AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Jennifer Fitch, P.E., Structures PIIT, Project Manager

MRG CEE

From: Matthew Gardner, Geotechnical Engineer via Callie Ewald, P.E., Senior Geotechnical Engineer

Date: October 26th, 2015

Subject: Woodford BF 010-1(52) – Geotechnical Recommendations

1.0 INTRODUCTION

We have completed our geotechnical investigation for Bridge #18 located on VT Route 9 over an unnamed brook near mile marker 8.997, approximately 2.4 miles west of the intersection with VT Route 8, in the Town of Woodford, Vermont. The proposed project includes the replacement of the existing pipe culvert with a 105 foot long, 8 foot x 7 foot concrete box culvert with new headwalls and wingwalls. Contained herein are the results of our geotechnical analysis and design recommendations as determined using the 2014 AASHTO LRFD Bridge Design Specifications.

2.0 FIELD INVESTIGATION

The field investigation was conducted between September 23rd and 25th, 2015. Four standard penetration borings were drilled to determine the existing subsurface stratum in order to aid in design and construction of the concrete box culvert. Boring locations were collected in the field using our Trimble GPS unit and are based on Vermont State Plane Grid NAD 83. Elevations were interpolated from a VTrans survey file based off of the Northings and Eastings. A summary of the boring locations can be found in Table 2.1. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used to determine them.

Table 2.1 Boring Locations

Boring Number	Station	Offset (ft)	Northing (ft)	Easting (ft)	Elevation (ft)
B-103	475+06	40.8	142298.692	1500789.764	2210.0
B-104	474+90	-35.3	142381.538	1500790.217	2216.0
B-105	475+10	-16.6	142357.869	1500806.262	2220.7
B-106	474+84	16.5	142332.722	1500773.735	2221.2

Borings B-103 through B-106 were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* For Boring B-103, split spoon samples and standard penetration tests (SPT) were taken continuously for depth of approximately 25 feet at which point the boring was terminated. For Boring B-104, split spoon samples and SPT's were taken in 5 foot intervals for the first 10 feet, then continuously until a depth of approximately 24 feet. For Borings B-105 and B-106, split spoon samples and SPT's were taken in 5 foot intervals for the first 15 feet, then taken continuously until a depth of approximately 30 feet. Bedrock was not encountered in any of the borings.

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs when applicable. Soil samples were preserved and returned to the Materials and Research laboratory for testing and further evaluation. Upon completion of the laboratory testing, the boring logs were revised to reflect the results of the laboratory classification analysis.

3.0 FIELD AND LABORATORY TESTING

The standard penetration resistance of the in-situ soil is determined by the number of blows required to drive a 2 inch OD split barrel sampler into the soil with a 140 pound hammer dropped from a height of 30 inches, in accordance with procedures specified in AASHTO T206. During the standard penetration test (SPT), the sampler is driven for a total length of 2 feet, while counting the blows for each 6 inch increment. The SPT N-value, which is defined as the sum of the number of blows required to drive the sampler through the second and third increments, is commonly used with established correlations to estimate a number of soil parameters, particularly the shear strength and density of cohesionless soils. The N-values provided on the boring logs are raw values and have not been corrected for energy, borehole diameter, rod length or overburden pressure. The VT Agency of Transportation has determined a hammer correction value, C_E, to account for the efficiency of the SPT hammer on the drill rig. For Borings B-103 and B-104, a CME 55 Track Rig was used, with a hammer energy correction factor of 1.46. For Borings B-105 and B-106, a CME 45C Skid Rig was used, with a hammer energy correction factor of 1.30. These values, included on the boring logs, were used in calculations to determine soil parameters. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, and percent finer than No. 200 sieve. This testing was conducted on all of the soil samples and results can be found on the attached boring logs.

Due to the presence of organic material in a sample brought back to the laboratory for testing, an additional test was done to determine the percentage of organic content. AASHTO T267, *Standard Method of Test for Determination of Organic Content in Soils by Loss on Ignition* was performed on the sample taken from a depth of 15 to 16 feet in Boring B-106. This method determines the quantitative oxidation of organic matter in these materials and gives a valid estimate of organic content. The percentage of organic contents is included on the boring log.

4.0 SOIL PROFILE

4.1 Culvert Borings

Review of the laboratory data and boring logs revealed the following information pertaining to the soil strata. It should be noted that groundwater elevations are subject to change given the fact that the boreholes were generally left open for a short period of time and groundwater readings were collected during the same day as drilling. Because groundwater elevations can fluctuate seasonally and are affected by temperature and precipitation, groundwater may be encountered during construction even when not previously noted on the boring logs.

