

**MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE**

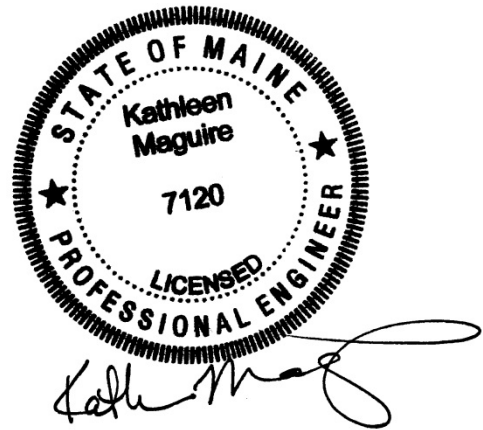
GEOTECHNICAL DESIGN REPORT

For the Replacement of:

**CROSS CULVERT #123152
ROUTE 106
LIVERMORE FALLS, MAINE**

Prepared by:

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Reviewed by:

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Senior Geotechnical Engineer.

Androscoggin County

WIN 23133.00
November 5, 2018

Soils Report 2018-17

PROJECT DETAILS

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical design and construction recommendations for the replacement of an existing 60-foot long, 48-inch culvert (#123152) on Route 106 in Livermore Falls. The floor of the existing culvert has rusted and detached from the rest of the culvert and a scour hole has formed on the culvert's outlet end. The culvert is located approximately 0.12 of a mile north of Strickland Loop Road as shown in the attached Location Map. Route 106 is a Highway Corridor Priority 3 road.

The proposed replacement structure will be a 110-foot long, 96-inch diameter Option III* pipe culvert on a skew of approximately 13 degrees to the roadway centerline. The invert of the proposed culvert is approximately 14 feet below the existing road grade at the roadway centerline. The invert of the proposed culvert will be lined with approximately 2 feet (at the culvert centerline) of Special Fill to facilitate fish passage. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V to protect against erosion.

SUBSURFACE INVESTIGATION

One (1) boring (HB-LIV-101) was drilled for this project on February 6, 2018 by Northern Test Boring (NTB) of Gorham, Maine using a track mounted drill rig and a second boring (HB-LIV-102) was drilled on February 27, 2018 by the MaineDOT drill crew using a trailer mounted drill rig. Exploration locations are shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are shown on the attached boring logs.

Boring HB-LIV-101 was drilled using hollow stem auger and rod probe drilling techniques. Soil samples were obtained in boring HB-LIV-101 at 5-foot intervals to a depth of approximately 22 feet using Standard Penetration Test (SPT) methods. The NTB drill rig is equipped with an automatic hammer to drive the split spoon. The NTB calibrated automatic hammer delivers approximately 63 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values (N_{60}) computed by applying an average energy transfer factor of 0.977 to the raw field N-values. Boring HB-LIV-102 was drilled using cased wash boring, open hole, and rod probe drilling techniques. No soil samples were obtained in boring HB-LIV-102. In-situ vane shear tests were attempted in boring HB-LIV-102 in the soft soil deposits to determine the shear strength of the soft strata. No refusal surface was encountered in either boring.

The MaineDOT Geotechnical Team member selected the boring and probe locations, drilling methods, designated type and depth of sampling, reviewed field logs for accuracy and identified field and laboratory testing requirements. A NorthEast Transportation Training and Certification (NETTCP) certified Subsurface Investigator logged the subsurface conditions encountered in both borings. The borings were located in the field by taping to surveyed site features after completion of the drilling program.

* Refer to MaineDOT Standard Specification Section 603.031 for types of pipe meeting the Option III category.

LABORATORY TESTING

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. Laboratory testing consisted of one (1) standard grain size analyses with natural water content, five (5) grain size analyses with hydrometer and natural water content and three (3) Atterberg Limits tests. The results of the laboratory testing program are discussed in the following section and are shown on the attached boring logs, Laboratory Testing Summary Sheet, and Grain Size Distribution Curve sheet.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test borings generally consisted of fill overlying native clayey silt. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet.

Boring HB-LIV-101 was drilled to a depth of approximately 65.5 feet below ground surface (bgs) and did not encounter a refusal surface. Boring HB-LIV-102 was drilled to a depth of approximately 58.4 feet bgs and did not encounter a refusal surface.

The table below summarizes the field and laboratory information obtained in boring HB-LIV-101:

Approx. Depth BGS ¹ (feet)	Soil Description	AASHTO ² Classification	USCS ³	WC% ⁴
0.0 – 13.5	Fill: Brown, damp, clayey silt, trace fine to coarse sand.	A-4	CL	29.4
	Brown, moist, fine to coarse sand, some silt, trace gravel.	A-2-4	SM	15.1
	Dark grey, wet, fine sand silt, trace clay.	A-4	ML	31.1
13.5 – 65.5	Olive grey to grey, wet, clayey silt, trace fine sand. No Refusal	A-4	ML, ML-CL, or CL	28.8- 31.6

¹BGS = below ground surface

²AASHTO = American Association of State Highway and Transportation Officials

³USCS = Unified Soil Classification System

⁴WC% = Water content in percent

Fill – The fill is comprised of interbedded layers of clayey silt, sand, and sandy silt. One (1) corrected N-value obtained in the clayey silt fill was 23 blows per foot (bpf), indicating that the clayey silt is very stiff in consistency. One (1) corrected N-value obtained in the sand fill was 8 bpf, indicating the sand fill is loose in consistency. One (1) N-value obtained in the sandy silt fill was 5 bpf, indicating that the sandy silt is medium stiff in consistency. Water contents from three (3) samples obtained within the fill layer range from approximately 15% to 31%. Three (3) grain

size analyses conducted on samples from the fill layer indicate that the fill is classified as an A-4 or A-2-4 by the AASHTO Classification System and a CL, SM, or ML by the Unified Soil Classification System.

Clayey Silt – Native clayey silt underlies the fill soils in both borings. Three (3) corrected N-values obtained in the clayey silt ranged from 5 to 10 bpf, indicating that the clayey silt is medium stiff to stiff in consistency. The full thickness of the clayey silt was not determined in the borings. Vane shear testing conducted within the clayey silt layer showed measured undrained shear strengths ranging from approximately 826 to 1295 pounds per square foot (psf) while the remolded shear strength ranged from approximately 223 to 312 psf. Based on the ratio of undrained to remolded shear strength from the vane shear tests, the clayey silt was determined to have a sensitivity of approximately 2.6 to 5.4 and is classified as moderately sensitive to sensitive. Water contents from three (3) samples obtained within the clayey silt layer range from approximately 29% to 32%. Three (3) grain size analyses conducted on samples from the clayey silt layer indicate that the clayey silt is classified as an A-4 by the AASHTO Classification System and a ML or CL-ML by the Unified Soil Classification System.

The following table summarizes the results of Atterberg Limits tests done on three (3) samples of the native clayey silt:

Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-LIV-101 4D	31.6	28	24	4	1.9
HB-LIV-101 5D	29.8	28	22	6	1.3
HB-LIV-101 6D	28.8	29	20	9	0.98

Interpretation of these results indicate that the clayey silt ranges from being slightly plastic to having low plasticity with plasticity increasing with depth. The clayey silts in samples 4D and 5D are on the verge of being a viscous liquid if disturbed. Overburden pressure and interparticle cementation is providing stability to keep the soil in its current state, but the slightest disturbance causing remolding could convert the soil into a viscous fluid. The clayey silt in sample 6D is normally consolidated, meaning it is currently experiencing its highest stress.

Groundwater was not recorded in the borings. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

Option III Culvert Pipe Construction – The proposed replacement structure will be a 110-foot long, 96-inch diameter Option III culvert pipe on a skew of approximately 13 degrees to the roadway centerline. The proposed pipe culvert shall be furnished and installed in accordance with MaineDOT Standard Specification 603.

The invert of the proposed culvert pipe ranges from approximately 293.78 feet at the inlet end to approximately 292.90 feet at the outlet end with a 0.8% slope. The culvert will be lined with approximately 2 feet of Special Fill to facilitate fish passage.

The full nature of the proposed culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone $\frac{3}{4}$ -Inch. The prepared subgrade shall be proofrolled using a static roller to visually confirm the prepared subgrade is firm and stable. The exposed subgrade shall be free of ponded water so that bedding material placement and compaction can be completed in the dry.

The proposed structure shall be bedded on a 2-foot thick, geotextile wrapped, geogrid reinforced, crushed stone mat (Underdrain Backfill Material, Type C; Pay Item 203.55). The Reinforcement Geotextile shall meet the requirements of MaineDOT Standard Specification 722.01. The soils at the bedding elevation shall be excavated using a smooth-edged backhoe bucket to limit disturbance. Any disturbed soils at the bedding elevation resulting from excavation activities shall be removed by hand prior to placement of the geotextile wrapped, geogrid reinforced, crushed stone mat. All subgrade surfaces should be protected from construction traffic in order to limit disturbance. Groundwater and surface water levels shall be depressed sufficiently to allow work in the dry.

The soil backfill shall consist of Granular Borrow (703.19) with a maximum particle size of 4 inches. The Granular Borrow backfill shall be placed in lifts of 6 to 8 inches loose measure and compacted to the manufacturer's specifications or, in the absence of manufacturer's specifications, to at least 92 percent of the AASHTO T-180 maximum dry density. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

Settlement – In order to design an existing driveway within the project limits to standard, the grade of the roadway will be raised approximately seven (7) inches. Due to the presence of soft, compressible soils underlying the site, the raise in grade will result in differential settlement between the alignment of the proposed culvert and the remainder of the roadway where the grade is being raised. The proposed Option III culvert pipe is larger than the existing culvert, limiting the net loading of the site soils at that location in relation to the adjacent roadway.

