REPORT

Preliminary Geotechnical Design Report (PGDR)

Thorne Brook Bridge No. 2850, Augusta, Maine (WIN 026444.00)

Submitted to:

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1.0 INTRODUCTION

This Preliminary Geotechnical Design Report (PGDR) summarizes the results of WSP USA Inc. (WSP's) geotechnical investigation and preliminary recommendations for the replacement of the culvert carrying Maine Route (RT) 17 over Thorne Brook in Augusta, Maine. Figure 1 shows the site location. The purpose of this report is to: present soil and bedrock information for the culvert replacement project obtained from subsurface investigations and laboratory tests; present recommended geotechnical parameters for design; and provide preliminary geotechnical construction recommendations for the replacement culvert.

2.0 PROJECT BACKGROUND

WSP reviewed the As-Built Plans[1,2] and recent Inspection Report[3] for the existing structure. These plans indicate that the original structure was constructed in 1936 and replaced in 1989. The current structure consists of an 11-foot 7-inch by 7-foot 5-inch steel structural plate pipe arch culvert. The proposed replacement design consists of a precast concrete box culvert based on the Thorne Brook bank full width of 10.3 feet[4].

3.0 GEOLOGIC SETTING

3.1 Regional Surficial Geology

The site lies within the Seaboard Lowland Section of the New England physiographic province, characterized by a topographic surface of low relief, that has been glaciated and eroded.[5] The site is mapped as lying within the Pleistocene-aged Presumpscot Formation, consisting of glaciomarine silt, clay and sand deposited on a late glacial sea floor. This formation often overlies older Pleistocene-aged glacial till, consisting of a loose to very dense, poorly sorted, massive to weakly stratified mixture of sand, silt, clay and gravel-sized debris deposited directly by glacial ice. This unit includes lenses of water lain sand and gravel, along with occasional boulders. The till generally overlies metamorphic schist, slate and granofels bedrock, described below. [6,7,8,9]

3.2 Regional Bedrock Geology

Bedrock beneath the site is mapped as the Mayflower Hill Formation, of the Silurian-Ordovician-aged Vassalboro Group. This formation consists of purplish brown, fine-grained to medium-grained quartz-feldspar-biotite granofels and schist.[10] This formation was previously mapped as part of the Silurian-aged Waterville Formation, consisting

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1 Maine State Highway Commission, Bridge Division. Thorne Bridge over Thorne Brook in the city of Augusta, Kennebec Co. Dated December 1932 and February 1936.

2 State of Maine Department of Transportation. Thorne Bridge & Spaulding Bridge in the city of Augusta, Kennebec County. Dated January 1988.

3 Stevens, John. Highway Bridge Inspection Report, BR# 2850 Thorne Brook, RTE 17 over Thorne Brook, Town: Augusta. Dated November 16, 2020.

4 Augusta-26444-Thorne_Br-2850-Hydro_Rpt, dated 23 September 2022.

5 Fenneman, N.M. and Johnson, D.W., 1946. Physical Divisions of the United States. U.S. Geological Survey, 1 sheet, scale 1:7,000,000.

6 USDA NRCS Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Accessed September 28, 2022.

7 Thompson, Woodrow B., 2007, Surficial geology of the Togus Pond quadrangle: Maine Geological Survey, Open-File Map 07-101, map, scale 1:24,000. Maine Geological Survey Maps. 1754. http://digitalmaine.com/mgs_maps/1754

8 Thompson, Woodrow B. and Locke, Daniel B., 2005, Surficial materials of the Togus Pond quadrangle, Maine: Maine Geological Survey, Open-File Map 05-3, map, scale 1:24,000. Maine Geological Survey Maps. 1501. http://digitalmaine.com/mgs_maps/1501

9 Maine Geological Survey Water Well Database. https://www.maine.gov/dacf/mgs/pubs/digital/well.htm. Accessed September 28, 2022.

10 Marvinney, R.G. and Barker, D.S., 2012. Bedrock Geology of the Augusta Quadrangle, Maine Geological Survey Open-File Report No. 12-36, 1 sheet, scale 1:24,000.

of slate, phyllite, schist, and graywacke. [11] The original thin to thick bedded shale, siltstone and sandstone of this formation was deposited in a broad, deep water basin, and was then later metamorphosed to greenschist facies during later regional compression associated with the mountain-building Acadian Orogeny. Both bedding and foliation regionally strike northeast, and dip steeply to the southeast and northeast, along with the axes of local folds.[12]

4.0 SUBSURFACE INVESTIGATIONS

WSP completed two (2) test borings (BB-ATB-101 and BB-ATB-102) between April 10 and April 18, 2023. The as-drilled boring location coordinates and ground surface elevations, provided by MaineDOT, are summarized in Table 1. Boring locations with respect to existing site features are illustrated in the Boring Location Plan (BLP, Figure 2). Both borings were performed within the paved roadway of RT 17 on either side of the existing culvert at Thorne Brook. The field program included Standard Penetration Testing (SPT) of predominantly fine-grained soils, in situ strength testing of unconsolidated materials, undisturbed Shelby tube sampling in the compressible clay strata, and recovery of rock core from the bedrock. A WSP geotechnical engineer monitored drilling activities, selected sampling intervals, logged subsurface conditions encountered, and obtained soil samples for use in visual descriptions and subsequent laboratory testing and classification.

WSP subcontracted Seaboard Drilling LLC (Seaboard, formerly S.W. Cole Explorations, LLC) of Bangor, Maine to complete the borings using a Mobile CME 850 truck-mounted drill rig for boring BB-ATB-101 and a Mobile B-48 track-mounted drill rig for boring BB-ATB-102. To advance the borings, Seaboard used solid stem augers in the upper 3 feet in BB-ATB-102 and upper 10 feet in BB-AB-101 and then drove 4-inch inside diameter casing in 5-foot lengths using an automatic safety hammer. Soil in the casing was washed out using a roller bit and water to the depth where samples were collected or where in situ field vane shear testing was performed. Both borings were advanced to refusal which was 58 feet below ground surface (bgs) at BB-ATB-101 and 70 feet bgs at BB-ATB-102.

Seaboard performed SPT using a calibrated automatic hammer system and standard 2-inch split spoon sampler in general accordance with American Society for Testing and Materials (ASTM) D1586. Sampling was conducted at approximately 5-foot intervals. Seaboard drove split spoons for 24 inches with a 140-pound hammer dropped 30 inches and WSP recorded the number of hammer blows required to advance the sampler through each 6-inch increment. Measured, uncorrected N-values, calculated as the sum of the hammer blows to advance the sampler during the 6-inch to 18-inch interval, are provided in the boring logs in Appendix A. WSP used a hammer energy transfer ratio of 86% for the CME 850 Rig and 91% for the Mobile Drill Rig provided by Seaboard to covert the measured N-values to N_{60} values for further calculations. WSP collected and stored soil samples in sealed glass jars for later evaluation and laboratory testing.

Seaboard conducted in situ field vane shear tests in the cohesive soil deposit using a WSP-owned Geonor rectangular vane set. For each test or pair of tests, the borehole was advanced either 6-inches or 1 foot above the desired test depth, after which the vane was advanced the remaining distance by hand using dedicated vane rods. At the desired test depth, Seaboard rotated the vane with a calibrated torque wrench at a rate of approximately 90 degrees per minute to obtain the peak torque, used to estimate the peak undrained shear

[11] Osberg, P.H., Hussey, A.M., and Boone, G.M., 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000. Digital Data – Maine Geological Survey. https://www.maine.gov/dacf/mgs/pubs/digital/bed500.htm

[12] Osberg, P.H., 1968. Stratigraphy, Structural Geology, and Metamorphism of the Waterville-Vassalboro Area, Maine. Maine Geological Survey Bulletin No. 20, June 1968, 64 p., 1 sheet, scale 1:62,500.

strength. The vane was then rotated rapidly at the same depth through 10 revolutions to remold the soil before being rotated again with a torque wrench at approximately 90 degrees per minute to obtain the residual torque, used to estimate the residual undrained shear strength. Results from vane shear testing are summarized in Table 2, including raw torque readings and calculated uncorrected undrained shear strengths, and are provided on the boring logs in Appendix A.

Seaboard collected two (2) undisturbed Shelby tube samples in borehole BB-ATB-102 in general accordance with ASTM D6519 using a GUS sampler. Samples were sealed in the field using wax and transported back to the WSP office for subsequent laboratory testing assignment.

Seaboard collected up to 10 feet of rock core using NQ/NX size (1-7/8-inch diameter) diamond tipped core barrels in the two borings following either refusal of casing, or failure to advance the split spoon sampler or roller bit. Rock core samples were placed in wooden boxes and transported to the WSP office. WSP recorded the lithology, Total Core Recovery (TCR), Rock Quality Designation (RQD), and coring rates for each core run which are provided in the boring logs in Appendix A. A detailed summary of the rock core quality parameters for the recovered rock core is presented in Table 3 and photographs of the rock core are presented in Appendix B.

The boring logs provided in Appendix A present details of the sampling methods used, field data obtained, and soil and rock conditions encountered during the investigation. Soils were field categorized in accordance with ASTM D2488. WSP field characterized the bedrock lithology, and the descriptions were revised in the office. A description of the boring log symbols and terms used for the soil and rock descriptions precedes the boring logs.

5.0 LABORATORY TESTING PROGRAM

After reviewing the collected samples in the office, WSP transferred select samples to GeoTesting Express (GTX) of Acton, Massachusetts for geotechnical laboratory testing in accordance with applicable AASHTO and ASTM testing procedures. WSP selected representative SPT split spoon soil samples from the borings for geotechnical laboratory testing to assist in soil classification. The types and numbers of each of the laboratory tests conducted on soil samples are presented in Table 5-1. Measured index and classification test results from soil samples are summarized in Table 4 and include AASHTO and Unified Soil Classification System (USCS) classifications. Soil testing results are included on the boring logs in Appendix A. Measured strength and consolidation test results are summarized in Table 5. Complete laboratory testing results are provided in Appendix C.

Table 5-1: Number and Type of Laboratory Tests Performed

Laboratory Test	Test Standard	No. Tests Completed
Moisture content	ASTM D 2216, AASHTO T267	3
Grain size analysis (coarse)	ASTM D 6913, AASHTO T88	5
Grain size (fines)	ASTM D 7928, AASHTO T88	6
Atterberg Limits	ASTM D 4318, AASHTO T89	7
X-Ray Shelby Tubes	ASTM D4452	2
Incremental Load Consolidation (ILC)	ASTM D2435, AASHTO T 216	2
Direct Simple Shear (DSS)	ASTM D6528	2

6.0 SUBSURFACE CONDITIONS

The soils encountered in the borings generally consist of fill materials placed during construction of the culvert and roadway, naturally occurring silt interpreted as Presumpscot Formation silt, naturally occurring clay interpreted as Presumpscot Formation silty clay, and naturally occurring sandy/silty gravel interpreted as glacial till. Bedrock encountered consists of schist and granofels of the Mayflower Hill Formation. The boring logs in Appendix A provide detailed descriptions of the soil conditions encountered in the borings. Figure 3 provides WSP's Interpretive Subsurface Profile (ISP) along the centerline of the roadway. The following descriptions summarize the major stratigraphic units from the existing ground surface to depth.

Asphalt Pavement: Asphalt pavement thickness ranged from approximately 7.5 inches to 10 inches in borings BB-ATB-101 and BB-ATB-102, respectively.

Fill: A layer of fill was encountered between 0.6 feet and 8.5 feet below ground surface (bgs) in BB-ATB-101 and 0.8 feet and 5 feet bgs in BB-ATB-102. The fill consists of brown, very dense to medium dense, fine to coarse sand, with some gravel and little to some silt. Laboratory classifications generally described the layer as SM (USCS) and A-2-4 (AASHTO). N_{60}-values ranged from 18 to 46, where values generally decreased with increasing depth. The fill layer transitions to the underlying Presumpscot Formation silt layer at 8.5 feet bgs in BB-ATB-101 and at 5 feet bgs in BB-ATB-102.

Presumpscot Formation Silt: The silt encountered was encountered between 8.5 feet and 20 feet bgs in BB-ATB-101 and 5 feet and 10 feet bgs in BB-ATB-102. This layer consists of olive, grey and brown very stiff to stiff silt, with some fine sand and trace to little clay. This layer is generally described as ML (USCS) based on visual manual procedures[13].Silt N_{60}-values ranged from 7 to 14. The silt layer transitions to the Presumpscot Formation Clay layer at approximately 10 feet bgs in BB-ATB-102 and 20 feet bgs in BB-ATB-101.

Presumpscot Formation Clay: A layer of clay was encountered between 10 feet and 59.5 feet bgs in BB-ATB-102 and between 20 feet and 48 feet bgs in BB-ATB-101. The clay layer consists of stiff to very soft clay with trace amounts of sand, and little to some silt. Laboratory classifications generally described the layer as CL (USCS) and A-6 (AASHTO). N_{60}-values ranged from 0 (weight of hammer) to 24. The undrained shear strength for the clay, determined from field vane shear measurements and corrected using plasticity index, ranged from 532 psf to greater than 1266 psf, and the corrected remolded strength ranged from 112 psf to 289 psf. The clay layer transitions to the glacial till layer for both borings.

Glacial Till: A layer of glacial till was encountered between 48 feet and 58 feet bgs in BB-ATB-101 and between 59.5 feet and 65.7 feet bgs in BB-ATB-102. The till consists of medium dense to very dense, grey, gravelly fine to coarse sand, and silty, sandy gravel. Laboratory classifications generally described the layer as SM (USCS) and A-2-4 (AASHTO). N_{60}-values ranged from 32 to greater than 100. The till layer transitions to bedrock at 58 feet bgs in BB-ATB-101 and weathered bedrock at 65.7 feet bgs followed by bedrock at 70 feet bgs in BB-ATB-102.

Bedrock: Bedrock was cored from 58 feet to 68 feet bgs in BB-ATB-101 and from 70 feet to 71 feet bgs in BB-ATB-102. The bedrock consists of light grey, fine grained, strongly foliated, medium strong (R3) to strong (R4), fresh (W1), granofels and schist, with occasional quartz monzonite veins.

Groundwater: WSP measured groundwater levels in both borings. Groundwater was measured in BB-ATB-101 with the casing at a depth of 48 bgs at the end of the drilling day and then again the next morning as 3.7 feet and

[13] ASTM D2488-17e1 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

12.3 feet bgs, respectively. The groundwater level in BB-ATB-102 was measured with the casing at a depth of 52 feet bgs after sitting overnight as 10 feet bgs. Groundwater levels shown on the ISP in Figure 3 were interpreted based on these water level measurements and on moisture content observed in the soil samples. We note that groundwater levels will fluctuate due to seasonal, regional pumping, and precipitation trends.

7.0 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

The base elevation of the proposed box culvert as specified in the project plans[14] will be founded at EL. 170.7 feet within the Presumpscot silt and Presumpscot clay layers and the precast toe walls founded at EL. 168.8 feet. The culvert is proposed to be 56.7 feet long including the inlet sloped wingwalls and is 14 feet wide. The culvert location in plan is shown on the BLP (Figure 2) and in profile with respect to stratigraphy on the ISP (Figure 3). Site soils at and adjacent to RT 17 will need to be excavated approximately 17 feet bgs to install the culvert, including an additional 1 foot of excavation below the base of the culvert and toe walls to accommodate the proposed Granular Borrow for Underwater Backfill (MaineDOT Standard Specification[15] Section 703.19).

Our analyses and recommendations are described in the subsections below. Calculations, references, and assumptions are provided in Appendix D.

7.1 Design Parameters

WSP evaluated the subsurface geotechnical data collected and developed geotechnical material design parameters to serve as a basis for calculations, analyses, and evaluations discussed herein. Table 7-1 provides a summary of design parameters for each in situ soil layer (refer to Figure 3) encountered and material properties for fills as identified in the MaineDOT Standard Specifications.[15]

Table 7-1 provides lateral earth pressure coefficients for subsurface and fill soils. For a non-yielding, stiff structure like the box culvert and wingwall system proposed for this project, an at-rest lateral earth pressure coefficient of 0.47 for Granular Borrow is recommended for design.

Table 7-1: Recommended Geotechnical Design Parameters for In Situ Soils and Construction Fills

Soil Layer		γ (pcf)	ϕ (°)	Lateral Earth Pressure Coefficients[1]		
				K_0	K_a	K_p
In Situ Materials	Existing Fill	125	32	0.47	0.31	6.1
	Presumpscot Silt	120	31	0.48	0.32	5.6
	Presumpscot Clay	119	30	0.50	N/A	N/A
	Glacial Till	135	32	0.47	0.31	6.1
Construction Materials	Asphalt	140	N/A	N/A	N/A	N/A
	Granular Borrow (Section 703.19)	125	32	0.47	0.31	6.6
	Gravel Borrow	135	36	0.41	0.26	9.6

[14] State of Maine Department of Transportation, Thorne Brook Bridge, Route 17, Augusta, Kennebec County Route (Sheets 1 - 16), Dated 11/2023 (WSP Draft plans).

[15] MaineDOT Standard Specifications, March 2020. https://www.maine.gov/mdot/contractors/publications/standardspec/docs/2020/2020%20Standard%20Specification.pdf

Soil Layer		γ (pcf)	ϕ (°)	Lateral Earth Pressure Coefficients[1]		
				K_0	K_a	K_p
	(Section 703.20)					
	Special Fill (Stream Bed) (Section 203.33)	135	N/A	N/A	N/A	N/A
	Stream Channel Rock	140	N/A	N/A	N/A	N/A
	Riprap (Section 703.26)	140	42	N/A	N/A	N/A

Notes: [1]Lateral earth pressure coefficients were determined using Rankine method for K_a and using AASHTO LRFD[16] Figure 3.11.5.4-1 for K_p. The term N/A indicates these parameters are not used in our evaluations.

7.2 Culvert and Wingwall Design Recommendations

Culvert & Inlet Wingwalls

WSP evaluated the bearing resistance of the underlying soils for the proposed culvert and inlet wingwalls. We recommend a strength limit state bearing resistance factor of 0.45 and a strength limit state factored bearing resistance of 2.3 ksf be used for design. We recommend a service limit state bearing resistance factor of 1.0 and a factored presumptive bearing resistance of 2.0 ksf for the service limit state to limit settlement to 1 inch. These factored bearing resistances exceed the estimated bearing pressure of 1.6 ksf at the base of the proposed culvert that WSP determined as part of our settlement analysis.

We additionally evaluated the subgrade modulus for the proposed culvert using the corrected SPT N-values for the Presumpscot clay at the proposed culvert bearing elevation. We recommend a modulus of subgrade reaction of 6 pci (pounds per cubic inch) be used for structural design of the proposed culvert.

Outlet Wingwalls

We evaluated bearing resistance of the underlying soils for the proposed wingwalls on the outlet side of the proposed culvert. Bearing resistance for the eccentrically loaded wingwall footings was determined for nine (9) effective footing areas, with effective footing lengths of 10 feet, 12 feet, and 14 feet at the outlet and effective footing widths of 6 feet, 8 feet, and 10 feet. We recommend the following:

- A strength limit state bearing resistance factor of 0.45 and a strength limit state factored bearing resistance of 1.7 ksf to 1.9 ksf depending on the final effective footing length (10 feet to 12 feet) and width (6 feet to 10 feet) selected. The recommended strength limit state bearing resistance values are summarized in Table 7-2 for the wingwall lengths provided.[14]
- A strength limit state sliding resistance factor of 0.90 for precast concrete on sand or 0.80 for cast-in-place concrete on sand per Table 10.5.5.2.2-1 of AASHTO LRFD.[16]
- A service limit state bearing resistance factor of 1.0. The factored presumptive bearing resistance for the service limit state (limiting settlement to 1 inch) is 2.0 ksf at the outlet wingwalls.
- A coefficient of friction (tan δ) of 0.36 for formed or precast concrete on the Granular Borrow for Underwater Backfill as recommended per Table C3.11.5.3-1 of AASHTO LRFD.[16]

[16] AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020.

- Wingwalls be founded at least 4 feet bgs to accommodate the frost susceptibility of the bearing stratum.

Table 7-2: Summary of Nominal and Factored Bearing Resistance at Proposed Culvert Wingwalls

Wingwall Location	Effective Footing Length (ft)	Effective Footing Width (ft)	Effective Footing Area (ft^2)	Nominal Bearing Resistance (ksf)	Factored Bearing Resistance (ksf)
Outlet	10	6	60	4.0	1.8
		8	80	4.1	1.9
		10	100	4.3	1.9
	11	6	72	3.9	1.8
		8	96	4.0	1.8
		10	120	4.1	1.9
	12	6	84	3.9	1.7
		8	112	4.0	1.8
		10	140	4.1	1.8

7.3 Settlement

We estimate a net increase in effective stress will occur in the soils below the proposed culvert following installation and roadway reconstruction compared to present stress conditions. We evaluated settlement below the culvert in two locations along the culvert centerline: 1) where the Presumpscot Silt is thickest, 8.8 feet south of Sta. 115+26 and 2) where the Presumpscot Clay is thickest, 9.5 feet north of Sta. 115+26. We considered elastic settlement of fine-grained Presumpscot silt and coarse-grained glacial till and primary consolidation settlement for the fine-grained Presumpscot clay. The loads imposed by the proposed culvert and roadway fills were distributed through the subsurface soils using Boussinesq stress distribution theory for the given geometry. The subsurface soils were then discretized into layers less than 10 feet thick, and the effective stress, imposed stresses and other soil parameters were used to evaluate settlement within each layer. We estimated material properties for the cohesionless layers from the SPT N_{60} values (see Appendix A boring logs) and used the Hough Method to estimate immediate settlement in the Presumpscot silt and glacial till. Material properties for the Presumpscot clay layer were based on results from one-dimensional consolidation laboratory tests performed on BB-ATB-102 Shelby tubes and summarized in Table 5 and a correlated field vane shear test overconsolidation ratio (OCR) of 1.4. Consolidation theory was used to estimate primary consolidation settlement.

We estimate settlements of less than 1 inch total settlement and differential settlement of not exceeding 0.3 inches along the approximately 18-foot width of the culvert at the locations evaluated. Where Presumpscot silt is thickest at Sta. 115+26 offset 8.8 feet to the south, we estimate 0.8 inches of settlement and where Presumpscot clay is thickest at Sta. 115+26 offset 9.5 feet to the north, we estimate 0.5 inches of settlement.

Because the proposed final roadway embankment profile at this location is similar to the existing embankment configuration, we did not evaluate settlement at other locations along the culvert alignment. We expect limited settlement may occur in these areas due to construction activities.

7.4 Global Stability

WSP evaluated global stability transverse to RT 17 for a section with the greatest change in embankment geometry, specifically the northern slope at Station 116+25 west of the proposed box culvert. We performed the analyses using the two-dimensional limit equilibrium modeling software *Slide2* by Rocscience[17] for existing and post-construction static conditions. The embankment geometry is from the existing and proposed grades shown on the draft PDR plans[14] and subsurface stratigraphy is from the ISP (Figure 3).

We analyzed global stability using the Spencer method with auto refined search for circular failure surfaces and the Spencer Method with a Cuckoo search plus surface altering optimization for non-circular failure surfaces. The search algorithm that produced a lower factor of safety was selected, and the analyses show that non-circular surfaces govern potential slope failures. Per the MaineDOT Bridge Design Guide[18] Section 5.9.2, we used a minimum allowable design factor of safety (FS) of 1.3 for embankments to assess satisfactory global stability.

Results are summarized in Table 7-3. The existing embankment geometry at the north slope produced adequate FS values. The proposed embankment geometry for north slope produced FS values that meet the minimum allowable design FS for both granular borrow and gravel borrow.

Table 7-3: Summary of Global Stability Factors of Safety for Embankment at Sta. 116+25

Effective Footing Width (ft)	Effective Footing Area (ft^2)	Nominal Bearing Resistance (ksf)	Factored Bearing Resistance (ksf)
Circular (Right)	North Slope	Existing	1.56
Non-Circular (Right)	North Slope	Existing	1.51
Circular (Right)	North Slope	Proposed 2:1 slope geometry Fill with Granular Borrow	1.29
Non-Circular (Right)	North Slope		1.29
Circular (Right)	North Slope	Proposed 2:1 slope geometry Fill with Gravel Borrow	1.36
Non-Circular (Right)	North Slope		1.36

8.0 CONSTRUCTION CONSIDERATIONS

At the writing of this report, the sequence of the work and considerations for water diversion are unknown. However, construction activities will require soil excavation to below both the water table encountered during the geotechnical site investigation and the stream water level. Construction may require cofferdams and temporary earth support systems to support culvert and stream bed excavations and to control water flow. The design and maintenance of any temporary earth support systems must consider the weak nature of the subsurface Presumpscot silts and clays. The design of all temporary earth support systems should comply with Section 511 Cofferdams of the MaineDOT Standard Specifications[15] and OSHA requirements. Temporary dewatering of the stream and excavation may be required and should be performed to limit disturbance to the culvert bearing surfaces. Dewatering activities should comply with Section 656 Temporary Soil Erosion and Water Pollution

[17] Rocscience Inc. Slide2 software package, Version 9.027, build date February 13, 2023.

[18] Maine Department of Transportation, Bridge Design Guide, 2003 updated 2018. https://www.maine.gov/mdot/bdg/docs/BDGupdateJune2018.pdf

Control of the MaineDOT Standard Specifications.[15] The contractor should additionally control groundwater and surface water infiltration so that construction can be completed under dry conditions.

When excavating the existing embankment for the culvert replacement, low strength, fine-grained silts and clays will be encountered. Care should be taken to minimize disturbance to these low strength soils during excavation. Low tire or track pressure machines are recommended for use when operating on these soils. Subgrade should be prepared with a smooth-edged bucket to minimize disturbance. Where groundwater is encountered during subgrade excavation, the Contractor should provide temporary dewatering of subgrade excavations such that fill or structure placement is performed in the dry. Vibratory compaction equipment should not be used on these soils, as they have the potential to liquefy in the short term and experience vibration-induced settlements in the long-term. Other aspects related to subgrade preparation should be performed in accordance with Section 203.17 of the MaineDOT Standard Specifications.

Prior to placing the box culvert and wingwalls, we recommend undercutting the foundation 12 inches and placing a separation geotextile (Section 722.04) and 12 inches of Granular Borrow for Underwater Backfill to facilitate fine grading and dewatering for the installation of the culvert. The separation geotextile should fully encapsulate the Granular Borrow for Underwater Backfill and provide sufficient overlap under the box culvert such that the when the box culvert is installed the crushed stone remains in place and does not migrate into the Presumpscot silt and clay.

Culvert bedding and backfill material should be placed systematically in horizontal layers not more than 8 inches in thickness prior to compaction, in accordance with Section 534.20 of the MaineDOT Standard Specifications. Cobbles larger than 4 inches should be removed from the fill prior to placement, in accordance with Section 534.02 of the MaineDOT Standard Specifications. Compaction equipment should preferably consist of large, self-propelled rollers. Hand-guided equipment, such as a small vibratory plate compactor, should be used within five feet of the box culvert structure as well as over the top until it is covered with at least 12 inches of backfill, in accordance with Section 534.20. Where hand-guided equipment is used, the loose lift thickness shall not exceed 6 inches. Culvert backfill material should consist of Granular Borrow for Underwater Backfill (MaineDOT Standard Specification Section 703.19) in accordance with Section 534.02 of the MaineDOT Standard Specifications.

Culvert bedding and backfill material should be compacted to a dry density of no less than 92% of the maximum dry density determined in accordance with AASHTO T-180, Method C. Embankment material placed beyond the limits of the culvert Granular Borrow bedding and backfill should be compacted in accordance with the applicable subsections of Section 203, Excavations and Embankment of the MaineDOT Standard Specifications,

We recommend that both the culvert inlet and outlet be armored with riprap in accordance with MaineDOT Standard Details[19] and Standard Specifications[15]. We recommend the inlet and outlet include a 2-foot thick by 10-foot long Plain Riprap Apron (Detail 610(04)) comprised of Plain Riprap (Section 703.26) capped with a 2-foot-thick layer of Special Fill (Item No. 203.33, which will be specified later in a Special Provision). The riprap slope will be underlain by a Class 1 non-woven erosion control geotextile meeting the requirements of Section 722.03. The erosion control geotextile should encapsulate the riprap and extend up the sides of the embankment cut to prevent migration of the riprap into the Presumpscot clay.

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[19] MaineDOT Standard Details, March 2020. https://www.maine.gov/mdot/contractors/publications/standarddetail/docs/2020/2020-STANDARD_DETAILS.pdf

9.0 REPORT AND EXPLORATION LIMITATIONS

This Preliminary Geotechnical Design Report (PGDR) was prepared for the exclusive use of MaineDOT for specific application to the proposed replacement of the culvert that passes RT 17 over Thorne Brook in Augusta, Maine. We conducted our evaluations and compiled our recommendations in accordance with generally accepted soil and foundation engineering practices in this geographical area and under similar time and financial constraints. WSP makes no other warranty, either express or implied. If changes in the nature, design, or location of the proposed project are planned, WSP should be notified to review the appropriateness of our conclusions and recommendations, and to modify the recommendations as appropriate to reflect the changes in design. In addition, WSP should review the final plans and specifications to evaluate compliance with these recommendations.

Our analyses and recommendations are based, in part, on information obtained from the referenced subsurface explorations completed at the discrete locations described in the report. Variations in the nature and extent of subsurface conditions between explorations should be expected. WSP should be notified if conditions encountered during construction vary from those described in this report so that we may re-evaluate, and if necessary, revise the recommendations made in this report.

The professional services provided by WSP for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

Signature Page

WSP USA, Inc.

Melissa E. Landon, PhD, PE
Assistant Vice President, Geotechnical Engineering

Christopher C. Benda, PE
Vice President, Geotechnical Engineering

DEB/MEL/CCB

https://wsponlinenam.sharepoint.com/sites/us-mainegeotech/shared documents/mainedot augusta thorne brook culvert/06 deliverables/win 026444.00 thorne brook pgdr wsp 20260226.docx

TABLES

Table 1: **Subsurface Exploration Locations**
Preliminary Geotechnical Design Report
Augusta Thorne Brook Bridge #2850 Replacement, Augusta, Maine
MaineDOT WIN 026444.00

Boring Designation[1,2,3]	As-Drilled Locations[4]		Existing Ground Surface Elevation[4] (feet)	Maximum Depth of Investigation (feet bgs[5])
	Northing	Easting		
BB-ATB-101	535927.675	1151115.567	184.3	68.0
BB-ATB-102	535966.6271	1151088.344	185.1	71.0

Notes:
1. Test boring locations are shown in Figure 2 - Boring Location Plan.
2. Borings were performed by Seaboard Drilling, LLC in April 2023.
3. Boring logs are presented in Appendix A.
4. As-drilled locations and elevations are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" recieved by WSP on 08/17/2023.
5. bgs = below ground surface

Prepared By: KMB
Checked By: MEL
Reviewed By: JRS

Table 2: In-Situ Vane Shear Testing Results
Preliminary Geotechnical Design Report
Augusta Thorne Brook Bridge #2850 Replacement, Augusta, Maine
MaineDOT WIN 026444.00

Test Boring Designation[1]	Ground Surface Elevation[2] (feet)	Test Number	Test Depth Below Ground Surface (feet)	Approximate Test Elevation (feet)	Vane Size[3] (mm x mm)	Undisturbed		Remolded		Sensitivity S_t[6]
						Vane Reading Torque[4] (ft-lbs)	s_u from Vane Reading[5] (psf)	Vane Reading Torque[4] (ft-lbs)	s_{u-r} from Vane Reading[5] (psf)	
BB-ATB-101	184.3	V1	21.0	163.3	65 x 130	> 44.3	> 1218	N/A	N/A	-
		V2	26.0	158.3	65 x 130	25	688	6	165	4.2
		V3	27.0	157.3	65 x 130	22	605	5	138	4.4
		V4	31.0	153.3	65 x 130	19	523	4	110	4.8
		V5	32.0	152.3	65 x 130	23	633	6	165	3.8
		V6	46.0	138.3	65 x 130	30	825	8	220	3.8
		V7	47.0	137.3	65 x 130	29	798	7	193	4.1
BB-ATB-102	185.1	V1	26.0	159.1	65 x 130	42	1155	9	248	4.7
		V2	27.0	158.1	65 x 130	33	908	6	165	5.5
		V3	36.0	149.1	65 x 130	26	715	8	220	3.3
		V4	37.0	148.1	65 x 130	22	605	5	138	4.4
		V5	41.0	144.1	65 x 130	23	633	6	165	3.8
		V6	42.0	143.1	65 x 130	23	633	6	165	3.8
		V7	51.0	134.1	65 x 130	27	743	7	193	3.9
		V8	52.0	133.1	65 x 130	28	770	8	220	3.5
		V9	56.0	129.1	65 x 130	30	825	10	275	3.0
		V10	57.0	128.1	65 x 130	33	908	8	220	4.1

Notes:
1. Test boring locations are shown in Figure 2 - Boring Location Plan.
2. As-drilled elevations for borings BB-ATB-101 & BB-ATB-102 are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" received by WSP on August 17, 2023.
3. Geonor Rectangular Vane, mm = millimeters
4. Raw torque readings are presented as ft-lbs for the 65 x 130 mm vane.
5. s_u and s_{u-r} are the calculated peak and remolded undrained shear strengths, respectively. Conversion from torque readings to shear strengths are based on data from Geonor. For the 65 x 130 mm vane, 1 ft-lb of torque corresponds to 27.5 psf.
6. Sensitivity, $S_t = s_u/s_{u-r}$
7. Vane shear test results are shown on the boring logs in Appendix A of the Preliminary Geotechnical Design Report.

Prepared By: ATM
Checked By: DEB
Reviewed By: JRS

Table 3: Summary of Rock Core Quality
Preliminary Geotechnical Design Report
Augusta Thorne Brook Bridge #2850 Replacement, Augusta, Maine
MaineDOT WIN 026444.00

Test Boring Designation	Core Size [in]	Existing Ground Surface Elevation[1] [ft]	Run No.	Run Midpoint Depth Below Bedrock Surface [ft]	Run Depth Below Ground Surface [ft] Start	End	Midpoint	Run Length [ft]	TCR[2] Length [ft]	TCR[2] %	RQD[3] Length [ft]	RQD[3] %	RQD[3] Designation	Physical Rock Parameters Weathering[4]	Estimated Field Strength[4]	Rock Mass Rating [RMR][5]	Lithologic, Rock Mass and Discontinuity Description
BB-ATB-101	NQ [1.875"]	184.3	R1	2.50	58.00	63.00	60.50	5.0	4.9	98%	1.5	30%	Poor	Fresh (W1)	Medium Strong (R3)	50	58 ft - 63 ft: Light grey, fine grained, medium strong (R3), fresh (W1), strongly foliated GRANOFELS AND SCHIST, discontinuities low angle to moderately dipping, closely spaced (1 3/4-in to 10 inches) tight to open, rough to very rough, average of 4 fractures per foot [MAYFLOWER HILL FORMATION, VASSALBORO GROUP].
			R2	7.50	63.00	68.00	65.50	5.0	5.0	100%	2.6	52%	Fair	Fresh (W1)	Medium Strong (R3) to Strong (R4)	52	63 ft - 68 ft: Light grey, fine grained, medium strong (R3) to strong (R4), fresh (W1), strongly foliated GRANOFELS AND SCHIST, discontinuities low angle to moderately dipping, closely spaced (3 in-9.5 in.), tight to open, rough to very rough, quartz monzonite veins, average of 3 fractures per foot. [MAYFLOWER HILL FORMATION, VASSALBORO GROUP].
BB-ATB-102	NQ [1.875"]	185.1	R1	4.80	70.00	71.00	70.50	1.0	0.3	30%	0.0	0%	Very Poor	Fresh (W1)	Medium Strong (R3)	-	70 ft - 71 ft: Light grey, fine grained, medium strong (R3), fresh (W1), strongly foliated GRANOFELS AND SCHIST, discontinuities low angle, closely spaced (up to 3-in.), fresh, open, rough to very rough, average 8 fractures per foot. [MAYFLOWER HILL FORMATION, VASSALBORO GROUP].

Notes:
1. As-drilled locations and elevations are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" received by WSP on 08/17/2023.
2. TCR = total core recovery. Total core recovery is the length of core recovered divided by the length of the run.
3. RQD = rock quality designation. RQD is the total length of intact, full diameter core pieces recovered with a length greater than or equal to twice the core diameter (i.e., length of 4 inches) measured along the core axis. The percent RQD is the total length of RQD measured versus the run length. Note that vertical discontinuities are not included in determination of RQD.
4. Weathering and Estimated Field Strength based on Tables II.4 and II.3 (respectively) in Willey, 2004 (based on ISRM, 1981).
5. Rock Mass Rating System (RMR; Bieniawski, 1989) assigns numerical ratings to six parameters, including the strength of the intact rock, the RQD, the discontinuity spacing, discontinuity conditions, groundwater conditions, and orientation of discontinuities. These ratings are summed to give the RMR value. As proposed foundations or tie-back designs are not complete, the rating adjustment for joint orientation was assigned a value of 0.
6. ft = feet, in = inches

Prepared by: KMB
Checked by: ATM
Reviewed by: JRS

Table 4: Summary of Soil Index and Classification Laboratory Testing Results
Preliminary Geotechnical Design Report
Augusta Thorne Brook Bridge #2850 Replacement, Augusta, Maine
MaineDOT WIN 026444.00

Test Boring Designation[1]	Ground Surface Elevation[2] (feet)	Sample Number[3]	Sample Depth Below Ground Surface (feet)	Approximate Sample Elevation[2] (feet)	Laboratory Testing [3,4,5,6]						Soil Classification	
					Sieve Minus No. 200[4] (%)	Moisture Content[5] (%)	Liquid Limit[6]	Plastic Limit[6]	Plasticity Index[6]	Liquidity Index[6]	AASHTO[7]	USCS[7]
BB-ATB-101	184.3	S-2	5.0 - 7.0	179.3 - 177.3	28.4	5.2	-	-	-	-	A-2-4 (0)	SM
		S-5	20.0 - 22.0	164.3 - 162.3	-	31.0	32.0	17.0	15.0	0.9	-	CL
		S-7	30.0 - 32.0	154.3 - 152.3	-	35.0	35.0	17.0	18.0	1.0	-	CL
		S-12	55.0 - 57.0	129.3 - 127.3	32.1	13.0	-	-	-	-	A-2-4 (0)	SM
BB-ATB-102	185.1	S-3	10.0 - 12.0	175.1 - 173.1	-	23.0	31.0	19.0	12.0	0.3	-	CL
		S-5	20.0 - 22.0	165.1 - 163.1	-	30.0	33.0	18.0	15.0	0.8	-	CL
		S-6	25.0 - 27.0	160.1 - 158.1	-	30.0	32.0	18.0	14.0	0.9	-	CL
		U-1	30.0 - 32.0	155.1 - 153.1	98.7	34.0	31.0	17.0	14.0	1.2	A-6 (13)	CL
		U-2	45.0 - 47.0	140.1 - 138.1	99.8	37.0	38.0	20.0	18.0	1.0	A-6 (19)	CL
		S-11	60.0 - 62.0	125.1 - 123.1	23.5	15.0	-	-	-	-	A-2-4 (0)	SM

Notes:

1. Test boring locations are illustrated in Figure 2 - Boring Location Plan.
2. As-drilled elevations for borings BB-ATB-101 & BB-ATB-102 are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" received by WSP on August 23, 2023.
3. Laboratory testing was performed by Geotesting Express of Acton, MA.
4. Particle size testing was performed in accordance with ASTM D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
5. Moisture content testing was performed in accordance with ASTM D2216, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
6. Atterberg Limits testing was performed in accordance with ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
7. AASHTO and USCS symbols were assigned based on interpreted laboratory test results provided by Geotesting Express on May 2nd, 2023 and May 16th, 2023.
8. Complete laboratory test results for soil testing are provided in Appendix C.

Prepared By: KMB
Checked By: ATM
Reviewed By: JRS

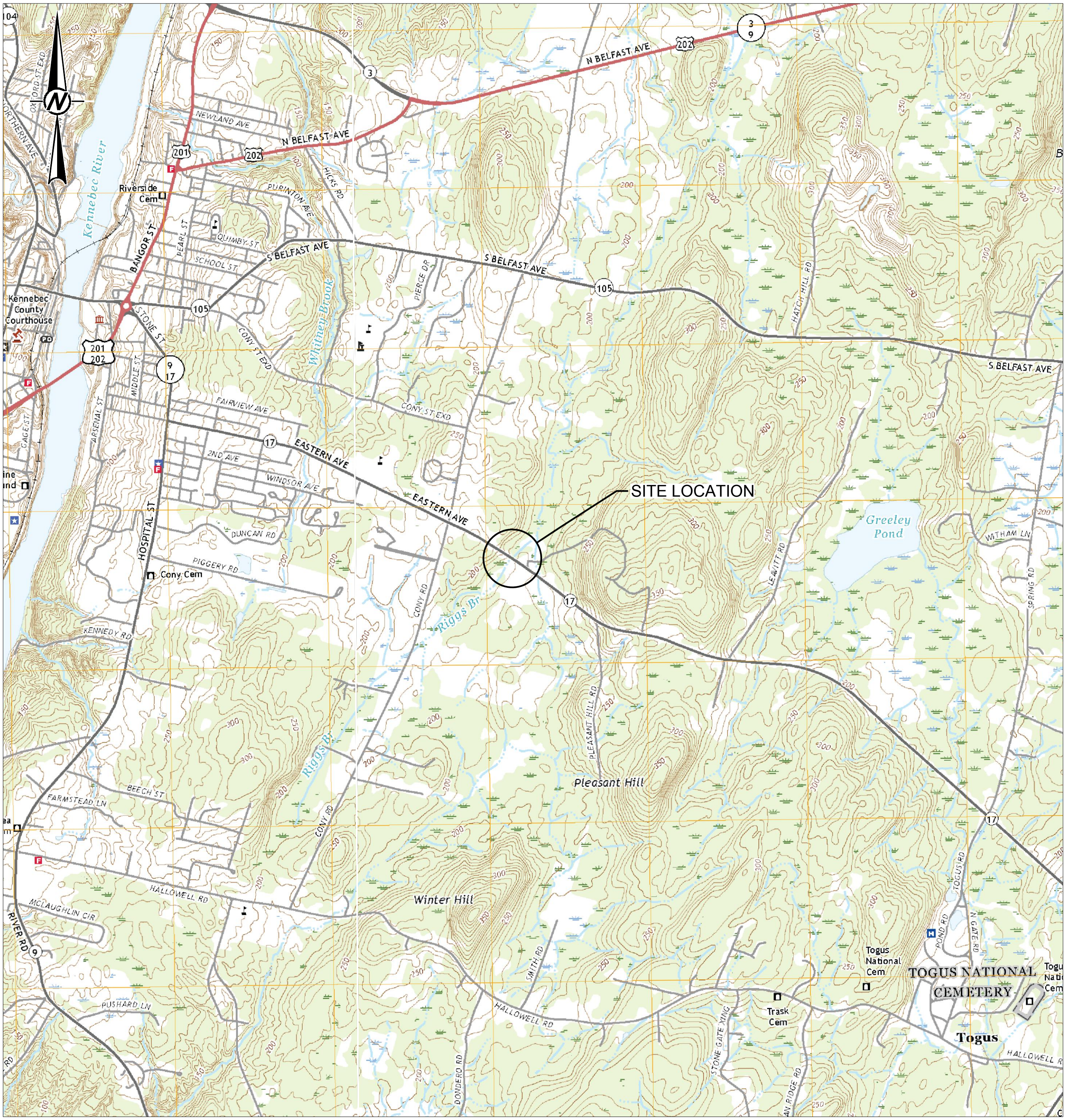
Table 5: Summary of Soil Engineering Laboratory Testing Results
Preliminary Geotechnical Design Report
Augusta Thorne Brook Bridge #2850 Replacement, Augusta, Maine
MaineDOT WIN 026444.00

Test Boring Designation[1] (-)	Ground Surface Elevation[2] (feet)	Sample Number[3] (-)	Depth Below Ground Surface (feet)	Approximate Sample Elevation (feet)	Tube X-ray (-)	Test Type[4,5] (-)	Test No. (-)	Unit Weight, γ[6] (pcf)	Void Ratio, e (-)	σ'_{v0}[7] (psf)	σ'_{vc}[8] (psf)	s_u[9] (psf)	s_u/σ'_{vc} (-)	σ'_p[10] (psf)	OCR[11] (-)	C_c[12] (-)	C_r[12] (-)	c_v[13] (ft^2/day)
BB-ATB-102	185.1	U-1	30.0 - 32.0	155.1 - 153.1	Y	ILC	IP-1	119.6	0.91	2404	-	-	-	N/A	N/A	0.14	0.012	0.020
					Y	DSS-R	DSS-1	121.0	0.87		2370	346	0.15	-	-	-	-	-
	184.1	U-2	45.0 - 47.0	139.1 - 137.1	Y	ILC	IP-2	119.1	0.92	3253	-	-	-	N/A	N/A	0.19	0.040	0.022
					Y	DSS-R	DSS-2	118.0	1.02		3190	676	0.21	-	-	-	-	-

Notes:
1. Test boring locations are illustrated in Figure 2 - Boring Location Plan.
2. As-drilled elevations for boring BB-ATB-102 are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" received by WSP on August 17, 2023.
3. Laboratory testing was performed by Geotesting Express of Acton, MA.
4. ILC = Incremental Load Consolidation, DSS-R = Direct Simple Shear - Recompression
5. DSS-R tests were performed using the recompression method, where the sample was consolidated to the estimated in-situ effective stress before shear.
6. γ = bulk unit weight. Values were measured during engineering property testing. Refer to Appendix C for more detailed laboratory results.
7. σ'_{v0} is the in situ vertical effective stress for each sample, and was estimated using the interpreted engineering profiles, average water table, and estimates or measurements of unit weight for each soil type in the profile.
8. σ'_{vc} is the vertical effective stress state at the end of consolidation, also known as the pre-shear effective stress.
9. s_u = undrained shear strength determined as the peak of the stress vs. strain plot resulting from direct simple shear (DSS) tests.
10. σ'_p is the preconsolidation stress. Values not able to be interpreted from the data, no apparent initial recompression slope on consolidation curve.
11. Overconsolidation ratio is OCR = σ'_p/σ'_{v0} for ILC tests.
12. Recompression and compression indices were determined by interpretation of stress vs. void ratio plots from ILC tests (recompression Index taken from reload).
13. Coefficient of consolidation values reported are from the ILC tests at 1 tsf applied stress during the initial loading.
14. Secondary compression and recompression indices were determined by interpretation of strain vs. log time plots from ILC test.
15. Complete laboratory test results for soil testing are provided in Appendix C.

Prepared By: DEB
Checked By: ATM
Reviewed By: JRS/MEL

FIGURES



REFERENCE(S)

BASE MAP TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLES OF AUGUSTA AND TOGUS POND, MAINE DATED 2021.

0 1500 3000
1" = 3000' FEET

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
THORNE BROOK BRIDGE No. 2850
AUGUSTA, MAINE (WIN 026444.00)

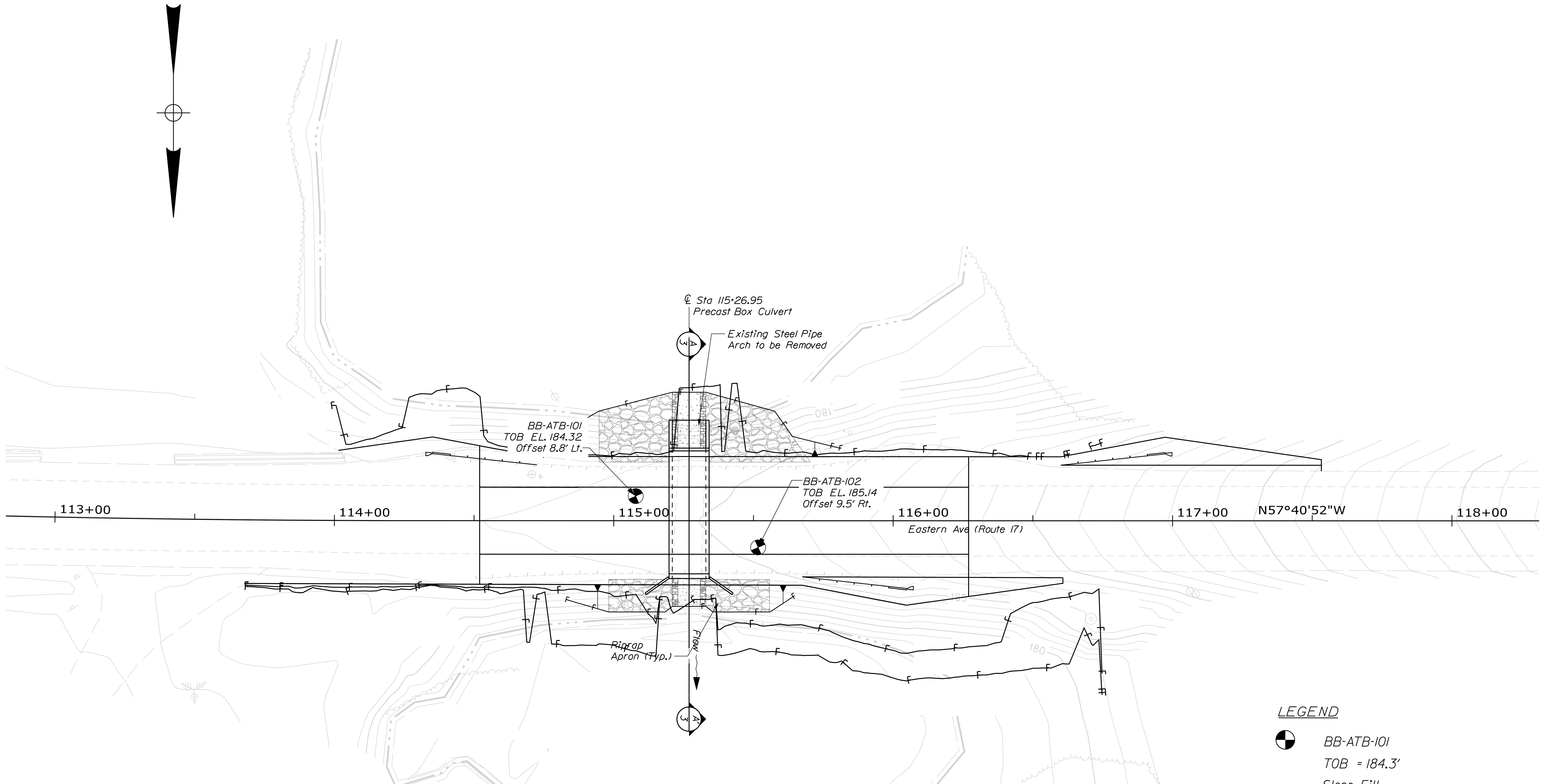
CONSULTANT

YYYY-MM-DD	2023-11-15
DESIGNED	DB
PREPARED	AM
REVIEWED	MEL
APPROVED	CCB

TITLE
SITE LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
30900914.004	0001-001	0	1

Filename: ...\BRIDGE\MSTA\00X_BorPlan.dgn   Division: BRIDGE   Username: Date:11/16/2023



BORING LOCATION PLAN

25 0 25 50

Scale of Feet

NOTES:

1. As drilled Boring Locations derived from the electronic file "CORRECTED BORINGS 17 AUG 23" provided to WSP by MaineDOT on August 30, 2023.

2. For detailed Lithologic Description See Boring Logs in Appendix A of the Preliminary Geotechnical Design Report (PGDR).

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2644(400)

BRIDGE NO. 2850

WIN
026444.00

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	B.NICHOLS	
DESIGN-DETAILED	E. CARON	W. GERHOLD	11/2023
CHECKED-REVIEWED	T. POLSON	E. CARON	11/2023
DESIGN2-DETAILED3	D. BURGESS	C. BENDA	11/2023
DESIGN3-DETAILED3		$detailer3$	
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

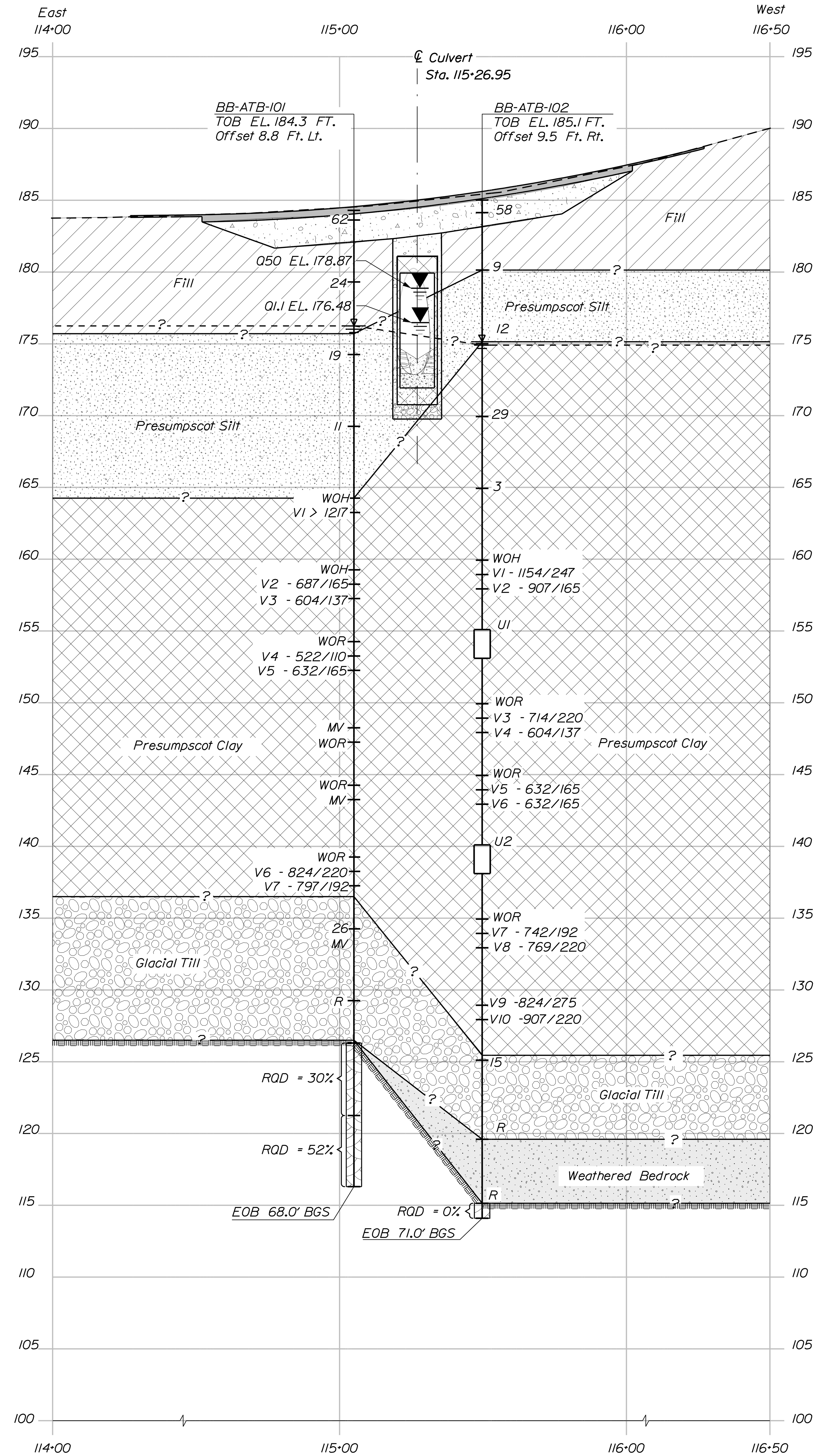
THORNE BROOK BRIDGE
ROUTE 17
AUGUSTA KENNEBEC COUNTY

BORING LOCATION PLAN

SHEET NUMBER

2

OF 3



LEGEND

- Brown, Dry, Very Dense to Medium Dense, Fine to Coarse Sand, Gravelly to Some Gravel, Little to some Silt (Fill).
- Grey to Brown and Olive, Moist To Wet, Stiff to very Stiff, Sandy Silt, Trace Clay. (Presumpscot Silt).
- Grey to Dark Grey, Wet, Stiff to Very Soft Clay, Trace Sand (Presumoscot Clay).
- Grey, Wet, Medium Dense to Very Dense, Fine to Coarse Sand, Little to Some Gravel, Trace to some Silt (Glacial Till).
- Weathered Bedrock
- Light Grey, Fine Grained, Strongly Foliated Granofels and Schist, Medium Strong to Strong, Fresh (Bedrock).
- Existing Ground Surface
- Existing Groundwater Elevations
- Interpreted Ground Water Surface At Boring Locations At The Time Of Drilling
- Design Water Level
- Boring Location I.D.
  - Elevation
  - Offset (Ft.) From ℄ of Roadway
- Top of Boring
- 30 — SPT: N60 - Value (Corrected for Hammer Efficiency)
- MV — Missed Vane
- V1 - 1154/247 — Field Vane Shear Test Location and Undrained Shear Strength (PSF) (Peak/Remolded)
- WOR — Weight Of Rod
- WOH — Weight Of Hammer
- MS — Missed Sample
- U1 Thin Wall Tube Sample
- —? — Strata Interface
- Run 1 = 92% Core Run Number and Rock Quality Designation (RQD)
- EOB — End of Boring Depth Below Ground Surface (BGS)

NOTES:

1. As drilled Boring Locations Derived from the Electronic file "CORRECTED BORINGS 17 AUG 23" Provided to WSP by MaineDOT on August 17, 2023.
2. For Detailed Lithologic Descriptions see Boring Logs in Appendix A of the Preliminary Geotechnical Design Report (PGDR).
3. For Complete Laboratory Data, see Laboratory Results in Appendix C of the Preliminary Geotechnical Design Report (PGDR).
4. Groundwater Surface is Interpreted from Localized Water Levels and Measurements Taken During the Subsurface Exploration Program, see the Preliminary Geotechnical Design Report (PGDR) and Boring Logs in Appendix A.
5. This Generalized Subsurface Profile is Intended to Convey Trends in Subsurface conditions. The Boundaries between Strata are Approximate and Idealized and have been Developed based on Interpretations of Widely Spaced Explorations. Actual Soil and Rock Transitions may vary and may be Erratic.

