

- Dark brown-black, moist, fine gravelly medium sand, trace silt, trace pavement;
- Brown, moist to wet, fine to medium sand, trace to some gravel, trace to little silt;
- Brown/tan to dark brown/tan, dry to moist, sand, little to some gravel, trace silt, trace asphalt;
- Grey, wet, sand, little silt;
- Cobbles and boulders;
- Timber cribbing.

Cobbles and boulders were encountered in BB-FSRO-101 from 7.5 to 10.0 feet below the ground surface (bgs) and in BB-FSRO-101A from 7.2 to 10.1 feet bgs. These two borings were terminated on boulders or the existing abutment and broken steel casing was abandoned in each borehole. Frequent boulders and cobbles were also encountered in the fill layers in borings BB-FSRO-101B, BB-FSRO-201 and BB-FSRO-202. Wood cribbing was encountered in BB-FSRO-202 from 17.4 to 19.7 and 20.0 to 22.5 feet bgs.

SPT N₆₀-values in the fill unit ranged from 7 to 70 blows per foot (bpf), indicating the fill is loose to very dense in consistency. Four grain size analyses of samples from the fill unit resulted in soil classifications of A-1-a, A-1-b, under the AASHTO Soil Classification System and SW, SW-SM and SP-SM under the Unified Soil Classification System (USCS). The natural water content of the samples tested ranged from approximately 2 to 14 percent.

5.2 Stream Alluvium

Stream alluvium was encountered beneath the fill unit in the borings. The thickness of the alluvium was approximately 23 to 42 feet thick in those borings that fully penetrated the deposit. The alluvium encountered generally consisted of:

- Olive-brown or grey, wet, silty fine sand, trace fine gravel;
- Brown, wet, sand, trace fine gravel, trace silt;
- Brown, orange/brown, or grey, wet, fine to medium sand, trace to some silt, trace gravel;
- Grey, wet, sand, little to some silt, trace to little gravel;
- Grey, wet, clayey silt, little fine sand;
- Tan/grey, wet, sand, little silt, with organic odor.

SPT N_{60} -values in the alluvium deposit ranged from 4 to 17 bpf indicating that the stream alluvium is very loose to medium dense in consistency. Nine grain size analyses conducted on samples from the alluvium deposit resulted in classifications of A-1-b, A-3 and A-4 under the AASHTO Soil Classification System and SW-SM, SP, SP-SM and SM under the USCS. The natural moisture content of the samples tested ranged from approximately 21 to 34 percent.

5.3 Glaciolacustrine Deposit

Glacial lake bottom (glaciolacustrine) deposits were encountered beneath the stream alluvium in two borings. The thickness of the deposit encountered ranged from approximately 14 to 29 feet. The deposit generally consisted of:

- Grey, wet, silt, trace to some clay, trace to some fine sand.

SPT N_{60} -values ranged from 1 to 17 bpf indicating that the silt is very soft to very stiff in consistency. Six grain size analyses conducted resulted in the soils being classified as A-4 under the AASHTO Soil Classification System and CL, ML and CL-ML under the USCS. The moisture contents of the samples tested ranged from approximately 34 to 48 percent.

5.4 Glacial Till

A deposit of glacial till was encountered beneath the alluvium in boring BB-FSRO-201 and the glaciolacustrine deposit in borings BB-FSRO-101B and BB-FSRO-102. The thickness of the deposit encountered ranged from approximately 9 to 39 feet. The deposit generally consisted of:

- Grey, wet, fine sandy gravel, trace silt;
- Grey, wet, sand, trace to some gravel, trace to some silt;
- Grey, wet, fine sandy silt, trace fine gravel, trace clay;
- Grey, wet, silt, little to some clay, trace to some fine sand, trace gravel;
- Grey, wet, silty clay, little coarse sand, trace gravel;
- Cobbles and boulders.

SPT N_{60} -values in the coarse-grained and cohesive till subunits ranged from 4 to 119 bpf indicating that the deposit is loose/soft to very dense/hard in consistency. Eleven grain size

analyses were conducted and resulted in the soils being classified as A-1-a, A-1-b, A-2-4 and A-4 under the AASHTO Classification System and GW-GM, SW-SM, SM and SC-SM, CL, and CL-ML under the USCS. The moisture contents of the samples tested ranged from approximately 9 to 25 percent.

5.5 Bedrock

Bedrock was encountered and cored in the borings. Table 1 summarizes approximate depth to bedrock, corresponding approximate top of the bedrock elevation, and RQD.

Boring	Station	Offset (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock Surface (feet)	RQD R1, R2 (%)
BB-FSRO-101B	299 + 23.2	3.4 L	110.9	266.6	88, 95
BB-FSRO-102	299 + 61.2	12.7 L	114.4	263.6	85, 90

Table 1 – Summary of Approximate Bedrock Depths and Elevations

Bedrock descriptions of the bedrock core obtained were not recorded. The bedrock mapped at the site is granite.

5.6 Groundwater

Groundwater was observed in the borings ranging from 7.8 to 13.0 feet bgs during the subsurface investigations. Note that water was introduced into the borehole during drilling operations. Groundwater levels will fluctuate with seasonal changes, precipitation, runoff, river levels, and construction activities.

6.0 FOUNDATION ALTERNATIVES

The Preliminary Design Report (PDR) considered steel girders, prestressed concrete NEXT F beams, voided slabs and a precast concrete arch for superstructure alternatives. The superstructure alternatives were evaluated in conjunction with pile-supported integral abutments or, in the case of the arch, a traditional pile-supported footing. Considering the higher cost of the concrete arch and voided slab alternatives, the proximity of high water relative to the steel option, and the ease of constructing NEXT F beams, precast concrete NEXT F tee beams on H-pile supported integral abutments is the preferred bridge alternative.

7.0 GEOTECHNICAL DESIGN CONSIDERATIONS AND RECOMMENDATIONS

The following sections provide geotechnical design considerations and recommendations for H-pile supported integral bridge abutments, which are the proposed substructures for the Eddy Flats Bridge replacement project.

7.1 Integral Abutment H-Piles

Abutments No. 1 and No. 2 will be integral abutments founded on a single row of driven H-piles. The piles shall be end bearing on or within bedrock and driven to the required resistances. Piles will be HP 14x89. H-piles shall be 50 ksi, Grade A572 steel. Piles shall be driven with pile points conforming to MaineDOT Standard Specification 711.10 to protect pile tips and improve penetration.

Pile lengths at the proposed abutments may be estimated based on Table 2.

Location	Approximate Bottom Elevation of Proposed Abutment (feet)	Approximate Top of Bedrock Elevation (feet)	Estimated Pile Lengths with 2-ft embedment in pile cap (feet)
Abutment No. 1	372	266.6	108
Abutment No. 2	372	263.6	111

Table 2 – Estimated Pile Lengths for Integral Abutments No. 1 and No. 2

The estimated pile lengths in Table 2 do not take into account locations where bedrock may be deeper or shallower than that encountered in the test borings, damaged pile, the additional five feet of pile required for dynamic testing instrumentation (per ASTM D4945), or additional pile length needed to accommodate leads and driving equipment.

7.1.1 Strength Limit State Design

The design of pile foundations bearing on bedrock at the strength limit state shall consider;

- compressive axial geotechnical resistance of individual piles bearing on bedrock,
- drivability resistance of individual piles driven to bedrock,
- structural resistance of individual piles in axial compression, and
- structural resistance of individual piles in combined axial loading and flexure.

The pile groups should be designed to resist all lateral earth loads, vehicular loads, dead and live loads, and lateral forces transferred through the pile caps. The pile group resistance after

scour due to the design flood shall provide adequate foundation resistance using the resistance factors given in this section.

Per AASHTO LRFD Bridge Design Specifications 7th Edition with interim revisions through 2016 (LRFD) Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c = 0.50$ (severe driving conditions) shall be applied to the structural compressive resistance of the pile. Since the H-piles will be subjected to lateral loading, the piles shall also be checked for resistance against combined axial compression and flexure as prescribed in LRFD Articles 6.9.2.2 and 6.15.2. This design axial load may govern the design. Per LRFD Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c = 0.70$ and the flexural resistance factor $\phi_f = 1.0$ shall be applied to the combined axial and flexural resistance of the pile in the interaction equation (LRFD Eq. 6.9.2.2-1 or -2). H-piles shall also be analyzed for fixity using LPILE® v2016 (LPILE) software, or similar.

Structural Resistance. The nominal axial compressive structural resistance (P_n) for piles loaded in compression shall be as specified in LRFD Article 6.9.4.1. Preliminary estimates of the structural axial resistance of a HP 14x89 HP was calculated. The resistance shown in Table 3 is for the lower braced pile segment, using a resistance factor, $\phi_c = 0.50$ for severe driving conditions and an assumed effective length factor (K). Supporting calculations are provided in Appendix C – Calculations.

Factored structural resistances should be calculated for upper and lower unbraced segments based on LPILE results using a resistance factor $\phi_c = 0.70$, for combined axial loading and bending. This is the responsibility of the structural engineer.

Geotechnical Resistance. The nominal axial geotechnical resistance in the strength limit state was calculated using the guidance in LRFD Article 10.7.3.2.1 which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the structural pile resistances obtained from LRFD Article 6.9.4.1 with a resistance factor ϕ_c , of 0.50, for severe driving conditions applied. The resulting limiting factored geotechnical compressive resistance for piles driven to rock are provided in Table 3.

Drivability Analyses. Drivability analyses were performed to determine the pile resistance that might be achieved considering available diesel hammers. The maximum driving stress in the pile, assuming the use of 50 ksi steel, shall be less than 45 ksi. The drivability resistance was calculated using the resistance factor, ϕ_{dyn} , of 0.65, for a single pile in axial compression when a dynamic test is performed as specified in LRFD Table 10.5.5.2.3-1.

A summary of the calculated factored axial compressive structural, geotechnical, and drivability resistances of a 14x89 H-pile section for the strength limit state are provided in Table 3. Supporting calculations are provided in Appendix C – Calculations.

Pile Section	Strength Limit State Factored Axial Pile Resistance			
	Structural Resistance ¹ $\phi_c=0.50$ (kips)	Controlling Geotechnical Resistance ² (kips)	Drivability Resistance ³ $\phi_{dyn} = 0.65$ (kips)	Governing Axial Pile Resistance (kips)
HP 14 x 89	652	652	384 (559) ⁴	384 (559) ⁵

Table 3 – Factored Axial Compressive Resistances for H-Piles at Strength Limit States

LRFD Article 10.7.3.2.3 states that the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance with a resistance factor for severe driving conditions applied. However, for the site conditions, the estimated factored axial pile resistances from the drivability analyses for the H-pile section evaluated are less than the controlling factored axial structural resistance per LRFD Article 10.7.3.2.3. Local experience also supports the estimated factored resistances from the drivability analyses. Therefore, drivability controls and the recommended governing resistance for pile design is the resistance provided in the rightmost column “Governing Axial Pile Resistance (kips)” in Table 3. The maximum applied factored axial pile load should not exceed the governing factored axial pile resistance shown in Table 3 above.

7.1.2 Service and Extreme Limit State Design

The design of H-piles at the service limit state shall consider tolerable transverse and longitudinal movement of the piles and pile group movements/stability considering changes in soil conditions due to scour due to the design flood (Q_{100}). For the service limit state, resistance factors of $\phi = 1.0$ should be used in accordance with LRFD Article 10.5.5.1. The exception is the overall global stability of the foundation which should be investigated at the Service I load combination and a resistance factor, ϕ , of 0.65.

Extreme limit state design checks for the H-piles shall include pile axial compressive resistance, overall global stability of the pile group, pile failure by uplift in tension, and

¹ Structural resistances were calculated for a braced pile segment in pure axial compression, using a resistance factor, ϕ_c , for severe driving conditions. Factored structural resistances should be calculated for upper and lower unbraced pile segments based upon L-Pile results using a resistance factor of $\phi_c = 0.70$ for combined axial loading and bending. These resistances may be the controlling values.

² Based on guidance in LRFD Article 10.7.3.2.3., *Piles Driven to Hard Rock*.

³ The drivability resistances were calculated using the resistance factor, ϕ_{dyn} , of 0.65, for a single pile in axial compression when a dynamic test is performed as specified in LRFD Table 10.5.5.2.3-1.

⁴ Driving resistance is for Delmag 19-32 hammer and 2.7 kip helmet; driving resistance in parentheses is for Delmag 36-32 with 3.20 kip helmet.

structural failure. The extreme event load combinations are those related to seismic forces, ice loads, debris loads, and certain hydraulic events. Extreme limit state design shall also check that the nominal pile foundation resistance remaining after scour due to the check flood (Q_{500}) can support the extreme limit state loads. Resistance factors for extreme limit states, per LRFD Article 10.5.5.3, shall be taken as $\phi = 1.0$ with the exception of uplift of piles, for which the resistance factor, ϕ_{up} , shall be 0.80 or less per LRFD Article 10.5.5.3.2.

The nominal axial geotechnical pile resistance at the service and extreme limit state was calculated using the guidance in LRFD Article 10.7.3.2.3. The calculated factored axial structural, geotechnical, and drivability resistances of an HP 14x98 section for the extreme and service limit states are provided in Table 4. Supporting documentation is provided in Appendix C – Calculations.

Pile Section	Service and Extreme Limit State Factored Axial Pile Resistance			
	Structural Resistance ⁵ $\phi_c=1.0$ (kips)	Controlling Geotechnical Resistance ⁶ $\phi=1.0$ (kips)	Drivability Resistance $\phi=1.0$ (kips)	Governing Axial Pile Resistance (kips)
HP 14 x 89	1305	1305	590 (860) ⁸	590 (860) ⁷

Table 4 – Factored Axial Compressive Resistances for H-Piles at Service and Extreme Limit States

LRFD Article 10.7.3.2.3 states that the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance with a resistance factor for severe driving conditions applied. However, the estimated factored axial pile resistance from the drivability analyses for the H-pile section evaluated is less than the controlling factored axial structural resistance per LRFD Article 10.7.3.2.3 and the nominal structural resistance. Therefore, drivability controls, and the recommended governing resistance for pile design is the resistance provided in the rightmost column “Governing Axial Pile Resistance (kips)” in Table 4. The maximum applied factored axial pile load for the extreme and service limit states should not exceed the governing factored pile resistance shown in Table 4 above.

⁵ Structural resistances were calculated for a braced pile segment in pure axial compression. Factored structural resistances should be calculated for upper and lower unbraced pile segments upon L-Pile results. These resistances may be the controlling values.

⁶ Nominal pile axial compressive resistance calculated per guidance in LRFD Article 10.7.3.2.3. *Piles Driven to Hard Rock*.

⁷ Driving resistance is for Delmag 19-32 hammer and 2.70 kip helmet; driving resistance in parentheses is for Delmag 36-32 with 3.20 kip helmet.

7.1.3 Lateral Pile Resistance/Behavior

In accordance with LRFD Article 6.15.1, the structural analysis of pile groups subjected to lateral loads shall include explicit consideration of soil-structure interaction effects as specified in LRFD Article 10.7.3.9. Assumptions regarding a fixed or pinned condition at the pile tip should be also confirmed with soil-structure interaction analyses.

A series of lateral pile resistance analyses were performed to evaluate pile behavior at both abutments using LPILE with pile head deflections, moments, and axial loads supplied by the structural engineer. The results of the LPILE analyses for a 14x89 section (the pile section selected for final design) were provided to the structural designer to evaluate the associated pile stresses, bending moments, and fixity due to factored pile head loads and displacements.

The results of the LPILE analyses for the Abutment No. 1 pile section selected for final design are provided in Appendix C – Calculations.

Geotechnical parameters used for generation of soil-resistance (p-y) curves in lateral pile analyses are provided in Table 5. In general, the models developed emulate the soil at the site by using the soil layers (referenced in Table 5 by elevations) and using appropriate structural parameters and pile-head boundary conditions for the pile section being analyzed.

Soil Layer	Approx. Elevation of Soil Layer (feet)	Water Table Condition	Effective Unit Weight (lbs/ft ³)	Horizontal Soil Modulus, k _s (lb/in ³)	ϕ^8 / S _u ⁹ (psf)	ϵ_{50} ¹⁰
Medium dense, SAND (Granular Borrow)	380.0 – 371.0	Above	125	90	32°	
Dense, SAND (Fill)	371.0 – 364.5	Above	125	90	32°	
Very loose, Silty fine SAND	364.5 – 327.0	Below	64	20	29.5°	
Soft, SILT	327.0 – 313.0	Below	67	-	500	0.020
Glacial Till	313.0 – 266.6	Below	88	125	40°	

Table 5 – Soil Parameters for Generation of Soil-Resistance (p-y) Curves

⁸ Internal angle of friction.

⁹ Undrained shear strength.

¹⁰ Strain at 50 percent of the ultimate stress.

7.1.4 Pile Downdrag Loads

Liquefaction analyses were conducted using the Simplified Procedure originally developed by Seed and Idriss (1983). Liquefaction is a phenomenon whereby loose, saturated cohesionless soil deposits lose shear strength in response to cyclic stresses associated with earthquakes. The in-situ alluvial soils present beneath the west and east approach embankments and adjacent to Abutments No. 1 and 2 were judged to be susceptible to liquefaction ($FS < 1$). The temporary loss of soil strength due to liquefaction can result in settlement arising from volume changes, and can initiate downdrag loads on piles. Specific details regarding the methodology and result of the liquefaction susceptibility evaluation are detailed in Section 7.8.2 and Appendix C – Calculations.

Downdrag due to liquefaction was estimated in accordance with NAVFAC DM 7.2 with beta (β) values reduced per Meyerhof (1976) for non-displacement piles and as verified by Sandford (1998)¹¹. The computed downdrag load due to liquefaction is on the order of 119 kips at Abutment No. 1 and 116 kips at Abutment No. 2. Downdrag loads due to liquefaction should be considered in the Extreme Event I Limit State. The depths below the ground surface where liquefaction is likely to occur in the approach embankments, and resulting downdrag loads, are summarized in Table 6.

Location	Elevation of Top of Liquefied Zone	Elevation of Bottom of Liquefied Zone	Downdrag Load per Pile (kips) ¹¹
Abutment No. 1	Elev. 363	El. 327	119
Abutment No. 2	Elev. 363	Elev. 318	116

Table 6 – Zones Susceptible to Liquefaction and Downdrag Load per Pile

7.1.5 Driven Pile Resistance and Pile Quality Control

The contract plans shall require the contractor to perform a wave equation analysis of the proposed pile-hammer system and conduct dynamic pile load tests with signal matching at each abutment. The first pile driven at each abutment should be dynamically tested to confirm nominal pile resistance and verify the stopping criteria developed by the contractor in the wave equation analysis. Restrikes or additional dynamic tests may be required as part of the pile field quality control program should pile behavior vary radically between adjacent piles, should pile behavior indicate a pile is refusing on a boulder or in a cobble layer above

¹¹ Downdrag computed per NAVFAC DM 7.2 with β -values reduced per Meyerhof (1976) for non-displacement piles and confirmed with field testing by Dixon and Sandford, Effects of Bitumen Coating on the Axial and Lateral Loadings of Abutment Piles Subject to Downdrag, (1998)

bedrock, should the pile tip be not firmly embedded in bedrock, or if the pile “walk” out of position.

With this level of quality control, the ultimate resistance that must be achieved in the wave equation analysis and dynamic testing will be the factored axial pile load divided by a resistance factor, ϕ_{dyn} , of 0.65. The maximum factored axial pile load should be shown on the plans.

Piles should be driven to an acceptable penetration resistance as determined by the contractor based on the results of a wave equation analysis and as approved by the Resident. Driving stresses in the pile determined in the drivability analysis shall be less than 45 ksi, in accordance with LRFD Article 10.7.8. A hammer should be selected which provides the required pile resistance when the penetration resistance for the final 3 to 6 inches is 3 to 15 blows per inch (bpi). If an abrupt increase in driving resistance is encountered, the driving may be terminated when the penetration is less than 0.5-inch in 10 consecutive blows.

7.2 Integral Abutment Design

Integral abutment sections shall be designed for all relevant strength, service, and extreme limit states and load combinations specified in LRFD Articles 3.4.1 and 11.5.5. Stub abutments shall be designed to resist all lateral earth loads, vehicular loads, dead and live loads, and lateral forces transferred through the integral superstructure. The design of the integral abutment at the strength limit state shall consider reinforced-concrete structural design.

A resistance factor (ϕ) of 1.0 shall be used to assess abutment design at the service limit state, including: settlement, excessive horizontal movement, and movement resulting after scour due to the design (Q_{100}) flood. The overall stability of the foundation should be investigated at the Service I Load Combination and a resistance factor, ϕ , of 0.65.

Extreme limit state design of integral abutment supported on H-piles shall include pile structural resistance, pile geotechnical resistance, pile resistance in combined axial and flexure, and overall stability. Resistance factors for extreme limit state shall be taken as 1.0. Extreme limit state design shall also check that the nominal foundation resistance remaining after scour due to the check (Q_{500}) flood can support the extreme limit state loads with a resistance factor of 1.0.

The designer may assume Soil Type 4 (MaineDOT Bridge Design Guide (BDG) Section 3.6.1) for abutment backfill material soil properties. The backfill properties are as follows: angle of internal friction (ϕ) of 32 degrees, total unit weight (γ) of 125 pcf, and a soil-concrete interface friction angle (δ) of 20 degrees.

Integral abutment sections shall be designed to withstand a lateral earth load equal to the passive pressure state. Calculation of passive earth pressures should assume a Coulomb passive earth pressure coefficient, K_p , of 6.73. Developing full passive pressure assumes that

the ratio of lateral abutment movement to abutment height (y/H) exceeds 0.005. If the calculated displacements are significantly less than that required to develop full passive pressure the designer may consider using the Rankine passive earth pressure coefficient of 3.25. A load factor for passive earth pressure is not specified in LRFD. For purposes of the integral abutment backwall reinforcing steel design, use a maximum load factor (γ_{EH}) of 1.50 to calculate factored passive earth pressures.

Additional lateral earth pressure due to live load surcharge is required per Section 3.6.8 of the MaineDOT BDG for abutments if an approach slab is not specified. When a structural approach slab is specified, reduction, not elimination of the surcharge load, is permitted per LRFD Article 3.11.6.5. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from Table 7:

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

Table 7 – Equivalent Height of Soil for Estimating Live Load Surcharge on Abutments

The abutment design shall include a drainage system behind the abutment to intercept any groundwater. Drainage behind the structure shall be in accordance with MaineDOT BDG Section 5.4.2.13.

Backfill within 10 feet of the abutments and side slope fill shall conform to MaineDOT Specification 703.19 – Granular Borrow for Underwater Backfill. The gradation of this material specifies 7 percent or less of the material passing the No. 200 sieve. Limiting the amount of fines is intended to facilitate drainage and minimize frost action behind the structure.

Slopes in front of the pile supported integral abutments should be constructed with riprap and erosion control geotextile. The slopes should not exceed 1.75H:1V in accordance with MaineDOT Standard Detail 610(03).

7.3 In-line Wingwalls

In-line, cantilevered “butterfly” wingwalls may be used in conjunction with the integral abutments. The wingwalls shall be designed for all relevant strength, service, and extreme limit states and load combinations specified in LRFD Articles 3.4.1, 11.5.5 and 11.6. The walls shall be designed to resist lateral earth pressures, vehicular loads, and collision loads, as well as, creep, temperature, and shrinkage deformations. The design of “butterfly” wingwalls shall account for the additional bending stresses resulting from the wingwall being cantilevered off the abutment. These additional bending stresses may require wingwalls longer than 10 feet to be independently supported.

The design of the “butterfly” wingwalls shall at a minimum consider a load case where the wingwall is subjected to passive earth pressure to account for the bridge moving laterally and pushing the wingwall into the fill. Calculation of passive earth pressures may assume a Rankine passive earth pressure coefficient, K_p , of 3.25 assuming small wingwall movements. See Appendix C – Calculations for supporting documentation. A load factor for passive earth pressure is not specified in LRFD; use a maximum load factor (γ_{EH}) of 1.50 to calculate factored passive earth pressures.

The wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) per LRFD Article 3.11.6.4. An at-rest earth pressure coefficient, K_o , of 0.47 should be used for live load surcharge loads placed upon wingwalls cantilevered off of abutments with the top of the wall restrained from movement. See Appendix C – Calculations for supporting documentation.

There are no bearing resistance considerations or special foundation supports needed for wingwalls that are cantilevered off the abutment.

7.4 Settlement

The deep alluvium deposit is very loose to medium dense in consistency. These coarse-grained materials undergo elastic, immediate, compression in response to an increase in vertical overburden pressure. The glaciolacustrine deposits contain subunits of soft silt. These soils are anticipated to undergo long-term consolidation settlement. An increase in overburden pressure will result from the proposed grade raise and roadway widening on the west and east bridge approaches. The proposed grade will be approximately 5 feet higher than the existing grade. Total settlement resulting from this grade increase is anticipated to be on the order of 3.5 inches. The consolidation settlement component is estimated to be on the order 0.1-inch.

LRFD Article 3.11.8 states that piles can be subject to downdrag (negative skin friction) when long-term, consolidation settlement is 0.4 inches or greater. Downdrag forces, when anticipated, should be considered in the pile design as contributing to the maximum factored axial pile load. Because long term consolidation settlement is less than 0.4 inches, downdrag forces due to settlement are not considered in the pile loads.

7.5 Approach Embankment Stability

Reconstruction of the approach roadways will require a grade raise on the order of 5 feet and roadway widening up to 10 feet on the north side slopes. The widened approaches result in new fill up to 10 feet high on north sideslopes of both approaches.

Slope stability evaluations of the proposed approach embankments were performed using the compute program Slide v6.0 by Rocscience. AASHTO LRFD 11.6.2.3 requires a global stability resistance factor, ϕ , of 0.75 when embankments do not contain or support structural elements. This resistance factor results in a minimum required factor of safety of 1.3. Spencer's method, which satisfies both force and moment equilibrium, was used.

Several slope geometries were evaluated. 1.5H:1V slopes with heavy riprap and 1.75H:1V slopes with plain riprap did not meet minimum requirements for global stability. 2H:1V slopes with 3 feet of plain riprap were determined to meet minimum requirements for stability. Toe berms were added where needed to increase the minimum factor of safety. The results of the embankment stability analyses for the final, proposed conditions, in the transverse direction, are summarized in Table 8, below.

Location	Station	Sideslope	Slope Geometry	Water condition	FS
West Approach	298+50	Right	2H:1V	Q ₁₀	1.3
	298+75 to 299+00	Right	2H:1V	Q ₁₀	1.3
	298+75 to 299+00	Left	2H:1V	Q ₁₀	1.3
East Approach	300+00	Right	2H:1V with toe berm	Q ₁₀	1.3
	300+00	Left	2H:1V	Q ₁₀	1.4

Table 8 – Summary of Stability Analyses for Proposed Embankment Sideslopes.

The evaluations were repeated for a “rapid drawdown” scenario with the embankment groundwater surface at the Q₅₀ elevation and the water level in the Saco River Overflow at Q_{1.1}. The factors of safety for a rapid drawdown scenario were considered acceptable.

Global stability at the bridge abutments was also evaluated in a direction longitudinal to the bridge alignment. When stability analyses are performed and the slope contains a structural element, such as an abutment, AASHTO LRFD Section 11.6.2.3. required a resistance factor, ϕ , of 0.65. This resistance factor results in a minimum required factor of safety of 1.5.

Longitudinal global stability analyses were performed at Abutments No. 1 and No. 2 with ground water levels corresponding to the Q₁₀ flood elevation of 134 feet. A rapid drawdown condition was also evaluated. With the inclusion of shear reinforcement in the longitudinal

direction due to the abutment piles, the factors of safety of both abutments for both water conditions satisfy the AASHTO required minimum factor of safety of 1.5.

Location	Abutment Slope Geometry	Water condition	Factor of Safety
Abutment No. 1	1.75H:1V	Q ₁₀	2.0
	1.75H:1V	Q ₅₀ to Q ₁₀	1.8
Abutment No. 2	1.75H:1V	Q ₁₀	2.0
	1.75H:1V	Q ₅₀ to Q ₁₀	1.8

Table 9 – Summary of Stability Analyses Longitudinal to Bridge Abutments

7.6 Frost Protection

Pile-supported integral abutments shall be embedded a minimum of 4.0 feet for frost protection per MaineDOT BDG Figure 5-2.

Foundations placed on the native soils should be designed with an appropriate embedment for frost protection. According to MaineDOT BDG Figure 5-1, Maine Design Freezing Index Map, Fryeburg has a design freezing index (DFI) of approximately 1390 F-degree days. The anticipated coarse-grained fill material was assigned a water content of 10%. These components correlate to a frost depth of 6.6 feet. A similar analysis was performed using Modberg software by the US Army Cold Regions Research and Engineering Laboratory (CRREL). For the Modberg analysis, Lewiston, Maine has a DFI from the Modberg database of approximately 1224 F-degree days. Lewiston was selected because it lies on the same isoline as Fryeburg and Fryeburg is not available in the Modberg database. A water content of 10% was used. These components correlate to a frost depth of approximately 5.3 feet.

Based on the MaineDOT BDG methodology it is recommended that foundations bearing on coarse-grained soils be designed with an embedment of approximately 6.6 feet for frost protection. See Appendix C – Calculations for supporting calculations.

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

7.7 Scour and Riprap

Grain size analyses were performed on samples from the stream alluvium deposit to generate grain size curves for determining parameters to be used in scour analyses. Samples BB-FSRO-101B/1D, BB-FSRO-101B/3D, BB-FSRO-102/3D, and BB-FSRO-1024D were judged to be similar in nature to the soils likely to be exposed to scour conditions. The following streambed grain size parameter can be used in scour analyses:

Sample	Sample Depth bgs (ft)	D ₅₀ (mm)
BB-FSRO-101B/1D	15-17	0.12
BB-FSRO-101B/3D	30-32	0.6
BB-FSRO-102/3D	20-22	0.65
BB-FSRO-102/4D	30-32	0.3
	Average	0.42

Table 10 - Average D₅₀ of Representative Samples for Scour

The grain size curves are included in Appendix B – Laboratory Test Results.

The consequences of changes in foundation conditions resulting from the design (Q₁₀₀) and check (Q₅₀₀) floods for scour shall be considered at the strength and extreme limit states, respectively. Design at the strength limit state should consider loss of lateral and vertical support due to scour. Design at the extreme limit state should check that the nominal foundation resistance due to the check flood (Q₅₀₀) event is no less than the extreme limit state loads. At the service limit state, the design shall limit movements and ensure overall stability considering scour at the design load.

For scour protection of the pile supported abutments, the PDR indicates the bridge approach slopes and the abutment slopes will be armored with a 3-foot layer of plain riprap. Refer to MaineDOT BDG Section 2.3.11.3 for information regarding scour design. Typically, the top of the riprap is located at, or above, the Q₅₀ elevation.

Plain riprap shall conform to MaineDOT Standard Specification 703.26 – Plain and Hand Laid Riprap. The toe of the riprap section shall be constructed at least 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material conforming to MaineDOT Standard Specification 703.19 and Class 1 nonwoven erosion control geotextile per MaineDOT Standard Details 610(02) and 610(03).

7.8 Seismic Design Recommendations

7.8.1 Site Evaluations

The United States Geological Survey Seismic Design CD (Version 2.1) provided with the LRFD Manual, and LRFD Articles 3.10.3.1 and 3.10.6 were used to develop parameters for seismic design. Based on site coordinates, the software provided the recommended AASHTO Response Spectra for a 7 percent probability of exceedance in 75 years. These results are summarized in Table 11:

Parameter	Design Value
Peak Ground Acceleration (PGA)	0.10g
Acceleration Coefficient (As)	0.25g
S _{DS} (Period = 0.2 sec)	0.49g
S _{D1} (Period = 1.0 sec)	0.17g
Site Class	E
Seismic Zone	2

Table 11 – Seismic Design Parameters

In conformance with LRFD Article 4.7.4.2 seismic analysis is not required for single-span bridges regardless of seismic zone. However, superstructure connections and minimum support length requirements shall be designed per LRFD Articles 3.10.9.2 and 4.7.4.4, respectively.

See Appendix C – Calculations for supporting documentation.

7.8.2 Liquefaction Evaluations

The liquefaction susceptibility of the in-situ soils present along the proposed roadway/bridge alignment was evaluated based on the subsurface conditions encountered in the borings. Liquefaction is a phenomenon whereby loose, saturated cohesionless soil deposits lose shear strength in response to an applied cyclic stress, typically associated with earthquake shaking. This temporary loss of soil strength can result in ground settlement, lateral ground movement and downdrag on piles.

An initial screening was conducted to assess whether the potential for liquefaction exists for the site. The most susceptible soils to liquefaction are fills, alluvial and marine sands and deltaic sands. In general, deposits meeting the following criteria and are not considered susceptible to liquefaction:

- Soils with fines content (percent passing the No. 200 sieve) more than 35 percent;
- Soils classified as Marine and Lacustrine silt and clay;
- Soil deposit with SPT-N₆₀ values greater than 22 bpf;
- Unsaturated soils above the watertable.

Based on the above initial screening criteria, the potential for liquefaction of the lacustrine deposits can be dismissed, however the liquefaction potential of the loose, saturated alluvial deposits at the site cannot be dismissed. Therefore, a more thorough liquefaction evaluation was conducted using the Simplified Procedure originally developed by Seed and Idriss (1983) and detailed in FHWA Geotechnical Engineering Engineering Circular (GEC) No. 3.¹²

¹² FHWA GEC No. 3, “Design Guidance: Geotechnical Earthquake Engineering for Highways” (1997)

This evaluation generally included the following steps:

1. Determination of the Site Class and design response spectra.
2. Based on the design response spectra, the Seismic Zone is 2.
3. Using the earthquake deaggregation data from the USGS Unified Hazard Tool a design earthquake magnitude of 6 was determined for a seismic event having a 7% exceedance in 75 years.
4. The liquefaction susceptibility of the granular soils at the site was assessed by comparing the uniform cyclic stress ratio (CSR) imposed by the design earthquake to the cyclic resistance ratio (CRR) of each soil sample location. In the instances where the CSR exceeds the CRR, the factor of safety (FS) against liquefaction is less than 1.0.

The results of the simplified liquefaction evaluation are summarized below:

- In-situ alluvial soils present beneath the west approach embankment and adjacent to Abutment No. 1 were judged to be susceptible to liquefaction ($FS < 1$) from Elev. 363 to the depth corresponding to Elev. 327. Alluvial soils present beneath the east approach embankment and adjacent to Abutment No. 2 were judged to be susceptible to liquefaction from Elev. 363 to a depth corresponding to Elev. 318.
- The various depths below the ground surface where liquefaction is likely to occur in the approach embankments is summarized in Table 12.

Specific details regarding the methodology and results of the liquefaction susceptibility evaluation are provided in Appendix C – Calculations.

Location	Elevation of Top of Liquefied Zone	Elevation of Bottom of Liquefied Zone
West Approach/ Abutment No. 1 Area	Elev. 363	Elev. 327
East Approach/ Abutment No. 2 Area	Elev. 363	Elev. 318

Table 12 - Depths below the Ground Surface Susceptible to Liquefaction

7.8.3 Global Stability with Seismic Loading

Global slope stability of the proposed east and west approach embankments was evaluated for the seismic loading condition by incorporating a horizontal seismic coefficient, k_h , equal to one-half of the calculated acceleration coefficient of 0.25g, in accordance with AASHTO 11.6.5.2.2. The calculated factor of safety is approximately 1.0 for the critical slip surface

within the sideslope of the east approach. At the west bridge approach, the calculated factor of safety is approximately 0.9 for the critical slip surface, assuming 2H:1V sideslopes with 3 feet of plain riprap; this does not meet the minimum requirement of 1.0 per MaineDOT BDG Section 5.9.4. Longitudinal global stability analyses were performed at Abutments No. 1 and No. 2 for the seismic loading condition. The calculated factors of safety against rotational failure at both abutments were approximately 1.8 with the inclusion of shear reinforcement in the longitudinal direction due to the abutment piles, and are considered acceptable.

7.9 Construction Considerations

Incidental information provided by an abutting landowner during the 2018 subsurface investigation indicates that the causeway that forms the west bridge approach was constructed as a series of rock-filled timber cribs. Evidence of these reported crib structures was encountered in the form of horizontally oriented timber encountered in borings BB-FSRO-201 and BB-FSRO-202. In the west approach, cobbles and boulders are anticipated to be present to depths of at least 15 feet and evidence of the timber cribbing was present as feet as 23 feet. These materials will obstruct the installation of piles or sheeting piling for temporary earth support. The contractor may consider using an H-pile probe to evaluate the limits of the timber cribbing. It may be necessary to excavate the timber, cobbles and boulders for staging, temporary earth support systems and new foundation construction.

Construction of the proposed foundations will require pile driving. The contractor should assume that the existing abutments and timber piles, if not removed entirely, will obstruct pile driving operations. Furthermore, cobbles and boulders were encountered in the fills comprising the existing bridge approaches in borings BB-FSRO-101, BB-FSRO-101A, BB-FSRO-101B and BB-FSRO-102. The contractor shall be responsible for excavating cobbles and boulders, and those portions of existing structures, that conflict with piles by conventional excavation methods, pre-augering, predrilling, spudding, use of rock chisels, or down-hole hammers. The contractor should assume difficult pile driving even after the removal of obstructions. Care should be taken to drive H-piles within allowable tolerances without damaging the H-piles.

Two 10-foot sections of 4.5-inch diameter steel casing broke during geotechnical investigation and were abandoned in boreholes for borings BB-FSRO-101 and BB-FSRO-101A. The contractor should anticipate encountering these drill casings.

Excavations for the proposed abutments will expose soils that may become saturated and water seepage may occur during construction. There may be localized sloughing and instability in some excavations and cut slopes. The contractor should control groundwater, surface water infiltration and soil erosion. Water should be controlled by pumping from sumps.

8.0 CLOSURE

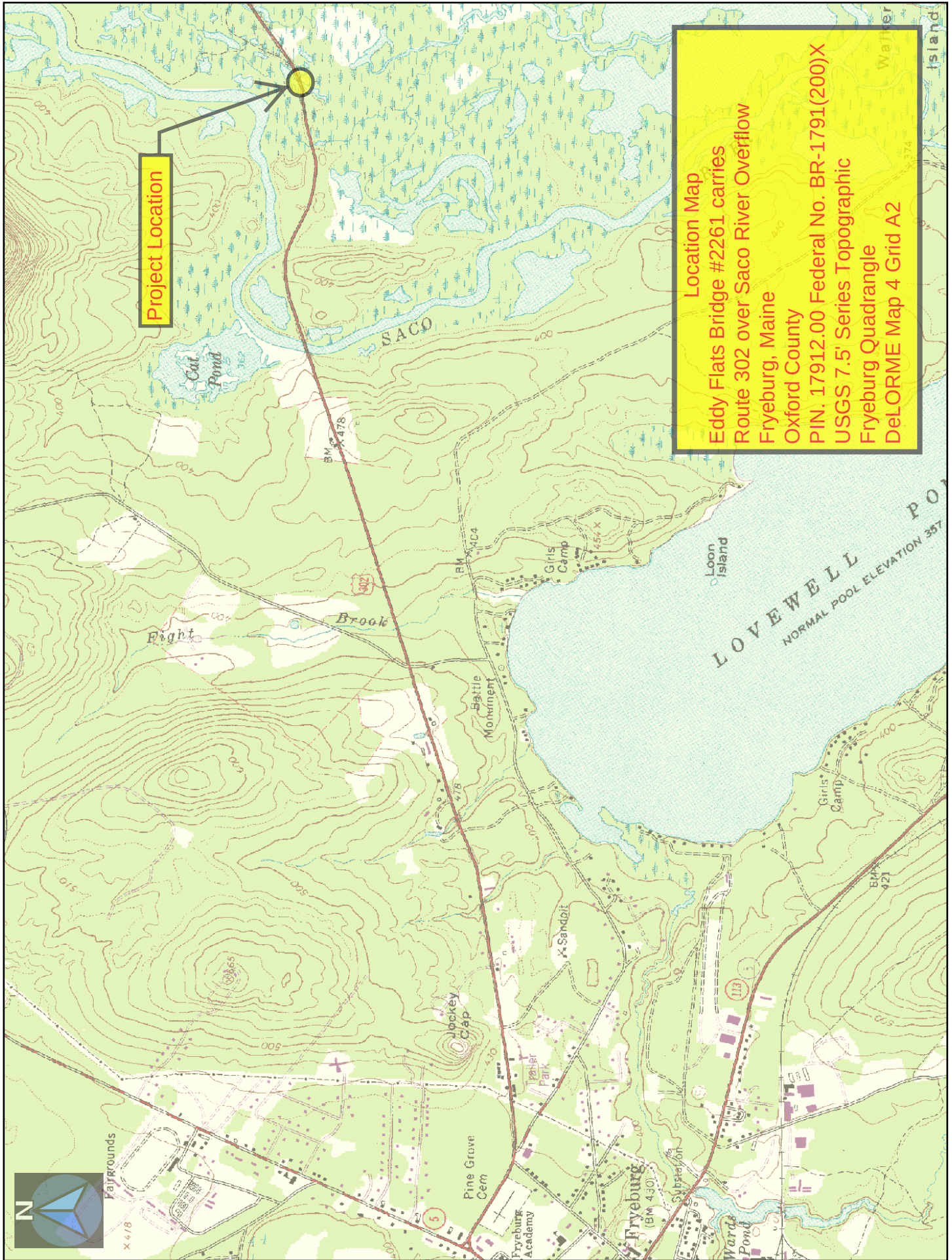
This report has been prepared for use by the MaineDOT Bridge Program for the specific application of the proposed replacement of Eddy Flats Bridge in Fryeburg, Maine in

accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

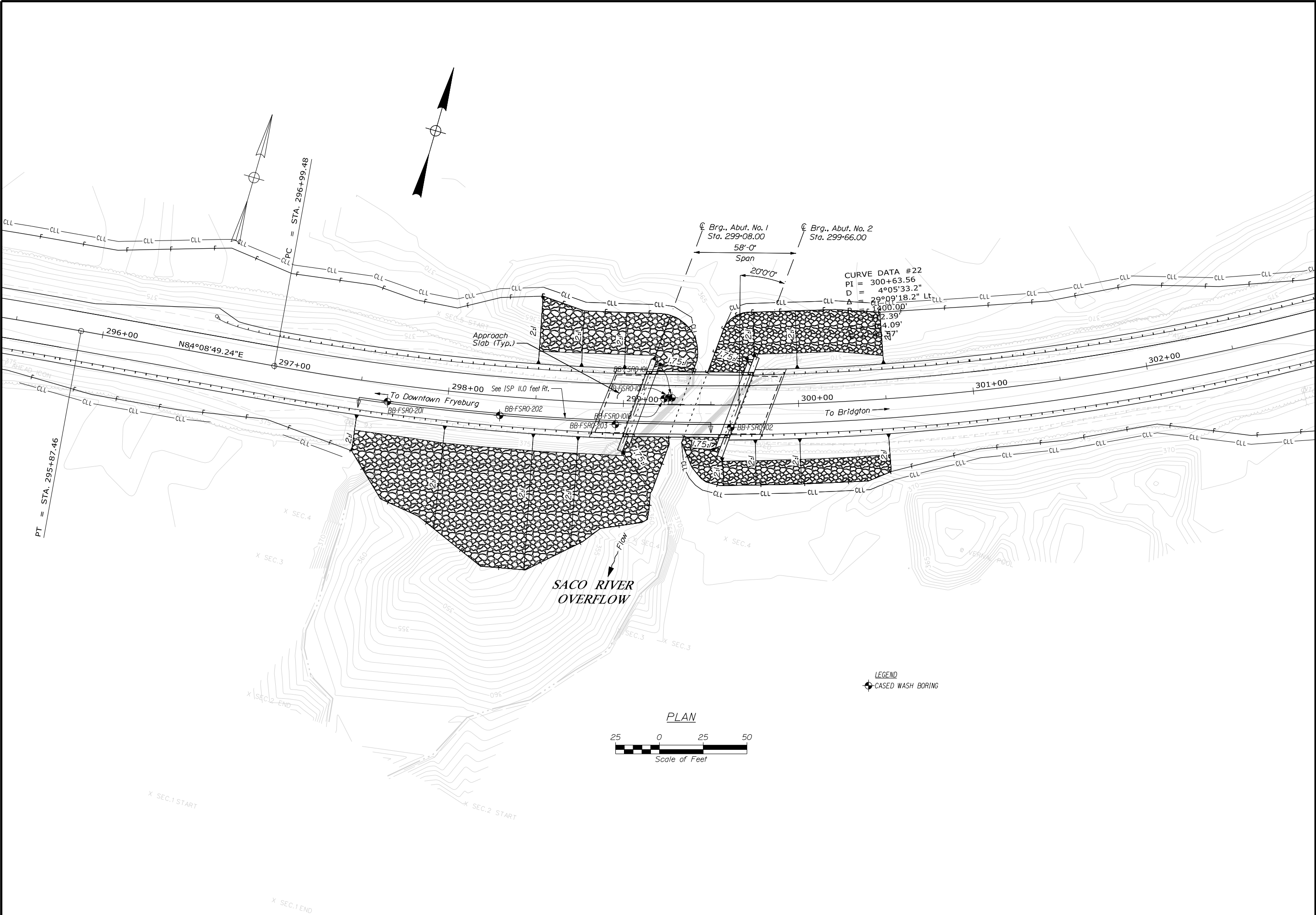
In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes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

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

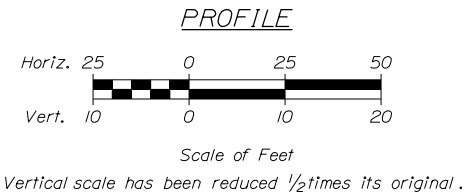
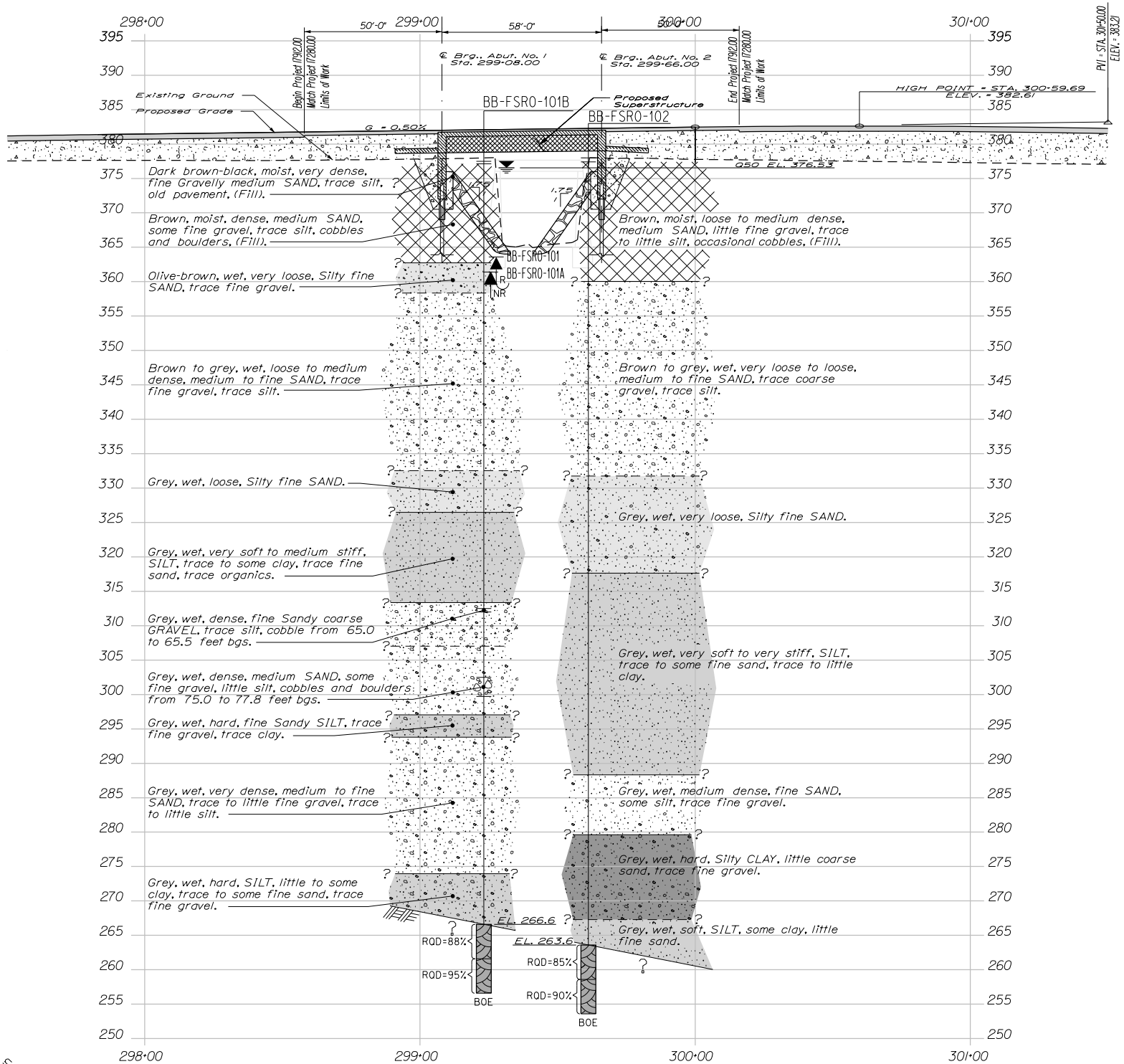
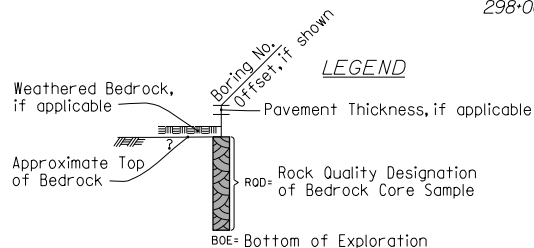
Sheets



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.

