REPORT

Geotechnical Engineering Services Bridge 36 Replacement, Waterbury, VT Waterbury BO 1446(40) - Rev 01

Submitted to:

Mr. Stephen Madden

Geotechnical Project Manager
Vermont Agency of Transportation
Highway Division, Construction & Materials Bureau
2178 Airport Road
Dill Building Unity B
Berlin, VT 05641

Submitted by:

Golder Associates Inc.

10 Al Paul Lane, Suite 103, Merrimack, NH 03101

+1 603 668-0880

21497656

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1.0 PROJECT BACKGROUND

Golder Associates USA, Inc. (WSP Golder), a member of WSP, is pleased to submit this report to the Vermont Agency of Transportation (VTrans) for geotechnical engineering services for the replacement of Bridge No. 36 carrying Town Highway 2 (Stowe Street) over Thatcher Brook in the town of Waterbury, Vermont. The site location is shown in Figure 1. The new bridge superstructure, abutments, and wingwalls are proposed to be precast concrete founded on cast-in-place concrete sub-footings. VTrans anticipates that the bridge replacement will consist of a buried structure utilizing an offsite detour to maintain traffic during construction. VTrans provided Golder with electronic survey and plan drawings[1] that detail the location and elevations of the roadway and bridge features. The proposed bridge is approximately 43 feet long, with the face of the proposed abutments located a few feet behind the face of the existing bridge's vertical abutments. The proposed bridge abutments are planned to have fill materials placed from abutment mid-height at a 1V:1.5H slope into Thatcher Brook. This design may narrow Thatcher Brook at high flows as it passes below the proposed bridge.

This report describes the results of the approved scope of work for geotechnical engineering services at Bridge No. 36 provided in our October 19, 2021 proposal and authorized on October 21, 2021 as well as the scope and budget modification to include two additional borings authorized on December 8, 2021. We have provided these services in accordance with our Contract for Geotechnical Engineering Services (PS0836), dated October 20, 2020.

2.0 SUBSURFACE INVESTIGATION

The following sections detail the methods used for the subsurface investigation to support the new bridge design. The methods consist of geotechnical test borings and surficial geophysical surveys.

2.1 Geotechnical Borings

WSP Golder completed four (4) test borings on November 18, November 19, and December 10, 2021. Borings B-101 and B-101A are located in the southbound lane of Stowe Street at proposed Abutment No. 1; boring B-103 is located in the northbound lane of Stowe Street at proposed Abutment No. 1; and boring B-102 is located in the northbound lane of Stowe Street at proposed Abutment No. 2. The field program included Standard Penetration Test (SPT) sampling of coarse-grained and fine-grained materials, and rock coring of the interpreted underlying bedrock. WSP Golder geotechnical engineers monitored drilling activities, selected sampling intervals, logged subsurface conditions encountered, and obtained soil samples and rock core for use in visual description and subsequent laboratory testing and classification. The boring location coordinates and ground surface elevations are summarized in Table 1, as provided by VTrans following survey. Boring locations with respect to existing site features are presented in Figure 2.

WSP Golder subcontracted Platform Environmental Drilling and Remediation Services (Platform) of Montpelier, Vermont to complete the borings using a Geoprobe 7822 DT drill rig. The drilling methods used a 4-inch inside diameter casing at B-101 and 3-inch inside diameter casing at borings B-101A, B-102 and B-103. Platform drove the casings with a percussion hammer and the out-the-end (OTE; i.e., direct push) drilling techniques.

Platform advanced all borings to the bedrock surface or refusal before collecting rock core. Soil sampling was performed in Borings B-101 and B-102 at 5-foot intervals by advancing a 2-inch outside diameter, 2-foot long SPT split spoon sampler below the casing and performing the SPT test in the undisturbed soil before removing the

[1] Electronic file "z93j040sv.dgn" provided to Golder on December 2, 2021.

sampler and advancing the casing to the next depth. Soil sampling was not conducted in borings B-101A or B-103 as the objective of these borings was to identify top of bedrock and collect rock core, if possible. Approximately 0.7 feet of rock core was obtained from boring B-101, 5 feet of rock core was obtained from boring B-102, and 2.2 feet of rock core was obtained from Boring B-103. Boring B-101A was advanced to approximately 11 feet below ground surface (bgs) where an obstruction crimped the casing preventing further advancement of the boring.

Where soil samples were obtained, Platform conducted SPT using a calibrated automatic hammer system and standard 1.5-inch inside diameter split spoon sampler in accordance with American Society for Testing and Materials (ASTM) D1586. Sampling was conducted at 5-foot intervals in the borings to refusal, where the sampler was driven 24 inches by a 140-pound hammer dropped 30 inches. WSP Golder recorded the number of hammer blows required to advance the split spoon sampler through each 6-inch increment. Raw, uncorrected N-values, calculated as the sum of the hammer blows to advance the sampler during the 6-inch to 18-inch interval, are provided on the boring logs (Appendix A) and have not been corrected for overburden, sample size, or other factors. A calibrated hammer energy correction factor of 1.68 provided by Platform for their Geoprobe 7822 DT rig can be used to convert the measured N-values to N_{60} values for further calculations. WSP Golder collected and stored soil samples in labelled standard VTrans plastic sample bags. Soils identified in boring B-101 consist of loose to very dense, sandy, fine to coarse gravel overlying bedrock. Soils identified in boring B-102 consist of very loose to very dense, fine to medium sand overlying bedrock.

Where rock core was obtained, Platform collected rock core using NX-size (2.15 inch inside diameter) diamond-tipped core barrels following refusal of either the casing or split spoon sampler to advance. Platform placed the rock core samples in rigid plastic sleeves for subsequent transportation to the WSP Golder office for further evaluation. WSP Golder recorded Total Core Recovery (TCR) and calculated Rock Quality Designation (RQD) for each core run, and these data are provided on the boring logs (Appendix A). Photographs of the rock core are presented in Appendix B. A detailed summary of rock quality parameters for the recovered rock core is presented in Table 2.

Details of the sampling methods used, field data obtained, and soil and rock conditions encountered during the investigation are presented on the boring logs provided in Appendix A. WSP Golder described the soil samples in the field in general accordance with ASTM D2488. Bedrock lithology was described in the field and revised in the office. A description of the symbols and terms used for the soil and rock descriptions precedes the boring logs.

2.2 Electrical Resistivity Imaging

To estimate depth to bedrock in areas not easily accessible to drilling equipment, and to facilitate foundation design and construction, WSP Golder conducted three focused, non-intrusive, linear geophysical surveys using electrical resistivity imaging (ERI) as the chosen method for field investigation based on site conditions and the project goals.

ERI Background

ERI geophysical surveys evaluate variations in the electrical properties of subsurface materials by measuring electrical potentials at the surface. Electrical resistivity is a fundamental property of a material that describes how easily the material can transmit electrical current. High values of resistivity imply that the material is resistant to the flow of electricity; low values of resistivity imply that the material transmits electricity with little resistance. Resistivity measurements are made by injecting current into the ground through two current electrodes and measuring the resulting voltage difference at two potential electrodes.

Resistivity (ρ) is then calculated by:

$$\rho = k\frac{V}{I}$$ (Equation 1: Ohm's Law)

where:

v = the voltage potential measured between two points (in volts)

I = the injected current (in amperes)

k = a geometric factor which depends on the cross-sectional area and length of the current flow path (in meters)

ρ = resistivity (ohm-meters; ohm-m)

The primary properties that affect the resistivity of subsurface materials are total porosity, pore interconnectivity and saturation, pore fluid salinity, and clay mineral and metal content. Since most soil- and rock-forming minerals are essentially nonconductive, most current flow takes place through the material's pore water. Therefore, resistivity generally decreases with increasing porosity and water saturation. Clay minerals and certain metallic minerals tend to be conductive because of the availability of free ions. Similarly, dissolved ions in groundwater make the water more conductive to electric current. Thus, electrical resistivity decreases with increasing clay content and ionic strength of the pore fluids. Electrical resistivity and conductivity values of common rocks and soil materials are provided in Table 2-1.

Different electrode configurations (e.g., Wenner, Schlumberger, dipole-dipole, and gradient configuration) can be used to collect ERI data and each produces unique data characteristics due to their geometric configuration. For the dipole-dipole array, current is applied to two adjacent current electrodes (A and B) positioned a predetermined distance apart (distance a). The voltage across two potential electrodes (M and N) is measured simultaneously with the applied current. The current electrodes are always spaced distance "a" apart and the distance between the current and potential electrodes is always a multiple of a (n • a). The strong gradient array takes advantage of multi-channel resistivity systems that can make several measurements simultaneously. This array measures all adjacent dipoles from one transmitter electrode to the other, including the center-most dipole, between two current electrodes. The lateral changes in the potential field of the gradient array are measured between the transmitter dipole A and B. Recording the lateral changes is often referred to as a profiling method, where the potential electrode pairs are at different locations without changing the positioning of the installed electrodes.

Various types of arrays have different strengths and weaknesses. Dipole-dipole arrays are a good choice for horizontal resolution of vertical or laterally discontinuous targets due to the increased data coverage and discrimination of small and sensitive targets. Dipole-dipole arrays can produce poor results in areas that have electrical noise due to the low signal strength. Strong gradient arrays produce high quality, but lower resolution data. WSP Golder combined ERI results from both the dipole-dipole array and the strong gradient array to generate high resolution ERI profiles. For more information, refer to Sirles (2006)[2] or USACE (1995)[3].

Table 2-1: Resistivity and Conductivity Values of Common Rock and Soil Materials

Material	Resistivity (ohm-m)	Electrical Conductivity (mS/m)
Bedrock		
Granite	5,000 to 10^6	0.001 to 0.2
Basalt	1,000 to 10^6	0.001 to 1
Sandstone	100 to 4,000	0.25 to 10
Shale	20 to 2,000	0.5 to 50
Porous Limestone	100 to 1,000	1 to 10
Dense Limestone	1,000 to 10^6	0.001 to 10
Soil and Water		
Clay	1 to 20	50 to 1,000
Sand (wet to moist)	20 to 200	5 to 50
Dry Loose Sand	500 to 10^5	0.01 to 2
Groundwater (fresh)	10 to 100	10 to 100
Seawater	0.2	5,000
Brine	0.05 to 0.13	7,500 to 20,000

Note: 1000/ohm-m = mS/m. Adapted from USACE (1995)[3]

ERI Field Procedures

A WSP Golder geophysicist collected subsurface data generated along three ERI profiles at the site, shown in Figure 2. Upon arrival to the site, the field geophysicist determined the original survey line positions identified in the proposal were not feasible or would not yield quality data. These profiles were adjusted from the original locations based on the encountered field conditions and the depth and velocity of the running water in Thatcher Brook. The three new locations were selected to collect high quality data as near to the boring locations as possible and across the site to image bedrock depth trends.

WSP Golder conducted the electrical resistivity surveys using a SuperSting R8/IP 8-channel automatic resistivity imaging system manufactured by Advanced Geosciences, Inc. (AGI) of Austin, Texas. With this system, 56 electrodes were connected to 18-inch stainless steel stakes that were inserted into the ground at a spacing of ten feet. A contact resistance test was performed prior to surveying to identify any potential problems that may affect

[2] Sirles, P.C. 2006 Use of Geophysics for Transportation Projects NCHRP Synthesis of Highway Practice No. 3657, Transportation Research Board, Washington DC, 117pp. Online: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_357.pdf (accessed June 2, 2021)

[3] U.S. Army Corps of Engineers (1995). Geophysical Exploration for Engineering and Environmental Investigations, EM 1110-1-1802, 208 pp. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-1-1802.pdf, Accessed 2022 January 28.

the recorded data. The area around several stakes were moistened with saltwater to improve the coupling between the stakes and the ground and reduce the measured contact resistance. The electrodes were attached to a multi-core cable, which was connected to an electronic switching unit. A 12-volt deep cycle battery was used to power the SuperSting. The switching unit automatically selected the appropriate electrodes for each measurement. Measurements were initiated along the line and were incrementally moved through the electrodes until readings were taken at every position along the line. Figure 2-1 shows the setup. Line 1 and Line 3 were 205 feet in length and Line 2 was 170 feet in length.

Each electrode stakeout was surveyed using a Garmin GPS unit receiver that had a site-specific accuracy of +/- 4 feet. Electrode positions are labeled by ERI line number and electrode number. Each line begins with electrode 01 at 0 feet. Figure 2 shows the location of the ERI lines and electrodes.

Once the resistivity data were collected, the geophysicist downloaded the raw data to a laptop computer for processing, and interpretation. The resistivity value measured in the field is not true resistivity of the subsurface, but an “apparent resistivity” value that is a combination of the subsurface materials and their contained fluids along the entire path of the electrical current. To determine the true subsurface resistivity, we processed the apparent resistivity values using inversion and forward modeling techniques using AGI’s EarthImager2D™ inversion software. The software program uses a smooth model inversion technique to generate a model of actual two-dimensional resistivity values along the profile. Details of the inversion process may be found in Advanced Geosciences, Inc. EarthImager2D Instruction Manual. This program produces an image of modeled resistivity values along the profile, which can then be contoured to evaluate spatial trends in subsurface resistivity values.

Figure 2-1: Setup of electrical resistivity imaging (ERI) system along ERI Line 2.
Photo date November 5, 2021, view to the west.

ERI Results

The quality of the data collected was considered good due to the strong contrast between subsurface materials. Resistivity values were generally low, ranging from 3 to 175 ohm-meters, which indicate conductive soil and bedrock subsurface material. The profiles show a characteristic two-layer model with a surficial layer of higher resistivity sandy soil or alluvium overlying a low resistivity layer representing bedrock. The bedrock layer at this site is a metamorphic greenschist.

ERI Line 1 (Figure 2, Figure 3) was oriented from west to east in the northern portion of the site, with electrode 01 at the west end, and electrode 42 at the east end. Bedrock depth is estimated to be approximately 5 feet to 9 feet bgs and relatively flat lying across the profile. Boring B-102 was drilled in the road approximately 10 feet east of electrode 42, where it encountered bedrock (metamorphic greenschist) at a depth of 18.3 feet bgs. The difference between ERI line and boring bedrock is likely related to rapid decrease in bedrock elevation toward the stream basin.

ERI Line 2 (Figure 2-1, Figure 2, Figure 4) was oriented from west to east in the southern portion of the site, with electrode 01 at the west end, and electrode 35 at the east end. Bedrock depth is estimated to be approximately 8 feet to 11 feet bgs and relatively flat lying across most of the profile. Boring B-101 was drilled in the road approximately 10 feet north-northeast of electrode 35, where it encountered bedrock (metamorphic greenschist) at a depth of 15.3 feet bgs. Bedrock was observed along Thatcher Brook at a similar depth that is imaged in ERI Line 2.

ERI Line 3 (Figure 2, Figure 5) was oriented from west to east in the northern portion of the site, with electrode 01 at the west end, and electrode 42 at the east end. Bedrock depth was approximately 5 feet to 12 feet bgs and relatively flat lying across most of the profile. Boring B-101 was drilled in the road approximately 55 feet west of electrode 1, where it encountered bedrock (metamorphic greenschist) at a depth of 15.3 feet bgs.

Geophysical Borehole Utility Clearance

WSP Golder performed geophysical utility clearance for the boring locations using electromagnetic radiodetection (RD) and Ground Penetrating Radar (GPR) surficial geophysical techniques. The utility clearance was carried out by investigating a ten-foot box around each proposed boring location first using RD. The RD was used to sweep the proposed area to detect possible utilities within the proposed boring locations. GPR data were then collected in orthogonal directions over the proposed area to identify potential utilities. No subsurface utilities were detected within the areas investigated for the proposed boring locations.

2.3 Rock Probes

VTrans completed (5) rock probes (BH-1 through BH-5) between April 27, 2022 and May 4, 2022 to further characterize the varying bedrock surface at the project site. The rock probe logs provided to WSP Golder[4] are included in Appendix C. Approximately 10 feet of rock core was obtained at each completed rock probe location. The locations of these rock probes are presented in Table 1. A detailed summary of rock quality parameters for the recovered rock cores is also presented in Table 2.

3.0 LABORATORY TESTING

The VTrans Soils Laboratory conducted testing of collected soil samples in accordance with applicable American Association of State Highway Transportation Officials (AASHTO) testing procedures. Geotechnical laboratory tests were performed on representative SPT split spoon soil samples collected from the borings to assist in soil classification. The types and number of each of the laboratory tests conducted on soil samples are summarized in Table 3-1. Measured index and classification test results from soil samples are summarized in Table 3. Soil testing results are included on the boring logs in Appendix A. Complete laboratory testing results are provided in Appendix D.

[4] Electronic file “Waterbury BO 1446(40) Rock Probe Logs.pdf” provided to WSP Golder on May 19, 2022.

Table 3-1: Soil Laboratory Testing

Laboratory Test	Test Standard	No. Tests Completed
Grainsize (sieve)	AASHTO T 88	12
Moisture Content	AASHTO T 265	12

4.0 SUBSURFACE CONDITIONS

The following descriptions summarize the major stratigraphic units encountered at the site during the geophysical testing and the geotechnical boring program. Figure 6 provides our interpreted stratigraphic profile along the centerline of the existing bridge showing existing stationing of Stowe Street, subsurface soils, and the bedrock surface. Figure 7 and Figure 8 provide our interpreted stratigraphic cross-sections of subsurface soils and bedrock along the centerline of the existing Abutment No. 1 and Abutment No. 2, respectively.

Very dense Sands and Gravels: Very dense Sands and Gravels were encountered in the shallow subsurface in the vicinity of Abutments No. 1 and No. 2 and is differentiated from the underlying layer by higher SPT N-values. WSP Golder interprets this layer to be directly below pavement at 0.3 feet bgs at Abutment No. 1 and 0.9 feet bgs at Abutment No. 2. The layer was observed to be approximately 1.3 feet thick at Abutment No. 1 and 0.7 feet thick at Abutment No. 2. Split spoon refusal was encountered in this layer at both borings B-101 and B-102.

Loose Sands and Gravels: Loose Sands and Gravels were encountered below the very dense Sands and Gravels in borings B-101 and B-102. WSP Golder interprets this layer to extend to approximately 2.5 feet bgs at Abutment No. 1 and to approximately 11 feet bgs at Abutment No. 2. The layer was observed to range in thickness from approximately 0.5 feet near Abutment No. 1 to 7 feet near Abutment No. 2. N-values for this layer ranged from 7 to 9 with an average of 8.

Medium dense Sands and Gravels: Medium dense Sands and Gravels were encountered 8 feet bgs at boring B-101 near Abutment No. 1, and 11 feet bgs at boring B-102 near Abutment No. 2. We interpret this layer to extend to approximately 14 feet bgs at both abutments. The layer ranges in thickness from approximately 3 feet at Abutment No. 1 to 6 feet at Abutment No. 2. N-values for this layer ranged from 14 to 24 with an average of 19.

Very dense Sand: Very dense Sand was encountered at 14 feet bgs in boring B-101 located at Abutment No. 1. We interpret this layer to extend to top of bedrock, with a layer thickness of approximately 1.3 feet.

