O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

J2950-11-02
February 28, 2023

Preliminary Geotechnical Engineering Recommendations
Mountain Avenue Culvert Replacement
South Hadley, Massachusetts, 01075

PREPARED FOR:
Fuss & O'Neill, Inc.
1550 Main Street, Suite 400
Springfield, Massachusetts, 01103

Attention: Ms. Lara Sup, PE

PREPARED BY:
O'Reilly, Talbot & Okun Associates, Inc.
293 Bridge Street, Suite 500
Springfield, MA 01103

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ENGINEERING ASSOCIATES

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Ms. Lara Sup, P.E.
Fuss & O'Neill, Inc.
1550 Main Street, Suite 400
Springfield, Massachusetts, 01103

Re: Preliminary Geotechnical Engineering Recommendations
Mountain Avenue Culvert Replacement Project
South Hadley, Massachusetts

Dear Ms. Sup:

O'Reilly, Talbot & Okun Associates, Inc. (OTO) is pleased to provide these geotechnical findings and recommendations for the culvert replacement project referenced above. The subject culvert carries Buttery Brook beneath Mountain Avenue. The project is located approximately 330 feet west of the intersection with Newton Street (Route 116) in South Hadley, Massachusetts. A Site Locus and Boring Location Plan are attached.

Our geotechnical recommendations are based upon published information and subsurface conditions observed in three soil borings. Our services consisted of a review of published geologic information, the full-time observation of the borings, review of the logs and soil samples, engineering analyses, and preparation of this report. This report is subject to the limitations attached in Appendix A.

The proposed replacement structure will have an open-bottom and will consist of either a three-sided concrete box or a corrugated metal pipe arch type culvert with a span of 15 feet. The significant geotechnical considerations for this project include the presence of compressible and potentially unsuitable soils, namely: debris fill in the upper 15 feet, followed by approximately four feet of organic silt and sand, and soft varved clay. The foundations for the new culvert will likely bear within the soft varved silt and clay layer. Other geotechnical issues include the need for dewatering to establish a dry excavation and allow the culvert footings to be constructed, excavation safety, temporary earth support, and earthwork related issues.

If you have any questions, please do not hesitate to contact the undersigned.

Sincerely yours,
O'Reilly, Talbot & Okun Associates, Inc.

Dustin A. Humphrey, P.E.
Project Engineer

Michael J. Talbot, P.E.
Principal

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

FIGURES

TABLES & SHEETS

APPENDICES

1.0 EXECUTIVE SUMMARY

This report provides our geotechnical findings and recommendations for the design and construction of the proposed replacement culvert to carry Buttery Brook beneath Mountain Avenue in South Hadley, Massachusetts.

We understand that the existing pipe culvert will be completely removed and will be replaced with an open-bottom culvert having a slightly different alignment. The type of structure has not been chosen, but it will likely consist of either a three-sided concrete box culvert or a corrugated metal pipe arch culvert. Based upon the existing data, soft fine-grained soils are located near the likely bearing level for the new culvert at the base of the brook channel. To provide a firm bearing surface for the new culvert, we recommend that footings bear on a minimum two-foot layer of imported Crushed Stone over the varved silt and clay present at footing levels. In addition, the upper 19 feet consist of debris fill and organic silt and sand, both of which are unsuitable for reuse as Engineered Fill. The debris and organic soils should be removed completely from beneath the culvert footings and from beneath wingwalls on each side of the culvert.

A sheet pile cofferdam will likely be necessary for temporary earth support and to prevent groundwater flow into the construction work area. Basal heave of the open excavations is a significant safety concern during construction. The contractor should evaluate the potential for basal heave when designing earth support and dewatering systems and include provisions to prevent this condition from occurring.

1.1 Subsurface Conditions

Borings MA-1 and MA-2 were performed near the alignment of the proposed culvert, within or off the shoulder of the road. Both of these borings encountered refusal upon bedrock at a depth of 39 feet below ground surface. These explorations met requirements for MGL Chapter 85 Section 35 Review Process for a bridge having a span between 10 and 20 feet along an Urban Local Road. Boring QD-2 was performed approximately 80 feet to the west during preliminary investigations. Although it is relatively far from the proposed alignment, boring QD-2 provides useful information on soil conditions in the area. Final boring locations were selected after considering the location of the overhead and buried utilities. We note that it was not possible to perform a boring near the western side of the culvert due to interference with utilities and other structures. Boring locations are shown on the attached Boring Location Plan.

Subsurface conditions at the Site generally consist of a surficial layer of asphalt with granular base, underlain in order of increasing depth by debris fill, organic silt and sand, varved clay, glacial till, and bedrock. The debris fill and organic silt layers extended to an approximate depth of 15 feet (elevation 132) and 19 feet (elevation 128), respectively. A ten-foot-thick layer of soft varved silt and clay was present below the organic silt layer. Glacial till was present at a depth of 30 feet (approximate elevation 118). A summary of conditions encountered in the soil borings is provided in Table 1.

Groundwater was encountered at a depth of approximately 14 feet below ground surface, corresponding to approximate elevation 133 feet, which is near the water elevation in Buttery Brook. We anticipate that groundwater levels will move up and down with changes in the brook level.

The seismic Site Class was determined according to the AASHTO LRFD Bridge Design Specifications, Article 3.10.3.1. Using the SPT N-value, the Site was determined to be Site Class E. Based upon conditions encountered in the soil borings and the observed density of saturated Site soils, it is unlikely that liquefaction would occur under the design earthquake.

1.2 Recommended Foundation System

Based upon our experience, we recommend that the new culvert and associated wingwalls be supported on traditional spread footings bearing on at least two feet of Crushed Stone. The base of the Crushed Stone layer should be below the organic silt and within the soft varved silt and clay layer (below elevation 130 feet). The Crushed Stone layer will provide a firm bearing surface and protect the subgrade from disturbance during construction. A geosynthetic separation fabric should be installed between the bottom of the Crushed Stone layer and the varved silt and clay. Foundation recommendations are presented in Table 2. Soil conditions and design parameters for use in the preliminary design of wingwalls are presented in Table 3.

1.3 Construction Considerations

The proposed culvert foundations will be installed below the base of Buttery Brook and below the maximum scour depth. We recommend that the designer consider requiring a sheet pile wall/cofferdam for temporary earth support and to allow for the construction of footings in the dry. The wall/cofferdam should also be designed to protect the work during periods of high water levels in Buttery Brook. Dewatering may also be required to install other culvert elements, such as wingwalls. We recommend that the sheet piles be embedded into glacial till at a depth of approximately 30 feet for lateral support and to limit the infiltration of water from the brook into the construction excavations.

2.0 INTRODUCTION

2.1 Scope of Report

This report provides geotechnical engineering recommendations for foundation design of the proposed replacement culvert to carry Buttery Brook beneath Mountain Avenue in South Hadley, Massachusetts. The location of the Site is shown on Figure 1. This report also addresses earthwork considerations associated with the proposed construction.

2.2 Subject Background, Proposed Construction, and History

2.2.1 Existing Conditions

The existing corrugated metal pipe culvert carries Buttery Brook, which flows from north to south within the Site area, beneath Mountain Avenue. The existing culvert and brook alignment are shown on the attached Boring Location Plan. The existing pipe culvert has a diameter of 24 inches and length of approximately 104 feet. The inlet and outfall invert elevations of the existing culvert are shown on a 2022 survey by Sherman and Frydryk to be at 135.72 and 130.28 feet, respectively.

The roadway surface in the subject area is approximately 15-feet above the brook (or near elevation 147 feet). The soils in the stream bed consist of fine sand and silt.

Buried water and sewer lines are located in the eastbound (southern) travel lane and off the southern shoulder of the road. These utilities appear to cross the location of the existing pipe culvert. In addition, overhead electric power and communication lines are located along the southern shoulder of the road.

2.2.2 Proposed Construction

The alternative selected for this project calls for the removal of the existing pipe culvert, which will be replaced with an open-bottom culvert with a span of 15 feet. The structure type has not been selected, but we understand that both a three-sided concrete box and a corrugated metal pipe arch type culvert are currently being considered. We assume the bottom of the new culvert will be near the base of the existing stream bed (which is near elevation 130 feet). We understand that the foundation system and other elements of the replacement culvert will be chosen based, in part, upon the conditions described and recommendations provided in this report. We anticipate that the replacement culvert will be founded upon traditional concrete spread footings.