INTERPRETIVE SUBSURFACE PROFILE

Horiz. 25 0 25 50
Vert. 5 0 5 10
SCALE

wsp

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS
WIN 026444.00
BRIDGE No. 2850

		BY	DATE
PROJ. MANAGER		B. NICHOLS	
DESIGN-DETAILED		E. CARON	W. GERHOLD	11/2023
CHECKED-REVIEWED		T. POLSON	E. CARON	11/2023
DESIGN2-DETAILED3		D. BURGESS	C. BENDA	11/2023
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE
P.E. NUMBER
DATE

THORNE BROOK BRIDGE
ROUTE 17
AUGUSTA KENNEBEC COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 3

Filename: ...\BRIDGE\MSTA\00x_GeoProfile.dgn
Division: BRIDGE
Username:
Date:2/23/2026

APPENDIX A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

MODIFIED BURMISTER SYSTEM

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

TERMS DESCRIBING DENSITY/CONSISTENCY

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

Density of Cohesionless Soils	Standard Penetration Resistance N_{60}-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) Gravelly, Sandy or Silty clays; and (3) Clayey silts. Consistency is rated according to undrained shear strength as indicated.

Consistency of Cohesive soils	SPT N_{60}-Value (blows per foot)	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$\text{RQD (\%)} = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

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

Rock Quality Based on RQD

Rock Quality	RQD (%)
Very Poor	≤25
Poor	26 - 50
Fair	51 - 75
Good	76 - 90
Excellent	91 - 100

Desired Rock Observations (in this order, if applicable):
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -tightness (tight, open, or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-101
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	184.3	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	J. Lee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	CME 850	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:40 4/10/23 - 9:10 4/11/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535927.675, E: 1151115.567	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.86	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/11	0.63 - 2.63	13-19-24-20	43	62	SSA	183.7		ASPHALT — 0.6	
										Brown, dry, very dense, gravelly fine to medium SAND, little silt, poorly-graded [FILL].	
5	2D	24/7	5.00 - 7.00	9-9-8-9	17	24				Brown, dry, medium dense, fine to coarse SAND, some gravel, some silt, poorly-graded [FILL]. Asphalt fragments at 6.5 feet bgs.	WC = 5.2% Fines = 28.4% A-2-4(0), SM
								175.8		8.5	
10	3D	24/22	10.00 - 12.00	4-6-7-7	13	19	37			Grey to brown, wet, very stiff, sandy SILT, trace clay [PRESUMPSCOT FORMATION SILT]. q_p = 3.5 ksf to 7 ksf (pocket penetrometer)	
							64				
							80				
							110				
							80				
15	4D	24/18	15.00 - 17.00	4-4-4-5	8	11	80			Olive, wet, stiff, sandy SILT, trace clay [PRESUMPSCOT FORMATION SILT]. q_p = 5 ksf to 6 ksf (pocket penetrometer)	
							98				
							85				
							105				
							116				
20	5D	24/24	20.00 - 22.00	WOH(24")	--		100	164.3		20.0 Grey, wet, stiff, CLAY [PRESUMPSCOT FORMATION CLAY].	WC = 31% LL = 32 PL = 17 PI = 15 LI = 0.9 CL
	V1			s_u > 1217 psf			104			65x130 mm vane raw torque readings: V1: Reached maximum torque 44.3 ft-lbs without failure.	
							95				
							109				
25							86				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - CME 850 with Automatic Hammer (S/N 295792)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level measured at 3.77 ft bgs at 14:30 on 4/10/2023 and 12.32 ft bgs at 7:55 on 4/11/2023.

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: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-101
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	184.3	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	J. Lee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	CME 850	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:40 4/10/23 - 9:10 4/11/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535927.675, E: 1151115.567	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.86	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	24/24	25.00 - 27.00	WOH(24")	--		64			Grey, wet, medium stiff, CLAY, interbedded silt lenses [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V2: 25/6 ft-lbs V3: 22/5 ft-lbs	
	V2			s_u = 687/165 psf			49				
	V3			s_u = 604/137 psf			54				
							43				
							33				
30	7D	24/24	30.00 - 32.00	WOR(24")	--		32			Grey to dark grey, wet, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V4: 19/4 ft-lbs V5: 23/6 ft-lbs	WC = 35% LL = 35 PL = 17 PI = 18 LI = 1 CL
	V4			s_u = 522/110 psf			35				
	V5			s_u = 632/165 psf			35				
							35				
							40				
35							51				
	MV			Would Not Push			45			Failed 65x130 mm vane, would not push to 36 ft bgs.	
	8D	24/24	37.00 - 39.00	WOR(24")	- -		49			Grey to dark grey, very soft, CLAY, frequent silt lenses [PRESUMPSCOT FORMATION CLAY].	
							52				
							51				
40	9D	24/24	40.00 - 42.00	WOR(24")	- -		49			Grey to dark grey, very soft, CLAY [PRESUMPSCOT FORMATION CLAY].	
	MV			Would Not Push			51			Failed 65x130 mm vane, would not push to 41 ft bgs.	
							55				
							54				
							60				
45	10D	24/24	45.00 - 47.00	WOR(24")	--		63			Grey to dark grey, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V6: 30/8 ft-lbs V7: 29/7 ft-lbs	
	V6			s_u = 824/220 psf			65				
	V7			s_u = 797/192 psf			55	136.3		48.0	
							84				
50							75				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - CME 850 with Automatic Hammer (S/N 295792)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level measured at 3.77 ft bgs at 14:30 on 4/10/2023 and 12.32 ft bgs at 7:55 on 4/11/2023.

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: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-101
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	184.3	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	J. Lee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	CME 850	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:40 4/10/23 - 9:10 4/11/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535927.675, E: 1151115.567	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor: 0.86		**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 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.
50	11D	24/4	50.00 - 52.00	WOR(6")-10-8-15	18	26	91			Grey, wet, medium dense, gravelly fine to coarse SAND, little silt [GLACIAL TILL]. Failed 65x130 mm vane, would not push to 51 ft bgs.	
	MV			Would Not Push			86				
							90				
							86				
							78				
55	12D	15/9	55.00 - 56.25	26-42-50/3"	R		OPEN			Grey, wet, very dense, fine to coarse SAND, some silt, little gravel [GLACIAL TILL].	WC = 13.0% Fines = 32.1% A-2-4(0), SM
								126.3		58.0	
	R1	60/59	58.00 - 63.00	RQD = 30%			NQ			Top of Bedrock at Elev. 126.3 feet. Roller bit refusal encountered at 58 feet bgs. R1: Light grey, fine grained, strongly foliated GRANOFELS and SCHIST, medium strong (R3), fresh (W1), discontinuities low angle to moderately dipping, closely spaced (1.75-10 in), tight to open, rough to very rough, average 4 fractures per foot [MAYFLOWER HILL FORMATION, VASSALBORO GROUP] Rock Mass Quality = Poor Rock Core Rate (min:sec) 58-59 ft (2:07) 59-60 ft (3:03) 60-61 ft (2:46) 61-62 ft (2:28) 62-63 ft (2:37) 98% Recovery	
60											
	R2	60/60	63.00 - 68.00	RQD = 52%							
65											
								116.3		R2: Light grey, fine grained, strongly foliated GRANOFELS and SCHIST, medium strong (R3) to strong (R4), fresh (W1), discontinuities low angle to moderately dipping, closely spaced (3-9.5 in), tight to open, rough to very rough, quartz monzonite veins, average 3 fractures per foot [MAYFLOWER HILL FORMATION, VASSALBORO GROUP] Rock Mass Quality = Fair Rock Core Rate (min:sec) 63-64 ft (2:23) 64-65 ft (3:10) 65-66 ft (3:01) 66-67 ft (3:10) 67-68 ft (3:34)	
70											
75											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - CME 850 with Automatic Hammer (S/N 295792)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level measured at 3.77 ft bgs at 14:30 on 4/10/2023 and 12.32 ft bgs at 7:55 on 4/11/2023.

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: Thorne Brook Bridge No. 2850 Replacement Location: Augusta, Maine	Boring No.: BB-ATB-101 WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	184.3	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	J. Lee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	CME 850	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:40 4/10/23 - 9:10 4/11/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535927.675, E: 1151115.567	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.86	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
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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
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WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
75										100% Recovery	
										68.0	
										Bottom of Exploration at 68.0 feet below ground surface. Boring backfilled with gravel to bottom of clay layer, bentonite chips within clay layer, gravel to bottom of pavement, and cold patch to top of pavement.	
80											
85											
90											
95											
100											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - CME 850 with Automatic Hammer (S/N 295792)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level measured at 3.77 ft bgs at 14:30 on 4/10/2023 and 12.32 ft bgs at 7:55 on 4/11/2023.

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: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-102
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	185.1	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	Mobile B-48	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:20 4/17/23 - 16:00 4/18/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535966.627, E: 1151088.344	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	10 ft bgs at 7:45 on 4/18/23
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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SSA = Solid Stem Auger
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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
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WC = Water Content, percent
LL = Liquid Limit
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PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	22/4	0.80 - 2.63	18-18-20-50/4"	38	58	SSA			ASPHALT	
								184.3		0.8 Brown, dry, very dense, gravelly fine to medium SAND, little silt, poorly-graded [FILL]. Split spoon refusal on possible cobbles.	
							30				
							18				
5	2D	24/15	5.00 - 7.00	2-2-4-4	6	9	21	180.1		5.0 Olive, moist, stiff, sandy SILT [PRESUMPSCOT FORMATION SILT].	
							19				
							54/8"				
							65				
							28			Cobbles encountered 0 to 10 feet bgs. Terminated boring at 10 feet bgs, offset 3 feet northwest, and redrilled.	
10	3D	24/20	10.00 - 12.00	1-3-5-6	8	12	29	175.1		10.0 Grey with orange mottling, wet, stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. q_p = 5 to 7 ksf (pocket penetrometer)	WC = 23% LL = 31 PL = 19 PI = 12 LI = 0.3 CL
							40				
							60				
							67				
							73				
15	4D	24/0	15.00 - 17.00	10-10-9-9	19	29	70			No recovery. Drill cuttings in wash water indicated CLAY.	
							75				
							81				
							96				
							77				
20	5D	24/24	20.00 - 22.00	1-1-1-2	2	3	54			Grey, wet, soft, CLAY [PRESUMPSCOT FORMATION CLAY]. q_p = 2 ksf (pocket penetrometer)	WC = 30% LL = 33 PL = 18 PI = 15 LI = 0.8 CL
							53				
							57				
							60				
25							50				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level reading was taken in the morning after an overnight pause in drilling with casing at 52 feet bgs.

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-102
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	185.1	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	Mobile B-48	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:20 4/17/23 - 16:00 4/18/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535966.627, E: 1151088.344	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	10 ft bgs at 7:45 on 4/18/23
Hammer Efficiency Factor:	0.91	**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
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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
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PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	24/24	25.00 - 27.00	WOH(24")	--		PUSH			Grey, wet, stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V1: 42/9 ft-lbs V2: 33/6 ft-lbs	WC = 30% LL = 32 PL = 18 PI = 14 LI = 0.9 CL
	V1			s_u = 1154/247 psf							
	V2			s_u = 907/165 psf							
30	1U	24/24	30.00 - 32.00	Piston Sampler						Grey, wet, CLAY, trace sand [PRESUMPSCOT FORMATION CLAY].	WC = 34% Fines = 98.7% LL = 31 PL = 17 PI = 14 LI = 1.2 A-6(13), CL
35	7D	24/24	35.00 - 37.00	WOR(24")	--					Grey, wet, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V3: 26/8 ft-lbs V4: 22/5 ft-lbs	
	V3			s_u = 714/220 psf							
	V4			s_u = 604/137 psf							
40	8D	24/24	40.00 - 42.00	WOR(24")	--					Grey, wet, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V5: 23/6 ft-lbs V6: 23/6 ft-lbs	
	V5			s_u = 632/165 psf							
	V6			s_u = 632/165 psf							
45	2U	24/24	45.00 - 47.00	Piston Sampler						Grey, wet, CLAY, trace sand [PRESUMPSCOT FORMATION CLAY].	WC = 37% Fines = 99.8% LL = 38 PL = 20 PI = 18 LI = 1 A-6(19), CL
50											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level reading was taken in the morning after an overnight pause in drilling with casing at 52 feet bgs.

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: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-102
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	185.1	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	Mobile B-48	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:20 4/17/23 - 16:00 4/18/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535966.627, E: 1151088.344	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	10 ft bgs at 7:45 on 4/18/23
Hammer Efficiency Factor:	0.91	**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 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.
50	9D	24/24	50.00 - 52.00	WOR(24")	--		34			Grey, wet, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V7: 27/7 ft-lbs V8: 28/8 ft-lbs	
	V7			s_u = 742/192 psf			39				
	V8			s_u = 769/220 psf			38				
							44				
							40				
55	10D	24/24	55.00 - 57.00	4-3-3-3	--		42			Grey, wet, medium stiff, CLAY [PRESUMPSCOT FORMATION CLAY]. 65x130 mm vane raw torque readings: V9: 30/10 ft-lbs V10: 33/8 ft-lbs	
	V9			s_u = 824/275 psf			40				
	V10			s_u = 907/220 psf			44				
							49				
							61	125.6		59.5	
60	11D	24/16	60.00 - 62.00	9-5-5-7	10	15	58			Increased casing and roller cone resistance encountered at 59.5 feet bgs. Grey, wet, medium dense, fine to coarse SAND, some silt, trace gravel, poorly-graded [GLACIAL TILL].	WC = 15.0% Fines = 23.5% A-2-4(0), SM
							54				
							57				
							81				
							56				
65	12D	8/8	65.00 - 65.67	32-50/2"	R		67	119.4		Grey, wet, very dense, gravelly fine to coarse SAND, trace silt, well-graded [GLACIAL TILL]. 65.7	
							89			Top of Bedrock at Elev. 119.4 feet. Weathered rock encountered at 65.7 feet bgs.	
							111				
							151				
							183				
70	R1	12/3.6	70.00 - 71.00	RQD = 0%			NQ	114.1		R1: Light grey, fine grained, strongly foliated GRANOFELS and SCHIST, medium strong (R3), fresh (W1), discontinuities low angle, closely spaced (up to 3 in), open, rough to very rough, average 8 fractures per foot [MAYFLOWER HILL FORMATION, VASSALBORO GROUP]. Rock Mass Quality = Very Poor Rock Core Rate (min:sec) 70-71 ft (1:02) 30% Recovery	
75											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level reading was taken in the morning after an overnight pause in drilling with casing at 52 feet bgs.

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: Thorne Brook Bridge No. 2850 Replacement
Location: Augusta, Maine

Boring No.: BB-ATB-102
WIN: 026444.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	185.1	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	Mobile B-48	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	8:20 4/17/23 - 16:00 4/18/23	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 535966.627, E: 1151088.344	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	10 ft bgs at 7:45 on 4/18/23
Hammer Efficiency Factor:	0.91	**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 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.
75										71.0 **Bottom of Exploration at 71.0 feet below ground surface.** Boring terminated due to core barrel damage. Backfilled with bentonite chips to 10 feet bgs, gravel to bottom of pavement, and cold patch to top of pavement.	
80											
85											
90											
95											
100											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geoscience Testing and Research Inc., dated 11/4/2022.
2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv".
3. Water level reading was taken in the morning after an overnight pause in drilling with casing at 52 feet bgs.

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.

Boring No.: BB-ATB-102

APPENDIX B

Rock Core Photographs

APPENDIX B
ROCK CORE PHOTOGRAPHS
THORNE BROOK CULVERT REPLACEMENT BRIDGE #2870, AUGUSTA, MAINE
MAINEDOT WIN 026444.00

Boring	Run	Depth Below Surface Feet			Recovery Feet			Recovery %	RQD Feet			RQD %	Rock Type	Box Row	Date Cored
BB-ATB-101	R1	58.0	-	63.0	4.9	/	5.0	98	1.5	/	5.0	30	GRANOFELD AND SCHIST	1	4/10/2023
	R2	63.0		68.0	5.0	/	5.0	100	2.6	/	5.0	52	GRANOFELS, SCHIST AND QUARTZ MONZONITE	2	4/10/2023
BB-ATB-102	R2	70.0	-	71.0	0.3	/	1.0	30	0.0	/	1.0	0	GRANOFELS AND SCHIST	3	4/17/2023

Notes:
1. "Box row" indicates the section of the box where the core is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

Prepared By: KMB
Checked By: ATM
Reviewed By: JRS

APPENDIX C

Laboratory Test Results

Client:	WSP USA, Inc.			
Project:	ME DOT Augusta Thorne Brook Culvert			
Location:	Augusta, ME		Project No:	GTX-317121
Boring ID:	---	Sample Type: ---	Tested By:	ckg
Sample ID:	---	Test Date: 05/02/23	Checked By:	ank
Depth :	---	Test Id: 713560		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-ATB-101	S- 2	5'-7'	Moist, dark olive brown silty sand with gravel	5.2
BB-ATB-101	S- 12	55'-57'	Moist, gray silty sand	13.0
BB-ATB-102	S- 11	60'-62'	Moist, gray silty sand	15.0

Notes: Temperature of Drying : 110º Celsius

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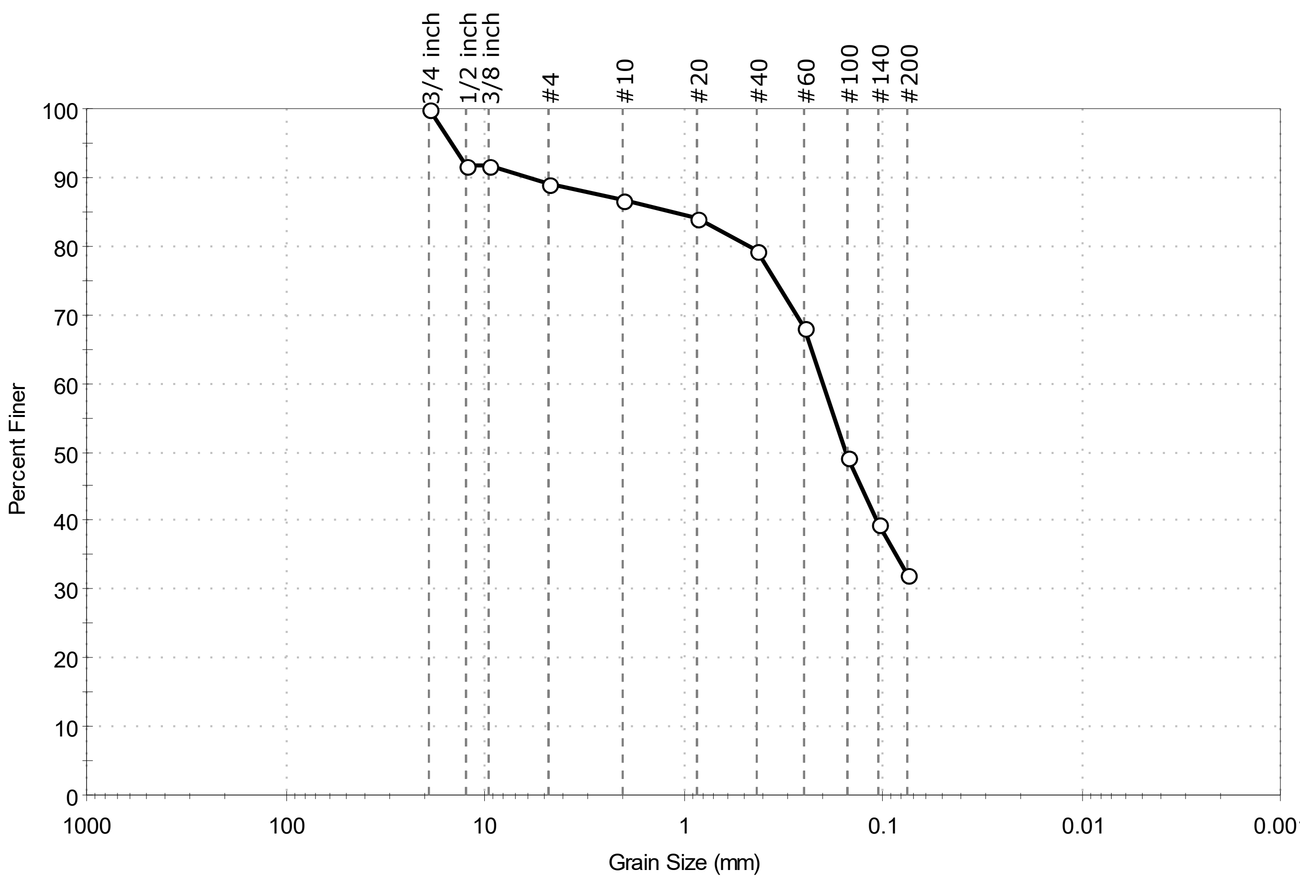
GeoTesting EXPRESS

Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-12	Test Date: 04/28/23	Checked By:	ank
Depth : 55'-57'	Test Id: 713552		
Test Comment:	---		
Visual Description:	Moist, gray silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	11.1	56.8	32.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.50	92		
3/8 inch	9.50	92		
#4	4.75	89		
#10	2.00	87		
#20	0.85	84		
#40	0.42	79		
#60	0.25	68		
#100	0.15	49		
#140	0.11	40		
#200	0.075	32		

Coefficients

D_{85} =1.1312 mm D_{30} =N/A

D_{60} =0.2010 mm D_{15} =N/A

D_{50} =0.1531 mm D_{10} =N/A

C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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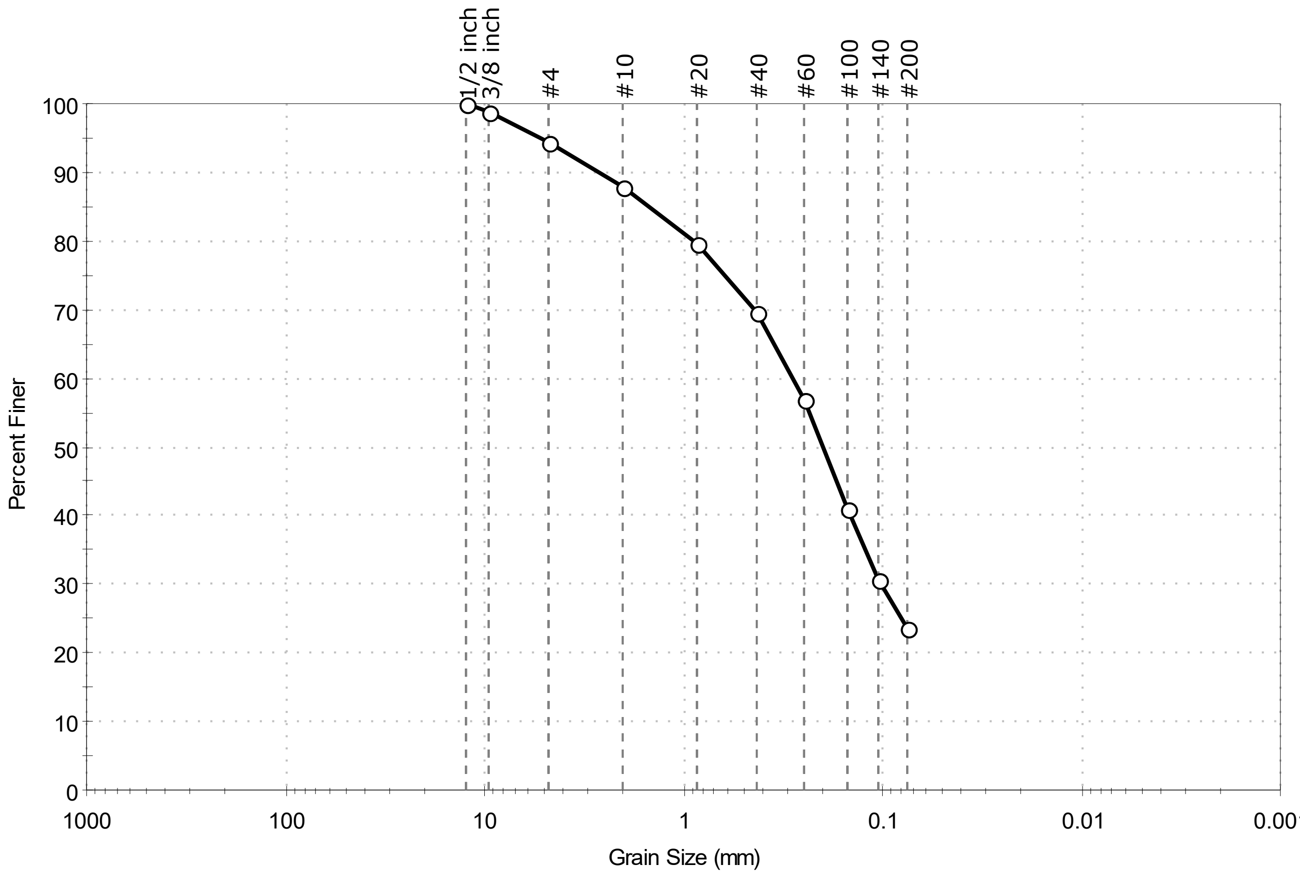
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-102	Sample Type: jar	Tested By:	ckg
Sample ID: S-11	Test Date: 04/28/23	Checked By:	ank
Depth : 60'-62'	Test Id: 713553		
Test Comment:	---		
Visual Description:	Moist, gray silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	5.7	70.8	23.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.50	100		
3/8 inch	9.50	99		
#4	4.75	94		
#10	2.00	88		
#20	0.85	80		
#40	0.42	70		
#60	0.25	57		
#100	0.15	41		
#140	0.11	31		
#200	0.075	24		

Coefficients

D_{85} =1.4750 mm | D_{30} =0.1033 mm

D_{60} =0.2853 mm | D_{15} =N/A

D_{50} =0.2008 mm | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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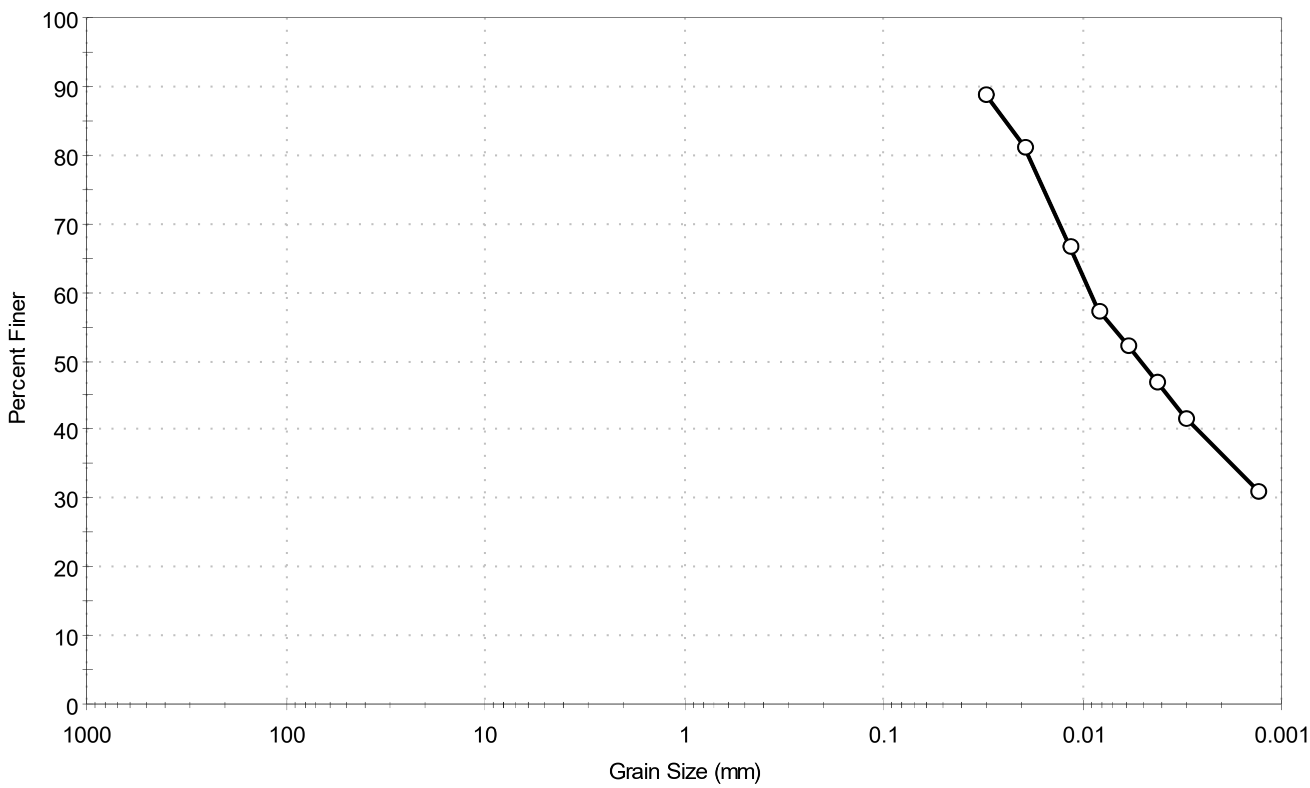
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-102	Sample Type: jar	Tested By:	ckg
Sample ID: S-6	Test Date: 05/03/23	Checked By:	ank
Depth : 25'-27'	Test Id: 713554		
Test Comment:	---		
Visual Description:	Moist, dark gray clay		
Sample Comment:	---		

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	—	—	—

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0309	89		
---	0.0196	81		
---	0.0117	67		
---	0.0085	58		
---	0.0060	52		
---	0.0043	47		
---	0.0031	42		
---	0.0013	31		

Coefficients

D_{85} =0.0242 mm D_{30} =N/A
D_{60} =0.0092 mm D_{15} =N/A
D_{50} =0.0052 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM   N/A

AASHTO   ()

Sample/Test Description

Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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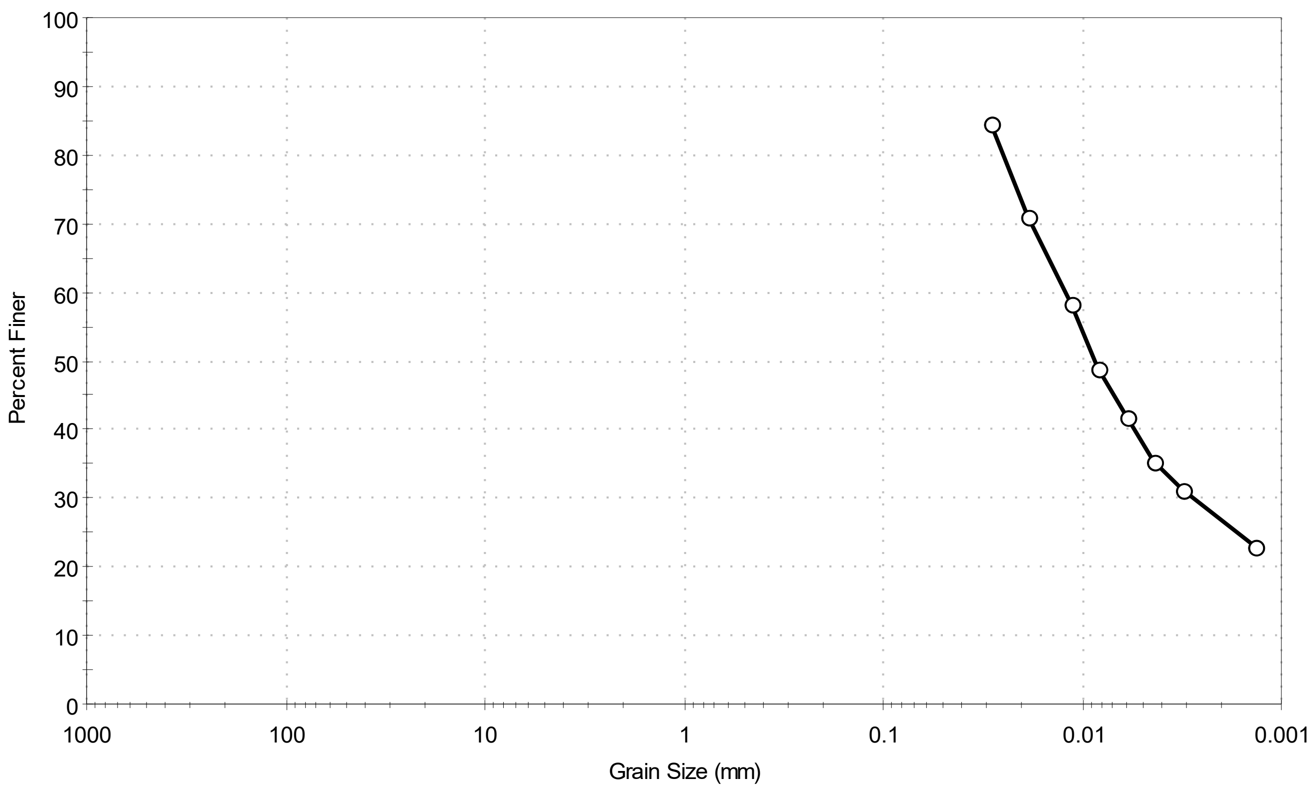
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-102	Sample Type: jar	Tested By:	ckg
Sample ID: S-3	Test Date: 05/03/23	Checked By:	ank
Depth : 10'-12'	Test Id: 713555		

Test Comment: ---
Visual Description: Moist, dark gray clay
Sample Comment: ---

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	—	—	—

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0286	85		
---	0.0189	71		
---	0.0115	59		
---	0.0084	49		
---	0.0060	42		
---	0.0044	35		
---	0.0031	31		
---	0.0014	23		

Coefficients

D_{85} =N/A | D_{30} =0.0027 mm
D_{60} =0.0122 mm | D_{15} =N/A
D_{50} =0.0086 mm | D_{10} =N/A
C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO ()

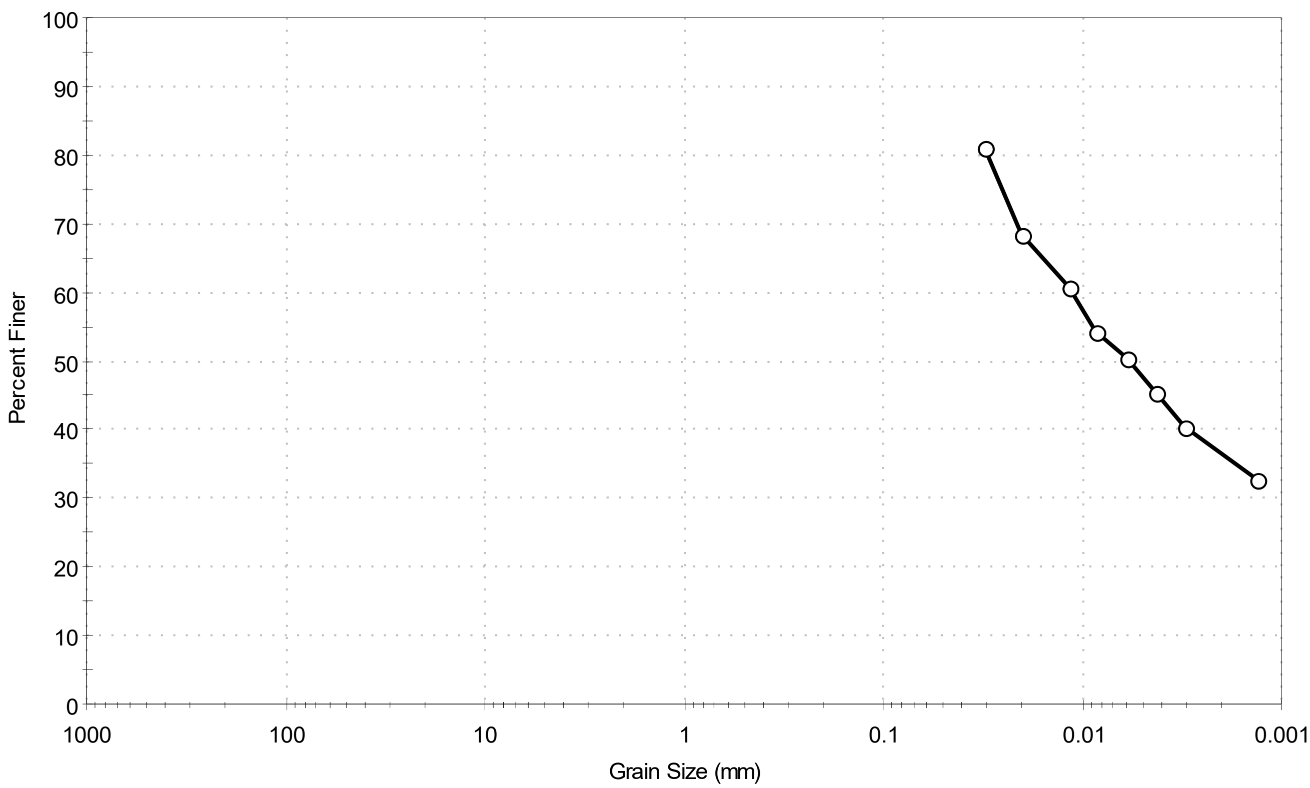
Sample/Test Description

Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

GeoTesting EXPRESS

Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-5	Test Date:	05/03/23	Checked By:	ank
Depth :	20'-22'	Test Id:	713556		
Test Comment:	---				
Visual Description:	Moist, gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	—	—	—

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0314	81		
---	0.0202	68		
---	0.0118	61		
---	0.0085	54		
---	0.0061	51		
---	0.0043	45		
---	0.0031	40		
---	0.0013	33		

Coefficients

D_{85} =N/A	D_{30} =N/A
D_{60} =0.0114 mm	D_{15} =N/A
D_{50} =0.0058 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

ASTM N/A

AASHTO ()

Sample/Test Description

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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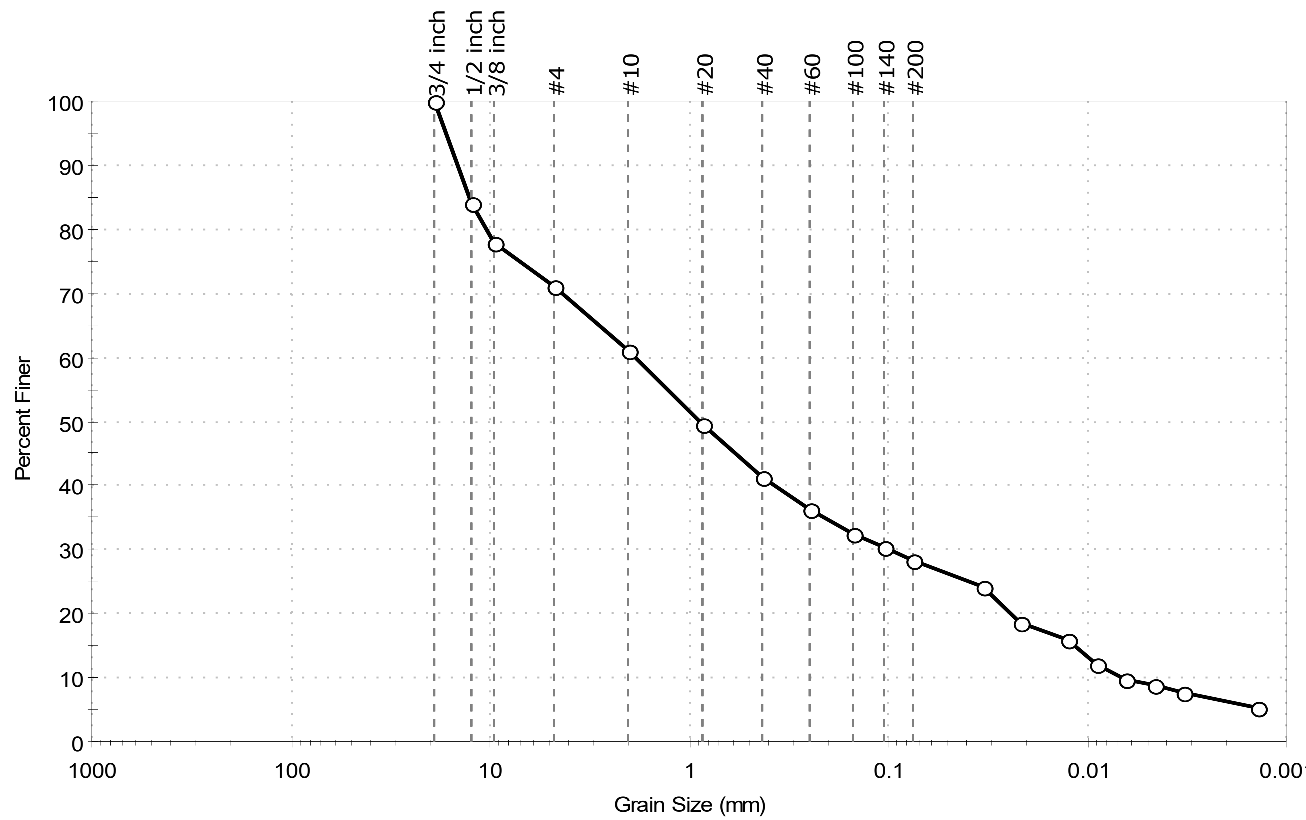
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-2	Test Date: 05/03/23	Checked By:	ank
Depth : 5'-7'	Test Id: 713557		
Test Comment:	---		
Visual Description:	Moist, dark olive brown silty sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	28.9	42.7	28.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.50	84		
3/8 inch	9.50	78		
#4	4.75	71		
#10	2.00	61		
#20	0.85	50		
#40	0.42	41		
#60	0.25	36		
#100	0.15	32		
#140	0.11	30		
#200	0.075	28		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0335	24		
---	0.0216	19		
---	0.0126	16		
---	0.0090	12		
---	0.0065	10		
---	0.0046	9		
---	0.0033	8		
---	0.0014	5		

Coefficients

D_{85} =12.8298 mm D_{30} =0.0998 mm

D_{60} =1.8528 mm D_{15} =0.0117 mm

D_{50} =0.8816 mm D_{10} =0.0067 mm

C_u =276.537 C_c =0.802

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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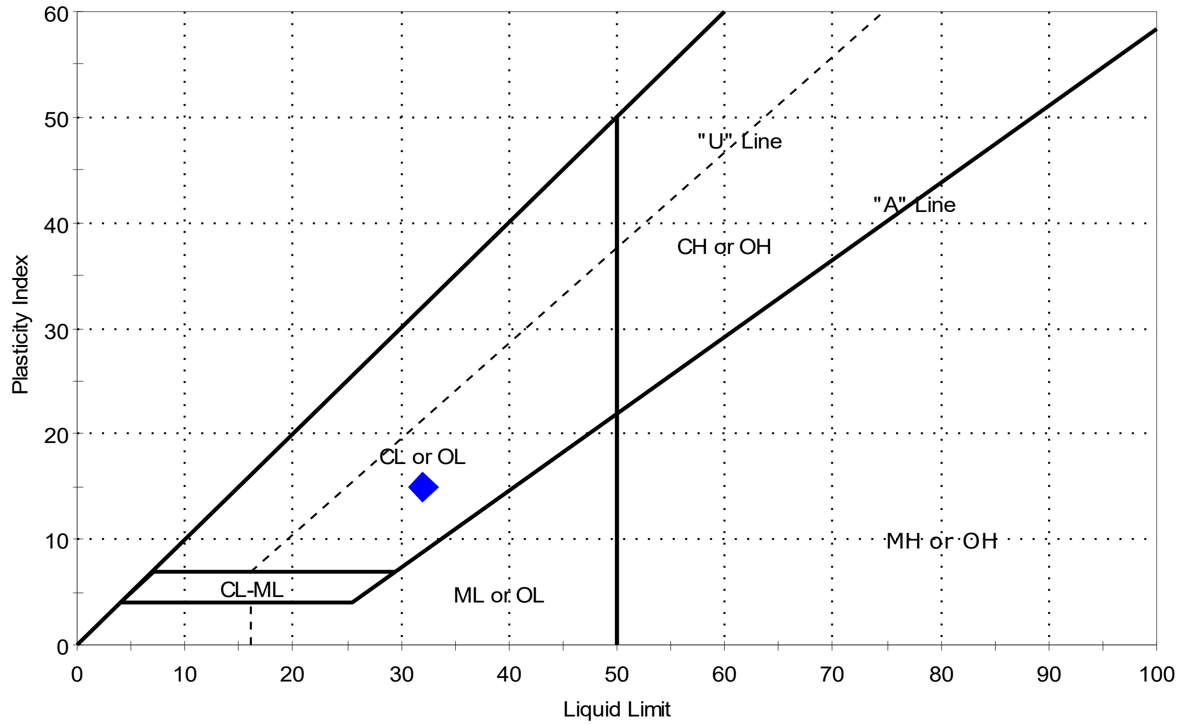
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-101	Sample Type: jar	Tested By:	GA
Sample ID: S-5	Test Date: 05/03/23	Checked By:	ank
Depth : 20'-22'	Test Id: 713546		
Test Comment:	---		
Visual Description:	Moist, dark gray clay		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



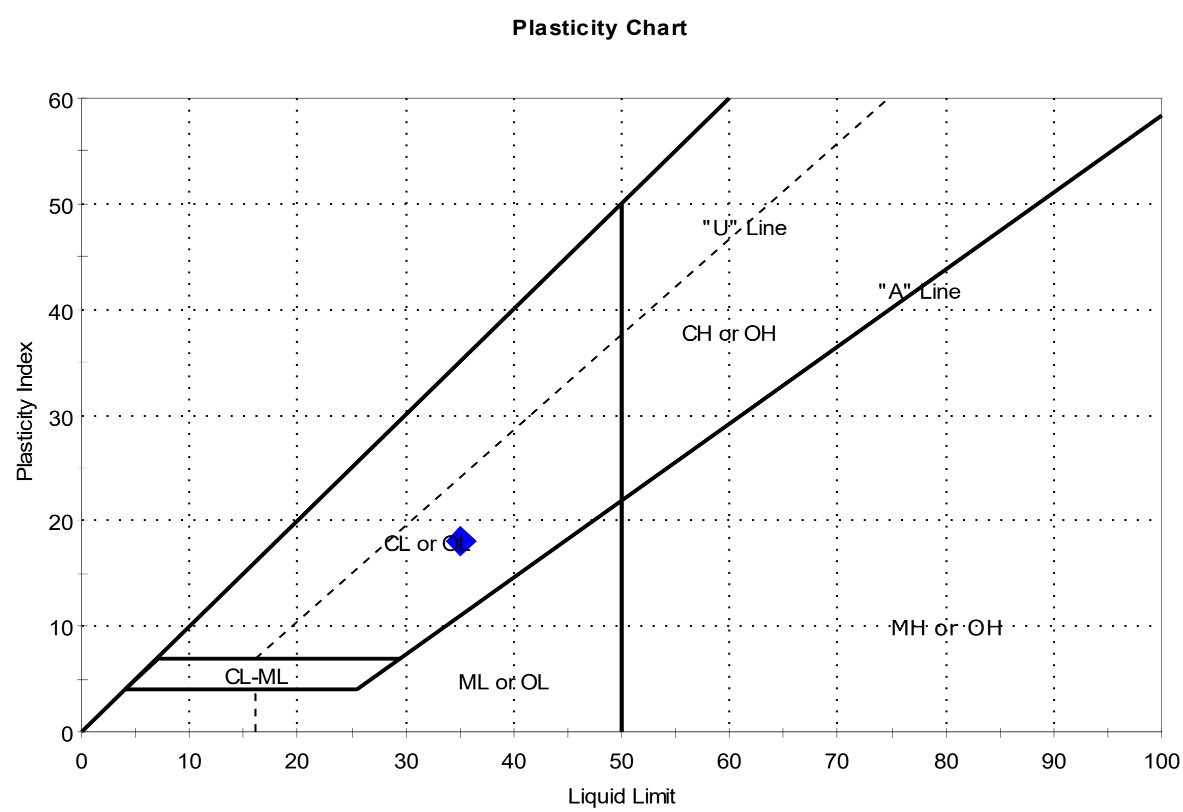
Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-5	B-ATB-10	20'-22'	31	32	17	15	0.9	

Sample Prepared using the WET method

Dry Strength: HIGH
Dilatancy: SLOW
Toughness: MEDIUM

Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-101	Sample Type:	jar	Tested By:	GA
Sample ID:	S-7	Test Date:	05/03/23	Checked By:	ank
Depth :	30'-32'	Test Id:	713547		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



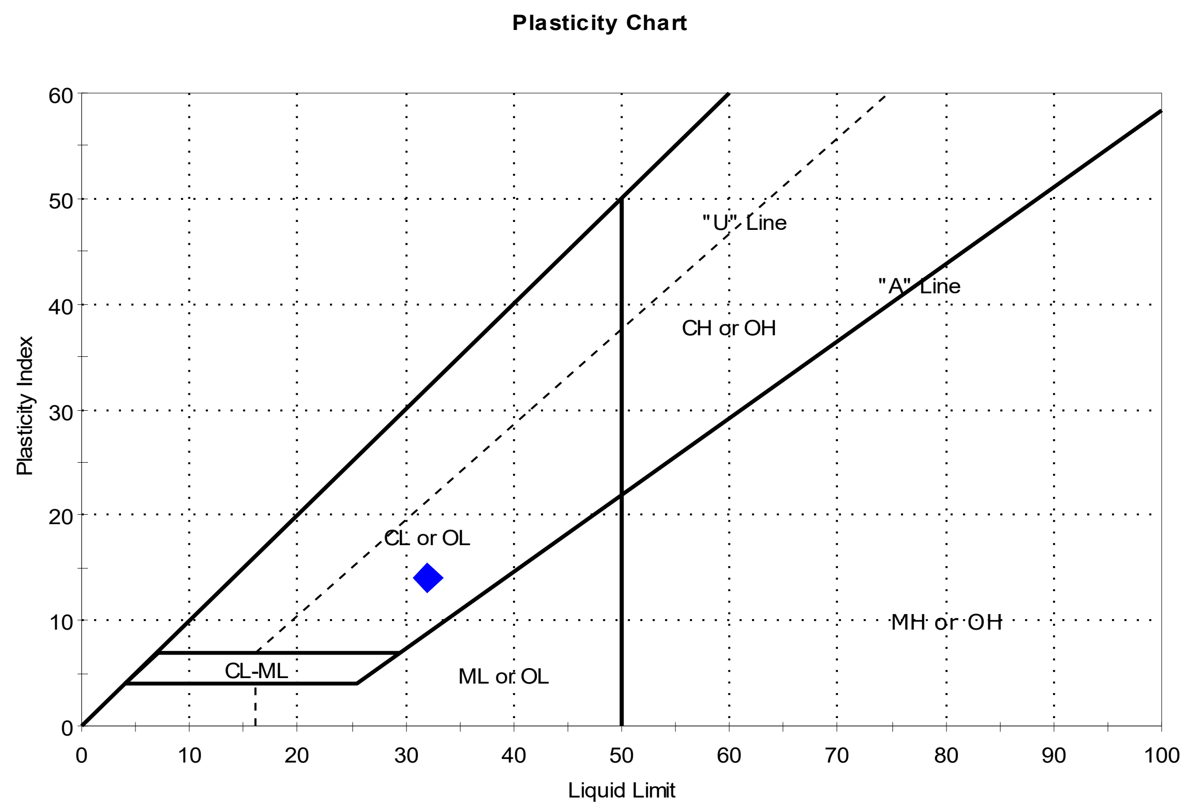
Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-7	B-ATB-10	30'-32'	35	35	17	18	1	

Sample Prepared using the WET method

Dry Strength: HIGH
Dilatancy: SLOW
Toughness: MEDIUM

Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type:	jar	Tested By:	GA
Sample ID:	S-6	Test Date:	05/03/23	Checked By:	ank
Depth :	25'-27'	Test Id:	713548		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-6	B-ATB-10	25'-27'	30	32	18	14	0.9	

Sample Prepared using the WET method

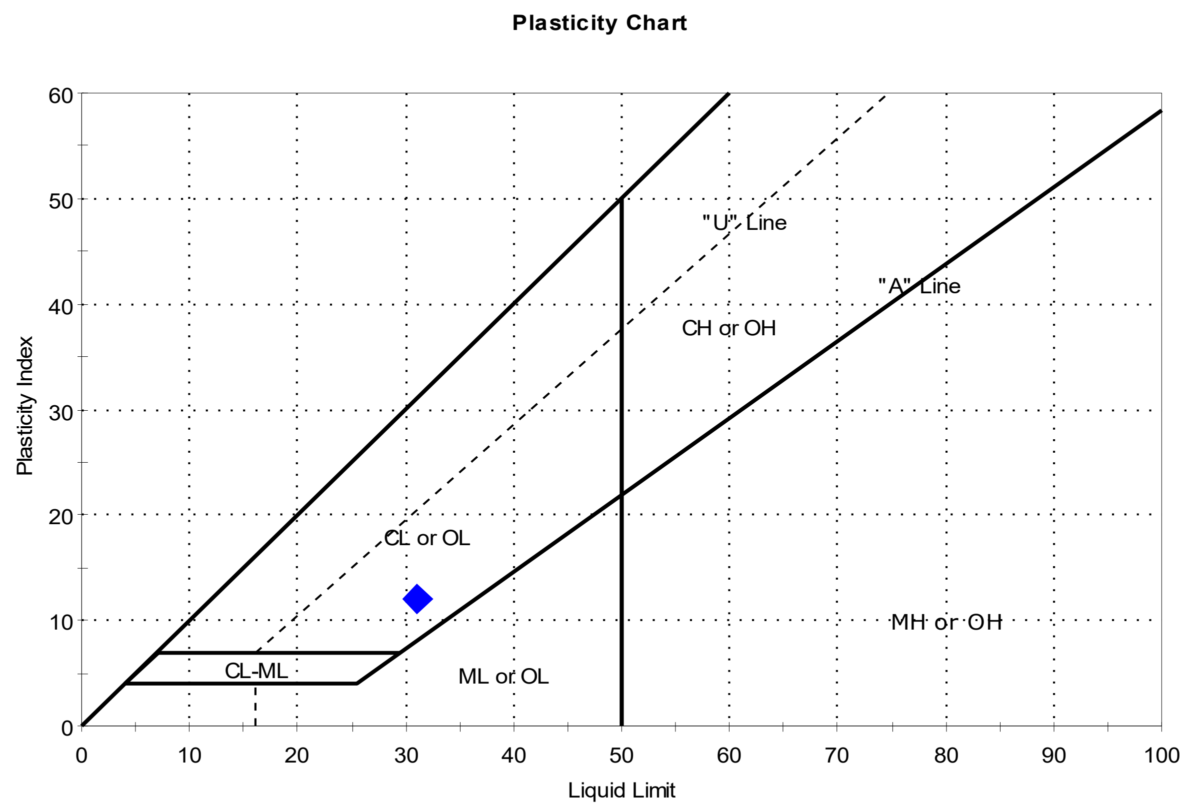
Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type:	jar	Tested By:	GA
Sample ID:	S-3	Test Date:	05/03/23	Checked By:	ank
Depth :	10'-12'	Test Id:	713549		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-3	B-ATB-10	10'-12'	23	31	19	12	0.3	

