Briggs Engineering & Testing
A Division of PK Associates, Inc.

November 8, 2018
Briggs Project No. 30425

The Carell Group
c/o Mr. Greg Carell
85 Main Street
Hopkinton, MA 01748

RE: Geotechnical Investigation Report
Proposed Police Station
106 West Main Street, Merrimac, MA

Briggs Engineering & Testing, *A Division of PK Associates* (Briggs) has completed our investigation of the subsurface conditions at the above referenced location and completed this Geotechnical Report. These services were accomplished in accordance with your authorization of Proposal No. MA. 02.1723.0 dated August 16, 2018.

1.0 Project Location and Description

The site is located in the southwest part of Merrimac about 1 mile northwest of the Merrimack River and about ½ mile northeast of the Haverhill town line.

The site is a wooded property located at the southeast corner West Main Street and newly constructed Jana Way. The front (north) part of the site abuts West Main Street. Vegetated wetlands extend across much of the front of the property. The north-central part of the site is gently sloped down to the south. Steep grades exist across the south-central part of the site. Grades to the south of this steeper zone are gently sloped and mostly wetlands comprising roughly 20% of the site at its south end.

A Police Station is proposed on the north-central part of the site. The building is proposed slab on grade construction at grade slightly higher than existing grades in that area. Existing grade at the center of the proposed building area is currently at elevation 199 feet. An access drive extends north from the east side of the proposed building to West Main Street. Two more entries are proposed at the west side of the site and access Jana Way. Proposed asphalt drives and parking areas are located all around the perimeter of the proposed building. An out-building is proposed southeast of the main building and proposed paved areas. A radio antenna is proposed east-northeast of the proposed Police Station. Refer to attached Figure 1 for site layout and elevation contours across the northerly half of the site. No construction is proposed on the south half of the site to our knowledge.

Several utilities including electric, natural gas, telephone and water are supplied to the surrounding area and are available to the subject project buildings. No existing public utilities were identified on the subject project interior by Dig Safe via our utility clearance accomplished prior to drilling test borings for the project.

2.0 Subsurface Explorations

The subsurface conditions at the Site were explored under the supervision of the undersigned Briggs' Geotechnical Engineer. The explorations consisted of advancing four (4) test borings (B-1 through B-4) at or near the proposed Police Station building and B-5 and B-6 at the proposed antenna and Out-Building, respectively as shown on attached Figure 1. Final boring depths are tabulated as follows:

Boring	Refusal Depth
B-1	17.2 feet
B-2	23.7 feet
B-3	24 feet
B-4	23 feet
B-5	24 feet
B-6	26 feet

Soil Exploration Corp. of Leominster, MA advanced the borings on September 14 and 17, 2018. The borings were drilled by a rubber tired All Terrain Vehicle (ATV) mounted drill rig in accordance with ASTM D1586, "Penetration Test and Split Barrel Sampling of Soils". Standard Penetration Tests (SPT) were performed every 5 feet of drilling or more frequently as noted on the attached test boring logs.

Soil samples were field classified by David Geisser of Briggs on a full-time basis using the Bermister Soil Classification System. Soil descriptions by Briggs are presented in the attached test boring logs.

3.0 Subsurface Conditions

Soils stratigraphy consists of topsoil over subsoil underlain by silty sands and gravelly silty sands to refusals. These soils are discussed below:

Topsoil – Silty sands with little to some (10 to 35%) non-plastic fines (silt) and little to some organic matter was encountered in all borings from ground surface to depth of 0.5 to 1 foot. The organic layer is generally dark brown to black and loose. No N-Values[1] were recorded as the required 18 inches thickness of this organic layer does not exist at boring locations as required to measure N-Values. Briggs indicates the topsoil is loose based on hand shovel probing and partial N-Values via split spoon sampler.

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1 SPT N-Value is the number of blows for a 140 lb. hammer falling freely through 30 inches, required to advance the standard split spoon sampler the last 12 inches of an 18 inch sampling interval.

Subsoil – Silty sands with trace (less than 10%) gravel or no gravel, little to some silt and few root fibers (less than 1%) was encountered in all borings below the topsoil to depths of 2 to 4 feet. The subsoil is generally orange brown to brown and loose with N-Values ranging from 6 to 9.

