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Subsurface Exploration
Foundation Specialty Systems

Laboratory Soil Testing
Ground Improvement

Geothermal Testing
Earthwork Testing

28 September 2021
File No. 2140

ESS Group, Inc.
404 Wyman Street – Suite 375
Waltham, MA 02451

Attention: Jason Gold, PE

Subject: ***Geotechnical Data Summary Report***
Proposed Alum Tanks' Site – 110 Shore Drive
Worcester, Massachusetts

Dear Jason:

This geotechnical data summary report provides our site background data review, subsurface explorations, field soil and bedrock review, engineering data summary, analyses and calculations for the proposed alum tanks' foundation on Shore Drive in Worcester, Massachusetts (*Figure 1A: Project Vicinity*).

Figure 1A: Project Vicinity

45 New Ocean Street – Suite A
Swampscott, MA 01907
Tel. 617/201-0914

354 Ashburnham Street
Fitchburg, MA 01420
Tel. 781/646-6982

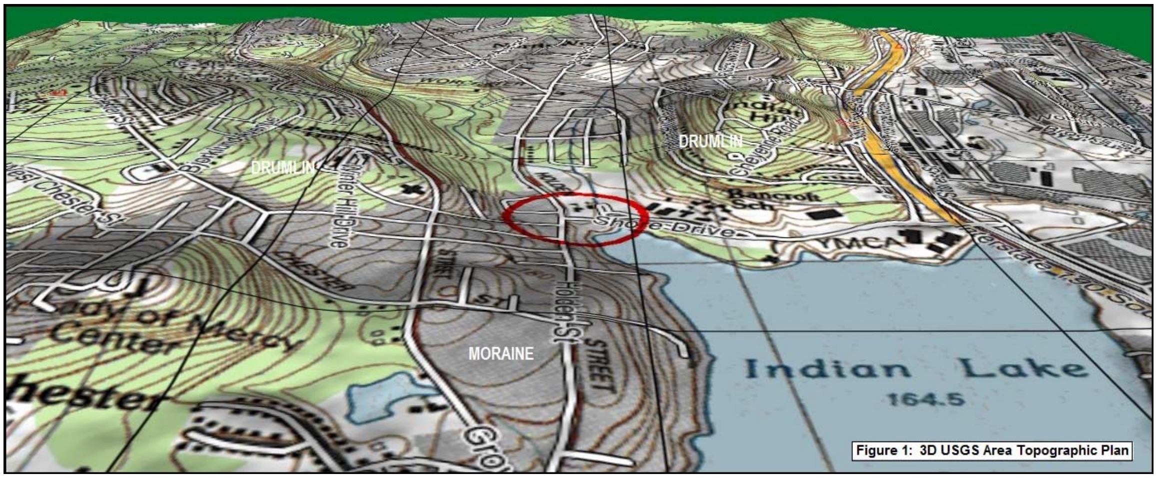


Figure 1: 3D USGS Area Topographic Plan

I. Proposed Construction:

Existing Conditions:

- Plan reference: an untitled pre-development site plan prepared by ESS Group dated 15 November 2019 (*Figure 2*).

- Direction, Datum, Elevation and Coordinates:
  - Direction:
    - Plan north: *Figure 1A, Figure 1*
    - Called north for this review: in the general direction of Ararat Street (*Figure 1*).
  - Elevation and datum:
    - Vertical elevations:
      - Site topographic elevations were provided on the 2019 site plan (*Figure 2*).
      - The alum tank locus was field estimated to be relatively level (*Figure 5)*.
    - Elevation datum:
      - No elevation datum was referenced on the 2019 site plan.
      - No elevation datum (e.g. NAV88) has been assumed in this review.
  - Site coordinates:
    - Latitude: 42.4043° N
    - Longitude: -71.0596° W

- Existing Site Conditions:
  - No attempt has been made to undertake a detailed history of this site. Historic review is included in research for environmental site assessments.
    - 1896 historic property mapping showed the site to be undeveloped. Shore Road did not exist. Indian Lake was known as North Pond (refer to *Figure 1B*).
    - 1900, 1917 and 1922 historic property maps revealed the same site conditions as shown in 1896.
    - Recent work on Shore Drive (reconfiguration) appears to have changed the ground surface on at least part of this site by addition of some leveling fill (see *Figure 1A*).
  - Site area topography is slightly sloping to steeply sloping (*Figure 1*).
    - The site is situated on a relatively level section of Shore Drive (*Figure 1*).
    - The work area itself is estimated to have less than 2 vertical feet of grade change (*Figure 2*).
  - Active site underground utilities lists are held by the test boring contractor. A Department of transportation steel cover box was found on-site near Shore Drive.

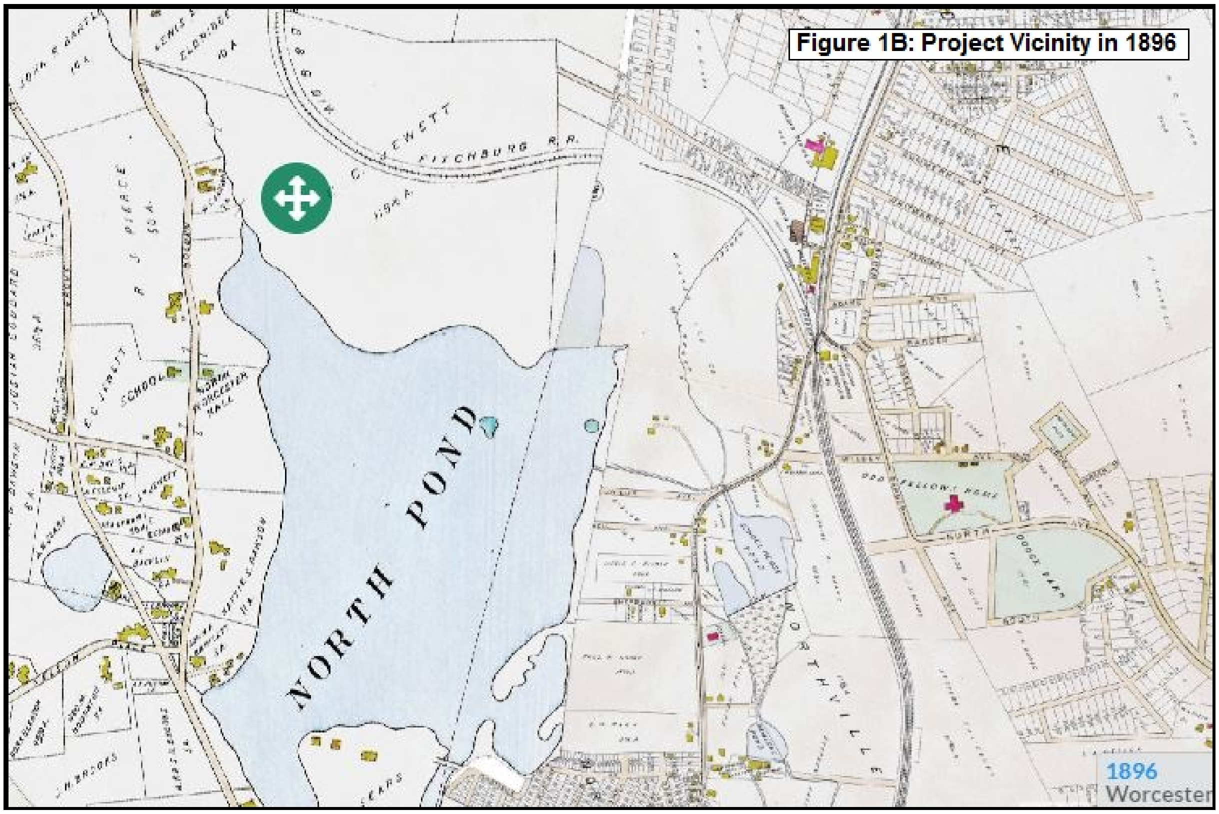


Figure 1B: Project Vicinity in 1896

Anticipated New Construction:

- <u>Plan Reference</u>:
  - *Proposed Construction City of Worcester – Notice of Intent Permitting Plans – 110 Shore Drive Worcester, MA 01605;* prepared by ESS Group of Waltham, MA; dated 6 October 2020.

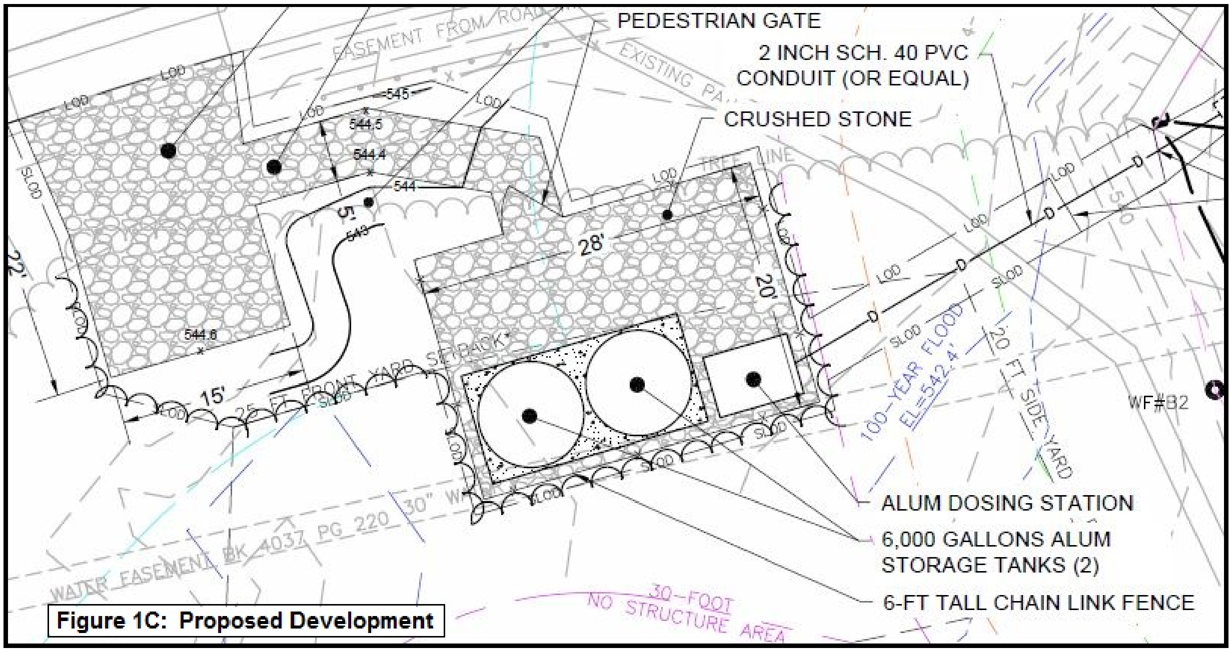


Figure 1C: Proposed Development

- Alum Tank Installation Information: (refer to *Figure 1C*)
  - New construction:
    - Two 6000 gallon tanks
    - Assumed mat support or circular footing support.
  - Mat foundation:
    - Top of mat elevation: estimated at El. 543 ft.+/- (Figure 2)
    - Applied mat load (assumed maximum) per Tripi Engineering Services: 1.5 KSF
    - Bottom of mat perimeter frost wall: at recommended frost depth (*Figure 5*)

