

To: Patti Coburn, Traffic Design Project Manager

From: ^{CEE} Callie Ewald, P. E., Senior Geotechnical Engineer, via ^{CCB} Christopher C. Benda, P.E., Geotechnical Engineering Manager

Date: April 22nd, 2015

Subject: Essex STP 5400(7) Geotechnical Data Report

1.0 INTRODUCTION

We have completed our geotechnical investigation for the Essex STP 5400(7) project located at the intersection of VT Route 2A and the VT Route 289 on and off ramps in Essex, Vermont. This project consists of widening the roadway, the installation of three new traffic signals, and other highway related items. This report summarizes the boring and laboratory testing information from our subsurface investigation and contains geotechnical parameters to be used by the roadway and foundation designer.

2.0 FIELD INVESTIGATION

The field investigation was conducted on March 24th and 25th, 2015. Three standard penetration borings were drilled in the approximate locations of the mast arms to determine the subsurface profile for design and construction of the mast arm foundations. Locations for all of the borings can be found in Table 2.1, as well as in the attached Boring Location Plan. Boring locations were supplied in the Geotechnical Services Request Form dated November 19, 2014 by the Traffic Design Section. The values for the Northings and Eastings are based on the Vermont State Plane Grid NAD 83 Coordinate System, and were located using a handheld Trimble GPS unit. The stations, offsets, and elevations were then determined based on the Northings and Eastings.

Table 2.1. Boring Locations

| Boring | Structure | Station (ft) | Offset (ft) | Northing (ft) | Easting (ft) | Elevation (ft) |
|---------------|------------------|---------------------|--------------------|----------------------|---------------------|-----------------------|
| B-101 | Mast Arm | 104+61.5 | -48.9 | 735170.42 | 1478018.75 | 350.0 |
| B-102 | Mast Arm | 104+53.5 | 38.1 | 735195.94 | 1478102.37 | 350.0 |
| B-103 | Mast Arm | 115+85.5 | -33.5 | 736272.15 | 1477813.69 | 367.0 |

Borings were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils*. During the boring operations, split spoon samples and standard penetration tests (SPT) were taken continuously for the first 12 feet and then at 5 foot intervals until a depth of approximately 25 feet. No bedrock was encountered during the drilling process. When cohesive soils were encountered during drilling operations, undisturbed sampling was performed in accordance with AASHTO T207, *Thin Walled Tube Sampling of Soils*. In boring B-103, a shelby tube was attempted to be pushed from 24 to 26 feet, however refusal of the Shelby tube was encountered at 25.2 feet.

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs. Soil samples were preserved and returned to Construction and Materials Bureau

Central 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 results. The attached boring logs display the types of soils and strata encountered and include the laboratory test results, SPT data, and any pertinent observations made by the boring crew.

3.0 FIELD AND LABORATORY TESTS

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 energy correction factor, C_E , to account for the efficiency of the SPT hammer on the drill rig. For this project, a CME 45C track rig was used, with a C_E of 1.34. This value, included on the boring logs, was used in soil parameter calculations. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, percent finer than No. 200 sieve, and liquid and plastic limits when applicable.

4.0 SOIL PROFILE

Review of 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 boreholes were generally left open for a short period of time. Because groundwater elevations can fluctuate seasonally and are affected by temperature and precipitation, groundwater may be encountered during construction when not previously noted in the logs.

A soil layer designation letter is assigned to each soil stratum to help identify the soil parameters determined to be used in design as listed in Table 5.1 below. There were five soil strata identified to be used in design of the four mast arms.

4.1 B-101 The ground surface elevation at B-101 was approximately 350 feet. Groundwater was encountered during drilling operations and was measured at a depth of 21.7 feet below the ground surface.