Silty Sands and Gravelly Silty Sands - Undisturbed silty sands and gravelly silty sands were encountered in all borings below the topsoil and subsoil layers. The surface of the inorganic silty soils is at 2 to 4 feet BGS.
This deposit has generally trace to some gravel and little to some silt. These soils are generally brown to grey and medium dense to very dense with SPT N-Values ranging from 17 to 81 except at refusal depths where N-Values exceed 100.

Refusal – Refusals were encountered in all of the test borings at depths ranging from 17.2 to 26 feet BGS.

3.1 Groundwater

Upon completion of each test boring and at later times up to 4 hours later, a tape measure with hollow "plunker" device was lowered into the bore-hole to measure water that might have seeped into the borehole during penetration of the boring and/or after removal of sampling equipment. All bore-holes were dry and collapsed at about 10 feet BGS. Soil samples recovered from all borings were dry to moist above 5 feet depth and generally moist below 5 feet, suggesting groundwater is at about 5 feet BGS or deeper. The bore-holes were backfilled within 0.2 to 4 hours after completion.

Groundwater levels may be affected by local anomalous conditions such as underground utilities or confining silty or clayey soils as well as seasonal factors and thus may not represent the level to be encountered in the future. Generally, groundwater levels are highest in the spring and lowest in the late fall. The borings were completed in mid-July when groundwater levels are typically deeper than other seasons.

4.0 FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Foundation Design

We recommend that the proposed building be supported on continuous wall and spread footings bearing on the undisturbed inorganic sands with varying silt and gravel content and/or Structural Fill or Crushed Stone over the sandy subgrade.

Briggs recommends a 4-inch thick lift of ¾ inch minus crushed stone be placed and compacted on undisturbed silty subgrade soils to protect the silty subgrade from softening during and after rain events.

Footings resting on crushed stone directly over the silty subrade with a footing width of 2 feet should be sized for an allowable bearing capacity of 6000 pounds per square foot (psf) at 4 foot burial depth below adjacent exterior grades. Interior footings are typically shallower than the exterior footings and need not extend to frost depth (4 feet) in heated space areas. Interior footings at 2 feet below slab grade and a minimum 3 feet wide should be sized for an allowable bearing capacity of 4300 psf.

Total settlement due to the compression of the bearing soils should be less than 1 inch and the total differential settlement should be less than 1/2 inch and should pose no significant structural problems.

Exterior footings should be a minimum of 4.0 feet below finished grade to provide adequate protection against frost heave action. The 4-foot frost depth would also apply to foundations in un-heated interior areas, if any. All footings should be installed at relatively consistent depths. Where footings step up or down for utilities of from basement to slab on grade areas, footings must step as discussed below.

Stepped Footings
Should elevation of wall or column footings vary along walls, the footings should step up and down at a 1 vertical to 2 horizontal series of steps or flatter to transition up from lower to higher footing elevation, if any.

4.2 Seismic Design
The undisturbed sandy subgrade, compacted Structural and Granular Fills and Crushed Stone are not susceptible to liquefaction during the postulated seismic event given their gradation, depth to groundwater and relative densities within the depths explored. Soil relative density is generally increasing with depth to the maximum depth of 27 feet. Also, most of the explored soils are silty sands with varying gravel and silt content with gradation not susceptible to liquefaction during postulated seismic event. This evaluation is in accordance with the International Building Code, 9th Edition with Massachusetts State Amendments.

The explored soils for the proposed buildings are Seismic Site Classification D in accordance with Table 20.3-1 of ASCE 7-10 as the average N-Value for each boring is between 15 and 50. Seismic parameters for Merrimac as found in Table 1604.11 of the 9th editions of the Massachusetts Building Code are $S_s = 0.265$ and $S_1 = 0.078$.

4.3 Excavation and Subgrade Protection
Topsoil, subsoil and existing fill (If any) must be excavated from all proposed structural areas including building areas, pavements, walkways and exterior slabs to the surface of the undisturbed silty sands and gravelly silty sands. No fills were found in the test borings but could exist between boring locations. The topsoil, subsoil and fill (if any) must be excavated from foundation stress zones plus under entire slabs, concrete walkways and pavement areas. The stress zone is the volume of soil under footing plus wedges of soil extending down and out from all edges of footing at a 45-degree angle.