B-103: The ground surface elevation at B-103 is approximately 2210.0 feet. The groundwater was measured after drilling at a depth of 3.5 feet below the ground surface on September 23rd, 2015. A large boulder was encountered from 17 feet to 23 feet. Bedrock was not encountered during boring operations.

Depth (Below Ground Surface Elevation)	Soil Profile
0-16 feet	Medium Dense Gravelly Sandy Silt
16-24.2 feet	Very Dense Sandy Gravel (Boulders)

B-104: The ground surface elevation at B-104 is approximately 2216.0 feet. The groundwater was measured before drilling at a depth of 5.5 feet below the ground surface on September 24th, 2015 and the groundwater was measured after drilling at a depth of 3.7 feet below the ground surface on the same day. Cobbles and boulders were encountered from 17.5 feet to 22 feet. Bedrock was not encountered during boring operations.

Depth (Below Ground Surface Elevation)	Soil Profile
0-10 feet	Loose Gravelly Sand
10-17.5 feet	Dense Gravelly Sandy Silt
17.5-22 feet	Cobbles and Boulders
22-24 feet	Very Loose Sand

B-105: The ground surface elevation at B-105 is approximately 2220.7 feet. The groundwater was measured after drilling at a depth of 3.5 feet below the ground surface on September 24th, 2015. Bedrock was not encountered during boring operations.

Depth (Below Ground Surface Elevation)	Soil Profile
0-17 feet	Dense Sandy Gravel
17-25 feet	Medium Dense Silt
25-29.5 feet	Very Dense Gravelly Sandy Silt

B-106: The ground surface elevation at B-106 is approximately 2221.2 feet. The groundwater was measured before drilling at a depth of 3.5 feet below the ground surface on September 25th, 2015. A soil sample from 15 to 16 feet contained 27.8% of organics and was recorded on the log. Bedrock was not encountered during boring operations.

Depth (Below Ground Surface Elevation)	Soil Profile
0-15 feet	Dense Silty Gravelly Sand
15-17 feet	Loose Sandy Gravel (Organics present)
17-27 feet	Medium Dense Silt
27-30.1 feet	Very Dense Gravelly Sand

5.0 ANALYSIS

5.1 Shallow Foundation Analysis

AASHTO's LRFD Bridge Design Specifications Manual (2012) was used as the reference for settlement and bearing resistance equations. Section 10.6.3.1.2 contains the equation used for bearing capacity. Neither depth factors nor load inclination factors were used in analysis as they were not considered pertinent. Hough's Method, used to calculate settlement in normally consolidated cohesionless soils, can be found in section 10.6.2.4.2.

We recommend the bottom of footing to be 4 feet below the ground surface based on frost susceptibility and the silty bearing stratum at the site. An embedment value of 4 feet was used for the strength limit state analysis and an embedment value of 0 ft was used for the service limit state analysis to account for scour conditions. A groundwater elevation at the bottom of footing elevation was used in design.

As per section 10.5.5.1 of the 2014 AASHTO LRFD Bridge Design Specifications, a resistance factor of 1.0 should be applied to the unfactored bearing resistance for use in service limit state design. Service limit state design includes, but is not limited to, settlement and scour. Section 10.5.5.2.2 specifies that a resistance factor of 0.45 should be applied to the unfactored bearing resistance for use in strength limit state design for spread footings on rock and soil. Strength limit state design includes, but is not limited to, checks for bearing resistance, sliding and constructability. Potential for overturning is limited by controlling the location of the resultant of the reaction forces (eccentricity). Eccentricity, e, shall be limited as follows:

Foundations on soil:	$|e| < b/3$
Foundations on rock:	$|e| < 0.45b$

Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. All footing widths presented in this report are <u>effective</u> footing widths.

5.1.1 Bearing Resistance - Wingwalls

The wingwall lengths are not yet determined as this project is in the early stages. Based on geometry of the proposed culvert as well as current topography, a wall length of 8 feet was analyzed conservatively for this preliminary analysis. Due to the similarities of the soils found at the wingwall bearing elevations across the footprint of the project, one bearing stratum can be assumed for use in design of all of the wingwalls.

The elevations of the bottom of footings for the wingwalls were assumed to be 2203 feet at the inlet and 2202 feet at the outlet. It was determined the bearing stratum soil for the wingwalls at the inlet and the outlet has a friction angle, $\phi = 33^{\circ}$ and density, $\gamma = 115$ lb/ft^3. The embedment for the wing wall foundations was assumed to be 4 feet below the bottom of the box to account for scour and frost effects. Figure 5.1 displays the minimum effective footing width per maximum bearing resistance, factored due to LRFD strength and service limit states.

