AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Rob Young, P.E., Structures Project Manager

From: Eric Denardo, P.E., Geotechnical Engineer, via Callie Ewald, P.E., Geotechnical Engineering Manager

Date: September 22, 2021

Subject: Lowell STP CULV(65) Subsurface Investigation

1.0 INTRODUCTION

As requested, we have completed our geotechnical investigation for the culvert replacement located on VT Route 100 approximately 0.2 miles south of the intersection of VT 100 and VT 58 in Lowell, VT. This project consists of the removal of the three existing culvert pipes and the construction of one larger buried pipe culvert. Contained herein are the results of our subsurface investigation, geotechnical analysis, and design parameters as estimated according to the 2020 AASHTO LRFD *Bridge Design Specifications*.

2.0 FIELD INVESTIGATION

The field investigation was conducted on August 4, 2021. One standard penetration boring, B-101, was advanced to evaluate the subsurface profile to aid in design and construction of the new structure. A preliminary boring location was provided by Andrew Lemieux, VTrans Structures Section, in the Geotechnical Request Form dated May 25, 2021. A summary of the boring location can be found in Table 2.1 as well as in the attached Boring Location Plan. The values for the Northing and Easting are based on the Vermont State Plan Grid Coordinate System NAD 83, and were located by the Geotechnical Engineering Section's Trimble Geoexplorer 600 handheld GPS with a decimeter accuracy. The elevation of the boring was determined from the VTrans MicroStation file s18b005top.dgn dated June 2021. The locations of the borings should be considered accurate only to the degree implied by the method used to determine them.

Table 2.1. Boring Locations and Elevations

Boring No.	Northing (ft.)	Easting (ft.)	Ground Surface Elev. (ft.)	Boring Depth (ft.)
B-101	837186.0	1653971.9	927.4	42

The boring was performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* During boring operations, split spoon samples and standard penetration tests (SPT) were taken continuously until 11 ft below ground surface (bgs), and then at 5 ft intervals from 15 ft bgs to a final depth of 40 ft bgs, where the boring was terminated. No bedrock was encountered to depth. Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs where applicable. Soil samples were

preserved and returned to the Construction and Materials Bureau Central Laboratory for testing and further evaluation.

3.0 FIELD AND LABORATORY TESTINGS

The standard penetration resistance of in-situ soil is determined by the number of blows required to drive a 2-inch outside diameter (OD) split-barrel sampler 24 inches into the soil with a 140-pound hammer dropped from a height of 30 inches, in accordance with procedures specified in AASHTO T206. The number of blows required to drive the sampler each 6-inch increment is recorded and the Standard Penetration Resistance (N-Value) is calculated as the sum of the blows over the second and third 6-inch intervals.

The SPT N-value is commonly used with established correlations to estimate several 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 Vermont Agency of Transportation has determined a hammer correction value, C_E, to account for the efficiency of the SPT hammers on its drill rigs. For B-101, a CME 45C Skid rig was used for the boring, with a hammer energy correction factor of 1.56. This value, included on the boring logs, should be used in calculations to estimate soil parameters.

Geotechnical laboratory tests were performed on select representative sample to assist with soil classification and evaluate engineering properties of the soil. Grain size analyses were performed on select soil samples in accordance with AASHTO T88, *Standard Method of Test for Particle Size Analysis of Soils.* Results from this testing can be found on the attached boring logs.

4.0 SOIL PROFILE

The following soil strata have been identified based on our review of the boring log and laboratory testing. 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 on the logs.

4.1 Boring-101

Within B-101, groundwater was measured after drilling operations on August 4, 2021 at a depth of 9.0 ft bgs corresponding to an elevation of 918.4 ft.