Very loose Silt: A very loose Silt was encountered at 14 feet bgs in boring B-102 located at the location of Abutment No. 2. WSP Golder interprets the thickness of this layer to be approximately 4.5 feet, extending to the top of bedrock. The split spoon was able to be advanced with the weight of the hammer in this layer.

Concrete: Concrete was encountered at 14 feet bgs in boing B-103 located at Abutment No.1. Concrete was cored a thickness of 1.0 feet, after which top of the bedrock was encountered.

Bedrock: WSP Golder encountered the bedrock surface in borings B-101 through B-103 and in rock probes BH-1 through BH-5. The bedrock lithology consists of green, gray and grayish green, very fine grained, slightly weathered to fresh schist and phyllite. The bedrock encountered in the borings and rock probes varies in depth from 10 feet bgs to 18.3 feet bgs. Bedrock was encountered at 15.3 feet bgs in B-101, 15.0 feet bgs in B-103 and at BH-1 which is located to the southwest from Abutment No. 1. Bedrock was encountered at 12.8 feet bgs in BH-5 located to the southeast of Abutment No. 1. B-102, near Abutment No. 2, encountered bedrock at 18.3 feet bgs, BH-2 located to the northwest of Abutment No. 2, encountered bedrock at 10 feet bgs and BH-3 also located to the northwest of Abutment No. 2 encountered bedrock at 18 feet bgs. We collected 0.7 feet of rock core from B-101, 5.0 feet of rock core from B-102, and 2.2 feet of rock core from B-103 in up to 5-foot runs. VTrans collected 10 feet of rock core from each of the rock probe locations (BH-1 through BH-5). Results from electrical resistivity imaging (Section 2.2) indicate that the bedrock at the site varied in depth from 5 feet bgs to 12 feet bgs. Table 2 provides detailed information about the recovery, TCR, RQD, rock mass rating (RMR), and descriptions of lithology, rock mass, and discontinuities.

Groundwater: WSP Golder measured the groundwater levels in borings B-101 and B-102 upon encountering refusal and before the start of rock coring. In boring B-101, no groundwater was detected to the top of bedrock. In boring B-102, groundwater was measured at 15.5 feet bgs. Groundwater levels were measured in borings B-101A and B-103 after the completion of the drilling. In boring B-101A, groundwater was measured at 7.4 feet bgs. In boring B-103, groundwater was detected at 12.6 feet bgs. Groundwater levels measured after completion of rock probes BH-1 through BH-5 ranged between 4.2 feet bgs and 14 feet bgs. Groundwater levels shown on the subsurface profiles (Figure 6, Figure 7, and Figure 8) were interpreted using the water level measurements from both the borings (B-10X) and probes (BH-X).

5.0 GEOTECHNICAL RECOMMENDATIONS

WSP Golder's geotechnical analyses and recommendations are based on the plan and profile drawings[1] of the existing site topography and existing bridge features provided to Golder by VTrans.

5.1 Engineering Properties

WSP Golder used the geotechnical data collected from the geotechnical boring program to develop design parameters for the in-situ soils and rock. Soil parameters are based on correlation of SPT N_{60} values with effective friction angles for in situ soil, on typical values for fill materials, and on values from AASHTO. The recommended design parameters are summarized in Table 5-1 for both in situ soils and proposed construction materials. The recommended design parameters are summarized in Table 5-2 for bedrock.

Table 5-1: Engineering Properties of In Situ Soil and Construction Materials

In Situ and Construction Materials	Design Friction Angle (°)	Unit Weight (pcf)	Coefficient of Friction	Earth Pressure Coefficients[1]		
				K_0	K_a	K_p
In Situ Sand and Gravel	33[2]	125	0.35[3]	0.46	0.29	0.39
Granular Backfill for Structures	34	140	0.45[4]	0.44	0.28	3.54

Notes: [1]Rankine, assuming a flat surface behind a wall; [2]Correlated from SPT N_{60} values corrected for hammer efficiency. [3]Formed or precast concrete against clean sand or silty sand-gravel mixture; [4]Formed or precast concrete against clean gravel or gravel-sand mixture from AASHTO (2020).

Table 5-2: Engineering Properties of Rock

Rock Type	Rock Mass Rating	RQD (%)	Friction Angle (°)[1]	Unconfined Compressive Strength (ksf)[2]	Coefficient of Friction[3]
Schist and Phyllite	55	46	69	1,600	0.7

Notes: [1]Correlated based on the RMR (Rock Mass Rating); [2]Correlated based on field classification strength tests; [3]Assumes concrete sliding on rock.

5.2 Frost

The 90% reliability predicted frost penetration depth below a paved surface at the site is 60 inches or 5 feet per the VTrans Pavement Design Guide[5]. We recommend a minimum frost penetration depth of 5 feet for design at the site where foundations are bearing on soil.

5.3 Lateral Earth Pressure

Abutments and wingwalls will be founded on spread footings. We recommend the abutments and wingwalls be designed to resist lateral earth pressures that may develop as a result of active earth pressure. We also recommend that granular backfill meeting the requirements of VTrans Standard Specification for Construction for Item 204.30, Granular Backfill for Structures be placed behind the abutment walls during construction. Rankine earth pressure coefficients are presented in Table 5-1 and calculations are provided in Appendix D.

5.4 Abutment and Wingwall Foundations

We understand that the bridge abutments and wingwalls are intended to consist of precast concrete founded on sub-footings bearing on bedrock. Boring B-103, located approximately 6.7 feet behind the east side of existing Abutment No. 1, encountered concrete on top of the bedrock surface at 14 feet to 15 feet bgs. Boring B-101, located approximately 12.2 feet behind the west side of existing Abutment No. 1, encountered the top of bedrock at 15.3 feet bgs. Rock probe BH-1, located approximately 20 feet behind the west side wingwall of the existing Abutment No. 1 encountered bedrock at a depth of 15 feet bgs at El. 489.2 feet. At the BH-5 rock probe which was located 42 feet to the east of the Abutment No.1 east wingwall, bedrock was encountered at depth of 12.8 feet bgs at El. 493.4 feet. The sloping of bedrock in the vicinity of Abutment No. 1 downstream from east to west (El. 493.4 to El. 489.2) indicates that the proposed sub-footings for the wingwalls and Abutment No. 1 will need to be constructed to match this bedrock slope.

Boring B-102, located approximately 19 feet behind the east side of existing Abutment No. 2, encountered the top of bedrock at 18.3 feet bgs, or El. 490.7 feet. At rock probe BH-2 bedrock was encountered at a depth of 10 feet bgs at El. 491.9 feet and at 18 feet bgs at El. 488.7 feet at BH-3, both of these rock probes were located behind the Abutment No. 2 west wingwall in the north to northwest direction. At the BH-4 rock probe which was located approximately 30 feet to the north from the Abutment No. 2 east wingwall, bedrock was encountered at a depth of 15 feet bgs at El. 494.9 feet. Similarly, to the bedrock slope at Abutment No. 1, the bedrock in the vicinity of Abutment No. 2 also slopes downstream from east to west (El. 495.0 to El. 490.7) the proposed sub-footings for the wingwalls and Abutment No. 2 will need to be constructed to match the bedrock slope. Bedrock elevation

[5] Vermont Agency of Transportation (2002). Flexible Pavement Design Procedures for use with the 1993 AASHTO Guide for Design of Pavement Structures. http://vtrans.vermont.gov/sites/aot/files/highway/documents/highway/PavementMgmtDesignGuide.pdf, Accessed 2021 January 25.

across the site ranges between El. 488.8 feet and El. 495.0 feet. We recommend footings for proposed bridge Abutment No.1 and Abutment No. 2 and wingwalls be placed on clean rock at or below the existing bedrock elevation.

WSP Golder estimated the spread footing geotechnical bearing resistance for proposed abutment dimensions from the schematic[6] provided by VTrans in the request for proposals using geotechnical design parameters determined using soil and bedrock data from the boring logs, and design procedures outlined in AASHTO (2020) for spread footings on rock. WSP Golder's calculation of estimated bearing resistance is based on an assumed effective footing width of 8 feet, the engineering properties of the bedrock, and the assumption that the footing or sub-footing will bear directly on the bedrock. Our recommended nominal geotechnical bearing resistance is 151.2 ksf for the strength limit state. We recommend a resistance factor of 0.45 be used at the strength limit state, which results in a factored bearing resistance of 68.0 ksf. To limit settlements to less than one inch, WSP Golder recommends a service limit state bearing resistance of 70 ksf be used for design of the spread footing. Since the service limit state bearing resistance is greater than the strength limit state bearing resistance, a limiting value for bearing resistance of 68.0 ksf should be used. Calculations are provided in Appendix E for Abutment No. 1 (Abutment No. 2 has similar footing dimensions and results).

Assuming the cast-in-place concrete sub-footing bears on bedrock, a sliding coefficient (tan δ) of 0.70 is recommended per AASHTO LRFD Table C3.11.5.3-1, provided the bedrock subgrade is prepared under dry conditions, can be visually inspected, and the slope of the bedrock shallower than 4H:1V in any direction. We recommend a resistance factor of 0.8 for sliding at the strength limit state. Additional sliding resistance can be provided by doweling the sub-footing to the bedrock.

Sliding between the precast concrete footing and cast-in-place concrete sub-footing should be treated as described in AASHTO LRFD Section 5.7.4 for the concrete surface conditions outlined therein. Sliding resistance can be improved by intentionally roughening the concrete surfaces and applying grout between the surfaces to improve full contact between the precast footing and cast-in-place sub-footing.

5.5 Settlement

Bedrock was encountered between 10 feet to 18.3 feet bgs and is overlain by coarse-grained sands and gravels. Assuming the proposed abutments and wingwalls will be founded on or within bedrock, settlement is anticipated to be negligible.

5.6 Scour Recommendations

VTrans' Preliminary Hydraulics Memorandum[7] indicates that the existing bridge with its 39-foot-wide clear span "does not meet state stream equilibrium standards for bankfull width", where bankfull width is estimated to be between 45 feet and 50 feet upstream and recommends "a minimum clear span of 45 feet for any new structure." The Memorandum[7] shows a potential bridge geometry where abutments have a 45-foot clear span from the abutment mid-height to the bridge deck with fill materials placed on a slope of 1V:1.5H from the mid-height of the abutments to the stream bed. The Memorandum[7] additionally identifies a preliminary design scour depth of 2.5

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6 Stantec, Waterbury BO 1446(40), z93j040borplanREVISED.pdf, dated 9/23/2021, provided by VTrans in the Work Order Request via email on September 29, 2021.

7 Vermont Agency of Transportation, Internal Technical Memorandum from Boisvert C. to Stone, L. and Wark, N. dated January 22, 2020 entitled: Waterbury BO 1446(40), Pin# 93J040, Waterbury, TH-2, Br36, over Thatcher Brook, Site location: Stowe Street and VT-100 Intersection, Coordinates: 44°20'40.1"N 72°44'49.1"W.

feet; recommends VTrans Specification 706.04 (Stone Fill, Type IV) be used to protect the stream channel banks; and notes that a final scour analysis will be performed during final design. WSP Golder supports VTrans' planned final hydraulic analyses of the proposed structure and fills, and recommends the evaluation considers: that the height of the bridge deck has sufficient freeboard during flooding for the new trapezoidal-shaped section at the bridge; that the velocity of the brook during flooding to design the sloped fill materials to resist erosion and scour; and possible ice jamming and its effects on the fill materials in the brook.

6.0 GENERAL CONSTRUCTION CONSIDERATIONS

General Subgrade Improvement

All areas proposed for embankment fill placement related to the wingwall or abutment construction should be cleared, grubbed, and stripped of existing vegetation and topsoil. During the grubbing and stripping process, unsuitable materials exposed at the subgrade level, such as wood, logs, tree stumps, forest mat materials, organic silt, peat, soft clay, cinders, debris fill, or other materials that may compress, decay or collapse should be removed. Subgrade surfaces should be prepared in accordance with VTrans Specification 203.12 (Subgrade) which requires a firm, unyielding surface compacted to attain at least 95 percent of the maximum dry density as determined by AASHTO T99, Method C. Where hand-guided equipment is used, such as a small vibratory plate compactor, the loose lift thickness shall not exceed 6 inches and cobbles larger than 4 inches should be removed from the fill prior to placement.

Rock Removal Recommendations

Golder recommends the planned spread footing be founded on the in-situ bedrock, or on a sub-footing supported on the bedrock. Rock excavation should be conducted carefully to prevent overbreakage and the removal of rock beyond the limits of excavation.

Where bedrock removal is needed for construction of the abutment sub-footing, the removal method should be limited to mechanical methods only and blasting methods (such as close-in blasting) should be avoided. Mechanical methods should consist of perforation drilling, line drilling, broaching, hydraulic splitting, ripping, use of hydraulic hammers/breakers, use of expansive agents, or other mechanical means of rock removal, as approved by the Engineer.

The bedrock subgrade that will bear foundation concrete for the abutment sub-footing should be cleaned of loose rock, soil, and dust and pressure washed. Cleaning of rock surfaces should consist of the removal of all organic materials, soil, dust, and loose rock. Cleaning may be performed with high-pressure air jets, water jets, brooms, or by any other method acceptable to the Engineer. The bedrock subgrade should consist of a reasonably level surface and be free of projections that cannot be spanned by footing reinforcement or that reduce the concrete cover over reinforcement by more than 30%. Where rock has been overexcavated to achieve a level bearing surface or a concrete sub-footing is specified, concrete having a minimum 28-day compressive strength of 3,000 psi should be placed on the cleaned bedrock surface to the foundation bearing elevation.

Sub-footing Doweling Recommendations

Where dowels are required to increase sliding resistance between the bedrock and concrete sub-footing, holes for the reinforcement should be at least 1 inch greater in diameter than the dowel when Type IV mortar is used per VTrans Specification 507.06, Placing Dowels. Where approved adhesives are used, the manufacturer's recommendations should be followed for hole sizing. The Contractor should flush the drill holes of all drill cuttings and debris with compressed air prior to the installation of the rock dowels.

Abutment and Wingwall Construction

Structural Fill for use in abutment construction should meet the requirements of VTrans Specification 704.08 for "Granular Backfill for Structures" and satisfy the gradation limits shown on VTrans Specification Table 704.08A. Structural Fill should be placed in accordance with VTrans Specification 204.05 (Backfill) and should be placed in layers not exceeding 6 inches in thickness, and compacted to at least 95 percent of its AASHTO T99, Method C maximum dry density. To verify consistency of material properties, gradation tests (ASTM D422, AASHTO T27) should be performed at a 1/1,000 cubic yard frequency, and moisture density testing to establish target densities (ASTM D698, AASHTO T99) should be performed at a 1/10,000 cubic yard frequency during construction. In addition, to verify in-place compacted density and moisture content, confirmatory field moisture and density tests (ASTM D6938, AASHTO T310) should be performed at a frequency of three (3) locations per lift, or at the discretion of the geotechnical engineer.

Construction Observation

The recommendations contained herein are based on the known and predictable behavior of properly engineered and constructed foundations. We recommend observation of the subsurface conditions during construction, subgrade preparation for spread footings, and spread footing installation to verify that the procedures and techniques used during construction are in accordance with our recommendations contained herein.

7.0 CLOSING

This report was prepared for VTrans specifically to provide general geotechnical foundation recommendations for the proposed replacement of Bridge 36 over Thatcher Brook in Waterbury, Vermont. We performed the site investigation and compiled our recommendations in accordance with generally accepted soil, bedrock, and foundation engineering practices in this geographical area and under similar time and financial constraints. The professional services provided by WSP Golder for this project include only the geotechnical aspects of the subsurface conditions at this site. Our general geotechnical recommendations are based, in part, on information obtained from the referenced subsurface explorations completed at the discrete locations described in this memorandum. Variations in the nature and extent of subsurface conditions between explorations should be expected. WSP Golder makes no other warranty, either express or implied.

Signature Page

Golder Associates Inc.

Melissa E. Landon, PhD, PE
Lead Consultant Geotechnical Engineer

Jay R. Smerekanicz, PG, CPG
Senior Lead Consultant, Geologist

Christopher C. Benda, PE
Director, Geotechnical Engineer

MA/MEL/CCB/JRS

https://golderassociates.sharepoint.com/sites/153945/project files/6 deliverables/final report/vtrans waterbury br36 bo1446(40) report golder-21497656 6.16.22.docx

Tables

Table 1: Bedrock Depths from Borings Nearby Abutments
Geotechnical Investigation and Recommendations
Bridge No. 36 Replacement, Waterbury, VT
Waterbury BO 1446(40)

Test Boring Designation[1,2]	As-Drilled Locations[3,4,5]		Existing Ground Surface Elevation[3] (ft)	Boring Depth[4] (ft)	Bedrock Elevation[4] (ft)	Bedrock Depth[4] (ft)	Nearby Feature
	Stationing	Offset					
B-101	32+37.7	8.5 ft L	507.6	16.5	492.3	15.3	Abutment 1
B-101A	32+43.8	4.7 ft L	507.8	11.1	-[5]	-	Abutment 1
B-102	33+08.9	5.0 ft R	509.0	23.5	490.7	18.3	Abutment 2
B-103	32+43.3	6.8 ft R	507.7	19.0	492.7	15.0	Abutment 1
BH-1	32+07.0	31.7 ft L	504.2	25.0	489.2	15.0	Abutment 1
BH-2	32+90.5	38.9 ft L	501.9	20.0	491.9	10.0	Abutment 2
BH-3	32+97.8	20.0 ft L	506.8	28.0	488.8	18.0	Abutment 2
BH-4	33+34.7	17.5 ft R	510.0	25.0	495.0	15.0	Abutment 2
BH-5	32+60.6	73.2 ft R	506.2	22.8	493.4	12.8	Abutment 1

Notes

1. Borings B-101 and B-102 were performed by Platform Environmental Drilling and Remediation Services (Platform) from November 18 to 19, 2021. Borings B-101A and B-103 were performed by Platform on December 10, 2021.
2. Rock Probes BH-1 through BH-5 were performed by VTrans from April 26 to May 4, 2022.
3. All boring (B-10X & BH-X) locations are illustrated in Figure 2 of the Geotechnical Services Report.
4. As-Drilled elevations for B-101 and B-102 are derived from the survey file received from VTrans on December 2, 2021 entitled: z93j040sv.DNG. As-drilled locations and elevations for B-101A and B-103 were provided in an email from VTrans on December 20th, 2021.
5. As-Drilled location and elevations for BH-1 through BH-5 are derived from the electronic file received from VTrans on May 19, 2022 entitled: Waterbury BO 1446 (40).PDF.
6. Boring logs with descriptions of the soil and rock encountered at the site are provided provided in Appendix A.
7. An obstruction crimped the casing at 11.1 ft below ground surface and the boring was terminated.