Sample Prepared using the WET method

Dry Strength: HIGH
Dilatancy: SLOW
Toughness: MEDIUM

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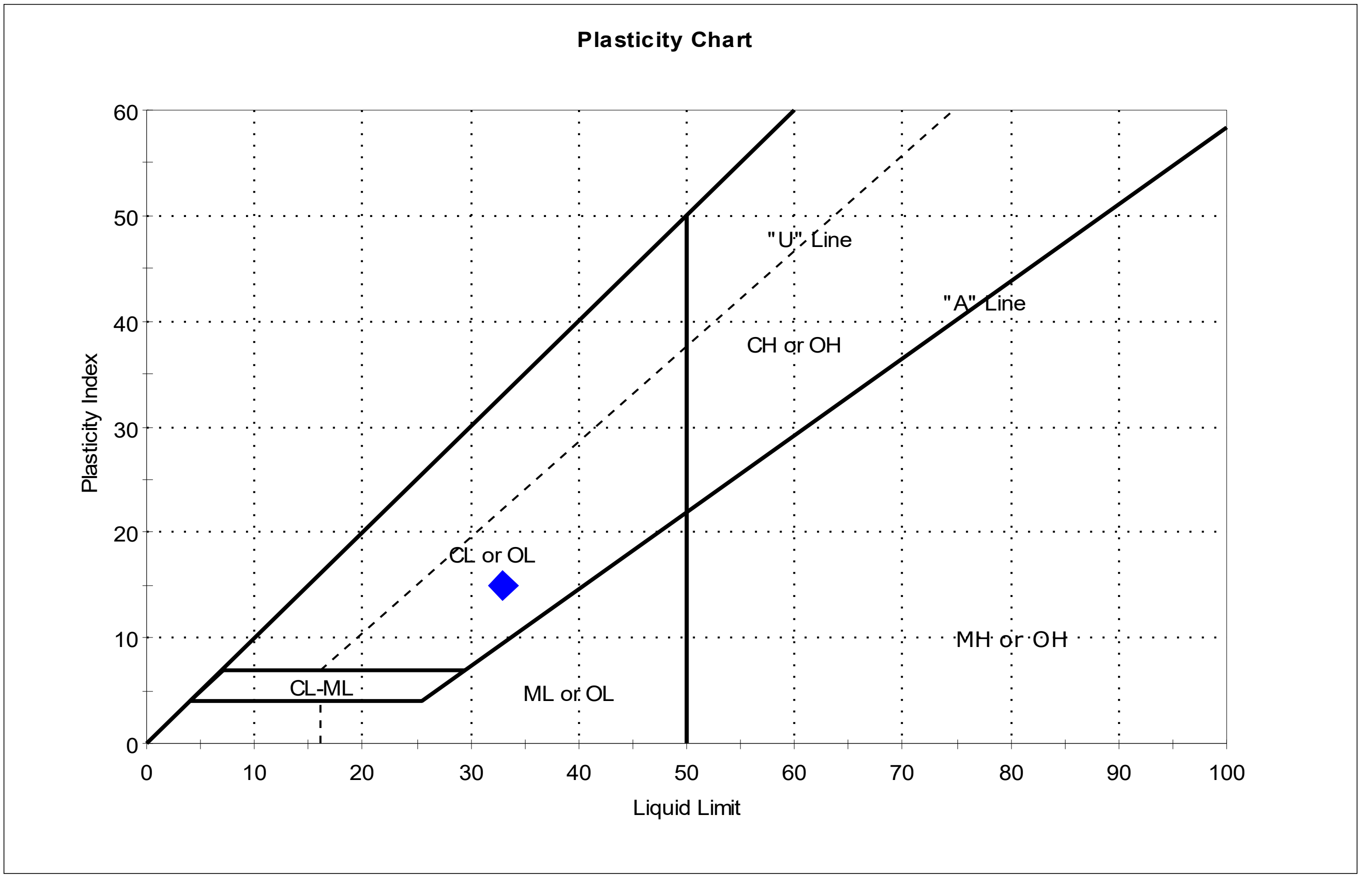
Client:	WSP USA, Inc.			
Project:	ME DOT Augusta Thorne Brook Culvert			
Location:	Augusta, ME		Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type: jar	Tested By:	GA
Sample ID:	S-5	Test Date: 05/03/23	Checked By:	ank
Depth :	20'-22'	Test Id: 713550		
Test Comment:	---			
Visual Description:	Moist, gray clay			
Sample Comment:	---			

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-5	B-ATB-10	20'-22'	30	33	18	15	0.8	

Sample Prepared using the WET method

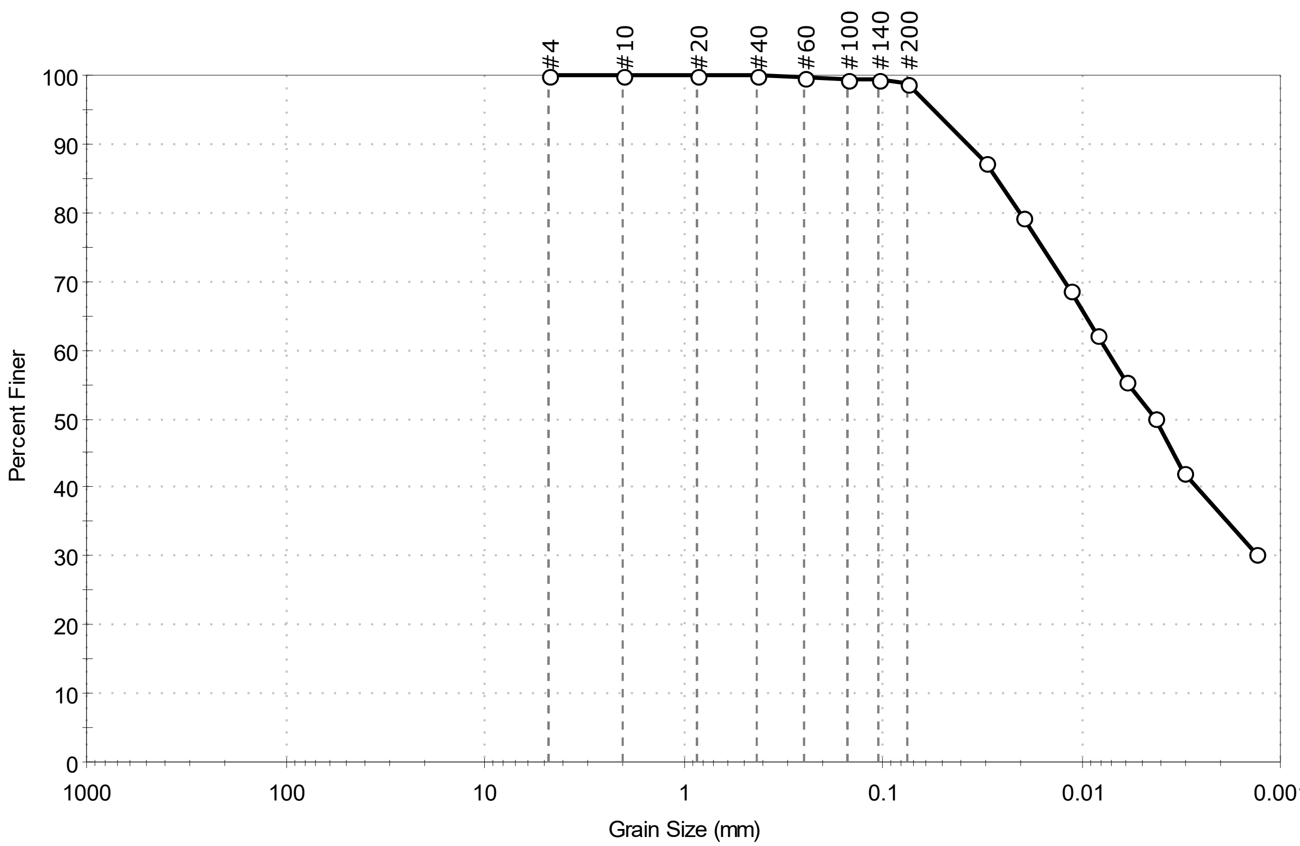
Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type:	tube	Tested By:	ckg
Sample ID:	U-1	Test Date:	05/16/23	Checked By:	ank
Depth :	30'-32'	Test Id:	714366		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	1.3	98.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	99		
#200	0.075	99		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0301	87		
---	0.0196	79		
---	0.0115	69		
---	0.0083	62		
---	0.0060	56		
---	0.0043	50		
---	0.0031	42		
---	0.0013	30		

Coefficients

D_{85} =0.0266 mm D_{30} =N/A

D_{60} =0.0075 mm D_{15} =N/A

D_{50} =0.0042 mm D_{10} =N/A

C_u =N/A C_c =N/A

Classification

ASTM   Lean CLAY (CL)

AASHTO   Clayey Soils (A-6 (13))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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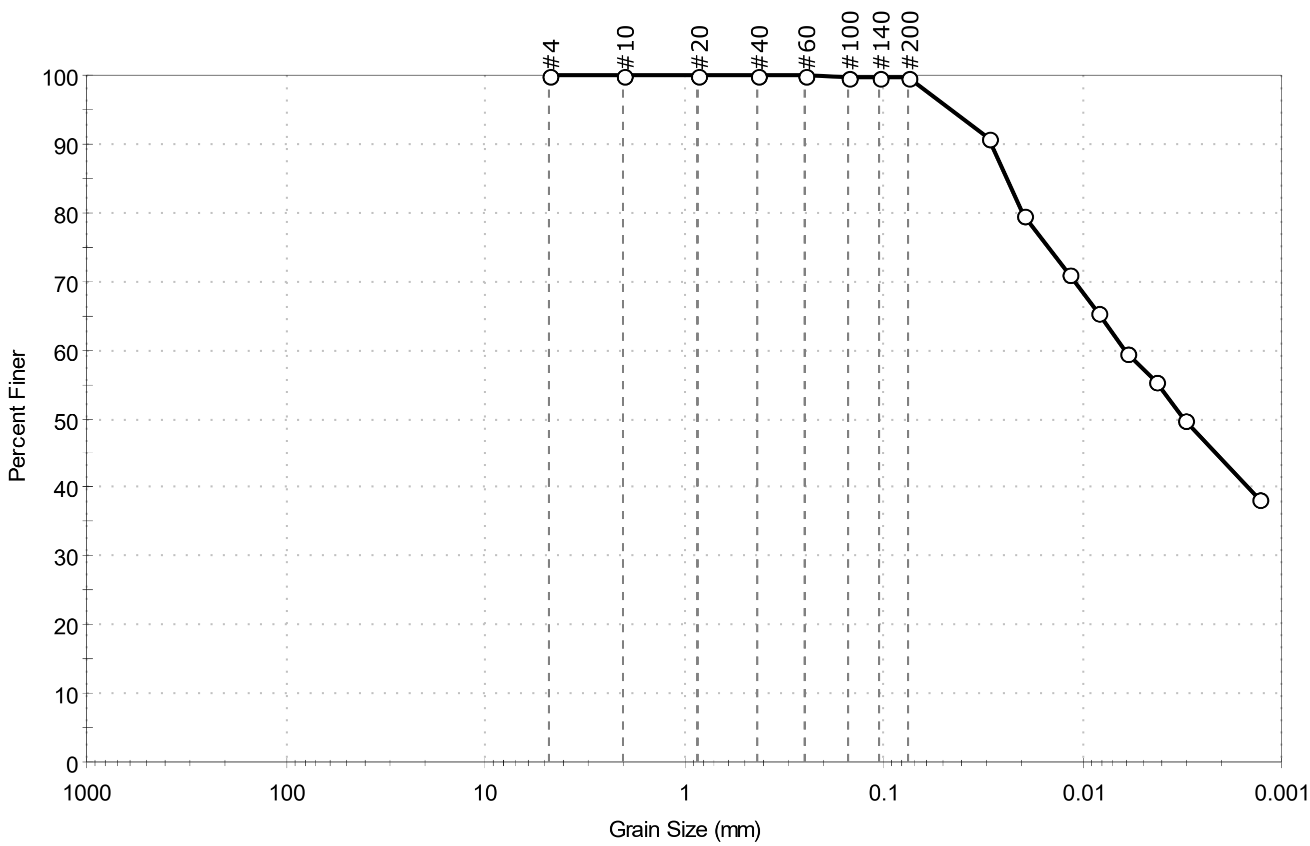
Client:	WSP USA, Inc.				
Project:	ME DOT Augusta Thorne Brook Culvert				
Location:	Augusta, ME			Project No:	GTX-317121
Boring ID:	BB-ATB-102	Sample Type:	tube	Tested By:	ckg
Sample ID:	U-2	Test Date:	05/16/23	Checked By:	ank
Depth :	45'-47'	Test Id:	714367		

Test Comment: ---
Visual Description: Moist, dark gray clay
Sample Comment: ---

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	0.2	99.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	100		
#200	0.075	100		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0296	91		
---	0.0199	80		
---	0.0117	71		
---	0.0083	65		
---	0.0060	60		
---	0.0043	55		
---	0.0031	50		
---	0.0013	38		

Coefficients

D_{85} =0.0241 mm D_{30} =N/A
D_{60} =0.0061 mm D_{15} =N/A
D_{50} =0.0031 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (19))

Sample/Test Description

Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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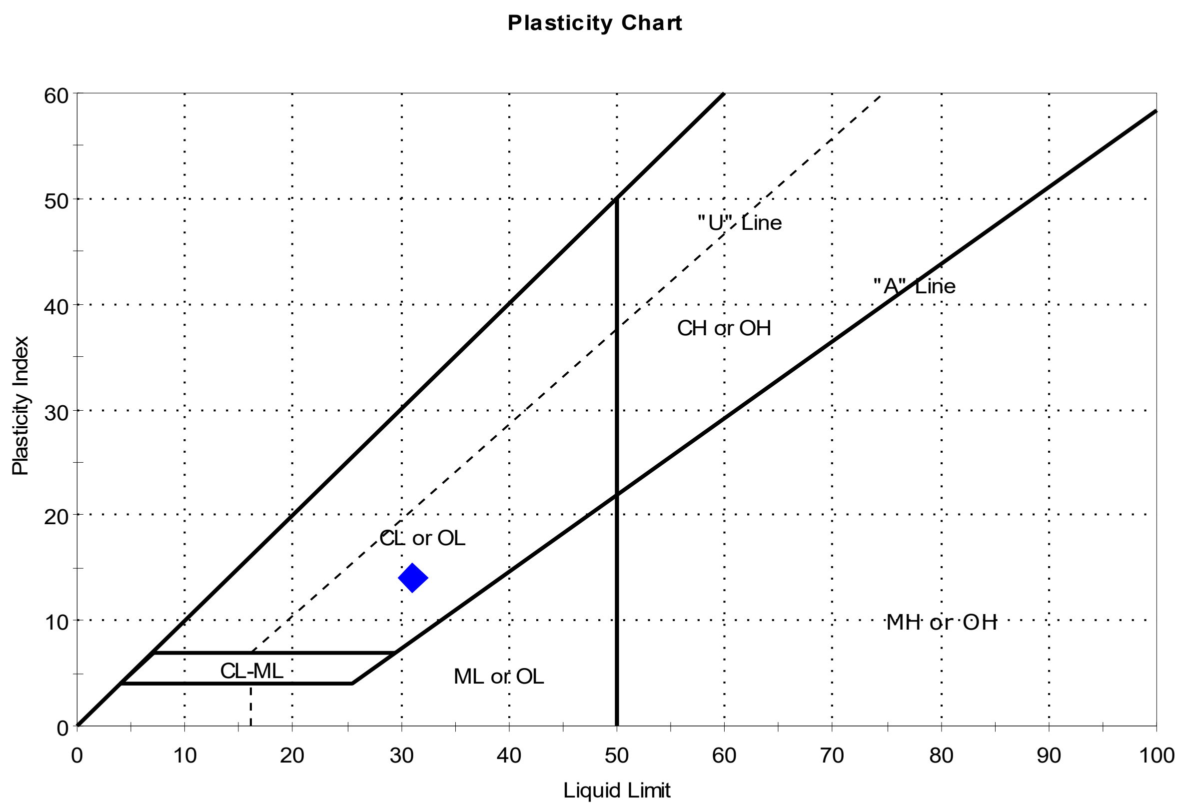
Client:	WSP USA, Inc.		
Project:	ME DOT Augusta Thorne Brook Culvert		
Location:	Augusta, ME	Project No:	GTX-317121
Boring ID: BB-ATB-102	Sample Type: tube	Tested By:	GA
Sample ID: U-1	Test Date: 05/15/23	Checked By:	ank
Depth : 30'-32'	Test Id: 714364		
Test Comment:	---		
Visual Description:	Moist, dark gray clay		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	U-1	B-ATB-10	30'-32'	34	31	17	14	1.2	Lean CLAY (CL)

Sample Prepared using the WET method

0% Retained on #40 Sieve

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	WSP USA, Inc.
Project:	ME DOT Augusta Thorne Brook Culvert
Location:	Augusta, ME

Project No: GTX-317121

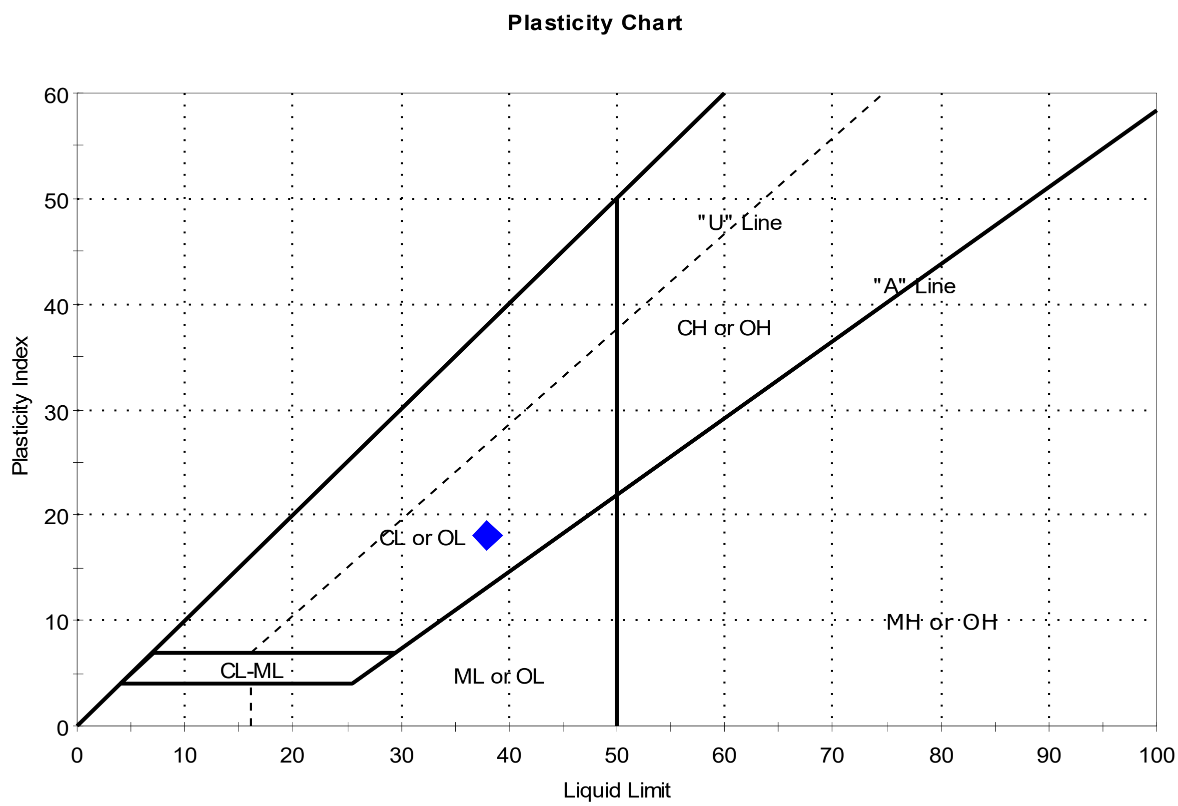
Boring ID:	BB-ATB-102	Sample Type:	tube	Tested By:	GA
Sample ID:	U-2	Test Date:	05/12/23	Checked By:	ank
Depth :	45'-47'	Test Id:	714365		

Test Comment: ---

Visual Description: Moist, dark gray clay

Sample Comment: ---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	U-2	B-ATB-10	45'-47'	37	38	20	18	1	Lean CLAY (CL)

Sample Prepared using the WET method

0% Retained on #40 Sieve

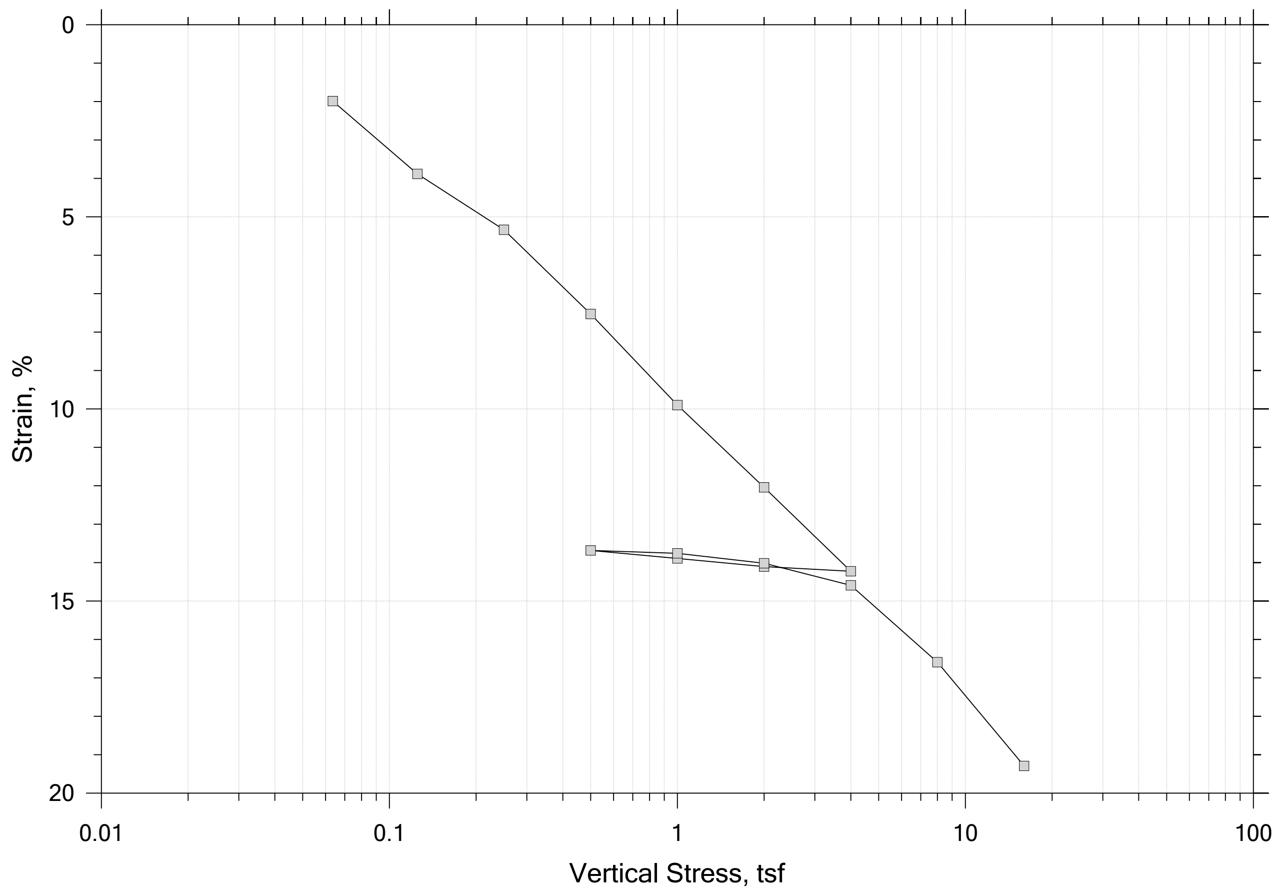
Dry Strength: HIGH

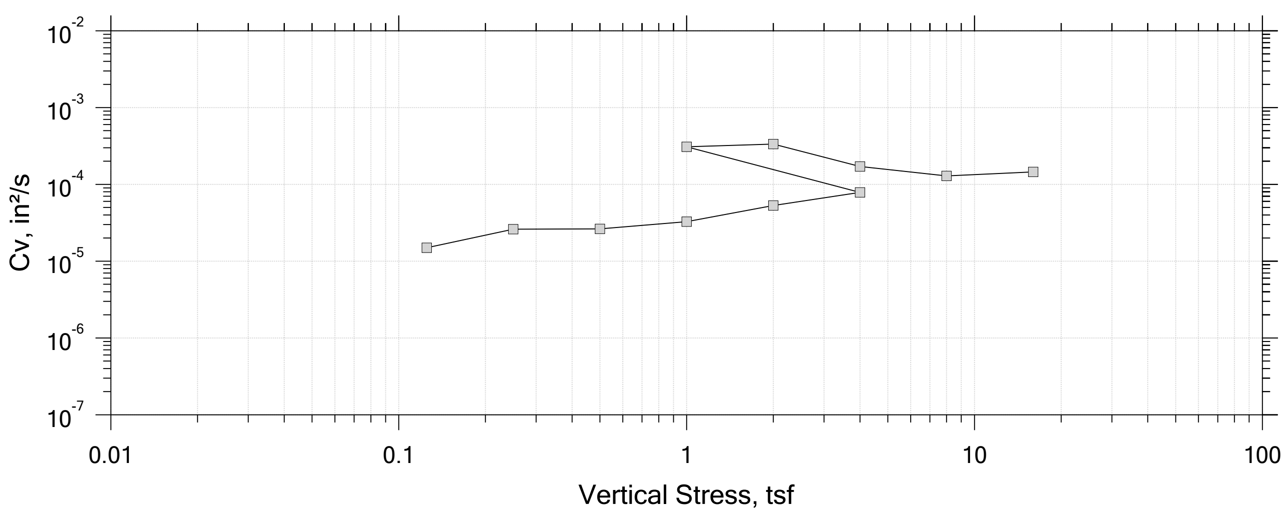
Dilatancy: SLOW

Toughness: MEDIUM

One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report

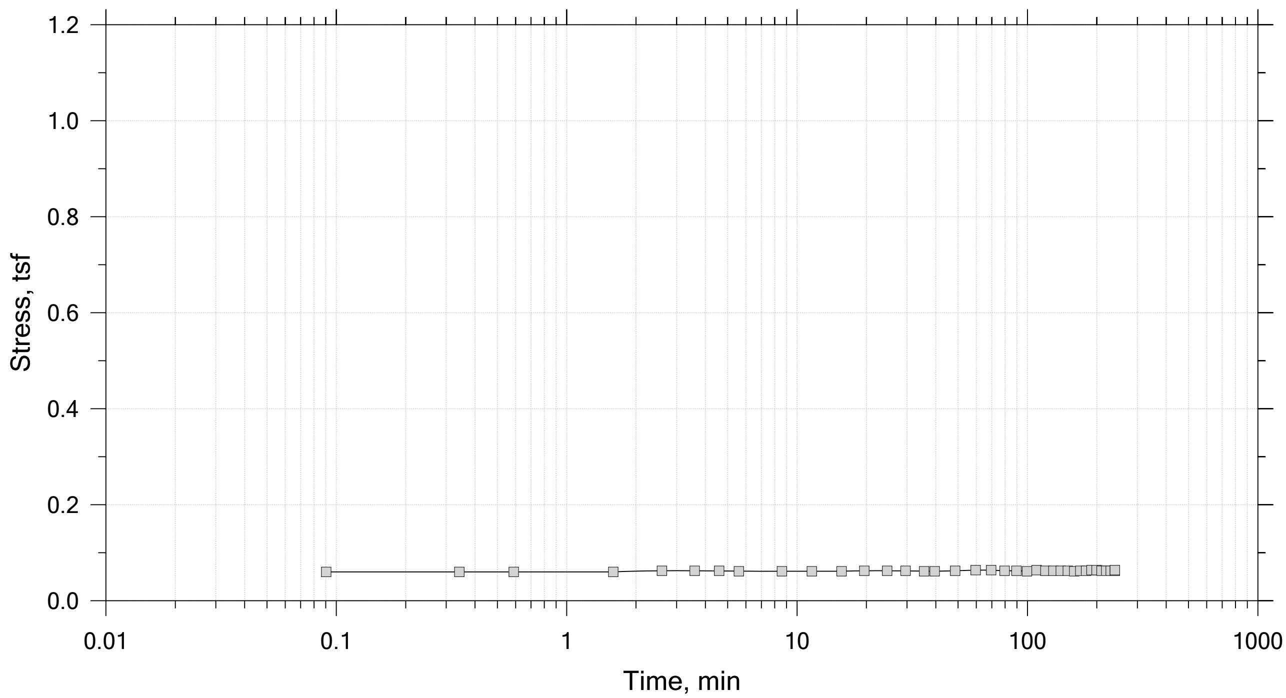


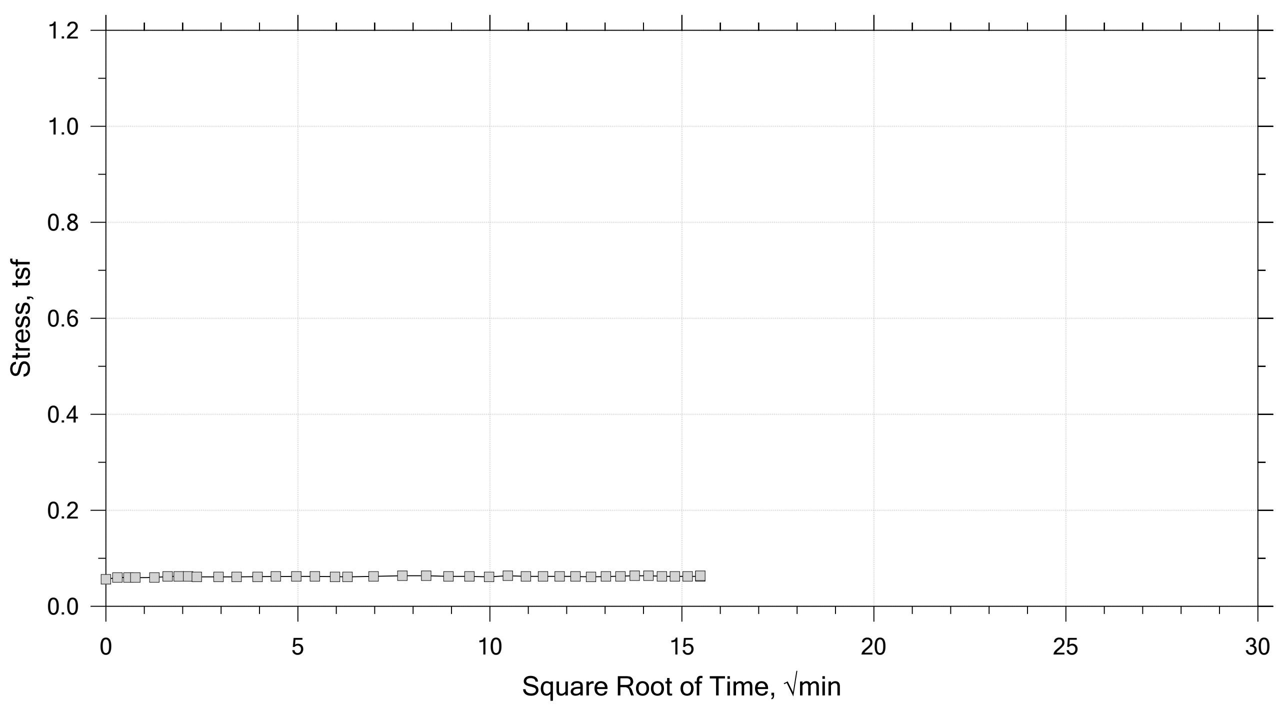


GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 15
Constant Volume Step
Stress: 0.0636 tsf

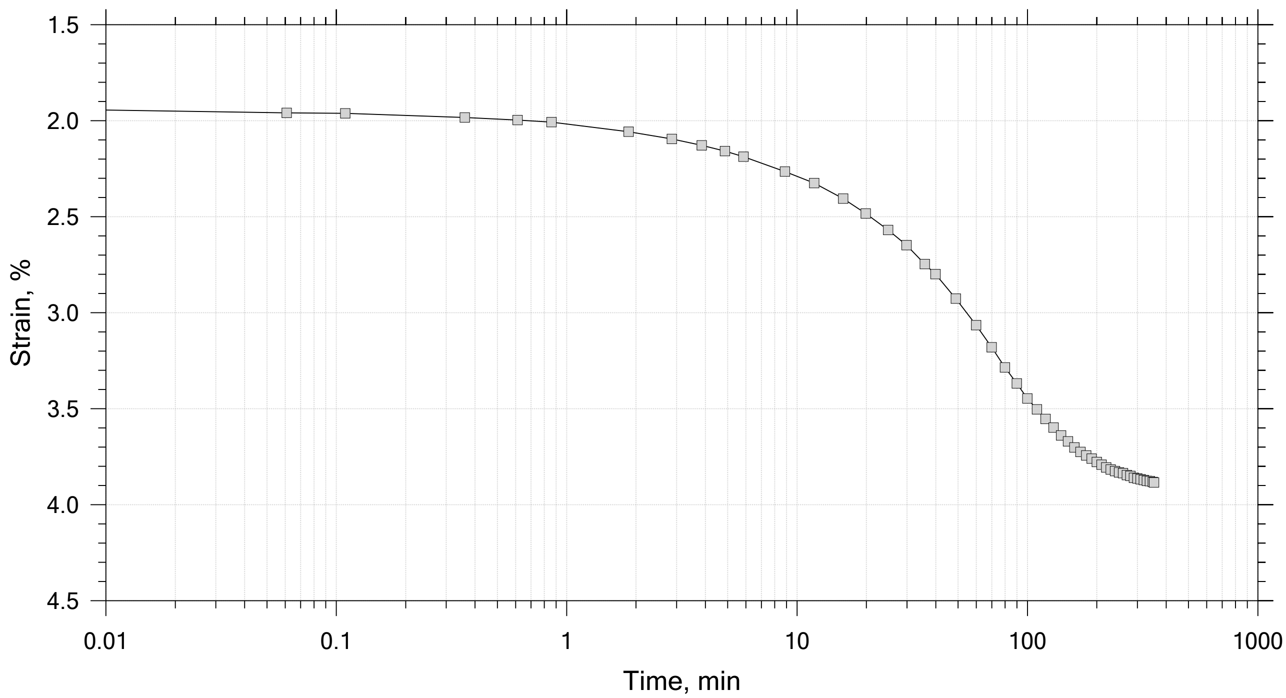


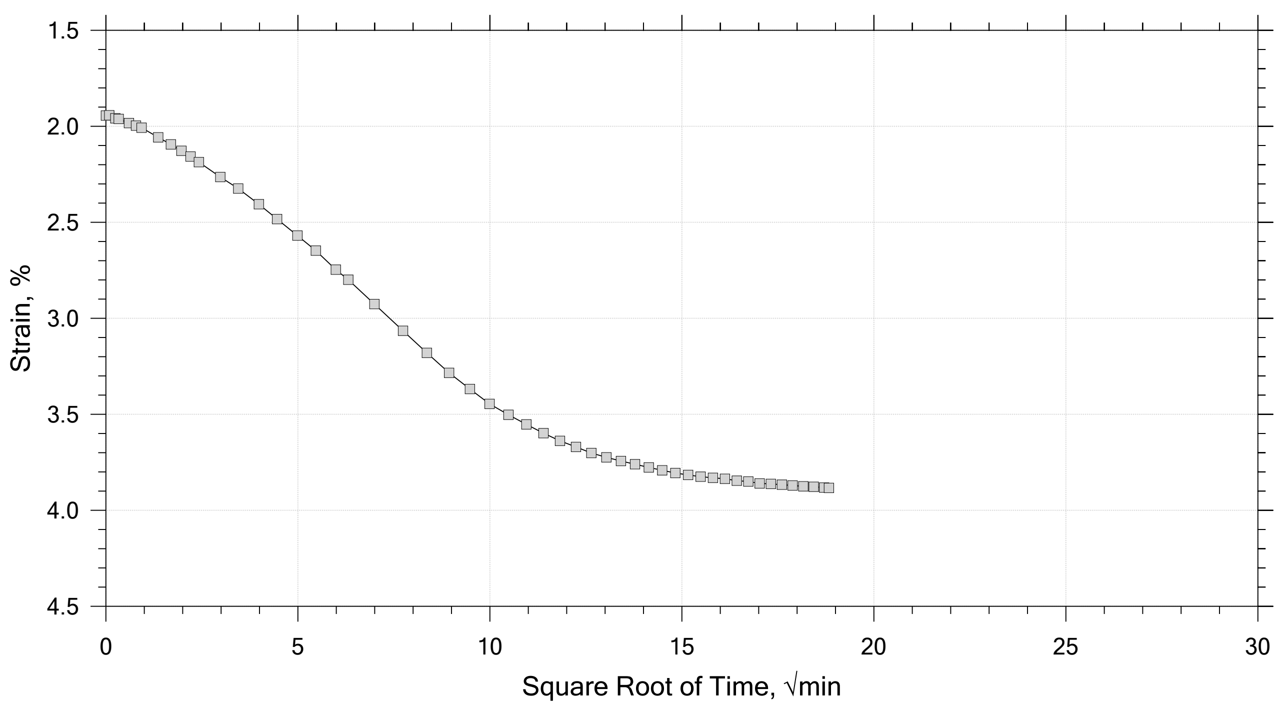


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 15
Constant Load Step
Stress: 0.125 tsf





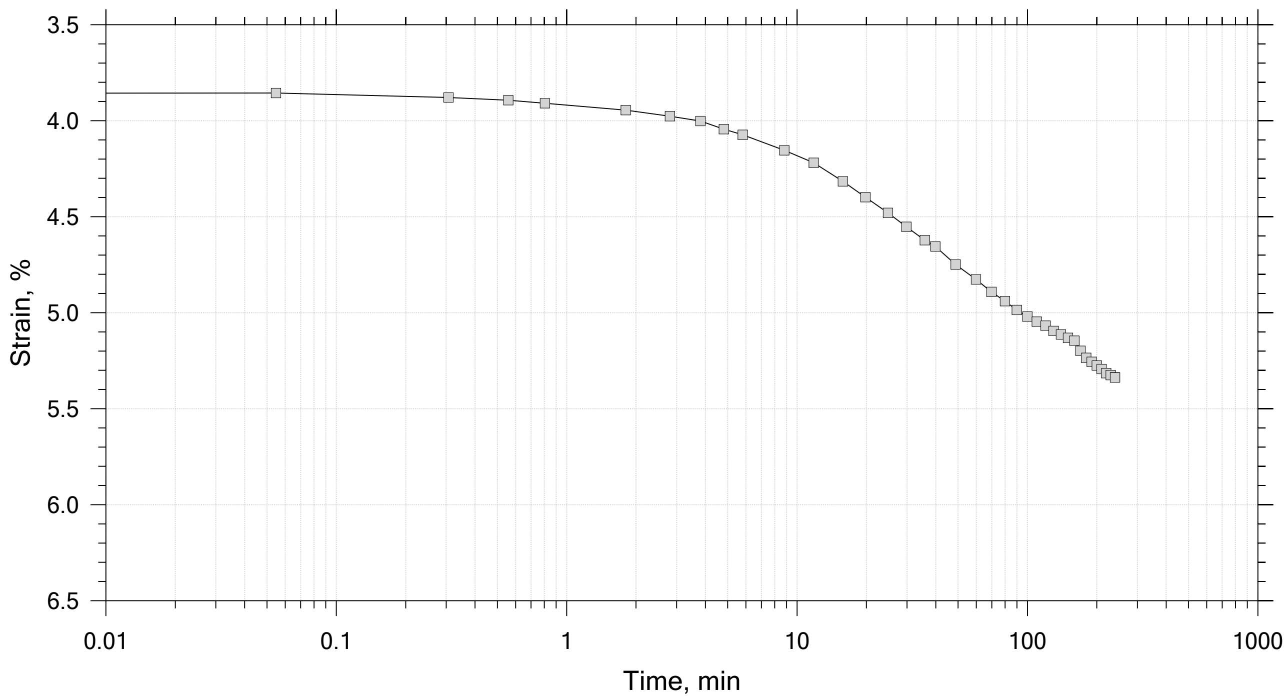
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

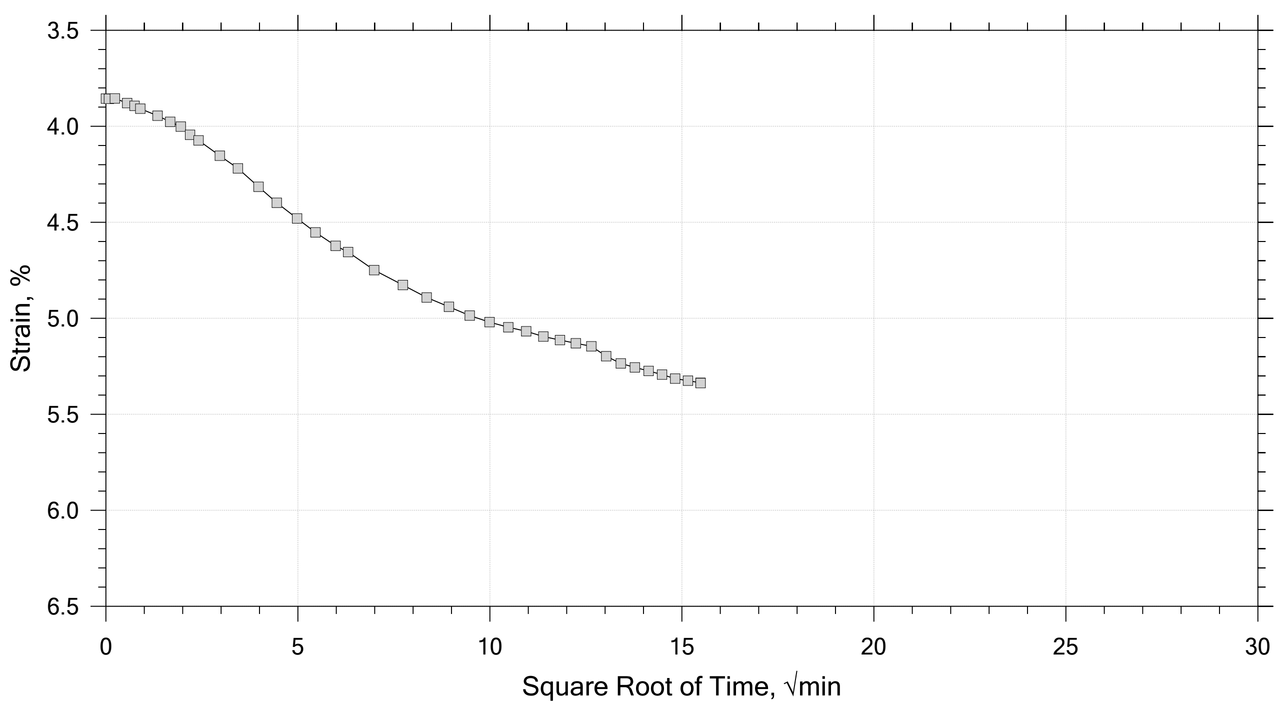
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 15

Constant Load Step

Stress: 0.25 tsf





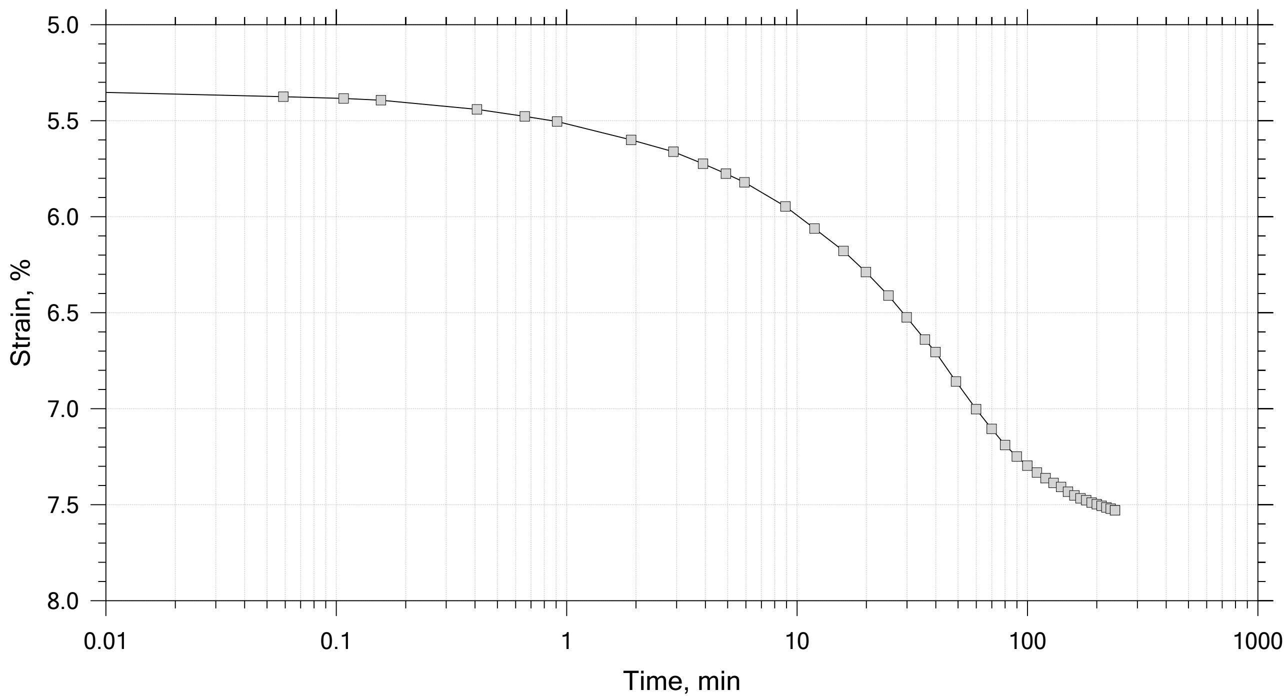
GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

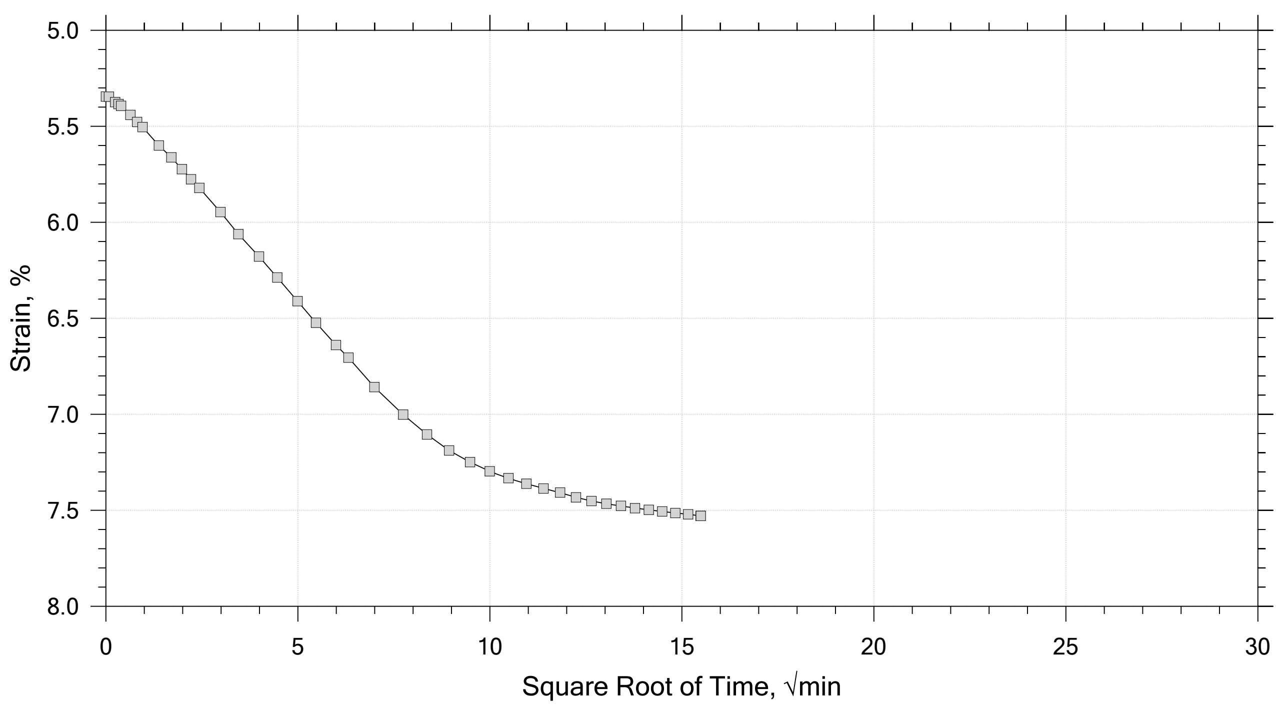
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 15

Constant Load Step

Stress: 0.5 tsf

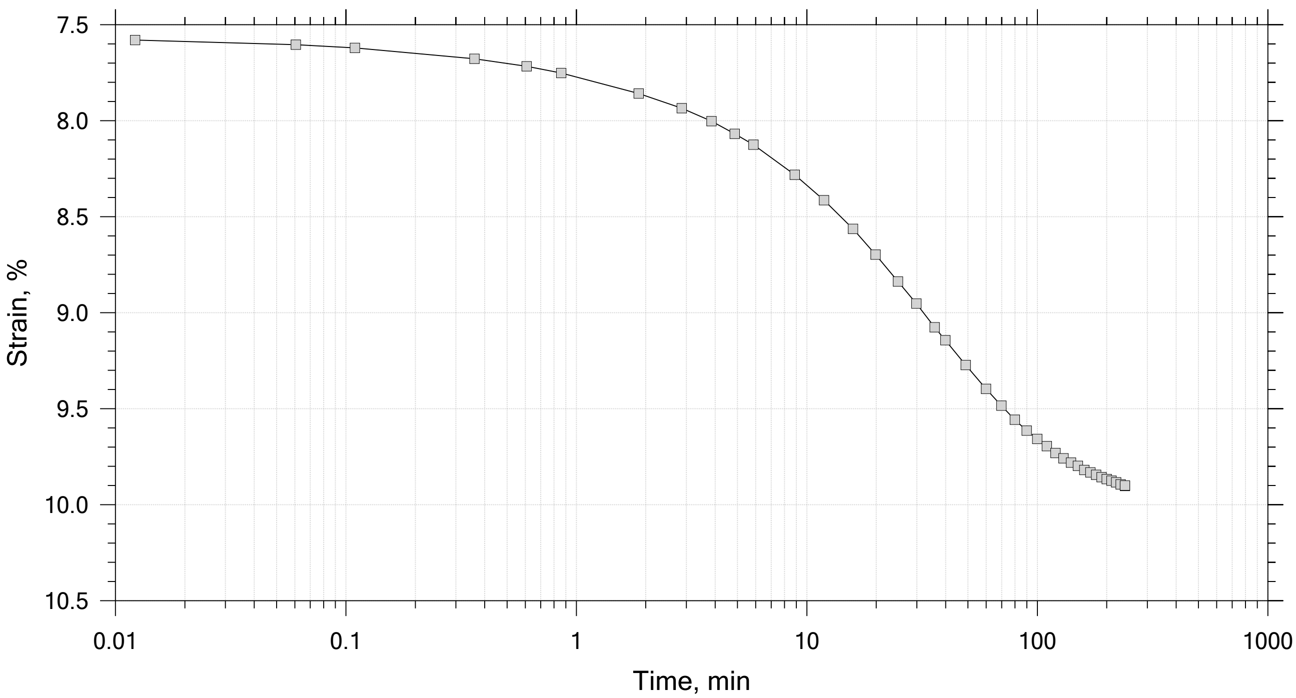


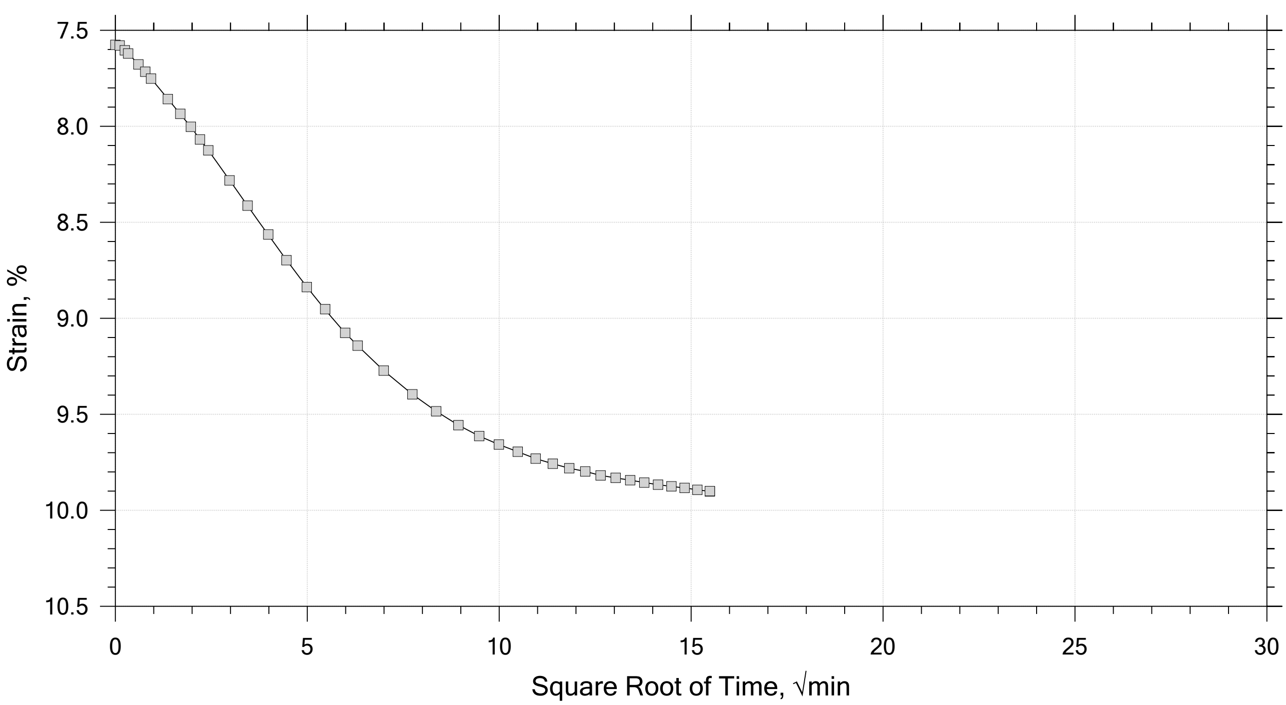


GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 15
Constant Load Step
Stress: 1 tsf





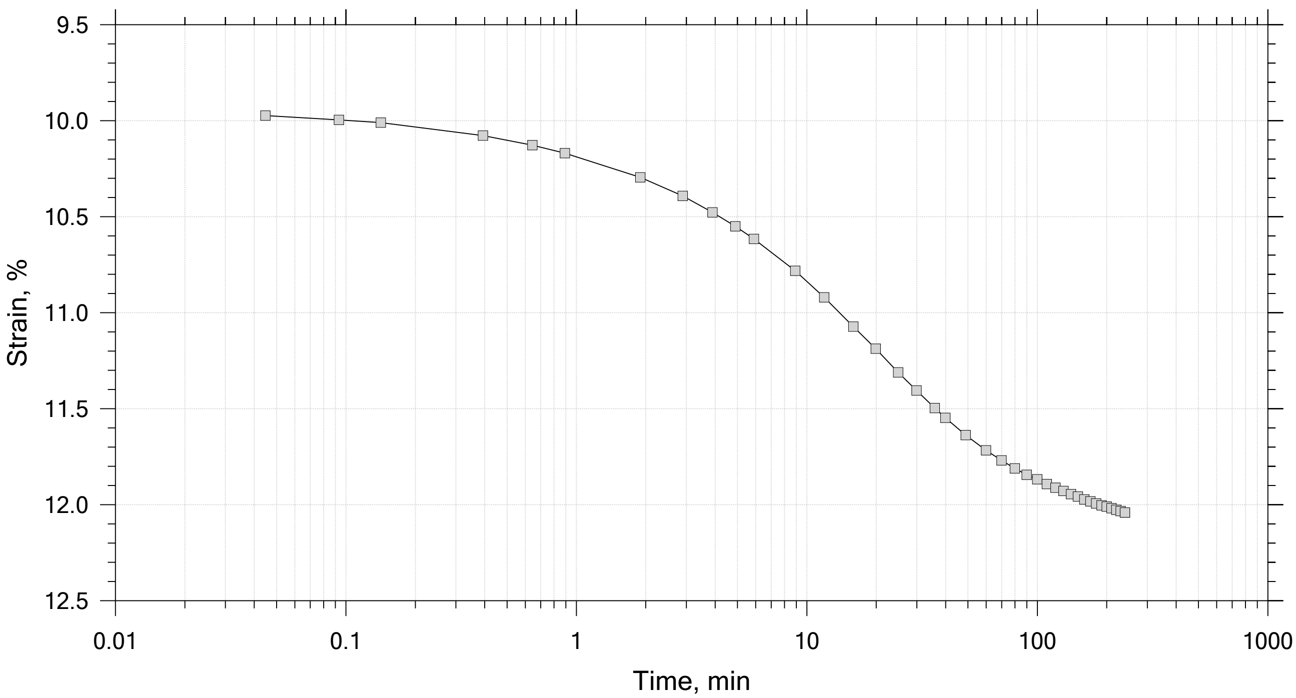
GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