Evaluation of the potential settlement due to raising the grade of the roadway resulted in approximately 0.5 inches of settlement along the proposed culvert alignment and approximately 2.4 inches of settlement along the rest of the roadway. Due to the cohesive nature of the soils at the site, this settlement will occur over a long period of time (years) and will require attention from MaineDOT maintenance crews.

Scour and Riprap – Both the inlet and outlet of the Option III culvert pipe shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. Slopes shall be no steeper than 2H:1V. No specific scour protection recommendations are needed other than armoring with riprap. The riprap on the slopes shall be underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03 that is underlain by a 1-foot layer of protective

aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19). The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

Construction Considerations – Construction activities will include construction of cofferdams and earth support systems to control stream flow during construction. Construction activities will also include common earth excavation. Construction of the proposed Option III culvert pipe will require deep soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is likely that the use of complex (four-sided) braced excavations with dewatering will be necessary due to the depth of the excavation. If this is the case, adequate embedment into firm soils underlying the native clayey silt will be necessary to allow for the excavation and maintenance of a stable excavation bottom. All earth support systems shall be designed by a Professional Engineer licensed in the State of Maine. Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill (MaineDOT 703.19) or Crushed Stone ¾-Inch (MaineDOT 703.13). All subgrade surfaces shall be proofrolled using a static roller to provide a firm and stable surface and protected from any unnecessary construction equipment or traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted Granular Borrow for Underwater Backfill (703.19) or Crushed Stone ¾-Inch (703.13).

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water as needed to maintain a stable excavation and allow work in the dry.

Using the excavated native soils as backfill around the culvert shall not be permitted. The native soils may only be used as Common Borrow in accordance with MaineDOT Standard Specifications 203 and 703.

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

CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed replacement of an existing culvert (XC-123152) under Route 106 in Livermore Falls, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

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

the changes in design. These analyses and recommendations are based in part upon a limited subsurface investigation at discrete exploratory location completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

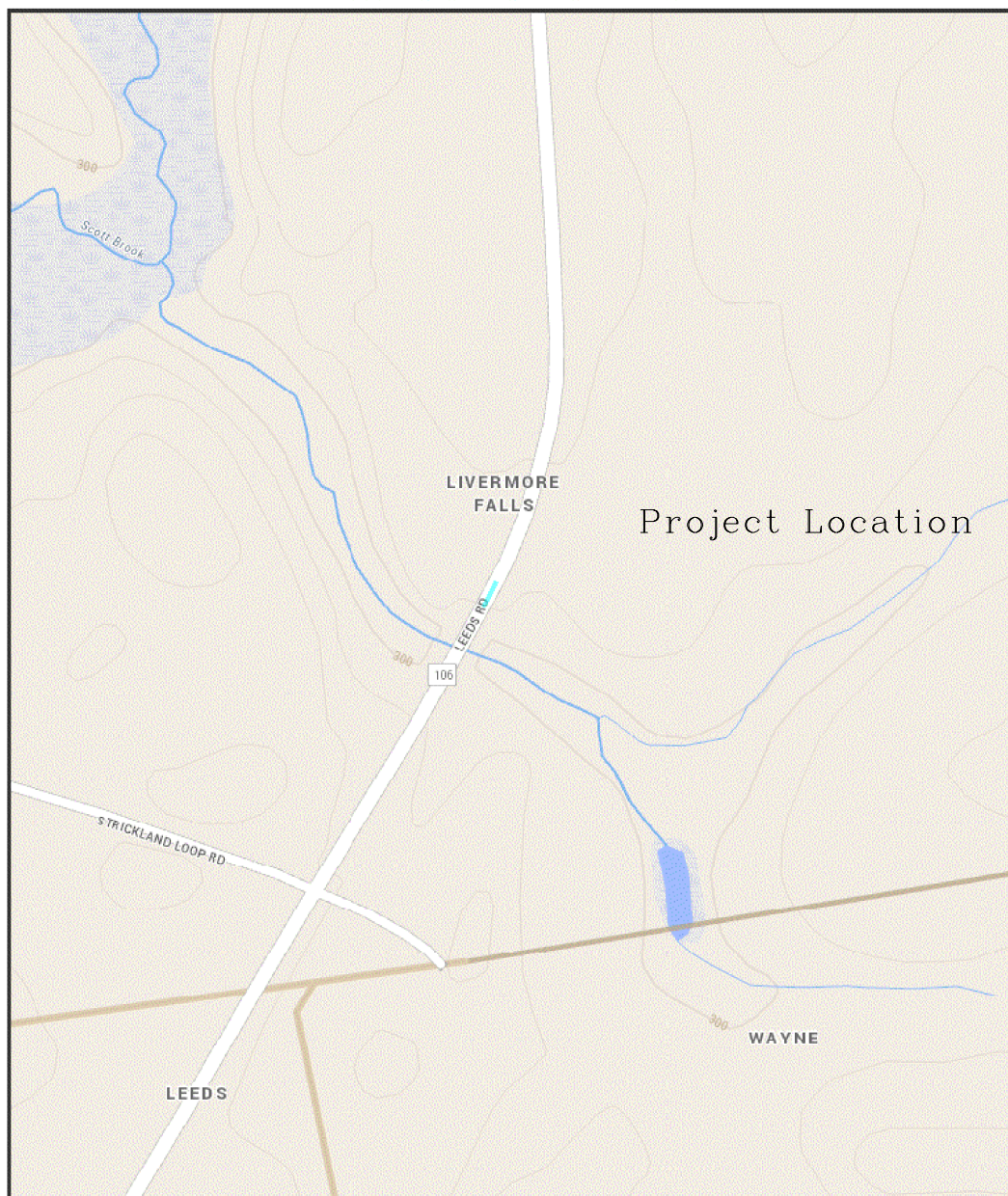
It is recommended that a Geotechnical engineer be provided the opportunity for a review of the design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.

Attachments:

Location Map
Boring Location Plan & Interpretive Subsurface Profile Sheet
Key to Soil and Rock Descriptions and Terms
Boring Logs
Laboratory Testing Summary Sheet
Grain Size Distribution Curve Sheet
Atterberg Limits Plots
Calculations