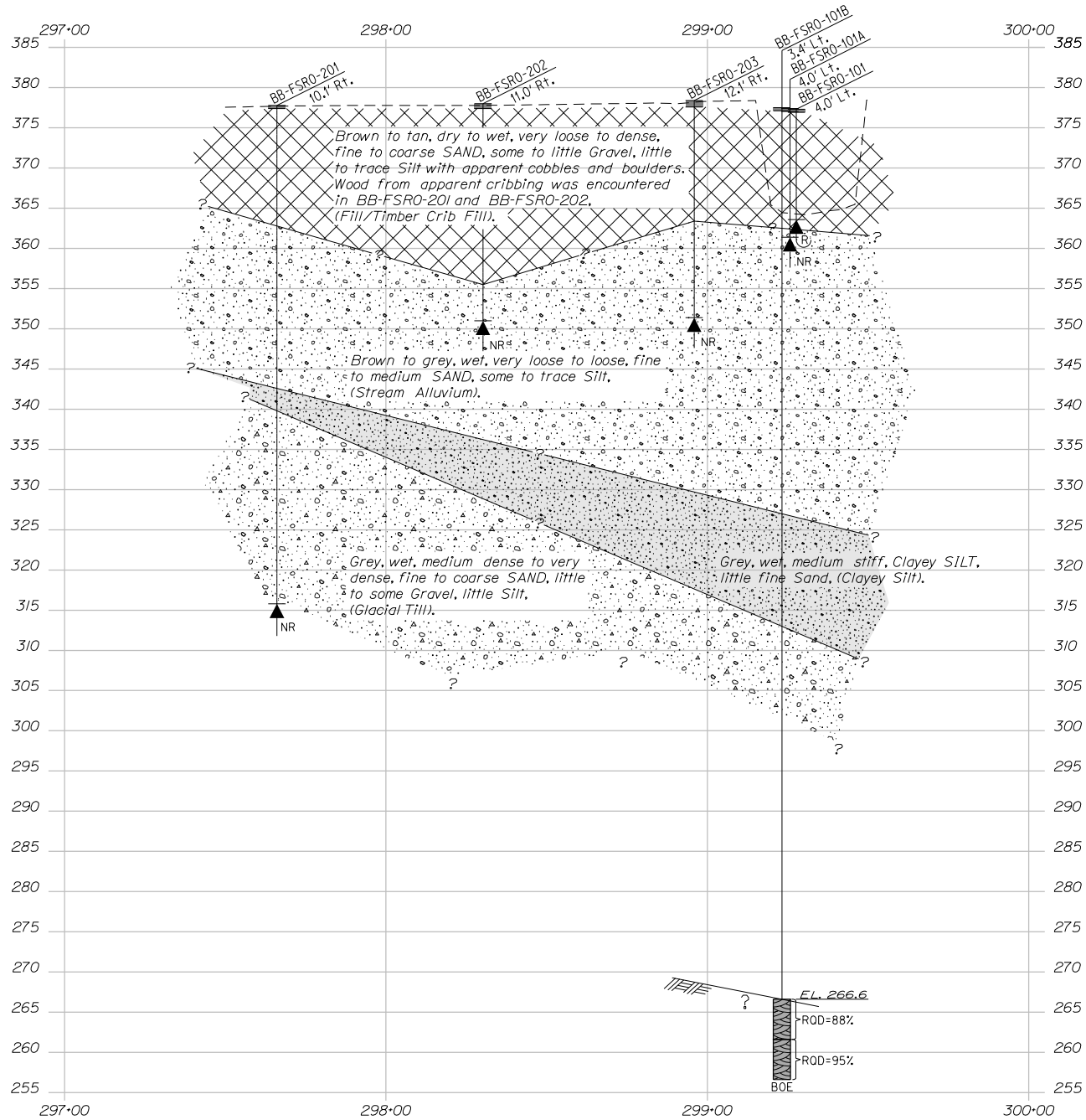
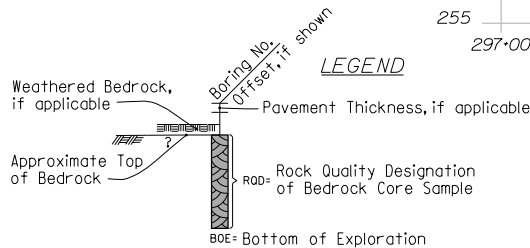


STATE OF MAINE		DEPARTMENT OF TRANSPORTATION	
BR-1791(200)X		BRIDGE NO. 2261	
PIN		17912.00	
BRIDGE PLANS			
EDDY FLATS BRIDGE		PROJ. MANAGER	BY
SACO RIVER OVERFLOW		CHECKED-REVIEWED	DATE
FRYEBURG		DESIGN-DETAILED	
OXFORD COUNTY		DESIGN-REVIEWED	
BORING LOCATION PLAN		DESIGN-DETAILED	
		REVISIONS 1	SIGNATURE
		REVISIONS 2	P.E. NUMBER
		REVISIONS 3	DATE
		REVISIONS 4	
		FIELD CHANGES	
SHEET NUMBER			
2			
OF 6			



Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE		DEPARTMENT OF TRANSPORTATION		BR-1791(200)X		PIN 17912.00		BRIDGE NO. 2261		BRIDGE PLANS	
EDDY FLATS BRIDGE		SACO RIVER OVERFLOW		OXFORD COUNTY		FRYEBURG		INTERPRETIVE SUBSURFACE PROFILE		SHEET NUMBER	
PROJ. MANAGER		BY		DATE		SIGNATURE		P.E. NUMBER		DATE	
DESIGN-DETAILED		M. PARLIN		M. LACHANCE APR. 2017		T. WHITE					
CHECKED-REVIEWED		R. NAJUS									
DESIGNS DETAILING		N. SHERWOOD									
REVISIONS 1											
REVISIONS 2											
REVISIONS 3											
REVISIONS 4											
FIELD CHANGES											
3		OF 6									



PROFILE - 11.0 feet Rt. of Construction

Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

SHEET NUMBER		EDDY FLATS BRIDGE		STATE OF MAINE							
4		SACO RIVER OVERFLOW		DEPARTMENT OF TRANSPORTATION							
		OXFORD COUNTY									
		FRYEBURG									
INTERPRETIVE SUBSURFACE PROFILE		DESIGN-DETAILED		PROJECT MANAGER		M. PARLIN		BY		DATE	
11.0 feet Rt.		CHECKED-REVIEWED		B. CROALL		MAY 2018					
		DESIGN-DETAILED 02		C. SNOW		MAY 2018		A. L. ASBELL			
		DESIGN-DETAILED 03		T. WHITE		MAY 2018				SIGNATURE	
		REVISIONS 1								P.E. NUMBER	
		REVISIONS 2									
		REVISIONS 3									
		REVISIONS 4									
		FIELD CHANGES								DATE	
										BRIDGE NO. 2261	
										PIN	
										17912.00	
										BRIDGE PLANS	
OF 6											

Maine Department of Transportation Soil/Bore Estimation Log US CUSTOMARY UNITS				Project Day Fills & Edge Haul (281) Carries Route 302 over Saco River Location Fryburg, Maine				Boring No.: BB-FSR0-101B WIN: 17912.00	
Drillers: WalneDOT		Elevation (ft.): 371.5		Auger ID(s): 5-inch Solid Stem		Operator: Cigars/Giles		Solum: NW088	
Logged By: WJH		Rtg type: CME 4SC		Hammer wt./fall(s): 140 lbs/30 inches		Date Start/Fn/Inst: 3/29, 30/11-4/1, 4, 5, 6/11		Drilling Method: Cased Wash Boring	
Boring Location: Sta 299+23.2, 3.4 feet L+		Casing ID(s): HW (4"x5") & NW (3"x5")		Core Barrel: N02 (2-inch-diameter)		Water Level(s): 15 feet bgs		Hammer Efficiency Factor(s) 0.84	
Hammer Type: Automatic BQ		Hydraulic □		Rope & Cathode □		Notes: D = Split Stem Sample A = Unsuccessful Split-Stem Tumbler Attempt U = Thin Wall Tube Sample M = Mechanical Test Result Value is Weight F = Field Note Sheet Name R = Unsuccessful Trial Run Spear Test Attempts		Sample Information S = Rock Core Sample SS = Self-Seal Steel Auger MS = Metal Strip Auger RC = Rebar Case WT = Weight of Rods, Hammer or ROPS (lb.) N/A = Not Applicable or Not Reported NA = NA - Hammer Efficiency Factor/Not Measured/Ungrouted C = Corrosion Test	
Depth (ft.)	Sample No.	Name / Desc. / Loc.	Time per Depth (min.)	Remarks / Notes / Comments	No. of Samples	Visual Description and Remarks	Laboratory Testing Results / Analysis and Unified Classification		
-						371.1	4.5-Inch-thick layer of pavement. Spun MW casing ahead to 15 feet bgs. Spun MW casing ahead to 20 feet bgs.		
-5							Cobbles from 5.5 to 6.5 feet bgs. Cobbles from 7 to 8.5 feet bgs.		
-10							Boulder from 10.3 to 11.5 feet bgs.		
-15	10	24/13	15.00 ~ 22.00	4/2/1/1	3	4	Drive brown, wet, very loose, stiffer fine SAND, trace fine gravel, (Stream alluvium).	GW45144 A=4, SW WC=31.5%	
-20	20	24/14	20.00 ~ 22.00	2/2/3/4	5	7	Brown, wet, looser, SAND, trace fine gravel, trace silt, (Stream alluvium).		
-25	M0	24/0	25.00 ~ 27.00	5/6/6/7	12	17	Similar to 20' in wash water.		
-30	30	24/16	30.00 ~ 31.00	2/3/5/5	8	11	Brown, wet, medium dense, medium SAND, trace fine gravel, trace silt, (Stream alluvium).	GW45147 A=4, SW-SM WC=31.5%	
-35	40	24/14	35.00 ~ 37.00	2/3/4/5	7	10	Grey, wet, looser, fine SAND, trace silt.	GW45145 A=3, SP-SM WC=23.1%	
-40	50	24/16	40.00 ~ 42.00	1/3/3/4	6	8	Grey, wet, looser, medium SAND, trace silt.	GW45146 A=4, SB-SM WC=31.5%	
-45	60	24/20	45.00 ~ 47.00	1/2/2/2	4	6	Grey, wet, looser, stiffer fine SAND.	GW45148 A=4, SW WC=31.5%	
-50	70	24/23	50.00 ~ 52.00	4/1/1/2	3	5	Grey, wet, soft, SILT, little fine sand, trace clay, trace organic, (Glacial outcrop).	GW45149 A=4, SB WC=31.5%	
-55	80	24/24	55.00 ~ 57.00	WD/WDR/WDR/WDR	---	--	Grey, wet, very soft, SILT, some clay, trace fine sand, (Glacial outcrop).	GW45150 A=4, CL WC=31.5%	
-60	M/RD	24/24	60.00 ~ 62.00	WDH/2/2/5	4	6	Failed 5x10-in vane attempt; would not push. Grey, wet, medium stiff, SILT, some clay, trace fine sand, (Glacial outcrop).	A=4, CL WC=35.7%	
-65	100	24/12	65.50 ~ 67.50	5/7/18/19	25	35	Cobble from 65 to 65.5 feet bgs. Grey, wet, dense, fine Sandy coarse GRAVEL, trace silt, (Glacial Till).	GW45152 A=1-co, GW-MC MC=14.1%	
-70	110	24/12	70.00 ~ 72.00	7/19/10/11	29	41	Grey, wet, dense, medium SAND, some fine gravel, silt, (Glacial Till). RC frust tip @ 110.9 feet bgs.	GW45153 A=1-co, SB-SM WC=10.6%	
REMARKS:									
-bgs = below existing ground surface (roadway)									
Split/Stiffen Tests represent approximate boundaries between soil types; transitions may be gradual.									
* Near level roadways have been made at times and under specific stress. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.									
						Page 7 of 2			
Boring No.: BB-FSR0-101B									

[illegible]

Maine Department of Transportation Soil/Track Exploration Log US CUSTOMARY UNITS										Project: Easy Flats Bridge No. 2261 Carries Route 302 over Saco River Location: Fryburg, Maine		Boring No.: BB-FSR0-102 WJN: 17912.00	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope & Cathode	
Soil/Track		MaineDOT		Elevation (ft.): 378.0		Auger ID/DB: 5-Inch Soils Steel		Operator: C/Quinn/Giles		Datum: NAVD83		Sampler: Standard Split Spoon	
Loggers By: WJN		Wtg Type: CME 45C		Drilling Method: Coated Wash Boring		Sampler Wt./Fall: 140 lbs./30 inches		Date Start/Finish: 4/18, 11/12/11		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Core Barrel: N02 (2-Inch-Diameter)	
Boring Location: Sta 299+62.5, 12.7 ft R.R.		Coring ID/DB: HW (4/4.5") & MW (3/3.5")		Water Level: 12 feet bgs		Header Efficiency Factor: 0.84		Header Type: Automatic B		Hydraulic B		Rope	

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Appendix A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM					MODIFIED BURMISTER 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	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	<u>Descriptive Term</u>		<u>Portion of Total (%)</u>														
		(little or no fines)	GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.	trace	0 - 10															
					little	11 - 20															
					some	21 - 35															
					adjective (e.g. sandy, clayey)	36 - 50															
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS	SW	Well-graded sands, gravelly sands, little or no fines	TERMS DESCRIBING DENSITY/CONSISTENCY																
		(little or no fines)	SP	Poorly-graded sands, gravelly sand, little or no fines.																	
		SANDS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	<u>Coarse-grained soils</u> (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) silty or clayey gravels; and (3) silty, clayey or gravelly sands. Density is rated according to standard penetration resistance (N-value).																
			GC	Clayey gravels, gravel-sand-clay mixtures.																	
			SM	Silty sands, sand-silt mixtures	<u>Density of Cohesionless Soils</u> Very loose Loose Medium Dense Dense Very Dense																
SC	Clayey sands, sand-clay mixtures.	<u>Standard Penetration Resistance N-Value (blows per foot)</u> 0 - 4 5 - 10 11 - 30 31 - 50 > 50																			
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.	<u>Fine-grained soils</u> (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) gravelly, sandy or silty clays; and (3) clayey silts. Consistency is rated according to undrained shear strength as indicated.													
		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.	<u>Approximate Undrained Shear Strength (psf)</u> WOH, WOR, WOP, <2 2 - 4 5 - 8 9 - 15 16 - 30 >30																	
		SILTS AND CLAYS (liquid limit greater than 50)	MH					Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	<u>Consistency of Cohesive soils</u> Very Soft Soft Medium Stiff Stiff Very Stiff Hard												
			CH	Inorganic clays of high plasticity, fat clays.	<u>SPT N-Value (blows per foot)</u> 250 - 500 500 - 1000 1000 - 2000 2000 - 4000 over 4000																
	OH		Organic clays of medium to high plasticity, organic silts.	<u>Field Guidelines</u> Fist easily penetrates Thumb easily penetrates Thumb penetrates with moderate effort Indented by thumb with great effort Indented by thumbnail Indented by thumbnail with difficulty																	
	HIGHLY ORGANIC SOILS	Pt	Peat and other highly organic soils.					Rock Quality Designation (RQD): RQD (%) = <u>sum of the lengths of intact pieces of core* > 4 inches</u> length of core advance *Minimum NQ rock core (1.88 in. OD of core)													
	Desired Soil Observations (in this order, if applicable): Color (Munsell color chart) Moisture (dry, damp, moist, wet) Density/Consistency (from above right hand side) Texture (fine, medium, coarse, etc.) Name (sand, silty sand, clay, etc., including portions - trace, little, etc.) Gradation (well-graded, poorly-graded, uniform, etc.) Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic) Structure (layering, fractures, cracks, etc.) Bonding (well, moderately, loosely, etc.,) Cementation (weak, moderate, or strong) Geologic Origin (till, marine clay, alluvium, etc.) Groundwater level					<u>Correlation of RQD to Rock Mass Quality</u> <table><tr><th>Rock Mass Quality</th><th>RQD (%)</th></tr><tr><td>Very Poor</td><td>≤25</td></tr><tr><td>Poor</td><td>26 - 50</td></tr><tr><td>Fair</td><td>51 - 75</td></tr><tr><td>Good</td><td>76 - 90</td></tr><tr><td>Excellent</td><td>91 - 100</td></tr></table> Desired Rock Observations (in this order, if applicable): Color (Munsell color chart) Texture (aphanitic, fine-grained, etc.) Rock Type (granite, schist, sandstone, etc.) Hardness (very hard, hard, mod. hard, etc.) Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.) Geologic discontinuities/jointing: -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.) -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet) -tightness (tight, open, or healed) -infilling (grain size, color, etc.) Formation (Waterville, Ellsworth, Cape Elizabeth, etc.) RQD and correlation to rock mass quality (very poor, poor, etc.) ref: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A Recovery (inch/inch and percentage) Rock Core Rate (X.X ft - Y.Y ft (min:sec))				Rock Mass Quality	RQD (%)	Very Poor	≤25	Poor	26 - 50	Fair	51 - 75	Good	76 - 90	Excellent	91 - 100
	Rock Mass Quality	RQD (%)																			
Very Poor	≤25																				
Poor	26 - 50																				
Fair	51 - 75																				
Good	76 - 90																				
Excellent	91 - 100																				
Maine Department of Transportation Geotechnical Section Key to Soil and Rock Descriptions and Terms Field Identification Information					Sample Container Labeling Requirements: WIN Bridge Name / Town Boring Number Sample Number Sample Depth Blow Counts Sample Recovery Date Personnel Initials																

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-201 WIN: 017912.00						
Driller: New England Boring Contractors				Elevation (ft.): 377.8				Auger ID/OD: 4.25" OD						
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon						
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30						
Date Start/Finish: 03-19-18 / 03-20-18				Drilling Method: Drive & Wash				Core Barrel: --						
Boring Location: Sta. 297+66.1, 10.1 ft RT				Casing ID/OD: 4" / 3"				Water Level*: 12.7'						
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐										
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _{u(lab)} = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test														
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.			
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows							
0	1D	24/13	0.40 - 2.40	9-10-10-63	20	29	SSA	377.4		-ASPHALT- Dark brown/tan, medium dense, fine to coarse SAND, little Gravel, trace Silt, dry. -FILL- (SW) Probable cobble/boulder from 3.1-3.8 ft.				
5	2D	23/16	5.00 - 6.92	10-10-38-100/5"	48	70	492						Dark brown/tan, very dense, fine to coarse SAND, some Gravel, trace Silt, moist, with a piece of asphalt, petroleum odor. -FILL- (SW) Probable cobble/boulder from 6.9-7.6 ft.	
10	3D	24/7	10.00 - 12.00	13-3-2-2	5	7	20			Brown, loose, fine to medium SAND, little Gravel, little Silt, wet. -FILL- (SP-SM)				
15	4D	24/7	15.00 - 17.00	3-4-3-3	7	10	17	362.8				Orange/brown, loose, fine to medium SAND, trace Silt, wet. -STREAM ALLUVIUM- (SP)		
20	5D	24/1	20.00 - 22.00	3-3-5-5	8	12	22			Orange/brown, medium dense, fine to medium SAND, trace Silt, wet. -STREAM ALLUVIUM- (SP)				
25														

Remarks:
 1. From 5.0-25.0 ft, wood fragments in wash.
 2. 4" casing to 40.0 ft, then 3" casing to 60 ft.

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

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

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Boring No.: BB-FSRO-201

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-201 WIN: 017912.00			
Driller: New England Boring Contractors				Elevation (ft.): 377.8				Auger ID/OD: 4.25" OD			
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon			
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30			
Date Start/Finish: 03-19-18 / 03-20-18				Drilling Method: Drive & Wash				Core Barrel: --			
Boring Location: Sta. 297+66.1, 10.1 ft RT				Casing ID/OD: 4" / 3"				Water Level*: 12.7'			
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25	6D	24/2	25.00 - 27.00	3-2-3-2	5	7	42		Tan/grey, loose, fine to coarse SAND, little Silt, wet, with organic odor. -STREAM ALLUVIUM- (SP) Orange/brown, loose, fine to medium SAND, trace Silt, wet. -STREAM ALLUVIUM- (SP) Top 2": Grey, fine to coarse SAND, some Silt, wet. Bottom 15": Grey, medium stiff, Clayey SILT, little fine Sand, wet. -STREAM ALLUVIUM- Recovery consisted of gravel stuck in tip of spoon. Probable cobble from 43.9-44.4 ft. Grey, medium dense, fine to coarse SAND, little Gravel, little Silt, wet. -GLACIAL TILL- (SM)		
							37				
							47				
							41				
							44				
30	7D	24/6	30.00 - 32.00	2-3-2-4	5	7	42				
							37				
							57				
							60				
							63				
35	8D	24/17	35.00 - 37.00	2-2-3-2	5	7	50				
							55				
							57				
							68				
							79				
40	9D	24/2	40.00 - 42.00	16-8-7-14	15	22	45				
							54				
							56				
							53				
							57				
45	10D	24/5	45.00 - 47.00	7-9-7-3	16	23	16				
							37				
							28				
							22				
							34				
50											
Remarks: 1. From 5.0-25.0 ft, wood fragments in wash. 2. 4" casing to 40.0 ft, then 3" casing to 60 ft.											
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 2 of 3 Boring No.: BB-FSRO-201	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-201 WIN: 017912.00							
Driller: New England Boring Contractors				Elevation (ft.): 377.8				Auger ID/OD: 4.25" OD							
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon							
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30							
Date Start/Finish: 03-19-18 / 03-20-18				Drilling Method: Drive & Wash				Core Barrel: --							
Boring Location: Sta. 297+66.1, 10.1 ft RT				Casing ID/OD: 4" / 3"				Water Level*: 12.7'							
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐											
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test															
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.				
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows								
50	11D	24/10	50.00 - 52.00	10-3-5-5	8	12	14	315.8		Grey, medium dense, fine to coarse SAND, little Gravel, little Silt, wet. -GLACIAL TILL- (SM)					
							14								
							26								
							63								
							58								
55	12D	24/12	55.00 - 57.00	27-12-14-14	26	38	47					62.0	Grey, dense, fine to coarse SAND, little Gravel, little Silt, wet. -GLACIAL TILL- (SM)		
							29								
							96								
							213								
							301								
60	13D	24/10	60.00 - 62.00	77-104-98-92	>100							315.8		Grey, very dense, fine to coarse SAND, some Gravel, little Silt, wet. -GLACIAL TILL- (SM)	
65								315.8		Bottom of Exploration at 62.0 feet below ground surface. No refusal.					
70								315.8							
75								315.8							

Remarks:
 1. From 5.0-25.0 ft, wood fragments in wash.
 2. 4" casing to 40.0 ft, then 3" casing to 60 ft.

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 3 of 3

Boring No.: BB-FSRO-201

[illegible]

[illegible]

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-203 WIN: 017912.00			
Driller:		New England Boring Contractors		Elevation (ft.)		378.4		Auger ID/OD:		4.25" OD	
Operator:		Mike Porter		Datum:		NAVD 88		Sampler:		Split Spoon	
Logged By:		B. Cardali		Rig Type:		Truck		Hammer Wt./Fall:		140/30	
Date Start/Finish:		03-21-18 / 03-21-18		Drilling Method:		Drive & Wash, SSA		Core Barrel:		--	
Boring Location:		Sta. 298+95.9, 12.1 ft RT		Casing ID/OD:		4"		Water Level*:		7.8'	
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
0							SSA	377.6		-ASPHALT-	
	1D	24/12	1.00 - 3.00	39-21-12-14	33	48				Brown/tan, dense, fine to coarse SAND, little Gravel, trace Silt, dry. -FILL- (SW)	
5	2D	24/18	5.00 - 7.00	5-3-2-3	5	7	24			Brown, loose, fine to medium SAND, trace Silt, moist. -FILL- (SD)	
							18				
							18				
							16				
							18				
10	3D	24/2	10.00 - 12.00	3-2-2-2	4	6	12			Brown, loose, fine to medium SAND, little Silt, wet. -FILL- (SP)	
							13				
							16				
							23				
							21				
15	4D	24/18	15.00 - 17.00	2-2-2-2	4	6	19			Dark brown/grey, loose, fine to medium SAND, some Silt, wet. -STREAM ALLUVIUM- (SM)	
							25				
							36				
							43				
							43				
20	5D	24/4	20.00 - 22.00	2-2-3-4	5	7	26			Brown, loose, fine to medium SAND, little Silt, wet. -STREAM ALLUVIUM- (SM)	
							31				
							41				
							55				
25							58				
Remarks: 1. 4" casing to 25.0 ft.											
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 1 of 2	
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.										Boring No.: BB-FSRO-203	

Maine Department of Transportation <u>Soil/Rock Exploration Log</u> <u>US CUSTOMARY UNITS</u>				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-203 WIN: 017912.00			
Driller: New England Boring Contractors				Elevation (ft.): 378.4				Auger ID/OD: 4.25" OD			
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon			
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30			
Date Start/Finish: 03-21-18 / 03-21-18				Drilling Method: Drive & Wash, SSA				Core Barrel: --			
Boring Location: Sta. 298+95.9, 12.1 ft RT				Casing ID/OD: 4"				Water Level*: 7.8'			
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_u(lab) = Lab Vane Undrained Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25	6D	24/13	25.00 - 27.00	2-3-3-5	6	9		351.4		Brown, loose, fine to medium SAND, little Silt, wet. -STREAM ALLUVIUM- (SM)	
										Bottom of Exploration at 27.0 feet below ground surface. No refusal.	
30											
35											
40											
45											
50											
Remarks: 1. 4" casing to 25.0 ft.											
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 2 of 2	
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.										Boring No.: BB-FSRO-203	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101 WIN: 17912.00				
Driller: MaineDOT		Elevation (ft.) 377.3		Auger ID/OD: 5-inch Solid Stem								
Operator: Giguere/Giles		Datum: NAVD 88		Sampler: Standard Split Spoon								
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs/30 inches								
Date Start/Finish: 3/28/11; 10:30-12:00		Drilling Method: Cased Wash Boring		Core Barrel: N/A								
Boring Location: Sta 299+27.7, 4.0 feet Lt.		Casing ID/OD: HW (4/4.5 inch)		Water Level*: 12.5 feet bgs								
Hammer Efficiency Factor: 0.84		Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐										
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test												
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.	
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0							SSA	376.9		4.5-inch-thick layer of pavement.	0.4	G#245142 A-1-a, SW WC=2.1% G#245143 A-1-b, SW-SM WC=4.0%
	1D	24/16	1.50 - 3.50	9/22/16/18	38	53				Dark brown-black, moist, very dense, fine Gravelly medium SAND, trace silt, old pavement, (Fill).		
5	2D	24/18	5.00 - 7.00	9/17/17/13	34	48				Brown, moist, dense, medium SAND, some fine gravel, trace silt, (Fill).		
										Cobbles and Boulders from 7.5 to 10 feet bgs.		
10	3D	24/5	10.00 - 12.00	5/5/6/7	11	15	111			Similar to 2D; except wet and medium dense.		
							119					
							47					
							a50			a50 blows for 8.4 inches.		
								363.6				
15										Bottom of Exploration at 13.7 feet below ground surface. BOULDER OR EXISTING FOOTING REFUSAL, broke casing, left 10 feet of HW casing in borehole, moved to BB-FSRO-101A.	13.7	
20												
25												
Remarks: -bgs = below existing ground surface (roadway)												
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 1 of 1		
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.										Boring No.: BB-FSRO-101		

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101A WIN: 17912.00																																																																																																																																																																																																																																																																						
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Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: N/A																																																																																																																																																																																																																																																																										
Date Start/Finish: 3/28/11; 13:00-14:30		Drilling Method: Cased Wash Boring		Core Barrel: N/A																																																																																																																																																																																																																																																																										
Boring Location: Sta 299+25.7, 4.0 ft Lt.		Casing ID/OD: HW (4/4.5 inches)		Water Level*: Not Observed																																																																																																																																																																																																																																																																										
Hammer Efficiency Factor:		Hammer Type: Automatic ☐ Hydraulic ☐ Rope & Cathead ☐																																																																																																																																																																																																																																																																												
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00																																																																																																																																																																																																																																																																																		
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Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs/30 inches																																																																																																																																																																																																																																																																																						
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11		Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)																																																																																																																																																																																																																																																																																						
Boring Location: Sta 299+23.2, 3.4 feet Lt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 13 feet bgs																																																																																																																																																																																																																																																																																						
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00					
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem					
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon					
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs//30 inches					
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)					
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs					
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐									
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test													
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows						
25	MD	24/0	25.00 - 27.00	5/6/6/7	12	17	24	332.5		Similar to 2D in wash water.	G#245147 A-1-b, SW-SM WC=32.4%		
							32						
							37						
							38						
							27						
30	3D	24/16	30.00 - 32.00	2/3/5/5	8	11	8					Brown, wet, medium dense, medium SAND, trace fine gravel, trace silt, (Stream Alluvium).	G#245147 A-1-b, SW-SM WC=32.4%
							15						
							27						
							34						
							46						
35	4D	24/14	35.00 - 37.00	2/3/4/5	7	10	12					Grey, wet, loose, fine SAND, trace silt.	G#245145 A-3, SP-SM WC=23.1%
							13						
							37						
							47						
							49						
40	5D	24/16	40.00 - 42.00	1/3/3/4	6	8	19					Grey, wet, loose, medium SAND, trace silt.	G#245146 A-1-b, SP WC=21.6%
							39						
							61						
							73						
							92						
45	6D	24/20	45.00 - 47.00	1/2/2/2	4	6	41			Grey, wet, loose, Silty fine SAND.	G#245148 A-4, SM WC=33.9%		
							35						
							41						
							47						
50							53						
Remarks: -bgs = below existing ground surface (roadway)													
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	7D	24/23	50.00 - 52.00	4/1/1/2	2	3	59	327.0		Grey, wet, soft, SILT, little fine sand, trace clay, trace organics, (Glaciolacustrine). G#245149 A-4, ML WC=36.9%	
							57				
							53				
							53				
							57				
55	8D	24/24	55.00 - 57.00	WOR/WOR/WOR/WOR	---		55			Grey, wet, very soft, SILT, some clay, trace fine sand, (Glaciolacustrine). G#245150 A-4, CL-ML WC=43.1%	
							69				
							69				
							68				
							82				
60	MV/9D	24/24	60.00 - 62.00	WOH/2/2/5	4	6	91			Failed 55x110 mm vane attempt, would not push. Grey, wet, medium stiff, SILT, some clay, trace fine sand, (Glaciolacustrine). G#245151 A-4, CL WC=35.7%	
							107				
							116				
							120				
							136				
65	10D	24/12	65.50 - 67.50	5/7/18/19	25	35	118	313.0	Cobble from 65 to 65.5 feet bgs. Grey, wet, dense, fine Sandy coarse GRAVEL, trace silt, (Glacial Till). G#245152 A-1-a, GW-GM WC=9.1%		
							108				
							152				
							127				
							97				
70	11D	24/12	70.00 - 72.00	7/19/10/11	29	41	119		Grey, wet, dense, medium SAND, some fine gravel, little silt, (Glacial Till) . RC from 71 to 110.9 feet bgs. G#245153 A-1-b, SW-SM WC=10.6%		
							250				
							200				
							158				
							162				
75											
Remarks: -bgs = below existing ground surface (roadway)											
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs//30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							150		Cobbles and Boulders from 75 to 77.8 feet bgs.		
							185				
							220				
							266				
							258				
80	12D	18/16	80.00 - 81.50	32/50/35	85	119	183		297.5	Grey, wet, hard, fine Sandy SILT, trace fine gravel, trace clay, (Glacial Till).	G#245154 A-4, SC-SM WC=13.1%
							170				
							132				
							127				
							275				
85	13D	8.4/8.4	85.00 - 85.70	10/50(2.4")	---		178	294.5	Grey, wet, very dense, medium SAND, little fine gravel, little silt, (Glacial Till).	G#245155 A-1-b, SM WC=12.8%	
							186				
							486				
							494				
							297				
90	14D	6/6	90.00 - 90.50	50	---		213		Grey, wet, very dense, fine SAND, little fine gravel, trace silt, (Glacial Till).	G#245156 A-1-b, SW-SM WC=13.2%	
							62				
							96				
							77				
							93				
95	15D	9.6/9	95.00 - 95.80	14/50(3.6")	---		87		Similar to 14D.		
							87				
							110				
							313				
							238				
100											
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
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Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
100	16D	10.8/10.8	100.00 - 100.90	50/50(4.8")	---		195		Grey, wet, very dense, fine SAND, little silt, trace fine gravel, (Glacial Till).	G#245157 A-2-4, SM WC=12.9%	
							235				
							242				
							275				
							370				
							300				
							167				
							222				
							294				
							402				
105	17D	14.4/12	105.00 - 106.20	10/60/40(2.4")	---		300		Grey, wet, very hard, SILT, some clay, some fine sand, trace fine gravel, (Glacial Till).	G#245158 A-4, CL WC=20.1%	
							167				
							222				
							294				
							402				
110	18D R1	9.6/9.6 60/55	110.00 - 110.80 110.90 - 115.90	29/50(3.6") RQD = 88%	---		NQ-2		Grey, wet, hard, SILT, little clay, trace fine sand. Top of Bedrock at Elev. 266.6 ft. R1:Bedrock: No bedrock description recorded. R1:Core Times (min:sec) 110.9-111.9 ft (2:55) 111.9-112.9 ft (2:45) 112.9-113.9 ft (2:45) 113.9-114.9 ft (2:50) 114.9-115.9 ft (3:00) 98% Recovery R2:Bedrock: No bedrock description recorded. R2:Core Times (min:sec) 115.9-116.9 ft (2:38) 116.9-117.9 ft (3:20) 117.9-118.9 ft (4:20) 118.9-119.9 ft (3:25) 119.9-120.9 ft (3:25) 100% Recovery	G#245159 A-4, CL-ML WC=23.6%	
115	R2	60/60	115.90 - 120.90	RQD = 95%					Bottom of Exploration at 120.9 feet below ground surface.		
120											
125											

Remarks:
 -bgs = below existing ground surface (roadway)

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

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Boring No.: BB-FSRO-101B

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00																																																																																																																																																																																																																																										
Driller: MaineDOT		Elevation (ft.) 378.0		Auger ID/OD: 5-inch Solid Stem																																																																																																																																																																																																																																														
Operator: Giguere/Giles		Datum: NAVD88		Sampler: Standard Split Spoon																																																																																																																																																																																																																																														
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Boring Location: Sta 299+62.5, 12.7 ft Rt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.																																																																																																																																																																																																																																														
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+62.5, 12.7 ft Rt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							28		Grey, wet, loose, fine SAND, trace silt, (Stream Alluvium).	G#245163 A-3, SP-SM WC=28.0%	
							28				
							39				
							43				
							62				
30	4D	24/14	30.00 - 32.00	2/3/3/3	6	8	16				
							19				
							30				
							41				
							64				
							79				
							116				
							119				
							155				
							158				
40	5D	24/20	40.00 - 42.00	1/1/2/3	3	4	73				
							73				
							76				
							77				
							108				
							127				
							165				
							167				
							169				
50							175				
Remarks: -bgs = below existing ground surface (roadway)											
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 2 of 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00					
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem					
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon					
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches					
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)					
Boring Location: Sta 299+62.5, 12.7 ft Rt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.					
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows						
50	6D	24/18	50.00 - 52.00	8/2/1/4	3	4	107	318.0		Grey, wet, very loose, Silty fine SAND.	G#245165 A-4, SM WC=32.6%		
							82						
							81						
							113						
							122						
55							122						G#245166 A-4, ML WC=47.6%
							127						
							138						
							176						
							192						
60	7D	24/24	60.00 - 62.00	1/WOR/1/WOR	1	1	159					Grey, wet, very soft, SILT, trace clay, trace fine sand, (Glaciolacustrine).	G#245166 A-4, ML WC=47.6%
							165						
							135						
							175						
							181						
65							181						G#245167 A-4, ML WC=43.3%
							186						
							186						
							178						
							178						
70	8D/MV	24/24	70.00 - 72.00	WOR/WOR/WOR/ WOR	---		129			Grey, wet, very soft, SILT, some fine sand, trace clay. Failed 55x110 mm vane attempt, would not push.	G#245167 A-4, ML WC=43.3%		
							130						
							165						
							165						
							178						
75													
Remarks: -bgs = below existing ground surface (roadway)													
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+62.5, 12.7 ft Rt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							162		G#245168 A-4, CL-ML WC=34.1%		
							224				
							224				
							224				
							224				
80	9D	24/20	80.50 - 82.50	10/5/7/8	12	17	176				
							166				
							167				
							167				
							169				
							170				
							167				
							164				
							164				
							164				
90	10D	24/14	90.00 - 92.00	4/7/10/15	17	24	166	Grey, wet, medium dense, fine SAND, some silt, trace fine gravel, (Glacial Till).	G#245169 A-2-4, SM WC=18.7%		
							98				
							105				
							97				
							112				
95							96				
							162				
							238				
							386				
							508				
100								289.0	89.0		
								280.0	98.0		
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00																																																																																																																																																																																																																																																																																													
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Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test																																																																																																																																																																																																																																																																																																					
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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 5 of 5 Boring No.: BB-FSRO-102																																																																																																																																																																																																																																																																																											

Appendix B

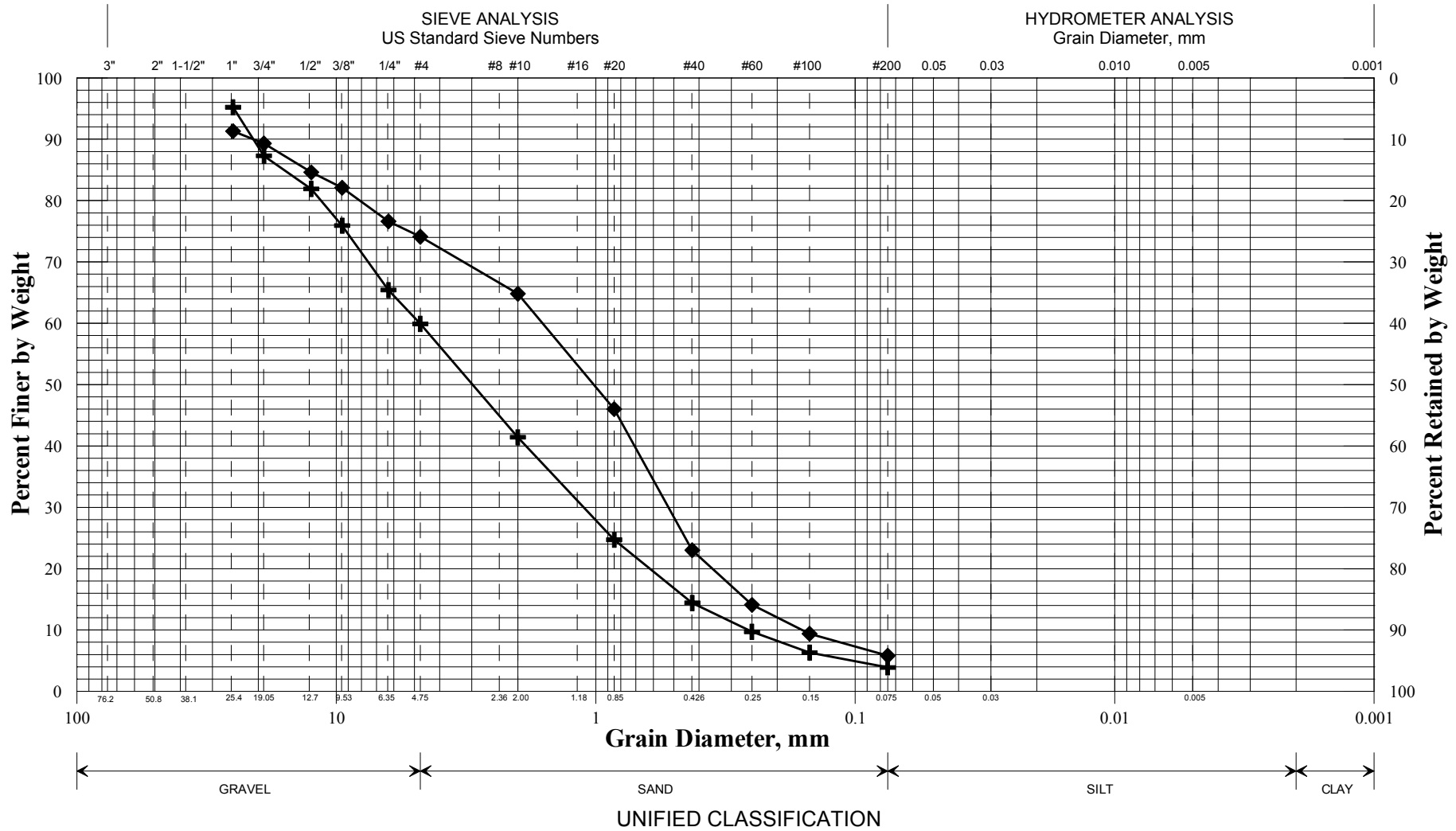
Laboratory Test Results

Project Number: 17912.00

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.

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

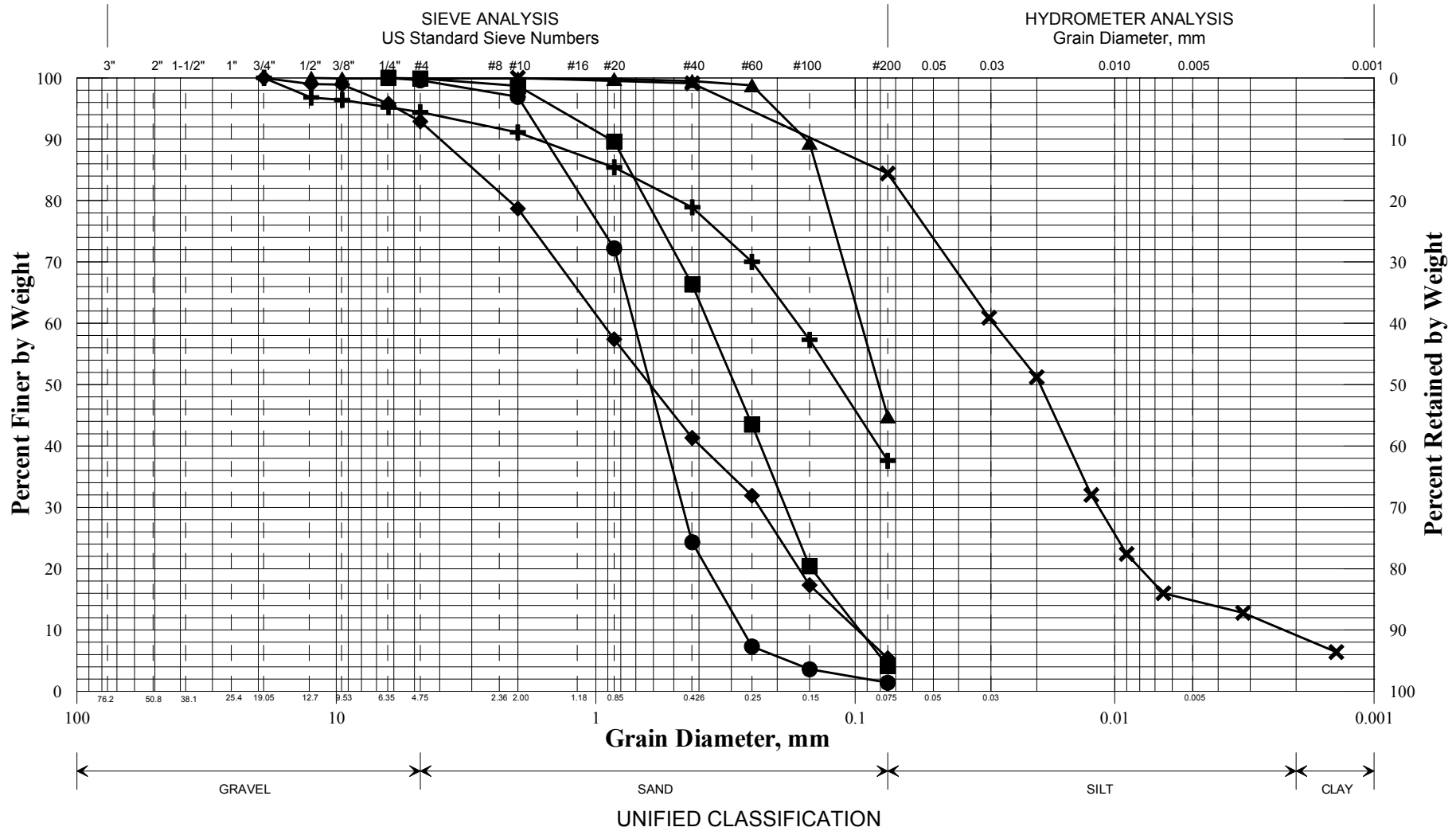
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101/1D	299+27.7	4.0 LT	1.5-3.5	Gravelly SAND, trace silt.	2.1			
◆	BB-FSRO-101/2D	299+27.7	4.0 LT	5.0-7.0	SAND, some gravel, trace silt.	4.0			
■									
●									
▲									
×									

PIN	
017912.00	
Town	
Fryeburg	
Reported by/Date	
WHITE, TERRY A	5/24/2011

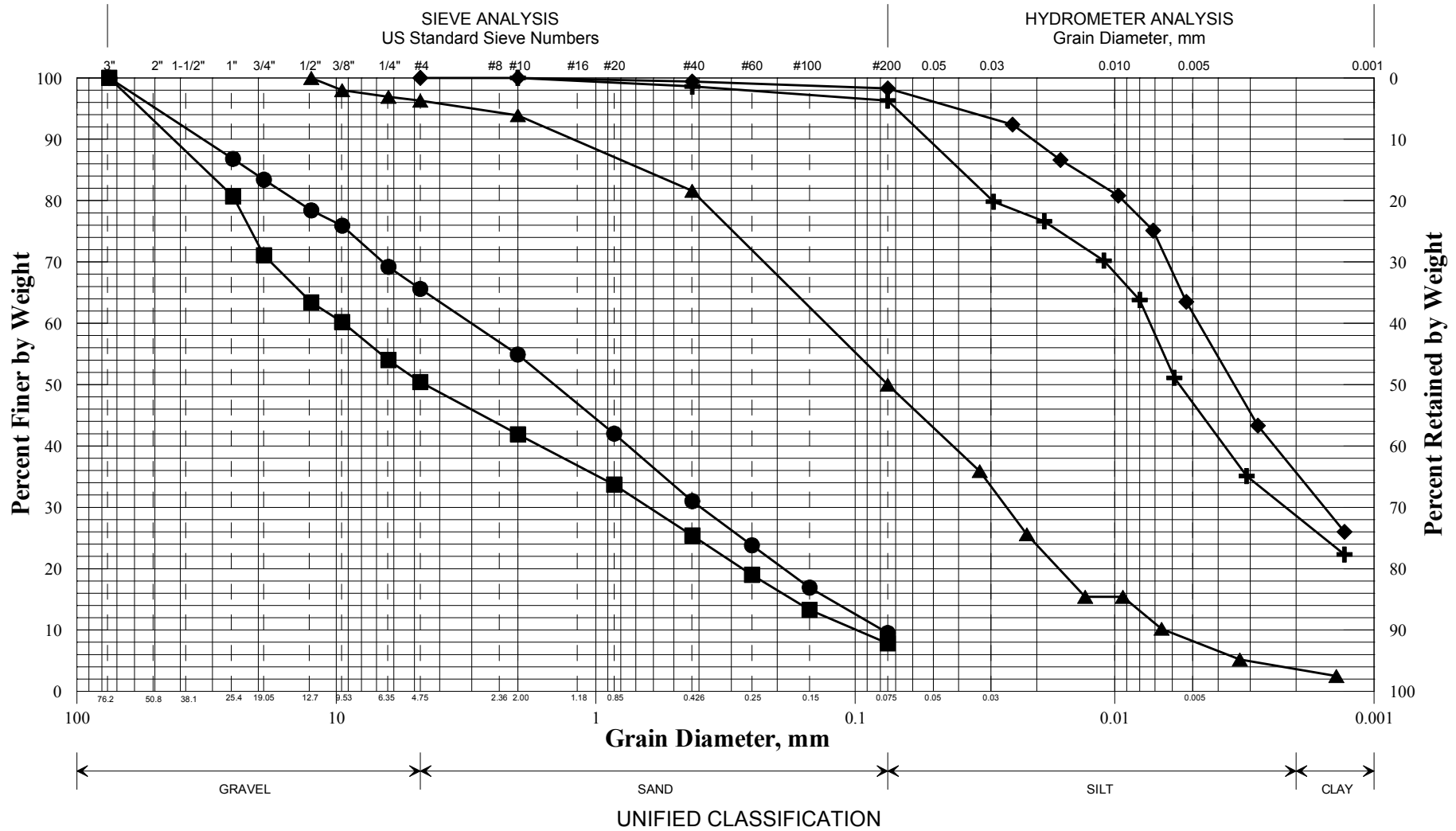
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101B/1D	299+23.2	3.4 LT	15.0-17.0	Silty SAND, trace gravel.	31.9			
◆	BB-FSRO-101B/3D	299+23.2	3.4 LT	30.0-32.0	SAND, trace gravel, trace silt.	32.4			
■	BB-FSRO-101B/4D	299+23.2	3.4 LT	35.0-37.0	SAND, trace silt, trace gravel.	23.1			
●	BB-FSRO-101B/5D	299+23.2	3.4 LT	40.0-42.0	SAND, trace silt, trace gravel.	21.6			
▲	BB-FSRO-101B/6D	299+23.2	3.4 LT	45.0-47.0	Silty SAND, trace gravel.	33.9			
×	BB-FSRO-101B/7D	299+23.2	3.4 LT	50.0-52.0	SILT, little sand, trace clay.	36.9			

PIN	
017912.00	
Town	
Fryeburg	
Reported by/Date	
WHITE, TERRY A	6/7/2011

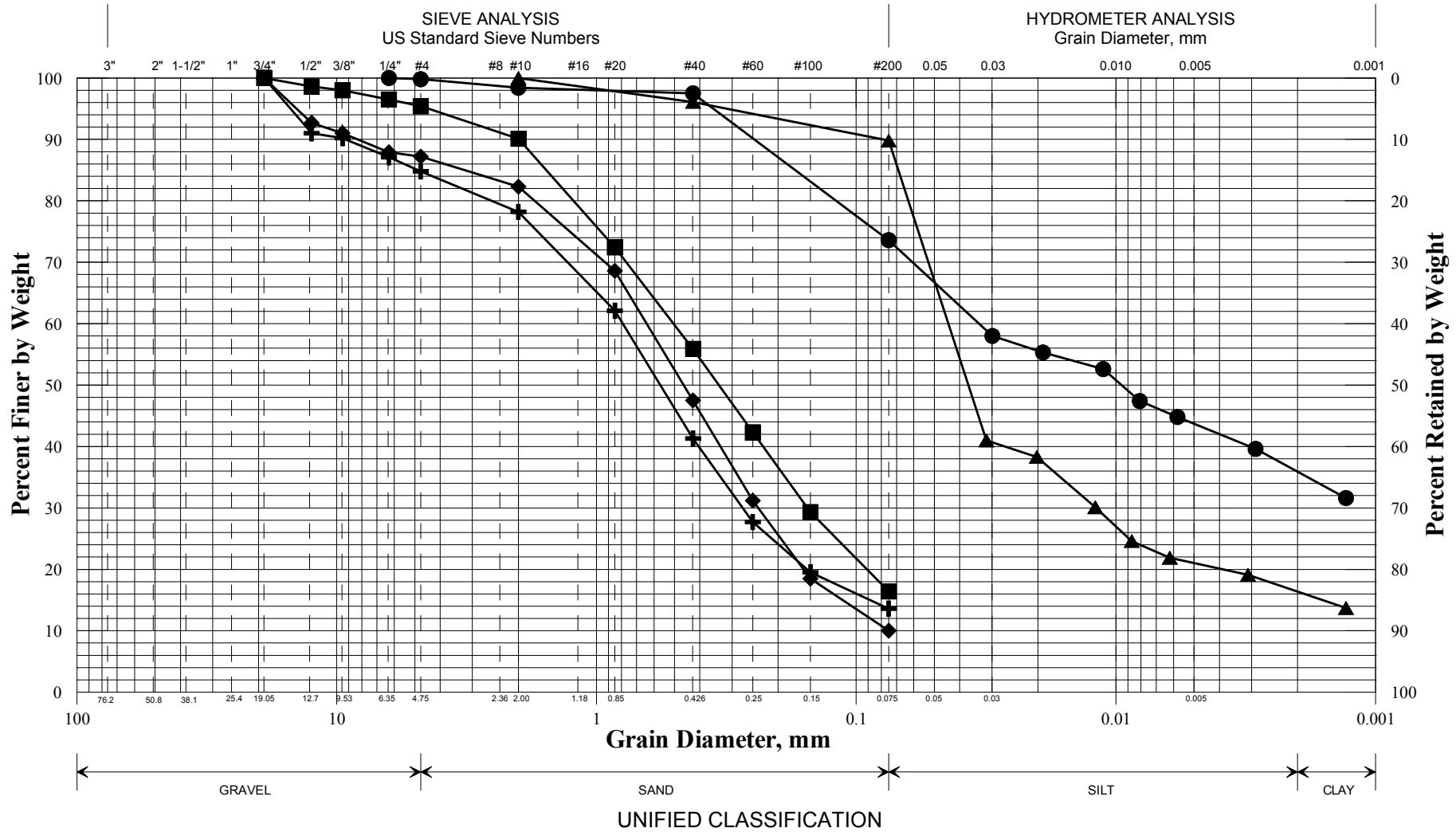
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101B/8D	299+23.2	3.4 LT	55.0-57.0	SILT, some clay, trace sand.	43.1			
◆	BB-FSRO-101B/9D	299+23.2	3.4 LT	60.0-62.0	Clayey SILT, trace sand.	35.7			
■	BB-FSRO-101B/10D	299+23.2	3.4 LT	65.5-67.5	Sandy GRAVEL, trace silt.	9.1			
●	BB-FSRO-101B/11D	299+23.2	3.4 LT	70.0-72.0	SAND, some gravel, trace silt.	10.6			
▲	BB-FSRO-101B/12D	299+23.2	3.4 LT	80.0-81.5	Silty SAND, trace gravel, trace clay.	13.1			
×									

PIN	
017912.00	
Town	
Fryeburg	
Reported by/Date	
WHITE, TERRY A	6/7/2011

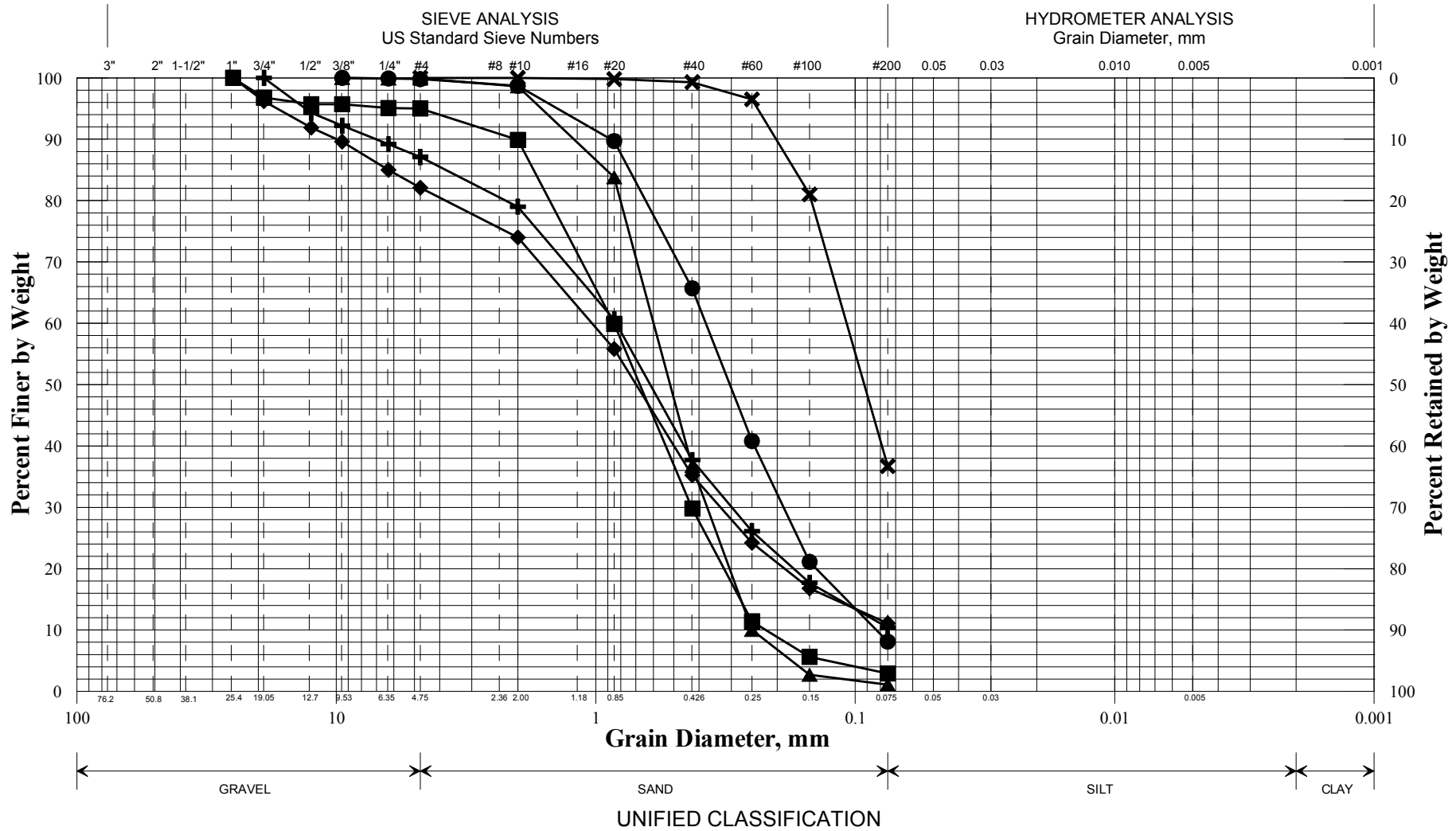
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101B/13D	299+23.2	3.4 LT	85.0-85.7	SAND, little gravel, little silt.	12.8			
♦	BB-FSRO-101B/14D	299+23.2	3.4 LT	90.0-90.5	SAND, little gravel, trace silt.	13.2			
■	BB-FSRO-101B/16D	299+23.2	3.4 LT	100.0-100.9	SAND, little silt, trace gravel.	12.9			
●	BB-FSRO-101B/17D	299+23.2	3.4 LT	105.0-106.2	Clayey SILT, some sand, trace gravel.	20.1			
▲	BB-FSRO-101B/18D	299+23.2	3.4 LT	110.0-110.8	SILT, little clay, little sand.	23.6			
×									

PIN
017912.00
Town
Fryeburg
Reported by/Date
WHITE, TERRY A 6/7/2011

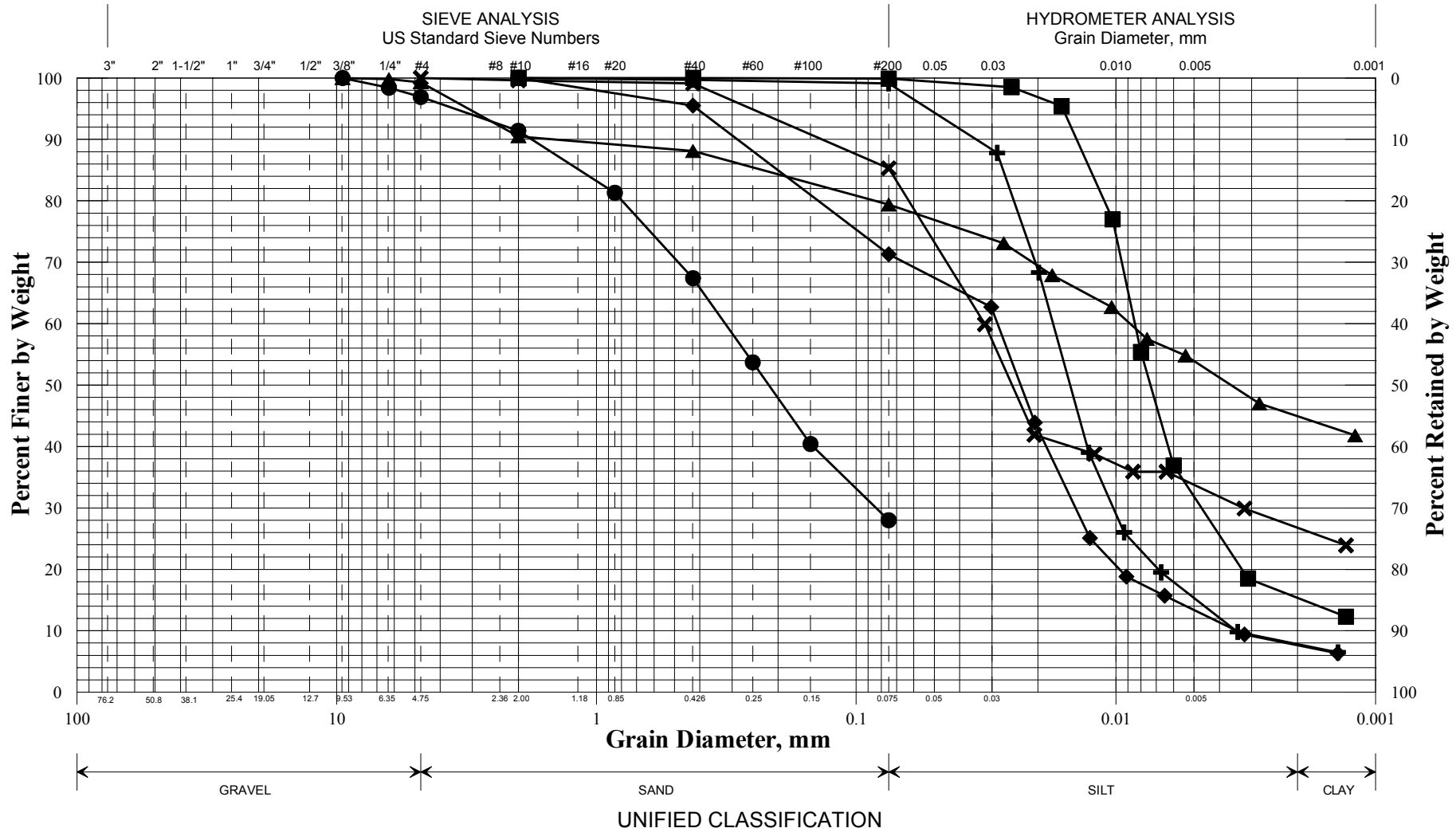
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FRSO-102/1D	299+61.2	12.7 LT	5.0-7.0	SAND, little gravel, little silt.	4.1			
◆	BB-FRSO-102/2D	299+61.2	12.7 LT	10.0-12.0	SAND, little gravel, little silt.	14.0			
■	BB-FRSO-102/3D	299+61.2	12.7 LT	20.0-22.0	SAND, trace gravel, trace silt.	22.1			
●	BB-FRSO-102/4D	299+61.2	12.7 LT	30.0-32.0	SAND, trace silt, trace gravel.	28.0			
▲	BB-FRSO-102/5D	299+61.2	12.7 LT	40.0-42.0	SAND, trace silt, trace gravel.	21.3			
×	BB-FRSO-102/6D	299+61.2	12.7 LT	50.0-52.0	Silty SAND.	32.6			

PIN	
017912.00	
Town	
Fryeburg	
Reported by/Date	
WHITE, TERRY A	5/24/2011

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-102/7D	299+61.2	12.7 LT	60.0-62.0	SILT, trace clay, trace sand.	47.6			
◆	BB-FSRO-102/8D	299+61.2	12.7 LT	70.0-72.0	SILT, some sand, trace clay.	43.3			
■	BB-FSRO-102/9D	299+61.2	12.7 LT	80.5-82.5	SILT, little clay, trace sand.	34.1			
●	BB-FSRO-102/10D	299+61.2	12.7 LT	90.0-92.0	SAND, some silt, trace gravel.	18.7			
▲	BB-FSRO-102/11D	299+61.2	12.7 LT	100.0-101.5	CLAY, some silt, little sand, trace gravel.	17.4			
×	BB-FSRO-102/12D	299+61.2	12.7 LT	110.0-112.0-		25.4			

PIN
017912.00
Town
Fryeburg
Reported by/Date
WHITE, TERRY A 6/7/2011

Appendix C

Calculations

H-Pile Resistance

Compressive Structural Strength of H-Pile (pure axial compression)

Constants			Comments
E	ksi	29,000	LRFD C4.6.2.5-1 (a)
K	-	0.65	
F _y	ksi	50	
l _{unbraced}	in.	1	nominal unbraced length

Input
Calculation
Output

	r (y-y)	A _s	
	in.	in. ²	Comments
14x89	3.53	26.1	ref: Skyline steel Data Sheet

Comments

Φ _c	0.50	LRFD 6.5.4.2: "For axial resistance of piles in compression and subject to damage due to severe driving conditions where use of a pile tip is necessary."
Φ _{service}	1.0	LRFD 1.3.2.1 "For service and extreme limit states resistance factors shall be taken as 1.0, except for . . . bolts . . . and concrete columns."
Φ _{extreme}	1.0	

	P _{e-braced}
	(kips)
14x89	2.20E+08

$$P_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} \times A_g \text{ (LRFD Eq. 6.9.4.1.2-1)}$$

	P _o
	(kips)
14x89	1305

$$P_o = QF_y A_g \text{ (LRFD Article 6.9.4.1.1)}$$

	P _{e-braced} / P _o	>= .44
14x89	168830	TRUE

$$\text{If } \frac{P_e}{P_o} < .44, \text{ then } P_n = .877 P_e$$

(LRFD Eq. 6.9.4.1.1-2)

$$\text{If } \frac{P_e}{P_o} \geq .44, \text{ then } P_n = \left[.658^{\left(\frac{P_o}{P_e}\right)} \right] P_o$$

(LRFD Eq. 6.9.4.1.1-1)

	P _{n-braced}
	(kips)
14x89	1305

	P _r = Φ _{strength} P _n	P _r = Φ _{service} P _n	P _r = Φ _{extreme} P _n
	(kips)	(kips)	(kips)
14x89	652	1305	1305

Input
Linked Cell
Output

Controlling Geotechnical Resistance

	Structural Resistance	ϕ_c	Controlling Geotechnical Resistance
	(kips)		(kips)
14x89	1305	0.5	652

Note: Based on guidance in LRFD Article 10.7.3.2.3., Piles Driven to Hard Rock. The nominal axial geotechnical resistance in the strength limit state was calculated using the guidance in LRFD Article 10.7.3.2.3 which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the structural resistance values obtained from LRFD Article 6.9.4.1 with a resistance factor ϕ_c of 0.50 for severe driving conditions applied.