Table 4.1. B-101 Soil Strata

| Depth (Below Ground Surface Elevation) | Soil Profile | Soil Layer Designation |
|---|-------------------------------------|-------------------------------|
| 0 – 14 feet | Medium Dense Gravelly Sand and Sand | A |
| 14 – 18 feet | Loose Silty Sand | B |
| 18 – 25 feet | Very Loose Silt | E |

4.2 B-102 The ground surface elevation at B-102 was approximately 350 feet. Groundwater was encountered during drilling operations and was measured at a depth of 18.8 feet below the ground surface.

Table 4.2. B-102 Soil Strata

| Depth (Below Ground Surface Elevation) | Soil Profile | Soil Layer Designation |
|--|-------------------|------------------------|
| 0 – 6 feet | Medium Dense Sand | A |
| 6 – 16 feet | Loose Sand | B |
| 16 – 26 feet | Very Loose Silt | D |

4.3 B-103 The ground surface elevation at B-103 was approximately 367 feet. Groundwater was encountered during drilling operations and was measured at a depth of 19.2 feet below the ground surface. Refusal

Table 4.3. B-103 Soil Strata

| Depth (Below Ground Surface Elevation) | Soil Profile | Soil Layer Designation |
|--|--------------------------------|------------------------|
| 0 – 12 feet | Medium Dense Sand | A |
| 12 – 18 feet | Medium Dense Silt | C |
| 18 – 25.2 feet | Very Loose Silt and Silty Clay | E |

5.0 RECOMMENDATIONS

5.1 Design Guidelines

The Geotechnical Engineering unit of VTrans has developed *Materials and Research Engineering Instructions (MREI) 10-01*, which “standardizes VTrans’ foundation designs for overhead structures such as signal or sign bridges, mast arms, and strain poles during plan (preliminary and final) development or construction.” This document should be referenced for the contractor’s use. The document is available on the Agency’s website at the following address:

http://vtransengineering.vermont.gov/sites/aot_program_development/files/documents/materialsandresearch/MandRSoilEI - Overhead Structures_030910.pdf

5.2 Design Parameters

Based on the soil profiles above, laboratory testing, and attached boring logs, the in-situ soil properties can be found in Table 5.1, while common construction materials can be found in Table 5.2. These values should be used in the design of the mast arm foundations at each location.

The boreholes were generally only open for a short time period during the drilling and clean-up activities. In addition, the soils at the site contain fines and produce water slowly. Since groundwater elevations can fluctuate seasonally and are effected by temperature and precipitation, **a groundwater level of 2 feet below the ground surface shall be used in design.**

The values listed below should be used when designing any substructure unit. 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. K_a and K_p values are based on a vertical back of wall and a horizontal ground surface behind the wall.

Table 5.1. Engineering Properties of In-Situ Soils

| Soil Layer | A | B | C | D | E |
|---|----------------------|-----------------|-----------------|-----------------|------------------------|
| | Med. Dense GrSa & Sa | Loose Sa & SiSa | Med. Dense Silt | Very Loose Silt | Very Loose Silt & ClSi |
| Density, γ (lbs/ft ³): | 120 | 115 | 110 | 105 | 105 |
| Internal Friction Angle, ϕ (degrees) | 34 | 31 | 34 | 28 | 29 |
| Soil Modulus, k (lb/in ³) | 90 | 20 | 60 | 20 | 20 |
| Coefficient of Friction, f | | | | | |
| - mass concrete cast against soil: | 0.46 | 0.39 | 0.32 | 0.32 | 0.32 |
| - soil against precast concrete: | 0.38 | 0.31 | 0.25 | 0.25 | 0.25 |
| Active Earth Pressure Coef., K_a : | 0.283 | 0.320 | 0.283 | 0.361 | 0.347 |
| Passive Earth Pressure Coef., K_p : | 3.537 | 3.124 | 3.537 | 2.770 | 2.882 |
| At-Rest Earth Pressure Coef., K_o : | 0.441 | 0.485 | 0.441 | 0.531 | 0.515 |