Prepared By: ATM/MA
Checked By: BK/FCT
Reviewed By: MEL

Table 2: Summary of Rock Core Quality
Geotechnical Investigation and Recommendations
Bridge No. 36 Replacement, Waterbury, VT
Waterbury BO 1446(40)

			Run						TCR [2]		RQD [3]			Physical Rock Parameters			
Test Boring Designation	Core Size	Existing Ground Surface Elevation[1]	No.	Midpoint Depth Below Bedrock Surface	Depth Below Ground Surface (ft)			Length	Length		Length		Designation	Weathering[4]	Estimated Field Strength[5]	Rock Mass Rating [RMR][6]	
(-)	(in)	(ft)	(-)	(ft)	Start	End	Midpoint	(ft)	(ft)	%	(ft)	%	(-)	(-)	(-)	(-)	Lithologic, Rock Mass and Discontinuity Description[7]
B-101	NQ (2.875)	507.6	R1	16.0	15.5	16.5	16.0	1.0	0.7	70%	0.00	0%	Very Poor	Fresh (W1)	Very Strong (R5)	57	15.5-16.5 ft: Greenish gray, fine grained, fresh (W1), very strong (R5), SCHIST and PHYLLITE, discontinuities horizontal to moderately dipping (0 to 30°), very closely spaced (0.2 ft); [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
B-102	NQ (2.875)	509.0	R1	21.0	18.5	23.5	21.0	5.0	4.3	86%	3.85	77%	Good	Fresh (W1)	Very Strong (R5)	69	18.5-23.5 ft: Green, fine-grained, fresh (W1), very strong (R5), GREENSCHIST and PHYLLITE; discontinuities low angle to steep (15 to 75°), very close to moderately closely spaced (0.15 to 2.0 ft); [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
B-103	NX (2.16)	507.7	R1	17.0	15.0	19.0	17.0	4.0	2.2	55%	1.15	29%	Poor	Fresh (W1)	Very Strong (R5)	62	15-19 ft: Gray, fine-grained, fresh (W1), very strong (R5), SCHIST and PHYLLITE; discontinuities low angle to steep (20 - 60°), very close to closely spaced (0.1 - 0.8 ft); [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-1	NX (2.16)	504.2	R1	17.5	15.0	20.0	17.5	5.0	5.0	100%	3.40	68%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Moderately Hard	60	15-20 ft: Gray-black & white, fine-grained, fresh (W1) to very slightly weathered (W2), moderately hard (R4), graphitic PHYLLITE; discontinuities steeply dipping (70° - 75°), close to moderately close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-1	NX (2.16)	504.2	R2	22.5	20.0	25.0	22.5	5.0	4.8	96%	3.05	61%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Hard	60	20-25 ft: Gray-black & white, fine-grained, fresh (W1) to very slightly weathered (W2), hard (R4), graphitic PHYLLITE; discontinuities steeply dipping (70° - 75°), close to moderate joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-2	NX (2.16)	501.9	R1	12.5	10.0	15.0	12.5	5.0	4.4	88%	1.55	31%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Moderately Hard	50	10-15 ft: Silver-gray & white, fine-grained, fresh (W1) to very slightly weathered (W2), moderately hard (R3), graphitic PHYLLITE; discontinuities steeply dipping (75° - 85°), close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-2	NX (2.16)	501.9	R2	17.5	15.0	20.0	17.5	5.0	4.5	90%	3.25	65%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Hard	50	20-25 ft: Silver-gray & white, fine-grained, fresh (W1) to very slightly weathered (W2), hard (R4), graphitic PHYLLITE; discontinuities steeply dipping (75° - 80°), close to moderate joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-3	NX (2.16)	506.8	R1	20.5	18.0	23.0	20.5	5.0	5.0	100%	2.10	42%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Moderately Hard	50	18-23 ft: Silver-gray & white, fine-grained, fresh (W1) to very slightly weathered (W2), moderately hard (R3), graphitic PHYLLITE; discontinuities steeply dipping (85°), close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-3	NX (2.16)	506.8	R2	25.5	23.0	28.0	25.5	5.0	5.0	100%	3.60	72%	Fair	Fresh (W1) to Very Slightly Weathered (W2)	Hard	55	23-28 ft: Silver-gray & white, fine-grained, fresh (W1) to very slightly weathered (W2), hard (R4), graphitic PHYLLITE; discontinuities steeply dipping (75° - 85°), close to moderate joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-4	NX (2.16)	510.0	R1	23.0	15-20	23.0	23.0	5.0	4.5	90%	1.05	21%	Poor	Slightly (W2) to Moderately Weathered (W3)	Moderately Hard	34	15-20 ft: Green-gray & white, fine-grained, slightly weathered (W2) to moderately weathered (W3), moderately hard (R3), PHYLLITE; discontinuities steeply dipping (85°), very close to close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-4	NX (2.16)	510.0	R2	22.5	20.0	25.0	22.5	5.0	5.0	100%	3.15	63%	Good	Fresh (W1)	Moderately Hard	65	20-25 ft: Green-gray & white, fine-grained, fresh (W1), moderately hard (R3), graphitic PHYLLITE; discontinuities steeply dipping (75° - 85°), moderately close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]

Table 2: Summary of Rock Core Quality
Geotechnical Investigation and Recommendations
Bridge No. 36 Replacement, Waterbury, VT
Waterbury BO 1446(40)

Test Boring Designation	Core Size	Existing Ground Surface Elevation[1]	Run						TCR [2]		RQD [3]			Physical Rock Parameters			
			No.	Midpoint Depth Below Bedrock Surface	Depth Below Ground Surface (ft)			Length	Length		Length		Designation	Weathering[4]	Estimated Field Strength[5]	Rock Mass Rating [RMR][6]	
(-)	(in)	(ft)	(-)	(ft)	Start	End	Midpoint	(ft)	(ft)	%	(ft)	%	(-)	(-)	(-)	(-)	Lithologic, Rock Mass and Discontinuity Description[7]
BH-5	NX (2.16)	506.2	R1	15.3	12.8	17.8	15.3	5.0	5.0	100%	1.75	35%	Fair	Slightly Weathered (W2)	Moderately Hard	55	12.8-17.8 ft: Gray & white, fine-grained, slightly weathered (W2), moderately hard (R3), graphitic PHYLLITE; discontinuities steeply dipping (65° - 75°), close to moderately close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]
BH-5	NX (2.16)	506.2	R2	20.3	17.8	22.8	20.3	5.0	5.0	100%	1.55	31%	Fair	Very Slightly Weathered (W2)	Moderately Hard	55	17.8-22.8 ft: Dark-gray & white to white & green-gray, fine-grained, very slightly weathered (W2), moderately hard (R3), graphitic PHYLLITE; discontinuities steeply dipping (65° - 80°), close to moderately close joint spacing; [CARBONACEOUS PHYLLITE MEMBER, OTTAUQUECHEE FORMATION]

Notes:

1. As-Drilled elevations for B-101 and B-102 are derived from the survey file received from VTrans on December 2, 2021 entitled: z93j040sv.DNG. The As-drilled elevation for B-103 was provided in an email from VTrans on December 20th, 2021.
2. As-Drilled elevations for BH-1 through BH-5 are derived from the rock probe logs provided to Golder on May 19, 2022 in electronic file entitled: Waterbury BO 1446 (40) Rock Probe Logs.
3. TCR = total core recovery. Total core recovery is the length of core recovered divided by the length of the run.
4. RQD = rock quality designation. RQD is the total length of intact, full diameter core pieces recovered with a length greater than or equal to 4 inches measured along the core axis. The percent RQD is the total length of RQD measured versus the run length. Note that vertical discontinuities are not included in determination of RQD.
5. Weathering and Estimated Field Strength for Golder Borings B-101, -102 and -103 based on Tables II.4 and II.3 (respectively) in Willey, 2004 (based on ISRM, 1981).
6. Rock Mass Rating (RMR) System (Bieniawski, 1989) assigns numerical ratings to six parameters, including the strength of the intact rock, the RQD, the discontinuity spacing, groundwater conditions, and orientation of discontinuities. These ratings are summed to give the RMR value. The rating adjustment for joint orientation was assigned a value of 0; correlation of geologic field mapping data of exposed rock outcrops with the rock core samples and proposed foundation type may allow for a different rating adjustment for joint orientation, and thus a modification to the RMR value shown on this table.
7. Mapped bedrock formation taken from: Bedrock Geologic Map of Vermont By Nicholas M Ratcliffe (USGS), Rolfe S Stanley (Univ. of Vermont), Marjorie H. Gale (Vermont Geological Survey), and Gregory J. Walsh (USGS), 2011.
8. ft = feet, in = inches

Prepared by: BK/ATM/MA
Checked by: MEL
Reviewed by: JRS

Table 3: Summary of Laboratory Soil Index and Classification Testing Results
Geotechnical Investigation and Recommendations
Bridge No. 36 Replacement, Waterbury, VT
Waterbury BO 1446(40)

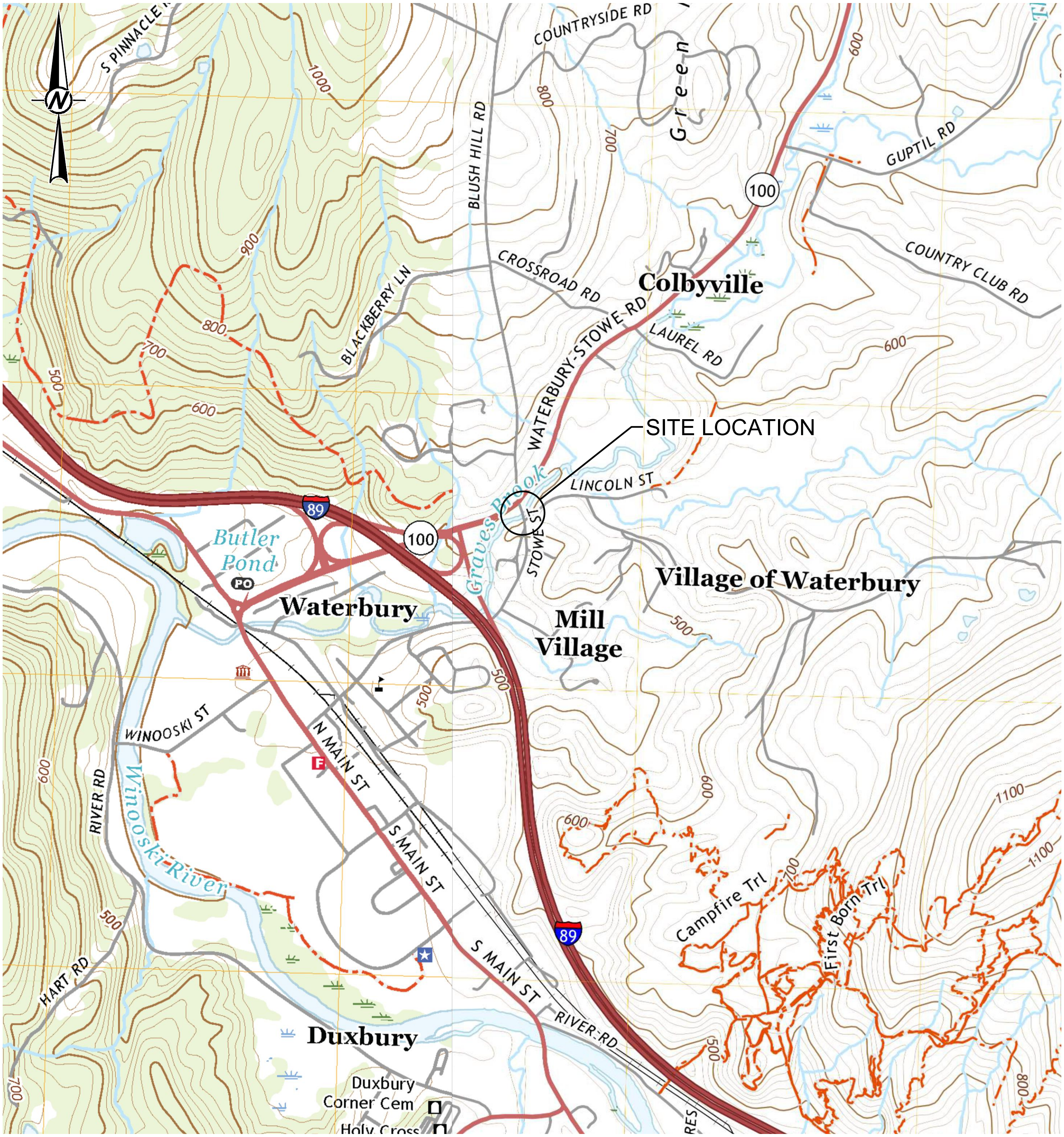
Test Boring Designation[1]	Ground Surface Elevation[2] (feet)	Sample Number[3]	Sample Depth Below Ground Surface (feet)	Approximate Sample Elevation (feet)	Laboratory Testing[4]		Soil Classification	
					Sieve Minus No. 200 (%)	Moisture Content (%)	AASHTO	USCS
B-101	507.6	1DB	0.30 - 0.75	507.3 - 506.8	9.8	8.8	A-1-b	SW-SM
B-101	507.6	1DA	0.75 - 1.55	506.8 - 506.0	9.5	13.0	A-1-b	SW-SM
B-101	507.6	2DB	2.00 - 2.50	505.6 - 505.1	8.4	4.8	A-1-a	GP-GM
B-101	507.6	2DA	2.50 - 4.00	505.1 - 503.6	36.0	11.5	A-4	SM
B-101	507.6	3DB	8.00 - 8.40	499.6 - 499.2	8.7	5.6	A-1-a	GW-GM
B-101	507.6	3DA	8.40 - 10.00	499.2 - 497.6	5.0	0.7	A-1-a	GW-GM
B-101	507.6	4DB	14.00 - 14.30	493.6 - 493.3	17.6	10.4	A-1-b	SM
B-101	507.6	4DA	14.30 - 15.30	493.3 - 492.3	12.8	5.4	A-1-b	SM
B-102	509.0	1D	0.90 - 1.60	508.1 - 507.4	10.5	3.4	A-1-a	GW-GM
B-102	509.0	2D	4.00 - 6.00	505.0 - 503.0	31.0	13.6	A-2-4	SM
B-102	509.0	3D	11.00 - 13.00	498.0 - 496.0	14.9	46.3	A-1-b	SM
B-102	509.0	4D	14.00 - 16.00	495.0 - 493.0	60.8	45.5	A-4	ML

Notes:

1. Test boring (B-10X) locations are illustrated in the plan titled "Waterbury BO 1446(40) Boring Locations with Ground & Bedrock Elevations.pdf".
2. As-drilled elevations for B-101 and B-102 are derived from electronic file "z93j040sv.dgn" received by Golder on December 2, 2021 from VTrans.
3. Laboratory testing was performed by VTrans Construction and Materials Bureau Central Laboratory
4. The particle size testing was done in accordance with AASHTO T 88, *Standard Method of Test for Particle Size Analysis of Soils* and the moisture contest testing was done in accordance with AASHTO T 265 *Standard Method of Test for Laboratory Determination of Moisture Content of Soils*.
5. AASHTO and USCS symbols assigned based on interpreted laboratory test results provided by VTrans on December 14, 2021.
6. Complete laboratory soil test results are provided in Appendix C.

Prepared By: ATM
Checked By: BK
Reviewed By: CCB

Figures



REFERENCE(S)

BASE MAPS TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLES OF MIDDLESEX AND WATERBURY, VERMONT DATED 2021.

NOT FOR CONSTRUCTION

0 250 500

1" = 500' FEET

CLIENT	PROJECT
VERMONT AGENCY OF TRANSPORTATION 219 N MAIN ST, BARRE, VT 05641	VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

TITLE

SITE LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	1

Last Edited By: gsantell Date: 2022-06-07 Time:1:18:54 PM | Printed By: GSantell Date: 2022-06-08 Time:1:47:08 PM
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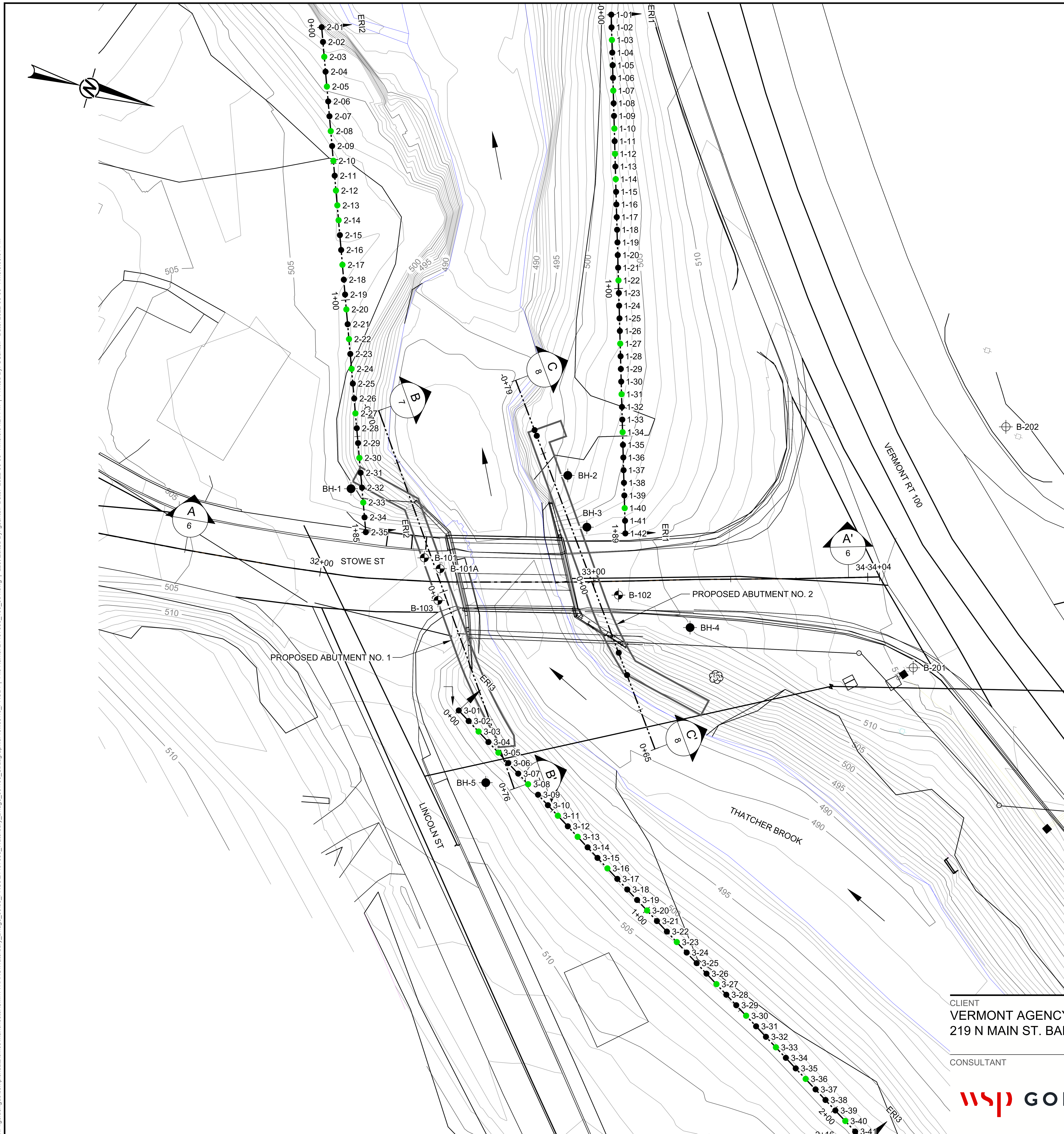
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

0



LEGEND

- EXISTING CONTOURS (1FT MINOR INTERVALS AND 5FT MAJOR INTERVALS)
- TEST BORING LOCATION GOLDER 2021
- BH-1 — ROCK PROBE LOCATION VTRANS 2022
- HISTORICAL BORING LOCATION
- ELECTRICAL RESISTIVITY IMAGING (ERI) LOCATIONS
- A 6 / A' 6 — SUBSURFACE PROFILE LOCATION AND VIEW DIRECTION
- PROPOSED ABUTMENT FEATURE
- SHORELINE
- FLOW DIRECTION

NOTE(S)

1. BASEMAP IS TAKEN FROM ELECTRONIC FILE "z93j040sv.dgn" PROVIDED TO GOLDER BY VTRANS ON DECEMBER 2, 2021.
2. THE AS-DRILLED GOLDER BORING LOCATIONS FOR BORINGS B-101 AND B-102 SHOWN IN THIS FIGURE ARE DERIVED FROM ELECTRONIC FILE "z93j040sv.dgn" PROVIDED TO GOLDER BY VTRANS ON DECEMBER 2, 2021.
3. THE AS-DRILLED GOLDER BORING LOCATIONS FOR BORINGS B-101A AND B-103 SHOWN IN THIS FIGURE WERE PROVIDED TO GOLDER BY VTRANS VIA EMAIL ON DECEMBER 20, 2021
4. THE PROPOSED ABUTMENT FEATURES SHOWN ARE DERIVED FROM ELECTRONIC FILE "bridge footing.dgn" PROVIDED TO GOLDER BY STANTEC ON FEBRUARY 9, 2022.
5. THE AS-DRILLED VTRANS ROCK PROBE LOCATIONS FOR BH-1 THROUGH BH-5 SHOWN IN THIS FIGURE ARE DERIVED FROM THE INFORMATION FOUND IN THE ELECTRONIC FILE "WATERBURY BO 1446 (40) ROCK PROBE LOGS.PDF" PROVIDED TO GOLDER BY VTRANS ON MAY 19, 2022.