2.3 Site Reconnaissance and Overall Description

The Site is located on Mountain Avenue, approximately 330 feet to the west of the intersection with Newton Street (Route 116) in South Hadley, Massachusetts. The federal classification for Mountain Avenue is ‘local’ (Code 7). A state (MassDOT) classification was not listed. An existing conditions survey plan has been completed for this location, which was used to generate the attached Boring Location Plan. Topography along the roadway near the proposed culvert is generally flat (approximate elevation 147 feet). The roadway embankment slopes downwards to the northeast and southwest, towards Buttery Brook and associated waterfront areas. The existing culvert at this location consists of a 24-inch diameter corrugated metal pipe, with an inlet invert of 135.72 to the north of Mountain Avenue and an outfall invert of 130.28 feet to the south. Therefore, the existing culvert is buried approximately 15 feet below the roadway surface. The location of the existing culvert is shown on the attached Boring Location Plan.

The streambank of the brook is shown near elevation 136 feet to the north of Mountain Avenue and approximately 130 feet to the south. At the time of the 2022 survey, the brook was relatively shallow at the culvert location, with a maximum depth on the order of one foot (we anticipate that the depth of the stream will vary based upon rainfall and snow melt). The roadway embankment would obstruct the flow of the brook without a culvert. The subject area is not located within or near a National Flood Insurance Program (NFIP) identified 100-year (Zone A) or 500-year (Zone B) flood boundary[1].

[1] U.S. Department of Housing and Urban Development (1979). "Flood Insurance Rate Map: Town of South Hadley, Massachusetts, Hampshire County", *National Flood Insurance Program*, Community Panel Number 250170 0010 A, Panel 10 of 10.

3.0 SUBSURFACE CONDITIONS

3.1 Local Geology

We reviewed the surficial geologic map for the Springfield North Quadrangle[2] to evaluate likely geologic conditions at the Site. This map indicates Buttery Brook flows through deposits of fine glacial soils at this crossing. This includes thin varves of very fine sand, silt, and clay. A Surficial Geologic Map of the Site area is provided as Figure 3. We note that Mountain Avenue appears to have been constructed on an earth embankment which spans a low-lying area.

3.2 Subsurface Exploration Program and Testing

Subsurface investigations consisted of three soil borings (MA-1, MA-2, and QD-2). The borings were performed on September 29, 2021 (QD-2) and September 21, 2022 (MA-1 and MA-2), by Seaboard Drilling of Chicopee, Massachusetts. The borings were performed using a Mobile B-53 truck mounted drill. They were advanced using drive and wash drilling techniques to a depth of 39 feet below ground surface. Each boring was performed within the roadway or along the shoulder of Mountain Avenue (at the top of the roadway embankment), approximately 40 to 50 feet from (horizontally) and about 15 feet above the water edge. The boring locations were selected based upon rig access and proximity to overhead and buried utilities. Boring locations are shown on the attached Boring Location Plan. Boring logs are provided in Appendix B.

Soil samples were generally collected on a continuous or semi-continuous basis from the ground surface to a depth of 17 feet, and at five-foot intervals thereafter. Soil samples were collected using a two-inch diameter split spoon sampler, driven 24 inches with a 140-pound safety hammer falling 30 inches (American Society for Testing and Materials Test Method D1586 "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils"). The number of blows required to drive the sampler each six inches was recorded. The standard penetration resistance, or N-value, is the number of blows required to drive the sampler the middle 12 inches. Soil properties, such as strength and density, are related to the N-value. The field N-values are corrected to a standard 60% hammer efficiency, known as N_{60}, to account for differing depth, sampler type, borehole diameter, and hammer efficiencies for each hammer type and drill rig. The N-values presented on the boring logs are field values, which are not adjusted for hammer efficiency. However, the adjusted N_{60} values were used in our engineering calculations and analysis.

An O'Reilly, Talbot & Okun Associates, Inc. (OTO) engineer observed and logged the borings. Samples were classified according to a modified version of the Burmister Soil Classification System. Borings performed in the roadway were finished with a surface layer of cold patch asphalt.

[2] Stone, Janet R. & DiGiacomo-Cohen, Mary (2018). "Surficial Materials Map of the Springfield North Quadrangle, Massachusetts" *US Geological Survey*, Scientific Investigations Map 3402, Quadrangle 45 – Springfield North.

3.2.1 Field Strength Testing

Field strength testing was performed on selected samples of the silt and clay using pocket torvane (E-285 Pocket Vane Shear Tester) and pocket penetrometer devices. These field measurements are intended to provide a rough measure of the strength of fine-grained soils. The pocket penetrometer provides a measure of the unconfined compressive strength of soil by failing the clay by "punching". The torvane device provides an estimate of the undrained shear strength of fine-grained soils by failing the silt and/or clay in a rotational shearing mode. Theoretically, the unconfined compressive strength is twice the undrained shear strength. A total of eight pocket penetrometer and torvane tests (each) were completed in the field. Pocket torvane and pocket penetrometer results are presented on the attached boring logs and are discussed below.

3.2.2 In-Situ Moisture Content

Selected samples collected of the varved silt and clay were analyzed for moisture content. Published correlations between moisture content and engineering properties of the varved silt and clay were used to determine the design parameters recommended in this report.

3.3 Verification of Sample Descriptions on Boring Logs

I, Dustin A. Humphrey, a Massachusetts registered professional engineer, attest that I visually and manually examined all soil samples as part of the preparation of this geotechnical report. Samples collected from the subsurface investigations were reviewed at the O'Reilly, Talbot, & Okun Associates, Inc. office, located in Springfield, Massachusetts on October 16, 2022. The soil descriptions presented on the boring logs are consistent with the soil samples collected during the Site explorations.

3.4 Subsurface Profile

Subsurface conditions were interpreted based upon information collected in the soil borings and upon our review of published geologic maps. In general, subsurface conditions consisted of the following, in order of increasing depth: a surface layer of asphalt or topsoil; debris fill; organic silt and sand; glacial till; and bedrock. A summary of subsurface conditions encountered in the soil borings is provided as Table 1. We note that the borings were performed at the top of the roadway embankment, approximately 40 to 50 feet (horizontally) from the bank of Buttery Brook. The ground surface at each boring location is approximately 15 feet above the level of the brook channel bottom.

Soil conditions are generally favorable for the proposed construction, and it appears that the foundation for the new culvert will bear in the medium stiff varved clay present at the Site. Since the new culvert foundations will be located adjacent to the brook, the control of water will be a significant construction consideration.

3.4.1 Soil Conditions

Soil conditions were similar between the three borings performed in the study area. Boring QD-2 was performed approximately 80 feet west of the alignment of the proposed culvert and therefore was used mostly as a reference to evaluate the consistency of subsurface conditions are in the study area.

Asphalt and Topsoil: Four inches of topsoil was present at the ground surface in boring MA-1. The topsoil generally consisted of fine sand, some silt, and trace organics (roots). Boring MA-2 was performed in the existing roadway. The pavement at this location consisted of three inches of asphalt, underlain by three inches of a granular base course. Boring QD-2 contained 7 inches of asphalt, but gravel base course was not observed at that location. The base course consisted of medium to coarse sand with some gravel.

Fill: Non-engineered fill containing debris was encountered in each boring to a maximum depth of 15.5 feet below ground surface, corresponding to an approximate elevation of 132 feet. The fill was apparently placed to form the earth embankment on which Mountain Avenue sits. These soils appear to consist of reworked native soils with varying amounts of debris. The fill generally consisted of loose to very loose, fine to coarse sand with varying amounts of gravel, silt, and debris (primarily ash and cinders). The deepest fill likely coincides with the location of the existing pipe culvert.

Organic Silt and Sand: An organic silt and sand (that appear to be riverbank or wetland deposits associated with Buttery Brook, based on the consistency, color, and odor) was encountered immediately below the debris fill in borings MA-1 and MA-2. These soils generally consisted of very loose to loose, fine to medium sand, with varying amounts of silt, isolated clayey layers, and organic odor. The organic silt layer was not observed in boring QD-2 (however, this boring was not located near the currently proposed culvert alignment).

Varved Silt and Clay: The organic layer was directly underlain by approximately 10 feet of varved silt and clay at an approximate depth of 19 to 19.5 feet to a depth of about 30 feet below ground surface (between elevation of 128 and 118 to 115.5 feet). The varved silt and clay layer was soft and is potentially compressible under heavy foundation loads. The varved clay appears to be present at the likely foundation level for the new culvert.

