MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN RECOMMENDATIONS

For the Replacement of:

POWNAL CENTER BRIDGE
OVER EAST BRANCH OF THE ROYAL RIVER
STATE ROUTE 9
POWNAL, MAINE

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Cumberland County
PIN 16741.00

Soils Report No. 2010-104
Bridge No. 5646

Fed No. AC-BH-1674(100)X
March 17, 2010

TEDOCS NO. 1022391

State of Maine

Department of Transportation
Bridge Program - Geotechnical
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Series 100 Report

To: Mark Parlin
cc: Jim Wentworth, PE, File, TEDOCS
Author: Kate Maguire, PE
Subject: Pownal Center Bridge
Subsurface Exploration Summary and
Geotechnical Design Recommendations
Document Type: 24
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Route: 9
PIN: 16741.00
Town: Pownal

INTRODUCTION

This report provides the results of a subsurface exploration program and makes geotechnical design recommendations for the replacement of Pownal Center Bridge which carries State Route 9 (Hallowell Road) over the East Branch of the Royal River in Pownal, Maine. See Sheet 1 – Location Map for site location. The purpose of the subsurface investigation was to identify soil and bedrock conditions in order to develop geotechnical design recommendations.

EXISTING SUBSTRUCTURES AND CONDITION

Pownal Center Bridge was built in 1955 and is made up of two (2), 16-foot diameter galvanized steel culverts with a total span of approximately 35 feet. The 2009 Maine Department of Transportation (MaineDOT) maintenance inspection reports indicate that the culverts are in serious condition with "excessive damage" (rating of 3). The Bridge Sufficiency Rating is 72.8. The structure has a scour critical rating of "8 Stable Above Footing" meaning that the foundations have been determined to be stable for the assessed or calculated scour condition. Inspection records note that the north culvert has significant rusting of the flow line and is perforated on both sides. The south culvert is in similar condition but not as advanced. Bank slumping was observed along the channel.

PROPOSED STRUCTURE

The proposed replacement structure is two (2), 14-foot 9-inch diameter steel vertical ellipse pipes with a 16-foot 3-inch rise with a 20 degree skew. The pipes will be founded on the native sands at the site. The proposed vertical and horizontal alignments will closely match the existing site conditions. The bridge will be closed to traffic during the replacement.

GEOLOGIC SETTING

The Pownal Center Bridge in Pownal carries State Route 9 (Hallowell Road) over the East Branch of the Royal River approximately 1.6 miles northeast of the North Yarmouth town line as shown on Sheet 1 - Location Map found at the end of this report.

According to the Surficial Geologic Map of Maine published by the Maine Geological Survey (1985) the surficial soils in the vicinity of the site consist of glaciomarine deposits. Soils in the site area are generally comprised of silt, clay, sand and minor amounts of gravel. Sand is dominant in some areas, but may be underlain by finer-grained sediments. The unit contains small areas of till not completely covered by marine sediments. The unit generally is deposited in areas where the topography is gently sloping except where dissected by modern streams and commonly has a branching network of steep-walled stream gullies. These soils were generally deposited as glacial sediments that accumulated on the ocean floor during the late-glacial marine submergence of lowland areas in southern Maine.

According to the Bedrock Geologic Map of Maine, published by the Maine Geological Survey (1985), the bedrock at the site is identified as igneous carboniferous muscovite-biotite granite commonly known as the Sebago pluton.

SUBSURFACE INVESTIGATION

Subsurface conditions were explored by drilling three (3) test borings at the site. Test borings BB-PEBR-101 and BB-PEBR-101A were drilled in the roadway at the west end of the existing structure. Boring BB-PEBR-102 was drilled in the roadway at the east end of the existing structure. The exploration locations are shown on Sheet 2 - Boring Location Plan and Interpretive Subsurface Profile found at the end of this report.

The borings were drilled on December 8, 2009 using the Maine Department of Transportation (MaineDOT) drill rig. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided at the end of this report.

The borings were drilled using driven cased wash boring and solid stem auger techniques. Soil samples were obtained where possible at 5-foot intervals using Standard Penetration Test (SPT) methods. The bedrock was cored in the borings using an NQ core barrel. The MaineDOT Geotechnical Team member selected the boring locations and drilling methods, designated type and depth of sampling techniques, logged the subsurface conditions encountered and identified field testing requirements. The borings were located in the field by use of a tape after completion if the drilling program.

LABORATORY TESTING

Laboratory testing for samples obtained in the borings consisted of four (4) standard grain size analyses with water content, four (4) grain size analyses with hydrometer and with water content and one (1) Atterberg Limits test. The results of these laboratory tests are found at the end of this report. Moisture content information and other soil test results are included on the Boring Logs at the end of this report.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test borings generally consisted of granular fill, overlying native sand, underlain by bedrock. The boring logs are provided at the end of this report. The following paragraphs are a brief summary description of the strata encountered during exploration activities:

Fill. Beneath the pavement, fill was encountered in all of the borings. The layer was found to be approximately 15.0 feet thick in boring BB-PEBR-101 and approximately 11.0 feet thick in boring BB-PEBR-102. The fill generally consisted of layers of:

- Brown, damp, fine to coarse sand with trace to some silt and broken rock,
- Brown, damp, silt with some sand, little clay and trace gravel,
- Brown, damp, , silty fine sand with trace clay, and
- Olive brown moist, clay with trace sand and trace gravel.

Corrected SPT N-values in the coarse grained fill ranged from 4 to 38 blows per foot (bpf) indicating that the coarse grained fill is very loose to dense in consistency. Water contents from one (1) sample obtained within the coarse grained fill layer was approximately 28%. One (1) grain size analysis with hydrometer conducted on a sample of the coarse grained fill indicate that the soil is classified as an A-4 by the AASHTO Classification System and a SC-SM by the Unified Soil Classification System.

Corrected SPT N-values in the fine grained fill ranged from 8 to 27 bpf indicating that the fine grained fill is medium stiff to very stiff in consistency. Water contents from two (2) samples obtained within the fine grained fill layer ranged from approximately 12% to 35%. Two (2) grain size analyses with hydrometer conducted on samples of the fine grained fill indicate that the soil is classified as an A-4 or A-7-6 by the AASHTO Classification System and a SC-SM or CL by the Unified Soil Classification System.

The following table summarizes the results of the Atterberg Limits test made from one (1) samples of the fine grained fill:

Sample No.	Soil Type	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
BB-PEBR-102 2D	Silt	34.6	41	24	17	0.62

Interpretation of these results indicates the silt has a water content that falls between the liquid limit and plastic limit and a liquidity index of less than 1 indicating soils which are over consolidated.

Native Sand. A layer of native sand was encountered beneath the fill. The thickness of the native sand layer ranged from approximately 8.2 feet in boring BB-PEBR-101 to approximately 16.8 feet thick boring BB-PEBR-102. The native sand generally consisted of brown and grey, damp to wet, fine silty sand with little clay and fine to coarse sand, with little to some gravel, and trace to some silt, with broken rock fragments. Corrected SPT N-values in the native sand layer ranged from 7 to 90 bpf indicating that the soil is loose to very dense in consistency. Water contents from five (5) samples obtained within the native sand layer range from approximately 5% to 21%. Four (4) grain size analyses and one (1) grain size analysis with hydrometer conducted on samples from the native sand layer indicate that the soil is classified as an A-1-b, A-4 or A-2-4 by the AASHTO Classification System and a SC-SM, SW-SM, or SM by the Unified Soil Classification System.

