



J2950-11-01
February 28, 2022

Ms. Julianne Busa, PhD, SE
Fuss & O'Neill, Inc.
1550 Main Street, Suite 400
Springfield, Massachusetts 01103

Re: Preliminary Geotechnical Engineering Evaluation Report
Queensville Dam Removal Feasibility Study and Culvert Replacement Project
Joffre and Mountain Avenue
South Hadley, Massachusetts

Dear Ms. Busa:

O'Reilly, Talbot & Okun Associates, Inc. (OTO) is pleased to provide these preliminary geotechnical recommendations for the proposed replacement of two culverts as part of the Queensville Dam Removal Feasibility Study and Culvert Replacement Project. One culvert is located along Joffre Avenue and the other is located along Mountain Avenue in South Hadley, Massachusetts. A Site Locus is provided as Figure 1. Site Plans for the proposed culverts are provided as Figure 2 and Figure 3, respectively.

We anticipate that the proposed replacement structures will consist of open bottom concrete culverts with spans (widths) of less than 10 feet (approximate). Therefore, the proposed construction at these locations would not be subject to the Massachusetts General Laws (MGL) Chapter 85, Section 35 Review Process for Municipal Bridge Projects. We note that if the proposed span will be greater than 10 feet, but less than 20 feet, the proposed construction would be subject to (MGL) Chapter 85, Section 35 Review Process for Municipal Bridge Projects. However, the proposed construction would fall into the category of a BRI Bridge and the review process would be abbreviated.

Our preliminary geotechnical recommendations are based upon subsurface conditions observed in two soil borings, one at each location. The borings were extended to a depth of approximately 40 feet below ground surface. Our services consisted of 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 attached limitations.

This discussion includes geotechnical considerations and preliminary recommendations for culvert foundations and construction related issues. Based upon our experience with similar structures, it is likely that the culverts will be supported on shallow foundations (spread footings) bearing on a layer of Crushed Stone over natural soils. The footings may be either precast concrete elements or cast-in-place concrete. The type of foundation will depend on final structure type and span, subsurface conditions, dimensions, and loading.

Additional investigations during final design and note that a final design report will be needed. Per Section 1.2.4.2 of the MassDOT LRFD Bridge Manual, two borings are

required for culverts up to 50 feet in length. Three borings are needed for culverts greater than 50 feet in length.

INTRODUCTION

This report includes a discussion of subsurface conditions and geotechnical considerations, and provides preliminary engineering recommendations for foundation design of the proposed Joffre Avenue and Mountain Avenue culvert replacement structures in South Hadley, Massachusetts. The locations of the existing culverts are shown on the Project Locus Map, attached as Figure 1. Water flows from north to south through the existing culvert at each location.

One of the culverts crosses Joffre Avenue, approximately 50 feet to the west of the intersection of Joffre Avenue and Vivian Street. Topography along the roadway near this location is generally flat and slopes upwards towards the east, north, and west and downwards to the south, towards a wetland located approximately 250 feet to the south of the culvert. A design phase survey has not yet been completed; therefore, detailed ground surface topography was not available at this location. We note that the culvert is not visible from the ground surface. We understand that the existing culvert consists of a fully buried pipe; however, the type or elevation of the pipe was not provided to us. The approximate location of the existing culvert, based upon our limited observations during field work, is shown on the Boring Location Plan, attached as Figure 2.

The second culvert crosses Mountain Avenue, approximately 330 feet to the west of the intersection with Route 116. An existing conditions survey plan has been completed for this location, which was incorporated into Figure 3. Topography along the roadway near the proposed culvert is generally flat (approximate elevation 148 feet) and topography slopes downwards towards the northeast and southwest, towards the wetland areas. The existing culvert at this location consists of a 24-inch diameter corrugated metal pipe, with pipe inverts of 135.72 on the north side of Mountain Avenue and 130.28 feet on the south side. Therefore, the existing pipe is buried approximately 10 feet below the roadway surface. The location of the existing culvert is shown on the Boring Location Plan, attached as Figure 3.

We anticipate that the replacement culverts may consist of open bottom structures. The exact location, alignment, and size of the new structures were unknown at the time of this report. However, we understand that the culverts will likely be reinforced concrete structures, with a clear span on the order of 10 feet or less¹. In addition, we have assumed the proposed construction also includes the full depth excavation and reconstruction of the existing roadways on each side of the culverts. We have assumed that the reconstructed roadways will be near that of existing grades.

¹ Categorized as a BRI along a Rural Minor Collector/Rural Local Road/Rural Urban Collector/Urban Local Road.

SUBSURFACE EXPLORATIONS

Preliminary subsurface investigations consisted of two soil borings (QD-1 and QD-2), one at each site. The soil borings were performed on September 29, 2021 by Seaboard Drilling of Chicopee, Massachusetts using a Mobile B-53 truck mounted drill rig, using hollow stem drilling techniques or roller bit with wash drilling techniques. Boring QD-1 was performed on Joffre Avenue to the west of the existing culvert, and boring QD-2 was performed on Mountain Avenue to the west of the existing culvert. Borings QD-2 and QD-1 were extended to a depth of 39.1 and 42 feet below ground surface, respectively. Boring QD-2 (Mountain) encountered auger refusal in dense glacial till. Boring locations are shown on Figures 2 and Figure 3. Boring logs are attached.

The thickness of the existing asphalt and base course (if encountered) was measured and is documented on the boring logs. Soil samples were collected continuously or semi-continuously from below the existing pavement section to a depth of seven or nine feet and every five feet 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 D1586-99 "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 hammer efficiencies for each hammer type and drill rig.