Glacial Till: A dense to very dense, glacial till was encountered in each of borings at a depth of 29.5 to 32 feet below ground surface, corresponding to approximate elevations 118.5 to 115.5 feet. Till was encountered at a depth of 30 feet (elevation 118) in boring QD-2, indicating that the surface of the till layer is fairly uniform in the study area.

Bedrock: Bit refusal upon what is likely bedrock was encountered in borings MA-1 and MA-2 at a depth of 39.4 feet below ground surface, corresponding to approximate elevations 108.1 to 107.6 feet. Rock fragments consisting of a dark gray sandstone were recovered in boring MA-2.

3.4.2 Laboratory Analysis Results

Six samples were analyzed for in-situ moisture content. One of the samples consisted of the organic silt and sand layer in boring MA-2, the remaining samples consisted of the varved silt and clay from varying depths in borings MA-1 and MA-2. Moisture content values ranged from 39 to 51 percent, and are presented on the boring logs.

3.4.3 Groundwater Conditions

Groundwater was encountered in borings MA-1 and MA-2 at a depth of approximately 14 feet below ground surface, corresponding to an approximate elevation of 133.5 feet. This groundwater elevation was near the water level in the brook at the time of our explorations. We note that groundwater will vary with changing water levels in Buttery Brook.

3.5 Seismic Design Category Evaluation

Earthquake loadings must be considered under requirements of the 2021 MassDOT *Bridge Manual* (MassDOT) and the most recent version of AASHTO *LRFD Bridge Design Specifications* (AASHTO).

Section 3.4 of MassDOT covers seismic analysis and design. Lateral forces generated during a seismic event are dependent on the type and properties of soils present beneath the Site as well as geographic location. The *USGS Seismic Design Maps* web service was used to determine seismic parameters for the Site. The peak ground acceleration (PGA), as well as the maximum considered earthquake spectral response accelerations for short periods (S_s) and for one-second (S_1) were determined to be 0.059, 0.13, and 0.038, respectively, for South Hadley, Massachusetts. These values are for a non-critical/non-essential bridge and based upon a seven percent probability of exceedance in 75 years for a 1,000-year event.

Soil properties are represented through Site Classification. Procedures for the Site-specific determination of Site Classification are provided in Article 3.10.3.1 of AASHTO. At this Site, we evaluated Site Classification using Standard Penetration Resistance (SPT N-value). Using the SPT N-value, the Site was determined to be Site Class E. Furthermore, the Site coefficients F_{pga}, F_a, and F_v are determined using the PGA, S_s, and S_1 values and the Site Class. For Site Class E, F_{pga}, F_a, and F_v were determined to be 2.5, 2.5, and 3.5, respectively.

3.6 Liquefaction Potential

The potential for liquefaction of the saturated Site soils was evaluated. Based upon the fine-grained nature of the varved silt and clay soils and the density of the underlying glacial till it is unlikely that liquefaction would occur during the design earthquake.

Seismic design and analysis of the proposed culvert should be performed in accordance with the specifications provided in the 2021 MassDOT *Bridge Manual* and the most recent AASHTO *LRFD Bridge Design Specifications*.

4.0 RECOMMENDED FOUNDATION SYSTEM

The following recommendations are provided for design of culvert and wingwall foundations. Foundations will be designed to resist lateral and vertical loads. Vertical loads consist of downward pressures due to the dead weight of the culvert, the weight of soils on the culvert roof, and live traffic loads, as well as uplift pressures due to overturning loads (such as buoyant and seismic forces). All foundations should be designed according to requirements provided in the 2021 MassDOT *Bridge Manual* (MassDOT) and the most recent AASHTO *LRFD Bridge Design Specifications* (AASHTO). We anticipate that the appropriate foundation system will be spread footings bearing upon a two-foot-thick (minimum) layer of Crushed Stone over the soft varved silt and clay.

4.1 Existing Foundation

Construction drawings were not available at the time of this report. However, we anticipate that the existing pipe culvert was bedded in engineered fill or directly in native Site soils. Therefore, we do not anticipate the presence any associated substructures, such as abutments or foundations. We note that the alignment of the new and existing culverts may be different.

4.2 Embankment Considerations

We anticipate that the proposed culvert will penetrate the existing embankment along Mountain Avenue. Therefore, the fills anticipated as part of this project will include:

- Placement of Crushed Stone beneath footings
- Backfill around and over the new culvert
- Replacement of soils disturbed during construction
- Backfill against wing walls
- Placement of Processed Gravel for Subbase (M1.03.1) beneath final pavements after the culvert is constructed

Since the installation of the new culvert will involve the removal of soil, which will reduce the stress on the underlying varved silt and clay, post-construction settlement should be small. Therefore, geotechnical concerns associated with the settlement or global stability of embankment soils are not significant. Earthwork recommendations provided in Section 5.0 should be followed.

4.3 Deep Foundations

At this time, we do not anticipate that deep foundations will be used to support the proposed replacement culvert.

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

4.4 Spread Footing Foundations for Culverts and Wingwalls

The proposed culvert and associated wingwalls may be founded upon shallow spread footings bearing on a two-foot-thick (minimum) layer of Crushed Stone over native Site soils. Table 2 provides soil properties and design parameters for use in design of spread footings. Spread footings should bear a minimum of four feet below adjacent ground surface for frost protection. Therefore, we anticipate that footings for the new culvert and wingwalls should bear in the varved clay below elevation 130 feet. Additional recommendations for design of footings can be provided after foundation systems for the culvert and associated wing walls have been selected.

We recommend that a geosynthetic separation fabric be placed beneath and around the Crushed Stone layer beneath footings to prevent the migration of granular soils into the Crushed Stone layer.

4.4.1 Lateral Earth Pressures

Static lateral earth pressures will be imposed against the proposed culvert, wingwalls, and any other earth retaining structures (such as earth support systems used during construction). In addition, dynamic lateral earth pressures under the design earthquake must be considered. These structures should be backfilled with MassDOT Gravel Borrow (M1.03.0 Type B). A drainage system should be provided as required by MassDOT specifications. Soil properties and design parameters for the determination of lateral loading under drained conditions are provided in Table 3.

4.4.2 Scour Protection

We understand that a scour analysis has been performed, and the modeled scour depth is on the order of 1.7 feet.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Groundwater Considerations and Recommended Method for Water Control

Groundwater was encountered a depth of approximately 14 feet below ground surface, corresponding to approximate elevation of 133 feet. We note that the groundwater levels will likely be higher in the future, due to fluctuations in the water level of Buttery Brook.

Based upon the observed groundwater levels and potential water levels in Buttery Brook, it is likely that groundwater will be present in excavations for foundations and the installation of the new culvert. During periods of relatively low water levels, it should be possible to dewater small, short duration excavations using sump pits and submersible pumps or well points. However, for work during high water periods, the contractor will either need to stop work or install a more robust system (such as sheet pile cutoff walls toed into glacial till) around excavations to cutoff groundwater flow. The contractor should review the results of the design phase hydraulic analysis (and supplement with their own analyses as appropriate) to evaluate potential water, which will need to be considered for construction.

5.2 Engineered Fill Recommendations

Four types of engineered fill are recommended:

- Gravel Borrow (MassDOT designation M1.03.0, Type B) for use immediately behind culvert walls and wingwalls
- Processed Gravel for Subbase (M1.03.1) for use immediately below pavements
- Special Borrow (M1.02.0) for use as miscellaneous fill
- Crushed Stone (M2.01.4) for use immediately below footings, in drainage structures, and in place of Gravel Borrow

Grain size distribution requirements are presented in Table 4. The existing Site soils do not meet requirements for reuse as engineered fill.

5.2.1 Footing Subgrade Preparation

We recommend that final footing subgrade excavations be completed with a smooth-bladed excavator bucket to prevent disturbance to the varved silt and clay subgrade. As discussed above, footings should be underlain by a minimum two-foot-thick layer of Crushed Stone to protect the subgrade from disturbance and provide a firm bearing surface. The Crushed Stone layer should be surrounded by a geosynthetic separation fabric to prevent the migration of granular soils into the Crushed Stone layer.

Compacted fill should be placed in lifts ranging in thickness between 6 and 12 inches depending on the size and type of equipment. Recommended degrees of compaction and compaction means and methods are presented on Sheet 1. Compaction within five feet of the culvert or wingwalls should be performed using a hand-operated roller or vibratory plate compactor weighing 250 pounds or less.

