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

# **GEOTECHNICAL DESIGN REPORT**

For the Construction of

WELD ROAD BRIDGE ROUTE 142 DIXFIELD, MAINE

Prepared by: Yueh-Ti Lee Assistant Geotechnical Engineer



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Oxford County WIN 26372.00 Soils Report 2025-13 Bridge No. 6739

May 27, 2025

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# **1.0** INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of an existing large culvert (#47306) on Route 142 in Dixfield. A subsurface investigation has been completed at the site to evaluate subsurface conditions and to develop geotechnical design and construction recommendations for the replacement structure. This report presents the subsurface information obtained during the subsurface investigation and soil laboratory testing programs and provides design and construction recommendations and geotechnical design parameters for the culvert replacement.

The existing structure consists of an approximately 6-foot span by 6-foot rise by 68-foot-long precast concrete box culvert. The box culvert is in poor condition and needs replacement both from an infrastructure and environmental standpoint. Route 142 is a Highway Corridor Priority 4 road.

The proposed replacement structure will be an approximately 10-foot span by 8-foot rise by 94-foot-long precast concrete box culvert. The invert of the proposed culvert is approximately 15.5 feet below the existing road grade at the roadway centerline. The roadway embankment slopes at the proposed culvert shall be no steeper than 1.75H:1V at the inlet and 2H:1V at the outlet to protect against erosion.

# **2.0** GEOLOGIC SETTING

The existing culvert carries an unnamed stream under Route 142 in Dixfield and is located approximately 0.06 of a mile north of Holt Hill Road as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Surficial Geology of the Dixfield Quadrangle, Maine, Open File 20-2 (2020) the surficial soils at the site consist of Alluvial Fan Deposits. Alluvial Fan Deposits consist of sand, gravel, and silt.

According to the map titled Bedrock Geologic Map of Maine (1985) published by the MGS, the bedrock in the vicinity of the site consists of interbedded pelite and sandstone of the Seboomook Formation Mount Blue Member.

# **3.0** SUBSURFACE INVESTIGATION

One (1) boring (HB-DIX-101) and one (1) probe (HB-DIX-102) were drilled for this project on November 19, 2024 by the MaineDOT drill crew using a trailer-mounted drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile with Boring Logs. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the Boring Logs in Appendix A.

Boring HB-DIX-101 was drilled using solid stem auger, cased wash boring, and open hole drilling techniques. Soil samples were obtained at 5-foot intervals using Standard Penetration Test (SPT) methods. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The MaineDOT calibrated automatic hammer delivers approximately 44 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 0.862 to the raw field N-values. Probe HB-DIX-102 was drilled using solid stem auger techniques. No soil samples were obtained in the probe.

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. The boring and probe were located in the field by taping to surveyed site features after completion of the drilling program.

# 4.0 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 five (5) standard grain size analyses with natural water content. The results of the laboratory testing program are discussed in the following section and are included in Appendix B – Laboratory Test Results. Laboratory test information is also shown on the Boring Logs in Appendix A.

# **5.0** SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test boring and probe generally consisted of sand fill underlain by native sand. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 2 - Boring Location Plan & Interpretive Subsurface Profile.

Boring HB-DIX-101 was drilled to depth of approximately 27.0 feet below ground surface (bgs) without encountering a refusal surface. Probe HB-DIX-102 was drilled to depth of approximately 25.0 feet bgs without encountering a refusal surface.

Approx. Depth BGS <sup>1</sup> (feet)	Soil Description	AASHTO <sup>2</sup> Classification	USCS <sup>3</sup>	WC% <sup>4</sup>
0.0 - 0.3	HMA Pavement			
0.3 – 12.0	Fill: Interbedded layers of: Brown and dark brown, damp to moist, fine to coarse sand, some silt, trace to little gravel, little organics. Grey-brown, damp, silty fine to coarse sand, trace gravel.	A-2-4 A-4	SM	8.4 to 22.5 14.3

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

	Brown and grey-brown, moist to wet, fine	A-2-4	SM	11.3
12.0 - 27.0	to coarse sand, little to some gravel, trace	or	or	to
	to little silt, occasional cobbles.	A-1-b	SW-SM	16.6

<sup>1</sup>BGS = below ground surface

<sup>2</sup>AASHTO = American Association of State Highway and Transportation Officials

<sup>3</sup>USCS = Unified Soil Classification System

 $^{4}WC\% = Water content in percent$ 

Three (3)  $N_{60}$ -value obtained in the sand fill ranged from 9 blows per foot (bpf) to 16 bpf indicating that the sand fill is loose to medium dense in consistency. Three (3)  $N_{60}$ -values obtained in the native sand ranged from 56 to 226 bpf, indicating that the native sand is very dense in consistency.

Groundwater was recorded at depth 10.0 feet bgs in boring HB-DIX-101. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

# 6.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following sections discuss geotechnical recommendations for the design and construction of the proposed culvert.

## 6.1 Precast Concrete Box Culvert Design and Construction

The proposed replacement structure will consist of a 10-foot span by 8-foot rise by 94-foot-long precast concrete box culvert. The proposed box culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 534.

The approximate invert of the proposed culvert ranges from an elevation of 458.60 feet at the inlet to 454.20 feet at the outlet with a 4.7% slope. To facilitate fish passage, Habitat Connectivity Design elements will be used inside the precast concrete box culvert as shown on the Streambed Details Sheet in the Plans.