NOT FOR CONSTRUCTION

0 20 40
1" = 20' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST. BARRE, VT 05641

CONSULTANT
WSP GOLDER

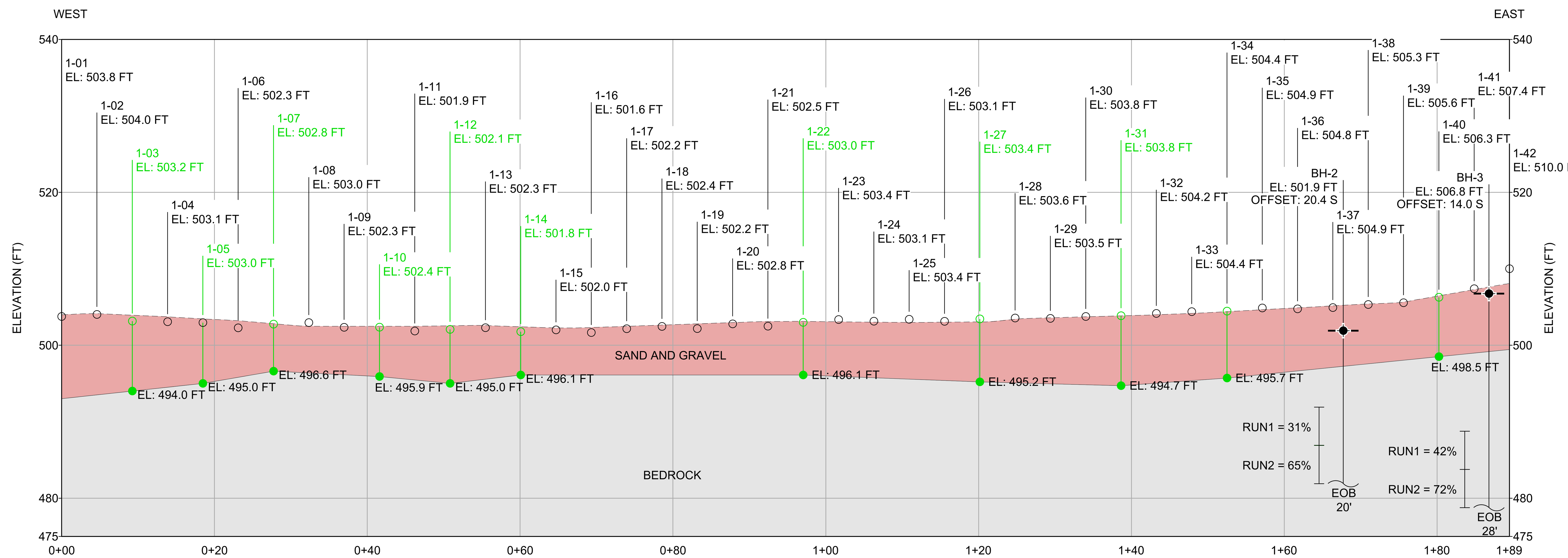
YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

TITLE
BORING LOCATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



LEGEND

BH-2 / EL: 501.9 FT / OFFSET: 20.4 S	BORING LOCATION I.D. / ELEVATION / OFFSET (FT) FROM SECTION LINE
RUN1 - 31%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 20'	END OF BORING BELOW GROUND SURFACE (BGS)
1-03 / EL:503.2 FT	ERI ID: LINE NO. - POINT NO. / SOURCE ELEVATION
EL: 494.0 FT	BEDROCK ELEVATION
(pink fill)	BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)
(gray fill)	GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)
(dashed line)	EXISTING GROUND SURFACE

NOTE(S)

1. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
2. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
3. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

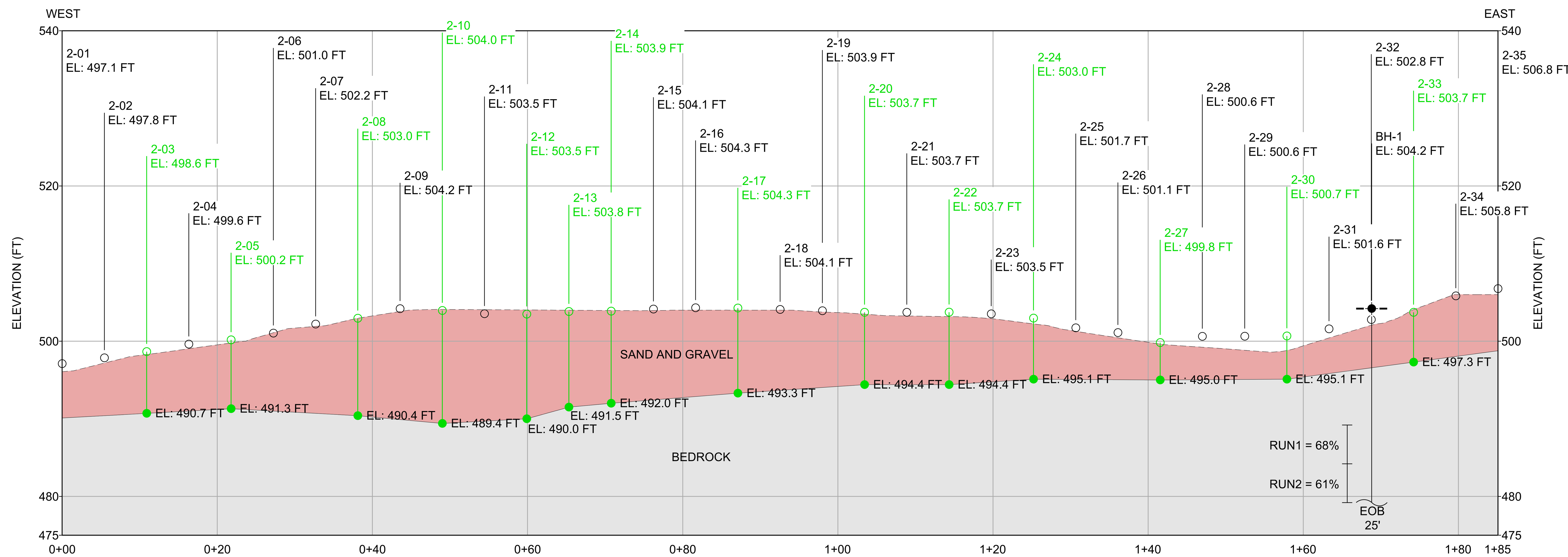
PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

TITLE
ELECTRICAL RESISTIVITY IMAGING PROFILE, ERI-1

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	3



LEGEND

BH-1 EL: 504.2 FT OFFSET: 4.0 S	BORING LOCATION I.D. ELEVATION OFFSET (FT) FROM SECTION LINE
RUN1 - 68%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 25'	END OF BORING BELOW GROUND SURFACE (BGS)
2-03 EL:498.6 FT	ERI ID: LINE NO. - POINT NO. SOURCE ELEVATION
EL: 490.7 FT	BEDROCK ELEVATION

- BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)
- GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)
- EXISTING GROUND SURFACE

NOTE(S)

1. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
2. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
3. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

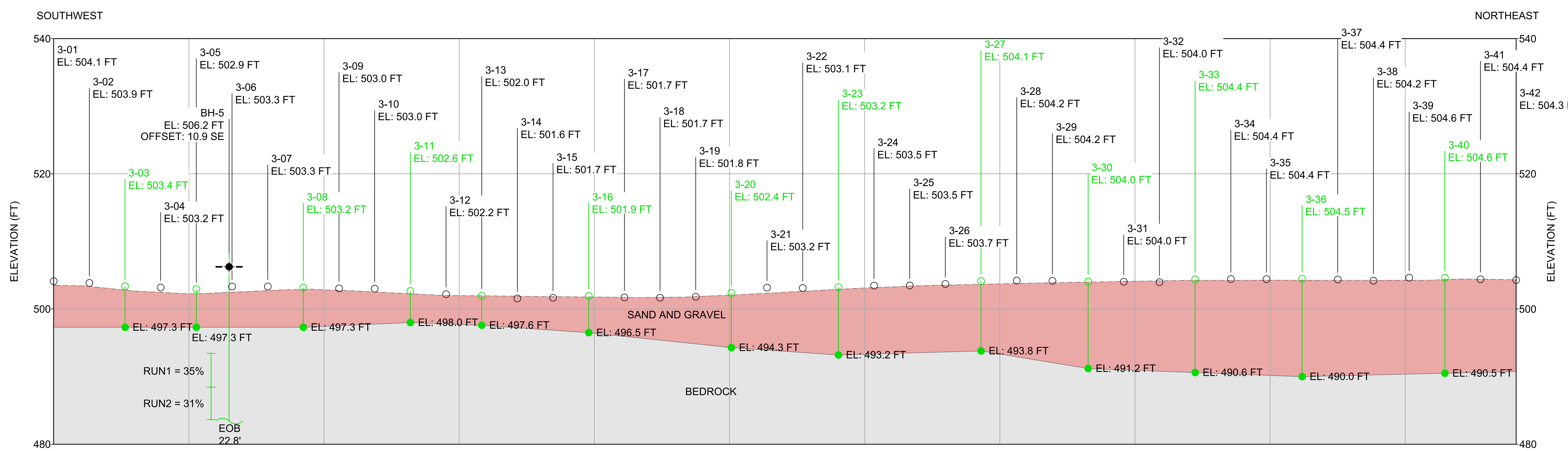
CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

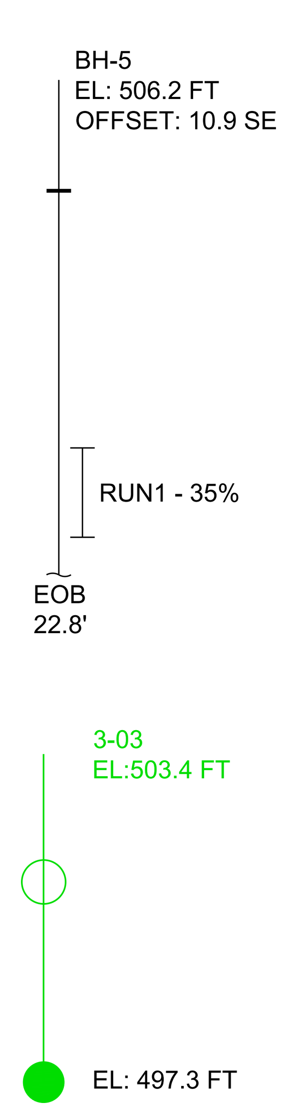
PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

TITLE
ELECTRICAL RESISTIVITY IMAGING PROFILE, ERI-2

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	4



LEGEND



BH-5 / EL: 506.2 FT / OFFSET: 10.9 SE	BORING LOCATION I.D. / ELEVATION / OFFSET (FT) FROM SECTION LINE
RUN1 - 35%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 22.8'	END OF BORING BELOW GROUND SURFACE (BGS)
3-03 EL:503.4 FT	ERI ID: LINE NO. - POINT NO. SOURCE ELEVATION
EL: 497.3 FT	BEDROCK ELEVATION

BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)

GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)

EXISTING GROUND SURFACE

NOTE(S)

1. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
2. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
3. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

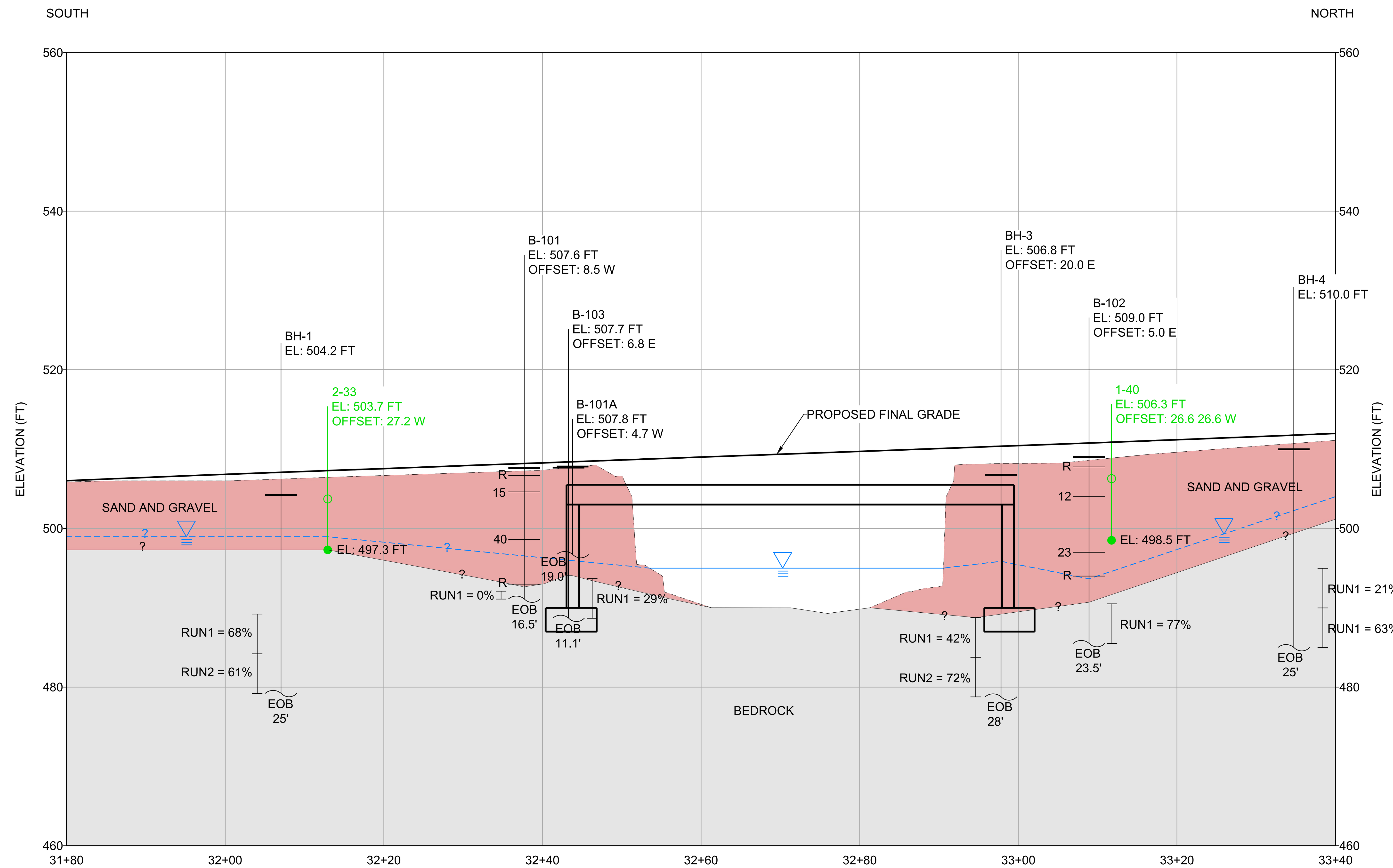
CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

TITLE
ELECTRICAL RESISTIVITY IMAGING PROFILE, ERI-3

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	5



LEGEND

B-101	BORING LOCATION I.D.
EL: 507.3 FT	ELEVATION
OFFSET: 8.5 W	OFFSET (FT) FROM SECTION LINE
30	SPT: N60 - VALUE (CORRECTED FOR HAMMER EFFICIENCY)
RUN1 - 0%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 16.5'	END OF BORING BELOW GROUND SURFACE (BGS)
2-33	ERI ID: LINE NO. - POINT NO.
EL:506.5 FT	SOURCE ELEVATION
OFFSET: 27.2 W	OFFSET (FT) FROM SECTION LINE
EL: 497.3 FT	BEDROCK ELEVATION

- BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)
- GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)
- EXISTING GROUND SURFACE
- INTERPRETED GROUNDWATER SURFACE
- PROPOSED GROUND SURFACE
- ESTIMATED UPSTREAM BANK FULL WIDTH WATER LEVEL OF THATCHER BROOK

NOTE(S)