5.3 Excavations

The need for temporary earth support should be evaluated by the contractor. Sloping and earth support may be needed if the excavation cannot be safely sloped to remove debris fill soils, install utilities, and construct the new culvert and its associated foundations. As discussed above, sheet pile cutoff walls may be needed to limit water infiltration into excavations.

5.3.1 Removal of Existing Culvert

The existing culvert will be removed as part of this project. The excavation should be backfilled with Special Borrow compacted to a minimum of 95% of the maximum dry density (as determined by ASTM D1557). If the excavation extends below the groundwater table, it may be appropriate to backfill portions of the excavation below the groundwater table with Crushed Stone.

Abandoned buried utilities containing asbestos (such as electrical conduit insulation or transite pipe) are commonly found during construction excavations. Furthermore, former structures (pipes, conduits, foundations walls) may contain or be covered with materials containing asbestos. Such materials should be handled in accordance with MassDEP's asbestos regulations (310 CMR 7.15). We recommend that suspect materials be managed appropriately and tested by a Department of Labor Standards (DLS) certified asbestos inspector prior to disturbances.

5.3.2 Sloping and Earth Support

Soil may become unstable when excavations extend deeper than four feet or beneath the groundwater table. The upper non-engineered fill and native silty sand encountered in the upper 20 feet are estimated to be Type C soils for slope stability purposes. The maximum allowable slope for excavations of Class C soils is 1.5H:1V (34°). All excavations should conform to current OSHA requirements. These conditions apply only to excavations above the groundwater table. We note that protective systems for any excavation exceeding 20 feet in depth must be designed by a registered professional engineer. All excavations should conform to current OSHA requirements. The contractor should also follow requirements in 29 CFR 1926.651(H)(3) for excavations that interrupt the natural drainage of surface water.

In areas where sloping is not feasible, a temporary earth support system will be required during construction. The design and engineering of the temporary earth support systems should be the responsibility of the contractor. Prior to construction, we recommend that the contractor evaluate the need for a temporary earth support system to protect the existing roadway and personnel during construction.

5.4 Obstructions

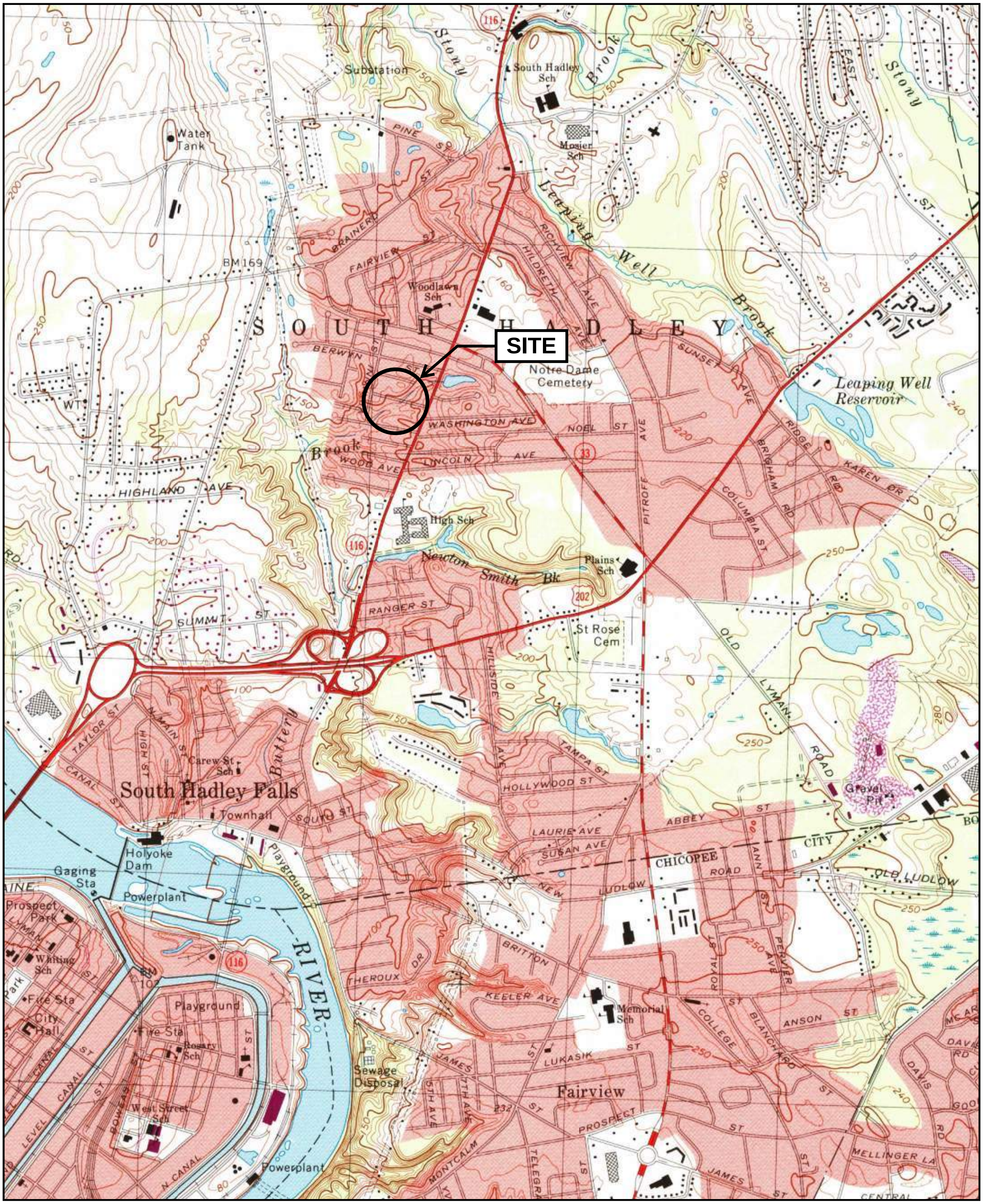
Large boulders, cobbles, or other obstructions may be encountered in the non-engineered fill. We recommend that provisions be made to remove obstructions, if encountered.

5.5 Protection of Adjacent Structures and Utilities

The nearest residences are located at 88 and 38 Mountain Avenue and are approximately 50 and 110 feet from the existing culvert, respectively. We anticipate vibrations associated with construction will be negligible at these residences. Nearby utilities include water and sewer that cross the existing culvert. Therefore, vibration monitoring is recommended during the installation of sheet piles. The contractor should evaluate the need for support and/or geotechnical monitoring of adjacent utilities.

FIGURES

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES



0 1000 FEET

0 0.5 1.0 MILES

0 0.5 1 KILOMETERS

1:25,000 SCALE NATIONAL GEODETIC VERTICAL DATUM 1929 10 FOOT CONTOUR INTERVAL

O:\J2900\2950 Fuss & O'Neill\11-02 South Hadley Mountain Ave Culvert Replacement Final Design\Figures