The full nature of the culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders in excess of 6 inches encountered at the bedding elevation shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone <sup>3</sup>/<sub>4</sub>-Inch. Any disturbed soils at the bedding elevation resulting from excavation activities should be removed by hand prior to placement of the bedding material. The prepared subgrade shall be proof rolled 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 1-foot-thick layer of Granular Borrow, Material for Underwater Backfill meeting the requirements of MaineDOT Standard Specification 703.19. The soil envelope and backfill shall consist of Standard Specification 703.19 - Granular Borrow with a maximum particle size of 4 inches. The Granular Borrow bedding and backfill material 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, the bedding and backfill soil shall be compacted to at least 92 percent of the AASHTO T-180 maximum dry density.

## 6.2 Settlement

No settlement issues are anticipated at the site. The proposed precast concrete box culvert is larger than the existing culvert and will result in a net unloading of the site soils at the proposed structure location. Placement of fill soils at the location of the existing structure is not anticipated to exceed the past loading condition of the site soils. Any settlement due to elastic compression of the bedding material will be immediate and negligible.

## 6.3 Bearing Resistance

The factored bearing resistances for the precast concrete box culvert bearing on compacted granular bedding material placed on native soils and/or bedrock at the service and strength limit states are presented in the table below. Supporting calculations in accordance with AASHTO LRFD Bridge Design Specifications 10<sup>th</sup> Edition 2024 (LRFD) are provided in Appendix C – Calculations.

Limit State	Resistance Factor	AASHTO LRFD	Factored Bearing
	Фb	Reference	Resistance (ksf)
Service	1.0	Article 10.5.5.1	6.0
Strength	0.45	Table 10.5.5.2.2-1	10.5

## 6.4 Modulus of Subgrade Reaction

A modulus of subgrade reaction  $(k_s)$  equal to 200 pounds per cubic inch shall be used for the structural design of the box culvert's base slab. Calculations are included in Appendix C – Calculations.

## 6.5 Scour and Riprap

Both the inlet and outlet of the precast concrete box culvert 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 1.75H:1V on the inlet end and 2H:1V on the outlet end. No specific scour protection recommendations are needed other than armoring with riprap. The riprap on the slopes shall be underlain by a 1-foot layer of protective aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19) that is underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03. The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

## 6.6 Seismic Design Considerations

In conformance with LRFD Article 3.10.1, seismic analysis is not required for buried structures, except where they cross active faults. There are no known active faults in Maine; therefore, seismic analysis is not required.

## 6.7 Construction Considerations

Construction activities may 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 precast concrete box culvert 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 sand or bedrock 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.

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.

# 7.0 CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed replacement of an existing large culvert (#47306) under Route 142 in Dixfield, 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.

**Sheets** 





			on p	roject: ocotion	Route	142 L Fields	arge Culvert Replaemnt Maine	Boring No.: WIN:		<u>x-101</u>				
	lineDOT	Elev	ation	(ft.)	472.	7		Auger 10/00:	5" Solid Ste	n				
	Wilder/Y-T. Lee /19/2024: 8:30-11:00	Rig	Type:	lethod:	CME	45C id Mas <sup>a</sup>	h Boring	Hammer Wt./Fall:	3/undord Spl 140#/30" N/A	. / spoon				
	+37.3, 10.7 ft Lt.	Cast	ing ID/	0D: e:	NW-3	r tic B3	Hydroulic 🗆	Noter Level*:	10.0 ft bgs.					
	R = Rock Cor SSA = Solid cn Somple Attempt RC = Roller Tube Somple Attempt PP = Rock Penetrometer MDR/C = No 5 Cheor Lest Attempt WDIP = Solid Comple Attempt NDP = Rock Comple Attempt NDP = Rock Compl	re Somo Sten A v Sten Cone it of 14 Keight o ht of 0	ile Juger Juger Olb. Ho of Rods Ine Perse	mer or Casing In	Su = Sul II 9p = N-und Homme N60 - N60 -	Peok/Re b) = Lo Unconfi correcte r Effic sPT N- (Homme	molded Field Vane Undrafned S na Yone Undrafned Shear Streng ned Compressive Strength (Lksf d = Row Field SPT N-volue Lancy Foctor = Rig Specific A undorrected Corrected for Hom r Efficiency Foctor/60%14%-un	hear Strength (psf)t,= Packel           th (psf)         MC = Not           th (psf)         MC = Not           PL         PL           nual Collbration Value         P1           mar Efficiency         0 = Grai           corrected         C = Constructed	t Torvane Shear ter Content, per auid Limit astic Limit = Plasticity inc in Size Analysis solidation Test	Strength (psf) roent Sex				
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Image:	10.00 - 2/3/3/4	6	9		460.7		Dark brown, moist, lo slit, trace gravel, i	ose, fine to coarse SAN Ittle organics, (Fill).	4D• some 	G#379227 A-2-4, SM WC=22.5%				
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	20.00 - 33/22/17/13	39	56	223 0PEN HOLE			Brown, moist, very der gravel, troce silt, or	nse, fine to coarse SAN ccasional cobbles,	kD∙ some	G#379229 1-1-D. SW-SM WC=11.3%				
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							DUNING LOCATION FLAN &	INTERPRETIVE SURSURFCE PROFILE		WITH BURING LUGS
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# Appendix A