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 0.6 ft	Asphalt Pavement
1 – 7 ft	Medium Dense Gravelly Sand/Silty Sand
7 – 13 ft	Medium Dense Gravelly Sand
13 – 38.5 ft	Medium Dense Sand
38.5 – 42 ft	Dense Sandy Gravel

5.0 RECOMMENDATIONS

Based on the conditions encountered during the subsurface investigation, the proposed pipe culvert bearing directly on the in-situ soils appears to be a feasible option for this project. The soils encountered were generally granular and no bedrock was encountered to the depth of the investigation. Settlement of the structure is anticipated to be negligible and any settlement that does occur should happen during or immediately after construction. No obstructions were encountered, and broken rock was not noted during drilling or observed in any of the samples.

5.1 Construction Considerations

5.1.1 Cofferdams/Temporary Earthwork Support: Cofferdams or temporary earthwork support may be necessary during construction of the abutments based on the proposed footing elevation. If required, the Contractor should be reminded that Section 208.06 of VTrans' *2018 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of 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) registered in the State of Vermont.

5.1.2 Construction Dewatering: Temporary construction dewatering will likely be necessary during construction of the culvert based on the proposed bottom of culvert elevations and water levels noted during drilling. Temporary dewatering may 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 water, or discharge, should comply with all applicable permits and regulations.

5.1.3 Placement and Compaction of Soils: Fills should be placed systematically in horizontal layers no more than 12 inches thick 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 is used, such as a small vibratory plate compactor, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement.

Embankment fills should be compacted to a dry density of at least 95% of the maximum dry density determined in accordance with AASHTO T-99 per section 203.11 of the *2018 VTrans Standard Specifications for Construction*. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density of 95% of the maximum dry density determined in accordance with AASHTO T-99.

5.2 Design Parameters: Tables 5.1 and 5.2 highlight the geotechnical design parameters of the in-situ soils and regularly specified construction materials, respectively. 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 backfill) and a vertical wall face.

Table 5.1: Engineering Properties of In-Situ Soils

	M. Dense Gravelly Sand/Silty Sand	**M. Dense Gravelly Sand (Culvert Bearing Stratum)**
Unit Weight, γ (lbs/ft^3):	120	130
Internal Friction Angle, ϕ (degrees):	36	33
Coefficient of Friction, f		
- mass concrete cast against soil:	0.50	0.57
- soil against precast/formed concrete:	0.25	0.40
Active Earth Pressure Coef., K_a:	0.26	0.30
Passive Earth Pressure Coef., K_p:	3.85	3.39
At-Rest Earth Pressure Coefficient, K_o:	0.41	0.46

Table 5.3: Engineering Properties of Construction Materials

	703.04 – Granular Borrow	**704.08 – Granular Backfill for Structures**
Unit Weight, γ (lbs/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 Coef., K_a:	0.31	0.28
Passive Earth Pressure Coef., K_p:	3.26	3.57
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.44

6.0 CONCLUSION

If you have any questions, or you would like to discuss this report, please contact us at (802) 595-4754 or at eric.denardo@vermont.gov. A Computer generated boring log is attached and available in the *M:\Projects\18b005\MaterialsResearch* folder.

cc: Andrew Lemieux, P.E., VTrans Structures Engineer
Electronic Read File/MG
Project File/CEE
END

Enclosures: Boring Location Plan (1 Page)
Boring Logs (1 Pages)

Z:\Highways\CMB\GeotechEngineering\Projects\Lowell STP CULV(65)\REPORTS\Lowell STP CULV(65) Geotechnical Data Report.docx

SOIL CLASSIFICATION

AASHTO	
A1	Gravel and Sand
A3	Fine Sand
A2	Silty or Clayey Gravel and Sand
A4	Silty Soil - Low Compressibility
A5	Silty Soil - Highly Compressible
A6	Clayey Soil - Low Compressibility
A7	Clayey Soil - Highly Compressible

ROCK QUALITY DESIGNATION

R.Q.D. (%)	ROCK DESCRIPTION
<25	Very Poor
25 to 50	Poor
51 to 75	Fair
76 to 90	Good
>90	Excellent

