

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

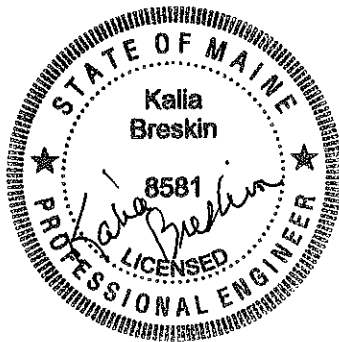
GEOTECHNICAL DESIGN REPORT

For the Replacement of:

**EXETER ROAD STRUT
GARLAND, MAINE**

Prepared by:

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Senior Geotechnical Engineer**



Penobscot County

WIN 19334.00

Soils Report No. 2012-120

April 20, 2012

GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of a box culvert which carries Allen Stream under the Exeter Road, 0.23 miles north of the Exeter town line. Exeter Road is a Priority 5 Highway Corridor. The proposed replacement structure will be a 6-foot high by 10-foot wide prefabricated concrete box with two feet of soil placed in the bottom. The structure will be 52 feet wide with 11-foot lanes and 5-feet from edge of travelled way to the face of guardrail. The following design and construction sections are discussed in detail in the attached report:

Box Culvert Design and Construction – The concrete box culvert will be supplier-designed as specified in Special Provision 534, Precast Structural Concrete Arches, Box Culverts, by either the LFD or LRFD method. The loading specified for the structure shall be MS-22.5 (HS-25) for LFD method or modified HL-93 Strength I for the LRFD method, in which the HS-20 design truck wheel loads are increased by a factor of 1.25.

The culvert will be constructed in general conformance with the MaineDOT Bridge Design Guide (BDG) Section 8, Buried Structures, and Special Provision 534. A copy of the Special Provision is attached to this report. The designer may assume Soil Type 4 (BDG Table 3-3) for backfill soil properties.

The box culvert will be bedded on a two-foot thick layer of $\frac{3}{4}$ inch crushed stone wrapped in a geotextile fabric. The culvert soil envelope backfill shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill with a maximum particle size of 4 inches. Backfill shall be placed in lifts 6 to 8 inches thick and compacted to manufacturer's specifications. In no case shall the backfill soil be compacted less than 92% of AASHTO T-180 maximum dry density.

Culvert Headwalls – Soil slopes steeper than 2h:1v will be built above the box culvert. We recommend the use of integral concrete headwalls to prevent gravel and fill soils from sliding or eroding from these slopes into the stream. These headwalls need not be larger than a nominal 1-foot by 1-foot dimension.

Box Culvert Bearing Resistance – For this project, the strength limit state controls bearing resistance. A factored bearing resistance of 3.3 ksf shall be used for this project.

Scour and Riprap – Inlet and outlet seepage cutoff walls below the culvert inverts should be provided for scour protection. These cutoff walls should extend below the anticipated depth of scour, or to a depth of at least two foot below the structure. Sideslopes should be armored with a 3-foot thick layer of plain riprap adjacent to the culvert openings. The toe of the riprap section shall be constructed 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material conforming to item number 703.19 of the Standard Specification and Class "1" Erosion Control Geotextile.

Seismic Design Considerations – Seismic analysis is not required for single span bridges regardless of seismic zone. However, superstructure connections and minimum support lengths should be designed in accordance with LRFD requirements.

Construction Considerations – A stratum of loose sandy silt soils was encountered from a depth of 3.8 feet to 9 feet below existing grade. These appear to be fill material from construction of the existing culvert, and should be assumed to be OSHA Class C soils for determination of excavation stability.

Power Auger refusals encountered during the subsurface investigation may have been either large boulders or bedrock. No rock cores were taken. Mapped soils data by Maine Geologic Survey and by the National Resources Conservation Service do not indicate shallow bedrock at this site. If large boulders are encountered within the construction limits for this project, the boulders must be removed and the excavation backfilled with granular borrow or soils from the surrounding excavation, similar to soils at the same depth within the excavation.