Boring Logs

	UNIFIE	ED SOIL C	LASSIFIC	CATION SYSTEM	MODIFIED BURMISTER SYSTEM						
MA		ONS	GROUP SYMBOLS	TYPICAL NAMES							
COARSE- GRAINED	GRAVELS	CLEAN GRAVELS	GW	Well-graded gravels, gravel- sand mixtures, little or no fines.	<u>Descrip</u> tr li	<u>tive Term</u> race ittle	Port	<u>ion of Total (%)</u> 0 - 10 11 - 20 21 - 25			
SUILS	f coarse nan No. 4 )	(little or no fines)	GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.	adjective (e.g.	Sandy, Clayey)		21 - 35 36 - 50			
	half o ger th e size						S DESCRIBIN	G			
	than is lar sieve	GRAVEL	GM	Silty gravels, gravel-sand-silt	Coarse-grained s	soils (more than half	of material is larger t	han No. 200			
5	more	WITH FINES		mixtures.	sieve): Includes (1 Clavev or Gravelly	1) clean gravels; (2) S v sands.  Densitv is ra	ilty or Clayey gravels ated according to sta	s; and (3) Silty, ndard			
is large ze)	fra fra	(Appreciable amount of	GC	Clayey gravels, gravel-sand-clay mixtures.	penetration resista	ance (N-value).	5				
aterial ieve siz		fines)			Den Cohesior	<u>isity of</u> nless Soils	<u>Standard Po</u> <u>N-Value</u>	enetration Resistance e (blows per foot)			
f of m 200 s		CLEAN	SW	Well-graded sands, Gravelly	Very Lc	/ loose oose		0 - 4 5 - 10			
No. 3	SANDS	SANDS		sands, little or no fines	Mediur	m Dense		11 - 30			
e thai than	9. e	(little or no	SP	Poorly-graded sands, Gravelly	Very	Dense		> 50			
(mor	an N	fines)		sand, little or no fines.	Fine grained coil	le (mara than half of r	natorial is smaller th	an No. 200			
	alf of ller th size)				sieve): Includes (1	) inorganic and organ	nic silts and clays; (2	) Gravelly, Sandy			
	lan ha smal	SANDS WITH	SM	Silty sands, sand-silt mixtures	or Silty clays; and strength as indicated	<li>(3) Clayey silts. Con ted.</li>	sistency is rated acc	ording to undrained shear			
	ore th ion is s	FINES	60		g		Approximate				
	(m fract	(Appreciable amount of	30	clayey sands, sand-clay mixtures.	Consistency of	SPT N-Value	Shear	Field			
		fines)			Cohesive soils	(blows per foot) WOH_WOR	Strength (psf)	Guidelines			
			ML	Inorganic silts and very fine	Very Soft	WOP, <2	0 - 250	Fist easily penetrates			
				sands, rock flour, Silty or Clayey fine sands, or Clayey silts with	Soπ Medium Stiff	2 - 4 5 - 8	250 - 500 500 - 1000	Thumb easily penetrates Thumb penetrates with			
	SILTS AN	ID CLAYS		slight plasticity.	Stiff	9 - 15	1000 - 2000	moderate effort Indented by thumb with			
FINE-			CL	Inorganic clays of low to medium	Vom Ctiff	16 20	2000 4000	great effort			
SOILS				clays, Silty clays, lean clays.	Hard	>30	over 4000	Indented by thumbhail			
	(liquid limit l	ess than 50)	OI	Organic silts and organic Silty	Rock Quality Des	signation (RQD):		with difficulty			
			01	clays of low plasticity.	RQD (%) = sum of the lengths of intact pieces of core* > 4 inches						
al is size)					*Minimum NQ rock core (1.88 in. OD of core)						
nateri sieve			MH	Inorganic silts, micaceous or diatomaceous fine Sandy or		Rock Quality Ba	ased on RQD				
lf of r 200	SILTS AN	ID CLAYS		Silty soils, elastic silts.		Rock Quality	RQD (%)				
an ha in No			СН	Inorganic clays of high		Poor	≤25 26 - 50				
re tha				plasticity, fat clays.		Fair Good	51 - 75 76 - 90				
(mc small	(liquid limit gr	eater than 50)	ОН	Organic clays of medium to	Desired Beak C	Excellent	91 - 100	cable).			
				ngn plasticity, organic sitts.	Color (Munsell	color chart)	ina order, if appli				
	HIGHLY	ORGANIC	Pt	Peat and other highly organic	Texture (aphani Rock Type (gra	itic, fine-grained, et nite, schist, sandste	tc.) one, etc.)				
	SO	ILS		soils.	Hardness (very	hard, hard, mod. h	ard, etc.)	· · · ·			
Desired So	il Observat	ions (in thi	s order. if	applicable):	vveatnering (fre	sn, very slight, slig ntinuities/iointina	nt, moderate, mod	i. severe, severe, etc.)			
Color (Mun	sell color ch	art)		<u> </u>		-dip (horiz - 0-5 de	g., low angle - 5-3	5 deg., mod. dipping -			
ivioisture (d Density/Coi	ry, ɑamp, m nsistency (fr	oıst, wet) om above ri	ght hand s	side)		35-55 deg., stee -spacing (very clos	ep - 55-85 deg., ve se - <2 inch, close	ertical - 85-90 deg.) - 2-12 inch, mod.			
Texture (fin	e, medium,	coarse, etc.	) inclusion	, nortional trace little -t- )		close - 1-3 feet,	, wide - 3-10 feet,	very wide >10 feet)			
Gradation (	u, Silty Sand well-graded	u, ciay, etc. , poorly-grad	, including ded, unifor	m, etc.)		<ul> <li>-ugntness (tight, op -infilling (grain size)</li> </ul>	e, color, etc.)				
Plasticity (n	on-plastic, s	lightly plast	ic, modera	tely plastic, highly plastic)	Formation (Wat	erville, Ellsworth, C	Cape Elizabeth, etc	c.) etc.)			
Bonding (w	ell, moderat	ely, loosely,	etc., )		ref: ASTM D6	032 and FHWA NF	y (very poor, poor, II-16-072 GEC 5 -	Geotechnical			
Cementatio	ementation (weak, moderate, or strong)					Site Characterization, Table 4-12					
Groundwate	er level	inne ciay, al	iuvium, et	s.j	Recovery (Inch/ Rock Core Rate	e (X.X ft - Y.Y ft (mi	je) in:sec))				
	Maina	)onort	nt of To	nonortotion	Sample Container Labeling Requirements:						
	wane L	vepartme Geotechi	nt of Tra nical Se	ansportation ction	WIN Bridge North	/ Town	Blow Counts	0.01/			
Ke	y to Soil a	and Rock	Descrip	otions and Terms	Boring Numbe	/ IOWN er	Sample Recov	ery			
	Fiel	d Identific	ation Inf	ormation	Sample Numb	ber	Personnel Initia	als			
					Sample Deptr	I					