An O'Reilly, Talbot & Okun Associates, Inc. (OTO) engineer observed and logged the borings. Samples were described according to a modified version of the Burmister Soil Classification System. Upon completion, bore holes were backfilled with soil cuttings and patched with asphalt, where applicable.

SUBSURFACE CONDITIONS

Subsurface conditions were interpreted based upon conditions encountered in the soil borings and as reviewed in published documents. In general, subsurface conditions consisted of a surface layer of asphalt; a gravel base course layer (where present); fill and/or reworked Site soils; varved silt and clay; and glacial till. Details are provided below.

Local Geology

Geologically, the Sites are located within the former Lake Hitchcock, which was a large post-glacial lake that formerly covered much of the Connecticut River Valley. The lake was present following the final retreat of the continental glaciers (which once covered all of New England) until about 14,000 years ago, when the natural dam that formed the southern edge of the lake was eroded and the lake drained. These sediments consist of thin, interbedded lenses of silt and clay (collectively known as varved clay). Along the edges of the lake the lake bottom deposits often contained significant amounts of sand.

Published geologic maps² indicate that the lake bottom deposits at the Site are on the order of 50 to 100 feet thick. Subsurface investigations performed for this study indicate that the clay extends to a depth of between 30 and approximately 50 feet below ground surface at the study locations.

Soil Conditions

Asphalt Pavement: The borings were performed in paved areas. The pavement consisted of 6 and 7 inches of asphalt at boring locations QD-1 and QD-2, respectively. At boring location QD-1 (Joffre), approximately 12 inches of base course was encountered beneath the asphalt. The base course consisted of dense, fine to medium sand with little amounts of gravel and coarse sand and trace amounts of silt. No base course was observed beneath the asphalt at boring location QD-2 (Mountain).

Fill/Reworked Site Soils: Fill was encountered beneath the asphalt pavement in both borings. The fill generally consisted of medium dense to dense, fine to medium sand, with varying amounts of coarse sand and silt. Trace amounts of debris (brick, coal, coal ash) were encountered boring QD-2 (Mountain). The fill extended to a depth of 5 and 6.5 feet at boring locations QD-1 and QD-2, respectively.

A thin layer of reworked Site soils (approximately 12 inches thick) was observed beneath the fill in boring QD-1 (Joffre). The reworked Site soils consisted of medium, clayey silt with trace amounts of fine to coarse sand and trace amount of fine gravel underlain by loose, fine to coarse sand with little amounts of silt and trace fine gravel.

Varved Silt & Clay: As stated above, the Site is located within the limits of the ancestral Lake Hitchcock, which filled much of the Connecticut River Valley from the retreat of the last continental glacier until approximately 14,000 years ago. The soil deposit associated with the glacial lake consists of alternating layers of silt, sand, and clay (collectively known as varved clay).

The native, varved silt and clay in the study borings consisted of medium stiff to very stiff, clay and silt or silt and clay with trace amounts of fine sand. Boring QD-1 (Joffre) was terminated within the varved silt and clay layer at a depth of 42 feet below ground surface.

Glacial Till: The varved silt and clay was fully penetrated and glacial till was encountered at a depth of 30 feet below ground surface (corresponding to elevation 118 feet) in boring QD-2 (Mountain). Glacial till is a very dense, heterogeneous mixture of silt, clay, sand and gravel, and is generally present immediately above bedrock throughout New England. Refusal was encountered and boring QD-2 was terminated within the glacial till at a depth of 39.1 feet. Refusal was likely upon dense, glacial till.

² Langer, W.H. (1979). "Map Showing Distribution and Thickness of the Principal Fine-Grained Deposits, Connecticut Valley Urban Area, Central New England", *Miscellaneous Investigations Series*, USGS Map No. 1-1074-C, Sheet 1 of 2.

Groundwater Conditions

Groundwater was first encountered at a depth of three feet below ground surface (elevation information was not available at this location) in boring QD-1 (Joffre). Groundwater was first encountered at a depth of five feet below ground surface (corresponding to elevation 143 feet) in boring QD-2 (Mountain). We note that these depths/elevations are higher than the culvert inverts and indicate perched groundwater layers. The depth to groundwater below the perched layers could not be determined due the drilling method utilized (drive and wash drilling techniques, which introduces water to the borehole, were utilized to complete the borings).

We note that continuous flow of water was observed in both of the existing culverts at the time of drilling, and it appears that water flows within the culverts during most, if not all of the time. Therefore, we expect that groundwater will be encountered during the replacement of the culverts. The level of the water will likely be dependent upon the time of year and precipitation patterns, and we recommend that this issue be evaluated in detail during the final design. Preliminary dewatering considerations are provided below.

GEOTECHNICAL CONSIDERATIONS AND PRELIMINARY RECOMMENDATIONS

The following recommendations are provided for preliminary design of foundations. Foundations will be designed to resist lateral and vertical loads. Vertical loads consist of downward pressures due to the dead weight of the structure, the overlying fill and live traffic loads, as well as uplift pressures due to lateral loads on the sides of the culvert (such as seismic forces). All foundations should be designed according to requirements provided in the 2013 MassDOT *LRFD Bridge Manual*, with 2020 Revisions (MassDOT) and the most recent edition of the *AASHTO LRFD Bridge Design Specifications* (AASHTO).

Details associated with the replacement structures were not available at the time of this report, as this was a preliminary assessment of soil conditions. However, we understand that the replacement structures will likely be a box culvert or open bottom precast concrete structure (preferred). The third alternative would be to construct a traditional short span bridge to carry the roadway over the stream. However, based upon cost, this third alternative appears unlikely.

