GZA
Known for excellence.
Built on trust.


# GEOTECHNICAL DESIGN REPORT
# MAIN STREET BRIDGE NO. 2504
# FALL BROOK
# MAINE DOT WIN 22260.01
SOLON, MAINE

**Prepared for:**
Hoyle, Tanner & Associates, Inc
Yarmouth, Maine

December 2022
09.0026012.01

**Prepared by:**
**GZA GeoEnvironmental, Inc.**
707 Sable Oaks Drive | Suite 150 | South Portland, Maine 04106
207.879.9190

31 Offices Nationwide
www.gza.com

GZA
Known for excellence.
Built on trust.

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

707 Sable Oaks Drive
Suite 150
South Portland, ME 04106
T: 207.879.9190
F: 207.536.1173
www.gza.com

**VIA EMAIL**

December 14, 2022
File No. 09.0026012.01

Mr. Owen Krauss, PE
Hoyle, Tanner & Associates, Inc
106 Lafayette Street, Suite 2D
Yarmouth, Maine 04096

Re: Geotechnical Design Report
Main Street Bridge No. 2504
Fall Brook
MaineDOT WIN 22260.01
Solon, Maine

Dear Owen:

We are pleased to provide this Geotechnical Design Report, which includes geotechnical design recommendations for the replacement of Main Street Bridge No. 2504 over Fall Brook in Solon, Maine. Our work was completed in accordance with the Agreement for Professional Services between Hoyle, Tanner & Associates, Inc. and GZA GeoEnvironmental, Inc. dated August 6, 2021 and the attached *Limitations* included in **Appendix A** of this report.

It has been a pleasure serving Hoyle, Tanner & Associates, Inc. on this phase of the project, and we look forward to our continued work with you through project completion. If you have any questions regarding the report, or if we can provide further assistance, please do not hesitate to contact the undersigned.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Michael R. Johnescu, P.E.
Assistant Project Manager

STATE OF MAINE
Andrew R. Blaisdell
10957
LICENSED
PROFESSIONAL ENGINEER
12/14/2022

Christopher L. Snow, P.E.
Consultant Reviewer

Andrew R. Blaisdell, P.E.
Associate Principal

MRJ/ARB/CLS:erc
p:\09 jobs\0026000s\09.0026012.00 - solon bridge over fall brook\01 - solon final design\report\final 26012.01 solon bridge gdr 12142022.docx

Attachment: Geotechnical Design Report

# TABLE OF CONTENTS

**Page**

**(TABLE OF CONTENTS)**

## TABLES



## FIGURES



## APPENDICES

## 1.0 INTRODUCTION

This report presents the results of the geotechnical evaluation by GZA GeoEnvironmental, Inc. (GZA) for the subject project. Our services were completed in accordance with the Agreement for Professional Services between Hoyle, Tanner & Associates, Inc. (Hoyle, Tanner) and GZA dated August 6, 2021, and the *Limitations* included in **Appendix A**.

### 1.1 BACKGROUND

The project includes replacement of the Main Street Bridge No. 2504 carrying Route 201 over Fall Brook in Solon, Maine, the location of which is shown on **Figure 1**. The existing bridge was constructed in 1931 and consists of an approximately 50-foot-long, single span bridge with reinforced concrete girders and integral deck slab. The bridge substructure consists of stone masonry abutments and wingwalls that exist from a prior bridge, which were then faced and capped with reinforced concrete as part of the 1931 reconstruction. Neither set of bridge plans specifies the foundation bearing material, but based on site visits, data from the subsurface investigation, and bridge sections and details, we believe the abutments and wingwalls are bearing directly on bedrock. During the time of construction in 1931, there was a dam, located roughly 50 feet downstream from the bridge which had a log crib wall tying into the northwest wingwall of the bridge and a gate controlling water flow downstream of Abutment 2. The dam was removed at an unknown date after the construction of the bridge, and we are not aware of evidence of the structures at the site today.

We understand that the preferred bridge replacement alternative is an approximately 53-foot-long, on-alignment single-span structure consisting of NEXT-F precast concrete beams and composite concrete deck over cast-in-place cantilever abutments and wingwalls supported by footings bearing on bedrock. The new abutments are within the footprint of existing concrete-faced stone abutments, which will be removed as part of the construction. The project is anticipated to be bid as a detail-build contract, allowing the contractor to bid alternative superstructures in addition to the NEXT-F beams. The proposed pavement grades at the approaches are approximately 4 to 5 feet higher than the existing grade along Route 201.

Cross Street intersects Main Street about 50 feet north of Abutment 2 and extends toward the west. Approximately the first 200 feet of Cross Street will be reconstructed as part of the project. The Cross Street alignment will be shifted north, away from Fall Brook, and a 1.75 feet horizontal to 1 foot vertical (1.75H:1V) to 2H:1V riprap slope will be constructed to stabilize the streambank. Grade raises of up to 8 feet above existing grade are proposed along the bridge approaches and along reconstructed Cross Street.

A temporary bridge is planned to the west (downstream) of the existing bridge to allow alternating one-way traffic during construction.

### 1.2 OBJECTIVES AND SCOPE OF SERVICES

The objectives of our work were to evaluate subsurface conditions and to provide geotechnical design recommendations for the proposed bridge and slope modifications along Cross Street. To meet these objectives, GZA completed the following Scope of Services:

- Conducted site visits to observe surficial conditions during preliminary design and reviewed mapped surficial and bedrock geology of the site;
- Reviewed existing bridge plans;
- Coordinated and observed subsurface explorations, consisting of three (3) test borings (BB-SFB-103 through -105) and four (4) auger probes (BB-SFB-101, -102, -106 and -107), to evaluate subsurface conditions;
- Conducted a laboratory testing program to evaluate engineering and index properties of the site soils;
- Conducted geotechnical engineering analyses and developed subsurface profiles; evaluated of soil and bedrock properties relative to stability and foundation support, settlement of proposed approach fills, and bearing resistance of the abutment footings bearing on rock;
- Developed geotechnical engineering recommendations including foundation design recommendations for footings on rock, lateral earth pressures, seismic design parameters and slope construction; and
- Prepared this report summarizing our findings and design recommendations.

## 2.0 SUBSURFACE EXPLORATIONS

### 2.1 BORINGS AND AUGER PROBES

GZA completed a subsurface exploration program consisting of three test borings (BB-SFB-103 through -105) and four auger probes (BB-SFB-101, -102, -106 and -107). New England Boring Contractors of Hermon, Maine provided drilling services and conducted utility clearance for this project. Drilling was completed February 11 through February 14, 2019. The explorations were completed using a Mobile B-53 truck-mounted drill rig. GZA personnel monitored the drilling work and prepared logs of each boring that are included in **Appendix B**.

Test borings BB-SFB-103 through -105 were drilled using 3- and 4-inch casing and drive-and-wash drilling techniques, as noted on the drilling logs. The test borings were drilled to depths of approximately 14.1 to 23.3 feet below ground surface (bgs) and were terminated approximately 5 to 11 feet into bedrock. Standard Penetration Test (SPT) and split spoon sampling were performed continuously or at 5-foot intervals using a 24-inch-long, 1-3/8-inch inside diameter sampler. SPTs were conducted using automatic hammer NEBC No. B-24 which had a rated hammer energy transfer ratio of 0.937. Bedrock core runs were obtained using NQ2 wireline coring equipment. The borings were generally backfilled with sand and topped with asphalt cold patch in pavement areas.

Auger probes were drilled using 4.25-inch solid stem augers (SSA) and 6.25-inch hollow stem augers (HSA), as noted on the drilling logs. Auger probes were drilled to depths of approximately 9.5 to 13.8 feet bgs. Grab samples were collected from SSA probes BB-SFB-101, -106 and -107. SPT and split spoon sampling were performed continuously using a 24-inch-long, 1-3/8-inch inside-diameter sampler for HSA probe BB-SFB-102.

The as-drilled boring locations for BB-SFB-101 through -104 and -107 were surveyed by Maine Department of Transportation (MaineDOT) and provided to GZA and are shown on **Figure 2**. Borings BB-SFB-105 and -106 were not surveyed by MaineDOT. These locations were determined using taped ties from known site features. Elevations at these borings were estimated by interpolating between contours shown on **Figure 2**. The locations and elevations determined by these means are considered approximate. Elevations referenced in this report are in feet and refer to North American Vertical Datum of 1988.

### 2.2 MAY 2022 SITE VISIT AND HAND AUGERS

GZA and Hoyle, Tanner made a site visit on May 5, 2022, to observe the condition of the existing slope between Fall Brook and Cross Street. The general condition of the slope was poor, with evidence of soil loss through piping erosion, and a surficial slope failure was documented at roughly STA 400+75; refer to **Photo 2** in **Section 4.3**. Ongoing soil erosion and the slope failure may be exacerbated by erosion at the toe of the slope and trees toppling over. The slope was covered with brush and a few small trees, with large boulders visible at ground surface throughout the entire extent of the slope. Bedrock outcrops were observed at the toe of the slope where it meets Fall Brook. Five hand auger probes were performed at the top of the slope to a depth of 3 feet to check for bedrock/boulder refusal. Refusal on probable boulders was encountered at two of the five locations at depths ranging between 1.5 to 3 feet. No refusal was encountered at the other three hand auger locations. An additional two hand augers were performed in areas of overburden at the base of the slope. Refusal on probable bedrock/boulders was encountered at both locations at depths ranging between 6 and 12 inches.

## 3.0 LABORATORY TESTING

GZA retained Thielsch Engineering of Cranston, Rhode Island to complete a laboratory testing program to assess the gradation and index properties of the soil and the strength of the bedrock. The testing program included:

Soil

- Eight (8) gradation analyses;
- Three (3) hydrometer tests;
- Eight (8) MaineDOT Frost Classification / Unified Soil Classification System (USCS) assessments;
- Eight (8) moisture content tests; and
- One (1) Atterberg limits analysis.

Rock

- Two (2) unconfined compression/ secant modulus tests; and
- Two (2) point load tests (one axial and one diametrical).

Results of the testing are included in **Appendix C**.

## 4.0 SURFACE AND SUBSURFACE CONDITIONS

### 4.1 SURFICIAL AND BEDROCK GEOLOGY

Based on available surficial geologic mapping[1], the soil units in the vicinity of the site consist of stream alluvium, fine-grained facies of glaciomarine deposits and glacial till. The steam alluvium is described as a mixture of sand, gravel, and silt that was deposited by flood plains and stream beds. The glaciomarine deposits (fine-grained facies) are described as silt, clay, sand and minor amounts of gravel that is commonly a clayey silt. Glaciomarine deposits is this area can be sand-dominant in some locations but may be underlain by fine-grained sediments. Glacial till is described as deposits of sand, silt and gravel. Bedrock outcrops are mapped within the vicinity of the site and are evident along the streambed and banks of Fall Brook. Available geologic mapping[2] shows that the site falls within the Fall Brook Formation (DSf) and near contacts with the Carrabassett Formation (DC) to the northwest and southeast. Both formations are mapped as bedded grey or purplish-grey metasandstone, metasiltstone and metapelite.

### 4.2 SUBSURFACE PROFILE

Two soil units were encountered beneath asphalt pavement and above bedrock at the site: Fill and Glacial Till. The approximate thickness and generalized descriptions of the subsurface units are presented in the following table, in descending order from existing ground surface. Detailed descriptions of the materials encountered at the specific locations are provided in the boring logs in **Appendix B**. An interpretive subsurface profile based on the test boring results is presented in **Figure 2**.

| Soil Unit | Approximate Encountered Thickness (ft) | Generalized Description |
|---|---|---|
| Fill | 3.5 to 14.5 | Variable from brown, medium dense to very dense, fine to coarse SAND, some to trace Gravel, some to trace Silt; to brown, stiff to very stiff, CLAY, varying Sand content. USCS: SM, SP, ML, GM, GP-GM, GW, GP and CL<br>MaineDOT Frost Classification = 0 to IV<br>*Encountered in all auger probes and borings.* |
| Glacial Till | 2.5 to 5 | Brown to grey-brown, very stiff, Silty CLAY, some to little fine to coarse Sand, little Gravel. USCS: CL<br>MaineDOT Frost Classification = IV<br>*Encountered in auger probes/borings BB-SFB-101 and -104 through -107.* |
| Encountered Top of Bedrock Elevation | South Abutment (BB-SFB-103): Approx. El. 368.4 (9.0 feet bgs)<br>North Abutment (BB-SFB-104): Approx. El. 360.3 (18.5 feet bgs) | |

Bedrock was cored in each test boring and was identified as Phyllite. The phyllite was described as very hard, fresh to slightly weathered, fine grained, and grey to dark grey. The joints are extremely close to moderately spaced, low to high angle, planar to stepped, rough to slickensided, fresh to decomposed, tight to widely

[1] Thompson, W.B. and Borns, Jr., H.W., 1985. Surficial Geologic Map of Maine: Maine Geological Survey, map, scale 1:500,000.

[2] Pankiwskyj, K.A., 1979. Bedrock Geologic Map of the Kingfield and Anson Quadrangles: Maine Geological Survey.

spaced, with occasional brown silt infilling. The Rock Quality Designation (RQD) ranged from 0 to 85 percent with a corresponding Rock Quality of Very Poor to Good.

Two laboratory unconfined compressive strength / secant modulus tests and two point-load tests (one axial and one diametrical) were conducted on bedrock core samples. The test results are included in **Appendix C**. The testing yielded:

- Unconfined compressive strengths of 2.5 and 37.7 kips per square inch (ksi) and secant modulus values of 1,360 ksi and 5,490 ksi; and
- Point load strength index values of 1.29 ksi and 1.39 ksi which correlate to approximate unconfined compressive strengths of 31.0 ksi and 33.3 ksi.

## 4.3 CROSS STREET SOUTH SIDE SLOPE

The new roadway side slopes along Cross Street will pass over/through an existing near-vertical slope along the edge of the Fall Brook channel to the northwest of the main run of Fall Brook. As described in **Section 2.2**, the slope appears to be comprised of a combination of an eroded soil slope and exposed bedrock. The slope is vegetated with numerous trees and includes organics, stumps, and loose/detached rock. Exposed bedrock and large boulders are present at the toe of slope. There appeared to be voids at several locations along the slope that are likely the result of ongoing piping erosion. A surficial slope failure was also observed, which was likely caused by a combination of piping erosion and tree loss. Representative photographs of the existing slope conditions are presented below.

***Photo 1:*** *Slope between Fall Brook and Cross Road, approximately STA 400+50, evidence of soil loss due to probable piping erosion can be seen in the middle and toe of the slope.*

***Photo 2:*** *Slope between Fall Brook and Cross Road, approximately STA 400+75, surficial slough-type failure of the slope that may have been exacerbated by pipping erosion and tree loss.*

***Photo 3:*** *Slope between Fall Brook and Cross Road, approximately STA 401+10. Exposed bedrock and boulders at the toe of the slope.*

# 5.0 ENGINEERING EVALUATIONS

## 5.1 GENERAL

GZA conducted preliminary geotechnical engineering evaluations in accordance with *2020 AASHTO LRFD Bridge Design Specifications, 9th Edition* (herein designated as AASHTO) and the *MaineDOT Bridge Design Guide, 2003 Edition*, with updates through 2018 (MaineDOT BDG). Calculations are presented in **Appendix E**.

## 5.2 APPROACH EMBANKMENTS AND SIDE SLOPES

The existing approaches are approximately 18 feet high at Abutments 1 and 2, measured from the existing roadway to the riverbed. At Abutments 1 and 2, the new substructures will be located within the footprint of the existing abutments. Therefore, maximum grade raises beneath the road will be approximately 4 to 5 feet, for a total height of approximately 22 feet above riverbed at both of the new abutments. The left wingwall at Abutment 1 and both wingwalls at Abutment 2 extend outside of the current approach embankment footprint. Therefore, maximum fill heights will range from approximately 5 to 10 feet at the proposed wingwalls.

We anticipate that the fill will be constructed over existing fill and rock. Based on the proposed geometry and anticipated subsurface conditions along Maine Street, it is our opinion that the potential for global instability of the proposed embankments is low. Settlement occurring under new fills is anticipated to occur primarily as elastic settlement. Therefore, post-construction settlement is anticipated to be negligible.

The proposed left side slope of Cross Street is planned to have a riprap slope ranging from 2.2H:1V to 1.75H:1V. We anticipate that the toe of the riprap slope will be constructed directly on bedrock on the brook side of the steep bank. The middle portion of the slope will likely be cut into the existing bank, and the upper 6 to 8 feet will be compacted fill material. Assuming preparation of the embankment toe provides suitable protection against loss of riprap material, and preparation of the cut portion of the slope removes all loose and deleterious materials, we anticipate a stable 1.75H:1V slope can be constructed. Recommendations are provided in **Section 6.1**.

## 5.3 EVALUATION OF FOUNDATIONS

### 5.3.1 Foundation Type Assessment

Based on the shallow bedrock encountered in the test borings and exposed along the river and at the proposed bridge abutments, spread footings bearing on rock were selected as the preferred foundation type.

### 5.3.2 Load and Resistance Factors

AASHTO LRFD load factors should be applied to horizontal earth pressure (EH), vertical earth pressure (EV), earth surcharge (ES), live load surcharge (LS) loads, and components and attachments (DC) loads using the load factors for permanent loads ($\gamma_p$) provided in LRFD Tables 3.4.1-2 for strength limit state foundation design. For service and extreme limit states, a load factor of 1.0 is recommended.