I	artment	of Transporta	atior	1	Project: Route 142 Large Culvert Replaemnt Boring No.: HB-D						IX-101			
		5	Soil/Rock Exp	loration Log			Loca	tior	1: Dix	ield, M	aine			
		ļ	US CUSTOM/	ARY UNITS					-	, -		WIN:	263'	72.00
Drill	or:		MaineDOT		Fla	vation	(ft)		472	7			5" Solid Stem	
One	rator:		Daggett/Andrl	0	Dat	um.	(10.)		NA	///////////////////////////////////////		Sampler:	Standard Split	Spoon
	nod By:		B Wilder/V T		Rig	Type			CM	F 45C		Hammer Wt /Fall:	140#/30"	Spoon
Date	Start/Ei	inich	11/10/2024. 8	· 11:00	Dril	ling M	Iotho	d٠	Can	d Week	Doring	Coro Barrol:	N/A	
Date		tion:	12+27.2 10.7	A I +		ing I		u.	NW	2"	bornig	Water Loval*	10.0 ft has	
Воп			12+57.5, 10.7	It Lt.	Uas	sing it	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		IN W	-3			10.0 ft bgs.	
Defini	tions:	Iclency F	actor: 0.862	R = Rock C	ore Sam	ple	Type	•	Autom S <sub>II</sub> =	atic 🖂 Peak/Re	molded Field Vane Undrained She	Rope & Cathead $\square$ ear Strength (psf) $T_v = F$	ocket Torvane She	ar Strength (psf)
D = S	plit Spoon	Sample	aan Camala Attan	SSA = Solic	I Stem A	uger			S <sub>u(la</sub>	b) = Lab	psf) WC =	Water Content, per	cent	
U = TI	hin Wall Tu	ibe Sample	oon Sample Allen	RC = Roller	Cone	Auger			ч <sub>р</sub> – N-ur	corrected	= Raw Field SPT N-value	PL = F	Plastic Limit	
MU = V = Fi	Unsuccess eld Vane S	sful Thin Wa Shear Test,	Il Tube Sample A PP = Pocket Pe	ttempt WOH = We netrometer WOR/C = V	ight of 14 /eight of	40lb. Ha Rods o	mmer r Casin	q	Ham Neo	mer Effic = SPT N-	ency Factor = Rig Specific Annual uncorrected Corrected for Hamme	Calibration Value PI = P er Efficiency G = G	lasticity Index rain Size Analysis	
MV =	Unsuccess	sful Field Va	ne Shear Test Att	tempt WO1P = W	eight of C	One Per	son		N <sub>60</sub>	= (Hamm	er Efficiency Factor/60%)*N-uncor	rected C = C	onsolidation Test	
	Sample Information													
	·     ·													
(H.)	Ž e	kec.	e e	(/6 Jth D (9	orre				lon	ic L	Visual De	scription and Remarks		AASHTO
pth	du l	n./F	ld m	ws ear ear RQ	nuc	0	sinç	SWS	evat )	aph				and
Ď	Sa	Pe	(ft. Sa	e (b st s Bi	ż	2 <sup>9</sup>	ů	ă	₩ E	Ģ				Unined Class.
0							SS	A	472.4	****	_4" HMA.		0 3	
	10		16		$\neg$			Brown, damp, medium den	se, fine to coarse SAND, s	ome silt, little	G#379225			
	ID	11	16	16 gravel, (Fill).										
														WC-0.470
- 5 -	20	24/24	5.00 7.00	4/4/4/4	0	11					Grey-brown, damp, medium	n dense, Silty fine to coars	e SAND, trace	G#379226
	20	24/24	3.00 - 7.00	4/4/4/4	0	11					gravel, (Fill).	A-4, SM WC=14.3%		
														WC 14.570
								_						
- 10 -								_			Dark brown moist loose f	ine to coarse SAND some	silt_trace	G#379227
	3D	24/24	10.00 - 12.00	2/3/3/4	6	9					gravel, little organics, (Fill)		sint, tidee	A-2-4, SM
														WC=22.5%
								_	460.7	****			12.0	
										H.				
								/						
							+	+						
- 15 -								/						
15	4D	24/20	15.00 - 17.00	14/18/28/22	46	66	50	5			Brown, wet, very dense, fin	e to coarse SAND, little si	lt, little gravel.	G#37/9228 A-2-4 SM
							1.2	-						WC=16.6%
							13	S						
							21	2						
							0,							
							0.	, 						
							22	3						
20 -	5D	24/14	20.00 - 22.00	33/22/17/13	39	56	OP	EN			Brown, moist, very dense, f	ine to coarse SAND, some	gravel, trace	G#379229
		2.011	20.00 22.00	55/22/17/15	57	50	HO	LE-			silt, occasional cobbles.			A-1-b, SW-SM WC=11.3%
l I														
								_						
25 <b>Remarks:</b>														
l I														
l I														
l I														
Stratif	ication line	s represent	approximate bour	ndaries between soil types; t	ransition	is may b	e grad	ual.				Page 1 of 2		
* Wate	er level rea	dings have	been made at tim	es and under conditions stat	ed. Gro	undwate	er fluctu	uatior	ns may c	ccur due	to conditions other			
than	those pres	sent at the ti	ime measurement	ts were made.					, -	-		Boring No.:	HB-DIX-	101