Based upon our experience, the first two alternatives would likely be supported on shallow foundations bearing on a Crushed Stone layer over natural soils. If the traditional short span bridge alternative is selected, that structure would likely be supported on driven piles deriving their capacity in dense soils present at a depth of 50 feet or more below ground surface.

Embankment Considerations

We anticipate that the project will not include any new embankments based upon the existing grades as roadway approaches at each culvert. Therefore, the only fill anticipated as part of this project will include backfill beneath foundation systems and against the

sides of the new culvert, and Gravel Base Course layers immediately below pavements. Therefore, no geotechnical concerns have been identified associated with the settlement or stability of embankment soils. We have assumed that any slopes on each side of culverts will be armored to protect against erosion. Provided the earthwork recommendations provided below are followed, side slopes at 2H:1V or flatter appear appropriate. However, we recommend that the stability of slopes be reviewed during final design.

Shallow Foundation Design

Based upon our understanding of the project, we anticipate that the streams will be channeled through either new concrete culverts or a precast concrete open bottom structure. Both structure types will be transported to the Site in segments and assembled in place. The design of the new elements will depend on roadway traffic, the depth and width of the section, Site access, and other construction consideration. The base of the structures should be constructed below the anticipated scour depth (under the design flood) and any foundations should bear at least 48 inches below the lowest adjacent grades for frost protection, whichever is deeper. The soils encountered near the anticipated foundation subgrade, at each proposed culvert location, will likely consist of the varved silt and clay. We note that the varved silt and clay is relatively compressible and is moderately erodible. Both these conditions need to be considered in final design.

We recommend that the proposed footings bear on crushed stone bearing on natural soils below the fill and reworked Site soils (which were present to a depth of 6.5 feet below the roadway surface but may extend deeper along the embankments). We note that organic soils may be present within foundation subgrades for the headwalls and culvert structure, based upon the presence of the nearby wetlands.

The fill and reworked Site soils encountered within the borings should be removed from beneath any shallow foundations. Organic soils should not be reused as fill beneath structures or pavements. Organic soils, non-engineered fill, and soft or disturbed areas should be removed and replaced with compacted Crushed Stone (MassDOT Specification M2.01.7) or Gravel Borrow (M1.03.0 Type B). Crushed Stone may be used to establish a firm subgrade below the groundwater table, as described below.

We recommend the following design parameters (presented in Table 1) be used for preliminary design for an open bottom culvert supported by spread footings. We note that these recommendations are preliminary and that final parameters will need to be determined based upon design loading conditions. The minimum footing width should be 24 inches.

Table 1
Preliminary Design Parameters

Parameter	Value
Strength Limit State – Nominal Bearing Resistance	4,000 psf
Strength Limit State – Factored Bearing Resistance	2,000 psf
Service Limit State – Bearing Resistance for Settlement of 1 inch	1,500 psf
Bearing Resistance Factor (AASHTO Table 10.5.5.2.2-1)	0.50
Coefficient of Friction for Sliding (AASHTO Table 3.11.5.3-1)	0.31
Sliding Resistance Factor (AASHTO Table 10.5.5.2.2-1)	0.85

The subgrade within the footprint of the proposed culverts and head/wing walls should be stripped of topsoil, organic soils, non-engineered fill, and any soft or loose soils. Based upon the proposed construction and the investigations performed for this study, we anticipate that the culvert and retaining walls will be founded upon the varved silty clay or clayey silt. Final excavations into the fine-grained subgrade should be performed using a smooth bladed bucket to limit disturbance of the clayey soils.

We recommend that foundation subgrades be over-excavated by a minimum of 12 inches and that Dense Graded Crushed Stone (M2.01.7) be placed to protect the subgrade from disturbance and provide a leveling pad for foundations. The Crushed Stone pad should be placed one foot beyond the edges of the footing and at a one horizontal to one vertical (1H:1V) slope down to native soils. The Crushed Stone should be wrapped with a non-woven geotextile filter fabric to inhibit the migration of soil particles into the Crushed Stone layer.

We estimate that settlement of the culverts bearing on Crushed Stone over natural soils should be small and largely elastic in nature. Maximum settlements should be less than 1.0 inch and should occur relatively quickly after load application (during construction).

Lateral Earth Pressures against Culvert and Retaining Walls

Static lateral earth pressures will be imposed on the rear of retaining walls, such as the culvert side walls, and the approach headwalls and wing walls. These walls should be designed for soil pressures and unbalanced loading conditions. The lateral forces against the wall will depend on whether or not the top of the wall is restrained. Rigid, braced walls (such as the culvert side walls) should be designed using an equivalent static fluid pressure equal to 55 pounds per square foot. Unbraced retaining walls (such as approach headwalls) that are free to deflect inward (cantilevered) may be designed using an equivalent fluid pressure of 35 pounds per cubic foot. The soil against the rear of retaining walls should not be over-compacted since this would greatly increase lateral loads against the walls. This assumes no unbalanced hydrostatic pressures (free draining backfill, seismic forces, or traffic surface loads). A traffic surcharge will need to be applied.

We recommend that passive resistance of soils in front of walls only be considered if not subject to erosion, with a minimum factor of safety of 1.5.

The final design of segmented block walls (which may be included in roadway approaches to the stream crossing) should address both internal and external drainage consistent with the wall manufacturer's guidelines. The approach walls should include at least one-foot width of pervious backfill (such as Crushed Stone, M2.01.7), perimeter drainage, and weep holes to allow drainage of surface water infiltration and relieve hydrostatic pressures behind the walls. A geotextile fabric should be placed between the Crushed Stone support layer below footings and the natural soil/granular backfill material.

