December 26, 2014

Mr. David G. McKinley
Kaestle Boos Associates, Inc.
325 Foxborough Blvd. Suite 100
Foxborough, MA 02035
Phone: (508) 549-9906
Fax: (508) 549-9907
E-mail: dmckinley@kba-architects.com

Re: **Preliminary Geotechnical Report**
Proposed Minuteman Vocational Technical High School
Western Wooded Parcel
Lexington, Massachusetts
LGCI Project No. 1440

Dear Mr. McKinley:

Lahlaf Geotechnical Consulting, Inc. (LGCI) has completed a preliminary geotechnical study for the feasibility study for the proposed Minuteman Vocational Technical High School in in the Western Wooded Parcel at the existing high school in Lexington, Massachusetts. We are submitting this report electronically via e-mail. Please let us know if you need a paper copy.

The soil samples from our explorations are currently stored at LGCI for further analysis, if requested. Unless notified otherwise, we will dispose of the soil samples after three months. The rock cores were left at the facilities department of the Minuteman Vocational Technical High School.

Thank you for choosing LGCI as your geotechnical engineer.

Very truly yours,

Lahlaf Geotechnical Consulting, Inc.

Abdelmadjid M. Lahlaf, Ph.D., P.E.
Principal Engineer

PRELIMINARY GEOTECHNICAL REPORT
PROPOSED MINUTEMAN VOCATIONAL TECHNICAL HIGH SCHOOL
WESTERN WOODED PARCEL
LEXINGTON, MASSACHUSETTS
LGCI Project No. 1440
December 26, 2014

Prepared for:

KAESTLE BOOS ASSOCIATES, INC.
325 Foxborough Blvd. Suite 100
Foxborough, MA 02035
Phone: (508) 549-9906
Fax: (508) 549-9907

PRELIMINARY GEOTECHNICAL REPORT
PROPOSED MINUTEMAN VOCATIONAL TECHNICAL HIGH SCHOOL
WESTERN WOODED PARCEL
LEXINGTON, MASSACHUSETTS
LGCI Project No. 1440
December 26, 2014

Prepared for:

KAESTLE BOOS ASSOCIATES, INC.
325 Foxborough Blvd. Suite 100
Foxborough, MA 02035
Phone: (508) 549-9906
Fax: (508) 549-9907

Prepared by:

LAHLAF GEOTECHNICAL CONSULTING, INC.
23 McGinness Way
Billerica, Massachusetts 01821
Phone: (978) 330-5912
Fax: (978) 330-5056

Abdelmadjid M. Lahlaf, Ph.D., P.E.
Principal Engineer

TABLE OF CONTENTS

List of Table, Figures, and Appendices

Preliminary Geotechnical Engineering Report
Proposed Minuteman Vocational Technical High School
Western Wooded Parcel
Lexington, Massachusetts
LGCI Project No. 1440

1. PROJECT INFORMATION

1.1 Project Authorization

This report presents the results of preliminary subsurface explorations and a geotechnical evaluation performed by Lahlaf Geotechnical Consulting, Inc. (LGCI) for the proposed Minuteman Vocational Technical High School in Lexington, Massachusetts. We performed our services in general accordance with our proposal No. 14078 dated November 24, 2014 and with terms and conditions of the Standard Form of Agreement Between Architect and Consultant for Special Services dated December 3, 2014. Mr. Brian A. Solywoda of Kaestle Boos Associates, Inc. (KBA) signed the Agreement on December 4, 2014.

1.2 Purpose and Scope of Services

The purpose of this study was to obtain preliminary subsurface information at the site and to provide preliminary recommendations for foundation design and construction. LGCI performed the following services:

- Coordinated our field explorations with KBA.
- Engaged a drilling subcontractor to advance eight (8) soil borings.
- Engaged an excavation subcontractor to excavate eight (8) test pits.
- Provided a geotechnical field engineer at the site to coordinate and observe the borings, describe the soil samples, and prepare field logs.
- Submitted two (2) soil samples for grain-size analysis.
- Prepared this preliminary geotechnical report containing the results of our subsurface explorations and our preliminary recommendations for foundation design and construction.

LGCI did not perform an assessment to evaluate the presence or absence of hazardous or toxic materials above or below the ground surface at or around the site. Any statement about the color, odor, or the presence of suspicious materials included in our boring logs or report were made by LGCI for information only and to support our geotechnical services. No environmental recommendations and/or opinions are included in this report.

Recommendations for unsupported slopes, stormwater management, erosion control, and detailed cost or quantity estimates are not included in our scope of work.

Our scope did not include reviewing contract drawings, and reviewing or preparing specifications. LGCI will be pleased to provide these services during the design phase.

1.3 Site Description

The existing high school is located off of North Great Road (Route 2A) at the Lexington/Lincoln Town line as shown in Figure 1. The high school property is comprised of the existing school building, parking lots, and athletic fields including a track field. The building is located in the Town of Lexington and the athletic fields are mostly located in the Town of Lincoln.

Our understanding of the existing conditions is based on our field observations and discussions with KBA. The high school is surrounded by private properties and wooded land, including wetlands. Wetlands are located on the northern and the southern sides of the western portion of the parking lot near the track. The pavement and sidewalks near the western side of the parking lot are in poor condition indicating that the fill for the parking lot was possibly placed over organic soil typical of wetland areas.

The ground surface elevations in the areas around the existing building range between about El. 196 feet and El. 201 feet. Topographic information is not available for the wooded area on the western side of the site. However, based on our field observation, this area is hummocky and has a variable topography. Rock outcrops are visible at many locations in the woods.

1.4 Background

We understand that KBA has been engaged to perform a feasibility study for a new high school building. The location of the new school building has not been selected. Possible locations include the existing parking lot and track and the mostly wooded land on the western side of existing school and track (western parcel).

As part of the feasibility study, LGCI previously explored the subsurface conditions within the existing parking lot and submitted the results in a preliminary geotechnical report dated July 9, 2013.

The present report contains the results of our subsurface explorations within the western parcel.

1.5 Project Description

Our understanding of the proposed school is based our discussions with KBA and on the following drawings:

- "Site Boring Plan – New School, Additions and Renovations to the Minuteman Vocational Technical High School, Lexington & Lincoln, Massachusetts," prepared by KBA and dated November 12, 2014.

The proposed school has an elongated, irregular shape that extends in the North –South direction from the wooded land just west of the existing track to the grass fields south of the track. The finished grade of the proposed building has not been established. However, we understand that in order to conform to the existing topography, and to reduce the magnitude of the cuts and the quantity of rock blasting, the proposed building may be stepped. Construction in the western parcel will require significant cuts and fill to achieve a level building pad.

2. SITE AND SUBSURFACE CONDITIONS

2.1 Surficial Geology

LGCI reviewed the "Surficial Geologic Map of the Clinton-Concord-Grafton-Medfield 12-quadrangle area in East Central Massachusetts," (Geologic Map) compiled by Janet R. Stone and Byron D. Stone, U.S. Geological Survey, Open-File Report 2006-1260A (2006). A portion of the surficial geologic map is shown in Figure 2.

Based on the geologic map, the surficial materials on the eastern side of the site consist of glacial stratified deposits consisting of coarse gravel, cobbles, and boulders; sand and gravel, or sand deposits. The surficial materials on the western side of the site consist of glacial till between 10 and 15 feet thick. The glacial till consists of an unsorted matrix of mostly sand, silt, and clay. The glacial till contains gravel and few large boulders. Swamp deposits are noted near the center of the site near the western side of the parking lot and track, and bedrock outcrops are identified to the north.

2.2 General

LGCI marked our test pit and boring locations in the field in the presence of a representative of KBA, and we notified the Towns of Lexington and Lincoln for utility clearance prior to drilling.

During the explorations, LGCI provided a field engineer at the site full-time to observe the borings and the test pits, collect soil samples, and prepare field logs.

Our exploration logs, included in Appendices A and B, do not include ground surface elevations. LGCI left stakes at the locations of the explorations. We understand that the ground surface elevations will be surveyed by a surveyor engaged directly by KBA.

2.3 Test Pits

LGCI engaged Silversmith Excavating of Wilmington, Massachusetts to excavate eight (8) test pits (TP-1 to TP-8) with a DEERE 410E rubber tire backhoe on December 8, 2014.

The test pits were advanced to depths ranging between 2 and 12.5 feet beneath the existing ground surface. The test pits were backfilled with the excavated materials. The backfill was placed and tamped with the excavator bucket.