Maine DOT
Fryeburg14x89 D19-32 Fuel Set 1

23-Jan-2018
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	24.07	3.46	3.0	7.63	17.67
400.0	24.97	1.74	5.2	8.01	18.71
500.0	25.52	2.49	9.0	8.19	19.20
550.0	27.60	3.23	11.8	8.33	19.55
560.0	27.97	3.39	12.6	8.34	19.58
570.0	28.39	3.55	13.3	8.39	19.70
580.0	28.75	3.70	14.2	8.40	19.74
590.0	29.12	3.84	15.0	8.44	19.82
600.0	29.49	3.97	15.9	8.46	19.91

Limit bpi to 15.

$$R_{dr_14x89} := 590 \text{ kip}$$

Strength Limit State

$$\varphi_{dyn} := .65$$

$$R_{dr_14x89_strength} := R_{dr_14x89} \cdot \varphi_{dyn}$$

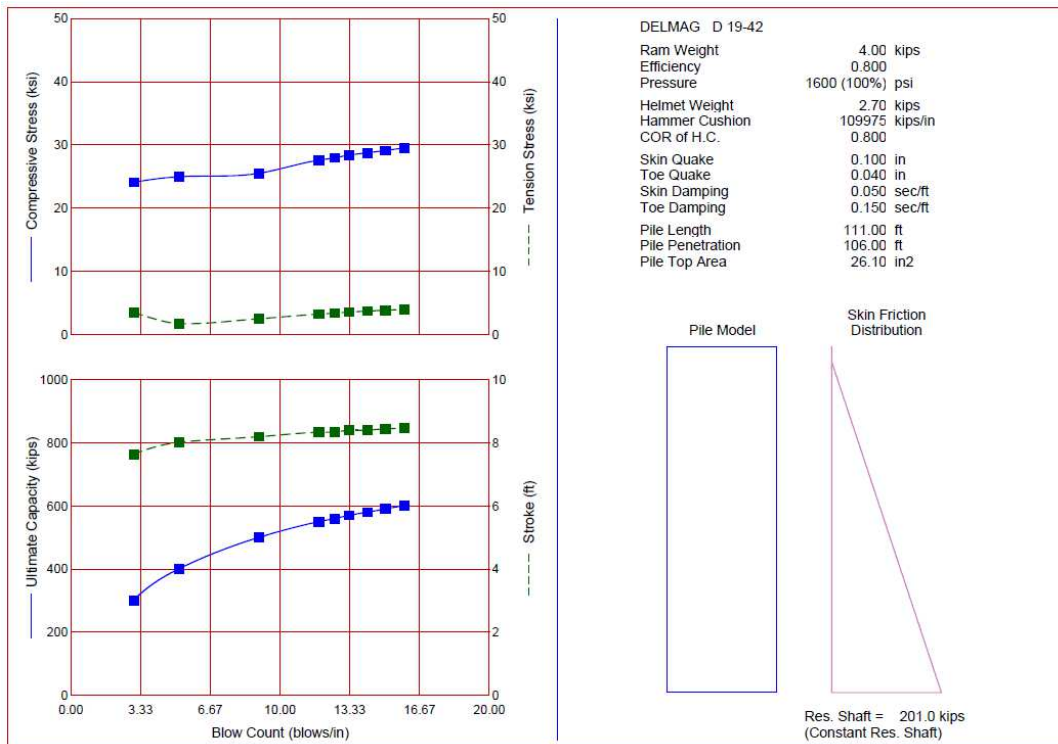
$$R_{dr_14x89_strength} = 384 \text{ kip}$$

Service and Extreme Limit State

$$\varphi := 1.0$$

$$R_{dr_14x89_servext} := R_{dr_14x89} \cdot \varphi$$

$$R_{dr_14x89_servext} = 590 \text{ kip}$$



Maine DOT
 Fryeburg14x89 D36-32 Fuel Set 1

01-May-2018
 GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
300.0	27.90	1.71	1.1	6.59	41.83
500.0	31.17	4.33	2.5	7.62	45.94
600.0	34.41	6.32	3.7	8.04	48.35
700.0	38.96	6.98	5.7	8.42	50.36
810.0	43.44	7.05	9.2	8.86	52.93
820.0	43.50	7.07	9.9	8.80	52.61
840.0	44.15	7.11	11.0	8.85	52.86
860.0	44.81	7.18	12.1	8.91	53.23
880.0	45.37	7.20	13.7	8.95	53.37
900.0	45.98	7.28	15.3	9.00	53.76

Limit driving stresses to 45 ksi.

$$R_{dr_14x89} := 860 \text{ kip}$$

Strength Limit State

$$\varphi_{dyn} := .65$$

$$R_{dr_14x89_strength} := R_{dr_14x89} \cdot \varphi_{dyn}$$

$$R_{dr_14x89_strength} = 559 \text{ kip}$$

Service and Extreme Limit State

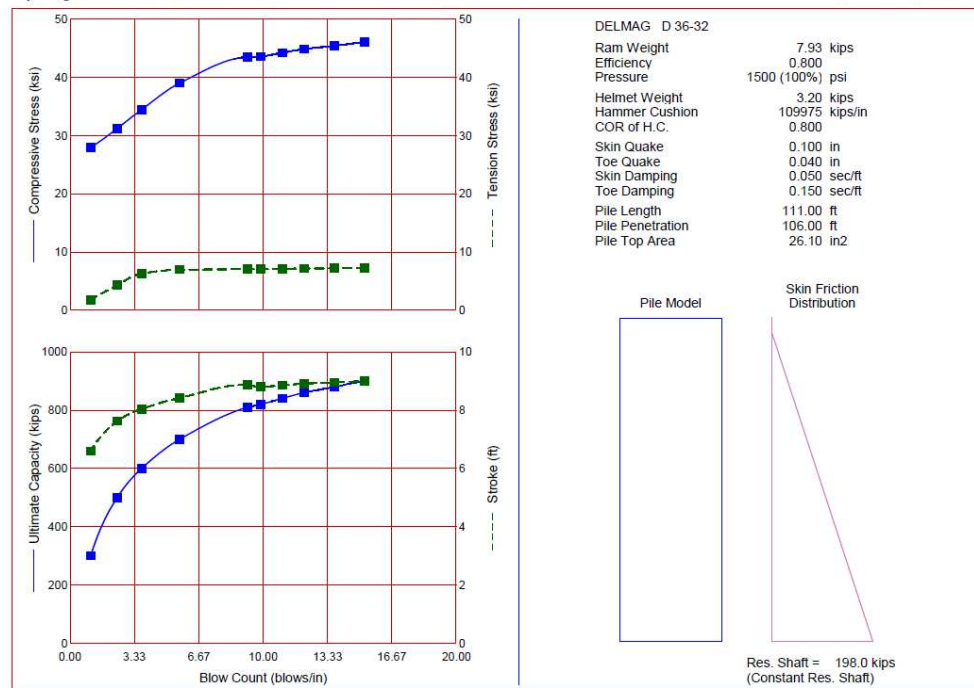
$$\varphi := 1.0$$

$$R_{dr_14x89_servext} := R_{dr_14x89} \cdot \varphi$$

$$R_{dr_14x89_servext} = 860 \text{ kip}$$

Maine DOT
 Fryeburg14x89 D36-32 Fuel Set 1

01-May-2018
 GRLWEAP Version 2010



Lateral Pile Analysis
Abutment No. 1

Fryeburg Eddy Flats Bridge #2261
 WIN 17912.00
 2/9/2018

Calculated by AVB
 Checked by _____
 L.K. 2/9/2018

L-Pile Results

14x89 Run 5

Section	Upper Limit	Lower Limit	Length	K	Φ_c	Φ_f
	(ft)	(ft)	(ft)	-	-	-
Unbraced Top Zone	0	2.62	2.62	2.1	0.7	1.0
Unbraced Middle Zone	2.62	14.21	11.59	1.0	0.7	1.0
Lower Zone	14.21	26.75	12.54	0.65	0.5	-

	in-lbs	k-in	k-ft
Max moment	-2.31E+06	-2.31E+03	-192.4
Point of fixity (ft)	26.75		

Krusinski, Laura

From: Naous, Roger
Sent: Friday, February 09, 2018 10:52 AM
To: VanBuskirk, Andrew
Cc: Krusinski, Laura
Subject: RE: 17912 Fryeburg LPile Results

Andrew: Plastic moment of 192 kip-ft provide for second LPile analysis.

The plastic moment at the top of the pile is 2309 kip-in. The resulting Moment at the top of the pile from the first run is 2980 kip-in. a plastic hinge will form. the displacement and axial load remain the same.

Roger M Naous, P.E.
Civil Engineer II
Bridge Program; Team South
Maine Department of Transportation
Tel: (207) 624-3361
Fax: (207) 624-3491
Roger.Naous@maine.gov



Integrity Competence Service

From: VanBuskirk, Andrew
Sent: Wednesday, February 07, 2018 1:29 PM
To: Naous, Roger <Roger.Naous@maine.gov>
Subject: 17912 Fryeburg LPile Results

Hi Roger,

Please find attached the LPile results for Fryeburg. Thanks!
Andrew

Andrew Van Buskirk, EI
Assistant Geotechnical Engineer
Desk phone: 207-624-3452
MaineDOT
16 Station House Street Augusta, ME 04333-0016



Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)

Displacement of pile head = 0.341000 inches

Moment at pile head = -2309000.0 in-lbs

Axial load at pile head = 327000.0 lbs

	Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch
	0	0.341	-2309000	97730	-0.00171	61400	9.45E+09	-1450	26387
	1.034	0.3009	-1194914	78613	-0.00401	37820	9.45E+09	-1631	67248
1st inflection	2.068	0.2414	-325562	57944	-0.00501	19419	9.45E+09	-1701	87417
2.62 feet	3.102	0.1766	283687	37071	-0.00504	18533	9.45E+09	-1664	116919
	4.136	0.1164	635278	17393	-0.00444	25975	9.45E+09	-1508	160823
	5.17	0.06649	751306	1725	-0.00353	28431	9.45E+09	-1017	189887
	6.204	0.02885	706686	-7527	-0.00257	27486	9.45E+09	-473.7726	203743
	7.238	0.00273	585362	-10532	-0.00172	24918	9.45E+09	-10.6352	48355
	8.272	-0.01386	459284	-10242	-0.00104	22250	9.45E+09	57.4627	51435
	9.306	-0.02297	339606	-9259	-5.11E-04	19717	9.45E+09	100.9347	54514
	10.34	-0.02656	233660	-7868	-1.35E-04	17474	9.45E+09	123.2587	57593
	11.374	-0.02633	145446	-6305	1.13E-04	15607	9.45E+09	128.7539	60672
	12.408	-0.02374	76280	-4749	2.59E-04	14143	9.45E+09	121.9684	63751
2nd inflection	13.442	-0.0199	25487	-3327	3.26E-04	13068	9.45E+09	107.2055	66830
14.21 feet	14.476	-0.01565	-8938	-2115	3.37E-04	12718	9.45E+09	88.2008	69910
	15.51	-0.01155	-29735	-1146	3.11E-04	13158	9.45E+09	67.9431	72989
	16.544	-0.00793	-39914	-423.3078	2.66E-04	13374	9.45E+09	48.617	76068
	17.578	-0.00496	-42395	74.6092	2.12E-04	13426	9.45E+09	31.6404	79147
	18.612	-0.00268	-39779	381.1197	1.58E-04	13371	9.45E+09	17.7649	82226
	19.646	-0.00105	-34216	536.0743	1.09E-04	13253	9.45E+09	7.2117	85305
	20.68	2.56E-05	-27360	579.6838	6.86E-05	13108	9.45E+09	-0.1824	88385
	21.714	6.55E-04	-20387	548.6156	3.73E-05	12960	9.45E+09	-4.8254	91464
	22.748	9.52E-04	-14049	473.6954	1.47E-05	12826	9.45E+09	-7.2507	94543
approx.	23.782	0.00102	-8752	378.9338	-2.46E-07	12714	9.45E+09	-8.0235	97622
fixity	24.816	9.45E-04	-4643	281.5496	-9.04E-06	12627	9.45E+09	-7.6735	100701
26.75 feet	25.85	7.96E-04	-1691	192.6612	-1.32E-05	12565	9.45E+09	-6.6541	103781
	26.884	6.18E-04	244.9296	118.3545	-1.41E-05	12534	9.45E+09	-5.3231	106860
	27.918	4.45E-04	1360	60.8902	-1.31E-05	12558	9.45E+09	-3.9394	109939
	28.952	2.93E-04	1862	19.8777	-1.10E-05	12568	9.45E+09	-2.6713	113018
	29.986	1.72E-04	1943	-6.6953	-8.48E-06	12570	9.45E+09	-1.6119	116097
	31.02	8.29E-05	1765	-21.6356	-6.04E-06	12566	9.45E+09	-0.7963	119176
	32.054	2.23E-05	1455	-27.9378	-3.93E-06	12560	9.45E+09	-0.2195	122256
	33.088	-1.47E-05	1103	-28.3814	-2.25E-06	12552	9.45E+09	0.148	125335
	34.122	-3.36E-05	768.8727	-25.3048	-1.02E-06	12545	9.45E+09	0.3479	128414
	35.156	-4.01E-05	483.7792	-20.5127	-2.02E-07	12539	9.45E+09	0.4245	131493
	36.19	-3.86E-05	261.4675	-15.2802	2.87E-07	12534	9.45E+09	0.4189	134572
	37.224	-3.29E-05	102.2541	-10.4151	5.26E-07	12531	9.45E+09	0.3653	137651
	38.258	-2.56E-05	-1.2628	-6.3496	5.92E-07	12529	9.45E+09	0.29	140731
	39.292	-1.82E-05	-60.1248	-3.2396	5.52E-07	12530	9.45E+09	0.2113	143810
	40.326	-1.19E-05	-86.1365	-1.0569	4.56E-07	12531	9.45E+09	0.1405	146889
	41.36	-6.91E-06	-90.0541	0.3333	3.40E-07	12531	9.45E+09	0.08356	149968
	42.394	-3.42E-06	-80.6268	1.1137	2.28E-07	12530	9.45E+09	0.04223	153047
	43.428	-1.25E-06	-64.2688	1.473	1.33E-07	12530	9.45E+09	0.01568	156126
	44.462	-1.15E-07	-45.1546	1.6851	6.15E-08	12530	9.45E+09	0.01852	1990069
	45.496	2.80E-07	-22.9492	1.5161	1.68E-08	12529	9.45E+09	-0.04576	2028559
	46.53	3.02E-07	-7.6674	0.9205	-3.29E-09	12529	9.45E+09	-0.05024	2067049
	47.564	1.98E-07	-0.07941	0.4	-8.37E-09	12529	9.45E+09	-0.03366	2105538
	48.598	9.38E-08	2.327	0.09059	-6.90E-09	12529	9.45E+09	-0.01621	2144028
	49.632	2.72E-08	2.2247	-0.03971	-3.91E-09	12529	9.45E+09	-0.00479	2182518
	50.666	-3.17E-09	1.3734	-0.06589	-1.55E-09	12529	9.45E+09	5.67E-04	2221007
	51.7	-1.12E-08	0.6021	-0.04973	-2.51E-10	12529	9.45E+09	0.00204	2259497
	52.734	-9.41E-09	0.1414	-0.02628	2.37E-10	12529	9.45E+09	0.00174	2297986
	53.768	-5.32E-09	-0.05196	-0.00926	2.95E-10	12529	9.45E+09	0.001	2336476
	54.802	-2.08E-09	-0.09073	-5.67E-04	2.02E-10	12529	9.45E+09	3.98E-04	2374966
	55.836	-3.20E-10	-0.06767	0.00229	9.76E-11	12529	9.45E+09	6.22E-05	2413455
	56.87	3.40E-10	-0.03469	0.00226	3.04E-11	12529	9.45E+09	-6.72E-05	2451945
	57.904	4.35E-10	-0.01187	0.0013	0	12529	9.45E+09	-8.74E-05	2490434
	58.938	3.37E-10	-0.00244	5.44E-04	-9.52E-12	12529	9.45E+09	-3.43E-05	1264462
	59.972	1.99E-10	0.00171	2.03E-04	-1.00E-11	12529	9.45E+09	-2.06E-05	1283707
	61.006	8.88E-11	0.00269	1.79E-05	-7.12E-12	12529	9.45E+09	-9.32E-06	1302952
	62.04	2.23E-11	0.00221	-5.47E-05	-3.90E-12	12529	9.45E+09	-2.38E-06	1322196
	63.074	-8.01E-12	0.00136	-6.41E-05	-1.55E-12	12529	9.45E+09	8.66E-07	1341441
	64.108	-1.62E-11	6.37E-04	-4.77E-05	0	12529	9.45E+09	1.77E-06	1360686
	65.142	-1.40E-11	1.81E-04	-2.71E-05	0	12529	9.45E+09	1.55E-06	1379931
	66.176	-8.78E-12	-3.65E-05	-1.13E-05	0	12529	9.45E+09	9.90E-07	1399176

67.21	-4.20E-12	-1.02E-04	-2.16E-06	0	12529	9.45E+09	4.80E-07	1418421
68.244	-1.28E-12	-9.24E-05	1.74E-06	0	12529	9.45E+09	1.48E-07	1437665
69.278	0	-5.98E-05	2.57E-06	0	12529	9.45E+09	-1.61E-08	1456910
70.312	0	-2.94E-05	2.04E-06	0	12529	9.45E+09	-6.90E-08	1476155
71.346	0	-9.40E-06	1.20E-06	0	12529	9.45E+09	-6.56E-08	1495400
72.38	0	5.32E-07	5.26E-07	0	12529	9.45E+09	-4.34E-08	1514645
73.414	0	3.78E-06	1.22E-07	0	12529	9.45E+09	-2.17E-08	1533889
74.448	0	3.66E-06	-5.68E-08	0	12529	9.45E+09	-7.16E-09	1553134
75.482	0	2.43E-06	-9.99E-08	0	12529	9.45E+09	2.05E-10	1572379
76.516	0	1.21E-06	-8.20E-08	0	12529	9.45E+09	2.68E-09	1591624
77.55	0	3.98E-07	-4.90E-08	0	12529	9.45E+09	2.65E-09	1610869
78.584	0	-8.28E-09	-2.16E-08	0	12529	9.45E+09	1.77E-09	1630113
79.618	0	-1.43E-07	-5.16E-09	0	12529	9.45E+09	8.83E-10	1649358
80.652	0	-1.40E-07	2.11E-09	0	12529	9.45E+09	2.89E-10	1668603
81.686	0	-9.23E-08	3.86E-09	0	12529	9.45E+09	-8.24E-12	1687848
82.72	0	-4.53E-08	3.15E-09	0	12529	9.45E+09	-1.06E-10	1707093
83.754	0	-1.44E-08	1.85E-09	0	12529	9.45E+09	-1.03E-10	1726337
84.788	0	7.61E-10	7.93E-10	0	12529	9.45E+09	-6.74E-11	1745582
85.822	0	5.50E-09	1.72E-10	0	12529	9.45E+09	-3.26E-11	1764827
86.856	0	5.18E-09	-9.18E-11	0	12529	9.45E+09	-9.96E-12	1784072
87.89	0	3.29E-09	-1.48E-10	0	12529	9.45E+09	0	1803317
88.924	0	1.54E-09	-1.15E-10	0	12529	9.45E+09	4.25E-12	1822561
89.958	0	4.39E-10	-6.50E-11	0	12529	9.45E+09	3.87E-12	1841806
90.992	0	-7.25E-11	-2.60E-11	0	12529	9.45E+09	2.41E-12	1861051
92.026	0	-2.13E-10	-4.30E-12	0	12529	9.45E+09	1.09E-12	1880296
93.06	0	-1.84E-10	4.25E-12	0	12529	9.45E+09	0	1899541
94.094	0	-1.10E-10	5.53E-12	0	12529	9.45E+09	0	1918786
95.128	0	-4.75E-11	4.01E-12	0	12529	9.45E+09	0	1938030
96.162	0	-1.07E-11	2.10E-12	0	12529	9.45E+09	0	1957275
97.196	0	4.80E-12	0	0	12529	9.45E+09	0	1976520
98.23	0	8.03E-12	0	0	12529	9.45E+09	0	1995765
99.264	0	6.18E-12	0	0	12529	9.45E+09	0	2015010
100.298	0	3.37E-12	0	0	12529	9.45E+09	0	2034254
101.332	0	1.29E-12	0	0	12529	9.45E+09	0	2053499
102.366	0	0	0	0	12529	9.45E+09	0	2072744
103.4	0	0	0	0	12529	9.45E+09	0	1045994

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LPILE for Windows, Version 2016-09.008

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:

\GeoTech\GeoTech_Public\Common-Geotech\Andrew\Fryeburg 17912 Eddy Flats 2261\Lpile\LPILE 14x89 run 5\

Name of input data file:

LPILE 14x89 run 5.lp9d

Name of output report file:

LPILE 14x89 run 5.lp9o

Name of plot output file:

LPILE 14x89 run 5.lp9p

Name of runtime message file:

LPILE 14x89 run 5.lp9r

Date and Time of Analysis

Date: February 9, 2018 Time: 11:33:50

Problem Title

Project Name: Fryeburg Eddy Flats Bridge Bridge #2261

Job Number: 17912.00

Client:

Engineer: A. Van Buskirk

Description:

Program Options and Settings

Computational Options:

- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Use of p-y modification factors for p-y curves not selected
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 103.400 ft
Depth of ground surface below top of pile = -9.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	13.8000
2	103.400	13.8000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Weak H-Pile
Length of section = 103.400000 ft
Flange Width = 14.700000 in
Section Depth = 13.800000 in
Flange Thickness = 0.615000 in
Web Thickness = 0.615000 in
Section Area = 26.100000 sq. in
Moment of Inertia = 326.000000 in⁴
Elastic Modulus = 29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = -9.000000 ft
Distance from top of pile to bottom of layer = 0.010000 ft
Effective unit weight at top of layer = 125.000000 pcf
Effective unit weight at bottom of layer = 125.000000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 90.000000 pci
Subgrade k at bottom of layer = 90.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 0.010000 ft
Distance from top of pile to bottom of layer = 6.500000 ft
Effective unit weight at top of layer = 125.000000 pcf
Effective unit weight at bottom of layer = 125.000000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 90.000000 pci
Subgrade k at bottom of layer = 90.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 6.500000 ft
Distance from top of pile to bottom of layer = 44.000000 ft
Effective unit weight at top of layer = 69.200000 pcf
Effective unit weight at bottom of layer = 69.200000 pcf
Friction angle at top of layer = 29.500000 deg.
Friction angle at bottom of layer = 29.500000 deg.
Subgrade k at top of layer = 20.000000 pci
Subgrade k at bottom of layer = 20.000000 pci

Layer 4 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 44.000000 ft
Distance from top of pile to bottom of layer = 58.000000 ft
Effective unit weight at top of layer = 66.500000 pcf
Effective unit weight at bottom of layer = 66.500000 pcf
Undrained cohesion at top of layer = 500.000000 psf
Undrained cohesion at bottom of layer = 500.000000 psf
Epsilon-50 at top of layer = 0.020000
Epsilon-50 at bottom of layer = 0.020000
Subgrade k at top of layer = 0.0000 pci
Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 58.000000 ft
Distance from top of pile to bottom of layer = 104.400000 ft
Effective unit weight at top of layer = 87.700000 pcf
Effective unit weight at bottom of layer = 87.700000 pcf
Friction angle at top of layer = 40.000000 deg.
Friction angle at bottom of layer = 40.000000 deg.
Subgrade k at top of layer = 125.000000 pci
Subgrade k at bottom of layer = 125.000000 pci

(Depth of the lowest soil layer extends 1.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	E50 or krm	kpy pci
1	Sand (Reese, et al.)	-9.0000 0.01000	125.0000 125.0000	-- --	32.0000 32.0000	-- --	90.0000 90.0000
2	Sand (Reese, et al.)	0.01000 6.5000	125.0000 125.0000	-- --	32.0000 32.0000	-- --	90.0000 90.0000
3	Sand	6.5000	69.2000	--	29.5000	--	20.0000

	(Reese, et al.)	44.0000	69.2000	--	29.5000	--	20.0000
4	Stiff Clay	44.0000	66.5000	500.0000	--	0.02000	default
	with Free Water	58.0000	66.5000	500.0000	--	0.02000	default
5	Sand	58.0000	87.7000	--	40.0000	--	125.0000
	(Reese, et al.)	104.4000	87.7000	--	40.0000	--	125.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4 y =	0.341000 in	M = -2309000. in-lbs	327000.	N.A.

Provided by RN

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf Above ft	Same Layer Type As Rock Layer	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer
1	-9.0000	0.00	N.A.	No	0.00	237.0675
2	0.01000	9.0100	Yes	No	237.0675	78499.
3	6.5000	15.5000	Yes	No	78736.	2418669.
4	44.0000	4535.	No	No	2497406.	7764.
5	58.0000	67.0000	No	No	2505170.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)

Displacement of pile head = 0.341000 inches

Moment at pile head = -2309000.0 in-lbs

Axial load at pile head = 327000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Stress psi*	Total Stiffness in-lb^2	Bending p lb/inch	Soil Res. Es*h lb/inch	Soil Spr. Lat. Load lb/inch	Distrib.
0.00	0.3410	-2309000.	97730.	-0.00171		61400.	9.45E+09	-1450.	26387.	0.00
1.0340	0.3009	-1194914.	78613.	-0.00401		37820.	9.45E+09	-1631.	67248.	0.00
2.0680	0.2414	-325562.	57944.	-0.00501		19419.	9.45E+09	-1701.	87417.	0.00
3.1020	0.1766	283687.	37071.	-0.00504		18533.	9.45E+09	-1664.	116919.	0.00
4.1360	0.1164	635278.	17393.	-0.00444		25975.	9.45E+09	-1508.	160823.	0.00
5.1700	0.06649	751306.	1725.	-0.00353		28431.	9.45E+09	-1017.	189887.	0.00
6.2040	0.02885	706686.	-7527.	-0.00257		27486.	9.45E+09	-473.7726	203743.	0.00
7.2380	0.00273	585362.	-10532.	-0.00172		24918.	9.45E+09	-10.6352	48355.	0.00
8.2720	-0.01386	459284.	-10242.	-0.00104		22250.	9.45E+09	57.4627	51435.	0.00
9.3060	-0.02297	339606.	-9259.	-5.11E-04		19717.	9.45E+09	100.9347	54514.	0.00
10.3400	-0.02656	233660.	-7868.	-1.35E-04		17474.	9.45E+09	123.2587	57593.	0.00
11.3740	-0.02633	145446.	-6305.	1.13E-04		15607.	9.45E+09	128.7539	60672.	0.00
12.4080	-0.02374	76280.	-4749.	2.59E-04		14143.	9.45E+09	121.9684	63751.	0.00
13.4420	-0.01990	25487.	-3327.	3.26E-04		13068.	9.45E+09	107.2055	66830.	0.00
14.4760	-0.01565	-8938.	-2115.	3.37E-04		12718.	9.45E+09	88.2008	69910.	0.00
15.5100	-0.01155	-29735.	-1146.	3.11E-04		13158.	9.45E+09	67.9431	72989.	0.00
16.5440	-0.00793	-39914.	-423.3078	2.66E-04		13374.	9.45E+09	48.6170	76068.	0.00
17.5780	-0.00496	-42395.	74.6092	2.12E-04		13426.	9.45E+09	31.6404	79147.	0.00
18.6120	-0.00268	-39779.	381.1197	1.58E-04		13371.	9.45E+09	17.7649	82226.	0.00
19.6460	-0.00105	-34216.	536.0743	1.09E-04		13253.	9.45E+09	7.2117	85305.	0.00
20.6800	2.56E-05	-27360.	579.6838	6.86E-05		13108.	9.45E+09	-0.1824	88385.	0.00
21.7140	6.55E-04	-20387.	548.6156	3.73E-05		12960.	9.45E+09	-4.8254	91464.	0.00
22.7480	9.52E-04	-14049.	473.6954	1.47E-05		12826.	9.45E+09	-7.2507	94543.	0.00
23.7820	0.00102	-8752.	378.9338	-2.46E-07		12714.	9.45E+09	-8.0235	97622.	0.00
24.8160	9.45E-04	-4643.	281.5496	-9.04E-06		12627.	9.45E+09	-7.6735	100701.	0.00
25.8500	7.96E-04	-1691.	192.6612	-1.32E-05		12565.	9.45E+09	-6.6541	103781.	0.00
26.8840	6.18E-04	244.9296	118.3545	-1.41E-05		12534.	9.45E+09	-5.3231	106860.	0.00
27.9180	4.45E-04	1360.	60.8902	-1.31E-05		12558.	9.45E+09	-3.9394	109939.	0.00
28.9520	2.93E-04	1862.	19.8777	-1.10E-05		12568.	9.45E+09	-2.6713	113018.	0.00
29.9860	1.72E-04	1943.	-6.6953	-8.48E-06		12570.	9.45E+09	-1.6119	116097.	0.00
31.0200	8.29E-05	1765.	-21.6356	-6.04E-06		12566.	9.45E+09	-0.7963	119176.	0.00
32.0540	2.23E-05	1455.	-27.9378	-3.93E-06		12560.	9.45E+09	-0.2195	122256.	0.00
33.0880	-1.47E-05	1103.	-28.3814	-2.25E-06		12552.	9.45E+09	0.1480	125335.	0.00
34.1220	-3.36E-05	768.8727	-25.3048	-1.02E-06		12545.	9.45E+09	0.3479	128414.	0.00
35.1560	-4.01E-05	483.7792	-20.5127	-2.02E-07		12539.	9.45E+09	0.4245	131493.	0.00
36.1900	-3.86E-05	261.4675	-15.2802	2.87E-07		12534.	9.45E+09	0.4189	134572.	0.00
37.2240	-3.29E-05	102.2541	-10.4151	5.26E-07		12531.	9.45E+09	0.3653	137651.	0.00
38.2580	-2.56E-05	-1.2628	-6.3496	5.92E-07		12529.	9.45E+09	0.2900	140731.	0.00
39.2920	-1.82E-05	-60.1248	-3.2396	5.52E-07		12530.	9.45E+09	0.2113	143810.	0.00
40.3260	-1.19E-05	-86.1365	-1.0569	4.56E-07		12531.	9.45E+09	0.1405	146889.	0.00
41.3600	-6.91E-06	-90.0541	0.3333	3.40E-07		12531.	9.45E+09	0.08356	149968.	0.00
42.3940	-3.42E-06	-80.6268	1.1137	2.28E-07		12530.	9.45E+09	0.04223	153047.	0.00
43.4280	-1.25E-06	-64.2688	1.4730	1.33E-07		12530.	9.45E+09	0.01568	156126.	0.00
44.4620	-1.15E-07	-45.1546	1.6851	6.15E-08		12530.	9.45E+09	0.01852	1990069.	0.00
45.4960	2.80E-07	-22.9492	1.5161	1.68E-08		12529.	9.45E+09	-0.04576	2028559.	0.00
46.5300	3.02E-07	-7.6674	0.9205	-3.29E-09		12529.	9.45E+09	-0.05024	2067049.	0.00
47.5640	1.98E-07	-0.07941	0.4000	-8.37E-09		12529.	9.45E+09	-0.03366	2105538.	0.00
48.5980	9.38E-08	2.3270	0.09059	-6.90E-09		12529.	9.45E+09	-0.01621	2144028.	0.00
49.6320	2.72E-08	2.2247	-0.03971	-3.91E-09		12529.	9.45E+09	-0.00479	2182518.	0.00
50.6660	-3.17E-09	1.3734	-0.06589	-1.55E-09		12529.	9.45E+09	5.67E-04	2221007.	0.00
51.7000	-1.12E-08	0.6021	-0.04973	-2.51E-10		12529.	9.45E+09	0.00204	2259497.	0.00
52.7340	-9.41E-09	0.1414	-0.02628	2.37E-10		12529.	9.45E+09	0.00174	2297986.	0.00
53.7680	-5.32E-09	-0.05196	-0.00926	2.95E-10		12529.	9.45E+09	0.00100	2336476.	0.00
54.8020	-2.08E-09	-0.09073	-5.67E-04	2.02E-10		12529.	9.45E+09	3.98E-04	2374966.	0.00
55.8360	-3.20E-10	-0.06767	0.00229	9.76E-11		12529.	9.45E+09	6.22E-05	2413455.	0.00
56.8700	3.40E-10	-0.03469	0.00226	3.04E-11		12529.	9.45E+09	-6.72E-05	2451945.	0.00
57.9040	4.35E-10	-0.01187	0.00130	0.00		12529.	9.45E+09	-8.74E-05	2490434.	0.00
58.9380	3.37E-10	-0.00244	5.44E-04	-9.52E-12		12529.	9.45E+09	-3.43E-05	1264462.	0.00
59.9720	1.99E-10	0.00171	2.03E-04	-1.00E-11		12529.	9.45E+09	-2.06E-05	1283707.	0.00
61.0060	8.88E-11	0.00269	1.79E-05	-7.12E-12		12529.	9.45E+09	-9.32E-06	1302952.	0.00
62.0400	2.23E-11	0.00221	-5.47E-05	-3.90E-12		12529.	9.45E+09	-2.38E-06	1322196.	0.00
63.0740	-8.01E-12	0.00136	-6.41E-05	-1.55E-12		12529.	9.45E+09	8.66E-07	1341441.	0.00
64.1080	-1.62E-11	6.37E-04	-4.77E-05	0.00		12529.	9.45E+09	1.77E-06	1360686.	0.00
65.1420	-1.40E-11	1.81E-04	-2.71E-05	0.00		12529.	9.45E+09	1.55E-06	1379931.	0.00
66.1760	-8.78E-12	-3.65E-05	-1.13E-05	0.00		12529.	9.45E+09	9.90E-07	1399176.	0.00
67.2100	-4.20E-12	-1.02E-04	-2.16E-06	0.00		12529.	9.45E+09	4.80E-07	1418421.	0.00
68.2440	-1.28E-12	-9.24E-05	1.74E-06	0.00		12529.	9.45E+09	1.48E-07	1437665.	0.00
69.2780	0.00	-5.98E-05	2.57E-06	0.00		12529.	9.45E+09	-1.61E-08	1456910.	0.00
70.3120	0.00	-2.94E-05	2.04E-06	0.00		12529.	9.45E+09	-6.90E-08	1476155.	0.00
71.3460	0.00	-9.40E-06	1.20E-06	0.00		12529.	9.45E+09	-6.56E-08	1495400.	0.00

72.3800	0.00	5.32E-07	5.26E-07	0.00	12529.	9.45E+09	-4.34E-08	1514645.	0.00
73.4140	0.00	3.78E-06	1.22E-07	0.00	12529.	9.45E+09	-2.17E-08	1533889.	0.00
74.4480	0.00	3.66E-06	-5.68E-08	0.00	12529.	9.45E+09	-7.16E-09	1553134.	0.00
75.4820	0.00	2.43E-06	-9.99E-08	0.00	12529.	9.45E+09	2.05E-10	1572379.	0.00
76.5160	0.00	1.21E-06	-8.20E-08	0.00	12529.	9.45E+09	2.68E-09	1591624.	0.00
77.5500	0.00	3.98E-07	-4.90E-08	0.00	12529.	9.45E+09	2.65E-09	1610869.	0.00
78.5840	0.00	-8.28E-09	-2.16E-08	0.00	12529.	9.45E+09	1.77E-09	1630113.	0.00
79.6180	0.00	-1.43E-07	-5.16E-09	0.00	12529.	9.45E+09	8.83E-10	1649358.	0.00
80.6520	0.00	-1.40E-07	2.11E-09	0.00	12529.	9.45E+09	2.89E-10	1668603.	0.00
81.6860	0.00	-9.23E-08	3.86E-09	0.00	12529.	9.45E+09	-8.24E-12	1687848.	0.00
82.7200	0.00	-4.53E-08	3.15E-09	0.00	12529.	9.45E+09	-1.06E-10	1707093.	0.00
83.7540	0.00	-1.44E-08	1.85E-09	0.00	12529.	9.45E+09	-1.03E-10	1726337.	0.00
84.7880	0.00	7.61E-10	7.93E-10	0.00	12529.	9.45E+09	-6.74E-11	1745582.	0.00
85.8220	0.00	5.50E-09	1.72E-10	0.00	12529.	9.45E+09	-3.26E-11	1764827.	0.00
86.8560	0.00	5.18E-09	-9.18E-11	0.00	12529.	9.45E+09	-9.96E-12	1784072.	0.00
87.8900	0.00	3.29E-09	-1.48E-10	0.00	12529.	9.45E+09	0.00	1803317.	0.00
88.9240	0.00	1.54E-09	-1.15E-10	0.00	12529.	9.45E+09	4.25E-12	1822561.	0.00
89.9580	0.00	4.39E-10	-6.50E-11	0.00	12529.	9.45E+09	3.87E-12	1841806.	0.00
90.9920	0.00	-7.25E-11	-2.60E-11	0.00	12529.	9.45E+09	2.41E-12	1861051.	0.00
92.0260	0.00	-2.13E-10	-4.30E-12	0.00	12529.	9.45E+09	1.09E-12	1880296.	0.00
93.0600	0.00	-1.84E-10	4.25E-12	0.00	12529.	9.45E+09	0.00	1899541.	0.00
94.0940	0.00	-1.10E-10	5.53E-12	0.00	12529.	9.45E+09	0.00	1918786.	0.00
95.1280	0.00	-4.75E-11	4.01E-12	0.00	12529.	9.45E+09	0.00	1938030.	0.00
96.1620	0.00	-1.07E-11	2.10E-12	0.00	12529.	9.45E+09	0.00	1957275.	0.00
97.1960	0.00	4.80E-12	0.00	0.00	12529.	9.45E+09	0.00	1976520.	0.00
98.2300	0.00	8.03E-12	0.00	0.00	12529.	9.45E+09	0.00	1995765.	0.00
99.2640	0.00	6.18E-12	0.00	0.00	12529.	9.45E+09	0.00	2015010.	0.00
100.2980	0.00	3.37E-12	0.00	0.00	12529.	9.45E+09	0.00	2034254.	0.00
101.3320	0.00	1.29E-12	0.00	0.00	12529.	9.45E+09	0.00	2053499.	0.00
102.3660	0.00	0.00	0.00	0.00	12529.	9.45E+09	0.00	2072744.	0.00
103.4000	0.00	0.00	0.00	0.00	12529.	9.45E+09	0.00	1045994.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.34100000 inches
 Computed slope at pile head = -0.00171426 radians
 Maximum bending moment = -2309000. inch-lbs
 Maximum shear force = 97730. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 6
 Number of zero deflection points = 13

Summary of Pile-head Responses for Conventional Analyses

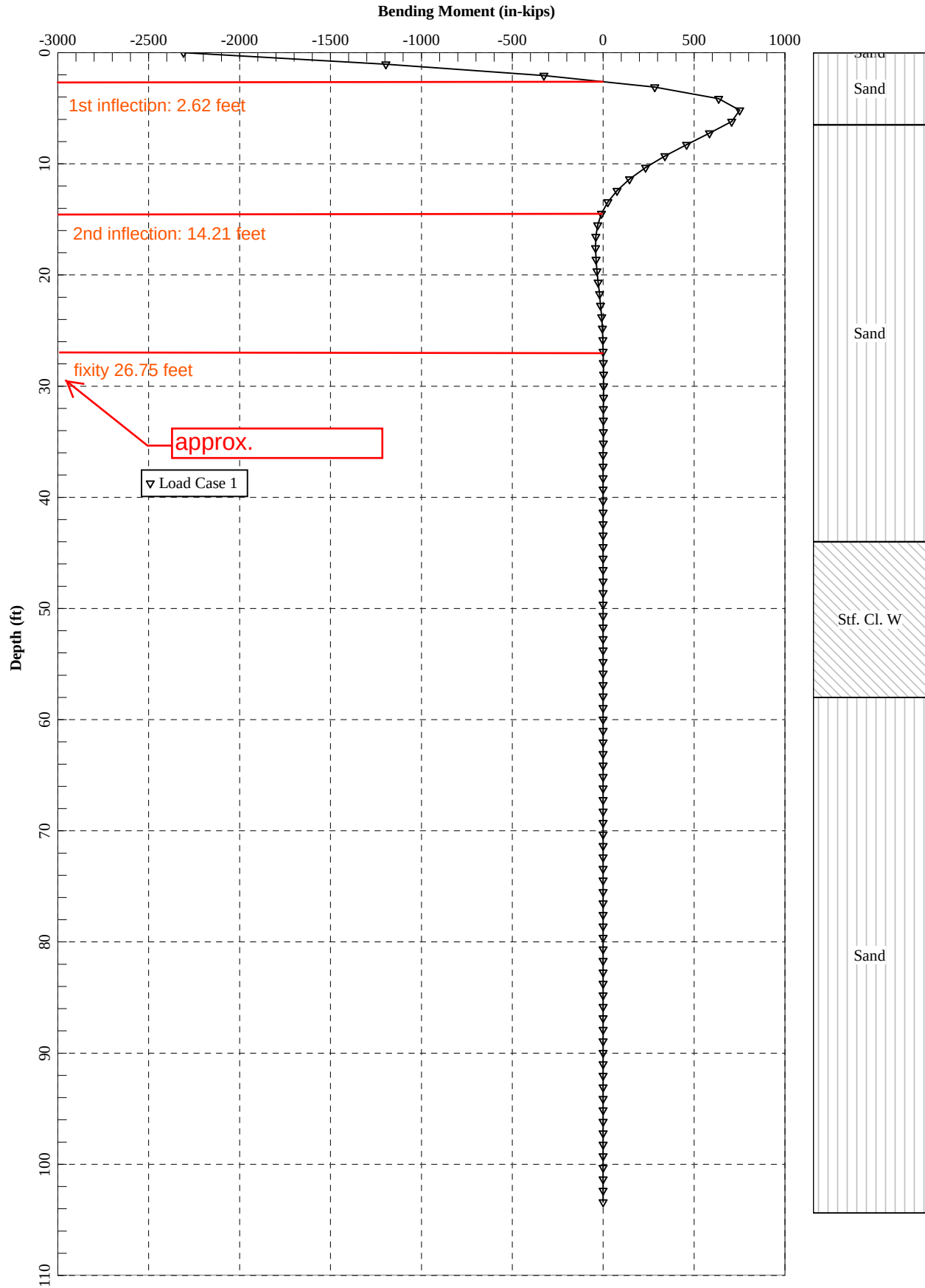
Definitions of Pile-head Loading Conditions:

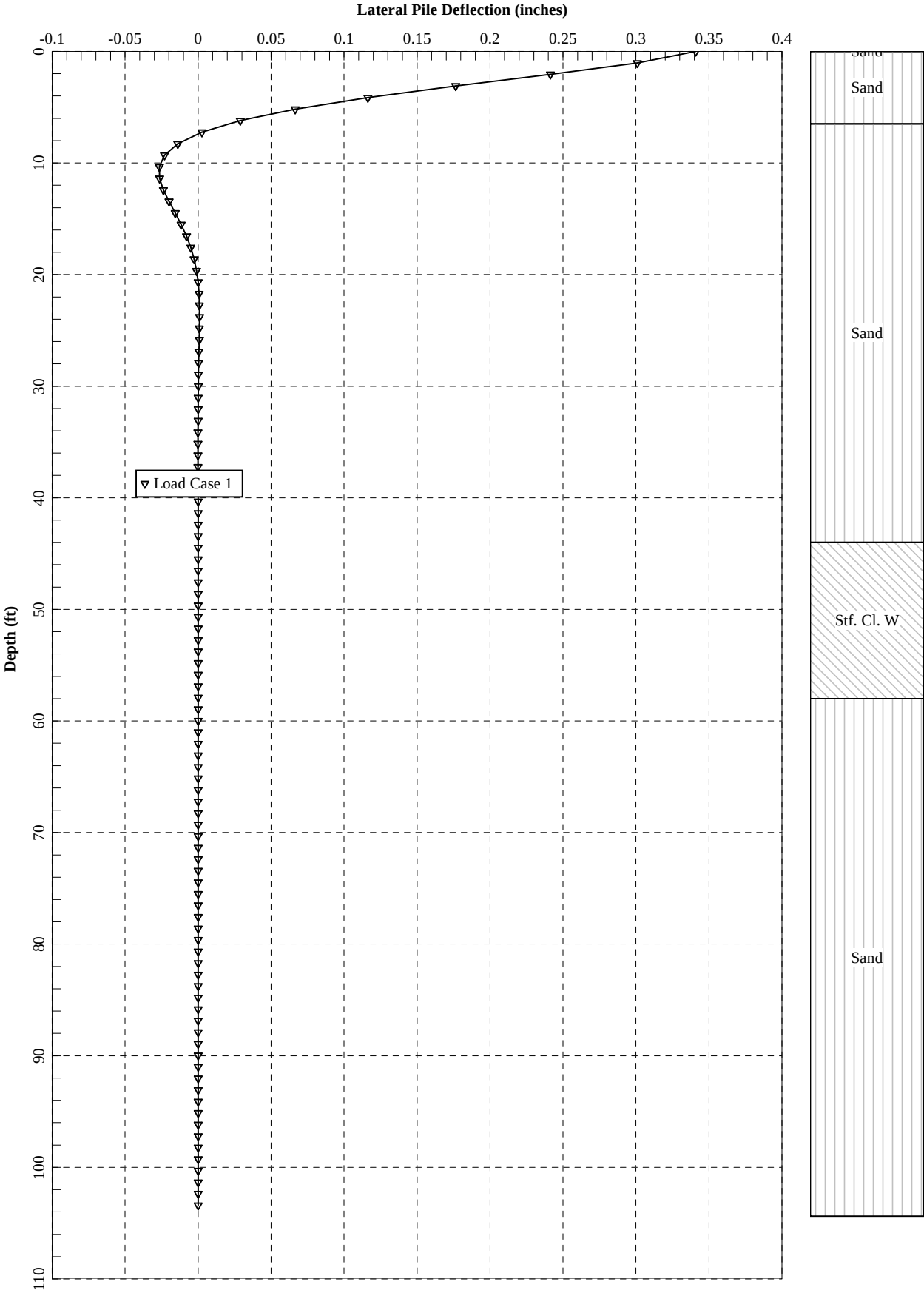
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

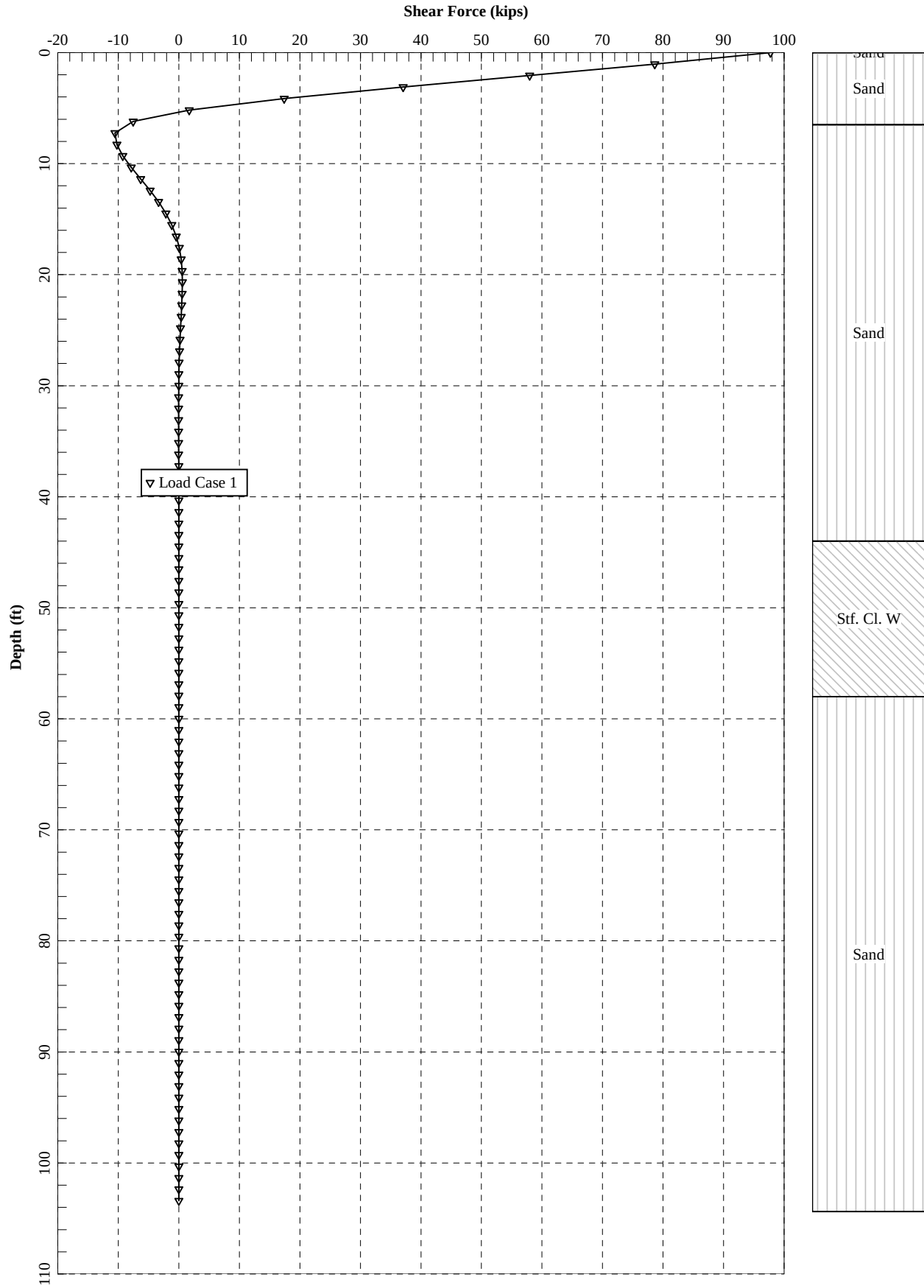
Load Load	Load	Axial	Pile-head	Pile-head	Max Shear	Max Moment
Case Type	Pile-head	Type	Pile-head	Loading	Deflection	Rotation
No. 1	Load 1	2	Load 2	lbs	inches	radians
1 y, in	0.3410	M, in-lb	-2309000.	327000.	0.3410	-0.00171

Maximum pile-head deflection = 0.341000000 inches
 Maximum pile-head rotation = -0.0017142626 radians = -0.098220 deg.

The analysis ended normally.







LK 2/9/2018
supporting calcs
4 sheets with
boring log & design profile,
and references

References

- ① Bridge Design Guide. Prepared by Guertin Elherton and Associates. MaineDOT. Aug. 2003
- ② LPile Technical Manual 2016. Isenhower, Wang, and Vasquez. Jan. 2016.
- ③ Principles of Geotechnical Engineering. Das, Braja. Seventh Edition. 2010.
- ④ Soil Mechanics. Lambe and Whitman. Fig. 11.14. 1969.

MaineDOT

MaineDOT

PRELIM. BY AVB
FINAL CHK. BY _____
ITEM NO. _____

DATE 11/30/18
DATE _____
SUBJECT _____

PROJ. NO. 17912.00
LOCATION Fryeburg

FILE NO. _____ OF _____
SHEET NO. 2 OF 3

L Pile Analysis 14x89 Run 2

Soil Layer 1

Top of Abutment: Elev. 380.0'
Pile Head: Elev. 371.0'

$\gamma = 125$ pcf (Ref. 1, B06 3-3 granular borrow for underwater fill)
 $\phi = 32^\circ$ (as above)
 $K_H = 90$ pci (Ref. 2, LPile Technical Manual Table 3-7
medium relative density)

Soil Layer 2

Elev. 364.5' to 371.0'

soil properties same as Soil Layer 1

Soil Layer 3

Elev. 364.5' - 327.0'

$\bar{N} = 8$ bpf
water content = 29% (average of tested samples)

$\gamma_{dry} = 102$ pcf (Ref. 3, Principles of Geotech Engr 7th Ed.,
Das, Table 3-2)

$\gamma_{sat} = \gamma_{dry} (1 + w)$

$\gamma_{sat} = 102 (1 + .29) = 131.6$ pcf

$\gamma' = \gamma_{sat} - \gamma_{water}$
 $\gamma' = 131.6$ pcf - 62.4 pcf = 69.2 pcf

$\phi = 29.5$ (Ref. 4, Peck, Hansen, and Thornburn)

$K = 20$ pci (Ref. 2, LPile Technical Manual) (Table 3-6)

MaineDOT

MaineDOT

Soil Layer 4 - Soft Silt

Elev. 313' - 327'

$$\bar{N} = 4 \text{ bpf}$$

$$w = 38.6\% \quad (\text{Average of 3 tested samples})$$

$$\gamma_{\text{dry}} = 93 \text{ pcf} \quad (\text{Ref. 3, Das, Table 3-2})$$

$$\gamma' = 93(1 + 0.386) - 62.4 = 66.5 \text{ pcf}$$

$$c = 500 \text{ psf}$$

$$E_{s0} = 0.020 \quad (\text{Ref. 2, L-Pile Technical Manual Table 3-2})$$

Soil Layer 5 - Glacial Till

Elev. 266.6' - 313.0'

$$\bar{N} > 50$$

$$w = 11.95\% \quad (\text{Average of representative samples})$$

$$\gamma = 134 \text{ pcf} \quad (\text{Ref. 3, Das Table 3.2, Glacial Till})$$

$$\gamma' = 134 \text{ pcf} \quad (1 + 0.12) - 62.4 = 87.7 \text{ pcf}$$

$$\phi = 40^\circ \quad (\text{Ref. 4, Pech, Hansen, and Thornburn})$$

$$K = 125 \text{ pci} \quad (\text{Ref. 2, L-Pile Technical Manual}) \quad (\text{Table 3-6})$$

MaineDOT

MaineDOT

MaineDOT

MaineDOT

DEPTH

-9.0'

0.0'

6.5'

44.0'

58'

104.4'



380

371

SOIL LAYER (2) $t = 6.5'$

364.5

SOIL LAYER (3)

$t = 37.5'$

327

(4)

$t = 14'$

313

(5)

$t = 46.4'$

266.6

LENGTH = $371 - 266.6 = 104.4'$



Maine Department of Transportation				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow		Boring No.: BB-FSRO-101B						
Soil/Rock Exploration Log US CUSTOMARY UNITS				Location: Fryeburg, Maine		WIN: 17912.00						
Driller: MaineDOT		Elevation (ft.): 377.5		Auger ID/OD: 5-inch Solid Stem								
Operator: Giguere/Giles		Datum: NAVD88		Sampler: Standard Split Spoon								
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs/30 inches								
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11		Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)								
Boring Location: Sta 299+23.2, 3.4 feet Lt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 13 feet bgs								
Hammer Efficiency Factor: 0.84		Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐										
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person Su = Peak/Remolded Field Vane Undrained Shear Strength (psf) Su(lab) = Lab Vane Undrained Shear Strength (psf) qp = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N60 = SPT N-uncorrected Corrected for Hammer Efficiency N60 = (Hammer Efficiency Factor/60%) * N-uncorrected Tv = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test												
Sample Information												
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.	
0							SSA aSP	377.13		4.5-inch-thick layer of pavement.		
										Fill soils similar to BB-FSRO-101 to 15 feet bgs. aSpun HW casing ahead to 20 feet bgs.		
5										Cobbles from 5.5 to 6.5 feet bgs.		
										Cobbles from 7 to 8.5 feet bgs.		
10										Boulder from 10.3 to 11.5 feet bgs.		
15	ID	24/13	15.00 - 17.00	4/2/1/1	3	4		362.50			Olive-brown, wet, very loose, Silty fine SAND, trace fine gravel.	G#245144 A-4, SM WC=31.9%
20	2D	24/14	20.00 - 22.00	2/2/3/4	5	7	25	358.50			Brown, wet, loose, SAND, trace fine gravel, trace silt. Dropped in NW casing at 20 feet bgs.	
							22					
							33					
							31					
							35					
25												
Remarks: - bgs = below existing ground surface (roadway)												
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 1 of 5		
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.										Boring No.: BB-FSRO-101B		

Maine Department of Transportation				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow				Boring No.: BB-FSRO-101B																																																																																																																																																																																																																																																																																								
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Boring No.: BB-FSRO-101B

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B																																																																																																																																																																																																																													
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B	
				WIN: 17912.00					
Driller: MaineDOT		Elevation (ft.) 377.5		Auger ID/OD: 5-inch Solid Stem					
Operator: Giguere/Giles		Datum: NAVD88		Sampler: Standard Split Spoon					
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs//30 inches					
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11		Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)					
Boring Location: Sta 299+23.2, 3.4 feet Lt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 13 feet bgs					
Hammer Efficiency Factor: 0.84		Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _{u(lab)} = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test									

Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							150		Cobbles and Boulders from 75 to 77.8 feet bgs.		
							185				
							220				
							266				
							258				
80	12D	18/16	80.00 - 81.50	32/50/35	85	119	183	297.50		Grey, wet, hard, fine Sandy SILT, trace fine gravel, trace clay.	80.00 G#245154 A-4, SC-SM WC=13.1%
							170				
							132				
							127	294.50		Grey, wet, very dense, medium SAND, little fine gravel, little silt.	83.00 G#245155 A-1-b, SM WC=12.8%
							275				
							178				
							186				
							486				
							494		Grey, wet, very dense, fine SAND, little fine gravel, trace silt.	G#245156 A-1-b, SW-SM WC=13.2%	
							297				
							213				
							62				
							96				
							77		Similar to 14D.		
							93				
							87				
							87				
							110				
							313		Similar to 14D.		
							238				

100

Remarks: -bgs = below existing ground surface (roadway)

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

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

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Boring No.: BB-FSRO-101B

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B																																																																																																																																																																																																																																																												
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Remarks: - bgs = below existing ground surface (roadway)																																																																																																																																																																																																																																																																				
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.																																																																																																																																																																																																																																																																				

loading. The load was applied in two directions, with the load in the forward direction being more than twice as large as the load in the backward direction. After a significant number of cycles, the deflection at the top of the pile was either stable or creeping slowly, so an equilibrium condition was assumed. The p - y curves for cyclic loading are intended to represent a lower-bound condition. Thus, a designer might possibly be computing an overly conservative response of a pile, if the cyclic p - y curves are used and if there are only a small number of applications of the design load (the factored load).