In areas where fills are required to reach footing grades, the lateral excavation of unsuitable fill and organic soils from under footing stress zones must extend laterally outside the outside edge of footing a distance equal to the height of fill above undisturbed inorganic sandy bearing subgrade to BOF grade (resulting in a 45 degree angle slope of Structural Fill under all footing areas) or as indicated in IBC, 9th Edition, whichever is greater lateral excavation. Briggs does not expect this to be required for this project based on anticipated footing depths and thickness of organic soils encountered in the borings.

Subgrade Protection
The undisturbed silty sand subgrade is moisture sensitive as it has generally about 20 to 30% fines. The subgrade may become disturbed by rainfall and construction traffic. If the subgrade becomes wet, it should be allowed to dry or be excavated to moist or dry subgrade prior to placing footings or fills. Backfill over subgrade soils should be 4-inch minimum thickness layer of ¾ inch minus crushed stone. Crushed stone thickness should be increased to 8 inches if wet subgrades are encountered. Any areas with one foot or thicker crushed stone fills should have the crushed stone completely wrapped by Mirafi 140N filter fabric or equivalent. Subsequent fills over the crushed stone can be Structural Fill and/or Granular Fill as discussed in Section 4.6.

Footings subgrades will consist of compacted undisturbed, inorganic silty sands, gravelly silty sands covered with a minimum 4 inches of crushed stone. The Crushed Stone fill layer should be placed immediately after excavation so that the subgrades will be protected against rainfall or water seepage through sides of excavation.

Unsupported excavations should slope up from the bottom of excavation in compliance with OSHA guidelines/standards. If excavation to proposed foundation grades extend deeper than 4 feet below footing grade, then these excavations should slope away from the excavation areas. If the Contractor chooses to use trench boxes or other lateral earth support measures, the lateral support systems must be designed by the Contractors' Engineer.

Geotechnical Department personnel should witnessed excavation subgrades to confirm that organic, loose or fill soils do not exist at proposed footing areas or other structural areas. The Geotechnical personnel would also determine if the bearing subgrade relative density is consistent with the test boring data and determine if the subgrade has become disturbed by excavation, water movement or dewatering activities.

Excavation effort should be easy to moderate to reach the undisturbed, inorganic silty sand subgrade. Bedrock removal is not anticipated as refusals were not encountered within 15 feet of existing ground surface and anticipated excavation depths will be less than 8 feet. However, if bedrock extends above footings, slabs or proposed utility elevations, then removal can be accomplished by blasting, hoe ramming or hydraulic wedge and splitting methods depending on local, state and federal regulations.

Boulders and cobbles may be encountered in soils within the proposed excavation zone. An excavator would typically be used to remove soils, cobbles and boulders in proposed foundation areas.

4.4 Water Control

Groundwater is deeper than 5 feet based on the explorations conducted in this investigation. Water seepage could occur at shallower depths due to rainfall as perched water seeps through the ground.

Silty sand subgrades that become wet by rain should not be traveled on or they may become disturbed. Disturbed silty sands should be excavated and be replaced by compacted lifts of crushed stone wrapped by filter fabric in proposed structural areas.

Water infiltration into excavations should be monitored during the construction phase. Damp proofing should be applied to all below grade foundation footings and walls.

A perimeter drain is not warranted since groundwater was not encountered at or above anticipated slab on grade elevation. Open excavations should be assessed during excavation phase do determine if oxidized or mottled soils exist above floor grade. Such soils were not encountered in the test borings at depths shallower than 10 feet. Briggs can provide conceptual design recommendations should perimeter drainage become warranted based on evidence of high groundwater at or above the proposed slab grades.

All backfilling must be placed "in the dry" after water is pumped to at least 6 inches below the base of excavations. Pumping might be necessary to allow placement "in the dry". Granular Fill and Structural Fill must be adequately compacted as discussed in Section 4.6 prior to placing additional fill.