1. THE AS-DRILLED GOLDER BORING LOCATIONS AND ELEVATIONS FOR BORINGS B-101 AND B-102 SHOWN IN THIS FIGURE ARE DERIVED FROM ELECTRONIC FILE "z93j040sv.dgn" PROVIDED TO GOLDER BY VTRANS ON DECEMBER 2, 2021.
2. THE AS-DRILLED BORING LOCATIONS AND ELEVATIONS FOR BORINGS B-101A AND B-103 SHOWN IN THIS FIGURE WERE PROVIDED TO GOLDER BY VTRANS VIA EMAIL ON DECEMBER 20, 2021
3. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
4. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
5. THE GROUNDWATER TABLE SHOWN IN THIS FIGURE IS INTERPRETED FROM FIELD MEASUREMENTS DURING DRILLING AND ACTUAL FIELD CONDITIONS WILL VARY.
6. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.
7. WATER LEVEL IN THATCHER BROOK IS BASED ON VTRANS PRELIMINARY HYDRAULIC ANALYSIS ESTIMATED UPSTREAM BANK FULL WIDTH.
8. THIS FIGURE DEPICTS THE INTERPRETED SUBSURFACE CONDITIONS AT THE CENTERLINE OF THE EXISTING ROAD AND DOES NOT SHOW THE EXISTING BRIDGE ABUTMENTS.
9. THE STATIONING SHOWN ON THIS FIGURE IS THE EXISTING STOWE ST STATIONING AND OFFSET DISTANCES ARE FROM THE CENTERLINE OF THE EXISTING ROADWAY.
10. PROPOSED GRADES WERE TAKEN FROM DWG TITLED "z93j040_corridor_Default-3D.dwg" PROVIDED TO GOLDER BY VTRANS ON JANUARY 12, 2022.
11. THE PROPOSED ABUTMENT AND SUPERSTRUCTURE FEATURES SHOWN ARE DERIVED FROM ELECTRONIC FILE "BRIDGE FOOTING.DGN" PROVIDED TO GOLDER BY STANTEC ON FEBRUARY 9, 2022.
12. THE AS-DRILLED VTRANS ROCK PROBE LOCATIONS FOR BH-1 THROUGH BH-5 SHOWN IN THIS FIGURE ARE DERIVED FROM THE INFORMATION FOUND IN THE ELECTRONIC FILE "WATERBURY BO 1446 (40) ROCK PROBE LOGS.PDF" PROVIDED TO GOLDER BY VTRANS ON MAY 19, 2022.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

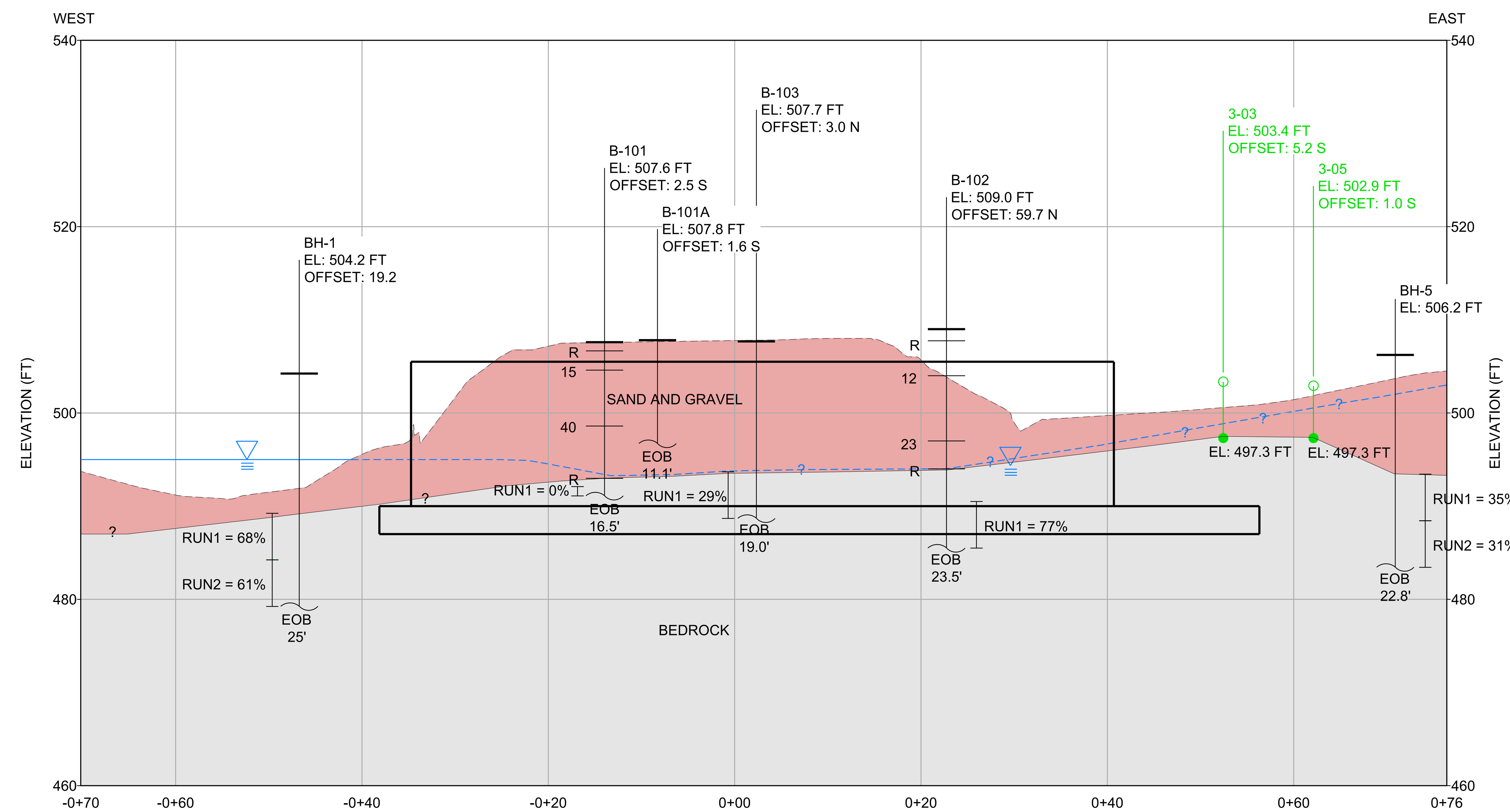
PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

TITLE
INTERPRETED SUBSURFACE PROFILE A-A'

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	6



LEGEND

B-101 EL: 507.6 FT OFFSET: 10.8 W	BORING LOCATION I.D. ELEVATION OFFSET (FT) FROM SECTION LINE
30	SPT: N60 - VALUE (CORRECTED FOR HAMMER EFFICIENCY)
RUN1 - 0%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 16.5'	END OF BORING BELOW GROUND SURFACE (BGS)
3-03 EL:503.4 FT OFFSET: 5.5 S	ERI ID: LINE NO. - POINT NO. SOURCE ELEVATION OFFSET (FT) FROM SECTION LINE
EL: 497.3 FT	BEDROCK ELEVATION

- BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)
- GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)
- EXISTING GROUND SURFACE
- INTERPRETED GROUNDWATER SURFACE
- ESTIMATED UPSTREAM BANK FULL WIDTH WATER LEVEL OF THATCHER BROOK

NOTE(S)

1. THE AS-DRILLED GOLDER BORING LOCATIONS AND ELEVATIONS FOR BORINGS B-101 AND B-102 SHOWN IN THIS FIGURE ARE DERIVED FROM ELECTRONIC FILE "z93j040sv.dgn" PROVIDED TO GOLDER BY VTRANS ON DECEMBER 2, 2021.
2. THE AS-DRILLED BORING LOCATIONS AND ELEVATIONS FOR BORING B-103 SHOWN IN THIS FIGURE WAS PROVIDED TO GOLDER BY VTRANS VIA EMAIL ON DECEMBER 20, 2021
3. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
4. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
5. THE GROUNDWATER TABLE SHOWN IN THIS FIGURE IS INTERPRETED FROM FIELD MEASUREMENTS DURING DRILLING AND ACTUAL FIELD CONDITIONS WILL VARY.
6. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.
7. WATER LEVEL IN THATCHER BROOK IS BASED ON VTRANS PRELIMINARY HYDRAULIC ANALYSIS ESTIMATED UPSTREAM BANK FULL WIDTH.
8. THIS FIGURE DEPICTS THE INTERPRETED SUBSURFACE CONDITIONS AT THE CENTERLINE OF THE EXISTING ROAD AND DOES NOT SHOW THE EXISTING BRIDGE ABUTMENTS.
9. THE OFFSET DISTANCES SHOWN IN THIS FIGURE ARE FROM THE LOCATION OF THE EXISTING ABUTMENT NO. 1.
10. THE PROPOSED ABUTMENT AND SUPERSTRUCTURE FEATURES SHOWN ARE DERIVED FROM ELECTRONIC FILE "BRIDGE FOOTING.DGN" PROVIDED TO GOLDER BY STANTEC ON FEBRUARY 9, 2022.
11. THE AS-DRILLED VTRANS ROCK PROBE LOCATIONS FOR BH-1 THROUGH BH-5 SHOWN IN THIS FIGURE ARE DERIVED FROM THE INFORMATION FOUND IN THE ELECTRONIC FILE "WATERBURY BO 1446 (40) ROCK PROBE LOGS.PDF" PROVIDED TO GOLDER BY VTRANS ON MAY 19, 2022.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

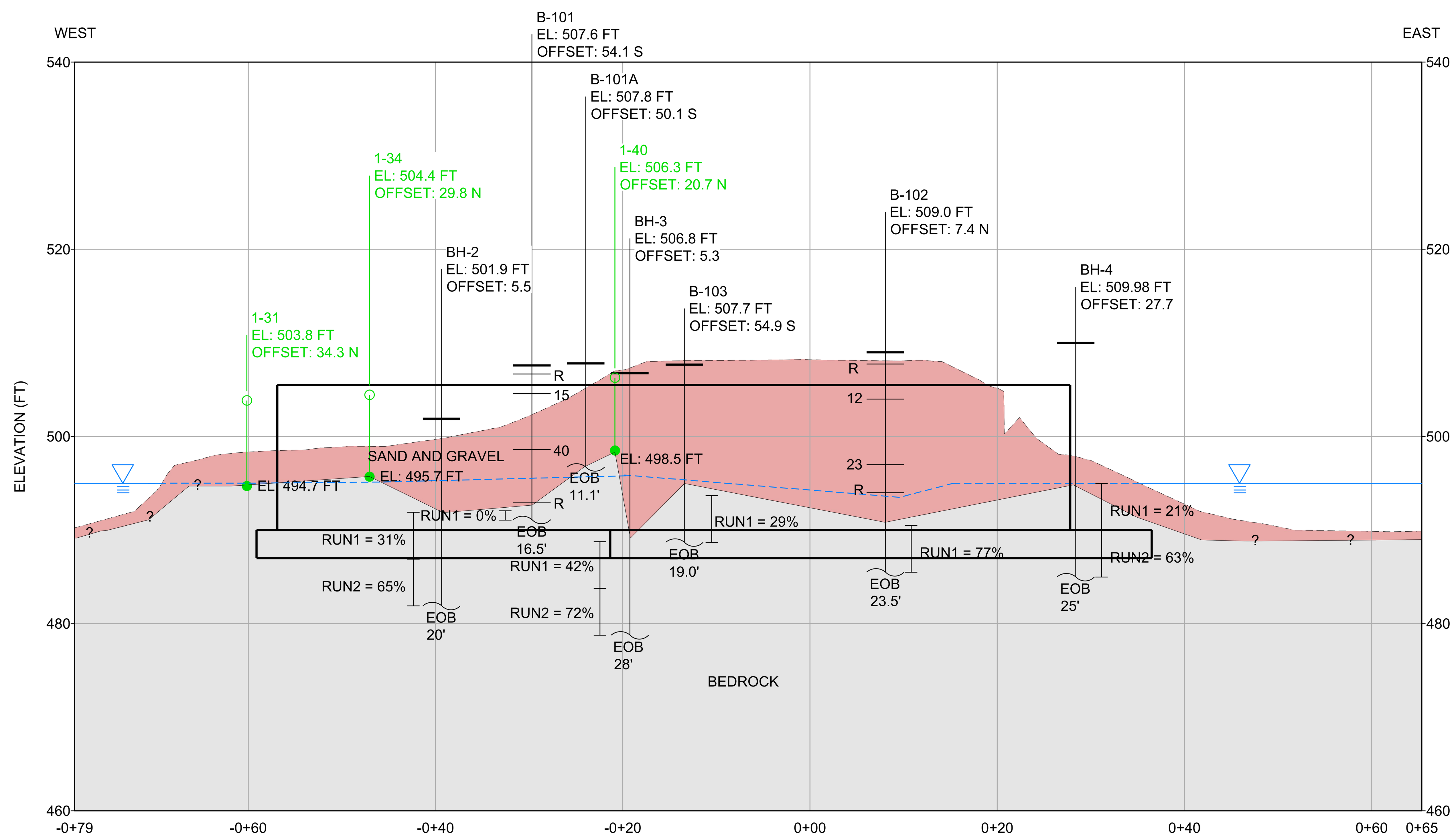
PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

TITLE
INTERPRETED SUBSURFACE CROSS SECTION B-B'

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	7



LEGEND

B-101 EL: 507.6 FT OFFSET: 50.5 W	BORING LOCATION I.D. ELEVATION OFFSET (FT) FROM SECTION LINE
30	SPT: N60 - VALUE (CORRECTED FOR HAMMER EFFICIENCY)
RUN1 - 0%	ROCK CORE RUN NUMBER AND ROCK QUALITY DESIGNATION (RQD)
EOB 16.5'	END OF BORING BELOW GROUND SURFACE (BGS)
1-34 EL:504.4 FT OFFSET: 29.9 N	ERI ID: LINE NO. - POINT NO. SOURCE ELEVATION OFFSET (FT) FROM SECTION LINE
EL: 495.7 FT	BEDROCK ELEVATION

- BROWN, LOOSE TO VERY DENSE, FINE TO COARSE SAND AND GRAVEL, TRACE TO SOME SILT (SAND AND GRAVEL)
- GREENISH GRAY, FINE-GRAINED, FRESH, VERY STRONG, SCHIST AND PHYLLITE (BEDROCK)
- EXISTING GROUND SURFACE
- INTERPRETED GROUNDWATER SURFACE
- PROPOSED ABUTMENT ELEMENTS
- ESTIMATED UPSTREAM BANK FULL WIDTH WATER LEVEL OF THATCHER BROOK

NOTE(S)

1. THE AS-DRILLED GOLDER BORING LOCATIONS AND ELEVATIONS FOR BORINGS B-101 AND B-102 SHOWN IN THIS FIGURE ARE DERIVED FROM ELECTRONIC FILE "z93j040sv.dgn" PROVIDED TO GOLDER BY VTRANS ON DECEMBER 2, 2021.
2. THE AS-DRILLED BORING LOCATIONS AND ELEVATIONS FOR BORINGS B-101A AND B-103 SHOWN IN THIS FIGURE WERE PROVIDED TO GOLDER BY VTRANS VIA EMAIL ON DECEMBER 20, 2021
3. THE GOLDER GEOPHYSICS ERI POINT LOCATIONS SHOWN IN THIS FIGURE ARE APPROXIMATE AND ARE BASED ON MEASUREMENTS TAKEN BY GOLDER ASSOCIATES IN THE FIELD.
4. SEE BORING LOGS FOR DETAILED LITHOLOGICAL DESCRIPTIONS.
5. THE GROUNDWATER TABLE SHOWN IN THIS FIGURE IS INTERPRETED FROM FIELD MEASUREMENTS DURING DRILLING AND ACTUAL FIELD CONDITIONS WILL VARY.
6. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED AND HAVE BEEN DEVELOPED BASED ON INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY AND ARE PROBABLY MORE ERRATIC. FOR MORE SPECIFIC INFORMATION REFER TO BORING LOGS.
7. WATER LEVEL IN THATCHER BROOK IS BASED ON VTRANS PRELIMINARY HYDRAULIC ANALYSIS ESTIMATED UPSTREAM BANK FULL WIDTH.
8. THIS FIGURE DEPICTS THE INTERPRETED SUBSURFACE CONDITIONS AT THE CENTERLINE OF THE EXISTING ROAD AND DOES NOT SHOW THE EXISTING BRIDGE ABUTMENTS.
9. THE OFFSET DISTANCES SHOWN IN THIS FIGURE ARE FROM THE LOCATION OF THE EXISTING ABUTMENT NO. 2.
10. THE PROPOSED ABUTMENT AND SUPERSTRUCTURE FEATURES SHOWN ARE DERIVED FROM ELECTRONIC FILE "BRIDGE FOOTING.DGN" PROVIDED TO GOLDER BY STANTEC ON FEBRUARY 9, 2022.
11. THE AS-DRILLED VTRANS ROCK PROBE LOCATIONS FOR BH-1 THROUGH BH-5 SHOWN IN THIS FIGURE ARE DERIVED FROM THE INFORMATION FOUND IN THE ELECTRONIC FILE "WATERBURY BO 1446 (40) ROCK PROBE LOGS.PDF" PROVIDED TO GOLDER BY VTRANS ON MAY 19, 2022.

NOT FOR CONSTRUCTION

0 10 20
1" = 10' FEET

CLIENT
VERMONT AGENCY OF TRANSPORTATION
219 N MAIN ST, BARRE, VT 05641

CONSULTANT

YYYY-MM-DD	2022-06-08
DESIGNED	MEL
PREPARED	AAZ
REVIEWED	CCB
APPROVED	JRS

PROJECT
VTRANS BRIDGE 36 REPLACEMENT, WATERBURY, VT, BO 1446(40)

TITLE
INTERPRETTED SUBSURFACE CROSS SECTION C-C'

PROJECT NO.	CONTROL	REV.	FIGURE
21497656		1	8

APPENDIX A

Boring Logs

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

BORING LOG

Waterbury
BO 1446(40)
TH2, Br #36 GAU 21497656

Boring No.: **B-101**

Pin No.: 93J040
Checked By: BK

Boring Crew: Platform - Michael Jordan, GAU Begum Kurtoglu
Date Started: 11/18/21 Date Finished: 11/18/21
VTSPG NAD83: N 672320.08 ft E 1575820.54 ft
Station: 32+37.7 Offset: 8.5 ft L
Ground Elevation: 507.6 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	2 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/NWJ	
Rig:	Geoprobe 7822DT	C_E = 1.68

Groundwater Observations

Date	Depth (ft)	Notes
11/18/21	14.4	Dry, after drilling

Depth (ft)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
	0.0 ft - 0.3 ft, Asphalt								
	S1: 0.3 ft - 0.75 ft, A-1-b, Rec. = 0.7 ft, Top 0.45 ft: Brown, damp, very dense, fine to coarse SAND, some gravel, trace silt, well-graded (SW-SM)				8-21-50/(3") (R)	8.8	44.5	45.7	9.8
	0.75 ft - 1.55 ft, A-1-b, Bottom 0.25 ft: White, dry, very dense, fine to coarse SAND, some gravel, trace silt, well-graded (SW-SM)					13.0	43.6	46.9	9.5
	1.55 ft - 2.0 ft, Driller Notes: Drilled through a thin concrete obstruction								
2.5	S2: 2.0 ft - 2.5 ft, A-1-a, Rec. = 1.2 ft, Top 0.50 ft: Grayish brown, damp, loose, sandy fine to coarse GRAVEL, trace silt, poorly-graded (GP-GM)				7-5-4-3 (9)	4.8	58.1	33.5	8.4
	2.5 ft - 4.0 ft, A-4, Bottom 0.70 ft: Brown, damp, loose, silty fine to medium SAND, trace gravel, well-graded (SM)					11.5	1.1	62.9	36.0
5.0	4.0 ft - 8.0 ft, Driller Notes: Brown, damp, fine to medium SAND, little silt								
7.5									
	S3: 8.0 ft - 8.4 ft, A-1-a, Rec. = 0.7 ft, Top 0.40 ft: Brown, damp, medium dense, fine to coarse GRAVEL, some sand, trace silt, well-graded (GW-GM)				5-8-16-14 (24)	5.6	69.5	21.8	8.7
	8.4 ft - 10.0 ft, A-1-a, Bottom 0.30 ft: Greenish gray, dry, medium dense, fine to coarse GRAVEL, little sand, trace silt, trace weathered rock, poorly-graded (GP-GM)					0.7	82.2	12.8	5.0
10.0	10.0 ft - 14.0 ft, Driller Notes: Grayish brown, damp, fine to coarse GRAVEL, some sand, trace silt, rock fragments								
12.5									
	S4: 14.0 ft - 14.3 ft, A-1-b, Rec. = 1.1 ft, Top 0.30 ft: Brown, wet, very dense, fine to coarse SAND, little gravel, little silt, poorly-graded (SM)				29-40-50/(3") (R)	10.4	29.0	53.4	17.6
15.0	14.3 ft - 15.3 ft, A-1-b, Bottom 0.80 ft: Gray, dry, very dense, fine to coarse SAND, some gravel, little silt, poorly-graded (SM)					5.4	46.3	40.9	12.8
	Top of Bedrock @ 15.3 ft								
	15.5 ft - 16.5 ft, NQ, Greenish gray, fine grained, fresh (W1), very strong (R5), SCHIST and PHYLLITE; discontinuities horizontal to moderately dipping (0 to 30°), very closely spaced (0.2 ft) [Carbonaceous Phyllite Member, Ottauquechee Formation]	1	70 (0)	11.7	(R)				
17.5	Hole stopped @ 16.5 ft								
20.0									
22.5									

Remarks:
- AASHTO and USCS classifications are based on the results of sieve analyses of the samples
- Boring backfilled with all purpose gravel to ground surface by the Town of Waterbury Highway Department

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.

