GEOTECHNICAL ENGINEERING REPORT
NORWELL DPW BUILDING
ALTERNATIVE I
310 MAIN STREET (ROUTE 123)
NORWELL, MASSACHUSETTS 02061

SUBMITTED TO:

Town of Norwell DPW
Mr. Glenn Ferguson – DPW Director
345 Main Street
Norwell, MA 02061

December 14, 2018
Project No. 181111

CGE Engineering, Inc.

Civil ♦ Geotechnical ♦ Environmental

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Consulting
Engineers & Scientists

December 14, 2018
Project No. 181111

Town of Norwell DPW
Mr. Glenn Ferguson – DPW Director
345 Main Street
Norwell, MA 02061

RE: Geotechnical Engineering Report
Proposed Norwell DPW Building
310 Main Street (Route 123)
Norwell, MA 02061

Dear Mr. Ferguson:

CGE Engineering, Inc. (CGE) has conducted an initial geotechnical investigation of soil conditions at the proposed DPW Building "Site" (Alternative I) located at 310 Main Street (Route 123), Norwell, Massachusetts. The purpose of this geotechnical investigation was to evaluate subsurface conditions and to provide geotechnical engineering recommendations for foundation design and construction.

CGE is pleased to submit our Geotechnical Engineering Report on the subsurface investigation and geotechnical engineering evaluation. This report contains the results of our findings and engineering interpretations with respect to the available project characteristics. Recommendations are also provided to aid in the design and construction of foundations and other earth-connected phases of this project. If there are any questions, please contact the undersigned.

Sincerely,
CGE Engineering, Inc.

Ronald F. Bukoski, P.E., L.S.P.
Project Engineer

RFB:cb

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APPENDICES

1.0 INTRODUCTION

CGE's understanding and objective of this geotechnical investigation is based on a conceptual plan provided by the Norwell DPW for a vehicle storage/ maintenance building located adjacent to the southern side of the existing Norwell DPW maintenance building. The addition has a nearly rectangular configuration occupying a footprint area of approximately 19,000 square feet (approximately 100 ft wide by 190 ft long), as shown in the Test Boring Location Plan, Figure 1. The anticipated foundation scheme was for concrete strip footings, spread footings for isolated columns, and a concrete slab-on-grade ground floor.

CGE's understanding is that the structural design of the foundation will be performed by other design professionals including stability analysis under vertical and lateral forces such as wind or earthquake loading. No unusual design restrictions were provided to CGE which would impact the conceptual foundation design scheme, or that would alter a typical geotechnical field investigation. Limitations of the geotechnical investigation included one day of test borings at accessible locations for a truck-mounted drill rig. No specific structural or conceptual foundation plans for the proposed structure were provided to CGE prior to the field investigation.

2.0 FIELD INVESTIGATION

The field investigation included a surficial examination of the Site area and five geotechnical test borings. A surficial Site investigation was performed to document surface conditions for evidence of unsuitable soil conditions or previous earthwork activities which may have disturbed potential bearing materials.

The building footprint location had not been surveyed prior to the time of the field investigation/ test borings. However, the Site Plan provided to CGE showed the approximate location of the proposed building footprint relative to existing features and the test boring locations were selected based on this information and adjusted in the field to avoid underground utilities or obstructions.

The test borings were performed by Soil Exploration Corporation from Leominster, Massachusetts, on November 9, 2018. Field activities were overseen by an experienced CGE Professional Engineer. Weather conditions were clear to cloudy; the temperature ranged from 28 to 33 degrees, Fahrenheit. Soil samples obtained from the test borings were classified in the field by visual and textural examination in accordance with ASTM D 2488. These classifications were later confirmed through further examination and the final Test

Boring Reports were prepared. The Test Boring Reports are presented in Appendix A with photographs of test boring locations and soil samples presented in Appendix B.

The test borings were drilled using a truck-mounted Acker AD-II rotary drill rig. The test boring designated B-1 was located near the northwestern corner of the proposed structure; B-2 was located near the southwestern corner; B-3 was located near the southeastern corner; B-4 was located near the northeastern building corner; and B-5 was located in the vicinity of the center of the Building footprint, as shown in the Test Boring Location Plan, Figure 1. For this initial subsurface investigation program, the drilling was limited to one day with Site characteristics assimilated and engineering interpretation and recommendations based on field data collected.

Boreholes were advanced using hollow stem augers with soil sampling performed from 1-foot below the ground surface or bituminous paved surface. Sampling was then performed in 2-foot increments to undisturbed soil or 12.0 feet below grade and then at 5.0-foot increments to a maximum depth of 27.0 feet below grade at test boring locations B-1 and B-2; to Refusal at 15.9 feet below grade at B-3; Refusal at 5.66 feet at B-4; and auger Refusal at 18.0 feet at B-5 . All test borings encountered groundwater/ saturated soil between 2.5 and 3.0 feet below grade.

The surface elevations of the test boring locations were not surveyed as part of this geotechnical investigation; however, the ground surface was relatively level across the Site footprint.

Soil samples were collected using a 2-inch outside diameter, 24-inch long split-barrel sampler, following ASTM D 1586 procedures. The sampler was inserted into the borehole and then advanced into undisturbed materials using a 140-lb automatic hammer free-falling a distance of 30 inches. The number of blows required to drive the sampler 24 inches was recorded as a measure of resistance to penetration. The blows required to drive the split-barrel sampler the second and third 6-inch driving interval is referred to as the Standard Penetration Test (SPT) *N-value* and was used to estimate the allowable bearing capacity of the soil formation.