Surface drainage should be directed away from excavations during construction so that the bearing surfaces do not become softened by water flow or puddling. Rapid water movement can also scour soils and undermine foundations, therefore surface water protection such as earth berms should be constructed. This can be accomplished with proper grading or construction of small dikes at the edge of the excavation.

Damp-proofing of all below grade foundations is recommended due to moderate permeability of site soils. The damp-proofing should reduce but not eliminate moisture infiltration through foundation walls. Vapor barrier or retarder should be installed under all slab areas if specified by the Architect. Briggs does not provide any warrantee against moisture infiltration or mildew or bacterial growth inside the proposed buildings.

4.5 Proposed Slabs

A minimum 12-inch thick layer of Structural Fill is recommended immediately beneath all proposed slabs after removal of fill and organic soils down to the undisturbed inorganic silty sand subgrade. The surface organic soils must be also removed from proposed pavement and other structural areas such as transformer pads, antenna foundation, etc.

Backfill above footing grade to within 12 inches of underside of interior or exterior slabs, pavements or concrete walkways can be Granular Fill as referenced in Section 4.6. However, Granular Fill must not be used in foundation stress zones.

A modulus of vertical subgrade reaction of 130 pound per cubic inch (pci) would apply to slabs resting on compacted Structural Fill over the undisturbed, inorganic silty sands and gravelly silty sands subgrade or Granular Fill.

Hydrostatic uplift design will not be necessary for proposed slabs placed at or above elevation 199 feet. Additional investigations may be necessary to evaluate need for uplift design if any slabs are to be constructed deeper than elevation 199 feet.

4.6 Backfill and Compaction

Silty sands, gravelly silty sands excavated in proposed footing and slab areas can be reused as Granular Fill to within one foot of the underside of pavement and one foot below interior slabs provided these inorganic soils can be compacted to 95% of their maximum dry unit weight and gradation meets the recommendations listed below. This material might be moisture sensitive and will be very difficult or impossible to adequately compact if it becomes wet by rain or is excavated below the water table. Wet silty sands should be segregated from dry silty sands so that the dry materials might be re-useable as compacted Granular Fill provided they meet the Granular Fill gradation recommendations presented later in this section.

As previously noted, the silty sand subgrade soils may be moisture sensitive and should be protected from disturbance due to water movement or foot traffic if they are wet. This material may be reusable as Granular Fill if it remains dry to moist. Otherwise the material should be stockpiled separately and may require offsite disposal.

Structural Fill should be placed on the subgrade soils to underside of footings and within the stress zones of all footings. Gradation for Structural Fill is listed later in this section. The foundation stress zone is the volume of soil extending down and out from all sides of the footing at a 45-degree angle.

Structural Fill should also be used as backfill against the exterior side of foundation walls extending out a minimum 3 feet from the foundation walls and vertically down to the bottom of footing elevation.

Within the areas excavated for footings, walls, and other limited areas where large compaction equipment cannot work, we recommend that the fill be placed in loose lifts no more than six inches in thickness and be compacted with small hand manipulated machines such as pneumatic compactors, vibratory compactors, etc. In areas where large vibratory compactors such as a Raygo 400A or equivalent can be used, we recommend that the loose lift thickness not exceed 12 inches.

All backfill placed in load bearing areas including under non-Structural Slabs and under footings should be compacted to a minimum of 95% of the maximum dry density as determined by the test designated modified ASTM D1557.

Crushed stone layers requires compaction by making at least three passes by a vibratory plate compactor or vibratory roller with minimum static weight of 400 pounds per 12 inch maximum lift thickness. No compaction testing will be necessary for the crushed stone fills. Crushed stone fills thicker than 12 inches should be placed in one-foot lifts and be monitored by a Technician or Geotechnical Engineer.