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

BORING LOG

Waterbury
BO 1446(40)
TH2, Br #36 GAU 21497656

Boring No.: **B-101A**

Pin No.: 93J040
Checked By: BK

Boring Crew: Platform - Michael Jordan, GAU Andrew Martin
Date Started: 12/10/21 Date Finished: 12/10/21
VTSPG NAD83: N 672326.74 ft E 157822.76 ft
Station: 32+43.8 Offset: 4.7 ft L
Ground Elevation: 507.8 ft

	Casing	Sampler
Type:	WASH BORE	N.A.
I.D.:	3 in	
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/NWJ	
Rig:	Geoprobe 7822DT	C_E = 1.68

Groundwater Observations

Date	Depth (ft)	Notes
12/10/21	7.4	Taken after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0.0		0.0 ft - 0.3 ft, ASPHALT					
1.0		1.0 ft - 2.5 ft, Driller Notes: Drilled through a concrete obstruction					
4.5		4.5 ft - 6.0 ft, Driller Notes: Drilling dificulty increased. Wood present in the drill cuttings					
11.0		11.0 ft - 11.1 ft, Driller Notes: Casing refusal at 11 ft bgs. Apparent cement chips in the drill cuttings					

Hole stopped @ 11.1 ft
Terminated due to time constraints

Remarks:
- After termination of the boring, when the casing was removed from the boring it was observed that the bottom of the casing had been crimped due to the obstruction at 11 ft bgs which prevented further advancement of the boring
- Boring backfilled with all purpose gravel to ground surface by the Town of Waterbury Highway Department

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.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG	
	Waterbury **BO 1446(40)** **TH2, Br #36 GAU 21497656**	Boring No.: **B-102** Page No.: 1 of 2 Pin No.: 93J040 Checked By: BK

Boring Crew: Platform - Michael Jordan, GAU Andrew Martin
Date Started: 11/19/21 Date Finished: 11/19/21
VTSPG NAD83: N 672391.97 ft E 1575814.11 ft
Station: 33+08.9 Offset: 5.0 ft R
Ground Elevation: 509.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	2 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/NWJ	
Rig:	Geoprobe 7822DT	C_E = 1.68

Groundwater Observations

Date	Depth (ft)	Notes
11/19/21	15.5	When casing in
11/19/21	7.1	Before rock coring

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		0.0 ft - 0.9 ft, Asphalt								
		S1: 0.9 ft - 1.6 ft, A-1-a, Rec. = 0.5 ft, Gray, dry, very dense, sandy fine to coarse GRAVEL, trace silt, well-graded (GW-GM)				40-50/(2") (R)	3.4	64.3	25.2	10.5
2.5		1.6 ft - 3.9 ft, Driller Notes: Suspected Boulder								
5.0		S2: 4.0 ft - 6.0 ft, A-2-4, Rec. = 0.8 ft, Brown, moist, loose, fine to coarse SAND, some silt, little gravel, poorly-graded (SM)				6-4-3-6 (7)	13.6	26.6	42.4	31.0
7.5										
10.0		9.0 ft - 11.0 ft, Rec. = 0.0 ft				2-2-3-4 (5)				
12.5		S3: 11.0 ft - 13.0 ft, A-1-b, Rec. = 1.0 ft, Brown, wet, medium dense, fine to coarse SAND, little silt, trace gravel, wood chips in the top 3", well-graded (SM)				2-5-9-8 (14)	46.3	18.1	67.0	14.9
15.0		S4: 14.0 ft - 16.0 ft, A-4, Rec. = 1.0 ft, Gray, wet, very loose, SILT, some sand, trace gravel, poorly-graded (ML)				1-WOH-WOH-WOH (WOH)	45.5	5.1	34.1	60.8
17.5							Top of Bedrock @ 18.3 ft			
20.0 / 22.5		18.5 ft - 23.5 ft, NQ, Green, fine-grained, fresh (W1), very strong (R5), SCHIST and PHYLLITE; discontinuities low angle to steep (15 to 75°), very close to moderately closely spaced (0.15 to 2.0 ft) [Carbonaceous Phyllite Member, Ottauquechee Formation]	1	86 (77)	5.3 5.9 5.9 4.3 5.5	(R)				
		Hole stopped @ 23.5 ft								

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.

VTrans Working to Get You There — Vermont Agency of Transportation	STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **Waterbury** **BO 1446(40)** **TH2, Br #36 GAU 21497656**

Boring No.: **B-102**
Page No.: 2 of 2
Pin No.: 93J040
Checked By: BK

Boring Crew: Platform - Michael Jordan, GAU Andrew Martin
Date Started: 11/19/21 Date Finished: 11/19/21
VTSPG NAD83: N 672391.97 ft E 1575814.11 ft
Station: 33+08.9 Offset: 5.0 ft R
Ground Elevation: 509.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	2 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:		Auto/NWJ
Rig:	Geoprobe 7822DT	C_E = 1.68

Groundwater Observations

Date	Depth (ft)	Notes
11/19/21	15.5	When casing in
11/19/21	7.1	Before rock coring

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Remarks: - AASHTO and USCS classifications are based on the results of sieve analyses of the samples - Boring backfilled with all purpose gravel to ground surface by the Town of Waterbury Highway Department								
27.5										
30.0										
32.5										
35.0										
37.5										
40.0										
42.5										
45.0										
47.5										

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.

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

BORING LOG

Waterbury
BO 1446(40)
TH2, Br #36 GAU 21497656

Boring No.: **B-103**
Page No.: 1 of 1
Pin No.: 93J040
Checked By: BK

Boring Crew: Platform - Michael Jordan, GAU Andrew Martin
Date Started: 12/10/21 Date Finished: 12/10/21
VTSPG NAD83: N 672329.16 ft E 157834.09 ft
Station: 32+43.3 Offset: 6.8 ft R
Ground Elevation: 507.7 ft

	Casing	Sampler
Type:	WASH BORE	N.A.
I.D.:	3 in	
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/NWJ	
Rig:	Geoprobe 7822DT	C_E = 1.68

Groundwater Observations

Date	Depth (ft)	Notes
12/10/21	12.6	Taken after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0.0		0.0 ft - 0.3 ft, ASPHALT								
1.0		1.0 ft - 2.0 ft, Driller Notes: Drilled through concrete obstruction								
7.0		7.0 ft - 8.0 ft, Driller Notes: Drilling difficulty increased. Possible cobbles								
14.0		14.0 ft - 15.0 ft, CONCRETE								
15.0		15.0 ft - 19.0 ft, NX, Gray, fine-grained, fresh (W1), very strong (R5), SCHIST and PHYLLITE; discontinuities low angle to steep (20 - 60°), very close to closely spaced (0.1 - 0.8 ft) [Carbonaceous Phyllite Member, Ottauquechee Formation]	1	55 (29)	6.5 7.9 9.3 9.5	(R)	Top of Bedrock @ 15.0 ft			

Hole stopped @ 19.0 ft

Remarks:
- Boring backfilled with all purpose gravel to ground surface by the Town of Waterbury Highway Department

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.

APPENDIX B

Rock Core Photographs

APPENDIX B

Rock Core Photographs

Geotechnical Investigation and Recommendations

Bridge No. 36 Replacement, Waterbury, VT

Waterbury BO 1446(40)

Boring	Date Cored	Run	Depth Below Surface feet	Recovery		RQD	
				Feet	%	Feet	%
B-101	11/18/2021	R1	15.5 - 16.5	0.7 / 1.0	70	0.00 / 1.0	0

B-101 Run 1: 15.5 - 16.5 ft bgs

APPENDIX B

Rock Core Photographs

Geotechnical Investigation and Recommendations

Bridge No. 36 Replacement, Waterbury, VT

Waterbury BO 1446(40)

Boring	Date Cored	Run	Depth Below Surface feet	Recovery		RQD	
				Feet	%	Feet	%
B-102	11/19/2021	R1	18.5 - 23.5	4.3 / 5.0	86	3.85 / 5.0	77

B-102 Run 1: 18.5 - 23.5 ft bgs

APPENDIX B

Rock Core Photographs

Geotechnical Investigation and Recommendations

Bridge No. 36 Replacement, Waterbury, VT

Waterbury BO 1446(40)

Boring	Date Cored	Run	Depth Below Surface feet	Recovery		RQD	
				Feet	%	Feet	%
B-103	12/10/2021	R1	15.0 - 19.0	2.2 / 4.0	55	1.15 / 4.0	29

B-103 Run 1: 15.0 - 19.0 ft bgs

APPENDIX C

Rock Probe Logs

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

BORING LOG

Waterbury
BO 1446(40)
TH2, Br #36

Boring No.: **BH-1**
Page No.: 1 of 1
Pin No.: 93J040
Checked By: SPM

Boring Crew: Monette, McGinley, Zottola
Date Started: 5/04/22 Date Finished: 5/04/22
VTSPG NAD83: N 672287.43 ft E 1575803.65 ft
Station: ____ Offset: ____
Ground Elevation: 504.24 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich 25	C_E = 1.45

Groundwater Observations

Date	Depth (ft)	Notes
05/04/22	14.0	Measured after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0		Field Note:, No sampling - boring advanced to bedrock								
15		15.0 ft - 20.0 ft, Gray-black & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains some CaCO3, ranges from 1-10 mm wide, & some is aligned with foliation.. NX, Close to moderately close joint spacing. Rough to slightly smooth. Moderately hard. Fresh to very slightly weathered. RMR = 60 (FAIR ROCK)	R-1 (70-75)	100 (68)	5 7 5 6 6	Top of Bedrock @ 15.0 ft				
20		20.0 ft - 25.0 ft, Gray-black & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains some CaCO3, ranges from 1-15 mm wide, & some is aligned with foliation.. NX, Close to moderately joint spacing. Slighty rough. Hard. Fresh to very slightly weathered. RMR = 60 (FAIR ROCK)	R-2 (70-75)	96 (61)	5 5 5 4 5					
25		Hole stopped @ 25.0 ft Remarks: Hole collapse at 20.3 ft								

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.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	**BORING LOG** **Waterbury** **BO 1446(40)** **TH2, Br #36**	Boring No.: **BH-2** Page No.: 1 of 1 Pin No.: 93J040 Checked By: SPM	

Boring Crew: Monette, McGinley, Zottola
Date Started: 4/27/22 Date Finished: 4/27/22
VTSPG NAD83: N 672362.16 ft E 1575777.21 ft
Station: Offset:
Ground Elevation: 501.9 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich 25	C_E = 1.45

Groundwater Observations

Date	Depth (ft)	Notes
04/27/22	6.5	Measured after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0		Field Note:, No sampling - boring advanced to bedrock								
10		10.0 ft - 15.0 ft, Silver-gray & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains $CaCO_3$, ranges from 1-10 mm wide, & is primarily aligned along foliation.. NX, Close joint spacing. Rough to slightly smooth. Moderately hard. Fresh to very slightly weathered. RMR = 50 (FAIR ROCK)	R-1 (75-85)	88 (31)	10 9 6 5 5	Top of Bedrock @ 10.0 ft				
15		15.0 ft - 20.0 ft, Silver-gray & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains $CaCO_3$, ranges from 1-10 mm wide, & is primarily aligned along foliation.. NX, Close to moderately joint spacing. Rough to slightly smooth. Hard. Fresh to very slightly weathered. RMR = 50 (FAIR ROCK)	R-2 (75-80)	90 (65)	6 6 5 4 4					
20		Hole stopped @ 20.0 ft								

Remarks:
Hole collapse at 12.3 ft

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.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **Waterbury** **BO 1446(40)** **TH2, Br #36**	Boring No.: **BH-3** Page No.: 1 of 1 Pin No.: 93J040 Checked By: SPM	

Boring Crew: Monette, McGinley, Zottola
Date Started: 4/26/22 Date Finished: 4/26/22
VTSPG NAD83: N 672374.04 ft E 1575793.45 ft
Station: Offset:
Ground Elevation: 506.76 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich 25	C_E = 1.45

Groundwater Observations

Date	Depth (ft)	Notes
04/26/22	10.9	Measured after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0–11		Field Note:, No sampling - boring advanced to bedrock								
11–18		Field Note:, RC cleanout 11.0'-14.0'. Wood from 12.5'-14.0'. RC cleanout 17.0'-18.0'.								
18–23		18.0 ft - 23.0 ft, Silver-gray & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains $CaCO_3$, ranges from 1-10 mm wide, & is primarily aligned along foliation.. NX, Close joint spacing. Rough to slightly smooth. Moderately hard. Fresh to very slightly weathered. RMR = 50 (FAIR ROCK)	R-1 (85)	100 (42)	10, 13, 6, 6, 6	Top of Bedrock @ 18.0 ft				
23–28		23.0 ft - 28.0 ft, Silver-gray & white graphitic PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. Quartz contains $CaCO_3$, ranges from 1-10 mm wide, & is primarily aligned along foliation.. NX, Close to moderately joint spacing. Rough to slightly smooth. Hard. Fresh to very slightly weathered. RMR = 55 (FAIR ROCK)	R-2 (75-85)	100 (72)	5, 4, 6, 4, 4					

Hole stopped @ 28.0 ft

Remarks:
Hole collapse at 14.2 ft

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.

VTrans Working to Get You There, Vermont Agency of Transportation	STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **Waterbury** **BO 1446(40)** **TH2, Br #36**	Boring No.: **BH-4** Page No.: 1 of 1 Pin No.: 93J040 Checked By: SPM

Boring Crew: Monette, McGinley, Zottola
Date Started: 5/03/22 Date Finished: 5/03/22
VTSPG NAD83: N 672420.36 ft E 1575818.33 ft
Station: Offset:
Ground Elevation: 509.98 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich 25	C_E = 1.45

Groundwater Observations

Date	Depth (ft)	Notes
05/03/22	8.0	Measured after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, No sampling - boring advanced to bedrock								
5										
10										
15		15.0 ft - 20.0 ft, Green-gray & white PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Discoloration and some weathering out of sulfides and quartz. Quartz contains CaCO3, ranges from 1-15 mm wide, & is primarily aligned with foliation.. NX, Very close to close joint spacing. Rough. Moderately hard. Slightly weathered to moderately weathered. RMR = 34 (POOR ROCK)	R-1 (85)	90 (21)	6 6 12 11 4	Top of Bedrock @ 15.0 ft				
20		20.0 ft - 25.0 ft, Green-gray & white PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Quartz contains CaCO3, ranges from 1-15 mm wide, & is primarily aligned with foliation.. NX, Moderately close joint spacing. Rough. Moderately hard. Fresh. RMR = 65 (GOOD ROCK)	R-2 (75-85)	100 (63)	4 4 4 4 5					
25		Hole stopped @ 25.0 ft								
30										

Remarks:
Hole collapse at 11.2 ft

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.

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

BORING LOG

Waterbury
BO 1446(40)
TH2, Br #36

Boring No.: **BH-5**
Page No.: 1 of 1
Pin No.: 93J040
Checked By: SPM

Boring Crew: Monette, McGinley, Zottola
Date Started: 5/03/22 Date Finished: 5/03/22
VTSPG NAD83: N 672364.25 ft E 1575893.29 ft
Station: Offset:
Ground Elevation: 506.24 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	N.A.
Hammer Fall:	N.A.	N.A.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich 25	C_E = 1.45

Groundwater Observations

Date	Depth (ft)	Notes
05/03/22	4.2	Measured after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0–12.8		Field Note:, No sampling - boring advanced to bedrock								
12.8–17.8		12.8 ft - 17.8 ft, Gray & White PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Discoloration of sulfides. Quartz ranges from 1-10 mm wide.. NX, Close to moderately close joint spacing. Slightly rough. Moderately hard. Slightly weathered. RMR = 55 (FAIR ROCK)	R-1 (65-75)	100 (35)	5 5 4 5 5	Top of Bedrock @ 12.8 ft				
17.8–22.8		17.8 ft - 22.8 ft, Dark-gray & white to white & green-gray PHYLLITE with some sulfides and abundant quartz veining. Fine grained. Little discoloration of sulfides. At 0' - 1.9' of recovered portion, quartz ranges from 1-5 mm wide, with inclusions up to 30 mm wide.. NX, At 1.9' - 5.0' of recovered portion, primarily quartz with 1-5 mm wide phyllite pinstripes. Close to moderately close joint spacing. Slightly rough. Moderately hard. Very slightly weathered. RMR = 55 (FAIR ROCK)	R-2 (65-80)	100 (31)	4 5 6 7 8					

Hole stopped @ 22.8 ft

Remarks:
Hole collapse at 9.9 ft

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.