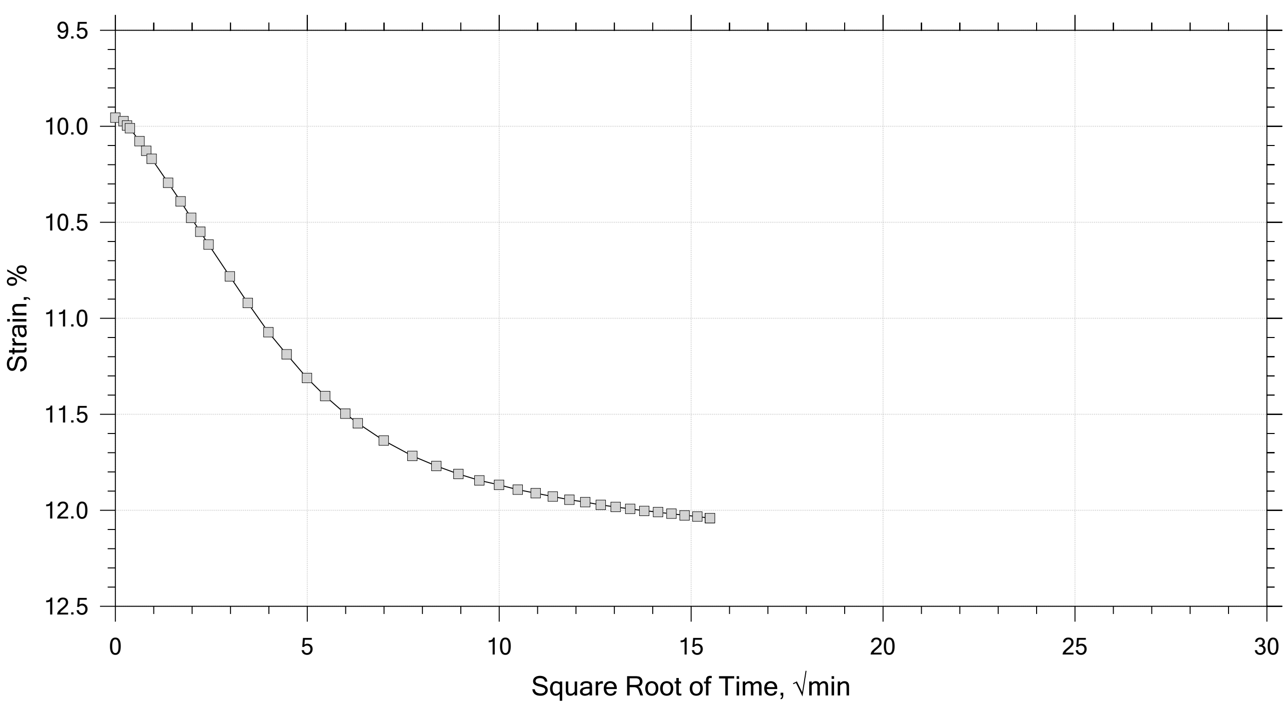
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 15

Constant Load Step

Stress: 2 tsf

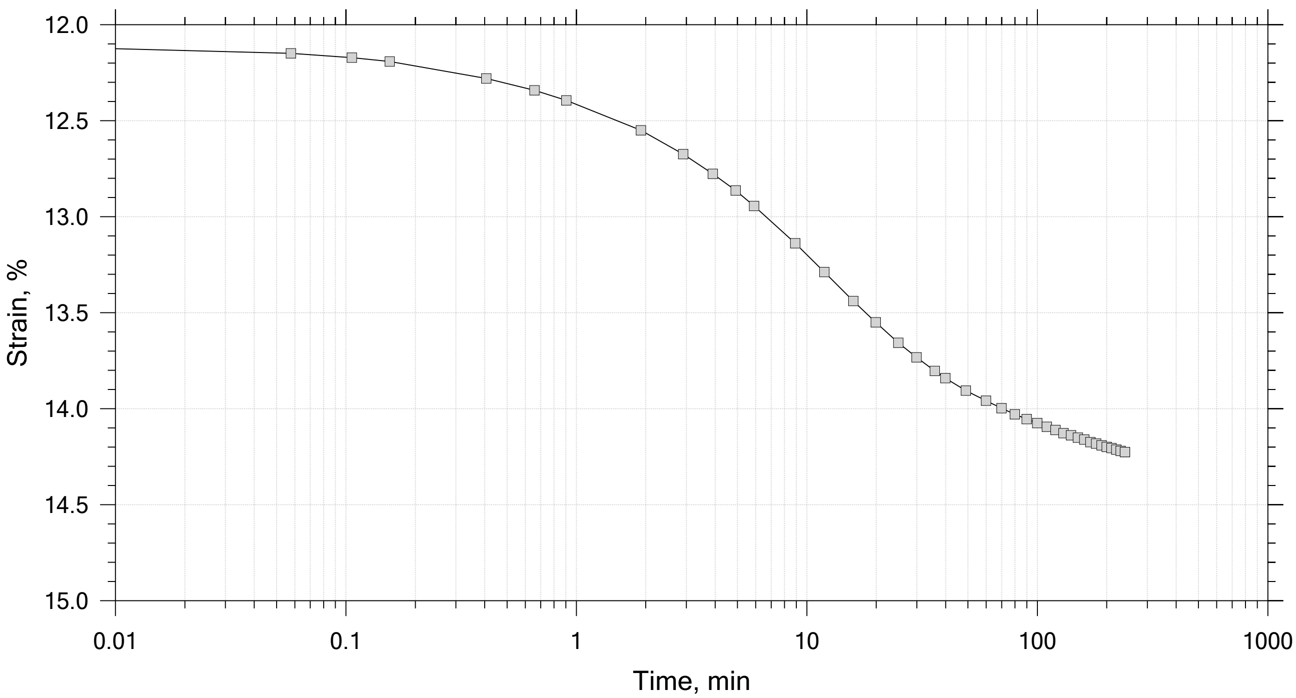


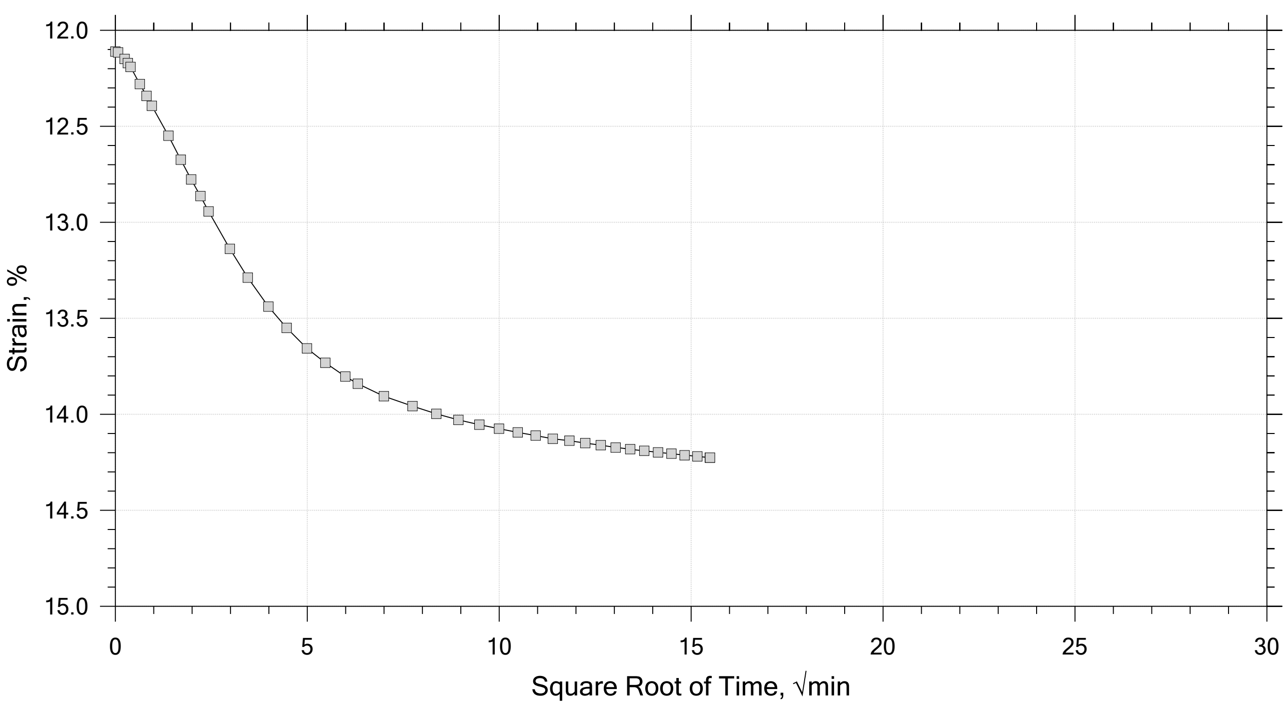


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 15
Constant Load Step
Stress: 4 tsf

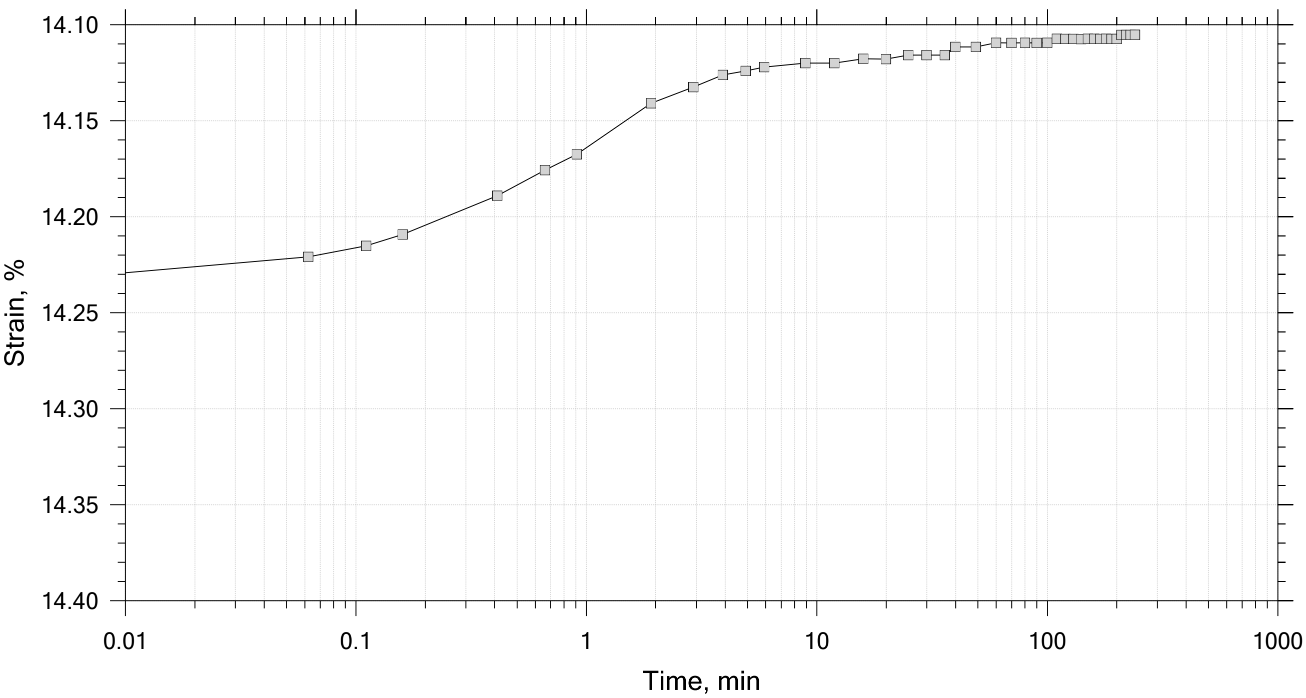


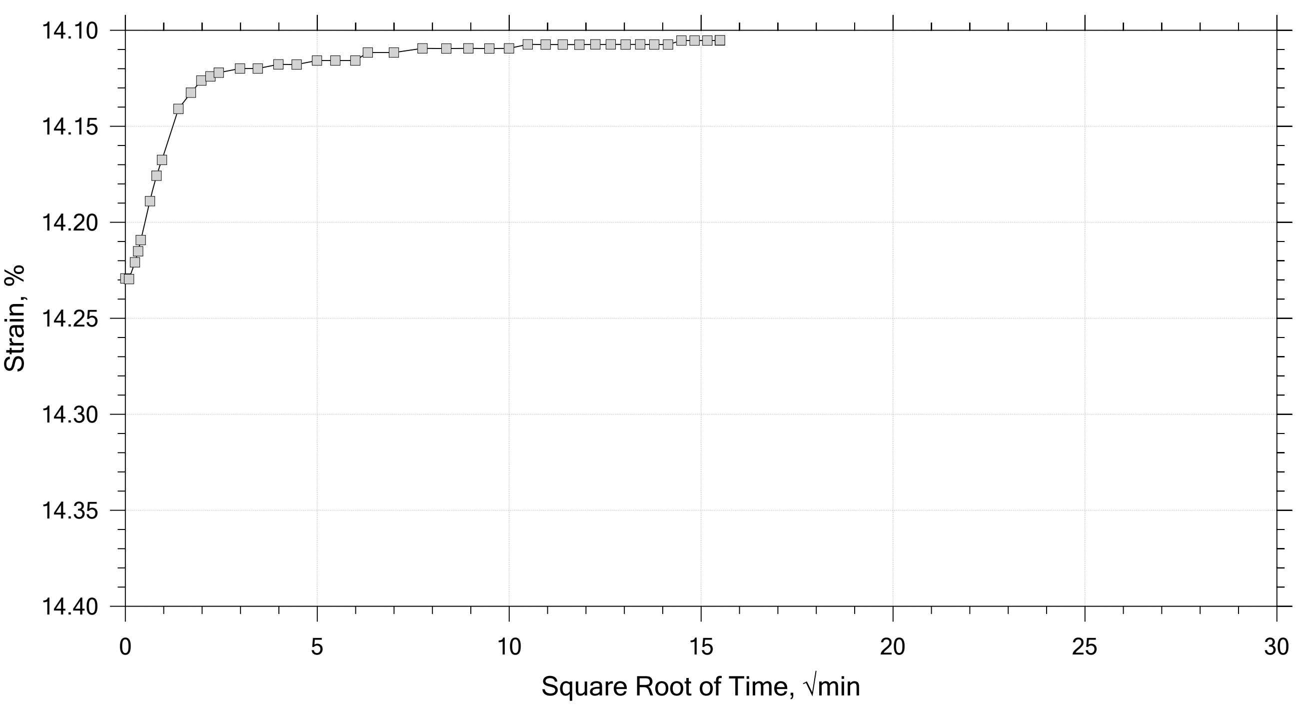


GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 15
Constant Load Step
Stress: 2 tsf





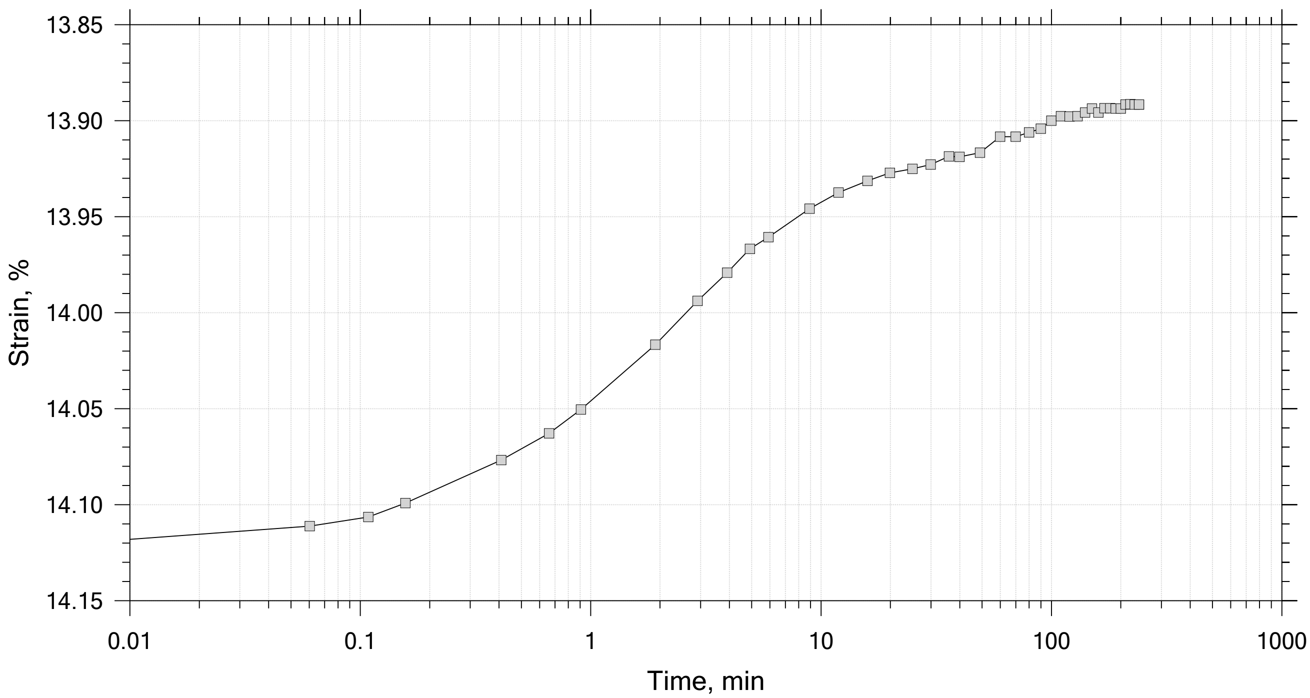
Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
Test No.: IP-1	Sample Type: intact	Elevation: ---
Description: Moist, dark gray clay		
Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

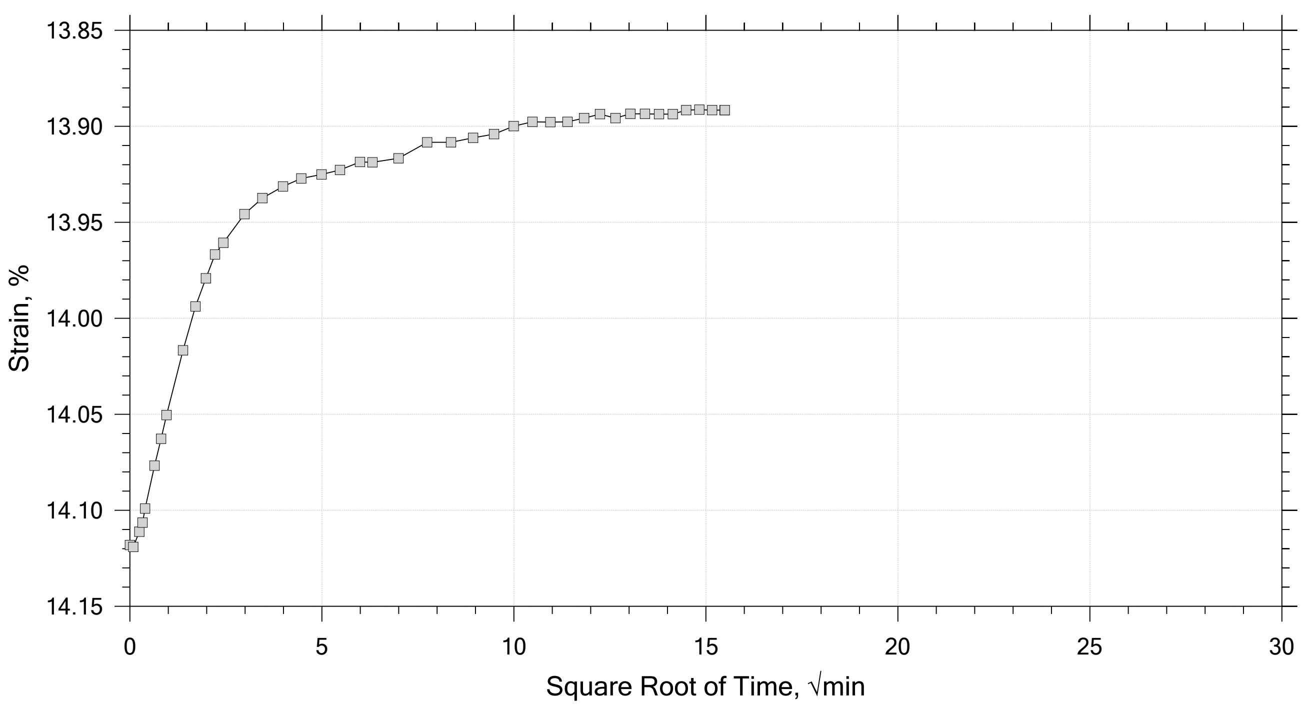
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 15

Constant Load Step

Stress: 1 tsf





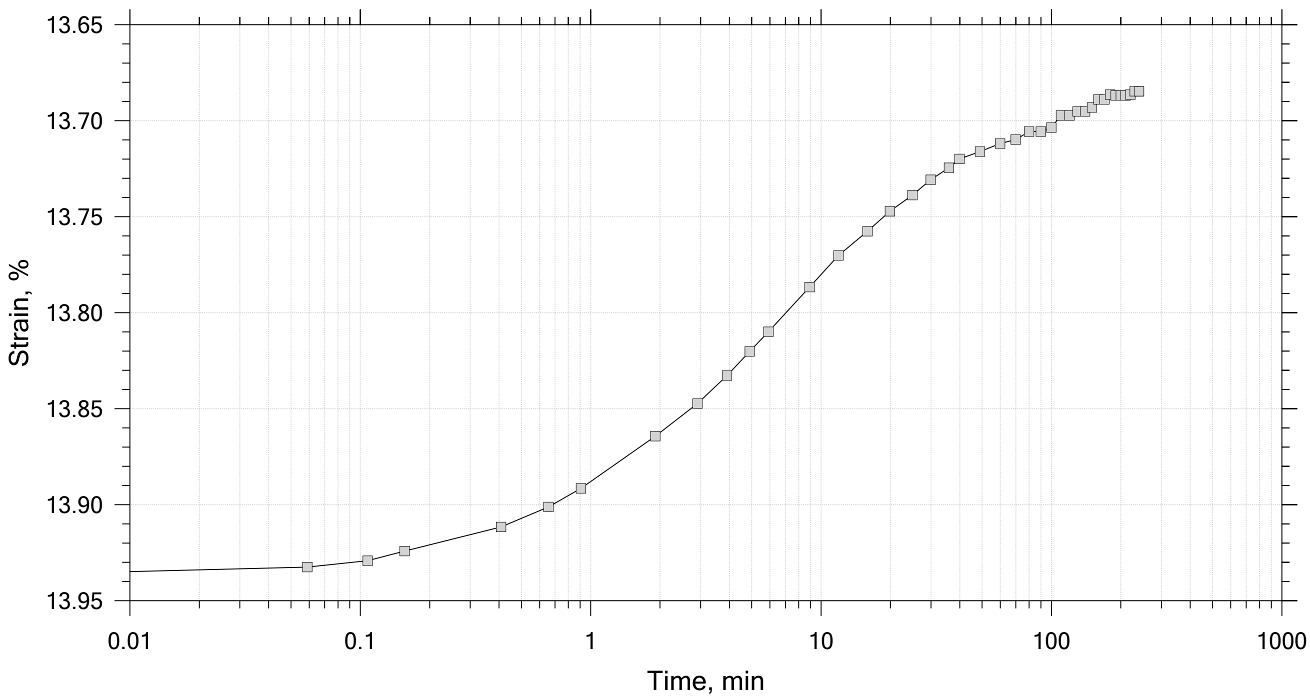
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

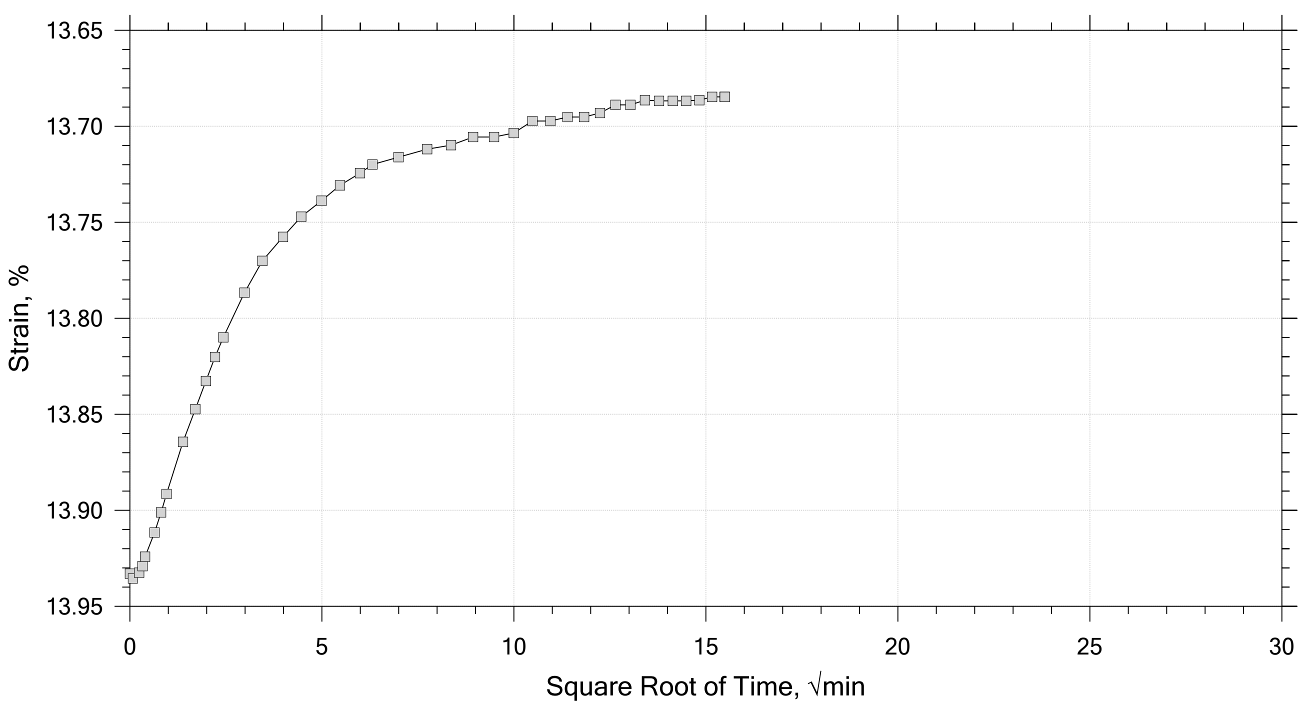
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 15

Constant Load Step

Stress: 0.5 tsf





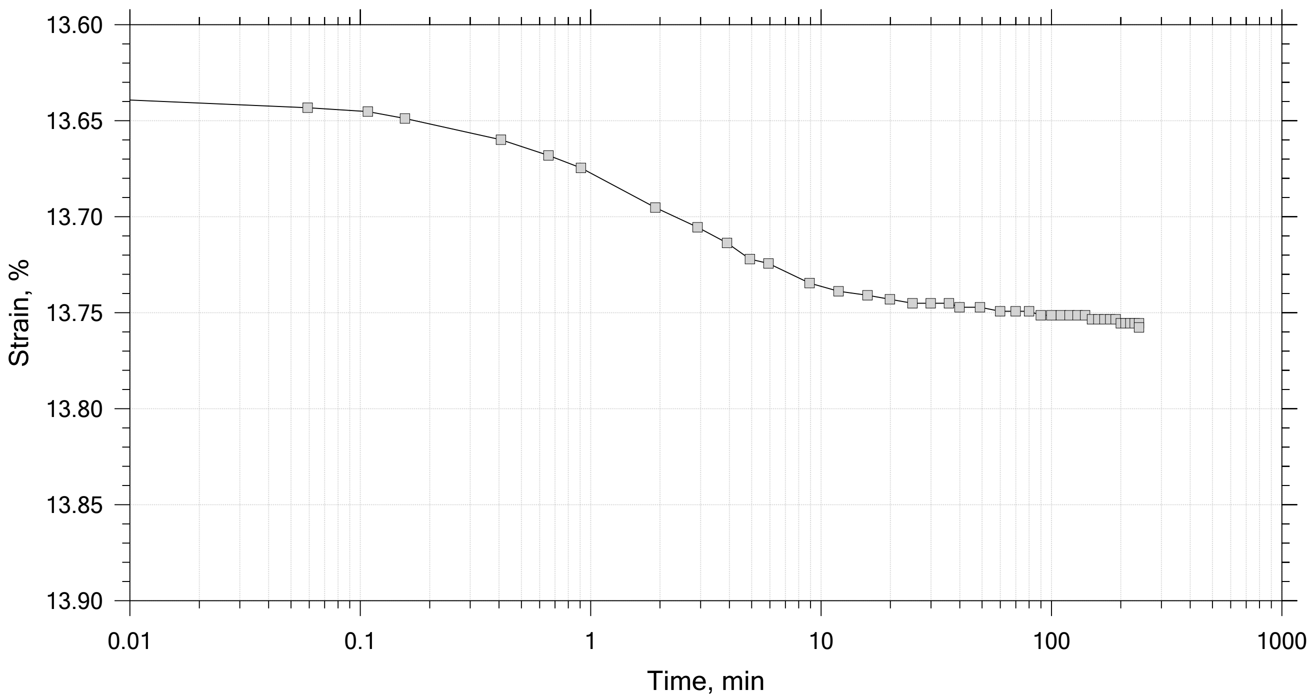
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

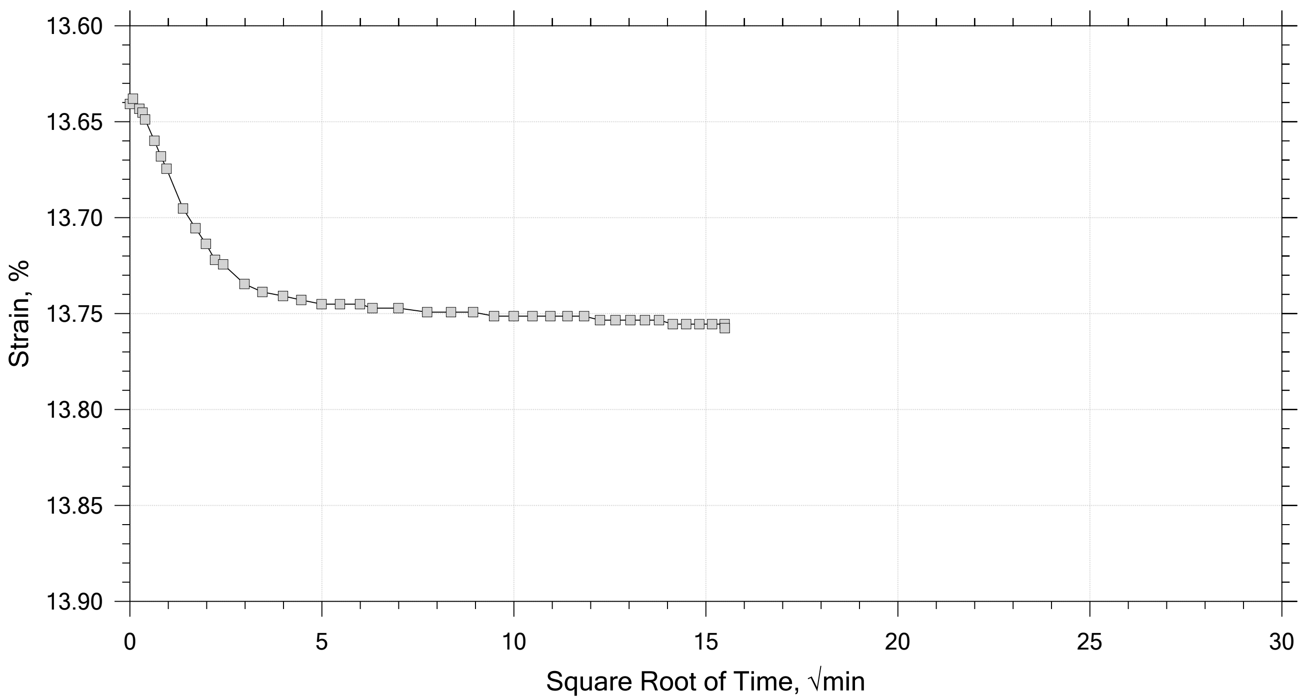
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 15

Constant Load Step

Stress: 1 tsf





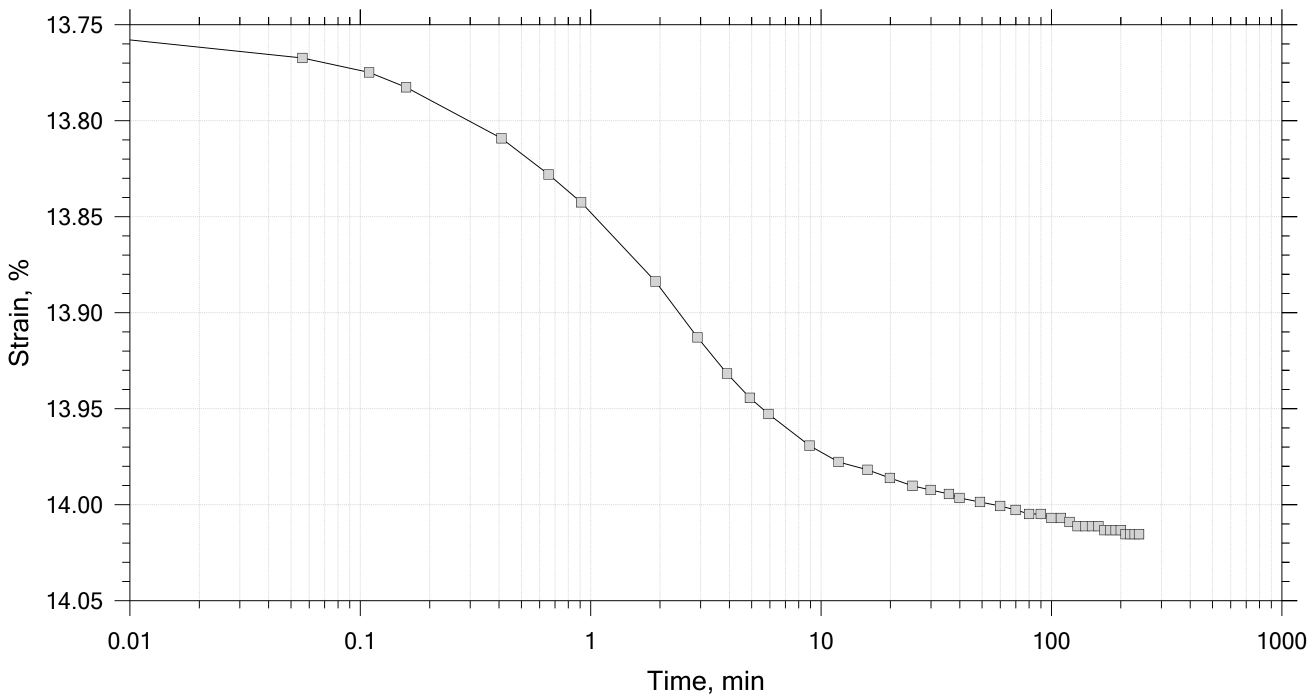
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

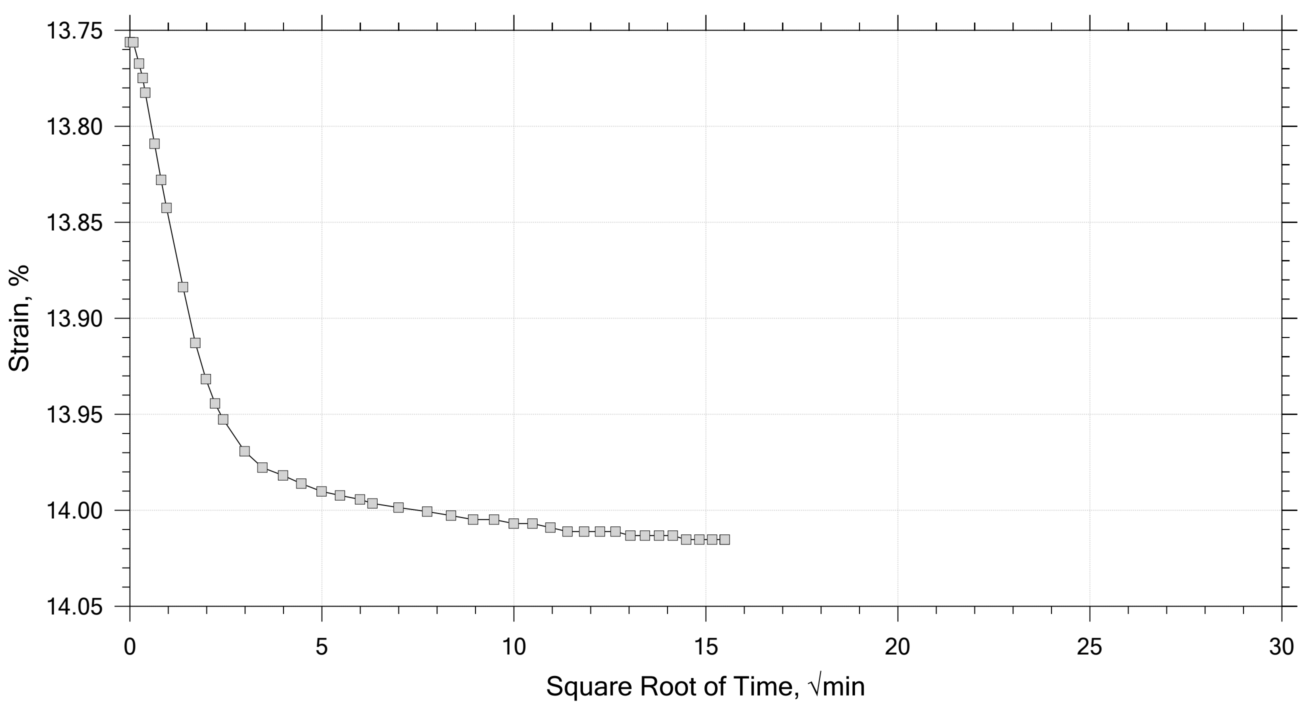
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 15

Constant Load Step

Stress: 2 tsf

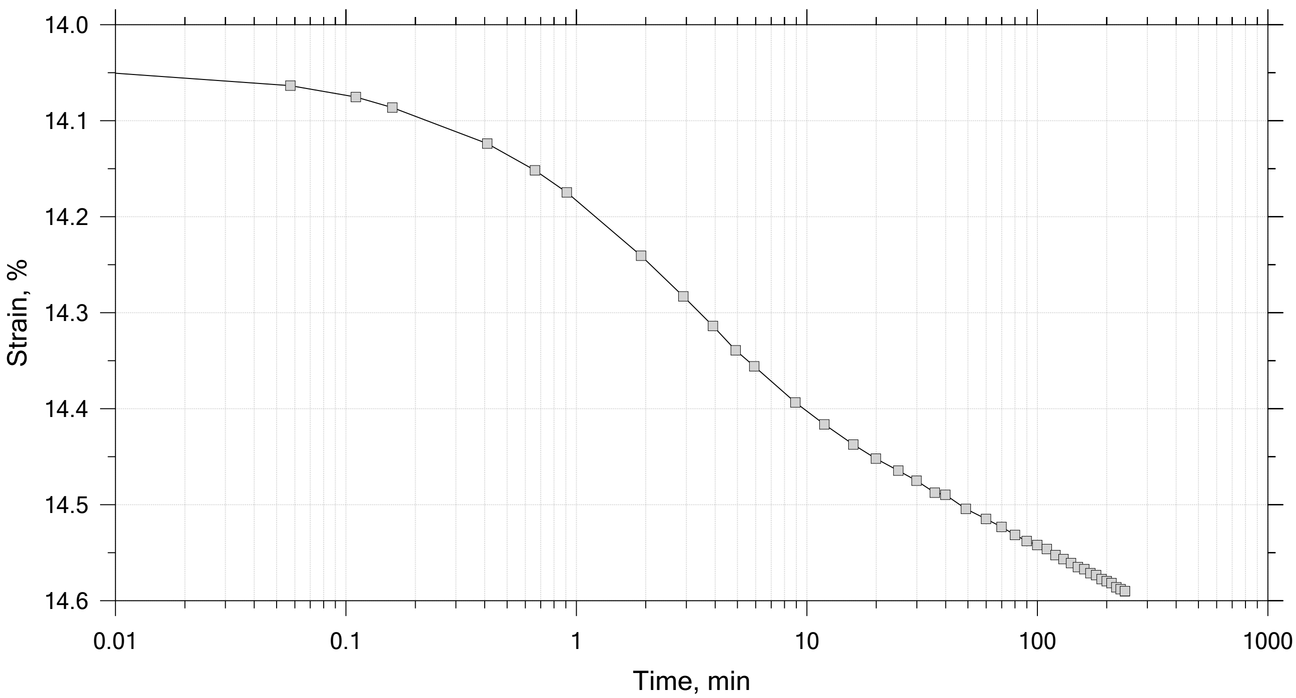


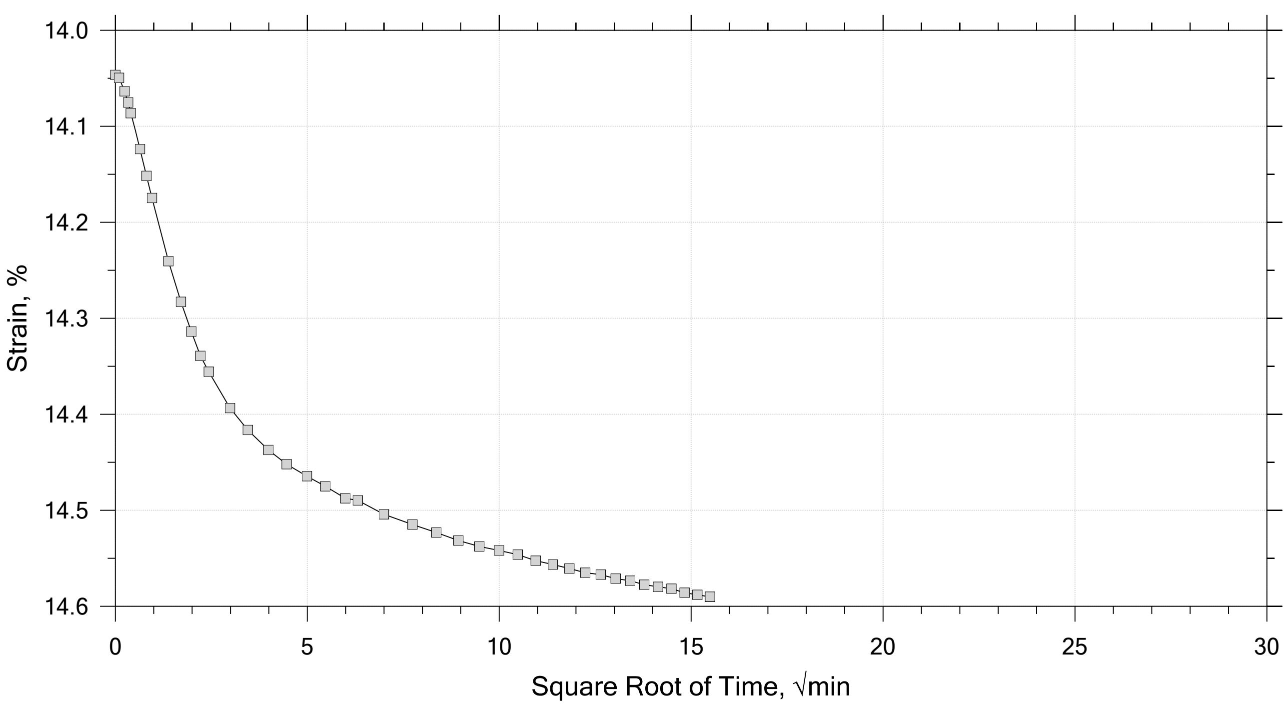


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 15
Constant Load Step
Stress: 4 tsf

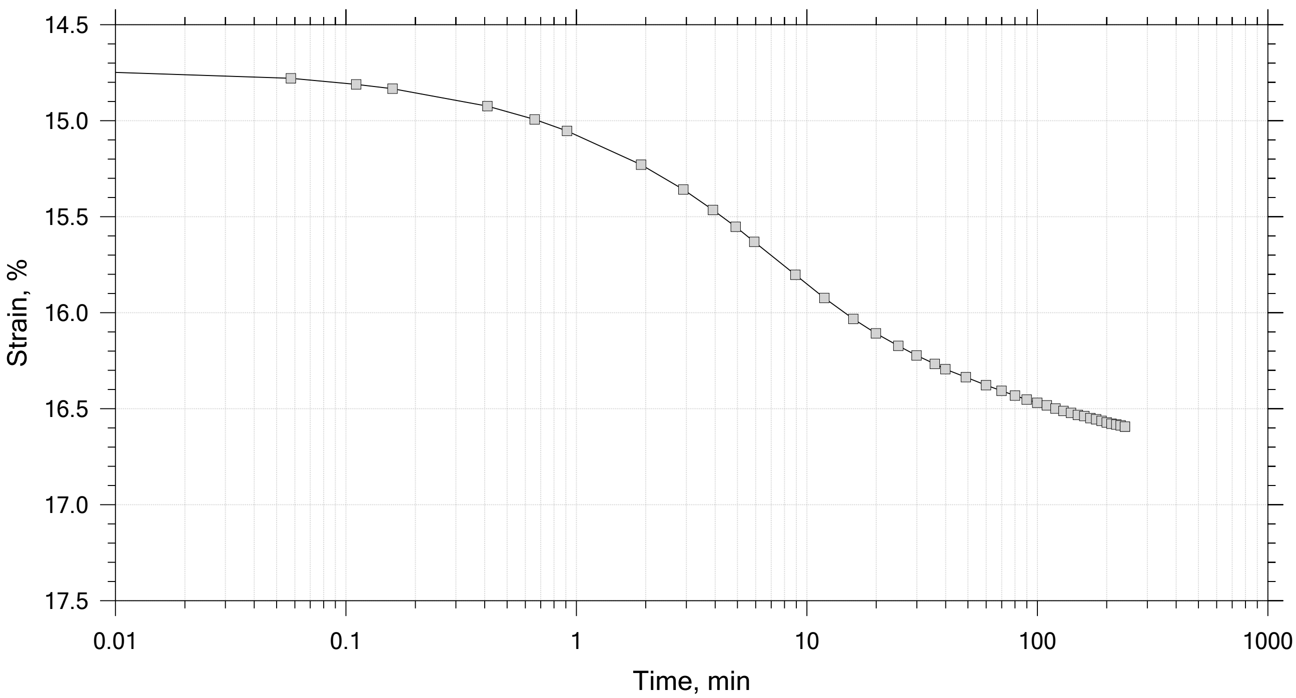


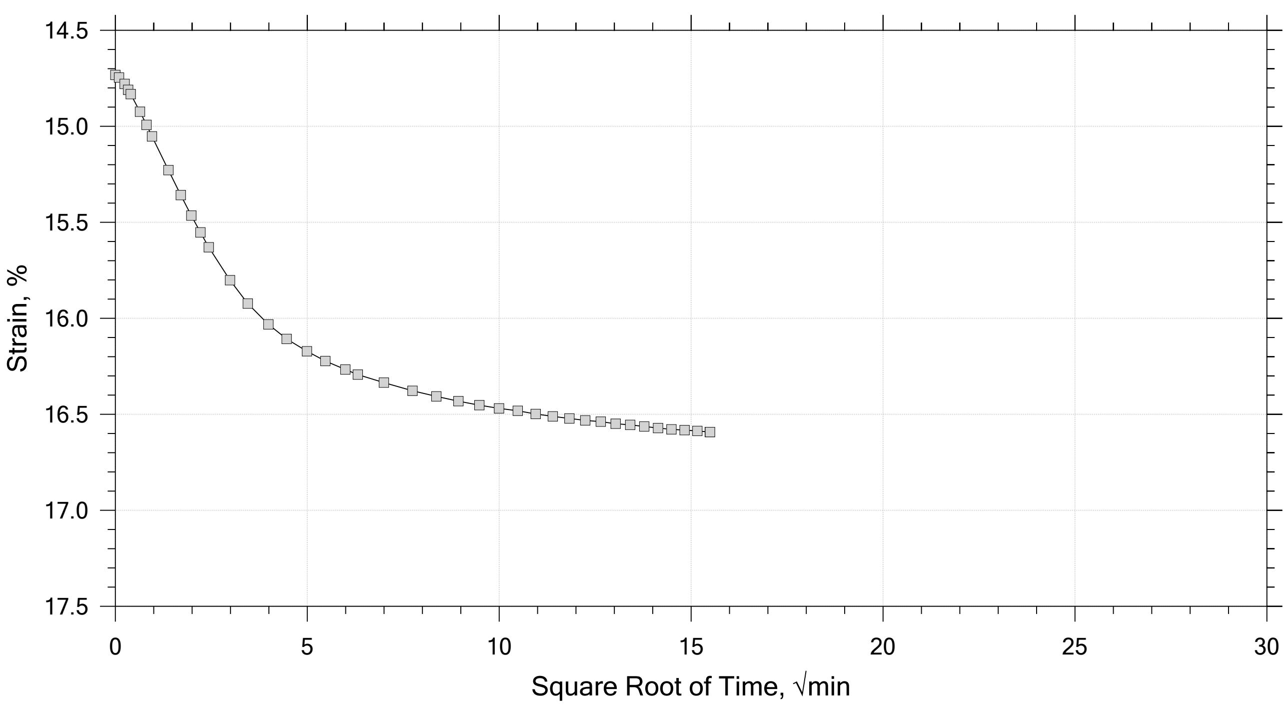


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 15
Constant Load Step
Stress: 8 tsf

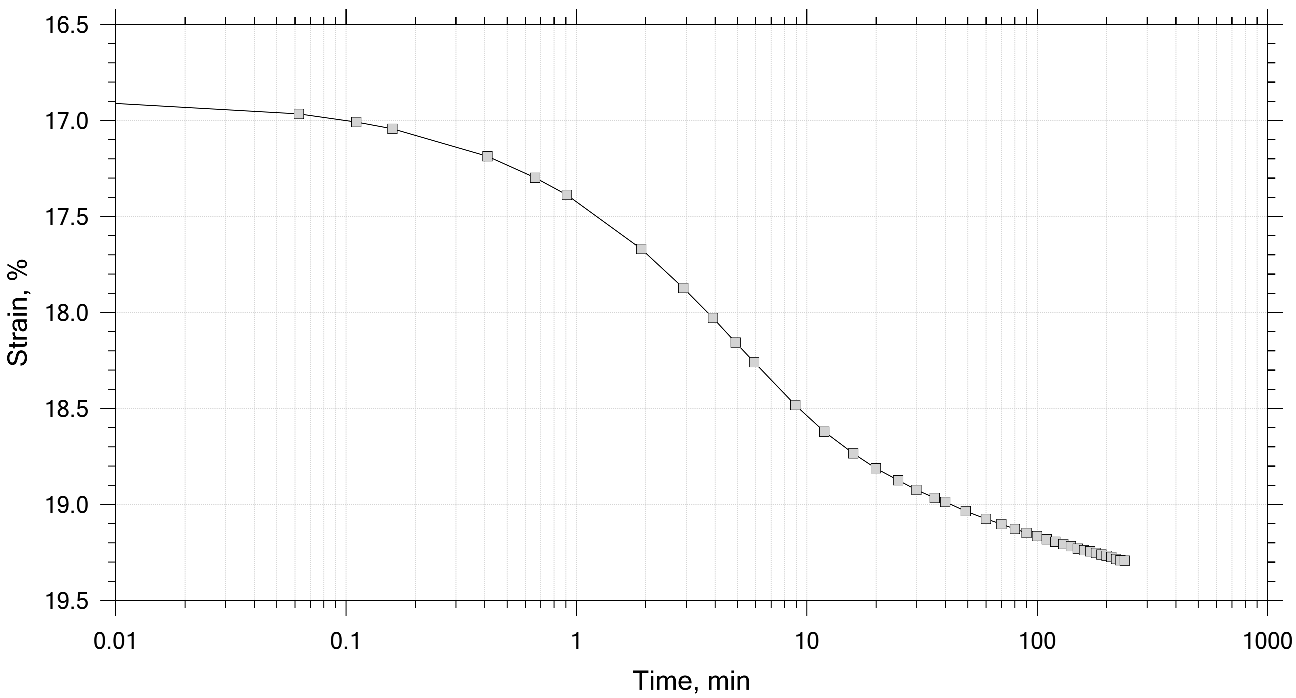


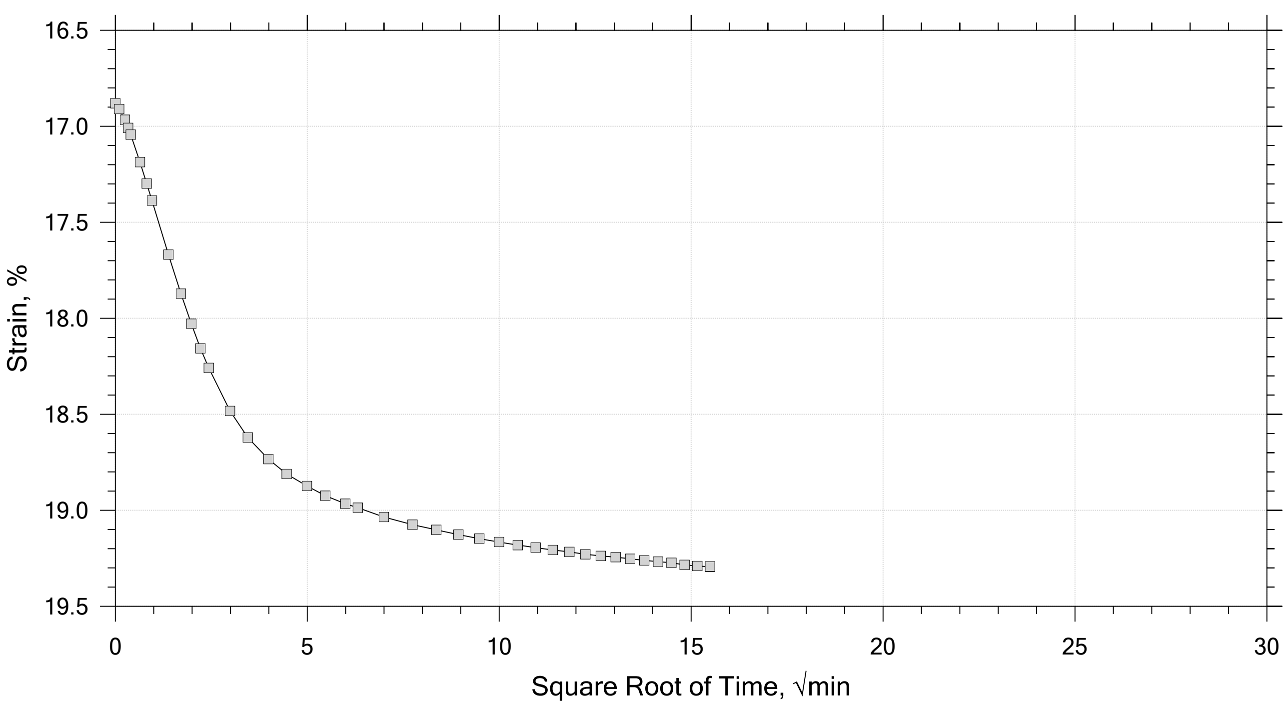


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 15
Constant Load Step
Stress: 16 tsf





GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.75	Liquid Limit: 31
Initial Height: 1.00 in	Initial Void Ratio: 0.907	Plastic Limit: 17
Final Height: 0.79 in	Final Void Ratio: 0.506	Plasticity Index: 14

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	E7449	RING		E5813
Mass Container, gm	9.01	110.05	110.05	8.28
Mass Container + Wet Soil, gm	157.29	264.14	247.41	146.12
Mass Container + Dry Soil, gm	119.33	226.05	226.05	124.69
Mass Dry Soil, gm	110.32	116	116	116.41
Water Content, %	34.41	32.83	18.41	18.41
Void Ratio	---	0.91	0.51	---
Degree of Saturation, %	---	99.58	100.00	---
Dry Unit Weight, pcf	---	90.029	113.96	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test.
Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