LIVERMORE FALLS



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

0.055 Miles
1 inch = 0.06 miles

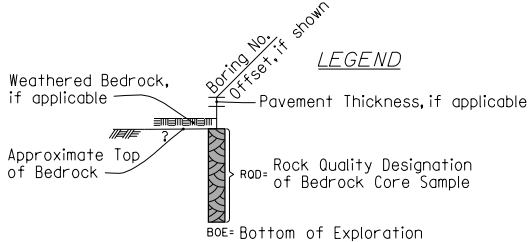
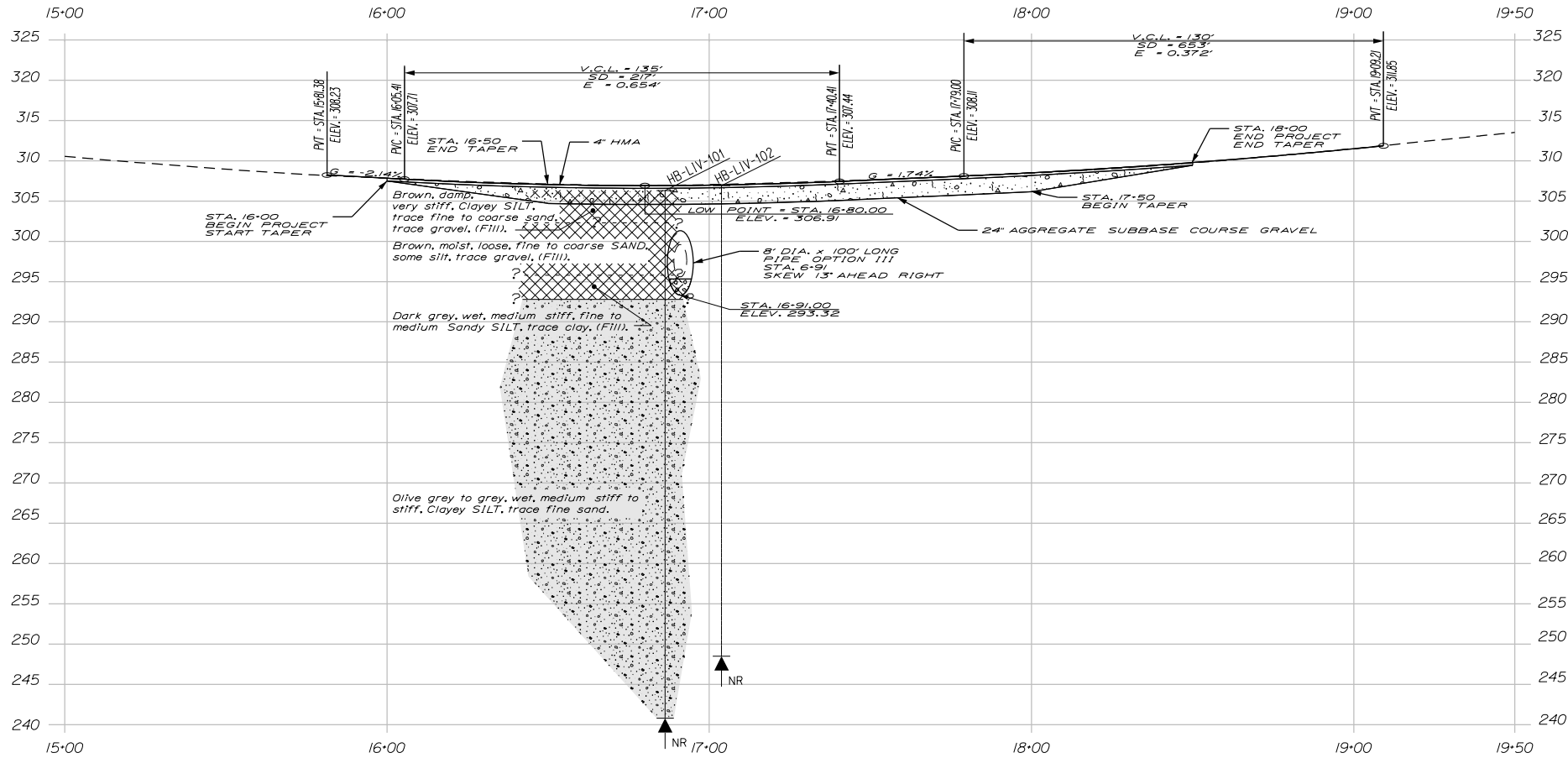
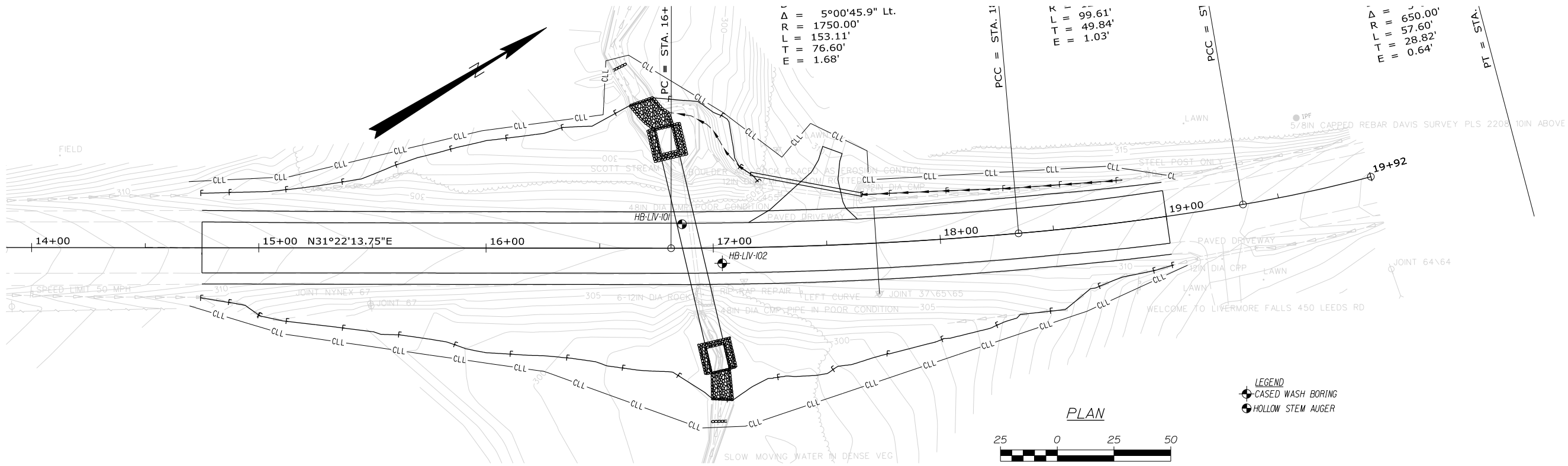
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SHEET NUMBER 1 OF 2	LIVERMORE FALLS ROUTE 106 ANDROSCOGGIN COUNTY	STATE OF MAINE DEPARTMENT OF TRANSPORTATION	
	LOCATION MAP	023133.00	
		WIN WIN 23133.00 HIGHWAY PLANS	

Date: 11/1/2018

Username: cody.a.russell

File: ... \GEO\TECH\N\STA\006_BLP&SP1.dgn Division: GEOTECH



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

STATE OF MAINE	WR33783	WIN	HIGHWAY PLANS
DEPARTMENT OF TRANSPORTATION		23133.00	

DATE	SIGNATURE	P.E. NUMBER	DATE
MAR 2018	T. WHITE		
DESIGN-REVIEWED	L. KANDKO		
DESIGN-DETAILED	C. RUSSELL		
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

LIVERMORE FALLS	ROUTE 106
BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE	

SHEET NUMBER	2
OF 2	

UNIFIED SOIL CLASSIFICATION SYSTEM					MODIFIED BURMISTER SYSTEM			
MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES				
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Descriptive Term		Portion of Total (%)	
		(little or no fines)	GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.	trace	0 - 10		
					little	11 - 20		
					some	21 - 35		
					adjective (e.g. sandy, clayey)	36 - 50		
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	TERMS DESCRIBING DENSITY/CONSISTENCY			
		GC	Clayey gravels, gravel-sand-clay mixtures.					
		CLEAN SANDS	SW	Well-graded sands, gravelly sands, little or no fines	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).			
		(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	Density of Cohesionless Soils			
SC	Clayey sands, sand-clay mixtures.		Standard Penetration Resistance N-Value (blows per foot)					
								Very loose
				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 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.	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.				
		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.	Approximate Undrained Shear Strength (psf)				
								Field Guidelines
		SILTS AND CLAYS (liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Consistency of Cohesive soils			
	CH		Inorganic clays of high plasticity, fat clays.	SPT N-Value (blows per foot)				
	OH		Organic clays of medium to high plasticity, organic silts.					WOP, WOR, WOP, <2
				2 - 4				
								5 - 8
			9 - 15					
		16 - 30						
						>30		
		over 4000						
						0 - 250		
		250 - 500						
						500 - 1000		
		1000 - 2000						
						2000 - 4000		
		over 4000						
						Fist easily penetrates		
		Thumb easily penetrates						
						Thumb penetrates with moderate effort		
		Indented by thumb with great effort						
						Indented by thumbnail		
		Indented by thumbnail with difficulty						
						Rock Quality Designation (RQD):		
		RQD (%) = sum of the lengths of intact pieces of core* > 4 inches / length of core advance						
						*Minimum NQ rock core (1.88 in. OD of core)		
		Correlation of RQD to Rock Mass Quality						
						Rock Mass Quality		
		Very Poor						
						Poor		
		Fair						
						Good		
		Excellent						
						Desired Rock Observations (in this order, if applicable):		
		Color (Munsell color chart)						
						Texture (aphanitic, fine-grained, etc.)		
		Rock Type (granite, schist, sandstone, etc.)						
						Hardness (very hard, hard, mod. hard, etc.)		
		Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)						
						Geologic discontinuities/jointing:		
		-dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)						
						-spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)		
		-tightness (tight, open, or healed)						
						-infilling (grain size, color, etc.)		
		Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)						
						RQD and correlation to rock mass quality (very poor, poor, etc.)		
		ref: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A						
						Recovery (inch/inch and percentage)		
		Rock Core Rate (X.X ft - Y.Y ft (min:sec))						
						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: Large Culvert Replacement Location: Livermore Falls, Maine Route 106				Boring No.: HB-LIV-101 WIN: 23133.00			
Driller: Northern Test Boring				Elevation (ft.): 306.3				Auger ID/OD: 2.25/6.25"			
Operator: Mike/Jan				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: B. Wilder				Rig Type: Diedrich D-50				Hammer Wt./Fall: 140#/30"			
Date Start/Finish: 2/6/2018; 08:00-11:00				Drilling Method: Hollow Stem Auger				Core Barrel: N/A			
Boring Location: 16+86.3, 10.6 ft Lt.				Casing ID/OD: N/A				Water Level*: None Observed			
Hammer Efficiency Factor: 0.977				Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample Attempt V = Field Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Field Vane Shear Test Attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = Weight of 140lb. Hammer WOR/C = Weight of Rods or Casing WO1P = Weight of One Person S _u = Peak/Remolded Field Vane Undrained Shear Strength (psf) S _u (lab) = Lab Vane Undrained Shear Strength (psf) q _p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw Field SPT N-value Hammer Efficiency Factor = Rig Specific Annual Calibration Value N ₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency N ₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected T _v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0							HSA			Brown, damp, very stiff, Clayey SILT, trace fine to coarse sand, trace gravel, (Fill).	G#303099 A-4, CL WC=29.4%	
	1D	24/24	1.50 - 3.50	17/10/4/5	14	23						
5										Brown, moist, loose, fine to coarse SAND, some silt, trace gravel, (Fill).	G#303100 A-2-4, SM WC=15.1%	
	2D	24/10	5.00 - 7.00	3/3/2/2	5	8						
10										Dark grey, wet, medium stiff, fine to medium Sandy SILT, trace clay, (Fill).	G#303176 A-4, ML WC=31.1%	
	3D	24/13	10.00 - 12.00	2/2/1/2	3	5						
15										Olive grey, wet, stiff, Clayey SILT, trace fine sand.	G#303177 A-4, ML WC=31.6% LL=28 PL=24 PI=4	
	4D	24/20	15.00 - 17.00	4/3/3/4	6	10						
20										Grey, wet, medium stiff, Clayey SILT, trace fine sand.	G#303178 A-4, CL-ML WC=29.8% LL=28 PL=22 PI=6	
	5D	24/24	20.00 - 22.00	1/1/2/2	3	5						
25										(Empty)	(Empty)	