3.0 SITE CONDITIONS

3.1 Surficial Features

The proposed Building connects to the southern side of the existing DPW structure. Except for the very eastern margin of the Site, the Site is covered by bituminous pavement. Along the eastern margin of the Site, approximately 30 feet from the pavement is a drainage swale with standing water estimated to be not more than 3 feet lower than the adjacent surficial grade. Between the drainage swale and eastern edge of the pavement is a 30-foot wide strip of land cover with wood chips and weeds. East of the drainage swale is wooded. Within the developed areas of the Site, the existing grade is relatively level with less than 2 feet of elevation change estimated.

The general landscape of this portion of Norwell owes its origins to the last continental glacier. Soils typically consist of granular glacial outwash soils and glacial till overlying bedrock. A large, post-glacial wetland area is located north of Main Street and along the western side of the Site.

Based on the Federal Flood Insurance Rate Map, Map Number 250023C0114J, dated July 17, 2012, the Site is considered within Zone X, which falls outside the 0.2 percent annual chance floodplain.

3.2 Subsurface Conditions

Shallow soil profiles have been altered from previous Site development activities associated with the apparent removal of top- and sub- soils and surficial grading activities within the developed portion of the Site and area corresponding with the proposed Building's footprint. Installation of utilities and a drainage swale have also altered subsurface conditions. The test borings were located to avoid conflicts with underground utilities. The Test Boring Reports are presented in Appendix A for a more detailed description of the soil stratigraphy and sampling data. Photographs of the recovered soil samples are presented in Appendix B. The following generalized subsurface conditions were encountered at the test boring locations.

- **Bituminous Pavement,** 2.5 to 3 inches in thickness was encountered in paved areas.
- **Silty Sandy Gravel, Silty Gravelly Sand, and Sand**, mostly medium dense, underlies the Bituminous Pavement all boring location to depths of 4 to 8 feet.
- **Silt and Clayey Silt** layer was encountered at test boring locations B-2, B-3,and B-5 between 4.5-5.0, 4.0-5.0, and 5.0-6.5 feet below grade, respectively. The consistency was judged to be stiff.
- **Till** was encountered in B-4 from 4.0-5.66 feet overlying Bedrock. The consistency of the Till was dense to very dense.
- **Stratified Sand and Silty Sand** at B-1 & B-2 boring locations extends to a layer of Silt & Clayey Silt at depths of 17.0 & 20.0 feet, respectively, and Bedrock or Till in B-3 & B-5 was encountered at 15.9 and 15.0 feet below grade, respectively. The consistency of the Sand and Silty was judged to be generally medium dense.
- **Bedrock**, mapped bedrock underlying the Site consists of the Rhode Island Formation, comprised of Sandstone, Graywacke, Shale, and Conglomerate with minor belts of meta-anthracite and fossil plants. The Bedrock was not cored as part of this initial subsurface investigation.

Groundwater/ saturated soil were encountered at 2.5 to 3.0 feet below grade. The boreholes did not remain open to allow for a stabilized groundwater measurement. From USGS monitoring well data in the vicinity of Eastern Massachusetts for November and December, groundwater conditions appear to be much above normal to high.

4.0 ENGINEERING CONSIDERATIONS

Primary *in situ* geotechnical concerns for the proposed Building (Alternative I) are associated with the following:

- Compatibility of the proposed foundations with the existing building foundation,
- Complete removal of undesirable surficial features within and around the proposed Building, e.g., bituminous pavement and landscaped areas, etc.,
- Avoid foundations bearing on dissimilar materials, i.e., Bedrock and soil,
- Removal of existing underground utilities, as necessary, with proper backfilling and compaction of excavations,
- Previously non-structurally backfilled areas abutting the existing building foundation within the proposed construction area should be carefully inspected during excavation activities for suitable bearing materials and appropriate compaction for its intended use,
- Groundwater was encountered between 2.5 and 3 feet below the existing grade,
- Proof-compaction of all bearing surfaces within the proposed Building footprint,
- Soil excavation activities on-Site must comply with all local, state, and federal regulations,
- Excavation sidewalls may be unstable, particularly in non-cohesive granular soils, and
- Surface water runoff should be controlled from entering the Site area/ excavations.

In general, the existing granular soils within the proposed Building footprint are suitable for supporting a shallow foundation scheme.

4.1 Building Foundation

Granular Fill and the Silty Gravelly Sand excavated from within the proposed building footprint may be reused as compacted Granular Fill or Structural Fill, provided it is not contaminated with unsuitable materials, and if placed under controlled conditions as specified in Section 1804.0 of the *International Building Code (2015)* and Section 5 of this report.

A shallow foundation scheme using strip and spread footings is feasible for the proposed Building. The minimum recommended dimension for a strip footing is 24 inches and 36 inches for a spread footing. Although the *Massachusetts State Building Code* no longer specifies the foundation depth for frost protection, the longstanding standard minimum construction practice for exterior foundations of 4.0 feet below grade is recommended. Interior footings should be a minimum of 12 to 18 inches below the top of the floor slab and above the top of interior column footings to minimize the possibility of the floor cracking and displacement of the floor slab because of differential movements between the slab and column foundation. A concrete slab-on-grade may be used as the floor slab bearing on a minimum of 12 inches of 1/2 to 3/4-inch crushed stone or on Structural Fill to provide uniform bearing. For proper slab-on-grade performance, the Granular Fill should conform to the gradation and compaction requirements in Section 5 of this report. Because of the potential for vapor or moisture migration, a sheet polyethylene moisture barrier should be used under any concrete slab-on-grade within any enclosed areas.