Crushed stone should have the following gradation:

CRUSHED STONE

U.S. Sieve Size & Number	Percent Passing Maximum	Minimum
1 inch	----	100
3/4 inch	100	90
1/2 inch	50	10
3/8 inch	20	0
No. 4	5	0

Structural Fill should consist of well-graded natural sands and gravel or crushed concrete. Structural Fill should be free from excessive plastic fines, organic matter and deleterious material including asphalt, and should have the following gradation:

RECOMMENDED STRUCTURAL FILL GRADATION

U.S. Sieve Size & Number	Percent Passing Maximum	Minimum
2/3 lift thickness	100	100
1 inch	100	60
No. 4	85	25
No. 20	60	10
No. 50	35	4
No. 200	8*	0

* Backfill within a minimum three (3) feet laterally of earth retaining walls or basement walls shall have 5% or less material passing the #200 sieve.

Granular Fill under proposed building space should be free of appreciable asphalt content as this can off-gas into occupied space causing possible health concerns. Granular Fill should consist of well graded natural sands and gravel free from excessive plastic fines, organic matter and deleterious material, and should have the following gradation:

RECOMMENDED GRANULAR FILL GRADATION

U.S. Sieve Size & Number	Percent Passing Maximum	Minimum

2/3 lift thickness	100	100
1 inch	100	60
No. 4	90	25
No. 200	25	0

5.0 Limitations and Exclusions

All the professional opinions presented in this report are based solely on the scope of work conducted and sources referred to in our report. The data presented by Briggs in this report were collected and analyzed using generally accepted industry methods and practices at the time the report was generated. This report represents the conditions, locations, and materials that were observed at the time the field-work was conducted. No inferences regarding other conditions, locations, or materials, at a later or earlier time may be made based on the contents of the report. No other warranty, express or implied is made.

This report was prepared for the sole use of our client. The use of this report by anyone other than our client or Briggs is strictly prohibited without the express prior written consent of Briggs. Portions of the report may not be used independently of the entire report.

The above recommendations and conclusions are based on our evaluation of the obtained data presented in the text. We would welcome the opportunity to monitor the pertinent phases of the foundation construction; thus, if differences are found between the field conditions described herein and those encountered during construction, we can modify our recommendations in a timely and professional manner.

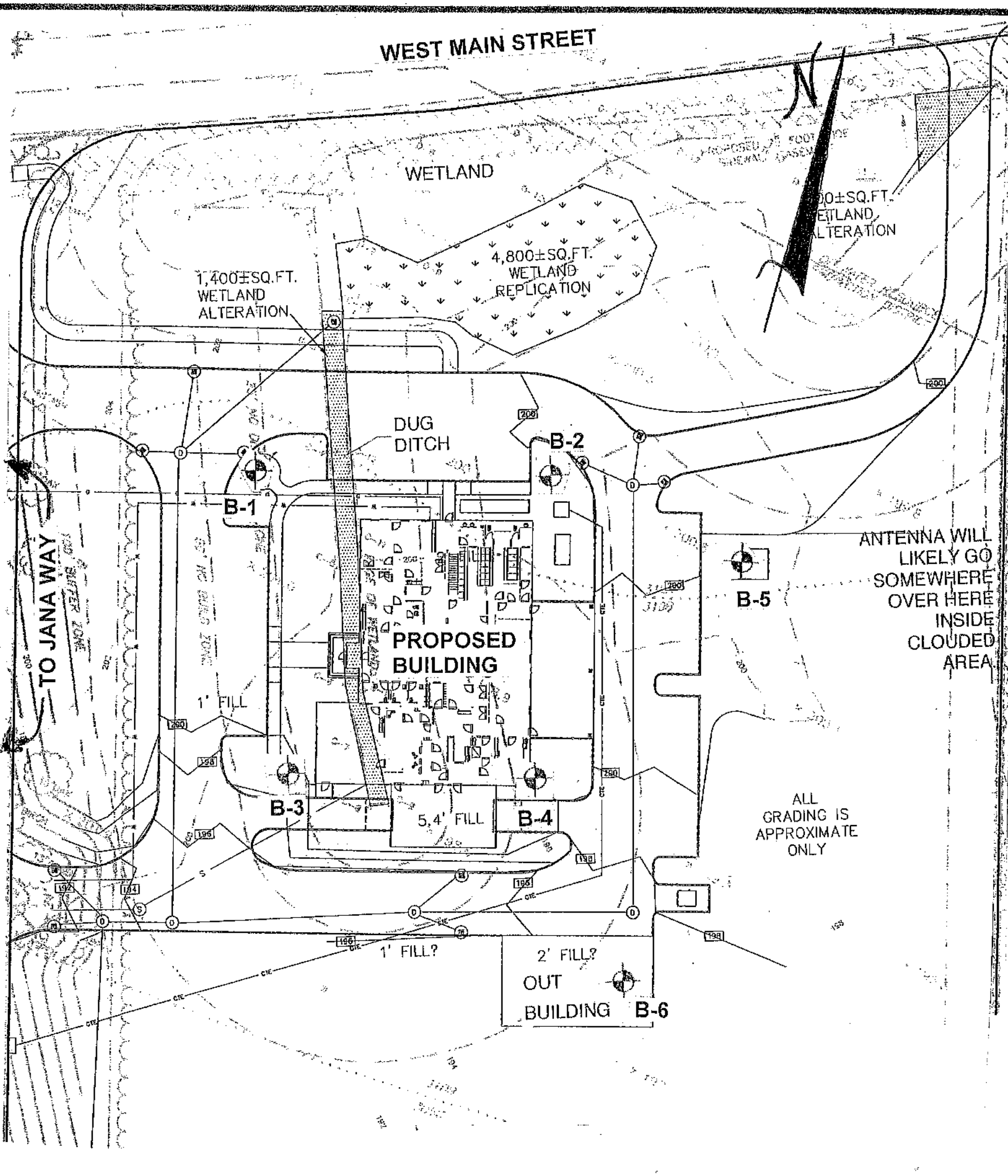
Thank you for engaging our services to undertake this project. If you have any questions, please do not hesitate to contact us at your convenience.