SHEAR STRENGTH

UNDRAINED SHEAR STRENGTH IN P.S.F.	CONSISTENCY
<250	Very Soft
250-500	Soft
500-1000	Med. Stiff
1000-2000	Stiff
2000-4000	Very Stiff
>4000	Hard

CORRELATION GUIDE OF "N" TO DENSITY/CONSISTENCY

DENSITY (GRANULAR SOILS)		CONSISTENCY (COHESIVE SOILS)	
N	DESCRIPTIVE TERM	N	DESCRIPTIVE TERM
<5	Very Loose	<2	Very Soft
5-10	Loose	2-4	Soft
11-24	Med. Dense	5-8	Med. Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

COMMONLY USED SYMBOLS

▼	Water Elevation
⊗	Standard Penetration Boring
⊕	Auger Boring
⊙	Rod Sounding
S	Sample
N	Standard Penetration Test Blow Count Per Foot For: 2" O.D. Sampler 1 3/8" I.D. Sampler Hammer Weight Of 140 Lbs. Hammer Fall Of 30"
VS	Field Vane Shear Test
US	Undisturbed Soil Sample
B	Blast
DC	Diamond Core
MD	Mud Drill
WA	Wash Ahead
HSA	Hollow Stem Auger
AX	Core Size 1 1/8"
BX	Core Size 1 5/8"
NX	Core Size 2 1/8"
M	Double Tube Core Barrel Used
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non Plastic
w	Moisture Content (Dry Wgt. Basis)
D	Dry
M	Moist
MTW	Moist To Wet
W	Wet
Sat	Saturated
Bo	Boulder
Gr	Gravel
Sa	Sand
Si	Silt
Cl	Clay
HP	Hardpan
Le	Ledge
NLTD	No Ledge To Depth
CNPF	Can Not Penetrate Further
TLOB	Top of Ledge Or Boulder
NR	No Recovery
Rec.	Recovery
%Rec.	Percent Recovery
RQD	Rock Quality Designation
CBR	California Bearing Ratio
<	Less Than
>	Greater Than
R	Refusal (N > 100)
VTSPG	NAD83 - See Note 7

COLOR

blk	Black	pnk	Pink
bl	Blue	pu	Purple
brn	Brown	rd	Red
dk	Dark	tn	Tan
gry	Gray	wh	White
gn	Green	yel	Yellow
lt	Light	mltc	Multicolored
or	Orange		

DEFINITIONS (AASHTO)

BEDROCK (LEDGE) - Rock in its native location of indefinite thickness.

BOULDER - A rock fragment with an average dimension > 12 inches.

COBBLE - Rock fragments with an average dimension between 3 and 12 inches.

GRAVEL - Rounded particles of rock < 3" and > 0.0787" (#10 sieve).

SAND - Particles of rock < 0.0787" (#10 sieve) and > 0.0029" (#200 sieve).

SILT - Soil < 0.0029" (#200 sieve), non or slightly plastic and exhibits no strength when air-dried.

CLAY - Fine grained soil, exhibits plasticity when moist and considerable strength when air-dried.

VARVED - Alternate layers of silt and clay.

HARDPAN - Extremely dense soil, cemented layer, not softened when wet.