Attachments

Sheets

Sheet 1 - Location Map

Sheet 2 - Boring Location Plan and Interpretive Subsurface Profile

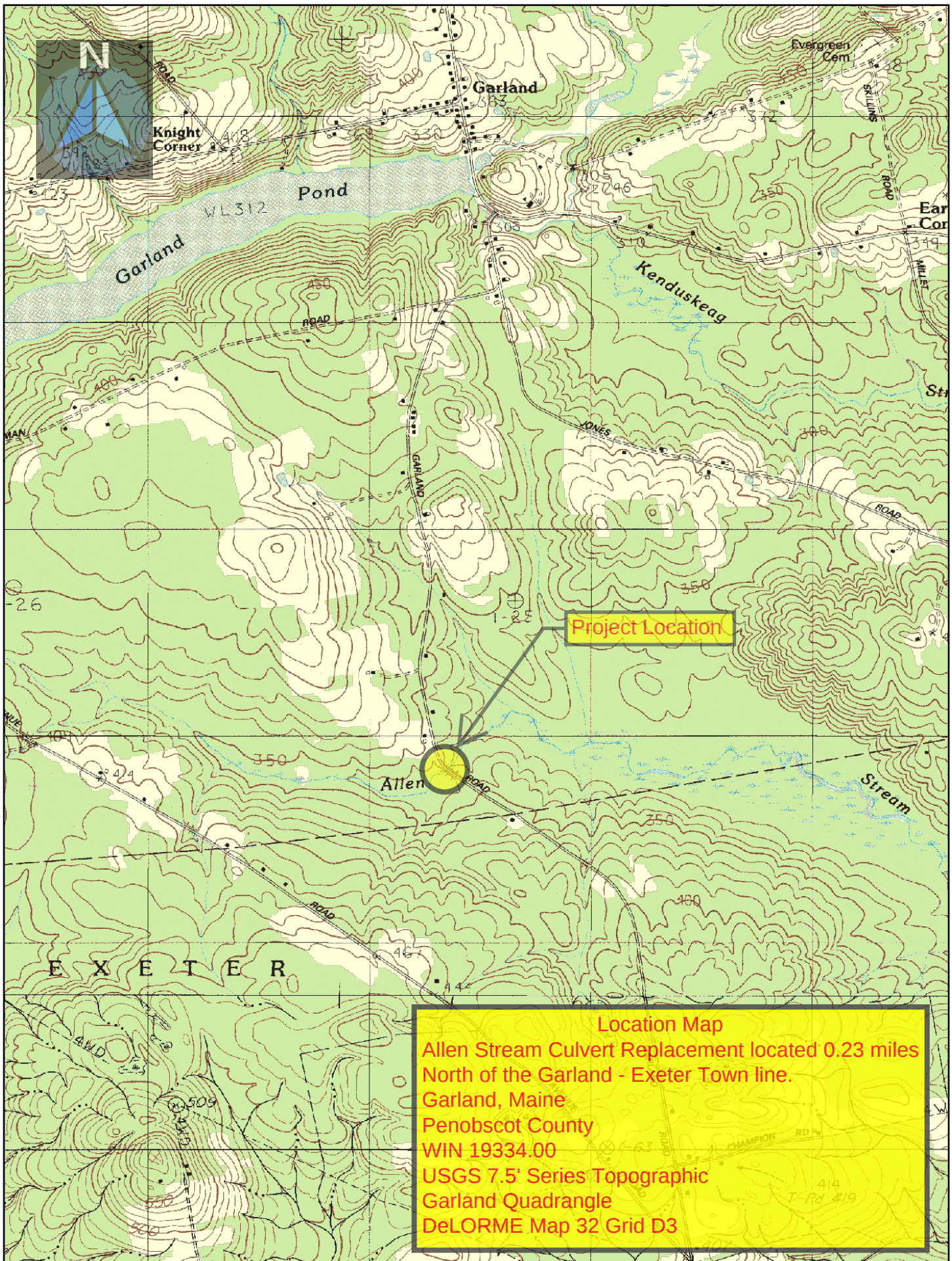
Sheet 3 – Boring Logs

Appendices

Appendix A - Boring Logs

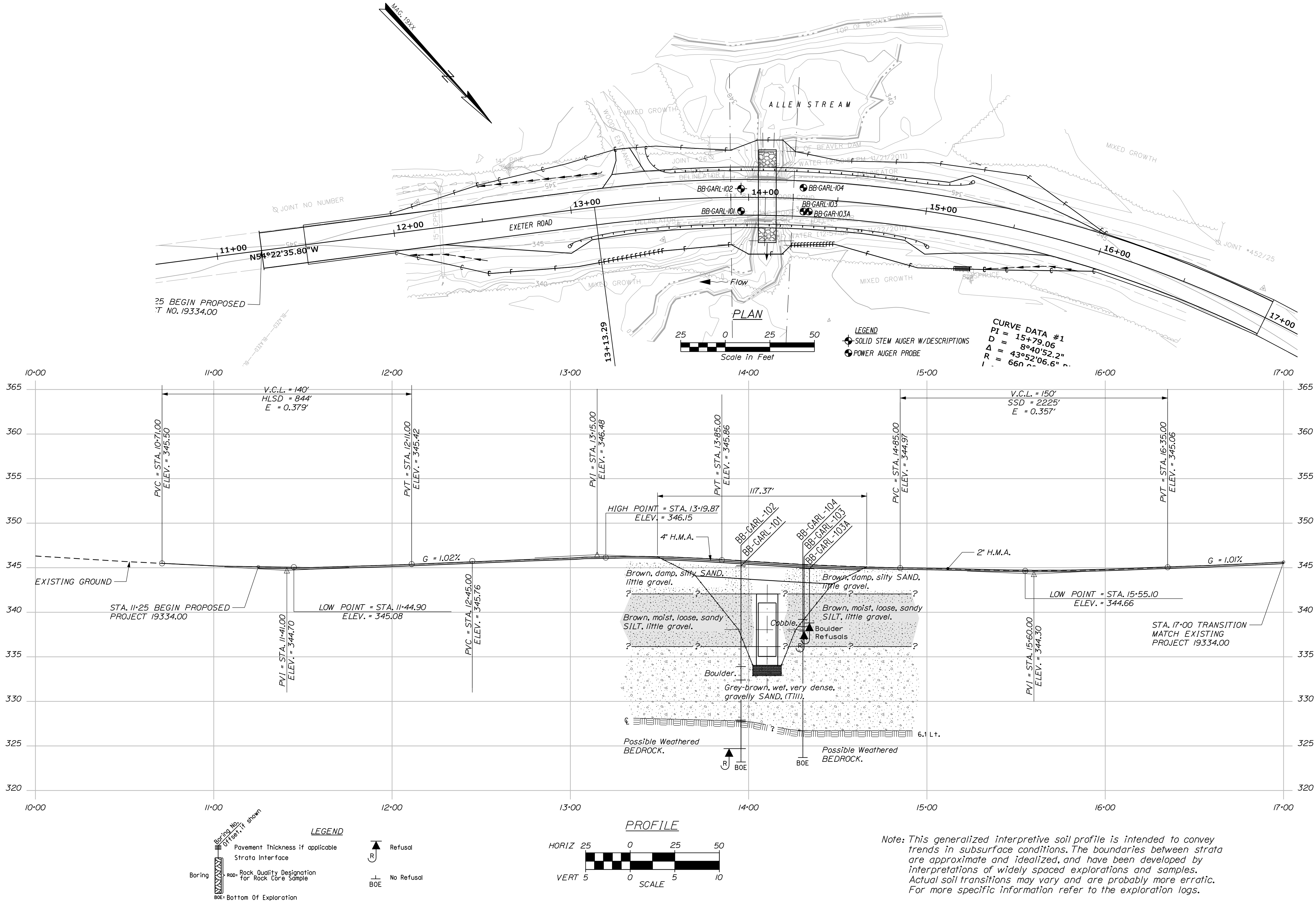
Appendix B - Laboratory Data

Appendix C - Calculations



Map Scale 1:24000

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



STATE OF MAINE		DEPARTMENT OF TRANSPORTATION		19334.00	
CULVERT REPLACEMENT		PENOBSCOT COUNTY		BRIDGE NO. N/A	
GARLAND		ALLEN STREAM		WIN	
BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE		SHEET NUMBER		19334.00	
		2		HIGHWAY PLANS	
		OF 3			
PROJECT MANAGER		DESIGN-DETAILED	CHECKED-REVIEWED	DESIGN-DETAILED	REVISIONS 1
S. DAVIS		K. BRESKIN	T. WHITE		REVISIONS 2
DATE		APR 2012			REVISIONS 3
BY					REVISIONS 4
SIGNATURE					FIELD CHANGES
P.E. NUMBER					
DATE					

Maine Department of Transportation				Project/Ester Road		Boring No.: BB-CARL-101						
Soil/Rock Exploration Log US CUSTOMARY UNITS				Location Gardano, Maine		WIN: 19334.00						