Very truly yours,
Briggs Engineering & Testing

David W. Geisser
Geotechnical Department Manager

Nicholas A Lanney, P.E.
Reviewer, Geotechnical Engineer

DWG:NAL:dg
Enclosures:
- Figure 1 – Exploration Location Plan
- Test Boring Logs



BRIGGS

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LEGEND:

B-1 Number and approx. Location of test boring.

NOTE Plan developed from "Concept Plan" dated 9/5/18 by Carell Group

EXPLORATION LOCATION PLAN
PROPOSED BUILDING
106 WEST MAIN STREET
MERRIMAC, MA

Scale: N.T.S.	*Drawn:* DWG	FIG. 1
SEPT 17, 2018	*Check:* NAL	

Leominster, MA 01453
978-840-0391

Soil Exploration Corp.
Field Log of Test Boring

Driller's Name		Date Begin	Date Finish	Hole No.	Job No.
George Giunta		9-14-18	9-14-18	B-1	
Hammer Wt.(Sampler)	Hammer Drop(Sampler)	Client		Hole Location	
		Briggs		Merrimac Police	
Hammer Wt.(Casing)	Hammer Drop(Casing)	Type of Hole	Hole Elevation		
		HSA		106 W. Main St	

Sample Number	Depth of Sample	Depth in Feet From	Depth in Feet To	Blows Per 6" on spoon with Hammer	Recovery in inches	Sample type	Casing blows per foot	Sample Description
S1	0-1	0	1	3-4	8			Topsoil - f/m, some Silt, trace Organic, black
S1A	1-2	1	2	5-6	7			Subsoil - f/c Sand, trace Gravel, some Silt, brown dry
S2	2-4	2		25-31-30-27	15			Gravelly Silty Sand - f/c, some Gravel, some Silt, olive grey brown, dry
S3	5-7			10-10-11-13	18			Silty Sand - f/c, some Silt, olive grey brown moist
S4	10-12			8-6-14-16	18			Similar to S-2, moist
S5	15-17			15-25-26-31	14			Similar to S4, grey
								Augur Refusal at 17.2 ft
S6	17.2			120/0				Sample Refusal

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978-840-0391

Soil Exploration Corp.
Field Log of Test Boring

Driller's Name		Date Begin	Date Finish	Hole No.	Job No.
George Guinto		9-14-18	9-14-18	B-2	
Hammer Wt.(Sampler)	Hammer Drop(Sampler)	Client: Briggs		Hole Location	
Hammer Wt.(Casing)	Hammer Drop(Casing)	Type of Hole: HSA	Hole Elevation		