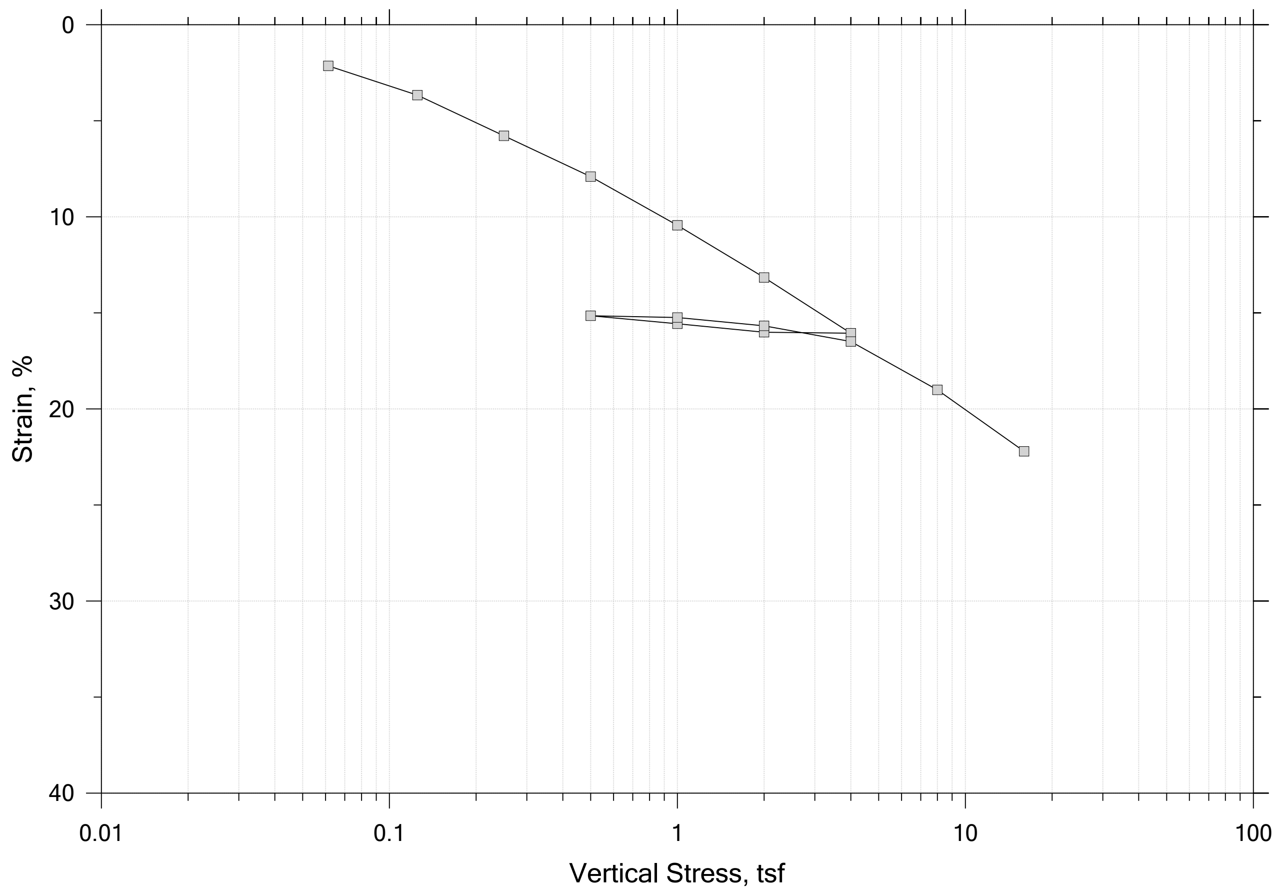
Square Root of Time Coefficients

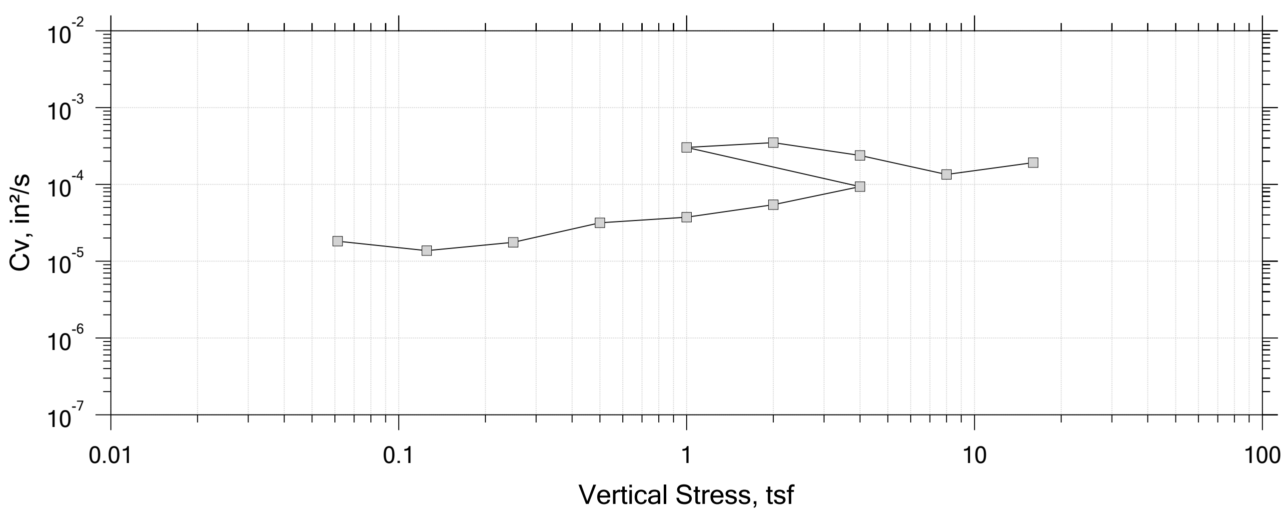
Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv in²/s	Mv 1/tsf	k ft/day
1	0.0636	0.01987	0.869	1.99	---	---	---	---
2	0.125	0.03884	0.832	3.88	222.582	1.50e-05	3.09e-01	8.65e-05
3	0.250	0.05338	0.805	5.34	123.269	2.61e-05	1.16e-01	5.68e-05
4	0.500	0.07529	0.763	7.53	117.568	2.63e-05	8.77e-02	4.32e-05
5	1.00	0.09900	0.718	9.90	89.963	3.27e-05	4.74e-02	2.91e-05
6	2.00	0.1204	0.677	12.0	52.855	5.30e-05	2.14e-02	2.12e-05
7	4.00	0.1423	0.635	14.2	33.909	7.86e-05	1.09e-02	1.61e-05
8	2.00	0.1411	0.638	14.1	4.433	5.87e-04	6.04e-04	6.64e-06
9	1.00	0.1389	0.642	13.9	8.046	3.25e-04	2.14e-03	1.30e-05
10	0.500	0.1368	0.646	13.7	18.293	1.44e-04	4.14e-03	1.11e-05
11	1.00	0.1376	0.644	13.8	8.534	3.08e-04	1.46e-03	8.42e-06
12	2.00	0.1402	0.639	14.0	7.826	3.35e-04	2.58e-03	1.62e-05
13	4.00	0.1459	0.628	14.6	15.160	1.71e-04	2.87e-03	9.21e-06
14	8.00	0.1659	0.590	16.6	19.578	1.29e-04	5.01e-03	1.21e-05
15	16.0	0.1929	0.539	19.3	16.361	1.45e-04	3.37e-03	9.19e-06

GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: jlw	Checked By: anm
	Sample No.: U-1	Test Date: 5/3/23	Depth: 30'-32'
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-G, Swell Pressure = 0.0636 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report





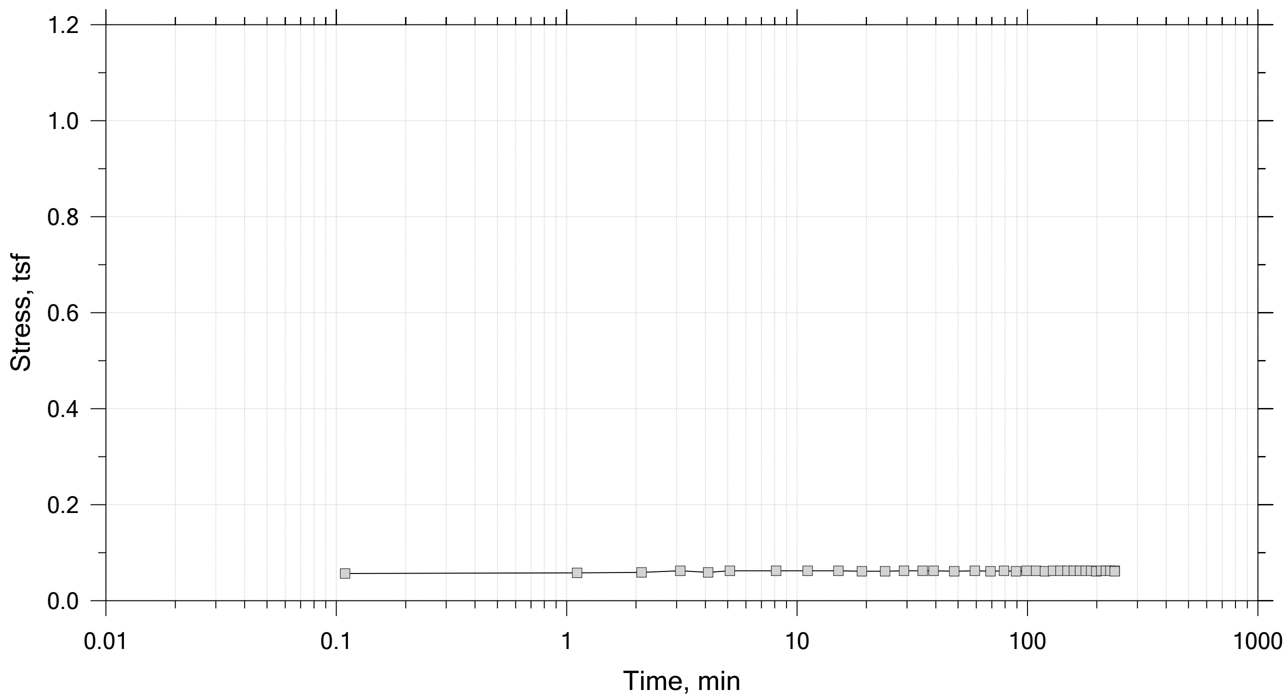
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		
	Displacement at End of Increment		

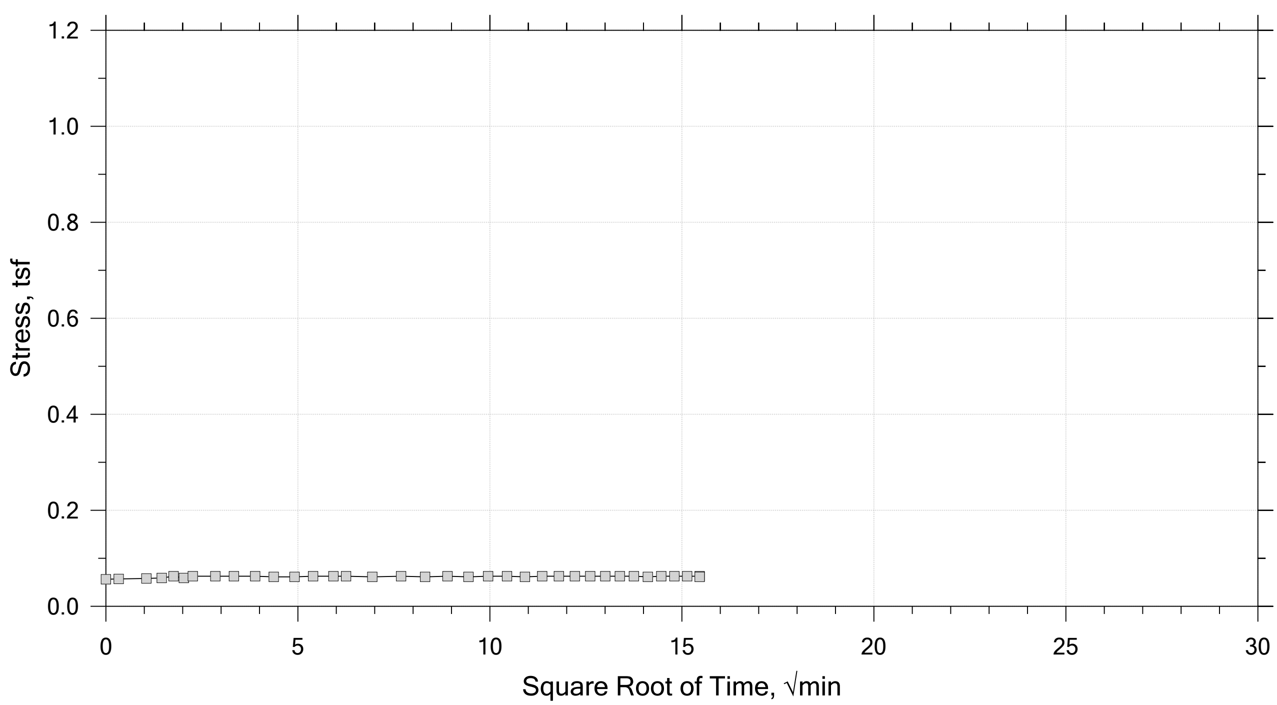
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 15

Constant Volume Step

Stress: 0.0613 tsf





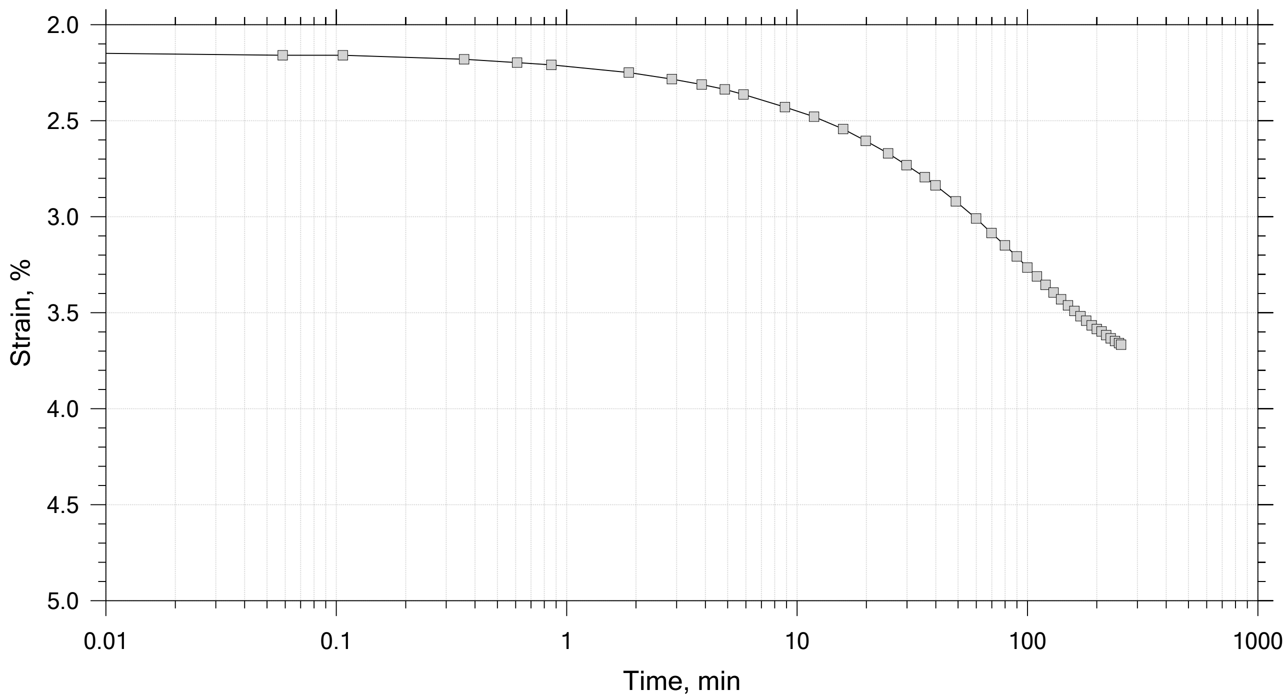
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

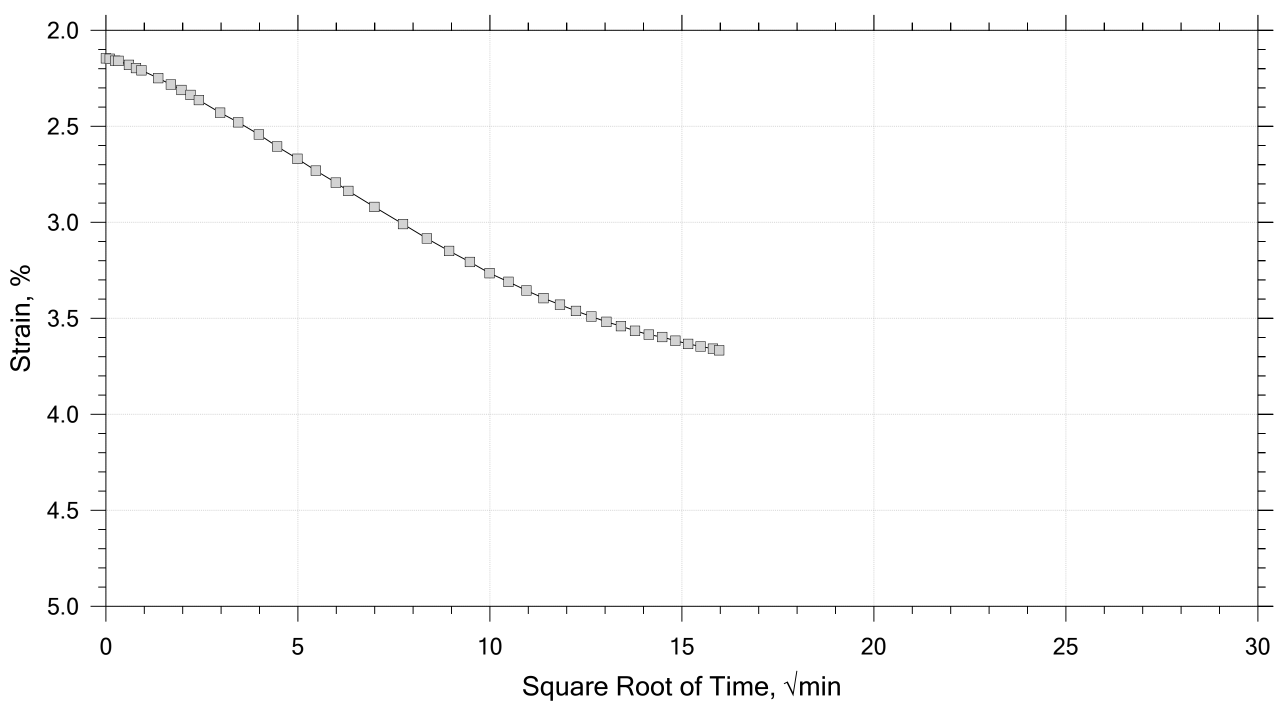
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 15

Constant Load Step

Stress: 0.125 tsf

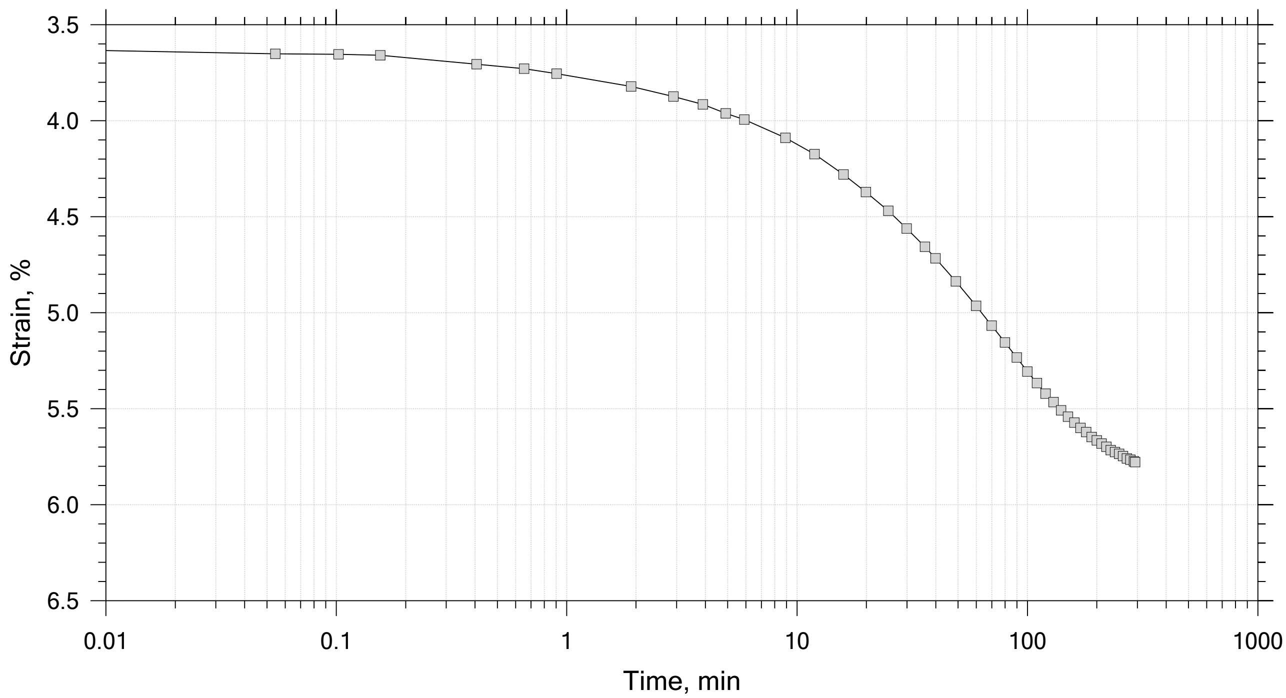


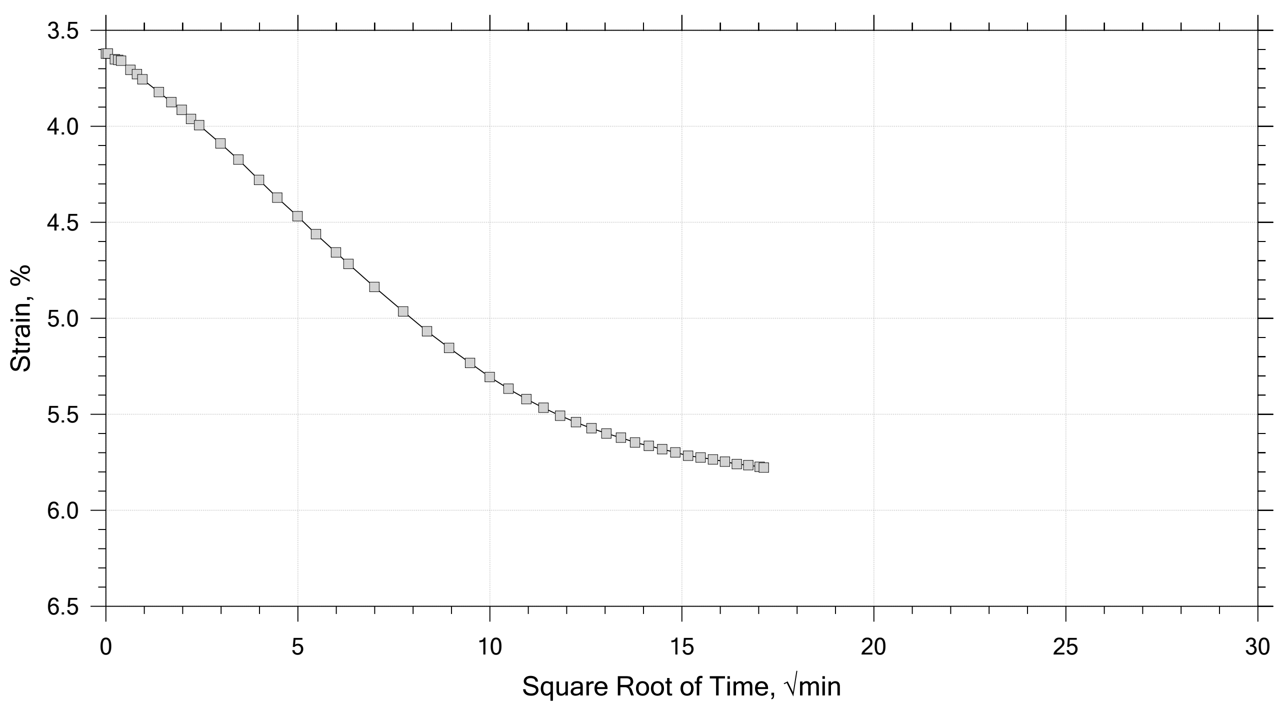


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 15
Constant Load Step
Stress: 0.25 tsf





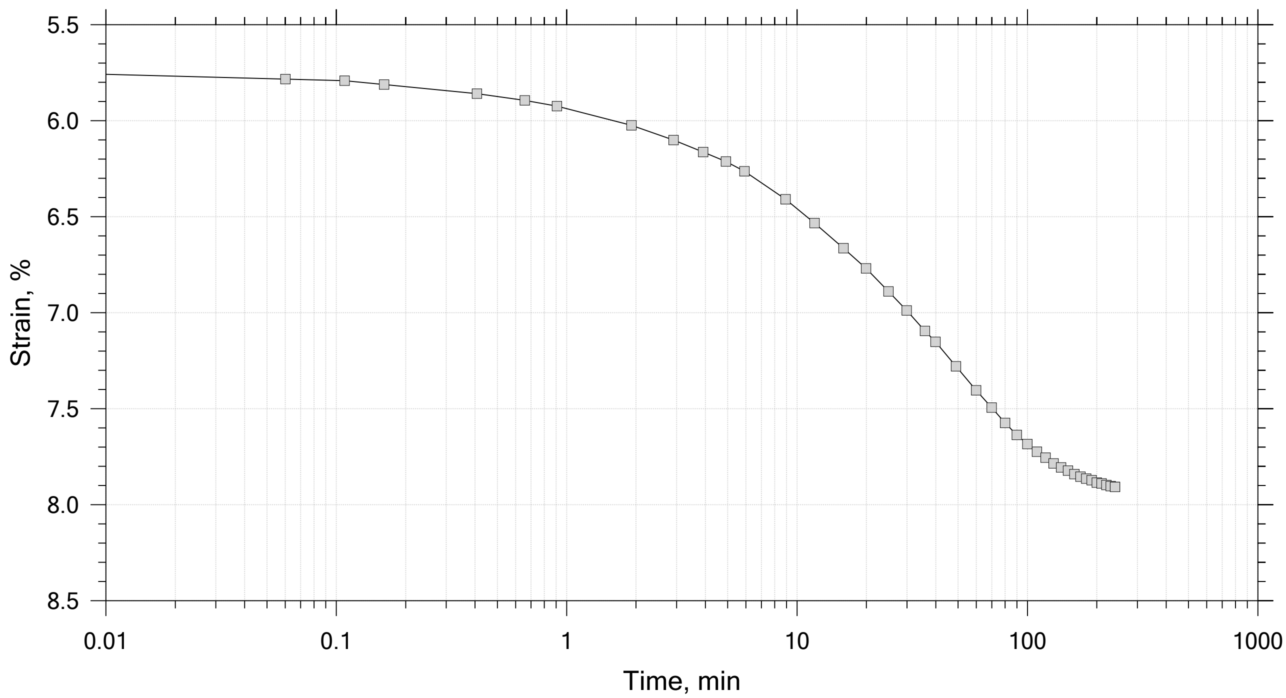
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

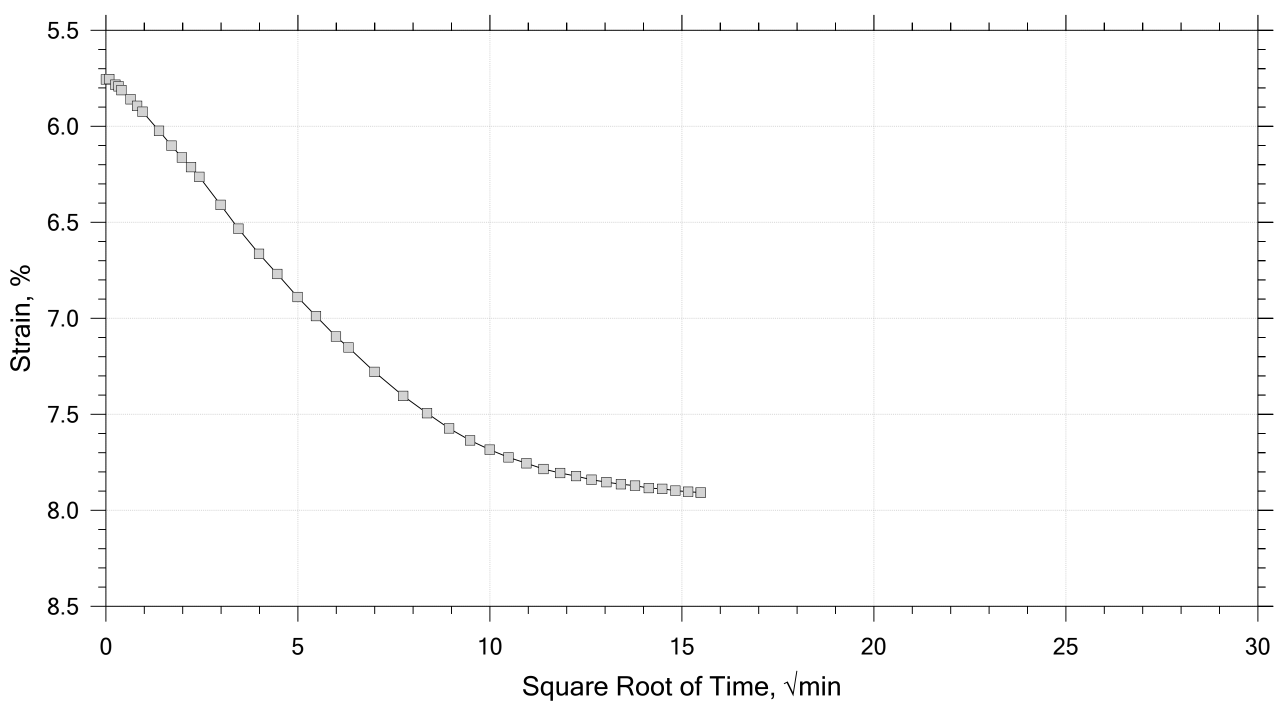
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 15

Constant Load Step

Stress: 0.5 tsf





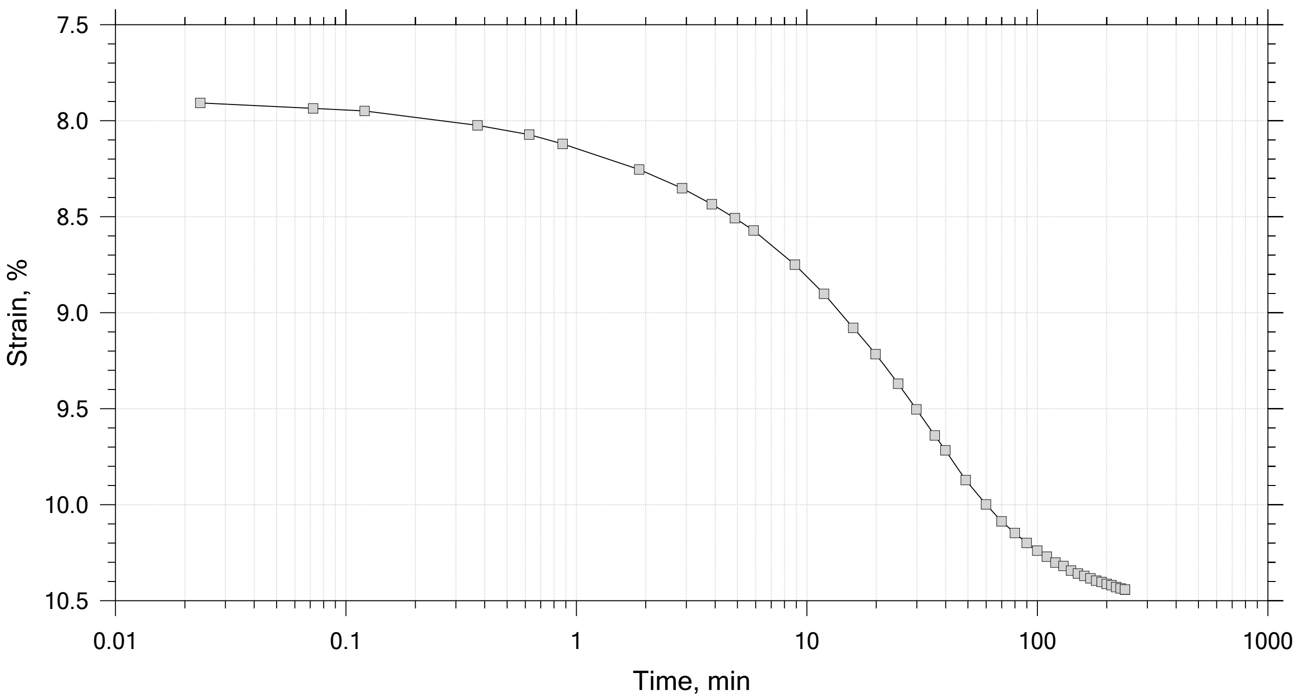
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

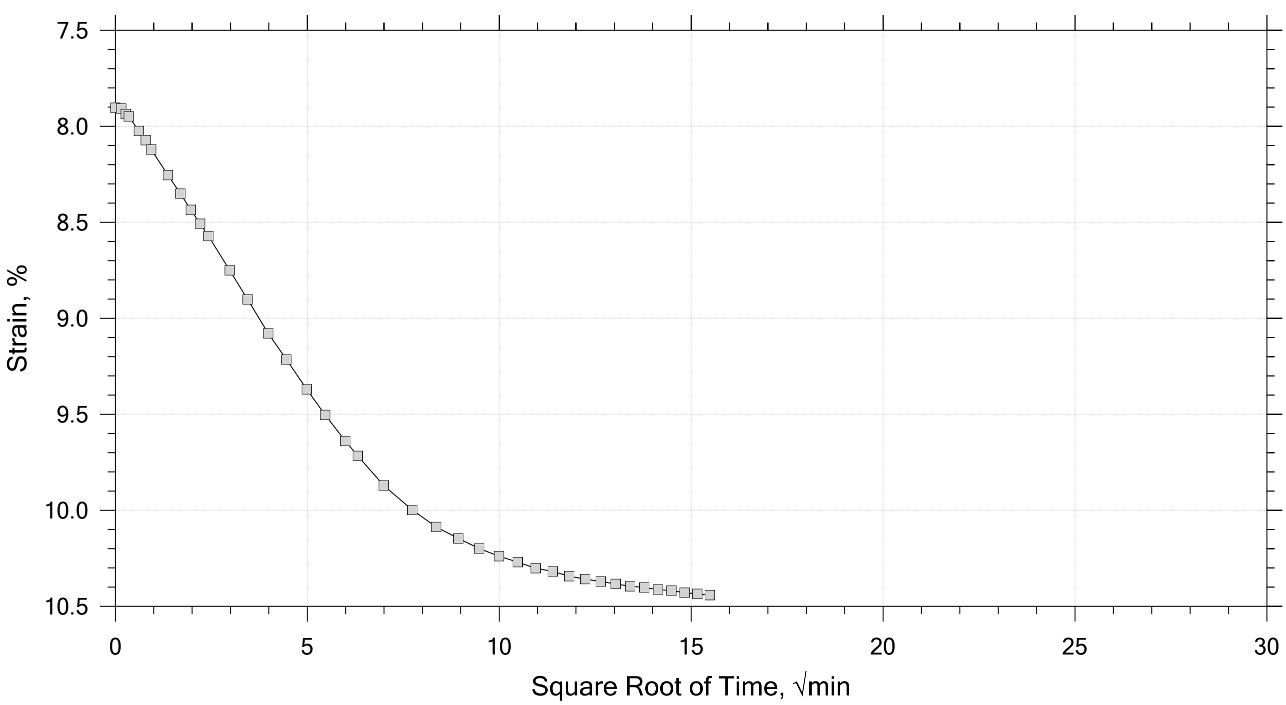
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 15

Constant Load Step

Stress: 1 tsf





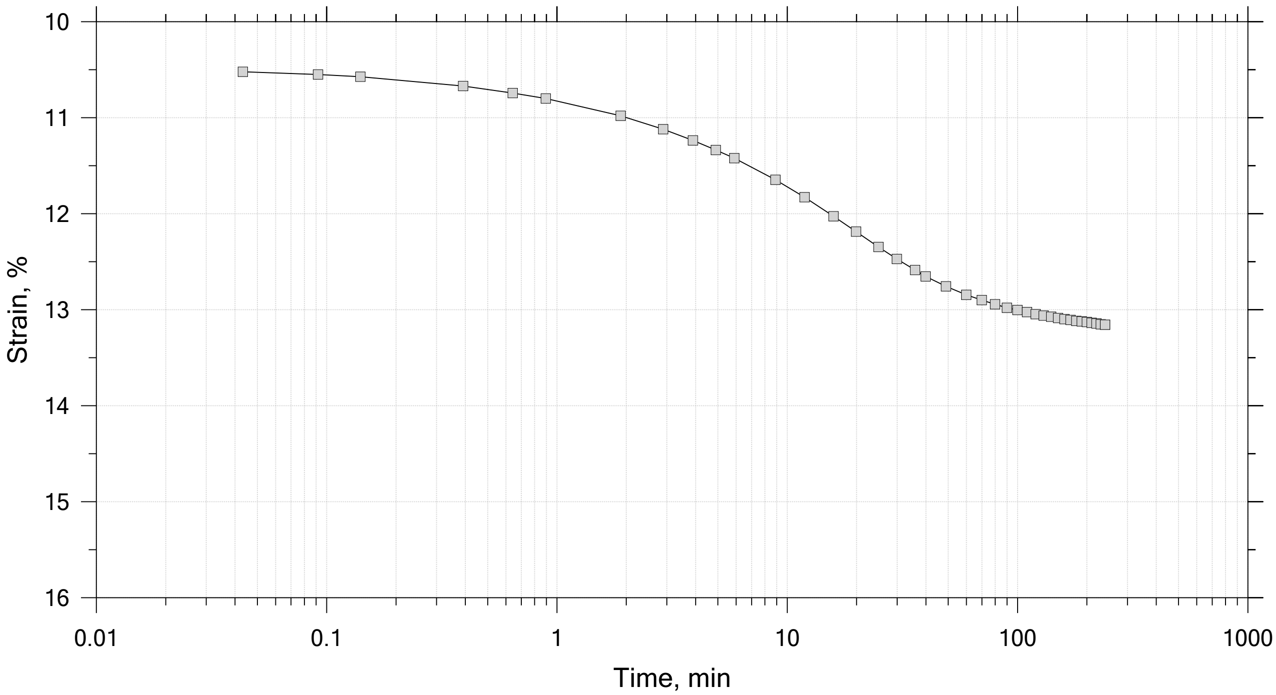
GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

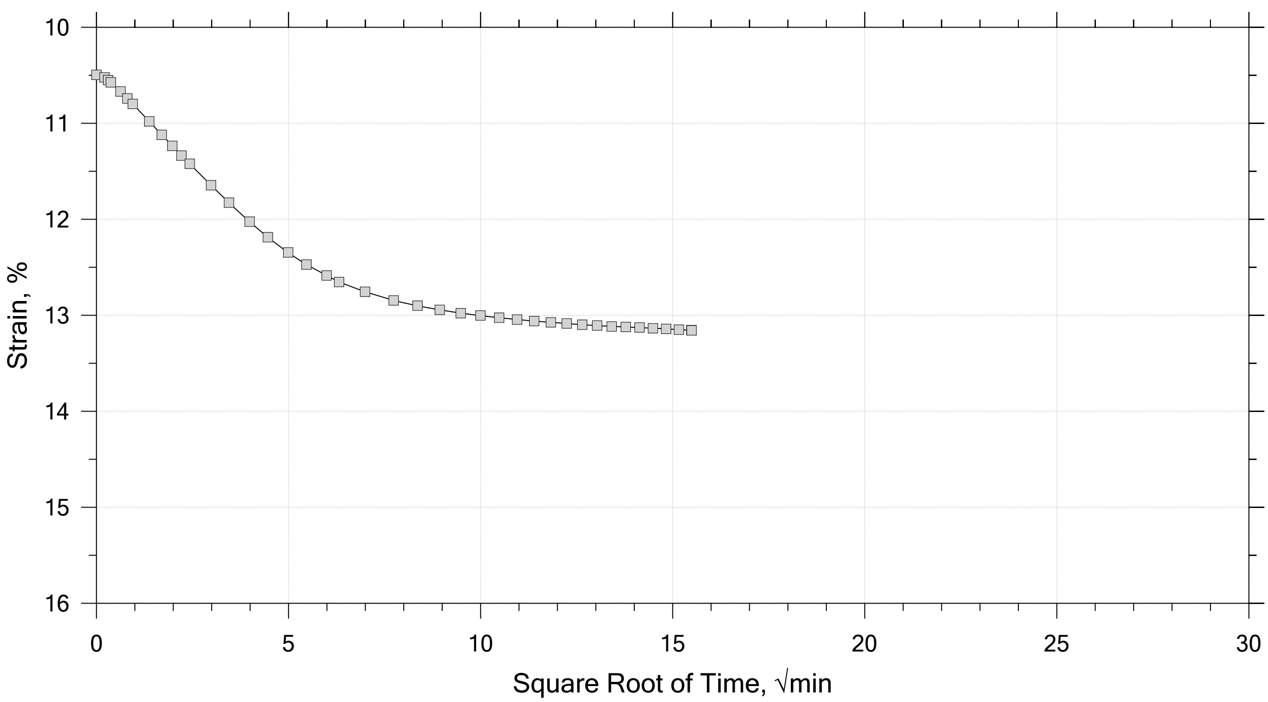
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 15

Constant Load Step

Stress: 2 tsf





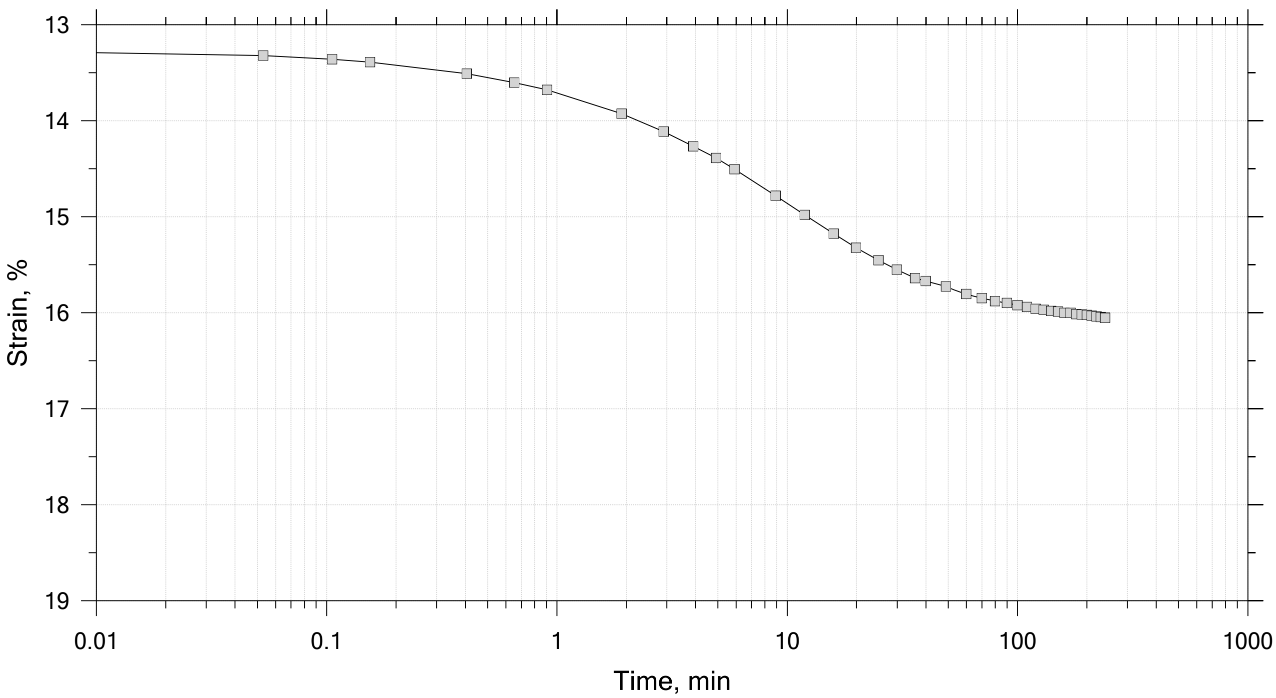
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

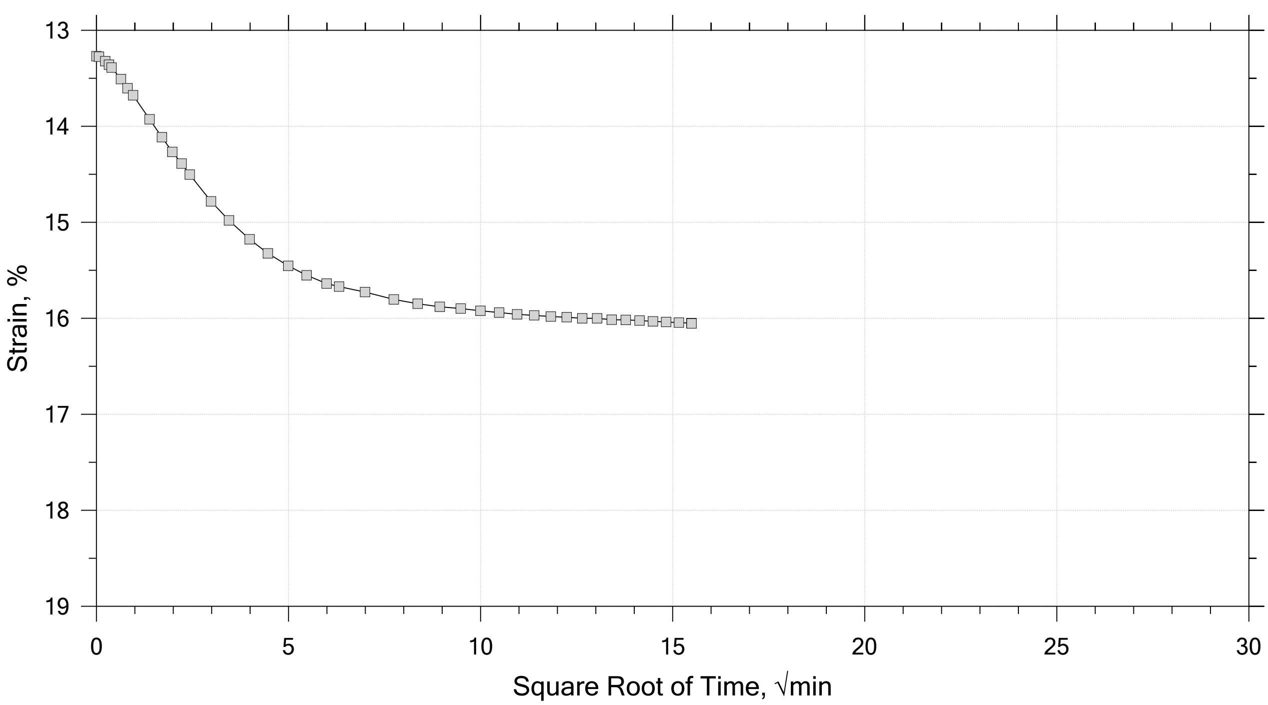
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 15

Constant Load Step

Stress: 4 tsf





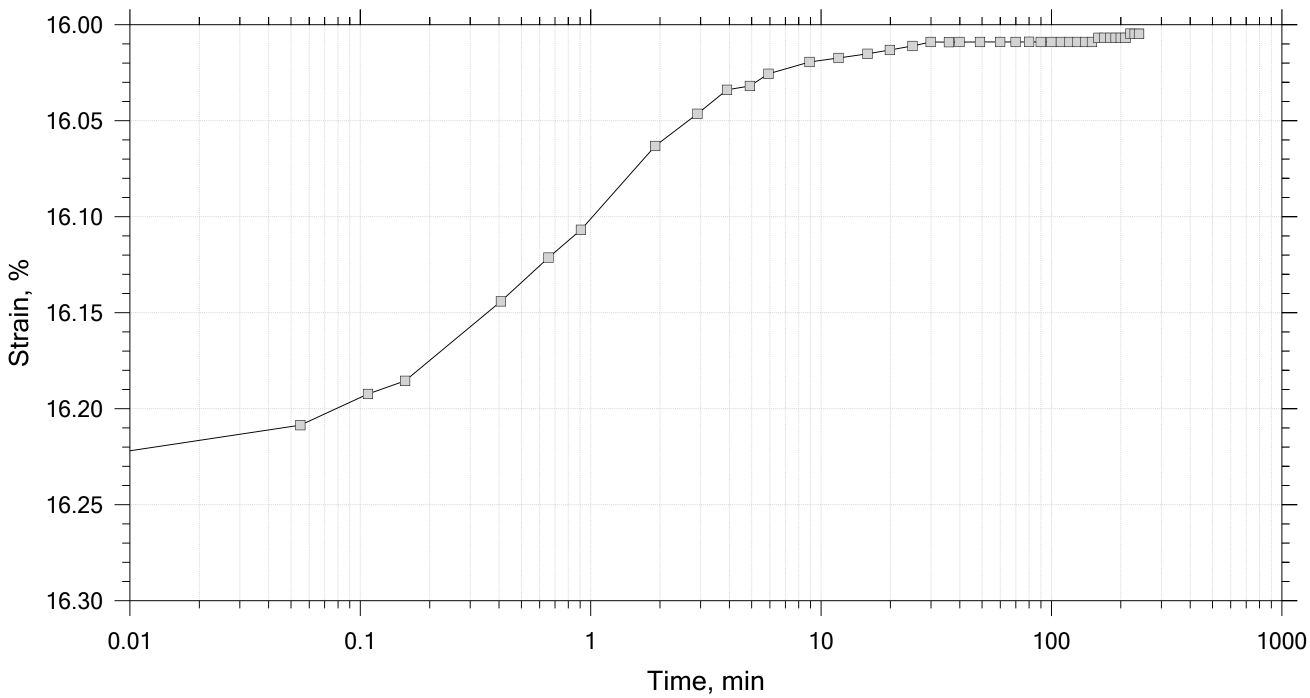
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

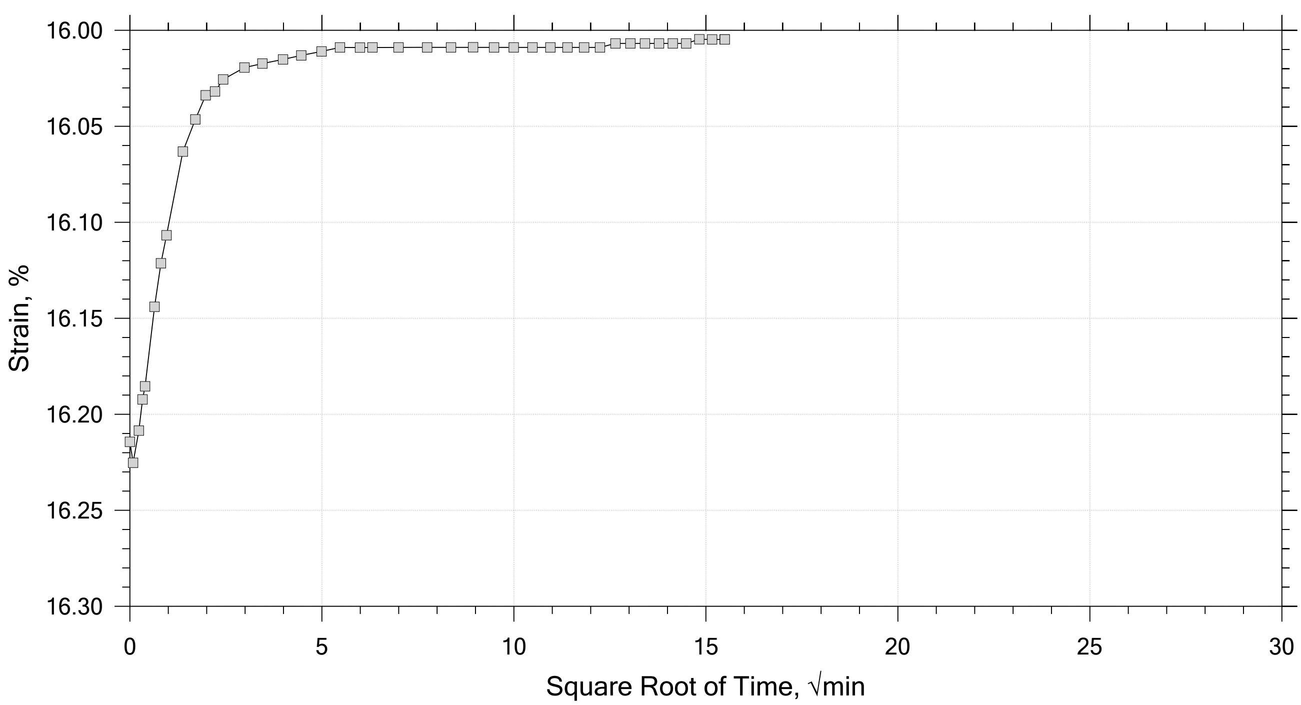
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 15

Constant Load Step

Stress: 2 tsf





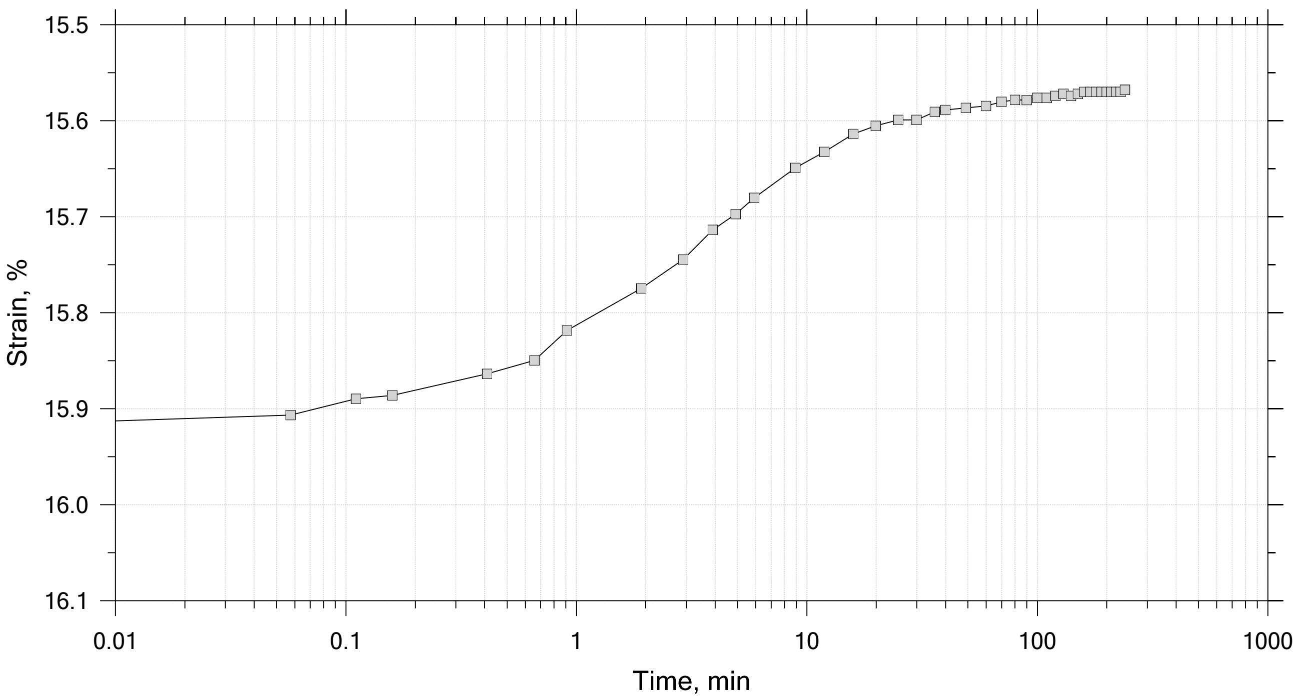
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

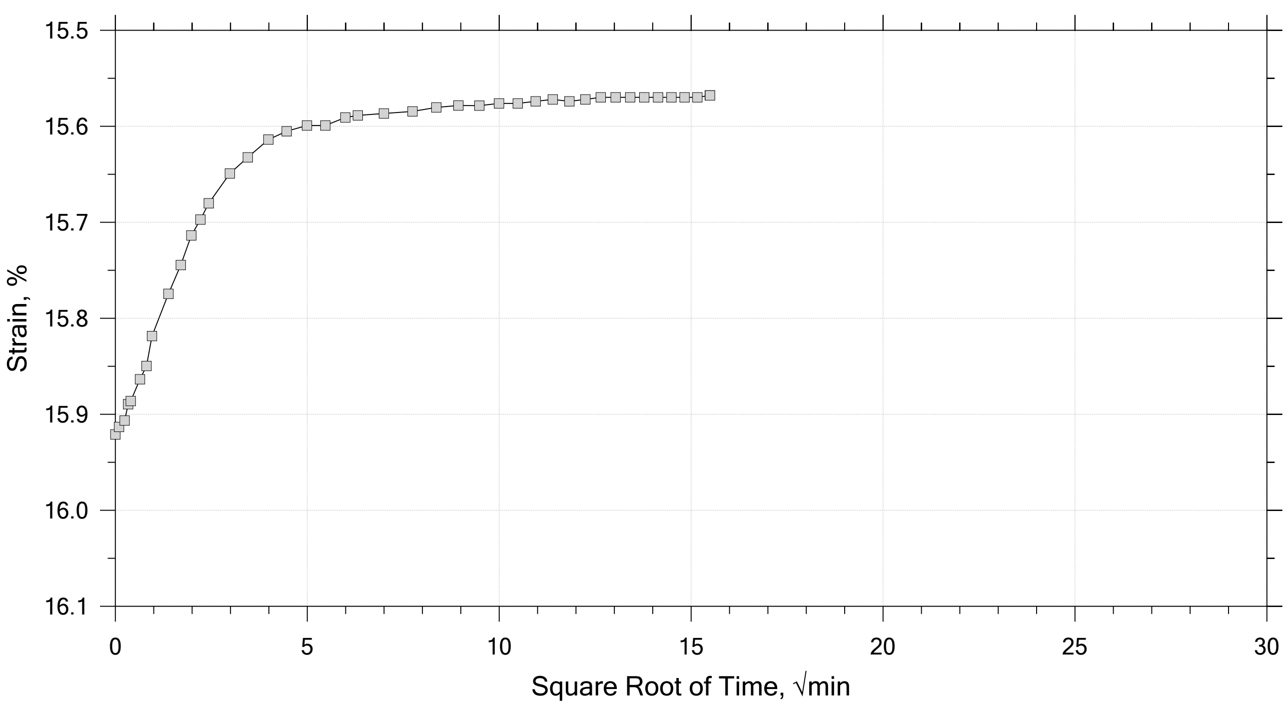
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 15