For effective footing widths of 4, 6, 8, and 10 ft, the maximum factored bearing resistances for the controlling service limit state are 3.2, 4.2, 4.9, and 5.1 kips/ft^2 (ksf), respectively.

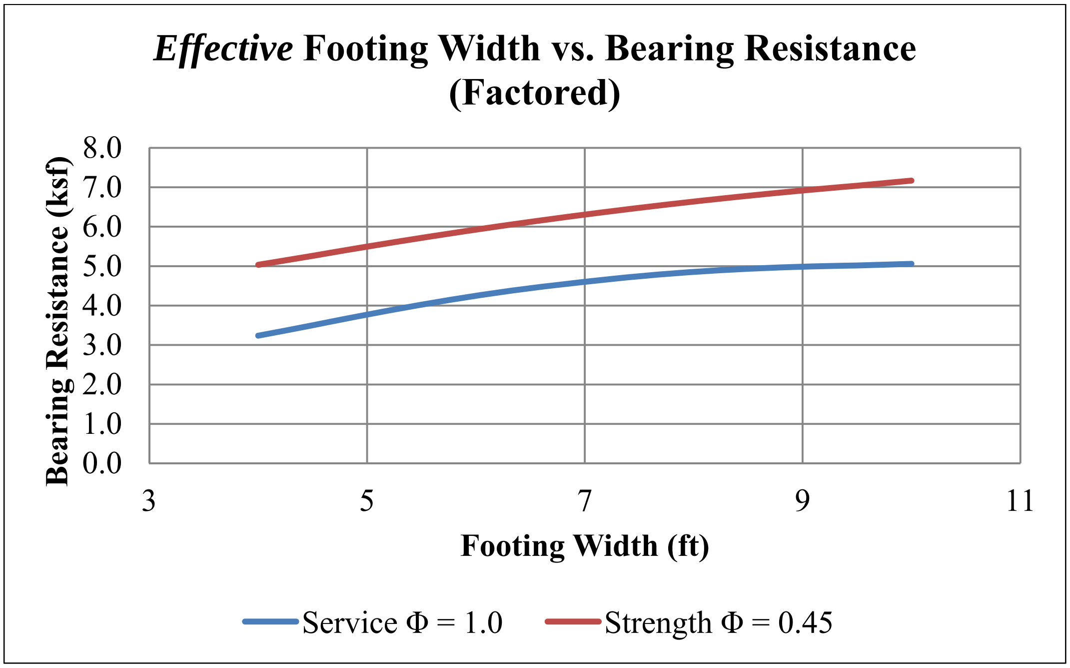

Figure 5.1 *Effective* Footing Width vs. Bearing Resistance for Wingwalls

Soil settlement values were calculated for various footing widths based on the nominal bearing pressure. Found in Figure 5.2 are the settlement values for effective footing widths of 4 to 10 feet for the wingwalls. Due to the granular nature of the foundation soils, settlement is expected to occur during or immediately after construction.