Sample Number	Depth of Sample	Depth in Feet From	Depth in Feet To	Blows Per 6" on spoon with Hammer	Recovery in inches	Sample type	Casing blows per foot	Sample Description
S1	0-2	0	0.5	3				Topsoil-f/m Sand, some silt,
		0.5		3-4-4	18			trace Organic dk brown
								Subsoil-f/m Sand,
			2					some silt, brown
S2	2-4	2		6-10-11-14	12			Silty Sand-f/m, some Silt
								olive grey brown, moist,
								mottled.
S3	5-7			8-9-8-10	18			Similar to above.
S4	10-12			10-16-24-36	14			Similar to above,
S5	15-17			21-30-31-31	18			Silty Sand, some Silt,
						▽	20'	olive grey blue, moist
S6	20-22			24-35-46-44				similar to above
			23.5					Auger Refusal
S7	23.5			120/2				Rock, plugged Sample
								Sampler Refusal 23.7ft

Leominster, MA 01453
978-840-0391

Soil Exploration Corp.
Field Log of Test Boring

Driller's Name	Date Begin	Date Finish	Hole No.	Job No.
George Gunto	9-14-18	9-14-18	B-3	

Hammer Wt.(Sampler)	Hammer Drop(Sampler)	Client	Hole Location
		Briggs	Merrimac Police

Hammer Wt.(Casing)	Hammer Drop(Casing)	Type of Hole	Hole Elevation	
		U		106 W. Main St

Sample Number	Depth of Sample	Depth in Feet From	Depth in Feet To	Blows Per 6" on spoon with Hammer	Recovery in inches	Sample type	Casing blows per foot	Sample Description
S1	0-2	0	0.5	2				Topsoil - f/m Sand,
				2-4-4	13			some Silt, trace Organic, dk brn
S2	2-4	0.5		6-10-13-14	15			Subsoil - f/m Sand, some
			4					silt, orange brown
S3	5-7	4		7-8-9-9	16			Silty Sand - f/m Sand,
								some Silt, mottled, grey,
S4	10-12			11-21-15-17	4			brown Gravelly Silty Sand f/c
								some Gravel, some Silt, olive
								brown.
S5	15-17			22-32-36-44	18			Similar to above, grey
S6	20-22			28-35-41-49	17			Similar to above, little Gravel
								Auger Refusal 24 ft
S7	24			120/0	0			Sample Refusal 24 ft

Leominster, MA 01453
978-840-0391

Soil Exploration Corp.
Field Log of Test Boring

Driller's Name		Date Begin	Date Finish	Hole No.	Job No.
Pat		9-17-18	9-17-18	B-6	
Hammer Wt.(Sampler)	Hammer Drop(Sampler)	Client		Hole Location	
		Briggs		Merrimac Police	
Hammer Wt.(Casing)	Hammer Drop(Casing)	Type of Hole	Hole Elevation	106 W Main St	
		HSA			

Sample Number	Depth of Sample	Depth in Feet From	Depth in Feet To	Blows Per 6" on spoon with Hammer	Recovery in inches	Sample type	Casing blows per foot	Sample Description
S1	0-2	0	0.5	1				Topsoil - f/c Sand, trace
					15			Gravel, some silt, trace organic
		0.5		3-6-8				Subsoil - f/m Sand, some
~~S2~~			2					silt, light brown, dry
S2	2-4	2	4	8-8-21-19	18			Silty Sand - f/c, trace Gravel
								some Silt, olive grey, dry
S3	5-7			9-8-9-11	21			Similar to above, mottled
S4	10-12			18-25-27-31	18			Similar to S-2
S5	15-16.6			28-37-41	15			Gravelly Silty Sand - f/c
				100/1				Some Gravel, some Silt,
								grey brown, dry
S6	20-22			18-30-22-27				Silty Sand - f/c, trace Gravel
								some Silt, grey, moist
S7	25-26			42-123				Similar to above, some
								Gravel, grey, moist
								Auger Refusal at 25.5 ft
								Sampler Refusal at 26 ft
								No Groundwater