Seismic Design Category Evaluation

Earthquake loadings must be considered under requirements of the 2013 MassDOT *Bridge Manual*, with 2020 Revisions (MassDOT) and the most recent edition of the AASHTO *LRFD Bridge Design Specifications* (AASHTO). However, per AASHTO Article 3.10.1, seismic effects need not be considered for box culverts and buried structures, except where they cross active faults. In addition, a seismic design is not considered mandatory for Sites where the Site adjusted peak ground acceleration is less than or equal to 0.4g (AASHTO Article 11.5.4.2). Neither of these conditions appear to apply for either of the study locations. However, the potential for soil liquefaction and slope movements under extreme events should be considered.

If seismic effects need to be considered, 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*³ 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 (approximate 1,000-year return period).

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). The Site Class was determined to be Class D for each location based upon soil data collected and general knowledge of the Site vicinity. Furthermore, the Site coefficients F_{pga} , F_a , and F_v were determined using the PGA, S_s , and S_1 values and the Site Class. For this Site, F_{pga} , F_a , and F_v were determined to be 1.6, 1.6, and 2.4, respectively. This classification should be reviewed during final design.

³ <https://earthquake.usgs.gov/ws/designmaps/> accessed in December 2021.

Liquefaction Potential

The potential for liquefaction was evaluated for the Site soils beneath the groundwater table. Based upon conditions encountered in the soil borings, liquefaction is unlikely to occur under the design earthquake.

Flexible Pavement Design

We understand that the project will likely include pavement reconstruction in areas disturbed by the replacement of the culverts. We have assumed that the extent of pavement reconstruction will be minimal and will match that of the existing pavements. We recommend the thickness of the new pavements be consistent with the existing pavements and meet minimum requirements of the Town of South Hadley.

We recommend that the pavement subgrade be proof compacted to treat any loose areas present. The granular base course should meet the gradation requirements for MassDOT Specification M1.03.1, Processed Gravel for Subbase. All other requirements of the MassDOT Standard Specifications for Highways and Bridges should be followed.

PRELIMINARY CONSTRUCTION CONSIDERATIONS

These recommendations are provided for preliminary review of the project and should be reviewed with consideration to final design of the project. Supplemental investigations will be required for final design.

Groundwater and Surface Water Control

Groundwater was encountered in the upper three to five feet of each boring, indicating perched water layers above the existing culvert invert elevations. The depth to groundwater below the perched layers could not be determined due the drilling method utilized (drive and wash drilling techniques were utilized to complete the borings).

We anticipate that a dewatering/groundwater control system will be required during construction. Any surface water runoff and groundwater infiltration encountered during the excavations will need to be controlled via a positive cutoff wall (such as a sheet pile wall, dewatering wells, or trenching and sumps). We also anticipate that temporary water controls (such as cut off walls, temporary cofferdams, or bypass pumping) will be needed to divert the stream during construction. We recommend that careful consideration be given to groundwater control and stream diversion during final design. We note that is important to keep the excavation stable and dry.

Supplemental investigations, such as test pits and/or the installation of piezometers, should be considered to determine and document groundwater levels prior to final design.

Excavations and Demolition of Existing Culvert

We understand that the existing culvert structure will be removed in their entirety. Existing structures (e.g., abutments, piers, utilities) outside of the new foundation area should be removed to at least 24 inches below the final ground surface or the bottom of the new pavement section. Any excavations resulting from the removal of existing foundations, piles, abutments, utilities, or other structures should be backfilled with compacted engineered fill, consistent with the recommendations provided below.

Soil may become unstable when excavations extend deeper than four feet. Shoring or sloping will be necessary to protect personnel and to provide stability. The soils encountered in the upper 6 feet in the borings were 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°), provided the water levels are below the bottom of the excavation. We note that the varved clay soils encountered below the upper granular soils may be considered a Type B soil. The maximum allowable slope for excavations of Class B soils is 1H:1V (45°), provided the water levels are below the bottom of the excavation. All excavations should conform to current OSHA requirements.

In areas where sloping is not feasible, excavations may require temporary earth support systems during construction. The design 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 personnel during construction. We note that protective systems for any excavation exceeding 20 feet in depth must be designed by a registered professional engineer.

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) may contain or be covered with materials containing asbestos. Such materials should be handled in accordance with MassDEP 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.

Engineered Fill Recommendations

We anticipate that engineered fill will need to be imported for this project, such as the following MassDOT material specifications:

- M1.03.0 Type B: Gravel Borrow for use immediately behind abutments and retaining walls and below footings
- M2.01.7: Dense Graded Crushed Stone for use immediately below abutments and footings and in place of Gravel Borrow (as needed)
- M1.03.1: Processed Gravel for Subbase for use immediately below pavements
- M1.01.0: Ordinary Borrow for use as miscellaneous fill

Due to the high silt and clay content and variability in composition, it is unlikely that the native Site soils and near surface fill will be suitable for reuse as engineered fill.

Fill materials should be free of debris, organics, and other unsuitable materials. If loose non-engineered fill or wet/disturbed soils are observed in the excavations, they should be removed and replaced with Crushed Stone. Any organic soils found in excavations should not be reused as fill. To avoid point loads, any cobbles or boulders larger than four inches in diameter encountered at the subgrade should be removed and replaced with Crushed Stone.