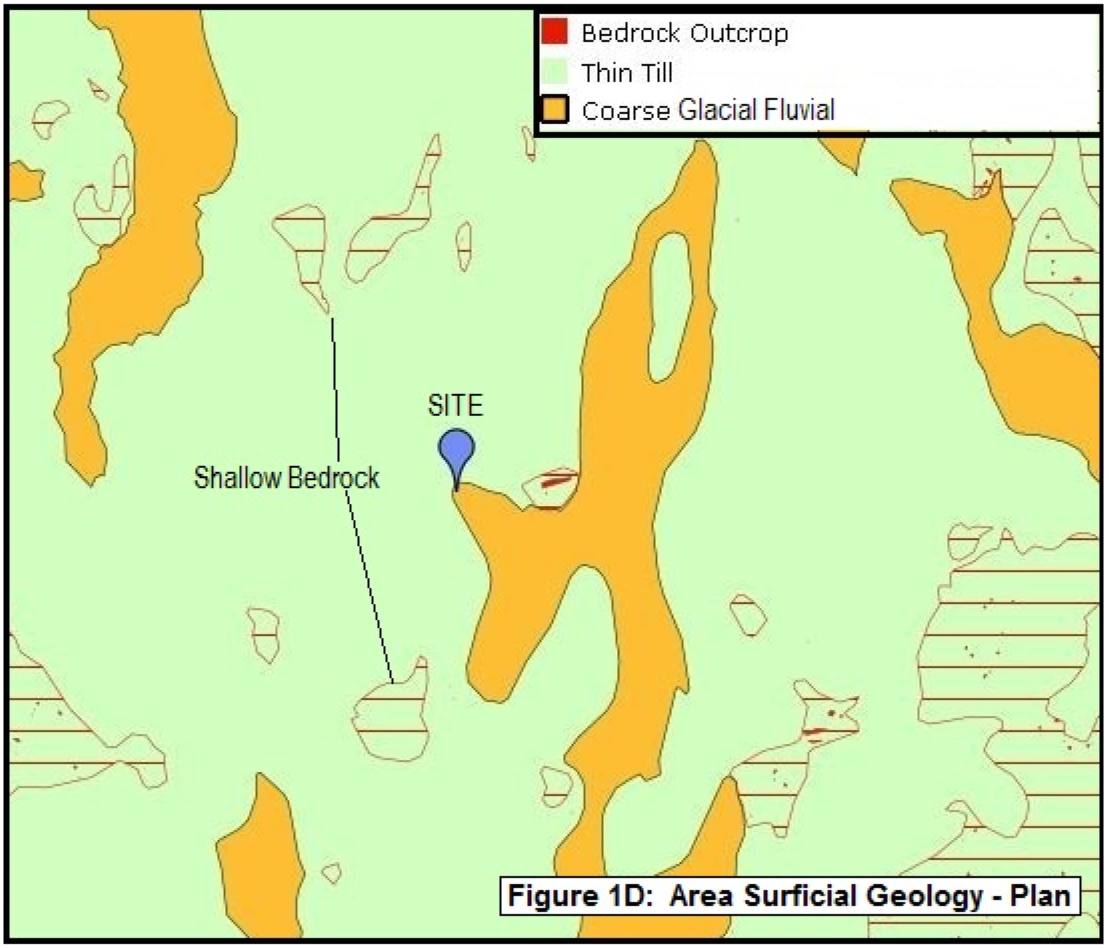


Figure 1D: Area Surficial Geology - Plan

II. Subsurface Conditions:

Topographic Data:

- Elevation Range: The immediate site area topography is slightly to steeply sloping.

- Area Surficial Geology:
  - Area surficial geology is the result of glacial advance and retreat and post-glacial surface changes.
    - The result was extensive land areas of glacial moraines and glacial drumlins (*Figure 1, Figure 1D-1*) and included glacial outwash plains.
    - The glacial drumlin and moraine formations were left behind by glacial scour and melt.

        - Areas near rivers and streams also had alluvial (river flood) contributions within their lowland formation (alluvial land) as contrasted with glacial outwash plains (*Figure 1D-1*).
        - According to *Figure 1D-1*, 110 Shore Drive is situated on or near the nose of a glacial drumlin formation; however *Figure 1D* reveals the site native subsoil is likely thinly bedded over shallow bedrock.
            - Glacial moraines are an accumulation of glacial drift (silt, sand and gravel) within a glaciated region by deposition and thrust of glacial ice (bulldozed material. Exposed bedrock is common.
            - Glacial drumlins are oval hills of clay, silt, sand and gravel compacted under pressure at the base of hundreds of vertical feet of glacial ice. A drumlin's axis indicates the direction of ice movement (compacted material).
            - An alluvial plain is formed by granular soil left behind by the repeated river flooding providing the silt, sand and gravel commonly found in the relatively level areas beyond the local moraine below fill. Glacial fluvial (outwash plain) soils are similarly formed within glacial meltwater.
    - According to area surficial geologic mapping utilizing the site latitude and longitude coordinates [*Massachusetts GIS, Surficial Geology;* Commonwealth of Massachusetts Office of Geographic Information; September 2012; updated 2018] the site was predicted to be situated upon one or both of the following surficial native soil units:
        - Glacial outwash: water sorted silt, sand and gravel
        - Glacial till (ablation till; basal till)

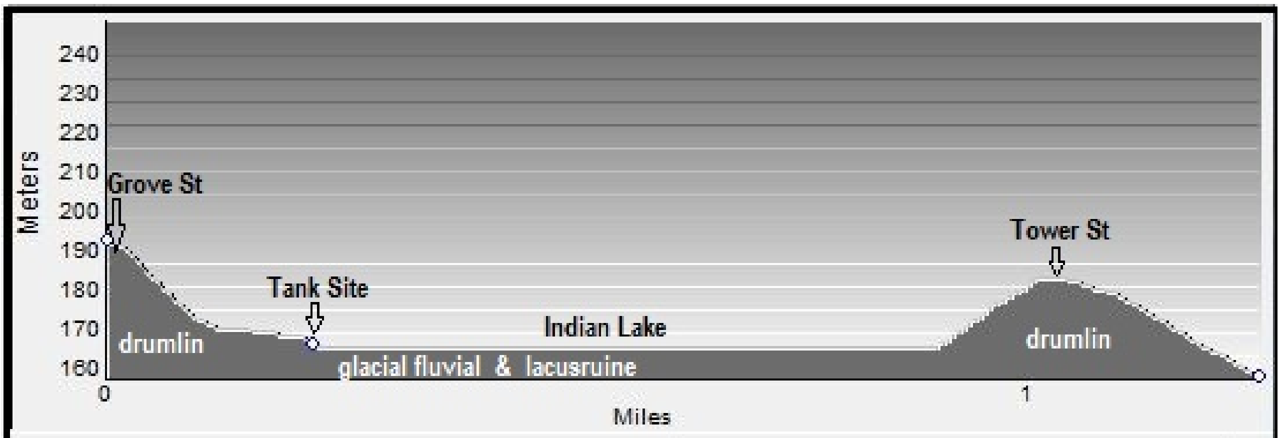
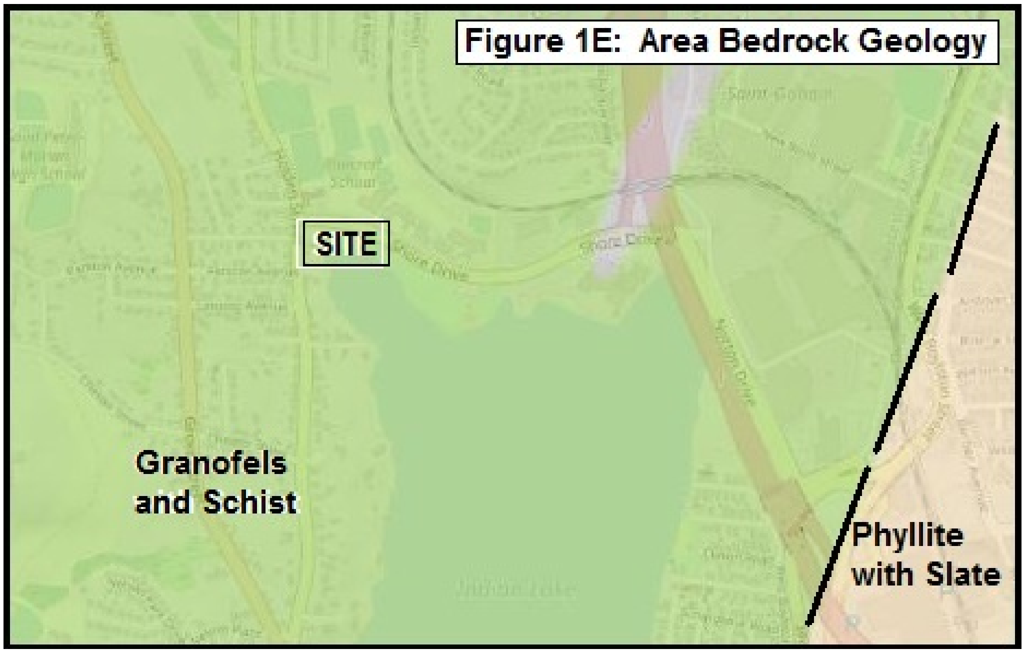


Figure 1D-1: Area Surficial Deposits - Profile

- Water Bodies:
    - The following mapped water bodies are closest to the subject site:
        - Indian Lake: adjacent
        - Former stream emptying into Indian Lake (North Pond) as seen on *Figure 1B*).
    - No other significant project area water bodies (ponds, lakes, rivers, streams) are mapped on *Figure 1* within a 1 mile radius of the subject site.
    - Unmapped woodland wetlands exist sporadically in low spots, typically below fill.