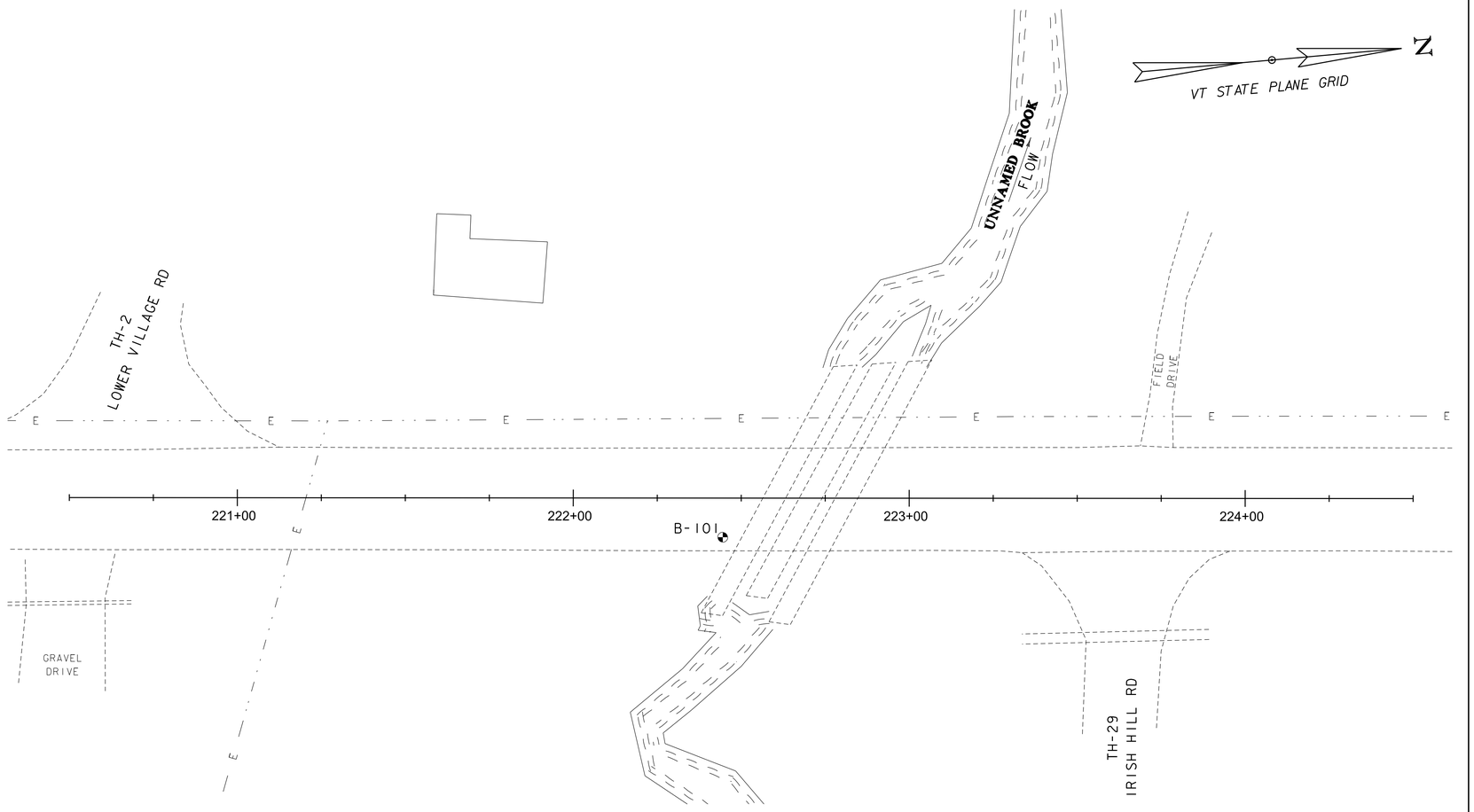
MUCK - Soft organic soil (containing > 10% organic material.

MOISTURE CONTENT - Weight of water divided by dry weight of soil.

FLOWING SAND - Granular soil so saturated (loose) that it flows into drill casing during extraction of wash rod.

STRIKE - Angle from magnetic north to line of intersection of bed with a horizontal plane.

DIP - Inclination of bed with a horizontal plane.