Compaction Recommendations

Fill placed beneath foundations should be densified to at least 95% of the Modified Proctor dry density as defined in ASTM D1557, Method C. General fills should be placed in lifts of no more than 9 inches and compacted with at least four passes with a vibrating drum roller (minimum of 3,000-pound weight). We note that fills placed immediately beneath pavements shall be compacted in lifts of 6 inches or less. In tight areas around the new culvert or existing utilities and structures, it may be necessary to place the fill in 6-inch lifts and use a vibratory plate compactor. To facilitate compaction, the moisture content of the on-Site material should be maintained at or near the optimum moisture content.

Compaction within five feet of foundations or headwalls should be performed using a hand-operated roller or vibratory plate compactor. Placement and compaction of engineered fill around foundations should proceed on both sides of the wall so that the difference in top of fill on either side does not exceed two feet. Headwalls should be designed for unbalanced loading conditions and the engineered fill within ten feet of the wall should be compacted using hand-operated plate or drum rollers weighing 250 pounds or less.

FINAL DESIGN RECOMMENDATIONS AND SUPPLEMENTAL INVESTIGATIONS

Additional borings will be required, either during final design or early during construction. Per Section 1.2.4.2 of the MassDOT LRFD Bridge Manual, two borings are required for culverts up to 50 feet in length. Three borings are needed for culverts greater than 50 feet in length. We note that because of certain physical conditions which may prevent access to additional boring locations, borings may be included in the construction contract. However, we recommend that efforts be made to obtain required subsurface information during design phases.

In addition to borings, we recommend that additional investigations, such as test pits and piezometers, be considered during final design to provide additional information regarding soils at the bearing depth of the new culverts and groundwater levels. However, we understand that accessible locations are likely limited, and possible locations will need to be explored, as described above. We recommend that selected samples be analyzed in the laboratory for grain size distribution, moisture content, and Atterberg limits to estimate the behavior of the soil. Additional laboratory testing may be required to evaluate erodibility, hydraulic conductivity, and compressibility of the Site soils.


It is recommended that O'Reilly, Talbot & Okun Associates, Inc. (OTO) be retained during final design to prepare the final design geotechnical report and to review appropriate specification sections and drawings, if necessary. During construction phases, we recommend that OTO be retained to provide engineering support and to document subgrade conditions and preparation. Earthwork observation during construction should occur during the removal of existing fill and subgrade preparation.