Remarks:
 Auto Hammer #377

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

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

Page 1 of 3

Boring No.: HB-LIV-101

[illegible]

[illegible]

Maine Department of Transportation <u>Soil/Rock Exploration Log</u> <u>US CUSTOMARY UNITS</u>				Project: Large Culvert Replacement Location: Livermore Falls, Maine Route 106				Boring No.: HB-LIV-102 WIN: 23133.00																																																																																																																																																																																																																																																
Drilling Contractor: MaineDOT				Elevation (ft.): 306.9				Auger ID/OD: 5" Solid Stem																																																																																																																																																																																																																																																
Operator: Travis				Datum: NAVD88				Sampler: Standard Split Spoon																																																																																																																																																																																																																																																
Logged By: B. Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140#/30"																																																																																																																																																																																																																																																
Date Start/Finish: 2/27/2018; 08:30-12:00				Drilling Method: Cased Wash Boring				Core Barrel: N/A																																																																																																																																																																																																																																																
Boring Location: 17+03.8, 6.9 ft Rt.				Casing ID/OD: HW-4"				Water Level*: 9.5 ft bgs.																																																																																																																																																																																																																																																
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Page 1 of 3										Boring No.: HB-LIV-102																																																																																																																																																																																																																																														

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Large Culvert Replacement Location: Livermore Falls, Maine Route 106				Boring No.: HB-LIV-102 WIN: 23133.00			
Drilling Contractor: MaineDOT				Elevation (ft.): 306.9				Auger ID/OD: 5" Solid Stem			
Operator: Travis				Datum: NAVD88				Sampler: Standard Split Spoon			
Logged By: B. Wilder				Rig Type: CME 45C				Hammer Wt./Fall: 140#/30"			
Date Start/Finish: 2/27/2018; 08:30-12:00				Drilling Method: Cased Wash Boring				Core Barrel: N/A			
Boring Location: 17+03.8, 6.9 ft Rt.				Casing ID/OD: HW-4"				Water Level*: 9.5 ft bgs.			
Definitions: D = Spilt Spoon Sample S = Sample off Auger Flights B = Bucket Sample off Auger Flights MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MV = Unsuccessful Field Vane Shear Test Attempt V = Field Vane Shear Test, PP= Pocket Penetrometer MU = Unsuccessful Thin Wall Tube Sample 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 1 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-value = Raw Field SPT N-value T_v = Pocket Torvane Shear Strength (psf) WC = Water Content, percent ≈ = Similar or Equal too LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information								Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.	
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-value	Casing Blows	Elevation (ft.)	Graphic Log			
25	V3		25.00 - 25.37	Su=893/246 psf					55x110 mm vane raw torque readings: V3: 20.0/5.5 ft-lbs V4: 21.0-5.0 ft-lbs		
	V4		26.00 - 26.37	Su=937/223 psf							
30									55x110 mm vane raw torque readings: V5: 27.0/5.0 ft-lbs V6: 28.0/6.0 ft-lbs		
	V5		30.00 - 30.37	Su=1205/223 psf							
	V6		31.00 - 31.37	Su=1250/268 psf					55x110 mm vane raw torque readings: V7: 28.5/6.0 ft-lbs V8: 29.0/7.0 ft-lbs		
35	V7		35.00 - 35.37	Su=1272/268 psf					From 35.0-54.0 ft bgs., 400 lbs psi of hydraulic push.		
	V8		36.00 - 36.37	Su=1295/312 psf							
40											
45											
50											
Remarks:											
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.										Page 2 of 3	
* 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.: HB-LIV-102	

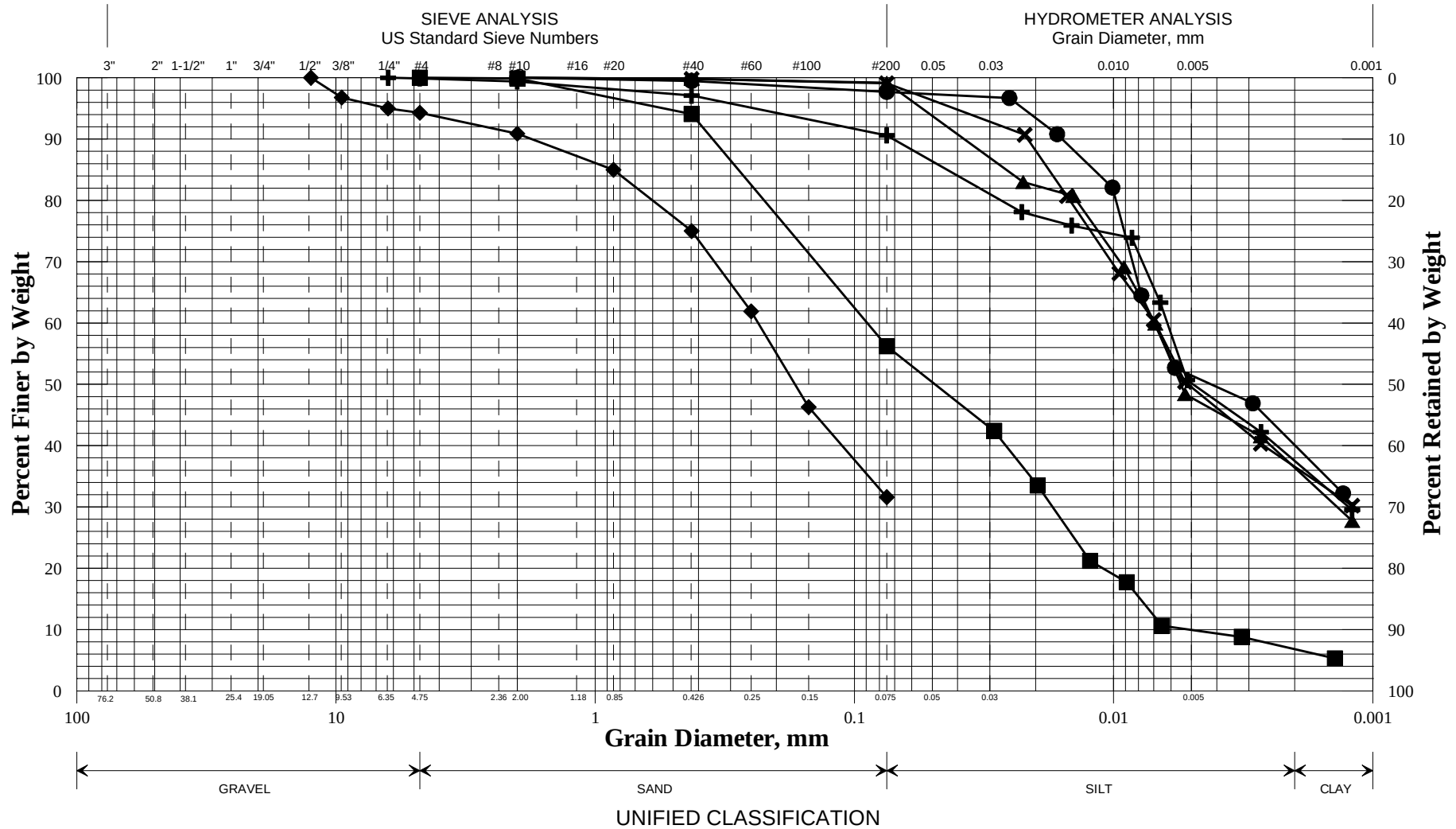
[illegible]