Recommended LRFD resistance factors for strength limit state design of the bedrock-bearing foundations were derived from LRFD Table 10.5.5.2.2-1 and are presented in the following table.

| **RESISTANCE FACTORS – STRENGTH** | | |
|---|---|---|
| **Foundation Resistance Type** | **Method/Condition** | **Resistance Factor ($\phi_\tau$)** |
| Bearing | Footing on Rock | 0.45 |
| Sliding | Tremie Concrete on Rock* | 0.8 |

*Sliding resistance factor for concrete on rock or concrete is taken as equal to footing on sand.

## 5.4 SPREAD FOOTINGS ON BEDROCK

Nominal and factored bearing resistances were calculated for footings bearing on rock using the Rock Mass Rating- (RMR-) based empirical correlation presented in "Foundations on Rock," by Duncan Wyllie.

RMR was evaluated in accordance with Table 10.4.6.4-1 of the *2012 AASHTO LRFD Bridge Design Specifications, 6th Edition* (AASHTO). The current (9th Edition) of the AASHTO *Design Specifications* does not include the RMR formulation included in the 6th Edition. However, Articles C10.4.6.4 and 10.6.2.5.2 of the 9th Edition refer to RMR-based design procedures for footings on rock, so the 6th Edition methodology was followed.

GZA used bedrock data obtained in test borings BB-SFB-103, -104 and -105 to develop foundation design parameters at the abutments. Of the four tests available to characterize the rock, three indicate an unconfined compressive strength of 31 kips per square inch (ksi) or greater, and the fourth indicates a much lower strength and appears to have been controlled by a weak foliation plane and is not judged to be characteristic of intact rock. Therefore, an unconfined compressive strength of 30 ksi was assumed for design, and the RMR parameters were selected based on a strength range of 15 to 30 ksi. Based on the available data and the stated methodology, the calculated nominal bearing resistance is 95 kips per square foot (ksf). This provides a factored bearing resistance of 43 ksf for the strength loading condition, which can be used for strength and service conditions.

LRFD Article 10.6.2.4.4 indicates that the footings bearing on rock with an RMR-based rock quality of fair and designed using LRFD methods are generally anticipated to experience ½ inch or less of elastic settlement. Although the overall characterization is poor to fair based on the RMR, we anticipate that the settlement will be less than ½ inch considering the hard rock and typical tight aperture and minimal infilling of the joints.

## 5.5 SEISMIC DESIGN CONSIDERATIONS

Seismic site class was determined in general accordance with LRFD Table C3.10.3.1. The subsurface profile for seismic design includes fills and Glacial Tills overlying bedrock. However, we conclude that the overlying soils can be ignored from the site classification since the foundation is to be placed directly on competent bedrock. Therefore, the bridge is assigned to Site Class B.

The available subsurface data indicates that the natural materials encountered at the site are sufficiently cohesive or dense that the potential for liquefaction is low.

## 5.6 FROST PENETRATION

Fill soils are anticipated to be present at the abutments, as existing and newly imported backfill. Based on the MaineDOT BDG, Section 5.2.1, the Freezing Index for the site is 1,850, and with low to moderate moisture content (±15 percent) soils, the estimated depth of frost penetration is 6 feet. However, because the foundations consist of footings on sound bedrock, there is no requirement for footing embedment.

## 6.0 RECOMMENDATIONS

### 6.1 SIDE SLOPE DESIGN CONSIDERATIONS

Heavy riprap should be placed to a minimum thickness of 4 feet and should be underlain by a minimum 12-inch-thick protective aggregate cushion and non-woven erosion control geotextile in accordance with MaineDOT Standard Details 610(02) and 610(03) with modification to the toe trench as described below.

It is anticipated that riprap at the base of the Cross Street slope and adjacent to the wing walls will bear directly on bedrock, due to the likelihood that soil would experience erosion and allow the slope to be undermined. The bedrock should be exposed and documented prior to placement of the riprap. MaineDOT Standard Detail 610(02) shows a toe trench for the riprap. The support surface at the toe of the riprap slope should be constructed to provide lateral restraint of the riprap consistent with the intent of the standard detail. This could be achieved by excavating rock to create a toe trench or doweling riprap blocks at the base into the bedrock. Large boulders present near or removed from the slope may work well for doweled toe blocks. The riprap should not be built on a surface of existing smooth rock that is flat or slopes out toward the brook. Hoe ramming will likely be required to provide suitable restraint if doweled key blocks are not used. We recommend that the resident engineer and/or the geotechnical engineer should review the proposed toe stabilization approach and the prepared support surface at the toe of the riprap to assess lateral restraint.

Prior to fill placement over the existing bank of the brook, the contractor should completely grub all organics and remove all stumps, large roots (greater than 1 inch in diameter), and loose/detached rock. The geotextile placed beneath against the prepared slope surface should meet the material requirements for Class 1 geotextile per MaineDOT Standard Specification 722.00 and the requirements for Erosion Control Geotextile per MaineDOT Standard Specification Section 722.03. The existing riverbank slope should be benched beneath the riprap if the inclination is greater than 1.5H:1V. Intact bedrock extending above the finished slope line may remain partially in place if approved by the resident engineer. However, partial removal/hoe ramming will likely be needed to promote stability of the riprap placed above.

We recommend that a rock excavation bid item be included in the contract documents in case significant hoe ramming is required to provide either a stable toe or a relatively uniform slope in the vicinity of the brook side slope.

### 6.2 SEISMIC DESIGN

The peak ground acceleration coefficient, and short- and long-period spectral acceleration coefficients were interpolated from the *AASHTO Design Guide* maps (3.10.2.101 through -21 as appropriate). Based on the site coordinates, the recommended AASHTO Response Spectra (Site Class B) for a 7 percent probability of exceedance in 75 years are summarized for the site as follows:

| SITE CLASS B SEISMIC DESIGN PARAMETERS | |
|---|---|
| **Parameter** | **Design Value** |
| Fpga | 1.0 |
| Fa | 1.0 |
| Fv | 1.0 |
| As (Period = 0.0 sec) | 0.08 g |
| SDs (Period = 0.2 sec) | 0.16 g |
| SD1 (Period = 1.0 sec) | 0.05 g |

## 6.3 ABUTMENT AND WINGWALL DESIGN

The full height abutments and wingwalls will be free to rotate and therefore should be designed for active earth pressure using the Rankine method. The material properties will be controlled by the backfill material, which is anticipated to consist of BDG Type 4 soil.

- Backfill in a zone between new abutments and a 1.5H:1V plane extending up and back from the bottom of the abutment to the pavement subgrade should consist of MaineDOT 703.19 Granular Borrow for Underwater Backfill, BDG Type 4 soil. Recommended soil properties for Type 4 soils to be used as backfill are as follows:
  - Internal Friction Angle of Soil = 32°
  - Soil Total Unit Weight = 125 pcf
  - Coefficient of Active Earth Pressure, $K_a$=0.31 (use for design of abutments and wingwalls)
- Live load surcharge should be applied as a uniform lateral surcharge pressure using the equivalent fill height (Heq) values developed in accordance with AASHTO Article 3.11.6.4 based on the abutment/wingwall height and distance from the wall back face to the edge of traffic.
- Foundation drainage should be provided in accordance with Section 5.4.1.9 of the MaineDOT BDG. We recommend the use of French drains on the uphill side of abutments and wing walls to prevent buildup of differential hydrostatic pressure. The drains should be sloped to drain by gravity and should outlet through a series of 4-inch-diameter weep holes, spaced approximately 10 feet center-to-center.

## 6.4 SPREAD FOOTING DESIGN

- The proposed abutments should be supported on spread footing foundations bearing on lean concrete or a tremie seal bearing on sound, intact bedrock. Footings designed to bear on intact bedrock should be designed using a nominal bearing resistance, $q_n$, of 95 ksf. At the strength limit state, footings should be designed for a maximum factored bearing resistance of 43 ksf. A bearing resistance of 43 ksf should be used for service limit state design.
- For tremie seal evaluation, the top of bedrock elevation in the boring at Abutment 1 was found to be at El. 368.4 and Abutment 2 was found to be at El. 360.3. However, exposed bedrock at the riverbed in front of existing abutments also represents likely bedrock elevations, which is at approximately El. 359 at Abutment 1 and approximately El. 361 at Abutment 2. It is important to note that the top of intact rock

cannot be known for the entire foundation area prior to construction. We expect that intact rock may be encountered above and below the anticipated levels. Specifically at Abutment 1, bedrock appears to slope up steeply from the bottom of Fall Brook to boring BB-SF-103. Some construction-phase engineering should be anticipated to address the potential variability of the encountered bedrock surface conditions.

- Spread footings founded on bedrock should be checked for eccentricity in accordance with AASHTO Article 10.6.3.3. Eccentricity of the footing reaction at the strength limit state should be limited such that the resultant reaction on the base of the footing is no further than 0.45 B from the centerline of the footing, where B is the footing width perpendicular to the axis of rotation.
- The base resistance against sliding may be based on NAVFAC DM7.02-63, Table 1, which indicates the sliding resistance coefficient (tan $\delta$) is equal to 0.7 for cast-in-place concrete on sound rock. Therefore, the nominal sliding resistance between footings and bedrock subgrades is equal to the vertical force multiplied by 0.7. The factored sliding resistance coefficient is 0.56 for Strength Limit State.
- The bedrock surface should be cleaned of loose soil or rock at the time of concrete placement for subfooting concrete or the footing. Bearing surface preparation should be in accordance with **Section 7.2**.
- If the bedrock level extends above the design bottom of footing elevation, the footing may be raised and vertical reinforcement shortened in the wall, subject to review and approval of the Designer to limit over-excavation of bedrock.
- If, after cleaning, the exposed bedrock surface is below the design footing bearing level, fill concrete may be placed up to the bottom of footing level.
- Anchoring, doweling, benching or other means of improving sliding resistance is recommended at locations where the prepared bedrock surface is steeper than 4H:1V in any direction.
- Rock dowels may be used to supplement the footing sliding resistance. If used, the dowels should be grouted a minimum of 2 feet into intact bedrock and embedded at least 1.5 feet into concrete. The unconfined compressive strength of the bedrock should be assumed to be 4.0 ksi for design of rock dowels.
- Dowels should be grouted with a cementitious grout on the MaineDOT Qualified Products List of Grout Materials for Keyways and Anchoring (pre-qualified for anchoring). Epoxy grout should not be used.
- Since the footings will be founded on bedrock, there is no minimum embedment required for frost protection per BDG Article 5.2.1.
- Where they interfere with new foundations, existing substructures should be completely removed prior to new foundation construction.

## 7.0 CONSTRUCTION CONSIDERATIONS

This section provides guidance regarding quality control during slope preparation, excavation, dewatering, and foundation subgrade preparation and protection. These items are discussed in the paragraphs that follow.

### 7.1 EXCAVATION AND DEWATERING

Excavations for abutment foundations will involve removing the existing abutments and excavating to expose bedrock. The excavations will extend up to about 18 feet below existing roadway grade, corresponding to depths of approximately 2.5 to 5 feet below the Q1.1 river elevation (El. 363.4). These excavation depths would typically require a four-sided, internally- and/or externally-braced sheet pile cofferdam for excavation support. The sheetpiles on the brook side would rest directly on bedrock, and a significant differential lateral load would be imposed from the approach side toward the brook side. Depending on water levels at the time of construction and permitting, it may also be feasible to temporarily divert the brook through a pipe and to prepare the excavations inside of a dam-type cofferdam or to use sandbags to facilitate dewatering using sumps. In this case, it may be feasible to prepare the approach embankment excavations as sloped open cuts. Depending on the length and proximity of the downstream temporary bridge, it may be necessary to install a row of sheetpile longitudinally to separate the temporary fill from the excavation. The contractor should be responsible for design of all temporary excavation support structures.

Dewatering considerations will depend on the brook level at the time of construction. If brook levels are several feet above bedrock elevations and water control measures are not implemented or successful, we anticipate that dewatering using sumps will be impractical, and the foundations will need to be constructed on tremie seals placed in the wet. Otherwise, it may be feasible to dam and divert streamflow and dewater cofferdam(s) by pumping from sumps placed within the excavations in low water conditions. The contractor should be responsible for controlling groundwater, surface runoff, infiltration and water from all other sources. Discharge of pumped groundwater and river water should comply with all local, State, and federal regulations.

## 7.2 FOUNDATION SUBGRADE PREPARATION

If necessary, bedrock bearing surface preparation may be conducted in the wet. We anticipate that the bedrock surface will be variable in terms of elevation, slope and localized weathering. A combination of standard excavation equipment, hydraulic hoe-ramming equipment, and/or air lifting may be needed to remove the overburden and fractured/weathered rock. The existing foundations, all soil, and loose, decomposed, highly weathered and fractured bedrock should be removed from the footing bearing surface prior to placement of tremie seals or footings. The prepared bedrock surface should be evaluated for suitable cleanliness prior to concrete placement. Even if water is present in the excavation, we anticipate that a combination of visual assessment of cleanliness and soundings will be feasible.

The Geotechnical Engineer and Designer should be provided cross-sections showing the prepared rock surface geometry prior to placement of concrete to evaluate whether benching, doweling, or subfooting reinforcement is needed for that foundation location. If the exposed bedrock surface is steeper than 4H:1V, then anchoring, doweling, benching or other means should be employed to improving sliding resistance.

## 7.3 RIPRAP SLOPE CONSTRUCTION

Because of potential for smooth flat rock, doweling of boulders or hoe-ram excavation of a toe trench will most likely be required for the Cross Street side slope. The contractor should provide a pre-excavation submittal indicating their proposed method to support the toe of the riprap slope where embedment is not feasible. After excavation to the proposed toe of slope location and elevation, the contractor should conduct a survey and submit cross-sections that show how the proposed toe support will allow construction of the required slope geometry.

TABLES

## Table 1 - Summary of Bedrock Data
## Main Street Bridge #2504
## Fall Brook, Solon, Maine
## WIN 022260.01

| Boring | Run | GS Elevation | Depth of Core Run below GS (ft) | | | Depth to Rock (ft) | Depth (ft) Below Top of Rock | | | Length of Core Run (ft) | Rec (in) | Rec (%) | RQD (in) | RQD % | Joint Spacing Desc. | Corr. Spacing (in) | Aperture Desc. | Corr. Aperture (in) | Elev. (ft) | | LAB | | | | | | | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Top | | Bottom | | Top | | Bottom | | | | | | | | | | Top | Bottom | Depth of Sample (ft) | Depth of Sample into Rock (ft) | Elev Top of Sample (ft) | UCS (psi) | Point Load Index, Is50 (psi) | Modulus (ksi) | Unit Wt (pcf) | |
| BB-SFB-103 | R1 | 377.4 | 9.0 | - | 13.6 | 9.0 | 0.0 | - | 4.6 | 4.6 | 42 | 76% | 20 | 37% | Very Close to Close | 0.75-8 | Tight to Wide | 0.004-0.4 | 368.4 | 363.8 | 9.0 | 0 | 368.4 | 37,699 | -- | 5.49 | 169.2 | PHYLLITE |
| BB-SFB-103 | R2 | 377.4 | 13.6 | - | 15.8 | 9.0 | 4.6 | - | 6.8 | 2.2 | 23 | 87% | 14 | 53% | Extremely Close | <.75 | Tight | 0.004-0.01 | 363.8 | 361.6 | | | | | | | | PHYLLITE |
| BB-SFB-103 | R3 | 377.4 | 15.8 | - | 19.8 | 9.0 | 6.8 | - | 10.8 | 4.0 | 48 | 100% | 41 | 84% | Extremely Close to Moderate | <0.75-24 | Tight | 0.004-0.01 | 361.6 | 357.6 | | | | | | | | PHYLLITE |
| BB-SFB-104 | R2 | 378.8 | 18.5 | - | 22.5 | 18.5 | 0.0 | - | 4.0 | 4.0 | 41 | 85% | 12 | 25% | Extremely Close to Close | <0.75-8 | Tight | 0.004-0.01 | 360.3 | 356.3 | 18.7 | 0.2 | 360.1 | 31,008* (D), 33,264* (A) | 1,292 (D), 1,386 (A) | -- | 181.1 (D), 168.4 (A) | PHYLLITE |
| BB-SFB-104 | R3 | 378.8 | 22.5 | - | 23.3 | 18.5 | 4.0 | - | 4.8 | 0.8 | 9 | 100% | 0 | 0% | Extremely Close to Close | <0.75-8 | Tight | 0.004-0.01 | 356.3 | 355.5 | | | | | | | | PHYLLITE |
| BB-SFB-105 | R1 | 370.0 | 9.0 | - | 14.0 | 8.5 | 0.5 | - | 5.5 | 5.0 | 60 | 100% | 51 | 85% | Very Close to Moderate | 0.75-24 | Tight | 0.004-0.01 | 361.0 | 356.0 | 9.4 | 0.9 | 360.6 | 2,520 | -- | 1.36 | 171.4 | PHYLLITE |

Note: "UCS" is unconfined compressive strength. UCS values marked with "*" are from diametrical (D) and axial (A) point load tests and are correlated from the point load test results.

FIGURES


USGS QUADRANGLE LOCATION

N
W E
S

SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS. THIS MAP ALSO CONTAINS THE ESRI ARCGIS ONLINE USA COUNTIES WHICH PROVIDES DETAILED BOUNDARIES THAT ARE CONSISTENT WITH THE TRACT, BLOCK GROUP, AND STATE DATA SETS AND ARE EFFECTIVE AT REGIONAL AND STATE LEVELS.