The approximate test pit locations are shown in Figure 3. The test pit logs are included in Appendix A, and a summary of the test pits is shown in Table 1.

2.4 Soil Borings

LGCI engaged Northern Drill Services, Inc. of Northborough, Massachusetts to advance eight (8) borings (B-101 to B-108) on December 15 and 16, 2014. The borings were advanced with an ATV-mounted drill rig using 4 1/4-inch-inner-diameter hollow stem augers (HSA) or 4-inch-diameter casing as noted on the boring logs. The borings extended to depths ranging between 5.5 and 22 feet beneath the ground surface. Rock was cores in two borings: B-101 and B-102.

An LGCI engineer observed and logged the borings in the field. The drillers performed Standard Penetration Tests (SPT) and obtained split spoon samples with an automatic hammer semi-continuously or at five-foot intervals as noted on the boring logs in general accordance with ASTM D-1586. Upon completion, the boreholes were backfilled with the soil cuttings. The borings in the grass field were topped with sand.

The approximate boring locations are shown in Figure 3. The boring logs are included in Appendix B, and a summary of the borings is shown in Table 1.

Unless notified otherwise, we will dispose of the soil samples after three months. The rock cores were left at the facilities department of the Minuteman Vocational Technical High School.

2.5 Subsurface Conditions

The subsurface description in this report is based on a limited number of borings and test pits and is intended to highlight the major soil strata encountered during our borings and test pits. The subsurface conditions are known only at the actual boring and test pit locations. Variations may occur and should be expected between boring and test pit locations. The boring and test pit logs represent conditions that we observed at the time of our explorations and were edited, as appropriate, based on the results of the laboratory test data and inspection of the soil samples in the laboratory. The strata boundaries shown in our boring and test pit logs are based on our interpretations and the actual transition may be gradual. Graphic soil symbols are for illustration only.

The soil strata encountered in our test pits and borings were as follows, starting from the ground surface.

Topsoil/Subsoil – A layer of organic topsoil and subsoil was encountered at the ground surface in the test pits and borings and extended to depths of 0.5 to 2.5 feet beneath the ground surface. In general, this layer was thicker than 1.5 feet.

Fill – Fill was encountered below the topsoil/subsoil in borings B-103 to B-108, advanced in or near the grass field. The fill extended to depths ranging between 2 and 6 feet beneath the ground surface. The fill generally consisted of silty sand with up to 20 percent fines and up to 30 percent fine gravel. The fill contained roots, wood, and traces of organics.

The standard penetration test (SPT) N-values in this layer ranged between 2 and 19 blows per foot (bpf) with most values below 10 bpf, indicating mostly loose fill.

Peat/Buried Topsoil – Slightly fibrous, compressible, peat and buried topsoil were encountered below the fill in borings B-106 and B-108, advanced near the southern side of the proposed building. This layer extended to depths of 6.5 feet and 8.3 feet beneath the ground surface in borings B-106 and B-108, respectively. Please note that due to the proximity of the proposed building footprint to wetlands, this layer may exist within the proposed building footprint at other locations not explored by LGCI.

Glacial Till – A layer of mostly silty sand with up to 30 percent fines and up to 35 percent fine to coarse gravel was encountered in all test pits and borings, except in test pit TP-7 and boring B-104. In a few explorations, the sand contained less than 15 percent fines and was classified as poorly graded or well graded sand. This layer, characteristic of glacial till, contained up to 5 percent cobbles and boulders up to 2 feet in size.

This layer extended to refusal of the backhoe bucket in test pits and to auger refusal in the soil borings at depths ranging between 2 and 20.2 feet beneath the ground surface. The bottom of this layer was generally the deepest on the southern side of the proposed building footprint in the grass field. The SPT N-values in this layer ranged between 11 and 50 bpf, indicating mostly medium dense to dense sand. One SPT N-value of 8 bpf that was recorded in boring B-108, advanced using HSAs, may have been caused by bottom blow-in.

Rock – Bucket refusal was encountered in the test pits and auger refusal was encountered in the borings at depths of 2 to 20.2 feet beneath the ground surface. Refusal was possibly encountered at the surface of bedrock. The depth to refusal was generally irregular, but was the deepest in the borings advanced in the grass fields on the southern side of the proposed building footprint. The top of the rock appeared to be weathered, as it was penetrated in many test pits and borings with the excavator bucket and augers, respectively.

To confirm and characterize the rock, the drillers obtained two (2) rock cores between depths of 9.2 and 13.9 feet in boring B-101 and between 13 and 18 feet in boring B-102. The rock in the cores consisted of medium hard to hard, slightly weathered to fresh, fine grained, pink to dark gray GRANITE with close to very close joints. The rock recoveries were 68 and 97 percent, and the rock quality designation (RQD) values were 0 and 66.7 percent in borings B-101 and B-102, respectively.

2.6 Groundwater

Groundwater was observed in test pits TP-2 to TP-5 and in borings B-103 to B-108 at depths ranging between 2 and 9 feet beneath the ground surface.

The reported levels may not represent the actual groundwater conditions, as additional time may be required for the groundwater levels to stabilize. The groundwater levels presented in this report only represent the conditions encountered at the time and locations of our explorations. Seasonal fluctuation should be anticipated.

2.7 Laboratory Test Data

LGCI submitted two (2) soil samples obtained from the test pits for grain-size analysis. The laboratory data sheets are included in Appendix C and the results are summarized below.

Test Pit No.	Sample Type	Sample Depth (ft)	Percent Gravel	Percent Sand	Percent Fines
TP-1	Grab Sample	3 – 5	32.6	41.9	25.5
TP-4	Grab Sample	2 – 4.5	30.5	44.7	24.8

3. EVALUATION AND RECOMMENDATIONS

3.1 General

Based on the results of the test pits and borings, the topsoil/subsoil layer, the existing fill, and the peat and buried topsoil are not suitable to support the proposed building and should be entirely removed from within the proposed building footprint.

The proposed building should be founded on spread and wall footings bearing on Structural Fill placed directly on top of the natural sand or on bedrock. Our preliminary recommendations for footing design are presented in section 3.4. Our recommendations for the proposed slab are presented in Section 3.4.

Weathered and/or competent rock was encountered in many test pits and borings. We anticipate rock removal will be needed within the proposed building footprint. Based on the rock cores, rock removal will require rock blasting.

We anticipate that the major considerations during construction will be: 1) the removal and replacement of unsuitable materials including the existing fill and buried topsoil/peat layer, 2) groundwater control during the removal of the unsuitable materials, and 3) rock removal, including rock blasting. Our preliminary recommendations for rock blasting are presented in Section 4.3.

The limits of the existing fill and buried topsoil/peat layer and the top of bedrock need to be further explored once the proposed building location is selected. Accordingly, additional explorations, including soil borings, test pits, and groundwater observation wells will be required during final design.

3.2 Footing Design

- For preliminary footing design, we recommend a net allowable bearing pressure of 4,000 pounds per square foot (psf) for footings bearing on Structural Fill placed directly on the natural sand or on bedrock. The recommended bearing pressure may be revised based on observations in explorations advanced during the design phase.

- All foundations should be designed in accordance with *The Commonwealth of Massachusetts State Building Code 780 CMR, Eighth Edition* (MSBC 8th Edition).

- Exterior footings and footings in unheated areas should be placed at a minimum depth of 4 feet below the final exterior grade to provide adequate frost cover protection. Interior footings in heated areas may be designed and constructed at a minimum depth of 2 feet below finished floor grades.

- We recommend that wall footings have a minimum width of 2 feet, and that column footings have a minimum width of 3 feet. For foundations with a least lateral dimension smaller than 3 feet, the allowable bearing pressure should be reduced to 1/3 of the recommended allowable bearing pressure times the least dimension in feet.

- Wall footings should be designed and constructed with continuous, longitudinal steel reinforcement for greater bending strength to span across small areas of loose or soft soils that may go undetected during construction.

- Rock should be cut at a minimum to 12 inches beneath the bottom of footings to allow for placement of Structural Fill to provide a level subgrade.

- To reduce the potential for cracking of wall foundations due to differential settlement over short distances, footings should not bear partially on sound rock and partially on soil. In transition areas, the excavations should be performed so as to allow the footings to bear entirely on rock, or the rock should be over-excavated to allow placement of a minimum of 12 inches of crushed stone over a distance of about 10 feet to act as a cushion between the footings and rock.