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

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



Ashley L. Sullivan P.E.
Principal

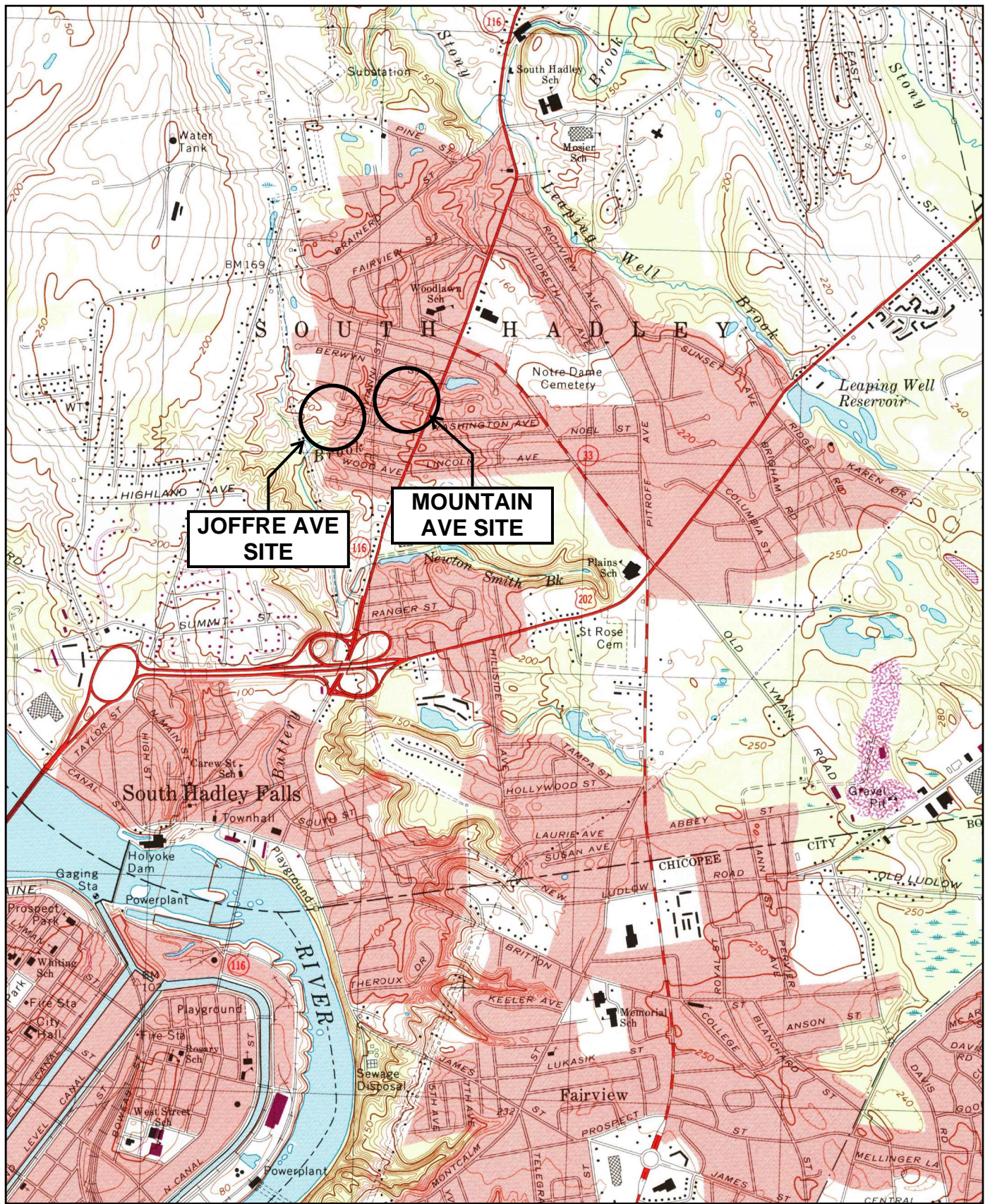


Michael J. Talbot, P.E.
Reviewer

Attachments: Limitations, Figures, Boring Logs

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. Observations were made of the site and site structures; however no opinion is rendered as to the condition of portions of the site or site structures where access was limited or unavailable.
5. The response of the watershed was analyzed for storm conditions stated herein. For other conditions other than those analyzed, the response of the watershed has not been evaluated.
6. In reviewing this report, the condition of the dam as reported is based upon observations of field conditions at the time of site visits, along with review of data available to O'Reilly Talbot & Okun Associates, Inc. It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.
7. 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.
8. 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.



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

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

293 Bridge Street, Suite 500 Springfield, MA 01103 413.788.6222
www.OTO-ENV.com

CULVERT REPLACEMENT
JOFFRE AVENUE AND MOUNTAIN AVENUE
SOUTH HADLEY, MASSACHUSETTS

SITE LOCUS

Topographic Map Quadrant:
SPRINGFIELD NORTH, MA

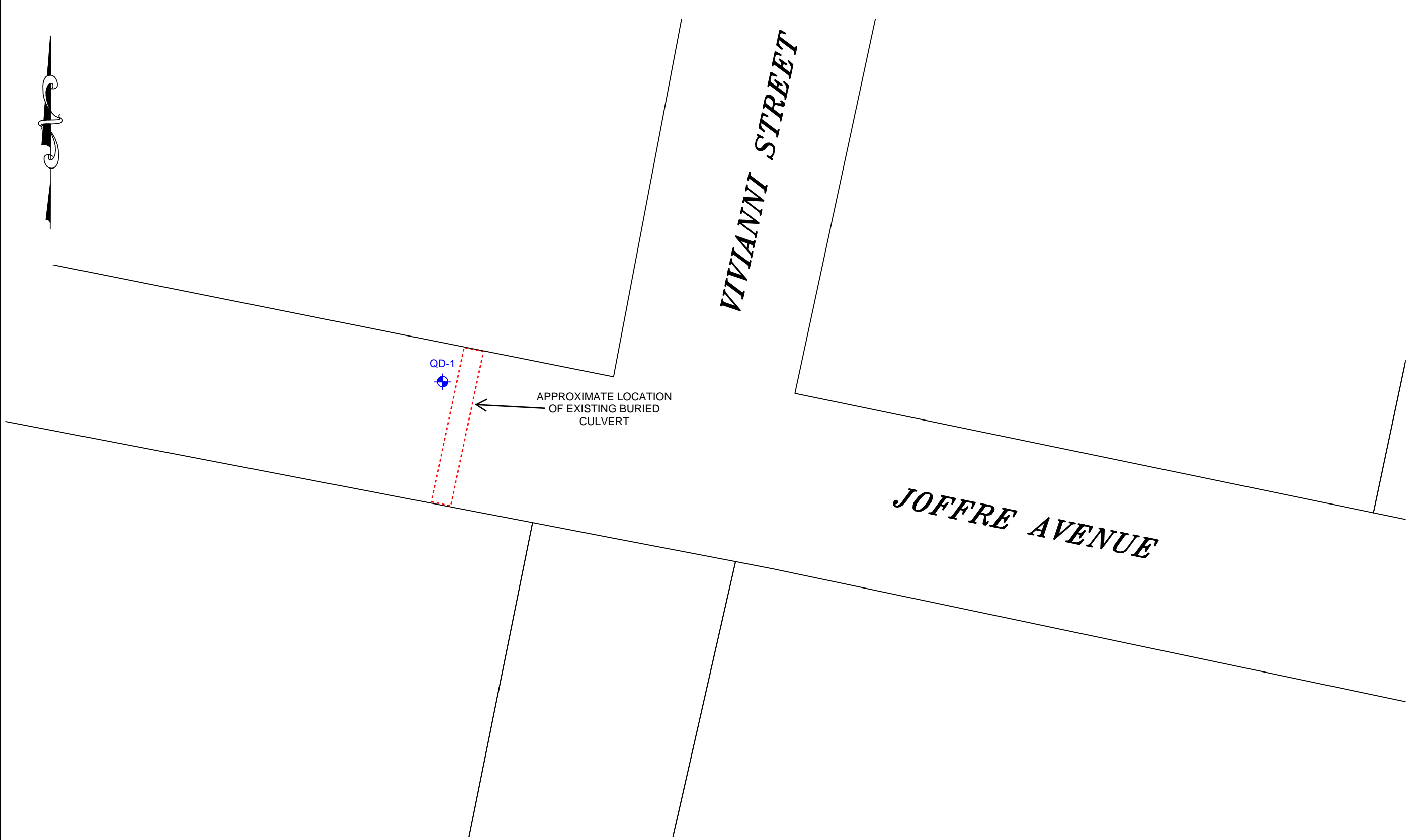
Map Version: 1972
Current As Of: 1979
Date: DECEMBER 2021

PROJECT No.
J2950-11-01


FIGURE No.
1

OU20002950.Fras & ONell11-01 South Hadley Dam Removal and Culvert Replacement - Geotech\Figures\Figure 1 - Site Locus.pdf