0 1,000 2,000 4,000 6,000

SCALE IN FEET

Data Supplied by :

esri

USGS science for a changing world

GZA

PROJ. MGR.: BC
DESIGNED BY: MRJ
REVIEWED BY: ARB
OPERATOR: MRJ

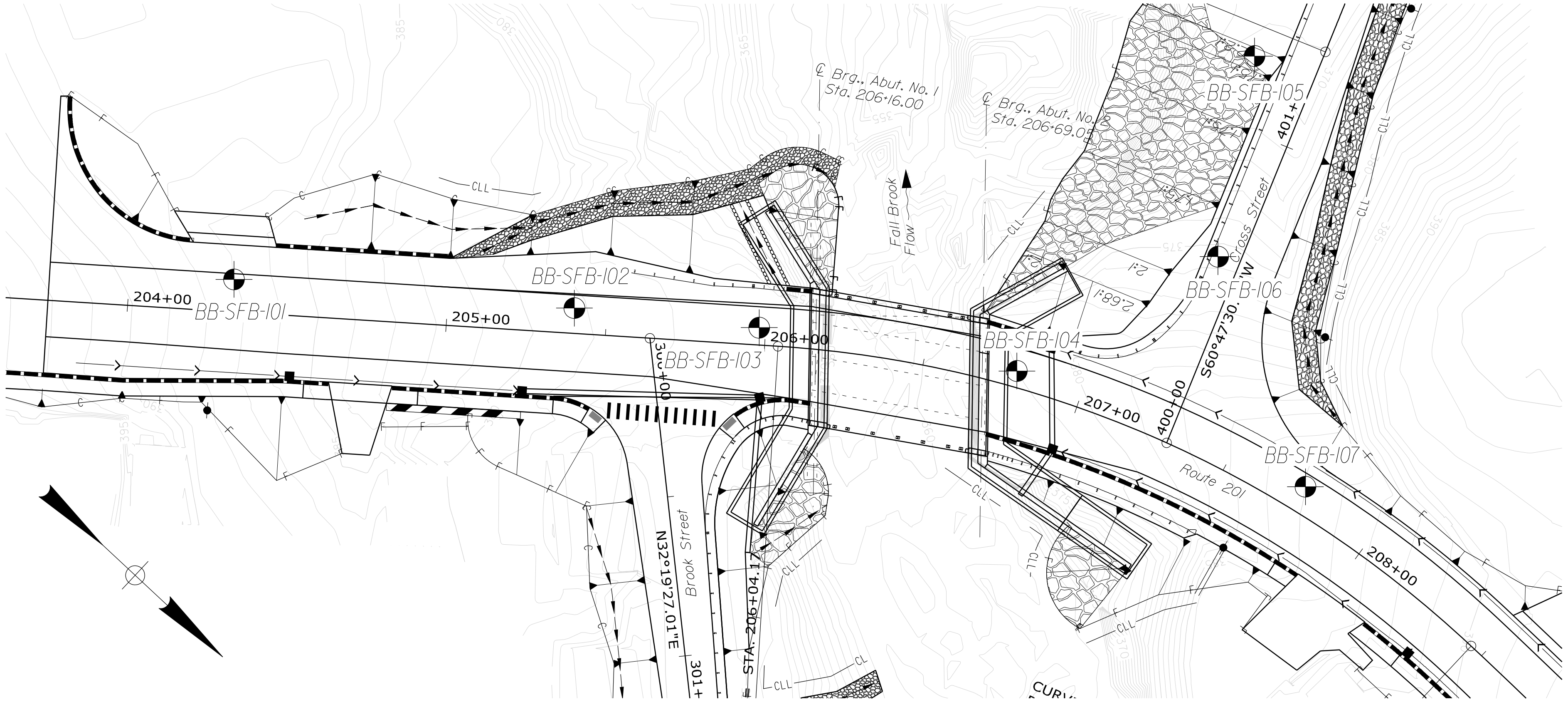
DATE: 02-04-2020

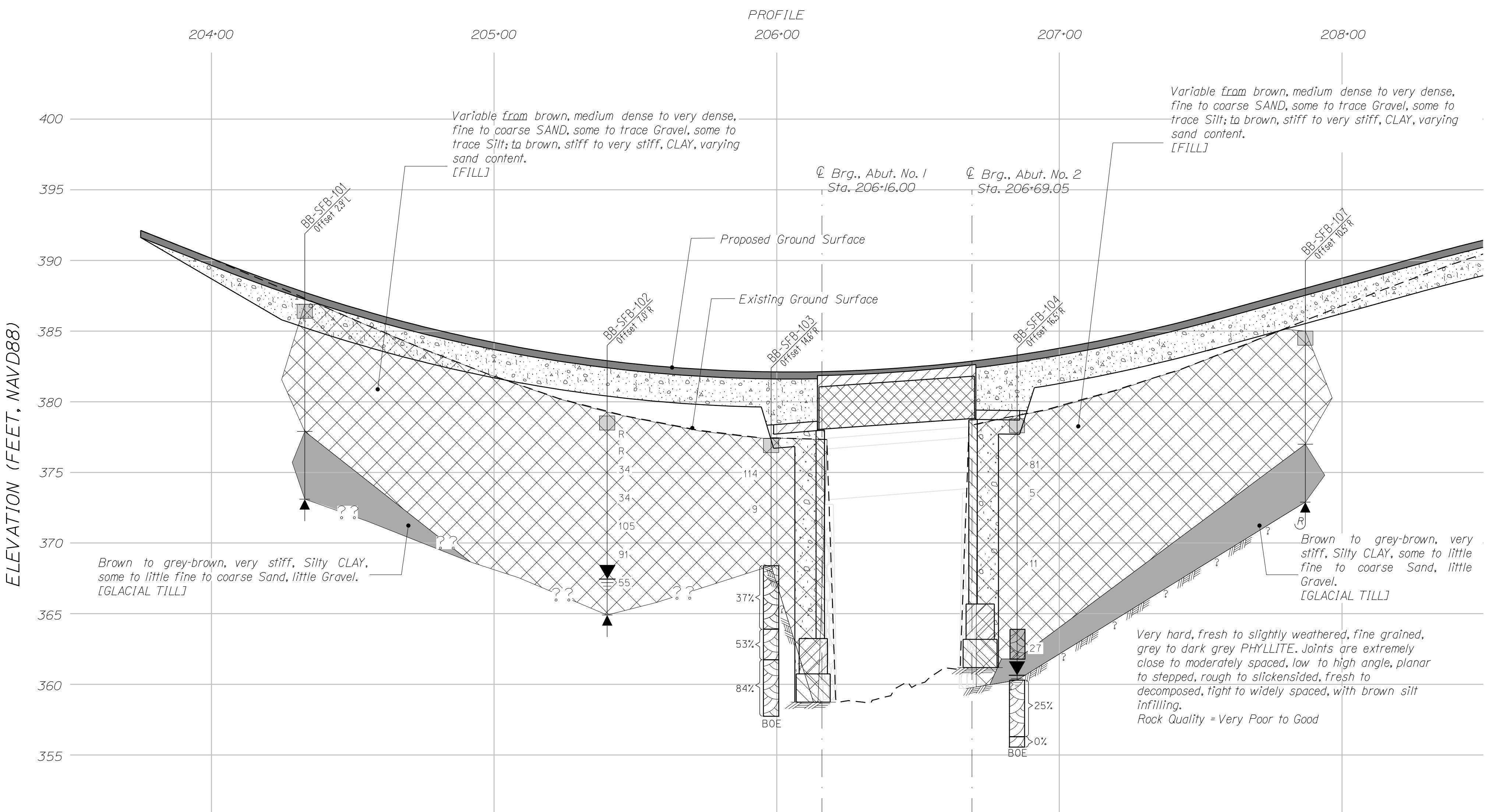
**LOCUS PLAN**

FALL BROOK BRIDGE NO. 2504
SOLON, MAINE

JOB NO.
09.0026012.01

FIGURE NO.
**1**




## NOTES

1) Base map developed from electronic files provided by Hoyle, Tanner & Associates, Inc. on September 26, 2022 (Files included Alignments.dgn, Bridge.dgn and Contours.dgn).

2) Profile developed from electronic file Profile.dgn provided by Hoyle, Tanner & Associates, Inc. on June 16, 2021.

3) The as-drilled locations of the test borings were surveyed by a MaineDOT survey crew and supplied to GZA, except for BB-SFB-105 and -106, which were located by GZA using taped ties from known features and should be considered approximate.

4) BB-SFB-100 series borings were performed by New England Boring Contractors and observed by GZA personnel between February 11 and February 14, 2019.

5) This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

## BORING LOCATION PLAN LEGEND

BB-SFB-107 — Location and designation of cased wash borings and auger probes

## INTERPRETIVE SUBSURFACE PROFILE LEGEND

- Interpreted Top of Bedrock (See Note 5)
- Boring No., Offset, if shown
- Pavement Thickness if applicable
- 6 — Energy-Corrected SPT N60 Value (blows/foot)
- Strata Interface
- Encountered Groundwater Level
- R — Split Spoon Refusal (>50 blows for 1" penetration)
- Rock Core through Apparent Boulder
- RQD = Rock Quality Designation for Rock Core Sample
- BOE — Bottom of Exploration
- Bottom of Exploration, Refusal
- Bottom of Exploration, No Refusal

PLAN

25 0 25 50
Scale In Feet

PROFILE

Horiz. 25 0 25 50
Vert. 5 0 5 10
Scale In Feet

**PRELIMINARY**
**NOT FOR CONSTRUCTION**

PREPARED BY: GZA

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

22260.01

WIN 022260.01

BRIDGE PLANS

BRIDGE NO. 2504

| | BY | DATE |
|---|---|---|
| PROJ. MANAGER | ANDREW LATHE | |
| DESIGN-DETAILED | MRJ | SEPT. 2022 |
| CHECKED-REVIEWED | ARB | CLS |
| DESIGN2-DETAILED2 | | |
| DESIGN3-DETAILED3 | | |
| REVISIONS 1 | | |
| REVISIONS 2 | | |
| REVISIONS 3 | | |
| REVISIONS 4 | | |
| FIELD CHANGES | | |

SIGNATURE

P.E. NUMBER

DATE

MAIN STREET BRIDGE
FALL BROOK
SOLON SOMERSET COUNTY

BORING LOCATION PLAN &
INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
8
OF 66

Filename: ...\BLP 09_30_2022.dgn
Division: HIGHWAY
Username:
common
Date:12/15/2022

APPENDIX A – LIMITATIONS

## GEOTECHNICAL LIMITATIONS

### Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

### Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

### Subsurface Conditions

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or

spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

8. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

9. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

**Compliance with Codes and Regulations**

10. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

**Cost Estimates**

11. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

**Additional Services**

12. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

APPENDIX B –TEST BORING LOGS

## UNIFIED SOIL CLASSIFICATION SYSTEM

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

**Desired Soil Observations (in this order, if applicable):**

Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
Name (Sand, Silty Sand, Clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc., )
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

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

## MODIFIED BURMISTER SYSTEM

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

## TERMS DESCRIBING DENSITY/CONSISTENCY

**Coarse-grained soils** (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) Silty or Clayey gravels; and (3) Silty, Clayey or Gravelly sands. Density is rated according to standard penetration resistance (N-value).

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

**Fine-grained soils** (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) Gravelly, Sandy or Silty clays; and (3) Clayey silts. Consistency is rated according to undrained shear strength as indicated.

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

**Rock Quality Designation (RQD):**

RQD (%) = $\frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$

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

**Rock Quality Based on RQD**

| Rock Quality | RQD (%) |
|---|---|
| Very Poor | ≤25 |
| Poor | 26 - 50 |
| Fair | 51 - 75 |
| Good | 76 - 90 |
| Excellent | 91 - 100 |

**Desired Rock Observations (in this order, if applicable):**

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -tightness (tight, open, or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

**Sample Container Labeling Requirements:**

| | |
|---|---|
| WIN | Blow Counts |
| Bridge Name / Town | Sample Recovery |
| Boring Number | Date |
| Sample Number | Personnel Initials |
| Sample Depth | |

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-101
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 386.9 | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Grab |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | -- |
| **Date Start/Finish:** | 2/12/19-2/12/19 | **Drilling Method:** | SSA | **Core Barrel:** | -- |
| **Boring Location:** | 204+32.7, 10.3' LT | **Casing ID/OD:** | -- | **Water Level*:** | Not Observed |
| **Hammer Efficiency Factor:** | -- | **Hammer Type:** | Automatic ☐ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | | | 0'-1.0': Asphalt | |
| | | | | | | | | 385.9 | | 1.0 | |
| | G1 | | 2.0 - 4.0 | | | | | | | Brown, moist, fine to coarse SAND, little gravel, little silt, (Fill). | G# S-1<br>A-1-b, SM<br>WC=9.1 |
| | G2 | | 4.0 - 6.0 | | | | | | | Brown, moist, GRAVEL, some fine to coarse sand, little silt, (Fill). | |
| 5 | | | | | | | | | | | |
| | | | | | | | | 377.9 | | 9.0 | |
| 10 | | | | | | | | | | | |
| | G3 | | 13.0 - 15.0 | | | | | | | Brown, moist, Silty CLAY, little fine sand, (Glacial Till). | |
| | | | | | | | | 373.1 | | 13.8 | |
| | | | | | | | | | | **Bottom of Exploration at 13.8 feet below ground surface.** | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Grab samples taken from the auger flights at depths indicated.
2. Clay observed in auger cuttings at 9.0'.
3. As-drilled boring location was surveyed by MaineDOT (N 771962.8, E 1117546.6).
4. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-102
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 379.0 | **Auger ID/OD:** | 4.25/6.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Split Spoon |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | 140/30 |
| **Date Start/Finish:** | 2/14/19-2/14/19 | **Drilling Method:** | SSA/HSA | **Core Barrel:** | -- |
| **Boring Location:** | 205+39.7, 8.0' LT | **Casing ID/OD:** | -- | **Water Level*:** | 12.5' |
| **Hammer Efficiency Factor:** | 0.937 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | | | 0'-1.3': Asphalt | |
| | 1D | 3/3 | 1.5 - 1.8 | 100/3" | R | | | 377.7 | | 1.3 — Grey-brown, frozen, fine to coarse SAND, some gravel, some silt, (Fill). | G# S-2 A-1-b, SM WC=6.7 |
| | 2D | 3/3 | 3.0 - 3.3 | 100/3" | R | | | | | Brown, frozen, fine to coarse SAND, some gravel, some silt, (Fill). | |
| | 3D | 24/15 | 4.0 - 6.0 | 33-14-8-11 | 22 | 34 | | | | Brown, medium dense, fine to coarse SAND, some gravel, (Fill). | |
| 5 | | | | | | | | | | | |
| | 4D | 24/18 | 6.0 - 8.0 | 4-11-11-18 | 22 | 34 | | 373.0 | | 6.0 — Brown and black mottled, moist, medium dense, Sandy SILT, little gravel, (Fill). | |
| | 5D | 24/24 | 8.0 - 10.0 | 35-51-16-25 | 67 | 105 | | | | Brown and grey, moist, very dense, fine to coarse Sandy GRAVEL, little silt, angular. | |
| | | | | | | | HSA | | | | |
| 10 | 6D | 24/20 | 10.0 - 12.0 | 16-30-28-28 | 58 | 91 | | | | Brown and grey, moist, very dense, GRAVEL, some fine to coarse sand, trace silt, angular. | |
| | 7D | 24/18 | 12.0 - 14.0 | 16-18-17-55 | 35 | 55 | | | | Brown, moist to wet (bottom 2"), dense, fine to coarse Sandy GRAVEL (angular), little silt, trace quartz fragments (gravel sized). | |
| | | | | | | | | 364.9 | | 14.1 — **Bottom of Exploration at 14.1 feet below ground surface.** | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Automatic hammer NEBC #B-24 Energy Transfer Ratio=0.937.
2. Heavy auger grinding from 7.0'-14.1'.
3. As-drilled boring location was surveyed by MaineDOT (N 772036.4, E 1117468.9).
4. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.