- A representative of LGCI should observe the subgrade of footings to verify that the subgrade has been prepared in accordance with our recommendations.

3.3 Settlement

We anticipate for foundations constructed in accordance with the preliminary recommendations contained in this report, that the total post-construction settlement will be less than about 1 inch and that the differential settlement will be 3/4 inch or less over a distance of 25 feet. Total and differential settlements of these magnitudes are usually considered tolerable for the anticipated construction. However, the tolerance of the proposed structure to the predicted total and differential settlements should be assessed by the structural engineer.

3.4 Concrete Slab Considerations

- The proposed floor slabs can be constructed as slabs-on-grade.

- The proposed floor slabs should be supported on a minimum of 12 inches of Structural Fill placed directly over the natural sand.

- Where rock is cut, and to facilitate the installation of utilities under the slab, the bedrock should be cut at least 2 feet beneath the bottom of the proposed slab and the slab placed on Structural Fill (or on crushed stone where an under-slab drainage system is required).

- Exposed boulders should be removed from the subgrade of the slab and the resulting excavation should be backfilled with Structural Fill.

- A vapor retarder membrane with a minimum thickness of 15 mils could be used beneath the slab. The need for such a membrane should be evaluated by the architect. The membrane should be protected from puncture during placement of the steel mesh and construction of the slabs.

- For the design of the floor slabs bearing on the materials described above, we recommend using a modulus of subgrade reaction, k_{s1}, of 150 tons per cubic foot (tcf) (170 pci). Please note that the values of k_{s1} are for a 1 x 1 square foot area. These values should be adjusted for larger areas using the following expression:

$$Modulus\ of\ Subgrade\ Reaction\ (k_s) = k_{s1} * \left(\frac{B+1}{2B}\right)^2$$

where:

k_s = Coefficient of vertical subgrade reaction for loaded area,
k_{s1} =Coefficient of vertical subgrade reaction for 1 x 1 square foot area, and
B = Width of area loaded, in feet.

Please note that cracking of slabs-on-grade can occur as a result of heaving or compression of the underlying soil, but also as a result of concrete curing stresses. To reduce the potential for cracking, the precautions listed below should be closely followed for construction of all slabs-on-grade:

- Construction joints should be provided between the floor slab and the walls and columns in accordance with the American Concrete Institute (ACI) requirements, or other applicable code.

- Backfill in interior and exterior utility trenches should be properly compacted.

- In order for the movement of exterior slabs not to be transmitted to the building foundation or superstructure, exterior slabs such as approach slabs and sidewalks, should be isolated from the building superstructure.

3.5 Under-Slab and Perimeter Drains

The finished floor elevation of the proposed building has not been established yet. LGCI will provide recommendations for under-slab and perimeter drains, if needed, after the proposed building layout and FFE are established and after LGCI has conducted additional explorations during the design phase.

3.6 Seismic Design Criteria

The following seismic criteria are provided for preliminary design in accordance with Section 1615 of MSBC 8th Edition.

- Site Class: D
- Spectral Response Acceleration at short period (S_s): 0.29g
- Spectral Response Acceleration at 1 sec. (S_1): 0.070g
- Site Coefficient F_a (Table 9.4.1.2.4a): 1.568
- Site Coefficient F_v (Table 9.4.1.2.4b): 2.4
- Adjusted spectral response S_{ms}: 0.455g
- Adjusted spectral responses S_{m1}: 0.168g

The data from the preliminary borings indicates that the natural sand is not likely susceptible to liquefaction during a seismic event. The data from B-108 which was advanced with augers is not reliable due to the drilling method and high groundwater table at the site. We recommend that additional borings advanced with casing and drilling mud be advanced during the design phase to confirm our assessment that the sand is not susceptible to liquefaction.

3.7 Lateral Pressures for Wall Design

3.7.1 Static Lateral Earth Pressures

We recommend using the following values for the design of below grade building or site retaining walls:

Coefficient of Active Earth Pressure, K_A:	0.31
Coefficient of At-Rest Earth Pressure, K_o:	0.5
Coefficient of Passive Earth Pressure, K_p:	3.3
Total Unit Weight, γ:	125 pounds per cubic foot

Note: The values in the table are based on a friction angle for the backfill of 32 degrees and neglecting friction between the backfill and the wall. The design active and passive coefficients are based on horizontal surfaces (non-sloping backfill) on both the active and passive sides, and a vertical wall face.

- Flexible site retaining walls should be designed using the active earth pressure coefficient described above. Rigid retaining walls (such as below grade building walls or cast concrete site walls) should be designed using the at rest earth pressures.

- Passive earth pressures should only be used at the toe of the wall where special measures or provisions are taken to prevent disturbance or future removal of the soil on the passive side of the wall, or in areas where the wall design includes a key.

- Where a permanent vertical uniform load will be applied on the active side immediately adjacent to the wall, a horizontal surcharge load equal to half of the uniform vertical load should be applied over the height of the wall. At a minimum, a temporary construction surcharge of 100 psf should be applied uniformly over the height of the wall.

- We recommend using an ultimate friction factor of 0.5 between the Structural Fill and the bottom of the retaining wall. Retaining walls should be designed for minimum factors of safety of 1.5 for sliding and 2.0 for overturning.

3.7.2 Seismic Lateral Earth Pressure

- In accordance with the Massachusetts State Building Code, 8th Edition, Section 1610, a lateral earthquake force equal to $0.100*(S_s)*(F_a)*\gamma*H^2$ should be included in the design of the wall (for horizontal backfill), where S_s is the maximum considered earthquake spectral response acceleration (defined in Section 3.6), F_a is the site coefficient (defined in Section 3.6), γ is the total unit weight of the soil backfill, and H is the height of the wall.

  The earthquake force should be distributed as an inverted triangle over the height of the wall. In accordance with MSBC 8th Edition, Section 1610.2, a load factor of 1.43 shall be applied to the earthquake force for wall strength design.

- Temporary surcharges should not be included when designing for earthquake loads. Surcharge loads applied for extended periods of time shall be included in the total static lateral soil pressure and their earthquake lateral force shall be computed and added to the force determined above.

3.8 Parking Lots, Driveways, and Sidewalks

The peat encountered below the fill will undergo total and differential settlement if fill is placed to raise the grades within the proposed paved areas. The settlement potential is a function of the depth and thickness of the fill and thickness of the peat layer. Additional explorations will be required during the design phase within the proposed parking areas to assess the subsurface conditions and provide corresponding pavement recommendations.

3.9 Underground Utilities

Exposed competent rock and boulders at the bottom of utility trenches should be removed to at least 12 inches below the pipe invert and the resulting excavation should be backfilled with suitable backfill.

Utilities should be placed on suitable bedding material in accordance with the manufacturer's recommendations. "Cushion" material should be placed, by hand, above the utility pipe in maximum 6-inch lifts. The lift should be compacted by hand to avoid damage to the utility. Where the bedding/cushion material consists of crushed stone, it should be wrapped in a geotextile fabric.

Compaction of fill in utility trenches should be in accordance with our recommendations in Section 4.4. To reduce the potential for damage to utilities, placement and compaction of fill immediately above the utilities should be performed in accordance with the manufacturer's recommendations.

4. CONSTRUCTION CONSIDERATIONS

4.1 Subgrade Preparation

- Recommendations for footing subgrade preparation will be presented in our final report after the proposed building layout is established and additional explorations are performed at the site.

- Fill placed within the footprint of the proposed building should meet the gradation and compaction requirements of Structural Fill shown in Section 4.4.

- Fill placed under the subbase of paved areas and on the building exterior, should meet the gradation and compaction requirements of Ordinary Fill shown in Section 4.4.

- Fill placed in the top 12 inches beneath sidewalks should consist of Structural Fill with less than 5 percent fines.

- When crushed stone is required in the drawings or it is used for the convenience of the contractor, it should be wrapped in a geotextile fabric.

- A representative of LGCI should observe the exposed subgrades prior to fill and concrete placement to verify that the exposed bearing materials are suitable for the design soil bearing pressure. If soft or loose pockets are encountered in the footing excavations, the soft or loose materials should be removed, and the bottom of the footing should be placed at a lower elevation on firm soil, or the resulting excavation should be backfilled with Structural Fill, or crushed stone wrapped in a filter fabric.