Bedrock. Bedrock was encountered and cored in two of the borings. The table below summarizes the depths to bedrock and corresponding elevations of the top of bedrock:

Boring Number	Approximate Depth to Bedrock	Approximate Bedrock Elevation	RQD
BB- PEBR -101	23.2 feet	82.3 feet	88%
BB- PEBR -102	27.8 feet	77.4 feet	18%

Table 5-1 - Summary of Bedrock Depths, Elevations and RQD

The bedrock is identified as white, grey and black, medium grained, pegmatite granite with mica and garnet and iron staining at fractures. The rock quality designation (RQD) of the bedrock was determined to range from 18 to 88 percent indicating a rock mass quality of very poor to good quality.

Groundwater. Groundwater was observed at a depths ranging from approximately 8.0 feet to 9.3 feet below the existing ground surface. The water levels measured upon completion of drilling are indicated on the boring logs found in the end of this report. Note that water was introduced into the boreholes during the drilling operations. It is likely that the water levels indicated on the boring logs do not represent stabilized groundwater conditions. Additionally, groundwater levels are expected to fluctuate seasonally depending upon the local precipitation magnitudes.

FOUNDATION ALTERNATIVES AND RECOMMENDATIONS

This project has been chosen as a culvert replacement project by the MaineDOT Bridge Program. The twin steel pipe replacement structure will be founded on the native sand at the site. The following paragraphs discuss the geotechnical recommendations for the project.

Frost Protection. Any foundation is placed on granular soils should be designed with an appropriate embedment for frost protection. According to the Modberg Software by the US Army Cold Regions Research and Engineering Laboratory the site has an air design-freezing index of approximately 1195 F-degree days. In a granular soil with a water content of approximately 20%, this correlates to a frost depth of approximately 5.5 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 5.5 feet below finished exterior grade for frost protection.

Bearing Resistance. It is anticipated that the replacement structure will be founded on native sands at the site. Applicable permanent and transient loads are specified in AASHTO LFRD Bridge Design Specifications 4th Edition (LRFD) Article 11.5.5. Buried structure footings shall be proportioned to provide stability against bearing capacity failure.

Additional design and foundation preparation requirements are specified in BDG Sections 8.1 and 8.2.

Bearing resistance for any structure founded on native sands shall be investigated at the strength limit state using factored loads and a factored bearing resistance of 7 ksf. Per BDG Section 8.2.1, the maximum corner pressure shall be 4.0 ksf. If the corner pressure exceeds 4.0 ksf, then the lateral limits of the pipe soil envelope should be increased to half of the span plus 6 feet each side. The bearing resistance factor, ϕ_b, for spread footings on bedrock is 0.45. A factored bearing resistance of 6 ksf may be used when analyzing the service limit state.

Settlement. As the replacement structure will be founded on native sands and the site vertical alignment will not be changed, post-construction settlements are anticipated to be negligible.

Construction Considerations. Construction of the replacement structure will require soil excavation and removal of the existing twin pipes. Construction activities may require the use of cofferdams.

The soil envelope bedding and backfill shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, except that the minimum particle size should be limited to 4 inches. Bedding and backfill should be placed in lifts 6 inches thick, loose measure, and compacted to the manufacturer’s specifications, but no less than 92% of AASHTO T-180 maximum dry density. The existing subgrade should also be compacted to no less than 92% of AASHTO T-180 prior to placing bedding material.

In some locations the native soils may be saturated and significant water seepage may be encountered during construction. There may be localized sloughing and surface instability in some soil slopes. The Contractor should control groundwater, surface water infiltration and soil erosion during construction.

It is recommended that a person qualified by training and experience be present to inspect the condition of the native sand bearing surface prior to placement of the steel pipes.

Using the excavated native soils as structural backfill should not be permitted. The native soils may only be used as common borrow in accordance with MaineDOT Standard Specifications 203 and 703.

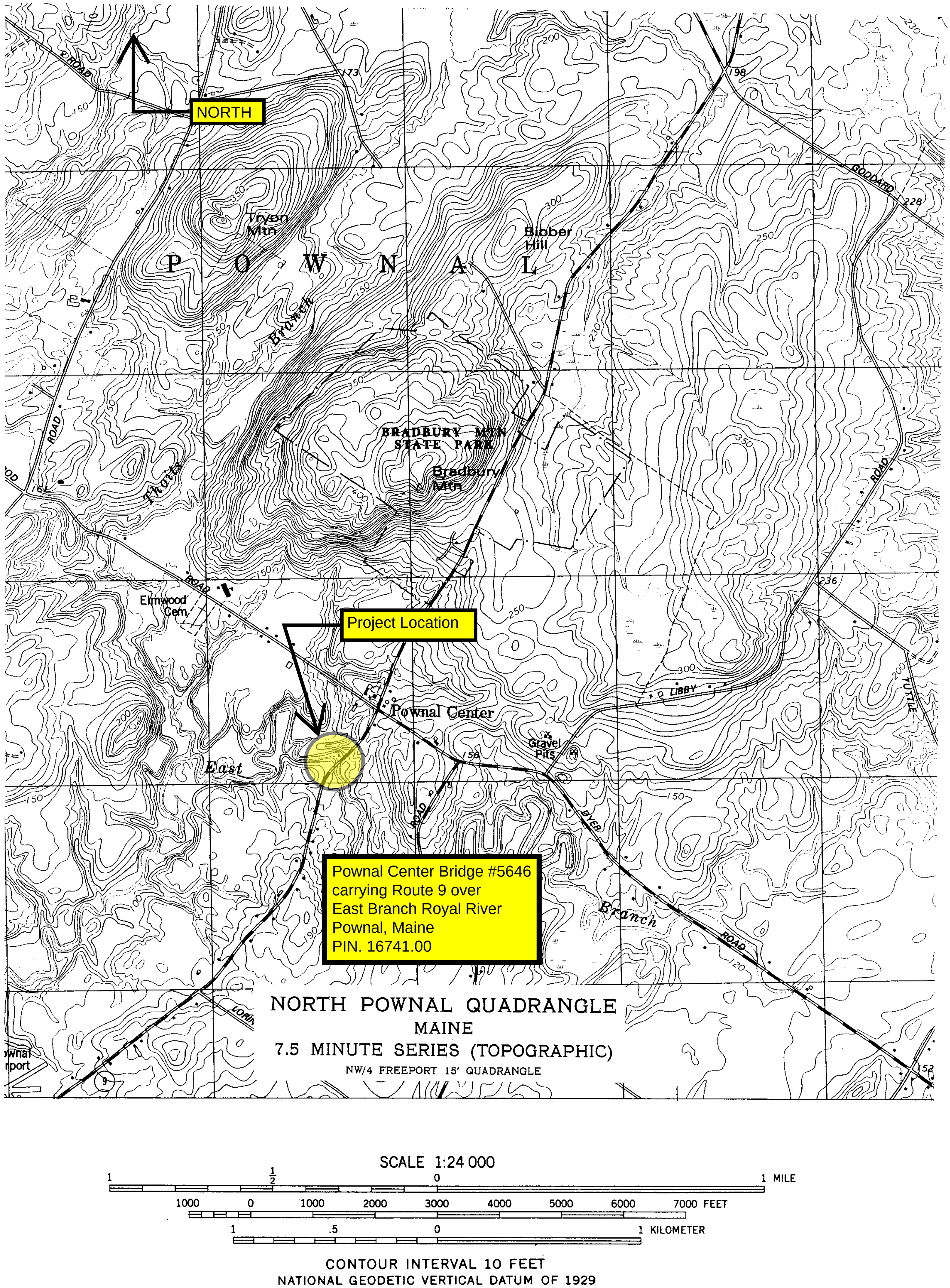
The Contractor will have to excavate the existing subbase and subgrade fill soils in the approaches. These materials should not be used to re-base the new approaches. Excavated subbase sand and gravel may be used as fill below subgrade level in fill areas provided all other requirements of MaineDOT Standard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