3-3-7-2 Procedure for Computing p - y Curves in Soft Clay for Static Loading

The following procedure is for short-term static loading and is illustrated by Figure 3-12(a). As noted earlier, the curves for static loading constitute the basis for indicating the influence of cyclic loading and would be rarely used in design if cyclic loading is of concern.

1. Obtain the best possible estimates of the variation of undrained shear strength c and effective unit weight with depth. Also, obtain the value of ε_{50} , the strain corresponding to one-half the maximum principal stress difference. If no stress-strain curves are available, typical values of ε_{50} are given in Table 3-2.

Table 3-2 Representative Values of ε_{50} for Soft to Stiff Clays

Consistency of Clay	ε_{50}
Soft	0.020
Medium	0.010
Stiff	0.005

2. Compute the ultimate soil resistance per unit length of pile, using the smaller of the values given by the equations below.

$$p_u = \left[3 + \frac{\gamma'_{avg}}{c} x + \frac{J}{b} x \right] cb \dots\dots\dots (3-20)$$

$$p_u = 9cb \dots\dots\dots (3-21)$$

where

γ'_{avg} = average effective unit weight from ground surface to p - y curve,¹

x = depth from the ground surface to p - y curve,

c = shear strength at depth x , and

b = width of pile.

¹ Matlock did not specify in his original paper whether the unit weight was total unit weight or effective unit weight. However, API RP2A specifies that effective unit weight be used. Most users have adopted the recommendation by API and this is the implementation chosen for LPile.

Table 3-6 Representative Values of k for Fine Sand Below the Water Table for Static and Cyclic Loading

Recommended k	Relative Density		
	Loose	Medium	Dense
MN/m ³ (pci)	5.4 (20.0)	16.3 (60.0)	34 (125.0)

Table 3-7 Representative Values of k for Fine Sand Above Water Table for Static and Cyclic Loading

Recommended k	Relative Density		
	Loose	Medium	Dense
MN/m ³ (pci)	6.8 (25.0)	24.4 (90.0)	61.0 (225.0)

If the sand profile is coarse or well-graded sand, the user may consider using a higher value of k than those suggested in the tables above. While experimental data for k in well-graded sands is poorly documented, use of values 10 to 50 percent higher may be appropriate in dense and very dense well-graded sands that do not contain any compressible minerals such as mica.

7. Fit the parabola between point k and point m as follows:
 - a. Compute the slope of the p - y curve between point m and point u using

$$m = \frac{p_u - p_m}{y_u - y_m} \dots\dots\dots (3-62)$$

- b. Compute the power of the parabolic section using

$$n = \frac{p_m}{m y_m} \dots\dots\dots (3-63)$$

- c. Compute the coefficient $\bar{C}$ using

$$\bar{C} = \frac{p_m}{y_m^{1/n}} \dots\dots\dots (3-64)$$

8. Compute the y value defining point k using

$$y_k = \left(\frac{\bar{C}}{kx} \right)^{\frac{n}{n-1}} \dots\dots\dots (3-65)$$

Compute the p value defining point k using

3.4 Various Unit-Weight Relationships

In Sections 3.2 and 3.3, we derived the fundamental relationships for the moist unit weight, dry unit weight, and saturated unit weight of soil. Several other forms of relationships that can be obtained for γ , γ_d , and γ_{sat} are given in Table 3.1. Some typical values of void ratio, moisture content in a saturated condition, and dry unit weight for soils in a natural state are given in Table 3.2.

Table 3.1 Various Forms of Relationships for γ , γ_d , and γ_{sat}

Moist unit weight (γ)		Dry unit weight (γ_d)		Saturated unit weight (γ_{sat})	
Given	Relationship	Given	Relationship	Given	Relationship
w, G_s, e	$\frac{(1+w)G_s\gamma_w}{1+e}$	γ, w	$\frac{\gamma}{1+w}$	G_s, e	$\frac{(G_s+e)\gamma_w}{1+e}$
S, G_s, e	$\frac{(G_s+Se)\gamma_w}{1+e}$	G_s, e	$\frac{G_s\gamma_w}{1+e}$	G_s, n	$[(1-n)G_s+n]\gamma_w$
w, G_s, S	$\frac{(1+w)G_s\gamma_w}{1+\frac{wG_s}{S}}$	G_s, n	$G_s\gamma_w(1-n)$	G_s, w_{sat}	$\left(\frac{1+w_{\text{sat}}}{1+w_{\text{sat}}G_s}\right)G_s\gamma_w$
w, G_s, n	$G_s\gamma_w(1-n)(1+w)$	G_s, w, S	$\frac{G_s\gamma_w}{1+\left(\frac{wG_s}{S}\right)}$	e, w_{sat}	$\left(\frac{e}{w_{\text{sat}}}\right)\left(\frac{1+w_{\text{sat}}}{1+e}\right)\gamma_w$
S, G_s, n	$G_s\gamma_w(1-n)+nS\gamma_w$	e, w, S	$\frac{eS\gamma_w}{(1+e)w}$	n, w_{sat}	$n\left(\frac{1+w_{\text{sat}}}{w_{\text{sat}}}\right)\gamma_w$
		γ_{sat}, e	$\gamma_{\text{sat}} - \frac{e\gamma_w}{1+e}$	γ_d, e	$\gamma_d + \left(\frac{e}{1+e}\right)\gamma_w$
		γ_{sat}, n	$\gamma_{\text{sat}} - n\gamma_w$	γ_d, n	$\gamma_d + n\gamma_w$
		γ_{sat}, G_s	$\frac{(\gamma_{\text{sat}} - \gamma_w)G_s}{(G_s - 1)}$	γ_d, S	$\left(1 - \frac{1}{G_s}\right)\gamma_d + \gamma_w$
				γ_d, w_{sat}	$\gamma_d(1+w_{\text{sat}})$

Table 3.2 Void Ratio, Moisture Content, and Dry Unit Weight for Some Typical Soils in a Natural State

Type of soil	Void ratio, e	Natural moisture content in a saturated state (%)	Dry unit weight, γ_d	
			lb/ft ³	kN/m ³
Loose uniform sand	0.8	30	92	14.5
Dense uniform sand	0.45	16	115	18
Loose angular-grained silty sand	0.65	25	102	16
Dense angular-grained silty sand	0.4	15	121	19
Stiff clay	0.6	21	108	17
Soft clay	0.9–1.4	30–50	73–93	11.5–14.5
Loess	0.9	25	86	13.5
Soft organic clay	2.5–3.2	90–120	38–51	6–8
Glacial till	0.3	10	134	21

3.4 Construction Loads

The construction live load to be used for constructibility checks is 50 psf applied over the entire deck area. Consideration should be given to slab placement sequence for calculation of maximum force effects.

3.5 Railroad Loads

Railroad bridges should be designed according to the latest American Railroad Engineering and Maintenance-of-Way Association specifications (AREMA, 2002), with the Cooper live loading as determined by the railroad company.

3.6 Earth Loads

3.6.1 General

Earth pressures considered for wall and substructure design must use the appropriate soil weight shown in Table 3-3.

Table 3-3 Material Classification

Soil Type	Soil Description	Internal Angle of Friction of Soil, ϕ	Soil Total Unit Weight (pcf)	Coeff. of Friction, $\tan \delta$, Concrete to Soil	Interface Friction, Angle, Concrete to Soil δ
1	Very loose to loose silty sand and gravel Very loose to loose sand Very loose to medium density sandy silt Stiff to very stiff clay or clayey silt	29°*	100	0.35	19°
2	Medium density silty sand and gravel Medium density to dense sand Dense to very dense sandy silt	33°	120	0.40	22°
3	Dense to very dense silty sand and gravel Very dense sand	36°	130	0.45	24°
4	Granular underwater backfill Granular borrow	32°	125	0.45	24°
5	Gravel Borrow	36°	135	0.50	27°

* The value given for the internal angle of friction (ϕ) for stiff to very stiff silty clay or clayey silt should be used with caution due to the large possible variation with different moisture contents.

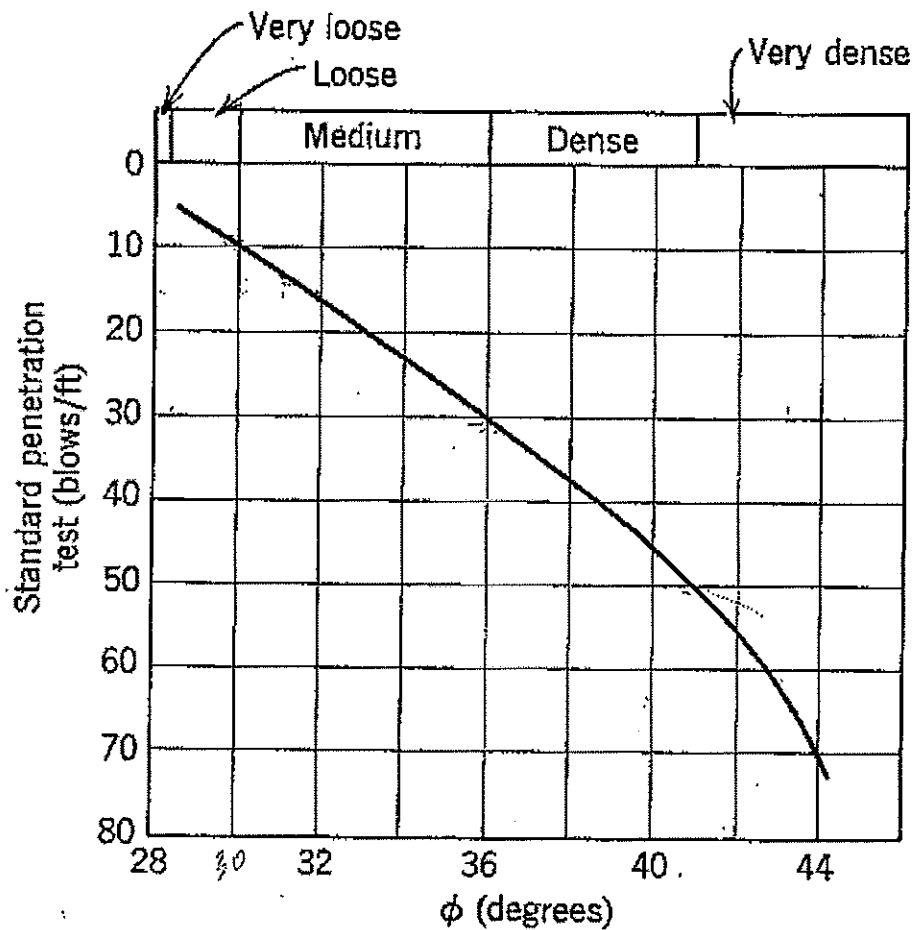


Fig. 11.14 Correlation between friction angle and penetration resistance (From Peck, Hanson, and Thornburn, 1953).

Earth Pressure

Earth Pressure:

Backfill engineering strength parameters

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

Unit weight $\gamma_1 := 125 \cdot \text{pcf}$

Internal friction angle $\phi' := 32 \cdot \text{deg}$

Cohesion $c_1 := 0 \cdot \text{psf}$

Integral Abutment - Passive Earth Pressure - Coulomb Theory

α = Angle of fill slope to the horizontal

$\alpha := 0 \cdot \text{deg}$

ϕ_1 = Angle of internal friction

$\phi' = 32 \cdot \text{deg}$

β = Angle of back face of wall to the horizontal

$\beta := 90 \cdot \text{deg}$

Use Coulomb for cases where interface friction is considered; typically gravity shaped structures, and integral abutments where the ratio of wall height to wall movement is .005 or greater. Coulomb should also be used when the fill slope is greater than horizontal.

For precast IAB abutment against clean sand, silty sand-gravel mixture use $\delta = 17 - 22$, per LRFD Table 3.11.5.3-1

δ = friction angle between fill and wall taken as specified in LRFD Table 3.11.5.3-1 (degrees)

$\delta' := 19.5 \cdot \text{deg}$

$$K_{p_coulomb} := \frac{\sin(\beta - \phi')^2}{\sin(\beta)^2 \cdot \sin(\beta + \delta') \cdot \left(1 - \sqrt{\frac{\sin(\phi' + \delta') \cdot \sin(\phi' + \alpha)}{\sin(\beta + \delta') \cdot \sin(\beta + \alpha)}} \right)^2}$$

Das, Principles of
Foundation Engineering
7th Ed. p. 366 Eq. 7.71

$$K_{p_coulomb} = 6.73$$

Integral Abutment and Wingwall - Passive Earth Pressure - Rankine Theory

Use Rankine only if the ratio of wall height to wall movement is significantly less than .005 and the fill slope is horizontal to the top of the wall. Bowles does not recommend use of Rankine method for K_p when $\alpha > 0$.

α = Angle of fill slope to the horizontal

$\alpha := 0 \cdot \text{deg}$

$$K_{p_rank} := \cos(\alpha) \cdot \frac{\cos(\alpha) + \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}{\cos(\alpha) - \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}$$

Das, Principles of
Foundation Engineering
7th Ed. p. 363 Eq. 7.67

$$K_{p_rank} = 3.25$$

P_p is oriented at an angle of α to the vertical plane

Cantilevered Wingwall Live Load Surcharge
At-Rest Earth Pressure - Rankine Theory

$$K_o := 1 - \sin(\phi')$$

$$K_o = 0.47$$

Das, Principles of
Geotechnical Engineering
7th Ed. p 427 Eq. 13.5

Frost Depth

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

From Design Freezing Index Map: Fryeburg, **Maine**

Case 1 - coarse grained granular fill soils W=10%

$$DFI_1 := 1300 \quad d_1 := 76.3 \cdot \text{in}$$

$$DFI_2 := 1400 \quad d_2 := 79.2 \cdot \text{in}$$

Approximate DFI at project = 1390 find frost depth by interpolation:

$$DFI_3 := 1390$$

$$d_3 := d_1 + \frac{(DFI_3 - DFI_1) \cdot (d_2 - d_1)}{(DFI_2 - DFI_1)} \quad d_3 = 78.9 \cdot \text{in}$$

$$\text{Depth of Frost Penetration} \quad d_3 = 6.6 \cdot \text{ft}$$

Method 2 - ModBerg Software

Examine foundations placed on coarse grained fill soils

--- ModBerg Results ---

Project Location: Lewiston, Maine

Air Design Freezing Index = 1224 F-days

N-Factor = 0.80

Surface Design Freezing Index = 979 F-days

Mean Annual Temperature = 46.4 deg F

Design Length of Freezing Season = 118 days

Layer

#:Type	t	w%	d	Cf	Cu	Kf	Ku	L
--------	---	----	---	----	----	----	----	---

1-Coarse	63.5	10.0	125.0	28	34	2.0	1.6	1,800
----------	------	------	-------	----	----	-----	-----	-------

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).

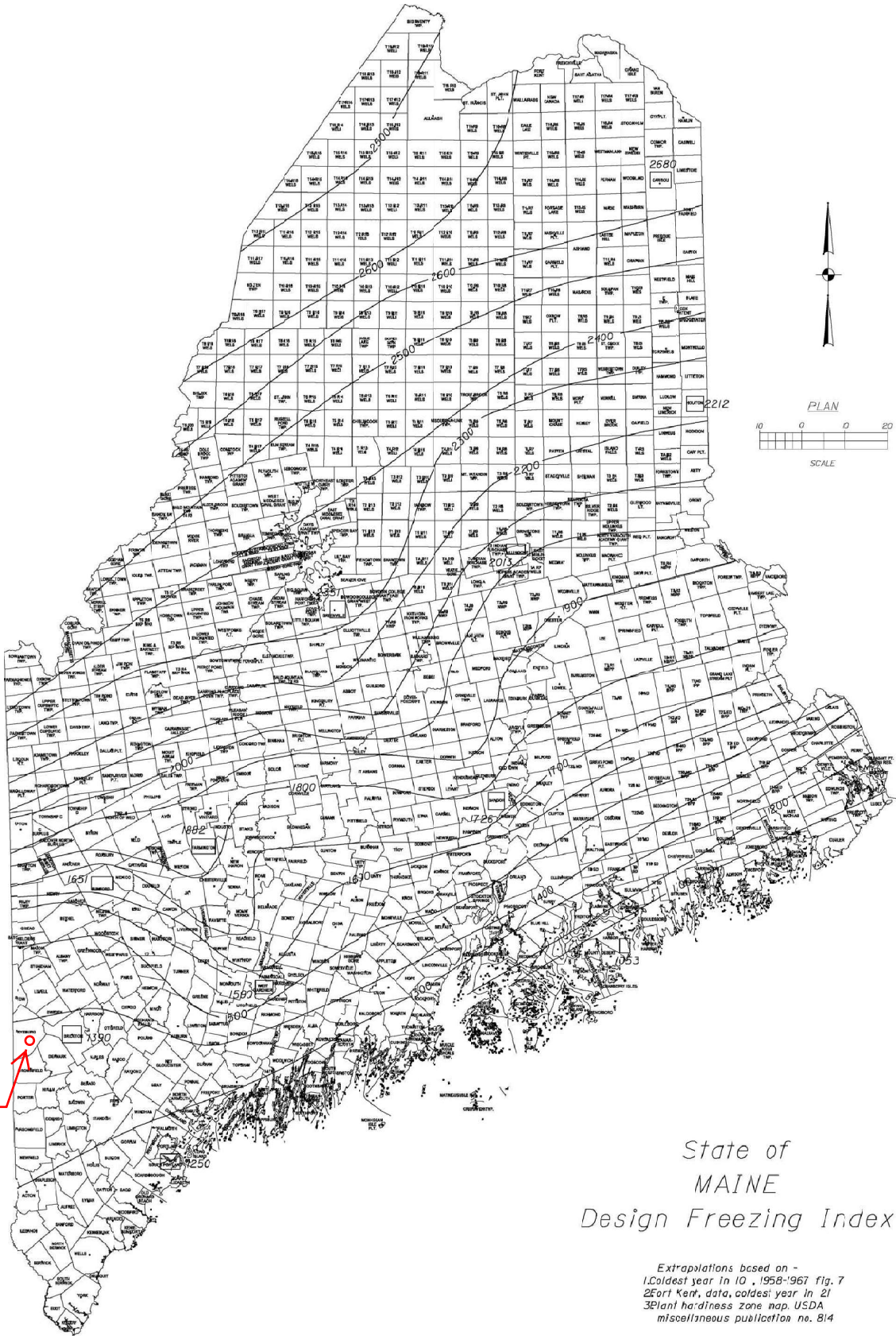
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).

L = Latent heat of fusion, in BTU / cubic ft.

Total Depth of Frost Penetration = 5.29 ft = 63.5 in.

Recommendation: 6.6 feet for design of foundations constructed on coarse grained soils

Figure 5-1 Maine Design Freezing Index Map



Project Location

5.2 General

5.2.1 Frost

Any foundation placed on seasonally frozen soils must be embedded below the depth of frost penetration to provide adequate frost protection and to minimize the potential for freeze/thaw movements. Fine-grained soils with low cohesion tend to be most frost susceptible. Soils containing a high percentage of particles smaller than the No. 200 sieve also tend to promote frost penetration.

In order to estimate the depth of frost penetration at a site, Table 5-1 has been developed using the Modified Berggren equation and Figure 5-1 Maine Design Freezing Index Map. The use of Table 5-1 assumes site specific, uniform soil conditions where the Geotechnical Designer has evaluated subsurface conditions. Coarse-grained soils are defined as soils with sand as the major constituent. Fine-grained soils are those having silt and/or clay as the major constituent. If the make-up of the soil is not easily discerned, consult the Geotechnical Designer for assistance. In the event that specific site soil conditions vary, the depth of frost penetration should be calculated by the Geotechnical Designer.

Table 5-1 Depth of Frost Penetration

Design Freezing Index	Frost Penetration (in)					
	Coarse Grained			Fine Grained		
	w=10%	w=20%	w=30%	w=10%	w=20%	w=30%
1000	66.3	55.0	47.5	47.1	40.7	36.9
1100	69.8	57.8	49.8	49.6	42.7	38.7
1200	73.1	60.4	52.0	51.9	44.7	40.5
1300	76.3	63.0	54.3	54.2	46.6	42.2
1400	79.2	65.5	56.4	56.3	48.5	43.9
1500	82.1	67.9	58.4	58.3	50.2	45.4
1600	84.8	70.2	60.3	60.2	51.9	46.9
1700	87.5	72.4	62.2	62.2	53.5	48.4
1800	90.1	74.5	64.0	64.0	55.1	49.8
1900	92.6	76.6	65.7	65.8	56.7	51.1
2000	95.1	78.7	67.5	67.6	58.2	52.5
2100	97.6	80.7	69.2	69.3	59.7	53.8
2200	100.0	82.6	70.8	71.0	61.1	55.1
2300	102.3	84.5	72.4	72.7	62.5	56.4
2400	104.6	86.4	74.0	74.3	63.9	57.6
2500	106.9	88.2	75.6	75.9	65.2	58.8
2600	109.1	89.9	77.1	77.5	66.5	60.0

Interpolate - - -

Seismic Parameters

BB-FSRO-101B			
Depth	101 N ₆₀	di	di/N
3	53	3	0.06
6	48	3	0.06
11	15	5	0.33
16	4	5	1.25
21	7	5	0.71
26	17	5	0.29
31	11	5	0.45
36	10	5	0.50
41	8	5	0.63
46	6	5	0.83
51	3	5	1.67
56	1	5	5.00
61	6	5	0.83
66.5	25	5.5	0.22
71	41	4.5	0.11
81	50	10	0.20
85	50	4	0.08
90	50	5	0.10
95	50	5	0.10
95	50	0	0.00
100	50	5	0.10
SUM		100	6.73
		di/di/N	14.85

BB-FSRO-102			
Depth	102 N ₆₀	di	di/N
6	11	6	0.55
11	7	5	0.71
16	17	5	0.29
21	7	5	0.71
31	8	10	1.25
41	4	10	2.50
51	4	10	2.50
61	1	10	10.00
71	1	10	10.00
81.5	17	10.5	0.62
91	24	9.5	0.40
100	63	9	0.14
SUM		100	28.99
		di/di/N	3.45

SUM	Nav.	9.15
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$$N_{av} < 15$$

Conclusion: Site Class E

Site Classification per LRFD Table C3.10.3.1-1 - Method B

Fryeburg Eddy Flats Bridge #2261

WIN 21688.00

Sesmic

5/4/2018

Conterminous 48 States

2007 AASHTO Bridge Design Guidelines

AASHTO Spectrum for 7% PE in 75 years

Latitude = 44.029542

Longitude = -070.904463

Site Class B

Data are based on a 0.05 deg grid spacing.

Period Sa

(sec) (g)

0.0	0.100	PGA - Site Class B
0.2	0.196	Ss - Site Class B
1.0	0.049	S1 - Site Class B

Conterminous 48 States

2007 AASHTO Bridge Design Guidelines

Spectral Response Accelerations SDs and SD1

Latitude = 44.029542

Longitude = -070.904463

As = FpgaPGA, SDs = FaSs, and SD1 = FvS1

Site Class E - Fpga = 2.50, Fa = 2.50, Fv = 3.50

Data are based on a 0.05 deg grid spacing.

Period Sa

(sec) (g)

0.0	0.250	As - Site Class E
0.2	0.489	SDs - Site Class E
1.0	0.172	SD1 - Site Class E

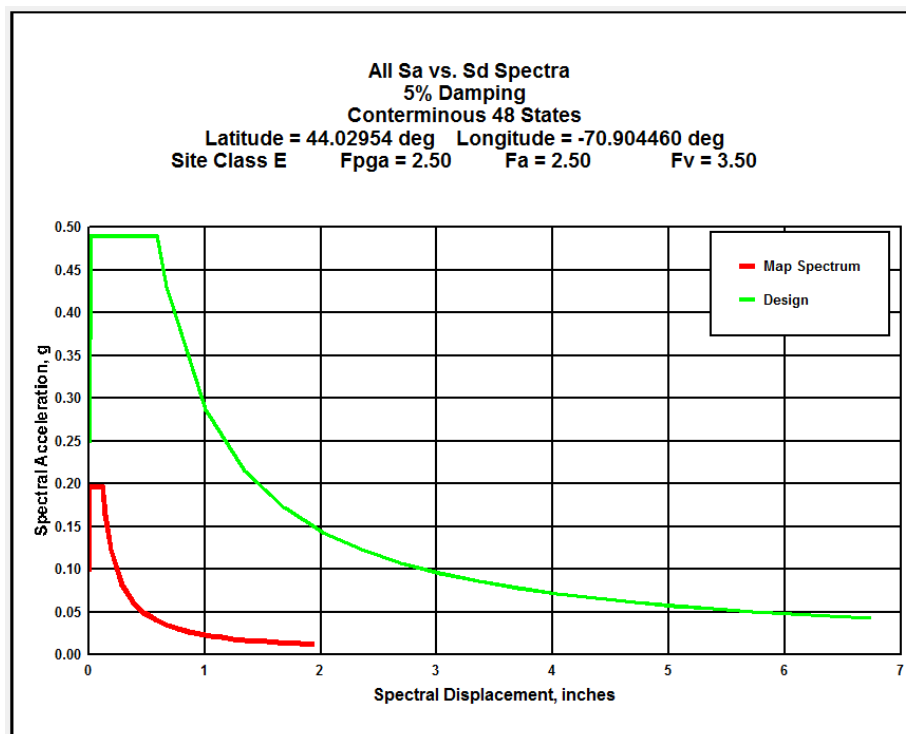
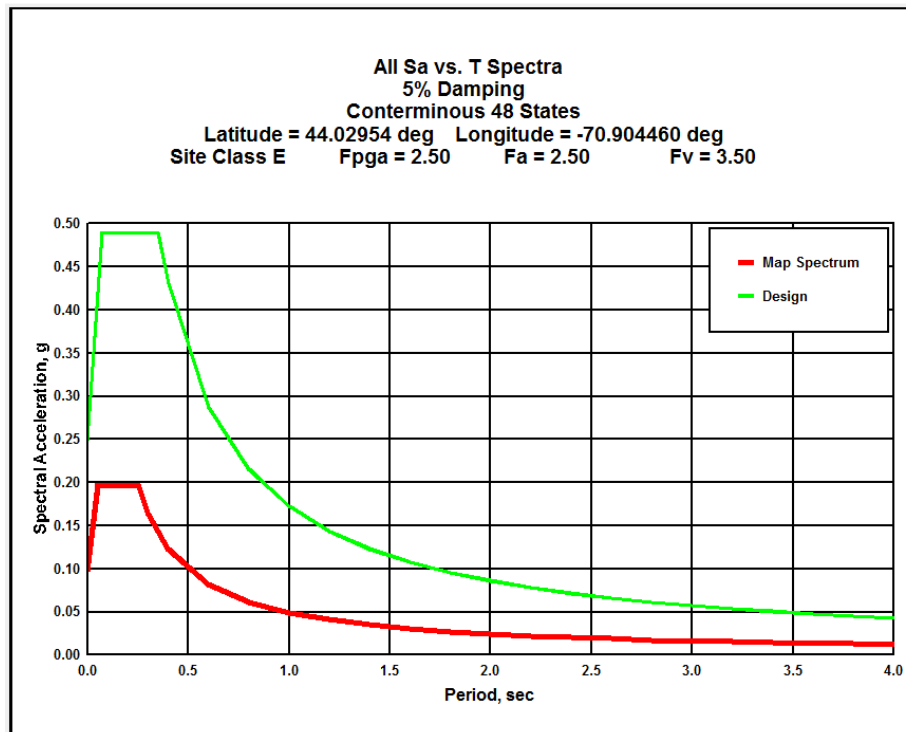
Fryeburg Eddy Flats Bridge #2261

WIN 21688.00

Sesmic

5/4/2018

LK 5/2018



Downdrag

DOWNDRAG DUE TO LIQUEFACTION - DOWNDRAG COMPUTATION PER NAVFAC and Sandford - Abutment No. 1 Piles

1. NAVFAC DM 7.2-211: DD Load per soil layer = Beta*Po (effective vertical stress midlayer)
2. Beta Values PER NAVFAC 7.2-211
3. Beta values per Sandford (1998) Pages 151 - 152; field measurements confirmed one-half reduction of NAVFAC Beta's recommended by Meyerhof (1976) for non-displacement piles.

 = soil deposits subject to liquefaction

Sample	soil type	thickness feet	Total Unit Weight	Effective Unit Weight	Effective Vertical Overburden Pressure at bottom of each layer	Cummulative Vertical Overburden Pressure at bottom of layers	Effective Vertical Overburden Pressure at midpoint of each layer	Cummulative Effective Stress at each midpoint
	New fill	11	125	125	1375	1375	688	688
	Existing Fill	5	125	125	625	2000	313	1688
	Loose fill	4.5	120	120	540	2540	270	2270
1D	V. loose Alluvium	4	118	56	222	2762	111	2651
2D	Loose alluvium	6	110	48	286	3048	143	2905
MD, 3-5D	Loose alluvium	20	112	50	992	4040	496	3544
6D	Silty Sand	10	136	74	736	4776	368	4408
7, 8, 9D	Soft Silt	10	--	--	--	--	--	--
10D	Till	20	--	--	--	--	--	--

stratum no.	soil type	thickness feet	effective stress at midlayer (psf)	Beta per NAVFAC	Beta per Sandford	Pile Area (box perimeter x L)	Downdrag per NAVFAC Beta (kips)	Downdrag per Sandford Betas rhof 1/2 reduction justified (kips)
	new fill	11	688	abutment	abutment	abutment		
	existing fill	5	1688	0.35	0.175	23.75	14.03	7.01
	loose fill	4.5	2270	0.35	0.175	21.38	16.98	8.49
1D	v. loose alluvium	4	2651	0.35	0.175	19.00	17.63	8.82
2D	loose alluvium	6	2905	0.35	0.175	28.50	28.98	14.49
MD, 3-5D	loose alluvium	20	3544	0.35	0.175	95.00	117.84	58.92
6D	Silty Sand	10	4408	0.35	0.175	47.50	73.28	36.64
7, 8, 9D	Soft Silt	10	--	--	--	--	--	--
10D	Till	20	--	--	--	--	--	--

Downdrag load due to liquefaction (kips)	238	119
--	-----	-----

Pile size	Flange Width	Depth	Box Perimeter	Box Perimeter (ft)
14x89	14.70	13.80	57.00	4.75
14x117	14.90	14.20	58.20	4.85

DOWNDRAG DUE TO LIQUEFACTION - DOWNDRAG COMPUTATION PER NAVFAC and Sandford

1. NAVFAC DM 7.2-211: DD Load per soil layer = Beta*Po (effective vertical stress midlayer)
2. Beta Values PER NAVFAC 7.2-211
3. Beta values per Sandford (1998) Pages 151 - 152; field measurements confirmed one-half reduction of NAVFAC Beta's recommended by Meyerhof (1976) for non-displacement piles.

 = soil deposits subject to liquefaction

stratum no.	soil type	thickness feet	Total Unit Weight	Effective Unit Weight	Effective Vertical Overburden Pressure at bottom of each layer	Cummulative Vertical Overburden Pressure at bottom of layers	Effective Vertical Overburden Pressure at midpoint of each layer	Cummulative Effective Stress at each midpoint
1	sand	11	125	125	1375	1375	688	688
2	sand	4	125	125	500	1875	250	1625
3	sand	5	105	43	213	2088	107	1982
4	sand	3	118	56	167	2255	83	2171
5	sand	12	112	50	595	2850	298	2552
6	sand	10	118	56	556	3406	278	3128
7	sand	10	98	36	356	3762	178	3584
8	sand	10	135	73	726	4488	363	4125
9	clay	20	122	60	1192	5680	596	5084

stratum no.	soil type	thickness feet	effective stress at midlayer (psf)	Beta per NAVFAC	Beta per Sandford	Pile Area (box perimeter x L)	Downdrag per NAVFAC Beta (kips)	Downdrag per Sandford Betas (Meyerhof 1/2 reduction justified) (kips)
1	sand	11	688	abutment	abutment	abutment		
2	sand	4	1625	0.35	0.175	19.00	10.81	5.40
3	sand	5	1982	0.35	0.175	23.75	16.47	8.24
4	sand	3	2171	0.35	0.175	14.25	10.83	5.41
5	sand	12	2552	0.35	0.175	57.00	50.92	25.46
6	sand	10	3128	0.35	0.175	47.50	52.00	26.00
7	sand	10	3584	0.35	0.175	47.50	59.58	29.79
8	sand	10	4125	0.35	0.175	47.50	68.58	34.29
9	clay	20	5084	0.20	0.160	95.00	96.60	77.28

Downdrag load due to liquefaction (kips)	231	116
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Pile size	Flange Width	Depth	Box Perimeter	Box Perimeter (ft)
14x89	14.70	13.80	57.00	4.75
14x117	14.90	14.20	58.20	4.85

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows	Elevation (ft.)			
25	MD	24/0	25.00 - 27.00	5/6/6/7	12	17	24			Similar to 2D in wash water.	9 bpf BB-FSRO-203 Dry Unit weight = 92 pcf Sat. Unit weight = 112 pcf
							32				
							37				
							38				
							27				
30	3D	24/16	30.00 - 32.00	2/3/5/5	8	11	8			Brown, wet, medium dense, medium SAND, trace fine gravel, trace silt.	G#245147 A-1-b, SW-SM WC=32.4%
							15				
							27				
							34				
							46				
35	4D	24/14	35.00 - 37.00	2/3/4/5	7	10	12			Grey, wet, loose, fine SAND, trace silt.	G#245145 A-3, SP-SM WC=23.1%
							13				
							37				
							47				
							49				
40	5D	24/16	40.00 - 42.00	1/3/3/4	6	8	19			Grey, wet, loose, medium SAND, trace silt.	G#245146 A-1-b, SP WC=21.6%
							39				
							61				
							73				
							92				
45	6D	24/20	45.00 - 47.00	1/2/2/2	4	6	41	332.5	Grey, wet, loose, Silty fine SAND, (Glaciolacustrine probably)	G#245148 A-4, SM WC=33.9% Dry Unit weight = 102 pcf Sat. Unit weight = 136 pcf	
							35				
							41				
							47				
							53				
50											

Remarks:
 -bgs = below existing ground surface (roadway)

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: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	7D	24/23	50.00 - 52.00	4/1/1/2	2	3	59	327.0		Grey, wet, soft, SILT, little fine sand, trace clay, trace organics, (Glaciolacustrine). Sat. Unit weight = 92 pcf	G#245149 A-4, ML WC=36.9%
							57				
							53				
							53				
							57				
55	8D	24/24	55.00 - 57.00	WOR/WOR/WOR/ WOR	---		55			Grey, wet, very soft, SILT, some clay, trace fine sand.	G#245150 A-4, CL-ML WC=43.1%
							69				
							69				
							68				
							82				
60	MV/9D	24/24	60.00 - 62.00	WOH/2/2/5	4	6	91			Failed 55x110 mm vane attempt, would not push. Grey, wet, medium stiff, SILT, some clay, trace fine sand.	G#245151 A-4, CL WC=35.7%
							107				
							116				
							120				
							136				
65	10D	24/12	65.50 - 67.50	5/7/18/19	25	35	118	313.0	Cobble from 65 to 65.5 feet bgs. Grey, wet, dense, fine Sandy coarse GRAVEL, trace silt, (Glacial Till). Sat. Unit weight = 147 pcf	G#245152 A-1-a, GW-GM WC=9.1%	
							108				
							152				
							127				
							97				
70	11D	24/12	70.00 - 72.00	7/19/10/11	29	41	119	307.5	Grey, wet, dense, medium SAND, some fine gravel, little silt. RC from 71 to 110.9 feet bgs.	G#245153 A-1-b, SW-SM WC=10.6%	
							250				
							200				
							158				
							162				
75											
Remarks: -bgs = below existing ground surface (roadway)											
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 3 of 5 Boring No.: BB-FSRO-101B	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 Saturated Unit Weights shown if not otherwise specified WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _{u(lab)} = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											

Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
0							SSA	377.4		7-inch-thick layer of pavement.	
										Cobble from 1.5 to 2.2 feet bgs.	
										Granular Borrow 125 pcf	
5	1D	24/12	5.00 - 7.00	2/3/5/3	8	11				Brown, moist, medium dense, medium SAND, little fine gravel, trace silt, occasional cobbles, (Fill).	G#245160 A-1-b, SP-SM WC=4.1%
										Bottom of Abutment	372
										Granular Borrow 125 pcf	
10	2D	24/14	10.00 - 12.00	2/2/3/6	5	7	aSP			Brown, moist, loose, medium SAND, little fine gravel, little silt, (Fill). aSpun HW casing to 20 feet bgs.	G#245161 A-1-b, SP-SM WC=14.0%
										Layer 2 (Elev. 368.0 - 363.0)	
										Saturated unit weight = 105 pcf, 29 degrees	
15	MD	24/1	15.00 - 17.00	5/5/7/8	12	17				Similar to 2D.	
										Layer 3 (Elev. 363.0 - 359.5)	
										118 pcf, 32 degrees	
										Top Elevation of Liquefaction Zone	360
										Layer 4 (Elev. 359.5 - 348.0)	
										112 pcf 29 degrees	
20	3D	24/18	20.00 - 22.00	2/3/2/3	5	7	10			Brown, wet, loose, medium SAND, trace coarse gravel, trace silt, (Stream Alluvium). Dropped in NW casing at 20 feet bgs.	G#245162 A-1-b, SP WC=22.1%
							10				
							12				
							12				
25							13				

Remarks:
 -bgs = below existing ground surface (roadway)

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 5

Boring No.: BB-FSRO-102

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							28		Grey, wet, loose, fine SAND, trace silt, (Stream Alluvium). Layer 5 (Elev. 348.0 - 338.0) 118 pcf 29 degrees	348 G#245163 A-3, SP-SM WC=28.0%	
							28				
							39				
							43				
							62				
30	4D	24/14	30.00 - 32.00	2/3/3/3	6	8	16				
							19				
							30				
							41				
							64				
35							79				
							116				
							119				
							155				
							158				
40	5D	24/20	40.00 - 42.00	1/1/2/3	3	4	73				
							73				
							76				
							77				
45							108				
							127				
							165				
							167				
							169				
50							175				
Remarks: -bgs = below existing ground surface (roadway)											
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 2 of 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	6D	24/18	50.00 - 52.00	8/2/1/4	3	4	107	318.0	Grey, wet, very loose, Silty fine SAND. Layer 7 (Elev. 328.0 - 318.0) 135 pcf 28 degrees	G#245165 A-4, SM WC=32.6%	
							82				
							81				
							113				
							122				
55							122				
							127				
							138				
							176				
							192				
60	7D	24/24	60.00 - 62.00	1/WOR/1/WOR	1	1	159	318.0	Grey, wet, very soft, SILT, trace clay, trace fine sand, (Glaciolacustrine). Layer 8 (Elev. 318.0 - 298.0) 122 pcf Su = 250 psf	G#245166 A-4, ML WC=47.6%	
							165				
							135				
							175				
							181				
65							181				
							186				
							186				
							178				
							178				
70	8D/MV	24/24	70.00 - 72.00	WOR/WOR/WOR/WOR	---		129	318.0	Grey, wet, very soft, SILT, some fine sand, trace clay. Failed 55x110 mm vane attempt, would not push.	G#245167 A-4, ML WC=43.3%	
							130				
							165				
							165				
							178				
75											
Remarks: -bgs = below existing ground surface (roadway)											
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Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
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Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							162		Grey, wet, very stiff, SILT, little clay. Layer 9 (Elev. 298.0 - 289.0) Saturated Unit Weight = 145 pcf Su = 2000 psf	298 G#245168 A-4, CL-ML WC=34.1%	
							224				
							224				
							224				
							224				
80	9D	24/20	80.50 - 82.50	10/5/7/8	12	17	176				
							166				
							167				
							167				
							169				
85							170				
							167				
							164				
							164				
							164				
90	10D	24/14	90.00 - 92.00	4/7/10/15	17	24	166		Grey, wet, medium dense, fine SAND, some silt, trace fine gravel, (Glacial Till). Layer 10 (Elev. 289.0 - 280.0)	G#245169 A-2-4, SM WC=18.7%	
							98				
							105				
							97				
							112				
95							96				
							162				
							238				
							386		RC to 100 feet bgs. Layer 11 (Elev. 280.0 - 268.0)	98.0	
100							508				
Remarks: -bgs = below existing ground surface (roadway)											
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 4 of 5 Boring No.: BB-FSRO-102	

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Layer 12 (Elev. 268.0 - 263.6) </td> <td rowspan="5"> G#245171 A-4, CL-ML WC=25.4% </td> </tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>187</td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>178</td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>220</td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr> <td>115</td> <td>R1</td> <td>60/60</td> <td>114.40 - 119.40</td> <td>RQD = 85%</td> <td></td> <td></td> <td>b150 NQ 2</td> <td rowspan="10"> </td> <td rowspan="10"> b150 blows for 0.4 ft. Top of Bedrock at Elev. 263.6 ft. R1:Bedrock: No bedrock description recorded. R1:Core Times (min:sec) 114.4-115.4 ft (5:25) 115.4-116.4 ft (3:40) 116.4-117.4 ft (3:50) 117.4-118.4 ft (2:05) 118.4-119.4 ft (3:00) 100% Recovery R2:Bedrock: No bedrock description recorded. R2:Core Times (min:sec) 119.4-120.4 ft (4:00) 120.4-121.4 ft (3:15) 121.4-122.4 ft (3:10) 122.4-123.4 ft (3:00) 123.4-124.4 ft (4:00) 100% Recovery </td> <td rowspan="10"></td> </tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr> <td>120</td> <td>R2</td> <td>60/60</td> <td>119.40 - 124.40</td> <td>RQD = 90%</td> <td></td> <td></td> <td></td> <td rowspan="5"> </td> <td rowspan="5"></td> <td rowspan="5"></td> </tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr> <td>125</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>												Depth (ft.)	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The effectiveness of bitumen coating in reducing downdrag is clearly illustrated in the comparisons between coated and uncoated piles despite the estimated 10% to 25% coating losses. Table 5.10 compares estimated downdrag on the instrumented piles, from pile cap to neutral point, with reductions from 59% to 75% seen for the coated piles. There is slightly greater reduction evident for the coated vertical pile versus the coated batter piles. This difference is probably due to the greater coating losses witnessed on the batter piles during pile driving. There may also have been subsurface losses of coating during driving but the downdrag comparisons between coated and uncoated piles indicate that sufficient coating remained after driving to effect significant downdrag reduction.

5.2.6 Beta and Alpha coefficients

Beta (β) coefficients may be back-calculated from the downdrag values for each of the significant soil layers and these back-calculated coefficients are shown in Table 5.11. The coefficients have been calculated assuming downdrag was acting on the box-shaped, pile perimeter. The coefficients shown in Figure 2.5 for uncoated piles are lower than those suggested by most authorities. FHWA (Hannigan, et al. 1996) and Fellenius (1991) recommend a β of 0.50 for clay having a friction angle of 34° (Figure 2.5), while NAVFAC (1982) as well as Briaud and Tucker (1996) recommend β 's ranging from 0.20 to 0.30 for soft to medium clays. The recommended values for sands range from 0.30 to 0.60.

The recommended β 's are based on data obtained primarily from studies involving displacement piles. No specific corrections are mentioned by FHWA (Hannigan, et al. 1996), NAVFAC (1982), or Briaud and Tucker (1996) for non-displacement piles such as H-piles.

Sandford (1989) found a β of 0.06 in clay having an undrained strength as low as 12 kPa (250 psf), compared to a strength of 41 kPa (850) and higher for the clay at the Brunswick site. Additionally, Sandford measured no downdrag through the sand fill zone on an instrumented H-pile at a site in Biddeford, Maine. The low downdrag seen in the fill zone in both Brunswick and Biddeford (Sandford, 1989) is probably due to the effects of soil arching. Soil arching occurs when pile oscillations during driving create voids around the pile. Infilling of the voids from the surface results in a looser confining soil, having a smaller friction angle, and consequently a lower β than the compacted fill.

The measured values in Table 5.11, as well as those found by Sandford (1989), indicate that the one-half reduction recommended by Meyerhof (1976) for non-displacement piles is justified. When a one-half reduction is applied, there is good agreement with the β 's recommended by NAVFAC (1982) and Briaud and Tucker (1996) for clay, and the β 's calculated for the uncoated piles (Table 5.11). Even after the one-half reduction, the β of 0.50 recommended by FHWA (Hannigan, et al. 1996) would overestimate downdrag in the clay layer by about 100%.

Table 5.11 β coefficients.

Deposit	Pile					
	V1U	V2C	B1C	B2U	B3C	B4U
Sand fill	0.10	0.03	0.03	0.10	0.04	0.11
Marine sand & organic	0.06	0.02	0.02	0.09	0.01	0.10
Marine clay	0.16	0.05	0.05	0.13	0.06	0.13

The Alpha (α) coefficient may similarly be back-calculated for the clay layer. Using an average value of undrained strength of 50 kPa (1040 psf), determined from in situ vane shear tests and triaxial tests, for the marine clay, the α coefficients shown in Table 5.12 were obtained. These α 's were obtained using the box perimeter area of the H-pile, but without the 1/2 reduction for the H-pile used with the β method. Using Figure 2.3(a) (Tomlinson, 1980), with $D = 20b$, an α coefficient of 1.00 is obtained.

Table 5.12 α coefficients.

Deposit	Pile					
	V1U	V2C	B1C	B2U	B3C	B4U
Marine clay	1.14	0.23	0.42	0.97	0.67	0.94

There are additional methods of downdrag reduction besides those listed by Briaud. In NAVFAC (1982) the authors recommend the simple expedient of using slender non-displacement piles, such as H-piles, to reduce downdrag. This recommendation is supported by Sandford (1989), who investigated downdrag on an H-pile and back-calculated the β value for a soft clay layer to be 0.06 using the full perimeter of the pile section. This is also supported by Meyerhof (1976) who recommended a one-half reduction for downdrag calculations on steel H-piles. Dawson (1970) also reported that driven displacement piles have 50% higher β values than do driven non-displacement or predrilled piles. Yet another option is offered by Tawfiq and Caliendo (1993) who have investigated the use of polyethylene sheeting to reduce downdrag on drilled piles and have reported reductions ranging from 78% to 95%, but this method would be inappropriate for driven piles.

2.4.2 Bitumen coating

In most cases the use of bitumen coating will be the most cost effective method of reducing downdrag. But there are a number of factors to be considered when using bitumen coating for downdrag reduction. These factors include: design of the bitumen coating such that it will survive both handling prior to installation of the coated pile as well as the installation process itself; appropriate design thickness and penetration resistance of the coating to ensure adequate strength and durability of the bitumen coating; compatibility of the soil

Negative skin friction develops along that portion of the pile shaft where settlement of the adjacent soil exceeds the downward displacement of the shaft. The "neutral point" is that point of no relative movement between the pile and adjacent soil. Below this point, skin friction acts to support pile loads. The ratio of the depth of the neutral point to the length of the pile in compressible strata may be roughly approximated as 0.75. The position of the neutral point can be estimated by a trial and error procedure which compares the settlement of the soil to the displacement of adjacent sections of the pile. (For further guidance see Reference 14, Pile Design and Construction Practice, by Tomlinson.)

Observations indicate that a relative downward movement of 0.6 inch is expected to be sufficient to mobilize full negative skin friction (Reference 6).

c. Magnitude of Negative Skin Friction on Single Pile. The peak negative skin friction in granular soils and cohesive soils is determined as for positive skin friction.

The peak unit negative skin friction can also be estimated from (after Reference 15, Prediction of Downdrag Load at the Cutler Circle Bridge, by Garlanger):

$$f_n = \beta P_o$$

where: f_n = unit negative skin friction (to be multiplied by area of shaft in zone of subsiding soil relative to pile)

P_o = effective vertical stress

β = empirical factor from full scale tests

<u>Soil</u>	<u>β</u>
Clay	0.20 - 0.25
Silt	0.25 - 0.35
Sand	0.35 - 0.50

d. Safety Factor for Negative Skin Friction. Since negative skin friction is usually estimated on the safe side, the factor of safety associated with this load is usually unity. Thus:

$$Q_{all} = \frac{Q_{ult}}{F_s} - P_n$$

where: Q_{all} = allowable pile load

Q_{ult} = ultimate pile load

F_s = factor of safety

P_n = ultimate negative skin friction load

Settlement

Settle3D Analysis Information

17912.00 Fryburg Eddy Flats

Project Settings

Document Name 17912 settlement eastern approach-r3.s3z
Project Title 17912.00 Fryburg Eddy Flats
Author A. Van Buskirk
Company MaineDOT
Date Created 6/13/2018, 2:05:16 PM Check: LK 8/3/2018
Stress Computation Method Boussinesq
Use average properties to calculate layered stresses

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.0450299 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.45348
Consolidation Settlement [in]	0	0.274471
Immediate Settlement [in]	0	3.179
Loading Stress [ksf]	0	0.6
Effective Stress [ksf]	0	7.59377
Total Stress [ksf]	0	13.8837
Total Strain	0	0.0049628
Pore Water Pressure [ksf]	0	6.28992
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.05875	11.6955
Over-consolidation Ratio	1	1.99638
Void Ratio	0	1.3995
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	2.04424

Loads

1. Rectangular Load

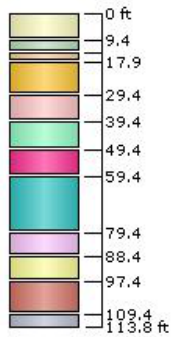
Length 100 ft
Width 40 ft
Rotation angle 0 degrees
Load Type Flexible
Area of Load 4000 ft²
Load 0.6 ksf
Depth 0 ft
Installation Stage Stage 1

Coordinates

X [ft]	Y [ft]
-50	-20
50	-20
50	20
-50	20

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	1- Granular Borrow	9.4	0
2	2 - Loose med. Sand	5	9.4
3	3 - Med. dense Sand	3.5	14.4
4	4 - Loose Sand	11.5	17.9
5	5 - Loose fine Sand	10	29.4
6	6- Very loose Sand	10	39.4
7	7- Very loose, Silty fine Sand	10	49.4
8	8 - Very soft Silt (Glaciolacustrine)	20	59.4
9	9 - Very stiff Silt	9	79.4
10	10 - Medium dense Sand, some silt	9	88.4
11	11 - Hard Silty Clay	12	97.4
12	12 - Very soft, Silt	4.4	109.4



Soil Properties

Property	1- Granular Borrow	2 - Loose med. Sand	3 - Med. dense Sand	4 - Loose Sand	5 - Loose fine Sand	6- Very loose Sand	7- Very loose, Silty fine Sand	8 - Very soft Silt (Glaciolacustrine)	9 - Very stiff Silt	10 - Medium dense Sand, some silt	11 - Hard Silty Clay	12 - Very soft, Silt
Color												
Unit Weight [kips/ft³]	0.125	0.092	0.1035	0.092	0.092	0.081	0.102	0.083	0.108	0.121	0.108	0.093
Saturated Unit Weight [kips/ft³]	0.131	0.1049	0.118	0.112	0.1178	0.098	0.135	0.123	0.145	0.127	0.127	0.117
Immediate Settlement	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Es [ksf]	450	220	160	110	115	95	95	42	138	195	414	60
Esur [ksf]	1800	880	640	440	460	380	380	168	552	780	1656	240
Primary Consolidation	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Enabled	Enabled	Disabled	Enabled	Enabled
Material Type								Non-Linear	Non-Linear		Non-Linear	Non-Linear
Cc								0.287	0.345		0.497	0.287
Cr								0.032	0.0621		0.0768	0.032
e0								1.28	1.3		1.4	1.28
OCR	1	1	1	1	1	1	1	2	2	1	1	1
Undrained Su A [kips/ft²]	0	0	0	0	0	0	0	0	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1	1	1	1	1	1	1	1	1

Groundwater

Groundwater method Piezometric Lines
Water Unit Weight 0.0624 kips/ft³

Piezometric Line Entities

ID	Depth (ft)
1	13 ft

Query Points

Point #	(X,Y) Location	Number of Divisions
1	2.13163e-014, 7.10543e-015	Auto: 91
2	2.13163e-014, 7.10543e-015	Auto: 91

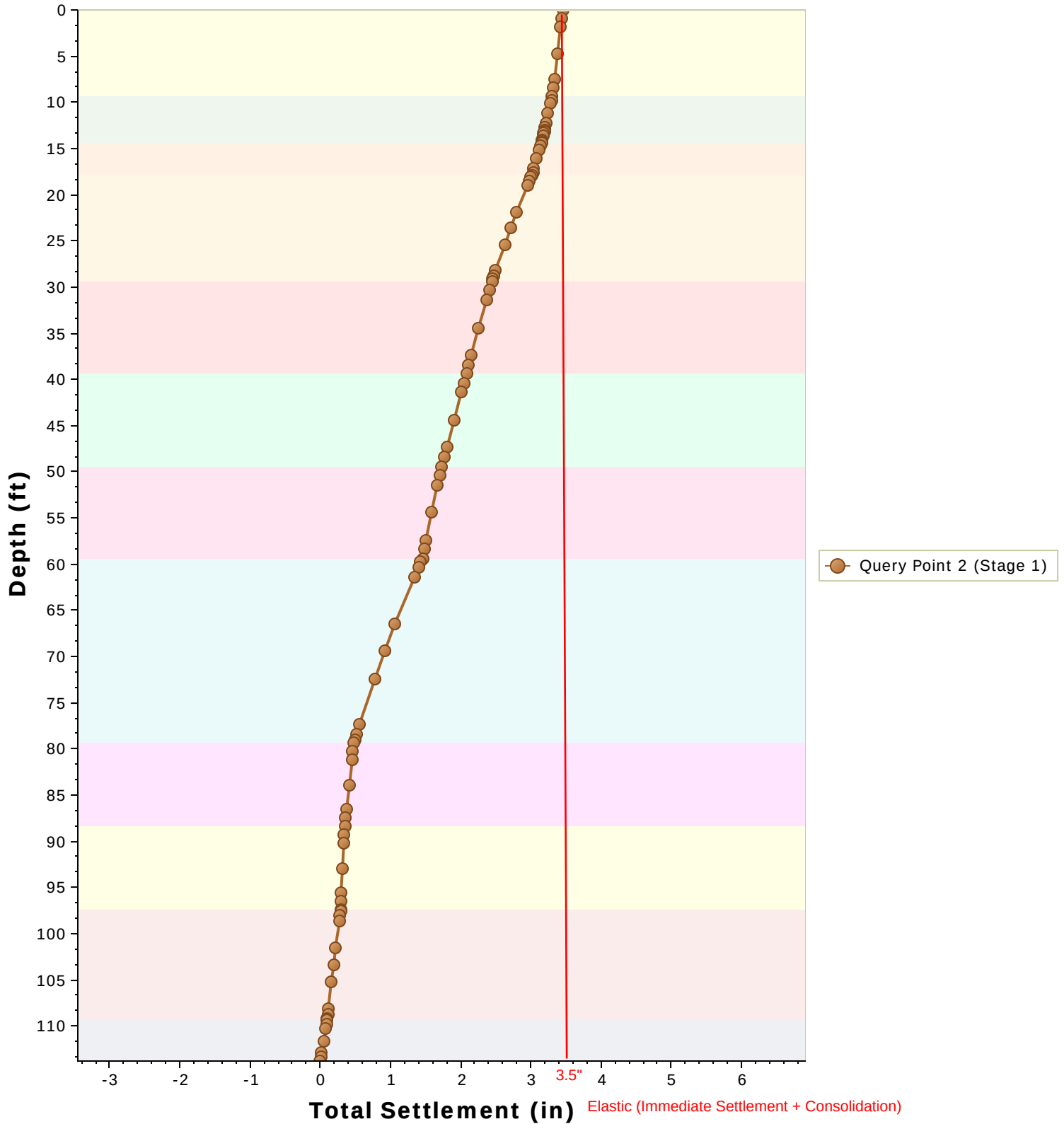
Field Point Grid

Number of points 294
Expansion Factor 2

Grid Coordinates

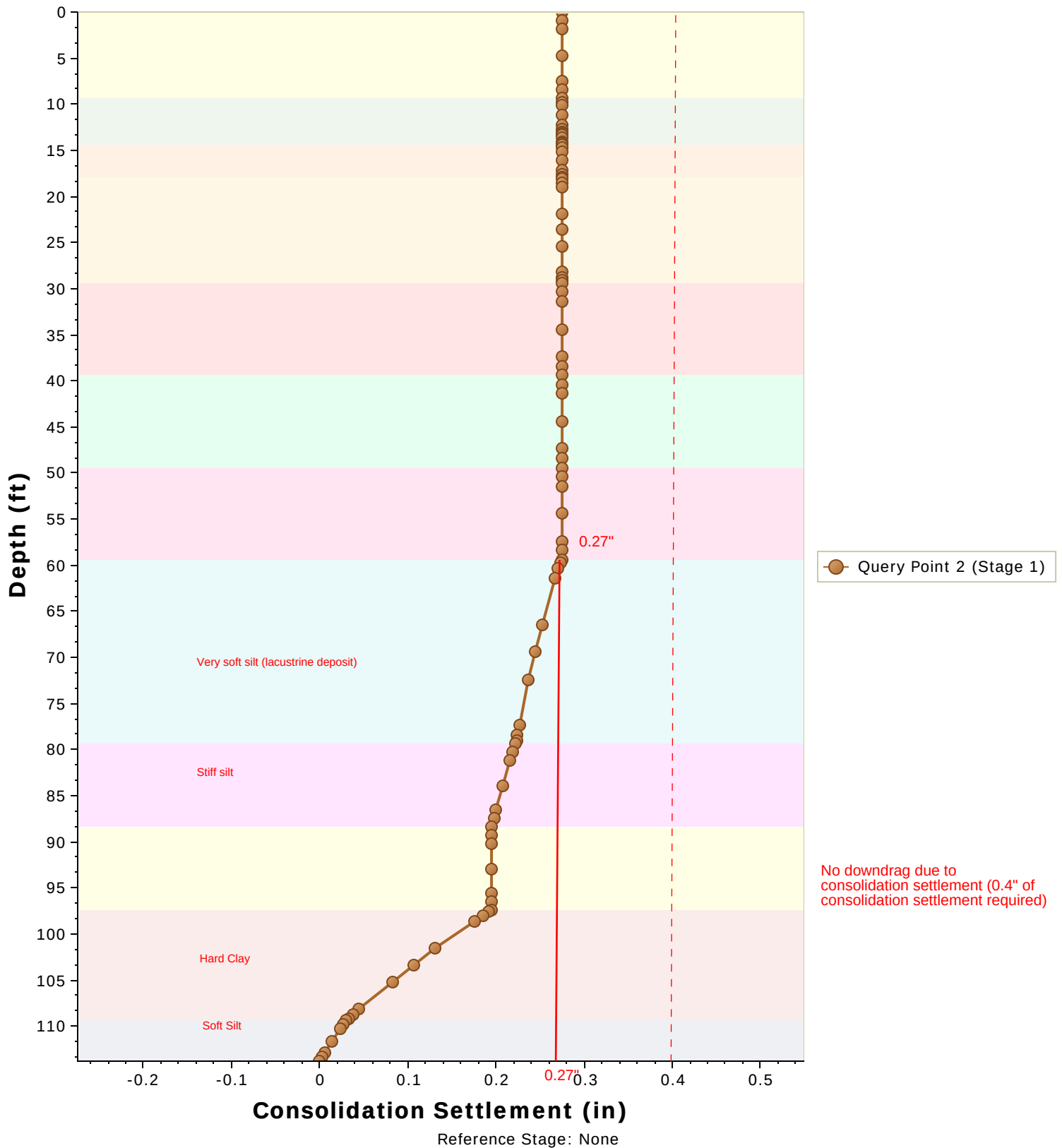
X [ft]	Y [ft]
100	70
100	-70
-100	-70
-100	70

Total Settlement vs. Depth



	Project			17912.00 Fryburg Eddy Flats
	Analysis Description			
	Drawn By	A. Van Buskirk	Check: LK 8/3/2018	Company MaineDOT
	Date	6/13/2018, 2:05:16 PM		File Name 17912 settlement eastern approach-r3.s3z

Consolidation Settlement vs. Depth



	Project		17912.00 Fryburg Eddy Flats
	Analysis Description		
	Drawn By	A. Van Buskirk	Company MaineDOT
	Date	6/13/2018, 2:05:16 PM	File Name 17912 settlement eastern approach-r3.s3z

Development of embankment soil model for Settle 3D

OBJECTIVE

To estimate soil parameters for Settle 3D analysis at Abutment No. 2.