Town(s): Livermore Falls **Work Number:** 23133.00

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

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

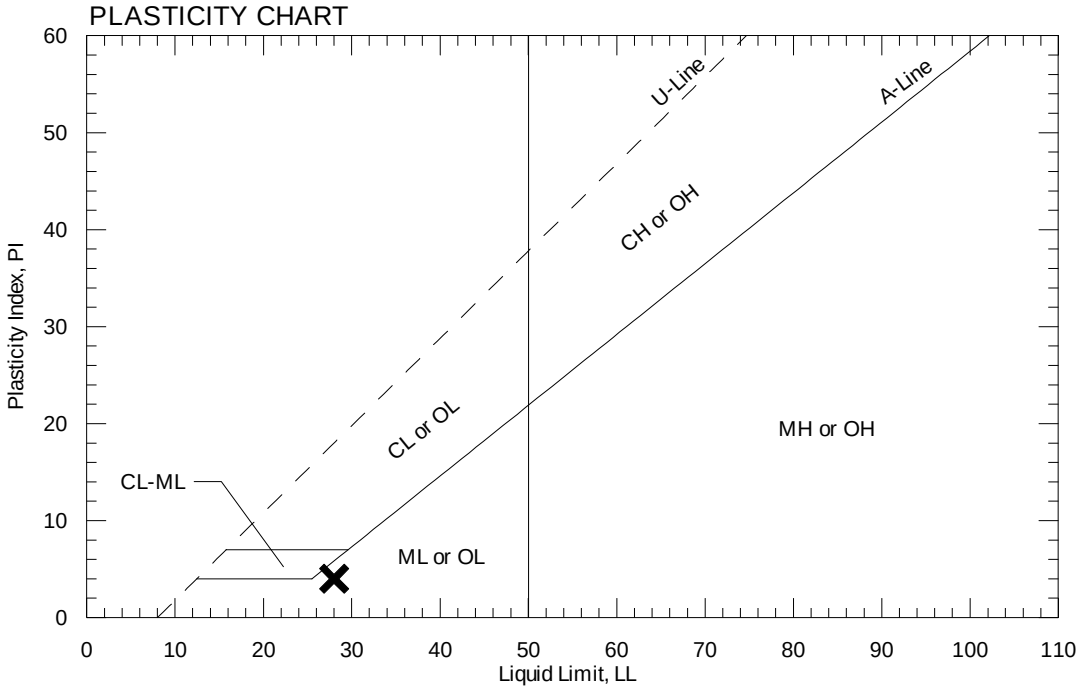
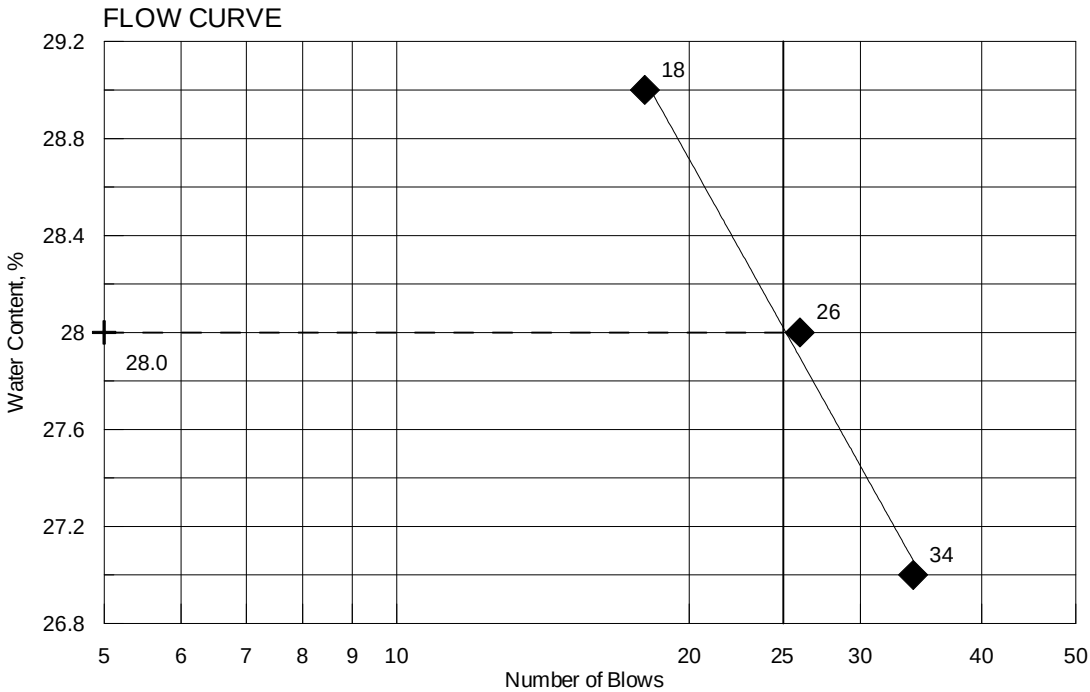
State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



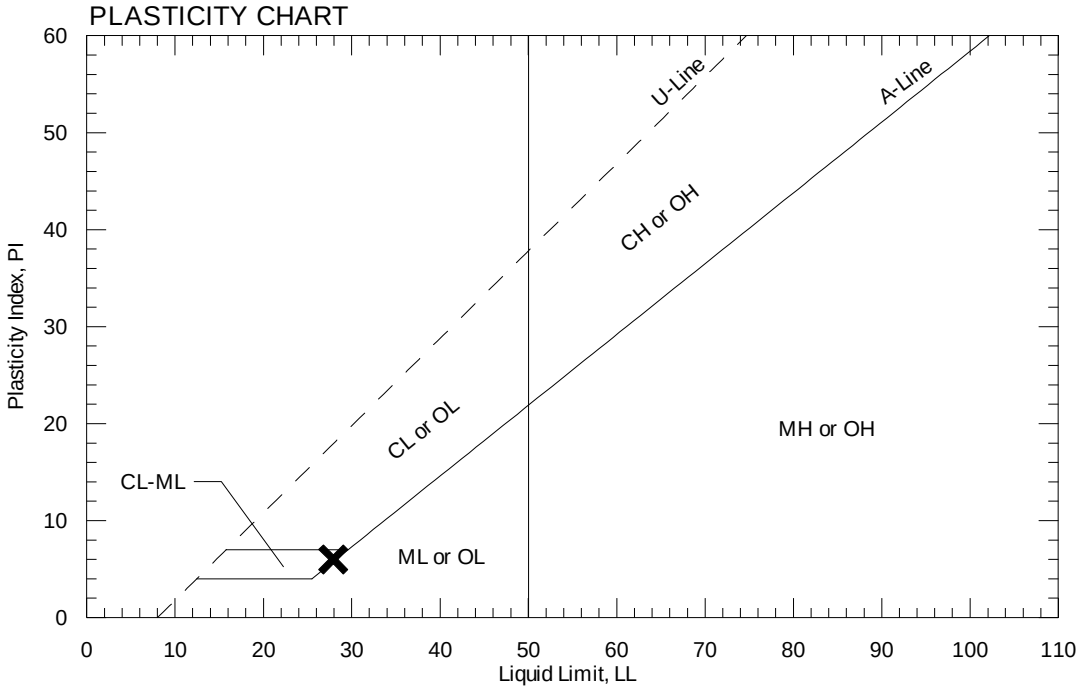
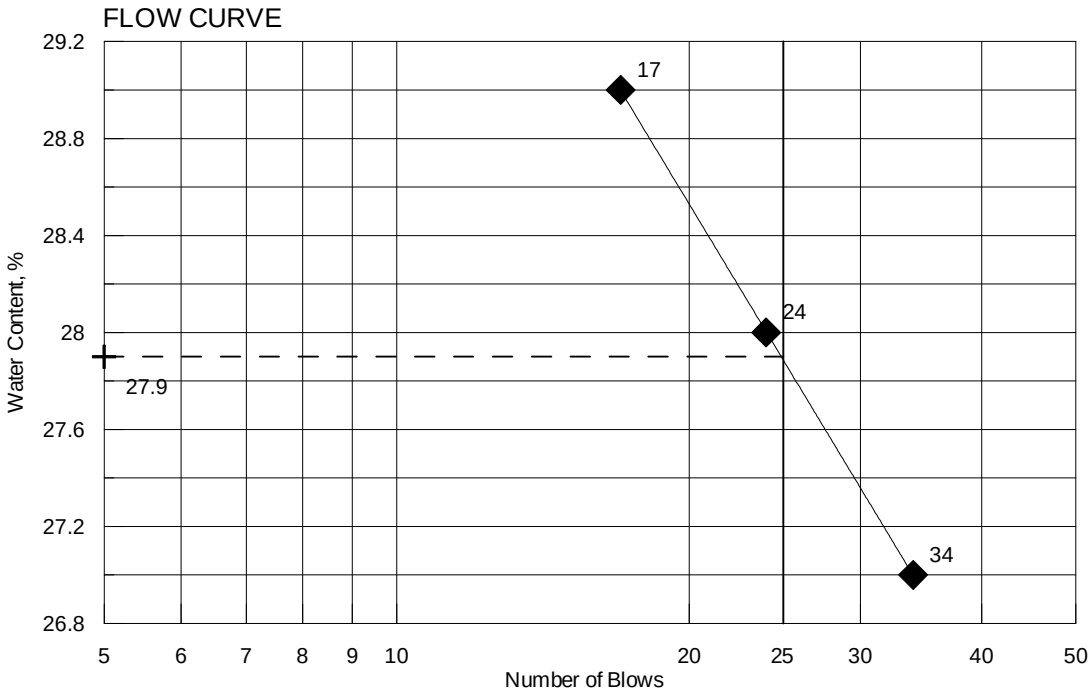
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
+	HB-LIV-101/1D	16+86.3	10.6 LT	1.5-3.5	Clayey SILT, trace sand, trace gravel.	29.4			
◆	HB-LIV-101/2D	16+86.3	10.6 LT	5.0-7.0	SAND, some silt, trace gravel.	15.1			
■	HB-LIV-101/3D	16+86.3	10.6 LT	10.0-12.0	Sandy SILT, trace clay.	31.1			
●	HB-LIV-101/4D	16+86.3	10.6 LT	15.0-17.0	Clayey SILT, trace and.	31.6	28	24	4
▲	HB-LIV-101/5D	16+86.3	10.6 LT	20.0-22.0	Clayey SILT, trace sand.	29.8	28	22	6
×	HB-LIV-101/6D	16+86.3	10.6 LT	25.0-27.0	Clayey SILT, trace sand.	28.8	29	20	9

WIN	
023133.00	
Town	
Livermore Falls	
Reported by/Date	
WHITE, TERRY A	3/16/2018