- Anticipated Site Substrata: Based upon the collected geologic and topographic data, anticipated native site substrata were considered to potentially include:
    - Man-placed fill
    - Glacial outwash
    - Glacial till
    - Bedrock



- Area Bedrock Geology: [US Department of the Interior; US Geological Survey, *Massachusetts State Geologic Map*; 1998; updated 2018; see *Figure 1E*]
  - Common area rock:
    - Common rock: granofels
      - Hardness: a medium hard rock; metamorphic
      - Structure: very irregular fine grained (granoblastic)
      - Mineralogy: silt sized quartz and feldspar grains
    - Secondary rock: schist
      - Hardness: a medium hard rock; metamorphic
      - Structure: schistose; foliated
      - Mineralogy: quartz, feldspar; other components vary
  - Other area rock: phyllite and slate
    - Hardness: medium hard; metamorphic
    - Structure: foliated; slaty texture
    - Mineralogy: mica, quartz
  - Depth to bedrock was estimated as relatively shallow from the MA GIS (2018 database; see *Figure 1D*)

Previous Test Borings and Monitoring Wells

- On-Site Borings: no on-site boring records were found

- Nearby Borings: no immediate area boring records were found

- Existing Groundwater Monitoring Wells:
  - No remnant active groundwater monitoring wells were found on this site.
  - No new well was installed as part of this review.

Test Borings Undertaken for this Study

- Dig Safe:
  - General Dig Safe site underground utility clearance: was provided by the test boring contractor.
    - The Dig Safe ticket number is held by the test boring contractor.
    - Utilities contacted: utilities' list is held by the test boring contractor.
  - Test boring drilling locations were laid out as part of the Dig Safe site clearance.

- Test Borings:
  - Drilling was performed by Cosmo Drilling. of Ocean Bluffs, MA:
    - Two (2) structural test borings (designated B1 and B2) were planned to be drilled on-site on 17 September 2021.
    - Refer to *Figure 2: Subsurface Explorations* for approximate as-drilled test boring locations.
  - A track mounted drill-rig equipped with an auto-hammer drilled and sampled soils in the borings below grade (*Photo 1*).
    - 6-in. dia. NW percussion borings were advanced to a refusal surface (340 pound hammer driven casing and 140 pound hammer driven split spoon) with soil samples taken continuously.
    - Drive and wash drilling was undertaken once groundwater was encountered from 10 foot depth.
    - Soil samples were retrieved continuously in 2 foot length split spoons.

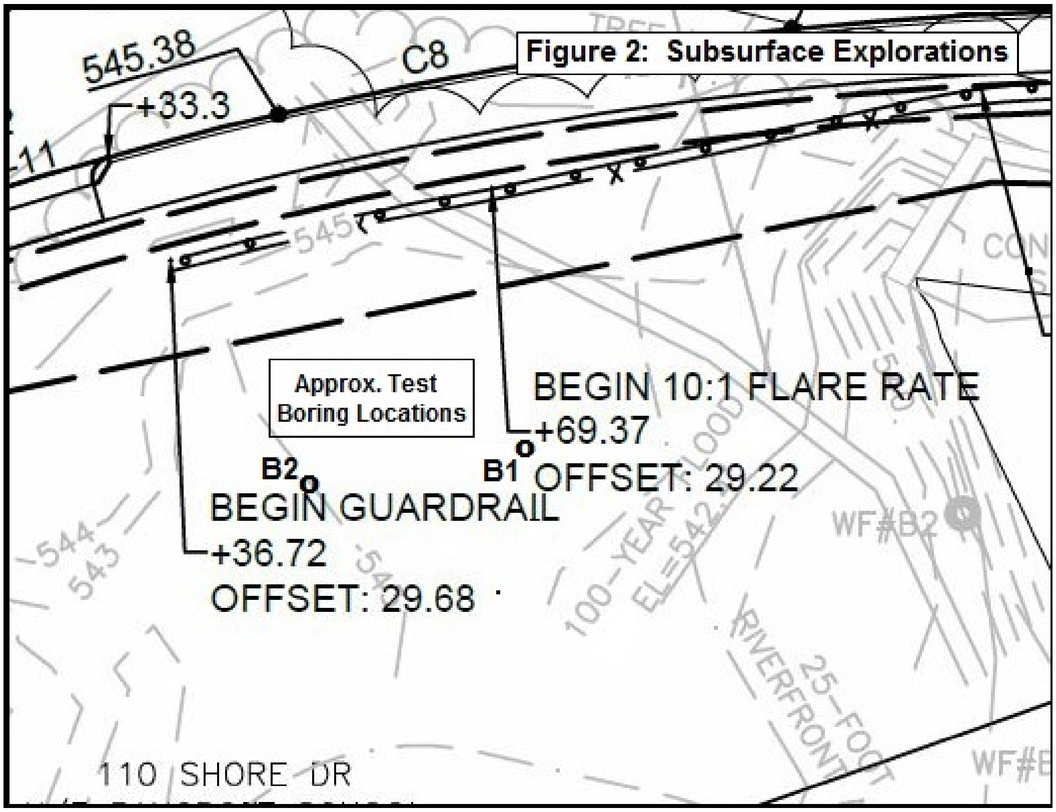


Figure 2: Subsurface Explorations

- Digital Boring Logs:
  - Recovered test boring soil samples were digitally logged by the geotechnical engineer in accordance with *ASTM D-5434-97: Standard Guide for Logging of Subsurface Explorations of Soil and Rock*.

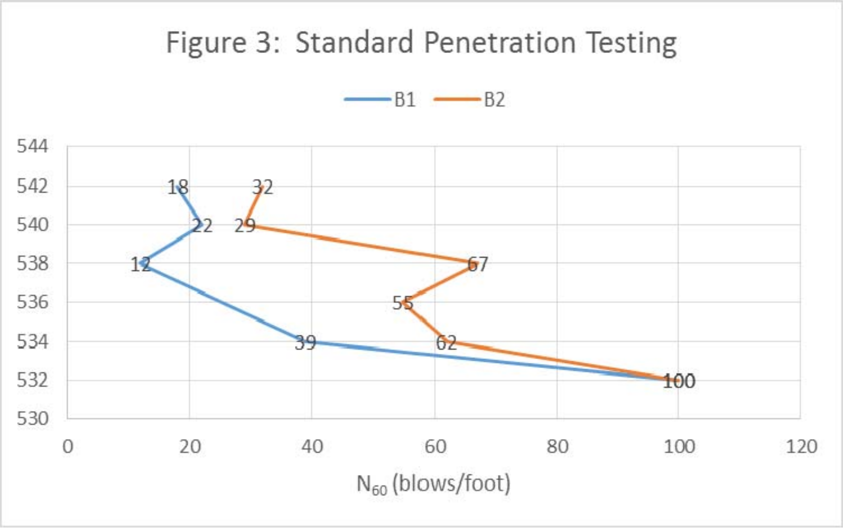
- Boring logs prepared by the engineer are presented in soil boring log sheets in *Appendix A.* Log details soil type, boundary elevation or depth, density, consistency, thickness, coloration, moisture and composition.

III. Geotechnical Testing:

Field Testing Performed:

- Standard Penetration Tests (SPT) (N_{70} in blows/foot)
- Field Gradation Tests

Standard Penetration Testing (SPT):



- SPT Presentation and Definition:
  - A standard penetration test is defined as the number of blows of a 140 lb. hammer falling 30 inches to drive a standard soil split spoon sampler 12 vertical inches. The number of blows is designated as "N"
  - Standard penetration tests (SPT) N are summarized for the borings with depth on the boring logs in *Appendix A* and in *Figure 5.*
  - Field SPT N (blows/foot) is taken from blow count graphs provided on the boring logs.
  - Standard penetration test N is plotted for the borings in *Figure 3.*

- SPT Type: The borings drilled for this study (see *Appendix A*) used a rope and cathead manual sampler drive system (*Photo 1*).

- SPT N Data Analysis of this Site:
  - Note that in the plots of N with depth in *Figure 3*:
    - Boring N values are lower within the near surface existing fill
    - Boring N values jump up in value in the native glacial till deposit.
      - Plotted N drop in value at the water table.
      - Plotted curves show some minor oscillation which is typical of random soil particle relative percentages found in soil formation within glacial till
    - Refusal surface found in the borings drilled may have been indicative of potential top of bedrock. Area surficial geologic mapping expected thin glacial till soil over bedrock (*Figure 1D*).
  - See also the N pattern variation with respect to soil type in *Figure 5* as well as in the blow count graphs on individual boring logs in *Appendix A.*

- SPT N Engineering Uses: SPT data can be useful in determination of values of soil bearing capacity, Young's Modulus for footing settlement evaluation, as well as input to footing base soil friction angle, seismic site class and slab subgrade modulus determination.

Field Gradation Tests:

- Test Use:
  - Limited field gradation tests were performed to better determine the relative percents of coarse gravel, fine gravel, coarse sand, and medium sand and fines (silt and fine sand) in recovered site granular fill and sandy glacial till subsoil samples.
  - Basal glacial till (hardpan) soils were not found in the borings to the refusal depths drilled.

- Limitations:
  - Field tests are limited to recovered dry or field air dried soil samples.
  - 4-sieve method does not allow for separation of silt from fine sand.

Laboratory Soil Tests:

- Test Boring Sampling:
  - No laboratory soil particle gradation testing was undertaken for this review.
  - Test boring samples are typically too small in recovered volume for accurate lab testing.

- Quality of Sampled Soils for Re-use: this subject is addressed in the report section entitled "Site Subsoil Descriptions" as well as in the final section of this report.

IV. Soil Strata:

Data Summaries:

- Subsoil Profile Data Summary: general summaries of soil substrata found in the subsurface explorations are provided in:
  - *Table I: Exploration Summary*;
  - The subsoil profile drawing (*Figure 5*);
  - The "Site Subsoil Descriptions" section; and
  - The test boring logs (*Appendix A*).