**Boring No.:** BB-SFB-102

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-103
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 377.4 | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Split Spoon |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | 140/30 |
| **Date Start/Finish:** | 2/14/19-2/14/19 | **Drilling Method:** | Drive & Wash | **Core Barrel:** | NQ |
| **Boring Location:** | 205+97.9, 5.5' LT | **Casing ID/OD:** | 4/4.5", 3/3.5" | **Water Level*:** | Not Observed |
| **Hammer Efficiency Factor:** | 0.937 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | | | 0'-1.3': Asphalt | |
| | | | | | | | | 376.1 | | 1.3 | |
| | 1D | 24/24 | 2.0 - 4.0 | 36-45-27-16 | 73 | 114 | | | | Brown, frozen, Clayey SILT, some fine to coarse sand, trace gravel, (Fill). | G# S-3 A-4, ML WC=14.2 |
| 5 | 2D | 24/24 | 5.0 - 7.0 | 2-2-4-3 | 6 | 9 | | | | Brown, moist, loose, fine to coarse SAND, some silt, trace gravel, trace wood fragments, (Fill). | G# S-4 A-2-4, SM WC=18.9 |
| | | | | | | | | 368.4 | | Increased SSA resistance at 8.5', SSA refusal at 9.0'; insert 3" casing and set up to core. 9.0 | $q_p$=5,428 ksf |
| | R1 | 54/42 | 9.0 - 13.5 | RQD = 37% | | | NQ | | | R1: Very hard, fresh to slightly weathered, fine grained, dark grey, PHYLLITE. Joints are very close to close, low to high angle, planar and smooth to undulating and rough, fresh to decomposed, tight to widely spaced, with brown silt infilling. Intermittent resistance from 11.0'-12.0' indicates possible soil seam(s). -FALL BROOK FORMATION- Rock Quality = Poor Recovery = 78% Rock Core Times (min:sec); 9.0-10.0' (2:37), 10.0-11.0' (3:21), 11.0-12.0' (1:09), 12.0-13.0' (1:31), 13.0-13.6' (2:50) | |
| 10 | | | | | | | | | | | |
| | R2 | 26/23 | 13.6 - 15.8 | RQD = 53% | | | | | | R2: Very hard, fresh to slightly weathered, fine grained, dark grey, PHYLLITE. Joints are very close, low to high angle, planar to undulating, rough to smooth, fresh to decomposed, tight, with quartz seam observed at 15.5'. -FALL BROOK FORMATION- Rock Quality = Fair Recovery = 88% Rock Core Times (min:sec): 13.6-14.6' (1:18), 14.6-15.6' (2:26), 15.6-15.8' (0:58) | |
| 15 | R3 | 48/48 | 15.8 - 19.8 | RQD = 84% | | | | | | R3: Very hard, fresh to slightly weathered, fine grained, dark grey, PHYLLITE. Joints are extremely close to moderately spaced, low to high angle, planar to stepped, smooth to rough, fresh to decomposed, tight, with quartz seams observed at 17.1' and 19.8'. -FALL BROOK FOORMATION- Rock Quality = Good Recovery = 100% Rock Core Times (min:sec): 15.8-16.8' (2:20), 16.8-17.8' (3:03), 17.8-18.8' (3:19), 18.8-19.8' (3:48) | |
| 20 | | | | | | | | 357.6 | | 19.8 | |
| | | | | | | | | | | **Bottom of Exploration at 19.8 feet below ground surface.** | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Automatic hammer NEBC #B-24 Energy Transfer Ratio=0.937.
2. As-drilled boring location was surveyed by MaineDOT (N 772077.4, E 1117427.5).
3. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.



**Boring No.:** BB-SFB-103

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-104
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 378.8 | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Split Spoon |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | 140/30 |
| **Date Start/Finish:** | 2/11/19-2/12/19 | **Drilling Method:** | Drive & Wash | **Core Barrel:** | NQ |
| **Boring Location:** | 206+78.8, 5.1' LT | **Casing ID/OD:** | 4/4.5", 3/3.5" | **Water Level*:** | 18.3' |
| **Hammer Efficiency Factor:** | 0.937 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | | | 0'-1.5': Asphalt | |
| | | | | | | | | 377.3 | | 1.5 | |
| | | | | | | | | | | | |
| | 1D | 24/24 | 3.0 - 5.0 | 40-30-22-15 | 52 | 81 | | | | Top 12": Grey-brown, moist, medium to coarse Sandy GRAVEL, trace silt, (Fill). | G# S-5 A-1-a, GW WC=10.1 |
| | | | | | | | | 374.8 | | 4.0 Bottom 12": Brown, moist, very dense, fine to coarse SAND, some silt, trace gravel, (Fill). | |
| 5 | 2D | 24/8 | 5.0 - 7.0 | 4-1-2-17 | 3 | 5 | 19 | 373.8 | | 5.0 Top 18": Brown, moist, very loose, fine to coarse SAND, little gravel, trace silt, (Fill). | |
| | | | | | | | 55 | 372.8 | | 6.0 Bottom 6": 3" decomposed timber fragments and little grey Silty CLAY, (Fill). | |
| | | | | | | | 96 | | | | |
| | | | | | | | 38 | 370.3 | | 8.5 | |
| | | | | | | | | | | | |
| 10 | 3D | 24/8 | 10.0 - 12.0 | 7-4-3-10 | 7 | 11 | 32 | | | Brown, moist, stiff, Sandy CLAY, little gravel, (Fill). | |
| | | | | | | | 56 | | | | |
| | | | | | | | 50 | | | | |
| | | | | | | | 100/2 | | | | |
| | R1 | 24/11 | 14.0 - 16.0 | | | | RC | 364.8 | | 14.0 Advance roller cone to 14.0'; rock chips observed in return water. Set up to core. R1: Apparent Cobbles/Boulder. | |
| 15 | | | | | | | | | | | |
| | 4D | 24/9 | 16.0 - 18.0 | 4-5-12-44 | 17 | 27 | | 362.8 | | 16.0 Grey-brown, moist, very stiff, Silty CLAY, some fine to coarse sand, little gravel, (Glacial Till). 3" casing refusal at 18.4', advance roller cone to 18.5' and set up to core. | |
| | | | | | | | | | | | |
| | R2 | 48/41 | 18.5 - 22.5 | RQD = 25% | | | 100/5 | 360.3 | | 18.5 R2: Very hard, fresh, fine grained, grey, PHYLLITE. Joints are extremely close to close, low angle to high angle, planar, smooth, fresh to discolored, tight, brown silt infilling. -FALL BROOK FORMATION- Rock Quality = Very Poor Recovery = 85% Rock Core Times (min:sec): 18.5-19.5' (2:01), 19.5-20.5' (2:01), 20.5-21.5' (1:43), 21.5-22.5' (2:22) | |
| | | | | | | | NQ | | | | |
| 20 | | | | | | | | | | | |
| | | | | | | | | | | | |
| | R3 | 9/9 | 22.5 - 23.3 | RQD = 0% | | | | | | R3: Very hard, fresh, fine grained, grey, PHYLLITE. Joints are extremely close to close, low angle to high angle, planar, smooth, fresh to discolored, tight, brown silt infilling. -FALL BROOK FORMATION- Rock Quality = Very Poor | |
| | | | | | | | | 355.5 | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Automatic hammer NEBC #B-24 Energy Transfer Ratio=0.937.
2. As-drilled boring location was surveyed by MaineDOT (N 772138.4, E 1117373.0).
3. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-104
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 378.8 | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Split Spoon |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | 140/30 |
| **Date Start/Finish:** | 2/11/19-2/12/19 | **Drilling Method:** | Drive & Wash | **Core Barrel:** | NQ |
| **Boring Location:** | 206+78.8, 5.1' LT | **Casing ID/OD:** | 4/4.5", 3/3.5" | **Water Level*:** | 18.3' |
| **Hammer Efficiency Factor:** | 0.937 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_V$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | | | | | | | | | | Recovery = 100%<br>Rock Core Times (min:sec): 22.5-23.3' (1:02) 23.3 | |
| | | | | | | | | | | **Bottom of Exploration at 23.3 feet below ground surface.** | |
| 30 | | | | | | | | | | | |
| 35 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 45 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |

**Remarks:**

1. Automatic hammer NEBC #B-24 Energy Transfer Ratio=0.937.
2. As-drilled boring location was surveyed by MaineDOT (N 772138.4, E 1117373.0).
3. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-105
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 370.0 (est) | **Auger ID/OD:** | 4.25 |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Split Spoon |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | 140/30 |
| **Date Start/Finish:** | 2/12/19-2/14/19 | **Drilling Method:** | Drive & Wash | **Core Barrel:** | NQ |
| **Boring Location:** | 401+23, 20' LT | **Casing ID/OD:** | 4/4.5", 3/3.5" | **Water Level*:** | 8.0' |
| **Hammer Efficiency Factor:** | 0.937 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | 369.3 | | 0'-0.7': Asphalt — 0.7 | |
| | 1D | 24/24 | 1.0 - 3.0 | 45-46-32-36 | 78 | 122 | | | | Brown to grey, frozen, Silty CLAY, some fine to coarse Sand, little gravel, (Fill). | G# S-6 A-6, CL WC=21.6 |
| | | | | | | | | 366.0 | | — 4.0 | |
| 5 | 2D | 24/12 | 4.0 - 6.0 | 4-16-5-8 | 21 | 33 | 32 | 365.5 | | Top 6": Grey, moist, medium dense, GRAVEL, trace silt, angular, (Fill). — 4.5 | G# S-7 A-4, ML WC=16.3 |
| | | | | | | | 45 | | | Bottom 6": Brown, moist, very stiff, Silty CLAY, some fine to medium sand, (Glacial Till). | |
| | | | | | | | 51 | | | | |
| | | | | | | | 100/3 | | | | |
| | | | | | | | RC | 361.5 | | — 8.5 | |
| | R1 | 60/60 | 9.0 - 14.0 | RQD = 85% | | | NQ | | | Heavy resistance at 8.5'; advance roller cone to 9.0' and set up to core. R1: Very hard, fresh, fine grained, grey, PHYLLITE. Joints are very close to moderately spaced, low to high angle, planar to undulating, smooth to rough, Slickenside observed at 12.0', discolored, tight, trace brown clay, infilling. Rock Quality = Good Recovery = 100% Rock Core Times (min:sec): 9.0-10.0' (2:38), 10.0-11.0' (2:33), 11.0-12.0' (2:12), 12.0-13.0' (2:03), 13.0-14.0' (2:30) | $q_p$=362 ksf |
| 10 | | | | | | | | | | | |
| | | | | | | | | 356.0 | | — 14.0 | |
| | | | | | | | | | | **Bottom of Exploration at 14.0 feet below ground surface.** | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Automatic hammer NEBC #B-24 Energy Transfer Ratio=0.937.
2. As-drilled boring location was determined by GZA using taped ties from known features and should be considered approximate (N 772108, E 1117253).
3. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.



**Boring No.:** BB-SFB-105

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-106
**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 375.5 (est) | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Grab |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | -- |
| **Date Start/Finish:** | 2/12/19-2/14/19 | **Drilling Method:** | SSA | **Core Barrel:** | -- |
| **Boring Location:** | 400+60, 7' LT | **Casing ID/OD:** | -- | **Water Level*:** | Not Observed |
| **Hammer Efficiency Factor:** | -- | **Hammer Type:** | Automatic ☐ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | 375.0 | | 0'-0.5': Asphalt — 0.5 | |
| | G1 | | 2.0 - 4.0 | | | | | | | Grey-brown, moist, fine to coarse SAND, trace gravel, trace silt, (Fill). | |
| 5 | | | | | | | | | | | |
| | G2 | | 6.0 - 8.0 | | | | | 368.5 | | Brown, moist, fine to coarse SAND, little gravel, trace silt, (Fill). — 7.0 | |
| | G3 | | 9.0 - 11.0 | | | | | 366.0 | | Brown, moist, Silty CLAY, little fine sand, (Glacial Till). — 9.5 | G# S-8<br>A-4 (7), CL<br>WC=22.8 |
| 10 | | | | | | | | | | **Bottom of Exploration at 9.5 feet below ground surface.** | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Grab samples taken from the auger flights at depths indicated.
2. Clay observed in auger cuttings at 7.0'.
3. As-drilled boring location was determined by GZA using taped ties from known features and should be considered approximate (N 772150, E 1117301).
4. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

# Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

**Project:** Main Street Bridge #2504 over Fall Brook
**Location:** Solon, Maine

**Boring No.:** BB-SFB-107

**WIN:** 22260.01

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | New England Boring Contractors | **Elevation (ft.)** | 385.0 | **Auger ID/OD:** | 4.25" |
| **Operator:** | J. Maynard, Jr. | **Datum:** | NAVD88 | **Sampler:** | Grab |
| **Logged By:** | E. Friede | **Rig Type:** | Mobile B-53 | **Hammer Wt./Fall:** | -- |
| **Date Start/Finish:** | 2/12/19-2/12/19 | **Drilling Method:** | SSA | **Core Barrel:** | -- |
| **Boring Location:** | 207+74.7, 8.3' LT | **Casing ID/OD:** | -- | **Water Level*:** | Not Observed |
| **Hammer Efficiency Factor:** | -- | **Hammer Type:** | Automatic ☐ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| Depth (ft.) | Sample No. | Pen./Rec. (in.) | Sample Depth (ft.) | Blows (/6 in.) Shear Strength (psf) or RQD (%) | N-uncorrected | $N_{60}$ | Casing Blows | Elevation (ft.) | Graphic Log | Visual Description and Remarks | Laboratory Testing Results/ AASHTO and Unified Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SSA | | | 0'-1.2': Asphalt | |
| | | | | | | | | 383.8 | | 1.2 | |
| | G1 | | 2.0 - 4.0 | | | | | | | Grey-brown, moist, fine to coarse SAND, little gravel, little silt, (Fill). | |
| 5 | G2 | | 5.5 - 7.5 | | | | | | | Brown, moist, Silty CLAY, some fine to coarse sand, trace gravel, (Fill). | |
| | | | | | | | | 377.0 | | 8.0 | |
| | G3 | | 9.0 - 11.0 | | | | | | | Brown, moist, Silty CLAY, little fine sand, (Glacial Till).<br>Heavy grinding starting at 10.0' btg, continue to auger to refusal. | LL=28<br>PL=9<br>PI=19<br>WC=22.8 |
| 10 | | | | | | | | | | | |
| | | | | | | | | 372.9 | | 12.1 | |
| | | | | | | | | | | **Bottom of Exploration at 12.1 feet below ground surface.** | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |

**Remarks:**

1. Grab samples taken from the auger flights at depths indicated.
2. Clay observed in auger cuttings at 8.0'.
3. As-drilled boring location was surveyed by MaineDOT (N 772223.2, E 1117325.0).
4. Fine-grained soil descriptions on this log are based on plasticity estimated using visual-manual techniques or laboratory Atterberg limits tests if available, rather than the MaineDOT standard based on percentages passing specific grain sizes.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

APPENDIX C – LABORATORY TEST RESULTS

THIELSCH ENGINEERING

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
*Let's Build a Solid Foundation*

Client Information:
GZA GeoEnvironmental
Portland, ME
PM: Erik Freide
Assigned By: Erik Freide
Collected By: Erik Freide

Project Information:
**Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)**
**Solon, ME**
GZA Project Number: 09.0026012.00
Summary Page: 1 of 1
Report Date: 03.05.19

# LABORATORY TESTING DATA SHEET

| Boring ID | Sample No. | Depth (ft) | Laboratory No. | Identification Tests | | | | | | Corrosivity Tests | | | | | | | | Laboratory Log and Soil Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Water Content % | LL % | PL % | Gravel % | Sand % | Fines % | Org. % | Sulfate (mg/kg) | Chloride (mg/kg) | Sulfide (mg/kg) | Redox Potential (mv) | Electrical Resist. As Received Ohm-cm @ 60°F | Electrial Resist. Saturated Ohm-cm @ 60°F | pH | |
| | | | | D2216 | D4318 | | D6913 | | | D2874 | EPA | | | | G57 | | G51 | |
| BB-SFB-101 | GB-1 | 2 | S-1 | 9.1 | | | 15.5 | 70.3 | 14.2 | | | | | | | | | Brown f-c SAND, little fine Gravel, little Silt |
| BB-SFB-102 | 1D | 1.5-1.8 | S-2 | 6.7 | | | 10.4 | 65.5 | 24.1 | | | | | | | | | Brown f-c SAND, some Silt, little fine Gravel |
| BB-SFB-103 | 1D | 2-4 | S-3 | 14.2 | | | 1.9 | 33.4 | 64.7 | | | | | | | | | Brown Clayey SILT, some f-c SAND, trace fine Gravel |
| BB-SFB-103 | 2D | 5-7 | S-4 | 18.9 | | | 4.6 | 65.8 | 29.6 | | | | | | | | | Brown f-m SAND, some Silt, trace fine Gravel |
| BB-SFB-104 | 1DA | 3-5 | S-5 | 10.1 | | | 57.8 | 39.2 | 3.0 | | | | | | | | | Brown f-c Sandy GRAVEL, trace Silt |
| BB-SFB-105 | 1D | 1-3 | S-6 | 21.6 | | | 15.1 | 24.6 | 60.3 | | | | | | | | | Brown Silty CLAY, some f-c SAND, little fine Gravel |
| BB-SFB-105 | 2DA | 5-6 | S-7 | 16.3 | | | 3.7 | 30.8 | 65.5 | | | | | | | | | Brown Silty CLAY, some f-c Sand, trace fine Gravel |
| BB-SFB-107 | GB-3 | 9 | S-8 | 22.8 | 28 | 19 | 0.0 | 11.0 | 89.0 | | | | | | | | | Brown Silty CLAY, little f-c Sand |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |

Date Received *02.26.19*  Reviewed By: [signature]  Date Reviewed: *03.07.2019*

THIELSCH ENGINEERING

State of Maine - Department of Transportation

**Laboratory Testing Summary Sheet**

## Fall Brook Bridge Route 201 over Fall Brook

## MDOT Project Number:

**GZA Project Number: 09.0026012.00**

## Town(s): Solon, ME

| Boring & Sample Identification Number | Station (Feet) | Sample No. | Depth (Feet) | Lab Number | Organic % | W.C. | L.L. | P.I. | Classification | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Unified | AASHTO | Frost |
| BB-SFB-101 | | GB-1 | 2 | S-1 | | 9.1 | | | SM | A-1-b | II |
| BB-SFB-102 | | 1D | 1.5-1.8 | S-2 | | 6.7 | | | SM | A-1-b | II |
| BB-SFB-103 | | 1D | 2-4 | S-3 | | 14.2 | | | ML | A-4(0) | IV |
| BB-SFB-103 | | 2D | 5-7 | S-4 | | 18.9 | | | SM | A-2-4(0) | II |
| BB-SFB-104 | | 1D | 3-5 | S-5 | | 10.1 | | | GW | A-1-a | 0 |
| BB-SFB-105 | | 1D | 1-3 | S-6 | | 21.6 | | | CL | A-6 | III |
| BB-SFB-105 | | 2DB | 5-6 | S-7 | | 16.3 | | | ML | A-4(0) | IV |
| BB-SFB-107 | | GB-3 | 9 | S-8 | | 22.8 | 28 | 9 | CL | A-4(7) | IV |

**Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MDOT and Corps of Engineers Classification Systems.**

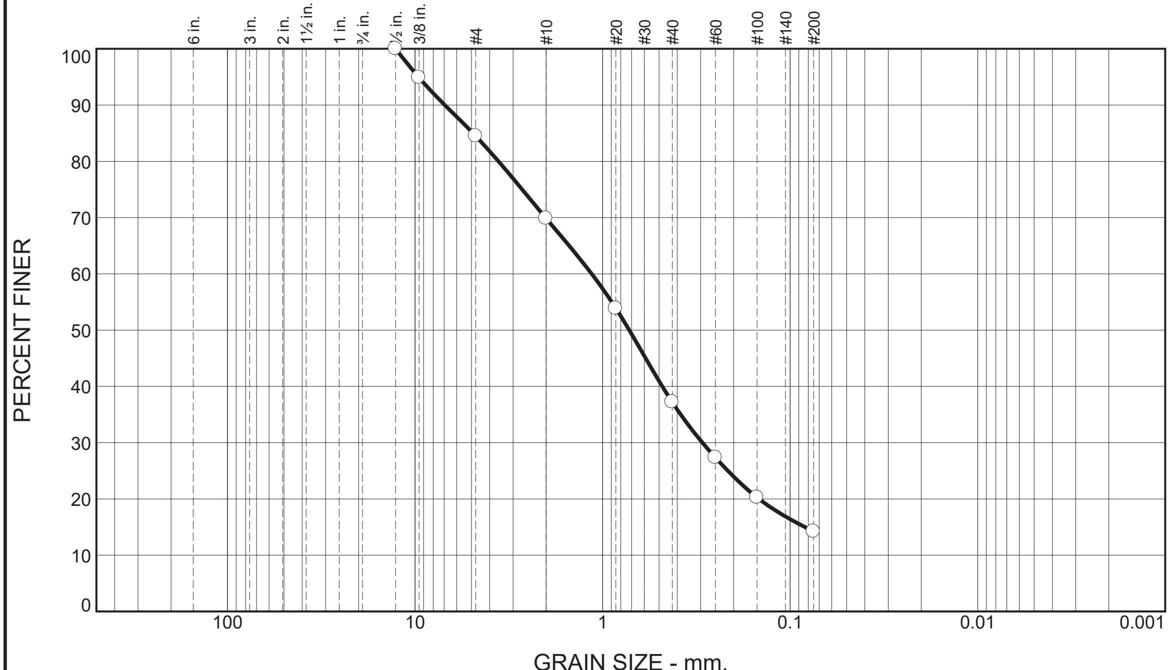
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98

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

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 15.5 | 14.6 | 32.7 | 23.0 | 14.2 | |

| Test Results (D6913 & ASTM D 1140) | | | |
|---|---|---|---|
| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
| 0.5" | 100.0 | | |
| 0.375" | 94.9 | | |
| #4 | 84.5 | | |
| #10 | 69.9 | | |
| #20 | 53.9 | | |
| #40 | 37.2 | | |
| #60 | 27.3 | | |
| #100 | 20.3 | | |
| #200 | 14.2 | | |

* (no specification provided)

**Material Description**

Brown f-c SAND, little fine Gravel, little Silt

**Atterberg Limits (ASTM D 4318)**

**PL=** NP **LL=** NV **PI=** NP

**Classification**

**USCS (D 2487)=** SM **AASHTO (M 145)=** A-1-b

**Coefficients**

$D_{90}$= 6.9340 $D_{85}$= 4.9068 $D_{60}$= 1.1433
$D_{50}$= 0.7209 $D_{30}$= 0.2935 $D_{15}$= 0.0834
$D_{10}$= $C_u$= $C_c$=

**Remarks**

**Date Received:** 02.26.19 **Date Tested:** 03.01.19

**Tested By:** ZS

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

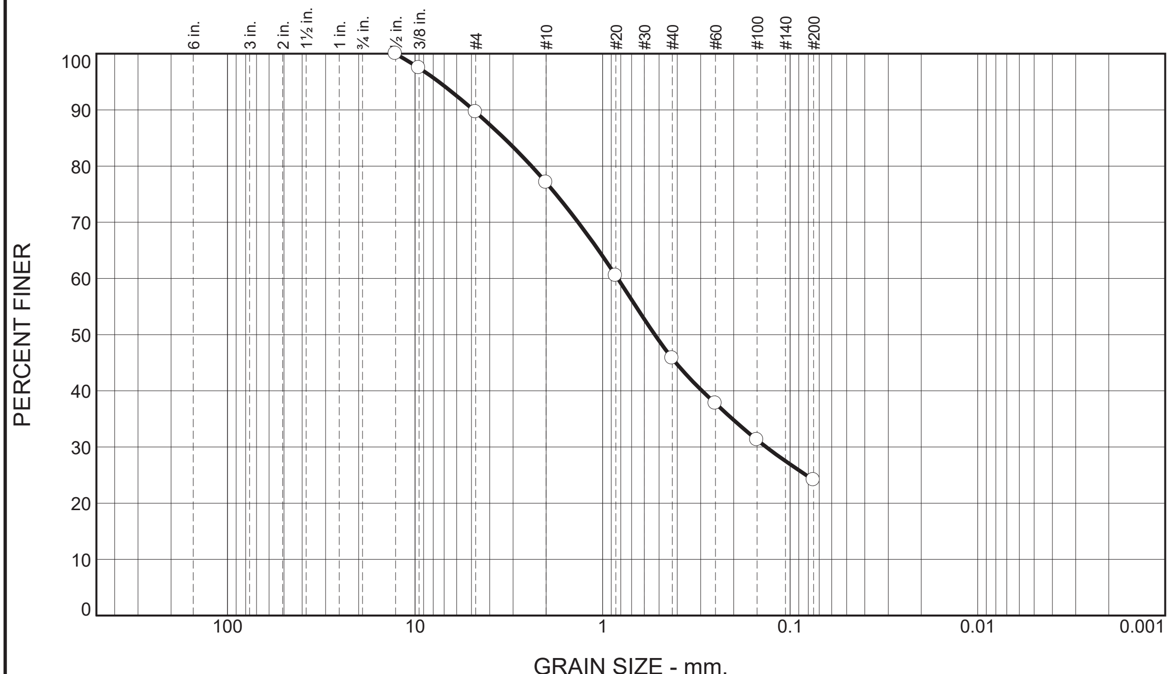
**Source of Sample:** Borings **Depth:** 2' **Date Sampled:**
**Sample Number:** BB-SFB-101 / GB-1

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00) Solon, ME
**Project No:** 09.0026012.00 **Figure** S-1

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 10.4 | 12.5 | 31.3 | 21.7 | 24.1 | |

**Test Results (D6913 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| 0.5" | 100.0 | | |
| 0.375" | 97.5 | | |
| #4 | 89.6 | | |
| #10 | 77.1 | | |
| #20 | 60.5 | | |
| #40 | 45.8 | | |
| #60 | 37.8 | | |
| #100 | 31.3 | | |
| #200 | 24.1 | | |

* (no specification provided)

**Material Description**

Brown f-c SAND, some Silt, little fine Gravel

**Atterberg Limits (ASTM D 4318)**

**PL=** NP **LL=** NV **PI=** NP

**Classification**

**USCS (D 2487)=** SM **AASHTO (M 145)=** A-1-b

**Coefficients**

$D_{90}$= 4.8950 $D_{85}$= 3.3575 $D_{60}$= 0.8312
$D_{50}$= 0.5271 $D_{30}$= 0.1342 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Remarks**

**Date Received:** 02.26.19 **Date Tested:** 03.01.19

**Tested By:** ZS

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

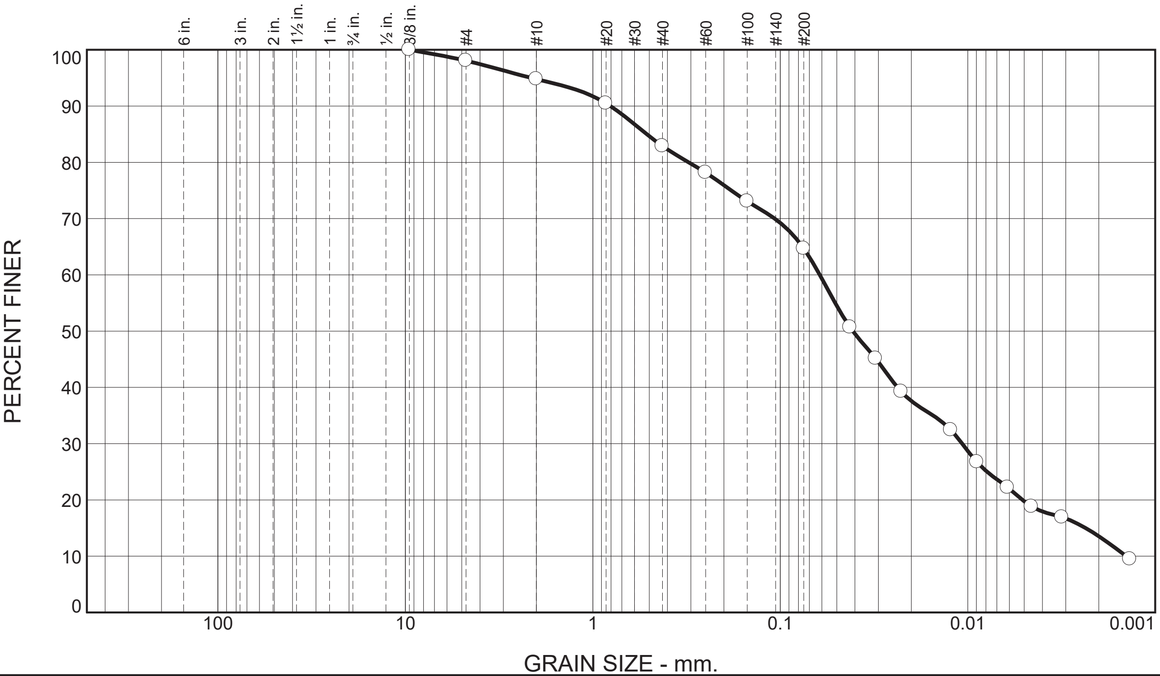
**Source of Sample:** Borings **Depth:** 1.5-1.8' **Date Sampled:**
**Sample Number:** BB-SFB-102 / 1D

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-2

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 1.9 | 3.3 | 11.9 | 18.2 | 51.2 | 13.5 |

**Test Results (D7928 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| 0.375" | 100.0 | | |
| #4 | 98.1 | | |
| #10 | 94.8 | | |
| #20 | 90.5 | | |
| #40 | 82.9 | | |
| #60 | 78.2 | | |
| #100 | 73.1 | | |
| #200 | 64.7 | | |
| 0.0425 mm. | 50.7 | | |
| 0.0310 mm. | 45.2 | | |
| 0.0226 mm. | 39.2 | | |
| 0.0123 mm. | 32.4 | | |
| 0.0089 mm. | 26.7 | | |
| 0.0061 mm. | 22.2 | | |
| 0.0046 mm. | 18.8 | | |
| 0.0031 mm. | 16.9 | | |
| 0.0014 mm. | 9.5 | | |

* (no specification provided)

**Material Description**

Brown Clayey SILT, some f-c SAND, trace fine Gravel

**Atterberg Limits (ASTM D 4318)**

**PL=** **LL=** **PI=**

**Classification**

**USCS (D 2487)=** ML **AASHTO (M 145)=** A-4(0)

**Coefficients**

$D_{90}$= 0.8067 $D_{85}$= 0.5151 $D_{60}$= 0.0616
$D_{50}$= 0.0410 $D_{30}$= 0.0107 $D_{15}$= 0.0023
$D_{10}$= 0.0014 $C_u$= 43.13 $C_c$= 1.30

**Remarks**

Sample visually classified as plastic. Sample rolled to 1/4".

**Date Received:** 02.25.19 **Date Tested:** 03.04.19

**Tested By:** MN / RR

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

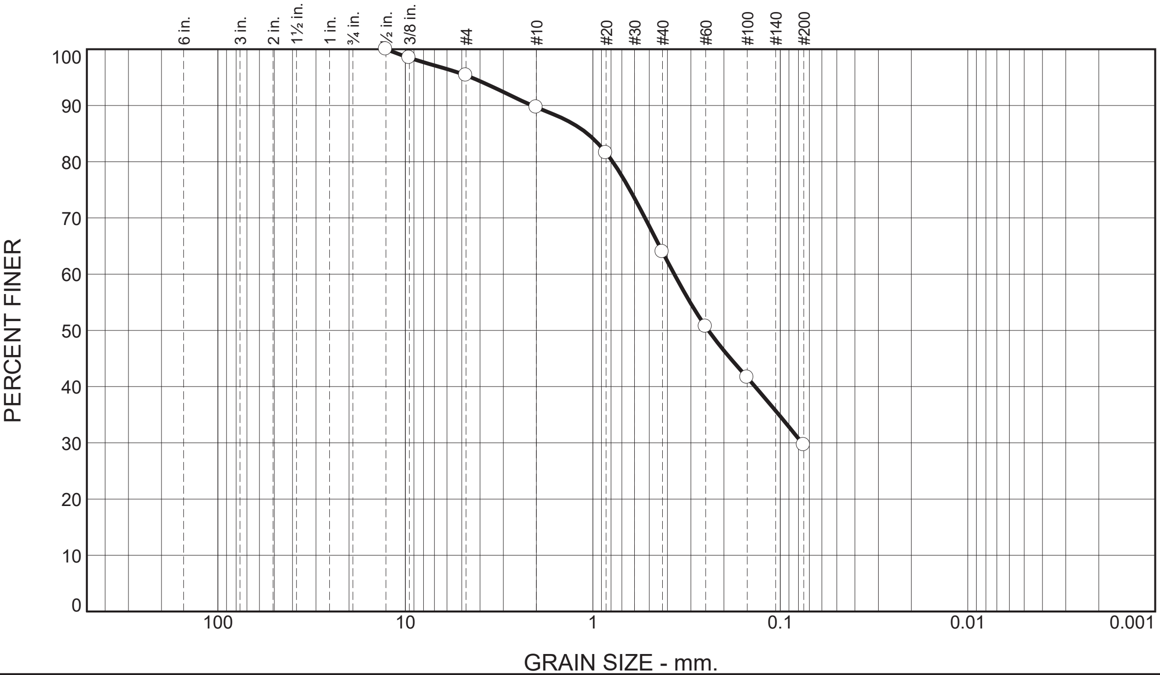
**Source of Sample:** Borings **Depth:** 2-4' **Date Sampled:**
**Sample Number:** BB-SFB-103 / 1D

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-3

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 4.6 | 5.7 | 25.7 | 34.4 | 29.6 | |

| Test Results (D6913 & ASTM D 1140) | | | |
|---|---|---|---|
| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
| 0.5" | 100.0 | | |
| 0.375" | 98.5 | | |
| #4 | 95.4 | | |
| #10 | 89.7 | | |
| #20 | 81.6 | | |
| #40 | 64.0 | | |
| #60 | 50.7 | | |
| #100 | 41.6 | | |
| #200 | 29.6 | | |

* (no specification provided)

**Material Description**

Brown f-m SAND, some Silt, trace fine Gravel

**Atterberg Limits (ASTM D 4318)**

**PL=** NP **LL=** NV **PI=** NP

**Classification**

**USCS (D 2487)=** SM **AASHTO (M 145)=** A-2-4(0)

**Coefficients**

$D_{90}$= 2.1067 $D_{85}$= 1.0699 $D_{60}$= 0.3678
$D_{50}$= 0.2421 $D_{30}$= 0.0766 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Remarks**

**Date Received:** 02.26.19 **Date Tested:** 03.01.19

**Tested By:** RR / ZS

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

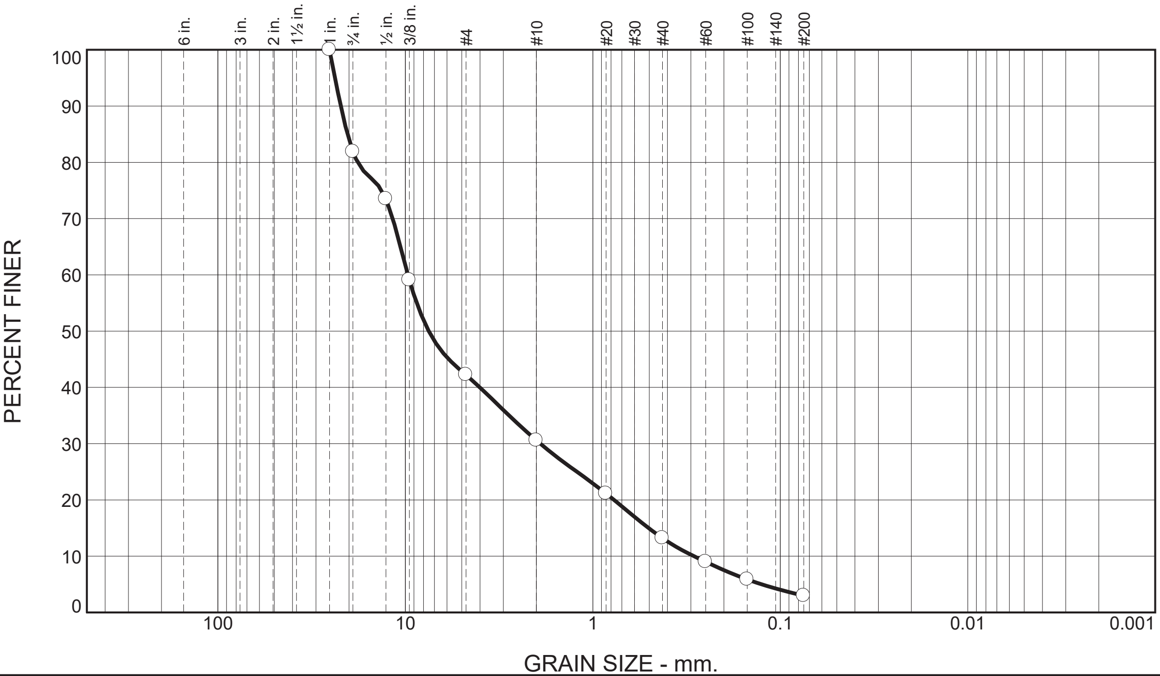
**Source of Sample:** Borings **Depth:** 5-7' **Date Sampled:**
**Sample Number:** BB-SFB-103 / 2D