Driller: MainDOT		Elevation (ft.):	345.2	Auger ID/GDI:		5" Dia.						
Operator: Giguere/Oiles		Datum:	NAVD88	Sampler:		n/a						
Logged By: B. Wilder		Rig Type:	CME 45C	Hammer Wt./Fall:		n/a						
Date Start/Finish: 2/22/12-2/22/12		Drilling Method:	Solid Stem Auger	Core Barrels:		N/A						
Boring Location: 13+95.7, 7.7 ft Br.		Casing ID/GDI:	N/A	Water Level#:		None Observed						
Hammer Efficiency Factor: 0.60		Hammer Type:	American ☐ Hydraulic ☐	Rope & Cathode ☐								
Definitions P = Rock Core Sample S = Split Spoon Sample M = Unsuccessful Split Spoon Sample attempt W = Thin Wall Tube Sample U = Unsuccessful Thin Wall Tube Sample attempt F = Insitu Vane Shear Test H = Unsuccessful Insitu Vane Shear Test attempt		Sample Information R = Rock Core Sample SA = Solid Stem Auger HA = Hollow Stem Auger EC = Electric Cone WD = Weight of Rods - Hammer MSA = Result of MSA section		% = Insitu Tests Note Shear Strength Test TS = Pocket Torque Shear Strength Test UC = Unclassified Compressive Strength Test Unreported = Raw Data SPT Results Hammer Efficiency Factor = Annual Calibration Value Ng = SPT Measurements corrected for hammer efficiency Na = Hammer Efficiency Factor/RODM-Unrecorded		Surveys = Lab Vane Shear Strength Test WC = Water Content Percent LL = Liquid Limit PL = Plasticity Limit PI = Plasticity Index No = Grain Size Analysis C = Consolidation Test						
Boring (ft.)	Sample No.	Pen./Rec. (in)	Sample Depth (ft.)	Notes / S/L	Strength (tsf) or MOD (%)	Humor/unconnected	Ng	Casing Depth	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ ASTM and Unified Class
0												
5												
-10												
-15												
-20												
-25												
-30												
Remarks												
Stratification lines represent approximate boundaries between soil types transitions may be gradual.												
* asterisk level readings were used as final and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present in the file measurements were made.												
Page 1 of 1											Boring No.: BB-CARL-101	

[illegible]