CLOSURE

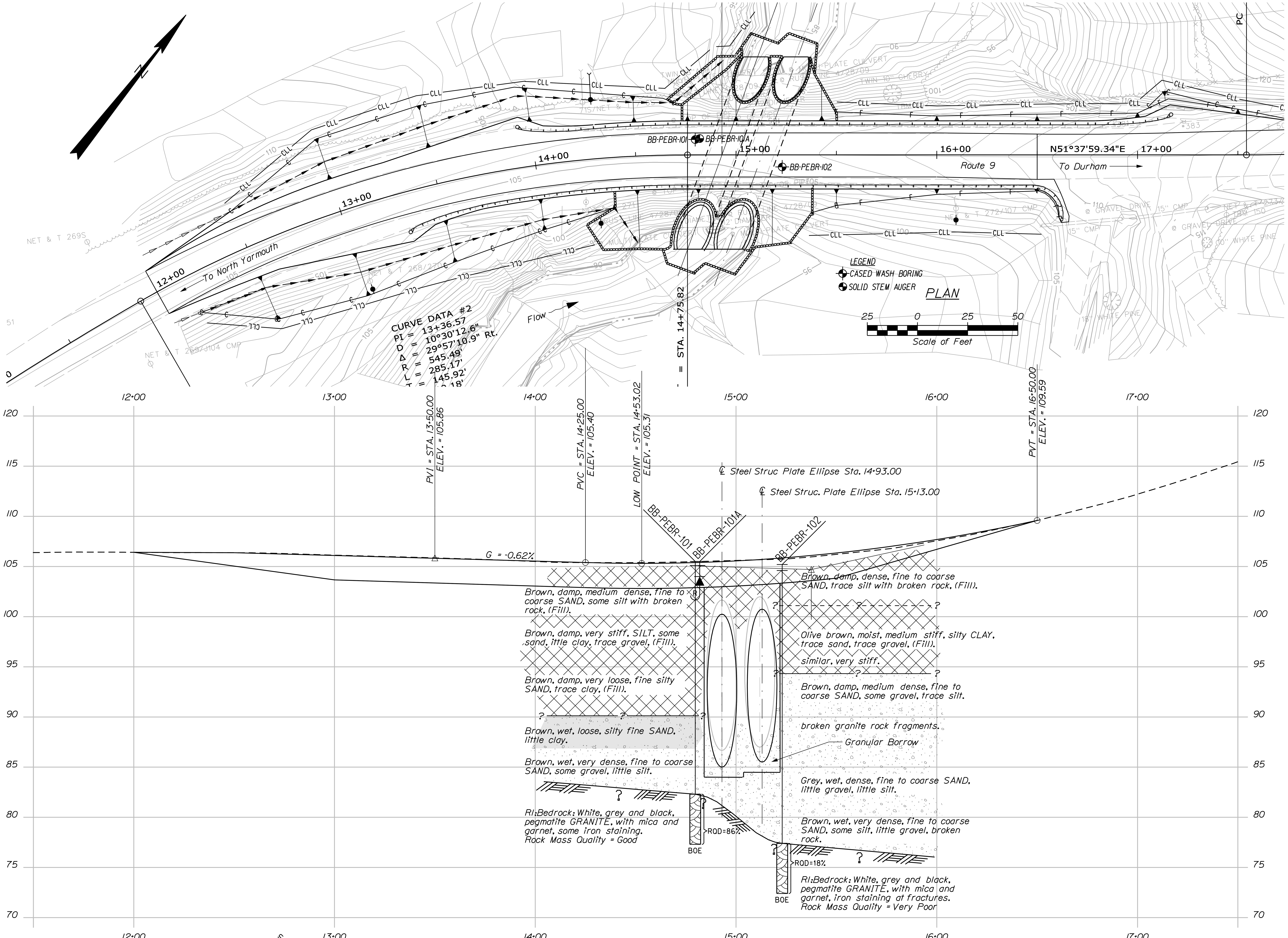
This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Pownal Center Bridge in Pownal, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is implied. 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. Further, the analyses and recommendations are based in part upon limited soil explorations at discrete locations completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

We also recommend that we be provided the opportunity for a general review of the final design and specifications in order that the earthwork and foundation recommendations may be properly interpreted and implemented in the design.

SHEETS


NORTH
Project Location
Pownal Center Bridge #5646
carrying Route 9 over
East Branch Royal River
Pownal, Maine
PIN. 16741.00
P O W N A L
Tryon Mtn
Bibber Hill
BRADBURY MTN STATE PARK
Bradbury Mtn
Elmwood Cem
Pownal Center
Gravel Pits
GODDARD
LIBBY
TUTTLE
BYER
ROAD
Branch
East
NORTH POWNAL QUADRANGLE
MAINE
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 FREEPORT 15' QUADRANGLE
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Filename: ...\GEOTECH\MSTA\005_BLP&SP1.dgn Division: GEOTECH Username: terry.white Date:4/7/2010



PROFILE

HORIZ 25 0 25 50
VERT 5 0 5 10
SCALE

Legend

Boring No. Offset, if shown

Strata Interface

Boring — RQD= Rock Quality Designation for Rock Core Sample

BOE= Bottom Of Exploration

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 transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1674(100)X

PIN 16741.00

BRIDGE NO. 5646

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	K.MAGUIRE	T.WHITE	DEC 2009
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

POWNAL CENTER BRIDGE
EAST BRANCH ROYAL RIVER
POWNAL CUMBERLAND COUNTY

BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

2

OF 3

Filename: ...\msta\007_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:3/15/2010

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch	Location: Pownal, Maine			Boring No.:	BB-PEBR-101
				PIN:	16741.00
Driller:	MaineDOT	Elevation (ft.)	105.5	Auger ID/OD:	5" Solid Stem
Operator:	Wilder/Giguere/Giles	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	K. Maguire	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	12/8/09; 08:30-11:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	14+79.7, 7.7 Lt.	Casing ID/OD:	NW	Water Level*:	8.0' bgs.
Hammer Efficiency Factor: 0.84		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = 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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	105.10	Pavement ——— 0.40	
5	1D	24/16	5.00 - 7.00	9/11/8/7	19	27			Brown, damp, very stiff, SILT, some sand, little clay, trace gravel, (Fill).	G#241470 A-4, SC-SM WC=11.8%
10	2D	24/20	10.00 - 12.00	2/2/1/1	3	4	7		Brown, damp, very loose, fine Silty SAND, trace clay, (Fill).	G#241471 A-4, SC-SM WC=27.7%
							6			
							6			
							9			
							10			
15	3D	24/16	15.00 - 17.00	1/2/3/4	5	7	10	90.50	——— 15.00 Brown, wet, loose, Silty fine SAND, little clay.	G#241472 A-4, SC-SM WC=21.4%
							12			
							22			
							28			
							51			
20	4D	24/6	20.00 - 22.00	21/28/36/18	64	90	48		Brown, wet, very dense, fine to coarse SAND some gravel, little silt.	G#241473 A-1-b, SM WC=10.7%
							74			
							81			
	R1	60/60	23.20 - 28.20	RQD = 86%			a31 NQ-2	82.30	a31 blows for 0.2'. ——— 23.20 Top of Bedrock at Elev. 82.3'. R1:Bedrock: White, grey and black, pegmatite GRANITE with mica and garnet, some iron staining. Rock Mass Quality: Good R1:Core Times (min:sec) 23.2-24.2' (2:33) 24.2-25.2' (1:41) 25.2-26.2' (1:59) 26.2-27.2' (1:35) 27.2-28.2' (2:25) 100% Recovery	
25										
								77.30	——— 28.20 Bottom of Exploration at 28.20 feet below ground surface.	
30										
35										
40										
45										
50										