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

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CULVERT REPLACEMENT

MOUNTAIN AVENUE
SOUTH HADLEY, MASSACHUSETTS

SITE LOCUS

Topographic Map Quadrant: SPRINGFIELD NORTH, MA

Map Version: 1972

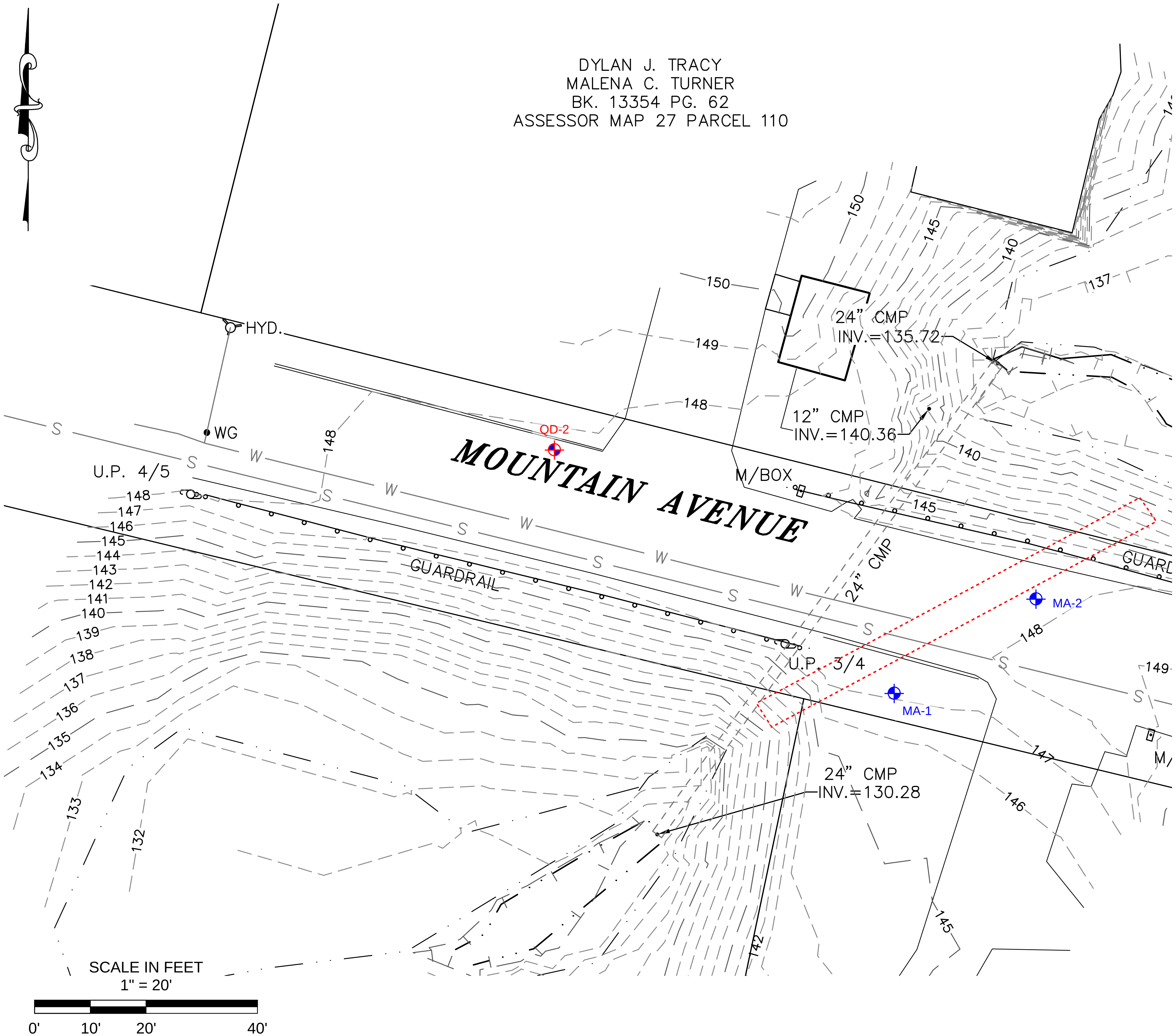
Current As Of: 1979

Date: DECEMBER 2021

PROJECT No.
J2950-11-02

FIGURE No.
1

BORING LOCATIONS (FEET)					
BORING	NORTHING	EASTING	STATION	OFFSET	SURFACE ELEV.
MA-1	2,911,842	362,061	-	-	147
MA-2	2,911,858	362,086	-	-	147.5



LEGEND:

- APPROXIMATE SOIL BORING LOCATION PERFORMED BY SEABOARD DRILLING ON 9/29/2021, OBSERVED BY OTO
- APPROXIMATE SOIL BORING LOCATION PERFORMED BY SEABOARD DRILLING ON 9/21/2022, OBSERVED BY OTO
- APPROXIMATE ALIGNMENT OF PROPOSED CULVERT

NOTES:

1. PLAN CREATED IN PART FROM PLAN TITLED "PARTIAL EXISTING CONDITIONS" SHEET 3 OF 4 BY SHERMAN & FRYDRYK DATED 1/24/2022.
2. SAMPLE LOCATIONS ARE SHOWN ACCORDING TO TAPED MEASUREMENTS TAKEN FROM EXISTING SITE FEATURES.
3. ALL DATA IS TO BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHODS USED IN THE DEVELOPMENT OF THIS PLAN.

PROJECT FILE NO. 2950-11-02

massDOT Massachusetts Department of Transportation Highway Division

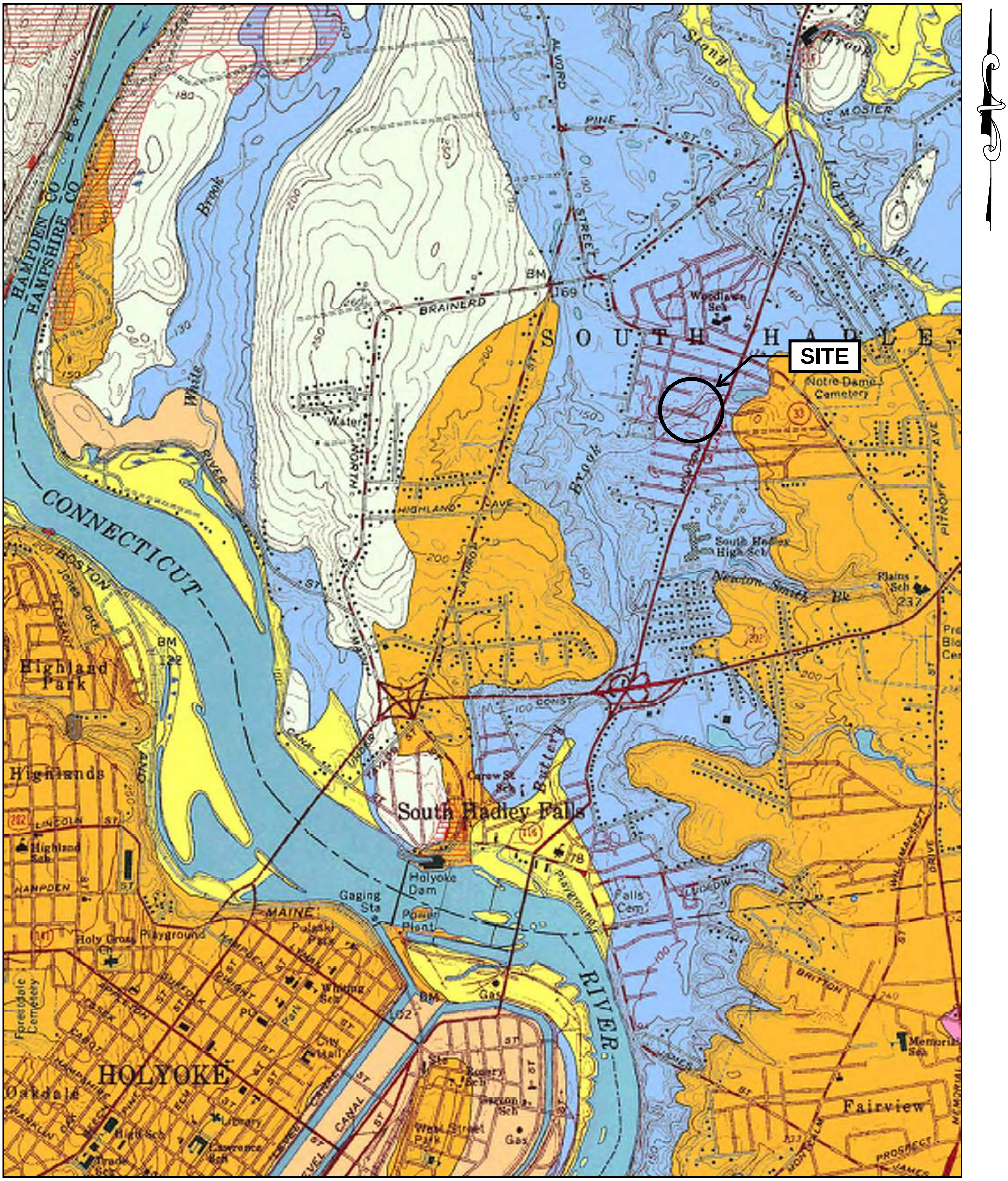
BORING PLAN OF PROPOSED BRIDGE IN SOUTH HADLEY

BOX CULVERT AT MOUNTAIN AVENUE

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

SCALE: 1" = 20'-0" JANUARY, 2023

BRIDGE NO. NOT YET DESIGNATED



0 1000 FEET
0 0.5 1.0 MILES
0 0.5 1 KILOMETERS

1:24,000 SCALE NATIONAL GEODETIC VERTICAL DATUM 1929 10 FOOT CONTOUR INTERVAL

O:\J2900\2950 Fuss & O'Neill\11-02 South Hadley Mountain Ave Culvert Replacement Final Design\Figures

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES
293 Bridge Street, Suite 500 Springfield, MA 01103 413.788.6222
www.OTO-ENV.com

CULVERT REPLACEMENT

MOUNTAIN AVENUE
SOUTH HADLEY, MASSACHUSETTS

SURFICIAL GEOLOGIC MAP

Source:
"Surficial Materials Map of the Springfield North Quadrangle, Massachusetts" US Geological Survey, Scientific Investigations Map 3402, Quadrangle 45 – Springfield North, 2018

PROJECT No.
J2950-11-02

FIGURE No.
3

TABLES AND SHEETS

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

Table 1
Summary of Soil Boring Information

Boring	Ground Surface Elevation[1] (ft)	Depth (ft) / Elevation (ft)			
		Ground Water	Bottom of Fill	Glacial Till	Refusal[2]
MA-1	147	14 / 133	15 / 132	28.5 / 118.5	39.4 / 107.6
MA-2	147.5	14 / 133.5	15.5 / 132	32 / 115.5	39.4 / 108.1

Notes:
1. Ground surface elevations were estimated by referring to the Boring Location Plan. Data presented in this table are based upon conditions encountered in the soil borings. Data shown in this table should be considered accurate only to the degree implied by the methods used.
2. Bit refusal upon likely bedrock.