Maine Department of Transportation Soil/Borehole Exploration Log U.S. CUSTOMARY UNITS				Project: Exeter Road Location: Garland, Maine		Boring No.: <u>BB-GARL-103A</u> WIN: <u>19334.00</u>	
Drillers: <u>MairnDOT</u>		Elevation (ft.): <u>344.9</u>		Auger ID/OD: <u>5" Dia.</u>			
Operators: <u>Ciudad/Diles</u>		Datum: <u>NAVD83</u>		Sampler: <u>n/a</u>			
Loaded By: <u>B. Walker</u>		Rig Type: <u>CME 452</u>		Hammer Ret./Fall: <u>n/a</u>			
Date Start/Finish: <u>2/22/12-2/22/12</u>		Drilling Method: <u>Solid Stem Auger</u>		Core Barrel: <u>N/A</u>			
Boring Location: <u>14+34.1, 7.1 ft Rr.</u>		Casing ID/OD: <u>N/A</u>		Water Level#: <u>None Observed</u>			
Hammer Efficiency Factor: <u>0.60</u>		Hammer Type: ☐ Automatic ☐ Hydraulic ☐ Rope & Cathead ☐					
Definitions: B = Split Spoon Sample SA = unconsolidated Split Spoon Sample attempt M = Moisture T = Thin Wall Tube Sample M = Moisture T = Thin Wall Tube Sample attempt W = Weight W = Weight of soil or casing W = Weight of one section		R = Rock Core Sample SA = Solid Stem Auger M = Moisture T = Thin Wall Tube Sample W = Weight of soil or casing W = Weight of one section		L _p = Instr. First Time Shear Strength Test L _p = Instr. Second Time Shear Strength Test L _p = Instr. Third Time Shear Strength Test L _p = Instr. Fourth Time Shear Strength Test L _p = Instr. Fifth Time Shear Strength Test L _p = Instr. Sixth Time Shear Strength Test L _p = Instr. Seventh Time Shear Strength Test L _p = Instr. Eighth Time Shear Strength Test L _p = Instr. Ninth Time Shear Strength Test L _p = Instr. Tenth Time Shear Strength Test L _p = Instr. Eleventh Time Shear Strength Test L _p = Instr. Twelfth Time Shear Strength Test L _p = Instr. Thirteenth Time Shear Strength Test L _p = Instr. 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OF 3 SHEET NUMBER 3	CULVERT REPLACEMENT ALLEN STREAM GARLAND PENOBSCOT COUNTY BORING LOGS	PROJ. MANAGER	S. DAVIS	BY	DATE
		DESIGN-DETAILED	K.BRESKIN	T. WHITE	APR 2012
		CHECKED-REVIEWED			
		DESIGN2-DETAILED2			
		DESIGN3-DETAILED3			
		REVISIONS 1			
		REVISIONS 2			
		REVISIONS 3			
		REVISIONS 4			
		FIELD CHANGES			
				DATE	
				P.E. NUMBER	
				SIGNATURE	
STATE OF MAINE DEPARTMENT OF TRANSPORTATION					
19334.00					
BRIDGE NO. N/A		WIN 19334.00			
HIGHWAY PLANS					

Exeter Road Strut
Allen Stream
Garland, Maine
WIN 19334.00

Appendix A Boring Logs

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Exeter Road Location: Garland, Maine		Boring No.: BB-GARL-101 WIN: 19334.00																																																																																																			
Driller: MaineDOT			Elevation (ft.) 345.2		Auger ID/OD: 5" Dia.																																																																																																				
Operator: Giguere/Giles			Datum: NAVD88		Sampler: n/a																																																																																																				
Logged By: B. Wilder			Rig Type: CME 45C		Hammer Wt./Fall: n/a																																																																																																				
Date Start/Finish: 2/22/12-2/22/12			Drilling Method: Soild Stem Auger		Core Barrel: N/A																																																																																																				
Boring Location: 13+95.7, 7.7 ft Rt.			Casing ID/OD: N/A		Water Level*: None Observed																																																																																																				
Hammer Efficiency Factor: 0.60			Hammer Type: Automatic ☐ Hydraulic ☐ Rope & Cathead ☐																																																																																																						
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample attempt V = Insitu Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Insitu Vane Shear Test attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = weight of 140lb. hammer WOR/C = weight of rods or casing WO1P = Weight of one person S_u = Insitu Field Vane Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N_{uncorrected} = Raw field SPT N-value Hammer Efficiency Factor = Annual Calibration Value N₆₀ = SPT N-uncorrected corrected for hammer efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N_{uncorrected} S_{u(lab)} = Lab Vane Shear Strength (psf) WC = water content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test																																																																																																									
<table><tr><th rowspan="2">Depth (ft.)</th><th colspan="8">Sample Information</th><th rowspan="2">Graphic Log</th><th rowspan="2">Visual Description and Remarks</th><th rowspan="2">Laboratory Testing Results/ AASHTO and Unified Class.</th></tr><tr><th>Sample No.</th><th>Pen./Rec. (in.)</th><th>Sample Depth (ft.)</th><th>Blows (6 in.) Shear Strength (psf) or RQD (%)</th><th>N-uncorrected</th><th>N₆₀</th><th>Casing Blows</th><th>Elevation (ft.)</th></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td><td>SSA</td><td></td><td></td><td></td><td>Power Auger Probe, no description given.</td><td></td></tr><tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								Depth (ft.)	Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows	Elevation (ft.)	0							SSA				Power Auger Probe, no description given.		5													10													15													20													25												
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Stratification lines represent approximate boundaries between soil types; transitions may be gradual. * Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.											Page 1 of 1 Boring No.: BB-GARL-101																																																																																														