O:\2950\2950_Fuss & O'Neill\11-01 South Hadley Dam Removal and Culvert Replacement - Geotech\Figures\Figure 2 - Site Plan (Joffre Ave).pdf

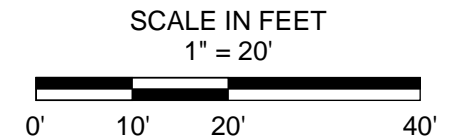


LEGEND:

 APPROXIMATE SOIL BORING LOCATION PERFORMED BY SEABOARD DRILLING ON 9/29/2021, OBSERVED BY OTO

NOTES:

1. PLAN CREATED IN PART FROM PLAN TITLED "PARTIAL EXISTING CONDITIONS" SHEET 4 OF 4 BY SHERMAN & FRYDRYK DATED 1/24/2022.
2. SAMPLE LOCATIONS ARE SHOWN ACCORDING TO GPS COORDINATES, TAKEN ON 12/28/2021
3. ALL DATA IS TO BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHODS USED IN THE DEVELOPMENT OF THIS PLAN.



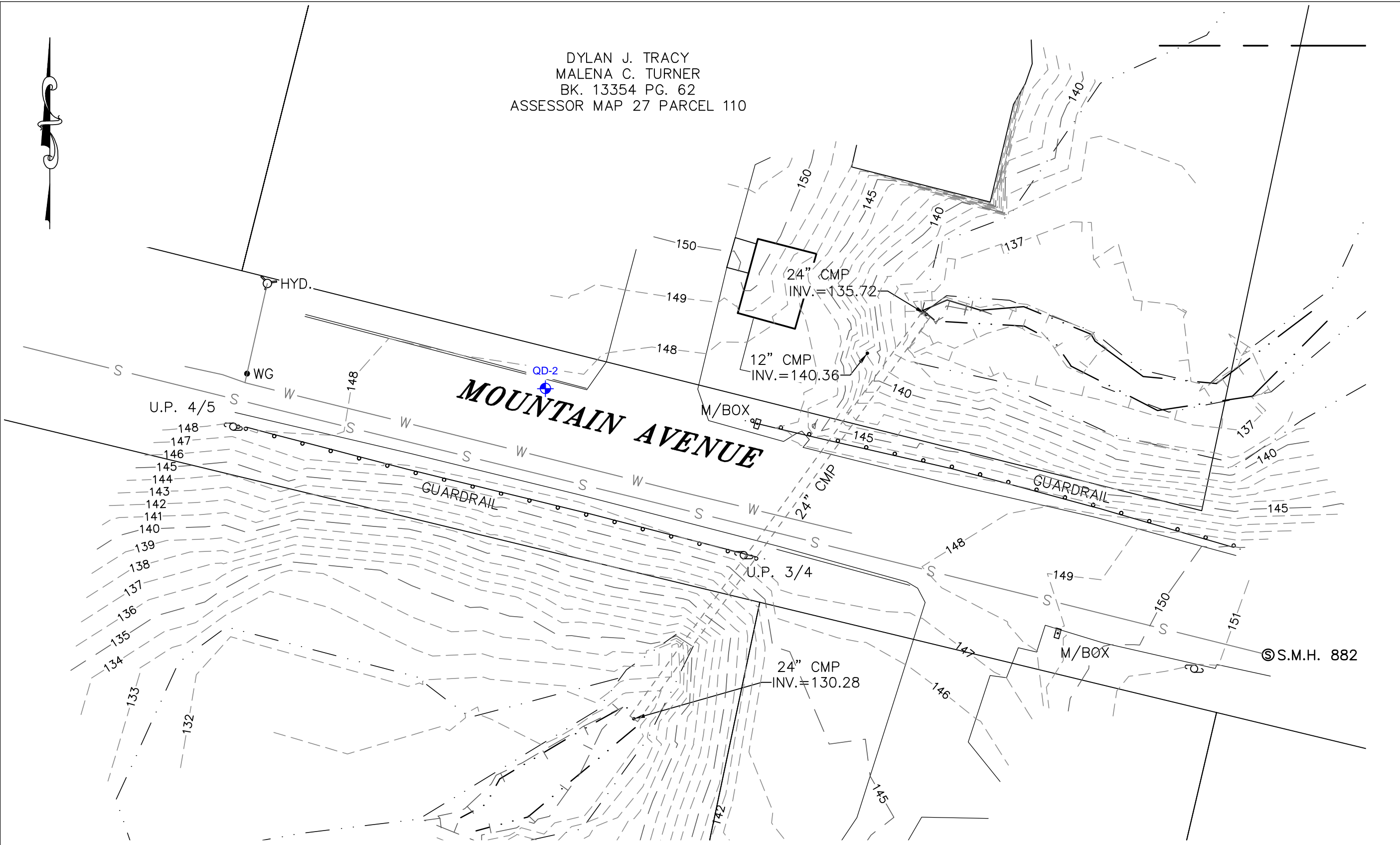
DESIGNED BY: JE
 DRAWN BY: JE
 CHECKED BY:
 DATE: 2/4/2022
 REV. DATE:

CULVERT REPLACEMENT
 JOFFRE AVENUE
 SOUTH HADLEY, MASSACHUSETTS
SITE PLAN


PROJECT NO.
J2950-11-01

FIGURE NO.
2

DYLAN J. TRACY
 MALENA C. TURNER
 BK. 13354 PG. 62
 ASSESSOR MAP 27 PARCEL 110

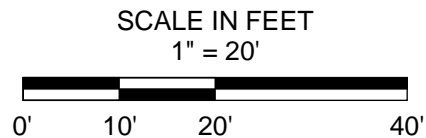


LEGEND:

 APPROXIMATE SOIL BORING LOCATION PERFORMED BY SEABOARD DRILLING ON 9/29/2021, OBSERVED BY OTO

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.