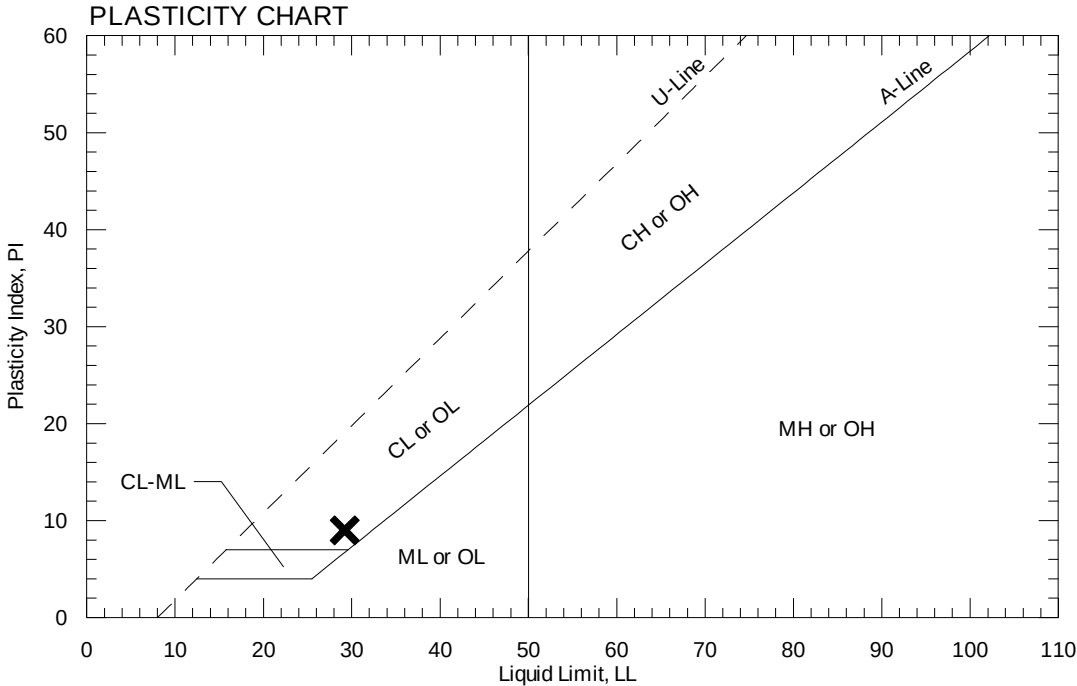
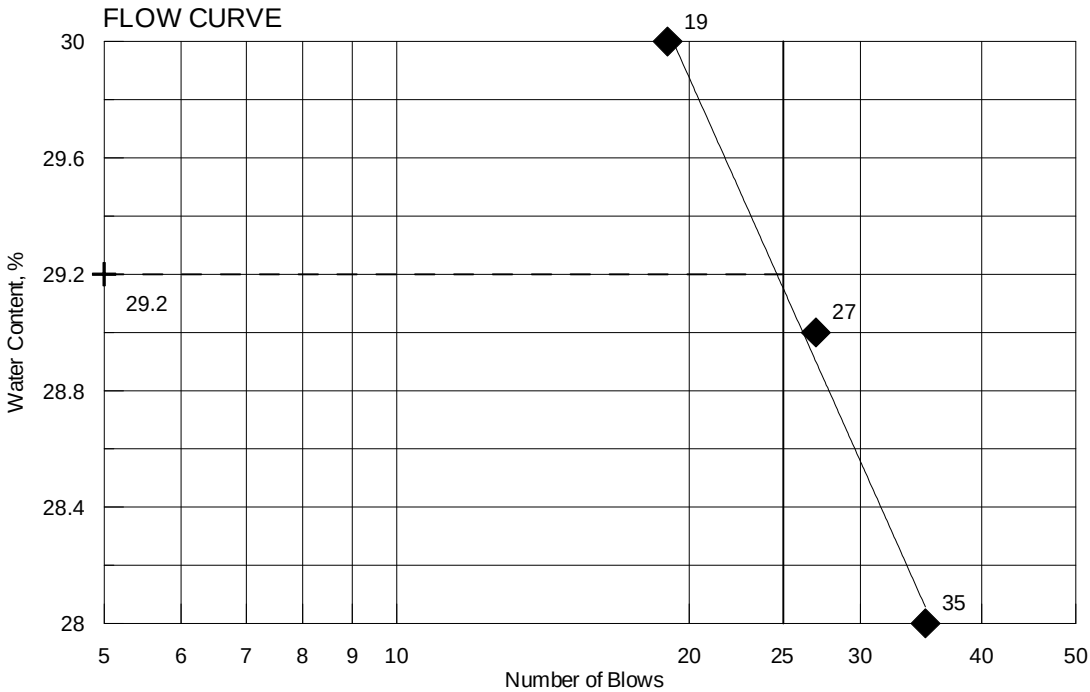
TOWN	Livermore Falls	Reference No.	303177
WIN	023133.00	Water Content, %	31.6
Sampled	2/6/2018	Liquid Limit @ 25 blows (T 89), %	28
Boring No./Sample No.	HB-LIV-101/4D	Plastic Limit (T 90), %	24
Station	16+86.3	Plasticity Index (T 90), %	4
Depth	15.0-17.0	Tested By	BBURR



TOWN	Livermore Falls	Reference No.	303178
WIN	023133.00	Water Content, %	29.8
Sampled	2/6/2018	Liquid Limit @ 25 blows (T 89), %	28
Boring No./Sample No.	HB-LIV-101/5D	Plastic Limit (T 90), %	22
Station	16+86.3	Plasticity Index (T 90), %	6
Depth	20.0-22.0	Tested By	BBURR



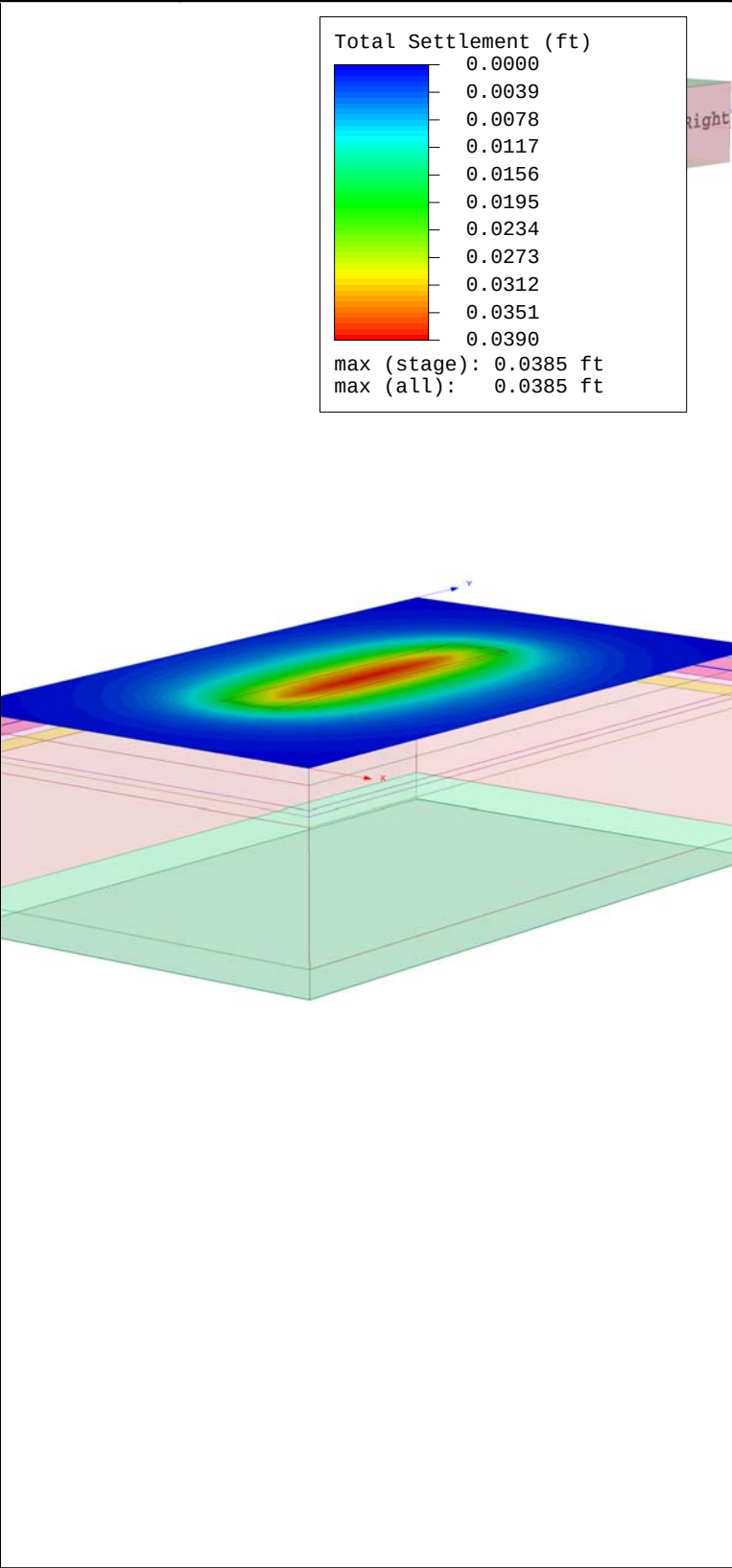
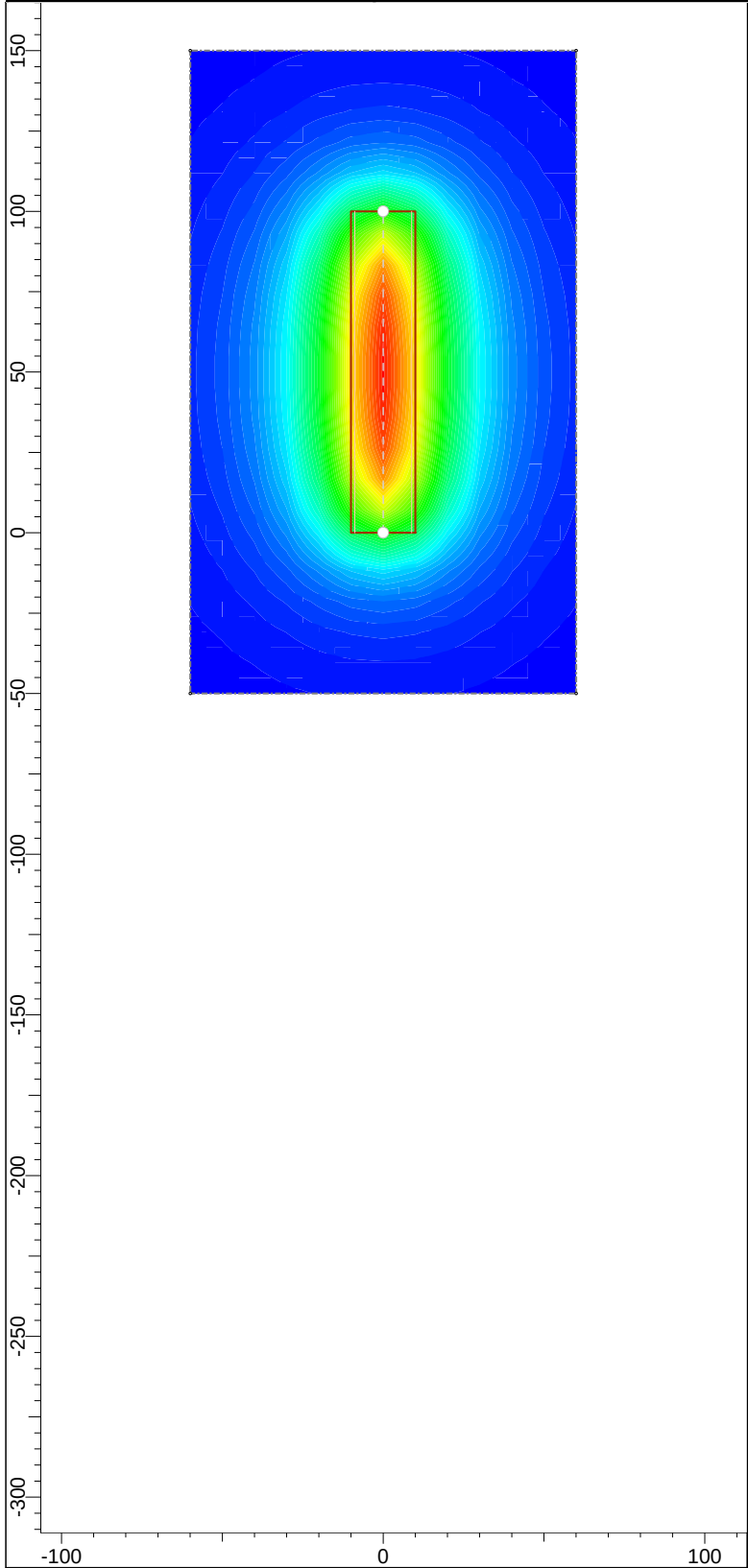
TOWN	Livermore Falls	Reference No.	303179
WIN	023133.00	Water Content, %	28.8
Sampled	2/6/2018	Liquid Limit @ 25 blows (T 89), %	29
Boring No./Sample No.	HB-LIV-101/6D	Plastic Limit (T 90), %	20
Station	16+86.3	Plasticity Index (T 90), %	9
Depth	25.0-27.0	Tested By	BBURR