To provide uniform perimeter foundation bearing and to minimize shifting of Fines within bearing soils due to fluctuation of the high groundwater table, 6-12 inches of compacted 1/2 to 3/4-inch Crushed Stone wrapped in geotextile filter fabric may be provided beneath perimeter footings. A perimeter foundation underdrain should be provided on the outside edge of the geotextile wrapped Crushed Stone layer. Interior footings should bear on at least 6-inches of compacted Structural Fill or 1/2 to 3/4- inch Crushed Stone. The interior on-grade floor slab should bear on at least 12-inches of compacted Structural Fill.

4.2 Bearing Capacity

Shallow Foundation Scheme

Even shallow foundations will most likely intercept the groundwater table. Site grading activities will probably place proposed foundations within or bearing on undisturbed granular soils, Structural Fill, or Crushed Stone. Crushed Stone, Structural Fill, and undisturbed granular soils will be capable of supporting a net design load of 4,000 pounds per square foot (PSF/ 2.0 TSF – Tons per Square Foot). Settlement should be less than 1-inch with a safety factor of 3 against bearing failure and differential settlement should be less than 1/2-inch. In addition, The *Massachusetts Building Code Amendments* (9th Edition) to the *International Building Code* (2015) Table 1806.2a PRESUMPTIVE ALLOWABLE VERTICAL BEARING PRESSURE for a Class 7 soil - Gravel, widely-graded Sand and Gravel; loose to medium dense has a presumptive allowable bearing capacity from 2 to 4 TSF (4,000 to 8,000 PSF) which is equal to or greater than the recommended foundation design net bearing pressure of 4,000 PSF.

The most critical aspect during foundation construction is maintaining the integrity of the bearing surface by minimizing disturbance of bearing soils and the removal or compaction of any soil that has been disturbed.

4.3 Soil Parameters

Soil parameters (Angle of Internal Friction and Dry Unit Weight) are estimated for each stratum of the general soil profile noted above.

Soil Parameters			
Depth (feet)	**Stratum**	**Angle of Internal Friction ϕ (Degrees)**	**Dry Unit Weight (pcf)**
1.0. - 4.0/8.0	Silty Sandy Gravel, Silty Gravelly Sand, and Sand – medium dense	34	110
4.0 - 6.5	Silt and Clayey Silt - Stiff	31	90
5.0 - 15.0/28.0	Stratified Sand and Silty Sand – medium dense	34	105
4.0/15.0/26.0 - 27.0	Till - Dense to Very Dense	36	122

4.4 Modulus of Subgrade Reaction

Modulus of subgrade reaction (k-value, pounds per cubic inch, pci) is used in concrete pavement, floor slabs, and rigid foundation design models. The k-value can be measured using a field plate test directly on the subgrade. A 30-inch diameter rigid plate is loaded at a specified rate and the resulting deflection is measured. From $k = p/\Delta$, where: p = unit pressure on the plate, generally 10 psi, and Δ = vertical deflection in inches. However, actual field-testing, given the number of subgrade variables, is generally not practical for small or limited projects, so k-values are often estimated using soil classification, soil moisture, dry density, or correlation with the SPT, California Bearing Ratio, or Dutch Cone Penetration tests. However, the applicability of the concept of Modulus of Subgrade Reaction to a particular project/ model requires careful consideration and application. Construction disturbance and dynamic impact to soil will alter the Modulus of Subgrade Reaction; therefore, we recommend the use of the allowable soil bearing capacity, assuming a value for allowable settlement, for foundation design. For compacted Structural Fill an assumed Modulus of Subgrade Reaction of 200 pci may be used for determining the thickness of a concrete slab.

4.5 Seismic Design Criteria

Seismic design criteria are based upon informed judgments regarding probable earthquake ground motions in the region and probabilities of occurrence. The objectives of seismic design are to protect life safety by limiting total structural collapse. Every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their support at attachments, shall be designed and constructed in accordance with the current edition of *ASCE 7* and *The Massachusetts State Building Code (9th Edition).*

The maximum considered earthquake spectral response acceleration at short periods (S_s) and a 1-sec (S_1) were determined from Table 1604.11 of *The Massachusetts State Building Code*. Accordingly, a soil S_s-factor equal to 0.203 and S_1-factor of 0.065 can be used in the seismic analysis. The soil Site Classification from *ASCE* 9.4.1.2.1, is D, using the N Method.

Based on CGE's evaluation of the soil data obtained at the Site, it is concluded that the natural soils are not vulnerable to collapse under seismic loading and given the depth to the groundwater table and soil density, the soils are not susceptible to liquefaction.

4.6 Utility Construction

Depending upon the excavation depths below grade, the excavation sidewalls should be flattened or braced to meet current OSHA requirements. The contractor must maintain safe and stable slopes in soil cuts, a minimum slope of 1.5 h:1v (horizontal:vertical) is recommended, if unbraced.

CGE recommends that underground utilities (piping) be placed on soil which can provide uniform support and a stable foundation. Unstable subgrade which is defined as a condition of running sand or silt, quick bottom or otherwise soft or spongy bottom shall be addressed by excavating, or dewatering and stabilizing the subgrade as necessary to provide a firm, stable foundation.

Where the bottom of the trench is stable, the piping shall be backfilled to the mid-diameter of the pipe with granular fill meeting the requirements of Granular Fill presented in Section 5.0. Above the pipe, ordinary granular fill may be used so long as it does not have greater than 3/4-inch stones and will provide adequate support of the area for its intended use.