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[illegible]

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Exeter Road Location: Garland, Maine				Boring No.: BB-GARL-103A WIN: 19334.00			
Driller: MaineDOT				Elevation (ft.) 344.9				Auger ID/OD: 5" Dia.			
Operator: Giguere/Giles				Datum: NAVD88				Sampler: n/a			
Logged By: B. Wilder				Rig Type: CME 45C				Hammer Wt./Fall: n/a			
Date Start/Finish: 2/22/12-2/22/12				Drilling Method: Soild Stem Auger				Core Barrel: N/A			
Boring Location: 14+34.1, 7.1 ft Rt.				Casing ID/OD: N/A				Water Level*: None Observed			
Hammer Efficiency Factor: 0.60				Hammer Type: Automatic ☐ Hydraulic ☐ Rope & Cathead ☐							
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall Tube Sample attempt V = Insitu Vane Shear Test, PP = Pocket Penetrometer MV = Unsuccessful Insitu Vane Shear Test attempt R = Rock Core Sample SSA = Solid Stem Auger HSA = Hollow Stem Auger RC = Roller Cone WOH = weight of 140lb. hammer WOR/C = weight of rods or casing WO1P = Weight of one person S_u = Insitu Field Vane Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf) q_p = Unconfined Compressive Strength (ksf) N-uncorrected = Raw field SPT N-value Hammer Efficiency Factor = Annual Calibration Value N₆₀ = SPT N-uncorrected corrected for hammer efficiency N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected S_{u(lab)} = Lab Vane Shear Strength (psf) WC = water content, percent LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index G = Grain Size Analysis C = Consolidation Test											
Depth (ft.)	Sample Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows	Elevation (ft.)			
0							SSA	338.80	Power Auger Probe, no description given.		
5											
									Bottom of Exploration at 6.10 feet below ground surface. BOULDER REFUSAL	6.10	
25											
Remarks:											
Stratification lines represent approximate boundaries between soil types; transitions may be gradual.											
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.											
Page 1 of 1											
Boring No.: BB-GARL-103A											

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS				Project: Exeter Road Location: Garland, Maine		Boring No.: BB-GARL-104 WIN: 19334.00																																																																																																																
Driller: MaineDOT			Elevation (ft.) 345.2		Auger ID/OD: 5" Dia.																																																																																																																	
Operator: Giguere/Giles			Datum: NAVD88		Sampler: n/a																																																																																																																	
Logged By: B. Wilder			Rig Type: CME 45C		Hammer Wt./Fall: n/a																																																																																																																	
Date Start/Finish: 2/22/12-2/22/12			Drilling Method: Soild Stem Auger		Core Barrel: N/A																																																																																																																	
Boring Location: 14+30.4, 6.1 ft Lt.			Casing ID/OD: N/A		Water Level*: None Observed																																																																																																																	
Hammer Efficiency Factor: 0.60			Hammer Type: Automatic ☐ Hydraulic ☐ Rope & Cathead ☐																																																																																																																			
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Exeter Road Strut
Allen Stream
Garland, Maine
WIN 19334.00