4.2 Subgrade Protection

The on-site sand may be frost susceptible. If construction takes place during freezing weather, special measures should be taken to prevent the subgrade from freezing. Such measures should include the use of heat blankets, or excavating the final six inches of soil just before pouring concrete. Footings should be backfilled as soon as possible after footing construction. Soil used as backfill should be free of frozen material, as should the ground on which it is placed. Filling operation should be halted in freezing weather.

Materials with high fine contents are typically difficult to handle when wet as they are sensitive to moisture content variations. Subgrade support capacities may deteriorate when such soils become wet and/or disturbed. The contractor should keep exposed subgrades properly drained and free of ponded water. Subgrades should be protected from machine and foot traffic to reduce disturbance.

4.3 Rock Blasting Consideration

4.3.1 Rock Removal

Rock cuts are anticipated especially on the northern side of the proposed building footprint.

Minor rock cuts (less than one foot) over short distances may be achieved using hoe-rams or using other non-blasting techniques. However, based on the borings and test pits, we anticipate that rock blasting will be required.

- Rock should be cut at least 12 inches beneath the bottom of footings, 2 feet beneath the bottom of slabs, 18 inches beneath the bottom of paved areas, and 18 inches beneath the ground surface of athletic fields.
- Under utility pipes, manholes, and catch basins, rock should be cut a minimum of 12 inches beneath the pipe or structure.
- The rock should be cut laterally at least one foot beyond each side of the footing. For retaining wall footings, the rock should be cut laterally at least 2 feet from the outside face of the wall to allow for placement of the formwork.
- Rock should be cut a minimum of 12 inches outside utility structures and a minimum of 18 inches on each side of utility pipes.
- To reduce overblasting and the potential for heaved rock, drill holes for blasting should not extend more than 2 feet beneath the minimum depths shown above.
- Rock blasting should be controlled to reduce vibrations and airblast overpressure to below thresholds established in the earth moving specifications.
- Pre-splitting or controlled blasting may be desirable to reduce the amount of overblast.
- To reduce the potential of blasted rock mixing with organic soil, we recommend that the topsoil, roots, tree stumps, and vegetation be removed before blasting. The remainder of the overburden soils and excavatable weathered rock should not be removed before blasting.

4.3.2 Pre-Construction Condition Survey

We recommend that the Owner perform a pre-construction condition survey of structures located within 250 feet of the nearest blasting operation to document the existing conditions of the structures. The Owner may also consider using crack monitoring gauges to monitor large cracks identified during the pre-construction surveys.

4.4 Proposed Fill

Structural Fill and Ordinary Fill should consist of inert, hard, durable sand and gravel, free from organic matter, clay, surface coatings and deleterious materials, and should conform to the gradation requirements shown below.

4.4.1 Structural Fill

The Structural Fill should have a plasticity index of less than 6, and should meet the gradation requirements shown below. Structural Fill should be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture contents within ±2 percentage points of optimum moisture content.

Sieve Size	Percent Passing by Weight
3 inches	100
1 ½ inch	80 - 100
½ inch	50 – 100
No. 4	30 – 85
No. 20	15 – 60
No. 60	5 – 35
No. 200*	0 – 10

* 0 – 5 Under sidewalks

4.4.2 Ordinary Fill

Ordinary Fill should have a plasticity index of less than 6, and should meet the gradation requirements shown below. Ordinary Fill should be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture contents within ±2 percentage points of optimum moisture content.

Sieve Size	Percent Passing by Weight
6 inches	100
1 inch	50 - 100
No. 4	20 – 100
No. 20	10 - 70
No. 60	5 – 45
No. 200	0 – 20

4.5 Reuse of Onsite Materials

Based on the grain-size analyses, the natural sand does not meet the gradation requirements for Structural Fill or Ordinary Fill.

Soils with more than 20 percent fine contents are generally very sensitive to moisture content variations and are susceptible to frost. Such soils are very difficult to compact at moisture contents that are much higher or much lower than the optimum moisture content determined from the laboratory compaction test. Therefore, strict moisture control should be implemented during stockpiling, placement, and compaction of the onsite soils.

All materials to be used as fill should first be tested for compliance with the applicable gradation specifications. During earthwork operations, the contractor should avoid mixing the reusable soils with fine-grained and/or organic soils. The soils to be reused should be excavated and stockpiled separately.

The contractor may consider mobilizing a rock crusher to the site. Blasted rock and boulders may be processed by blending them with the onsite soil and crushing them to produce a well graded material. Processed blasted rock should meet the gradation requirements of Ordinary Fill or Structural Fill.

Non-processed blasted rock should not be used as fill.

4.6 Groundwater Control Procedures

Based on the groundwater levels encountered in our explorations, we anticipate that groundwater control procedures will be needed during building footing and utility excavations. We anticipate that multiple filtered sump pumps installed in pits located at least three feet below the bottom of the excavation will be required to handle groundwater and surface runoff that may enter the excavation during the removal of unsuitable materials and excavations for footings and utilities.

The contractor should be permitted to employ whatever commonly accepted means and practices as necessary to maintain the groundwater level below the bottom of the excavation, and to maintain a dry excavation during wet weather. Groundwater levels should be maintained at a minimum of 1-foot below the bottom of excavations during construction. Placement of reinforcing steel or concrete in standing water should not be permitted.

Disposal of groundwater collected from the groundwater control system should follow the requirements of local, state, and federal regulations.

4.7 Temporary Excavations

Excavations to receive human traffic, including utility trenches, basement or footing excavations, or others (i.e. underground storage tanks, etc.), should be constructed in accordance with the OSHA guidelines.

The site soils should generally be considered Type "C" and should have a maximum allowable slope of 1.5 Horizontal to 1 Vertical (1.5H:1V) for excavations less than 20 feet deep. Deeper excavations, if needed, should have shoring designed by a professional engineer.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of the excavation sides and bottom.

5. RECOMMENDATIONS FOR FUTURE WORK

We recommend engaging LGCI to perform the following services:

- Perform additional explorations consisting of borings and test pits during the design phase to provide information on the depth and lateral extent of the peat and the depth to bedrock within the proposed building footprint. The borings should be advanced with casing and drilling mud to assess the liquefaction potential of the sand. We recommend installing at least one groundwater observation well to assess the groundwater level.

- Review the geotechnical aspect of the foundation drawings and the Earth Moving Specifications.

- Perform a pre-construction conditions survey of buildings within 250 feet of blasting operations.

- Review the geotechnical aspects of the contract drawings and provide comments in a letter.

- Review the geotechnical aspects of contractor submittals.

- Provide a field representative during construction to observe the subgrades for footings, floor slabs, and paved areas.

6. REPORT LIMITATIONS

Our analysis and recommendations are based on project information provided to us at the time of this report. The recommendations contained in this report shall not be considered valid unless the project definition and/or changes are reviewed and the conclusions and recommendations modified in writing by LGCI. LGCI cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design.

It is not part of our scope to perform a more detailed site history; therefore, we have not explored for or researched the locations of buried utilities or other structures in the area of the proposed construction. Our scope did not include environmental services or services related to moisture, mold, or other biological contaminates in or around the site.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. We cannot accept responsibility for designs based on recommendations in this report unless we are engaged to 1) make site visits during construction to check that the subsurface conditions exposed during construction are in general conformance with our design assumptions and 2) ascertain that, in general, the work is being performed in compliance with the contract documents.

Our report has been prepared in accordance with generally accepted engineering practices and in accordance with the terms and conditions set forth in our agreement. No other warranty, expressed or implied, is made. This report has been prepared for the exclusive use of Kaestle Boos Associates for the specific application to the preliminary design of the proposed Minuteman Vocational Technical High School in Lexington, Massachusetts as conceived at this time.

7. REFERENCES

The Commonwealth of Massachusetts (2010), "The Massachusetts State Building Code, 780 CMR, Eighth Edition."

The Department of Labor, Occupational Safety and Health Administration, "Occupational Safety and Health Standards - Excavations; Final Rule," 20 CFR Part 1926, Subpart P.

U.S. Geological Survey (2006), "Surficial Geologic Map of the Clinton-Concord-Grafton-Medfield 12-quadrangle area in East Central Massachusetts," compiled by Janet R. Stone and Byron D. Stone, Open-File Report 2006-1260A.