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-PEBR-101

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch	Location: Pownal, Maine			Boring No.:	BB-PEBR-101A
				PIN:	16741.00
Driller:	MaineDOT	Elevation (ft.)	105.5	Auger ID/OD:	5" Dia.
Operator:	Wilder/Giguere/Giles	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	K. Maguire	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	12/8/09; 08:20-08:30	Drilling Method:	Solid Stem Auger	Core Barrel:	N/A
Boring Location:	14+81.9, 8.2 Lt.	Casing ID/OD:	N/A	Water Level*:	None Observed
Hammer Efficiency Factor: 0.84		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = 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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0								105.10	Pavement ——— 0.40	
	1D	10.8/6	1.00 - 1.90	19/50(4.8")	---			104.00	Augered into obstruction at 0.6' bgs. Brown, damp, medium dense, fine to coarse SAND, some silt with broken rock, (Fill). ——— 1.50 Bottom of Exploration at 1.50 feet below ground surface. AUGER REFUSAL	
5										
10										
15										
20										
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-PEBR-101A

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch	Location: Pownal, Maine			Boring No.:	BB-PEBR-102
				PIN:	16741.00
Driller:	MaineDOT	Elevation (ft.)	105.2	Auger ID/OD:	5" Solid Stem
Operator:	Wilder/Giguere/Giles	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	K. Maguire	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	12/8/09; 11:00-14:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	15+23, 6.0 Rt.	Casing ID/OD:	NW	Water Level*:	9.3' bgs.
Hammer Efficiency Factor: 0.84		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = 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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	104.60	Pavement ——— 0.60	
	1D	24/12	1.00 - 3.00	11/18/9/12	27	38			Brown, damp, dense, fine to coarse SAND, trace silt with broken rock, (Fill).	
								101.20	- - - - 4.00	
5	2D	24/16	5.00 - 7.00	2/3/3/3	6	8			Olive brown, moist, medium stiff, Silty CLAY, trace sand, trace gravel, (Fill).	G#241474 A-7-6, CL WC=34.6% LL=41 PL=24 PI=17
10	3D	24/14	10.00 - 12.00	4/6/6/6	12	17	10		Similar to above to 11.0' bgs.	G#241475 A-1-b, SW-SM WC=5.1%
							27	94.20	——— 11.00 Brown, damp, medium dense, fine to coarse SAND, some gravel, trace silt.	
							47			
							35			
							35			
15	4D	24/1	15.00 - 17.00	19/8/5/10	13	18	20		Broken granite rock fragments.	
							53			
							38			
							38			
							89			
20	5D	24/15	20.00 - 22.00	7/18/18/17	36	50	43		Grey, wet, dense, fine to coarse SAND, little gravel, little silt.	G#236826 A-1-b, SM WC=11.3%
							81			
							69			
							58			
							72			
25	6D	24/12	25.00 - 27.00	8/22/30/28	52	73	57		Brown, wet, very dense, fine to coarse SAND, some silt, little gravel, broken rock in nose of spoon.	G#236827 A-2-4, SM WC=9.5%
							176		a168 blows for 0.8'.	
	R1	60/53	27.80 - 32.80	RQD = 18%			a168 NQ-2	77.40	——— 27.80 Top of Bedrock at Elev. 77.4'. R1:Bedrock: Grey, black and white, pegmatite GRANITE with mica and garnets, iron staining at fractures. Rock Mass Quality: Very Poor R1:Core Times (min:sec) 27.8-28.8' (2:03) 28.8-29.8' (1:47) 29.8-30.8' (1:36) 30.8-31.8' (2:04) 31.8-32.8' (3:10) 88% Recovery	
30										
								72.40	——— 32.80 Bottom of Exploration at 32.80 feet below ground surface.	
35										
40										
45										
50										

Remarks:

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

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Page 1 of 1   Boring No.: BB-PEBR-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

AC-BH-1674(100)X

PIN 16741.00

BRIDGE PLANS

BRIDGE NO. 5646

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	T.WHITE	MAR 2010
CHECKED-REVIEWED	K.MAGUIRE	
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

POWNAL CENTER BRIDGE
EAST BRANCH ROYAL RIVER
POWNEL CUMBERLAND COUNTY

BORING LOGS

SHEET NUMBER

3

OF 3

BORING LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations: (in this order)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
Name (sand, silty sand, clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

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

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) silty or clayey gravels; and (3) silty clayey or gravelly sands. Consistency is rated according to standard penetration resistance.

Modified Burmister System

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

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

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

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

Rock Quality Designation (RQD):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

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

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, 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, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
-spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
-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: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch Royal River
Location: Pownal, Maine

Boring No.: BB-PEBR-101A
PIN: 16741.00

Driller:	MaineDOT	**Elevation (ft.)**	105.5	**Auger ID/OD:**	5" Dia.
Operator:	Wilder/Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/8/09; 08:20-08:30	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	14+81.9, 8.2 Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = 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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0								105.10		Pavement	
										0.40	
	1D	10.8/6	1.00 - 1.90	19/50(4.8")	---			104.00		Augered into obstruction at 0.6' bgs. Brown, damp, medium dense, fine to coarse SAND, some silt with broken rock, (Fill).	
										1.50	
										Bottom of Exploration at 1.50 feet below ground surface. AUGER REFUSAL	
5											
10											
15											
20											
25											

Remarks:

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch Royal River
Location: Pownal, Maine

Boring No.: BB-PEBR-101
PIN: 16741.00

Driller:	MaineDOT	**Elevation (ft.)**	105.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Wilder/Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/8/09; 08:30-11:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+79.7, 7.7 Lt.	**Casing ID/OD:**	NW	**Water Level*:**	8.0' bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	105.10		Pavement 0.40	
5	1D	24/16	5.00 - 7.00	9/11/8/7	19	27				Brown, damp, very stiff, SILT, some sand, little clay, trace gravel, (Fill).	G#241470 A-4, SC-SM WC=11.8%
10	2D	24/20	10.00 - 12.00	2/2/1/1	3	4	7			Brown, damp, very loose, fine Silty SAND, trace clay, (Fill).	G#241471 A-4, SC-SM WC=27.7%
							6				
							6				
							9				
							10				
15	3D	24/16	15.00 - 17.00	1/2/3/4	5	7	10	90.50		15.00 Brown, wet, loose, Silty fine SAND, little clay.	G#241472 A-4, SC-SM WC=21.4%
							12				
							22				
							28				
							51				
20	4D	24/6	20.00 - 22.00	21/28/36/18	64	90	48			Brown, wet, very dense, fine to coarse SAND some gravel, little silt.	G#241473 A-1-b, SM WC=10.7%
							74				
							81				
	R1	60/60	23.20 - 28.20	RQD = 86%			a31 NQ-2	82.30		a31 blows for 0.2'. 23.20 Top of Bedrock at Elev. 82.3'. R1:Bedrock: White, grey and black, pegmatite GRANITE with mica and	
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch Royal River
Location: Pownal, Maine