SETTLE3D 3.020

Project	23133 Livermore Falls		
Analysis Description	Embankment Settlement		
Drawn By	Cody Russell	Company	MaineDOT
Date	6/21/2018, 7:24:11 AM	File Name	Settlement At Proposed Culvert.s3z



Settle3D Analysis Information

23133 Livermore Falls

Project Settings

Document Name	Settlement At Proposed Culvert
Project Title	23133 Livermore Falls
Analysis	Embankment Settlement
Author	Cody Russell
Company	MaineDOT
Date Created	6/21/2018, 7:24:11 AM

Comments

Stiff and Medium Stiff Clayey Silt Soil Properties estimated from 1986 David W. Andrews paper, "A Summary of the Engineering Information on the Presumpcot Formation Silty Clay"

Other Soil Properties estimated from typical values provided by software

Stress Computation Method Boussinesq

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.809529 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [ft]	0	0.0385073
Consolidation Settlement [ft]	0	0.0296338
Immediate Settlement [ft]	0	0.00887346
Loading Stress [ksf]	0	0.0787422
Effective Stress [ksf]	0	3.92046
Total Stress [ksf]	0	8.00766
Total Strain	0	0.0026663
Pore Water Pressure [ksf]	0	4.0872
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.034375	3.91422
Over-consolidation Ratio	1	1
Void Ratio	0	1.15
Hydroconsolidation Settlement [ft]	0	0
Undrained Shear Strength	0	0.782626

Embankments

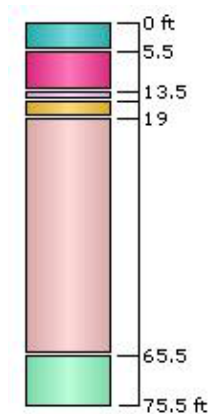
1. Embankment

Center Line (0, 0) to (0, 100)
 Number of Layers 1
 Near End Angle 90 degrees
 Far End Angle 90 degrees
 Base Width 20

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1	0	26.6	0.583	0.135	26.6	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Granular Fill	5.5	0
2	Culvert	8	5.5
3	Stone Bedding	2	13.5
4	Stiff Clayey Silt	3.5	15.5
5	Medium Stiff Clayey Silt	46.5	19
6	Silty Sand	10	65.5



Soil Properties

Property	Stiff Clayey Silt	Medium Stiff Clayey Silt	Silty Sand	Culvert	Granular Fill	Stone Bedding
Color						
Unit Weight [kips/ft ³]	0.097	0.084	0.103	0.02	0.125	0.131
Saturated Unit Weight [kips/ft ³]	0.118	0.112	0.125	0.02	0.135	0.14
Immediate Settlement	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Es [ksf]	281	146	292.396	1100	1000	2819.53
Esur [ksf]	281	146	208.9	1100	1000	2819.53
Primary Consolidation	Enabled	Enabled	Disabled	Disabled	Disabled	Disabled
Material Type	Non-Linear	Non-Linear				
Cc	0.21	0.18				
Cr	0.02	0.018				
e0	1.15	1.15				
OCR	1	1	1	1	1	1
Undrained Su A [kips/ft ²]	0	0	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1	1	1