Constant Load Step

Stress: 1 tsf

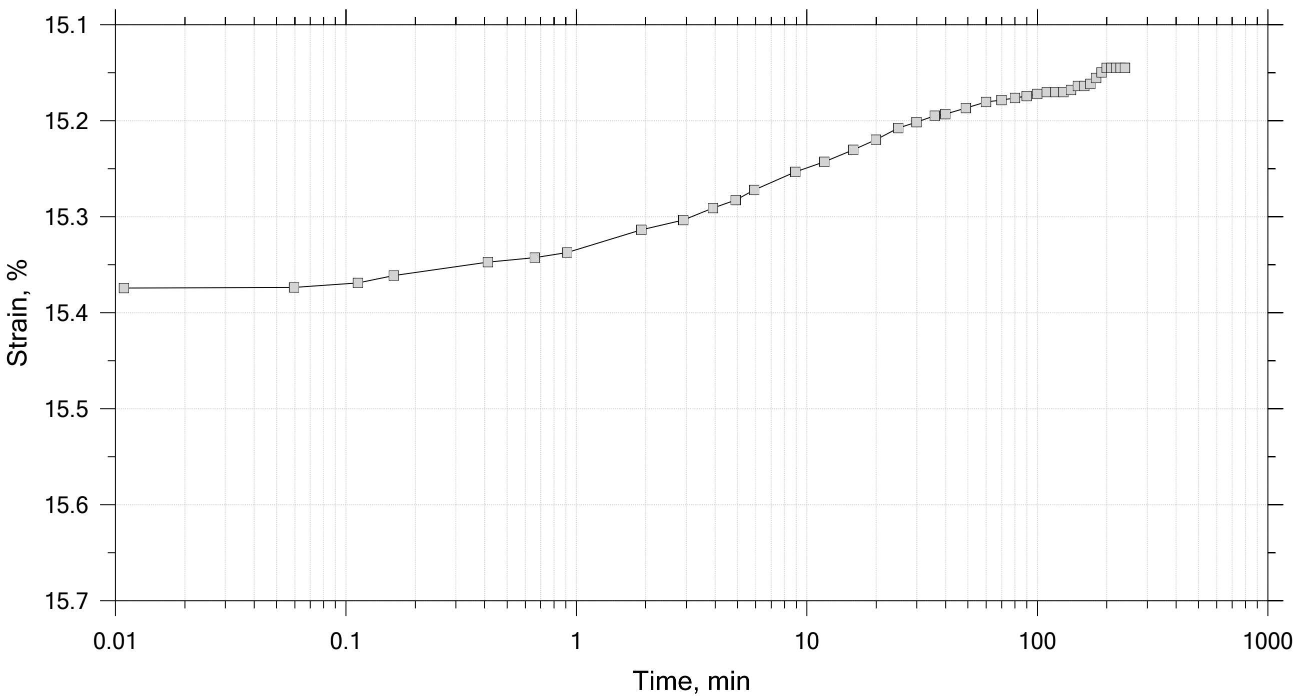


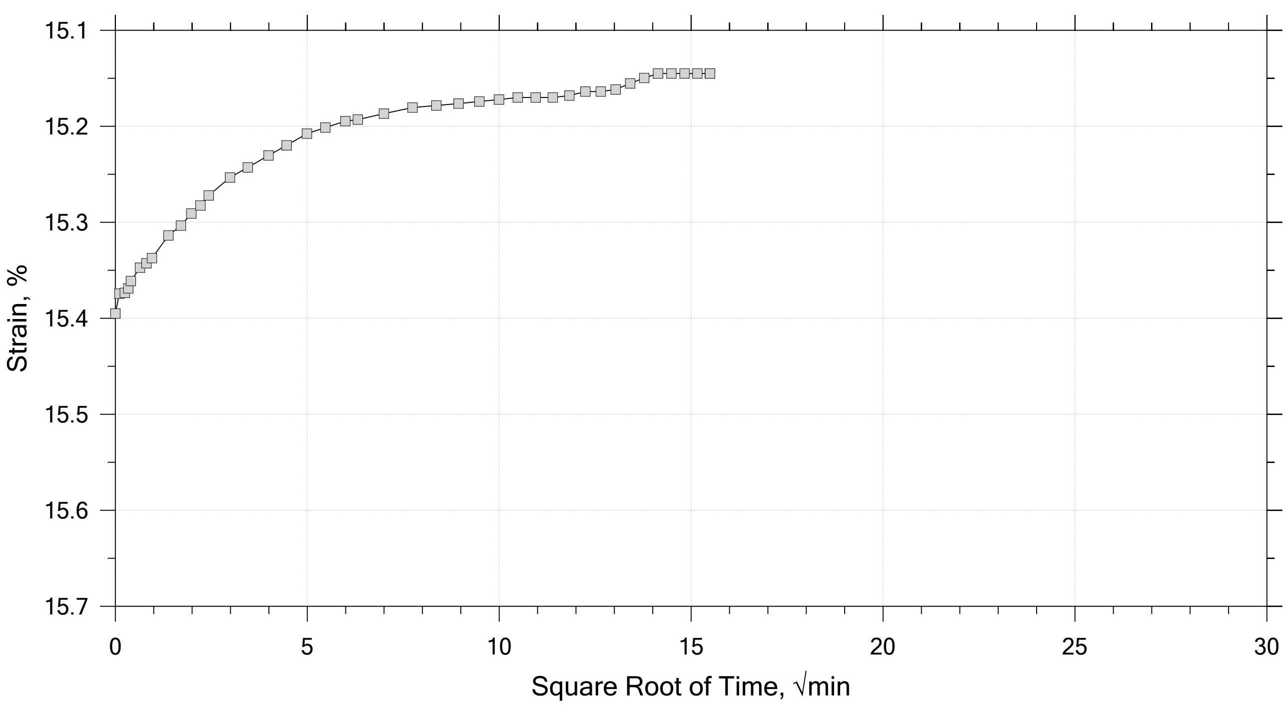


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 15
Constant Load Step
Stress: 0.5 tsf





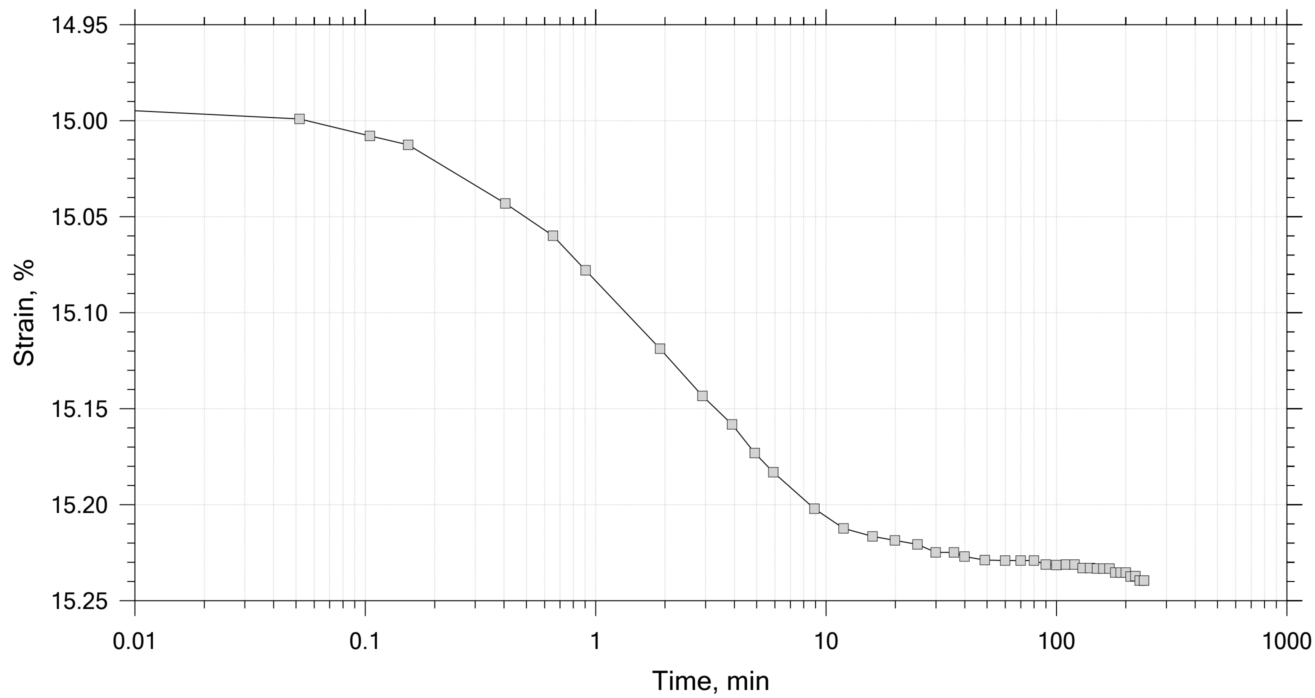
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

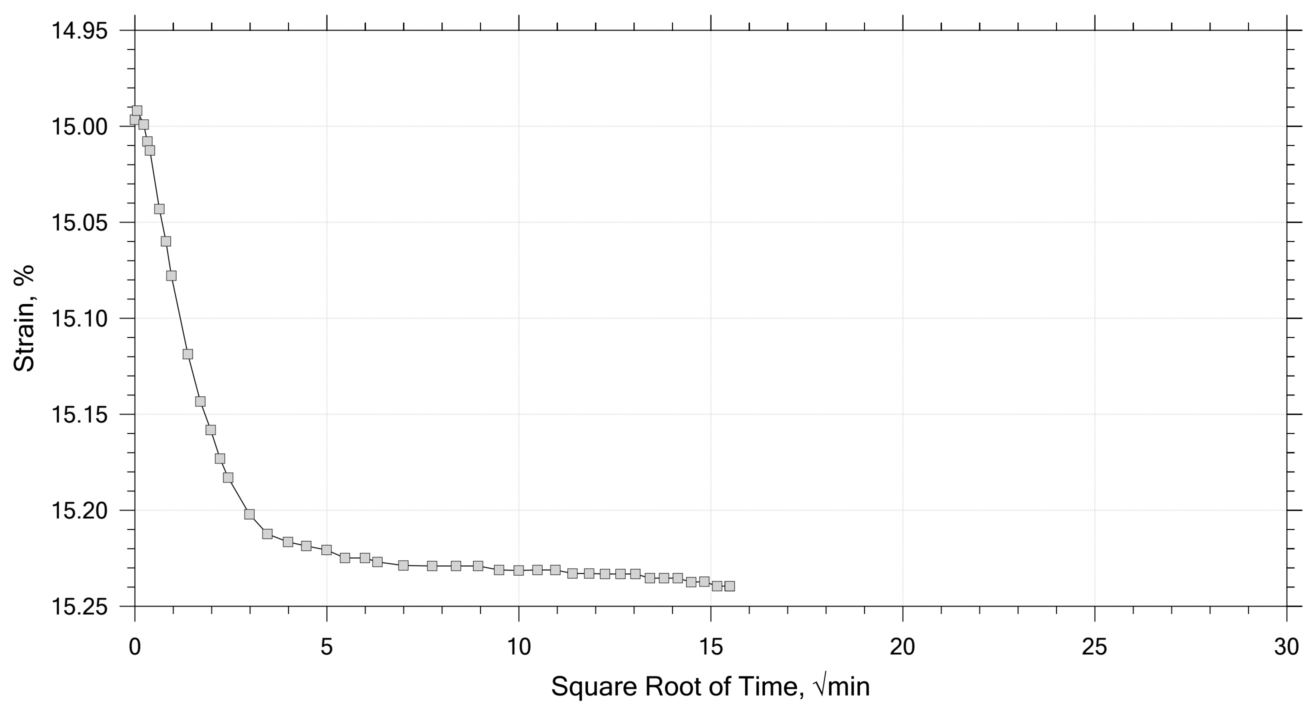
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 15

Constant Load Step

Stress: 1 tsf





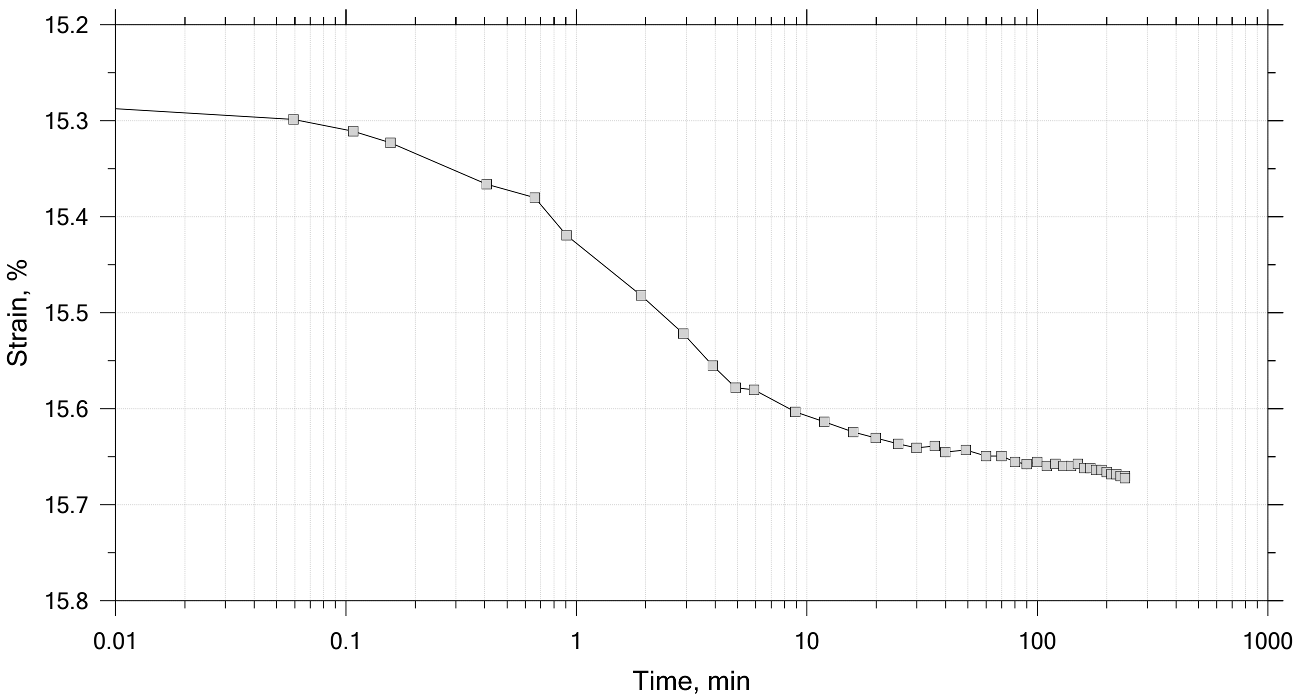
GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

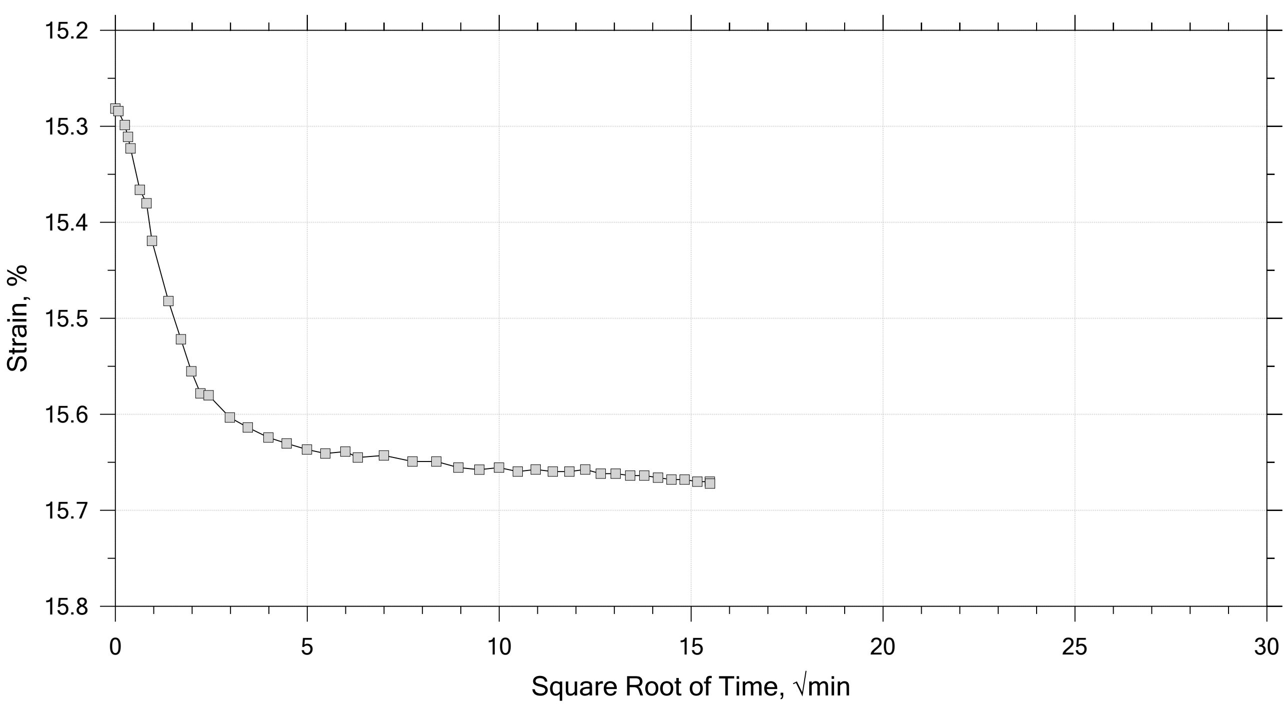
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 15

Constant Load Step

Stress: 2 tsf

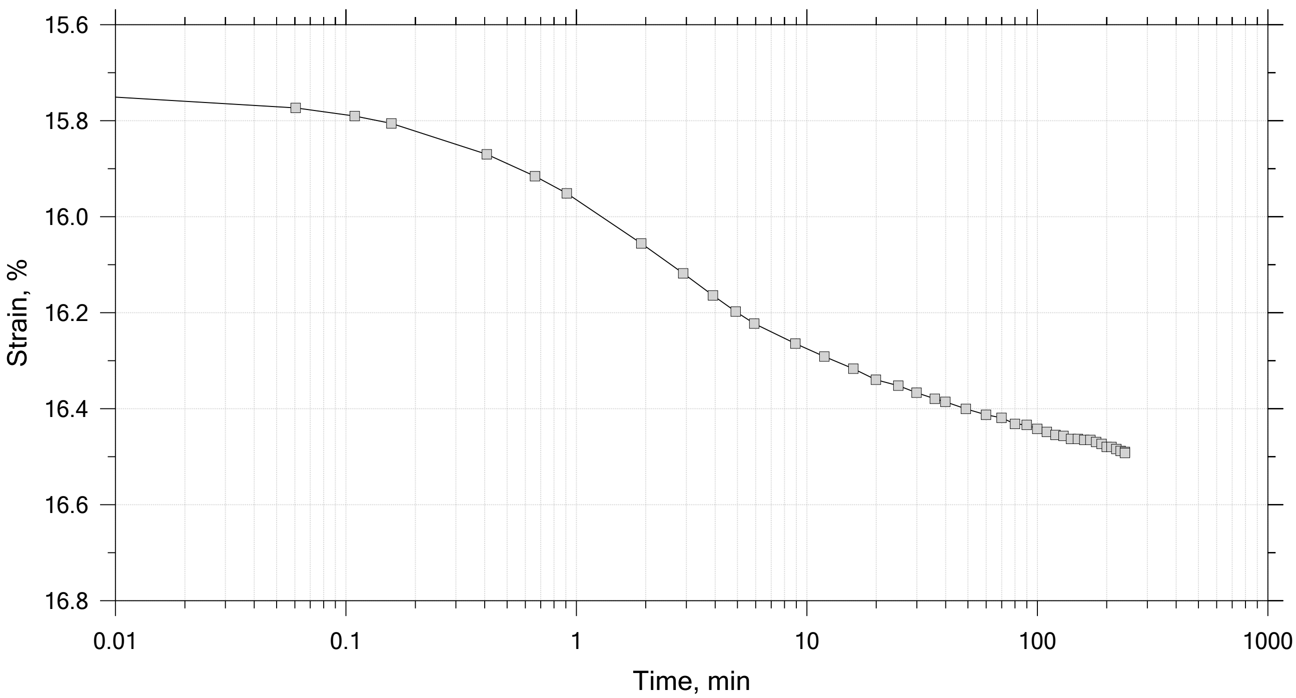


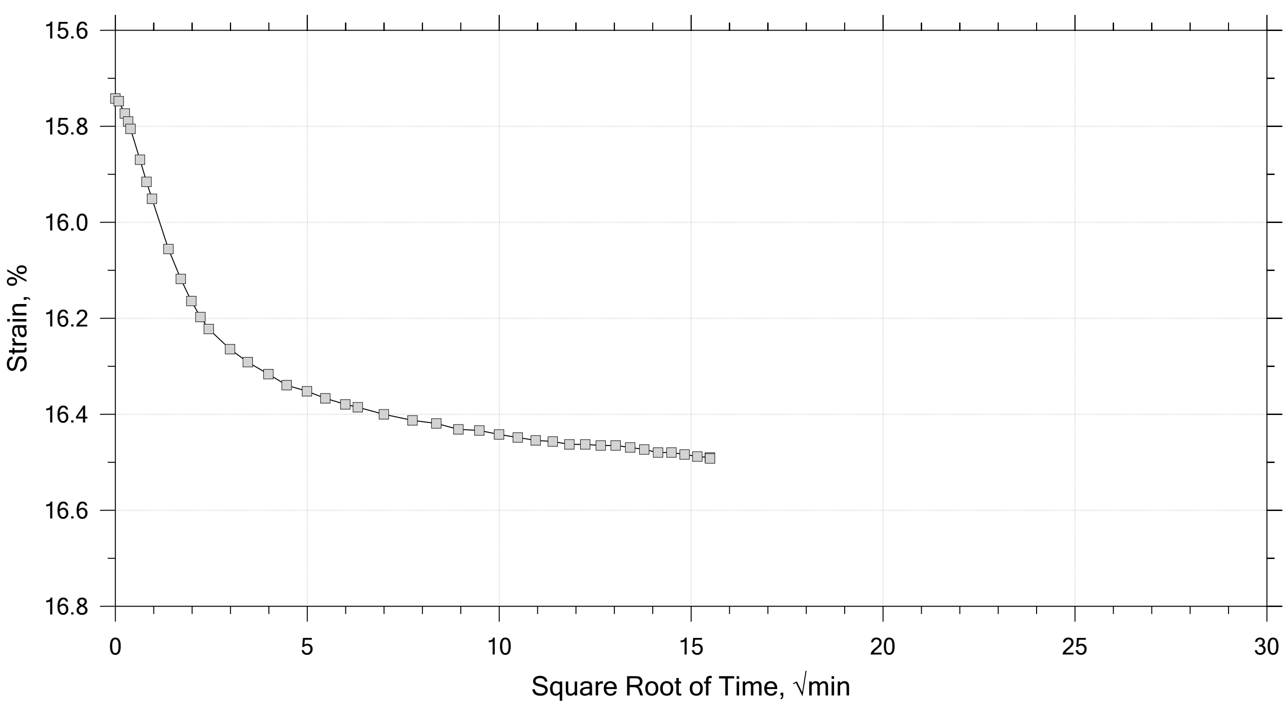


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 15
Constant Load Step
Stress: 4 tsf





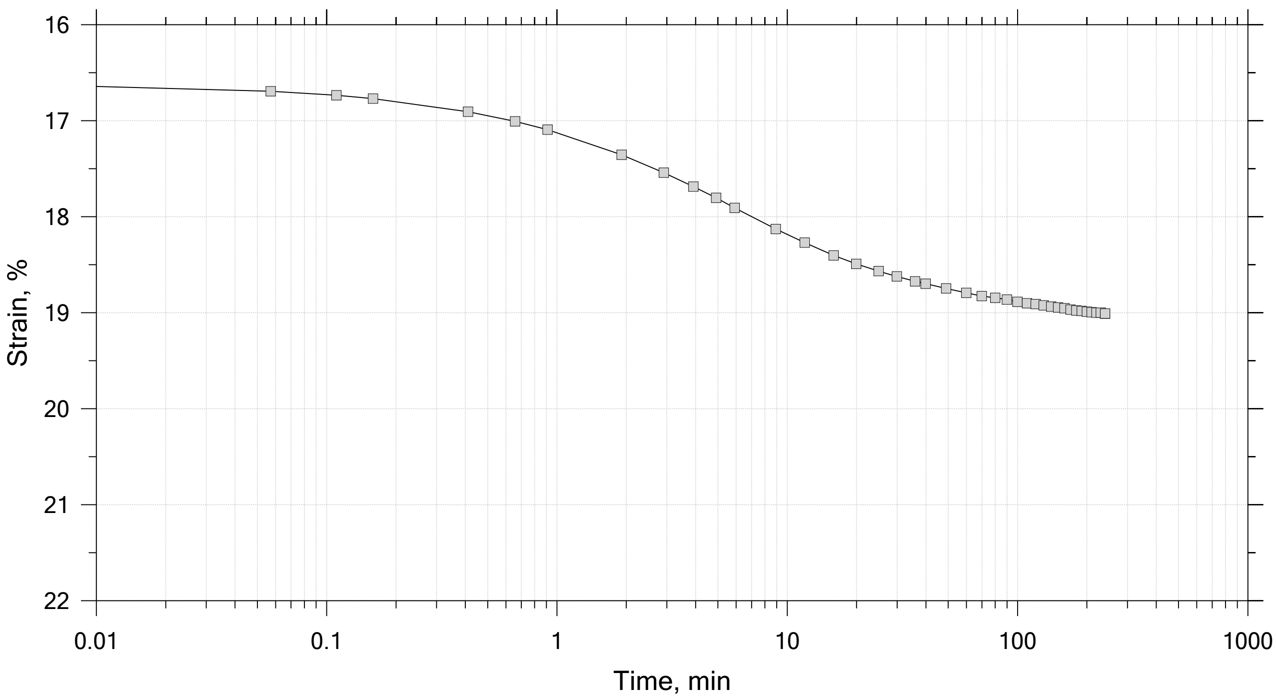
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
GeoTesting EXPRESS	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

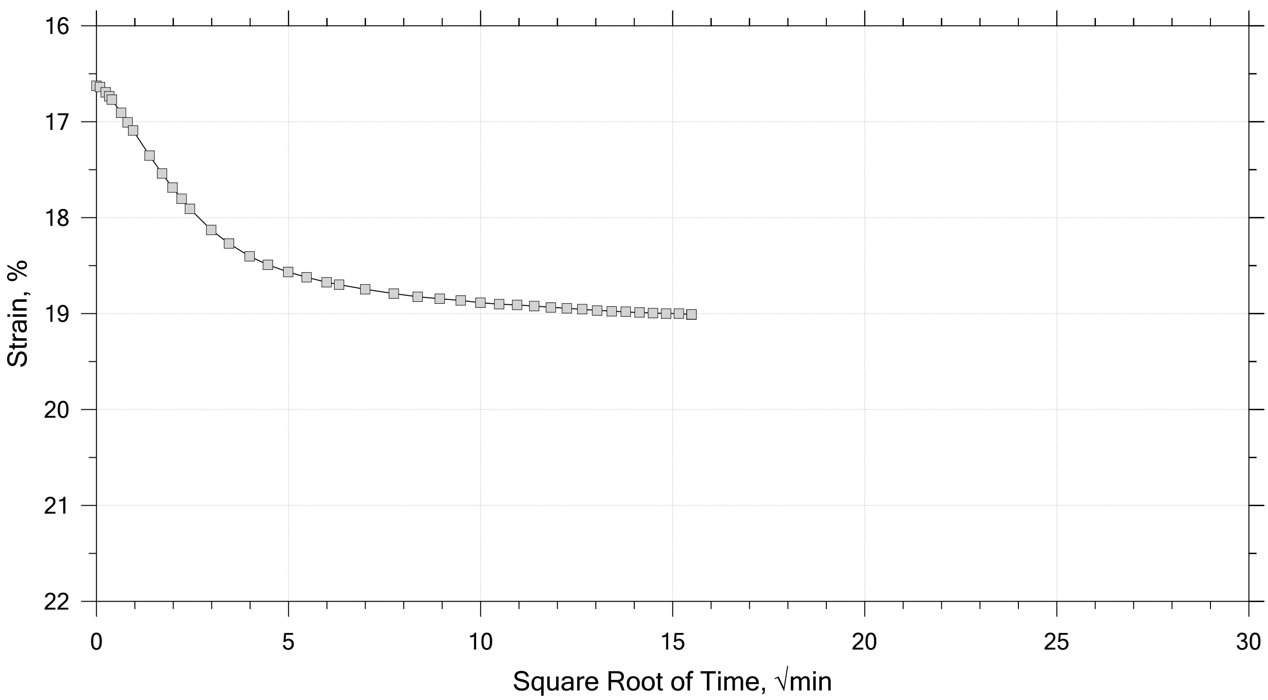
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 15

Constant Load Step

Stress: 8 tsf

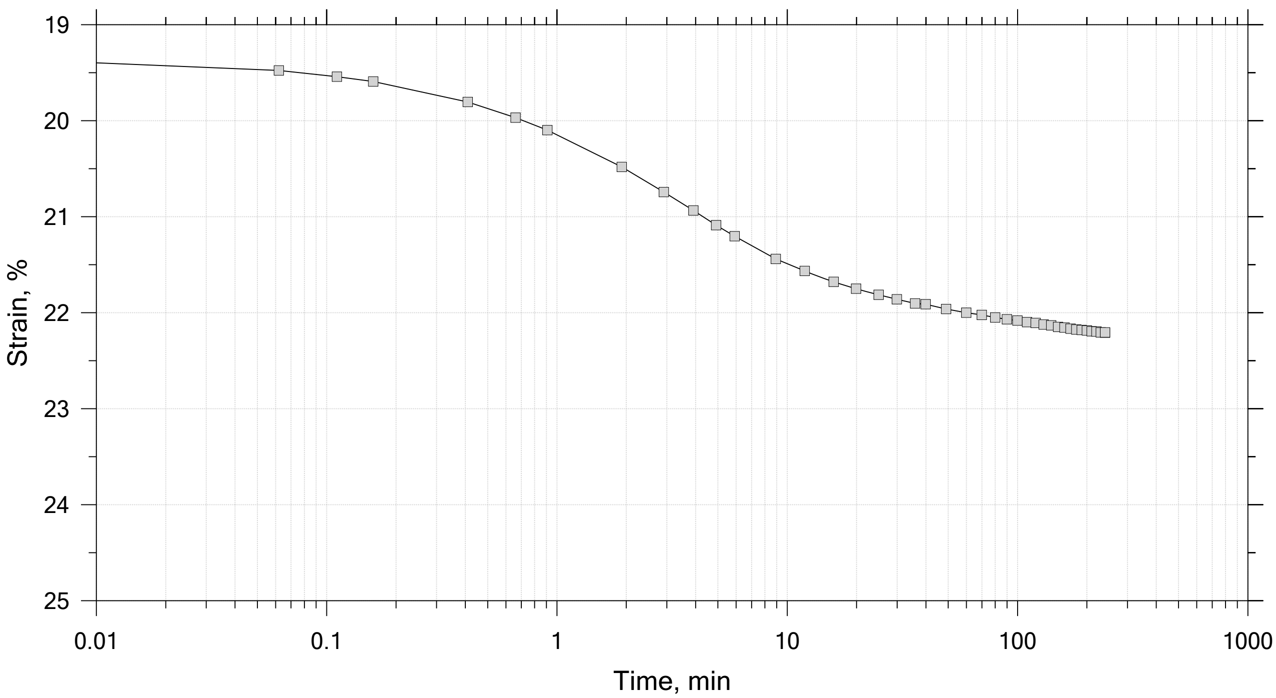


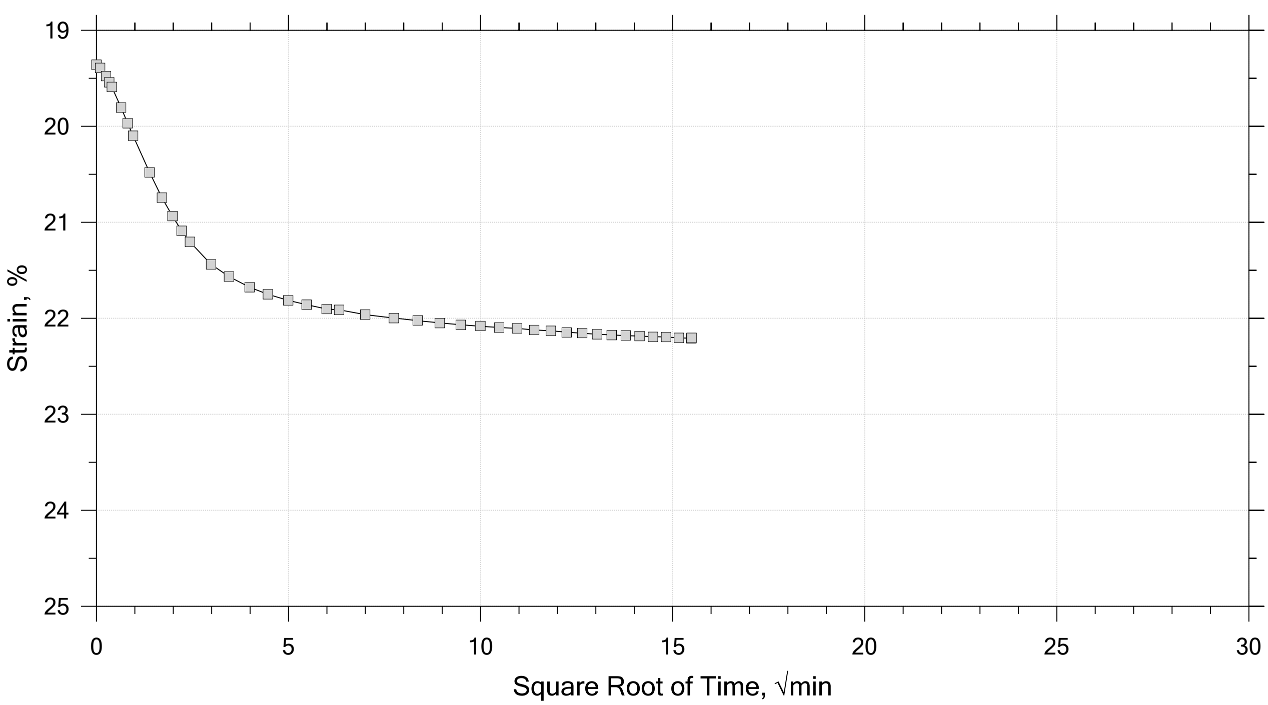


GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 15
Constant Load Step
Stress: 16 tsf





GeoTesting EXPRESS	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.75	Liquid Limit: 38
Initial Height: 1.00 in	Initial Void Ratio: 0.922	Plastic Limit: 20
Final Height: 0.77 in	Final Void Ratio: 0.48	Plasticity Index: 18

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	E2253	RING		E5868
Mass Container, gm	8.22	109.67	109.67	8.53
Mass Container + Wet Soil, gm	131.39	263.12	245	145.78
Mass Container + Dry Soil, gm	97.83	224.91	224.91	125.41
Mass Dry Soil, gm	89.61	115.24	115.24	116.88
Water Content, %	37.45	33.15	17.43	17.43
Void Ratio	---	0.92	0.48	---
Degree of Saturation, %	---	99.01	100.00	---
Dry Unit Weight, pcf	---	89.44	116.16	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test.
Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS			
	Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
	Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
	Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
	Test No.: IP-2	Sample Type: Intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Square Root of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv in²/s	Mv 1/tsf	k ft/day
1	0.0613	0.02136	0.881	2.14	190.474	1.82e-05	3.48e-01	1.18e-04
2	0.125	0.03667	0.851	3.67	242.405	1.37e-05	2.40e-01	6.19e-05
3	0.250	0.05778	0.811	5.78	182.562	1.76e-05	1.69e-01	5.56e-05
4	0.500	0.07908	0.770	7.91	97.115	3.16e-05	8.52e-02	5.04e-05
5	1.00	0.1044	0.721	10.4	78.156	3.73e-05	5.07e-02	3.54e-05
6	2.00	0.1316	0.669	13.2	50.550	5.44e-05	2.72e-02	2.76e-05
7	4.00	0.1605	0.613	16.1	27.573	9.34e-05	1.45e-02	2.53e-05
8	2.00	0.1600	0.614	16.0	3.616	6.89e-04	2.41e-04	3.11e-06
9	1.00	0.1557	0.623	15.6	11.702	2.14e-04	4.37e-03	1.75e-05
10	0.500	0.1514	0.631	15.1	29.002	8.73e-05	8.46e-03	1.38e-05
11	1.00	0.1524	0.629	15.2	8.410	3.02e-04	1.89e-03	1.07e-05
12	2.00	0.1567	0.621	15.7	7.226	3.50e-04	4.33e-03	2.83e-05
13	4.00	0.1649	0.605	16.5	10.460	2.38e-04	4.10e-03	1.83e-05
14	8.00	0.1901	0.557	19.0	17.772	1.35e-04	6.29e-03	1.58e-05
15	16.0	0.2220	0.495	22.2	11.623	1.92e-04	4.00e-03	1.43e-05

Project: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project No.: GTX-317121
Boring No.: BB-ATB-102	Tested By: trm	Checked By: anm
Sample No.: U-2	Test Date: 5/3/23	Depth: 45'-47'
Test No.: IP-2	Sample Type: Intact	Elevation: ---
Description: Moist, dark gray clay		
Remarks: System LTIII-H, Swell Pressure = 0.0613 tsf		
Displacement at End of Increment		

GeoTesting EXPRESS

Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils by ASTM D6528

Client:	WSP USA, Inc.	GTX#:	317121
Project Name:	ME DOT Augusta Thorne Brook Culvert	Test Date:	5/24/23
Project Location:	Augusta, ME		

Boring ID: BB-ATB-102
Sample ID: U-1
Depth, ft: 30-32

Visual Description: Moist, dark gray clay

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked rings used. Set up included porous stones with pins.

Test Condition: Inundated prior to consolidating to 2,370 psf.

Sample Type and Preparation: density — Extruded from tube, cut, trimmed and placed into apparatus at as-received and moisture content.

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
Test No.	DSS-1				
Initial Moisture Content, %	32.1				
Initial Dry Density, pcf	91.6				
Nominal Rate of Shear Strain, %/hr	5.0				
Maximum Vertical Consolidation Stress, psf	2,370				
Vertical Consolidation Stress at time of shear, psf	2,370				
Final Moisture Content, %	25.7				
Measured Peak Shear Stress, psf	396				
Shear Strain at Peak Shear Stress, %	6.6				
Membrane Correction, psf	50				
Corrected Peak Shear Stress, psf	346				
S_u / σ'_{vc}	0.15				

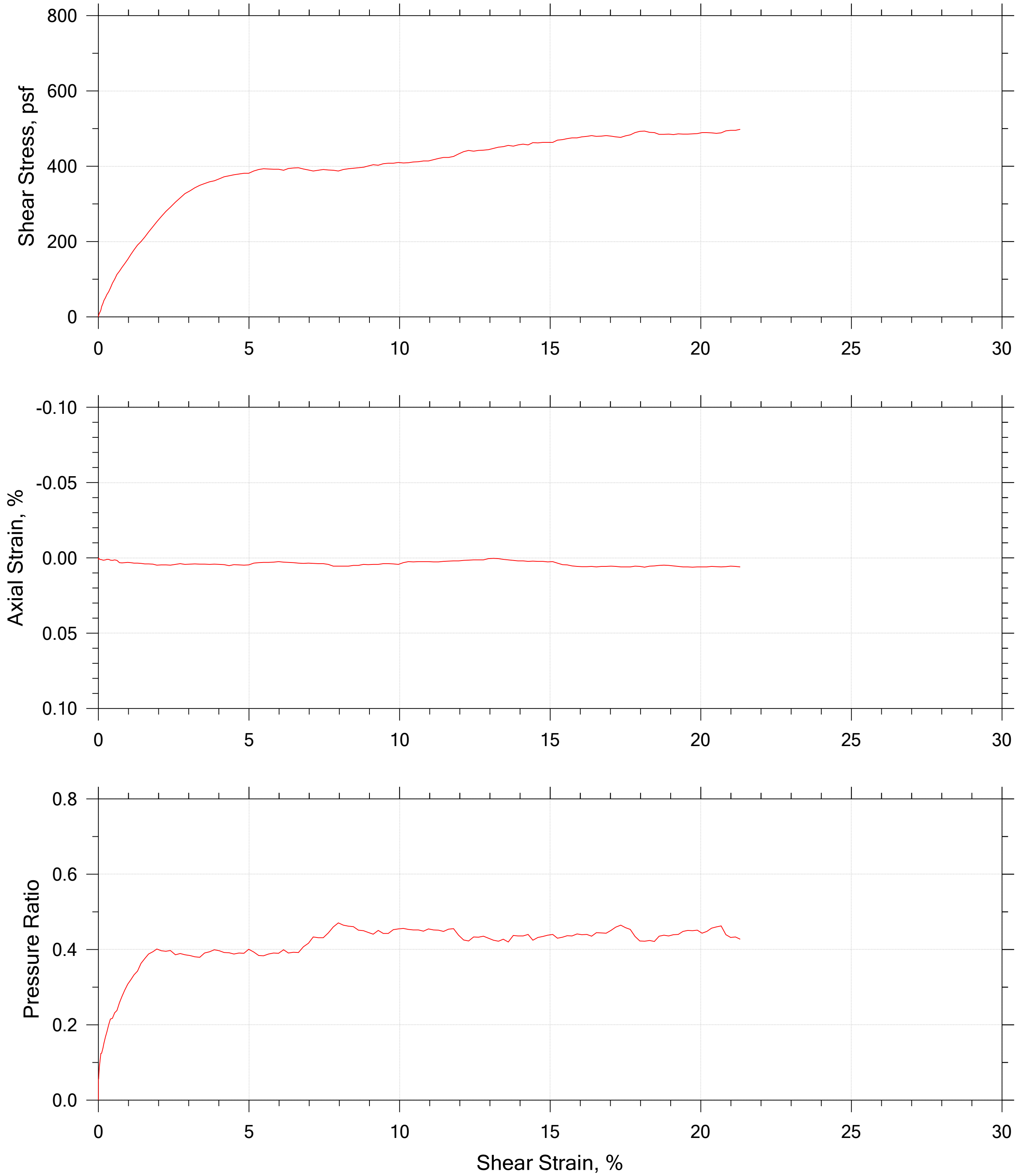
Comments: Peak Shear Stress chosen per client request.

Tested By: jlw

Checked By: njh

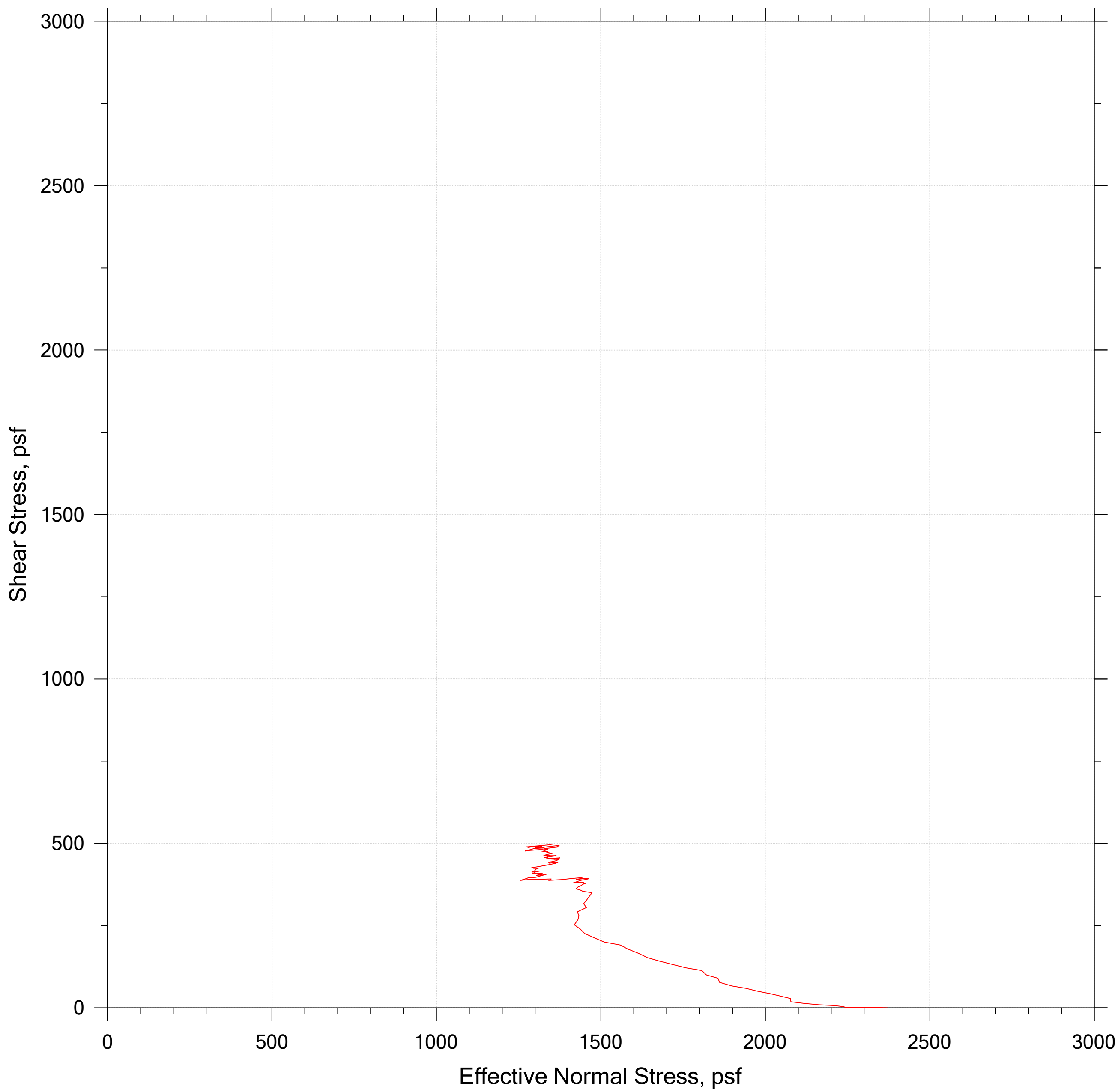
Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Direct Simple Shear Test



Project Name: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project Number: GTX-317121
Boring Number: BB-ATB-102	Tester: jlw	Checker: njh
Sample Number: U-1	Test Date: 5/24/23	Depth: 30-32
Test Number: DSS-1	Preparation: intact	Elevation: ---
Description: Moist, dark gray clay		
Remarks: CST- 004		

Direct Simple Shear Test



Project Name: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project Number: GTX-317121
Boring Number: BB-ATB-102	Tester: jlw	Checker: njh
Sample Number: U-1	Test Date: 5/24/23	Depth: 30-32
Test Number: DSS-1	Preparation: intact	Elevation: ---
Description: Moist, dark gray clay		
Remarks: CST- 004		

Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils by ASTM D6528

Client:	WSP USA, Inc.	GTX#:	317121
Project Name:	ME DOT Augusta Thorne Brook Culvert	Test Date:	5/26/23
Project Location:	Augusta, ME		

Boring ID: BB-ATB-102
Sample ID: U-2
Depth, ft: 45-47

Visual Description: Moist, dark gray clay

Test Equipment: Top and bottom box (circular) = 2.50 in diameter. Load cells and LVDT's connected to data acquisition system for shear force, normal load, horizontal and vertical displacement; surface area = 4.91 in^2, soil height = 1 inch. Stacked rings used. Set up included porous stones with pins.

Test Condition: Inundated prior to consolidating to 3,190 psf.

Sample Type and Preparation: Extruded from tube, cut, trimmed and placed into apparatus at as-received density and moisture content.

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5
Test No.	DSS-2				
Initial Moisture Content, %	37.9				
Initial Dry Density, pcf	85.6				
Nominal Rate of Shear Strain, %/hr	5.0				
Maximum Vertical Consolidation Stress, psf	3,190				
Vertical Consolidation Stress at time of shear, psf	3,190				
Final Moisture Content, %	28.0				
Measured Peak Shear Stress, psf	698				
Shear Strain at Peak Shear Stress, %	2.2				
Membrane Correction, psf	22				
Corrected Peak Shear Stress, psf	676				
S_u / σ'_{vc}	0.21				

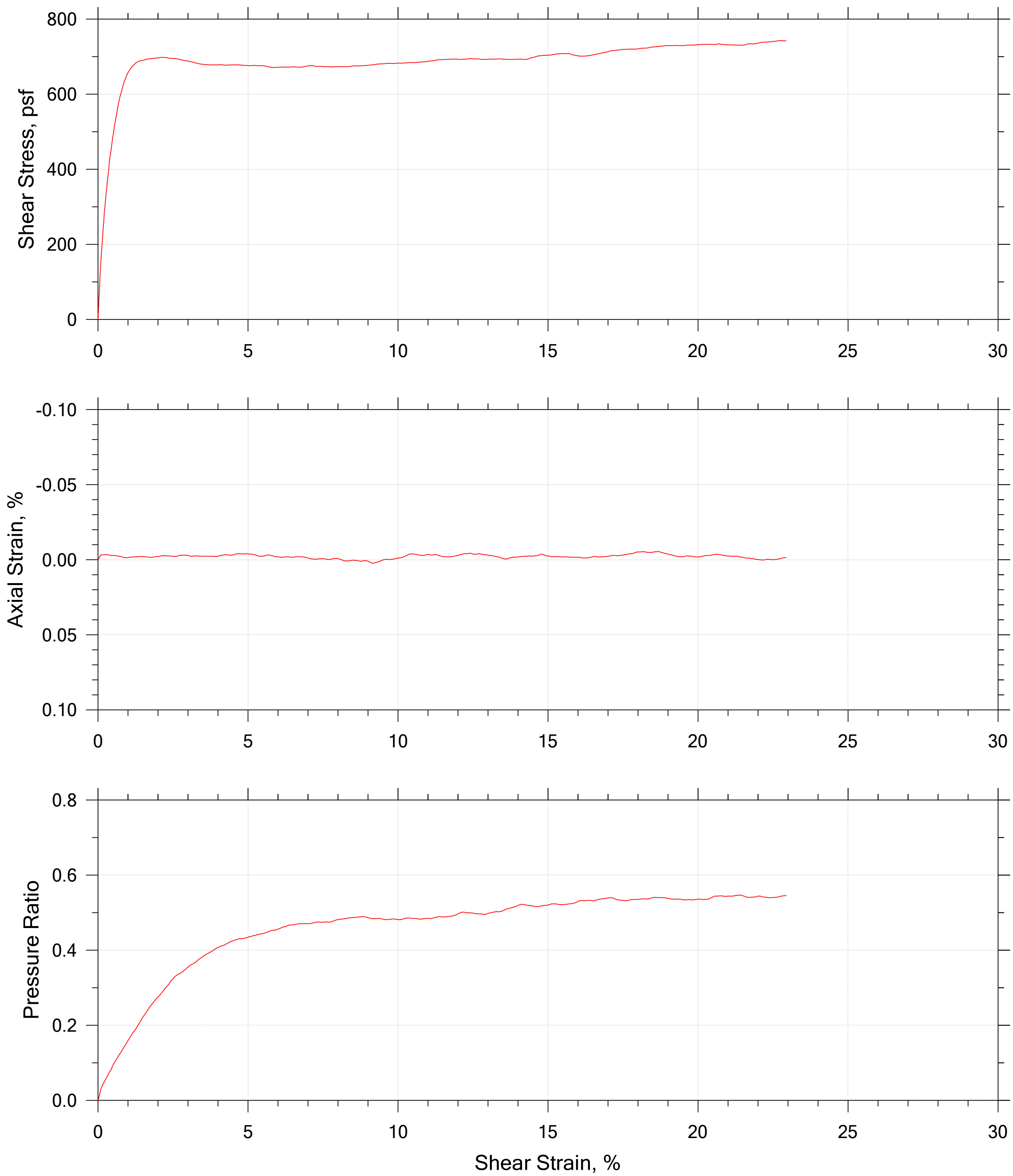
Comments: Peak Shear Stress chosen per client request.

Tested By: jlw

Checked By: njh

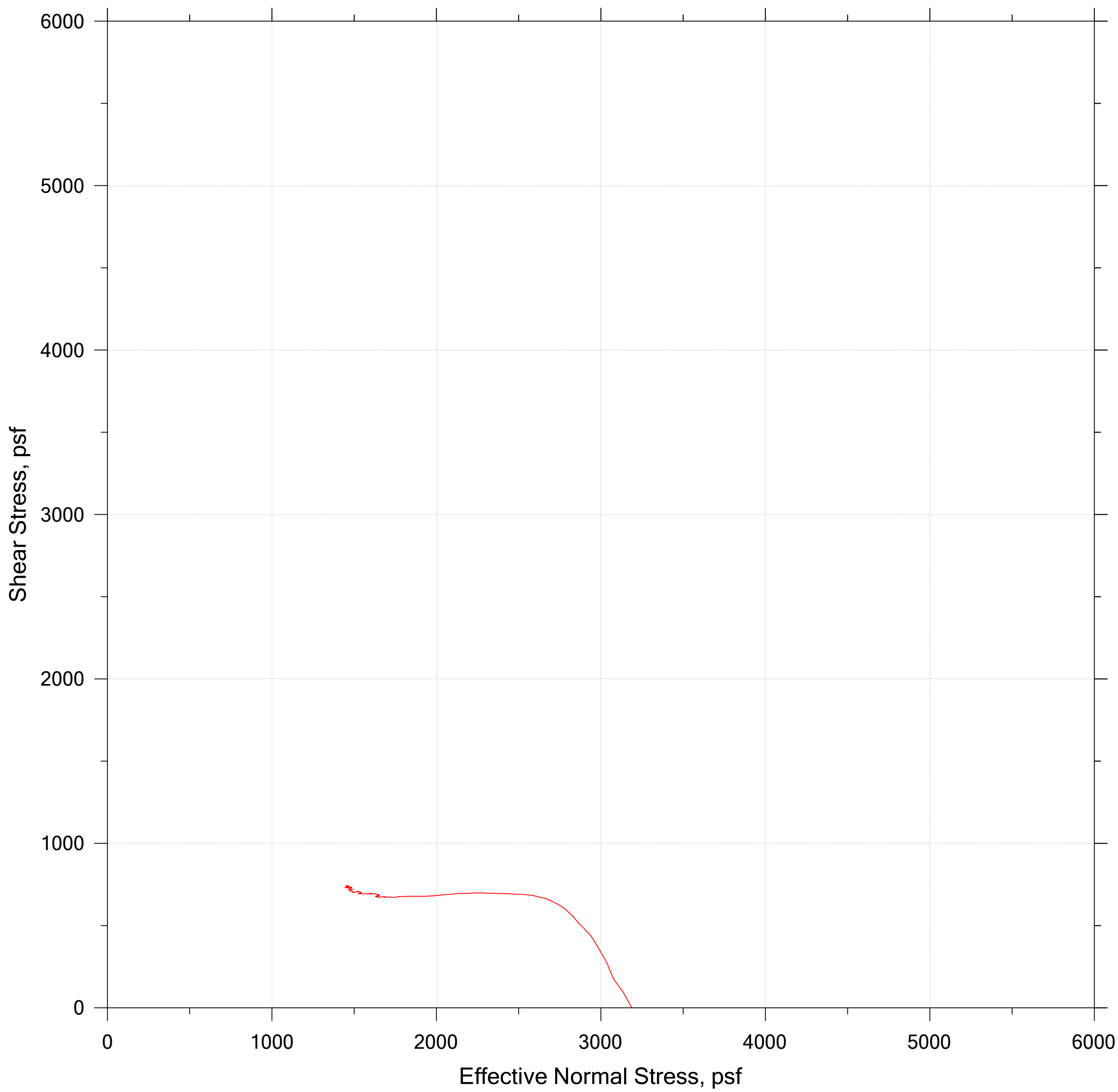
Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

Direct Simple Shear Test



GeoTesting EXPRESS	Project Name: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project Number: GTX- 317121
	Boring Number: BB-ATB-102	Tester: jlw	Checker: njh
	Sample Number: U-2	Test Date: 5/26/23	Depth: 45-47
	Test Number: DSS-2	Preparation: intact	Elevation: ---
	Description: Moist, dark gray clay		
	Remarks: CST-001		

Direct Simple Shear Test



Project Name: ME DOT Augusta Thorne Brook	Location: Augusta, ME	Project Number: GTX- 317121
Boring Number: BB-ATB-102	Tester: jlw	Checker: njh
Sample Number: U-2	Test Date: 5/26/23	Depth: 45-47
Test Number: DSS-2	Preparation: intact	Elevation: ---
Description: Moist, dark gray clay		
Remarks: CST-001		

APPENDIX D

Calculations

CALCULATIONS

Date:	12/18/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Lateral Earth Pressure	**Reviewed by:**	CCB
Project Short Title:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

OBJECTIVE

Determine lateral earth pressure acting on the proposed culvert wingwalls.