4.7 Pavement Design

Suggested minimum pavement sections and compaction effort of the base courses are as follows:

Pavement Design

	Parking, Passenger Car and Light Truck Traffic Areas (inches)	Heavy Truck and Loading Areas (inches)
Bituminous Pavement		
Surface Course	1.5	1.5
Binder Course	2.0	3.0
Base Course (Dense Pack or Granular Fill)		
Granular Fill Thickness	12	18
Minimum Degree of Compaction	95%	95%

A steel reinforced concrete slab is recommended for areas where heavy vehicles or trash dumpsters will be parked or stored, respectively, with a dense-graded crushed stone base. Gradation of Granular Fill bases for parking and driveway areas may also meet the gradation recommendations for dense-graded crushed stone shown below.

Dense-Graded Crushed Stone		
	Percent Finer by Weight	
U.S. Sieve Size and Number	Minimum	Maximum
3-inch	100	---
1-1/2 inch	70	100
3/4	50	85
No. 4	30	55
No. 50	8	24
No. 200	3	12

5.0 SITE PREPARATION

5.1 Construction Monitoring

It is recommended that competent field monitoring services be retained at the Site during earthwork and foundation construction in order to:

1. Observe removal of unsuitable material from within the building footprint locations.

2. Determine that suitable soil exists at foundation bearing elevations and confirm the bearing capacity recommendations made herein.

3. Observe preparation of bearing surfaces for footings prior to forming and placement of concrete.

4. It is also recommended that a soil testing technician be retained to observe and test placement and compaction of Granular Fill and backfill.

5.2 Earthwork

Overburden soils may be excavated by conventional earth-moving equipment. Depending upon the final elevation of the foundation below grade, the excavation sidewalls should be flattened or braced to meet current OSHA requirements. The bearing surface should be free from loose or disturbed soil and inspected by a geotechnical engineer.

The contractor is solely responsible for construction site safety and maintaining safe and stable slopes. Depending upon the excavation depths below grade, the excavation sidewalls should be flattened or braced to meet current OSHA requirements, or those specified in local, state and federal regulations. The contractor's responsible person, as defined in 29 CFR Part 1926, should evaluate all excavations as part of the contractor's safety procedures. CGE is not assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

Excavation of uncontrolled Fill and unsuitable soils around and beneath structures should be accomplished to provide adequate structural bearing soil. Excavation of unsuitable soils should extend a minimum of 2 feet from the outside of the foundation footing and continue at a 1h:1v (horizontal:vertical) slope to suitable bearing soils. Backfilling with compacted Granular Fill should follow the same slope and offset requirement from the footing for proper bearing and lateral support.

Backfill around foundations should consist of clean 3/4-minus stone or well graded sand and gravel free of organic material, trash, ice, frozen soil, and other deleterious materials. The recommended gradation for Granular Fill should satisfy the following limits.

Granular Fill/ Structural Fill

U.S. Sieve Size and Number	Percent Finer by Weight	
	Minimum	Maximum
4 inch	100	---
2 inch	65	100
No. 4	30	80
No. 20	10	65
No. 40	5	40
No. 100	0	20
No. 200	0	8

The moisture content of the Granular Fill material should be adjusted prior to placement so that it is within 2 percent of the optimum moisture content. Fill should be placed in loose lifts not exceeding 6 inches in thickness and compacted with a minimum of 4 passes of a suitability-sized vibratory compactor to a dry density of at least 95 percent of the maximum dry density as determined by the laboratory test designated ASTM D 1557.

5.3 Groundwater Control

The groundwater level at the time of construction may be higher or lower, subject to seasonal variations, runoff, or seepage. Groundwater based on the test boring data, may be encountered in almost any shallow excavation. Groundwater or stormwater runoff may also be perched on soils having a low permeability, but can be easily controlled by sumps and pumps, if necessary. Surficial runoff due to heavy rains during construction should be controlled and directed away from the foundation excavations. Any bearing soils disturbed by surface water should be removed prior to placement of Structural Fill or foundation concrete.

6.0 LIMITATIONS

The conclusions expressed by CGE in this report are based solely on the references cited. Observations, analyses, and recommendations were made under the conditions stated and where information was provided by others it was relied upon as complete. The purpose of this study was to establish by a limited scope of work subsurface conditions and provide a recommendation of the bearing capacity. The nature and extent of subsurface conditions are developed through both engineering and geological interpretations and variations between the investigation and the actual subsurface conditions may not become evident until construction. If differences are found, CGE should be given the opportunity to reevaluate the recommendations of this report. In the event that changes in preliminary design, specifications, or location of the proposed building foundation are planned, the conditions and recommendations contained in this report shall not be considered valid unless CGE can review and modify them as necessary.

Base Plan: Google Earth – N.T.S.

B-1 ● Test Boring Location and Number

CGE Engineering, Inc.

Test Boring Location Plan

Proposed DPW Building
310 Main Street
Norwell, Massachusetts

FIGURE 1

Appendix A

Test Boring Reports

CGE Engineering, Inc.	TEST BORING REPORT

PROJECT:	Norwell, Massachusetts	BORING NO.	**B-1**
LOCATION:	310 Washington Street	PAGE 1 OF	2
DRILLING CO:	Soil Exploration Corp.	DATE STARTED:	11/9/18
EQUIPMENT:	Truck-Mounted Acker AD-II Rotary Drill	DATE FINISHED:	11/9/18
DRILLED BY:	George Guinto	SURFACE ELEV:	N.D.
INSPECTED BY:	Ronald Bukoski, P.E., L.S.P.		Site Relatively Level

GROUNDWATER OBSERVATIONS

NOT ENCOUNTERED

DEPTH	STABILIZATION TIME
2.75'	0

	CASING	SAMPLER	CORE BAR.
TYPE	HSA	S-B	
SIZE ID:	4.25"	1 3/8"	
HAMMER WT:	N/A	140 lbs	
HAMMER FALL:		30"	