Table 5.2. Engineering Properties of Construction Materials

| | 703.01A - Granular Borrow | 704.08 - Granular Backfill for Structures |
|---|----------------------------------|--|
| Density (lb/ft ³): | 130 | 140 |
| | | |
| Internal Friction Angle, ϕ (degrees) | 32 | 34 |
| | | |
| Coefficient of Friction, f | | |
| - mass concrete cast against soil: | 0.45 | 0.55 |
| - soil against precast/formed concrete | 0.40 | 0.48 |
| | | |
| Active Earth Pressure Coefficient, K_a : | 0.307 | 0.283 |
| Passive Earth Pressure Coefficient, K_p : | 3.255 | 3.537 |
| At-Rest Earth Pressure Coefficient, K_0 : | 0.470 | 0.441 |

6.0 CONCLUSION

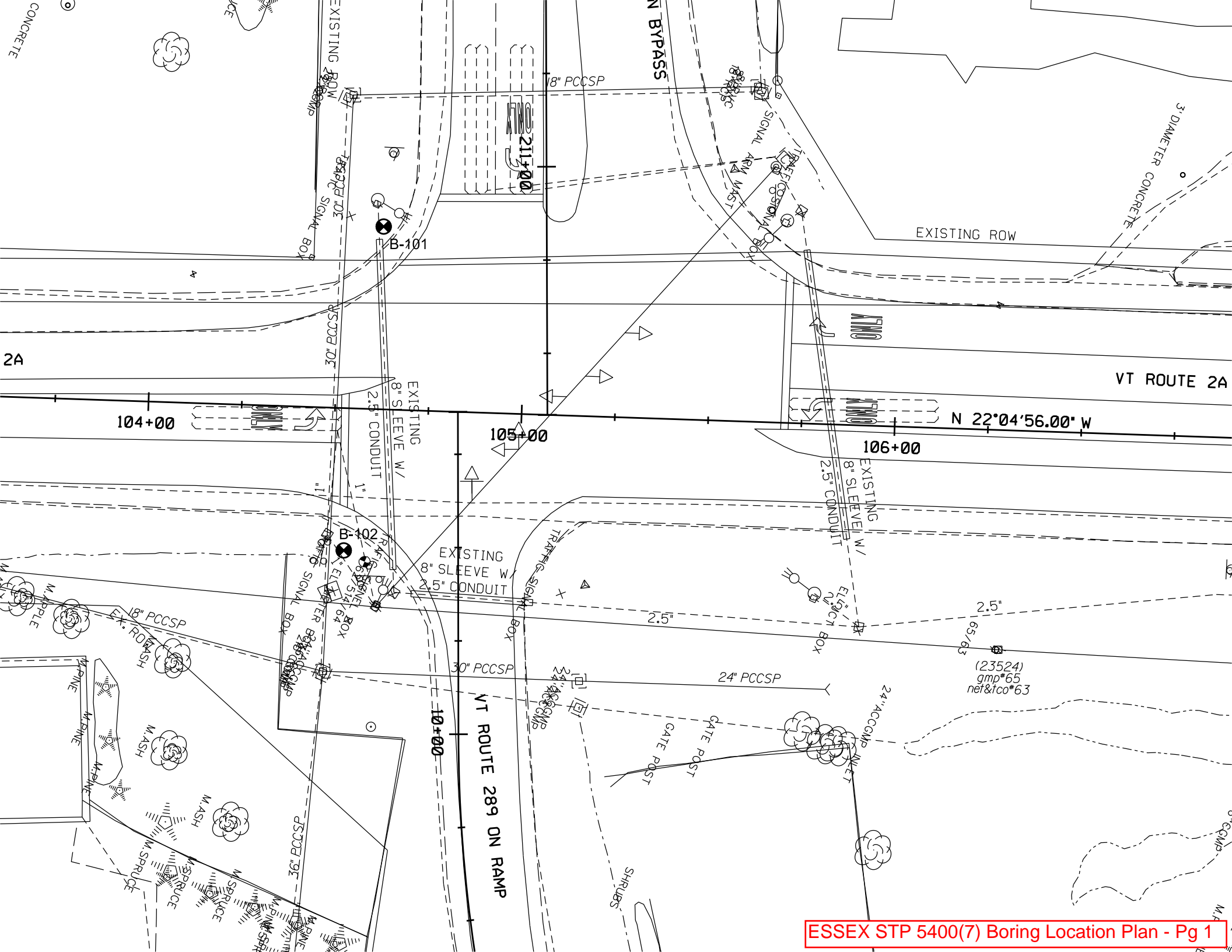
We recommend this report be included with the contract documents when the project is advertised.