Boring No.: BB-PEBR-101
PIN: 16741.00

Driller:	MaineDOT	**Elevation (ft.)**	105.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Wilder/Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/8/09; 08:30-11:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+79.7, 7.7 Lt.	**Casing ID/OD:**	NW	**Water Level*:**	8.0' bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										garnet, some iron staining. Rock Mass Quality: Good R1:Core Times (min:sec) 23.2-24.2' (2:33) 24.2-25.2' (1:41) 25.2-26.2' (1:59) 26.2-27.2' (1:35) 27.2-28.2' (2:25) 100% Recovery	
								77.30		28.20 **Bottom of Exploration at 28.20 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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Boring No.: BB-PEBR-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch Royal River
Location: Pownal, Maine

Boring No.: BB-PEBR-102
PIN: 16741.00

Driller:	MaineDOT	**Elevation (ft.)**	105.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Wilder/Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/8/09; 11:00-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	15+23, 6.0 Rt.	**Casing ID/OD:**	NW	**Water Level*:**	9.3' bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (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 No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	104.60		Pavement — 0.60	
	1D	24/12	1.00 - 3.00	11/18/9/12	27	38				Brown, damp, dense, fine to coarse SAND, trace silt with broken rock, (Fill).	
								101.20		— 4.00	
5	2D	24/16	5.00 - 7.00	2/3/3/3	6	8				Olive brown, moist, medium stiff, Silty CLAY, trace sand, trace gravel, (Fill).	G#241474 A-7-6, CL WC=34.6% LL=41 PL=24 PI=17
10	3D	24/14	10.00 - 12.00	4/6/6/6	12	17	10			Similar to above to 11.0' bgs.	G#241475 A-1-b, SW-SM WC=5.1%
							27	94.20		— 11.00 Brown, damp, medium dense, fine to coarse SAND, some gravel, trace silt.	
							47				
							35				
							35				
15	4D	24/1	15.00 - 17.00	19/8/5/10	13	18	20			Broken granite rock fragments.	
							53				
							38				
							38				
							89				
20	5D	24/15	20.00 - 22.00	7/18/18/17	36	50	43			Grey, wet, dense, fine to coarse SAND, little gravel, little silt.	G#236826 A-1-b, SM WC=11.3%
							81				
							69				
							58				
25							72				

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Pownal Center Bridge #5646 carrying Route 9 over East Branch Royal River
Location: Pownal, Maine

Boring No.: BB-PEBR-102
PIN: 16741.00

Driller:	MaineDOT	**Elevation (ft.)**	105.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Wilder/Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/8/09; 11:00-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	15+23, 6.0 Rt.	**Casing ID/OD:**	NW	**Water Level*:**	9.3' bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒	Hydraulic ☐	Rope & Cathead ☐

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q_p = Unconfined Compressive Strength (ksf)
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N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	24/12	25.00 - 27.00	8/22/30/28	52	73	57			Brown, wet, very dense, fine to coarse SAND, some silt, little gravel, broken rock in nose of spoon.	G#236827 A-2-4, SM WC=9.5%
							176				
	R1	60/53	27.80 - 32.80	RQD = 18%			a168			a168 blows for 0.8'.	
							NQ-2	77.40		27.80 Top of Bedrock at Elev. 77.4'. R1:Bedrock: Grey, black and white, pegmatite GRANITE with mica and garnets, iron staining at fractures. Rock Mass Quality: Very Poor R1:Core Times (min:sec) 27.8-28.8' (2:03) 28.8-29.8' (1:47) 29.8-30.8' (1:36) 30.8-31.8' (2:04) 31.8-32.8' (3:10) 88% Recovery	
30											
								72.40		32.80 **Bottom of Exploration at 32.80 feet below ground surface.**	
35											
40											
45											
50											

Remarks:

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LABORATORY TEST RESULTS

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Pownal — Project Number: 16741.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification Unified	Classification AASHTO	Classification Frost
BB-PEBR-101, 1D	14+79.7	7.7 Lt.	5.0-7.0	241470	1	11.8			SC-SM	A-4	IV
BB-PEBR-101, 2D	14+79.7	7.7 Lt.	10.0-12.0	241471	1	27.7			SC-SM	A-4	IV
BB-PEBR-101, 3D	14+79.7	7.7 Lt.	15.0-17.0	241472	1	21.4			SC-SM	A-4	IV
BB-PEBR-101, 4D	14+79.7	7.7 Lt.	20.0-22.0	241473	1	10.7			SM	A-1-b	II
BB-PEBR-102, 2D	15+23	6.0 Rt.	5.0-7.0	241474	2	34.6	41	17	CL	A-7-6	III
BB-PEBR-102, 3D	15+23	6.0 Rt.	10.0-12.0	241475	2	5.1			SW-SM	A-1-b	0
BB-PEBR-102, 5D	15+23	6.0 Rt.	20.0-22.0	236826	2	11.3			SM	A-1-b	II
BB-PEBR-102, 6D	15+23	6.0 Rt.	25.0-27.0	236827	2	9.5			SM	A-2-4	II

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.

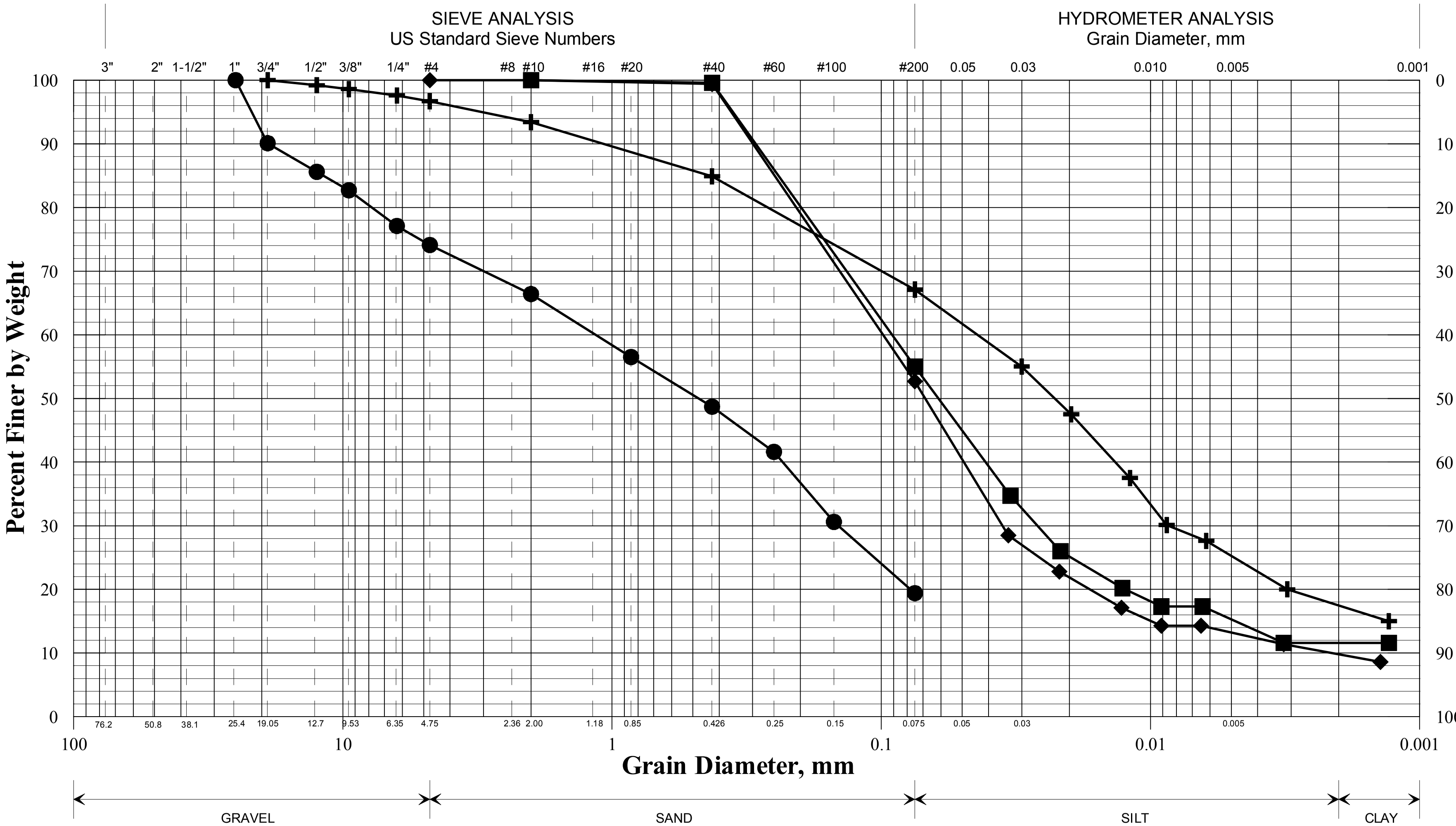
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