- Exploration Summary Table:

Table I: Exploration Summary

Location	***Surface El. (ft.)***	***Depth Drilled (ft.)***	***Granular Fill (ft.)***	***Common Fill; Buried Topsoil Loam (ft.)***	***Ablation Glacial Till (ft.)***	***Basal Glacial Till (ft.)***	***Depth to Top of Possible Bedrock (ft.)***
B1	543	11.8R	2.5	2.8	5.3	---	11.8R
B2	543	10.5R	2.3	3.7	4.5	---	10.5R

R – indicates rock refusal surface found; massive boulder or possible bedrock

- Subsurface Profile Drawing:
  - Refer to the subsoil profile sketched in *Figure 5* to gain an overview of site subsurface soil conditions at the locations drilled (*Figure 2*).
  - Subsoil profiles' orientations are parallel to Shore Drive (*Figure 2)*.

- Subsoil Profile Field Descriptions: Detailed field subsoil descriptions are given in the logs of the borings presented in *Appendix A*.

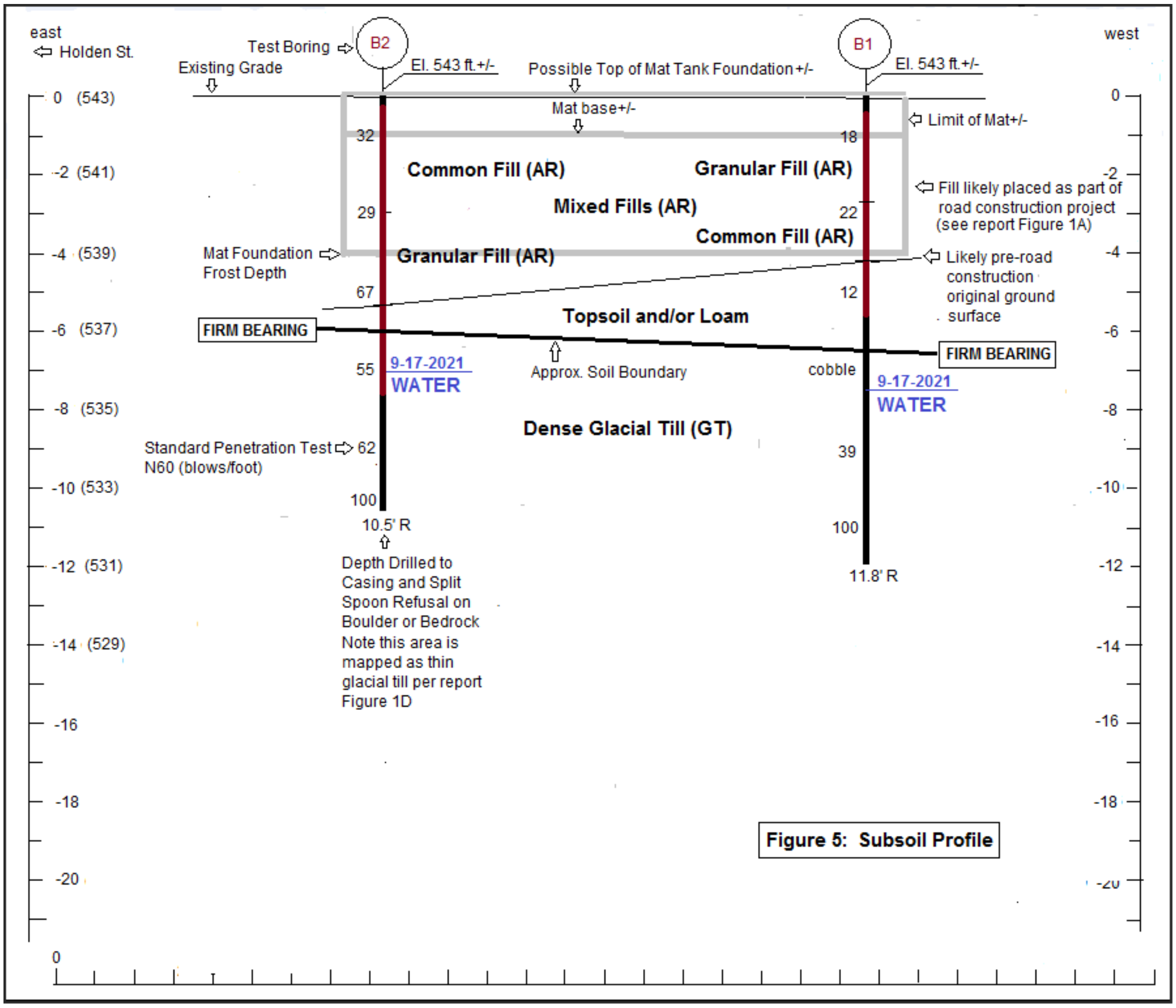


Figure 5: Subsoil Profile

Soil Classification System Used for this Site Investigation:

- Soil Classification System: Project soils have been classified in accordance with the Unified Soil Classification System (USCS; MIT System). This is reflected in the test boring logs in *Appendix A*.

- Soil Descriptions: Soils are described in terms of color, grain size, moisture content, density (coarse grained soils), consistency (fine grained soils), plasticity and cementation, as appropriate.

Grain	Size Boundaries (dia.)	Common Size Example
Boulder	>12 in.	>Basketball
Cobble	3-in. to 12-in.	Grapefruit size
Coarse Gravel	¾-in. to 3-in.	Lemon size
Fine Gravel	#4 Sieve (4.75mm) to ¾-in.	Pea to grape size
Coarse Sand	#10 Sieve (2 mm) to #4 Sieve	Peppercorn size
Medium Sand	# 40 Sieve (.425 mm) to #10 Sieve	Sugar to table salt size
Fine Sand	#200 Sieve (.075 mm) to #40 Sieve	Powdered sugar size
Silt/Clay	<#200 Sieve (.075 mm)	Flour particle or finer

- Soil Moisture Content:
    - Dry: no moisture noted
    - Moist: some moisture observed
    - Very moist: very moist, but not saturated (possible vadose zone)
    - Wet: saturated above the liquid limit (likely groundwater zone)

- Soil Density and Consistency:
    - Density of coarse grained soils (non-plastic silts, sands, gravels): defined in terms of standard penetration test blowcount N values (refer to the summary table at the bottom of any boring log)
    - Consistency (plastic silts, clay, and organics): defined secondarily in terms of blowcount N values and primarily with respect to field unconfined compressive strength in TSF (refer to the summary table at the bottom of any boring log).

- Soil Particle Percentage Field Designation: Relative soil particle size percentages (trace, few, little, some, mostly [capitalized soil unit]): refer to summary table at bottom of any boring log. These are more accurately tallied by laboratory soil particle gradation tests.

- Subsoil Classes on this Site: USCS soil type designations utilized in this report:
    - AR = man placed fill; artificial soil stratum; granular fill, common fill
    - GT = glacial till; ablation till
    - ME = bedrock; metamorphic rock; granofels, schist, phyllite

Photo 1: Trailer mounted drill rig

Photo 2: Granular Fill (AR) in boring B1 at 1 ft.

Site Subsoil Descriptions:

- Existing Fill (AR):
    - Fill types: two (2) general types of fill were found on-site:
        - Granular fill: cohesionless soil with a lesser silt content (< 20%); possibly imported during Shore Drive reconfiguration work (see *Figure 1A*) (*Photo 2, Photo 3*)
        - Common fill: cohesionless soil with a high silt content (> 25%)
    - Coloration:
        - Granular fill: tan, tan-yellow
        - Common fill: tan, tan-brown, brown
    - Thickness (t): at the borings drilled
        - Granular fill: 2.3 ft. ≤ t ≤ 2.5 ft.
        - Common fill: 1.6 ft. ≤ t ≤ 3.0 ft.

  - Density:
    - Granular fill: medium dense to dense in-situ soil density (*Appendix A*)
    - Common fill: low medium dense to medium dense in-situ soil density (*Appendix A*)
  - Fill source:
    - Granular fill: possibly imported during Shore Drive reconfiguration work (*Figure 1A*)
    - Common fill: possibly imported during Shore Drive reconfiguration work (*Figure 1A*)
  - Competence:
    - Granular fill: where found, could be re-used as earthwork phase engineered fill ("granular fill", see final report sections) pending results of earthwork phase laboratory soil gradation tests.
    - Common fill: no common fill type observed should be allowed to remain in-place below structural units (footings, grade slabs). Topsoil should not be left in-place.
    - Re-use of non-urban fill common fill would be limited as backfill in planted areas
    - Re-use of any urban fill, if found, could have environmental engineering limitations with associated off-site disposal restrictions.

- <u>Organics</u>:
  - No woodland wetland organic soils (peat, organic silt) were found in the borings drilled
  - Buried topsoil and silt/silt loam subsoils were found (*Figure 5, Appendix A, Photo 4*) which are indicative of the likely former site original ground surface and native subsoils.

- <u>Glacial Fluvial (Glacial Outwash)</u>: no water sorted silt, sand or gravel deposits were found

Photo 3: Granular Fill (AR) in B2 at 4 ft.

Photo 4: Buried Topsoil & Silt/Silt Loam in B1 at 4.2 ft.

- <u>Glacial Till</u>:
  - Types: two varieties of glacial till are found in the general site area
    - Ablation till: a cohesionless, granular glacial till (*Photo 5, Photo 6*)
    - Basal till: a cohesive or particle-cemented granular glacial till
  - Description:
    - Coloration:
      - Ablation till: tan, tan-yellow
      - Basal till: typically darker colors
    - Soil description:
      - Ablation till (*Photo 5, Photo 6*):
        - Can be water bearing (*Photo 5*)
        - Ablation till here is sandy throughout and can transmit water within the entire subsoil unit rather than being restricted to highly sandy flow channels.

- Ablation till was found below the existing fill, topsoil and loam soils (*Figure 5*; *Appendix A*).
- Ablation till on this site is a granular cohesionless uncemented till and varies in soil particle distribution; typical soil type characterizations include:
  - Variable non-plastic silt content
  - In general sandy ablation till was a sand with variable gravel content or a gravel with variable sand content.
  - Particle variation reflects the randomness of formation within the ablation till formation.
  - Cobbles were encountered.