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-4

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 18.1 | 39.7 | 11.6 | 17.4 | 10.2 | 3.0 | |

**Test Results (D6913 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| 1" | 100.0 | | |
| 0.75" | 81.9 | | |
| 0.5" | 73.5 | | |
| 0.375" | 59.1 | | |
| #4 | 42.2 | | |
| #10 | 30.6 | | |
| #20 | 21.1 | | |
| #40 | 13.2 | | |
| #60 | 9.0 | | |
| #100 | 5.9 | | |
| #200 | 3.0 | | |

* (no specification provided)

**Material Description**

Brown f-c Sandy GRAVEL, trace Silt

**Atterberg Limits (ASTM D 4318)**

**PL=** NP **LL=** NV **PI=** NP

**Classification**

**USCS (D 2487)=** GW **AASHTO (M 145)=** A-1-a

**Coefficients**

$D_{90}$= 22.1117 $D_{85}$= 20.3625 $D_{60}$= 9.6990
$D_{50}$= 7.4977 $D_{30}$= 1.9094 $D_{15}$= 0.5042
$D_{10}$= 0.2885 $C_u$= 33.62 $C_c$= 1.30

**Remarks**

**Date Received:** 02.26.19 **Date Tested:** 03.01.19

**Tested By:** RR / ZS

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

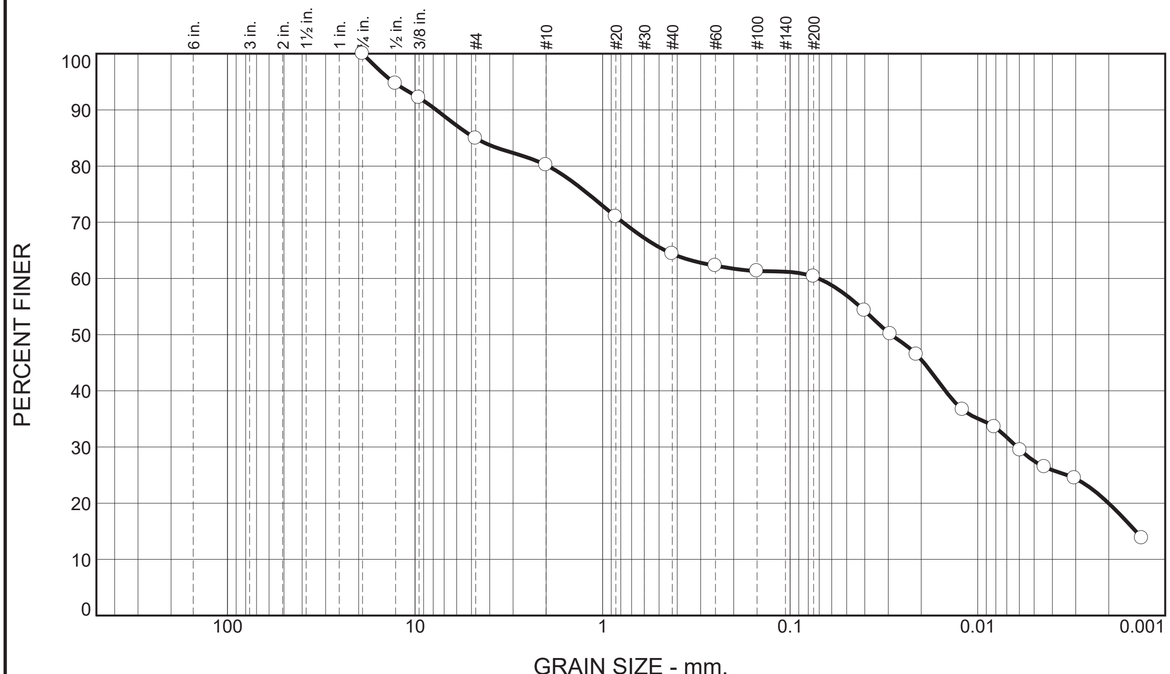
**Source of Sample:** Borings **Depth:** 3-5' **Date Sampled:**
**Sample Number:** BB-SFB-104 / 1DA

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-5

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 15.1 | 4.7 | 15.8 | 4.1 | 40.3 | 20.0 |

| Test Results (D7928 & ASTM D 1140) | | | |
|---|---|---|---|
| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
| 0.75" | 100.0 | | |
| 0.5" | 94.7 | | |
| 0.375" | 92.2 | | |
| #4 | 84.9 | | |
| #10 | 80.2 | | |
| #20 | 71.0 | | |
| #40 | 64.4 | | |
| #60 | 62.3 | | |
| #100 | 61.3 | | |
| #200 | 60.3 | | |
| 0.0401 mm. | 54.3 | | |
| 0.0292 mm. | 50.1 | | |
| 0.0212 mm. | 46.5 | | |
| 0.0120 mm. | 36.6 | | |
| 0.0081 mm. | 33.6 | | |
| 0.0059 mm. | 29.5 | | |
| 0.0044 mm. | 26.5 | | |
| 0.0030 mm. | 24.4 | | |
| 0.0013 mm. | 13.8 | | |

* (no specification provided)

**Material Description**

Brown CLAY & SILT, some f-c SAND, little fine Gravel

**Atterberg Limits (ASTM D 4318)**

PL= LL= PI=

**Classification**

USCS (D 2487)= CL AASHTO (M 145)= A-6

**Coefficients**

$D_{90}$= 7.7032 $D_{85}$= 4.7835 $D_{60}$= 0.0705
$D_{50}$= 0.0290 $D_{30}$= 0.0062 $D_{15}$= 0.0014
$D_{10}$= $C_u$= $C_c$=

**Remarks**

Sample visually classified as plastic. Sample rolled to 1/16".

**Date Received:** 02.25.19 **Date Tested:** 03.04.19

**Tested By:** MN / RR

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

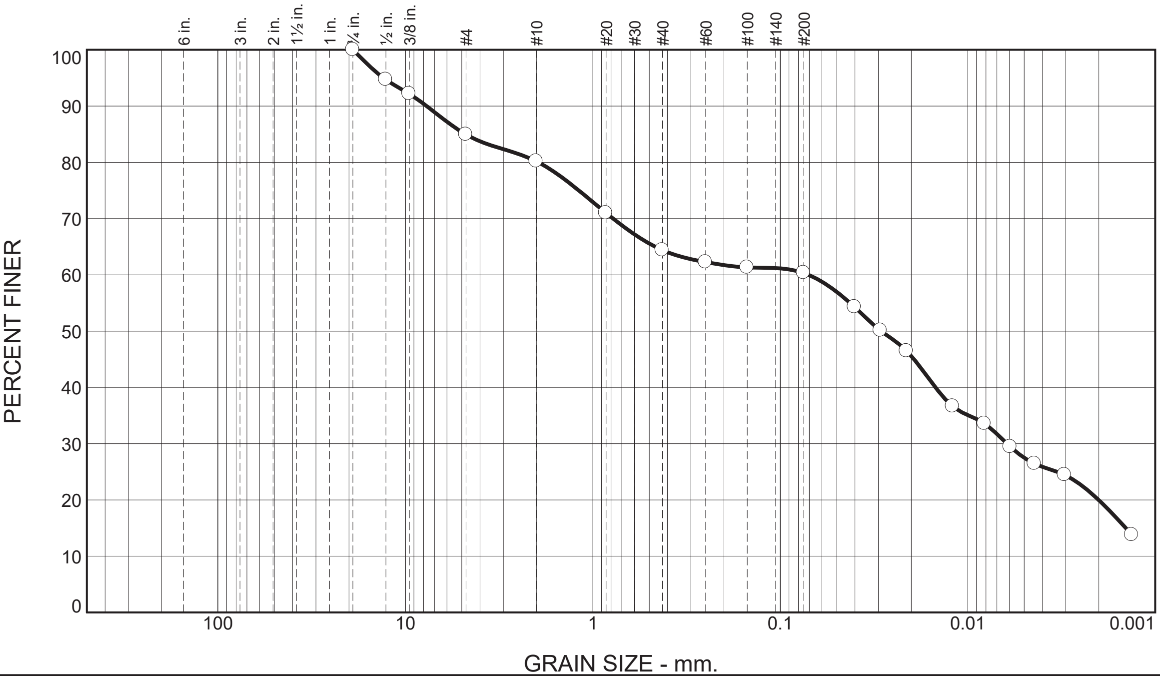
**Source of Sample:** Borings **Depth:** 1-3' **Date Sampled:**
**Sample Number:** BB-SFB-105 / 1D

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-6

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 15.1 | 4.7 | 15.8 | 4.1 | 40.3 | 20.0 |

**Test Results (D7928 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| 0.75" | 100.0 | | |
| 0.5" | 94.7 | | |
| 0.375" | 92.2 | | |
| #4 | 84.9 | | |
| #10 | 80.2 | | |
| #20 | 71.0 | | |
| #40 | 64.4 | | |
| #60 | 62.3 | | |
| #100 | 61.3 | | |
| #200 | 60.3 | | |
| 0.0401 mm. | 54.3 | | |
| 0.0292 mm. | 50.1 | | |
| 0.0212 mm. | 46.5 | | |
| 0.0120 mm. | 36.6 | | |
| 0.0081 mm. | 33.6 | | |
| 0.0059 mm. | 29.5 | | |
| 0.0044 mm. | 26.5 | | |
| 0.0030 mm. | 24.4 | | |
| 0.0013 mm. | 13.8 | | |

* (no specification provided)

**Material Description**

Brown CLAY & SILT, some f-c SAND, little fine Gravel

**Atterberg Limits (ASTM D 4318)**

PL= LL= PI=

**Classification**

USCS (D 2487)= CL AASHTO (M 145)= A-6

**Coefficients**

$D_{90}$= 7.7032 $D_{85}$= 4.7835 $D_{60}$= 0.0705
$D_{50}$= 0.0290 $D_{30}$= 0.0062 $D_{15}$= 0.0014
$D_{10}$= $C_u$= $C_c$=

**Remarks**

Sample visually classified as plastic. Sample rolled to 1/16".

**Date Received:** 02.25.19 **Date Tested:** 03.04.19

**Tested By:** MN / RR

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

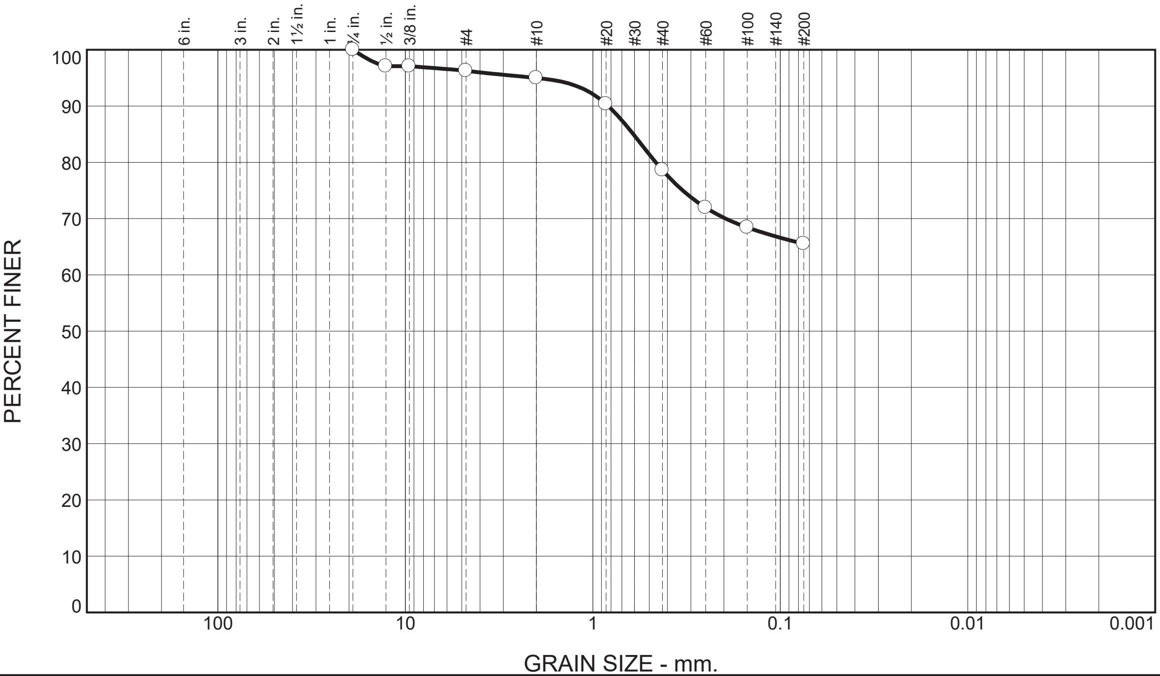
**Source of Sample:** Borings **Depth:** 1-3' **Date Sampled:**
**Sample Number:** BB-SFB-105 / 1D

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-6

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 3.7 | 1.3 | 16.4 | 13.1 | 65.5 | |

**Test Results (D6913 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| 0.75" | 100.0 | | |
| 0.5" | 97.1 | | |
| 0.375" | 97.1 | | |
| #4 | 96.3 | | |
| #10 | 95.0 | | |
| #20 | 90.4 | | |
| #40 | 78.6 | | |
| #60 | 71.9 | | |
| #100 | 68.4 | | |
| #200 | 65.5 | | |

* (no specification provided)

**Material Description**

Brown SILT, some f-m Sand, trace fine Gravel

**Atterberg Limits (ASTM D 4318)**

**PL=** NP **LL=** NV **PI=** NP

**Classification**

**USCS (D 2487)=** ML **AASHTO (M 145)=** A-4(0)

**Coefficients**

$D_{90}$= 0.8272 $D_{85}$= 0.6083 $D_{60}$=
$D_{50}$= $D_{30}$= $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Remarks**

Sample visually classified as non-plastic.

**Date Received:** 02.26.19 **Date Tested:** 03.01.19

**Tested By:** RR / ZS

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

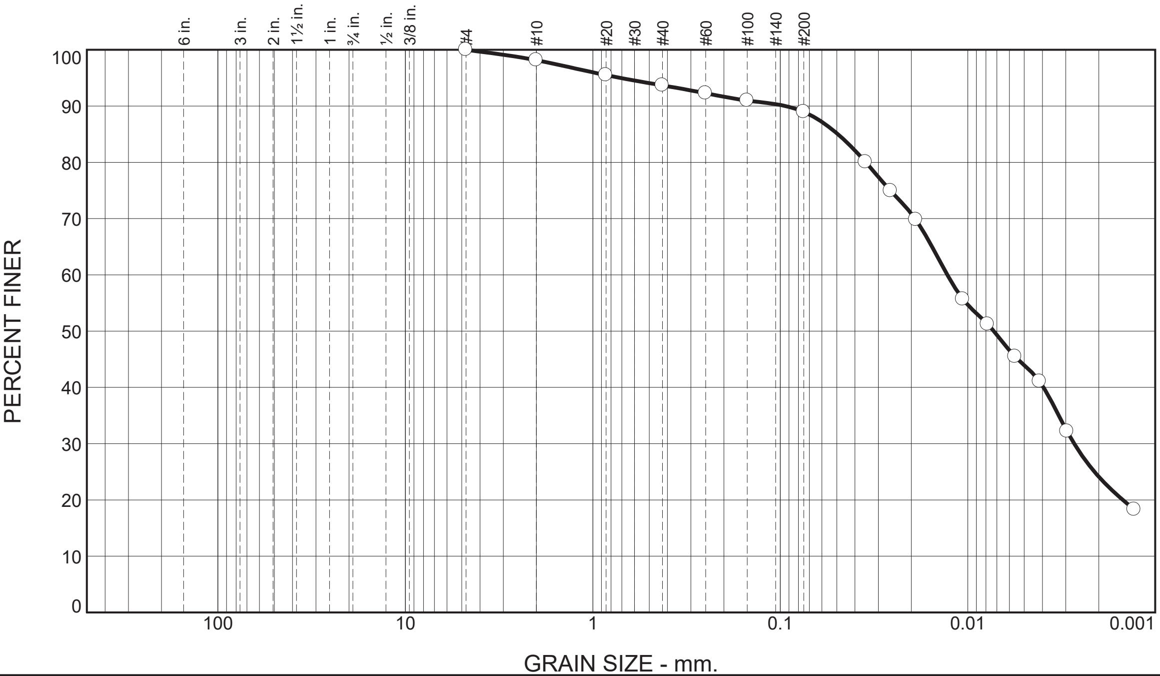
**Source of Sample:** Borings **Depth:** 5-6' **Date Sampled:**
**Sample Number:** BB-SFB-105 / 2DA