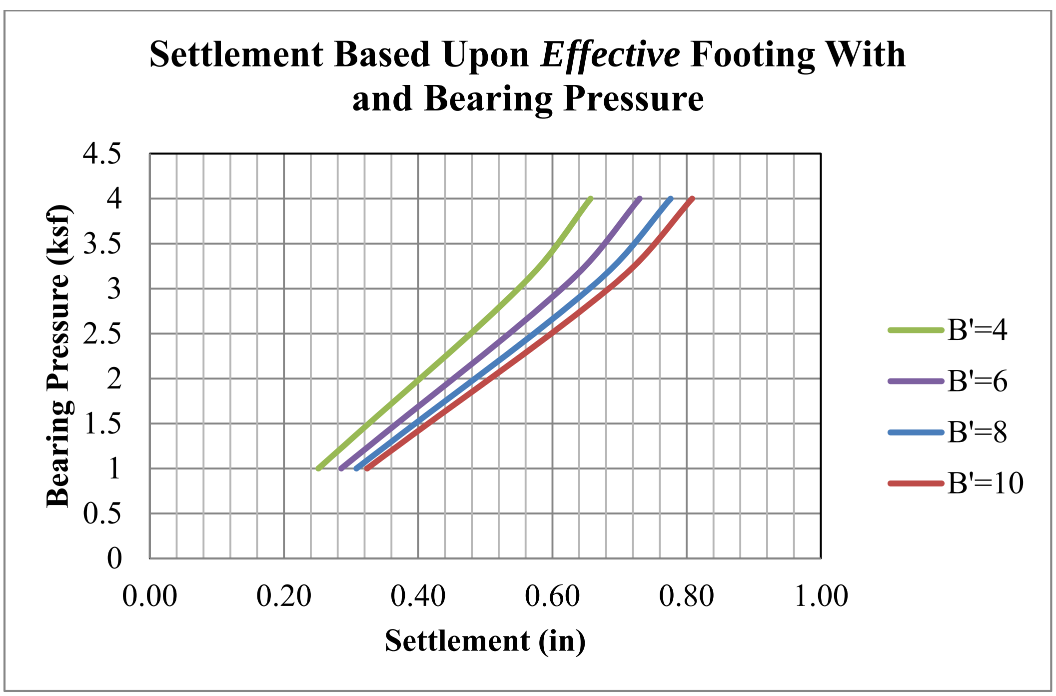

Figure 5.2 Settlement vs. Nominal Bearing Pressure

5.2 Global Stability Analysis

A global stability analysis was conducted to evaluate the overall stability of the soil slope and proposed wingwalls. Using Slide 6.0, developed by Rocscience, a slope stability analysis was performed which evaluated both compound and deep-seated failures. A wall height of 12.0 feet was used in the analysis based on the existing cross sections provided by the Structures Section. The soil slope was modeled using a conservative assumption of a high water table, indicative of a large rain event. According to the VTrans Slope Stability Investigation and Evaluation Manual, GEI 14-01, the Spencer Method is recommended to be used for slope stability analyses of failure surfaces of any shape and a minimum factor of safety of 1.3 shall be used for slopes adjacent to but not directly supporting structures. As a result, the Spencer Method produced a factor of safety against slope failure of 1.419. Figure 5.3 below shows a cross-section of the wingwall with the most critical failure surface using the Spencer Method.