Photo 5: Water in Ablation Till (GT) in B1 at 8 ft.

Photo 6: Ablation Till (GT) in B2 at 6 ft.

- Basal till: was not found to the depth drilled on-site
  - Basal till is found directly below the ablation till zone
  - Can be water bearing within internal sand seams and lenses within the low permeable basal till soil mass.
  - Characteristics include:
    - Basal till is typically cohesive (plastic) or strongly cemented fine grained granular soil with lesser sand and gravel
    - Typically, where cohesive, a high clayey silt content soil; with sand and gravel found in varying percentages.
    - Particle variation shows the randomness of soil formation within the basal till.
- Thickness (t) (*Table I*):
  - Ablation till: 4.5 ft. ≤ t ≤ 5.3 ft.
  - Basal till: not found at the drilled boring locations to the depth drilled.
- Density or consistency:
  - Ablation till: dense
  - Basal till: typically hard
  - A false higher N can occur due to the presence of encountered included cobbles.
- Competence: dense granular ablation till on this site in natural undisturbed state is an acceptable bearing material.
- Re-use:
  - The granular ablation till may be re-usable and should undergo soil particle gradation testing during earthwork to confirm re-use as an engineered fill material.
  - The silt of some of the ablation till (*Appendix A, Figure 5*) precludes re-use as engineered fill and is limited to re-use as common (ordinary) fill below planted areas.

- Bedrock:
    - No rock outcropping was noted either on-site or in the general site area.
    - Shallow bedrock below thin glacial till and isolated rock outcrops were noted in the area surficial geology plan (*Figure 1D*). The plan is not meant to be site specific.
    - It is highly possible that the rock refusal surfaces seen in the borings were top of bedrock. It is also possible, but less likely, the refusals were upon two separate massive boulders.
    - See also the "Area Bedrock Geology" report section and *Figure 1E*

V. Groundwater Behavior

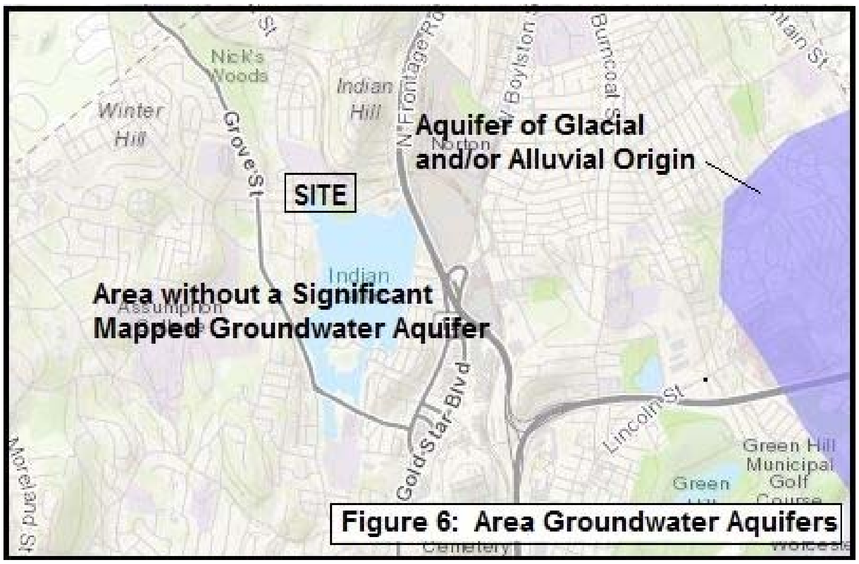


Figure 6: Area Groundwater Aquifers

- Free Water:
    - Wet (saturated) soil was encountered at depth in both borings (*Figure 5*, *Appendix A*).
    - Test boring drill holes were dry to moist throughout much of the depths drilled.
    - No groundwater monitoring well was installed in completed boreholes.
    - Water in some ablation till can occur within a largely interconnected network of water bearing sandy channels. On this site, however the granular ablation till is clean enough to readily transmit water throughout the entire deposit itself (*Photo 5*).
    - The site does not lie within a mapped significant groundwater aquifer (*Figure 6*).

- Groundwater Level Variation:
    - Clear soil mottling (color variation, typically splotches, due to past or current water presence) or rust staining was not seen in site soil borings.
        - Rust staining and mottling give an indication of a past water level possibly indicative of seasonal high groundwater level.
        - No mottling or rust staining was found in the borings to depth.
    - Found water levels are summarized in *Table II:*

Table II: Groundwater Data

Location	Surface Elevation	Depth to Water	Water Elevation
B1	543 ft.+/-	7.5 ft.	535.5 ft.+/-
B2	543 ft.+/-	7.0 ft.	536.0 ft.+/-

- Localized temporary and long term changes to groundwater level can be natural or man-made. These changes source from activities such as:
    - The 2016 extreme drought condition and the relatively dry summer of 2017, and the recent 2020 and 2021 droughts.
    - A notably wetter 2018 and parts of 2019, with near record high water levels in many parts of eastern and central Massachusetts. Alternating dry and wet periods now seem to be the norm.
    - Winter drier season water levels.
    - Heavy rainstorms or lengthy precipitation periods exacerbated by snow melt.

        - Leaky underground structures (pipes, tunnels)
        - Underground flow retarders (buried structures, walls, rock outcrops)
        - Percent of land surface covered by pavement and buildings without ability to recharge.
        - Nearby construction dewatering or recharging.
        - Changes to the existing surface drainage pattern due to new site topography, trenches, infiltrators, bio-retention basins and subgrade structures.
    - Groundwater impact based upon the data collected to date (*Table II, Appendix A*):
        - Groundwater was found at depth and is not expected to impact foundation excavations.
        - Based on the data collected Seasonal High Groundwater is initially estimated for this site at El. 536.5 ft..
        - Underground utilities on some sites are designed to be installed deeper than foundations, however such data has not been provided us to-date for this project.

Hydraulic Conductivity (K in GPD/ft.^{2}):

- Scope: Laboratory soil gradation testing was not undertaken for this study and associated calculations and estimations of soil hydraulic conductivity (K) were not undertaken for any site subsoil unit.

- K Determination:
    - Many input factors go into determination of K. K is a function of particle grain sizes, soil density, soil particle uniformity, gravel content, soil cementation and soil layering.
    - Granular fill and granular ablation till soils (*Photo 2, Photo 3, Photo 5, Photo 6*) found in the borings are expected to be of at least moderate soil permeability.

Site Civil and Environmental Site Investigation and Remediation Structural Unit Impact:

- Intrusive Site Civil and Environmental Testing and Remediation:
    - Site civil and environmental exploration (test pits and test trenches) can damage anticipated building structural unit bearing soils by lowering native bearing capacity.
    - Site remediation work including underground tank removal and soil replacement can remove significant volumes of contaminated soil materials from within proposed new construction footprints and inadvertently cause structural unit bearing soil degradation at the excavation base.
    - Any new site soil remediation work should be reviewed by the design team for quality of soil material placed to replace removed soils and/or tanks, as well as documentation that replacement soils were placed in compacted lifts.

- Protection of Structural Unit Bearing Subgrade: to protect structural bearing areas, project specifications should require:
    - Test pit and test trench areas avoid proposed project footing and slab bearing zones.
    - Test pit and test trench depths be limited to structural bearing depths minus one foot.
    - Where contaminated soil removal is required, replacement soil should be structural fill placed in compacted lifts, verified by field soil density testing to a laboratory Proctor standard for the placed soil.

VI. Foundation Review and Recommendations:

Foundation System:

- <u>Subsoil Impacts to a Tank Foundation System with Top of Mat at about El. 543 ft.l</u>:
  - Key considerations are:
    - Existing poor quality uncontrolled site fill and buried topsoil and loam soils (*Figure 5, Table I, Appendix A*) should not remain below structural units.
    - Competent granular ablation till soil exists at depth (see “Firm Bearing” line on *Figure 5)*
    - Found groundwater is not expected to significantly impact anticipated site excavation (*Figure 5, Table II*).

- <u>Required Bulk Excavation and Replacement</u>:
  - Existing fill, buried topsoil and loam soils would have to be excavated out to the top of the undisturbed granular ablation till (see “Firm Bearing” line shown on *Figure 5*) and be replaced with acceptable engineered fill (see later section: “Engineered Fills and their Uses”) to structural unit bearing level.
  - Note that excavated granular fill and possibly some granular ablation till might be able to be re-used as engineered fill beyond the limits of the tank foundations dependent upon the results of earthwork phase soil particle gradation tests (*Figure 5*).

- <u>Bearing Capacity and Settlement</u>: shallow foundations
  - Initial settlement and bearing capacity calculations were undertaken for this review.
  - Bearing capacity (net allowable soil bearing pressure) was reviewed for the borings:

    Structural units will bear directly upon engineered fill over a minimum medium dense undisturbed granular ablation till (*Figure 5, Appendix A*).
    Net allowable soil bearing pressures for site subsoils are as follows.

    Medium dense granular ablation till = 8 KSF
    Dense granular ablation till = 12 KSF

    Recommended net allowable soil bearing pressure for this project = <u>8 KSF</u>

  - Settlement calculations basis: the elastic method

    $S = qBI\,(1 - \mu^2)\,/\,E_s\,)$ S-settlement; B-footing width; I-Westergaard depth factor; E_s – Young’s Modulus or elastic modulus; μ-Poisson’s ratio

  - Calculated total settlement for a <u>8 KSF net allowable soil bearing pressure</u> for site foundations was as follows:
    - < 1 in. total settlement and
    - < ½ in. differential settlement.
  - Granular ablation till on this site in natural undisturbed state is an acceptable bearing material in dry undisturbed condition. Granular ablation till is expected to be encountered at depth (*Figure 5, Appendix A*).