Appendix B

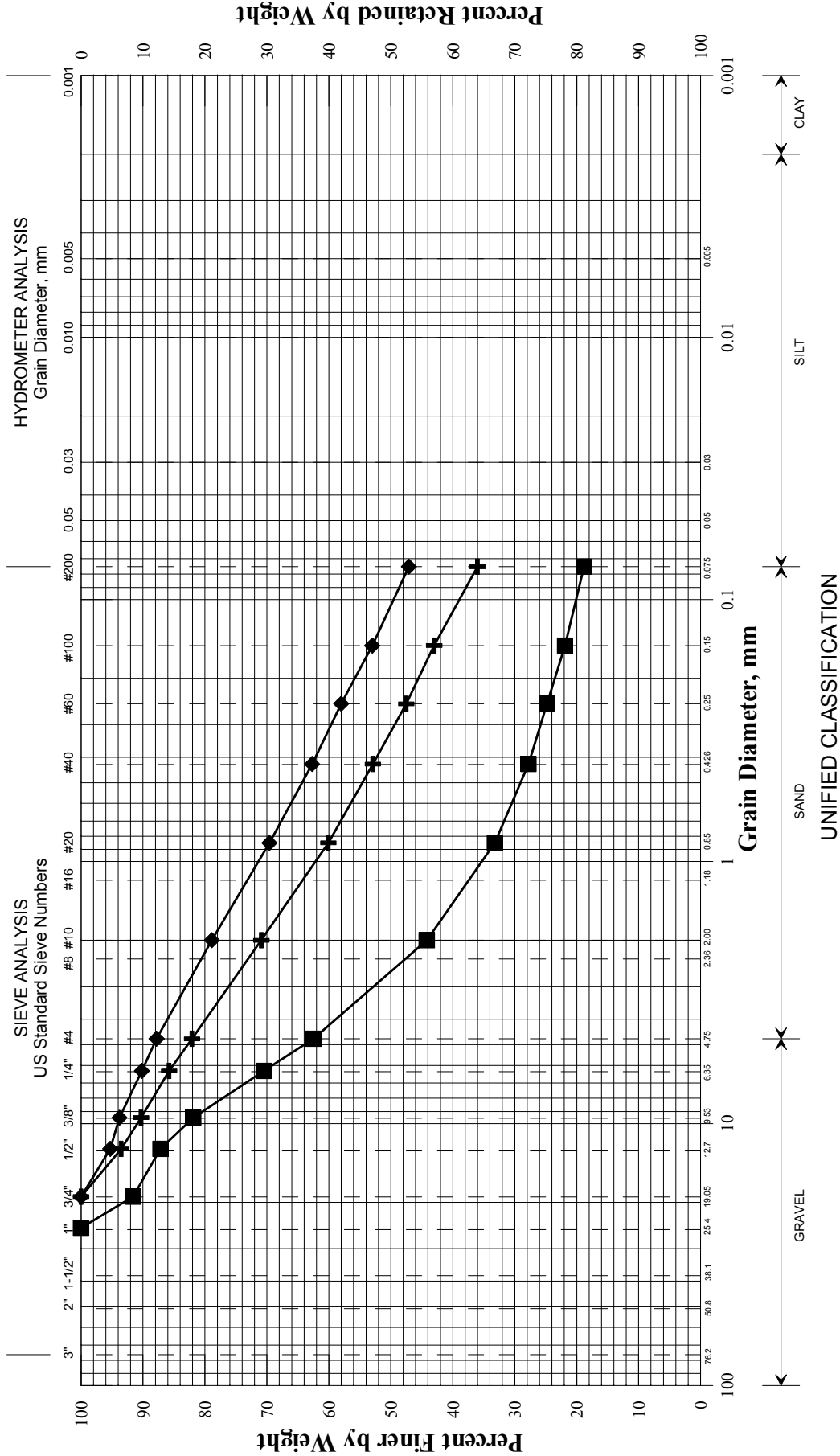
Laboratory Data

Town(s): Garland **Work Number: 19334.00**

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-GARL-102/1D	13+95.7	4.8 LT	1.5-3.5	Silty SAND, little gravel.	24.2			
◆	HB-GARL-102/2D	13+95.7	4.8 LT	5.0-7.0	Sandy SILT, little gravel.	28.6			
■	HB-GARL-102/3D	13+95.7	4.8 LT	10.0-11.3	Gravelly SAND, little silt.	17.1			
●									
▲									
×									