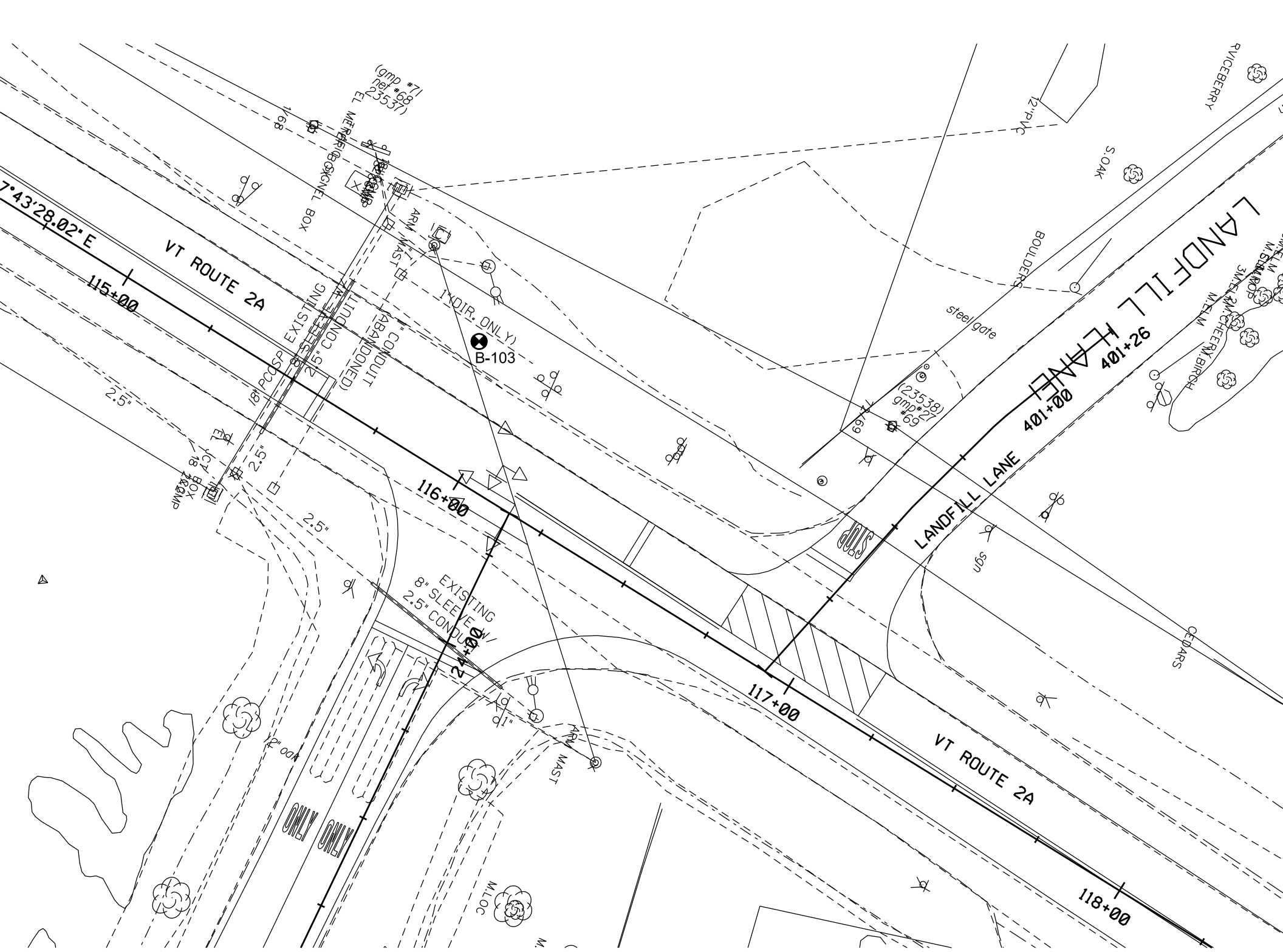
If any other design options wish to be explored or you would like to discuss this report, please contact us at (802) 828-2561. Typed boring logs are attached and are available in the CADD design files:

M:\Projects\13D330\MaterialsResearch

Attachments: Boring Location Plan (2 pages)
 Boring Logs (3 pages)

cc: Spencer Palmer, Traffic Design
 Read File/DJH
 Project File/CEE







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BORING LOG

ESSEX
STP 5400(7)
VT 2A, VT 289 MAST ARMS

Boring No.: B-101
Page No.: 1 of 1
Pin No.: 13D330
Checked By: CEE

Boring Crew: JUDKINS, DAIGNEAULT, HOOK
Date Started: 3/25/15 Date Finished: 3/25/15
VTSPG NAD83: N 735170.42 ft E 1478018.75 ft
Station: 104+61.5 Offset: -48.90
Ground Elevation: 350.0 ft

Casing H.S.A. Sampler SS
Type: H.S.A. 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 TRACK C_E = 1.34

| Groundwater Observations | | |
|--------------------------|------------|-----------------|
| Date | Depth (ft) | Notes |
| 03/25/15 | 21.7 | While drilling. |
| | | |
| | | |

| Depth (ft) | Strata (1) | CLASSIFICATION OF MATERIALS (Description) | Blows/6" (N Value) | Moisture Content % | Gravel % | Sand % | Fines % |
|------------|------------|---|--------------------|--------------------|----------|--------|---------|
| 5 | | A-1-b, SaGr, orange-brn, Moist, Rec. = 1.3 ft, Lab Note: Broken Rock was within sample. Frost area. | 13-32-18-15 (50) | 10.7 | 44.6 | 42.8 | 12.6 |
| | | A-3, GrSa, brn, Moist, Rec. = 1.5 ft, Lab Note: Broken Rock was within sample. | 11-9-8-6 (17) | 5.6 | 26.5 | 63.9 | 9.6 |
| 10 | | A-2-4, Sa, brn, Moist, Rec. = 1.6 ft | 7-7-7-7 (14) | 7.6 | 6.8 | 78.2 | 15.0 |
| | | A-2-4, Sa, brn, Moist, Rec. = 1.5 ft | 7-6-7-8 (13) | 13.9 | 0.8 | 87.6 | 11.6 |
| | | A-2-4, GrSa, brn, Moist, Rec. = 0.5 ft, Lab Note: Broken Rock was within sample. Stone stuck in end of sampler. | 13-13-13-11 (26) | 8.2 | 26.3 | 57.7 | 16.0 |
| | | A-2-4, Sa, brn, MTW, Rec. = 2.0 ft, Lab Note: Broken Rock was within sample. | 6-6-7-7 (13) | 20.7 | 2.6 | 80.5 | 16.9 |
| 15 | | A-2-4, Sa, brn, Wet, Rec. = 0.5 ft, Lab Note: Broken Rock was within sample. Stone stuck in end of sampler. | 3-5-5-6 (10) | 23.2 | 16.2 | 67.7 | 16.1 |
| | | A-4, SaSi, brn, MTW, Rec. = 1.6 ft | 3-3-5-4 (8) | 26.9 | 0.7 | 48.0 | 51.3 |
| 20 | | A-4, Si, gry, MTW, Rec. = 1.7 ft, Lab Note: A few layers of clay were noticeable. Sample tested: (NP) | 1-1-2-2 (3) | 31.5 | 0.1 | 4.7 | 95.2 |
| | | A-4, Si, gry, Wet, Rec. = 1.6 ft, Lab Note: A few layers of clay were noticeable. Sample tested: (NP) | 2-3-1-2 (4) | 31.5 | 0.1 | 8.0 | 91.9 |
| 25 | | Hole stopped @ 25.0 ft | | | | | |

Remarks:
1. Hole collapsed at 2.4 ft.
2. High blow counts from 0-2 feet due to frost.