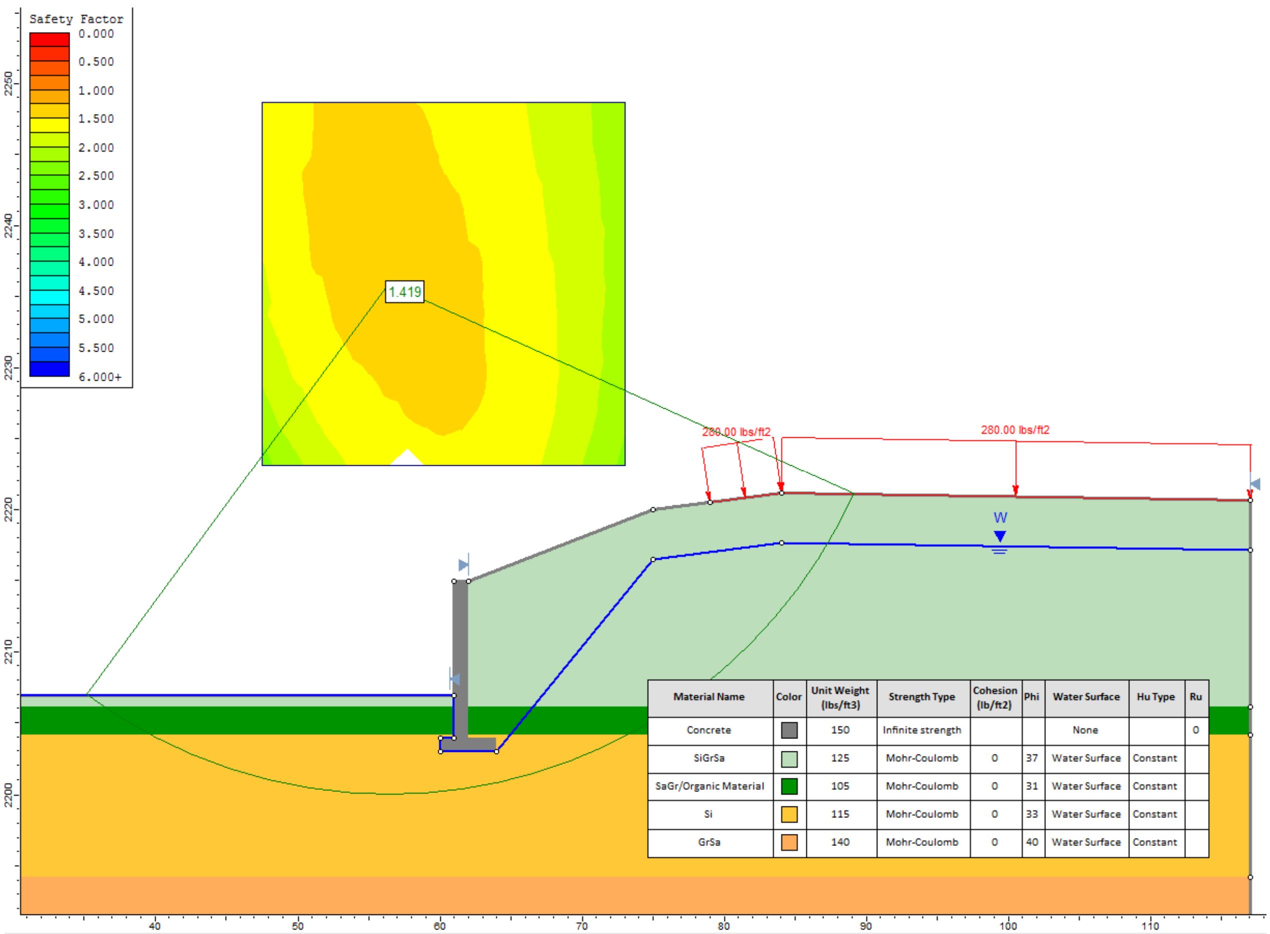

Figure 5.3 Wingwall modeled in Slide 6.0.

6.0 RECOMMENDATIONS

Shallow foundations appear to be feasible for the bottom of box elevation as well as for the wingwalls at the inlet and outlet location. Factored bearing resistances were calculated for various footing widths of the wingwalls and can be found in Figure 5.1. The settlement is expected to occur during or immediately after construction. These calculations are based on the geometric and geotechnical assumptions outlined in Sections 4.0 and 5.0. Sections 10.5.2 and 10.5.3 of AASHTO outline all design states relevant to spread footing design and their respective resistance factors. Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. Table 6.1 shows the appropriate resistance factors for various design states.

Table 6.1. Summary of resistance factors

Design State	Resistance Factor, φ
Settlement	1.0
Scour	1.0
Bearing Resistance	0.45
Sliding	0.80

A one foot layer of material containing organic properties was found in Boring B-106 as described in the laboratory testing section above. The sample tested resulted in an organic content of 27.8% and was encountered at approximately between Elevation 2206.2 and 2205.2 feet. Based on this elevation and the culvert location, we suspect that this layer of organic material may have been the old ground before the culvert was installed. The proposed bottom of box elevation is approximately 2206.5 feet near this location. We anticipate this material will be removed as part of excavation, however, if the organic material is at the bearing elevation, we recommend removing the organic material entirely prior to any placement of precast or cast-in-place concrete.

6.1 Construction Considerations

6.1.1 Cofferdams/Temporary Earthwork Support: The Contractor should be reminded that Section 208.07 of VTrans' *2011 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of its operation for each cofferdam specified in the Contract. The design and structural details of the cofferdam shall be signed, stamped, and dated by a Professional Engineer (Structural or Civil)."

6.1.2 Construction Dewatering: The bottom of foundation elevations for the wingwalls are estimated to be at 2203.0 feet for the inlet and 2202.0 feet for the outlet, with an expected water table above this elevation. Therefore, temporary construction dewatering may be required to construct the foundation. Temporary dewatering will also be necessary to limit disturbance to and maintain the integrity of the bearing surface.

Temporary dewatering can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. Sumps should be provided with filters suitable to prevent pumping of fine-grained soil particles. The water trapped by the temporary dewatering controls should be discharged to settling basins or an approved filter "sock" so that the fine particles suspended in the discharge have adequate time to "settle out" prior to discharge. All effluent, or discharge, should comply with all applicable permits and regulations.

6.1.3 Subgrade Preparation: The subgrade shall be compacted until it is able to provide a firm and stable condition. Wet subgrade soils shall be proofrolled without vibration.

Areas exhibiting excessive weaving, soft, or unstable soils should be excavated and replaced with compacted Granular Backfill for Structures (VTrans' pay item 204.30) in the area of the wingwalls and culvert, and Granular Borrow (VTrans' pay item 203.32) in the embankments. In areas of steep terrain, the subgrade should be stripped, benched, and proofrolled to provide a level surface on which to place fill.

6.1.4 Placement and Compaction of Soils: Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment (such as a small vibratory plate compactor) is used, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement.

General embankment fills should be compacted to a dry density of at least 90% of the maximum dry density determined in accordance with AASHTO T-99. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density equal to 95% of the maximum dry density as determined in accordance with AASHTO T-99.