Ι	Maine	e Depa	artment	of Transport	ation	Project	: Route	142 La	rge Culvert Replaemnt	Boring No.:	HB-D	IX-101
		<u>9</u>	Soil/Rock Exp JS CUSTOM	loration Log ARY UNITS		Locatio	on: Dixf	ield, M	aine	WIN:	2637	72.00
Drille	er:		MaineDOT		Elevatio	n (ft.)	472.	7		Auger ID/OD:	5" Solid Stem	
Oper	ator:		Daggett/Andr	le	Datum:	( )	NAV	/D88		Sampler:	Standard Split	Spoon
Logo	ed By:		B. Wilder/Y-1	Г. Lee	Rig Typ	e:	CMI	E 45C		Hammer Wt./Fall:	140#/30"	1
Date	Start/Fi	nish:	11/19/2024; 8	:30-11:00	Drilling	Method:	Case	d Wasl	1 Boring	Core Barrel:	N/A	
Bori	ng Loca	tion:	12+37.3, 10.7	ft Lt.	Casing	ID/OD:	NW	.3"		Water Level*:	10.0 ft bgs.	
Ham	mer Effi	ciency F	actor: 0.862		Hamme	r Type:	Automa	ıtic ⊠	Hydraulic 🗆	Rope & Cathead □		
Definit D = SI MD = U = TH MU = V = Fi MV =	ions: blit Spoon S Unsuccess hin Wall Tu Unsuccess eld Vane S <u>Unsuccess</u>	Sample ful Split Spo be Sample ful Thin Wa hear Test, ful Field Va	oon Sample Atter II Tube Sample A PP = Pocket Pe ne Shear Test At	R = Rock C           SSA = Soli           mpt         HSA = Holl           RC = Rolle           ktempt         WOH = We           unetrometer         WOR/C = V           WOR/D = W         WO1P = W           Sample Information         Sample Information	ore Sample d Stem Auger ow Stem Auger Cone ight of 140 lb. Veight of Rods eight of One F	r Hammer or Casing erson	S <sub>u</sub> = S <sub>u(la</sub> q <sub>p</sub> = N-un Ham N <sub>60</sub> : N <sub>60</sub> :	Peak/Re b) = Lab Unconfir correcter mer Effic = SPT N = (Hamn	wolded Field Vane Undrained Sh- Vane Undrained Shear Strength (ksf) eed Compressive Strength (ksf) = Raw Field SPT N-value iency Factor = Rig Specific Annua -uncorrected Corrected for Hamm wer Efficiency Factor/60%)*N-unco	ear Strength (psf)         Tv =           psf)         WC           LL         LL           I Calibration Value         PI =           er Efficiency         G =           rrected         C =	<ul> <li>Pocket Torvane Sheat</li> <li>Water Content, percent of the second se</li></ul>	ar Strength (psf) cent
		(·u	th		eq							Laboratory Testing
Depth (ft.)	Sample No.	Pen./Rec. (ii	Sample Dep (ft.)	Blows (/6 in. Shear Strength (psf) or RQD (%)	N-uncorrect	Casing Blows	Elevation (ft.)	Graphic Log	Visual De	scription and Remarks	3	Results/ AASHTO and Unified Class.
25	6D	24/24	25.00 - 27.00	45/74/83/95	157 220	5	-		Grey-brown, moist, very de trace silt, occasional cobble	ense, fine to coarse SAN es.	D, some gravel,	
							445.7		Bottom of Exploration NO REFUSAL	n at 27.0 feet below gro	und surface. 27.0-	
20												
30							-					
							-					
- 35 -							-					
							-					
- 40 -												
							-					
							-					
- 45 -							-					
50							1					
Rem	arks:		1			<u>    I                                </u>	1		1			
Stratif	cation line	s represent	approximate bou	ndaries between soil tunes.	transitions may	be gradual				Page 2 of 2		
* Wate	er level read	dings have l	been made at tim	tes and under conditions sta	ted. Groundw	ater fluctuation	ons may o	ccur due	to conditions other	Boring No		01
than	those pres	ent at the ti	me measuremen	ts were made.							пр-ріл-	101