Table 2
Properties and Design Parameters for Bridge Foundations Bearing on a Minimum Two-Foot Layer of Crushed Stone over Varved Clay

Property/Design Parameter	Recommended Value
Interface Friction Angle[2]	18 degrees (Cast in Place) 14 degrees (Precast)
Friction Factor[2]	0.33 (Cast in Place) 0.31 (Precast)
Strength Limit State – Nominal Bearing Resistance	3.0 ksf
Strength Limit State – Factored Bearing Resistance	1.5 ksf
Service Limit State – Bearing Resistance for Settlement of 1 inch	1.0 ksf
Bearing Resistance Factor[3], φ_b	0.50
Sliding Resistance Factor[3], φ_τ	0.85
Passive Earth Pressure Component of Sliding Resistance[3], φ_{ep}	0.50

Notes:
1. Values in this table are based upon a minimum two-foot thick layer of Crushed Stone placed below footings.
2. Interface friction and friction factor for Crushed Stone in contact with concrete from AASHTO Table 3.11.5.3-1.
3. Bearing and sliding resistance factors from AASHTO Table 10.5.5.2.2-1.

Table 3
Soil Properties and Design Parameters for Retaining Walls[1,2]

Soil Property/ Design Parameter	M1.03.0 Type B Gravel Borrow	Native Soils and Fill
Angle of Internal Friction	36 degrees	22 degrees
Soil Unit Weight	125 pcf	120 pcf
Equivalent Fluid Pressure (Active)[3]	35 pcf	35 pcf
Interface Friction Angle[4]	22 degrees	15 degrees
Earth Pressure Coefficients		
Active, K_a	0.26	N/A[5]
At-Rest, K_0	0.41	N/A
Passive, K_p[6]	3.00	N/A
Dynamic, K_{ae}	0.34	N/A

Notes:
1. Values presented in this table assume drained soil conditions.
2. Appropriate Resistance Factors from AASHTO LRFD Bridge Manual Table 11.5.7.1 should be applied
3. Equivalent fluid pressure assumes that retaining walls will be unbraced and free to deflect (cantilevered).
4. Interface friction assumes soil in contact with formed/precast concrete.
5. N/A indicates that the material is Not Applicable for use below footings or behind retaining walls and should be removed.
6. We recommend passive resistance be neglected for soils subject to frost and/or scour.

Table 4
Grain Size Distribution Requirements

Fill Type/Use	Gravel Borrow	Processed Gravel for Subbase	Special Borrow	Crushed Stone
MassDOT Designation	M1.03.0, Type B	M1.03.1	M1.02.0	M2.01.4
Sieve Size	**Percent Finer by Weight**			
3 inch	100	100	100 (6" max)	---
2 inch	---	---	90 – 100	---
1 ½ inch	---	70 – 100	---	---
1 inch	---	---	---	100
¾ inch	---	50 – 85	---	90 – 100
½ inch	50 – 85	---	---	10 – 50
⅜ inch	---	---	---	0 – 20
No. 4	40 – 75	30 – 60	20 – 65	0 – 5
No. 50	8 – 28	---	---	---
No. 200	0 – 10	0 – 10	0 – 12	---

Table 1-1
Degree of Compaction Recommendations

Location	Minimum Compaction
Below Structures (Foundations and Slabs)	95%
Below Pavements/Sidewalks/Exterior Slabs	95%
Against Basement Walls/Retaining Walls	92%
Utility Trenches	95%
General Landscaped Areas	90%

Notes.
1. Percentage of the maximum dry density as determined by Modified Proctor ASTM D1557, Method C.
2. When location falls into two or more categories, the engineer should be notified to determine appropriate compaction efforts and/or methods.
3. Crushed stone should be compacted in lifts of 12 inches to form a dense matrix using either traditional compaction methods (vibratory plate and/or roller) or tamping with an excavator bucket in deep excavations. It is generally not necessary to perform laboratory or field density testing on crushed stone.

Table 1-2
General Guidelines for Compaction Means and Methods

Compaction Method	Maximum Stone Size (Inches Diameter)	Maximum Lift Thickness (Inches)		Minimum Number of Passes	
		Below Structures & Pavement	Non-Critical Areas	Below Structures & Pavement	Non-Critical Areas
Hand-operated Vibratory Plate and confined spaces	3	6	8	6	4
Hand-operated vibratory drum roller (less than 1000 pounds)	3	6	8	6	4
Hand-operated vibratory drum roller (at least 1,000 pounds)	6	8	10	6	4
Light vibratory drum roller (minimum 3000 pounds)	6	10	14	6	4
Heavy vibratory drum roller (minimum 6000 pounds)	6	12	18	6	4

Note: The contractor should reduce or stop drum vibration if pumping of the subgrade is observed.

O:\J2900\2950 Fuss & O'Neill\11-02 South Hadley Mountain Ave Culvert Replacement Final Design\Figures

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CULVERT REPLACEMENT

MOUNTAIN AVENUE
SOUTH HADLEY, MASSACHUSETTS

GENERAL COMPACTION GUIDELINES

DESIGNED BY: ALS
DRAWN BY: DAH
CHECKED BY: MJT
DATE: 11/09/2016
REV. DATE: 9/21/2022

PROJECT No.
J2950-11-02

SHEET No.
1

APPENDIX A

Limitations

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

LIMITATIONS

1. The observations presented in this report were made under the conditions described herein. The conclusions presented in this report were based solely upon the services described in the report and not on scientific tasks or procedures beyond the scope of the project or the time and budgetary constraints imposed by the client. The work described in this report was carried out in accordance with the Statement of Terms and Conditions attached to our proposal.

2. The analysis and recommendations submitted in this report are based in part upon the data obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

3. The generalized soil profile described in the text 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 are probably more erratic. For specific information, refer to the boring logs.

4. In the event that any changes in the nature, design or location of the proposed structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by O'Reilly, Talbot & Okun Associates Inc. It is recommended that we be retained to provide a general review of final plans and specifications.

5. Our report was prepared for the exclusive benefit of our client. Reliance upon the report and its conclusions is not made to third parties or future property owners.

APPENDIX B

BORING LOGS

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

BORING LOGS

SUMMARY OF THE BURMISTER SOIL CLASSIFICATION SYSTEM (MODIFIED)

RELATIVE DENSITY (of non-plastic soils) OR CONSISTENCY (of plastic soils)

STANDARD PENETRATION TEST (SPT)
Method: Samples were collected in accordance with ASTM D1586, using a 2" diameter split spoon sampler driven 24 inches. If samples were collected using direct push methodology (Geoprobe), SPTs were not performed and relative density/consistency were not reported. N-Value: The number of blows with a 140 lb. hammer required to drive the sampler the middle 12 inches. WOR: Weight Of Rod (depth dependent) WOH: Weight Of Hammer (140 lbs.)