6.2 Design Parameters: Table 6.2 highlights the geotechnical design parameters of the foundation bearing soil as well as regularly specified aggregates. These values should be used when designing the substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. The design earth pressure coefficients are based on horizontal surfaces (non-sloping and backfill) and a vertical wall face.

Table 6.2. Engineering Properties of Construction Materials

Design Parameter	703.01A - Granular Borrow	704.08 - Granular Backfill for Structures	In-Situ M. Dense Si (Bearing Stratum)
Density (lb/ft^3):	130	140	115
Internal Friction Angle, φ (degrees):	32	35	33
Coefficient of Friction, f			
- mass concrete cast against soil:	0.50	0.55	0.31
- soil against precast/formed concrete:	0.40	0.45	0.25
Active Earth Pressure Coefficient, K_a:	0.31	0.27	0.29
Passive Earth Pressure Coefficient, K_p:	3.22	3.69	3.39
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.43	0.46

7.0 CONCLUSION

If any further analysis is needed or you would like to discuss this report, please contact us at (802) 828-2561. Computer generated boring logs are attached and available in the *M:\Projects\13b270\MaterialsResearch* folder.

Attachments: Boring Logs (4 pages)
Boring Location Plan (1 Page)

cc: Electronic Read File/DJH
Project File/CEE
MRG

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Woodford
BF010-1(52)
VT-9 BR#18

Boring No.: **B-103**

Pin No.: 13b270
Checked By: MRG

Boring Crew: GARROW, NIETO
Date Started: 9/23/15 Date Finished: 9/23/15
VTSPG NAD83: N 142298.69 ft E 1500789.76 ft
Station: 475+06 Offset: 40.80
Ground Elevation: 2210.0 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.

Hammer/Rod Type: Auto/AWJ
Rig: CME 55 TRACK C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
09/23/15	3.5	W.T. after drilling.

Depth (ft)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
	A-1-b, Sa, Dk/brn, Moist, Rec. = 0.4 ft, Lab Note: Roots were within sample.	WH-4-6-4 (10)	19.4	17.9	68.7	13.4
	Field Note:, No Recovery	4-4-1-3 (8)				
5	A-2-4, SiSa, Dk/brn-gry, Wet, Rec. = 0.3 ft, Lab Note: Roots were within sample.	3-2-WH-2 (W.H.)	26.0	19.4	51.3	29.3
	A-2-4, SaGr, Dk/brn-gry, Moist, Rec. = 1.0 ft	3-8-6-4 (14)	12.1	48.4	34.7	16.9
	A-4, GrSaSi, gry-Dk/brn-blk, Moist, Rec. = 1.0 ft, Lab Note: Sample tested non-plastic. A trace (<5%) organics were within sample.	3-4-6-9 (10)	28.0	24.5	34.1	41.4
10	Field Note:, No Recovery	4-6-5-6 (11)				
	A-4, GrSi, gry, Moist, Rec. = 0.4 ft	6-7-6-8 (13)	18.9	29.9	18.1	52.0
15	A-4, Si, gry, Moist, Rec. = 1.4 ft, Lab Note: Sample tested non-plastic.	4-4-5-4 (9)	29.7	0.1	9.3	90.6
	A-4, SaSi, gry, Moist, Rec. = 0.4 ft, Lab Note: Sample tested non-plastic.	6-R@5" (R)	20.6	17.1	31.1	51.8
	Field Note:, Cleaned out casing.					
20	Field Note:, Boulder					
	A-1-B, SaGr, gry-Lt/brn, Moist, Rec. = 1.1 ft, Lab Note: Broken Rock was within sample.	6-38-R@2.5" (R)	9.1	53.3	30.6	16.1
25	Hole stopped @ 24.2 ft					

Remarks:
Hole Collapsed at 3.5 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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AGENCY OF TRANSPORTATION
CONSTRUCTION AND
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CENTRAL LABORATORY