USGS Lexington, MA topographic map from http://mapserver.mytopo.com

Table 1 - Summary of Test Pits and Borings
Proposed Minuteman Vocational Technical High School
Lexington, Massachusetts
LGCI Project No. 1440

Borings/ Test Pit	Depth to Groundwater (ft.)	Depth to Bot. of Topsoil/Subsoil (ft.)	Depth to Bot. of Fill (ft.)	Depth to Bot. of Buried Topsoil/Peat (ft.)	Depth to Bot. of Natural Sand (Top of Rock[1]) (ft.)	Bottom of Boring/Test Pit (ft.)
TP-1	NE[2]	2.5	-	-	5	5
TP-2	9.0	2.5	-	-	9.8	9.8
TP-3	9.0	2.5	-	-	9	10.5
TP-4	5.0	1.5	-	-	4.5	5.7
TP-5	NE[2]	2.5	-	-	12.5	12.5
TP-6	NE[2]	2.5	-	-	8.5	8.5
TP-7	NE[2]	2	-	-	2	2
TP-8	NE[2]	2	-	-	3	6
B-101	NM[3]	2	-	-	9	13.9
B-102	NM[3]	2	-	-	11.5	18
B-103	3.0	0.7	3	-	16.5	17
B-104	2.0	0.4	2	-	2	5.5
B-105	5.2	2.5	4.5	-	13	19
B-106	3.7	1.5	4.2	6.5	15.2	22
B-107	5.2	2.5	4	-	10	13.5
B-108	8.0	0.5	6	8.3	20.2	22

1 - Top of rock in based on bucket refusal (scratching of hard surface) in test pits and on auger refusal in the borings where a rock core was not obtained. Refusal may be on a large boulder.

2 - NE = Not Encountered

3 - NM = Not Measured

4 - A dash means that the layer was not encountered.

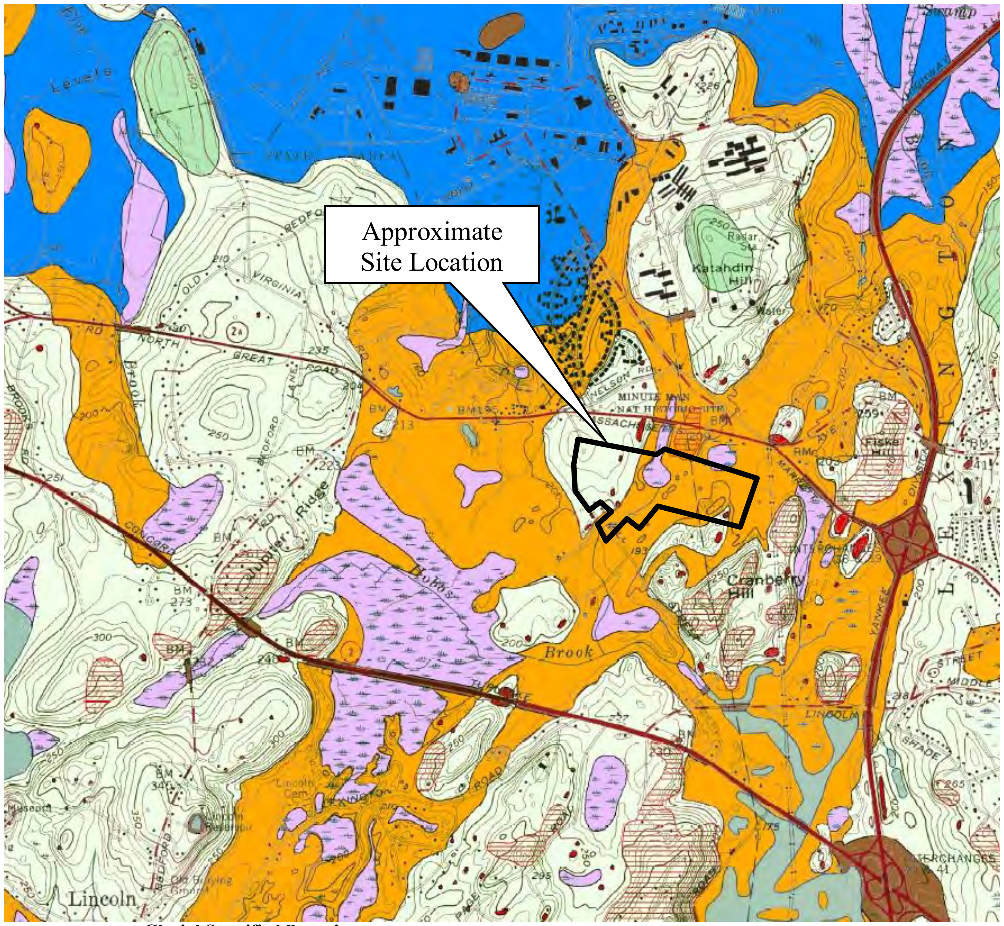
N

Approximate Scale: 1:25000
Contour intervals: 3 meters

Note: Figure based on USGS topographic map of Lexington, MA – from http://mapserver.mytopo.com

Client:	Project:	
Kaestle Boos Associates, Inc.	Proposed Minuteman Vocational Technical High School	Figure 1 – Site Location Map

	Project Location:	LGCI Project No.:	Date:
LGCI Lahlaf Geotechnical Consulting, Inc.	Lexington, MA	1440	Dec. 2014



Glacial Stratified Deposits

Coarse deposits include: *Gravel deposits* composed mainly of gravel-sized clasts; cobbles and boulders predominate; minor amounts of sand within gravel beds, and sand comprises few separate layers. Gravel layers generally are poorly sorted and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay.

Glacial Till Deposits

N

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; in areas where till is generally less than 10-15 ft thick and including areas of bedrock outcrop where till is absent. Predominantly upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places; a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer-grained lodgement facies deposited subglacially. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarser grained crystalline rocks. Fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut River lowland, marble in the western river valleys, and fine-grained schists in upland areas.

Bedrock Areas

Bedrock outcrops and areas of abundant outcrop or shallow bedrock— Solid color shows extent of individual bedrock outcrops; line pattern indicates areas of shallow bedrock or areas where small outcrops are too numerous to map individually; in areas of shallow bedrock, surficial materials are less than 5-10 ft thick.

Swamp deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, stratified and poorly sorted, in kettle depressions or poorly drained areas. Most swamp deposits are less than about 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits.

Note: Figure based on map titled: "Surficial Geologic Map of the Clinton-Concord-Grafton-Medfield 12-quadrangle area in East Central Massachusetts," compiled by Janet R. Stone and Byron D. Stone, US Geological Survey, Open-File Report 2006-1260A (2006).

Client:	Project:		
Kaestle Boos Associates, Inc.	Proposed Minuteman Vocational Technical High School	Figure 2 – Surficial Geologic Map	
LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location: Lexington, MA	LGCI Project No.: 1440	Date: Dec. 2014

Legend

Approximate location of boring advanced by Northern Drill Service of Northborough, Massachusetts on December 15 and 16, 2014 and observed by Lahlaf Geotechnical Consulting, Inc. (LGCI).

Approximate location of test pit excavated by the Silversmith Excavating of Wilmington, Massachusetts on December 8, 2014 and observed by LGCI.

Note: Figure based on Site Boring Plan – New School, Additions and Renovations to the Minuteman Vocational Technical High School, Lexington & Lincoln, Massachusetts," prepared by KBA and dated November 12, 2014

APPROXIMATE SCALE

0 50' 100' 200'

Client:	Project:	
Kaestle Boos Associates, Inc.	Proposed Minuteman Vocational Technical High School	Figure 3 – Boring and Test Pit Location Plan

LGCI Lahlaf Geotechnical Consulting, Inc.	Project Location:	LGCI Project No.:	Date:
	Lexington, MA	1440	Dec. 2014

Attachment A – Test Pit Logs

Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**		LGCI Project No.: 1440
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Northern side of prop. building, near center
Ground Surface El:	NA	Total Depth:	5.0 feet
Groundwater Depth:	NE	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x15'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil	8" - Topsoil/Forest mat
	E		8" to 2.5' - Silty SAND (SM), fine, trace medium, ~25% fines, roots, traces of Organic Silt (OL), orange-brown, moist (subsoil), 2 boulders up to 3' near surface
	E	2.5' Sand	2.5 to 5' - Silty SAND with Gravel (SM), fine to medium, trace coarse, ~25% fines, 30-35% fine to coarse gravel, ~5% cobbles and boulders up to 15", olive-gray, moist
	M		
5 ft	D		Scratching surface of rock at 5.0 feet (sloping to 3 feet)
			End of test pit at 5.0 feet. Backfilled with excavated material.
10 ft			
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