Maine Department of Transportation								roject:	Route	142 Large Culvert Replaemnt	Boring No.:	HB-DI	K-102
		<u>s</u> L	oil/Rock Exp JS CUSTOM/	Ioration Log	<u>g</u> <u>6</u>		L	ocation.	: Dixt	ĩeld, Maine	WIN:	2637	72.00
Drillin	ng Conti	actor:	MaineDOT			Elevat	on (	ft.)	471	7	Auger ID/OD:	5" Dia.	
Opera	ator:		Daggett/Andrl	le		Datum	:	,	NAV	/D88	Sampler:	N/A	
	ed By:		B Wilder			Rig Ty	ne.		CM	F 45C	Hammer Wt /Fall	N/A	
Date	Start/Fir	vieh:	11/10/2024·1	1.00 11.30		Drilling	1 Mo	thod:	Soli	Stem Auger	Core Barrel:	N/A	
Borin	a Locat	ion:	12+77 4 12 6	ft Pt		Casing			N/A	i Stelli Augel	Water Level*	None Observe	4
Definitio	ons: D =	Spilt Spoor	Sample	2.6 IT Rt. Casing ID/OD: MU = Unsuccessful Thin Wall Tube Sam						pt WO1P = Weight of 1 Person	Match Level .	Tone Observer	
S = Sample off Auger Flights     R = Rock Core Sample       B = Bucket Sample off Auger Flights     SSA = Solid Stem Auger       MD = Unsuccessful Split Spoon Sample Attempt     HSA = Hollow Stem Auger       U = Thin Wall Tube Sample     RC = Roller Cone       MV = Unsuccessful Field Vane Shear Test Attempt     WOR/C = Weight of 140lb. Han       V = Field Vane Shear Test Attempt     WOR/C = Weight of Rods or										$\begin{array}{l} S_u = \text{Peak/Remolded Field Vane U}\\ S_u(lab) = Lab Vane Undrained She \\ q_p = Unconfined Compressive Stre \\ N-value = Raw Field SPT N-value \\ T_v = \text{Pocket Torvane Shear Streng} \end{array}$	ndrained Shear Strength (psf) ar Strength (psf) ngth (ksf) th (psf)	LL = Liquid Lim PL = Plastic Lin PI = Plasticity II G = Grain Size	it nit Analysis
V = Fiel	d vane Sr	lear Test,	PP= Pocket Per	Sample Int	formation	gnt of Roas	or Ca	Ising		wc = water Content, percent ≅ =	Similar or Equal too	C = Consolidati	on rest
		<u> </u>	ے										Laboratory
Depth (ft.)	epth (ft.) ample No. en./Rec. (in.) en./Rec. (in.) hear t.) hear r.RQD (%) r.RQD (%) r.RQD (%) estig								Graphic Log	Visual Descr	iption and Remarks		Results/ AASHTO and Unified Class.
0	••									Probe, no material samples taken.			
						8	SA			-			
			1					1					
								4					
								1					
- 5 -							-	-					
							+	-					
							-	-					
10													
10													
							-						
							-						
								1					
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15													
15													
							-	1					
								1					
							-	-					
20													
20													
							-	1					
							$\downarrow$						
							+	1					
							1/						
25							V						
Rema	rks:		•	•	I		•	•					
Stratific	ation lines	represent a	approximate bour	ndaries betwe	en soil types: tr	ansitions ma	ay be	gradual.			Page 1 of 2		
* 10/04/2-	level read	inge beve	een modo of t	ae and unde-	conditions state	d Crown-	,	fluctuatio-	e mov -	cour due to conditions other			
than t	hose prese	ngs nave t ent at the ti	ne measurement	ts were made	conuitions state	a. Ground	vatëľ	nuctuation	is may o	cour que lo conditions otner	Boring No.	: HB-DIX-	102

Maine Department of Transportation								Project:	Route	142 Large Culvert Replaemnt	Boring No.:	HB-DI	K-102
		<u>s</u> L	Soil/Rock Exp JS CUSTOM	Ioration Log	<u>]</u> <u>}</u>		L	ocation	: Dix	ield, Maine	WIN:	263	72.00
Drillir	a Cont	ractor:	MaineDOT			Elevat	on (	ft.)	471	7	Auger ID/OD:	5" Dia	
Opera	tor:		Daggett/Andr	le		Datum	:	,	NAV	/ /D88	Sampler:	N/A	
Logg	ad By:		B Wilder			Pig Ty	no:		CM	5.45C	Hammer Wt /Fall:	N/A	
Data	Stort/Ei	aich:	11/10/2024. 1	1.00 11.20		Drilling	ре. • Мо	CME 45C			Coro Parroli	N/A	
Date		ion:	12+77 4 12 6	ft D+		Casing			NI/A	i Stein Auger	Weter Level*	N/A	J
Definitio	ns: D =	Spilt Spoor	12+77.4, 12.0	II KI.	MU = Unsucc		Vall Ti	ube Sampl	IN/A	pt WO1P = Weight of 1 Person	Water Lever .	None Observe	u
S = Sar B = Buc MD = U U = Thi MV = U V = Fiel	nple off Au ket Samp nsuccessi n Wall Tut nsuccessi d Vane Si	uger Flights le off Auger ful Split Spo pe Sample ful Field Var near Test,	Flights ion Sample Atten ne Shear Test Att PP= Pocket Per	npt tempt <u>netrometer</u> Sample Int	R = Rock Corr SSA = Solid S HSA = Hollow RC = Roller C WOH = Weigh WOR/C = We	e Sample item Auger Stem Auge one nt of 140lb. H ight of Rods	lamm or Ca	er asing		$\begin{array}{l} S_{u} = \text{Peak/Remolded Field Vane U}\\ S_{u(lab)} = \text{Lab Vane Undrained She}\\ q_{p} = \text{Unconfined Compressive Stree}\\ q_{v} = \text{Noralue} = \text{Raw Field SPT N-value}\\ T_{v} = \text{Pocket Torvane Shear Strengt}\\ WC = Water Content, percent = = 5 \end{array}$	ndrained Shear Strength (psf) ar Strength (psf) ngth (ksf) th (psf) Similar or Equal too	LL = Liquid Lim PL = Plastic Lir PI = Plasticity I G = Grain Size C = Consolidat	it nit Analysis on Test Laboratory
Jepth (ft.)	Sample No.	<sup>o</sup> en./Rec. (in.)	sample Depth ft.)	Blows (/6 in.) Shear	psf) br RQD (%)	V-value	U C C C C C C C C C C C C C C C C C C C				iption and Remarks		Testing Results/ AASHTO and Unified Class.
25	0)	<u> </u>	0.5		000		ш	<u>446.7</u>	0	Bottom of Exploration at	t 25.0 feet below ground s	25.0-	
- 30 -								-		NO REFUSAL			
- 35 -								-					
- 45 -								-					
								-					
50													
<u>Rema</u>	<u>rks:</u>												
Stratific	ation lines	represent	approximate bou	ndaries betwe	en soil types; ti	ansitions m	ay be	gradual.			Page 2 of 2		
* Water	level read	lings have H	peen made at tim	es and under	conditions state	ed, Ground	vater	fluctuation	s mav o	ccur due to conditions other			
than t	hose pres	ent at the ti	me measuremen	ts were made.	- 5.1.0.0013 3100	_ a. Ground			ay U		Boring No.	: HB-DIX-	102