Given:

Boring Log BB-FSRO-102 and lab test data.

Assumptions:

- 1) Groundwater table was observed at Elev. 366.
- 2) MaineDOT Bridge Design Guide (BDG) Soil Type 4 is used to construct the proposed raise in grade.

Calculations for approach embankment behind Abutment No. 2

Overburden

Maximum depth of new fill = 5 ft.

$$H_{\text{fill}} := 5\text{ft}$$

$$\gamma_{\text{fill}} := 125\text{pcf} \quad \text{BDG Table 3-3, Soil Type 4, Granular Borrow}$$

$$\sigma_{z_induced} := \gamma_{\text{fill}} \cdot H_{\text{fill}}$$

$$\sigma_{z_induced} = 0.6 \cdot \text{ksf}$$

Soil Layer 1 (Elev. 377.4 - 368.0): Granular Borrow, with drainage system

$$N_1 := 30 \quad \text{Assumed}$$

$$E_{s1} := 500 \frac{(N_1 + 15)}{50} \quad \text{Bowles Table 5-6, Equation for stress-strain modulus } E_s \text{ for Sand (normally consolidated)}$$

$$E_{s1} = 450 \quad \text{ksf}$$

$$E_{ur_1} := 4 \cdot E_{s1} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_1} = 1.8 \times 10^3 \quad \text{ksf}$$

$$\gamma_{\text{dry_1}} := 125\text{pcf} \quad \text{BDG Table 3-3, Soil Type 4, Granular Borrow}$$

$$w_{\text{sat_1}} := 5\% \quad \text{Assumed}$$

$$\gamma_{\text{sat_1}} := \gamma_{\text{dry_1}} \cdot (1 + w_{\text{sat_1}})$$

$$\gamma_{\text{sat_1}} = 131.3 \cdot \text{pcf}$$

Soil Layer 2 (Elev. 368.0 - 363.0): Loose, medium SAND

$$N_{60_2} := 7$$

$$E_{s2} := 500 \frac{(N_{60_2} + 15)}{50}$$

Bowles Table 5-6, Equation for stress-strain modulus E_s
 for Sand (normally consolidated)

$$E_{s2} = 220 \text{ ksf}$$

$$E_{ur_2} := 4 \cdot E_{s2}$$

Equation 5, Mayne and Cox, Constitutive Model Input Parameters, $E_s = E_{50}$

$$E_{ur_2} = 880 \text{ ksf}$$

$$\gamma_{dry_2} := 92 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Loose uniform sand

$$w_{sat_2} := 14.0\%$$

BB-FSRO-102 2D Natural water content

$$\gamma_{sat_2} := \gamma_{dry_2} \cdot (1 + w_{sat_2})$$

$$\gamma_{sat_2} = 104.9 \cdot \text{pcf}$$

Soil Layer 3 (363.0 - 359.5) Medium dense, medium SAND

$$N_{60_3} := 17$$

$$E_{s3} := \frac{250 \cdot (N_{60_3} + 15)}{50}$$

Bowles Table 5-6, Equation for stress-strain modulus E_s
 Sand (saturated)

$$E_{s3} = 160 \text{ ksf}$$

$$E_{ur_3} := 4 \cdot E_{s3}$$

Equation 5, Mayne and Cox, Constitutive Model Input Parameters, $E_s = E_{50}$

$$E_{ur_3} = 640 \text{ ksf}$$

$$\gamma_{dry_3} := \frac{(115 \text{ pcf} - 92 \text{ pcf})}{2} + 92 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table 3.2:
 Dry Unit Weights, Average of Loose and dense uniform
 sand unit weight

$$\gamma_{dry_3} = 103.5 \cdot \text{pcf}$$

$$w_{sat_3} := 14.0\%$$

BB-FSRO-102 2D, Natural water content

$$\gamma_{sat_3} := \gamma_{dry_3} \cdot (1 + w_{sat_3})$$

$$\gamma_{sat_3} = 118.0 \cdot \text{pcf}$$

Soil Layer 4 (359.5 - 348.0) Loose, medium SAND

$$N_{60_4} := 7$$

$$E_{s4} := 250 \frac{(N_{60_4} + 15)}{50}$$

Bowles Table 5-6, Equation for stress-strain modulus E_s ,
 Sand (saturated)

$$E_{s4} = 110 \text{ ksf}$$

$$E_{ur_4} := 4 \cdot E_{s4}$$

Equation 5, Mayne and Cox, Constitutive Model Input Parameters, $E_s = E_{50}$

$$E_{ur_4} = 440 \text{ ksf}$$

$$\gamma_{dry_4} := 92 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table 3.2:
 Dry Unit Weights, Loose sand unit weight

$$\gamma_{dry_4} = 92 \cdot \text{pcf}$$

$$w_{sat_4} := 22.1\%$$

BB-FSRO-102 3D, Natural water content 22.1%

$$\gamma_{sat_4} := \gamma_{dry_4} \cdot (1 + w_{sat_4})$$

$$\gamma_{sat_4} = 112.3 \cdot \text{pcf}$$

Soil Layer 5 (348.0 - 338.0) Loose, fine SAND

$$N_{60_5} := 8$$

$$E_{s5} := 250 \frac{(N_{60_5} + 15)}{50}$$

Bowles Table 5-6, Equation for stress-strain modulus E_s ,
 Sand (saturated)

$$E_{s5} = 115 \text{ ksf}$$

$$E_{ur_5} := 4 \cdot E_{s5}$$

Equation 5, Mayne and Cox, Constitutive Model Input Parameters, $E_s = E_{50}$

$$E_{ur_5} = 460 \text{ ksf}$$

$$\gamma_{dry_5} := 92.0 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table
 3.2: Dry Unit Weights, Loose uniform sand

$$w_{sat_5} := 28.0\%$$

BB-FSRO-102 5D, Natural water content 28.0%

$$\gamma_{sat_5} := \gamma_{dry_5} \cdot (1 + w_{sat_5})$$

$$\gamma_{sat_5} = 117.8 \cdot \text{pcf}$$

Soil Layer 6 (Elev. 338.0 - 328.0): Very loose, medium SAND

$$N_{60_6} := 4$$

$$E_{s_6} := 250 \frac{(N_{60_6} + 15)}{50} \quad \text{Bowles Table 5-6, Equation for stress-strain modulus } E_s, \text{ Sand (saturated)}$$

$$E_{s_6} = 95 \quad \text{ksf}$$

$$E_{ur_6} := 4 \cdot E_{s_6} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_6} = 380 \quad \text{ksf}$$

$$\gamma_{dry_6} := 81 \text{ pcf} \quad \text{Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Very loose uniform sand}$$

$$w_{sat_6} := 21.3\% \quad \text{BB-FSRO-102, 5D Natural moisture content}$$

$$\gamma_{sat_6} := \gamma_{dry_6} \cdot (1 + w_{sat_6})$$

$$\gamma_{sat_6} = 98.3 \cdot \text{pcf}$$

Soil Layer 7 (Elev. 328.0 - 318.0): Very loose, Silty fine SAND

$$N_{60_7} := 4$$

$$E_{s_7} := \frac{250(N_{60_7} + 15)}{50} \quad \text{Bowles Table 5-6, Equations for stress-strain modulus } E_s, \text{ Sand (Saturated)}$$

$$E_{s_7} = 95 \quad \text{ksf}$$

$$E_{ur_7} := 4 \cdot E_{s_7} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_7} = 380 \quad \text{ksf}$$

$$\gamma_{dry_7} := 102 \text{ pcf} \quad \text{Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Loose angular-grained silty sand}$$

$$w_{sat_7} := 32.6\% \quad \text{BB-FSRO-102, 6D Natural moisture content}$$

$$\gamma_{sat_7} := \gamma_{dry_7} \cdot (1 + w_{sat_7})$$

$$\gamma_{sat_7} = 135.3 \cdot \text{pcf}$$

Soil Layer 8 (Elev. 318.0 - 298.0) Very soft, SILT

$$N_{60_8} := 1$$

$$E_{s_8} := \frac{[300 \cdot (N_{60_8} + 6)]}{50} \quad \text{Bowles Table 5-6, Equations for stress-strain modulus } E_s, \text{ Silt}$$

$$E_{s_8} = 42 \quad \text{ksf}$$

$$E_{ur_8} := 4 \cdot E_{s_8} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_8} = 168 \quad \text{ksf}$$

$$\gamma_{dry_8} := 83 \text{pcf} \quad \text{Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Soft clay 73-93 pcf}$$

$$w_{sat_8} := 47.6\% \quad \text{BB-FSRO-102, 7D Natural moisture content}$$

$$\gamma_{sat_8} := \gamma_{dry_8} \cdot (1 + w_{sat_8})$$

$$\gamma_{sat_8} = 122.5 \cdot \text{pcf}$$

Soil Layer 9 (Elev. 298.0 - 289.0) Very stiff, SILT

$$N_{60_9} := 17$$

$$E_{s_9} := \frac{[300 \cdot (N_{60_9} + 6)]}{50} \quad \text{Bowles Table 5-6, Equations for stress-strain modulus } E_s, \text{ Silt}$$

$$E_{s_9} = 138 \quad \text{ksf}$$

$$E_{ur_9} := 4 \cdot E_{s_9} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_9} = 552 \quad \text{ksf}$$

$$\gamma_{dry_9} := 108 \text{pcf} \quad \text{Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Stiff Clay 108 pcf}$$

$$w_{sat_9} := 34.1\% \quad \text{BB-FSRO-102, 9D Natural moisture content}$$

$$\gamma_{sat_9} := \gamma_{dry_9} \cdot (1 + w_{sat_9})$$

$$\gamma_{sat_9} = 144.8 \cdot \text{pcf}$$

Soil Layer 10 (Elev. 289.0 - 280.0) Medium dense, fine SAND, some silt

$$N_{60_10} := 24$$

$$E_{s_10} := \frac{[250 \cdot (N_{60_10} + 15)]}{50} \quad \text{ksf} \quad \text{Bowles Table 5-6, Equations for stress-strain modulus } E_s, \text{ Sand (Saturated)}$$

$$E_{s_10} = 195 \text{ ksf}$$

$$E_{ur_10} := 4 \cdot E_{s_10} \text{ ksf}$$

Equation 5, Mayne and Cox, Constitutive Model Input
 Parameters, $E_s = E_{50}$

$$E_{ur_10} = 780 \text{ ksf}$$

$$w_{sat_10} := 18.7\%$$

BB-FSRO-102, 10D Natural moisture content

$$\gamma_{dry_10} := 121 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights,
 Dense angular-grained silty sand

$$\gamma_{sat_10} := \gamma_{dry_10} \cdot (1 + w_{sat_10})$$

$$\gamma_{sat_10} = 143.6 \text{ pcf}$$

Soil Layer 11 (Elev. 280.0 - 268.0) Hard Silty CLAY

$$N_{60_11} := 63$$

$$E_{s_11} := \frac{300 \cdot (N_{60_11} + 6)}{50} = 414$$

Bowles Table 5-6, Equations for stress-strain modulus
 E_s , Clayey Silt

$$E_{s_11} = 414 \text{ ksf}$$

$$E_{ur_11} := 4 \cdot E_{s_11}$$

Equation 5, Mayne and Cox, Constitutive Model Input
 Parameters, $E_s = E_{50}$

$$E_{ur_11} = 1656.0 \text{ ksf}$$

$$\gamma_{dry_11} := 108 \text{ pcf}$$

Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights,
 Stiff Clay

$$w_{sat_11} := 17.4\%$$

BB-FSRO-102, 11D Natural moisture content

$$\gamma_{sat_11} := \gamma_{dry_11} \cdot (1 + w_{sat_11})$$

$$\gamma_{sat_11} = 126.8 \text{ pcf}$$

Soil Layer 12 (Elev. 268.0 - 263.6) Very soft, SILT

$$N_{60_12} := 4$$

$$E_{s_12} := \frac{[300 \cdot (N_{60_12} + 6)]}{50} \quad \text{Bowles Table 5-6, Equations for stress-strain modulus } E_s, \text{ Silt}$$

$$E_{s_12} = 60 \quad \text{ksf}$$

$$E_{ur_12} := 4 \cdot E_{s_12} \quad \text{Equation 5, Mayne and Cox, Constitutive Model Input Parameters, } E_s = E_{50}$$

$$E_{ur_12} = 240 \quad \text{ksf}$$

$$\gamma_{dry_12} := 93 \text{pcf} \quad \text{Das, Principles of Geotechnical Engineering, Table 3.2: Dry Unit Weights, Soft Clay 73-93 pcf}$$

$$w_{sat_12} := 25.4\% \quad \text{BB-FSRO-102, 12D Natural moisture content}$$

$$\gamma_{sat_12} := \gamma_{dry_12} \cdot (1 + w_{sat_12})$$

$$\gamma_{sat_12} = 116.6 \cdot \text{pcf}$$

TABLE 5-6

Equations for stress-strain modulus E_s by several test methods

E_s in kPa for SPT and units of q_c for CPT; divide kPa by 50 to obtain ksf. The N values should be estimated as N_{55} and not N_{70} . Refer also to Tables 2-7 and 2-8.

Soil	SPT	CPT
Sand (normally consolidated)	$E_s = 500(N + 15)$ $= 7000 \sqrt{N}$ $= 6000N$ $\frac{1}{2}E_s = (15\,000 \text{ to } 22\,000) \cdot \ln N$	$E_s = (2 \text{ to } 4)q_u$ $= 8000 \sqrt{q_c}$ $E_s = 1.2(3D_r^2 + 2)q_c$ $*E_s = (1 + D_r^2)q_c$
Sand (saturated)	$E_s = 250(N + 15)$	$E_s = Fq_c$ $e = 1.0 \quad F = 3.5$ $e = 0.6 \quad F = 7.0$
Sands, all (norm. consol.)	$\dagger E_s = (2600 \text{ to } 2900)N$	
Sand (overconsolidated)	$\dagger E_s = 40\,000 + 1050N$ $E_{s(\text{OCR})} \approx E_{s,nc} \sqrt{\text{OCR}}$	$E_s = (6 \text{ to } 30)q_c$
Gravelly sand	$E_s = 1200(N + 6)$ $= 600(N + 6) \quad N \leq 15$ $= 600(N + 6) + 2000 \quad N > 15$	
Clayey sand	$E_s = 320(N + 15)$	$E_s = (3 \text{ to } 6)q_c$
Silts, sandy silt, or clayey silt	$E_s = 300(N + 6)$	$E_s = (1 \text{ to } 2)q_c$
	If $q_c < 2500$ kPa use $2500 < q_c < 5000$ use where	$^{\$}E'_s = 2.5q_c$ $E'_s = 4q_c + 5000$
	$E'_s = \text{constrained modulus} = \frac{E_s(1 - \mu)}{(1 + \mu)(1 - 2\mu)} = \frac{1}{m_v}$	
Soft clay or clayey silt		$E_s = (3 \text{ to } 8)q_c$

4. It is not easy to determine if a cohesionless deposit is overconsolidated or what the OCR might be. Cementation may be less difficult to discover, particularly if during drilling or excavation sand "lumps" are present. Carefully done consolidation tests will aid in obtaining the OCR of cohesive deposits as noted in Chap. 2.

In general, with an $\text{OCR} > 1$ you should carefully ascertain the site conditions that will prevail at the time settlement becomes the design concern. This evaluation is, of course, true for any site, but particularly so if $\text{OCR} > 1$.

5-9 SIZE EFFECTS ON SETTLEMENTS AND BEARING CAPACITY

5-9.1 Effects on Settlements

A major problem in foundation design is to proportion the footings and/or contact pressure so that settlements between adjacent footings are nearly equal. Figure 5-9 illustrates the problem

3.4 Various Unit-Weight Relationships

In Sections 3.2 and 3.3, we derived the fundamental relationships for the moist unit weight, dry unit weight, and saturated unit weight of soil. Several other forms of relationships that can be obtained for γ , γ_d , and γ_{sat} are given in Table 3.1. Some typical values of void ratio, moisture content in a saturated condition, and dry unit weight for soils in a natural state are given in Table 3.2.

Table 3.1 Various Forms of Relationships for γ , γ_d , and γ_{sat}

Moist unit weight (γ)		Dry unit weight (γ_d)		Saturated unit weight (γ_{sat})	
Given	Relationship	Given	Relationship	Given	Relationship
w, G_s, e	$\frac{(1+w)G_s\gamma_w}{1+e}$	γ, w	$\frac{\gamma}{1+w}$	G_s, e	$\frac{(G_s+e)\gamma_w}{1+e}$
S, G_s, e	$\frac{(G_s+Se)\gamma_w}{1+e}$	G_s, e	$\frac{G_s\gamma_w}{1+e}$	G_s, n	$[(1-n)G_s+n]\gamma_w$
w, G_s, S	$\frac{(1+w)G_s\gamma_w}{1+\frac{wG_s}{S}}$	G_s, n	$G_s\gamma_w(1-n)$	G_s, w_{sat}	$\left(\frac{1+w_{\text{sat}}}{1+w_{\text{sat}}G_s}\right)G_s\gamma_w$
w, G_s, n	$G_s\gamma_w(1-n)(1+w)$	G_s, w, S	$\frac{G_s\gamma_w}{1+\left(\frac{wG_s}{S}\right)}$	e, w_{sat}	$\left(\frac{e}{w_{\text{sat}}}\right)\left(\frac{1+w_{\text{sat}}}{1+e}\right)\gamma_w$
S, G_s, n	$G_s\gamma_w(1-n)+nS\gamma_w$	e, w, S	$\frac{eS\gamma_w}{(1+e)w}$	n, w_{sat}	$n\left(\frac{1+w_{\text{sat}}}{w_{\text{sat}}}\right)\gamma_w$
		γ_{sat}, e	$\gamma_{\text{sat}} - \frac{e\gamma_w}{1+e}$	γ_d, e	$\gamma_d + \left(\frac{e}{1+e}\right)\gamma_w$
		γ_{sat}, n	$\gamma_{\text{sat}} - n\gamma_w$	γ_d, n	$\gamma_d + n\gamma_w$
		γ_{sat}, G_s	$\frac{(\gamma_{\text{sat}} - \gamma_w)G_s}{(G_s - 1)}$	γ_d, S	$\left(1 - \frac{1}{G_s}\right)\gamma_d + \gamma_w$
				γ_d, w_{sat}	$\gamma_d(1+w_{\text{sat}})$

Table 3.2 Void Ratio, Moisture Content, and Dry Unit Weight for Some Typical Soils in a Natural State

Type of soil	Void ratio, e	Natural moisture content in a saturated state (%)	Dry unit weight, γ_d	
			lb/ft ³	kN/m ³
Loose uniform sand	0.8	30	92	14.5
Dense uniform sand	0.45	16	115	18
Loose angular-grained silty sand	0.65	25	102	16
Dense angular-grained silty sand	0.4	15	121	19
Stiff clay	0.6	21	108	17
Soft clay	0.9–1.4	30–50	73–93	11.5–14.5
Loess	0.9	25	86	13.5
Soft organic clay	2.5–3.2	90–120	38–51	6–8
Glacial till	0.3	10	134	21

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine		Boring No.: BB-FSRO-102				
Driller: MaineDOT				Elevation (ft.): 378.0		Auger ID/OD: 5-inch Solid Stem				
Operator: Giguere/Giles				Datum: NAVD88		Sampler: Standard Split Spoon				
Logged By: Wilder				Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs./30 inches				
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)				
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.				
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐						
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt				R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person		S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected				
						T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test				
Depth (ft.)	Sample Information							Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows			
0							SSA	377.4	7-inch-thick layer of pavement.	
									Layer 1 (Elev. 377.4 - 368.0) Cobble from 1.5 to 2.2 feet bgs. $\gamma_{dry} = 125 \text{ pcf}$ $\gamma_{sat} = 131 \text{ pcf}$	
5	1D	24/12	5.00 - 7.00	2/3/5/3	8	11			Brown, moist, medium dense, medium SAND, little fine gravel, trace silt, occasional cobbles, (Fill).	G#245160 A-1-b, SP-SM WC=4.1%
10	2D	24/14	10.00 - 12.00	2/2/3/6	5	7	aSP		Brown, moist, loose, medium SAND, little fine gravel, little silt, (Fill). aSpun HW casing to 20 feet bgs. Layer 2 (Elev. 368.0 - 363.0) $\gamma_{dry} = 92 \text{ pcf}$ $\gamma_{sat} = 105 \text{ pcf}$	368 G#245161 A-1-b, SP-SM WC=14.0%
15	MD	24/1	15.00 - 17.00	5/5/7/8	12	17			Similar to 2D.	363
									Layer 3 (Elev. 363.0 - 359.5) $\gamma_{dry} = 103.5 \text{ pcf}$ $\gamma_{sat} = 118$	
20	3D	24/18	20.00 - 22.00	2/3/2/3	5	7	10	359.5	Brown, wet, loose, medium SAND, trace coarse gravel, trace silt, (Stream Alluvium). Dropped in NW casing at 20 feet bgs. Layer 4 (Elev. 359.5 - 348.0) $\gamma_{dry} = 92 \text{ pcf}$ $\gamma_{sat} = 112 \text{ pcf}$	359.5 G#245162 A-1-b, SP WC=22.1%
25							13			
Remarks: -bgs = below existing ground surface (roadway)										
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 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							28			$\gamma_{dry} = 92 \text{ pcf}$ $\gamma_{sat} = 112 \text{ pcf}$ Grey, wet, loose, fine SAND, trace silt, (Stream Alluvium). Layer 5 (Elev. 348.0 - 338.0) $\gamma_{dry} = 92 \text{ pcf}$ $\gamma_{sat} = 118$	348 G#245163 A-3, SP-SM WC=28.0%
							28				
							39				
							43				
							62				
30	4D	24/14	30.00 - 32.00	2/3/3/3	6	8	16				
							19				
							30				
							41				
							64				
35							79				
							116				
							119				
							155				
							158				
40	5D	24/20	40.00 - 42.00	1/1/2/3	3	4	73				
							73				
							76				
							77				
							108				
45							127				
							165				
							167				
							169				
							175				
50											
Remarks: -bgs = below existing ground surface (roadway)											
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 2 of 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00					
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem					
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon					
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches					
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)					
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.					
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐									
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test													
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.		
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows						
50	6D	24/18	50.00 - 52.00	8/2/1/4	3	4	107	318.0	Grey, wet, very loose, Silty fine SAND. Layer 7 (Elev. 328.0 - 318.0) $\gamma_{dry} = 102 \text{ pcf}$ $\gamma_{sat} = 135$	G#245165 A-4, SM WC=32.6%			
							82						
							81						
							113						
							122						
55							122						
							127						
							138						
							176						
							192						
60	7D	24/24	60.00 - 62.00	1/WOR/1/WOR	1	1	159				60.0	Grey, wet, very soft, SILT, trace clay, trace fine sand, (Glaciolacustrine). Layer 8 (Elev. 318.0 - 298.0) $\gamma_{dry} = 83 \text{ pcf}$ $\gamma_{sat} = 123 \text{ pcf}$	G#245166 A-4, ML WC=47.6%
							165						
							135						
							175						
							181						
65							181						
							186						
							186						
							178						
							178						
70	8D/MV	24/24	70.00 - 72.00	WOR/WOR/WOR/WOR	---		129	298	Grey, wet, very soft, SILT, some fine sand, trace clay. Failed 55x110 mm vane attempt, would not push.	G#245167 A-4, ML WC=43.3%			
							130						
							165						
							165						
							178						
75							178						
Remarks: -bgs = below existing ground surface (roadway)													
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine		Boring No.: BB-FSRO-102 WIN: 17912.00					
Driller: MaineDOT			Elevation (ft.): 378.0		Auger ID/OD: 5-inch Solid Stem						
Operator: Giguere/Giles			Datum: NAVD88		Sampler: Standard Split Spoon						
Logged By: Wilder			Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs./30 inches						
Date Start/Finish: 4/7,8,11,12/11			Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)						
Boring Location: Sta 299+61.2, 12.7 feet Lt.			Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.						
Hammer Efficiency Factor: 0.84			Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐								
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_u(lab) = Lab Vane Undrained Shear Strength (psf) q_u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							162		γ_{sat} = 108 γ_{dry} = 125 pcf γ	Grey, wet, very stiff, SILT, little clay. Layer 9 (Elev. 298.0 - 289.0)	G#245168 A-4, CL-ML WC=34.1%
						224					
						224					
						224					
						224					
80	9D	24/20	80.50 - 82.50	10/5/7/8	12	17	176				
	84% Silt 16% Clay						166				
							167				
							167				
							169				
85							170				
							167				
							164				
							164				
90	10D	24/14	90.00 - 92.00	4/7/10/15	17	24	166	γ_{dry} = 121 pcf γ_{sat} = 144 pcf RC to 100 feet bgs.	Grey, wet, medium dense, fine SAND, some silt, trace fine gravel, (Glacial Till). Layer 10 (Elev. 289.0 - 280.0)	G#245169 A-2-4, SM WC=18.7%	
							98				
							105				
							97				
							112				
95							96				
							162				
							238				
							386				
							508				
100											
Remarks: -bgs = below existing ground surface (roadway)											
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 4 of 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine		Boring No.: BB-FSRO-102	
Driller: MaineDOT				Elevation (ft.): 378.0		Auger ID/OD: 5-inch Solid Stem	
Operator: Giguere/Giles				Datum: NAVD88		Sampler: Standard Split Spoon	
Logged By: Wilder				Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs./30 inches	
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)	
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.	
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐			
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_u(lab) = Lab Vane Undrained Shear Strength (psf) q_u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test							
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
100	11D	18/18	100.00 - 101.50	21/26/19	45	63	290
		35% Silt 45% Clay					294
							232
							186
							178
105							173
							189
							162
							216
							216
110	12D	24/18	110.00 - 112.00	WOH/WOH/3/10	3	4	150
		92% Silt 8% Clay					187
							178
							220
115	R1	60/60	114.40 - 119.40	RQD = 85%			b150 NQ 2
120	R2	60/60	119.40 - 124.40	RQD = 90%			
125							
				Visual Description and Remarks Laboratory Testing Results/AASHTO and Unified Class.			
				Grey, wet, hard, Silty CLAY, little coarse sand, trace fine gravel. G#245170 A-4, CL WC=17.4%			
				γ_{dry} = 108 pcf γ = 127 pcf 268			
				Grey, wet, soft, SILT, some clay, little fine sand. G#245171 A-4, CL-ML WC=25.4%			
				Layer 12 (Elev. 268.0 - 263.6) γ_{dry} = 93 pcf γ_{sat} = 117			
				b150 blows for 0.4 ft. 114.4			
				Top of Bedrock at Elev. 263.6 ft. R1:Bedrock: No bedrock description recorded. R1:Core Times (min:sec) 114.4-115.4 ft (5:25) 115.4-116.4 ft (3:40) 116.4-117.4 ft (3:50) 117.4-118.4 ft (2:05) 118.4-119.4 ft (3:00) 100% Recovery 114.4			
				R2:Bedrock: No bedrock description recorded. R2:Core Times (min:sec) 119.4-120.4 ft (4:00) 120.4-121.4 ft (3:15) 121.4-122.4 ft (3:10) 122.4-123.4 ft (3:00) 123.4-124.4 ft (4:00) 100% Recovery 124.4			
				Bottom of Exploration at 124.4 feet below ground surface. 124.4			
Remarks: -bgs = below existing ground surface (roadway)							
Stratification lines represent approximate boundaries between soil types; transitions may be gradual. Page 5 of 5							
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made. Boring No.: BB-FSRO-102							

HB-32F(U3)

		Top of Clay
10% clay	CR = .125 RR = .014 $e_o = 1.28$ $C_{vr} = 2.5 \text{ ft}^2/\text{day}$ $C_c = .287$ $C_{cr} = .032$	El. +120
20% clay	CR = .15 RR = .027 $e_o = 1.3$ $C_{vr} = 2.4 \text{ ft}^2/\text{day}$ $C_c = .345$ $C_r = .0621$	
		El. 105
30% clay	CR = .175 RR = .030 $e_o = 1.3$ $C_{vr} = 2.2 \text{ ft}^2/\text{day}$ $C_c = .4025$ $C_r = .069$	
		El. 95
40% clay	CR = .207 RR = .032 $e_o = 1.4$ $C_{vr} = 2.0 \text{ ft}^2/\text{day}$ $C_c = .497$ $C_{cr} = .0768$	
		El. 85

STA 196+00

Lab Bulk Sample : 40% CLAY

CR = .2021
RR = .034
 $e_o = 1.28$
 $C_{vr} = 2.3 \text{ ft}^2/\text{day}$
 $C_c = .4650$
 $C_{cr} = .078$
O.C.R. = 5

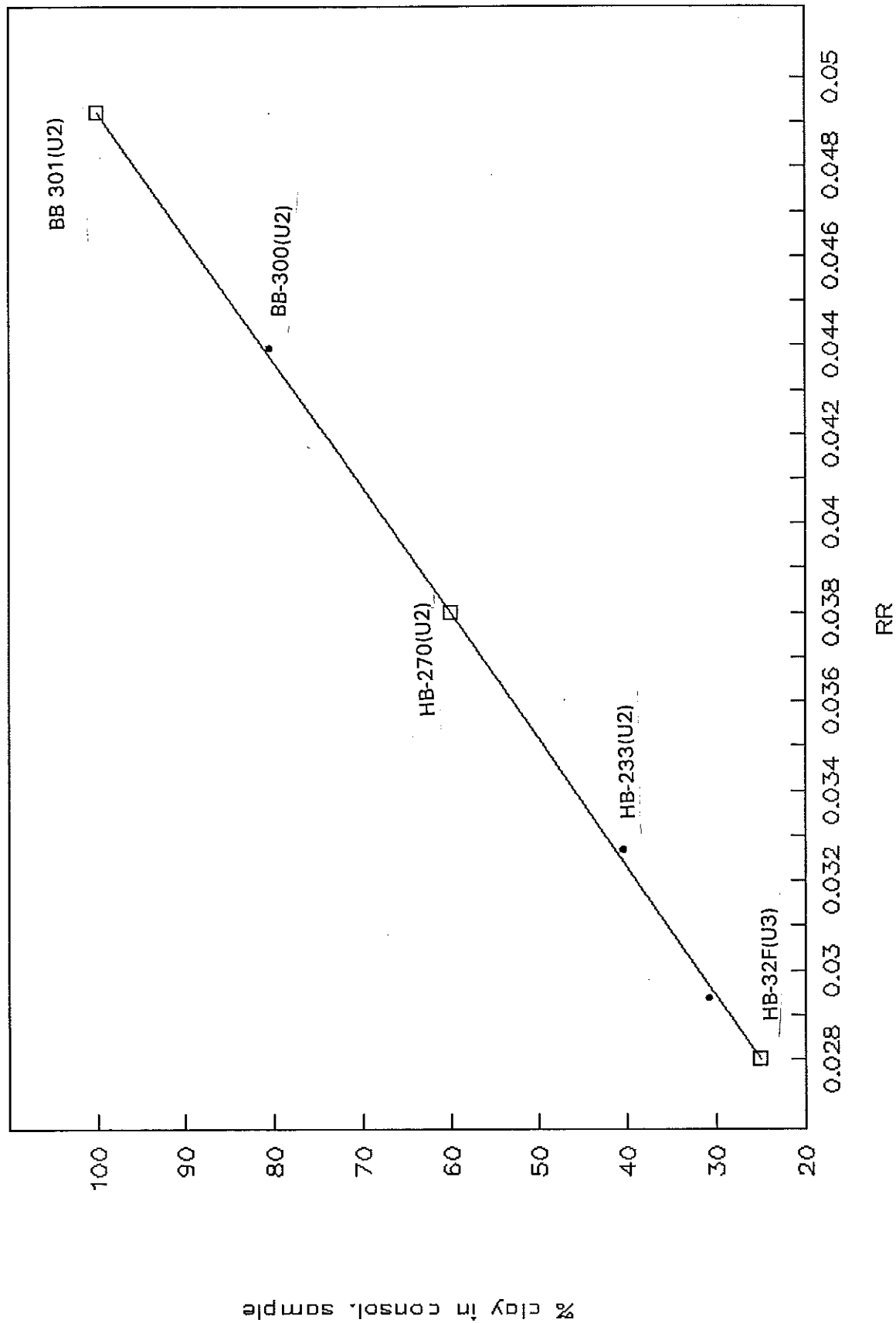
Liquid Limit 40%
Plastic Limit 27%

Shear Strengths:

C_u (min) = 900 psf
 C_u (max) = 1700 psf

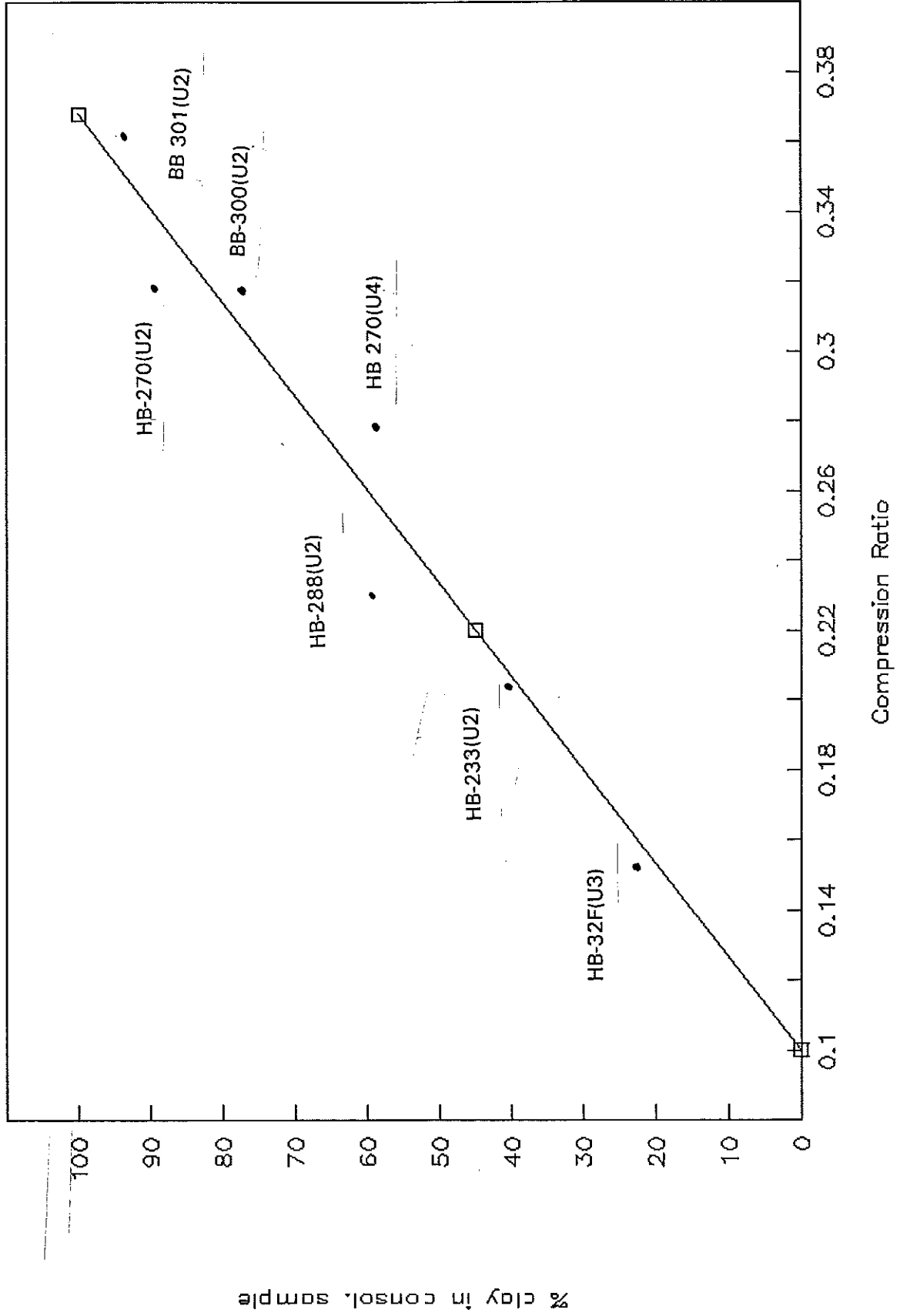
% Clay vs. RR

Agawam Route 57



% Clay vs. CR

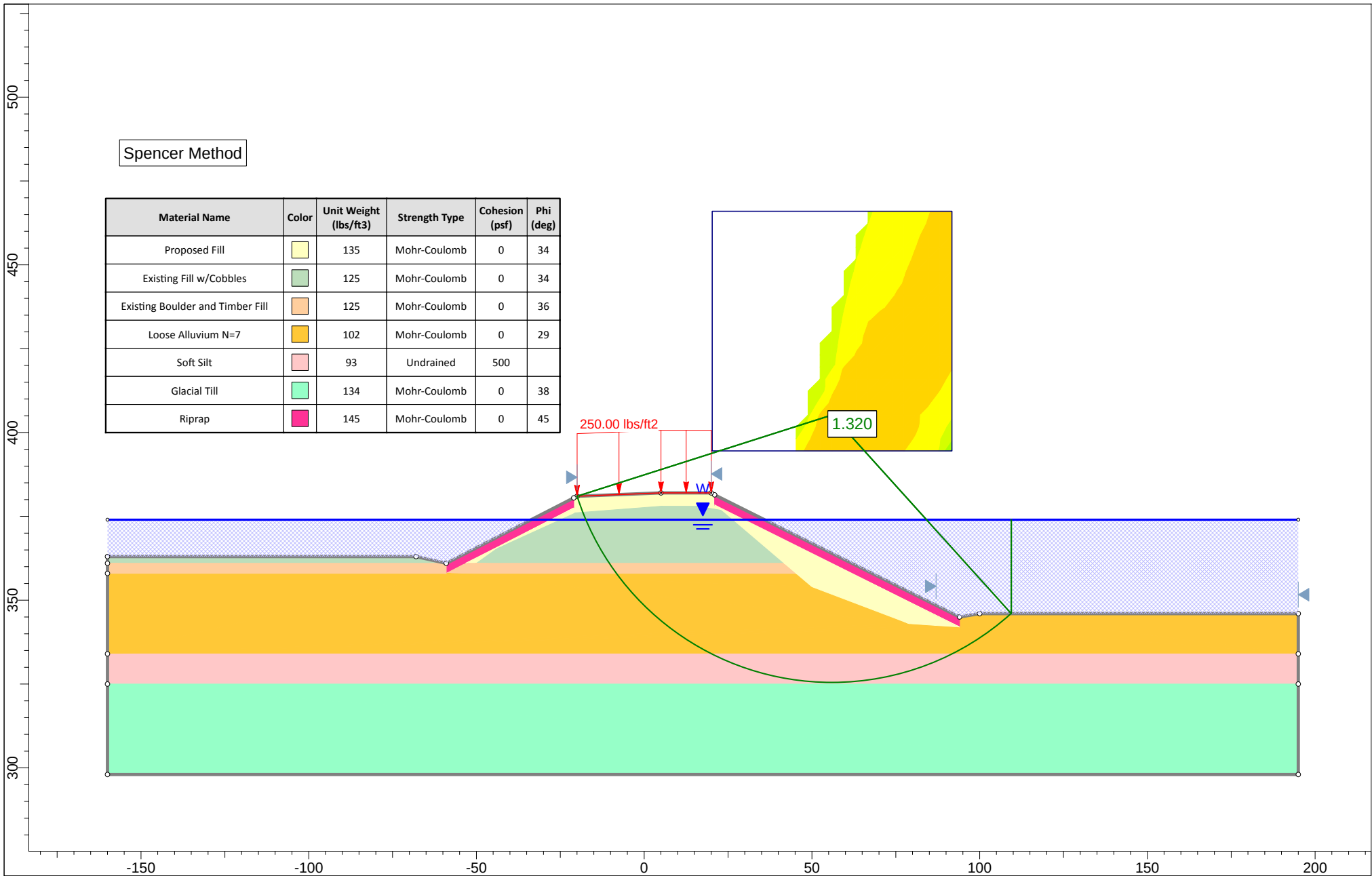
Agawam, Route 57



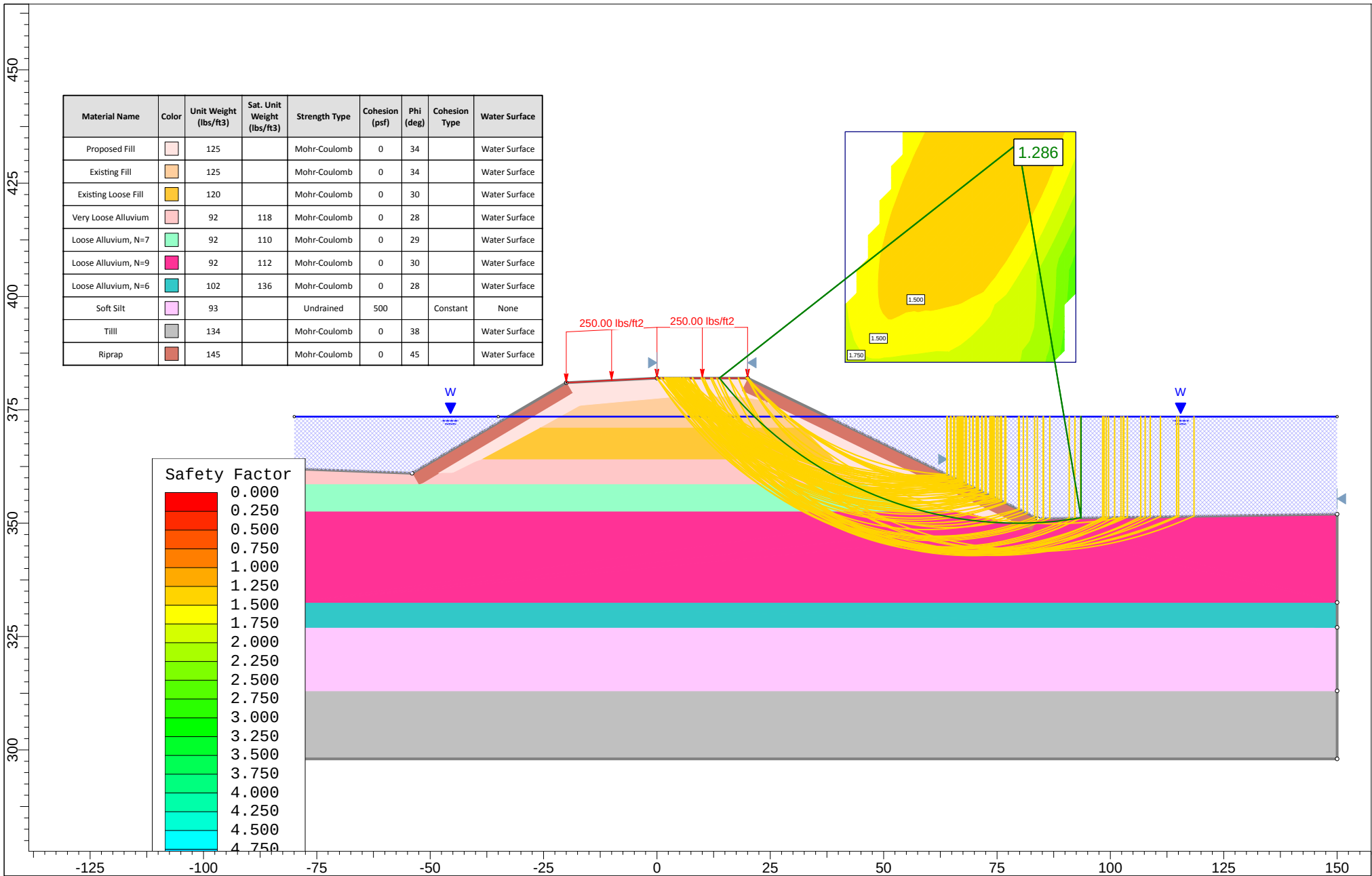
Global Stability

Spencer Method

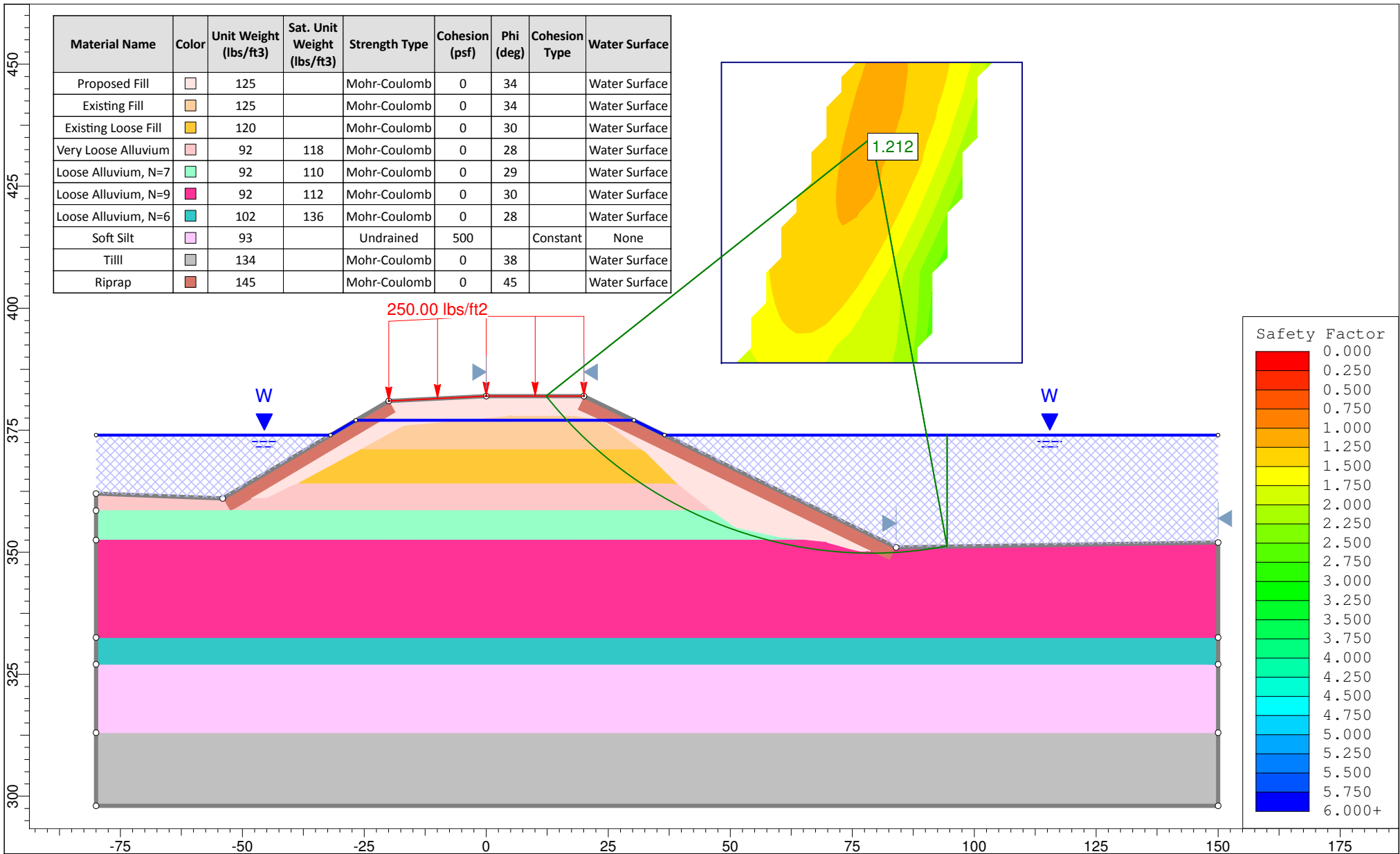
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Proposed Fill		135	Mohr-Coulomb	0	34
Existing Fill w/Cobbles		125	Mohr-Coulomb	0	34
Existing Boulder and Timber Fill		125	Mohr-Coulomb	0	36
Loose Alluvium N=7		102	Mohr-Coulomb	0	29
Soft Silt		93	Undrained	500	
Glacial Till		134	Mohr-Coulomb	0	38
Riprap		145	Mohr-Coulomb	0	45

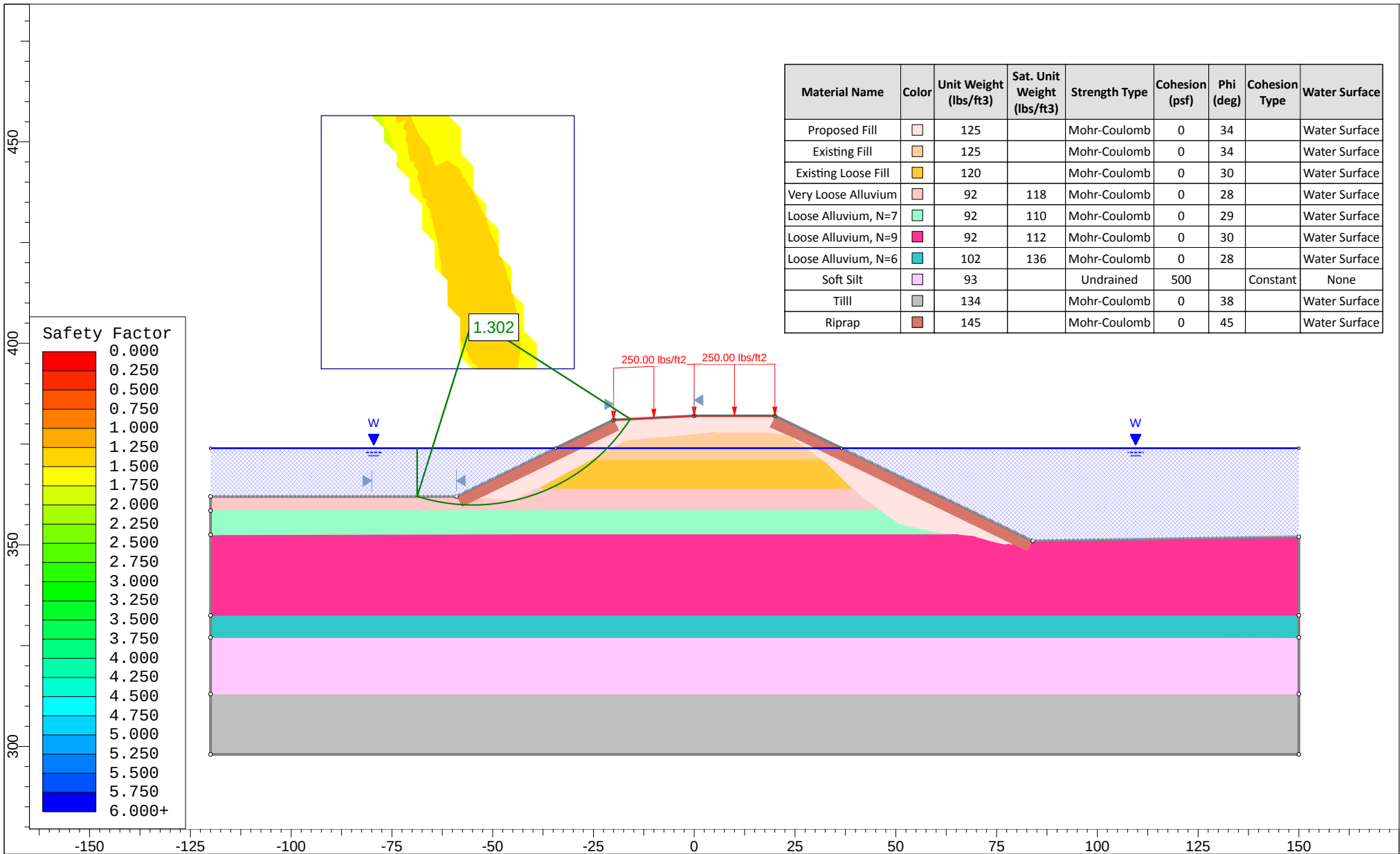


	Project			17912 Fryeburg Eddy Flats No. 2261	
	Analysis Description			Station 298 + 50; Right slope 2 to 1; Q10	
	Drawn By	A. Van Buskirk/L. Krusinski	Scale	1:466	Company
	Date	8/15/2018, 9:03:17 AM	MaineDOT		
	File Name			298+50 l to r slope 2 to 1.slim	

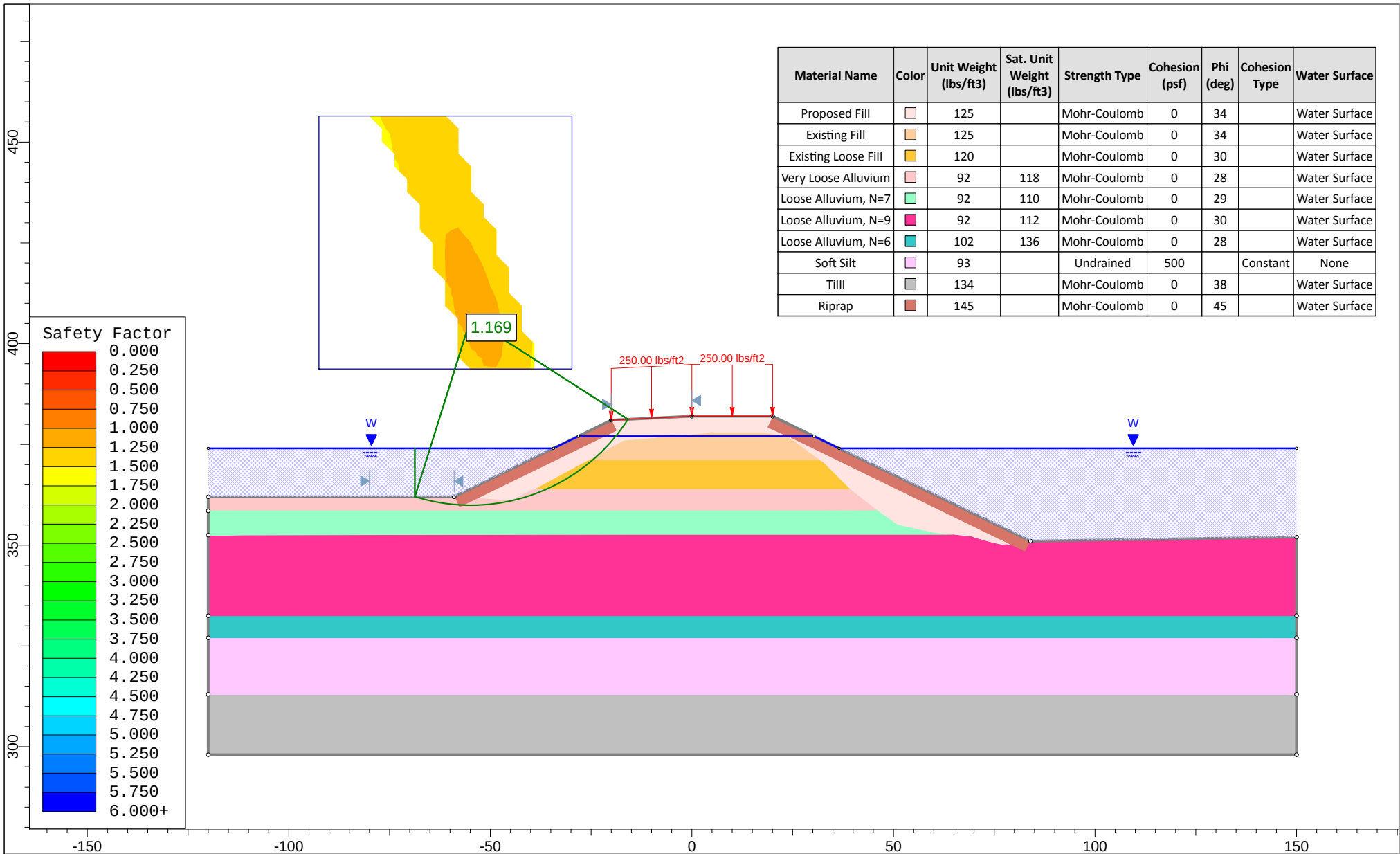


 SLIDEINTERPRET 6.029	Project				Fryeburg Eddy Flats No. 2261 WIN 17912.00											
	Analysis Description				Station 298 + 75; 2:1 slope on right side; Q10											
	Drawn By		L. Krusinski & A. Van Buskirk		Scale		1:345		Company		MaineDOT					
	Date		7/19/2018, 10:18:06 AM						File Name		station 298+75 l to r 2 to 1 Q10 r-4 extend rt.slim					