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM – TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
						0.25'	**Surface: 2.5-3.0" Bituminous Pavement.**			
							Silty Sandy Gravel, subrounded to angular			
	1.0 – 3.0'	2	15	15	12		m-f Gravel, 30-40% c-f Sand, 15-20% nonplastic Fines, moist to saturated at 2.75′, brown.	S-1	24/13	
	3.0 - 5.0'	9	5	7	10		**Silty Sandy Gravel,** similar gradation as S-1, 15-20% slightly plastic Fines.	S-2	24/12	
5.0							**1-5 ft** – Auger chatter at 2 ft. Auger resistance low.			
	5.0 - 7.0'	17	20	17	22		**Silty Sandy Gravel,** similar gradation as S-1, 15-20% slightly less plastic Fines.	S-3	24/14	
							5-10 ft - Auger resistance low, no chatter.			
						8.0'±	**Silty Sandy Gravel**			
10.0										
	10.0 - 12.0'	8	3	4	6		**Silty Sand,** stratified, c-f Sand, 10-20% nonplastic Fines, <5% fine Gravel, saturated, brown.	S-4	24/10	
							10-15 ft - Auger resistance low, no chatter.			
15.0										
	15.0 - 17.0'	5	5	4	7		**Sand,** stratified, mostly m-f Sand, 2″ c-f seam, <5% nonplastic Fines, saturated, dark orange brown – tip gray Silt.	S-5	24/22	
						17.0'±				
							15-20 ft - Auger resistance low, no chatter on stones.			
20.0	20.0 - 22.0'	1	2	6	6		**Silt,** nonplastic Fines, 1/16″ seam m Sand,	S-6	24/24	

GENERAL REMARKS: 1. Automatic hammer for soil sampling.

CGE Engineering, Inc.	TEST BORING REPORT
PROJECT: Norwell, MA	BORING NO. **B-1**
LOCATION: 310 Washington Street	PAGE 2 OF 2

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM - TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
	20.0 – 22.0'	1	2	6	6		**Silt,** nonplastic Fines, 1/16″ seam medium, Sand, saturated, grayish brown.	S-6	24/24	
							20-25 ft - Auger resistance low, no chatter on stones.			
25.0	25.0 – 27.0'	2	6	19	24		**Sand,** mostly m-f Sand, <5% nonplastic Fines, saturated, rusty brown.	S-7	24/9	
						26.0'±	**Till: Silty Gravel**, m-f angular Gravel, saturated, gray.			
							End of Test Boring 27.0 ft.			
30.0										
35.0										
40.0										
45.0										

GENERAL REMARKS:

CGE Engineering, Inc.	TEST BORING REPORT

PROJECT:	Norwell, Massachusetts	BORING NO.	**B-2**
LOCATION:	310 Washington Street	PAGE 1 OF	2
DRILLING CO:	Soil Exploration Corp.	DATE STARTED:	11/9/18
EQUIPMENT:	Truck-Mounted Acker AD-II Rotary Drill	DATE FINISHED:	11/9/18
DRILLED BY:	George Guinto	SURFACE ELEV:	N.D.
INSPECTED BY:	Ronald Bukoski, P.E., L.S.P.		Site Relatively Level

GROUNDWATER OBSERVATIONS

NOT ENCOUNTERED

DEPTH	STABILIZATION TIME
2.5'	0

	CASING	SAMPLER	CORE BAR.
TYPE	HSA	S-B	
SIZE ID:	4.25"	1 3/8"	
HAMMER WT:	N/A	140 lbs	
HAMMER FALL:		30"	

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM – TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
						0.5'	**Surface: 2.5-3.0" Bituminous Pavement.**			
	1.0 – 3.0'	8	11	9	6		**Silty Gravelly Sand,** c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 2.5′, brown.	S-1	24/20	
	3.0 - 5.0'	3	2	2	9		**Silty Gravelly Sand,** similar to S-1. **1-5 ft** - Auger resistance mod. w/chatter 1-2 ft, Auger resistance low 2-5 ft, no chatter.	S-2	24/16	
						4.5'±				
5.0						5.0'±	**Silt,** slightly plastic Fines, 2″ brown over gray.			
	5.0 - 7.0'	8	16	15	14		**Silty Gravelly Sand,** c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, saturated, brown w/ orange layer. **5-10 ft** - Auger resistance low, no chatter.	S-3	24/22	
10.0						10.0'±				
	10.0 - 12.0'	5	8	24	30		**Gravelly Sand,** stratified, mostly m-f Sand, 5-15% fine subrounded to angular Gravel, <5% nonplastic Fines, saturated, brown. **10-15 ft** - Auger resistance low, no chatter.	S-4	24/24	
15.0										
	15.0 - 17.0'	2	3	2	6		**6″ Gravelly Sand,** c-f Sand, 15-25% angular Gravel, <2% nonplastic Fines, brown.	S-5	24/19	
						16.0'±	**Sand,** stratified fine Sand, horizontal mottling, grayish brown/ orange brown. **15-20 ft** - Auger resistance low, no chatter on stones.			
20.0	20.0 - 22.0'	1	3	5	6	20.0'±	**Clayey Silt,** non- to slightly plastic Fines gray,	S-6	24/18	

GENERAL REMARKS: 1. Automatic hammer for soil sampling.