BORING LAYOUT

SCALE 1" = 20'-0"

20 0 20

BORING CHART

HOLE NO.	STATION	OFFSET	NORTHING	EASTING	GROUND ELEV.	BEDROCK ELEV.
B-101	222+44.5	11.7	837184.6	1653972.5	927.4	_____

GENERAL NOTES

1. The subsurface explorations shown herein were made between -------- and ---------- by the Agency.
2. Soil and rock classifications, properties and descriptions are based on engineering interpretation from available subsurface information by the Agency and may not necessarily reflect actual variations in subsurface conditions that may be encountered between individual boring or sample locations.
3. Observed water levels and/or conditions indicated are as recorded at the time of exploration and may vary according to the prevailing rainfall, methods of exploration and other factors.
4. Engineering judgment was exercised in preparing the subsurface information presented herein. Analysis and interpretation of subsurface data was performed and interpreted for Agency design and estimating purposes. Presentation of the information in the Contract is intended to provide the Contractor access to the same data available to the Agency. The subsurface information is presented in good faith and is not intended as a substitute for personal investigation, independent interpretation, independent analysis or judgment by the Contractor.
5. Pictorial structure details shown on the boring plan layout or soils profile are for illustrative purposes only and may not accurately portray final contract details.
6. Terminology used on boring logs to describe the hardness, degree of weathering, and spacing of fractures, joints and other discontinuities in the bedrock is defined in the AASHTO Manual on Subsurface Investigations, 1988.
7. Northing and Easting coordinates are shown in Vermont State Plane Grid North American Datum 1983 in meters and survey feet.

PROJECT NAME: LOWELL

PROJECT NUMBER: STP CULV (65)

FILE NAME: sl8b005bor.dgn	PLOT DATE: $$$$DATE$$$
PROJECT LEADER: R. YOUNG	DRAWN BY: A.LEMIUEX
DESIGNED BY: A. LEMIEUX	CHECKED BY: ------
BORING INFORMATION	SHEET $S#$ OF $T#$

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

BORING LOG

LOWELL
STP CULV(77)
VT-100 Br 237

Boring No.: **B-101**
Page No.: 1 of 1
Pin No.: 18B005
Checked By: END

Boring Crew: JUDKINS, BROCHU
Date Started: 8/04/21 Date Finished: 8/04/21
VTSPG NAD83: N 837184.60 ft E 1653972.50 ft
Station: 222+45 Offset: 11.70
Ground Elevation: 927.4 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_F = 1.56

Groundwater Observations

Date	Depth (ft)	Notes
08/04/21	9.0	WT after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, Asphalt 0.0' - 0.6'					
		Field Class:, Gravelly Sand, brn, Moist, Rec. = 1.0 ft, RC cleanout 2.4'-3.0'	8-8-10-7 (18)				
		A-2-4, SiSa, brn, Moist, Rec. = 0.9 ft	5-5-4-4 (9)	12.1	17.2	60.2	22.6
5		Field Class:, Sand, brn, Moist, Rec. = 0.8 ft, RC cleanout 6.4'-7.0'	3-4-4-5 (8)				
		A-1-b, GrSa, brn, MTW, Rec. = 0.4 ft, RC cleanout 8.5'-9.0'	4-5-4-4 (9)	14.2	27.8	59.7	12.5
10		Field Class:, Silty Gravelly Sand, brn, MTW, Rec. = 0.4 ft, RC cleanout 13.9'-15.0'	4-3-4-6 (7)				
15		Field Class:, Sand, gry, MTW, Rec. = 0.2 ft	4-3-2-2 (5)				
20		A-2-4, Sa, brn, Moist, Rec. = 0.8 ft	4-4-3-4 (7)	22.4	0.8	86.9	12.3
25		Field Note:, No Recovery	5-6-7-9 (13)				
30		Field Class:, Sand, brn, Moist, Rec. = 0.7 ft	2-5-6-5 (11)				
35		A-2-4, SiSa, brn, MTW, Rec. = 0.85 ft, NXDC cleanout 39.0'-40.0'	1-2-2-4 (4)	25.0	0.1	67.2	32.7
40		Field Class:, Sandy Gravel, gry, Moist, Rec. = 1.0 ft	8-14-15-32 (29)				
		Hole stopped @ 42.0 ft					
45		Remarks: Hole collapsed at 10.7'					

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 LOWELL STP CULV(65).GPJ VERMONT AOT.GDT 9/14/21