O:\2950\2950_Fuss & O'Neill\11-01_South Hadley Dam Removal and Culvert Replacement - Geotech\Figures\Figure 2 - Site Plan (Mountain Ave).pdf

O'Reilly, Talbot & Okun
 ENGINEERING ASSOCIATES
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DESIGNED BY: JE
 DRAWN BY: JE
 CHECKED BY:
 DATE: 2/4/2022
 REV. DATE:

CULVERT REPLACEMENT
 MOUNTAIN AVENUE
 SOUTH HADLEY, MASSACHUSETTS
SITE PLAN

PROJECT NO.
J2950-11-01
 FIGURE NO.
3

BORING LOGS

SUMMARY OF THE BURMISTER SOIL CLASSIFICATION SYSTEM (MODIFIED)

RELATIVE DENSITY (of nonplastic soils) OR CONSISTENCY (of plastic soils)

STANDARD PENETRATION TEST (SPT)
<p>Method: Samples were collected in accordance with ASTM D1586-99, 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.</p> <p>N-Value: The number of blows with a 140 lb. hammer required to drive the sampler the middle 12 inches.</p> <p>WOR: Weight Of Rod (depth dependent)</p> <p>WOH: Weight Of Hammer (140 lbs.)</p>

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
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	Nonplastic	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

<p>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.</p> <p>Varved clay: Fine-grained, post-glacial lake sediments characterized by alternating layers (or varves) of silt, sand and clay.</p> <p>Fill: Material used to raise ground, can be engineered or non-engineered.</p>

COMMON FIELD MEASUREMENTS

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

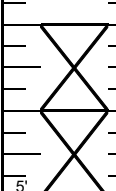
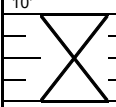
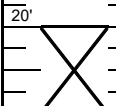
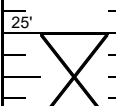
Penetrometer: Unconfined compressive strength is estimated using a Pocket Penetrometer (PP). Values in tons/ft².

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.

LOG OF BORING QD-1









PROJECT	Queensville Dam Removal and Culvert Replacements			CONTRACTOR	Seaboard Environmental Drilling			
JOB NUMBER	2950-11-01	FINAL DEPTH (ft)	42.0	DRILLING EQUIPMENT	B-53 Truck Mounted Rig			
LOCATION	South Hadley, MA	SURFACE ELEV (ft)	--	FOREMAN	Mike G	CASING		
START DATE	9/29/2021	DISTURBED SAMPLES	9	HELPER	Ben B	CASE DIAMETER	3"	
FINISH DATE	9/29/2021	UNDISTURBED SAMPLES	--	BIT TYPE	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 Joffre Avenue		FIRST (ft)	3.0	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				SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE		REMARKS/ WELL CONSTRUCTION
	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA		DEPTH (ft)	ELEV.	
	22/18/16/13	9/24	S-1 (1-3')	--	8": ASPHALT Top 7": Dense, brown, fine to medium SAND, little gravel, little coarse sand, trace silt, damp (BASE COURSE) Bottom 2": Dense, dark brown, fine to medium SAND, some silt, trace coarse sand, damp (FILL) No recovery, Likely pushing rock	ASPHALT		1
	8/7/6/4	0/24	S-2 (3-5')	--		BASE COURSE	1.5	
	6/3/3/6	9/24	S-3 (5-7')	--	Top 4": Medium, gray, clayey SILT, trace fine to coarse sand, trace fine gravel (REWORKED SITE SOILS) Middle 2": Loose, dark brown, fine to coarse SAND, little silt, trace fine gravel Bottom 3": Medium, gray, SILT and CLAY, trace fine sand (Varved)	FILL	3.0	
	2/2/3/4	19/24	S-4 (10-12')	PP=1.25 TSF TV=0.45 TSF	Medium, gray with slight rust staining, CLAY and SILT, trace fine sand (Varved)	REWORKED SITE SOILS	6.5	2
	3/4/5/5	20/24	S-5 (15-17')	PP=0.25 TSF TV=0.15 TSF	Stiff, gray, CLAY and SILT, trace fine sand (Varved)	VARVED SILT AND CLAY		
	2/5/6/5	1/24	S-6 (20-22')	--	Stiff, gray, CLAY and SILT, trace fine sand (Varved)			
	4/6/5/5	18/24	S-7 (25-27')	PP=0.75 TSF TV=0.3 TSF	Stiff, gray, SILT and CLAY, trace fine sand (Varved)			

Remarks: 1. Began drilling with wash after sampling S-2 2. Began open hole drilling at 10 feet, after sampling S-4 3. Undrained shear strength estimated in field using E285 Pocket Torvane (TV). Values in tons/ft ² . 4. Unconfined compressive strength estimated in field using Pocket Penetrometer (PP). Values in tons/ft ² .	PROJECT NO. 2950-11-01
	LOG OF BORING QD-1

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				SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE		REMARKS/ WELL CONSTRUCTION
	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA		DEPTH (ft)	ELEV.	
	12/10/8/7	13/24	S-1 (0.5-2.5')	--	7": ASPHALT Medium dense, dark brown to black, fine to medium SAND, some coarse sand, little silt, trace debris (brick, coal), damp (FILL)	ASPHALT 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)	▽ 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	
		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)		
		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)		
		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)		
		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-3 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