REFERENCES

1. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.
2. WSP geotechnical test boring logs (Appendix A, Preliminary Geotechnical Design Report, dated November 2023).
3. Guertin Elkerton & Associates for Maine Department of Transportation. Bridge Design Guide. Dated August 2003 with 2018
4. Holtz, R.D. , Kovacs, W.D., and Sheahan, T.C. 2010. An Introduction to Geotechnical Engineering, 2nd ed. Pearson Education, Hoboken, NJ.
5. AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020.

ASSUMPTIONS

1. The backfill surface behind the wingwalls is assumed to be horizontal.
2. The design friction angles for the in-situ soil layers are based on correlation (Ref. 1, Equation 18.15) to the average N_{60}-values encountered in all borings for each layer (Ref. 2). The design friction angle for the Fill material is based on the standard MaineDOT practice (Ref. 3). The design friction angle for the Presumpscot Clay is based on correlation to Plasticity Index (PI) for normally consolidated clays (Ref. 4, Figure 12.50).The design friction angles are:

   ϕ_{Fill} = 32 degrees
   $\phi_{Presump.\ Silt}$ = 31 degrees
   $\phi_{Presump.\ Clay}$ = 30 degrees
   $\phi_{Glacial\ Till}$ = 32 degrees

3. The design friction angles for the proposed fill construction materials (Reference 3), based on MaineDOT standard practice, are:

   $\phi_{Granular\ Borrow}$ = 32 degrees
   $\phi_{Gravel\ Borrow}$ = 36 degrees

4. Average plasticity index (PI) (Ref. 2):

   $PI_{Presump.\ Clay}$ = 15

CALCULATION

1. Calculate the at-rest lateral earth pressure coefficient.

$$K_0 = 1 - \sin\phi$$ (Ref. 1, Eqn. 13.5) For coarse-grained soils

$$K_0 = 0.44 + 0.42(PI/100)$$ (Ref. 4, Fig. 12.50) For normally consolidated clays (Applicable to Presumpscot Clay)

where:
- ϕ = internal friction angle of soil
- PI = plasticity index

K_0 =	0.47	Existing Fill
	0.48	Presumpscot Silt - In Situ
	0.50	Presumpscot Clay- In Situ
	0.47	Glacial Till - In Situ
	0.47	Granular Borrow - Fill
	0.41	Gravel Borrow - Fill

Date:	12/18/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Lateral Earth Pressure	**Reviewed by:**	CCB
Project Short Title:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

2. Calculate the full active and full passive earth pressure coefficients using Rankine theory.

$$K_a = \tan^2\left(45° - \frac{\phi}{2}\right)$$ (Ref. 3, page 3-7)

for horizontal backfill surface, where:
ϕ = internal friction angle of soil

K_a =		
	0.31	Existing Fill
	0.32	Presumpscot Silt - In Situ
	0.31	Glacial Till - In Situ
	0.31	Granular Borrow - Fill
	0.26	Gravel Borrow - Fill

3. Calculate the full passive earth pressure coefficients.

Per the MaineDOT Bridge Design Guide Section Chapter 3, section 3.6.6 (Ref. 3), Values of the coefficient of passive lateral earth pressure, K_p, may be taken from Figures 3.11.5.4-1 and 2 in AASHTO LRFD (Ref. 6).

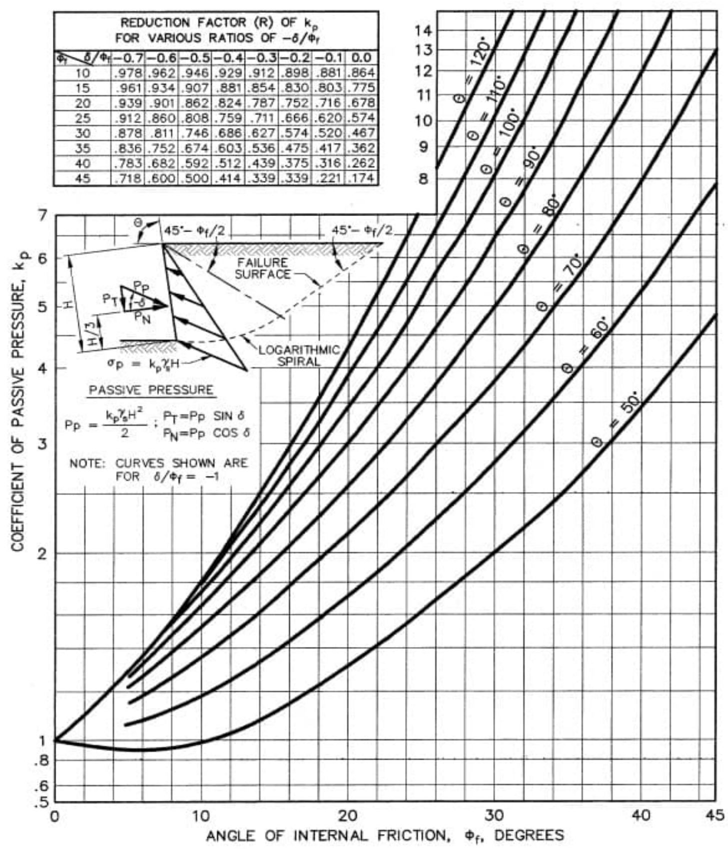


Figure 3.11.5.4-1—Computational Procedures for Passive Earth Pressures for Vertical and Sloping Walls with Horizontal Backfill (U.S. Department of the Navy, 1982a)

CALCULATIONS

Date:	12/18/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Lateral Earth Pressure	**Reviewed by:**	CCB
Project Short Title:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

for horizontal backfill surface, where:

θ = angle of wall from horizontal = 90 degrees

δ = Friction angle between fill and culvert (Ref. 3, Table 3-3)

R = Reduction Factor of K_p (Ref. 6 Figure 3.11.5.4-1)

Material	φ (degrees)	δ (degrees)	$\frac{-\delta}{\phi}$	Uncorrected K_p	R	K_p
Existing Fill	32	22	-0.69	7.7	0.79	6.1
Presumpscot Silt - In Situ	31	19	-0.61	7.0	0.80	5.6
Glacial Till - In Situ	32	22	-0.69	7.7	0.79	6.1
Granular Borrow - Fill	32	24	-0.75	7.7	0.86	6.6
Gravel Borrow - Fill	36	27	-0.75	11.6	0.83	9.6

CONCLUSIONS

For a non-yielding, stiff structure like the box culvert and wingwall system proposed for this project, an at-rest lateral earth pressure coefficient of 0.47 is recommended for design.

CALCULATIONS

Date:	9/10/2024	**Created**	ATM/RJN
Project No.:	30900914.004	**Checked:**	TJ/KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

OBJECTIVE

Calculate the bearing resistance of the proposed culvert for the strength limit state and the service limit state at a location where the culvert invert is at the roadway centerline at Station 115+26.

REFERENCES

1. WSP interpreted subsurface profile Sta. 115+26. (State of Maine Department of Transportation, Thorne Brook Bridge, Augusta, Kennebec County, Route 17, Sheet 3)

2. Soil/Rock Exploration Logs (Appendix A, Preliminary Geotechnical Design Report, dated November 2023).

3. Typical Box Details and Cross Sections (State of Maine Department of Transportation, Thorne Brook Bridge, Augusta, Kennebec County, Route 17 Sheets 1-16).

4. AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.

5. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.

6. WSP settlement analysis (Appendix D, Preliminary Geotechnical Design Report, dated November 2023).

7. NAVFAC Design Manual 7.2 Foundations and Earth Structures, dated May 1982.

8. MaineDOT Geotechnical Section, Key to Soil and Rock Descriptions and Terms, dated May 2024.

ASSUMPTIONS

1. The average friction angle for the Presumpscot Silt layer based on the corrected N60 values for all Standard Penetrations Tests (Reference 2) is:	ϕ, silt =	31	deg
2. The undrained shear strength for the Presumpscot Clay was calculated as the 33rd percentile of the corrected undrained strength measured with the field vane shear tests (Reference 2):	$s_{u,33\%}$ =	0.664	ksf
3. The proposed finish grade elevation and proposed culvert invert elevation at the location of analysis are (Reference 3):	El. finish grade =	185.1	feet
	El. proposed invert =	171.9	feet
4. Based on Reference 3 and information provided by the WSP structures team, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:	Proposed culvert wall thickness =	1.2	feet
	Excavation/fill thickness beneath culvert =	1.0	feet
5. The interpreted water table elevation, based on measurements taken during the subsurface exploration program and observed moisture content of the samples, is (Reference 1):	WL elev. =	175.3	feet

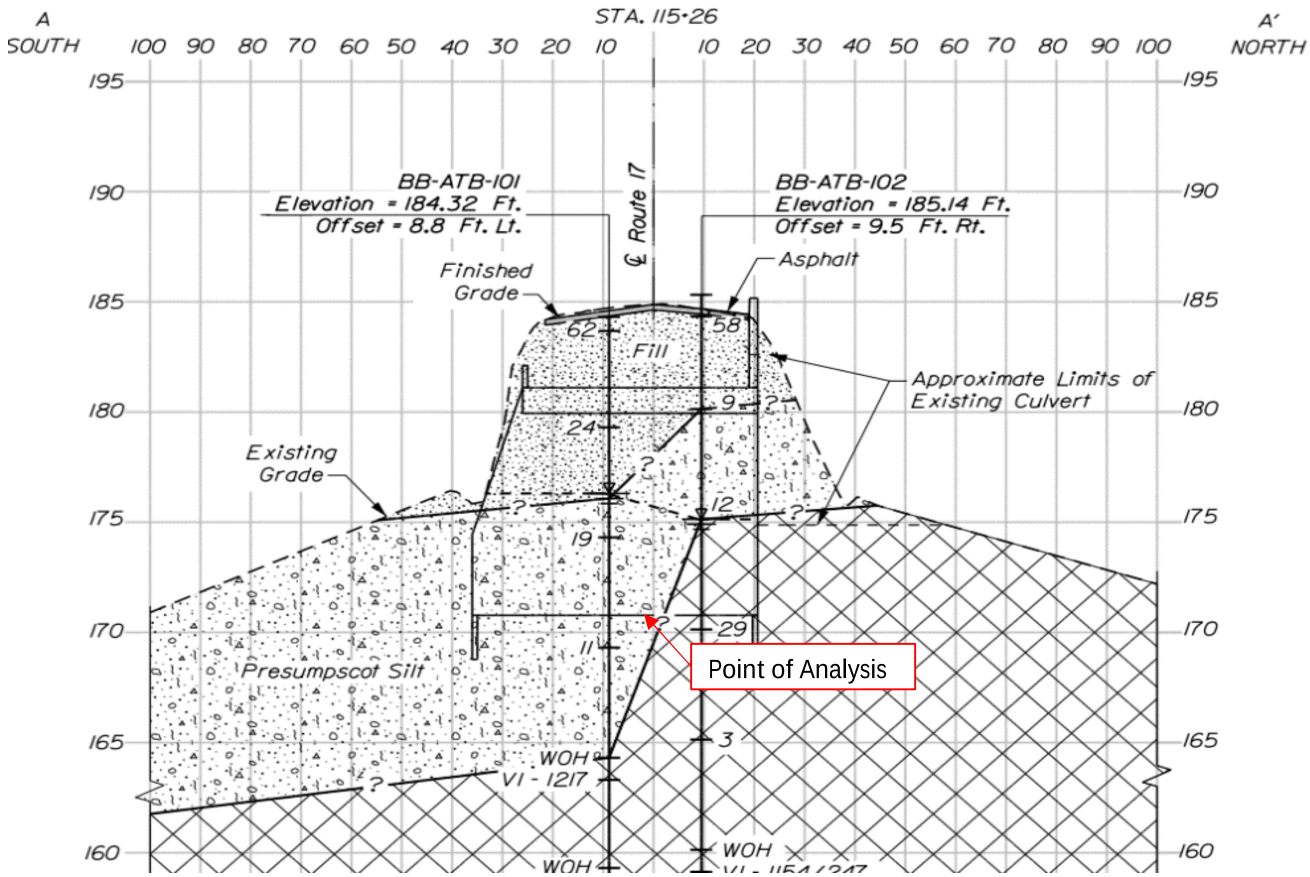
6. After excavating for the minimum of 1-foot of granular borrow beneath the culvert it is assumed that at the centerline of Route 17 the culvert will be founded on a very thin layer of the Presumpscot Silt layer or directly in the Presumpscot Clay layer. Therefore, bearing resistance is based on the Presumpscot Clay below the fill and Presumpscot Silt layer.

![wsp logo]

CALCULATIONS

Date:	9/10/2024	**Created**	ATM/RJN
Project No.:	30900914.004	**Checked:**	TJ/KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

Location of Analysis:



(Reference 1)

CALCULATION

A. Determine the bearing resistance at the strength limit state. Use Article 10.6.3, Strength Limit Design, from the AASHTO

Based on Reference 1, the proposed culvert invert will be founded within the Presumpscot Clay layer.

CALCULATIONS

Date:	9/10/2024	**Created**	ATM/RJN
Project No.:	30900914.004	**Checked:**	TJ/KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

1. Calculate the nominal bearing resistance.

$$q_n = cN_{cm} + \gamma_q D_f N_{qm} C_{wq} + 0.5\gamma_f B N_{\gamma m} C_{w\gamma}$$ (Ref. 4, Eqn. 10.6.3.1.2a-1)

where:

c = cohesion, ksf		c =	0.664	ksf
γ = total unit weight of soil, kcf		γ =	0.119	kcf

Since the same design unit weight is used for the soil above and below the bearing depth of the footing, $\gamma_q = \gamma_f$.

D_f = footing embedment depth, ft		D_f =	14.3	feet
$N_{cm} = N_c s_c i_c$	(Ref. 4, Eqn. 10.6.3.1.2a-2)	N_{cm} =	5.4	
N_c = Cohesion term		N_c =	5.14	(Table 10.6.3.1.2a-1)
S_c = footing shape correct factor (cohesion)		S_c =	1.05	(Ref. 4, Table 10.6.3.1.2a-3)
B = footing width, ft		B =	14	feet (Ref. 3, Sheet 5)
L = footing length, ft		L =	57	feet (Ref. 3, Sheet 19)
$i_c = 1 - \left(\frac{nH}{cBLN_c}\right)$		i_c =	1.0	(Eqn. 10.6.3.1.2a-5)

i_c = load inclination factor (neglected as per Ref. 4, Article C10.6.3.1.2a)

$N_{qm} = N_q s_q d_q i_q$	(Ref. 4, Eqn. 10.6.3.1.2a-3)	N_{qm} =	1.0	
N_q = surcharge term (undrained)		N_q =	1.0	
S_q = footing shape correction factor (cohesion)		S_q =	1.0	(Ref. 4, Table 10.6.3.1.2a-3)
d_q = depth correction factor		d_q =	1.0	Neglected as per Ref. 4,
i_q = load inclination factor		i_q =	1.0	Article C10.6.3.1.2a
$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$	(Ref. 5, Eqn. 10.6.3.1.2a-4)	$N_{\gamma m}$ =	0.0	
N_γ = unit weight factor		N_γ =	0.0	(Table 10.6.3.1.2a-1)
	(Ref. 5, Table 10.6.3.1.2a-3)	s_γ =	1.00	

i_γ = load inclination factor (neglected as per Ref. 5, Article C10.6.3.1.2a)

Since in Reference 4 C_{wq} and $C_{w\gamma}$ are determined based on D_w using Table 10.6.3.1.2a-2, which does not contain the value of D_w determined in this analysis, the equations in Reference 5 will be used instead.

$C_{wq} = 0.5 + 0.5\left(\frac{D_w}{D_f}\right) \leq 1.0$	C_{wq} =	0.84	
D_w = groundwater depth, ft	D_w =	9.8	feet
	q_n =	5.0	ksf

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Project Short Title:	MaineDOT Thorne Brook Culvert		

2. Apply resistance factor.

$q_R = \varphi_b q_n$ (Ref. 4, Eqn. 10.6.3.1.1-1)

φ_b = resistance factor specified in LRFD 10.5.5.2.2 — φ_b = 0.45 (Table 10.5.5.2.2-1)

Semi-empirical methods, all soils

q_R = 2.3 ksf

B. Determine the bearing resistance at the service limit state.

Use AASHTO LRFD Table C10.6.2.5.1-1 (Ref. 4) and NAVFAC 7.2 Table 1 (Ref. 7) to determine the presumptive bearing resistance at the service limit state.

Undrained shear strength for the Presumpcot Clay = 664 psf (Assumption 2)

(calculated as the 33 percentile of the corrected undrained strength measured with the field vane shear tests, Ref. 2)

Based on the MaineDOT Geotechnical Section soil key (Ref. 8), this undrained shear strength corresponds to a soil consistency of "medium stiff".

From AASHTO LRFD Table C10.6.2.5.1-1 (Ref. 4) and NAVFAC 7.2 Table 1 (Ref. 7):

Type of Bearing Material:	Homogeneous inorganic clay, sandy or silty clay (CL, CH)	
Consistency in Place:	medium stiff	
Bearing Resistance Ordinary Range:	2 to 6 ksf	(for medium stiff to stiff soils)
Bearing Resistance Selected Value:	2 ksf	(lower end of range, for medium stiff soils)

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

Resistance factor for the service limit state = 1.0 (Ref 4 Article 10.5.5.1)

Factored bearing resistance = 2.0 ksf

C. Confirm that the calculated bearing resistance satisfies the estimated bearing pressure.

Note: the bearing pressure was estimated in the settlement calculations (Ref. 7).

Bearing pressure = 1.6 ksf

Bearing Pressure			Factored Bearing Resistance			
1.6	ksf	<	2.3	ksf	(STR)	OK
1.6	ksf	<	2.0	ksf	(SRV)	OK

CONCLUSIONS

For the proposed culvert, the recommended nominal bearing resistance is 5.0 ksf. A resistance factor of 0.45 is recommended for use at the strength limit state and a resistance factor of 1.0 is recommended for use at the service limit state. The factored bearing resistance for the strength limit state is estimated to be 2.3 ksf and the factored presumptive bearing resistance for the service limit state is estimated to be 2.0 ksf. The factored bearing resistance at both the strength limit state and the service limit state was determined to be higher than the estimated bearing pressure.

CALCULATIONS

Date:	9/9/2024	**Created:**	ATM/RJN
Project No.:	30900914.004	**Checked:**	TJ/KAR
Subject:	Bearing Resistance at Proposed Culvert Outlet	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

OBJECTIVE

Calculate the bearing resistance of the proposed culvert outlet wingwalls for the strength limit state and the service limit state at Station 115+26.

REFERENCES

1. WSP interpreted subsurface profile Sta. 115+26. (State of Maine Department of Transportation, Thorne Brook Bridge, Augusta, Kennebec County, Route 17, Sheet 3)
2. Soil/Rock Exploration Logs (Appendix A, Preliminary Geotechnical Design Report, dated November 2023).
3. Typical Box Details and Cross Sections (State of Maine Department of Transportation, Thorne Brook Bridge, Thorne Brook, Augusta, Kennebec County, (Sheet 5 of 19) dated 11/2023 (WSP Draft plans).
4. AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.
6. Box Culvert Details (State of Maine Department of Transportation, Snake River Bridge, York County, Sheet 11)
7. WSP settlement analysis (Appendix D, Preliminary Geotechnical Design Report, dated November 2023).
8. NAVFAC Design Manual 7.2 Foundations and Earth Structures, dated May 1982.
9. MaineDOT Geotechnical Section, Key to Soil and Rock Descriptions and Terms, dated May 2024.

ASSUMPTIONS

1. The average friction angle for the Presumpscot Silt layer based on the corrected N_{60} values for all Standard Penetrations Tests (Reference 2) is:	ϕ,Silt =	31	deg
2. The undrained shear strength for the Presumpscot Clay was calculated as the 33 percentile of the corrected undrained strength measured with the field vane shear tests (Reference 2):	$s_{u,33\%}$ =	0.664	ksf
3. The proposed finish grade elevation and proposed culvert invert elevation at the location of analysis are (Reference 3):	El. finish grade =	173.9	feet
	El. proposed invert =	171.9	feet
4. Based on Reference 3 and information provided by the WSP structures team, the proposed wingwall is built contigent upon the proposed culvert. The proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the wingwall are estimated to be:	Proposed culvert wall thickness =	1.2	feet
	Excavation/fill thickness beneath wingwall =	1.0	feet
5. The interpreted water table elevation, based on measurements taken during the subsurface exploration program and observed moisture content of the samples, is (Reference 1):	WL elev. =	175.3	feet

6. After excavating for the minimum of 1-foot of granular borrow beneath the culvert it is assumed that at the centerline of Route 17 the wingwalls will be founded on a very thin layer of the Presumpscot Silt layer or directly in the Presumpscot Clay layer. Therefore, bearing resistance is based on the Presumpscot Clay below the fill and Presumpscot Silt layer.

7. Several combinations of footing dimensions of the proposed outlet wingwalls were analyzed for bearing resistance as the final dimensions have not been determined.

8. A minimum footing embedment depth of 4 feet has been assumed to limit frost heave potential.

9. The proposed wingwall is assumed to be precast or cast-in-place concrete.

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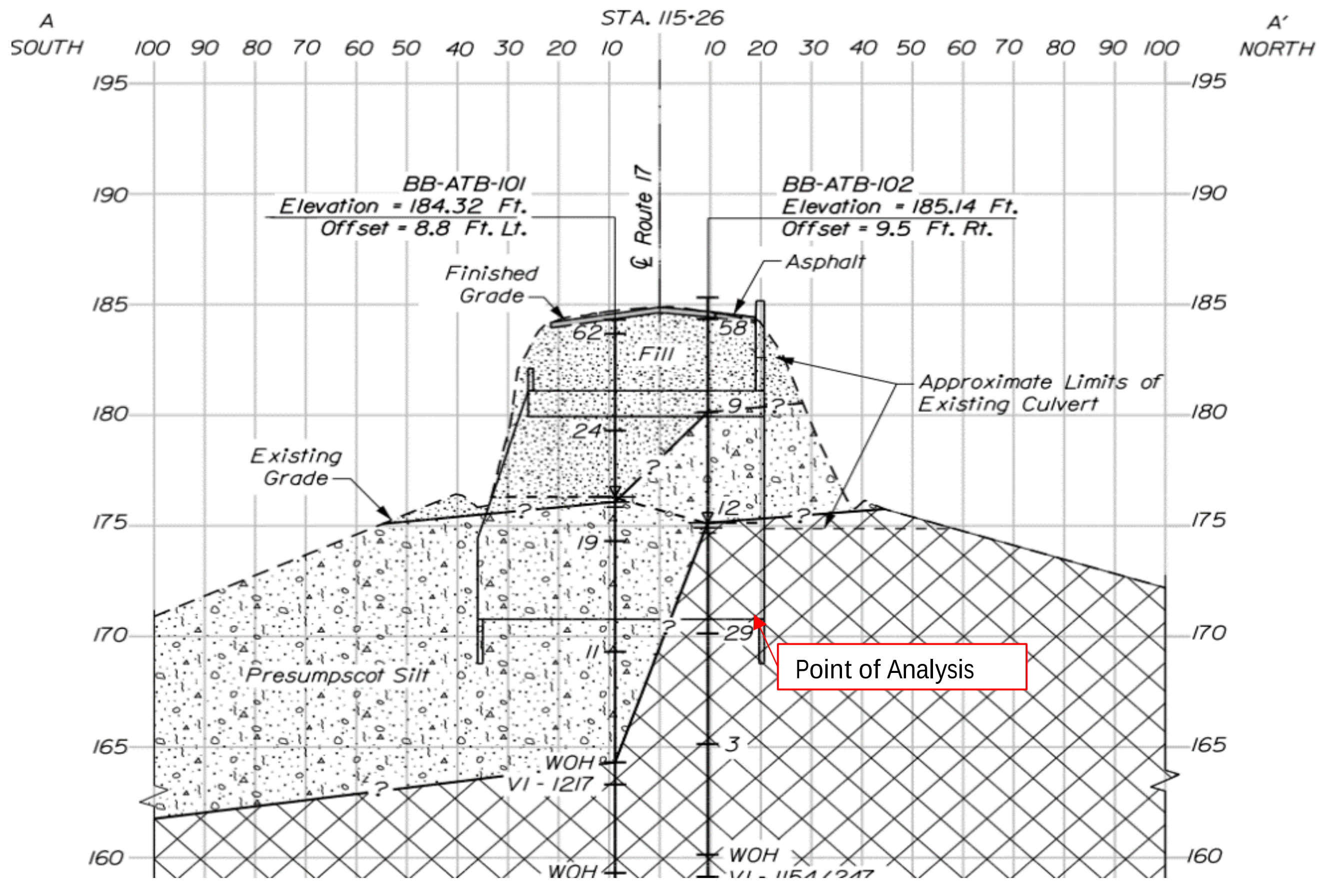
Project Short Title:	MaineDOT Thorne Brook Culvert		

Location of Analysis:



(Reference 1)

CALCULATION

A. Determine the bearing resistance at the strength limit state. Use Article 10.6.3, Strength Limit Design, from the AASHTO LRFD Bridge Design Specifications.

Based on Reference 1, the proposed culvert invert will be founded within the Presumpscot Clay layer.

Date:	9/9/2024	**Created:**	ATM/RJN
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Subject:	Bearing Resistance at Proposed Culvert Outlet	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

1. Calculate the nominal bearing resistance.

$$q_n = cN_{cm} + \gamma_q D_f N_{qm} C_{wq} + 0.5\gamma_f B N_{\gamma m} C_{w\gamma}$$ (Ref. 4, Eqn. 10.6.3.1.2a-1)

where:

c = cohesion, ksf — c = 0.664 ksf

γ = total unit weight of soil, kcf — γ = 0.119 kcf

Since the same design unit weight is used for the soil above and below the bearing depth of the footing, $\gamma_q = \gamma_f$.

D_f = footing embedment depth, ft — D_f = 4.0 feet (see Assumption 8)

$$N_{cm} = N_c s_c i_c$$ (Ref. 4, Eqn. 10.6.3.1.2a-2) — N_{cm} = 5.9

N_c = Cohesion term — N_c = 5.14 (Table 10.6.3.1.2a-1)

S_c = footing shape correct factor (cohesion) — S_c = 1.14 (Ref. 4, Table 10.6.3.1.2a-3)

B = footing width, ft — B = 10 feet (see Assumption 7)

L = footing length, ft — L = 14 feet (see Assumtion 7)

$$i_c = 1 - \left(\frac{nH}{cBLN_c}\right)$$ i_c = 1.0 (Eqn. 10.6.3.1.2a-5)

i_c = load inclination factor (neglected as per Ref. 4, Article C10.6.3.1.2a)

$$N_{qm} = N_q s_q d_q i_q$$ (Ref. 4, Eqn. 10.6.3.1.2a-3) — N_{qm} = 1.0

N_q = surcharge term (undrained) — N_q = 1.0

S_q = footing shape correction factor (cohesion) — S_q = 1.0 (Ref. 4, Table 10.6.3.1.2a-3)

d_q = depth correction factor — d_q = 1.0 Neglected as per Ref. 4,

i_q = load inclination factor — i_q = 1.0 Article C10.6.3.1.2a

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$$ (Ref. 5, Eqn. 10.6.3.1.2a-4) — $N_{\gamma m}$ = 0.0

N_γ = unit weight factor — N_γ = 0.0 (Table 10.6.3.1.2a-1)

(Ref. 5, Table 10.6.3.1.2a-3) — s_γ = 1.00

i_γ = load inclination factor (neglected as per Ref. 5, Article C10.6.3.1.2a)

Since in Ref. 4 C_{wq} and $C_{w\gamma}$ are determined based on D_w using Table 10.6.3.1.2a-2, which does not contain the value of D_w determined in this analysis, the equations in Ref. 5 will be used instead.

$$C_{wq} = 0.5 + 0.5\left(\frac{D_w}{D_f}\right) \leq 1.0$$ C_{wq} = 0.33

D_w = groundwater depth, ft — D_w = -1.4 feet

q_n = 4.1 ksf

2. Apply resistance factor.

$q_R = \varphi_b q_n$ (Ref. 4, Eqn. 10.6.3.1.1-1)

φ_b = resistance factor specified in LRFD 10.5.5.2.2-1 φ_b = 0.45 (Table 10.5.5.2.2-1)
Semi-empirical methods, all soils

q_R = 1.8 ksf

B. Repeat Part A for various effective footing areas.

As per Reference 4, Article 10.6.1.3, for the eccentrically loaded wingwall footings, a reduced effective area shall be used in design for bearing resistance. Thus this analysis was performed using three effective wingwall foundation footing widths and three effective foundation footing lengths. Since the expected wingwall foundation footing width and length and length were not included in Ref. 3, effective footing widths and lengths were selected based on local engineering experience.

Effective L (ft)	Effective B (ft)	Effective Area (ft^2)	q_n (ksf)	q_R (ksf)
10	6	60	4.0	1.8
	8	80	4.1	1.9
	10	100	4.3	1.9
12	6	72	3.9	1.8
	8	96	4.0	1.8
	10	120	4.1	1.9
14	6	84	3.9	1.7
	8	112	4.0	1.8
	10	140	4.1	1.8

C. Determine the bearing resistance at the service limit state.

Use AASHTO LRFD Table C10.6.2.5.1-1 (Ref. 4) and NAVFAC 7.2 Table 1 (Ref. 8) to determine the presumptive bearing resistance at the service limit state.

Undrained shear strength for the Presumpcot Clay = 664 psf (Assumption 2)
(calculated as the 33 percentile of the corrected undrained strength measured with the field vane shear tests, Ref. 2)

Based on the MaineDOT Geotechnical Section soil key (Ref. 9), this undrained shear strength corresponds to a soil consistency of "medium stiff".

From AASHTO LRFD Table C10.6.2.5.1-1 (Ref. 4) and NAVFAC 7.2 Table 1 (Ref. 8):

Type of Bearing Material:	Homogeneous inorganic clay, sandy or silty clay (CL, CH)	
Consistency in Place:	medium stiff	
Bearing Resistance Ordinary Range:	2 to 6 ksf	(for medium stiff to stiff soils)
Bearing Resistance Selected Value:	2 ksf	(lower end of range, for medium stiff soils)

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

Date:	9/9/2024	**Created:**	ATM/RJN
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Subject:	Bearing Resistance at Proposed Culvert Outlet	**Reviewed:**	CCB/MEL
Project Short Title:	MaineDOT Thorne Brook Culvert		

Resistance factor for the service limit state = 1.0 (Ref. 4, Article 10.5.5.1)

Factored bearing resistance = 2.0 ksf

D. Confirm that the calculated bearing resistance satisfies the estimated bearing pressure.

Note: the bearing pressure was estimated in the settlement calculations (Ref. 7).

Bearing pressure = 1.6 ksf

Bearing Pressure			Factored Bearing Resistance			
1.6	ksf	<	1.8	ksf	(STR)	OK
1.6	ksf	<	2.0	ksf	(SRV)	OK

CONCLUSIONS

For the proposed outlet wingwalls, the recommended nominal bearing resistance at the strength limit state for a footing length of 10 feet to 14 feet is 3.9 to 4.3 ksf depending on the effective footing width (between 6 feet and 10 feet) selected. A resistance factor of 0.45 is recommended for use at the strength limit state and a resistance factor of 1.0 is recommended for use at the service limit state. The factored bearing resistance at the strength limit state for a footing length of 10 feet to 14 feet is estimated to be 1.7 to 1.9 ksf depending on the effective footing width, and the factored presumptive bearing resistance for the service limit state is estimated to be 2.0 ksf. The factored bearing resistance at both the strength limit state and the service limit state was determined to be higher than the estimated bearing pressure.

CALCULATIONS

Date:	12/18/2023	**Made by:**	DEB
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	Thorne Brook Bridge No. 2850, Augusta, ME		

OBJECTIVE

Determine the modulus of subgrade reaction using one method in the Presumpscot clay, and two methods in the Presumpscot silt.

REFERENCES

1. Das, Braja M. 2011. Principles of Foundation Engineering, 8th ed. Cengage Learning, Stamford, CT.

2. WSP geotechnical test boring logs (Appendix A, Preliminary Geotechnical Design Report, dated December 2023).

3. State of Maine Department of Transportation, Thorne Brook Bridge, Thorne Brook, Augusta, Kennebec County, (Sheets 1 - 16), Dated 11/2023 (WSP Draft plans).

4. Federal Highway Administration, 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.

2. Bridge Software Institute FB-MultiPier Soil Parameter Table (https://bsi.ce.ufl.edu/downloads/files/MultiPier_Soil_Table.pdf).

ASSUMPTIONS

1. Proposed box culvert bearing El. (Ref 3.)	Invert El.=	171.93	feet
	Bottom Thickness =	1.2	feet
	Bearing El. =	170.8	feet
2. Average Presumpscot clay cohesive consistency at bearing elevation (Ref 2.)	Consistency =	Stiff	
3. Proposed box culvert width (Ref. 3).	B =	14	feet
4. The average design N_{60} value for the Presumpscot Silt (Ref 2).	N_{60}=	10	
5. Average Presumpscot Silt consistency based on N_{60} value (Ref 2).	Consistency =	Stiff	

Date:	12/18/2023	**Made by:**	DEB
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	Thorne Brook Bridge No. 2850, Augusta, ME		

CALCULATION

1. Determine Modulus of Subgrade Reaction for the Presumpscot Clay.

Determine Modulus of Subgrade Reaction (K) using Eqn. 8.47b (Ref. 1), based on Table 8.2 below. Consistency of stiff cohesive soil based on SPT N-value of 9 to 15 (Ref 2). Based on the average SPT N-value of 13.5 (Ref. 2) in the Presumpscot clay at the approximate bearing elevation of 170.8 feet, the higher bound of the stiff clay range for k $_1$ was used in Table 8.2.

Table 8.2 Typical Subgrade Reaction Values, $k_{0.3}(k_1)$

Soil type	$k_{0.3}(k_1)$ MN/m³	$k_{0.3}(k_1)$ lb/in.³
Dry or moist sand:		
Loose	8–25	30–90
Medium	25–125	90–450
Dense	125–375	450–1350
Saturated sand:		
Loose	10–15	35–55
Medium	35–40	125–145
Dense	130–150	475–550
Clay:		
Stiff	10–25	40–90
Very stiff	25–50	90–185
Hard	>50	>185

$$k = k_1\left(\frac{1}{B}\right)$$ (lb/in^3) Eqn. 8.47b (Ref. 1)

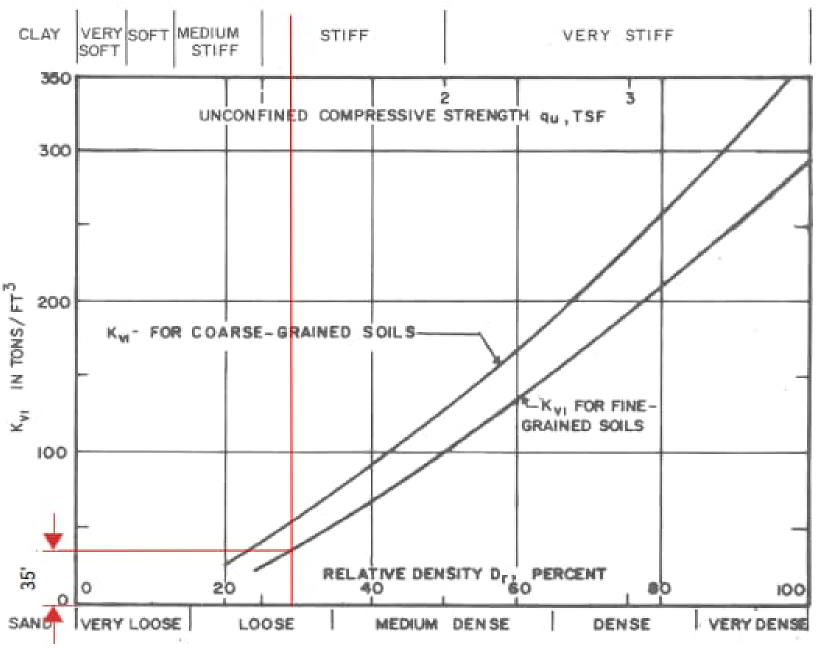
k_1 =	90	(lb/in^3)	(Table 8.2, Ref. 1)
k =	6.4	(lb/in^3)	
k =	5.6	(tons/ft^3)	

CALCULATIONS

Date:	12/18/2023	**Made by:**	DEB
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	Thorne Brook Bridge No. 2850, Augusta, ME		

2. Determine Modulus of Subgrade Reaction for the Presumpscot Silt (Method 1).

Determine Modulus of Subgrade Reaction (K_{IV}) using Figure 8-3 below (Ref. 4). Based on WSP logs stiff soil has N values ranging from 9 to 15, the Presumpscot Silt has an average N_{60} value of 10. An N60 value of 10 was estimated in the stiff range of the chart, and the fine grained soil curve are used to determine K_{VI}.



DEFINITIONS

ΔH_i = IMMEDIATE SETTLEMENT OF FOOTING
q = FOOTING UNIT LOAD IN tsf
B = FOOTING WIDTH

D = DEPTH OF FOOTING BELOW GROUND SURFACE
K_{VI} = MODULUS OF VERTICAL SUBGRADE REACTION

COARSE-GRAINED SOILS

(MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH)
SHALLOW FOOTINGS $D \leq B$
FOR $B \leq 20$ FT:

$$\Delta H_i = \frac{4\,q\,B^2}{K_{VI}\,(B+1)^2}$$

FOR $B \geq 40$ FT:

$$\Delta H_i = \frac{2\,q\,B^2}{K_{VI}\,(B+1)^2}$$

INTERPOLATE FOR INTERMEDIATE VALUES OF B

DEEP FOUNDATION $D \geq 5B$
FOR $B \leq 20$ FT:

$$\Delta H_i = \frac{2\,q\,B^2}{K_{VI}\,(B+1)^2}$$

NOTES: 1. NONPLASTIC SILT IS ANALYZED AS COARSE-GRAINED SOIL WITH MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH.
2. VALUES OF K_{VI} SHOWN FOR COARSE-GRAINED SOILS APPLY TO DRY OR MOIST MATERIAL WITH THE GROUNDWATER LEVEL AT A DEPTH OF AT LEAST 1.5B BELOW BASE OF FOOTING. IF GROUNDWATER IS AT BASE OF FOOTING, USE $K_{VI}/2$ IN COMPUTING SETTLEMENT

Figure 8-3: Modulus of Subgrade Reaction (NAVFAC, 1986a)

$K_{IV=}$	35	Tons/ft^3	$K_{IV=}$	40	lb/in^3

CALCULATIONS

Date:	12/18/2023	**Made by:**	DEB
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	Thorne Brook Bridge No. 2850, Augusta, ME		

2. Determine Modulus of Subgrade Reaction for the Presumpscot Silt (Method 2).

Determine Modulus of Subgrade Reaction (K) using FB-Multipier Soil Parameter Table (Ref. 2), using the average N_{60} value of 10 in the Presumpscot Silt. Subgrade Modulus was determined for the below water table condition.

Cohesionless Soil

Soil properties for preliminary design only.

Cohesionless Soil Properties	Symbol	Units	Loose		Medium		Dense	
Total Unit Weight	γ	pcf	90	115	110	130	110	140
Corrected SPT Blow Count	N_{60}		4	10	10	30	30	50
Relative Density	D_r	%	15	35	35	65	65	85
Angle of Internal Friction	ϕ	deg	29	30	30	36	36	41
Coefficient of Lateral Earth Pressure (From Eqn. (1) using ϕ)	K_0		0.51	0.5	0.5	0.41	0.41	0.34
Subgrade Modulus (Below Water Table)	k_{bw}	pci	20	30	30	100	100	160
Subgrade Modulus (Above Water Table)	k_{aw}	pci	20	50	50	165	165	275

$K_{bw=}$ 26 Tons/ft^3 $K_{bw=}$ 30 lb/in^3

CONCLUSIONS

The modulus of subgrade reaction (K) has been determined for the Presumpscot Clay using one method, and the Presumpscot Silt using two methods. The methods are based on using the average N_{60} value within the Presumpscot Silt and the Presumpscot Clay at the proposed bearing elevation of 170.8 feet. The lower value of K = 6 lb/in^3 determined for the Presumpscot Clay will be recommended in the Preliminary Geotechnical Design Report (PGDR).

CALCULATIONS

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

OBJECTIVE

Calculate the primary settlement beneath the proposed culvert after construction, at the location where the Presumpscot Clay is thickest (9.5 feet north from Station 115+26 along the proposed culvert centerline)

REFERENCES

1. Holtz, Robert D. and Kovacs, William D. An Introduction to Geotechnical Engineering, 1st Ed. Prentice-Hall, 1981.

2. GEOTECHNICAL ENGINEERING CIRCULAR NO. 6: Shallow Foundations. FHWA: September 2002. (FHWA)

3. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.

4. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.

5. WSP boring logs, included as Appendix A of the Preliminary Geotechnical Design Report.

6. WSP Interpretive Subsurface Profile A-A', included as Sheet 3 Preliminary Geotechnical Design Report.

7. GeoTesting Express laboratory testing results, included as Appendix C and summarized in Table 5 of the Preliminary Geotechnical Design Report.

8. State of Maine Department of Transportation, Thorne Brook Bridge, Thorne Brook, Augusta, Kennebec County, (Sheets 1 - 19), Dated 11/2023 (WSP Draft plans).

9. Maine Department of Transportation Bridge Design Manual, dated August 2003.

10. State of Maine Department of Transportation, Thorne Bridge and Spaulding Bridge in the city of Augusta, Kennebec County, General Plan (sheets 1 and 2), dated Jan. 1988. Marked as as-built-1989.

ASSUMPTIONS

1. The existing stratigraphy and water table surface are estimated from samples and groundwater measurements encountered during drilling at location BB-ATB-102 (Reference 5 and 6).	GS EL =	185.1	feet
	Water table EL. =	175.1	feet
2. Clay consolidation parameters for the Presumpscot layer are based on laboratory test results for boring BB-ATB-102 (Ref 7). The OCR is a design value obtained by averaging OCR values over depths at locations BB-ATB-101 and BB-ATB-102.	C_c =	0.17	
	C_r =	0.026	
	e_0 =	0.92	
	OCR =	1.4	
3. N60-values for the soil layers, based on correlation (Reference 3, Equation 18.5) to the measured N values are:	$N_{60\ Existing\ Fill}$ =	36	
	$N_{60\ Presump.\ Silt}$ =	10	
	$N_{60\ Glacial\ till}$ =	21	
4. The proposed road grade elevation taken at the roadway centerline and proposed culvert invert elevation at the location of analysis are (Reference 8, Sheet 5 and 19):	Road EL =	184.9	feet
	Proposed invert EL =	171.9	feet
5. Based on Reference 8, Sheet 5, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:	Proposed culvert wall thickness =	1.2	feet
	Excavation/fill thickness beneath culvert =	1.0	feet
6. Based on Reference 8, Sheet 5, the culvert interior will be filled with Stream Channel Rock and Special Fill with a thickness of:	Stone fill thickness =	2.4	feet

CALCULATIONS

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

7. The unit weight for the proposed fill construction material (Reference 9), based on MaineDOT standard practice, are:	Granular Borrow=	125	pcf
	Gravel Borrow =	136	pcf
	Agg. Subbase =	136	pcf
8. Unit weights for concrete and steel are assumed based on local engineering experience:	Concrete =	150	pcf
	Steel =	490	pcf
9. The stream elevation within the culvert is assumed to be the groundwater elevation measured at Boring BB-ATB-101. The loading from this groundwater elevation includes anticipated increased flow from spring thaw.	Stream EL above Stream Channel Fill =	176.3	feet

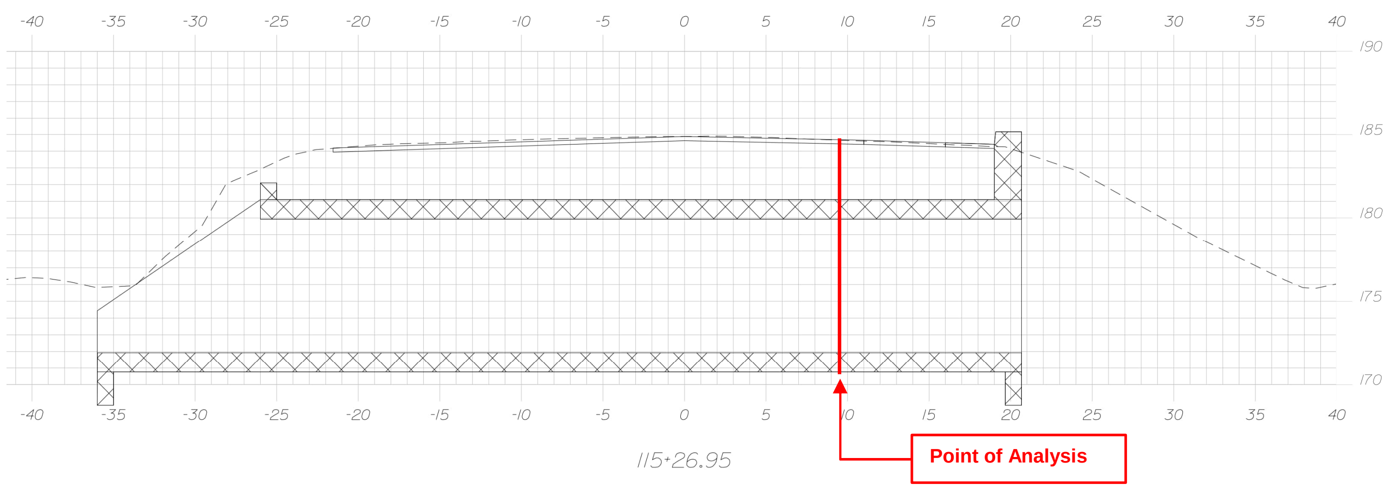
10.The stress will be uniformly distributed over the culvert box length. Localized stress concentration is not considered for the analysis.

11. This evaluation does not include the downstream wingwall loading as the full geometry is not known at this time. It is assumed the wingwall will be fixed to the proposed but culvert therefore an independent settlement analysis for the downstream wingwall was not conducted.

12. Primary consolidation settlement is assumed to be based on a preconsolidation stress calculated using the existing effective stress outside of the existing culvert area, to reflect the preconsolidation past pressure in the Presumpscot Clay.

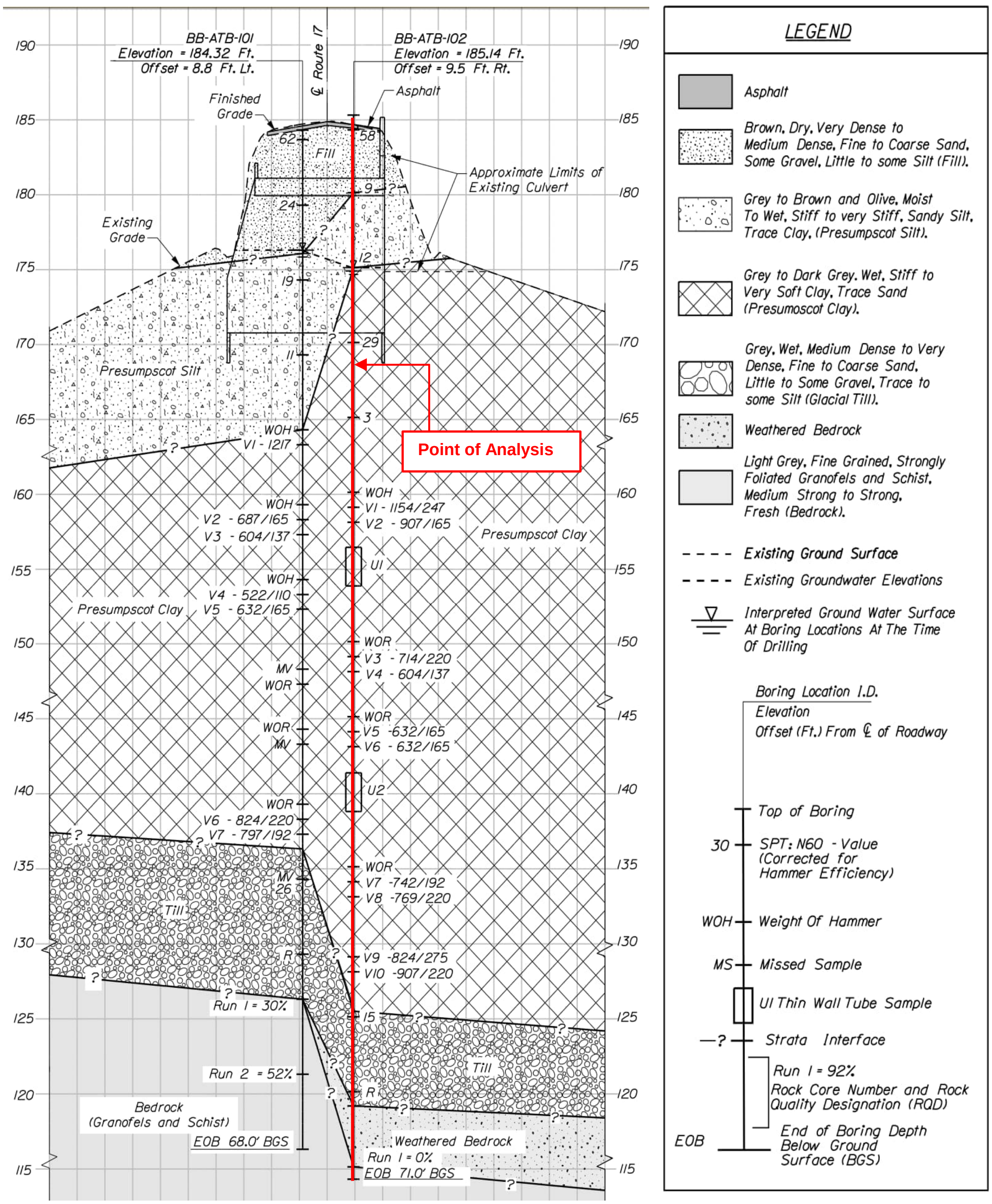
13. The area of the existing steel pipe arch culvert is approximated by assuming a box geometry.

Location of the Analysis:



(Reference 8, Sheet 19)

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		



(Reference 6)

CALCULATION

CALCULATIONS

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

A. Determine the change in effective stress state within the soil beneath the proposed culvert to identify if settlement or heave will occur. Calculate the vertical stress change beneath the proposed culvert due to culvert construction.

The change in effective stress state due to the excavation of the existing steel culvert and the construction of the proposed concrete box culvert is determined at the lower limit of the proposed excavation for the concrete box culvert along the culvert centerline: Elevation 169.7 feet (culvert invert elevation 171.9 feet minus culvert base thickness 1.2 feet and excavation/fill thickness 1.0 feet). Based on Reference 6, the excavation limit will be founded within the Presumpscot Clay layer at the point of analysis.

1. Load from existing steel culvert, per linear foot (Ref. 10):

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of steel (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	11.6	7.4	85.9			
Internal dimensions (Ref. 10, Sheet 2)	11.6	7.4	85.5			
		Culvert steel:	0.436	490	213.9	18.5

2. Load from proposed culvert concrete, per linear foot:

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of concrete (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	14.0	10.5	147.0			
Internal dimensions (Ref. 8, Sheet 5)	12.0	8.0	96.0			
		Culvert concrete:	51.0	150	7650.0	546.4

3. Existing conditions outside of the existing culvert (Ref. 5 & 6) for preconsolidation stress calculation:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Pavement	140	185.1	184.3	0.8	112	112
Fill	125	184.3	180.1	4.2	520	520
Presumpscot Silt	120	180.1	175.1	5.0	600	600
Presumscot Clay	119	175.1	169.7	5.4	648	308

CALCULATIONS

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4. Current conditions at the center of the existing steel arch culvert (Ref. 6 & 10):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Pavement	140	185.1	184.3	0.8	112	N/A
Fill	125	184.3	182.2	2.1	263	N/A
Existing Culvert	N/A	182.2	174.8	7.4	18	N/A
Granular Borrow Fill	125	174.8	169.7	5.1	638	319
				Total =	1030	

5. Proposed conditions at the center of the proposed concrete box culvert after construction (Ref. 8):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Pavement	140	184.9	184.4	0.5	70	N/A
Aggregate Subbase	135	184.4	182.4	2.0	270	N/A
Granular Borrow Backfill	125	182.4	181.2	1.2	150	N/A
Culvert	N/A	181.2	170.7	10.5	546	N/A
Stream Above Fill (inside)	62.4	176.3	174.3	2.0	125	N/A
Stream Channel Rock and Special Fill (inside)	140	174.3	171.9	2.4	336	N/A
Granular Borrow Backfill	125	170.7	169.7	1.0	125	63
				Total =	1622	

Calculate the increase or decrease in effective stress as a result of construction.

	σv at Elev. 169.7 ft (psf)	σ'v at Elev. 169.7 ft (psf)	Δσ'v at Elev. 169.7ft	Result
Existing conditions	1030	712	848	Settlement
After construction	1622	1560		

CALCULATIONS

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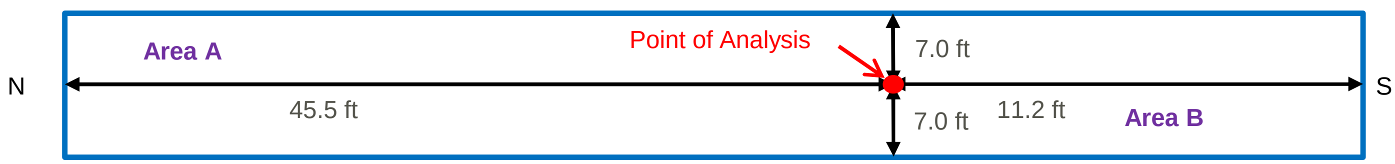
B. Subdivide the subsurface soils into layers no larger than 10 feet thick extending to bedrock. Calculate the vertical stress increase at each layer, assuming the Boussinesq stress distribution method for stress under the corner of a rectangular load.

Assumed Loading (plan view):



$\sigma_z = q_0 \times I$ — Reference 1, Eqn. 8-30
$m = x/z$ — Reference 1, Figure 8.21
$n = y/z$ — Reference 1, Figure 8.21

where:

	Area A	Area B		
σ_z = half of the vertical stress increase, psf	(each half of the culvert width is calculated separately for each area)			
q_0 = net stress applied by culvert	848		psf	(Part A)
x = half of the width of the loading area, feet	7.0	7.0	feet	(Ref. 8, Sheet 5)
y = length of the loading area, feet	45.5	11.2	feet	(Ref. 8, Sheet 17)
z = depth to midpoint of layer, feet	(z_{max} = to the top of bedrock = 50.3 ft)			

Area A:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Presumpscot Clay	1	0-10	10.0	5.0	1.4	9.1	0.228	386.7
Presumpscot Clay	2	10-20	10.0	15.0	0.5	3.0	0.139	235.7
Presumpscot Clay	3	20-30	10.0	25.0	0.3	1.8	0.088	149.2
Presumpscot Clay	4	30-40	10.0	35.0	0.2	1.3	0.058	98.4
Presumpscot Clay	5	40-44.2	4.2	42.1	0.2	1.1	0.055	93.3
Glacial Till	6	44.2-50.2	6.0	47.2	0.1	1.0	0.029	49.2

CALCULATIONS

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Area B:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Presumpscot Clay	1	0-10	10.0	5.0	1.4	2.2	0.223	378.2
Presumpscot Clay	2	10-20	10.0	15.0	0.5	0.7	0.105	178.1
Presumpscot Clay	3	20-30	10.0	25.0	0.3	0.4	0.049	83.1
Presumpscot Clay	4	30-40	10.0	35.0	0.2	0.32	0.028	47.5
Presumpscot Clay	5	40-44.2	4.2	42.1	0.2	0.27	0.027	45.8
Glacial Till	6	44.3-50.3	6.0	47.2	0.1	0.2	0.001	1.5

Area A + Area B:

Layer		Depth below lower limit of excavation (ft)	Stress Increase σ_z (psf)
Presumpscot Clay	1	0-10	765
Presumpscot Clay	2	10-20	414
Presumpscot Clay	3	20-30	232
Presumpscot Clay	4	30-40	146
Presumpscot Clay	5	40-44.2	139
Glacial Till	6	44.3-50.3	51

C. Use consolidation theory to estimate settlement of the Presumpscot Clay layer beneath the proposed culvert (Layers 1 to 5). Use the Hough method to estimate settlement of the Till beneath the proposed culvert (Layer 6).

1 Calculate $\sigma'_{v0\text{-}E}$ based on pre-construction stratigraphy outside of the existing steel culvert area for use in determining the preconsolidated stress in the clay layers, based on the initial pre-construction effective stress state.