LGCI
Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.: 1440	
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Near center of propsed building
Ground Surface El:	NA	Total Depth:	9.8 feet
Groundwater Depth:	9.0 feet	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x10'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil	12" - Topsoil/Forest mat
	M		12" to 30": Silty SAND (SM), fine, ~25% fines, traces of organics, traces of roots, orange-brown (subsoil)
	M	2.5'	
	M	Sand	
5 ft	D		3' to 8' - Silty SAND (SM), fine to medium, trace coarse, ~ 20% fines, ~10% fine to coarse gravel, 2 boulders up to 2 feet near bottom, olive-gray, moist
	D		
	D		
	D		8' to 9.8' - Angular pieces of rock.
	D		Scratching possible rock at 8 to 9.8 feet. Possible bedrock, sloping in northerly direction.
10 ft	D		
			End of test pit at 9.8 feet. Backfilled with excavated material.
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

LGCI

Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**
Client:	**Kaestle Boos Associates, Inc.** — LGCI Project No.: 1440

Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Near center of propsed building
Ground Surface El:	NA	Total Depth:	10.5 feet
Groundwater Depth:	9.0 feet	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x10'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil	6" - Topsoil/subsoil 6" to 2.5' - Silty SAND (SM), fine, ~20% fines, roots, traces of roots, a few cobbles, moist, orange-brown (subsoil)
	M		
	M	2.5'	
	M	Sand	2.5' to 9' - Silty SAND with Gravel (SM), fine to medium, trace coarse, ~30% slightly plastic fines, ~15% fine to coarse gravel, olive-gray moist
5 ft	M		
	D		
	D		
	D		
	D	9.0'	
10 ft	D	Rock	9.0' to 10.5' - Broken, angular rock pieces, possible rock (scratching at 10.5 feet)
	D		End of test pit at 10.5 feet. Backfilled with excavated material.
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**		LGCI Project No.: 1440
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Near center of proposed building
Ground Surface El:	NA	Total Depth:	5.7 feet
Groundwater Depth:	5.0 feet	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	6'x8'

Depth Scale	Exc. Effort	Strata	Soil Description
	E, M	Topsoil / Subsoil 1.5'	8" - Topsoil/Forest mat 8" to 18" - Silty SAND (SM), fine, trace roots, orange-brown (subsoil)
	M, M, M	Sand 4.5'	18" to 4.5' - Silty SAND (SM), fine to coarse, ~25% fines (slightly plastic), ~30% fine to coarse gravel, brown, moist
5 ft	M, D	Rock	4.5' to 5.7' - Angular pieces of rock, possible bedrock
10 ft 15 ft			End of test pit at 5.7 feet. Backfilled with excavated material.

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

LGCI
Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**		LGCI Project No.: 1440
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Near southwest corner of prop. building
Ground Surface El:	NA	Total Depth:	12.5 feet
Groundwater Depth:	NE	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x10'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil	6" - Topsoil/Forest mat
	M		6" to 2.5' - Silty SAND (SM), fine, ~20% fines, traces of organics, traces of roots, orange-brown, moist (subsoil)
	M	2.5'	
	M	Sand	2.5' to 5' - Silty SAND (SM), fine to medium, trace coarse, ~20% fines, ~10% fine gravel, boulder ~3' in size near top, olive-gray, moist
5 ft	M		
	D		
	D		
	D		5' to 12.5' - Hard angular rock that breaks into Silty Sand with Gravel (SM), rusty-brown, moist (weathered rock)
	D		
10 ft	D		
	D		
	D		Possible refusal at 12.5 feet.
	D		End of test pit at 12.5 feet. Backfilled with excavated material.
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**		LGCI Project No.: 1440
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Western side of propsed building
Ground Surface El:	NA	Total Depth:	8.5 feet
Groundwater Depth:	NE	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x11'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil	12" - Topsoil/Forest mat
	M		12" to 2.5' - Silty SAND (SM), fine, ~25% fines, roots and traces of Organic Silt (OL), 10-15% fine gravel, orange-brown, moist (subsoil)
	M	2.5'	
	M	Sand	
5 ft	M		2.5' to 9.0' - Well-Graded SAND with Silt and Gravel (SW-SM), fine to medium, trace coarse, 10-15% fines, ~20% fine to coarse gravel, ~5% cobbles and boulders up to 15"
	D		
	D		
	D		Scratching possible rock at 8.5 feet.
	D		End of test pit at 8.5 feet. Backfilled with excavated material.
10 ft			
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

LGCI
Lahlaf Geotechnical Consulting, Inc.

Project:	Proposed Minuteman Vocational Technical High School, Lexington, MA		
Client:	Kaestle Boos Associates, Inc.		LGCI Project No.: 1440
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Western side of propsed building
Ground Surface El:	NA	Total Depth:	2.0 feet
Groundwater Depth:	NE	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	4'x10'

Depth Scale	Exc. Effort	Strata	Soil Description
	E D	Topsoil / Subsoil 2.0'	6" - Topsoil/Forest mat 6" to 24" - Silty SAND (SM), fine, ~30% fines, traces of Organic Silt (OL), roots, ~2.5-foot boulder near surface, orange-brown, moist (subsoil) Scratching rock surface at 2 feet.
5 ft 10 ft 15 ft			End of test pit at 2.0 feet. Backfilled with excavated material.

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.: 1440	
Excavation Subcontractor:	Silversmith Excavating	Date Started:	12/08/14
Excavation Foreman:	David Tibbetts	Date Completed:	12/08/14
LGCI Engineer:	A. M. Lahlaf	Location:	Western side of propsed building
Ground Surface El:	NA	Total Depth:	6.0 feet
Groundwater Depth:	NE	Excavator Type:	John Deere 410E Backhoe
		Test Pit Dimensions:	5'x8'

Depth Scale	Exc. Effort	Strata	Soil Description
	E	Topsoil / Subsoil 2.0'	10" - Topsoil/Forest mat
	E		10" to 2' - Silty SAND (SM), fine to medium, ~30% fines, trace Organic Silt (OL), roots, orange-brown (subsoil)
	M	Sand 3.0'	2' to 3' - Silty SAND (SM), fine to medium, trace coarse, ~15% fines, ~20% fine to coarse gravel, ~5% cobbles, olive-gray, moist
	D	Rock	3' to 6' - Highly fractured, slightly weathered rock
5 ft	D		
	D		Scratching on hard rock surface at 6 feet.
			End of test pit at 6.0 feet. Backfilled with excavated material.
10 ft			
15 ft			

Remarks: E = Easy, M = Moderate, D = Difficult, V = Very Difficult

Attachment B - Boring Logs

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.:	1440
Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/16/2014
Drilling Foreman:	Tim Tucker	Date Completed:	12/16/2014
LGCI Engineer:	Alan Smith	Location:	Northern side of proposed building
Ground Surface El:	NA	Total Depth:	13.9 ft
Groundwater Depth:	Not measured	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4" casing, drive and wash
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	NX
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	1	1	2	3	24	16		Forest Mat & Subsoil (2')	S1-Top 6": Forest mat Bottom 10": Silty SAND (SM), fine, 15-20% fines, brown, moist (Subsoil)
	2 - 4	S2	2	5	12	16	24	14		Sand	S2: Silty SAND (SM), fine to medium, trace coarse, 15-20% fines, gray-brown, moist
5ft										Sand	4 - 5 ft cored 8" cobble
	5 - 7	S3	9	14	15	15	24	14		Sand (9')	S3: Silty SAND (SM), fine, trace medium, 15-20% fines, light brown, moist
10ft	9	S4	100/1"				1	0		Rock	S4: No recovery
	9.2-13.9	C1					56	38		Rock	C1: Medium hard, fine grained, top 2 ft slightly weathered, bottom slightly weathered to fresh, pink to gray GRANITE, very close jointing core rate: 5-5-4-6-4 min/ft RQD = 0%
15ft											Bottom of boring at 13.9 ft, backfilled with cuttings.
20ft											

Remarks:

LGCI
Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**
Client:	**Kaestle Boos Associates, Inc.** — LGCI Project No.: 1440

Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/16/2014
Drilling Foreman:	Tim Tucker	Date Completed:	12/16/2014
LGCI Engineer:	Alan Smith	Location:	Western side of proposed building
Ground Surface El:	NA	Total Depth:	18 ft
Groundwater Depth:	Not measured	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4" casing, drive and wash
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	X
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	1	1	1	3	24	12		Forest Mat & Subsoil (to 2')	S1-Top 6": Forest Mat Bottom 6": Silty SAND (SM), fine, 30-40% fines, brown, moist (Subsoil)
	2 - 4	S2	11	16	23	18	24	22		Sand	S2: Silty SAND (SM), fine, trace medium, 15-20% fines, trace gravel, brown, moist
5ft	4 - 6	S3	14	17	15	15	24	16		Sand	S3: Similar to S2
10ft	9 - 11	S4	30	30	20	18	24	16		Sand (to 11.5')	S4: Similar to S2, 4" of fractured rock in top
										Rock	Encountered rock at 11.5 ft. Advanced to 13 ft with roller bit
	13 - 18	C1					60	58		Rock	C1: Hard, fresh, fine grained, dark gray GRANITE, close jointing core rate: 3½-6-5-4-5 min/ft RQD= 66.7%
15ft											
20ft											Bottom of boring at 18 ft, backfilled with cuttings.