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.

BORING LOG 2 ESSEX STP 5400(7).GPJ VERMONT AOT.GDT 4/21/15



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BORING LOG

ESSEX
STP 5400(7)
VT 2A, VT 289 MAST ARMS

Boring No.: B-102
Page No.: 1 of 1
Pin No.: 13D330
Checked By: CEE

Boring Crew: JUDKINS, DAIGNEAULT, HOOK
Date Started: 3/25/15 Date Finished: 3/25/15
VTSPG NAD83: N 735195.94 ft E 1478102.37 ft
Station: 104+53.5 Offset: 38.10
Ground Elevation: 350.0 ft

Casing: H.S.A. Sampler: SS
Type: H.S.A. 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 TRACK $C_F = 1.34$

| Groundwater Observations | | |
|--------------------------|------------|-----------------|
| Date | Depth (ft) | Notes |
| 03/25/15 | 18.8 | While drilling. |
| | | |
| | | |

| Depth (ft) | Strata (1) | CLASSIFICATION OF MATERIALS (Description) | Blows/6" (N Value) | Moisture Content % | Gravel % | Sand % | Fines % | LL % | PI % |
|--|------------|--|--------------------|--------------------|----------|--------|---------|------|------|
| 5 | | A-1-b, SaGr, white-brn, Moist, Rec. = 1.6 ft, Lab Note: Broken Rock was within sample. Frost area. | 22-23-26-17 (49) | 13.8 | 46.6 | 41.6 | 11.8 | | |
| | | A-2-4, Sa, brn, Moist, Rec. = 1.5 ft, Lab Note: Broken Rock was within sample. | 16-13-6-6 (19) | 7.3 | 11.1 | 75.8 | 13.1 | | |
| | | A-2-4, Sa, brn, Moist, Rec. = 1.6 ft, Lab Note: Small pieces of plywood were within sample. | 6-9-8-9 (17) | 6.7 | 0.1 | 87.8 | 12.1 | | |
| | | A-3, Sa, brn-Dk/brn, Moist, Rec. = 1.7 ft | 7-5-4-5 (9) | 7.3 | 0.1 | 93.1 | 6.8 | | |
| 10 | | A-2-4, Sa, orange-brn, MTW, Rec. = 1.9 ft | 3-3-1-2 (4) | 25.8 | 0.1 | 80.5 | 19.4 | | |
| | | A-2-4, SiSa, orange-brn, MTW, Rec. = 1.3 ft | 3-4-6-4 (10) | 23.2 | 0.1 | 75.6 | 24.3 | | |
| | | A-2-4, Sa, orange-brn, MTW, Rec. = 2.0 ft | 4-3-3-4 (6) | 22.2 | 1.4 | 80.3 | 18.3 | | |
| | | A-2-4, Sa, orange-brn, MTW, Rec. = 1.5 ft | 2-3-2-4 (5) | 20.5 | 2.5 | 78.7 | 18.8 | | |
| 15 | | A-4, Si, gry, Moist, Rec. = 0.5 ft | | 30.4 | | 2.2 | 97.8 | 27 | 2 |
| 20 | | A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: A few thin layers of clay were noticeable. Sample tested: (NP) | WH-WH-WH-WH (WH) | 34.1 | | 1.0 | 99.0 | | |
| 25 | | Field Note: SiCl Shelby Tube, gry, MTW, Rec. = 2.0 ft | | | | | | | |
| Hole stopped @ 26.0 ft | | | | | | | | | |
| Remarks: 1. Hole collapsed at 11.3 ft. 2. High blow counts from 0-2 feet due to frost. | | | | | | | | | |