σ'v at Elev. 169.7 ft (psf)	1540	(Part A)

Layer		Unit weight (pcf)	Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	σ'_{v0} (psf)	σ'_{v0} (kPa)
Presumpscot Clay	1	119	0-10	10.0	5.0	1823	87.3
Presumpscot Clay	2	119	10-20	10.0	15.0	2389	114.3
Presumpscot Clay	3	119	20-30	10.0	25.0	2955	141.4
Presumpscot Clay	4	119	30-40	10.0	35.0	3521	168.5
Presumpscot Clay	5	119	40-44.2	4.2	42.1	3923	187.8
Glacial Till	6	135	44.2-50.3	6.0	47.2	4259	203.9

CALCULATIONS

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2 Calculate the total settlement of the Presumpscot Clay (Layers 1 and 2) using the consolidation theory:

General Equation (Das, Eqn 1.61, 1.63, 1.65)

$$\Delta H_i = C_{r\varepsilon} H_c \log\frac{\sigma'_p}{\sigma'_{v0}} + C_{c\varepsilon} H_c \log\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_p}$$

for underconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v > \sigma'_p$

$$\Delta H_i = C_{r\varepsilon} H_c \log\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$

for overconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v \le \sigma'_p$

$$\Delta H_i = C_{c\varepsilon} H_c \log\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$

for normally consolidated clay

where:			Layer 1 - Presump. Clay	Layer 2 - Presump. Clay	Layer 3 - Presump. Clay	Layer 4 - Presump. Clay	Layer 5 - Presump. Clay
H_c	initial height of layer i, ft		10.0	10.0	10.0	10.0	4.2
$\Delta\sigma_v$	surcharge load, psf		765	414	232	146	139
σ'_{v0}	in situ vertical effective stress, psf		1823	2389	2955	3521	3923
$\sigma'_{v0} + \Delta\sigma_v$	check against σ'_p to select eqn.		2588	2803	3187	3667	4062
σ'_p	preconsolidated stress, psf		2552	3344	4137	4929	5492
$C_{r\varepsilon}$	modified recompression index		0.01	0.01	0.01	0.01	0.01
$C_{c\varepsilon}$	modified compression index		0.09	0.09	0.09	0.09	0.09
ΔH_i		ft	0.025	0.009	0.004	0.002	0.0009
		in	0.301	0.113	0.054	0.029	0.010

3 Determine C' and σ'_{v0} for in situ existing soil. Use FHWA Figures 5-18 and 5-19 to obtain N' and C' for the Glacial Till layer (Layer 6), assuming the Glacial Till is "Well graded silty SAND & GRAVEL".

Layer		Layer Thickness (ft)	Unit Weight of Layer (pcf)	σ'_{v0} at layer midpoint (psf)	σ'_{v0} at layer midpoint (kPa)	N_{60}	N'	C'
Presumpscot Clay	1	10.0	119	1823	87	Not required, for clay consolidation analysis		
Presumpscot Clay	2	10.0	119	2389	114			
Presumpscot Clay	3	10.0	119	2955	141			
Presumpscot Clay	4	10.0	119	3521	169			
Presumpscot Clay	5	4.2	119	3923	188			
Glacial Till	6	6.0	135	4259	204	21	14	63

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4 Calculate the total settlement of the Glacial Till (Layer 6) using the Hough method:

General Equation (Ref. 2, Eqn 5-24)

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}\right)$$

where:

ΔH_i	settlement in each layer, ft
H_c	initial height of layer i, ft
C'	bearing capacity index from Ref. 5, Figure 5-19
$\Delta\sigma_v$	vertical stress increase, ksf

ΔH_i (Layer 6)	ft	0.00049
	in	0.0059

	Settlement
Layer	ΔH_i (in)
Presumpscot Clay,1	0.301
Presumpscot Clay,2	0.113
Presumpscot Clay,3	0.054
Presumpscot Clay,4	0.029
Presumpscot Clay,5	0.010
Glacial Till,6	0.0059
Total Settlement (in)	0.51

CONCLUSIONS

The estimated primary consolidation settlement 9.5 feet right of the roadway centerline under the proposed culvert is estimated to be 0.5 in.

CALCULATIONS

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OBJECTIVE

Calculate the primary settlement beneath the proposed culvert after construction, at the location where the Presumpscot Silt is thickest (8.8 feet south from Station 115+26 along the proposed culvert centerline)

REFERENCES

1. Holtz, Robert D. and Kovacs, William D. An Introduction to Geotechnical Engineering, 1st Ed. Prentice-Hall, 1981.

2. GEOTECHNICAL ENGINEERING CIRCULAR NO. 6: Shallow Foundations. FHWA: September 2002. (FHWA)

3. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.

4. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.

5. WSP boring logs, included as Appendix A of the Preliminary Geotechnical Design Report.

6. WSP Interpretive Subsurface Profile A-A', included as Sheet 3 Preliminary Geotechnical Design Report.

7. GeoTesting Express laboratory testing results, included as Appendix C and summarized in Table 5 of the Preliminary Geotechnical Design Report.

8. State of Maine Department of Transportation, Thorne Brook Bridge, Augusta, Kennebec County, Route 17 (Sheets 1 - 16), Dated 11/2023 (WSP Draft plans).

9. Maine Department of Transportation Bridge Design Manual, dated August 2003.

10. State of Maine Department of Transportation, Thorne Bridge and Spaulding Bridge in the city of Augusta, Kennebec County, General Plan (sheets 1 and 2), dated Jan. 1988. Marked as as-built-1989.

ASSUMPTIONS

1. The existing stratigraphy and water table surface are estimated from samples and groundwater measurements encountered during drilling at location BB-ATB-101 (Reference 5 and 6).	GS EL =	184.3	feet
	Water table EL. =	176.3	feet
2. Clay consolidation parameters for the Presumpscot layer are based on laboratory test results for boring BB-ATB-102 (Ref 7). The OCR is a design value obtained by averaging OCR values over depths at locations BB-ATB-101 and BB-ATB-102.	C_c =	0.17	
	C_r =	0.026	
	e_0 =	0.92	
	OCR =	1.4	
3. N60-values for the soil layers, based on correlation (Reference 3, Equation 18.5) to the measured N values are:	$N_{60\ Existing\ Fill}$ =	36	
	$N_{60\ Presump.\ Silt}$ =	10	
	$N_{60\ Glacial\ till}$ =	21	
4. The proposed road grade elevation taken at the roadway centerline and proposed culvert invert elevation at the location of analysis are (Reference 8, Sheet 5 and 19):	Road EL =	184.9	feet
	Proposed invert EL =	171.9	feet
5. Based on Reference 8, Sheet 5, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:	Proposed culvert wall thickness =	1.2	feet
	Excavation/fill thickn. beneath culvert =	1.0	feet
6. Based on Reference 8, Sheet 5, the culvert interior will be filled with Stream Channel Rock and Special Fill with a thickness of:	Stone fill thickness =	2.4	feet

CALCULATIONS

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7. The unit weight for the proposed fill construction material (Reference 9), based on MaineDOT standard practice, are:	Granular Borrow=	125	pcf
	Gravel Borrow =	136	pcf
	Aggregate Subbase =	136	pcf
8. Unit weights for concrete and steel are assumed based on local engineering experience:	Concrete =	150	pcf
	Steel =	490	pcf
9. The stream elevation within the culvert is assumed to be the groundwater elevation measured at Boring BB-ATB-101. The loading from this groundwater elevation includes anticipated increased flow from spring thaw.	Stream EL above Stream Channel Fill =	176.3	feet

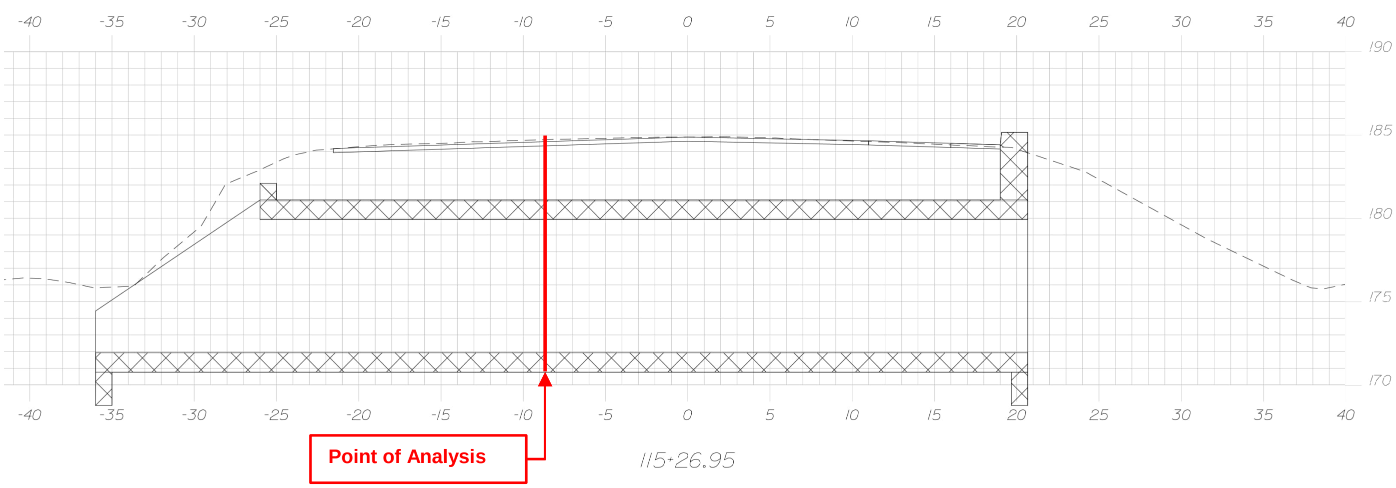
10.The stress will be uniformly distributed over the culvert box length.

11. This evaluation does not include the downstream wingwall loading as the full geometry is not know at this time. It is assumed the wingwall will be fixed to the proposed but culvert therefore an independent settlement analysis for the downstream wingwall was not conducted.

12. Primary consolidation settlement is assumed to be based on a preconsolidation stress calculated using the existing effective stress outside of the existing culvert area, to reflect the preconsolidation past pressure in the Presumpscot Silt.

13. The area of the existing steel pipe arch culvert is approximated by assuming a box geometry.

Location of the Analysis:



(Reference 8)

CALCULATIONS

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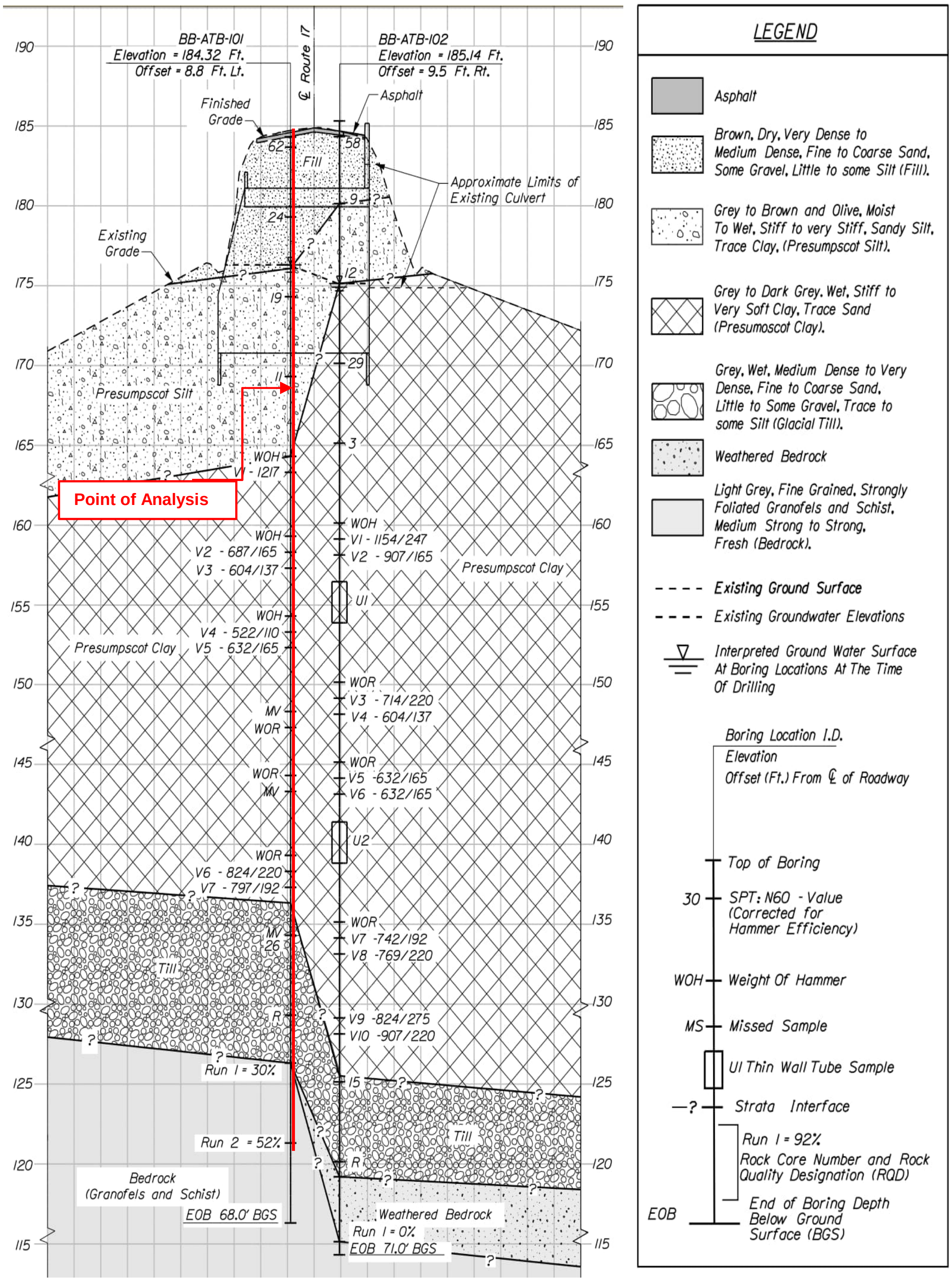

(Reference 6)

CALCULATIONS

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CALCULATION

A. Determine the change in effective stress state within the soil beneath the proposed culvert to identify if settlement or heave will occur. Calculate the vertical stress change beneath the proposed culvert due to culvert construction.

The change in effective stress state due to the excavation of the existing steel culvert and the construction of the proposed concrete box culvert is determined at the lower limit of the proposed excavation for the concrete box culvert along the culvert centerline: elevation 169.7 feet (culvert invert elevation 171.93 feet minus culvert base thickness 1.2 feet and excavation/fill thickness 1.0 feet). Based on Reference 6, the excavation limit will be founded within the Presumpscot Silt layer at the point of analysis.

1. Load from existing steel culvert, per linear foot (Ref. 10):

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of steel (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	11.6	7.4	85.9			
Internal dimensions (Ref. 10, Sheet 2)	11.6	7.4	85.5			
Culvert steel:			0.436	490	213.9	18.5

2. Load from proposed culvert concrete, per linear foot:

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of concrete (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	14.0	10.5	147.0			
Internal dimensions (Ref. 8, Sheet 5)	12.0	8.0	96.0			
Culvert concrete:			51.0	150	7650.0	546.4

3. Existing conditions outside of the existing culvert (Ref. 5 & 6) for preconsolidation stress calculation:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Pavement	125	184.3	183.7	0.6	75	75
Fill	120	183.7	175.8	7.9	948	917
Presumpscot Silt	119	175.8	169.7	6.1	726	345

wsp

CALCULATIONS

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4. Current conditions at the center of the existing steel arch culvert (Ref. 6 & 10):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Pavement	140	184.3	183.7	0.6	84	N/A
Fill	125	183.7	182.2	1.5	188	N/A
Existing Culvert	N/A	182.2	174.8	7.4	18	N/A
Granular Borrow Fill	125	174.8	169.7	5.1	638	319
				Total =	927	

5. Proposed conditions at the center of the proposed concrete box culvert after construction (Ref. 8):

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vertical Stress Contribution of Layer (psf)	Vertical Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Fill	140	184.9	184.4	0.5	70	N/A
Aggregate Subbase	135	184.4	182.4	2.0	270	N/A
Granular Borrow Backfill	125	182.4	181.2	1.2	150	N/A
Culvert	N/A	181.2	170.7	10.5	546	N/A
Stream Above Fill (inside)	62.4	176.3	174.3	2.0	125	N/A
Stream Channel Rock and Special Fill (inside)	140	174.3	171.9	2.4	336	N/A
Granular Borrow Backfill	125	170.7	169.7	1.0	125	63
				Total =	1622	

Calculate the increase or decrease in effective stress as a result of construction.

	σv at Elev. 169.7 ft (psf)	σ'v at Elev. 169.7 ft (psf)	Δσ'v at Elev. 169.7ft (psf)	Result
Existing conditions	927	609	951	Settlement
After construction	1622	1560		

CALCULATIONS

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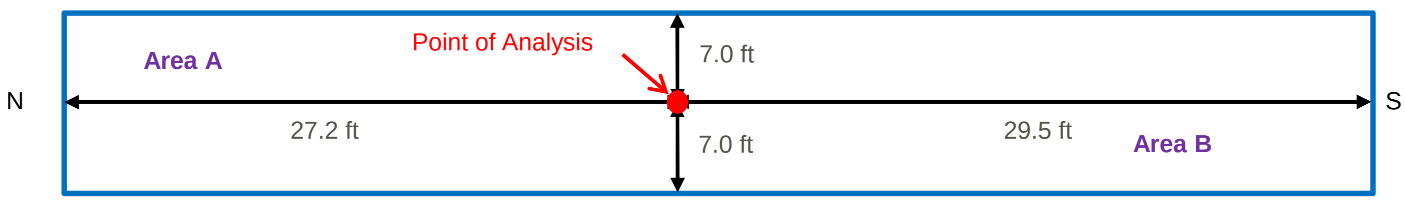
B. Subdivide the subsurface soils into layers no larger than 10 ft thick extending to bedrock. Calculate the vertical stress increase at each layer, assuming the Boussinesq stress distribution method for stress under the corner of a rectangular load.

Assumed Loading (plan view):



$\sigma_z = q_0 \times I$ Reference 1, Eqn. 8-30

$m = x/z$ Reference 1, Figure 8.21

$n = y/z$ Reference 1, Figure 8.21

where:	Area A	Area B		
σ_z = half of the vertical stress increase, psf	(each half of the culvert width is calculated separately for each area)			
q_0 = net stress applied by culvert	951		psf	(Part A)
x = half of the width of the loading area, ft	7.0	7.0	feet	(Ref. 8, Sheet 5)
y = length of the loading area, ft	27.2	29.5	feet	(Ref. 8, Sheet 17)
z = depth to midpoint of layer, ft	(z_{max} = to the top of bedrock = 43.5 ft)			

Area A:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Presumpscot Silt	1	0-5.4	5.4	2.7	2.6	10.1	0.244	464.1
Presumpscot Clay	2	5.4-15.4	10.0	10.4	0.7	2.6	0.165	313.8
Presumpscot Clay	3	15.4-25.4	10.0	20.4	0.3	1.3	0.087	165.5
Presumpscot Clay	4	25.4-33.4	8.0	29.4	0.2	0.9	0.053	100.8
Glacial Till	5	33.4-43.4	10.0	38.4	0.2	0.7	0.048	91.3

CALCULATIONS

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Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

Area B:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Presumpscot Silt	1	0-5.4	5.4	2.7	2.6	11.0	0.244	464.1
Presumpscot Clay	2	5.4-15.4	10.0	10.4	0.7	2.8	0.166	315.7
Presumpscot Clay	3	15.4-25.4	10.0	20.4	0.3	1.4	0.088	167.4
Presumpscot Clay	4	25.4-33.4	8.0	29.4	0.2	1.0	0.054	102.7
Glacial Till	5	33.4-43.4	10.0	38.4	0.2	0.8	0.050	95.1

Area A + Area B:

Layer		Depth below lower limit of excavation (ft)	Increase σ_z (psf)
Presumpscot Silt	1	0-5.4	928
Presumpscot Clay	2	5.4-15.4	630
Presumpscot Clay	3	15.4-25.4	333
Presumpscot Clay	4	25.4-33.4	204
Glacial Till	5	33.4-43.4	186

C. Use consolidation theory to estimate settlement of the Presumpscot Clay layer beneath the proposed culvert (Layers 2 to 4); use the Hough method to estimate settlement of the Presumpscot Silt (Layer 1), and Glacial Till beneath the proposed culvert (Layer 5).

1 Calculate σ'_{v0} based on pre-construction stratigraphy for use in determining the preconsolidated stress in the clay layers

σ'v at Elev. 169.7 ft (psf)	1337	(Part A)

Layer		Unit weight (pcf)	Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	σ'_{v0} (psf)	σ'_{v0} (kPa)
Presumpscot Silt	1	120	0-5.4	5.4	2.7	1492	71.4
Presumpscot Clay	2	119	5.4-15.4	10.0	10.4	1930	92.4
Presumpscot Clay	3	119	15.4-25.4	10.0	20.4	2496	119.5
Presumpscot Clay	4	119	25.4-33.4	8.0	29.4	3006	143.9
Glacial Till	5	135	33.4-43.4	10.0	38.4	3596	172.1

CALCULATIONS

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

2 Calculate the total settlement of the Presumpscot Clay layer (Layers 2 to 4) using the consolidation theory:

General Equation (Das, Eqn 1.61, 1.63, 1.65)

$$\Delta H_i = C_{r\varepsilon} H_c \log \frac{\sigma'_p}{\sigma'_{v0}} + C_{c\varepsilon} H_c \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_p}$$

for underconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v > \sigma'_p$

$$\Delta H_i = C_{r\varepsilon} H_c \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$

for overconsolidated clay, $\sigma'_{v0} + \Delta\sigma_v \le \sigma'_p$

$$\Delta H_i = C_{c\varepsilon} H_c \log \frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}$$

for normally consolidated clay

where:			Layer 2 - Presump. Clay	Layer 3 - Presump. Clay	Layer 4 - Presump. Clay
H_c	initial height of layer i, ft		10.0	10.0	8.0
$\Delta\sigma_v$	surcharge load, psf		630	333	204
σ'_{v0}	in situ vertical effective stress, psf		1930	2496	3006
$\sigma'_{v0} + \Delta\sigma_v$	check against σ'_p to select eqn.		2560	2829	3209
σ'_p	preconsolidated stress, psf		2702	3494	4208
$C_{r\varepsilon}$	modified recompression index		0.01	0.01	0.01
$C_{c\varepsilon}$	modified compression index		0.09	0.09	0.09
ΔH_i		ft	0.017	0.007	0.003
		in	0.200	0.089	0.037

3 Determine C' and σ'_{v0} for in situ existing soil. Use FHWA Figures 5-18 and 5-19 to obtain N' and C' for the

Layer		Thickness	of Layer	midpoint	midpoint	N_{60}	N'	C'
Presumpscot Silt	1	5.4	120	1492	71	10.0	12	30
Presumpscot Clay	2	10.0	119	1930	92	Not required, for clay consolidation analysis		
Presumpscot Clay	3	10.0	119	2496	119			
Presumpscot Clay	4	8.0	119	3006	144			
Glacial Till	5	10.0	135	3596	172	21	16	65

CALCULATIONS

Date:	11/21/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	DEB
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	MEL
Project:	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

4 Calculate the total settlement of the Presumpscot Silt layer (Layer 1) using the Hough method:

General Equation (Ref. 2, Eqn 5-24)

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}\right)$$

where:

ΔH_i settlement in each layer, ft

H_c initial height of layer i, ft

C' bearing capacity index from Ref. 5, Figure 5-19

$\Delta\sigma_v$ vertical stress increase, ksf

ΔH_i (Layer 1)	ft	0.038
	in	0.452
ΔH_i (Layer 5)	ft	0.003
	in	0.041

	Settlement Based on Calculated Loading Stress
Layer	ΔH_i (in)
PRESUMP. SILT, 1	0.452
PRESUMP. CLAY, 2	0.200
PRESUMP. CLAY, 3	0.089
PRESUMP. CLAY, 4	0.037
GLACIAL TILL, 5	0.041
Total Settlement (in)	0.82

CONCLUSIONS

The estimated primary consolidation settlement 8.8 feet left of the roadway centerline under the proposed culvert is estimated to be 0.8 inches.

CALCULATIONS

Date:	12/20/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Global Stability Analysis	**Reviewed by:**	CCB
Project Short	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

OBJECTIVE

Determine the factor of safety for existing and proposed conditions for Sta. 116+25 at Thorne Brook Bridge in Augusta, Maine.

REFERENCES

1. WSP geotechnical test boring logs (Appendix A, Preliminary Geotechnical Design Report, dated December 2023).
2. WSP Corrected N_{60}-value to friction angle correlation titled "MaineDOT Augusta Thorne Brook Material Properties.xlsx"
3. State of Maine Department of Transportation, Thorne Brook Bridge, Thorne Brook, Augusta, Kennebec County (Sheets 1 - 16), Dated 11/2023 (WSP Draft plans).
4. Maine Department of Transportation. Bridge Design Guide. August 2003.
5. Rocscience Slide2 Software Package Version 9.027 64-bit, build date 02/13/2023.
6. American Association of State Highway and Transportation Officials (AASHTO). 2020. LRFD Bridge Design Specifications, 9th Edition.

ATTACHMENTS

1. Slide2 material properties.
2. Slide2 output figures for model with current conditions.
3. Slide2 output figures for model with proposed final loading with Granular Borrow fill.
4. Slide2 output figures for model with proposed final loading with Gravel Borrow fill.

ASSUMPTIONS

1. Circular surface searches were analyzed using the Spencer method. Non-circular surfaces searches were analyzed using the Spencer method and cuckoo search with surface altering optimization.
2. As per AASHTO LRFD Article 11.6.3.7 and Article C11.6.3.7 (Ref. 6) a minimum allowable factor of safety (FS) of 1.3 for overall stability of earth slopes with and without foundations.
3. As per Maine Department of Transportation, the load applied by the road and traffic for final design conditions is modeled as a 2-foot equivalent load of soil (Ref. 4, Table 3-4): 2 x 125 pcf (granular borrow) = 250 psf.
4. A FS ≥ 1.3 for static loading is recommended for potential failure surfaces on the embankment slope.
5. The water table elevation below the road was estimated from levels measured during the drilling at locations BB-ATB-101, and BB-ATB-102 (Ref. 1). At the toe of the slope, the water table was assumed to be at ground surface.
6. Ground surface elevations for the current and proposed final conditions were taken from the Proposed Plans (Ref. 3).
7. Subsurface profile at Sta. 116+25 was estimated based on the results from the boring locations, BB-ATB-101, and BB-ATB-102 (Ref. 1).

CALCULATIONS

Date:	12/20/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Global Stability Analysis	**Reviewed by:**	CCB
Project Short	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

CALCULATION

1. Global slope stability analysis based on the current site conditions (Ref. 3) at Sta. 116+25.

a. The material properties selected for use in the Slide2 models are shown in the table below and in the Attachment 1 figures.

b. The unit weight properties for most of the in-situ soils, excluding the Presumpscot Clay, were determined using Figure 12.14 in Holtz, Kovacs, and Sheahan (2011), and the final design unit weights were determined using engineering judgement and knowledge gained from previous experience. The unit weight of the Presumpscot Clay layer was determined using consolidation test results.

c. The friction angles for the in-situ soils were correlated to friction angles using Peck, Hanson, & Thornburn (1974), as provided in Das (2011) Friction Angle = $27.1 + 0.3*N_{60} - 0.00054*(N_{60})^2$ (Ref. 2).

d. The undrained strength from the Presumpscot Clay was calculated as the 33 percentile of the corrected undrained strength measured with the field vane shear test from boring locations BB-ATB-101, and BB-ATB-102.

Material Name	Unit Weight (pcf)	Strength Type	Cohesion (psf)	Friction Angle (°)
Pavement	140	Mohr-Coulomb	0	45
Fill (Existing)	125	Mohr-Coulomb	0	32
Presumpscot Silt	120	Mohr-Coulomb	0	31
Presumpscot Clay	119	Undrained	664	-
Glacial Till	135	Mohr-Coulomb	0	32
Bedrock (Quartz Monzonite)	170	Infinite Strength	-	-

The soil layer properties shown above were used to analyze circular surfaces using Spencer method and non-circular surfaces using the Spencer method.

The results of the Slide2 stability analyses are summarized in the following table.

Station	Surface Type	Failure Surface Location	Factor of Safety	Figure # (Attach. 1)	Condition
116 + 25	Circular (Right)	Global	1.56	2A	Existing slope geometry
	Non-Circular (Right)	Global	1.51	2B	

wsp

CALCULATIONS

Date:	12/20/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Global Stability Analysis	**Reviewed by:**	CCB
Project Short	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

2. Analyze slope stability based on the proposed conditions shown in the Proposed Plans (Ref. 3) at Sta. 116+25.

a. The material properties selected for use in the Slide2 models are shown in the table below and in Attachment 1 figures.

b. The unit weight properties for most of the in-situ soils, excluding the Presumpscot Clay, were determined using Figure 12.14 in Holtz, Kovacs, and Sheahan (2011), and the final design unit weights were determined using engineering judgement and knowledge gained from previous experience. The unit weight of the Presumpscot Clay layer was determined using consolidation test results.

c. The friction angles for the in-situ soils were correlated to friction angles using Peck, Hanson, & Thornburn (1974), as provided in Das (2011) Friction Angle = 27.1 + 0.3*N_{60} - 0.00054*(N_{60})2 (Ref. 2).

d. The undrained strength from the Presumpscot Clay was calculated as the 33 percentile of the corrected undrained strength measured with the field vane shear test from boring locations BB-ATB-101, and BB-ATB-102.

e. The unit weight and friction angles from the Granular Borrow and Gravel borrow follow MaineDOT practice (Ref. 4).

Material Name	Unit Weight (pcf)	Strength Type	Cohesion (psf)	Friction Angle (°)
Pavement	140	Mohr-Coulomb	0	45
Fill (Existing)	125	Mohr-Coulomb	0	32
Fill (Granular Borrow)	125	Mohr-Coulomb	0	32
Fill (Gravel Borrow)	135	Mohr-Coulomb	0	36
Aggregate Subbase	135	Mohr-Coulomb	0	36
Presumpscot Silt	120	Mohr-Coulomb	0	31
Presumpscot Clay	119	Undrained	664	-
Glacial Till	135	Mohr-Coulomb	0	32
Bedrock (Quartz Monzonite)	170	Infinite Strength	-	-

The soil layer properties shown above were used to analyze circular surfaces using Spencer method and non-circular surfaces using the Spencer method.

The proposed 2:1 slope geometry was evaluated using Granular Borrow and Gravel Borrow as fill materials, with a 1 foot horizontal bench on the slope base. The proposed geometry includes a 2 feet thick aggregate subbase layer below the pavement (Ref. 3)

The results of the Slide2 stability analyses are summarized in the following table.

Station	Surface Type	Failure Surface Location	Factor of Safety	Figure # (Attach. 2)	Condition
116 + 25	Circular (Right)	Global	1.29	3A	Proposed 2:1 slope geometry - Fill (Granular Borrow)
	Non-Circular (Right)	Global	1.29	3B	
116 + 25	Circular (Right)	Global	1.36	4A	Proposed 2:1 slope geometry - Fill (Gravel Borrow)
	Non-Circular (Right)	Global	1.36	4B	

CALCULATIONS

Date:	12/20/2023	**Made by:**	LMP
Project No.:	30900914.004	**Checked by:**	TJ
Subject:	Global Stability Analysis	**Reviewed by:**	CCB
Project Short	Augusta Thorne Brook Bridge No. 2850, Augusta, Maine		

Conclusions

1) The analyzed existing conditions at Sta. 116+25 have a computed factor of safety that meet the requirement of FS ≥ 1.3 for circular and non-circular potential slope failure surfaces.

3) The analyzed proposed conditions at Sta. 116+25 using Granular Borrow as fill material in the slope have a computed factor of safety that do not meet the requirement of FS ≥ 1.3 for circular and non-circular potential slope failure surfaces.

3) The analyzed proposed conditions at Sta. 116+25 using Gravel Borrow as fill material in the slope have a computed factor of safety that meet the requirement of FS ≥ 1.3 for circular and non-circular potential slope failure surfaces.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Allow Sliding	Water Surface	Hu Type	Hu
Pavement		140	Mohr-Coulomb	0	45			Water Surface	Custom	1
Fill (Existing)		125	Mohr-Coulomb	0	32			Water Surface	Custom	1
Fill (Granular Borrow)		125	Mohr-Coulomb	0	32			Water Surface	Custom	1
Fill (Gravel Borrow)		135	Mohr-Coulomb	0	36			Water Surface	Custom	1
Aggregate Subbase		135	Mohr-Coulomb	0	36			Water Surface	Custom	0
Presump. Silt		120	Mohr-Coulomb	0	31			Water Surface	Custom	1
Presump. Clay		119	Undrained	664		Constant		Water Surface	Custom	0
Glacial Till		135	Mohr-Coulomb	0	32			Water Surface	Custom	1
Bedrock (GRANOFELS)		170	Infinite strength				No	Water Surface	Custom	1

-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60

wsp

SLIDEINTERPRET 9.020

Project MaineDOT Thorne Brook Bridge No. 2850

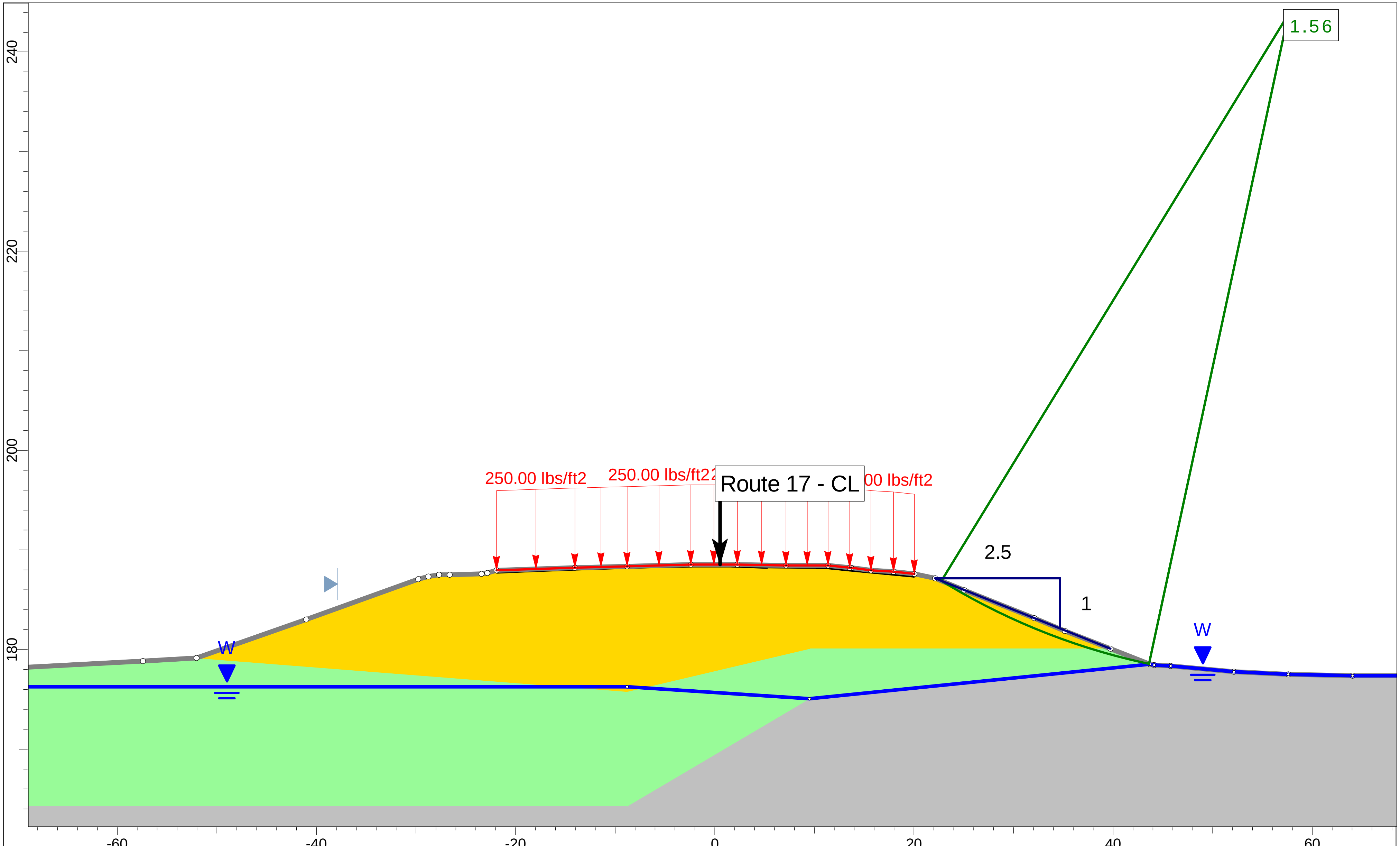
Analysis Description Material Properties Sta. 116+25

Drawn By	Checked By	Reviewed By	Scale
LMP	TJ	CCB	N/A

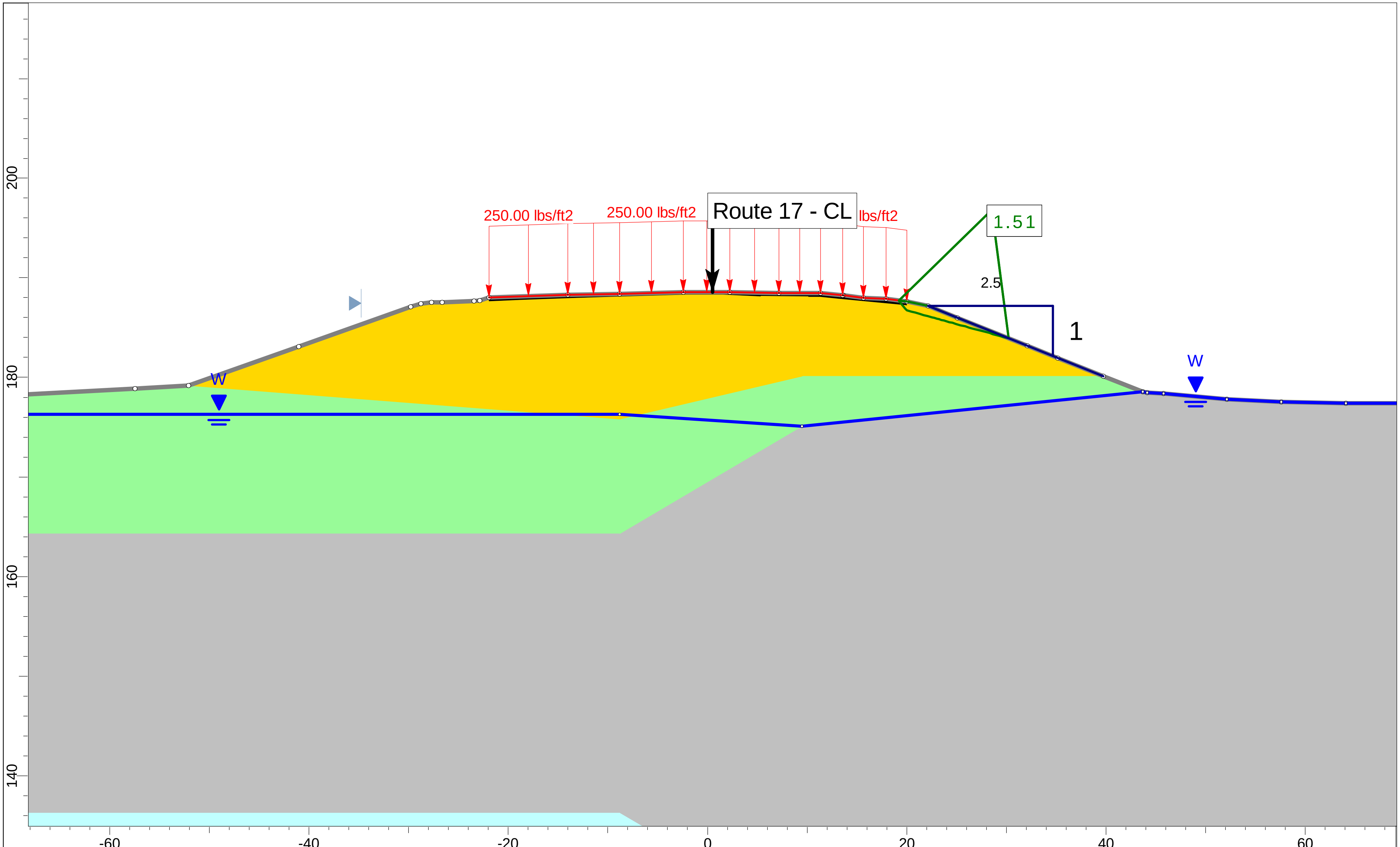
Date 12/20/2023

File Name Sta.116 25Right.slmd

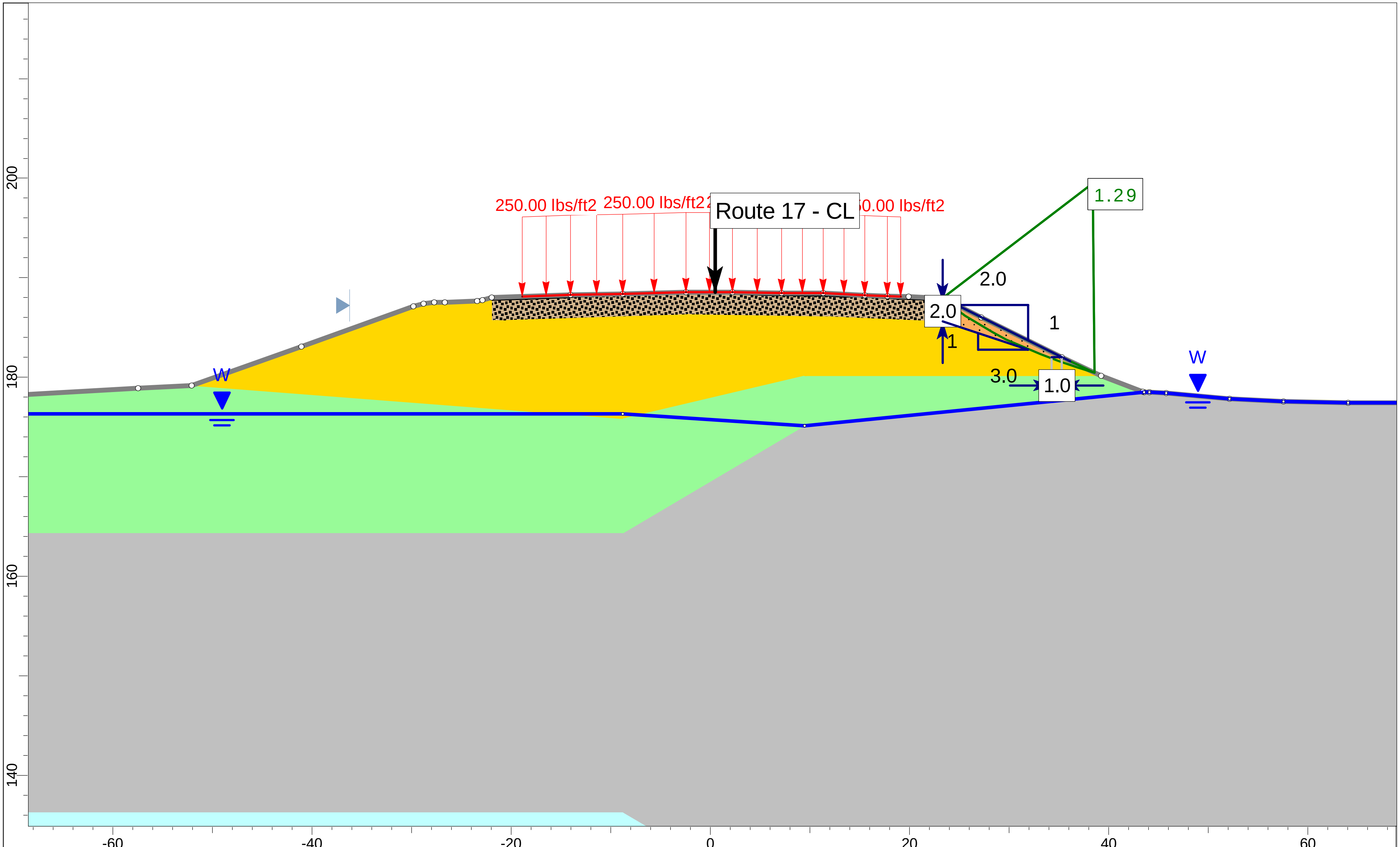
Figure 1



wsp	Project	MaineDOT Thorne Brook Bridge No. 2850			
	Analysis Description	Sta. 116+25 - Existing conditions (Right) - Circular			
	Drawn By LMP	Checked By TJ	Reviewed By CCB	Scale 1:160	Figure 2A
SLIDEINTERPRET 9.020	Date 12/20/2023	File Name Sta.116 25Right.slmd			

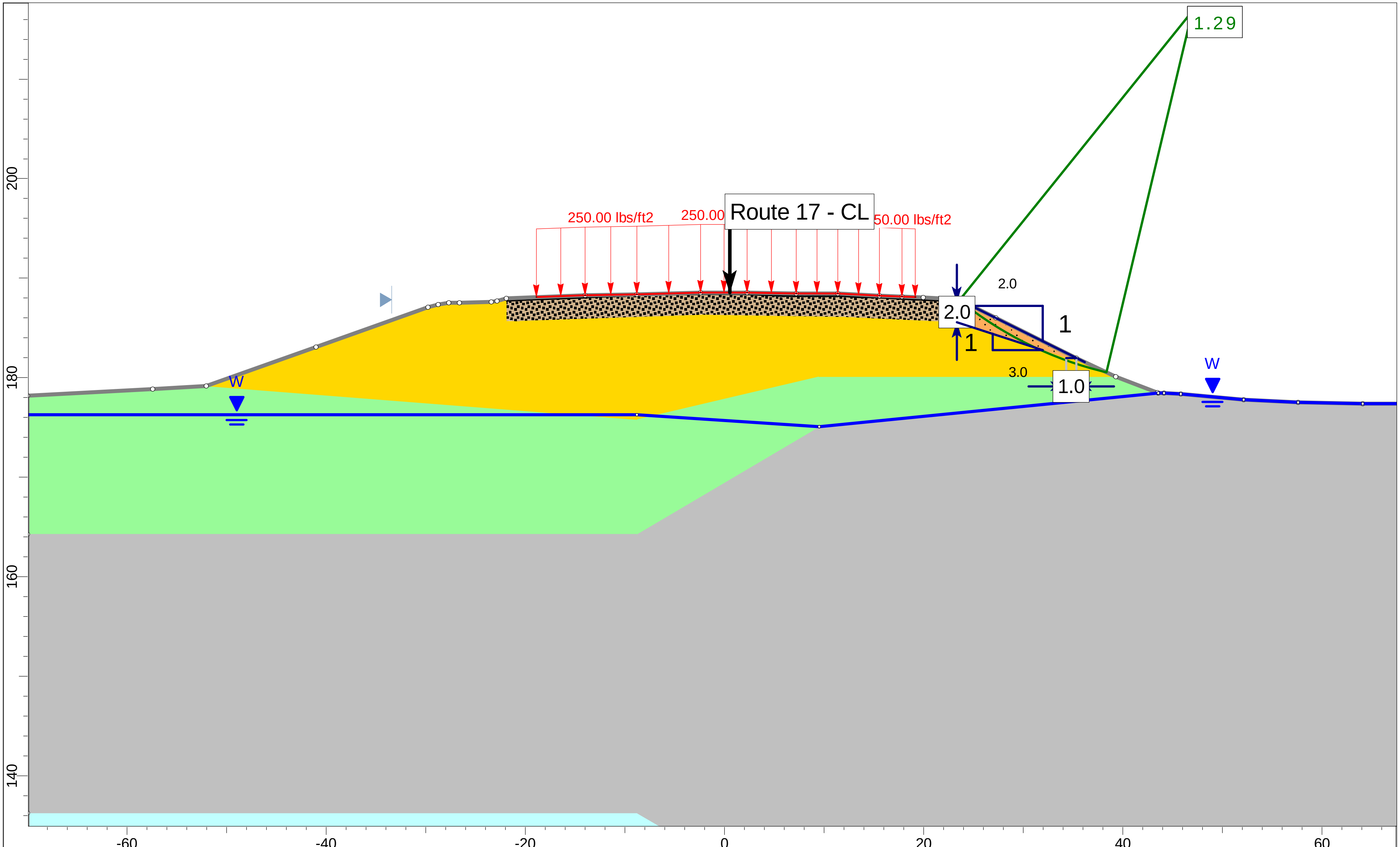


wsp	Project	MaineDOT Thorne Brook Bridge No. 2850					
	Analysis Description	Sta. 116+25 - Existing conditions (Right) - Non Circular					
	Drawn By	LMP	Checked By	TJ	Reviewed By	CCB	Scale 1:160
SLIDEINTERPRET 9.020	Date	12/20/2023	File Name	Sta.116 25Right.slmd			Figure 2B

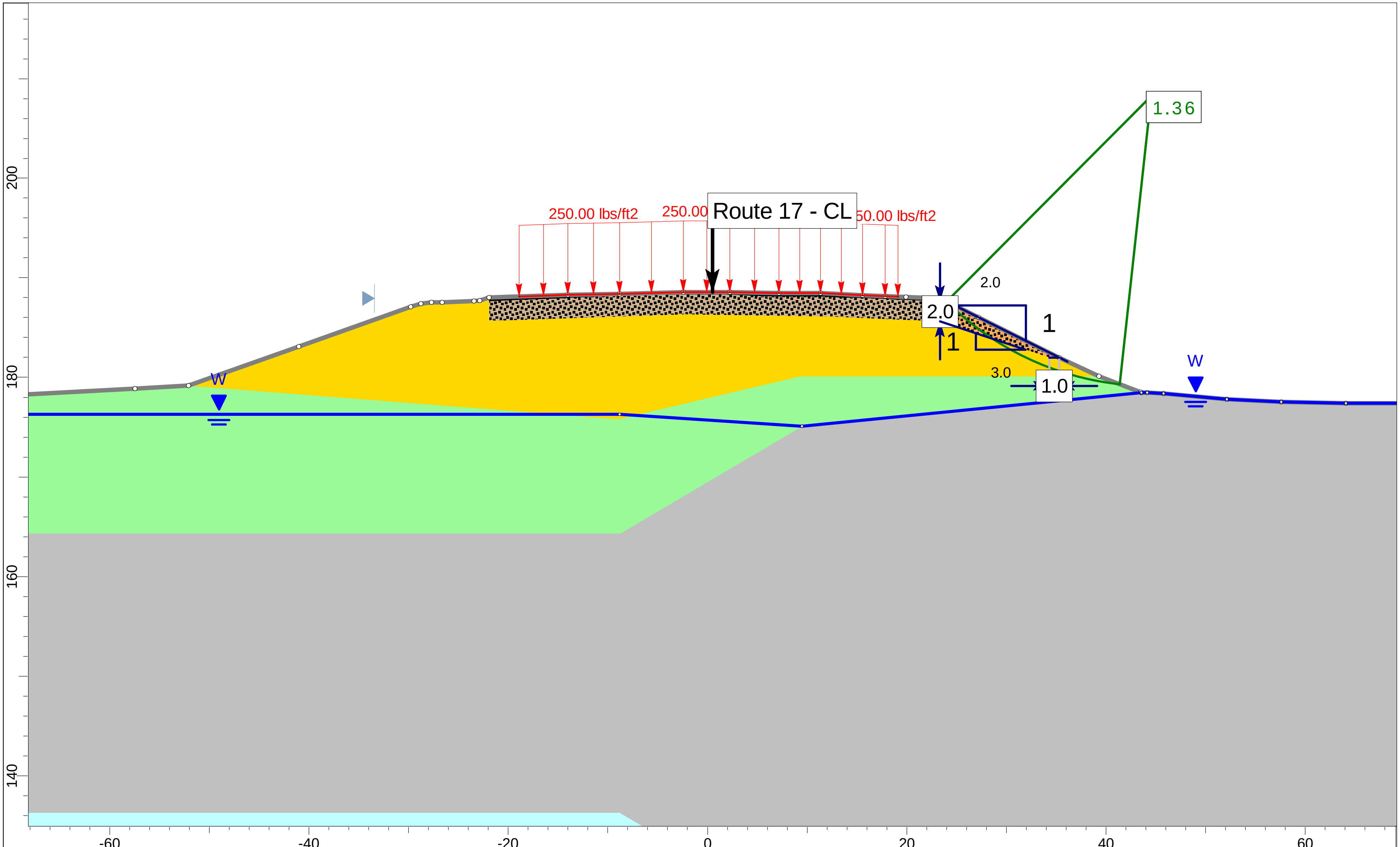


Project	MaineDOT Thorne Brook Bridge No. 2850			
Analysis Description	Sta. 116+25 - Proposed conditions (Right) - Non Circular			
Drawn By LMP	*Checked By* TJ	*Reviewed By* CCB	*Scale* 1:160	Figure 3B
Date 12/20/2023	*File Name* Sta.116 25Right.slmd			

SLIDEINTERPRET 9.020



wsp	*Project* MaineDOT Thorne Brook Bridge No. 2850			
	Analysis Description Sta. 116+25 - Proposed conditions (Right) - Circular			
	Drawn By LMP	*Checked By* TJ	*Reviewed By* CCB	*Scale* 1:160	Figure 3A
SLIDEINTERPRET 9.020	*Date* 12/20/2023	*File Name* Sta.116 25Right.slmd		



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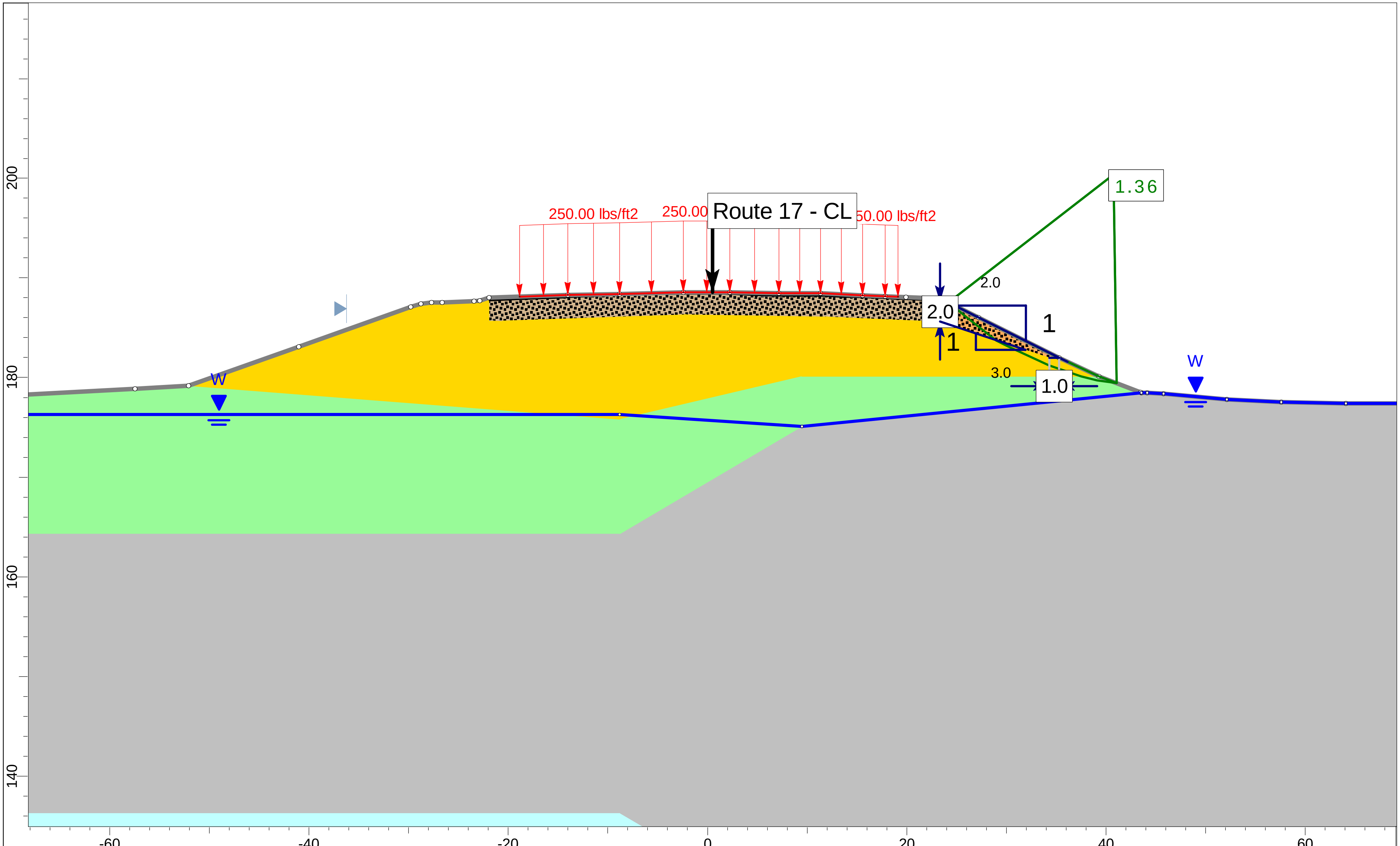
	Analysis Description Sta. 116+25 - Proposed conditions (Right) - Circular						
	Drawn By LMP	*Checked By* TJ	*Reviewed By* CCB	*Scale* 1:160	Figure 4A		
SLIDEINTERPRET 9.020	*Date* 12/20/2023	*File Name* Sta.116 25Right.slmd					



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	Analysis Description Sta. 116+25 - Proposed conditions (Right) - Non Circular			
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SLIDEINTERPRET 9.020	*Date* 12/20/2023	*File Name* Sta.116 25Right.slmd		Figure 4B

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