# <u>Appendix B</u>

Laboratory Test Results

## State of Maine - Department of Transportation Laboratory Testing Summary Sheet

Town(s):	Town(s):         Dixfield         Work Number:         26372.00           Reving & Sample         Station         Offeet         Death         Defenses         Offeet         Death													
Boring & Sample	Station	Offset	Depth	Reference	G.S.D.C.	W.C.	L.L.	P.I.	Cla	ssification				
Identification Number	(Feet)	(Feet)	(Feet)	Number	Sheet	%			Unified	AASHTO	Frost			
HB-DIX-101, 1D	12+37.3	10.7 Lt.	1.0-3.0	379225	1	8.4			SM	A-2-4				
HB-DIX-101, 2D	12+37.3	10.7 Lt.	5.0-7.0	379226	1	14.3			SM	A-4				
HB-DIX-101, 3D	12+37.3	10.7 Lt.	10.0-12.0	379227	1	22.5			SM	A-2-4				
HB-DIX-101, 4D	12+37.3	10.7 Lt.	15.0-17.0	379228	1	16.6			SM	A-2-4				
HB-DIX-101, 5D	12+37.3	10.7 Lt.	20.0-22.0	379229	1	11.3			SW-SM	A-1-b	0			
		ļ			ļ				ļ					
Classification of th	iese soil samp	oles is in a	cordance wit	h AASHTO C	lassificatio	on Syst	em M-	145-4	0. This cla	ssification				
is followed by the	Frost Suscep	otibility Rat	ing" from zero	o (non-frost s	susceptible	e) to Cl	ass IV	(high	ly frost su	sceptible).				
I ne "Frost Sus	ceptibility Rat	ing is bas	bu AAOUTO T				eers C		ication Sy	stems.				
GSDC = Grain Size Distribu	ution Curve as	aetermined	DY AASHIO T	88-93 (1996)	) and/or AS	IMD4	22-63	(кеар	proved 199	98)				

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98 NP = Non Plastic

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



#### UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
0	HB-DIX-101/1D	12+37.3	10.7 LT	1.0-3.0	SAND, some silt, little gravel.	8.4			
۲	HB-DIX-101/2D	12+37.3	10.7 LT	5.0-7.0	Silty SAND, trace gravel.	14.3			
	HB-DIX-101/3D	12+37.3	10.7 LT	10.0-12.0	SAND, some silt, trace gravel.	22.5			
	HB-DIX-101/4D	12+37.3	10.7 LT	15.0-17.0	SAND, little silt, little gravel.	16.6			
	HB-DIX-101/5D	12+37.3	10.7 LT	20.0-22.0	SAND, some gravel, trace silt.	11.3			
X									

WIN				
26372.00				
Town				
Dixfield				
Reported by/Date				
VHITE, TERRY A	1/17/2025			

# Appendix C

Calculations

# Bearing Resistance - Existing Soils:

#### Part 1 - Service Limit State

#### Nominal and factored Bearing Resistance - Box Culvert on Sand

#### Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 10th Edition 2024 Table C10.6.2.5.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Sand (SM)

Based on N-values, soils are very dense near the bearing elevation

Density In Place: very dense

Bearing Resistance: Ordinary Range (ksf) 6 to 10

Recommended Value of Use:  $q_{nom} := 6 \cdot ksf$ 

Resistance factor at the service limit state = $1.0$ (LRFD Article 10.5.5.1)	$b_{\text{service bc}} := 1$	1.0
--	------------------------------	-----

 $q_{factored\_service\_bc} := q_{nom} \cdot \phi_{service\_bc}$ 

 $q_{\text{factored}\_\text{service}\_\text{bc}} = 6 \cdot \text{ksf}$ 

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

#### Part 2 - Strength Limit State

#### Nominal and factored Bearing Resistance - Box Culvert on Sand

Reference: AASHTO LRFD Bridge Design Specifications 10th Edition 2024 - Article 10.6.3.1

Assumptions:

- 1. The box will be founded at ~ Elev 458.60 feet
  - Bottom of Construction will be 2 feet below box invert  $D_{footing} \coloneqq 2.0 \cdot ft$
- 2. Assumed parameters for fill soils:

Saturated unit weight:	$\gamma_s := 125 \cdot pcf$
Internal friction angle:	$\varphi_{ns} \coloneqq 32 \cdot deg$
Undrained shear strength:	$c_{ns} := 0 \cdot psf$

3. Box Culvert parameters

Width of box culvert, B	$B_{box} := 10 \cdot ft$
Length of box culvert, L	$L_{box} := 94 \cdot ft$