BORING LOG

Woodford
BF010-1(52)
VT-9 BR#18

Boring No.: **B-104**
Page No.: 1 of 1
Pin No.: 13b270
Checked By: MRG

Boring Crew: GARROW, NIETO
Date Started: 9/23/15 Date Finished: 9/24/15
VTSPG NAD83: N 142381.54 ft E 1500790.22 ft
Station: 474+90 Offset: -35.30
Ground Elevation: 2216.0 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
09/24/15	3.7	W.T. after drilling.
09/24/15	5.5	W.T. before drilling.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		A-1-B, GrSa, brn, Moist, Rec. = 0.4 ft	WH-1-3-4 (4)	12.2	33.8	53.5	12.7
		Field Note:, Cleaned out casing					
5		A-1-b, SaGr, Lt/brn, Moist, Rec. = 0.4 ft	4-3-4-4 (7)	10.5	53.4	28.4	18.2
		Field Note:, Cleaned out casing					
10		A-4, SaSi, gry, Moist, Rec. = 1.2 ft, Lab Note: Sample tested non-plastic.	3-3-7-5 (10)	25.8	2.6	27.9	69.5
		Field Note:, No Recovery	9-11-11-12 (22)				
15		A-4, GrSi, gry, Moist, Rec. = 1.3 ft, Lab note: Broken rock was within sample.	5-18-15-18 (33)	15.4	37.1	19.3	43.6
		A-1-b, SaGr, gry, Moist, Rec. = 1.1 ft, Lab note: Broken rock was within sample.	19-14-19-17 (33)	8.1	51.1	32.5	16.4
		Field Note:, Cleaned out casing					
		Field Note:, Cobbles and Boulders					
20		Field Note:, No Recovery	R@1.5" (R)				
		A-2-4, Sa, gry, Moist, Rec. = 1.1 ft	2-1-1-1 (2)	22.5	8.7	79.4	11.9
25		Hole stopped @ 24.0 ft					

Remarks:
Hole Collapsed at 6.9 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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BORING LOG

Woodford
BF010-1(52)
VT-9 BR#18

Boring No.: **B-105**
Page No.: 1 of 1
Pin No.: 13b270
Checked By: MRG

Boring Crew: GARROW, JUDKINS, NIETO
Date Started: 9/24/15 Date Finished: 9/24/15
VTSPG NAD83: N 142357.87 ft E 1500806.26 ft
Station: 475+10 Offset: -16.60
Ground Elevation: 2220.7 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.

Hammer/Rod Type: Auto/AWJ
Rig: CME 45C SKID C_E = Unknown

Groundwater Observations

Date	Depth (ft)	Notes
09/24/15	3.5	W.T. after drilling.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Asphalt Pavement, 0.0 ft - 0.67 ft					
		A-1-B, GrSa, Lt/brn, Moist, Rec. = 0.8 ft	7-8-11-11 (19)	8.6	43.3	45.9	10.8
		Field Note:, Cleaned out casing.					
5		Field Note:, No Recovery	7-9-6-8 (15)				
		Field Note:, Cleaned out casing.					
10		A-1-B, SaGr, Lt/brn-Lt/gry, Moist, Rec. = 0.8 ft	6-33-8-4 (41)	12.3	44.0	37.7	18.3
		Field Note:, Cleaned out casing.					
15		A-1-a, Gr, gry-brn, Moist, Rec. = 0.6 ft, Lab Note: A lot of broken rock was within sample. Field Note:, Cleaned out casing.	6-18-12-6 (30)	14.6	75.7	18.9	5.4
		Field Note:, No Recovery	4-6-6-7 (12)				
20		A-4, Si, gry, Moist, Rec. = 0.8 ft	6-5-6-4 (11)	27.8	4.9	7.6	87.5
		A-4, Si, gry, Moist, Rec. = 1.4 ft, Lab Note: Sample tested non-plastic.	4-4-4-4 (8)	29.5	2.9	6.7	90.4
		A-4, Si, gry, Moist, Rec. = 0.3 ft, Lab Note: Sample tested non-plastic.	3-4-4-7 (8)	28.9	6.6	9.3	84.1
25		A-4, GrSi, gry, MTW, Rec. = 0.8 ft, Lab Note: Broken rock was within sample.	4-8-R@5" (R)	22.8	34.8	17.5	47.7
		A-4, GrSaSi, gry, MTW, Rec. = 0.5 ft	R@6" (R)	19.7	20.9	37.8	41.3
		Field Note:, No Recovery	R@6" (R)				
30		Hole stopped @ 29.5 ft					

Remarks:
Hole Collapsed at 9.2 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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BORING LOG

Woodford
BF010-1(52)
VT-9 BR#18

Boring No.: **B-106**
Page No.: 1 of 1
Pin No.: 13b270
Checked By: MRG

Boring Crew: GARROW, NIETO
Date Started: 9/24/15 Date Finished: 9/25/15
VTSPG NAD83: N 142332.72 ft E 1500773.74 ft
Station: 474+84 Offset: 16.50
Ground Elevation: 2221.2 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.