APPENDIX D

Laboratory Testing Results

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 518 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 0 ft **to:** 0.45 ft **Examined For:** Class

Field Description: brn, wet, very dense, fine to coarse Gr, some Sa, t **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	Wt Retained	Wt Passing	% Passing
		308.4		
75mm	**3in**	0.0	308.4	100.0
37.5mm	**1.5in**	0.0	308.4	100.0
19mm	**3/4in**	14.6	293.8	95.3
9.5mm	**3/8in**	42.6	251.2	81.5
4.75mm	**No.4**	36.2	215.0	69.7
Reduced	**4.75mm**	214.6		
2.00mm	**No.10**	43.7	170.9	55.5
850um	**No.20**	50.5	120.4	39.1
425um	**No.40**	41.8	78.6	25.5
250um	**No.60**	21.2	57.4	18.6
150um	**No.100**	14.0	43.4	14.1
75um	**No.200**	13.3	30.1	9.8
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	450.74	g
Mass of can and DRY SOIL:	423.64	g
Mass of can:	115.23	g
Moisture content:	8.8	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 44.5 %

Sa: 45.7 %

Si: 9.8 %

100.0 %

M145: AASHTO Class: A-1-b

D2487: Soil Description: GrSa

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 519 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 0.45 ft **to:** 0.7 ft **Examined For:** Class

Field Description: white, dry, very dense, Gr, fine to med Sa, trace S **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	Wt Retained	Wt Passing	% Passing
		79.4		
75mm	**3in**	0.0	79.4	100.0
37.5mm	**1.5in**	0.0	79.4	100.0
19mm	**3/4in**	0.0	79.4	100.0
9.5mm	**3/8in**	8.5	70.9	89.3
4.75mm	**No.4**	13.2	57.7	72.7
Reduced	**4.75mm**	57.1		
2.00mm	**No.10**	12.8	44.3	56.4
850um	**No.20**	12.7	31.6	40.2
425um	**No.40**	9.7	21.9	27.9
250um	**No.60**	5.9	16.0	20.4
150um	**No.100**	4.1	11.9	15.1
75um	**No.200**	4.4	7.5	9.5
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	203.38	g
Mass of can and DRY SOIL:	193.04	g
Mass of can:	113.68	g
Moisture content:	13	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 43.6 %

Sa: 46.8 %

Si: 9.5 %

100.0 %

M145: AASHTO Class: A-1-b

D2487: Soil Description: GrSa

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 520 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 2 ft **to:** 2.5 ft **Examined For:** Class

Field Description: gry/brn, damp, loose, gravelly Sa, little Si **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	**Wt Retained**	**Wt Passing**	**% Passing**
		218.0		
75mm	**3in**	0.0	218.0	100.0
37.5mm	**1.5in**	0.0	218.0	100.0
19mm	**3/4in**	86.5	131.5	60.3
9.5mm	**3/8in**	11.4	120.1	55.1
4.75mm	**No.4**	11.4	108.7	49.9
Reduced	**4.75mm**	108.3		
2.00mm	**No.10**	17.2	91.1	41.9
850um	**No.20**	14.8	76.3	35.1
425um	**No.40**	15.4	60.9	28.0
250um	**No.60**	14.7	46.2	21.3
150um	**No.100**	13.3	32.9	15.1
75um	**No.200**	14.7	18.2	8.4
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	339.33	g
Mass of can and DRY SOIL:	328.85	g
Mass of can:	110.83	g
Moisture content:	4.8	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 58.1 %

Sa: 33.6 %

Si: 8.4 %

100.0 %

M145: AASHTO Class: A-1-a

D2487: Soil Description: SaGr

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 521 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 2.5 ft **to:** 3.2 ft **Examined For:** Class

Field Description: brn, damp, loose, fine to med Sa, trace Si **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	Wt Retained	Wt Passing	% Passing
		334.6		
75mm	**3in**	0.0	334.6	100.0
37.5mm	**1.5in**	0.0	334.6	100.0
19mm	**3/4in**	0.0	334.6	100.0
9.5mm	**3/8in**	2.4	332.2	99.3
4.75mm	**No.4**	0.7	331.5	99.1
Reduced	**4.75mm**	330.9		
2.00mm	**No.10**	0.7	330.2	98.9
850um	**No.20**	1.3	328.9	98.5
425um	**No.40**	1.7	327.2	98.0
250um	**No.60**	8.9	318.3	95.3
150um	**No.100**	44.1	274.2	82.1
75um	**No.200**	154.0	120.2	36.0
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	486.27	g
Mass of can and DRY SOIL:	447.90	g
Mass of can:	113.27	g
Moisture content:	11.5	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 1.1 %

Sa: 62.9 %

Si: 36.0 %

100.0 %

M145: AASHTO Class: A-4

D2487: Soil Description: SaSi

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 522 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 8 ft **to:** 8.4 ft **Examined For:** Class

Field Description: green/gry, dry, med dense, fine to coarse Gr, som **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	**Wt Retained**	**Wt Passing**	**% Passing**
		144.2		
75mm	**3in**	0.0	144.2	100.0
37.5mm	**1.5in**	0.0	144.2	100.0
19mm	**3/4in**	69.2	75.0	52.0
9.5mm	**3/8in**	21.6	53.4	37.0
4.75mm	**No.4**	16.3	37.1	25.7
Reduced	**4.75mm**	36.7		
2.00mm	**No.10**	11.3	25.4	17.8
850um	**No.20**	7.0	18.4	12.9
425um	**No.40**	3.9	14.5	10.2
250um	**No.60**	2.9	11.6	8.1
150um	**No.100**	2.5	9.1	6.4
75um	**No.200**	1.9	7.2	5.0
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	256.11	g
Mass of can and DRY SOIL:	255.08	g
Mass of can:	110.86	g
Moisture content:	0.7	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 82.2 %

Sa: 12.8 %

Si: 5.0 %

100.0 %

M145: AASHTO Class: A-1-a

D2487: Soil Description: Gr

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 523 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 8 ft **to:** 8.4 ft **Examined For:** Class

Field Description: brn, M, med dense, fine to coarse Gr, some Sa, lit **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	Wt Retained	Wt Passing	% Passing
		122.5		
75mm	**3in**	0.0	122.5	100.0
37.5mm	**1.5in**	0.0	122.5	100.0
19mm	**3/4in**	49.6	72.9	59.5
9.5mm	**3/8in**	19.9	53.0	43.3
4.75mm	**No.4**	8.5	44.5	36.3
Reduced	**4.75mm**	44.2		
2.00mm	**No.10**	7.1	37.1	30.5
850um	**No.20**	5.0	32.1	26.4
425um	**No.40**	4.9	27.2	22.4
250um	**No.60**	5.3	21.9	18.0
150um	**No.100**	5.6	16.3	13.4
75um	**No.200**	5.7	10.6	8.7
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	239.87	g
Mass of can and DRY SOIL:	232.99	g
Mass of can:	110.47	g
Moisture content:	5.6	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 69.5 %

Sa: 21.8 %

Si: 8.7 %

100.0 %

M145: AASHTO Class: A-1-a

D2487: Soil Description: SaGr

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 524 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 14 ft **to:** 14.3 ft **Examined For:** Class

Field Description: brn, wet, very dense, fine to coarse Sa, trace Gr, t **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	**Wt Retained**	**Wt Passing**	**% Passing**
		143.2		
75mm	**3in**	0.0	143.2	100.0
37.5mm	**1.5in**	0.0	143.2	100.0
19mm	**3/4in**	0.0	143.2	100.0
9.5mm	**3/8in**	6.7	136.5	95.3
4.75mm	**No.4**	15.5	121.0	84.5
Reduced	**4.75mm**	120.9		
2.00mm	**No.10**	19.3	101.6	71.0
850um	**No.20**	20.0	81.6	57.0
425um	**No.40**	16.2	65.4	45.7
250um	**No.60**	14.1	51.3	35.9
150um	**No.100**	12.8	38.5	26.9
75um	**No.200**	13.3	25.2	17.6
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	271.79	g
Mass of can and DRY SOIL:	256.86	g
Mass of can:	113.62	g
Moisture content:	10.4	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 29.0 %

Sa: 53.4 %

Si: 17.6 %

100.0 %

M145: AASHTO Class: A-1-b

D2487: Soil Description: GrSa

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 525 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-101 **Depth:** 14.3 ft **to:** 15.1 ft **Examined For:** Class

Field Description: gry, dry, very dense, fine to coarse Sa, little Gr, tr **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	Wt Retained	Wt Passing	% Passing
		363.0		
75mm	3in	0.0	363.0	100.0
37.5mm	1.5in	0.0	363.0	100.0
19mm	3/4in	32.5	330.5	91.0
9.5mm	3/8in	20.7	309.8	85.3
4.75mm	No.4	52.7	257.1	70.8
Reduced	4.75mm	256.3		
2.00mm	No.10	62.1	194.2	53.7
850um	No.20	65.4	128.8	35.6
425um	No.40	30.5	98.3	27.2
250um	No.60	17.2	81.1	22.4
150um	No.100	13.9	67.2	18.6
75um	No.200	20.9	46.3	12.8
<75um	<No.200			

T-265 **Moisture Content**

Mass of can and WET SOIL:	492.00	g
Mass of can and DRY SOIL:	472.43	g
Mass of can:	109.42	g
Moisture content:	5.4	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 46.3 %

Sa: 40.9 %

Si: 12.8 %

100.0 %

M145: AASHTO Class: A-1-b

D2487: Soil Description: SaGr

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 526 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-102 **Depth:** 0.8 ft **to:** 1.6 ft **Examined For:** Class

Field Description: gry, dry, dense, Sa, fine to coarse Gr, trace Si **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

	TOTAL:	**Wt Retained** 244.6	**Wt Passing**	**% Passing**
75mm	**3in**	0.0	244.6	100.0
37.5mm	**1.5in**	0.0	244.6	100.0
19mm	**3/4in**	13.9	230.7	94.3
9.5mm	**3/8in**	70.9	159.8	65.3
4.75mm	**No.4**	39.8	120.0	49.1
Reduced	**4.75mm**	119.6		
2.00mm	**No.10**	32.7	86.9	35.7
850um	**No.20**	22.0	64.9	26.6
425um	**No.40**	12.5	52.4	21.5
250um	**No.60**	8.6	43.8	18.0
150um	**No.100**	8.0	35.8	14.7
75um	**No.200**	10.3	25.5	10.5
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	362.18	g
Mass of can and DRY SOIL:	353.97	g
Mass of can:	109.33	g
Moisture content:	3.4	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 64.3 %

Sa: 25.2 %

Si: 10.5 %

100.0 %

M145: AASHTO Class: A-1-a

D2487: Soil Description: SaGr

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 527 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-102 **Depth:** 4 ft **to:** 6 ft **Examined For:** Class

Field Description: brn, damp, loose, fine to med Sa, some Si, trace (**Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 Sieve Analysis

	TOTAL:	Wt Retained	Wt Passing	% Passing
		410.1		
75mm	**3in**	0.0	410.1	100.0
37.5mm	**1.5in**	0.0	410.1	100.0
19mm	**3/4in**	0.0	410.1	100.0
9.5mm	**3/8in**	50.8	359.3	87.6
4.75mm	**No.4**	29.7	329.6	80.4
Reduced	**4.75mm**	329.0		
2.00mm	**No.10**	28.6	300.4	73.4
850um	**No.20**	30.6	269.8	65.9
425um	**No.40**	34.9	234.9	57.4
250um	**No.60**	35.9	199.0	48.6
150um	**No.100**	30.2	168.8	41.2
75um	**No.200**	42.0	126.8	31.0
<75um	**<No.200**			

T-265 Moisture Content

Mass of can and WET SOIL:	577.04	g
Mass of can and DRY SOIL:	521.47	g
Mass of can:	111.36	g
Moisture content:	13.6	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 26.6 %

Sa: 42.4 %

Si: 31.0 %

100.0 %

M145: AASHTO Class: A-2-4

D2487: Soil Description: GrSiSa

Comments: 0

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 528 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-102 **Depth:** 11 ft **to:** 13 ft **Examined For:** Class

Field Description: brn, wet, wed dense, fine to med Sa, some Si, trac **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 Sieve Analysis

	TOTAL:	Wt Retained	Wt Passing	% Passing
		125.5		
75mm	**3in**	0.0	125.5	100.0
37.5mm	**1.5in**	0.0	125.5	100.0
19mm	**3/4in**	0.0	125.5	100.0
9.5mm	**3/8in**	10.4	115.1	91.7
4.75mm	**No.4**	2.6	112.5	89.6
Reduced	**4.75mm**	112.0		
2.00mm	**No.10**	9.7	102.3	81.9
850um	**No.20**	21.3	81.0	64.8
425um	**No.40**	25.1	55.9	44.7
250um	**No.60**	15.6	40.3	32.3
150um	**No.100**	11.4	28.9	23.1
75um	**No.200**	10.3	18.6	14.9
<75um	**<No.200**			

T-265 Moisture Content

Mass of can and WET SOIL:	293.29	g
Mass of can and DRY SOIL:	235.22	g
Mass of can:	109.72	g
Moisture content:	46.3	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr:	18.1	%
Sa:	67.0	%
Si:	14.9	%
	100.0	%

M145: AASHTO Class: A-1-b

D2487: Soil Description: Sa

Comments: LAB NOTE: Some wood was within sample.

Reviewed By: Stephen Madden, Geotechnical Engineer

State of Vermont
Agency of Transportation
Construction and Materials Bureau
Central Laboratory

Report on Soil Sample

Lab Number: E21 529 **Report Date:** 12/14/2021

Project: Waterbury BO 1446 (40) **Site:** **Tested By:** D. Judkins

Date Sampled: 11 / 18 / 2021 **Date Received:** 11 / 18 / 2021 **Date Tested:** 11 / 22 / 2021

Station: 0 + 0 **Offset:** 0 **Hole:** B-102 **Depth:** 14 ft **to:** 16 ft **Examined For:** Class

Field Description: gry, wet, very loose, Si, fine Sa **Submitted By:** B. Kurtoglu **Sample Type:** SS

Test Results

T-88 **Sieve Analysis**

		Wt Retained	Wt Passing	% Passing
	TOTAL:	306.5		
75mm	**3in**	0.0	306.5	100.0
37.5mm	**1.5in**	0.0	306.5	100.0
19mm	**3/4in**	12.8	293.7	95.8
9.5mm	**3/8in**	0.2	293.5	95.8
4.75mm	**No.4**	1.5	292.0	95.3
Reduced	**4.75mm**	290.8		
2.00mm	**No.10**	1.0	289.8	94.9
850um	**No.20**	1.5	288.3	94.4
425um	**No.40**	7.4	280.9	92.0
250um	**No.60**	19.5	261.4	85.6
150um	**No.100**	23.5	237.9	77.9
75um	**No.200**	52.2	185.7	60.8
<75um	**<No.200**			

T-265 **Moisture Content**

Mass of can and WET SOIL:	559.61	g
Mass of can and DRY SOIL:	420.08	g
Mass of can:	113.62	g
Moisture content:	45.5	%

T-90 **PL =** **PI =** 0

T-89 **LL =**

Gr: 5.1 %

Sa: 34.1 %

Si: 60.8 %

100.0 %

M145: AASHTO Class: A-4

D2487: Soil Description: SaSi

Comments: LAB NOTE: Some wood was within sample.

Reviewed By: Stephen Madden, Geotechnical Engineer

APPENDIX E

Calculations

CALCULATIONS

Date:	6/16/2022	**Made by:**	ATM/FCT
Project No.:	21497656	**Checked by:**	BK/ATM
Subject:	Geotechnical Bearing Resistance - Abutment No. 1 Spread Footing	**Reviewed by:**	CCB/
Project Short Title:	VTrans Waterbury Bridge 36 Replacement		

OBJECTIVE

Calculate the nominal and factored bearing capacity of the proposed spread footing on bedrock at Abutment No. 1.

METHOD

Use the method described in the AASHTO LRFD Bridge Design Specifications, 9th Ed, 2020 and the empirical correlations from Wyllie, D.C. Foundations on Rock to calculate the bearing capacity for both the strength limit and service limit states.

REFERENCES

1. AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020 (LRFD).
2. Stantec, Waterbury BO 1446(40), z93j040borplanREVISED.pdf, dated September 23, 2021, provided by VTrans in the Work Order Request via email on September 29, 2021.
3. Wyllie, D.C. 1999. Foundations on Rock, 2nd ed. E&FN Spon, NY.
4. Appendix A - boring logs and Appendix C - rock probe logs from Waterbury Bridge 36 Geotechnical Services Report GAUI-21497656.
5. Golder Associates, Waterbury Bridge 36 Geotechnical services Report GAUI-21497656, Table 2 Summary of Rock Core Quality Table

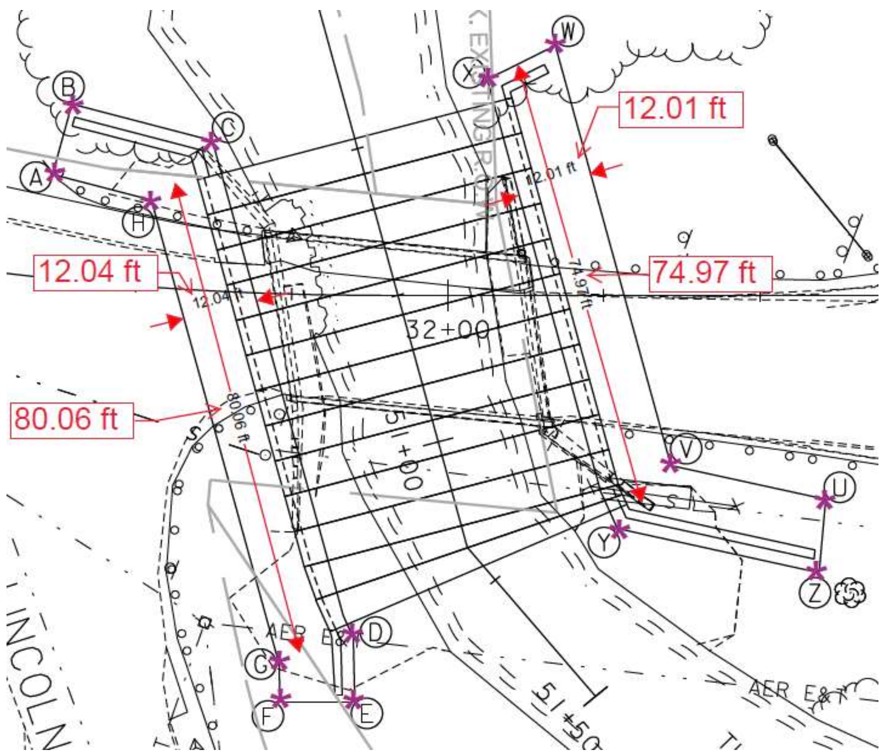


Figure 1: Proposed Abutment Dimensions (from Reference 2)

ASSUMPTIONS

1. Unconfined compressive strength of 1600 ksf (~11300 psi) was used for the strength of the bedrock (Schist and Phyllite) in the analysis of Abutment No.1 based on averaging unconfined compressive strengths, correlating from rock core descriptions from the WSP Golder boring logs and VTrans rock probe logs ("Very Hard Rock" correlating to 15000 to 35000 psi, "Hard Rock" correlating to 7500 to 15000 psi, and "Medium Hard Rock" correlating to 3500 to 7500 psi; References 4 and 5).

2. Embedment depth of zero conservatively assumed since the footing will be bearing on bedrock and frost protection is not needed.

3. For the purposes of this evaluation a load eccentricity of 2 feet and an effective footing width of 8 feet has been assumed.