Seismic Recommendations:

- <u>Seismic Site Hazard Review</u>:
  - Probabilistic Site Hard Analysis [*PSHA Interactive Deagregation*; Geologic Hazards Science Center, US Geologic Survey; 2008 v.2]
    - Decimal site latitude and longitude utilized in this review: (42.3045° N, -71.8172° W)

        - Probability of magnitude 5 (M5.0) or greater earthquake occurrence within 50 miles of the subject site within a 50-year building design life is considered relatively low (< 1.5%+/-) according to *Figure 7*.
    - Area earthquake history:
        - Typical measured earthquakes within the past 40 years have magnitude ≤ 3.1+/-
        - Past significant earthquakes with area impact recreated from the geologic record:

Year	Magnitude	Location	Intensity in Boston
1638	6.5	Central New Hampshire	MMI: V-VII
1663	7.0	Charlevoix, Quebec	MMI: V-VI
1727	5.6	Newbury, MA	MMI: V-VI
1755	5.9	Scituate, MA	MMI: IX

MMI: Modified Mercalli Scale (subjective; observed damage and effects)

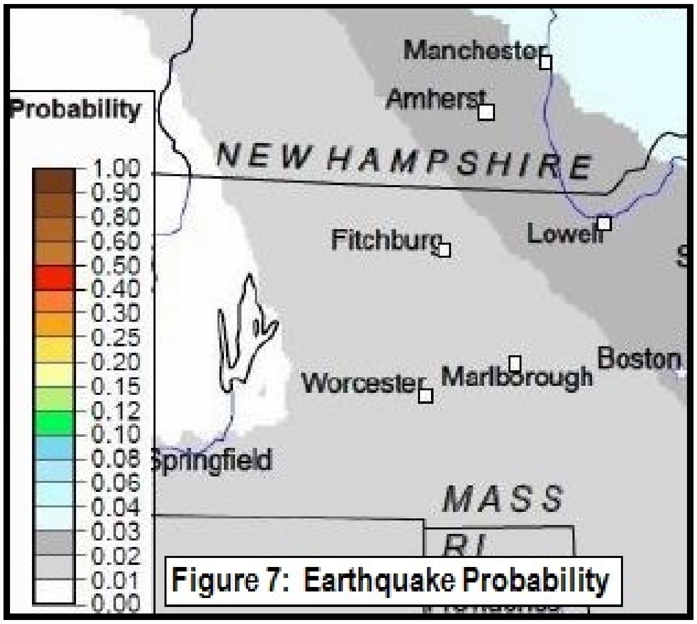


Figure 7: Earthquake Probability

- Seismic Site Class: The collected site subsoil data has been applied to the Massachusetts adopted *International Building Code (2015)*. According to the *Building Code*
    - Analytic depth:
        - The upper 100 feet of soil and bedrock are subject to analysis.
        - Soil data on-site has been collected to 11.8 ft. depth; *Table I, Appendix A*).
        - Native soils tested were typically dense granular ablation till.
    - Bedrock:
        - Bedrock is hard metamorphic rock (see "Area Bedrock Geology" report section).
        - Bedrock may have been found at less than 8 ft. below frost depth foundations.
        - Depth to probable intact bedrock as measured from likely bottom of foundation is < 10 ft. which would allow assignment of a rock controlled seismic Site Class B to this project.
        - However as a precaution, this site is classified as seismic Site Class C.

- Seismic Design Factors: Preliminary estimated Earthquake Design Factors for Worcester, Massachusetts (*Massachusetts Amendments to the International Building Code (2017; 9th Edition))* and *IBC (2015)*:
        - S_s = 0.180g (short interval)
        - S_1 = 0.066g (1-second interval)
        - F_a = 1.2 (site coefficient, classification as Site Class C)
        - F_v = 1.7 (site coefficient, classification as Site Class C)

Liquefaction:

- Liquefaction Factors:
    - Earthquake magnitude
    - Earthquake amplitude (duration)
    - Subsoil types and condition

- Earthquake Magnitude:
  - Collected data indicates that the probability of occurrence of an earthquake of magnitude 5 or higher is low probable during a 50 year building design life.
  - However, with a time period measured in centuries instead of decades, earthquakes of magnitude 5 or greater can be expected to occur as the earthquakes listed above indicate.

- Earthquake Duration: This topic is beyond the scope of this review.

- Subsoil Data Input: Review of the site subsoil profile was necessary for soil liquefaction determination below structural units:
  - Relevant test boring information: no thickness of post compaction, loose to very loose saturated silty to clean sands and non-plastic silts (SM, SP, SW, ML) would be found below structural units.
  - Drill rig, site groundwater level and measured soil strength data with depth:
    - Drill rig hammer type: drop hammer
    - Groundwater level: El. 536.5 ft. (seasonal high estimate; page 15)
    - Plotted field N_{60}-values from the borings with depth (*Figure 3*).

- Site Liquefaction Determination:
  - Review of field drop hammer N_{60} from the borings with depth with respect to *Figure 1806.4a* of the *Massachusetts Amendments (2017; 9th Edition)* for preliminary liquefaction exclusion review compared to a range of (seasonal high) groundwater levels.
  - Assumption that site subgrade preparation will be performed as described in the "Excavated Base and Working Base" report section.
  - Result: liquefaction settlement is not of concern for this site were a 5M or greater earthquake to occur here.

Structural Unit Frost Protection Depth:

- Definition:
  - Frost depth, freezing depth or frost line is the depth to which moisture in subsoil is expected to freeze.
  - Frost line varies in position (elevation) during seasonal freeze and thaw.

- *Massachusetts State Building Code* Mandated Frost Protection Depth Changes:
  - 7th Edition: "All foundations for buildings and structures shall extend to a minimum of 4 ft. below (exterior) finished grades…"
  - 8th Edition: Foundations and permanent building supports should be protected by "extending below the frost line of the locality…" This suggests a 4 ft. frost depth is too deep for coastal and southern areas and too shallow for northern or topographically elevated locales.

- Site Structural Unit Frost Protection Depth:
  - Frost line:
    - Average area frost line value: 0.9 m = 35.5 in. [J.E. *Bowles; Foundation Analysis and Design 5th Ed.*; 1997; Figure 7-1].
    - Extreme frost line based upon state average: 53 in. [NAVFAC DM-7.1; *Soil Mechanics Design Manual 7.1*; Figure 7; 1982].
    - Based upon the data collected to-date: recommended minimum site structural unit frost protection depth in soil bearing for this property as measured from final adjacent exterior grade: = 48 in. (4 ft.)
    - Direct bearing on intact bedrock does not require a minimum frost depth embedment.

- Cold Weather Work Soil Protection:
    - During construction earthwork the contractor must be prepared to provide protection and/or thawing of foundation bearing soils against freezing.
        - Footings: insulation blankets and/or ground heating hoses should be utilized if footing subgrade is exposed to freezing during cold weather periods.
        - Lowest Level Slabs:
            - Typically slab subgrade areas are thawed once basic framing is up by providing heaters after enclosing the lowest level in plastic sheeting.
            - Then any remaining required grade raise fill, treatment and placement of the slab base pad can be properly performed.

Structural Units Bearing on Soil and Bedrock:

- Structural Units Bearing on Soil:
    - Structural units may be founded directly upon:
        - Compacted structural fill, compacted ¾ inch crushed stone, mudmats, or 300 PSI flowable fill.
        - Undisturbed, medium dense to dense glacial till (ablation till)
    - Structural units should be designed to bear such that:
        - They meet frost depth (page 18)
        - They meet the requirements of "Bulk Excavation and Replacement" (page 16)
        - They are founded below a minimum 1H:1V line as drawn from the bottom exterior edge of adjacent footings or utilities.
    - Water intrusion:
        - Groundwater seepage within bulk excavation zones on-site is not expected based upon the water levels found in the borings (*Figure 5, Table II, Appendix A*).
        - However, seepage and influx following rain and melt events should be anticipated.
        - Wet conditions require use of protective caps where any highly silty ablation till is exposed or allowance for adequate on-site drying of bearing soils prior to re-commencing structural unit subgrade preparation and concrete placement.

- Footing Soil Base Friction:
    - Anticipated footing base friction angle is given as:

        Φ' = 36° (compacted structural fill over medium dense sandy ablation till)
        Φ' = 36° (medium dense ablation till)
        Use: Φ' = 36°

- Footings Bearing on Rock: none anticipated on this project

Foundation Wall Design (Restrained Walls): if excavation to direct bearing of structural units on undisturbed granular ablation till is undertaken in lieu of bulk excavation and replacement; otherwise this section can be ignored.

- Lateral Earth Pressure and Hydrostatic Pressure:
    - New foundation walls should be designed to resist lateral pressures calculated on the basis of an equivalent fluid weight of:
        - 65 PCF (not designed to resist hydrostatic pressure: drains provided)
        - 95 PCF (designed to resist hydrostatic pressure: no drains provided)
    - The recommendations assume an at-rest earth pressure coefficient (K_o) as follows [Knappett & Craig, *Craig's Soil Mechanics*; 2012; Figure 11.11]:
        - K_o = 0.42 (Φ'=36°)
        - Where the calculated earth pressure behind walls is < 250 PSF, it should be increased to 250 PSF to account for stresses caused by compaction within 5 lateral feet from the wall face.

- Surcharge Loads:
  - Surcharge loads are generated by adjacent loads of construction equipment, materials, stockpiles and traffic loads
  - Surcharge loads can be determined on the basis of a uniform lateral pressure equal to K_o multiplied by the vertical surcharge load applied over the full height of the wall.

- Seismically Induced Loads:
  - Seismically-induced earth pressures (*earthquake force*, F_w) should be distributed as an inverted triangle over the height of the wall (*Massachusetts Amendments (2017))*.
  - $F_w = 0.1 (S_s)(F_a)(Y_t)(H)^2$
    - S_s = 0.180g (see "Seismic Recommendations" report section)
    - F_a = Site Coefficient = 1.2 (classification as Site Class C)
    - Y_t = Total Soil Unit Weight = use 125 PCF (ablation till or granular fill as back fill)
    - H = height of foundation wall

- Total Lateral Stress: The two static lateral pressures and the seismic pressure when added yield the total lateral stress for structural design of the walls.

Cantilever Earth Retaining Wall Design:

- Retaining Wall Construction:
  - It is not known if a cantilever wall will be required in site design.
  - Clean, free-draining granular backfill should be placed behind a new wall.
  - Weep holes should be provided in the wall to prevent hydrostatic pressure build up behind the wall.
  - Wall should be founded upon compacted structural fill placed upon an undisturbed glacial till subgrade or native conglomerate rock.