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00) Solon, ME
**Project No:** 09.0026012.00 **Figure** S-7

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.0 | 1.8 | 4.5 | 4.7 | 64.9 | 24.1 |

**Test Results (D7928 & ASTM D 1140)**

| Opening Size | Percent Finer | Spec.* (Percent) | Pass? (X=Fail) |
|---|---|---|---|
| #4 | 100.0 | | |
| #10 | 98.2 | | |
| #20 | 95.5 | | |
| #40 | 93.7 | | |
| #60 | 92.3 | | |
| #100 | 91.0 | | |
| #200 | 89.0 | | |
| 0.0351 mm. | 80.1 | | |
| 0.0258 mm. | 74.9 | | |
| 0.0189 mm. | 69.8 | | |
| 0.0106 mm. | 55.7 | | |
| 0.0078 mm. | 51.2 | | |
| 0.0056 mm. | 45.5 | | |
| 0.0041 mm. | 41.1 | | |
| 0.0030 mm. | 32.2 | | |
| 0.0013 mm. | 18.3 | | |

* (no specification provided)

**Material Description**

Brown SILT & CLAY, little f-c Sand

**Atterberg Limits (ASTM D 4318)**

**PL=** 19 **LL=** 28 **PI=** 9

**Classification**

**USCS (D 2487)=** CL **AASHTO (M 145)=** A-4(7)

**Coefficients**

$D_{90}$= 0.0936 $D_{85}$= 0.0493 $D_{60}$= 0.0129
$D_{50}$= 0.0073 $D_{30}$= 0.0027 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Remarks**

**Date Received:** 02.25.19 **Date Tested:** 03.04.19

**Tested By:** RR / MN

**Checked By:** Steven Accetta

**Title:** Laboratory Coordinator

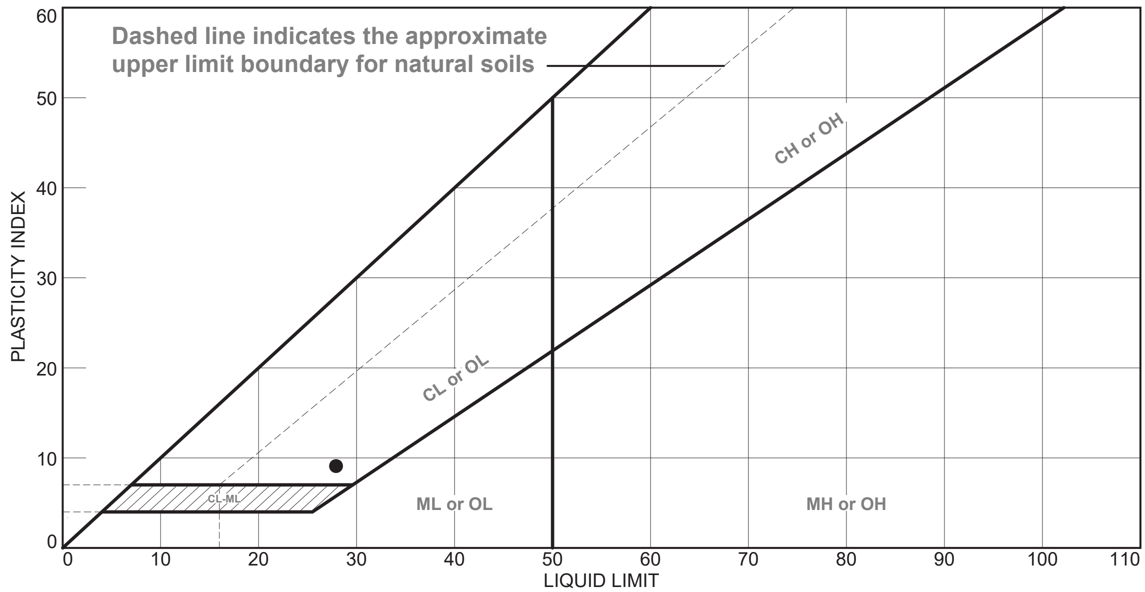
**Source of Sample:** Borings **Depth:** 9' **Date Sampled:**
**Sample Number:** BB-SFB-107 / GB-3

**Thielsch Engineering Inc.**

**Cranston, RI**

**Client:** GZA GeoEnvironmental
**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
Solon, ME
**Project No:** 09.0026012.00 **Figure** S-8

# LIQUID AND PLASTIC LIMITS TEST REPORT





| | MATERIAL DESCRIPTION | LL | PL | PI | %<#40 | %<#200 | USCS |
|---|---|---|---|---|---|---|---|
| ● | Brown SILT & CLAY, little f-c Sand | 28 | 19 | 9 | 93.7 | 89.0 | CL |

**Project No.** 09.0026012.00 **Client:** GZA GeoEnvironmental

**Project:** Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)

Solon, ME

**Source of Sample:** Borings **Depth:** 9'

**Sample Number:** BB-SFB-107 / GB-3

**Thielsch Engineering Inc.**

**Cranston, RI**

**Remarks:**

**Figure** S-8

**Tested By:** MN **Checked By:** sa

THIELSCH ENGINEERING

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
*Let's Build a Solid Foundation*

Client Information:
GZA GeoEnvironmental, Inc
Portland, ME
PM: E. Friede
Assigned By: EDF
Collected By: EDF

Project Information:
**Fall Brook Bridge Route 201 over Fall Brook**
**Solon, ME**
GZA Project Number: 09.0026012.00
Summary Page: 1 of 1
Report Date: 03.07.19

# LABORATORY TESTING DATA SHEET

| Boring No. | Sample No. | Depth (ft) | Laboratory No. | Specimen Data: Mohs Hard-ness | Diameter (in) | Length (in) | (1) Unit Weight (PCF) | (2) Wet Density (PCF) | Bulk $G_s$ | Compressive Strength Tests: (3) Other Tests | (4) Strength PSI | (5) Strain % | (6) E sec PSI EE+06 | (7) Poisson's Ratio | στ PSI | $Is_{50}$ PSI | (8) $s_c$ PSI | Rock Formation or Description or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BB-SFB-103 | R1 | 9-9.5 | R-9 | | 1.988 | 4.685 | 169.2 | | | | 37699 | 0.541 | 5.49 | 0.05 | | | | PHYLLITE; fresh break |
| BB-SFB-104 | R2 | 18.7-19.4 | R-10D | | 1.989 | 1.406 | 181.1 | | | PLD | | | | | | 1292 | 31008 | PHYLLITE |
| BB-SFB-104 | R2 | 18.7-19.4 | R-10A | | 1.988 | 1.055 | 168.4 | | | PLA | | | | | | 1386 | 33264 | PHYLLITE |
| BB-SFB-105 | R1 | 9.4-9.9 | R-11 | | 1.985 | 4.664 | 171.4 | | | | 2520 | 0.163 | 1.36 | 0.09 | | | | PHYLLITE; broke along foliation |

Notes

(1) Volume Determined By Measuring Dimensions

(2) Determined by Measuring Dimensions and Weight of Saturated Sample

(3) PLD=Point Load (diametrical), PLA= Point Load (Axial) ST= Splitting Tensile U= Unconfined Compressive Strength

(4) Taken at Peak Deviator Stress

(5) Strain at Peak Deviator Stress

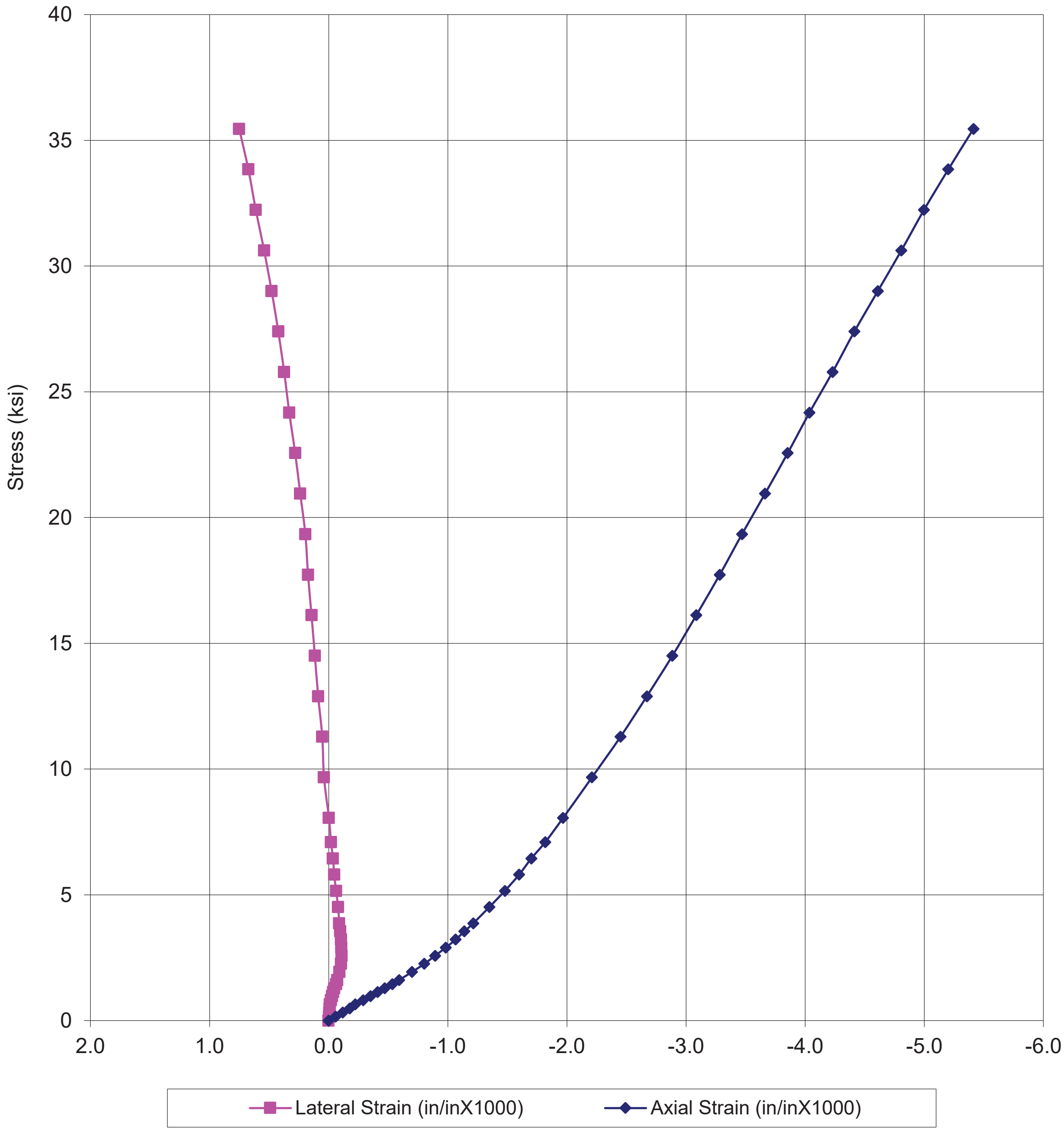
(6) Represents Secant Modulus at 50% of Total Failure Stress

(7) Represents Secant Poisson's Ratio at 50% of Total Failure Stress

(8) Estimated UCS from Table 1 of ASTM D5731 for NX cores (Is x 24)

Date Received: *02.26.19*    Reviewed By:    Date Reviewed: *03.07.2019*

## Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
## Solon, ME

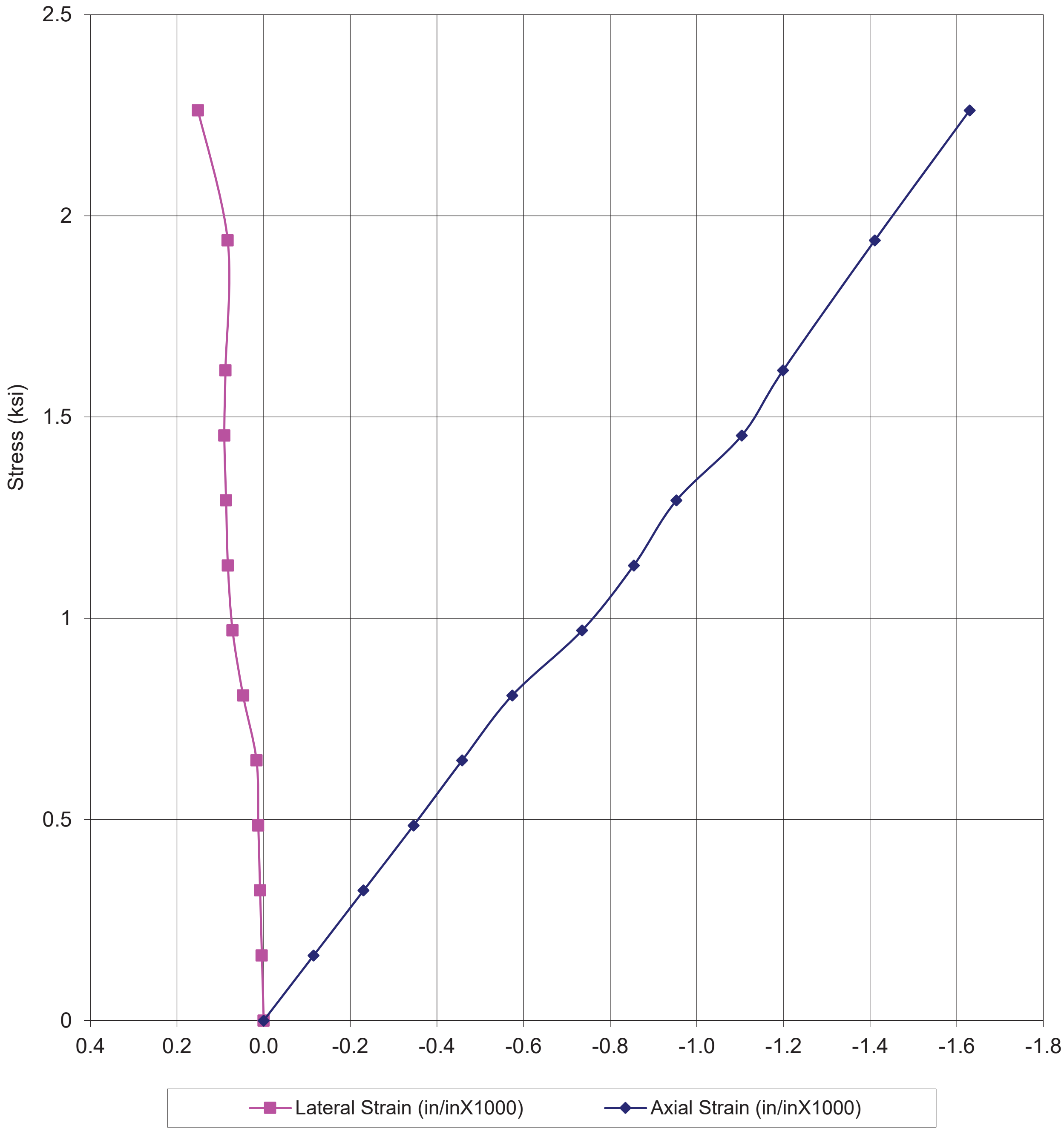



## Rock Unconfined Compression Testing - ASTM D7012

| | | | |
|---|---|---|---|
| Boring No. | BB-SFB-103 | File No. | 09.0026012.00 |
| Sample No. | R1 | Date: | 3.7.19 |
| Depth: | 9-9.5 | Test No. | U-9 |

THIELSCH ENGINEERING

## Fall Brook Bridge Route 201 over Fall Brook (WIN 22260.00)
## Solon, ME




## Rock Unconfined Compression Testing - ASTM D7012

| | | | |
|---|---|---|---|
| Boring No. | BB-SFB-105 | File No. | 09.0026012.00 |
| Sample No. | R1 | Date: | 3.7.19 |
| Depth: | 9.4-9.9 | Test No. | U-11 |

THIELSCH ENGINEERING


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
BB-SFB-103
R1 (9-9.5')
Boring No.
Sample No.
Depth
BB-SFB-103
R1
9-9.5'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
R1 (9-9.5')
Lufkin
MADE IN U.S.A.
Boring No.
Sample No.
Depth
BB-SFB-103
R1
9-9.5'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-103
R1
9-9.5'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
BB-SFB-104
Sample No.
R2
Depth
18.7-19.4'

Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-104
R2
18.7-19.4'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-104
R2
18.7-19.4'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-105
R1
9.4-9.9'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-105
R1
9.4-9.9'


Fall Brook Bridge Route 201 over Fall Brook
Solon, ME
09.0026012.00
Boring No.
Sample No.
Depth
BB-SFB-105
R1
9.4-9.9'

APPENDIX D – BEDROCK CORE PHOTOGRAPHS

**MaineDOT Fall Brook Bridge**
**Main Street Bridge #2504, Fall Brook**
**Solon, ME**
Rock Core Photographs

| Boring No. | Run | Depth (ft) | | | Recovery (in) | Recovery (%) | RQD (in) | RQD (%) | Rock Type | Box Row |
|---|---|---|---|---|---|---|---|---|---|---|
| BB-SFB-104 | R1 | 14 | - | 16 | 11 | 46% | 0 | 0% | BOULDER | 1 |
| BB-SFB-104 | R2 | 18.5 | - | 22.5 | 41 | 85% | 12 | 25% | PHYLLITE | 1 |
| BB-SFB-104 | R3 | 22.5 | - | 23.3 | 9 | 100% | 0 | 0% | PHYLLITE | 1 |
| BB-SFB-105 | R1 | 9 | - | 14 | 60 | 100% | 51 | 85% | PHYLLITE | 2 |
| BB-SFB-103 | R1 | 9 | - | 13.6 | 42 | 76% | 20 | 37% | PHYLLITE | 3 |
| BB-SFB-103 | R2 | 13.6 | - | 15.8 | 23 | 88% | 14 | 53% | PHYLLITE | 3,4 |
| BB-SFB-103 | R3 | 15.8 | - | 19.8 | 48 | 100% | 41 | 85% | PHYLLITE | 4 |

Notes:
1. Box row corresponds to the core box section in which the rock core sample is contained; Row 1=Top, Row 4=Bottom.
2. Top photo is dry, bottom photo is wet.
3. Red markers indicate breaks between core runs for Boring BB-SFB-104. Other breaks indicated by wooden blocks.