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

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

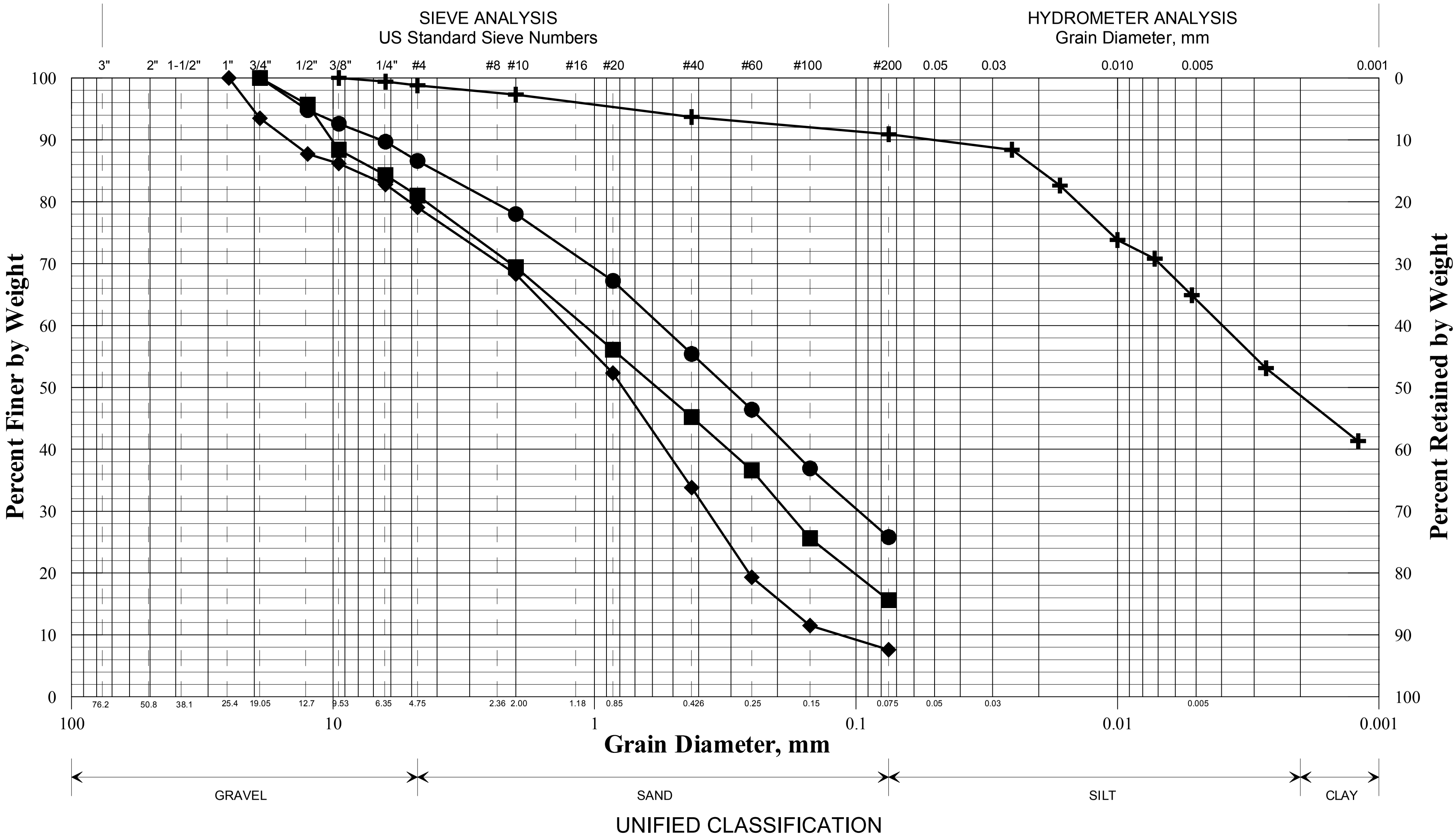


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-PEBR-101/1D	14+79.7	7.7 LT	5.0-7.0	SILT, some sand, little clay, trace gravel.	11.8			
◆	BB-PEBR-101/2D	14+79.7	7.7 LT	10.0-12.0	Silty SAND, trace clay.	27.7			
■	BB-PEBR-101/3D	14+79.7	7.7 LT	15.0-17.0	Silty SAND, little clay.	21.4			
●	BB-PEBR-101/4D	14+79.7	7.7 LT	20.0-22.0	SAND, some gravel, little silt.	10.7			
▲									
✖									