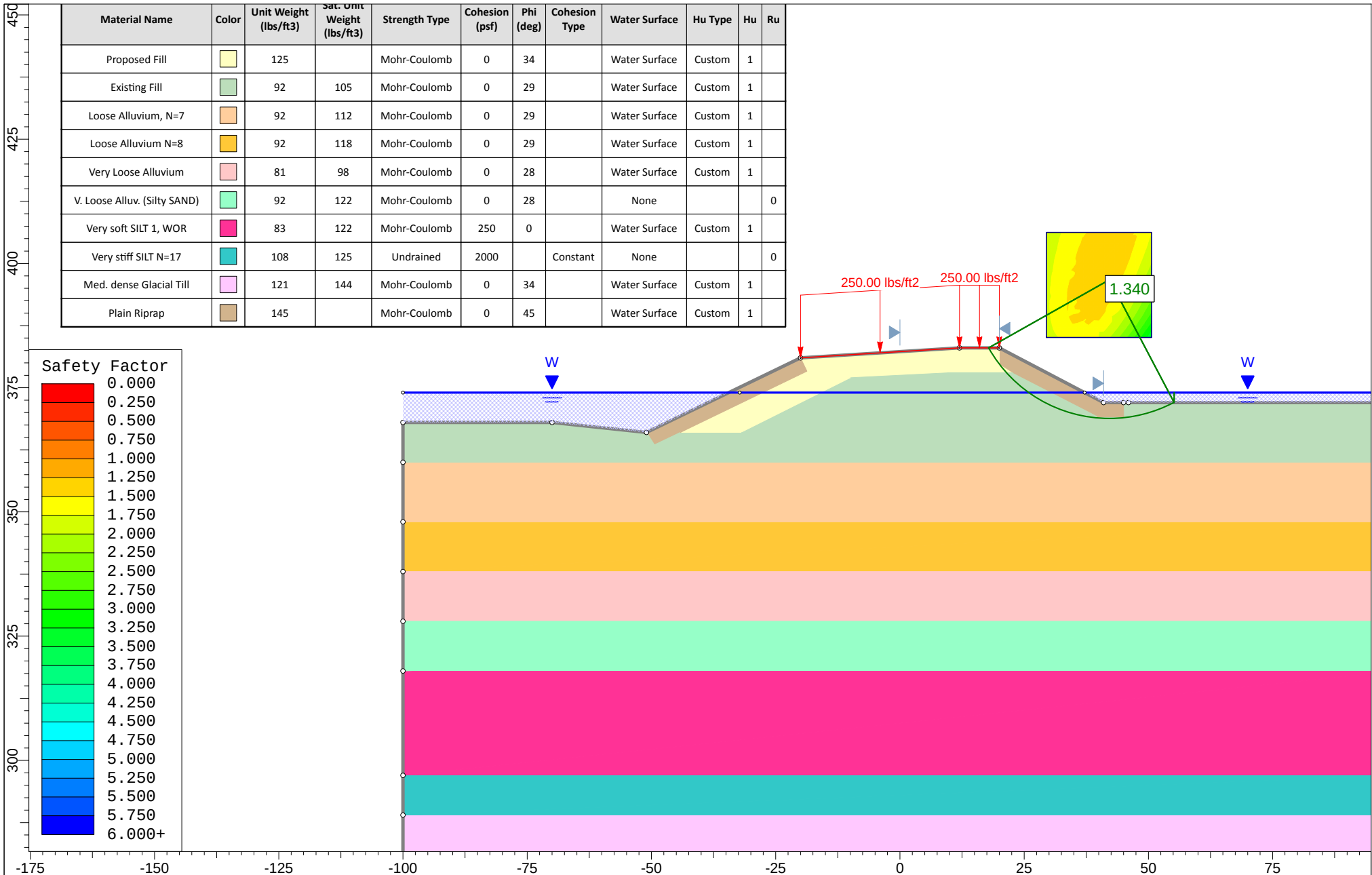




Project			Fryeburg Eddy Flats No. 2261 WIN 17912.00		
Analysis Description			Station 298 + 75; 2:1 slope on left side; Q10		
Drawn By		L. Krusinski & A. Van Buskirk	Scale	1:396	Company
Date		7/19/2018, 10:18:06 AM	File Name		
			station 298+75_r_to_l_2_to_1_Q10 r-7_extend_rt.slim		

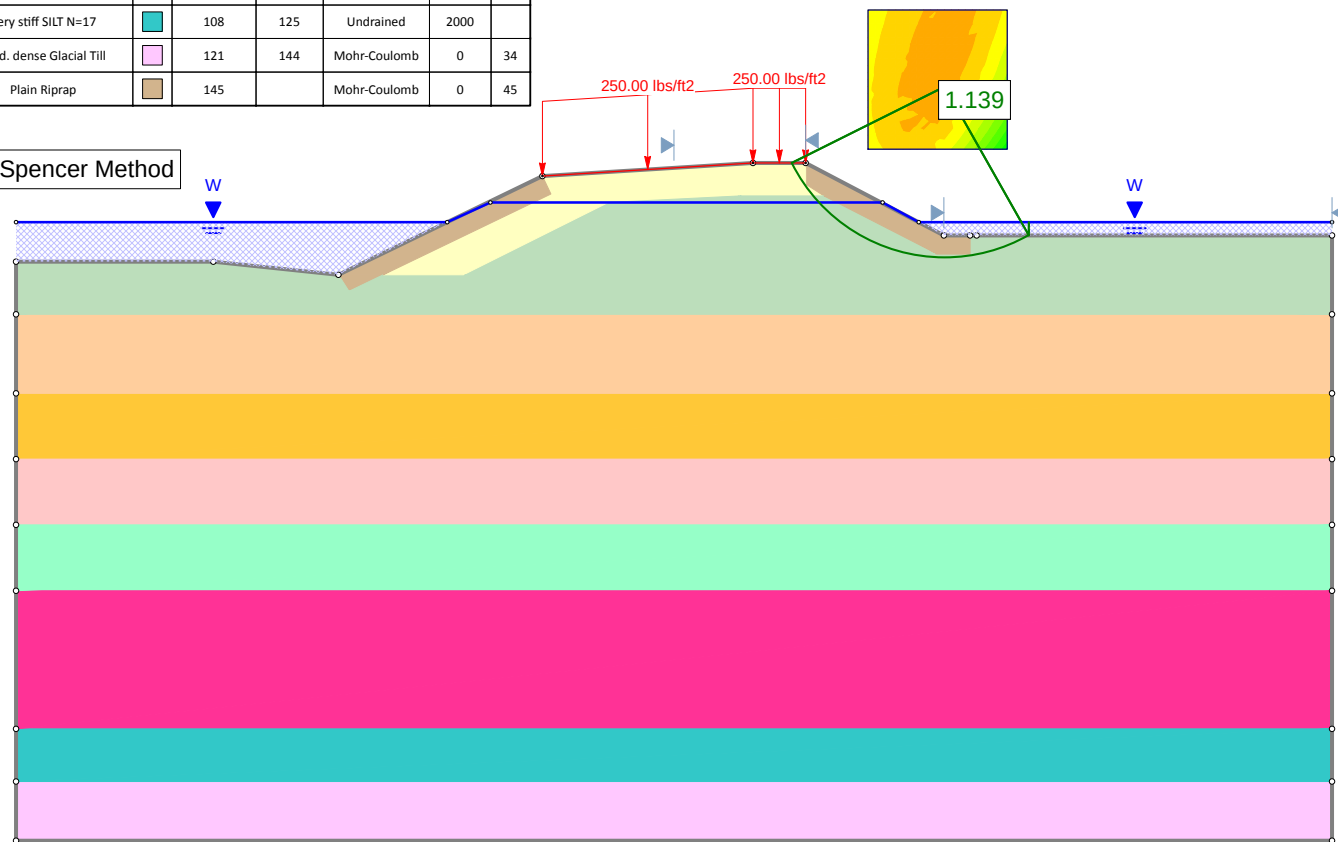


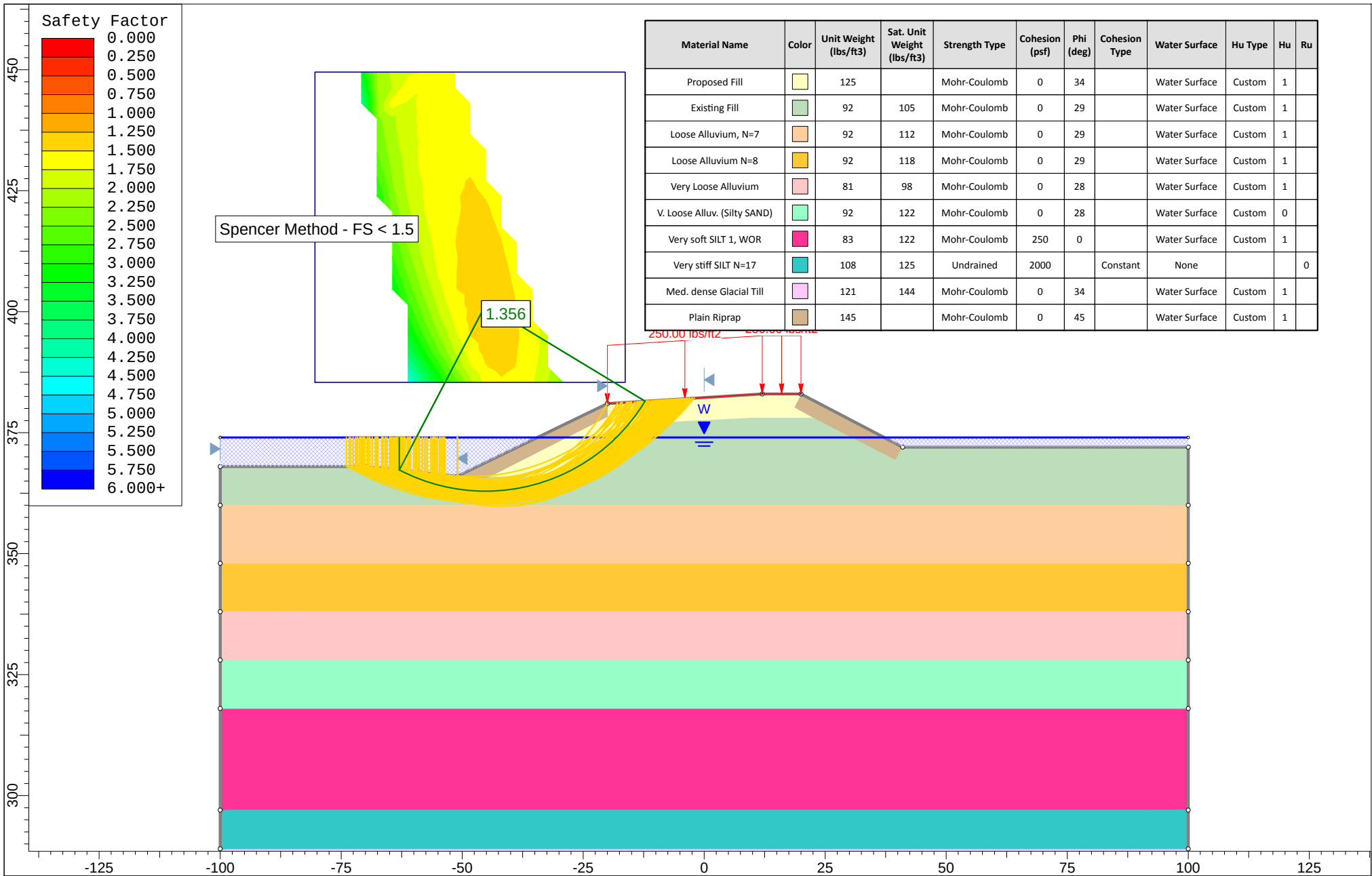
Project			Fryeburg Eddy Flats No. 2261 WIN 17912.00		
Analysis Description			Station 298 + 75; 2:1 slope on left side; Q50 (377') drawdown to Q10 (374')		
Drawn By	L. Krusinski & A. Van Buskirk	Scale	1:396	Company	MaineDOT
Date	7/19/2018, 10:18:06 AM			File Name	station 298+75_r_to_l_2_to_1_Q50 r-7_extend_rt_drawdown.slim



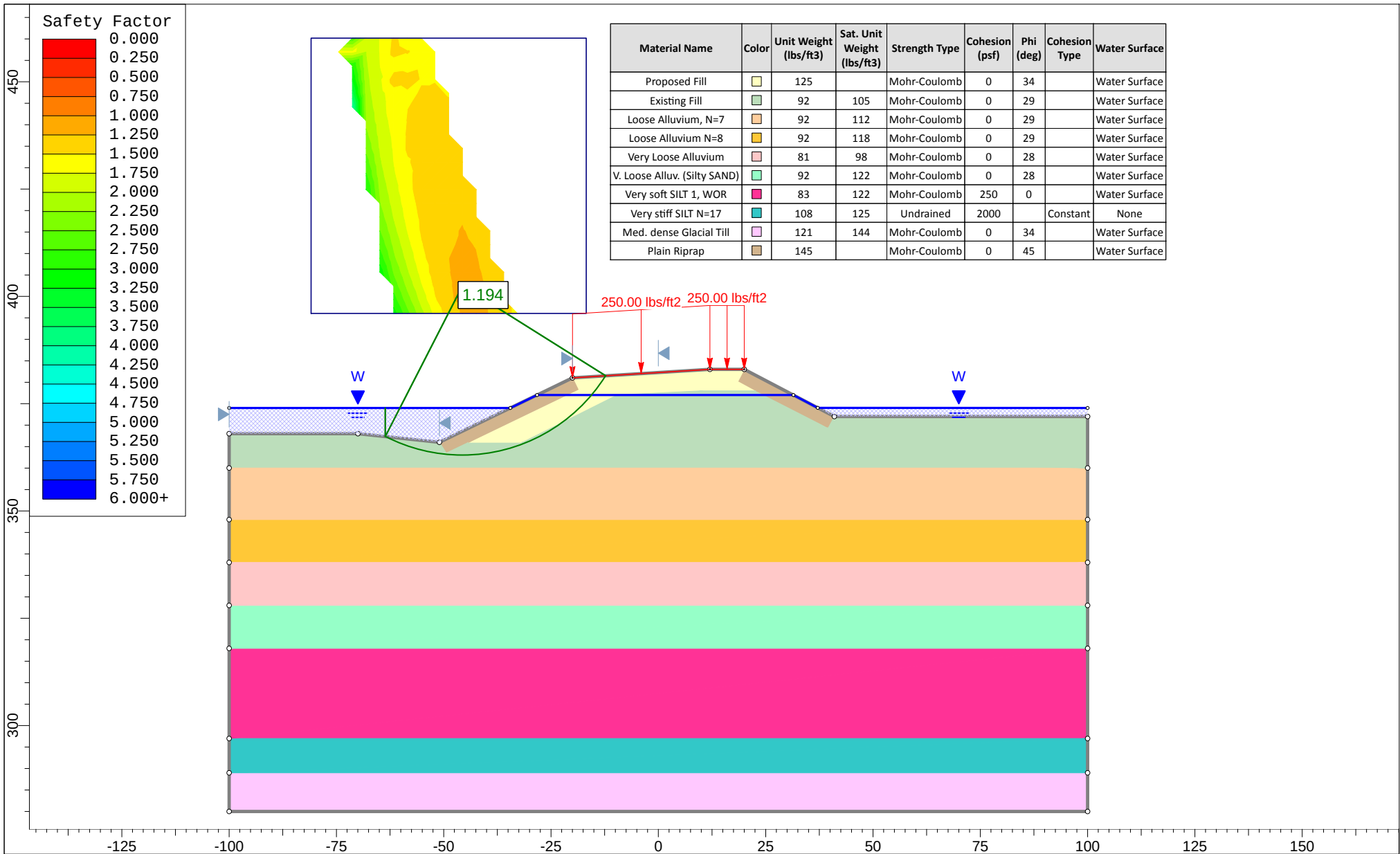
Material Name	Color	Unit Weight (lbs/ft ³)	Sat. Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Proposed Fill		125		Mohr-Coulomb	0	34
Existing Fill		92	105	Mohr-Coulomb	0	29
Loose Alluvium, N=7		92	112	Mohr-Coulomb	0	29
Loose Alluvium N=8		92	118	Mohr-Coulomb	0	29
Very Loose Alluvium		81	98	Mohr-Coulomb	0	28
V. Loose Alluv. (Silty SAND)		92	122	Mohr-Coulomb	0	28
Very soft SILT 1, WOR		83	122	Mohr-Coulomb	250	0
Very stiff SILT N=17		108	125	Undrained	2000	
Med. dense Glacial Till		121	144	Mohr-Coulomb	0	34
Plain Riprap		145		Mohr-Coulomb	0	45

Spencer Method

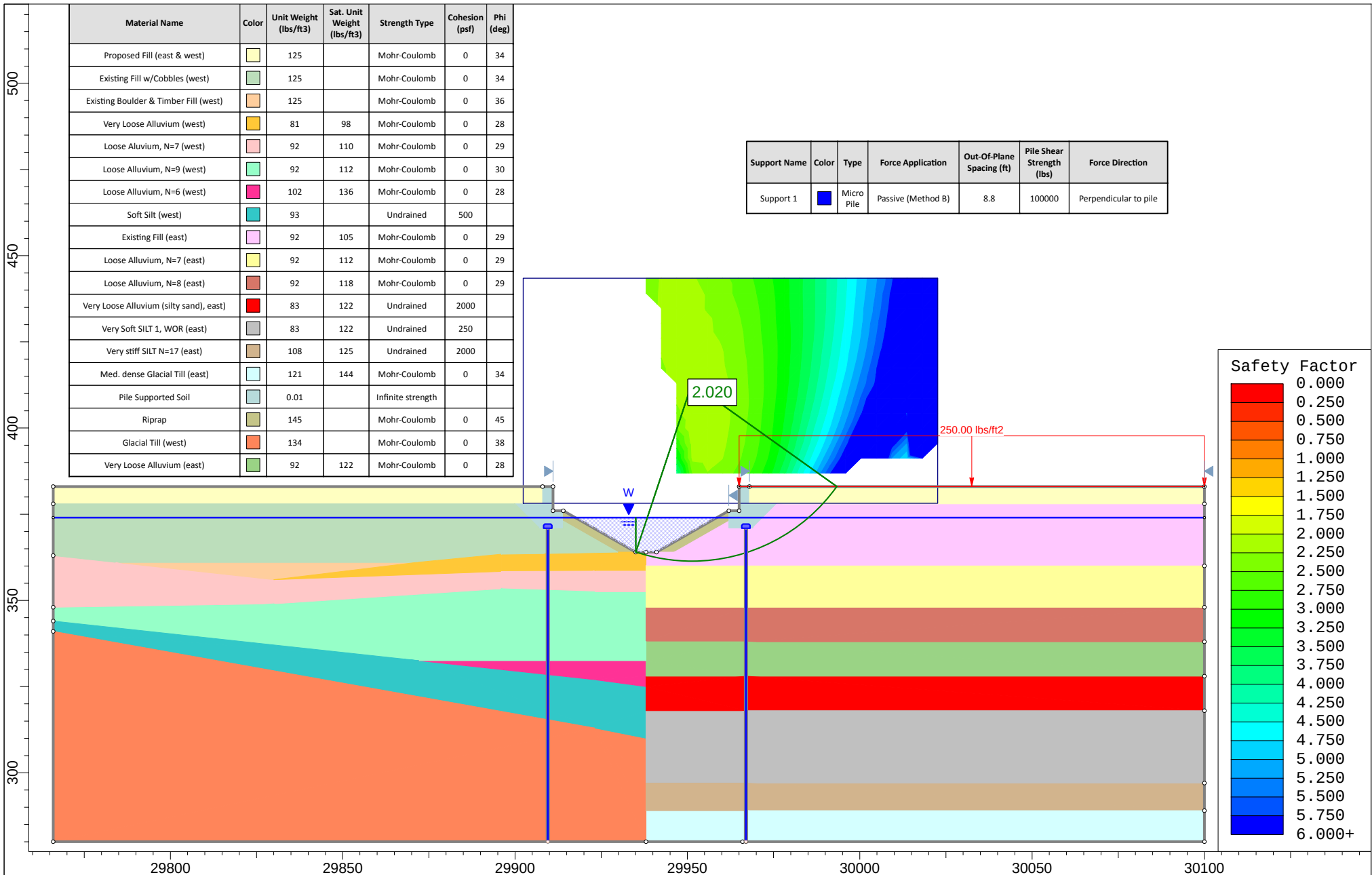




	Project			Fryeburg Eddy Flats No. 2261 WIN 17912.00	
	Analysis Description			Station 300 + 00; Left slope 2:1; Q10	
	Drawn By	A. Van Buskirk	Scale	1:323	Company
	Date	7/23/2018, 8:36:17 AM	File Name	station 300 + 00 r to l 2 to 1 Q10 r-7.slim	

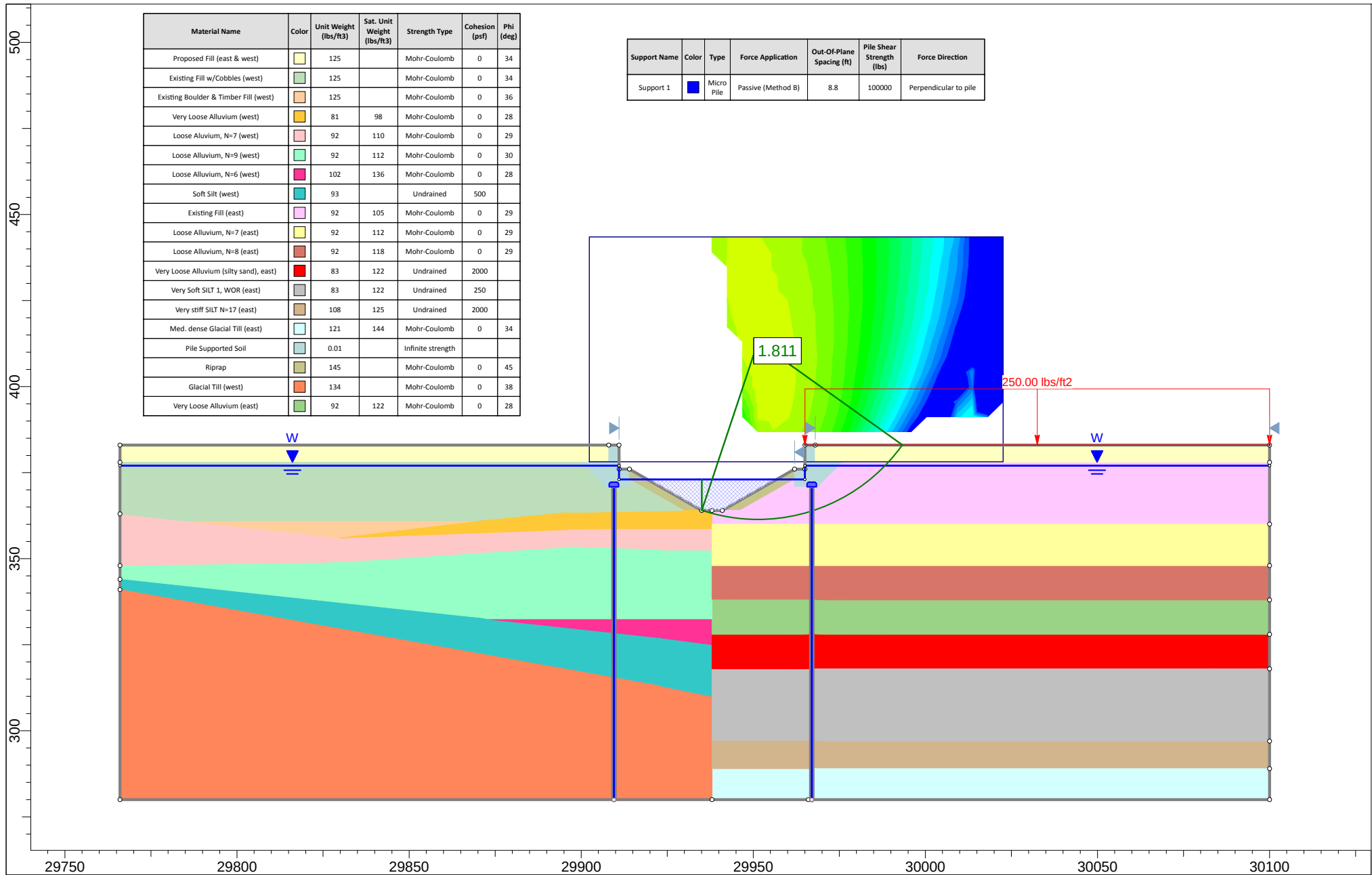


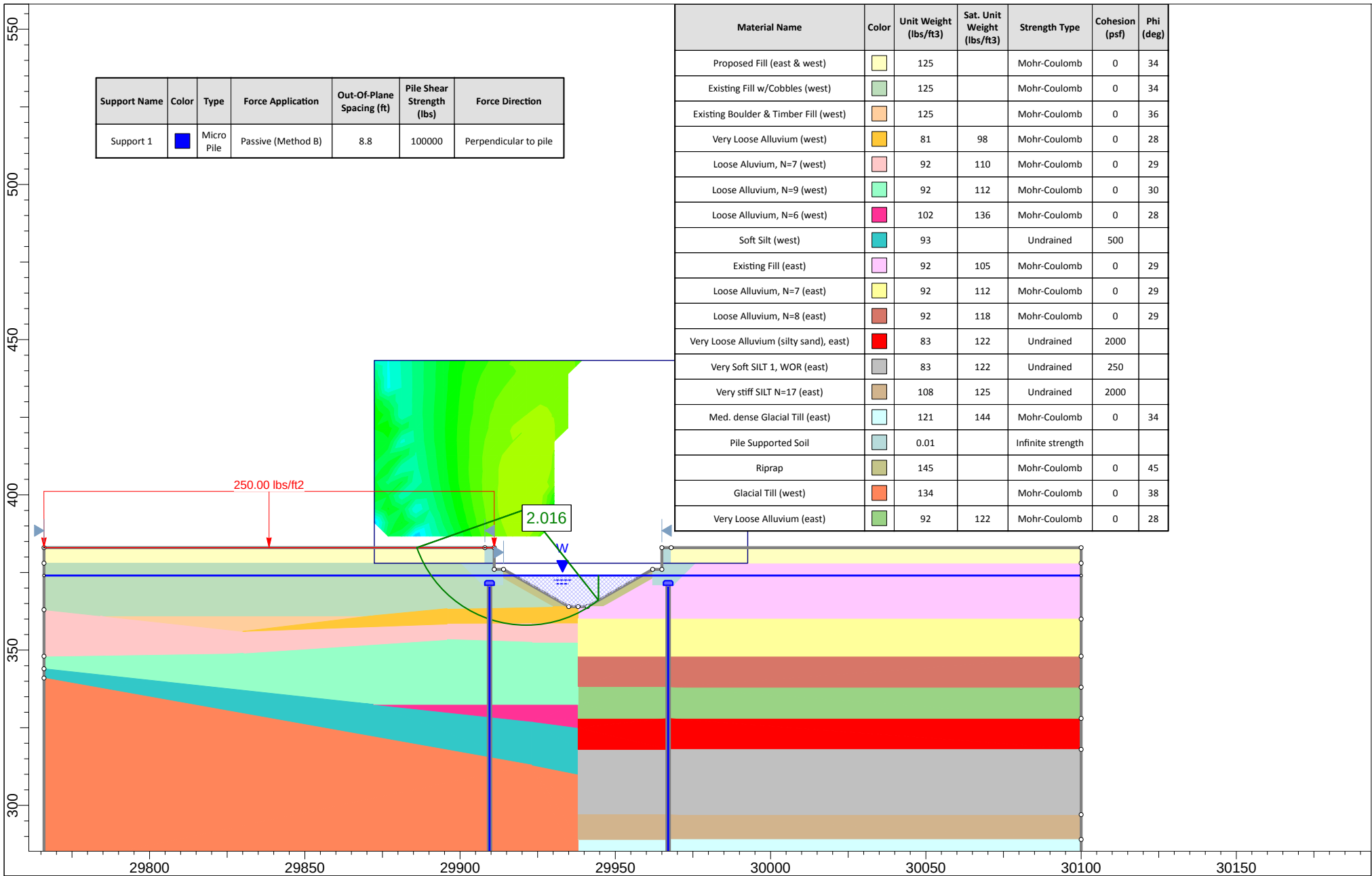
 SLIDEINTERPRET 6.039	Project				
	Fryeburg Eddy Flats No. 2261 WIN 17912.00				
	Analysis Description				
	Station 300 + 00; Left slope 2:1; Q50 (377') drawdown to Q10 (374')				
	Drawn By		A. Van Buskirk		Scale
			1:371	Company	
				MaineDOT	
	Date			7/23/2018, 8:36:17 AM	
				File Name	
				station 300 + 00_r_to_l_2_to_1_Q50_drawdown r-7.slim	

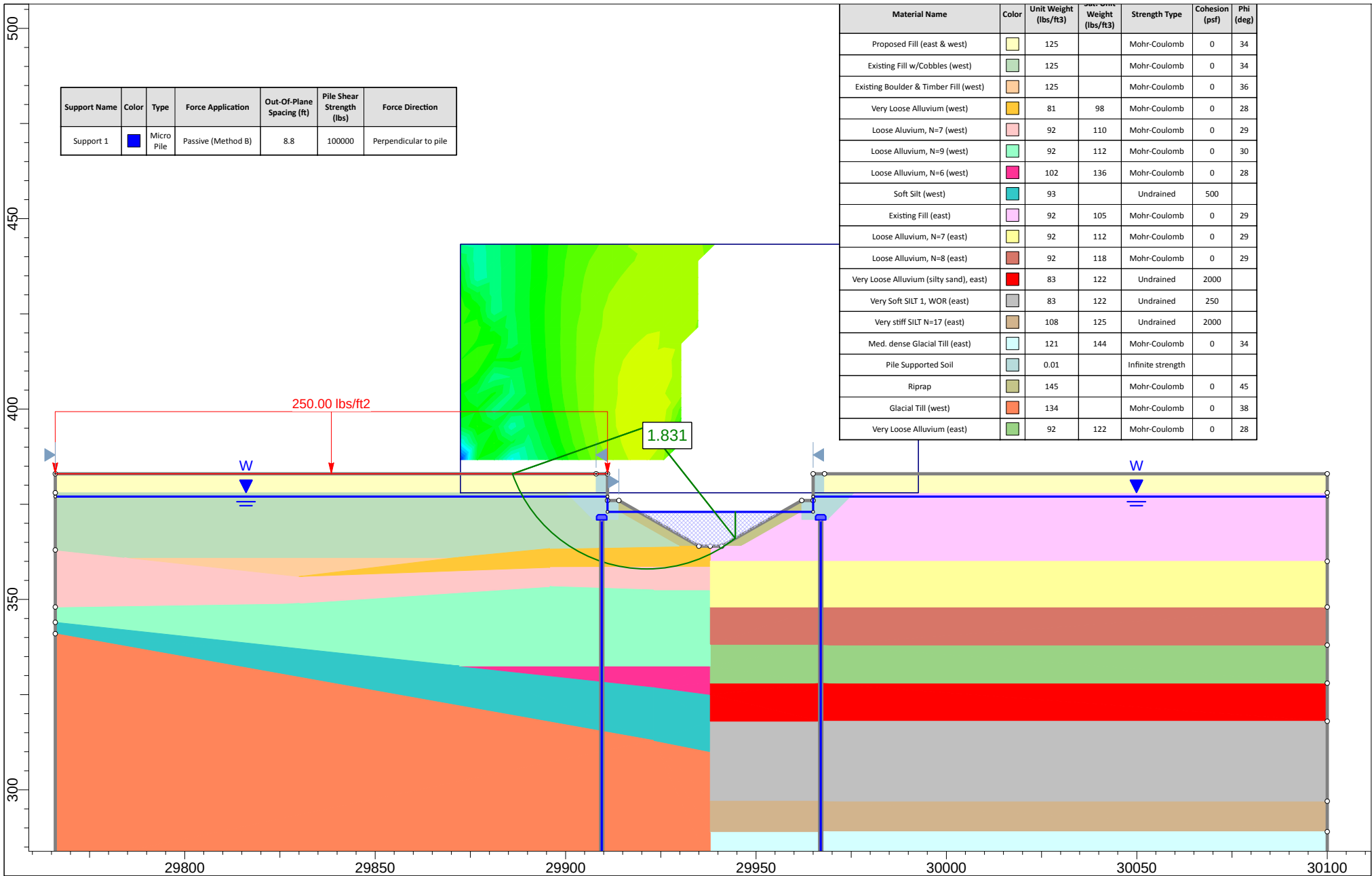


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Proposed Fill (east & west)		125		Mohr-Coulomb	0	34
Existing Fill w/Cobbles (west)		125		Mohr-Coulomb	0	34
Existing Boulder & Timber Fill (west)		125		Mohr-Coulomb	0	36
Very Loose Alluvium (west)		81	98	Mohr-Coulomb	0	28
Loose Alluvium, N=7 (west)		92	110	Mohr-Coulomb	0	29
Loose Alluvium, N=9 (west)		92	112	Mohr-Coulomb	0	30
Loose Alluvium, N=6 (west)		102	136	Mohr-Coulomb	0	28
Soft Silt (west)		93		Undrained	500	
Existing Fill (east)		92	105	Mohr-Coulomb	0	29
Loose Alluvium, N=7 (east)		92	112	Mohr-Coulomb	0	29
Loose Alluvium, N=8 (east)		92	118	Mohr-Coulomb	0	29
Very Loose Alluvium (silty sand), east		83	122	Undrained	2000	
Very Soft SILT 1, WOR (east)		83	122	Undrained	250	
Very stiff SILT N=17 (east)		108	125	Undrained	2000	
Med. dense Glacial Till (east)		121	144	Mohr-Coulomb	0	34
Pile Supported Soil		0.01		Infinite strength		
Riprap		145		Mohr-Coulomb	0	45
Glacial Till (west)		134		Mohr-Coulomb	0	38
Very Loose Alluvium (east)		92	122	Mohr-Coulomb	0	28

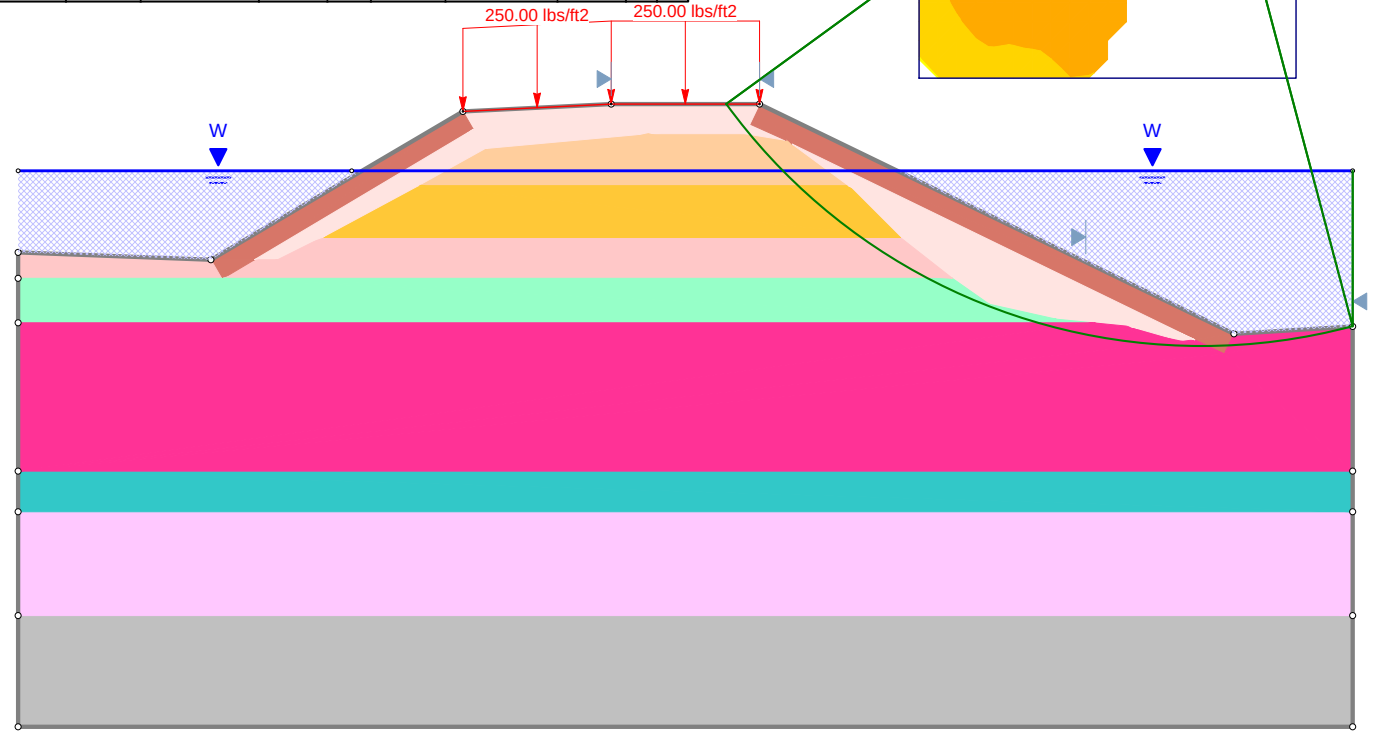
Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)	Force Direction
Support 1		Micro Pile	Passive (Method B)	8.8	100000	Perpendicular to pile



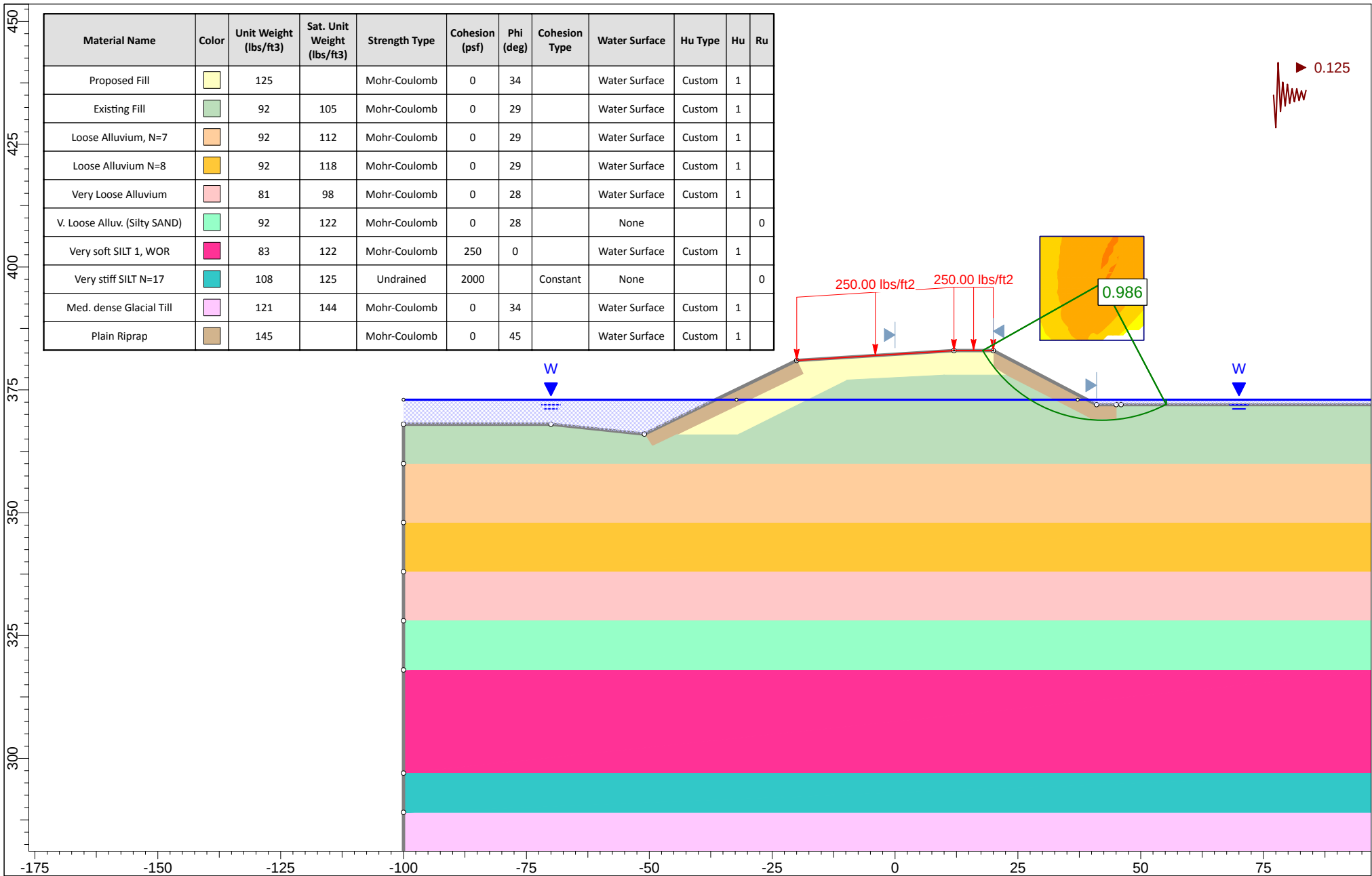


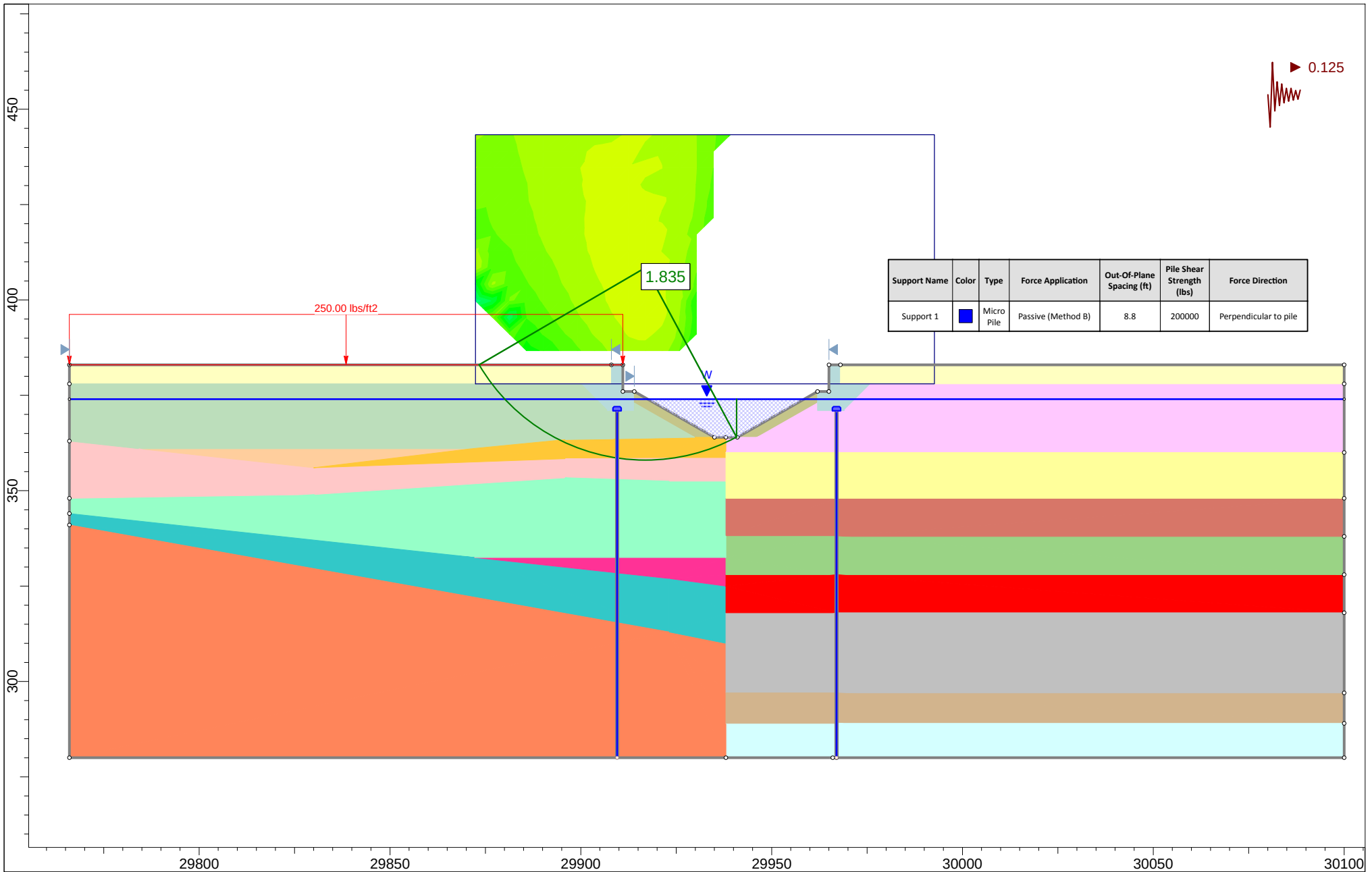


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu	Ru
Proposed Fill		125		Mohr-Coulomb	0	34		Water Surface	Custom	1	
Existing Fill		125		Mohr-Coulomb	0	34		Water Surface	Custom	1	
Existing Loose Fill		120		Mohr-Coulomb	0	30		Water Surface	Custom	1	
Very Loose Alluvium		92	118	Mohr-Coulomb	0	28		Water Surface	Custom	1	
Loose Alluvium, N=7		92	110	Mohr-Coulomb	0	29		Water Surface	Custom	1	
Loose Alluvium, N=9		92	112	Mohr-Coulomb	0	30		Water Surface	Custom	1	
Loose Alluvium, N=6		102	136	Mohr-Coulomb	0	28		Water Surface	Custom	1	
Soft Silt		93		Undrained	500		Constant	None			0
Till		134		Mohr-Coulomb	0	38		Water Surface	Custom	1	
Riprap		145		Mohr-Coulomb	0	45		Water Surface	Custom	1	

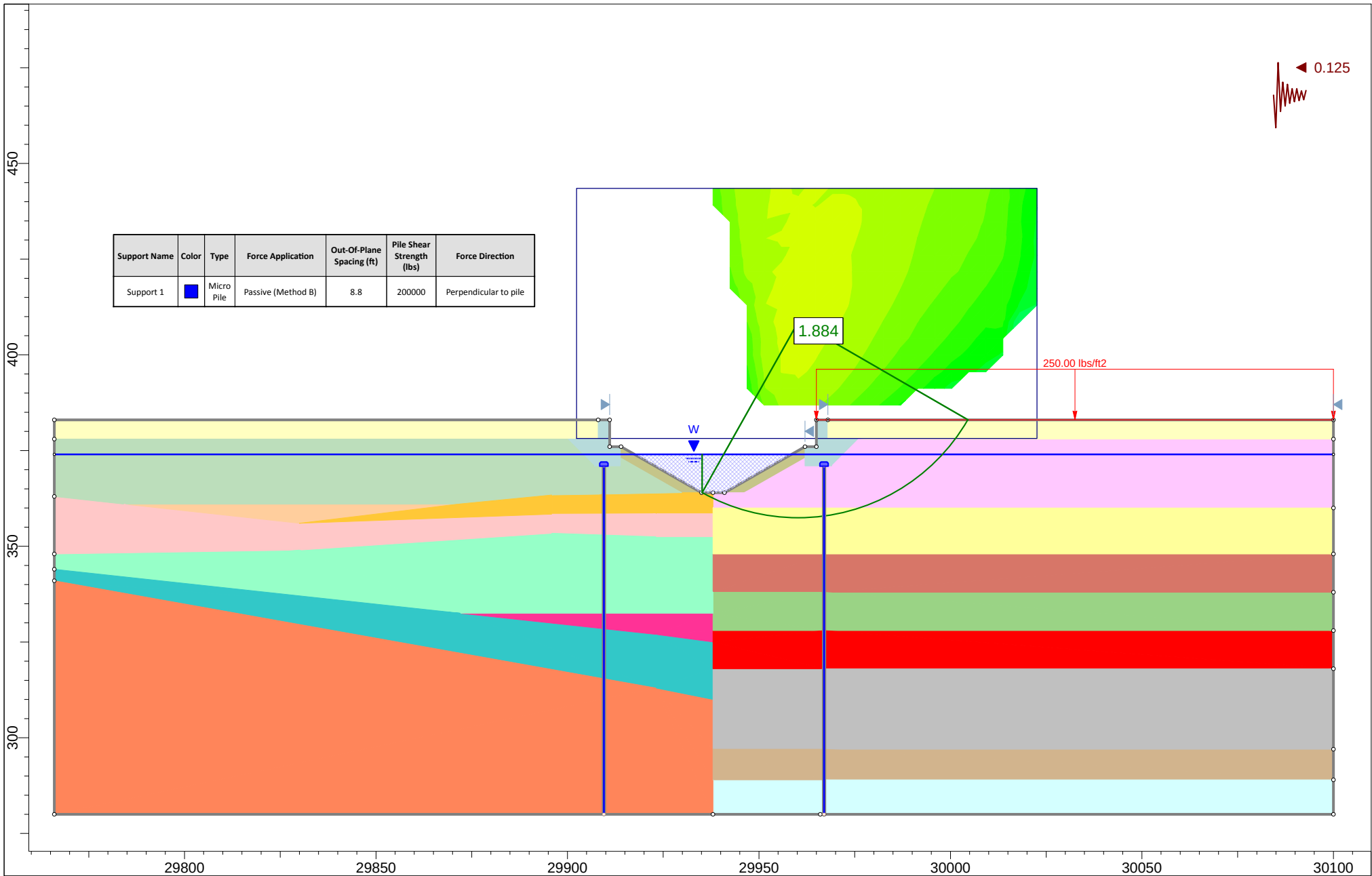


0.125





	Project					
	17912 Fryeburg Eddy Flats No. 2261					
	Analysis Description					
	Longitudinal Global Stability Analysis west approach					
	Drawn By	A. Van Buskirk/LK		Scale	1:408	Company
						MDOT
	Date	8/14/2018, 8:04:13 AM			File Name	17912 longitudinal profile_west_2-EQ-r1.slm



	Project			17912 Fryeburg Eddy Flats No. 2261		
	Analysis Description			Longitudinal Global Stability Analysis east approach		
	Drawn By	A. Van Buskirk/LK		Scale	1:408	Company
	Date	11/1/2018				MDOT
				File Name	17912 longitudinal profile_east_2_EQ-Kh.slim	

Liquefaction Analyses

17912.00 Fryeburg Eddy Flats Bridge - Liquifaction Potential Analyses - west approach (soil model based on BB-FSRO-101B)

As=Amax: 0.25 7% probability of Exceedence in 75 Years for determined site class and location caused by magnitude 5.95 earthquake (based on USGS Deaggregation).
Unit weight water (pcf) 62.4
Depth to Watertable (ft) 13

Watertable (ft) 13												Demand							Capacity	
Boring	Sample	Depth to top of SPT Test	Soil Layer	Sat. Unit Weight (PCF) ¹	Total Overburden Pressure	Water Table Condition	Effective Overburden Pressure	N ₆₀	C _n ²	(N ₁) ₆₀ ³	r _d ⁴	CSR _{EQ} ⁵	% Fines ⁶	CSR _{7.5}	K _m ⁷	K _σ ⁸	CSR _L ⁹	FS _L		
BB-FSRO-101B	1D	16	Alluvium	118	1993	Below	1806	4	1.05	4	0.927	0.166	38	0.12	1.31	1.20	0.189	1.13		
BB-FSRO-101B	2D	21	Alluvium	110	2567	Below	2068	7	0.98	7	0.904	0.182	6	0.07	1.31	1.20	0.110	0.60		
BB-FSRO-101B	MD	26	Alluvium	112	3119	Below	2308	9	0.93	8	0.881	0.193	6	0.11	1.31	1.10	0.159	0.82		
BB-FSRO-101B	3D	31	Alluvium	112	3679	Below	2556	11	0.88	10	0.858	0.201	6	0.12	1.31	1.00	0.157	0.78		
BB-FSRO-101B	4d	36	Alluvium	112	4239	Below	2804	10	0.84	8	0.835	0.205	4	0.09	1.31	0.95	0.112	0.55		
BB-FSRO-101B	5D	41	Alluvium	112	4799	Below	3052	8	0.81	6	0.812	0.208	2	0.07	1.31	0.90	0.083	0.40		
BB-FSRO-101B	6D	46	Alluvium	136	5383	Below	3324	6	0.78	5	0.790	0.208	44	0.15	1.31	0.85	0.167	0.80		
BB-FSRO-101B	7D	51	Silt	95	6090	Below	3719	3	0.73	2	0.767	0.204	94	-- ¹⁰	1.31	-- ¹⁰	--	--		
BB-FSRO-101B	8D	56	Silt	95	6565	Below	3882	1	0.72	1	0.744	0.204	96	-- ¹⁰	1.31	-- ¹⁰	--	--		
BB-FSRO-101B	9D	61	Silt	95	7040	Below	4045	6	0.70	4	0.721	0.204	98	-- ¹⁰	1.31	-- ¹⁰	--	--		
BB-FSRO-101B	10D	66.5	Till	147	7619	Below	4281	35	0.68	24	0.696	0.201	10	0.5	1.31	0.80	0.524	2.60		

Checks for Sample 6D at depth 46'
Total Overburden: = [15*125]+[4*118]+[6*110]+[20*112]+[1*136] = 5383
Effective Overburden: =5383-(46-13)*62.4 = 3324
C_n: 9.79*(1/(3324*.0479))^{.5} = .768 = 0.78
r_d: 1-(0.015*46*0.305) = 0.79
CSR_{EQ}: 0.65*0.25*.79*(5383/3324) = 0.208
CSR_{7.5}: Critical Stress Ratio for Magnitude 7.5 Earthwuake. Figure 58 in GEC No. 3, FHWA-SA-97-076 pg. 121

¹See Boring logs for BB-FSRO-101B for layer delination and unit weight determination.
²C_n= 9.79*(1/σ_v'*.0479)^{.5} Eq. 8-5 in GEC No. 3, FHWA-SA-97-076 pg. 120 and converting σ_v' from kPa to PSF.
³(N₁)₆₀=C_n*N₆₀ Eq. 8-5 in GEC No. 3, FHWA-SA-97-076 pg. 121
⁴r_d=1-0.015z EQ 8-1 in GEC No. 3, FHWA-SA-97-076 pg. 116 with conversion of feet to Z in meters.
⁵CSR_{EQ}= 0.65(a_{max}/g)*r_d*(σ_v/σ_v') EQ 8-3a in GEC No. 3, FHWA-SA-97-076 pg. 116. Amax is a percent of g. The g constant term cancels.

⁶Percent passing the 200 sieve. See Grain Size Distribution curves.
^{6*} Estimated from visual classification
⁷Magnitude Correction Factor. Magnitude 7.5 to 5.95: K_m=1.31 (Fig. 59, GEC 3)
⁸Resisting stress correction to 96 kPa (Figure 60, GEC 3)
⁹CSR_L=CSR_{7.5}*K_m*K_σ*K_α; K_α is theinitial driving static shear stress correction factor and conservatively assumed to be 1.0.
¹⁰ Liquefaction potential decreases with increasing fines content and increasing plasticity index
¹⁰ Soils having greater than 35 percent finer than 0.005 mm or a LL>35% or a WC < 0.9 x LL, generally do not liquefy.
¹⁰ Liquefaction is a term used in reference to the behavior of cohesionless soils (gravels, sands, and very-low-plasticity silts). The term 'cyclic softening' is used to describe the behavior of clays and plastic silts.

Regardless of the manner in which C_N is estimated, the normalized standardized blow count is calculated as:

$$(N_1)_{60} = C_N \cdot N_{60} \quad (8-6)$$

Other factors, such as grain size distribution, may influence C_N (Marcuson and Bieganousky, 1977). However, considering the uncertainties involved in the SPT itself, the application of equipment and overburden pressure correction factors should be sufficient for engineering purposes.

Step 7: Evaluate the critical stress ratio $CSR_{7.5}$ at which liquefaction is expected to occur during an earthquake of magnitude M_w 7.5 as a function of $(N_1)_{60}$. Use the chart developed by Seed et al. (1985), shown in figure 58, to find $CSR_{7.5}$.

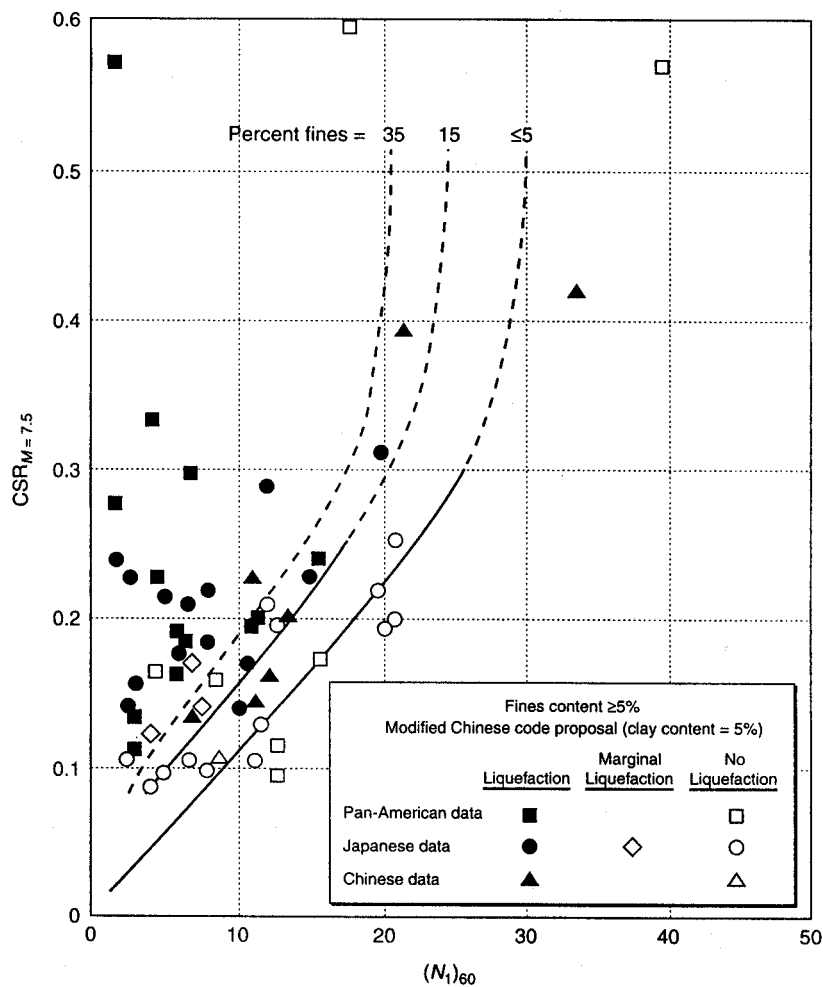


Figure 58. Relationship between stress ratio causing liquefaction and $(N_1)_{60}$ values for sands for M_w 7.5 earthquakes (Seed et al., 1985, reprinted by permission of ASCE).