CGE Engineering, Inc.	TEST BORING REPORT
PROJECT: Norwell, MA	BORING NO. **B-2**
LOCATION: 310 Washington Street	PAGE 2 OF 2

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM - TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
	20.0 – 22.0'	1	3	5	6		**Clayey Silt,** non- to slightly plastic Fines gray.	S-6	24/18	
							20-25 ft - Auger resistance low, no chatter on stones.			
25.0	25.0 – 27.0'	5	10	15	23		**Transition to Till: Silty Sand.** m-f Sand. 10-20% nonplastic Fines, saturated, gray.	S-7	24/22	
						26.0'±	**Till: Silty Gravelly Sand**. c-f Sand. m-f subangular Gravel,10-15% NPF, gray.			
							End of Test Boring 27.0 ft.			
30.0										
35.0										
40.0										
45.0										

GENERAL REMARKS:

CGE Engineering, Inc.	TEST BORING REPORT

PROJECT:	Norwell, Massachusetts	BORING NO.	**B-3**
LOCATION:	310 Washington Street	PAGE 1 OF	1
DRILLING CO:	Soil Exploration Corp.	DATE STARTED:	11/9/18
EQUIPMENT:	Truck-Mounted Acker AD-II Rotary Drill	DATE FINISHED:	11/9/18
DRILLED BY:	George Guinto	SURFACE ELEV:	N.D.
INSPECTED BY:	Ronald Bukoski, P.E., L.S.P.		Site Relatively Level

GROUNDWATER OBSERVATIONS

NOT ENCOUNTERED

DEPTH	STABILIZATION TIME
2.5'	0

	CASING	SAMPLER	CORE BAR.
TYPE	HSA	S-B	
SIZE ID:	4.25"	1 3/8"	
HAMMER WT:	N/A	140 lbs	
HAMMER FALL:		30"	

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM – TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
						1.0'±	**Surface: Woodchips, Organic Silt.** **Sand** - medium to fine.			
	1.0 – 3.0'	2	3	5	9		**Sand**, c-f Sand, <5% nonplastic Fines, moist to saturated at 2.5′, brown.	S-1	24/22	
							1-5 ft – Auger resistance low, no chatter.			
	3.0 - 5.0'	4	6	4	6	4.0'±		S-2	24/22	
5.0						5.0'±	**Silt**, 3″ Organic Silt, sat. blackish over, slightly plastic gray Fines.			
	5.0 - 7.0'	6	12	12	12		**Silty Sand**, m-f Sand, 15-25% nonplastic Fines, <5% f Gravel, gray to brown @ 6′±.	S-3	24/22	
							5-10 ft - Auger resistance low, no chatter.			
10.0						10.0'±				
	10.0 - 12.0'	6	10	9	9		**Sand**, stratified, mostly m-f Sand, <5% nonplastic Fines, saturated, brown.	S-4	24/22	
							10-15 ft - Auger resistance low, no chatter.			
15.0										
	15.0 - 17.0'	5	50/5″ - Refusal			15.9'±	**Stratified Sand w/Thin Silt Layers.** **Rock Fragments** tip of SB sampler.	S-5	11/11	
							End of Test Boring 15.9 ft.			
20.0										

GENERAL REMARKS: 1. Automatic hammer for soil sampling.

CGE Engineering, Inc.	TEST BORING REPORT

PROJECT:	Norwell, Massachusetts	BORING NO.	**B-4**
LOCATION:	310 Washington Street	PAGE 1 OF	1
DRILLING CO:	Soil Exploration Corp.	DATE STARTED:	11/9/18
EQUIPMENT:	Truck-Mounted Acker AD-II Rotary Drill	DATE FINISHED:	11/9/18
DRILLED BY:	George Guinto	SURFACE ELEV:	N.D.
INSPECTED BY:	Ronald Bukoski, P.E., L.S.P.		Site Relatively Level

GROUNDWATER OBSERVATIONS

NOT ENCOUNTERED

DEPTH	STABILIZATION TIME
2.75'	0

	CASING	SAMPLER	CORE BAR.
TYPE	HSA	S-B	
SIZE ID:	4.25"	1 3/8"	
HAMMER WT:	N/A	140 lbs	
HAMMER FALL:		30"	

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM – TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
						0.25'±	**Surface: 3 " Bituminous Pavement**			
	1.0 – 3.0'	10	12	7	6		**Silty Gravelly Sand,** c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 2.75′, Rock in tip of sampler. **1-5 ft** – Auger resistance moderate w/chatter. to 3 ft.	S-1	24/8	
	3.0 - 5.0'	5	6	17	23	4.0'±		S-2	24/18	
5.0							**Till Transitions to Weathered Rock.**			
	5.0 - 7.0'	12	50/2″ - Refusal			5.66'±	**Rock Fragments** tip of SB sampler. **End of Test Boring 5.66 ft.**	S-3	8/8	
10.0										
15.0										
			1							
20.0										

GENERAL REMARKS: 1. Automatic hammer for soil sampling.

CGE Engineering, Inc.	TEST BORING REPORT

PROJECT:	Norwell, Massachusetts	BORING NO.	**B-5**
LOCATION:	310 Washington Street	PAGE 1 OF	1
DRILLING CO:	Soil Exploration Corp.	DATE STARTED:	11/9/18
EQUIPMENT:	Truck-Mounted Acker AD-II Rotary Drill	DATE FINISHED:	11/9/18
DRILLED BY:	George Guinto	SURFACE ELEV:	N.D.
INSPECTED BY:	Ronald Bukoski, P.E., L.S.P.		Site Relatively Level

GROUNDWATER OBSERVATIONS

NOT ENCOUNTERED

DEPTH	STABILIZATION TIME
3.0'	0

	CASING	SAMPLER	CORE BAR.
TYPE	HSA	S-B	
SIZE ID:	4.25"	1 3/8"	
HAMMER WT:	N/A	140 lbs	
HAMMER FALL:		30"	