PIN
016741.00
Town
Pownal
Reported by/Date
WHITE, TERRY A 1/29/2010

SHEET 1

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

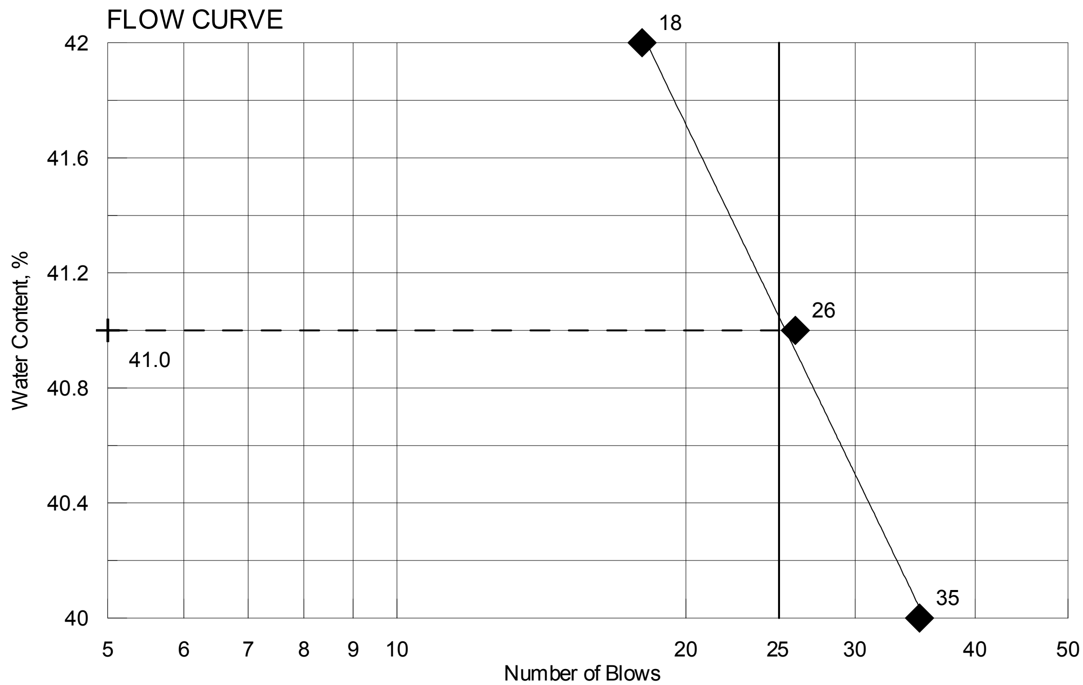


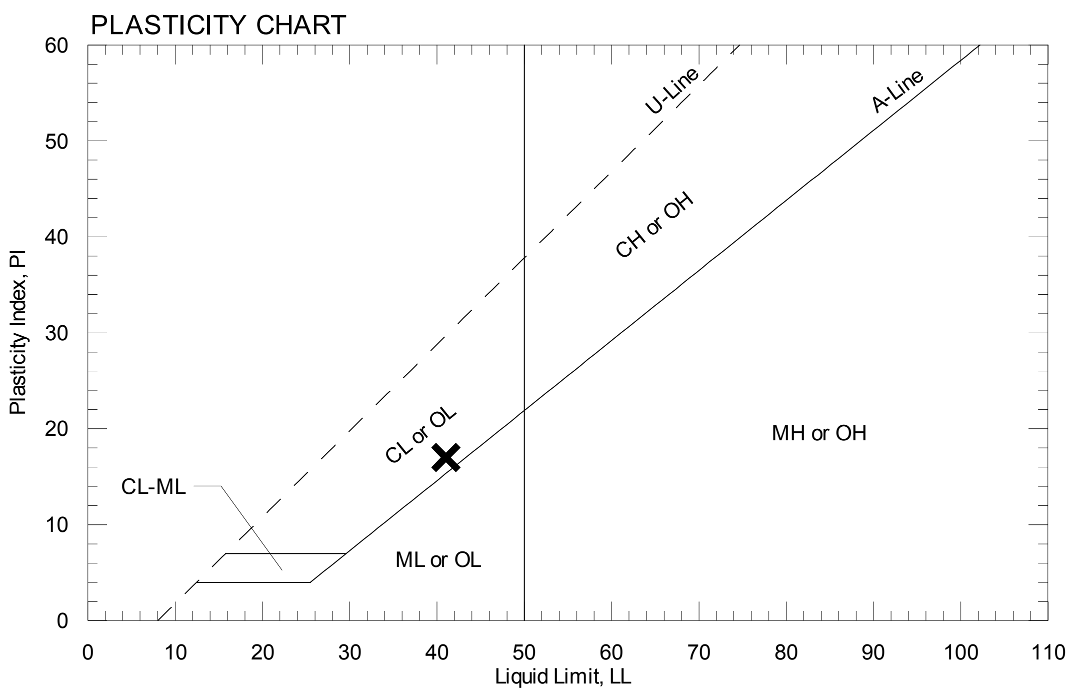
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-PEBR-102/2D	15+23	6.0 RT	5.0-7.0	Silty CLAY, trace sand, trace gravel.	34.6	41	24	17
◆	BB-PEBR-102/3D	15+23	6.0 RT	10.0-12.0	SAND, some gravel, trace silt.	5.1			
■	BB-PEBR-102/5D	15+23	6.0 RT	20.0-22.0	SAND, little gravel, little silt.	11.3			
●	BB-PEBR-102/6D	15+23	6.0 RT	25.0-27.0	SAND, some silt, little gravel.	9.5			
▲									
✖									

PIN
016741.00
Town
Pownal
Reported by/Date
WHITE, TERRY A 1/29/2010

SHEET 2

TOWN	Pownal	Reference No.	241474
PIN	016741.00	Water Content, %	34.6
Sampled	12/8/2010	Plastic Limit	24
Boring No./Sample No.	BB-PEBR-102/2D	Liquid Limit	41
Station	15+23	Plasticity Index	17
Depth	5.0-7.0	Tested By	BBURR





CALCULATIONS

LIQUIDITY INDEX (LI):

Liquidity Index = (natural water content - Plastic Limit) / (Liquid Limit -Plastic Limit)

wc is close to LL	Soil is normally consolidated
wc is close to PL	Soil is some-to-heavily over consolidated
wc is intermediate	Soil is over consolidated
wc is greater than LL	Soil is on the verge of being a viscous liquid when remolded

Sample	Soil	WC	LL	PL	PI	LI	
BB-PEBR-102 2D	Silt	34.6	41	24	17	0.62	Over consolidated

Frost Protection:

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

From the Design Freezing Index Map:
Pownal, Maine
DFI = 1200 degree-days

From the lab testing: soils are coarse grained with a water content = ~20%

From Table 5-1 MaineDOT BDG for Design Freezing Index of 1200 and wc = 20%
Frost Penetration = 60.4 inches

$Frost\_depth := 60.4in$ $\quad Frost\_depth = 5 \cdot ft$

Note: The final depth of footing embedment may be controlled by the scour susceptibility of the foundation material and may, in fact, be deeper than the depth required for frost protection.

Method 2 - Check Frost Depth using Modberg Software

ModBerg Results

Project Location: Portland Wsfo Airport, Maine

Air Design Freezing Index	=	1195 F-days
N-Factor	=	0.80
Surface Design Freezing Index	=	956 F-days
Mean Annual Temperature	=	45.5 deg F
Design Length of Freezing Season	=	118 days

Layer #:Type	t	w%	d	Cf	Cu	Kf	Ku	L
1-Coarse	68.1	20.0	125.0	34	46	3.8	1.9	3,600

t = Layer thickness, in inches.
w% = Moisture content, in percentage of dry density.
d = Dry density, in lbs/cubic ft.
Cf = Heat Capacity of frozen phase, in BTU/(cubic ft degree F).
Cu = Heat Capacity of thawed phase, in BTU/(cubic ft degree F).
Kf = Thermal conductivity in frozen phase, in BTU/(ft hr degree).
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).
L = Latent heat of fusion, in BTU / cubic ft.

Total Depth of Frost Penetration = 5.67 ft = 68.1 in.