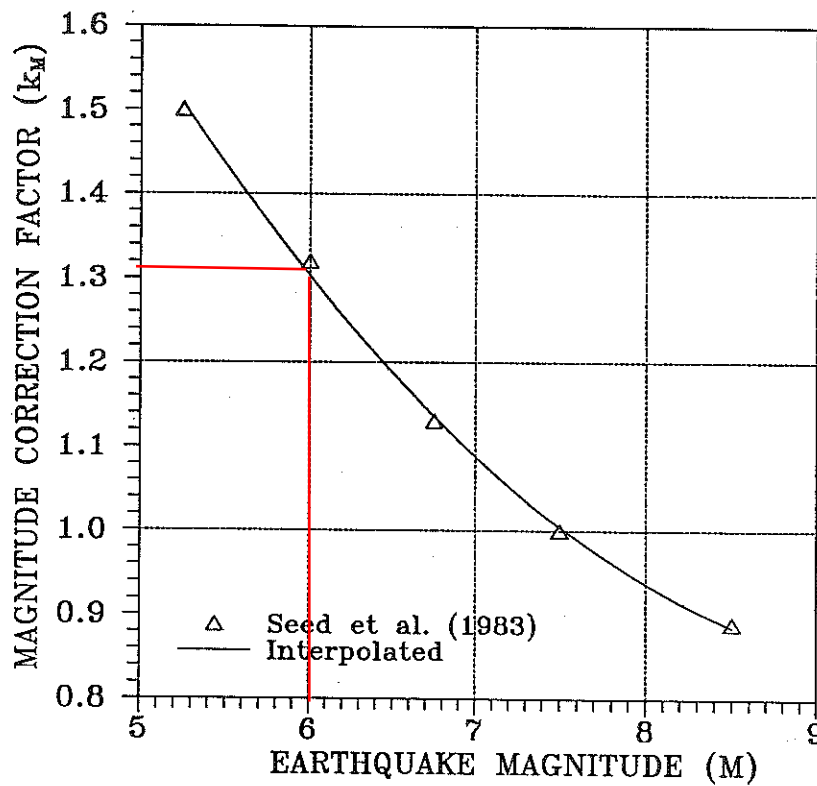


Figure 59. Curve for estimation of magnitude correction factor, k_M (after Seed et al., 1983).

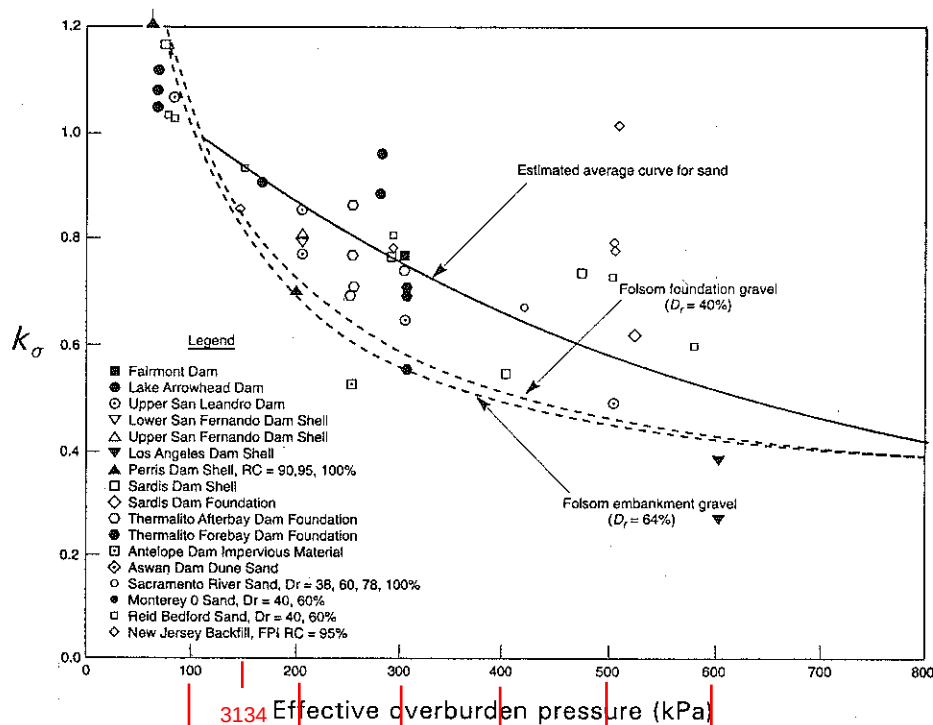


Figure 60. Curves for estimation of correction factor k_σ (Harder, 1988 and Hynes, 1988, as cited in Marcuson et al., 1990, reprinted by permission of EERI).

Unified Hazard Tool



Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the [U.S. Seismic Design Maps web tools](#) (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

^ Input

Edition

Dynamic: Conterminous U.S. 2008

Spectral Period

Peak ground acceleration

Latitude

Decimal degrees

44.029064

Time Horizon

Return period in years

975

Longitude

Decimal degrees, negative values for western long...

-70.908265

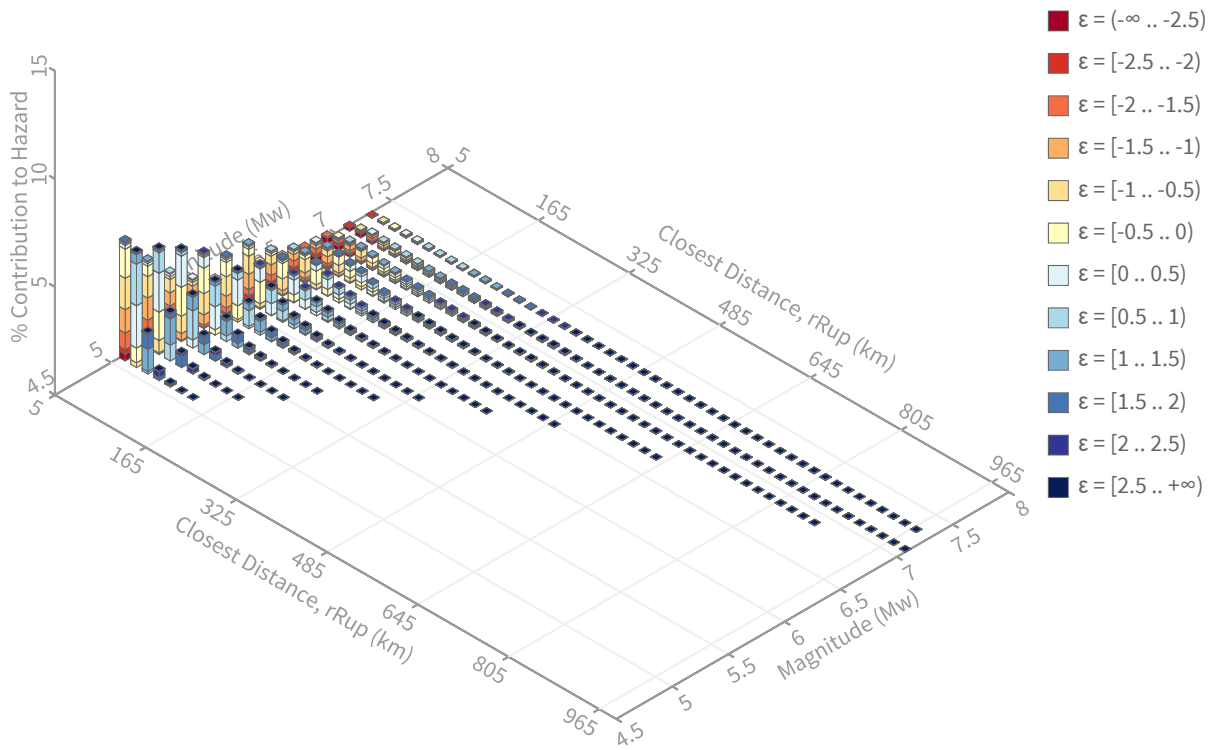
Site Class

760 m/s (B/C boundary)

^ Deaggregation

Component

Total



Summary statistics for, Deaggregation: Total

Deaggregation targets

Return period: 975 yrs

Exceedance rate: 0.001025641 yr⁻¹

PGA ground motion: 0.077609305 g

Recovered targets

Return period: 973.95142 yrs

Exceedance rate: 0.0010267453 yr⁻¹

Totals

Binned: 100 %

Residual: 0 %

Trace: 1.14 %

Mean (for all sources)

r: 63.2 km

m: 5.94

ϵ_0 : -0.17 σ

Mode (largest r-m bin)

r: 13.28 km

m: 5.1

ϵ_0 : -0.95 σ

Contribution: 5.5 %

Mode (largest ϵ_0 bin)

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00																																							
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem																																							
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon																																							
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches																																							
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)																																							
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs																																							
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐																																											
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt												R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person												S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _{u(lab)} = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected												T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											

Sample Information										Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows						
0								SSA	377.1		4.5-inch-thick layer of pavement.	0.4 11' at 125 pcf 372 Bottom proposed Abutment 9.5 ft at 125 pcf 2 ft 15.0'	G#245144 A-4, SM WC=31.9%
											Fill soils similar to BB-FSRO-101 to 15 feet bgs. aSpun HW casing ahead to 20 feet bgs.		
5											Cobbles from 5.5 to 6.5 feet bgs.		
											Cobbles from 7 to 8.5 feet bgs.		
											Boulder from 10.3 to 11.5 feet bgs.		
											water table		
											2 ft		
15	1D	24/13	15.00 - 17.00	4/2/1/1	3	4			362.5		Olive-brown, wet, very loose, Silty fine SAND, trace fine gravel, (Stream Alluvium). Dry Unit weight = 92 pcf Sat. Unit weight = 118 pcf	15.0'	
20	2D	24/14	20.00 - 22.00	2/2/3/4	5	7	25		358.5		Brown, wet, loose, SAND, trace fine gravel, trace silt, (Stream Alluvium). Dropped in NW casing at 20 feet bgs. Dry Unit weight = 92 pcf Sat. Unit weight = 110 pcf	19.0'	
							22						
							33						
							31						
							35						
25													

Remarks:
 -bgs = below existing ground surface (roadway)

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 5

Boring No.: BB-FSRO-101B

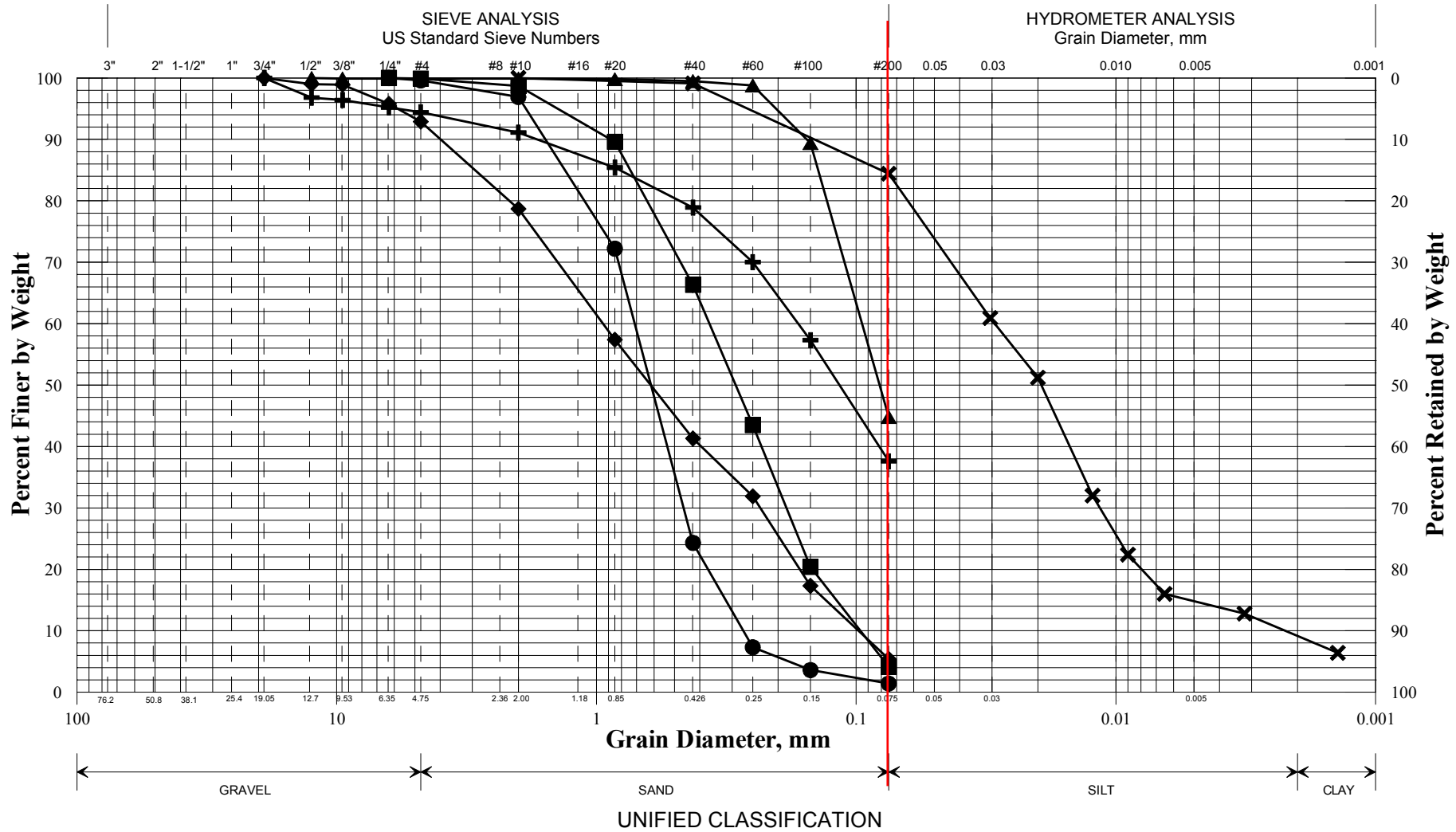
Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows	Elevation (ft.)			
25	MD	24/0	25.00 - 27.00	5/6/6/7	12	17	24			Similar to 2D in wash water.	9 bpf BB-FSRO-203 Dry Unit weight = 92 pcf Sat. Unit weight = 112 pcf
							32				
							37				
							38				
							27				
30	3D	24/16	30.00 - 32.00	2/3/5/5	8	11	8			Brown, wet, medium dense, medium SAND, trace fine gravel, trace silt.	G#245147 A-1-b, SW-SM WC=32.4%
							15				
							27				
							34				
							46				
35	4D	24/14	35.00 - 37.00	2/3/4/5	7	10	12			Grey, wet, loose, fine SAND, trace silt.	G#245145 A-3, SP-SM WC=23.1%
							13				
							37				
							47				
							49				
40	5D	24/16	40.00 - 42.00	1/3/3/4	6	8	19			Grey, wet, loose, medium SAND, trace silt.	G#245146 A-1-b, SP WC=21.6%
							39				
							61				
							73				
							92				
45	6D	24/20	45.00 - 47.00	1/2/2/2	4	6	41	332.5	Grey, wet, loose, Silty fine SAND, (Glaciolacustrine probably	G#245148 A-4, SM WC=33.9% Dry Unit weight = 102 pcf Sat. Unit weight = 136 pcf	
							35				
							41				
							47				
50							53				
Remarks: -bgs = below existing ground surface (roadway)											
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 2 of 5 Boring No.: BB-FSRO-101B	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	7D	24/23	50.00 - 52.00	4/1/1/2	2	3	59	327.0		Grey, wet, soft, SILT, little fine sand, trace clay, trace organics, (Glaciolacustrine). Sat. Unit weight = 92 pcf	G#245149 A-4, ML WC=36.9%
							57				
							53				
							53				
							57				
55	8D	24/24	55.00 - 57.00	WOR/WOR/WOR/ WOR	---		55			Grey, wet, very soft, SILT, some clay, trace fine sand.	G#245150 A-4, CL-ML WC=43.1%
							69				
							69				
							68				
							82				
60	MV/9D	24/24	60.00 - 62.00	WOH/2/2/5	4	6	91			Failed 55x110 mm vane attempt, would not push. Grey, wet, medium stiff, SILT, some clay, trace fine sand.	G#245151 A-4, CL WC=35.7%
							107				
							116				
							120				
							136				
65	10D	24/12	65.50 - 67.50	5/7/18/19	25	35	118	313.0	Cobble from 65 to 65.5 feet bgs. Grey, wet, dense, fine Sandy coarse GRAVEL, trace silt, (Glacial Till). Sat. Unit weight = 147 pcf	G#245152 A-1-a, GW-GM WC=9.1%	
							108				
							152				
							127				
							97				
70	11D	24/12	70.00 - 72.00	7/19/10/11	29	41	119	307.5	Grey, wet, dense, medium SAND, some fine gravel, little silt. RC from 71 to 110.9 feet bgs.	G#245153 A-1-b, SW-SM WC=10.6%	
							250				
							200				
							158				
							162				
75											
Remarks: -bgs = below existing ground surface (roadway)											
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 3 of 5 Boring No.: BB-FSRO-101B	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs//30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							150		Cobbles and Boulders from 75 to 77.8 feet bgs.		
							185				
							220				
							266				
							258				
80	12D	18/16	80.00 - 81.50	32/50/35	85	119	183		297.5	Grey, wet, hard, fine Sandy SILT, trace fine gravel, trace clay, (Glacial Till).	G#245154 A-4, SC-SM WC=13.1%
							170				
							132				
							127				
							275				
85	13D	8.4/8.4	85.00 - 85.70	10/50(2.4")	---		178	294.5	Grey, wet, very dense, medium SAND, little fine gravel, little silt, (Glacial Till).	G#245155 A-1-b, SM WC=12.8%	
							186				
							486				
							494				
							297				
90	14D	6/6	90.00 - 90.50	50	---		213		Grey, wet, very dense, fine SAND, little fine gravel, trace silt.	G#245156 A-1-b, SW-SM WC=13.2%	
							62				
							96				
							77				
							93				
95	15D	9.6/9	95.00 - 95.80	14/50(3.6")	---		87		Similar to 14D.		
							87				
							110				
							313				
							238				
100											
Remarks: -bgs = below existing ground surface (roadway)											
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 4 of 5 Boring No.: BB-FSRO-101B	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00						
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem						
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon						
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches						
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)						
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs						
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐										
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test														
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.			
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows							
100	16D	10.8/10.8	100.00 - 100.90	50/50(4.8")	---		195	274.5		Grey, wet, very dense, fine SAND, little silt, trace fine gravel.	G#245157 A-2-4, SM WC=12.9%			
							235							
							242							
							275							
							370							
105	17D	14.4/12	105.00 - 106.20	10/60/40(2.4")	---		300			266.6			Grey, wet, very hard, SILT, some clay, some fine sand, trace fine gravel, (Glacial Till).	G#245158 A-4, CL WC=20.1%
							167							
							222							
							294							
							402							
110	18D R1	9.6/9.6 60/55	110.00 - 110.80 110.90 - 115.90	29/50(3.6") RQD = 88%	---		NQ-2	256.6			Grey, wet, hard, SILT, little clay, trace fine sand.		G#245159 A-4, CL-ML WC=23.6%	
115	R2	60/60	115.90 - 120.90	RQD = 95%				256.6		Top of Bedrock at Elev. 266.6 ft. R1:Bedrock: No bedrock description recorded. R1:Core Times (min:sec) 110.9-111.9 ft (2:55) 111.9-112.9 ft (2:45) 112.9-113.9 ft (2:45) 113.9-114.9 ft (2:50) 114.9-115.9 ft (3:00) 98% Recovery R2:Bedrock: No bedrock description recorded. R2:Core Times (min:sec) 115.9-116.9 ft (2:38) 116.9-117.9 ft (3:20) 117.9-118.9 ft (4:20) 118.9-119.9 ft (3:25) 119.9-120.9 ft (3:25) 100% Recovery				
120								256.6		Bottom of Exploration at 120.9 feet below ground surface.				
125														
Remarks: -bgs = below existing ground surface (roadway)														
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 5 of 5 Boring No.: BB-FSRO-101B				

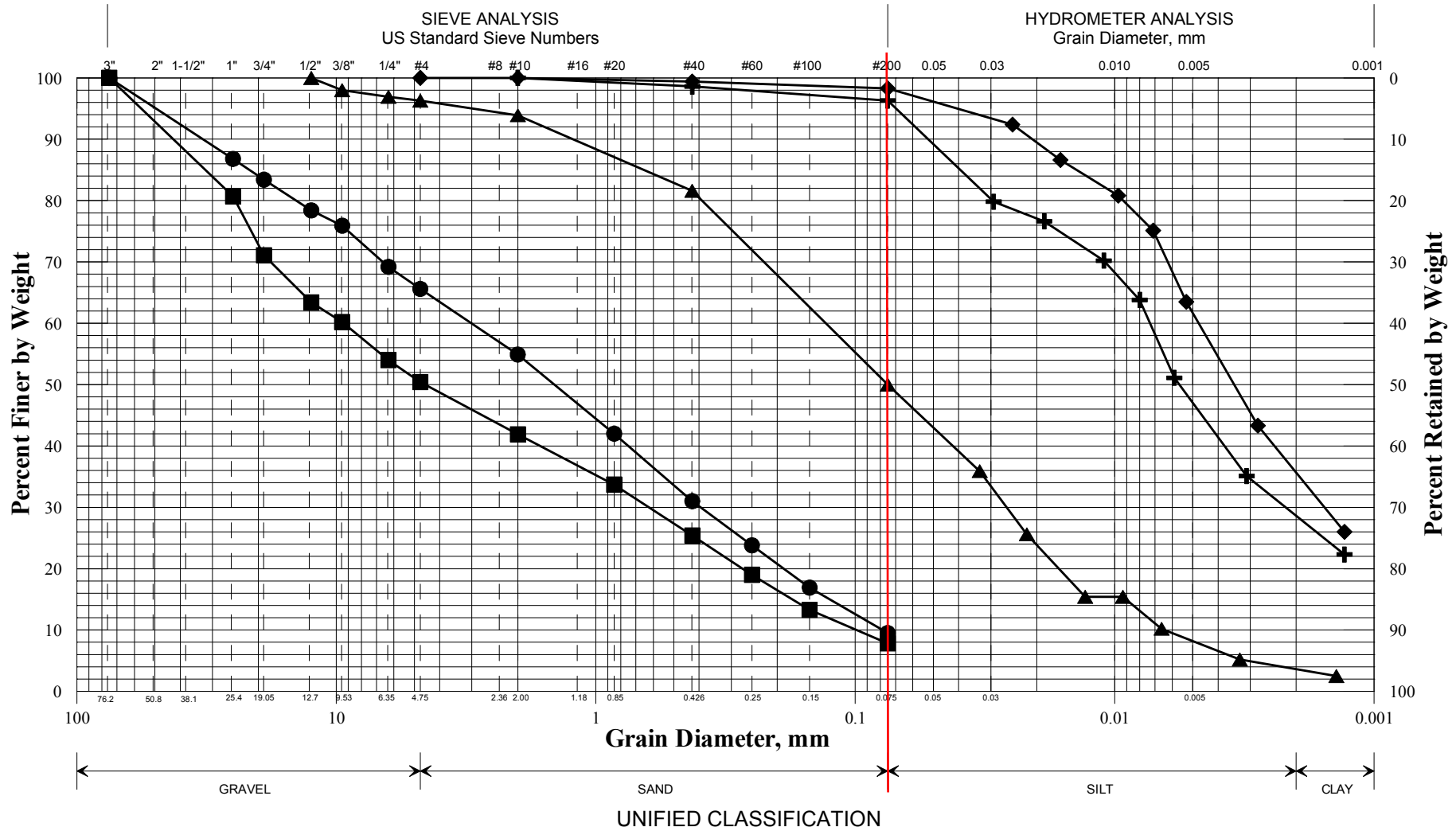
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101B/1D	299+23.2	3.4 LT	15.0-17.0	Silty SAND, trace gravel. 38%	31.9			
◆	BB-FSRO-101B/3D	299+23.2	3.4 LT	30.0-32.0	SAND, trace gravel, trace silt. 6	32.4			
■	BB-FSRO-101B/4D	299+23.2	3.4 LT	35.0-37.0	SAND, trace silt, trace gravel. 4	23.1			
●	BB-FSRO-101B/5D	299+23.2	3.4 LT	40.0-42.0	SAND, trace silt, trace gravel. 2	21.6			
▲	BB-FSRO-101B/6D	299+23.2	3.4 LT	45.0-47.0	Silty SAND, trace gravel. 44	33.9			
×	BB-FSRO-101B/7D	299+23.2	3.4 LT	50.0-52.0	SILT, little sand, trace clay. 94	36.9			

PIN
017912.00
Town
Fryeburg
Reported by/Date
WHITE, TERRY A 6/7/2011

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



% Fines

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	BB-FSRO-101B/8D	299+23.2	3.4 LT	55.0-57.0	SILT, some clay, trace sand.	96	43.1		
◆	BB-FSRO-101B/9D	299+23.2	3.4 LT	60.0-62.0	Clayey SILT, trace sand.	98	35.7		
■	BB-FSRO-101B/10D	299+23.2	3.4 LT	65.5-67.5	Sandy GRAVEL, trace silt.	8	9.1		
●	BB-FSRO-101B/11D	299+23.2	3.4 LT	70.0-72.0	SAND, some gravel, trace silt.		10.6		
▲	BB-FSRO-101B/12D	299+23.2	3.4 LT	80.0-81.5	Silty SAND, trace gravel, trace clay.		13.1		
×									

PIN	
017912.00	
Town	
Fryeburg	
Reported by/Date	
WHITE, TERRY A	6/7/2011

17912 Fryeburg Eddy Flats Liquifaction Potential Analyses - East Approach (BB-FSRO-102)

By: B. Slaven 7/2018
Check by: LK 7/2018
Spreadsheet check: LK

As=Amax: 0.25 7% probability of Exceedence in 75 Years for determined site class and location caused by magnitude 5.95 earthquake (based on USGS Deaggregation).
Unit Weight Water (pcf) 62.4
Depth to Watertable (ft) 12

Depth to Watertable (ft)		12										Demand					Capacity			
Boring	Sample	Depth Interval	Soil Layer	Unit Weight (PCF) ¹	Total Overburden Pressure	Water Table Condition	Effective Overburden Pressure	N ₆₀	C _n ²	(N ₁) ₆₀ ³	r _d ⁴	CSR _{EQ} ⁵	% Fines ⁶	CSR _{7.5}	K _m ⁷	K _σ ⁸	CSR _L ⁹	FS _L		
BB-FSRO-102	1D	5-7	1	131	786	Above	786	11	1.60	18	0.973	0.158	10	0.24	1.31	1.20	0.377	2.39		
BB-FSRO-102	2D	10-12	2	105	1415	Above	1415	7	1.19	8	0.950	0.154	11	0.12	1.31	1.20	0.189	1.22		
BB-FSRO-102	MD	15-17	3	118	1953	Below	1703	17	1.08	18	0.927	0.173	15 ^{6*}	0.24	1.31	1.20	0.377	2.18		
BB-FSRO-102	3D	20-22	4	112	2528	Below	1966	7	1.01	7	0.904	0.189	3	0.08	1.31	1.20	0.126	0.67		
BB-FSRO-102	4D	30-32	5	118	3654	Below	2468	8	0.90	7	0.858	0.206	8	0.09	1.31	1.00	0.118	0.57		
BB-FSRO-102	5D	40-42	6	98	4814	Below	3004	4	0.82	3	0.812	0.212	1	0.03	1.31	0.95	0.037	0.18		
BB-FSRO-102	6D	50-52	7	135	5831	Below	3397	4	0.77	3	0.767	0.214	37	0.1	1.31	0.92	0.121	0.56		
BB-FSRO-102	7D	60-62	8 - Silt	123	7169	Below	4111	1	0.70	1	0.721	0.204	99	-- ¹⁰	-- ¹⁰	-- ¹⁰	-- ¹⁰	--		
BB-FSRO-102	8D	70-72	8 - Silt	123	8399	Below	4717	--	0.65	--	0.675	0.195	77	-- ¹⁰	-- ¹⁰	-- ¹⁰	-- ¹⁰	--		
BB-FSRO-102	9D	80.5-82.5	9 - Silt	145	9834	Below	5497	17	0.60	10	0.627	0.182	99	-- ¹⁰	-- ¹⁰	-- ¹⁰	-- ¹⁰	--		
BB-FSRO-102	10D	90-92	10	144	11209	Below	6279	24	0.56	14	0.584	0.169	28	0.21	1.31	0.76	0.209	1.23		
BB-FSRO-102	11D	100-101.5	11 - Clay	127	12598	Below	7076	63	0.53	34	0.538	0.156	79	-- ¹⁰	-- ¹⁰	-- ¹⁰	-- ¹⁰	--		
BB-FSRO-102	12D	110-112	12 - Silt	117	13858	Below	7680	4	0.51	2	0.492	0.144	85	-- ¹⁰	-- ¹⁰	-- ¹⁰	-- ¹⁰	--		

Checks for Sample 6D at depth 51'
Total Overburden: [(378-368)*131]+[(368-363)*105]+[(363-359.5)*118]+[(359.5-348)*112]+[(348-338)*118]+[(338-328)*98]+[(328-327)*135] = 5831 (psf)
Effective Overburden: 5831-((51-12)*62.4)= 3397
C_n: 9.79*(1/(3397*.0479))^{.5} = .767
r_d: 1-(0.015*51*0.305)= 0.767
CSR_{EQ} : 0.65*0.25*.767*(5831/3397)= 0.214
CSR_{7.5}: Critical Stress Ratio for Magnitude 7.5 Earthwakeup. Figure 58 in GEC No. 3, FHWA-SA-97-076 pg. 121

¹See Development of Emankment Soil Model for Settle 3D calcs (BB-FSRO-102) for layer delination and unit weight determination.
²C_n= 9.79*(1/σ_v'*.0479)^{.5} Eq. 8-5 in GEC No. 3, FHWA-SA-97-076 pg. 120 and converting α_v' from kPa to PSF.
³(N₁)₆₀=C_n*N₆₀ Eq. 8-5 in GEC No. 3, FHWA-SA-97-076 pg. 121
⁴r_d=1-0.015z EQ 8-1 in GEC No. 3, FHWA-SA-97-076 pg. 116 with conversion of feet to Z in meters.
⁵CSR_{EQ} = 0.65(a_{max}/g)*r_d*(σ_v/σ_v') EQ 8-3a in GEC No. 3, FHWA-SA-97-076 pg. 116. Amax is a percent of g. The g constant term cancels.

⁶Percent passing the 200 sieve. See Grain Size Distribution curves.
^{6*}Estimated from visual classification
⁷Magnitude Correction Factor. Magnitude 7.5 to 5.95: K_m=1.31 (Fig. 59 GEC 3)
⁸Resisting stress correction to 96 kPa (Fig. 60 GEC 3)
⁹CSR_L=CSR_{7.5}*K_m*K_σ*K_α; K_α is theinitial driving static shear stress correction factor and conservatively assumed to be 1.0.
¹⁰Liquefaction potential decreases with increasing fines content and increasing plasticity index
¹⁰Soils having greater than 35 percent finer than 0.005 mm or a LL>35% or a WC < 0.9 x LL, generally do not liquefy.
¹⁰Liquefaction is a term used in reference to the behavior of cohesionless soils (gravels, sands, and very-low-plasticity silts). The term 'cyclic softening' is used to describe the behavior of clays and plastic silts.

Regardless of the manner in which C_N is estimated, the normalized standardized blow count is calculated as:

$$(N_1)_{60} = C_N \cdot N_{60} \quad (8-6)$$

Other factors, such as grain size distribution, may influence C_N (Marcuson and Bieganousky, 1977). However, considering the uncertainties involved in the SPT itself, the application of equipment and overburden pressure correction factors should be sufficient for engineering purposes.

Step 7: Evaluate the critical stress ratio $CSR_{7.5}$ at which liquefaction is expected to occur during an earthquake of magnitude M_w 7.5 as a function of $(N_1)_{60}$. Use the chart developed by Seed et al. (1985), shown in figure 58, to find $CSR_{7.5}$.

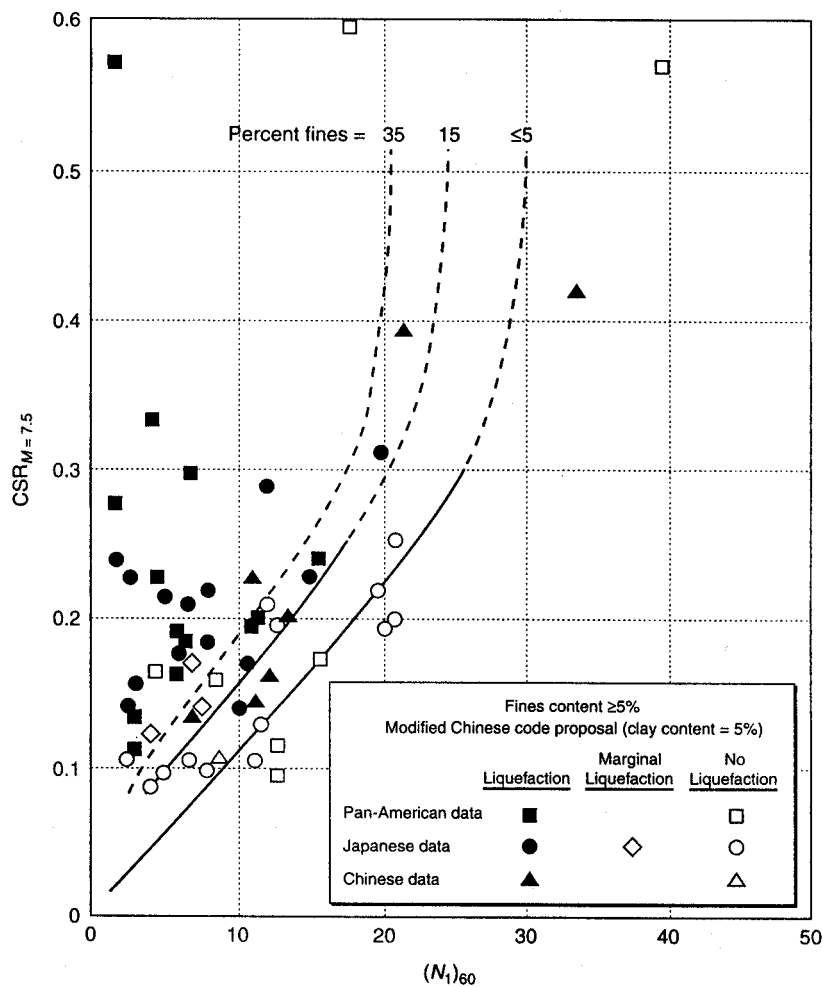


Figure 58. Relationship between stress ratio causing liquefaction and $(N_1)_{60}$ values for sands for M_w 7.5 earthquakes (Seed et al., 1985, reprinted by permission of ASCE).

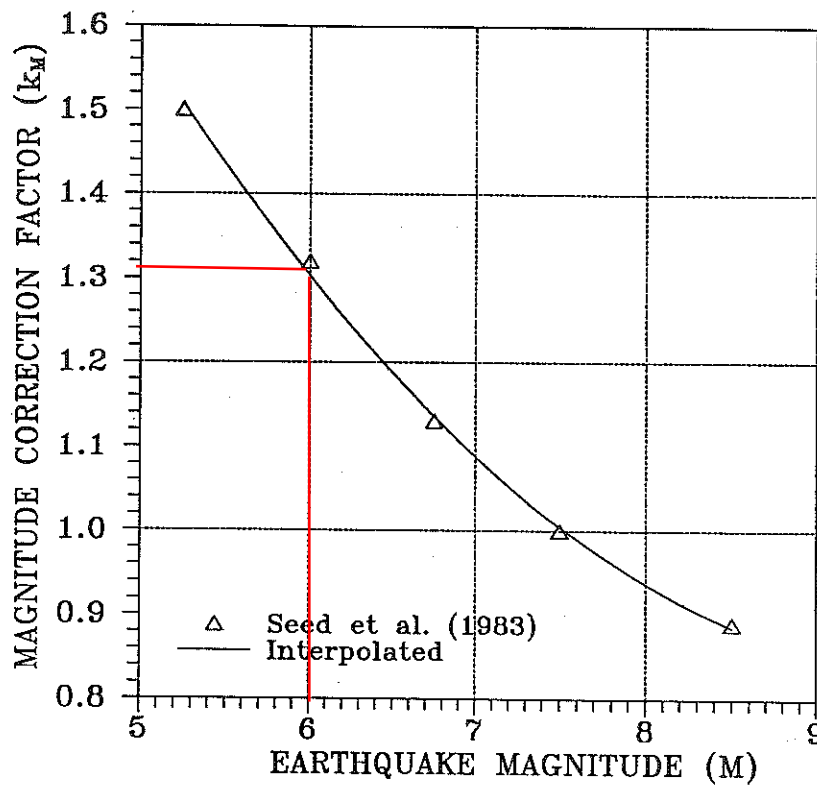


Figure 59. Curve for estimation of magnitude correction factor, k_M (after Seed et al., 1983).

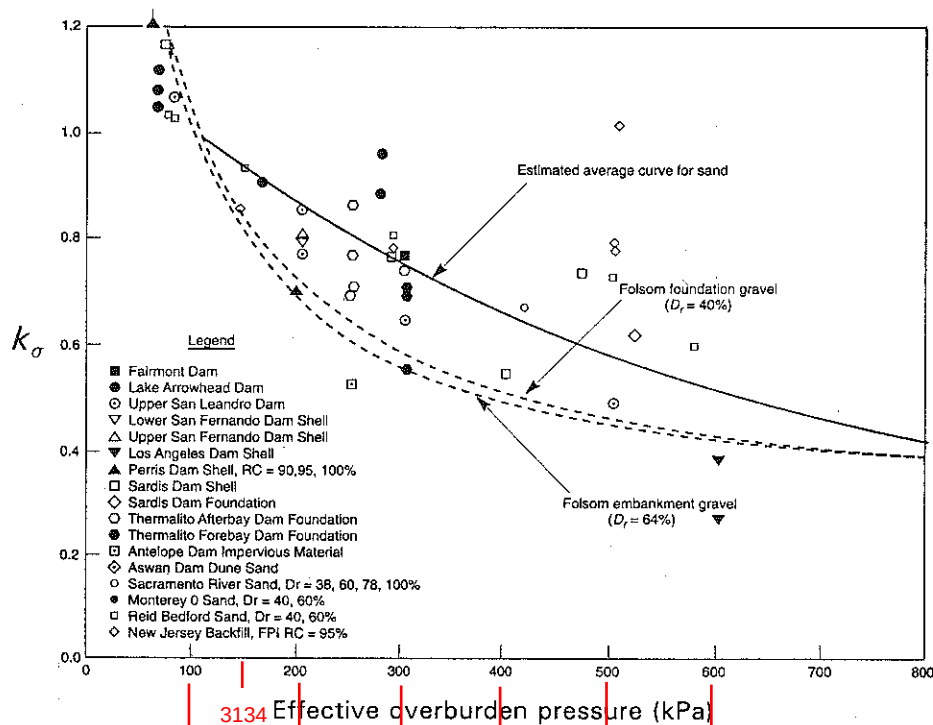


Figure 60. Curves for estimation of correction factor k_σ (Harder, 1988 and Hynes, 1988, as cited in Marcuson et al., 1990, reprinted by permission of EERI).

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00							
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem							
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon							
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches							
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)							
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.							
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐											
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt				R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person				S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) $S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) $N_{uncorrected}$ = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency $N_{60} = (\text{Hammer Efficiency Factor}/60\%)*N_{uncorrected}$				T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test			

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0							SSA	377.4		7-inch-thick layer of pavement.		
										378 0.6 Layer 1 (Elev. 378 - 368.0) Cobble from 1.5 to 2.2 feet bgs. $\gamma_{sat} = 131 \text{ pcf}$		
5	1D	24/12	5.00 - 7.00	2/3/5/3	8	11				Brown, moist, medium dense, medium SAND, little fine gravel, trace silt, occasional cobbles, (Fill).	G#245160 A-1-b, SP-SM WC=4.1%	
10	2D	24/14	10.00 - 12.00	2/2/3/6	5	7	aSP			368 Brown, moist, loose, medium SAND, little fine gravel, little silt, (Fill). aSpun HW casing to 20 feet bgs.	G#245161 A-1-b, SP-SM WC=14.0%	
										Layer 2 (Elev. 368.0 - 363.0) $\gamma_{sat} = 105 \text{ pcf}$		
15	MD	24/1	15.00 - 17.00	5/5/7/8	12	17				Similar to 2D.	363	
										Layer 3 (Elev. 363.0 - 359.5) $\gamma_{sat} = 118$		
											359.5	
20	3D	24/18	20.00 - 22.00	2/3/2/3	5	7	10	359.5		18.5 Layer 4 (Elev. 359.5 - 348.0) Brown, wet, loose, medium SAND, trace coarse gravel, trace silt, (Stream Alluvium). Dropped in NW casing at 20 feet bgs.	G#245162 A-1-b, SP WC=22.1%	
							10					
							12					
							12					
25							13			$\gamma_{sat} = 112 \text{ pcf}$		

Remarks:
 -bgs = below existing ground surface (roadway)

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 5

Boring No.: BB-FSRO-102

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00					
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem					
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon					
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches					
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)					
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.					
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐									
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test													
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.		
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows						
25							28			$\gamma_{sat} = 112 \text{ pcf}$ Grey, wet, loose, fine SAND, trace silt, (Stream Alluvium). Layer 5 (Elev. 348.0 - 338.0)	348 G#245163 A-3, SP-SM WC=28.0%		
							28						
							39						
							43						
							62						
30	4D	24/14	30.00 - 32.00	2/3/3/3	6	8	16						
							19						
							30						
							41						
							64						
35							79						
							116						
							119						
							155						
							158						
40	5D	24/20	40.00 - 42.00	1/1/2/3	3	4	73			$\gamma_{sat} = 118$ Grey, wet, very loose, medium SAND, trace silt, (Stream Alluvium). Layer 6 (Elev. 338.0 - 328.0)	338 G#245164 A-1-b, SP WC=21.3%		
							73						
							76						
							77						
							108						
45							127						
							165						
							167						
							169						
							175						
50												$\gamma_{sat} = 98 \text{ pcf}$ 	328
Remarks: -bgs = below existing ground surface (roadway)													
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 2 of 5 Boring No.: BB-FSRO-102			

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	6D	24/18	50.00 - 52.00	8/2/1/4	3	4	107	318.0	Grey, wet, very loose, Silty fine SAND. Layer 7 (Elev. 328.0 - 318.0) $\gamma_{sat} = 135$ Grey, wet, very soft, SILT, trace clay, trace fine sand, (Glaciolacustrine). Layer 8 (Elev. 318.0 - 298.0) $\gamma_{sat} = 123 \text{ pcf}$ Grey, wet, very soft, SILT, some fine sand, trace clay. Failed 55x110 mm vane attempt, would not push.	G#245165 A-4, SM WC=32.6% G#245166 A-4, ML WC=47.6% G#245167 A-4, ML WC=43.3%	
							82				
							81				
							113				
							122				
55							122				
							127				
							138				
							176				
							192				
60	7D	24/24	60.00 - 62.00	1/WOR/1/WOR	1	1	159				
							165				
							135				
							175				
							181				
65							181				
							186				
							186				
							178				
							178				
70	8D/MV	24/24	70.00 - 72.00	WOR/WOR/WOR/WOR	---		129				
							130				
							165				
							165				
							178				
75							178				
Remarks: -bgs = below existing ground surface (roadway)											
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 3 of 5 Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine		Boring No.: BB-FSRO-102 WIN: 17912.00					
Driller: MaineDOT		Elevation (ft.): 378.0		Auger ID/OD: 5-inch Solid Stem							
Operator: Giguere/Giles		Datum: NAVD88		Sampler: Standard Split Spoon							
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs./30 inches							
Date Start/Finish: 4/7,8,11,12/11		Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)							
Boring Location: Sta 299+61.2, 12.7 feet Lt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.							
Hammer Efficiency Factor: 0.84		Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐									
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_u(lab) = Lab Vane Undrained Shear Strength (psf) q_u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							162		γ_{sat} = 145 Grey, wet, very stiff, SILT, little clay. Layer 9 (Elev. 298.0 - 289.0) γ 289.0 Grey, wet, medium dense, fine SAND, some silt, trace fine gravel, (Glacial Till). Layer 10 (Elev. 289.0 - 280.0) γ_{sat} = 144 pcf RC to 100 feet bgs. 280.0 Layer 11 (Elev. 280.0 - 268.0)	G#245168 A-4, CL-ML WC=34.1% G#245169 A-2-4, SM WC=18.7%	
							224				
							224				
							224				
							224				
80	9D	24/20	80.50 - 82.50	10/5/7/8	12	17	176				
							166				
							167				
							167				
							169				
85							170				
							167				
							164				
							164				
90	10D	24/14	90.00 - 92.00	4/7/10/15	17	24	166				
							98				
							105				
							97				
							112				
95							96				
							162				
							238				
							386				
100							508				

Remarks:
 -bgs = below existing ground surface (roadway)

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

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

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Boring No.: BB-FSRO-102

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140 lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%) * N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
100	11D	18/18	100.00 - 101.50	21/26/19	45	63	290		Grey, wet, hard, Silty CLAY, little coarse sand, trace fine gravel.	G#245170 A-4, CL WC=17.4%	
							294				
							232				
							186				
							178				
105							173				
							189				
							162				
							216				
							216				
110	12D	24/18	110.00 - 112.00	WOH/WOH/3/10	3	4	150		Grey, wet, soft, SILT, some clay, little fine sand.	G#245171 A-4, CL-ML WC=25.4%	
							187				
							178				
							220				
115	R1	60/60	114.40 - 119.40	RQD = 85%			b150 NQ 2		Top of Bedrock at Elev. 263.6 ft. R1:Bedrock: No bedrock description recorded. R1:Core Times (min:sec) 114.4-115.4 ft (5:25) 115.4-116.4 ft (3:40) 116.4-117.4 ft (3:50) 117.4-118.4 ft (2:05) 118.4-119.4 ft (3:00) 100% Recovery R2:Bedrock: No bedrock description recorded. R2:Core Times (min:sec) 119.4-120.4 ft (4:00) 120.4-121.4 ft (3:15) 121.4-122.4 ft (3:10) 122.4-123.4 ft (3:00) 123.4-124.4 ft (4:00) 100% Recovery		
120	R2	60/60	119.40 - 124.40	RQD = 90%							
125											

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Appendix D



Proactive by Design

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION
MANAGEMENT

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Portland, ME 04101
T: 207.879.9190
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MEMORANDUM

TO: Ms. Laura Krusinski, Maine Department of Transportation

FROM: Blaine Cardali, Andrew Blaisdell, P.E.
Christopher Snow, P.E.

DATE: May 18, 2018

FILE NO.: 09.0025968.00

SUBJECT: Geotechnical Design Basis Memorandum
Eddy Flats Bridge No. 2261, Sheet Pile Wall
Maine Department of Transportation WIN 017912.00
Fryeburg, Maine



GZA GeoEnvironmental, Inc. (GZA) has prepared this geotechnical design basis memorandum for the sheet pile wall proposed as part of the Maine Department of Transportation (MaineDOT) Eddy Flats Bridge No. 2261 which carries Route 302 over the Saco River Overflow in Fryeburg, Maine. Our services were provided in accordance with Assignment Letter No. 15 (dated March 9, 2018) associated with the Bridge Program Multi-PIN Project Contract Number 20150608000000000793 between MaineDOT and GZA dated July 22, 2015, which incorporates GZA's Proposal No. 09.P000107.18, dated March 7, 2018. This memorandum is subject to the *Limitations* included in **Appendix A**.

BACKGROUND

The overall project consists of replacing the Eddy Flats bridge carrying Route 302 over the Saco River Overflow in Fryeburg. Subsurface explorations and geotechnical evaluations and recommendations have been completed for the bridge replacement. However, an anchored sheet pile wall concept was added to the project after the geotechnical evaluation was completed for the bridge. This memorandum presents the results of a supplemental subsurface exploration program and design basis recommendations for the sheet pile wall. The wall is proposed along the southwest bridge approach and is envisioned as a steel sheet pile wall with deadman anchors.

SUBSURFACE EXPLORATIONS

GZA completed a subsurface exploration program consisting of three (3) test borings (BB-FSRO-201 through BB-FSRO-203). The borings were drilled in the right shoulder of the west approach between 15 and 150 feet west to the existing abutment. The as-drilled boring locations were surveyed by MaineDOT and are shown on **Figure 1**.

The borings were drilled to depths of approximately 27 to 62 feet below ground surface. New England Boring Contractors of Hermon, Maine provided drilling services and



coordinated utility clearance. The drilling was completed between March 19 and March 21, 2018 using a truck-mounted drill rig. GZA personnel monitored the drilling work and prepared logs of each boring.

The borings were drilled using 3- and 4-inch driven casing and drive-and-wash drilling techniques. Standard penetration testing (SPT) and split-spoon sampling were performed at 5-foot typical intervals in the overburden using a 24-inch-long, 1-3/8-inch inside-diameter sampler, driven with a calibrated automatic hammer (NEBC No. 3, energy transfer ratio = .869). Upon completion, the borings were backfilled with cuttings and asphalt cold patch and marked for MaineDOT Survey. Survey locations were then supplied to GZA.

SUBSURFACE CONDITIONS

SURFICIAL AND BEDROCK GEOLOGY

Based on available surficial geologic mapping¹, the site is located within a Stream Alluvium deposit associated with the Saco River, which is roughly 700 feet north of the site. This unit consists of silt, sand, gravel and organic material deposited by modern streams. An area of Till is mapped beneath the Stream Alluvium west of the bridge. Large boulders are indicated in the mapped Till unit between the Saco River and Route 302. Lake Pigwacket lacustrine deposits are also mapped in the site vicinity, which contain sand, silt, clay and gravel deposited in successive stages during late-glacial to postglacial time.

Mapping indicates that the site is underlain by granite of the Sebago Pluton (Osberg et al., 1985; online GIS version).

SITE DEVELOPMENT HISTORY

Incidental information provided by an abutting landowner indicates that the causeway that forms the bridge approach in the area of the proposed sheet pile wall was constructed as a series of rock-filled timber cribs. Evidence of these reported timber crib structures was encountered in the form of horizontally-oriented timber encountered in some of the split spoon samples taken in the borings, as described below.

SUBSURFACE PROFILE

Four soil units were encountered in the test borings beneath approximately 5 to 10 inches of asphalt pavement: Timber Crib Fill, Stream Alluvium, Clayey Silt and Glacial Till. The units are listed in descending order from the ground surface along with thicknesses and generalized descriptions in the table below and are presented in **Figure 2, Interpretive Subsurface Profile**.

¹ Thompson, Woodrow B., 1999, Surficial geology of the Fryeburg 7.6-minute quadrangle, Oxford County, Maine: Maine Geological Survey, Open-File Report 99-8.



GENERALIZED SUBSURFACE CONDITIONS		
Soil Unit	Approximate Encountered Thickness (ft)	Generalized Description
Fill/Timber Crib Fill	15 to 23	Brown to tan, dry to wet, very loose to dense, fine to coarse SAND, some to little Gravel, little to trace Silt with apparent cobbles and boulders. (USCS: SW, SM, SP-SM). Wood from apparent cribbing was encountered in BB-FSRO- 201 and -202.
Stream Alluvium	5 to 20	Brown to grey, wet, very loose to loose, fine to medium SAND, some to trace Silt. (SP, SP-SM)
Clayey Silt	3	Grey, wet, medium stiff, Clayey SILT, little fine Sand (USCS: ML)
Glacial Till	24	Grey, wet, medium dense to very dense, fine to coarse SAND, little to some Gravel, little Silt. (USCS: SM).

GROUNDWATER

Groundwater was measured in each boring at depths of approximately 8 to 13 feet below pavement levels. Groundwater levels in the borings were taken during or immediately after drilling and may have been affected by drilling procedures, which included introduction of water for drilling purposes.

The groundwater observations were made at the times and under the conditions stated in the borings logs. Fluctuations in groundwater levels will occur due to variations season, precipitation, river level, and construction activity in the area. Consequently, water levels during and after construction are likely to vary from those encountered at the time the observations were made.

ENGINEERING EVALUATIONS AND RECOMMENDATIONS

GENERAL

GZA has conducted geotechnical engineering evaluations in accordance with 2017 AASHTO LRFD Bridge Design Specifications, 8th Edition, (herein known as AASHTO) and the MaineDOT Bridge Design Guide, 2014 Edition (MaineDOT BDG). The sections that follow describe the evaluations and the geotechnical basis for each element. Supporting calculations developed by GZA for the project are attached in **Appendix C** of this report.

Wall Type

We anticipate that the wall will be constructed as an anchored sheet pile wall. The anchors may be reacted by discreet deadman or by a continuous deadman. The discreet deadman could consist of precast concrete slabs or driven sheet piles. A continuous deadman could be constructed as a cast-in-place concrete wall, or a driven sheet pile wall. The location of the deadman should be far enough behind the wall such that the passive pressure zone in front of the deadman will not interact with the active pressure zone behind the sheet pile wall. If the deadman needs to be closer to the wall, the passive resistance on the deadman should be reduced accordingly.



Soil Properties for Design

GZA developed soil properties for use in the sheet pile wall design, to be completed by others, based on the test boring results. We used correlations² with SPT N-values to develop the soil internal friction angles.

We recommend that the sheet pile retaining wall be designed in accordance with MaineDOT Bridge Design Guide Section 3.6, AASHTO 3.11, and the following material properties:

Material Type	Friction Angle	Unit Weight (pcf)
New Fill "Common Borrow"	32	125
Existing Fill	30	120
Stream Alluvium	29	115
Glacial Till	32	125

Both Coulomb and Rankine earth pressures are referenced in AASHTO Section 3.11 and should be selected by the designer of the sheet pile wall.

CONSTRUCTION CONSIDERATIONS

Obstructions

As previously described, the causeway that forms the bridge approach in the area of the proposed sheet pile wall was constructed as a series of rock-filled timber cribs. Cobbles and boulders are anticipated to be present to depths of at least 15 feet and evidence of the timber cribbing was present as deep as approximately 23 feet. These materials will present obstructions to installation of sheet piling. It may be necessary to pre-excavate a trench along the wall line to remove obstructions. If excavated, the trench should be backfilled with crushed stone in order to expedite installation of the sheet piling. The limits of the timber were not established by the test borings. The contractor could consider using an H-pile probe at the outset of construction to evaluate the possible presence of obstructions along the wall line and plan accordingly.

Wall Drainage

Groundwater was encountered from 8 to 13 feet below grade which corresponds to approximately El. 370 feet to El. 365 feet. Weep holes are recommended to be installed in the sheets below the groundwater level to provide adequate drainage and reduce differential head on the sheet pile wall.

² The recommended internal friction angles to be used for design are based on the correlations presented by Peck, Hanson and Thornburn (PHT, 1974) as mentioned in Kulhawy and Mayne (1990) and recommended in NCHRP Report 651.



CLOSURE

We trust that this information meets current project needs. Please feel free to call Christopher Snow at (207) 358-5118 for additional information.

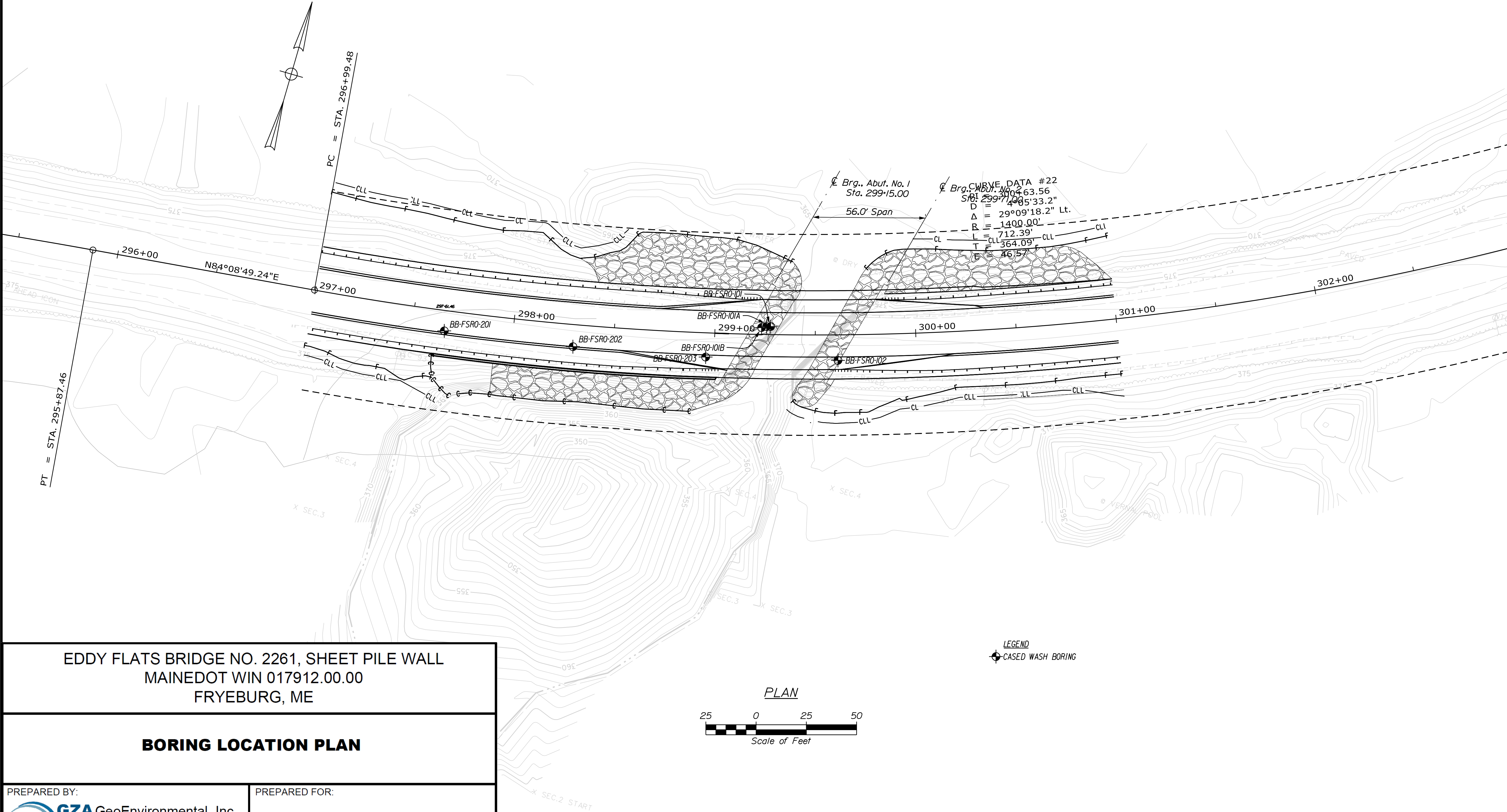
BMC/CLS/ARB:erc

P:\09 Jobs\0025900s\09.0025968.00 - Eddy Flats Sheet Pile Wall\Report\FINAL 25968 00 Eddy Flats Design Memo 051818.docx

Attachments: Figure 1 – Boring Location Plan
 Figure 2 – Interpretive Subsurface Profile, 11.0 feet Rt.
 Appendix A – Limitations
 Appendix B – Boring Logs
 Appendix C – Calculations



FIGURES



EDDY FLATS BRIDGE NO. 2261, SHEET PILE WALL
 MAINEDOT WIN 017912.00.00
 FRYEBURG, ME

BORING LOCATION PLAN

PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MAINE DEPARTMENT OF TRANSPORTATION	
PROJ MGR: BMC	REVIEWED BY: CLS	CHECKED BY: ARB	FIGURE 1 SHEET NO. 1 OF 1
DESIGNED BY: BMC	DRAWN BY: TW	SCALE: AS SHOWN	
DATE: MAY 2018	PROJECT NO. 09.0025968.00	REVISION NO. 0	

STATE OF MAINE		DEPARTMENT OF TRANSPORTATION	
BR-1791(200)X		PIN 17912.00	
BRIDGE NO. 2261		BRIDGE PLANS	
EDDY FLATS BRIDGE		SIGNATURE	
SACO RIVER OVERFLOW		P.E. NUMBER	
OXFORD COUNTY		DATE	
FRYEBURG		FIELD CHANGES	
BORING LOCATION PLAN		SHEET NUMBER	
2		OF 5	

Date: 5/18/2018

Username: Terry.White

Division: GEOTECH

Filename: ... \MSTAN008_ISP2 11RT.dgn

EDDY FLATS BRIDGE NO. 2261, SHEET PILE WALL
MAINEDOT WIN 017912.00.00
FRYEBURG, ME

INTERPRETIVE SUBSURFACE PROFILE,
11.0 FEET RT.