SAMPLING DATA

DEPTH (ft)	SAMPLING DEPTH FROM – TO	HAMMER BLOWS ON SAMPLER (inches) 0-6	6-12	12-18	18-24	STRATA CHANGE	LITHOLOGY (Description of Materials)	SAMPLE ID	PEN/ RECOV. (in./in.)	HNU (ppm) Lamp 11.7 eV.
						0.25'±	**Surface: 3″ Bituminous Pavement**			
	1.0 – 3.0'	16	19	12	9		**Silty Gravelly Sand.** c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 3.0′. **1-5 ft** – Auger resistance moderate from 1-3 ft w/chatter; 3-5 ft low, no chatter.	S-1	24/18	
	3.0 - 5.0'	9	8	7	9			S-2	24/11	
5.0						5.0'±				
	5.0 - 7.0'	5	9	14	19		**Clayey Silt**, slight plastic Fines, sat., gray.	S-3	24/17	
						6.5'±	**Silty Sand**, mostly m-f Sand, 15-25% non-plastic Fines, gray to mottled br. & rusty br. **5-10 ft** - Auger resistance low, no chatter.			
10.0						10.0'±				
	10.0 - 12.0'	1	3	7	11		**Sand**, stratified, mostly m-f Sand, <5% m-f Gravel, <5%nonplastic Fines, saturated, brown. **10-15 ft** - Auger resistance low, no chatter.	S-4	24/22	
15.0						15.0'±				
	15.0 - 17.0'	13	29	33	31		**Till: Silty Gravelly Sand.** c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, saturated, orange brown.	S-5	24/24	
						18.0'±	**Auger Refusal.**			
							End of Test Boring 18.0 ft.			
20.0										

GENERAL REMARKS: 1. Automatic hammer for soil sampling.

Appendix B

Site Photographs

Photo 1: Test boring B-1 location in the vicinity of the northwest corner of the proposed structure as viewed from the northwest. The existing DPW maintenance garage is located on the left side of the photograph. The new salt storage structure is located in the background of the photograph.

Photo 2: Test boring B-1 split-barrel soil samples S-1 & S-2 from 1.0 to 3.0 ft & 3.0 to 5.0 ft below the existing grade, respectively. For all photographs, the soil samples increase in depth from right to left within the split-barrel sampler. The number of hammer blows to advance the split-barrel sampler in 6-inch increments is shown just below the sampling depth on the sample jar lids. "R" represents the soil sample recovered in inches. Recovered in S-1 & S-2 was Silty Sandy Gravel, saturated at 2.75 ft.

Photo 3: Test boring location B-1, S-3: Silty Sandy Gravel, subrounded to angular m-f Gravel, 30-40% c-f Sand, 15-20% slightly plastic Fines.

Photo 4: Test boring location B-1, S-4: Silty Sand, stratified, c-f Sand, 10-20% nonplastic Fines, <5% fine Gravel, saturated.

Photo 5: Test boring location B-1, S-5: Sand, stratified, mostly m-f Sand, 2″ c-f seam, <5% nonplastic Fines, saturated, dark orange brown – tip gray Silt.

Photo 6: Test boring location B-1, S-6: Silt, nonplastic Fines, 1/16″ seam medium, Sand, saturated, grayish brown.

Photo 7: Test boring location B-1, S-7: Sand, mostly m-f Sand, <5% nonplastic Fines, saturated, rusty brown over Till consisting of gray Silty Gravel, m-f angular Gravel, saturated.

Photo 8: Test boring B-2 located near the southwest corner of the proposed building as viewed from the south/southwest. The existing garage structure is shown in the background.

Photo 9: Test boring B-2 split-barrel soil samples S-1 & S-2 from 1.0 to 3.0 ft & 3.0 to 5.0 ft below the existing grade, respectively. Silty Gravelly Sand, c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 2.5′, brown over gray Silt at 4.5 ft, consisting of slightly plastic Fines, 2″ brown over gray.

Photo 10: Test boring B-2, S-3: Silty Gravelly Sand, c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, saturated, brown with orange rusty brown.

Photo 11: Test boring B-2, S-4 consisted of Gravelly Sand, stratified, mostly m-f Sand, 5-15% fine subrounded to angular Gravel, <5% nonplastic Fines, saturated, brown.

Photo 12: Test boring B-2, S-5 consisted of 6″ Gravelly Sand, c-f Sand, 15-25% angular Gravel, <2% nonplastic Fines, brown over stratified fine Sand, with horizontal grayish and rusty brown mottling.

Photo 13: Test boring B-2, S-6 consisted of Clayey Silt, non- to slightly plastic Fines gray.

Photo 14: Test boring location B-3 located near the proposed southeast corner of the proposed building as viewed from the west. The test boring was located off the edge of the bituminous pavement adjacent to a drainage swale.

Photo 15: Test boring B-3 split-barrel soil samples S-1 & S-2 from 1.0 to 3.0 ft & 3.0 to 5.0 ft below the existing grade, respectively. Woodchips, Organic Silt and Sand over Organic Silt, blackish to dark gray between 4 and 5 ft, slightly plastic Fines.

Photo 16: Test boring B-3, S-3: Silty Sand, m-f Sand, 15-25% nonplastic Fines, <5% fine Gravel, gray to brown @ 6′±.