Remarks:

LGCI
Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**
Client:	**Kaestle Boos Associates, Inc.** — LGCI Project No.: 1440

Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/16/2014
Drilling Foreman:	Tim Tucker	Date Completed:	12/16/2014
LGCI Engineer:	Alan Smith	Location:	Eastern side of proposed building
Ground Surface El:	NA	Total Depth:	17 ft
Groundwater Depth:	~3 ft based on samples	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4" casing, drive and wash
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	1	1	2	4	24	20		Topsoil (0.7'); Fill (to 3')	S1 -Top 8": Topsoil Bottom 12": Poorly Graded SAND (SP-SM), fine, ~10% fines, brown, moist (fill)
	2 - 4	S2	5	5	11	9	24	18		Fill / Sand	S2 -Top 12": Poorly Graded SAND (SP), fine, <5% fines, brown, moist (fill) Bottom 6": Poorly Graded SAND (SP), fine to medium, stratified, <5% fines, brown, wet
5ft	4 - 6	S3	3	7	7	9	24	14		Sand	S3 -Top 10": Similar to bottom of S2 Bottom 4": Silty SAND (SM), fine, 20-25% fines, brown, wet
10ft	9 - 11	S4	3	4	7	10	24	15		Sand	S4 -Top 5": Poorly Graded SAND, fine, 5-10% fines, brown, wet Bottom 10": Silty SAND (SM), fine, 25-30% fines, brown, wet, thinly bedded sand and silt
15ft	14 - 16	S5	22	21	17	20	24	12		Sand (to 16.5')	S5: Silty SAND (SM), fine to medium, trace coarse, 15-20% fines, ~5% gravel, gray-brown, wet
										Rock	Rock at 16.5 ft, advanced with roller bit to 17 ft
											Bottom of boring at 17 ft, backfilled with cuttings.
20ft											

Remarks:

LGCI
Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**
Client:	**Kaestle Boos Associates, Inc.** — LGCI Project No.: 1440

Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/15/2014
Drilling Foreman:	Tim Tucker	Date Completed:	12/15/2014
LGCI Engineer:	Abdelmadjid Lahlaf	Location:	Eastern side of proposed building
Ground Surface El:	NA	Total Depth:	5.5 feet
Groundwater Depth:	2.0 feet	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4 1/4" HSA
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	7	7	7	5	24	17		Topsoil 0.4'; Fill 2'	S1 - Top 5": Topsoil Bottom 12": Silty SAND (SM), fine to medium, trace coarse, ~15% fines, ~10% fines gravel, brown, moist (fill)
	2 - 4	S2	9	8	11	9	24	6		Weathered Rock	S2 - broken rock, angular gravel pieces, wet
5ft	4-4.8	S3	14	60/4			10				S3 - Similar to S2, possible weathered rock Spoon bouncing and not advancing at 4.8 feet. Auger refusal at 5.5 feet. Boring hit rock outcrop.
											End of boring at 5.5 feet, backfilled with auger cuttings and topped with sand.
10ft											
15ft											
20ft											

Remarks:
* Auger grinding starting at about 5.0 feet.

LGCI
Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.:	1440
Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/15/2014
Drilling Foreman:	Tim Tucker/Steve	Date Completed:	12/15/2014
LGCI Engineer:	Abdelmadjid Lahlaf	Location:	SE corner of proposed building
Ground Surface El:	NA	Total Depth:	19 feet
Groundwater Depth:	5.2 feet	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4 1/4" HSA
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	WOH	2	4	5	24	16		Topsoil/ Subsoil (2.5')	S1 - Topsoil
	2 - 4	S2	6	5	3	4	24	16		Fill (4.5')	S2 - Top 6": Silty SAND (SM), fine to medium, ~20% fines, trace organics, roots, brown, moist (subsoil) Bottom 10": Silty SAND with Gravel (SM), fine to medium, ~20% fines, ~15% fine gravel, roots, wood pieces, gray (fill)
5ft	4-6	S3	4	10	11	9	24	14			S3 - Top 6": Silty SAND with Gravel (SM), fine to medium, ~15% fines, ~30% fine gravel, gray, moist (fill) Bottom 8": Well-Graded SAND with Silt (SW-SM), fine to coarse, ~10% fines, ~30% fine gravel, brown, moist, wet near bottom
10ft									1	Sand	
	10-12	S4	9	7	6	7	24	14		(13')	S4 - Poorly-Graded SAND with Silt (SP-SM), mostly medium, trace fine, trace coarse, 10-15% fines, olive gray, wet Augers grinding at ~13 feet
15ft	15-17	S5	4	25	45	12	24	7	2	Weathered Rock (17')	S5 - Well-Graded GRAVEL with Silt and Sand (GW-GM), fine, ~20% fines, ~30% fine to coarse, sand, gray with white and black mottles (possible weathered rock) Auger refusal at 19 feet.
20ft											End of boring at 19 feet. Backfilled with cuttings and topped with sand.

Remarks:
1 - Kept positive head in augers starting at 10 feet.
2 - Cuttings not enough to backfill borehole. Filled with sand.

BORING LOG

LGCI Lahlaf Geotechnical Consulting, Inc.

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**
Client:	**Kaestle Boos Associates, Inc.** — LGCI Project No.: 1440

Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/15/2014
Drilling Foreman:	Tim Tucker/Steve	Date Completed:	12/15/2014
LGCI Engineer:	Abdelmadjid Lahlaf	Location:	Southern side of proposed building
Ground Surface El:	NA	Total Depth:	22 feet
Groundwater Depth:	3.7 feet	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4 1/4" HSA
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	1	1	1	3	24	18		Topsoil/ Subsoil 1.5'	S1 - Top 6": Topsoil Bottom 12": Silty SAND (SM), fine, ~20% fines, trace roots, brown, moist (subsoil)
	2 - 4	S2	3	2	2	2	24	22		Fill 4.2'	S2 - Silty SAND (SM), fine, ~20% fines, brown, moist, wet near bottom (fill)
5ft	4-6	S3	WOH/2"		1	2	24	16		Buried Topsoil 6.5'	S3 - Top 4": Similar to S2 Bottom 12": Buried topsoil, fibrous, ~30% fine to medium sand, roots, sand at bottom of spoon
	6-8	S4	1	9	15	17	24	20			S4 - Poorly-Graded SAND with Silt (SP-SM), fine, ~10% fines, trace of roots, gray, wet (~2" of plastic silt near top of spoon and traces of organic sin top 6")
10ft	10-12	S5	3	7	9	10	24	8		Sand 15.2'	S5 - Poorly-Graded SAND (SP), medium, tan to gray, wet
15ft	15-17	S6	5	32	31	36	24	14	1		S6 - Top 2": Similar to S5 Bottom 12": Well-Graded GRAVEL with Silt and Sand (GW-GM), fine, angular ~10% fines, ~35% fine to coarse sand, gray (possible weathered rock)
20ft	20-22	S7	21	23	29	25	24	12		Weathered Rock 22'	S7 - Weathered rock (granite), breaks into Silty SAND (SM), fine to medium, trace coarse, ~20% fines, ~30% fine gravel, gray with black mottles, wet
											End of boring at 22 feet. Backfilled with soil cuttings and topped with sand.

Remarks:
1 - Auger grinding at about 16 feet to about 18 feet.