PREPARED BY:

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:

MAINE DEPARTMENT OF
TRANSPORTATION

PROJ MGR: BMC

REVIEWED BY: CLS

CHECKED BY: ARB

FIGURE

DESIGNED BY: BMC

DRAWN BY: TW

SCALE: AS SHOWN

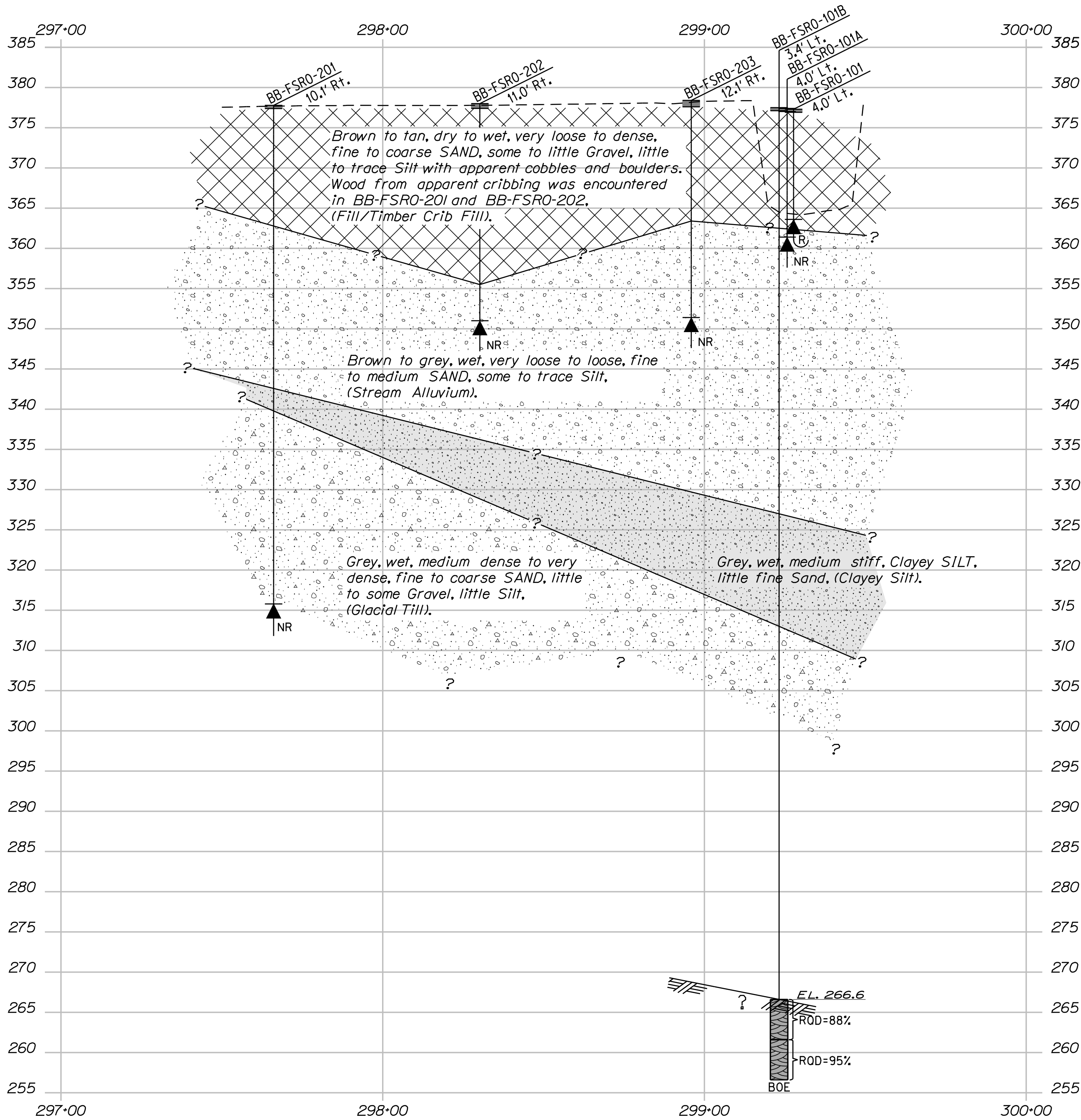
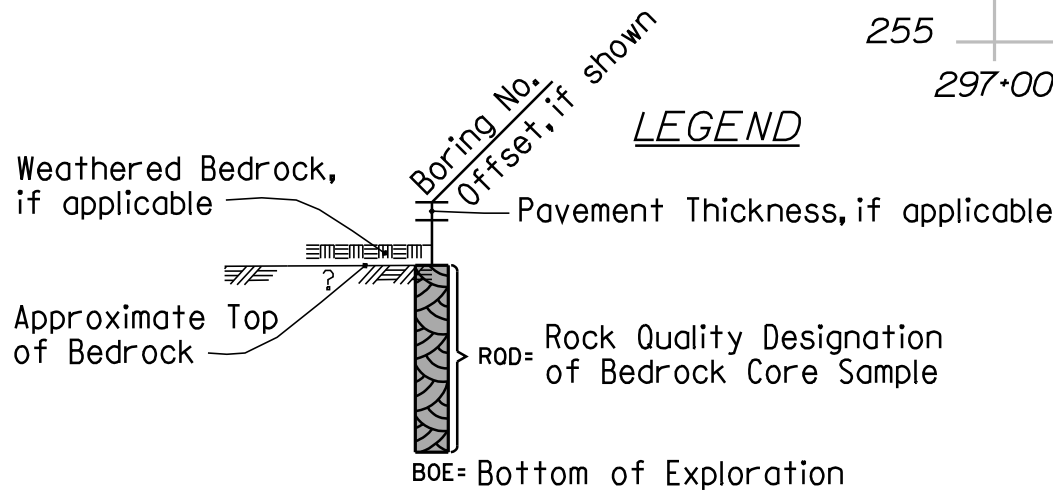
2

DATE: MAY 2018

PROJECT NO. 09.0025968.00

REVISION NO. 0

SHEET NO. 1 OF 1



Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE	BRIDGE PLANS
DEPARTMENT OF TRANSPORTATION	PIN 17912.00
BR-1791(200)X	BRIDGE NO. 2261

DATE	SIGNATURE	P.E. NUMBER	DATE
MAY 2018	A. BLAISDELL		
MAY 2018	T. WHITE		
DESIGN-DETAILED			
CHECKED-REVIEWED			
DESIGN-DETAILED			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

EDDY FLATS BRIDGE	OXFORD COUNTY
SACO RIVER OVERFLOW	
FRYEBURG	
INTERPRETIVE SUBSURFACE PROFILE	
11.0 feet Rt.	

SHEET NUMBER
4
OF 5



APPENDIX A – LIMITATIONS



LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions .
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs.
5. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.
6. Water level readings have been made in test holes (as described in the Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.
7. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

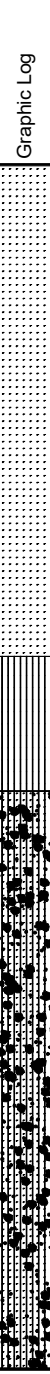
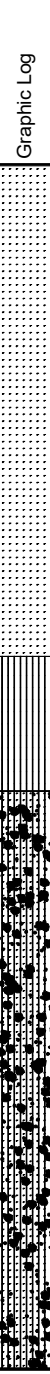
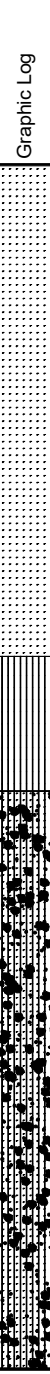
Compliance with Codes and Regulations

8. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.



APPENDIX B – BORING LOGS

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS					Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow			Boring No. BB-FSRO-201																																																																																																																																																																																																																																																																																																		
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Shear Strength (psf) or RQD (%)</th><th>N-uncorrected</th><th>N₆₀</th><th>Casing Blows</th><th>Elevation (ft.)</th></tr><tr><td>0</td><td>1D</td><td>24/13</td><td>0.4 - 2.4</td><td>9-10-10-63</td><td>20</td><td>29</td><td>SSA</td><td>377.4</td><td rowspan="20"></td><td>-ASPHALT- Dark brown/tan, medium dense, fine to coarse SAND, little Gravel, trace Silt, dry. -FILL- (SW) Probable cobble/boulder from 3.1-3.8 ft.</td><td rowspan="20"></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>2D</td><td>23/16</td><td>5.0 - 6.9</td><td>10-10-38-100/5"</td><td>48</td><td>70</td><td>492</td><td></td><td>Dark brown/tan, very dense, fine to coarse SAND, some Gravel, trace Silt, moist, with a piece of asphalt, petroleum odor. -FILL- (SW) Probable cobble/boulder from 6.9-7.6 ft.</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>66</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>120</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>72</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>34</td><td></td><td></td><td></td></tr><tr><td>10</td><td>3D</td><td>24/7</td><td>10.0 - 12.0</td><td>13-3-2-2</td><td>5</td><td>7</td><td>20</td><td></td><td>Brown, loose, fine to medium SAND, little Gravel, little Silt, wet. -FILL- (SP-SM)</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>19</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>12</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>34</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>54</td><td></td><td></td><td></td></tr><tr><td>15</td><td>4D</td><td>24/7</td><td>15.0 - 17.0</td><td>3-4-3-3</td><td>7</td><td>10</td><td>17</td><td>362.8</td><td>Orange/brown, loose, fine to medium SAND, trace Silt, wet. -STREAM ALLUVIUM- (SP)</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>17</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>23</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>35</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>41</td><td></td><td></td><td></td></tr><tr><td>20</td><td>5D</td><td>24/1</td><td>20.0 - 22.0</td><td>3-3-5-5</td><td>8</td><td>12</td><td>22</td><td></td><td>Orange/brown, loose, fine to medium SAND, trace Silt, wet. -STREAM ALLUVIUM- (SP)</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>33</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>44</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>51</td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td><td>61</td><td></td><td></td><td></td></tr></table>												Depth (ft.)	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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 3 Boring No.: BB-FSRO-201																																																																																																																																																																																																																																																																																																

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No. BB-FSRO-201 PIN: 017912.00																																																																																																																																																																																																																																																				
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Remarks: 1. From 5.0-25.0 ft, wood fragments in wash. 2. 4" casing to 40.0 ft, then 3" casing to 60 ft.																																																																																																																																																																																																																																																												
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 2 of 3 Boring No.: BB-FSRO-201																																																																																																																																																																																																																																																		

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No. BB-FSRO-201 PIN: 017912.00																																																																																																																																																																																																																																																																																																																																																
Driller: New England Boring Contractors				Elevation (ft.) 377.8				Auger ID/OD: 4.25" OD																																																																																																																																																																																																																																																																																																																																																
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon																																																																																																																																																																																																																																																																																																																																																
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30																																																																																																																																																																																																																																																																																																																																																
Date Start/Finish: 03-19-18 / 03-20-18				Drilling Method: Drive & Wash				Core Barrel: --																																																																																																																																																																																																																																																																																																																																																
Boring Location: Sta. 297+66.1, 10.1 ft RT				Casing ID/OD: 4" / 3"				Water Level*: 12.7'																																																																																																																																																																																																																																																																																																																																																
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Remarks: 1. From 5.0-25.0 ft, wood fragments in wash. 2. 4" casing to 40.0 ft, then 3" casing to 60 ft.																																																																																																																																																																																																																																																																																																																																																								
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 3 of 3 Boring No.: BB-FSRO-201																																																																																																																																																																																																																																																																																																																																														

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-202 PIN: 017912.00																							
Driller: New England Boring Contractors				Elevation (ft.): 378.0				Auger ID/OD: 4.25" OD																							
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon																							
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30																							
Date Start/Finish: 03-20-18 / 03-21-18				Drilling Method: Drive & Wash, SSA				Core Barrel: --																							
Boring Location: Sta. 298+30.2, 11.0 ft RT				Casing ID/OD: 4"				Water Level*: 12.5'																							
Hammer Efficiency Factor: 0.869				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 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 = weight of rods WO1P = Weight of one person				Su = Insitu Field Vane Shear Strength (psf) Tv = Pocket Torvane Shear Strength (psf) qp = Unconfined Compressive Strength (ksf) N-uncorrected = Raw field SPT N-value Hammer Efficiency Factor = Annual Calibration Value N60 = SPT N-uncorrected corrected for hammer efficiency N60 = (Hammer Efficiency Factor/60%)*N-uncorrected																							
				Su(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																											
<table><tr><th colspan="8">Sample Information</th><th rowspan="2">Graphic Log</th><th rowspan="2">Visual Description and Remarks</th><th rowspan="2">Laboratory Testing Results/ AASHTO and Unified Class.</th></tr><tr><th>Depth (ft.)</th><th>Sample No.</th><th>Pen./Rec. (in.)</th><th>Sample Depth (ft.)</th><th>Blows (6 in.) Shear Strength (psf) or RQD (%)</th><th>N-uncorrected</th><th>N60</th><th>Casing Blows</th><th>Elevation (ft.)</th></tr></table>												Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.	Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)
Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.																					
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows				Elevation (ft.)																				
0							SSA	377.4	-ASPHALT-																						
	1D	24/11	1.0 - 3.0	20-17-12-14	29	42			-FILL- Brown/tan, medium dense, fine to coarse SAND, little Gravel, trace Silt, dry. -FILL- (SW) Cobble from 4.8-5.3 ft.																						
5	2D	24/12	5.0 - 7.0	5-2-3-4	5	7	20		Top 3": Brown/tan, fine to coarse SAND, little Gravel, trace Silt, dry. Bottom 9": Tan, loose, fine to coarse SAND, some Gravel, trace Silt, moist. -FILL- (SW) Probable cobble/boulder from 8.5-9.1 ft.																						
							35																								
							138																								
							R/C																								
							AHEAD																								
10	3D	24/6	10.0 - 12.0	10-9-9-51	18	26	53		No recovery.																						
							183																								
							100																								
							53																								
							66																								
15							R/C		Probable boulder from 15.0-16.4 ft.																						
							AHEAD																								
	4D	24/20	17.0 - 19.0	10-25-14-45	39	56	181	360.6	Top 5": Grey, fine to coarse SAND, little Silt, wet. -FILL- (SW)																						
							R/C		Bottom 15": Wood with horizontal grain. Probable timber cribbing.																						
							AHEAD																								
20	5D	24/18	20.0 - 22.0	4-18-41-50	59	85	OPEN	358.3 358.0	-SAND- Wood with horizontal grain. Probable timber cribbing.																						
							HOLE																								
25								355.5																							

| **Remarks:** 1. Sand in wash from 19.7-20.0 ft. 2. Broke through timber cribbing with roller bit at 22.5 ft. 3. 4" casing to 17.4 ft, then open hole to 25.0 ft. | | | | | | | | | | | |
| 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 2 Boring No.: BB-FSRO-202 | |

[illegible]

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow Location: Fryeburg, Maine				Boring No. BB-FSRO-203 PIN: 017912.00			
Driller: New England Boring Contractors				Elevation (ft.) 378.4				Auger ID/OD: 4.25" OD			
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon			
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30			
Date Start/Finish: 03-21-18 / 03-21-18				Drilling Method: Drive & Wash, SSA				Core Barrel: --			
Boring Location: Sta. 298+95.9, 12.1 ft RT				Casing ID/OD: 4"				Water Level*: 7.8'			
Hammer Efficiency Factor: 0.869				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 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 = weight of rods 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 N₆₀ = SPT N-uncorrected corrected for hammer efficiency N₆₀ = (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							SSA	377.6		-ASPHALT-	
	1D	24/12	1.0 - 3.0	39-21-12-14	33	48				Brown/tan, dense, fine to coarse SAND, little Gravel, trace Silt, dry.	
										-FILL- (SW)	
5	2D	24/18	5.0 - 7.0	5-3-2-3	5	7	24			Brown, loose, fine to medium SAND, trace Silt, moist.	
							18			-FILL- (SD)	
							18				
							16				
							18				
10	3D	24/2	10.0 - 12.0	3-2-2-2	4	6	12			Brown, loose, fine to medium SAND, little Silt, wet.	
							13			-FILL- (SP)	
							16				
							23				
							21				
15	4D	24/18	15.0 - 17.0	2-2-2-2	4	6	19	363.4		Dark brown/grey, loose, fine to medium SAND, some Silt, wet.	
							25			-STREAM ALLUVIUM- (SM)	
							36				
							43				
							43				
20	5D	24/4	20.0 - 22.0	2-2-3-4	5	7	26			Brown, loose, fine to medium SAND, little Silt, wet.	
							31			-STREAM ALLUVIUM- (SM)	
							41				
							55				
							58				
25											
Remarks: 1. 4" casing to 25.0 ft.											
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 2 Boring No.: BB-FSRO-203	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge #2261 Route 302 Over Saco River Overflow				Boring No. BB-FSRO-203																																																																																																																																																																																					
				Location: Fryeburg, Maine				PIN: 017912.00																																																																																																																																																																																					
Driller: New England Boring Contractors				Elevation (ft.) 378.4				Auger ID/OD: 4.25" OD																																																																																																																																																																																					
Operator: Mike Porter				Datum: NAVD 88				Sampler: Split Spoon																																																																																																																																																																																					
Logged By: B. Cardali				Rig Type: Truck				Hammer Wt./Fall: 140/30																																																																																																																																																																																					
Date Start/Finish: 03-21-18 / 03-21-18				Drilling Method: Drive & Wash, SSA				Core Barrel: --																																																																																																																																																																																					
Boring Location: Sta. 298+95.9, 12.1 ft RT				Casing ID/OD: 4"				Water Level*: 7.8'																																																																																																																																																																																					
Hammer Efficiency Factor: 0.869				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐																																																																																																																																																																																									
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101 WIN: 17912.00																																																																																																																																																																																																																		
Driller: MaineDOT		Elevation (ft.) 377.3		Auger ID/OD: 5-inch Solid Stem																																																																																																																																																																																																																						
Operator: Giguere/Giles		Datum: NAVD 88		Sampler: Standard Split Spoon																																																																																																																																																																																																																						
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs/30 inches																																																																																																																																																																																																																						
Date Start/Finish: 3/28/11; 10:30-12:00		Drilling Method: Cased Wash Boring		Core Barrel: N/A																																																																																																																																																																																																																						
Boring Location: Sta 299+27.7, 4.0 feet Lt.		Casing ID/OD: HW (4/4.5 inch)		Water Level*: 12.5 feet bgs																																																																																																																																																																																																																						
Hammer Efficiency Factor: 0.84		Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐																																																																																																																																																																																																																								
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test																																																																																																																																																																																																																										
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Maine Department of Transportation						Project:							Boring No.:															
						Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow							BB-FSRO-101A															
Soil/Rock Exploration Log <u>US CUSTOMARY UNITS</u>						Location: Fryeburg, Maine							WIN: 17912.00															
Driller: MaineDOT						Elevation (ft.): 377.4							Auger ID/OD: 5-inch Solid Steam															
Operator: Giguere/Giles						Datum: NAVD 88							Sampler: N/A															
Logged By: Wilder						Rig Type: CME 45C							Hammer Wt./Fall: N/A															
Date Start/Finish: 3/28/11; 13:00-14:30						Drilling Method: Cased Wash Boring							Core Barrel: N/A															
Boring Location: Sta 299+25.7, 4.0 ft Lt.						Casing ID/OD: HW (4/4.5 inches)							Water Level*: Not Observed															
Hammer Efficiency Factor:						Hammer Type: Automatic ☐ Hydraulic ☒							Rope & Cathead ☐															
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt						R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WOP = Weight of One Person							Su = Peak/Remolded Field Vane Undrained Shear Strength (psf) Su(lab) = Lab Vane Undrained Shear Strength (psf) qp = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N60 = SPT N-uncorrected Corrected for Hammer Efficiency N60 = (Hammer Efficiency Factor/60%)*N-uncorrected															
						Tv = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test																						
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10									[Pattern]																			
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Page 1 of 1																												
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00																																																																																																																																																																																																																																																																																																																	
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Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
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Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25	MD	24/0	25.00 - 27.00	5/6/6/7	12	17	24		Similar to 2D in wash water.		
							32				
							37				
							38				
							27				
30	3D	24/16	30.00 - 32.00	2/3/5/5	8	11	8		Brown, wet, medium dense, medium SAND, trace fine gravel, trace silt.	G#245147 A-1-b, SW-SM WC=32.4%	
							15				
							27				
							34				
							46				
35	4D	24/14	35.00 - 37.00	2/3/4/5	7	10	12		Grey, wet, loose, fine SAND, trace silt.	G#245145 A-3, SP-SM WC=23.1%	
							13				
							37				
							47				
							49				
40	5D	24/16	40.00 - 42.00	1/3/3/4	6	8	19		Grey, wet, loose, medium SAND, trace silt.	G#245146 A-1-b, SP WC=21.6%	
							39				
							61				
							73				
							92				
45	6D	24/20	45.00 - 47.00	1/2/2/2	4	6	41	Grey, wet, loose, Silty fine SAND.	G#245148 A-4, SM WC=33.9%		
							35				
							41				
							47				
50							53				

Remarks:
 -bgs = below existing ground surface (roadway)

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 2 of 5

 Boring No.: BB-FSRO-101B

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
50	7D	24/23	50.00 - 52.00	4/1/1/2	2	3	59	327.00		Grey, wet, soft, SILT, little fine sand, trace clay, trace organics. G#245149 A-4, ML WC=36.9%	
							57				
							53				
							53				
							57				
55	8D	24/24	55.00 - 57.00	WOR/WOR/WOR/ WOR	---		55			Grey, wet, very soft, SILT, some clay, trace fine sand. G#245150 A-4, CL-ML WC=43.1%	
							69				
							69				
							68				
							82				
60	MV/9D	24/24	60.00 - 62.00	WOH/2/2/5	4	6	91			Failed 55x110 mm vane attempt, would not push. Grey, wet, medium stiff, SILT, some clay, trace fine sand. G#245151 A-4, CL WC=35.7%	
							107				
							116				
							120				
							136				
65	10D	24/12	65.50 - 67.50	5/7/18/19	25	35	118	313.00	Cobble from 65 to 65.5 feet bgs. Grey, wet, dense, fine Sandy coarse GRAVEL, trace silt. G#245152 A-1-a, GW-GM WC=9.1%		
							108				
							152				
							127				
							97				
70	11D	24/12	70.00 - 72.00	7/19/10/11	29	41	119	307.50	Grey, wet, dense, medium SAND, some fine gravel, little silt. RC from 71 to 110.9 feet bgs. G#245153 A-1-b, SW-SM WC=10.6%		
							250				
							200				
							158				
							162				
75											
Remarks: -bgs = below existing ground surface (roadway)											
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 3 of 5 Boring No.: BB-FSRO-101B	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs//30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							150		Cobbles and Boulders from 75 to 77.8 feet bgs.		
							185				
							220				
							266				
							258				
80	12D	18/16	80.00 - 81.50	32/50/35	85	119	183		297.50	Grey, wet, hard, fine Sandy SILT, trace fine gravel, trace clay.	G#245154 A-4, SC-SM WC=13.1%
							170				
							132				
							127				
							275				
85	13D	8.4/8.4	85.00 - 85.70	10/50(2.4")	---		178	294.50	Grey, wet, very dense, medium SAND, little fine gravel, little silt.	G#245155 A-1-b, SM WC=12.8%	
							186				
							486				
							494				
							297				
90	14D	6/6	90.00 - 90.50	50	---		213		Grey, wet, very dense, fine SAND, little fine gravel, trace silt.	G#245156 A-1-b, SW-SM WC=13.2%	
							62				
							96				
							77				
							93				
95	15D	9.6/9	95.00 - 95.80	14/50(3.6")	---		87		Similar to 14D.		
							87				
							110				
							313				
							238				
100											
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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-101B WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 377.5				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs/30 inches			
Date Start/Finish: 3/29,30/11-4/1,4,5,6/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+23.2, 3.4 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 13 feet bgs			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
100	16D	10.8/10.8	100.00 - 100.90	50/50(4.8")	---		195		Grey, wet, very dense, fine SAND, little silt, trace fine gravel.	G#245157 A-2-4, SM WC=12.9%	
							235				
							242				
							275				
							370				
							300				
							167				
							222				
							294				
							402				
105	17D	14.4/12	105.00 - 106.20	10/60/40(2.4")	---		300		Grey, wet, hard, SILT, some clay, some fine sand, trace fine gravel.	G#245158 A-4, CL WC=20.1%	
							167				
							222				
							294				
							402				
110	18D R1	9.6/9.6 60/55	110.00 - 110.80 110.90 - 115.90	29/50(3.6") RQD = 88%	---		NQ-2		Grey, wet, hard, SILT, little clay, trace fine sand.	G#245159 A-4, CL-ML WC=23.6%	
115	R2	60/60	115.90 - 120.90	RQD = 95%					Top of Bedrock at Elev. 266.6 ft. R1:Bedrock: R1:Core Times (min:sec) 110.9-111.9 ft (2:55) 111.9-112.9 ft (2:45) 112.9-113.9 ft (2:45) 113.9-114.9 ft (2:50) 114.9-115.9 ft (3:00) 98% Recovery R2:Bedrock: R2:Core Times (min:sec) 115.9-116.9 ft (2:38) 116.9-117.9 ft (3:20) 117.9-118.9 ft (4:20) 118.9-119.9 ft (3:25) 119.9-120.9 ft (3:25) 100% Recovery		
120									Bottom of Exploration at 120.90 feet below ground surface.		
125											

Remarks:
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Boring No.: BB-FSRO-101B

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00																																																																																																																																												
Driller: MaineDOT		Elevation (ft.): 378.0		Auger ID/OD: 5-inch Solid Stem																																																																																																																																																
Operator: Giguere/Giles		Datum: NAVD88		Sampler: Standard Split Spoon																																																																																																																																																
Logged By: Wilder		Rig Type: CME 45C		Hammer Wt./Fall: 140 lbs./30 inches																																																																																																																																																
Date Start/Finish: 4/7,8,11,12/11		Drilling Method: Cased Wash Boring		Core Barrel: NQ2 (2-inch-diameter)																																																																																																																																																
Boring Location: Sta 299+61.2, 12.7 feet Lt.		Casing ID/OD: HW (4/4.5") & NW (3/3.5")		Water Level*: 12 feet bgs.																																																																																																																																																
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Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							28		Grey, wet, loose, fine SAND, trace silt.	G#245163 A-3, SP-SM WC=28.0%	
							28				
							39				
							43				
							62				
30	4D	24/14	30.00 - 32.00	2/3/3/3	6	8	16				
							19				
							30				
							41				
							64				
35							79				
							116				
							119				
							155				
							158				
40	5D	24/20	40.00 - 42.00	1/1/2/3	3	4	73				
							73				
							76				
							77				
45							108				
							127				
							165				
							167				
							169				
50							175				
Remarks: -bgs = below existing ground surface (roadway)											
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 2 of 5	
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.										Boring No.: BB-FSRO-102	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00				
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem				
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon				
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches				
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)				
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.				
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐								
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _u = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test												
Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.	
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
50	6D	24/18	50.00 - 52.00	8/2/1/4	3	4	107	318.00		Grey, wet, very loose, Silty fine SAND.	G#245165 A-4, SM WC=32.6%	
							82					
							81					
							113					
							122					
55							122					
							127					
							138					
							176					
							192					
60	7D	24/24	60.00 - 62.00	1/WOR/1/WOR	1	1	159				Grey, wet, very soft, SILT, trace clay, trace fine sand.	G#245166 A-4, ML WC=47.6%
							165					
							135					
							175					
							181					
65							181					
							186					
							186					
							178					
							178					
70	8D/MV	24/24	70.00 - 72.00	WOR/WOR/WOR/ WOR	---		129		Grey, wet, very soft, SILT, some fine sand, trace clay. Failed 55x110 mm vane attempt, would not push.	G#245167 A-4, ML WC=43.3%		
							130					
							165					
							165					
75							178					
Remarks: -bgs = below existing ground surface (roadway)												
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 3 of 5 Boring No.: BB-FSRO-102		

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Eddy Flats Bridge (No. 2261) carries Route 302 over Saco River Overflow Location: Fryeburg, Maine				Boring No.: BB-FSRO-102 WIN: 17912.00			
Driller: MaineDOT				Elevation (ft.): 378.0				Auger ID/OD: 5-inch Solid Stem			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140 lbs./30 inches			
Date Start/Finish: 4/7,8,11,12/11				Drilling Method: Cased Wash Boring				Core Barrel: NQ2 (2-inch-diameter)			
Boring Location: Sta 299+61.2, 12.7 feet Lt.				Casing ID/OD: HW (4/4.5") & NW (3/3.5")				Water Level*: 12 feet bgs.			
Hammer Efficiency Factor: 0.84				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
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	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
75							162		Grey, wet, very stiff, SILT, little clay.	G#245168 A-4, CL-ML WC=34.1%	
							224				
							224				
							224				
							224				
80	9D	24/20	80.50 - 82.50	10/5/7/8	12	17	176				
							166				
							167				
							167				
							169				
85							170		Grey, wet, medium dense, fine SAND, some silt, trace fine gravel.	G#245169 A-2-4, SM WC=18.7%	
							167				
							164				
							164				
							164				
90	10D	24/14	90.00 - 92.00	4/7/10/15	17	24	166				
							98				
							105				
							97				
							112				
95							96		RC to 100 feet bgs.		
							162				
							238				
							386				
100							508				
Remarks: -bgs = below existing ground surface (roadway)											
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 4 of 5 Boring No.: BB-FSRO-102	

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R1:Bedrock: R1:Core Times (min:sec) 114.4-115.4 ft (5:25) 115.4-116.4 ft (3:40) 116.4-117.4 ft (3:50) 117.4-118.4 ft (2:05) 118.4-119.4 ft (3:00) 100% Recovery R2:Bedrock: R2:Core Times (min:sec) 119.4-120.4 ft (4:00) 120.4-121.4 ft (3:15) 121.4-122.4 ft (3:10) 122.4-123.4 ft (3:00) 123.4-124.4 ft (4:00) 100% Recovery </td> <td rowspan="10"></td> </tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr> <td>120</td> <td>R2</td> <td>60/60</td> <td>119.40 - 124.40</td> <td>RQD = 90%</td> <td></td> <td></td> <td></td> <td rowspan="5"> </td> <td rowspan="5"></td> <td rowspan="5"></td> </tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr> <td>125</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>												Depth (ft.)	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KEY TO SYMBOLS

Symbol Description

Symbol Description

Strata symbols

Misc. Symbols



Paving



Fill



Poorly graded silty
fine sand



Variable sand
and silt mix



Silty sand



Description not given for:
"Z:J"



Description not given for:
"03"



Description not given for:
"ZS"



Description not given for:
"SY"



Granite



Description not given for:
"Z0"



Silty low plasticity
clay



Description not given for:
"DOWNAROW"

Notes:

1. Exploratory borings were drilled on 4/7,8,11,12/11 using a 4-inch diameter continuous flight power auger.
2. No free water was encountered at the time of drilling or when re-checked the following day.
3. Boring locations were taped from existing features and elevations extrapolated from the final design schematic plan.
4. These logs are subject to the limitations, conclusions, and recommendations in this report.
5. Results of tests conducted on samples recovered are reported on the logs.



APPENDIX C – CALCULATIONS



Correlation of SPT N-Values to Internal Friction Angle (ϕ) Using LRFD

Project: Eddy Flats Sheet Pile Wall
Location: Fryeburg, Maine
Calculated By: BMC Date: 5/1/2018
Checked By: CLS Date: 5/1/2018

Objective: To estimate the internal friction angle (ϕ) of subsurface strata for the Eddy Flats Sheet Pile Wall based on Standard Penetration Test (SPT) measurements and empirical correlations using N_{field} , N_{corr} and $(N_1)_{60}$ for use in LRFD analyses.

Method: Correlations between SPT N-values and the soil internal friction angle are based on two (2) equations presented in NCHRP Report 651 and in Table 10.4.6.2.4-1 of the AASHTO, 8th Edition (2017). The correlated friction angle using these two (2) correlations are presented in this document. The recommended internal friction angle to be used for design is based on the correlation presented by Peck, Hanson and Thornburn (PHT, 1974) as mentioned in Kulhawy and Mayne (1990) and recommended in NCHRP Report 651 (below).

$$\phi \approx 54 - 27.6034 * e^{-0.014 * (N_1)_{60}}$$

Given Information: SPT measurements and subsurface conditions in borings BB-FSRO-201, BB-FSRO-202, and BB-FSRO-203 performed by New England Boring Contractors, Inc. between March 19, 2018 and March 21, 2018 and observed by GZA.

Assumptions: Split spoon samples and SPTs were performed using an automatic hammer. For this calculation, the hammer efficiency was 86.9%.

Analysis Results:

Layer	Range of SPT (N_1) ₆₀ - Values	Recomm. ϕ^1 (degrees)
Fill	6 to 89	30
Stream Alluvium	6 to 11	29
Glacial Till	8 to 98	32

Notes:

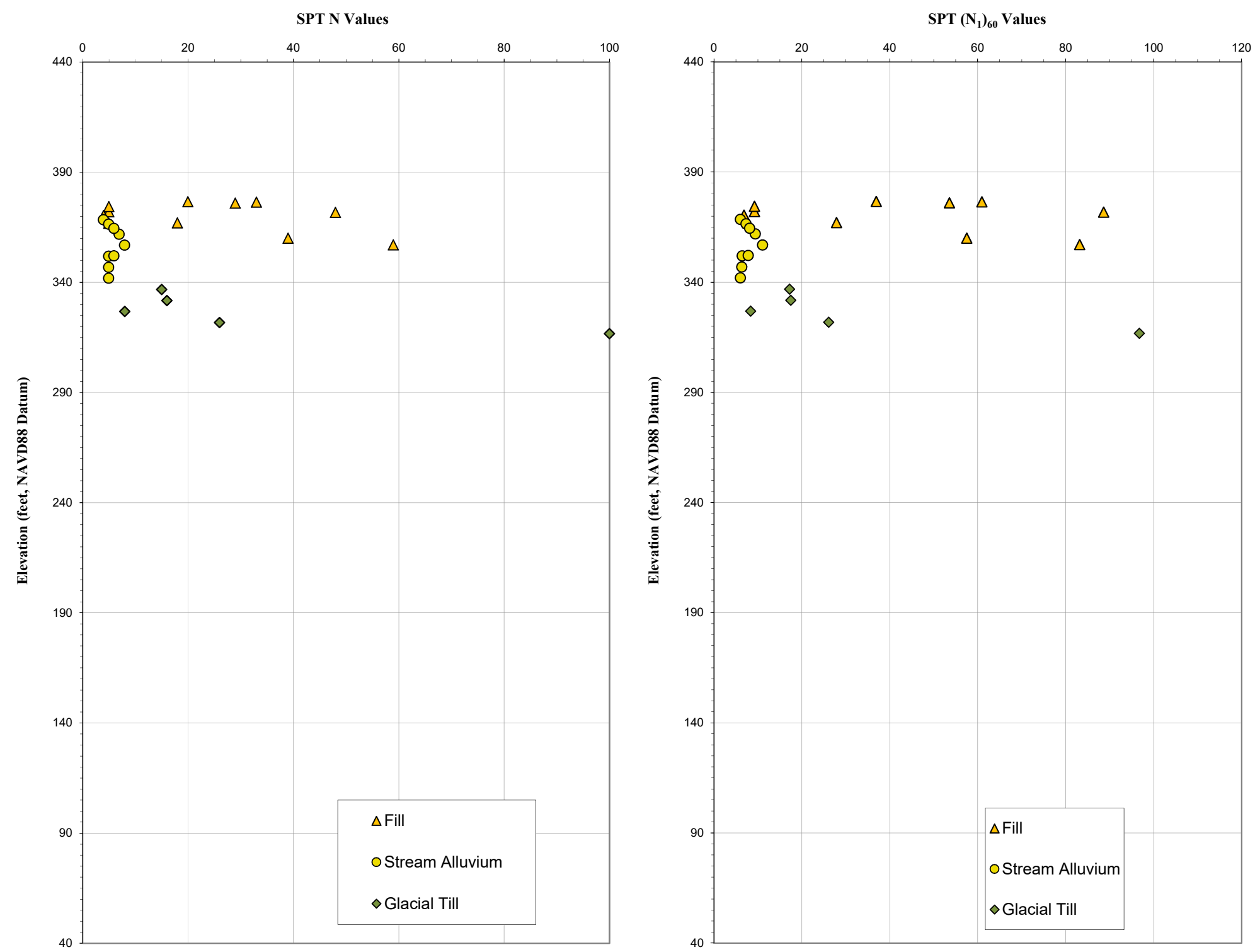
1) ϕ is based on the Peck, Hanson, & Thornburn (1974) empirical correlation, as mentioned by Kulhawy & Mayne (1990).

Attachments:

- 1) Figures
- 2) Calculations
- 3) Boring Logs BB-FSRO-201 through BB-FSRO-203

References:

- 1) AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017.
- 2) Boring Logs BB-FSRO-201 through BB-FSRO-203
- 2) NCHRP Report 651, "LRFD Design and Construction of Shallow Foundations for Highway Bridge Structures," 2010.
- 3) FHWA NHI-06-088, "Soils and Foundations," Volume 1, December 2006.
- 4) Youd, T.L., et. al., "Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and GeoEnvironmental Engineering, October 2001.
- 5) Peck, Hanson, and Thornburn; "Foundation Engineering" 2nd ed., Wiley, New York, 1974
- 6) Kulhawy, F. and Mayne, P (1990). *Manual on Estimation of Soil Properties for Foundation Design*, Report EPRI-EL-6800. Electric Power Research Institute, Palo Alto, CA.



- Notes:**
1. Project datum = North American Vertical Datum (NAVD 88).
 2. Standard Penetration Test (SPT) field values shown for borings BB-FSRO-201, -202 and -203 completed in the shoulder west of Eddy Flats bridge.
 3. N values greater than 100 have been plotted as 100 for clarity.
 4. Refer to the attached boring logs for additional information.
 5. Corrected, (N₁)₆₀, N values plotted on the figure are based on the following:

$$N_{1(60)} = N_m C_N C_E C_R C_S C_B$$

where:
N_M = measured SPT 'N' Value
C_N = normalization factor for overburden stress
 $C_N = (P_a/\sigma'_v)^{0.5} \leq 1.7$
P_a = 2088 psf (100 kPa)
σ_v' = effective overburden stress
C_E = hammer energy ratio correction factor
C_B = borehole diameter correction factor
C_R = rod length correction factor
C_S = sampler liner correction factor

Reference: Coduto, D.P. Foundation Design: Principles and Practices, 2nd Ed. (2001)



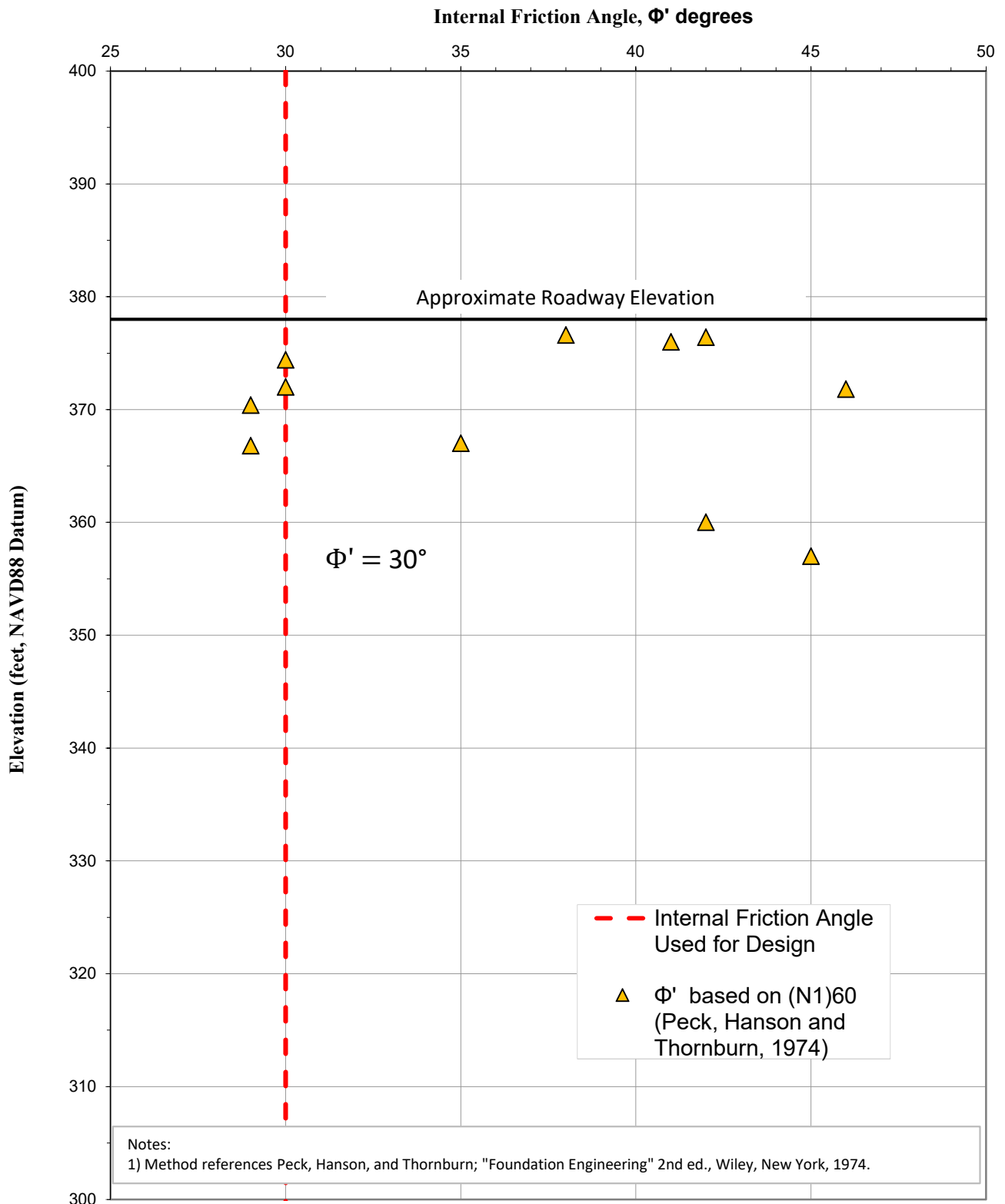
PROJ MGR: BMC
DESIGNED BY: BMC
REVIEWED BY:CLS

DRAWN BY: BMC
DATE: 5/1/2018

Eddy Flats Sheet Pile Wall
Fryeburg, Maine

UNCORRECTED AND CORRECTED N-VALUES VERSUS ELEVATION
BY STRATUM

FIGURE 1



PROJ MGR: BMC
DESIGNED BY: BMC
REVIEWED BY: CLS

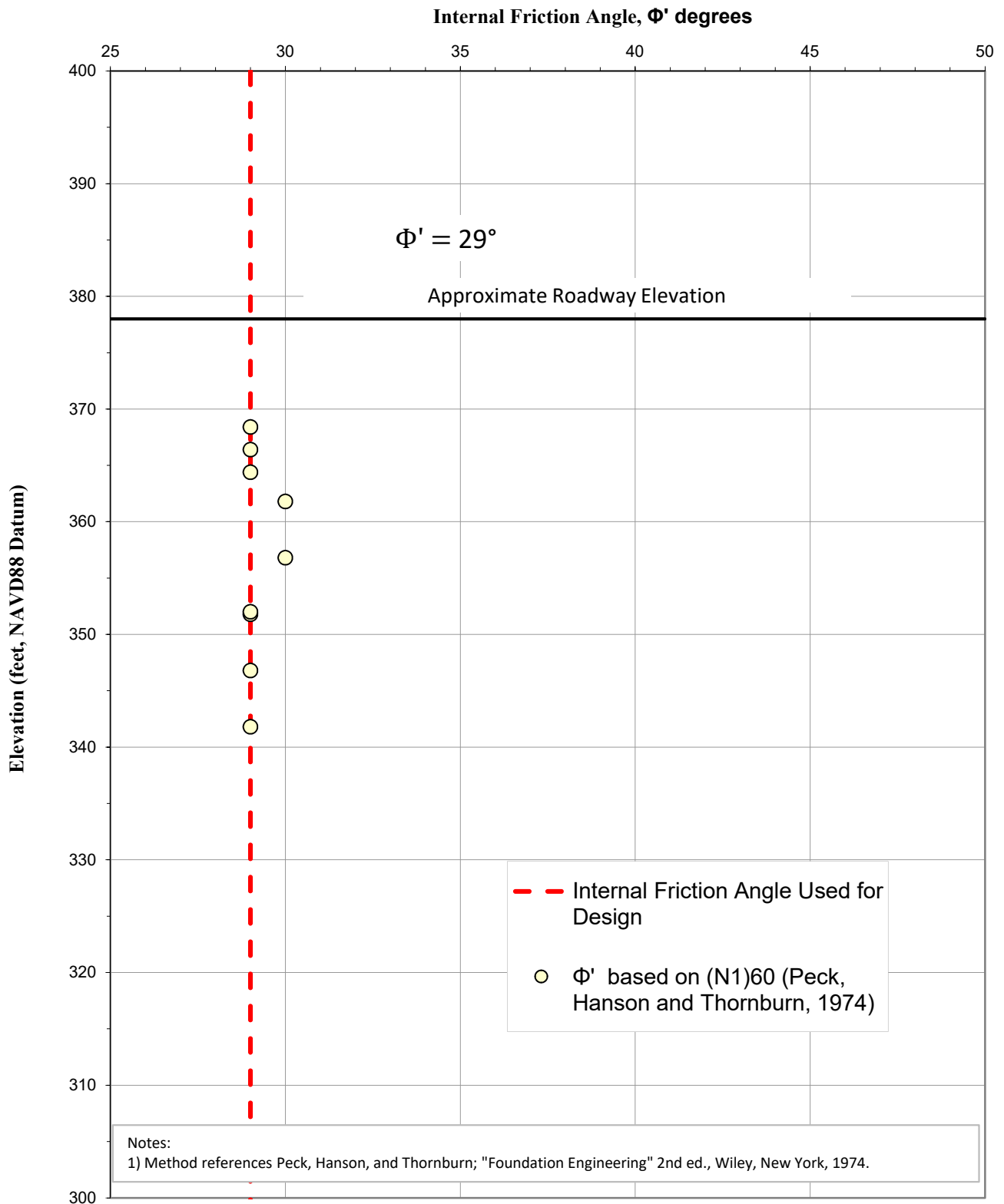
DRAWN BY: BMC
DATE: 5/1/2018



**Eddy Flats Sheet Pile Wall
Fryeburg, Maine**

**INTERNAL FRICTION ANGLES BASED ON STANDARD
PENETRATION TEST (SPT) N-VALUES FOR FILL**

FIGURE 2



PROJ MGR: BMC
 DESIGNED BY: BMC
 REVIEWED BY: CLS

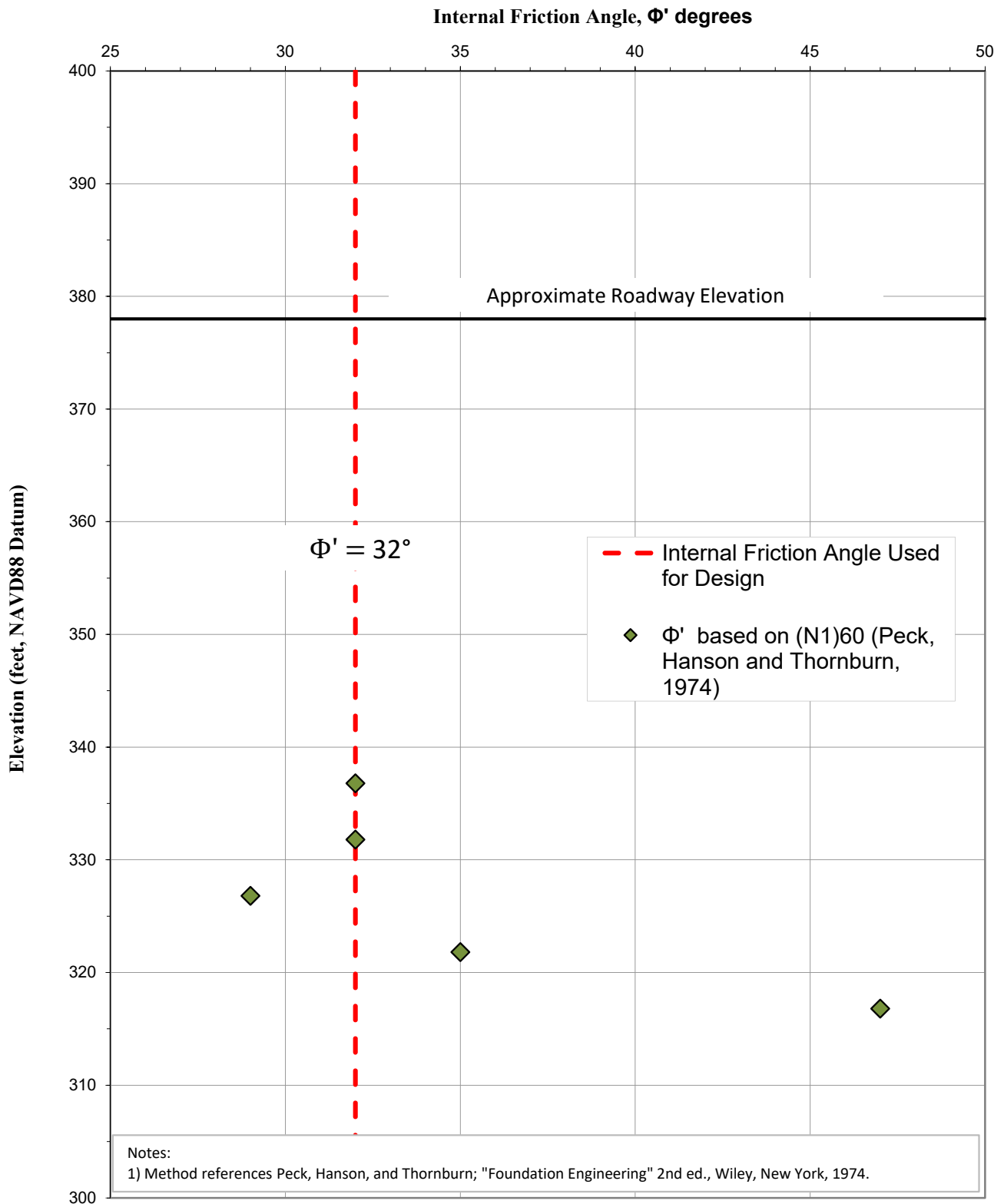
DRAWN BY: BMC
 DATE: 5/1/2018



**Eddy Flats Sheet Pile Wall
 Fryeburg, Maine**

**INTERNAL FRICTION ANGLES BASED ON STANDARD
 PENETRATION TEST (SPT) N-VALUES FOR STREAM
 ALLUVIUM**

FIGURE 3



PROJ MGR: BMC
DESIGNED BY: BMC
REVIEWED BY: CLS

DRAWN BY: BMC
DATE: 5/1/2018



**Eddy Flats Sheet Pile Wall
Fryeburg, Maine**

**INTERNAL FRICTION ANGLES BASED ON STANDARD
PENETRATION TEST (SPT) N-VALUES FOR GLACIAL
TILL**

FIGURE 4



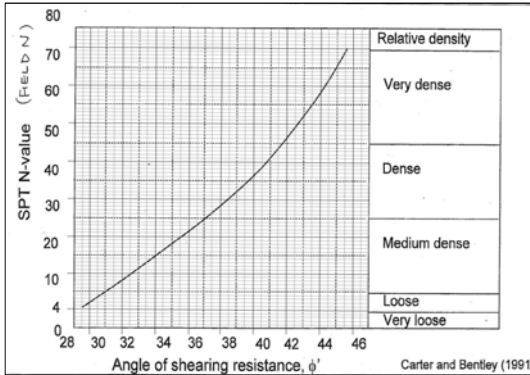
Corrected SPT N-Value and Internal Friction Angle Calculations

Project: Eddy Flats Sheet Pile Wall
 Location: Fryeburg, Maine
 Evaluated By: BMC
 Checked By: CLS
 Date: 5/1/2018
 Date: 5/1/2018

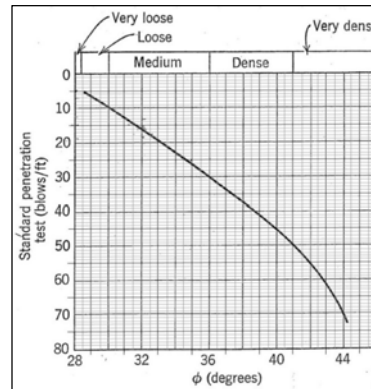
Objective: To estimate the internal friction angle (ϕ') of subsurface strata for Eddy Flats Sheet Pile Wall based on Standard Penetration Test (SPT) measurements and empirical correlations using N_{field} , N_{corr} and $(N_1)_{60}$ for use in LRFD analyses.

References: Boring BB-2 performed between 3/20/2018 and 3/21/2018 and observed by GZA.
 - Methods 1 and 2 estimate internal friction angle based on SPT N-values. Method 1 references M.Carter and S.P.Bentley (1991), Correlations of soil properties, Pentech Press Publishers, London, UK. Method 2 references Peck, Hanson, and Thornburn; "Foundation Engineering" 2nd ed., Wiley, New York, 1974. See figures labeled Method 1 and Method 2.

Method 1
 (Carter and Bentley, 1991)



Method 2
 (Peck, Hanson, and Thornburn, 1974)



Equation:
$$N_{1(60)} = N_m C_N C_E C_R C_S C_B$$

where:

N_m = measured SPT 'N' Value

C_N = normalization factor for overburden stress

$$C_N = (P_a / \sigma'_v)^{0.5} \leq 1.7$$

$$P_a = 2088 \text{ psf (100 kPa)}$$

σ'_v = effective overburden stress

C_E = hammer energy ratio correction factor

C_B = borehole diameter correction factor

C_R = rod length correction factor

C_S = sampler liner correction factor (= 1 for no liner)

Soil Type	Unit Weight (pcf)	Depth Below Ground Surface (feet)	
		Top	Bottom
Fill	120	0.0	22.5
Stream Alluvium	120	22.5	27.0

$$N_{corr} = N_m \times C_N$$

Calculation: Boring: **BB-FSRO-202**
 Ground Surface Elevation: **378**

Groundwater depth: **12.5**
 Groundwater Elevation: **365.5**
 Hammer Efficiency: **0.87**

Depth Below Ground Surface (mid-SPT interval)	Elevation (mid-SPT interval)	Depth	Total Stress, σ_v	Effective Stress, σ'_v	N (field)	C_R	C_N	C_s	C_B	N_{corr}	$(N_1)_{60}$	Method 1	Method 2	
												Φ' based on N (field)	Φ' based on $(N_1)_{60}$	
ft	ft	m	psf	psf										
1	2.0	376.0	0.6	240	240	29	0.75	1.70	1.00	1.00	49	54	36	41
2	6.0	372.0	1.8	720	720	5	0.75	1.70	1.00	1.00	9	9	29	30
3	11.0	367.0	3.4	1320	1320	18	0.85	1.26	1.00	1.00	23	28	33	35
4	18.0	360.0	5.5	2160	1817	39	0.95	1.07	1.00	1.00	42	58	39	42
5	21.0	357.0	6.4	2520	1990	59	0.95	1.02	1.00	1.00	60	83	42	45
6	26.0	352.0	7.9	3120	2278	6	0.95	0.96	1.00	1.00	6	8	29	29

Notes:

- 1) Assume average stick up of rods of 3 feet.
- 2) Assume GWT at Mudline for calculation purpose.