- Retaining Wall Design:
  - Backfill design factors: soil at 120 PCF; $\Phi=30°$; $k_a = 0.33$; triangular soil load distribution
  - Equivalent fluid pressure behind the wall: 40 PCF; level backfill, no surcharge loads; resultant (P), located at P = 1/3 H above base of wall.
  - Surcharge load (Q): an additional, uniform load on the wall = k_a x Q (resultant at 0.5 H)

Drainage and Waterproofing:

- General Comments/Good Practice:
  - Exterior grading at the tanks should be designed to carry surface water runoff away from the structures.
  - Planted areas or pavements should enhance the exterior grading performed to insure surface water runoff beyond building limits.
  - Roof downspout water or other water should not be allowed to pool near the building.

- Review Summary of Groundwater and Structural Unit Assumed Elevation Data:
  - Structural unit elevations were estimated at the time of this review (*Figure 5*):
    - Top of tank mat: El. 543 ft.
    - Structural unit frost depth: El. 539 ft.
    - Top of native ablation till bearing (bulk excavation to "Firm Bearing" line, *Figure 5*): El. 536.5 ft. to El. 537 ft.
  - Groundwater elevations*:*
    - Found groundwater in borings B1 and B2: El. 535.5 ft. to El. 536 ft.
    - Estimated seasonal high groundwater level: estimated at El. 536.5 ft. (page 15).
  - Site flooding: considered highly unlikely; confirm with project site civil engineer.

- Structural Unit Foundation Wall Drainage and Waterproofing: based upon the groundwater data collected and the assumed structural bearing elevations, foundation wall drains are not required.

- Mat Base Drainage and Waterproofing: waterproofing such as an under mat underdrain system (e.g. under mat perimeter and interior underdrain pipes set in a ¾ in. crushed stone bed upon geotextile outletting to a sump pit) is not required based upon the groundwater data collected.

Mat Design: mat is assumed to be soil supported as described in previous sections

- Subgrade Modulus: for mat design
  - The recommended modulus of subgrade reaction (K_s) is given in *Table III.*
  - The values given assume medium dense to dense undisturbed granular ablation till underlies any compacted structural fill material (*Figure 5*).

Table III: Slab Subgrade Moduli (K_s)

Mat	**Soil Type**	**K_s (KCF)**
Top at El. 536 ft. Alternate (TBD)	Compacted Structural Fill or Ablation Till	350 KCF

- Under Mat Pad and Control Joints:
  - A mat base pad will be provided as compacted ¾ inch crushed stone or compacted structural fill
  - Interior mat control joints, if any, should be utilized within patterns as determined by the Project Structural Engineer.

Excavation and Bracing:

- Excavation Depth ≤ 4 ft.+/- in Soil:
  - Common practice is to maintain a 1H:1V temporary side slope for shallow excavation (≤ 4 ft.+/-) during construction. Benched steps can also be executed.
  - Note that the sidewall stability will be undermined by:
    - Minor sloughing when sidewall bleeding occurs either from release of trapped water in soil or drainage following storm events; and
    - Surficial exposed granular sidewall soil drying and subsequent caving or sloughing.

- Excavation > 4 ft. in Soil: excavation up to about 6.5 ft. depth is expected on-site
  - Excavate with a 1.5 H:1 V sidewall layback.
  - A braced excavation is required where adequate lateral space does not exist for a temporary sloped excavation. On this site adequate lateral soil excavation layback space exists. Braced excavation will be unnecessary.
  - Excavation at this depth will take place primarily within granular soils which can be classified as OSHA Type C subsoils (*Appendix A*).

Construction Dewatering:

- Groundwater Impact:
  - Based upon the data collected to-date, groundwater seepage into excavations for foundations and lowest level floor slabs is unlikely (*Appendix A, Table II, Figure 5*).
  - Rain and melt seepage water intrusion should be expected.
  - Refer also to the “Groundwater Behavior” report section (pages 14-15).

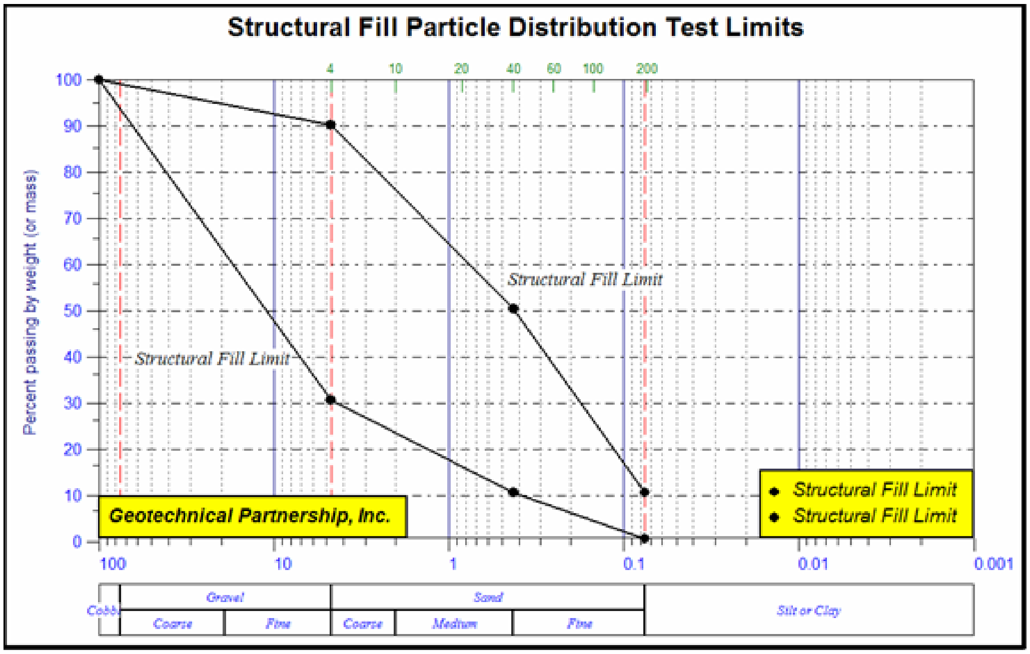
- Dewatering Required:
  - Intruding water into site excavation would be limited to rain and melt events.
  - Expected water can be controlled by ditching to filtered sumps.

- Pumped Discharge:
  - Discharge of any pumped water should be performed in accord with all City, Commonwealth and Federal regulations. Filtering of pumped water prior to discharge should be expected.
  - Permitting required by the USEPA, MWRA, or the City should be reviewed. Assessment by the Project Civil Engineer should be sought.
  - The contractor would be responsible for obtaining all permits and any associated laboratory testing required for construction dewatering.
  - Based upon City requirements the contractor may be required to use frac tanks to temporarily store pumped water at the work site. This possibility should be reviewed in conjunction with the Project Civil Engineer.

Engineered Fills and their Uses:

- Crushed stone: ¾ in. clean, hard, durable crushed stone; uses:
  - As a construction working pad
  - As a surface protection below structural units
  - As drainage media in wall and under slab drainage systems.

- Gravel: sandy gravel, bank run gravel; max. 3-in. gravel; limit No. 200 sieve content to about 6%; uses:
  - As base in a pavement section



- Structural fill: hard, durable sand and gravel;
  - Common gradation limits for structural fill are given in the plot shown above.
  - Gradation adjustments: gradations often specify
    - Minimum of 2% passing No. 200 to aid compaction
    - Maximum of 15% passing No. 200 with the assumption that work may not proceed during wet conditions using this material (Dense Grade can be substituted)

- Structural Fill Uses (in lieu of crushed stone):
  - To form a protective base directly below structural units
  - As a slab base pad
  - As a replacement fill below structural units (over-excavated soft areas)
  - As sub base in a pavement section

- Dense Grade Structural Fill/2-in. Crushed Stone: Structural fill/crushed stone meeting the following minimum requirements

Sieve Size	Percent Finer by Weight
2 in.	100
1.5 in.	70 – 100
¾ in.	50 – 85
No. 4	30 – 55
No. 50	8 – 24
No. 200	3 – 10

- Dense grade structural fill uses:
  - As a readily workable replacement for conventional or recycled concrete type structural fill when work must proceed during cold and/or wet conditions.
  - As a base pad for structural units

- Granular Fill: minor gravel; primarily medium to fine sand and silt meeting the following minimum requirements

Sieve Size	Percent Finer by Weight
4 in.	100
No. 10	30 – 95
No. 40	10 – 70
No. 200	0 – 15*

** May be as high as 20% if field compaction can be verified in **dry** conditions*

- Granular Fill Uses:
  - As under a building slab as fill below 12 in. depth as measured from the slab base.
  - As densified trench backfill

Re-use of Existing Site Subsoils as Engineered Fill:

- Existing Granular Fill:
  - Refer to the "Existing Fill" report section on pages 11-12.
  - Granular fill volume appears random with respect to vertical and horizontal control (see *Figure 5, Appendix A*).
  - Where granular fill soils are encountered and can be separated and stockpiled, they may be re-used as engineered fill (see previous section: "Engineered Fills and their Uses") pending construction phase soil particle gradation test results.
  - Any found excavated granular fill soil should be considered non-engineered:
    - Thus undertaking laboratory Proctor and associated field compaction tests is not useful as the silt-sand-gravel ratios will vary.
    - Re-use of these soils on-site would require experienced third party field observation of compaction equipment behavior, supported by consideration of addition of water to dry soil or drying of saturated soils (harrowing, land spreading) as needed.

- Existing Common Fill and Silty Ablation Till:
    - Refer to the “Existing Fill” report section on pages 11-12 and the glacial till section on pages 12-13.
    - The existing common fill (till fill) and silty ablation till can only be classified as ordinary fill or common fill.
    - Common fill can only be reused on-site below planted areas or any structural slabs.
    - Some earthwork specifications commonly in use provide strict silt content limits for “common fill”. The site common fill soil may not meet such a specification.

- Existing Sandy Ablation Till:
    - Refer to the “Glacial Till” report section on pages 12-13.
    - Sandy ablation till that is found in site excavations has low silt content: some (see *Appendix A*).
    - Low silt content sandy ablation till (<20% silt) could be re-used as engineered fill (granular fill, structural fill) pending construction phase soil particle gradation test results.
    - Sandy ablation till would be treated the same as “existing granular” fill summarized above as an uncontrolled material if it is re-used on-site.

Thank you for inviting us to perform this site study. Please contact us with any questions.

Sincerely yours,
Geotechnical Partnership, Inc.