Groundwater

Groundwater method Piezometric Lines
 Water Unit Weight 0.0624 kips/ft³

Piezometric Line Entities

ID	Depth (ft)
1	10 ft

Field Point Grid

Number of points 286
 Expansion Factor 2

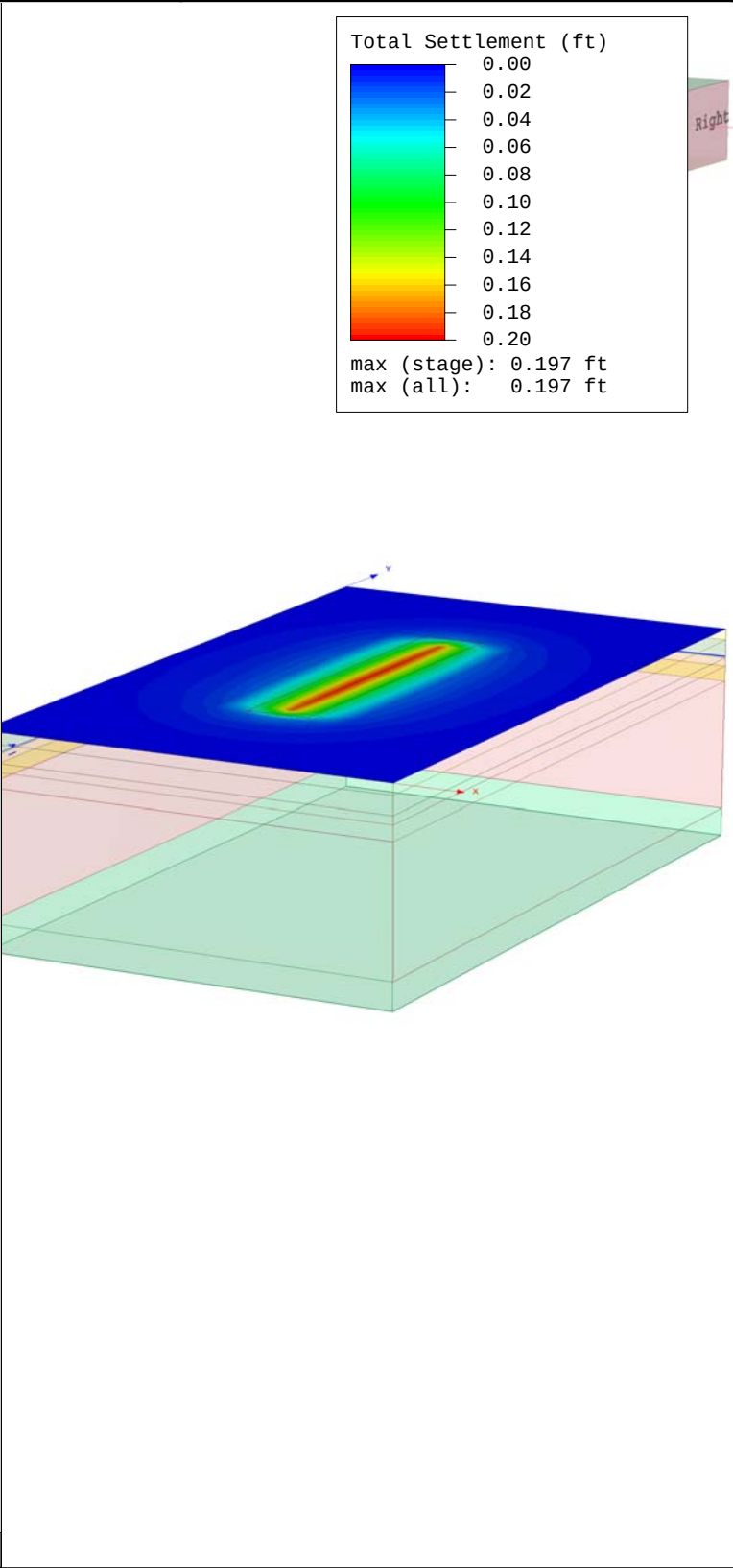
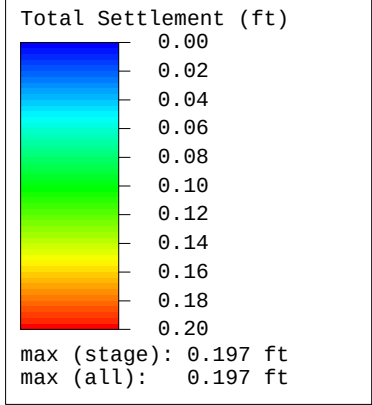
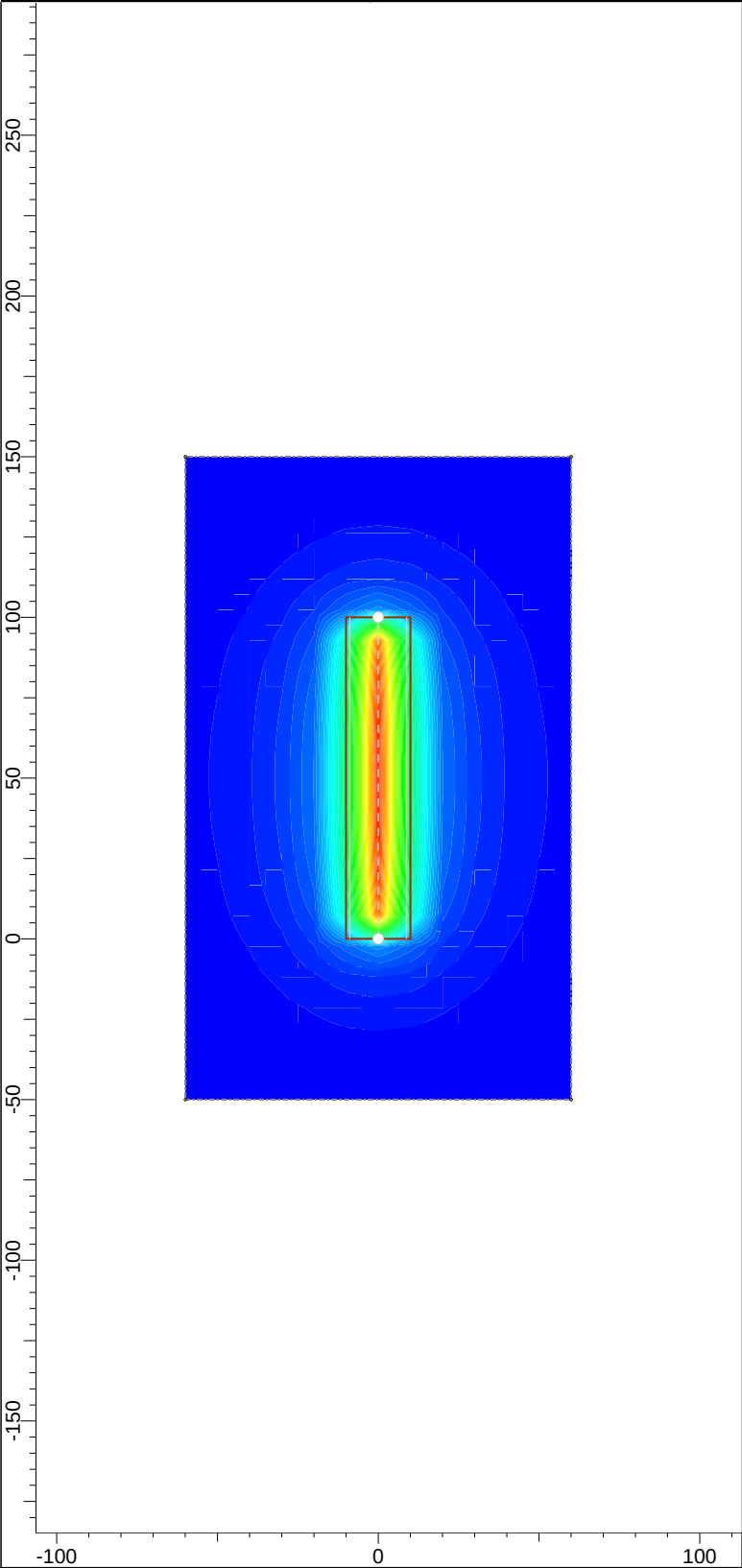
Grid Coordinates

X [ft]	Y [ft]
60	150
60	-50
-60	-50
-60	150



Project	23133 Livermore Falls		
Analysis Description	Embankment Settlement		
Drawn By	Cody Russell	Company	MaineDOT
Date	6/21/2018, 7:24:11 AM	File Name	Settlement Near Proposed Culvert.s3z

SETTLE3D 3.020



Settle3D Analysis Information

23133 Livermore Falls

Project Settings

Document Name	Settlement Near Proposed Culvert
Project Title	23133 Livermore Falls
Analysis	Embankment Settlement
Author	Cody Russell
Company	MaineDOT
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Comments

Stiff and Medium Stiff Clayey Silt Soil Properties estimated from 1986 David W. Andrews paper, "A Summary of the Engineering Information on the Presumpscot Formation Silty Clay"

Other Soil Properties estimated from typical values provided by software

Stress Computation Method Boussinesq

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.805885 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [ft]	0	0.196569
Consolidation Settlement [ft]	0	0.185443
Immediate Settlement [ft]	0	0.0111265
Loading Stress [ksf]	0	0.0787422
Effective Stress [ksf]	0	4.39546
Total Stress [ksf]	0	8.48266
Total Strain	0	0.119515
Pore Water Pressure [ksf]	0	4.0872
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0244	4.39022
Over-consolidation Ratio	1	1
Void Ratio	0	1.15
Hydroconsolidation Settlement [ft]	0	0
Undrained Shear Strength	0	0.877626

Embankments

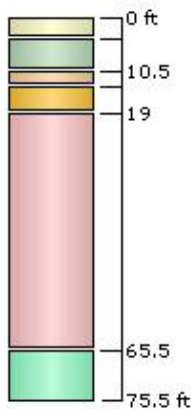
1. Embankment

Center Line (0, 0) to (0, 100)
 Number of Layers 1
 Near End Angle 90 degrees
 Far End Angle 90 degrees
 Base Width 20

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1	0	26.6	0.583	0.135	26.6	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Very Stiff Clayey Silt (fill)	4	0
2	Loose Sand (fill)	6.5	4
3	Medium Stiff Sandy Silt (fill)	3	10.5
4	Stiff Clayey Silt	5.5	13.5
5	Medium Stiff Clayey Silt	46.5	19
6	Silty Sand	10	65.5



Soil Properties

Property	Very Stiff Clayey Silt (fill)	Loose Sand (fill)	Medium Stiff Sandy Silt (fill)	Stiff Clayey Silt	Medium Stiff Clayey Silt	Silty Sand
Color						
Unit Weight [kips/ft ³]	0.122	0.091	0.103	0.097	0.084	0.103
Saturated Unit Weight [kips/ft ³]	0.137	0.115	0.125	0.118	0.112	0.115
Immediate Settlement	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Es [ksf]	290	397	290	281	146	292.396
Esur [ksf]	290	397	290	281	146	208.9
Primary Consolidation	Enabled	Disabled	Disabled	Enabled	Enabled	Disabled
Material Type	Non-Linear			Non-Linear	Non-Linear	
Cc	0.4			0.37	0.33	
Cr	0.04			0.037	0.033	
e0	1.1			1.15	1.15	
OCR	1	1	1	1	1	1
Undrained Su A [kips/ft ²]	0	0	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft ³
Generating excess pore pressure above water table	

Piezometric Line Entities

ID	Depth (ft)
1	10 ft

Field Point Grid

Number of points 286
Expansion Factor 2

Grid Coordinates

X [ft]	Y [ft]
60	150
60	-50
-60	-50
-60	150

Time Rate of Settlement:

Determine the time for 90% consolidation for primary settlement

Reference: *FHWA Soils and Foundation Reference Manual - Volume 1 page 7-30*

Thickness of the silt/clay layer = $H_{\text{siltclay}} := 52 \cdot \text{ft}$

Assume double drainage due to presence of sand layers above and below the clay layer.

$H_{\text{scv}} := 26 \cdot \text{ft}$

Time factor from Table on page 7-32 $T_v := 0.848$
At 90% primary consolidation

Assumed Coefficient of consolidation from *A Summary of Geotechnical Engineering Information on the Presumpscot Formation Silty Clay*, David W. Andrews, 1986:

$$C_v := 0.1 \frac{\text{ft}^2}{\text{day}}$$

Time rate of settlement to achieve 90% Primary Consolidation

$$t_{90} := \frac{T_v \cdot H_{\text{scv}}^2}{C_v} \quad t_{90} = 5732.48 \cdot \text{day} \quad \text{year} := 365 \cdot \text{day}$$
$$t_{90} = 15.705 \cdot \text{year}$$