APPENDIX E – ENGINEERING CALCULATIONS

# Objective

Assess nominal and factored bearing resistance of a foundation on rock based on support in PHYLLITE from borings BB-SFB-103, -104 and -105.

# Methodology

Use data from test borings and evaluate the nominal bearing resistance as follows:

1. Bedrock Properties From Test Borings
2. Calculation of Rock Mass Rating
3. Determine Rock Property Constants s and m
4. Calculate Nominal Bearing Resistance of Bedrock $q_n$

# References

1. American Association of State Highway and Transportation Officials, AASHTO LRFD Bridge Design Specifications: Customary U.S. Units, 6th edition, 2012. (AASHTO LRFD).

   *Note: AASHTO 9th Edition is now in effect, but the coefficients used in the bedrock bearing evaluations are understood to be correlated relative to the older Hoek and Brown 1988 methodology. Therefore, RMR is used for the evaluation per LRFD 6th Edition rather than GSI per LRFD 9th Edition.*

2. Wyllie, Duncan C., "Foundations on Rock", Second edition, 1992.

## 1. Rock Properties

Bedrock properties were obtained from rock core specimens and logs completed for the Fall Brook Bridge Project in Solon, ME. This calculation is based on the data from borings BB-SFB-103, -104, and -105.

Bedrock Quality

Representative RQD's are shown in the table below.

| Boring | Run | GS Elevation | Depth to Rock (ft) | Depth (ft) Below Top of Rock | | | Length of Core Run (ft) | Rec (in) | Rec (%) | RQD (in) | RQD % | Joint Spacing Desc. | Corr. Spacing (in) | Aperture Desc. | Corr. Aperture (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Top | | Bottom | | | | | | | | | |
| BB-SFB-103 | R1 | 377.4 | 9.0 | 0.0 | - | 4.6 | 4.6 | 42 | 76% | 20 | 37% | Very Close to Close | 0.75-8 | Tight to Wide | 0.004-0.4 |
| BB-SFB-103 | R2 | 377.4 | 9.0 | 4.6 | - | 6.8 | 2.2 | 23 | 87% | 14 | 53% | Extremely Close | <.75 | Tight | 0.004-0.01 |
| BB-SFB-103 | R3 | 377.4 | 9.0 | 6.8 | - | 10.8 | 4.0 | 48 | 100% | 41 | 84% | Extremely Close to Moderate | <0.75-24 | Tight | 0.004-0.01 |
| BB-SFB-104 | R2 | 378.8 | 18.5 | 0.0 | - | 4.0 | 4.0 | 41 | 85% | 12 | 25% | Extremely Close to Close | <0.75-8 | Tight | 0.004-0.01 |
| BB-SFB-104 | R3 | 378.8 | 18.5 | 4.0 | - | 4.8 | 0.8 | 9 | 100% | 0 | 0% | Extremely Close to Close | <0.75-8 | Tight | 0.004-0.01 |
| BB-SFB-105 | R1 | 370.0 | 8.5 | 0.5 | - | 5.5 | 5.0 | 60 | 100% | 51 | 85% | Very Close to Moderate | 0.75-24 | Tight | 0.004-0.01 |

RQD between 0% and 85% for core runs at each location. Representative RQD of 25-50% range selected.

Bedrock Strength

| Boring | Run | LAB | | | | | | | | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Depth of Sample (ft) | Depth of Sample into Rock (ft) | Elev Top of Sample (ft) | UCS (psi) | Point Load Index, Is50 (psi) | Modulus (ksi) | Unit Wt (pcf) | Rock Type | |
| BB-SFB-103 | R1 | 9.0 | 0 | 368.4 | 37,699 | -- | 5.49 | 169.2 | | PHYLLITE |
| BB-SFB-104 | R2 | 18.7 | 0.2 | 360.1 | 31,008* (D), 33,264* (A) | 1,292 (D), 1,386 (A) | -- | 181.1 (D), 168.4 (A) | | PHYLLITE |
| BB-SFB-105 | R1 | 9.4 | 0.9 | 360.6 | 2,520 | -- | 1.36 | 171.4 | | PHYLLITE |

Note: "UCS" is unconfined compressive strength. UCS values marked with "*" are from diametrical (D) and axial (A) point load tests and are correlated from the point load test results.

Testing values in the table above shown the range in compressive strength results across the site. The low strength break in BB-SFB-105 occured along a foliation plane, which is not considered representative of the intact rock strength. Value of 30,000 psi chosen as representative for borings at each abutment.

## 2. Calculation of Rock Mass Rating (RMR)

From AASHTO LRFD 6th Ed. Table 10.4.6.4-1, determine the RMR.

### Parameter 1- Uniaxial Compressive Strength

$\sigma_{u.r} := 4320\text{ksf} = 30\cdot\text{ksi}$

Unconfined compressive strength of samples from BB-SFB-103, -104. Lowest UCS 5,830 psi.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_1 := 12$ for $\sigma_{u.r}$ between 2,160 and 4,320 ksf, and Point Load Strength Index ($Is_{50}$) between 85 and 175 ksf.

### Parameter 2- Drill Core Quality

Representative RQD from table above: 0 - 85% for abutment borings; choose 25-50%

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_2 := 8$

### Parameter 3- Spacing of Joints

From Boring Logs, generally very close to moderately spaced = 0.3 in to 2 feet, Typical spacing was 4 in. to 8 in. Joints typically tight.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating

$RR_3 := 10$

### Parameter 4- Condition of Joints

From boring logs, hard joint walls and appeared smooth on surface, and described fresh to discolored. Water return was intermittent while coring in borings BB-SFB-103 and -104, indicating open joints are present. Few moderately wide joints and clay infilling in upper core run of boring -103.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_4 := 6$

### Parameter 5- Ground Water Conditions

Hydrostatic Conditions- Tremie seals bearing on rock below the river level. Assume water under moderate pressure.

From AASHTO LRFD Table 10.4.6.4-1

Relative Rating $RR_5 := 4$

### Parameter 6-Adjustment for joint orientation

The joint sets are generally moderately dipping to high angle and generally smooth and tight. Joints will not daylight below foundations because they will be at brook level. Assume fair conditions.

From AASHTO LRFD Table 10.4.6.4-2

Relative Rating $RR_6 := -7$

### Total RMR Rating

$$RMR := RR_1 + RR_2 + RR_3 + RR_4 + RR_5 + RR_6$$

$$RMR = 33$$

From AASHTO LRFD Table 10.4.6.4-3 RMR is indicative of Poor Rock Quality

## 3. Determine Rock Property Constants s and m

Use AASHTO LRFD 6th Ed. Table 10.4.6.4-4 to develop empirircal rock property constants

Phyllite is categorized as rock type B, lithified argrillaceous rock rocks, using s and m values interpolated from the logarithmic trend of plotted values from AASHTO Table 10.4.6.4-4 (plots on sheet 8).

$m := 0.085$

$s := 0.000014$

# 4. Calculate Nominal and Factored Bearing Resistance of Bedrock $q_n$ and $q_R$

From Wyllie "Foundations on Rock"

Eq. 5.4 Pg.138

$$q_n := C_{f1} \cdot \sqrt{s} \cdot \sigma_{u.r} \cdot \left[1 + \sqrt{m \cdot \left(s^{-\frac{1}{2}}\right) + 1}\right]$$

Where

$C_{f1} := 1.0$ — From Wyllie Table 5.4 Pg. 138 Correction factor for foundation shape for rectangular foundation:

For L/B>6, use factor $C_{fl}$=1.0,
For L/B=1, use factor $C_{fl}$=1.12, therefore,
For conservatism, assume long strip, lowest $C_{fl}$.

$s = 0.000014$

$m = 0.085$

$\sigma_{u.r} = 30 \cdot ksi$

## Nominal Bearing Resistance

$$q_n := C_{f1} \cdot \sqrt{s} \cdot \sigma_{u.r} \cdot \left[1 + \sqrt{m \cdot \left(s^{-\frac{1}{2}}\right) + 1}\right]$$

$q_n = 94.9 \cdot ksf$ — Say 95 ksf

## Factored Bearing Resistance (Strength Condition)

Bearing Resistance Factor is specified in Table 10.5.5.2.2-1

$\phi_b := 0.45$ — Footing on rock

$q_R := \phi_b \cdot q_n$

$q_R = 42.7 \cdot ksf$ — Say 43 ksf

Reference:I:\Mathcad\units.xmcd



**Table 10.4.6.4-1 Geomechanics Classification of Rock Masses.**

| | Parameter | | Ranges of Values | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Strength of intact rock material | Point load strength index | >175 ksf | 85–175 ksf | 45–85 ksf | 20–45 ksf | For this low range, uniaxial compressive test is preferred | | |
| | | Uniaxial compressive strength | >4320 ksf | 2160–4320 ksf | 1080–2160 ksf | 520–1080 ksf | 215–520 ksf | 70–215 ksf | 20–70 ksf |
| | Relative Rating | | 15 | 12 | 7 | 4 | 2 | 1 | 0 |
| 2 | Drill core quality RQD | | 90% to 100% | 75% to 90% | 50% to 75% | 25% to 50% | <25% | | |
| | Relative Rating | | 20 | 17 | 13 | 8 | 3 | | |
| 3 | Spacing of joints | | >10 ft. | 3–10 ft. | 1–3 ft. | 2 in.–1 ft. | <2 in. | | |
| | Relative Rating | | 30 | 25 | 20 | 10 | 5 | | |
| 4 | Condition of joints | | • Very rough surfaces<br>• Not continuous<br>• No separation<br>• Hard joint wall rock | • Slightly rough surfaces<br>• Separation <0.05 in.<br>• Hard joint wall rock | • Slightly rough surfaces<br>• Separation <0.05 in.<br>• Soft joint wall rock | • Slicken-sided surfaces<br>or<br>• Gouge <0.2 in. thick<br>or<br>• Joints open 0.05–0.2 in.<br>• Continuous joints | • Soft gouge >0.2 in. thick<br>or<br>• Joints open >0.2 in.<br>• Continuous joints | | |
| | Relative Rating | | 25 | 20 | 12 | 6 | 0 | | |
| 5 | Ground water conditions (use one of the three evaluation criteria as appropriate to the method of exploration) | Inflow per 30 ft. tunnel length | None | <400 gal./hr. | 400–2000 gal./hr. | >2000 gal./hr. | | | |
| | | Ratio = joint water pressure/ major principal stress | 0 | 0.0–0.2 | 0.2–0.5 | >0.5 | | | |
| | | General Conditions | Completely Dry | Moist only (interstitial water) | Water under moderate pressure | Severe water problems | | | |
| | Relative Rating | | 10 | 7 | 4 | 0 | | | |

**Table 10.4.6.4-2 Geomechanics Rating Adjustment for Joint Orientations.**

| Strike and Dip Orientations of Joints | | Very Favorable | Favorable | Fair | Unfavorable | Very Unfavorable |
|---|---|---|---|---|---|---|
| Ratings | Tunnels | 0 | –2 | –5 | –10 | –12 |
| | Foundations | 0 | –2 | –7 | –15 | –25 |
| | Slopes | 0 | –5 | –25 | –50 | –60 |

**Table 10.4.6.4-3 Geomechanics Rock Mass Classes Determined From Total Ratings.**

| RMR Rating | 100–81 | 80–61 | 60–41 | 40–21 | <20 |
|---|---|---|---|---|---|
| Class No. | I | II | III | IV | V |
| Description | Very good rock | Good rock | Fair rock | Poor rock | Very poor rock |

10-24 **AASHTO LRFD Bridge Design Specifications**

**Table 10.4.6.4-4 Approximate relationship between rock-mass quality and material constants used in defining nonlinear strength (*Hoek and Brown, 1988*)**

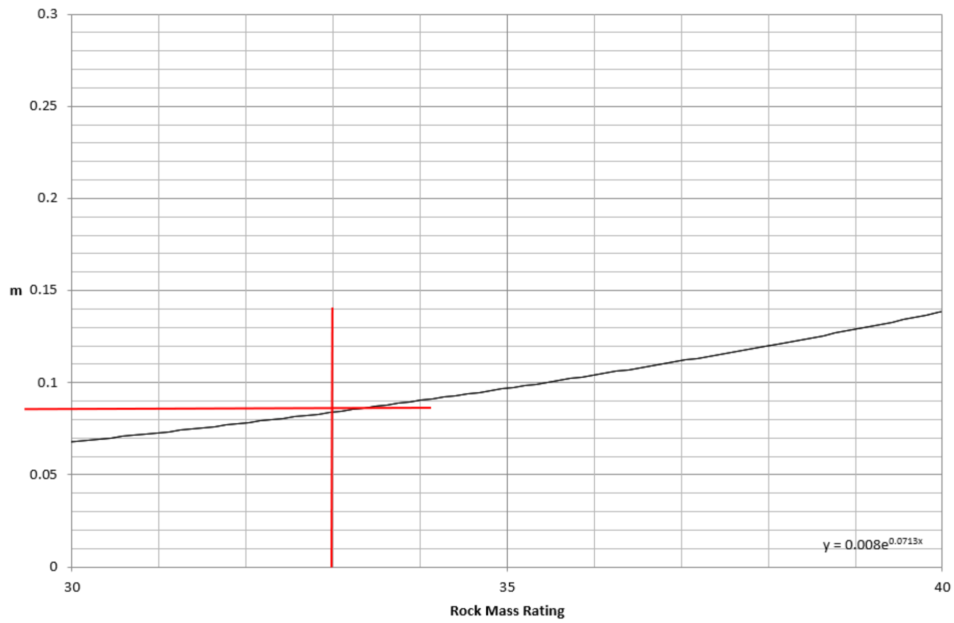
| Rock Quality | Constants | Rock Type: A = Carbonate rocks with well developed crystal cleavage—*dolomite, limestone and marble*; B = Lithified argrillaceous rocks—*mudstone, siltstone, shale and slate (normal to cleavage)*; C = Arenaceous rocks with strong crystals and poorly developed crystal cleavage—*sandstone and quartzite*; D = Fine grained polymineralic igneous crystalline rocks—*andesite, dolerite, diabase and rhyolite*; E = Coarse grained polymineralic igneous & metamorphic crystalline rocks—*amphibolite, gabbro gneiss, granite, norite, quartz-diorite* | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| INTACT ROCK SAMPLES<br>Laboratory size specimens free from discontinuities<br>CSIR rating: *RMR* = 100 | *m*<br>*s* | 7.00<br>1.00 | 10.00<br>1.00 | 15.00<br>1.00 | 17.00<br>1.00 | 25.00<br>1.00 |
| VERY GOOD QUALITY ROCK MASS<br>Tightly interlocking undisturbed rock with unweathered joints at 3–10 ft.<br>CSIR rating: *RMR* = 85 | *m*<br>*s* | 2.40<br>0.082 | 3.43<br>0.082 | 5.14<br>0.082 | 5.82<br>0.082 | 8.567<br>0.082 |
| GOOD QUALITY ROCK MASS<br>Fresh to slightly weathered rock, slightly disturbed with joints at 3–10 ft.<br>CSIR rating: *RMR* = 65 | *m*<br>*s* | 0.575<br>0.00293 | 0.821<br>0.00293 | 1.231<br>0.00293 | 1.395<br>0.00293 | 2.052<br>0.00293 |
| FAIR QUALITY ROCK MASS<br>Several sets of moderately weathered joints spaced at 1–3 ft.<br>CSIR rating: *RMR* = 44 | *m*<br>*s* | 0.128<br>0.00009 | 0.183<br>0.00009 | 0.275<br>0.00009 | 0.311<br>0.00009 | 0.458<br>0.00009 |
| POOR QUALITY ROCK MASS<br>Numerous weathered joints at 2 to 12 in.; some gouge. Clean compacted waste rock.<br>CSIR rating: *RMR* = 23 | *m*<br>*s* | 0.029<br>$3 \times 10^{-6}$ | 0.041<br>$3 \times 10^{-6}$ | 0.061<br>$3 \times 10^{-6}$ | 0.069<br>$3 \times 10^{-6}$ | 0.102<br>$3 \times 10^{-6}$ |
| VERY POOR QUALITY ROCK MASS<br>Numerous heavily weathered joints spaced <2 in. with gouge. Waste rock with fines.<br>CSIR rating: *RMR* = 3 | *m*<br>*s* | 0.007<br>$1 \times 10^{-7}$ | 0.010<br>$1 \times 10^{-7}$ | 0.015<br>$1 \times 10^{-7}$ | 0.017<br>$1 \times 10^{-7}$ | 0.025<br>$1 \times 10^{-7}$ |

**GZA**
**GeoEnvironmental, Inc**
707 Sable Oaks Drive - Suite 150
South Portland, Maine 04106
207-879-9190
Fax 207-879-0099
http://www.gza.com

*Engineers and Scientists*



**m for Rock Type B**




**s for Rock Type B**