WIN	019334.00	Town	Garland	Reported by/Date
				WHITE, TERRY A 4/3/2012

Exeter Road Strut
Allen Stream
Garland, Maine
WIN 19334.00

Appendix C Calculations

Headwall Active Earth Pressures:

Effective active earth pressure coefficient:

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

$\beta := 0 \cdot \text{deg}$ slope angle of backfill soils from horizontal

$\phi_a := 28 \cdot \text{deg}$ assumed effective friction angle for loose sandy silt

$$K_a := \tan\left(45 \cdot \text{deg} - \frac{\phi_a}{2}\right)^2 \quad K_a = 0.36$$

Service Limit State Bearing Resistance - Native Granular Soils:

Nominal and factored Bearing Resistance

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 5th Edition
Table C10.6.2.6.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: gravelly SAND (Till)

Consistency In Place: dense

Bearing Resistance: Ordinary Range (ksf)
8 - 14 medium dense to dense

Recommended Value of Use: 8 to 14 ksf

Recommended Value:

$$10 \cdot \text{ksf} = 5 \cdot \text{tsf}$$

$$\text{tsf} := g \cdot \left(\frac{\text{ton}}{\text{ft}^2}\right)$$

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

Characteristics of Native Soils at foundation level

Gray-brown, wet, dense gravelly fine to coarse SAND (Till)

$w_c := 0.171$ lab result for water content

$e := 0.6$ estimated void ratio

$\gamma_w := 62.4 \text{ pcf}$ unit weight of water

$sp := 2.65$ estimated specific gravity

saturation $sat := \frac{(w_c \cdot sp)}{e}$ $sat = 0.7553$

total unit weight $\gamma_t := \frac{(sp + sat \cdot e) \cdot \gamma_w}{(1 + e)}$ $\gamma_t = 121 \cdot \text{pcf}$

saturated unit weight $\gamma_{sat} := \frac{(sp + e) \cdot \gamma_w}{(1 + e)}$ $\gamma_{sat} = 127 \cdot \text{pcf}$

Strength Limit State Bearing Resistance - Native Granular Soils:

Nominal and factored Bearing Resistance for box culvert and wingwall base slab

Assumptions

- Box culvert will be embedded 2.0 feet below streambed

$$D_f := 2.0 \text{ ft}$$

- Assumed parameters based on granular fill

Moist unit weight $\gamma_m := 121 \text{ pcf}$

Saturated unit weight $\gamma_s := 127 \text{ pcf}$

Angle of internal friction $\phi_b := 36 \text{ deg}$

Undrained shear strength $c := 0$

Depth to groundwater $D_w := 0 \text{ ft}$

- $L > B$, so use Terzaghi strip foundation equations

Terzaghi shape factors $B := 10 \text{ ft}$

$$s_c := 1.0$$

Meyerhof bearing capacity factors $s_\gamma := 1.0$

$$N_c := 30.13$$

$$N_q := 18.4$$

$$N_{\gamma} := 15.1$$

Effective stress at footing level

$$q_{\text{eff}} := D_w \cdot \gamma_m + (D_f - D_w) \cdot (\gamma_s - \gamma_w)$$

$$q_{\text{eff}} = 129 \cdot \text{psf}$$

Nominal Bearing Resistance

$$q_{\text{nom}} := c \cdot N_c \cdot s_c + q_{\text{eff}} \cdot N_q + 0.5 \cdot (\gamma_s - \gamma_w) \cdot B \cdot N_{\gamma} \cdot s_{\gamma}$$

$$q_{\text{nom}} = 7.255 \cdot \text{ksf}$$

Resistance Factor from LRFD Table 10.5.5.2.2-1, pg 10-32

$$\Phi_b := 0.45$$

$$q_{\text{factored}} := q_{\text{nom}} \cdot \Phi_b$$

$$q_{\text{factored}} = 3.265 \cdot \text{ksf}$$

For this project, the Strength limit state controls.

Factored Bearing Resistance of 3.3 ksf should be used.