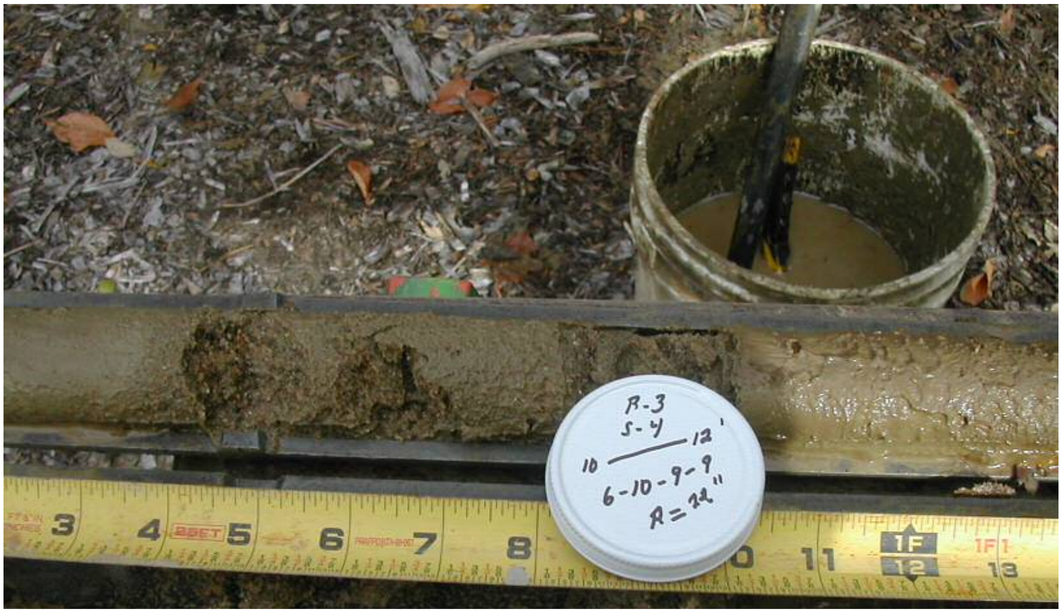

Photo 17: Test boring B-3, S-4. Recovered was stratified Sand, mostly m-f Sand, <5% nonplastic Fines, saturated, brown.

Photo 18: Test boring B-3, S-5: Stratified Sand w/Thin Silt Layers, with Rock Fragments in the tip of the sampler.

Photo 19: Test boring B-4 located near the northeast corner of the proposed structure as viewed from the southwest.

Photo 20: Test boring B-4 split-barrel soil samples S-1 & S-2 from 1.0 to 3.0 ft & 3.0 to 5.0 ft below the existing grade, respectively. Recovered was Silty Gravelly Sand, c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 2.75′ with rock in tip of S-1 sampler. Gray Till transitions to Weathered Rock from 4 to 5 ft.

Photo 21: Test boring B-4, S-3: Weathered Rock with Rock fragments in tip of sampler.

Photo 22: Test boring B-5 located near the center of the proposed building footprint as viewed from the south/southwest.

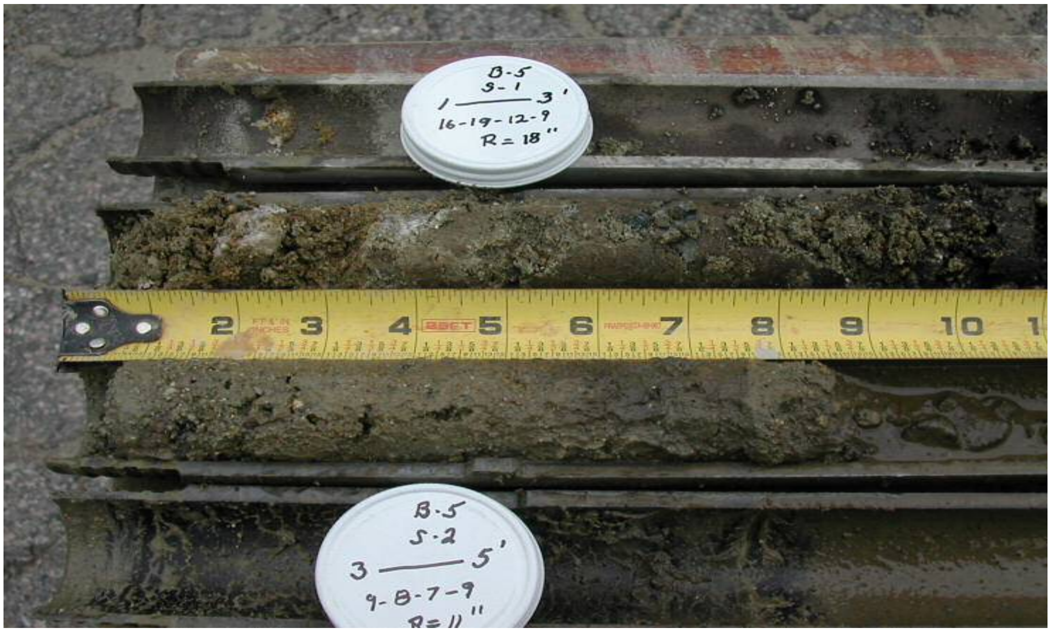

Photo 23: Test boring B-5 split-barrel soil samples S-1 & S-2 from 1.0 to 3.0 ft & 3.0 to 5.0 ft below the existing grade, respectively. Silty Gravelly Sand, c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, moist to saturated at 3.0 ft.

Photo 24: Test boring B-5, S-3: Clayey Silt, slight plastic Fines, saturated, gray transitioning to Silty Sand around 6.5 ft.

Photo 25: Test boring B-5, S-4: Sand, stratified, mostly m-f Sand, <5% m-f Gravel, <5% nonplastic Fines, saturated, brown.

Photo 26: Test boring B-5, S-5: Till: Silty Gravelly Sand, c-f Sand, 25-35% subrounded to angular m-f Gravel, 5-15% nonplastic Fines, saturated, orange brown. Auger refusal at 18.0 ft.

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