COHESIONLESS SOILS		COHESIVE SOILS	
BLOWS/FOOT (SPT N-Value)	RELATIVE DENSITY	BLOWS/FOOT (SPT N-Value)	CONSISTENCY
0-4	Very loose	<2	Very soft
4-10	Loose	2-4	Soft
10-30	Medium dense	4-8	Medium Stiff
30-50	Dense	8-15	Stiff
>50	Very dense	15-30	Very stiff
*Based upon uncorrected field N-values		>30	Hard

MATERIAL: (major constituent identified in CAPITAL letters)

COHESIONLESS SOILS		
MATERIAL	FRACTION	GRAIN SIZE RANGE
GRAVEL	Coarse	3/4" to 3"
	Fine	1/4" to 3/4"
SAND	Coarse	1/16" to 1/4"
	Medium	1/64" to 1/16"
	Fine	Finest visible & distinguishable particles
SILT/CLAY	see adjacent table	Cannot distinguish individual particles
COBBLES	3" to 6" in diameter	
BOULDERS	> 6" in diameter	
Note: Boulders and cobbles are observed in test pits and/or auger cuttings.		

COHESIVE SOILS		
SMALLEST DIAMETER	PLASTICITY	IDENTITY
None	Non-plastic	**SILT**
1/4" (pencil)	Slight	**Clayey SILT**
1/8"	Low	**SILT & CLAY**
1/16"	Medium	**CLAY & SILT**
1/32"	High	**Silty CLAY**
1/64"	Very High	**CLAY**
Wetted sample is rolled in hands to smallest possible diameter before breaking.		

ORGANIC SILT: Typically gray to dark gray, often has strong H2S odor. May contain shells or shell fragments. Light weight.
Fibrous PEAT: Light weight, spongy, mostly visible organic matter, water squeezed readily from sample. Typically near top of layer.
Fine grained PEAT: Light weight, spongy, little visible organic matter, water squeezed from sample. Typically below fibrous peat.
DEBRIS: Detailed contents described in parentheses (wood, glass, ash, crushed brick, metal, etc.)
BEDROCK: Underlying rock beneath loose soil, can be weathered (easily crushed) or competent (difficult to crush).

ADDITIONAL CONSTITUENTS

TERM	% OF TOTAL
and	35-50%
some	20-35%
little	10-20%
trace	1-10%

COMMON TERMS

Glacial till: Very dense/hard, heterogeneous mixture of sand, silt, clay, sub-angular gravel. Deposited at base of glaciers, which covered all of New England.

Varved clay: Fine-grained, post-glacial lake sediments characterized by alternating layers (or varves) of silt, sand and clay.

Fill: Material used to raise ground, can be engineered or non-engineered.

COMMON FIELD MEASUREMENTS

Torvane: Undrained shear strength is estimated using an E285 Pocket Torvane (TV). Values in tons/ft2.

Penetrometer: Unconfined compressive strength is estimated using a Pocket Penetrometer (PP). Values in tons/ft2.

RQD: Rock Quality Designation is determined by measuring total length of pieces of core 4" or greater and dividing by the total length of the run, expressed as %. 100-90% excellent; 90-75% good; 75-50% fair; 50-25% poor; 25-0% very poor.

PID: Soil screened for volatile organic compounds (VOCs) using a photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

LOG OF BORING MA-1

PROJECT	Mountain Ave Culvert Replacement			CONTRACTOR	Seaboard Environmental Drilling
JOB NUMBER	2950-11-02	FINAL DEPTH (ft)	39.4	DRILLING EQUIPMENT	Track Mounted Rig
LOCATION	South Hadley, MA	SURFACE ELEV (ft)	147	FOREMAN	Jeff
START DATE	9/21/2022	DISTURBED SAMPLES	12	HELPER	Joe
FINISH DATE	9/21/2022	UNDISTURBED SAMPLES	0	BIT TYPE	Roller Bit with Wash
ENGINEER/SCIENTIST	Caren Irgang	WATER LEVEL		ROD TYPE	N (2 3/8" O.D.)
BORING LOCATION	Southern shoulder of Mountain Ave	FIRST (ft)	14.0	SAMPLER	2" O.D. Split Spoon
		LAST (ft)	N/A	HAMMER TYPE	Automatic
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"

CASING	
CASE DIAMETER	4"
HAMMER WGT	300 lb
HAMMER DROP	30"
ROCK CORING INFORMATION	
TYPE	N/A
SIZE	N/A

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
	2/4/4/5	8/24	S-1 (0-2')	--	Top 4": Loose, dark brown, fine SAND, some silt, little medium sand, trace coarse sand, trace organics (grass, roots), damp (TOPSOIL) Bottom 4": Loose, black, fine to medium SAND, little to some silt, trace coarse sand, damp	TOPSOIL DEBRIS FILL	
	4/5/5/6	0/24	S-2 (2-4')	--	NO RECOVERY (likely pushing gravel pieces)		
5'	4/5/4/3	19/24	S-3 (4-6')	--	Loose, black, fine to medium SAND, little coarse sand, little fine gravel, little debris (cinders, ash), damp		
	1/1/1 for 12"	8/24	S-4 (6-8')	--	Top 5": Very loose, black, fine to medium SAND, little coarse sand, little fine gravel, little debris (cinders, ash), damp Bottom 3": Very loose, light red, fine SAND and SILT, trace debris (brick, coal), damp		
	WOH for 24"	11/24	S-5 (8-10')	--	Top 5": Very loose, brown, medium to coarse SAND, some silt, some fine sand, trace organics (roots), damp Bottom 6": Very loose, black, DEBRIS (cinders), damp		1
10'	1/1/1 for 12"	16/24	S-6 (10-12')	--	Top 6": Very loose, black, DEBRIS (cinders), damp Next 5": Very loose, brown, medium to coarse SAND, some silt, some fine sand, damp Bottom 5": Very loose, black, fine to medium SAND, little coarse sand, little fine gravel, little debris (cinders, ash), damp		2
						∇ 133.0 15.0 132.0	
15'	2/1/1/1	11/24	S-7 (15-17')	--	Top 1.5": Soft, brown gray, clayey SILT and fine SAND, little organics, trace medium to coarse sand (organic odor) Bottom 9.5": Very loose, brown gray, fine to medium SAND, trace silt	ORGANIC SILT AND SAND	3
						ORGANICS 19.0 128.0	3
20'	WOH for 18"/2	24/24	S-8 (20-22')	TV = 0.5 PP = 0.55 w= 49%	Soft, gray, varved SILT and CLAY (3/4" clay, 1/4" silt)	VARVED SILT AND CLAY	4, 5 6 7
25'	1/2/3/3	22/24	S-9 (25-27')	TV = 0.15 PP = 0.7 w= 49%	Medium stiff, gray, varved SILT and CLAY (1/2-3/4" clay, 1/4-1/2" silt)		

Remarks:
1. WOH = Weight of rods and 140 lb. hammer.
2. Drive casing and begin drilling with wash after sampling S-6.
3. Easy drilling conditions from 15' to 18'. Wood pieces in wash water at 18'.
4. Begin open-hole drilling at 20'.
5. Undrained shear strength estimated in field using E285 Pocket Torvane (TV). Values in tons/ft^2.
6. Unconfined compressive strength estimated in field using Pocket Penetrometer (PP). Values in tons/ft^2.
7. In-situ moisture content (w) determined according to ASTM D2216 Method A.
8. Bit bouncing at 28.5'.
9. Bit grinding at 39'.

PROJECT NO. 2950-11-02

LOG OF BORING MA-1

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

Job No. 2950-11-02

LOG OF BORING MA-1

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
						VARVED SILT AND CLAY (Continued)	
						GLACIAL TILL	8
30'	20/15/24/24	16/24	S-10 (30-32')	--	Dense, red brown, fine SAND, some silt, some medium to coarse sand, little coarse sand, little fine gravel, trace coarse gravel (1" gravel piece near bottom)		
35'	21/22/28/46	18/24	S-11 (35-37')	--	Very dense, red brown, fine SAND, some silt, some medium sand, little coarse sand, trace gravel (2" medium sand layer near top)		
						39.0 108.0	
	50 for 4"	0/4	S-12 (39-39.4')	--	NO RECOVERY	BEDROCK	9
40'					Bit refusal at 39.4'		
45'							
50'							
55'							
60'							

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LOG OF BORING MA-2

PROJECT	Mountain Ave Culvert Replacement			CONTRACTOR	Seaboard Environmental Drilling
JOB NUMBER	2950-11-02	FINAL DEPTH (ft)	39.4	DRILLING EQUIPMENT	Track Mounted Rig
LOCATION	South Hadley, MA	SURFACE ELEV (ft)	147.5	FOREMAN	Jeff
START DATE	9/21/2022	DISTURBED SAMPLES	11	HELPER	Joe
FINISH DATE	9/21/2022	UNDISTURBED SAMPLES	0	BIT TYPE	Roller Bit with Wash
ENGINEER/SCIENTIST	Caren Irgang	WATER LEVEL		ROD TYPE	N (2 3/8" O.D.)
BORING LOCATION	Westbound (northern) lane of Mountain Ave	FIRST (ft)	14.0	SAMPLER	2" O.D. Split Spoon
		LAST (ft)	N/A	HAMMER TYPE	Automatic
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"