Lisa R. Casselli, PE
Principal

Attachments: *Appendix A*: *Logs of Test Borings B1 and B2*

APPENDIX A: Logs of Structural Test Borings B1 and B2

Indian Lake – 110 Shore Drive
Worcester, Massachusetts

Geotechnical Partnership, Inc.
Swampscott, MA
File No. 2140

Geotechnical Partnership, Inc.
Swampscott, Massachusetts
Sanford, Maine

PROJECT: New Construction
Indian Lakes - 6000 gal. Tanks
Worcester, Massachusetts

CLIENT: ESS Group, Inc.

File No. 2140

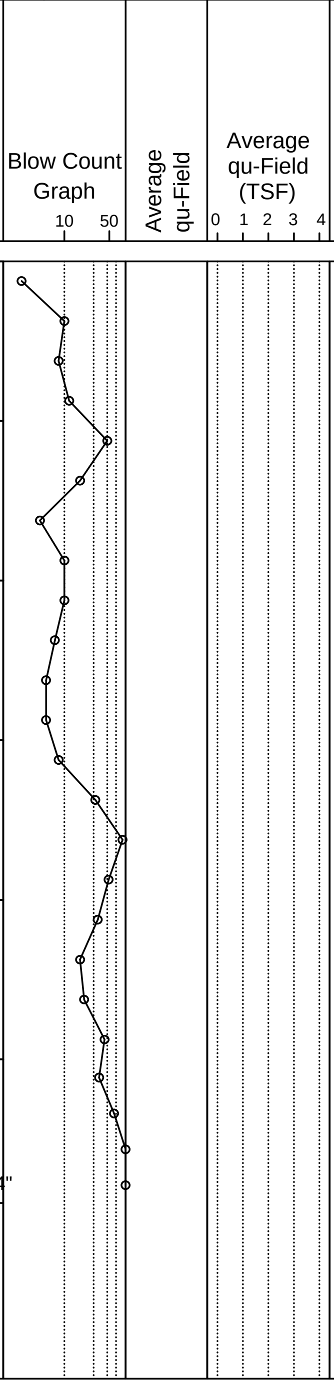
Date Drilled : 17 September 2021
Boring Location : Refer to Report Figure 2
Drilling Contractor : Cosmo Drilling
: Ocean Bluffs, MA
Driller : F. Sviokla
Rock Core : ---
GPI Field Engineer : LR Casselli, PE, MASCE CSI
Elevation and Datum : El. 543 ft.+/-
Drilling Mud Utilized : Not necessary
Constant Water Head : Wash boring from 10 ft

Test Boring No. B1

(1 of 1)

Drill Rig Type : Trailer mounted
Hammer Type : Drop
Cat-Head or Winch : Cat-Head
Soil Casing Type : 6 in. NW
Sampler Type : SS - 1.375 in. I.D.; unlined
Sampler Hammer Fall : 140 lbs. / 30 in.

Depth in Feet	Elev. in Feet 543	DESCRIPTIONS	USCS	Water Level	Sample No.	Blow Count	Average qu-Field	REMARKS
0	543	Dark-brown, SILT LOAM, few medium to fine sand (very soft; moist); fibers, roots	AR		1	2 10		Groundwater=7.5' Well Set: no Fill likely placed druing road reconstruction (see Figure 1A) SS-1: 0' - 2' R=14 N=18
1	542	Tan, medium to fine SAND, little coarse to fine gravel, few silt and coarse sand (medium dense; dry) with lens recycled pavment fragments --Granular Fill-- 3.0 ft.	AR			8 12		
2	541				2	50 18		
3	540	Tan-brown to tan, medium to fine sandy SILT (non-plastic), little coarse to fine gravel, trace coarse sand (medium dense; dry to moist) 4.2 ft. --Common Fill--	AR			4 10		SS-2: 2' - 4' R=19 N=22
4	539	Dark-brown, SILT LOAM, little medium to fine sand, few coarse to fine gravel (moist) 4.4 ft. --Buried Topsoil--	MH		3	10 7		
5	538	Orange-brown, SILT (non-plastic) to SILT LOAM, few medium to fine sand and fine gravel (loose; moist) --Loam-- 6.5 ft.	ML			5 5		SS-3: 4' - 6' R=14 N=12
6	537				4	8 32		
7	536	Tan, coarse to fine GRAVEL (angular), some silt and medium to fine sand, trace coarse sand (very dense; very moist); cobble	GT	▼		89 53		SS-4: 6' - 8' R=15 N=121 likely ablation till cobble elevated N value
8	535	Tan, silty medium to fine SAND and coarse to fine GRAVEL (angular), few coarse sand (dense; very moist)			5	35 18		
9	534					21 45		SS-5: 8' - 10' R=16 N=39
10	533	Tan to tan-orange, coarse to fine GRAVEL (angular), some to mostly silt and medium to fine sand, trace coarse sand (very dense; very moist) ; cobble --Glacial Till--			6	37 65		
11	532					105 100/4"		SS-6: 10' - 12' R=12 N=170 cobble in sample Boulder or top of bedrock refusal
12	531	Casing Refusal on Rock at 11.8 feet Depth						
13	530							
14	529							P=Penetrometer
15								



Particle Size: trace: <5%; few: 5-10%; little: 15-20%; some 30-45%; mostly: 50-100%

COHESIONLESS SOILS: 0-6 Very Loose 0-8
(DENSITY) 6-10 Loose 8-15
L: Sands; R: Gravels 11-30 Med-Dense 16-40
>30 Dense 41-50
Very Dense >50

COHESIVE SOILS: 0-2 Very Soft (<0.25 TSF)
(CONSISTENCY) 2-4 Soft (0.25-0.5 TSF)
4-8 Med. Stiff (0.5-1.0 TSF)
9-20 Stiff (1.0-4.0 TSF)
>20 Hard (>4.0 TSF)

Test Boring No. B1

(1 of 1)

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Geotechnical Partnership, Inc.
Swampscott, Massachusetts
Sanford, Maine

PROJECT: New Construction
Indian Lakes - 6000 gal. Tanks
Worcester, Massachusetts

CLIENT: ESS Group, Inc.

File No. 2140

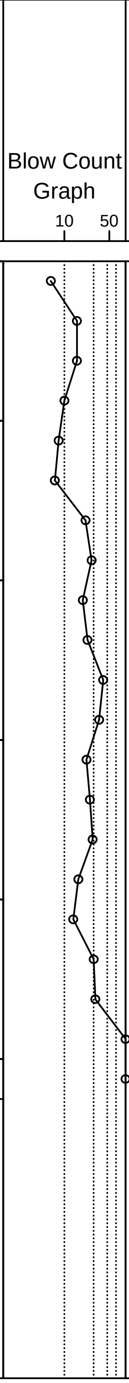
Date Drilled : 17 September 2021
Boring Location : Refer to Report Figure 2
Drilling Contractor : Cosmo Drilling
: Ocean Bluffs, MA
Driller : F. Sviokla
Rock Core : ---
GPI Field Engineer : LR Casselli, PE, MASCE CSI
Elevation and Datum : NA
Drilling Mud Utilized : El. 543 ft.+/-
Constant Water Head : Not necessary

Test Boring No. B2

(1 of 1)

Drill Rig Type : Trailer mounted
Hammer Type : Drop
Cat-Head or Winch : Cat-Head
Soil Casing Type : 6 in. NW
Sampler Type : SS - 1.375 in. I.D.; unlined
Sampler Hammer Fall : 140 lbs. / 30 in.

Depth in Feet	Elev. in Feet 543	DESCRIPTIONS	USCS	Water Level	Sample No.	Blow Count	REMARKS
0	543	Dark-brown, SILT LOAM, few medium to fine sand (dry to moist); fibers; roots 0.2 ft. --Topsoil Fill--	AR		1	6	Groundwater=7' Well Set: no Fill likely placed during roadway reconstruction: see Figure 1A SS-1: 0' - 2' R=11 N=32
						16	
1	542	Brown, silty medium to fine SAND, few to little coarse to fine gravel few coarse sand (medium dense; dry)	AR			16	
						10	
2	541	Brown, silty medium to fine SAND, few to little coarse to fine gravel few coarse sand (medium dense; dry) --Common Fill-- 3.0 ft.			2	8	
						7	
3	540					22	SS-2: 2' - 4' R=14 N=29 cobble?
		Tan to tan-yellow, medium to fine SAND, few to little silt, few coarse sand (medium dense; dry)	AR			28	
4	539				3	20	
		Tan, medium to fine SAND, little to some coarse to fine gravel, little silt, few coarse sand (dense; dry); cobble --Granular Fill-- 5.3 ft.				24	
5	538					43	SS-3: 4' - 6' R=19 N=67
		Dark-brown, SILT LOAM, little medium to fine sand, trace fine gravel --Buried Topsoil-- 6.0 ft.	MH			37	
6	537				4	23	
						26	
7	536	Tan-yellow, silty medium to fine SAND, some to mostly coarse to fine gravel (angular), few coarse sand (dense; very moist)	GT	▼		29	SS-4: 6' - 8' R=17 N=55 likey ablation till
						17	
8	535				5	14	
						30	
9	534	Tan-yellow, silty medium to fine SAND,and coarse to fine GRAVEL (angular), few coarse sand (dense; very moist) --Glacial Till--				32	SS-5: 8' - 10' R=16 N=62
						100	
10	533				6	120	SS-6: 10' - 12' R=6 N>120 On rock/boulder
		Casing Refusal on Rock at 10.5 feet Depth					
11	532						P=Penetrometer
12	531						
13	530						
14	529						
15							



Average qu-Field

Average qu-Field (TSF) 0 1 2 3 4

Particle Size: trace: <5%; few: 5-10%; little: 15-20%; some 30-45%; mostly: 50-100%

COHESIONLESS SOILS: (DENSITY) L: Sands; R: Gravels		L	R	COHESIVE SOILS: (CONSISTENCY)	
	Very Loose	0-6	0-8	0-2	Very Soft (<0.25 TSF)
	Loose	6-10	8-15	2-4	Soft (0.25-0.5 TSF)
	Med-Dense	11-30	16-40	4-8	Med. Stiff (0.5-1.0 TSF)
	Dense	>30	41-50	9-20	Stiff (1.0-4.0 TSF)
	Very Dense		>50	>20	Hard (>4.0 TSF)

Test Boring No. B2

(1 of 1)

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