$Frost\_depth_{modberg} := 68.1 \cdot in$ $\quad Frost\_depth_{modberg} = 5.7\,ft$

Use Frost Depth = 5.5 feet for design

Bearing Resistance - Native Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - spread footing on fill soils

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 4th 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: Coarse to medium sand, with little gravel (SW, SP)

Based on corrected N-values ranging from 4 to 38 - Soils are loose to medium dense

Consistency In Place: Medium dense

Bearing Resistance: Ordinary Range (ksf) 4 to 8

Recommended Value of Use: 6 ksf

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

Recommended Value: $6 \cdot ksf = 3 \cdot tsf$

Therefore: $q_{nom} := 3 \cdot tsf$

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1)

$q_{factored\_bc} := 3 \cdot tsf$ or $q_{factored\_bc} = 6 \cdot ksf$

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

Part 2 - Strength Limit State

Nominal and factored Bearing Resistance - spread footing on native soils

Reference: Foundation Engineering and Design by JE Bowles Fifth Edition

Assumptions:

1. Footings will be embedded 5.0 feet for frost protection. $D_f := 5.0 \cdot ft$
2. Assumed parameters for fill soils: (Ref: Bowles 5th Ed Table 3-4)
   - Saturated unit weight: $\gamma_s := 125 \cdot pcf$
   - Dry unit weight: $\gamma_d := 120 \cdot pcf$
   - Internal friction angle: $\phi_{ns} := 32 \cdot deg$
   - Undrained shear strength: $c_{ns} := 0 \cdot psf$
3. Use Terzaghi strip equations as L>B
4. Effective stress analysis footing on ϕ-c soil (Bowles 5th Ed. Example 4-1 pg 231)

Depth to Groundwater table: $D_w := 15 \cdot ft$ Based on boring logs

Unit Weight of water: $\gamma_w := 62.4 \cdot pcf$

Look at several footing widths

$$B := \begin{pmatrix} 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{pmatrix} \cdot ft$$

Terzaghi Shape factors from Table 4-1

For a strip footing: $s_c := 1.0$ $s_\gamma := 1.0$

Meyerhof Bearing Capacity Factors - Bowles 5th Ed. table 4-4 pg 223

For ϕ=32 deg

$N_c := 35.47$ $N_q := 23.2$ $N_\gamma := 22.0$

Nominal Bearing Resistance per Terzaghi equation (Bowles 5th Ed. Table 4-1 pg 220)

$q := D_f \cdot (\gamma_s - \gamma_w)$ $q = 0.1565 \cdot tsf$

$$q_{nominal} := c_{ns} \cdot N_c \cdot s_c + q \cdot N_q + 0.5(\gamma_s - \gamma_w)B \cdot N_\gamma \cdot s_\gamma$$

$$q_{nominal} = \begin{pmatrix} 6.4 \\ 7.1 \\ 7.8 \\ 8.5 \\ 9.1 \end{pmatrix} \cdot tsf$$

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

$q_{factored} := q_{nominal} \cdot \phi_b$

$$q_{factored} = \begin{pmatrix} 2.9 \\ 3.2 \\ 3.5 \\ 3.8 \\ 4.1 \end{pmatrix} \cdot tsf$$

Based on these footing widths

$$q_{factored} = \begin{pmatrix} 5.7 \\ 6.4 \\ 7 \\ 7.6 \\ 8.2 \end{pmatrix} \cdot ksf \qquad B = \begin{pmatrix} 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{pmatrix} ft$$

At Strength Limit State:

Recommend a limiting factored bearing resistance of 7 ksf for at 14 foot diameter pipe.

SPECIAL PROVISIONS

SPECIAL PROVISION
SECTION 610
STONE FILL, RIPRAP, STONE BLANKET,
AND STONE DITCH PROTECTION

Add the following paragraph to Section 610.02:

Materials shall meet the requirements of the following Sections of Special Provision 703:

Stone Fill	703.25
Plain and Hand Laid Riprap	703.26
Stone Blanket	703.27
Heavy Riprap	703.28
Definitions	703.32

Add the following paragraph to Section 610.032.a.

Stone fill and stone blanket shall be placed on the slope in a well-knit, compact and uniform layer. The surface stones shall be chinked with smaller stone from the same source.

Add the following paragraph to Section 610.032.b:

Riprap shall be placed on the slope in a well-knit, compact and uniform layer. The surface stones shall be chinked with smaller stone from the same source.

Add the following to Section 610.032:

Section 610.032.d. The grading of riprap, stone fill, stone blanket and stone ditch protection shall be determined by the Resident by visual inspection of the load before it is dumped into place, or, if ordered by the Resident, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load. A separate, reference pile of stone with the required gradation will be placed by the Contractor at a convenient location where the Resident can see and judge by eye the suitability of the rock being placed during the duration of the project. The Resident reserves the right to reject stone at the job site or stockpile, and in place. Stone rejected at the job site or in place shall be removed from the site at no additional cost to the Department.

SPECIAL PROVISION
SECTION 703
AGGREGATES

Replace subsections 703.25 through 703.28 with the following:

703.25 Stone Fill   Stones for stone fill shall consist of hard, sound, durable rock that will not disintegrate by exposure to water or weather. Stone for stone fill shall be angular and rough. Rounded, subrounded, or long thin stones will not be allowed. Stone for stone fill may be obtained from quarries or by screening oversized rock from earth borrow pits. The maximum allowable length to thickness ratio will be 3:1. The minimum stone size (10 lbs) shall have an average dimension of 5 inches. The maximum stone size (500 lbs) shall have a maximum dimension of approximately 36 inches. Larger stones may be used if approved by the Resident. Fifty percent of the stones by volume shall have an average dimension of 12 inches (200 lbs).

703.26 Plain and Hand Laid Riprap   Stone for riprap shall consist of hard, sound durable rock that will not disintegrate by exposure to water or weather. Stone for riprap shall be angular and rough. Rounded, subrounded or long thin stones will not be allowed. The maximum allowable length to width ratio will be 3:1. Stone for riprap may be obtained from quarries or by screening oversized rock from earth borrow pits. The minimum stone size (10 lbs) shall have an average dimension of 5 inches. The maximum stone size (200 lbs) shall have an average dimension of approximately 12 inches. Larger stones may be used if approved by the Resident. Fifty percent of the stones by volume shall have an average dimension greater than 9 inches (50 lbs).

703.27 Stone Blanket   Stones for stone blanket shall consist of sound durable rock that will not disintegrate by exposure to water or weather. Stone for stone blanket shall be angular and rough. Rounded or subrounded stones will not be allowed. Stones may be obtained from quarries or by screening oversized rock from earth borrow pits. The minimum stone size (300 lbs) shall have minimum dimension of 14 inches, and the maximum stone size (3000 lbs) shall have a maximum dimension of approximately 66 inches. Fifty percent of the stones by volume shall have average dimension greater than 24 inches (1000 lbs).

703.28 Heavy Riprap   Stone for heavy riprap shall consist of hard, sound, durable rock that will not disintegrate by exposure to water or weather. Stone for heavy riprap shall be angular and rough. Rounded, subrounded, or thin, flat stones will not be allowed. The maximum allowable length to width ratio will be 3:1. Stone for heavy riprap may be obtained from quarries or by screening oversized rock from earth borrow pits. The minimum stone size (500 lbs) shall have minimum dimension of 15 inches, and at least fifty percent of the stones by volume shall have an average dimension greater than 24 inches (1000 lbs).

Add the following paragraph:

703.32 Definitions (ASTM D 2488, Table 1).

Angular: Particles have sharp edges and relatively plane sides with unpolished surfaces
Subrounded: Particles have nearly plane sides but have well-rounded corners and edges
Rounded: Particles have smoothly curved sides and no edges