BORING LOG 2 ESSEX STP 5400(7), GPJ VERMONT AOT, GDT 4/21/15

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_F is the hammer energy correction factor.
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BORING LOG

**ESSEX
STP 5400(7)
VT 2A, VT 289 MAST ARMS**

Boring No.: **B-103**
Page No.: **1 of 1**
Pin No.: **13D330**
Checked By: **CEE**

Boring Crew: JUDKINS, DAIGNEAULT, HOOK
Date Started: 3/24/15 Date Finished: 3/24/15
VTSPG NAD83: N 736272.15 ft E 1477813.69 ft
Station: 115+85.5 Offset: -33.50
Ground Elevation: 367.0 ft

Casing: H.S.A. Sampler: SS
Type: H.S.A. 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 TRACK $C_F = 1.34$

| Groundwater Observations | | |
|--------------------------|------------|-----------------|
| Date | Depth (ft) | Notes |
| 03/24/15 | 19.2 | While drilling. |
| | | |
| | | |

| Depth (ft) | Strata (1) | CLASSIFICATION OF MATERIALS (Description) | Blows/6" (N Value) | Moisture Content % | Gravel % | Sand % | Fines % | LL % | PI % |
|------------|------------|--|--------------------|--------------------|----------|--------|---------|------|------|
| 5 | | A-2-4, SiGrSa, brn, Moist, Rec. = 1.5 ft, Lab Note: Broken Rock was within sample. Frost area. | 11-19-26-32 (45) | 20.3 | 20.7 | 58.9 | 20.4 | | |
| | | A-1-b, SaGr, white-brn, Moist, Rec. = 0.6 ft, Lab Note: Lots of Broken Rock was within sample. Frost area. | 36-32-28-22 (60) | 4.9 | 54.7 | 31.1 | 14.2 | | |
| 10 | | A-2-4, Sa, brn, Moist, Rec. = 1.0 ft | | 3.8 | 0.9 | 87.2 | 11.9 | | |
| | | A-3, Sa, brn, Moist, Rec. = 1.8 ft | 15-13-11-10 (24) | 4.4 | | 90.2 | 9.8 | | |
| | | A-3, Sa, brn, Moist, Rec. = 1.6 ft | 9-9-10-10 (19) | 5.8 | | 91.9 | 8.1 | | |
| | | A-2-4, Sa, brn, Moist, Rec. = 1.5 ft | 7-7-7-7 (14) | 12.8 | 0.1 | 85.6 | 14.3 | | |
| 15 | | A-2-4, Sa, brn, MTW, Rec. = 1.3 ft | 5-4-3-4 (7) | 20.7 | 0.9 | 72.8 | 26.3 | | |
| | | A-4, Si, brn, MTW, Rec. = 2.0 ft, Lab Note: A small layer of clay was noticeable. Sample tested: (NP) | 9-8-7-7 (15) | 24.5 | | 19.6 | 80.4 | | |
| | | A-4, SiSa, brn, MTW, Rec. = 1.3 ft | 6-7-8-8 (15) | 22.4 | | 60.8 | 39.2 | | |
| 20 | | A-4, Si, gry, MTW, Rec. = 0.7 ft | | 28.7 | | 3.4 | 96.6 | 29 | 3 |
| | | A-4, CISi, gry, MTW, Rec. = 2.0 ft | 1-1-2-2 (3) | 33.3 | | 1.0 | 99.0 | 33 | 10 |
| | | Shelby Tube, gry, Moist, Rec. = 2.0 ft, 22.0 ft - 24.0 ft | | | | | | | |
| 25 | | Shelby Tube, gry, Moist, Rec. = 1.2 ft, 24.0 ft - 25.2 ft | R@25.2 ft. | | | | | | |
| | | Hole stopped @ 25.2 ft | | | | | | | |

Remarks:
1. Hole collapsed at 8.5 ft.
2. High blow counts from 0-4 feet due to frost.

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_F 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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