Nominal Bearing Resistance per LRFD Equation 10.6.3.1.2a-1

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma BN_{\gamma m} C_{w\gamma}$$

Bearing Capacity Factors - LRFD Table 10.6.3.1.2a-1

For 
$$\phi$$
=32 deg N<sub>c</sub> := 35.5 N<sub>g</sub> := 23.2 N<sub>y</sub> := 30.2

Shape Correction Factors LRFD Table 10.6.3.1.2a.-3

for  $\phi$ =32 degrees

$$s_{c} := 1 + \left(\frac{B_{box}}{L_{box}}\right) \left(\frac{N_{q}}{N_{c}}\right) \qquad s_{c} = 1.07$$
$$s_{\gamma} := 1 - 0.4 \left(\frac{B_{box}}{L_{box}}\right) \qquad s_{\gamma} = 0.9574$$

$$s_q \coloneqq 1 + \left(\frac{B_{box}}{L_{box}} \cdot tan(\phi_{ns})\right) \qquad s_q = 1.07$$

Load Inclination Factors: Assume all are 1.0 (LRFD Article C10.6.3.1.2a)

 $i_c\coloneqq 1.0 \qquad \qquad i_q\coloneqq 1.0 \qquad \qquad i_\gamma\coloneqq 1.0$ 

Depth Correction Factor  $d_q := 1 + 2 \cdot tan(\phi_{ns}) \cdot (1 - sin(\phi_{ns}))^2 \cdot tan \left(\frac{D_{footing}}{B_{box}}\right)^{-1}$   $d_q = 2.3624$  LRFD Eq. 10.6.3.1.2a-10

$N_{cm} := N_c \cdot s_c \cdot i_c$	$N_{cm} = 37.9681$	LRFD Eq. 10.6.3.1.2a-2
$N_{qm} := N_q \cdot s_q \cdot d_q \cdot i_q$	$N_{qm} = 58.45$	LRFD Eq. 10.6.3.1.2a-3
$N_{\gamma m} \coloneqq N_{\gamma} \cdot s_{\gamma} \cdot i_{\gamma}$	$N_{\gamma m} = 28.91$	LRFD Eq. 10.6.3.1.2a-4

Coefficients for Groundwater Depths LRFD Table 10.6.3.1.2a-2

 $q_{nominal} = 23.6 \cdot ksf$ 

#### Factored Bearing Resistance for Strength Limit State

Resistance Factor:  $\phi_h := 0.45$  LRFD Table 10.5.5.2.2-1

 $q_{factored} \coloneqq q_{nominal} \cdot \varphi_b$ 

 $q_{factored} = 10.6 \cdot ksf$ 

Recommend a limiting factored bearing resistance of 10.5 ksf for the Strength Limit State.

## Modulus of Subgrade Reaction:

Reference: Foundation Analysis and Design 5th Edition JE Bowles Section 9-6

Width of box culvert, B		$B_{box} = 10  ft$			
Length of box culvert, L		$L_{box} = 94 \text{ ft}$			
Thickness of box culver	t, t	$t_{box} \coloneqq 12 \cdot in$	assumed		
Depth of box, D		$D_{box} := 15.0 \cdot ft$			
Bearing Resistance:		q <sub>factored_service_bc</sub> =	= 6 · ksf	Calculated above	
Modulus of Elasticity:	Site soils From Bo	at bearing elevatio wles Table 2-8 Moo	n are Sand. L dulus Es for De	lse values for Sand (v ense Sand, ranges fro	ery dense) om 1044 - 1692 ksf

Poisson's Ratio: Site conditions at bearing elevation are Sand. Use values for Sand (very dense) From Bowles Table 2-7 Poisson's Ration µ for Sand ranges from 0.3 - 0.4

Modulus of Elasticity, Es

$$\begin{array}{ccc} \text{Use} & \text{Possion's Ratio, } \mu & \mu := \\ \cdot & \\ E_{prime\_s} := \frac{1 - \mu^2}{E_s} & E_{prime\_s} = 0.00065 \cdot \frac{ft^2}{kip} \end{array}$$

Use

Analyze corner:

Take H as 5\*B as recommended in Bowles Chapter 5

$$\begin{array}{ll} H_{inf}\coloneqq \frac{5\cdot B_{box}}{B_{box}} & H_{inf}=5 & \text{N in Table 5-2} \end{array} \end{array} \begin{array}{ll} \text{From Table 5-2 for N=5 and M=9.4} \\ \hline I_1\coloneqq 0.535 \\ I_2\coloneqq 0.138 \end{array} \end{array}$$

0.3

 $E_s := 1400 \cdot ksf$ 

Determine Steinbrenner influence factor - Bowles Section 5-6:

$$I_s := I_1 + \left[\frac{1 - (2 \cdot \mu)}{1 - \mu}\right] \cdot I_2$$
  $I_s = 0.6139$ 

Determine Influence factor for footing depth - Bowles Figure 5-7

Depth ratio: 
$$\frac{D_{box}}{B_{box}} = 1.5$$
  $\frac{L_{box}}{B_{box}} = 9.4$   $\mu = 0.3$   $I_F := 0.73$ 

Calculate modulus of subgrade reaction - Bowles Eq. 9-7

$$k_s \coloneqq \frac{1}{B_{box} \cdot E_{prime\_s} \cdot I_s \cdot I_F} \qquad \qquad \text{Bowles Eq. 9-7}$$

 $k_s = 199 \cdot pci$ 

Recommend Modulus of Subgrade Reaction of 200 pci