CASING	
CASE DIAMETER	4"
HAMMER WGT	300 lb
HAMMER DROP	30"
ROCK CORING INFORMATION	
TYPE	N/A
SIZE	N/A

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
	5/7/5/3	16/24	S-1 (0-2')	--	Top 3": ASPHALT Next 3": Medium dense, dark gray, medium to coarse SAND, some fine gravel, damp Bottom 10": Medium dense, orange, black and brown, fine to coarse SAND, little to some fine gravel, little silt, damp	ASPHALT / BASE DEBRIS FILL	
	2/2/3/1	12/24	S-2 (2-4')	--	Loose, black to light gray, DEBRIS (cinders, ash), damp		
5'	2/2/2/2	21/24	S-3 (5-7')	--	Loose, black to light gray, DEBRIS (cinders, ash), damp		
10'							
	1/1/1/1	18/24	S-4 (11-13')	--	Top 11": Very loose, black, DEBRIS (cinders, ash), trace coarse sand Bottom 9": Very loose, gray and orange, DEBRIS (cinders, ash)		
	1/1/1/1	18/24	S-5 (13-15')	--	Very loose, black to gray, DEBRIS (cinders, ash), damp (rust stained orange at bottom)	▽ 133.5	
15'	3/2/2/2	24/24	S-6 (15-17')	w= 46%	Top 7": Loose, black to gray, DEBRIS (cinder, ash), little fine to coarse sand Next 10": Medium stiff, very dark brown to gray brown, clayey SILT and fine SAND, little organics (1/8" black seams in top 4" with 1/2" medium sand trace silt seam below, organic odor) Next 4": Loose, gray brown, fine SAND, trace silt, wet Bottom 3": Loose, gray brown, fine SAND and SILT, wet	15.5 132.0 ORGANIC SILT AND SAND	1, 2
						19.5 128.0	3
20'	2/1 for 12"/1	18/24	S-7 (20-22')	TV = 0.75 PP = 0.75 w= 39%	Very soft, gray to red brown, varved clayey SILT, trace fine sand (1/4-1/2" red brown silt, 1/4" clay)	VARVED SILT AND CLAY	4, 5 6
25'	1/2/3/3	6/24	S-8 (25-27')	TV = 0.25 PP = 0.25 w= 51%	Medium stiff, gray, varved SILT and CLAY, trace fine sand (3/4" clay, 1/4" silt)		

Remarks:
1. Drive casing and begin drilling with wash after sampling S-6.
2. In-situ moisture content (w) determined according to ASTM D2216.
3. Casing sinking at approximately 19'.
4. Begin open-hole drilling at 20'.
5. Undrained shear strength estimated in field using E285 Pocket Torvane (TV). Values in tons/ft^2.
6. Unconfined compressive strength estimated in field using Pocket Penetrometer (PP). Values in tons/ft^2.
7. Drilling slightly more difficult below 29.5'.
8. Bit grinding at 32' and 39'.

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

Job No. 2950-11-02

LOG OF BORING MA-2

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	SAMPLES: REC. (in)	SAMPLES: TYPE/ NO.	SAMPLES: FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
						VARVED SILT AND CLAY (Continued)	
30'	4/4/4/18	8/24	S-9 (30-32')	TV = 0.2 PP = 1.25 w= 41%	Stiff, gray to red brown, varved clayey SILT, trace fine sand (1/4" clay, 1/4" silt)		7
						32.0 115.5	
						GLACIAL TILL	8
35'	29/31/29/33	19/24	S-10 (35-37')	--	Very dense, red brown, fine SAND, some silt, little medium to coarse sand, little gravel		
						39.0 108.5	
	50 for 3.5"	2/24	S-11 (39-39.4')	--	Hard, dark gray, ROCK (fractured pieces of likely sandstone)	BEDROCK	8
40'					Bit refusal at 39.4'		
45'							
50'							
55'							
60'							

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

LOG OF BORING QD-2

PROJECT	Queensville Dam Removal and Culvert Replacements			CONTRACTOR	Seaboard Environmental Drilling		
JOB NUMBER	2950-11-01	FINAL DEPTH (ft)	39.1	DRILLING EQUIPMENT	B-53 Truck Mounted Rig		
LOCATION	South Hadley, MA	SURFACE ELEV (ft)	148.0	FOREMAN	Mike G	CASING	
START DATE	9/29/2021	DISTURBED SAMPLES	10	HELPER	Ben B	CASE DIAMETER	3"
FINISH DATE	9/29/2021	UNDISTURBED SAMPLES	--	BIT TYPE	H.S.A. & Roller Bit with Wash	HAMMER WGT	140 lb
ENGINEER/SCIENTIST	Jhonatan Escobar	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.) & N (2 3/8" O.D.)	HAMMER DROP	30"
BORING LOCATION	West of Existing Culvert Located on Mountain Avenue	FIRST (ft)	5.0	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION	
		LAST (ft)	--	HAMMER TYPE	Safety	TYPE	N/A
		TIME (hr)	--	HAMMER WGT/DROP	140 lb / 30" Wire Line	SIZE	N/A

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
					7": ASPHALT	ASPHALT	
	12/10/8/7	13/24	S-1 (0.5-2.5')	--	Medium dense, dark brown to black, fine to medium SAND, some coarse sand, little silt, trace debris (brick, coal), damp (FILL)	FILL	
	5/6/6/14	5/24	S-2 (2.5-4.5')	--	Medium dense, dark brown to black, fine to medium SAND, some coarse sand, little to trace silt, trace debris (coal, coal ash), damp (FILL)		
5'						▽ 143.0	
	7/9/4/4	12/24	S-3 (5-7')	--	Top 10": Medium dense, dark brown to black, fine to coarse SAND, little fine gravel, trace silt, wet (FILL) Bottom 2": Stiff, gray brown with slight rust staining, clayey SILT, trace fine sand, wet (Varved)	6.5 141.5	
	4/7/9/11	14/24	S-4 (7-9')	--	Very stiff, gray brown, SILT and CLAY, trace fine sand, damp (Varved)	VARVED SILT AND CLAY	
10'	4/5/6/6	24/24	S-5 (10-12')	PP=2.25 TSF TV=0.45 TSF	Stiff, brown, CLAY and SILT, trace fine sand, wet (Varved, 1/2 to 1" Varves)		1,2,3
15'	6/8/10/10	22/24	S-6 (15-17')	PP=1.0 TSF TV=0.6 TSF	Very stiff, brown, SILT and CLAY, trace fine sand (Varved)		
20'	3/3/4/4	24/24	S-7 (20-22')	PP=0.5 TSF TV=0.2 TSF	Medium, gray, CLAY and SILT, trace fine sand (Varved)		
25'	7/7/6/6	7/24	S-8 (25-27')	--	Stiff, gray, CLAY and SILT, trace fine sand (Varved)		

Remarks:
1. Augured to 10 feet then telescoped casing to 10 feet
2. Began drilling with wash after telescoping casing
3. Began open hole drilling at 10 feet, after sampling S-5
4. Roller bit grinding significantly from 33 to 39 feet, upon likely dense till
5. Undrained shear strength estimated in field using E285 Pocket Torvane (TV). Values in tons/ft^2.
6. Unconfined compressive strength estimated in field using Pocket Penetrometer (PP). Values in tons/ft^2.

PROJECT NO. 2950-11-01

LOG OF BORING QD-2

LOG OF BORING QD-2

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
						VARVED SILT AND CLAY (CONTINUED)	
30'	50 FOR 5"	5/5	S-8 (30-30.4')	--	Very dense, red brown, fine SAND, some silt, little medium sand, trace fine gravel (GLACIAL TILL)	30.0 118.0 GLACIAL TILL	
							4
35'	28/50 FOR 5"	8/11	S-9 (35-35.9')	--	Very dense, red brown, fine SAND, some silt, little medium sand, little gravel, trace coarse sand (GLACIAL TILL)		
	50 FOR 1"	0/1	S-10 (39-39.1')	--	No Recovery, Likely pushing rock	39.1 108.9	
40'					End of exploration at 39.1', upon likely dense till		
45'							
50'							
55'							
60'							