Hammer/Rod Type: Auto/AWJ
Rig: CME 45C SKID C_E = Unknown

Groundwater Observations

Date	Depth (ft)	Notes
09/25/15	3.5	W.T. before drilling.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Asphalt Pavement, 0.0 ft - 0.62 ft					
		A-1-B, GrSa, Lt/brn, Moist, Rec. = 1.3 ft	9-10-11-12 (21)	6.7	29.6	56.2	14.2
		Field Note:, Cleaned out casing.					
5		A-1-B, SiSaGr, brn, Moist, Rec. = 0.8 ft	16-12-12-15 (24)	10.9	40.7	35.2	24.1
		Field Note:, Cleaned out casing.					
10		A-1-B, SiGrSa, Lt/brn, Moist, Rec. = 0.2 ft	6-6-4-3 (10)	14.9	34.9	45.1	20.0
15		A-1-A, SaGr, blk-Dk/brn, Moist, Rec. = 0.4 ft, Lab Note: Sample contained 27.8% organics (AASHTO T-267). Broken rock was within sample.	2-1-4-5 (5)	107.0	66.4	28.2	5.4
		A-4, SiSa, brn, Moist, Rec. = 0.6 ft, Lab Note: Sample contained a trace (<5%) organics. (AASHTO T-267)		80.8	1.4	60.9	37.7
		A-4, SaSi, gry, Moist, Rec. = 1.4 ft	4-3-2-5 (5)	24.2	1.0	45.5	53.5
		A-4, Si, gry, Moist, Rec. = 1.1 ft, Lab Note: Broken rock was within sample.	9-6-6-16 (12)	22.6	14.3	19.1	66.6
20		A-4, SiSa, gry, Moist, Rec. = 0.3 ft	13-9-10-8 (19)	27.0	2.2	51.9	45.9
		Field Note:, Cleaned out casing.					
		A-4, Si, gry, Moist, Rec. = 1.0 ft	3-3-4-3 (7)	29.2	6.2	11.0	82.8
25		A-4, Si, gry, Moist, Rec. = 1.0 ft, Lab Note: Sample tested non-plastic. A very small amount of clay was present in the sample.	2-3-3-4 (6)	24.7	5.2	5.9	88.9
		Field Note:, Cleaned out casing.					
		A-4, GrSi, gry, Moist, Rec. = 0.5 ft, Lab Note: Broken rock was within sample.	9-16-R@0" (R)	18.5	33.1	18.0	48.9
		Field Note:, Cleaned out casing.					
		A-1-B, GrSa, gry, Moist, Rec. = 0.5 ft, Lab Note: Broken rock was within sample.	13-42-R@1.5" (R)	15.0	41.4	50.4	8.2
30		Hole stopped @ 30.1 ft					

Remarks:
Hole collapsed at 11.2 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.


B-104
STA = 474+90.00
OFFSET = -35.30
ELEV. = 2216.0
N 142381.54
E 1500790.22
B-105
STA = 475+10.00
OFFSET = -16.60
ELEV. = 2220.70
N 142357.87
E 1500806.26
BROOK FLOW
52+00
BEGIN APPROACH
STA 474+25.00
BEGIN PROJECT
STA 474+75.00
END PROJECT
STA 475+20.00
END APPROACH
STA 475+70.00
EXISTING
RIGHT-OF-WAY
VT ROUTE 9
TO BENNINGTON
VT ROUTE 9
TO SEARSBURG
472+00
473+00
474+00
475+00
476+00
477+00
478+00
51+00
50+00
HVCTRL
20
HVCTRL
21
CONCEPTUAL
PROJECT LIMITS
GRAVEL DRIVE
VAST TRAIL
AER E&T
BRIDGE
B-106
STA = 474+84.00
OFFSET = 16.50
ELEV. = 2221.20
N 142332.72
E 1500773.74
B-103
STA = 475+06.00
OFFSET = 40.80
ELEV. = 2210.00
N 142298.69
E 1500789.76
PI
STA 475+99.17
EXISTING CURVE
DELTA = 23°00′40″
D = 1°30′00″
R = 3819.72′
T = 777.51′
L = 1534.07′
E = 78.33′
N
VT STATE PLANE GRID
EXISTING 7′ CGMPP
92′ LONG, BUILT 1919
RECONSTRUCTED 1965
6′ AVERAGE COVER
38 SQFT WATERWAY AREA
ALTERNATIVE 3
SCALE 1″ = 20′-0″
20 0 20
BORING PLAN
Revised by the Geotechnical Engineering Section on 10/20/15
PROJECT NAME: WOODFORD
PROJECT NUMBER: BF 010-1(52)
FILE NAME: 13b270/s13b270border.dgn
PROJECT LEADER: J.FITCH
DESIGNED BY: G.SWEENY
ALTERNATIVE #3 LAYOUT
PLOT DATE: 27-MAY-2015
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 7 OF 13