Date:	6/16/2022	**Made by:**	ATM/FCT
Project No.:	21497656	**Checked by:**	BK/ATM
Subject:	Geotechnical Bearing Resistance - Abutment No. 1 Spread Footing	**Reviewed by:**	CCB/
Project Short Title:	VTrans Waterbury Bridge 36 Replacement		

CALCULATION

A. Determine the bearing resistance at the strength limit state.

As per AASHTO LRFD (Ref. 1) Article 10.6.3.2.2, the nominal bearing resistance of rock should be determined using empirical correlation with the geomechanics RMR system. Since AASHTO LRFD does not directly address bearing resistance on bedrock, this analysis will use Wyllie (1999) Foundations on Rock (Ref. 3) to calculate the unfactored bearing resistance based on correlation to the average RMR value determined for the abutment.

Since the footing is anticipated to be on flat bedrock (Ref. 3), the procedure in Ref. 3 Section 5.2.2 will be used.

1. Use the average RMR value determined for the bedrock at Bridge 36 to calculate the rock mass friction angle and cohesion.

Rock mass friction angle, ϕ'_i:

$$\phi'_i = \arctan\left[\frac{1}{(4h\cos^2\theta - 1)^{1/2}}\right] \qquad \text{(Ref. 3, Eqn 3.16)}$$

$$h = 1 + \frac{16(m\sigma' + s\sigma_{u(r)})}{3m^2\sigma_{u(r)}} \qquad \text{(Ref. 3, Eqn 3.17)}$$

$$\theta = \frac{1}{3}\left\{90 + \arctan\left[\frac{1}{(h^3 - 1)^{1/2}}\right]\right\} \qquad \text{(Ref. 3, Eqn 3.18)}$$

where:

σ' = vertical effective normal stress on bedrock

γ_{fill} =	130	pcf (granular backfill for structures)
fill thickness abutment location =	0	ft (assumed 0 since bearing on rock - frost protection not needed)
$\sigma' = \gamma_{fill}$ x fill thickness =	0.00	ksf

RMR = rock mass rating	56	(Ref. 4 & 5)
rock type:	Schist and Phyllite	(Ref. 4)
m = constant, dependent on rock type and RMR	1.334	(Ref. 3, Table 3.7) - Attachment 1
s = constant, dependent on rock type and RMR	0.00165	(Ref. 3, Table 3.7) - Attachment 1
$\sigma_{u(r)}$ = unconfined compressive strength of intact rock	1,600	ksf (Assumption 1)

h =	1.00	
θ =	57.7	degrees
ϕ'_i =	68.9	degrees

Date:	6/16/2022	**Made by:**	ATM/FCT
Project No.:	21497656	**Checked by:**	BK/ATM
Subject:	Geotechnical Bearing Resistance - Abutment No. 1 Spread Footing	**Reviewed by:**	CCB/
Project Short Title:	VTrans Waterbury Bridge 36 Replacement		

2. Calculate the nominal bearing resistance.

$$q_n = C_{f1} s^{1/2} \sigma_{u(r)} \left[1 + \left(m s^{-1/2} + 1\right)^{1/2}\right]$$ (Ref. 3, Eqn 5.4)

where:

L = footing length		80	ft (Ref. 2)
B = Actual footing width		12.00	ft (Ref. 2)
e_B = eccentricity parallel to footing width		2	ft (Assumption 3)
B_f = Effective footing width		8.0	ft (Ref. 1, 10.6.1.3)
D = footing embedment depth		0	ft (Assumption 2)
	D / B_f =	0.00	
	L / B_f =	10.00	
C_{f1} = foundation shape correction factor		1.00	(Ref. 3, Table 5.4) - Attachment 1
	q_n =	443	ksf

As per AASHTO LRFD (Ref. 1) Article 10.6.2.5.2, if the recommended value of bearing resistance exceeds either the unconfined compressive strength of the rock or the nominal resistance of the concrete, the bearing resistance shall be taken as the lesser of those values. The nominal resistance of concrete shall be taken as $0.3f'_c$.

f'_c = 3500 psi = 504 ksf (assumed)

$q_{n,concrete} = 0.3f'_c$ = 151 ksf

$q_{n,concrete}$	$q_{n,calculated}$	$\sigma_{u(r)}$	
151	443.1	1600	ksf

Thus, use q_n = **151.2** ksf

3. Calculate the factored bearing resistance.

$$q_r = \phi_b q_n$$

where:

ϕ_b = bearing resistance factor 0.45 (Ref. 1, Table 10.5.5.2.2-1, "Footings on rock")

q_r = **68.0** ksf

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B. Determine the bearing resistance at the service limit state.

Use AASHTO LRFD (Ref. 1) Table C10.6.2.5.1-1 to determine the presumptive bearing resistance at the service limit state.

Type of Bearing Material: Weathered or broken bedrock of any kind, except argillaceous rock (shale)

Bearing Resistance Recommended Value of Use = 70 ksf

Note: This bearing resistance is settlement limited (1.0 inch as per AASHTO LRFD Section 10.6.2.5.1) and applies only at the service limit state.

Resistance factor for the service limit state: 1.0 (Ref. 1, Section 10.5.5.1)

Factored bearing resistance = **70** ksf

CONCLUSIONS

1. For the proposed spread footing at Abutment No. 1, the recommended nominal bearing resistance is 151.2 ksf for the strength limit state. A resistance factor of 0.45 is recommended for use at the strength limit state; this results in a factored bearing resistance of 68.0 ksf.
2. The recommended value of use for the presumptive bearing resistance at the service limit state is 70 ksf based on LRFD Table C10.6.2.5.1-1. This bearing resistance is settlement limited (1.0-inch) and applies only at the service limit state. The resistance factor for the service limit state is 1.0 based on LRFD Section 10.5.5.1.

GOLDER
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CALCULATIONS

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Attachment 1

Reference 3, Table 3.7 Interpolation

Interpolation from table values (rock type = Granofels):

	RMR	m	s
	65	2.052	0.00293
	44	0.458	0.00009
interpolate:	56	1.334	0.00165

Table 3.7 Approximate relationship between rock mass quality and material constants (Hoek and Brown, 1988)

Empirical failure criterion:
$\sigma'_1 = \sigma'_3 + \sqrt{m\sigma_{u(r)}\sigma'_3 + s\sigma^2_{u(r)}}$
σ'_1 = major principal effective stress
σ'_3 = minor principal effective stress
$\sigma_{u(r)}$ = uniaxial compressive strength of intact rock, and
m and *s* are empirical constants.

		CARBONATE ROCKS WITH WELL DEVELOPED CRYSTAL CLEAVAGE *dolomite, limestone and marble*	LITHIFIED ARGILLACEOUS ROCKS *mudstone, siltstone, shale and slate (normal to cleavage)*	ARENACEOUS ROCKS WITH STRONG CRYSTALS AND POORLY DEVELOPED CRYSTAL CLEAVAGE *sandstone and quartzite*	FINE GRAINED POLYMINERALLIC IGNEOUS CRYSTALLINE ROCKS *andesite, dolerite, diabase and rhyolite*	COARSE GRAINED POLYMINERALLIC IGNEOUS & METAMORPHIC CRYSTALLINE ROCKS *amphibolite, gabbro gneiss, granite, norite, quartz-diorite*
INTACT ROCK SAMPLES *Laboratory size specimens free from discontinuities* *CSIR rating: *RMR* = 100 †NGI rating: *Q* = 500	m s	7.00 1.00	10.00 1.00	15.00 1.00	17.00 1.00	25.00 1.00
VERY GOOD QUALITY ROCK MASS *Tightly interlocking undisturbed rock with unweathered joints at 1–3 m* CSIR rating: *RMR* = 85 NGI rating: *Q* = 100	m s	2.40 0.082	3.43 0.082	5.14 0.082	5.82 0.082	8.56 0.082
GOOD QUALITY ROCK MASS *Fresh to slightly weathered rock, slightly disturbed with joints at 1–3 m* CSIR rating: *RMR* = 65 NGI rating: *Q* = 10	m s	0.575 0.00293	0.821 0.00293	1.231 0.00293	1.395 0.00293	2.052 0.00293
FAIR QUALITY ROCK MASS *Several sets of moderately weathered joints spaced at 0.3–1 m* CSIR rating: *RMR* = 44 NGI rating: *Q* = 1	m s	0.128 0.00009	0.183 0.00009	0.275 0.00009	0.311 0.00009	0.458 0.00009
POOR QUALITY ROCK MASS *Numerous weathered joints at 30–500 mm, some gouge. Clean compacted waste rock* CSIR rating: *RMR* = 23 NGI rating: *Q* = 0.1	m s	0.029 0.000003	0.041 0.000003	0.061 0.000003	0.069 0.000003	0.102 0.000003
VERY POOR QUALITY ROCK MASS *Numerous heavily weathered joints spaced <50 mm with gouge. Waste rock with fines* CSIR rating: *RMR* = 3 NGI rating: *Q* = 0.01	m s	0.007 0.0000001	0.010 0.0000001	0.015 0.0000001	0.017 0.0000001	0.025 0.0000001

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*CSIR Council of Scientific and Industrial Research (Bieniawski, 1974).
†NGI Norwegian Geotechnical Institute (Barton et al., 1974).

Reference 3, Table 5.4 interpolation

Interpolation from table values

	L/Bf	C_{f1}	C_{f2}
	5	1.05	0.95
	2	1.12	0.9
interpolate:	10.0	1.00	1.00

Table 5.4 Correction factors for foundation shapes (L = length, B = width)

Foundation shape	C_{f1}	C_{f2}
Strip ($L/B > 6$)	1.0	1.0
Rectangular		
$L/B = 2$	1.12	0.9
$L/B = 5$	1.05	0.95
Square	1.25	0.85
Circular	1.2	0.7

CALCULATIONS

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OBJECTIVE

Calculate the nominal and factored bearing capacity of the proposed spread footing on bedrock at Abutment No. 2.

METHOD

Use the method described in the AASHTO LRFD Bridge Design Specifications, 9th Ed, 2020 and the empirical correlations from Wyllie, D.C. Foundations on Rock to calculate the bearing capacity for both the strength limit and service limit states.

REFERENCES

1. AASHTO LRFD Bridge Design Specifications, 9th Ed. 2020 (LRFD).
2. Stantec, Waterbury BO 1446(40), z93j040borplanREVISED.pdf, dated September 23, 2021, provided by VTrans in the Work Order Request via email on September 29, 2021.
3. Wyllie, D.C. 1999. Foundations on Rock, 2nd ed. E&FN Spon, NY.
4. Appendix A - boring logs and Appendix C - rock probe logs from Waterbury Bridge 36 Geotechnical Services Report GAUI-21497656.
5. Golder Associates, Waterbury Bridge 36 Geotechnical services Report GAUI-21497656, Table 2 Summary of Rock Core Quality Table

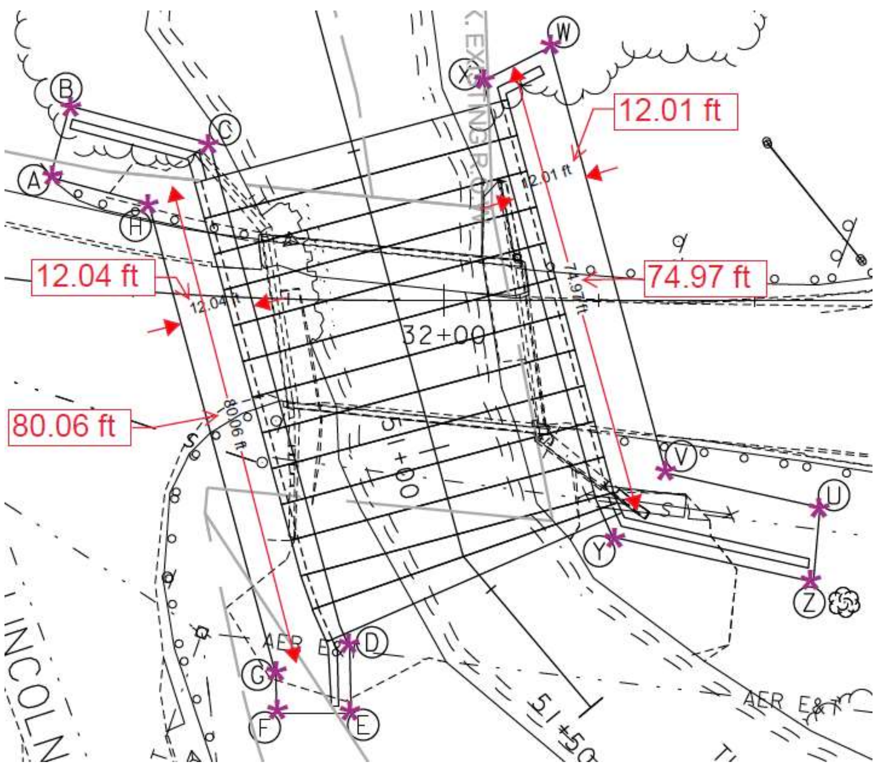

Figure 1: Proposed Abutment Dimensions (from Reference 2)

ASSUMPTIONS

1. Unconfined compressive strength of 1600 ksf (~11300 psi) was used for the strength of the bedrock (Schist and Phyllite) in the analysis of Abutment No.2 based on averaging unconfined compressive strengths, correlating from rock core descriptions from the WSP Golder boring logs and VTrans rock probe logs ("Very Hard Rock" correlating to 15000 to 35000 psi, "Hard Rock" correlating to 7500 to 15000 psi, and "Medium Hard Rock" correlating to 3500 to 7500 psi; References 4 and 5).
2. Embedment depth of zero conservatively assumed since the footing will be bearing on bedrock and frost protection is not needed.
3. For the purposes of this evaluation a load eccentricity of 2 feet and an effective footing width of 8 feet has been assumed.

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CALCULATION

A. Determine the bearing resistance at the strength limit state.

As per AASHTO LRFD (Ref. 1) Article 10.6.3.2.2, the nominal bearing resistance of rock should be determined using empirical correlation with the geomechanics RMR system. Since AASHTO LRFD does not directly address bearing resistance on bedrock, this analysis will use Wyllie (1999) Foundations on Rock (Ref. 3) to calculate the unfactored bearing resistance based on correlation to the average RMR value determined for the abutment

Since the footing is anticipated to be on flat bedrock (Ref. 3), the procedure in Ref. 3 Section 5.2.2 will be used.

1. Use the average RMR value determined for the bedrock at Bridge 36 to calculate the rock mass friction angle and cohesion.

Rock mass friction angle, ϕ'_i:

$$\phi'_i = \arctan\left[\frac{1}{(4h\cos^2\theta - 1)^{1/2}}\right]$$ (Ref. 3, Eqn 3.16)

$$h = 1 + \frac{16(m\sigma' + s\sigma_{u(r)})}{3m^2\sigma_{u(r)}}$$ (Ref. 3, Eqn 3.17)

$$\theta = \frac{1}{3}\left\{90 + \arctan\left[\frac{1}{(h^3 - 1)^{1/2}}\right]\right\}$$ (Ref. 3, Eqn 3.18)

where:

σ' = vertical effective normal stress on bedrock

γ_{fill} =	130	pcf (granular backfill for structures)
fill thickness abutment location =	0	ft (assumed 0 since bearing on rock - frost protection not needed)
$\sigma' = \gamma_{fill}$ x fill thickness =	0.00	ksf

RMR = rock mass rating	56	(Ref. 4 & 5)
rock type:	Schist and Phyllite	(Ref. 4)
m = constant, dependent on rock type and RMR	1.334	(Ref. 3, Table 3.7) - Attachment 1
s = constant, dependent on rock type and RMR	0.00165	(Ref. 3, Table 3.7) - Attachment 1
$\sigma_{u(r)}$ = unconfined compressive strength of intact rock	1,600	ksf (Assumption 1)

h =	1.00	
θ =	57.7	degrees
ϕ'_i =	68.9	degrees

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2. Calculate the nominal bearing resistance.

$$q_n = C_{f1} s^{1/2} \sigma_{u(r)} \left[1 + \left(m s^{-1/2} + 1\right)^{1/2}\right]$$ (Ref. 3, Eqn 5.4)

where:

L = footing length		75	ft (Ref. 2)
B = Actual footing width		12.00	ft (Ref. 2)
e_B = eccentricity parallel to footing width		2	ft (Assumption 3)
B_f = Effective footing width		8.0	ft (Ref. 1, 10.6.1.3)
D = footing embedment depth		0	ft (Assumption 2)
	D / B_f =	0.00	
	L / B_f =	9.38	
C_{f1} = foundation shape correction factor		1.00	(Ref. 3, Table 5.4) - Attachment 1
	q_n =	443	ksf

As per AASHTO LRFD (Ref. 1) Article 10.6.2.5.2, if the recommended value of bearing resistance exceeds either the unconfined compressive strength of the rock or the nominal resistance of the concrete, the bearing resistance shall be taken as the lesser of those values. The nominal resistance of concrete shall be taken as $0.3f'_c$.

f'_c = 3500 psi = 504 ksf (assumed)

$q_{n,concrete} = 0.3f'_c$ = 151 ksf

$q_{n,concrete}$	$q_{n,calculated}$	$\sigma_{u(r)}$	
151	443.1	1600	ksf

Thus, use q_n = **151.2** ksf

3. Calculate the factored bearing resistance.

$$q_r = \phi_b q_n$$

where:

ϕ_b = bearing resistance factor 0.45 (Ref. 1, Table 10.5.5.2.2-1, "Footings on rock")

q_r = **68.0** ksf

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B. Determine the bearing resistance at the service limit state.

Use AASHTO LRFD (Ref. 1) Table C10.6.2.5.1-1 to determine the presumptive bearing resistance at the service limit state.

Type of Bearing Material: Weathered or broken bedrock of any kind, except argillaceous rock (shale)

Bearing Resistance Recommended Value of Use = 70 ksf

Note: This bearing resistance is settlement limited (1.0 inch as per AASHTO LRFD Section 10.6.2.5.1) and applies only at the service limit state.

Resistance factor for the service limit state: 1.0 (Ref. 1, Section 10.5.5.1)

Factored bearing resistance = **70** ksf

CONCLUSIONS

1. For the proposed spread footing at Abutment No. 2, the recommended nominal bearing resistance is 151.2 ksf for the strength limit state. A resistance factor of 0.45 is recommended for use at the strength limit state; this results in a factored bearing resistance of 68.0 ksf.

2. The recommended value of use for the presumptive bearing resistance at the service limit state is 70 ksf based on LRFD Table C10.6.2.5.1-1. This bearing resistance is settlement limited (1.0-inch) and applies only at the service limit state. The resistance factor for the service limit state is 1.0 based on LRFD Section 10.5.5.1.

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Reference 3, Table 5.4 interpolation

Interpolation from table values

	L/Bf	Cf1	Cf2
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	2	1.12	0.9
interpolate:	9.38	1.00	1.00

Table 5.4 Correction factors for foundation shapes (L = length, B = width)

Foundation shape	C_{f1}	C_{f2}
Strip ($L/B > 6$)	1.0	1.0
Rectangular		
$L/B = 2$	1.12	0.9
$L/B = 5$	1.05	0.95
Square	1.25	0.85
Circular	1.2	0.7