LGCI Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.:	1440
Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/15/2014
Drilling Foreman:	Tim Tucker/Steve	Date Completed:	12/15/2014
LGCI Engineer:	Abdelmadjid Lahlaf	Location:	Near southwest corner of proposed building
Ground Surface El:	NA	Total Depth:	13.5 feet
Groundwater Depth:	5.2 feet	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4 1/4" HSA
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	1	5	5	9	24	14		Topsoil/ Subsoil	S1 - Top 6": Topsoil Bottom 8": Silty SAND (SM) fine, ~20% fines, ~10% fine gravel, trace roots, brown (subsoil)
	2 - 4	S2	7	3	3	3	24	16		2.5' Fill 4'	S2 - Top 6": Similar to Bottom 8" of S1 Bottom 10": Silty SAND (SM), fine, trace of organics, brown, moist (fill)
5ft	4-6	S3	4	8	12	8	24	14		Sand 10'	S3 - Poorly-Graded SAND with Silt and Gravel (SP-SM), mostly medium, trace fine, trace coarse, ~10% fines, ~20% fine gravel, orange-brown, moist
10ft	10-12	S4	12	14	29	38	24	12		Weathered Rock 13.5'	S4 - Silty SAND with Gravel (SM), fine to medium, trace coarse, ~15% fines, ~20% fine gravel, brown to gray, wet (possible weathered rock) Refusal at 13.5 feet.
15ft											End of boring at 13.5 feet. Backfilled with drilled cuttings and topped with sand.
20ft											

Remarks:

LGCI
Lahlaf Geotechnical Consulting, Inc.

BORING LOG

Project:	**Proposed Minuteman Vocational Technical High School, Lexington, MA**		
Client:	**Kaestle Boos Associates, Inc.**	LGCI Project No.:	1440
Drilling Subcontractor:	Northern Drill Service, Inc.	Date Started:	12/15/2014
Drilling Foreman:	Tim Tucker/Steve	Date Completed:	12/15/2014
LGCI Engineer:	Abdelmadjid Lahlaf	Location:	Southern side of proposed building
Ground Surface El:	NA	Total Depth:	22 feet
Groundwater Depth:	8 feet	Drill Rig Type:	Mobile Drill B-48 ATV
		Drilling Method:	4 1/4" HSA
Hammer Weight:	140 lbs	Split Spoon Diameter:	ID - 1.375", OD - 2"
Hammer Type:	Automatic	Rock Core Barrel Size:	N/A
Drop:	30 inches		

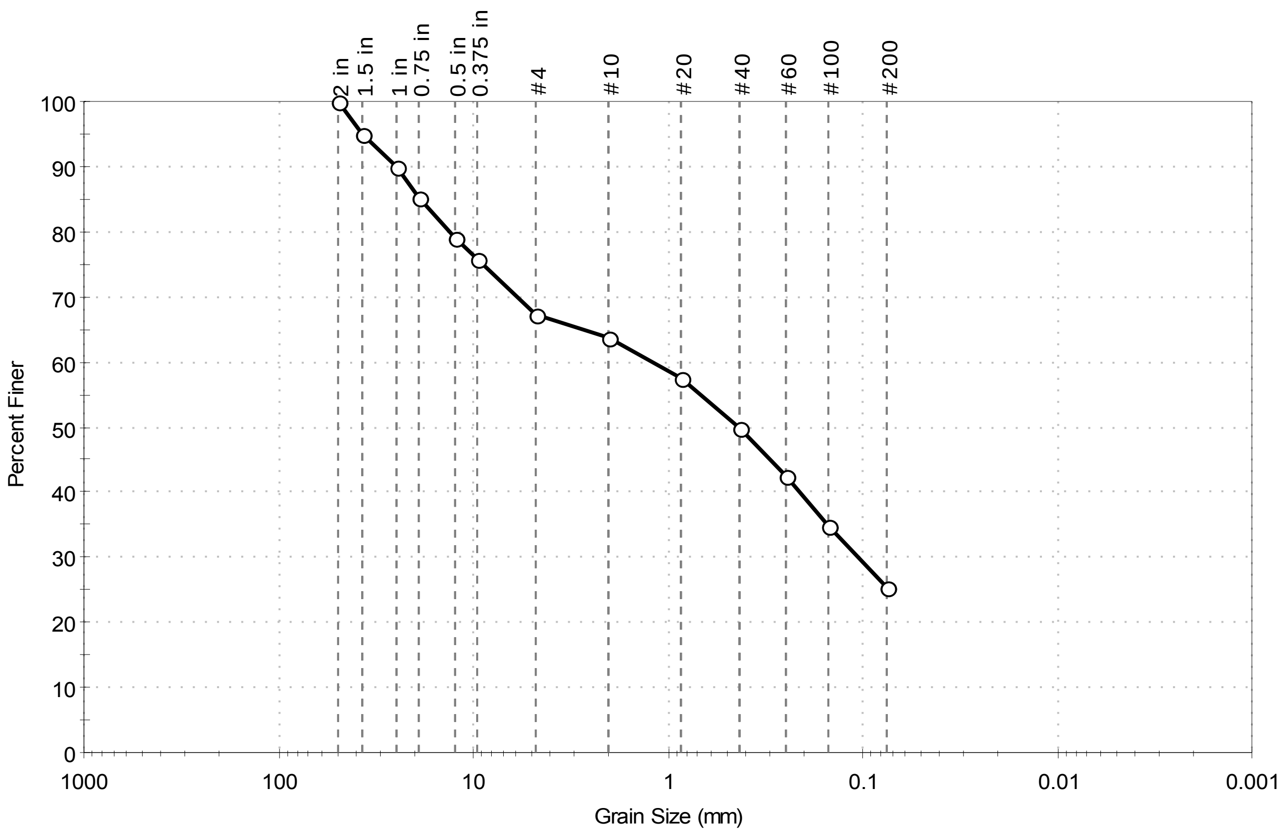
Depth Scale	Sample Depth (ft)	Sample No	Blows per 6 inches 0-6	6-12	12-18	18-24	Pen (in)	Rec (in)	Remarks	Strata	Sample Description
	0 - 2	S1	WOH	9	10	10	24	16		Topsoil	S1 - Top 6": Topsoil
										Fill	Bottom 10": Silty SAND (SM), fine, trace medium, ~20% fines, traces of Organic Silt (OL), traces of roots, ~10% fine gravel, brown (fill)
	2 - 4	S2	10	10	9	9	24	18			S2 - Similar to Bottom 10" of S1
5ft	4-6	S3	5	1	1	2	24	0		6'	S3 - No recovery, stone at tip of split spoon
	6-8	S4	4	2	2	3	24	10		Peat	S4 - Peat, fibrous, slightly plastic, black, moist
	8-10	S5	4	9	7	11	24	14		8.3'	S5 - Top 4": Similar to S4, wet
										Sand	Bottom 10": Poorly-Graded SAND (SP), fine, gray, wet
10ft									1		
	10-12	S6	2	5	6	7	24	22			S6 - Poorly-Graded SAND (SP), medium, tan to brown, wet
15ft											
	15-17	S7	3	4	4	6	24	14			S7 - Similar to S6, fine near bottom 2"
20ft	20-22	S8	7	9	14	18	24	10		20.2'	S8 - Top 2": Poorly-Graded SAND (SP), fine
										Weathered Rock 22'	Bottom 8": Well-Graded SAND with Silt and Gravel (SW-SM), fine to coarse, 5-10% fines, ~30% fine gravel, brown to gray (possible weathered rock)
											End of boring at 22 feet. Backfilled with cuttings and topped with sand.

Remarks:
1 - Kept positive head in augers starting at S6 (10 feet).

Attachment C – Laboratory Test Results

Client:	Lahlaf Geotechnical Consulting
Project:	Minuteman High School
Location:	Lexington, MA
Project No:	GTX-302658
Boring ID:	TP-1
Sample Type:	bag
Tested By:	jbr
Sample ID:	---
Test Date:	12/16/14
Checked By:	emm
Depth :	3-5 ft
Test Id:	318524
Test Comment:	---
Sample Description:	Moist, olive brown silty sand with gravel
Sample Comment:	---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	32.6	41.9	25.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	95		
1 in	25.00	90		
0.75 in	19.00	85		
0.5 in	12.50	79		
0.375 in	9.50	76		
#4	4.75	67		
#10	2.00	64		
#20	0.85	58		
#40	0.42	50		
#60	0.25	43		
#100	0.15	35		
#200	0.075	26		

Coefficients

D_{85} = 18.6442 mm
D_{30} = 0.1048 mm
D_{60} = 1.1863 mm
D_{15} = N/A
D_{50} = 0.4268 mm
D_{10} = N/A
C_u = N/A
C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

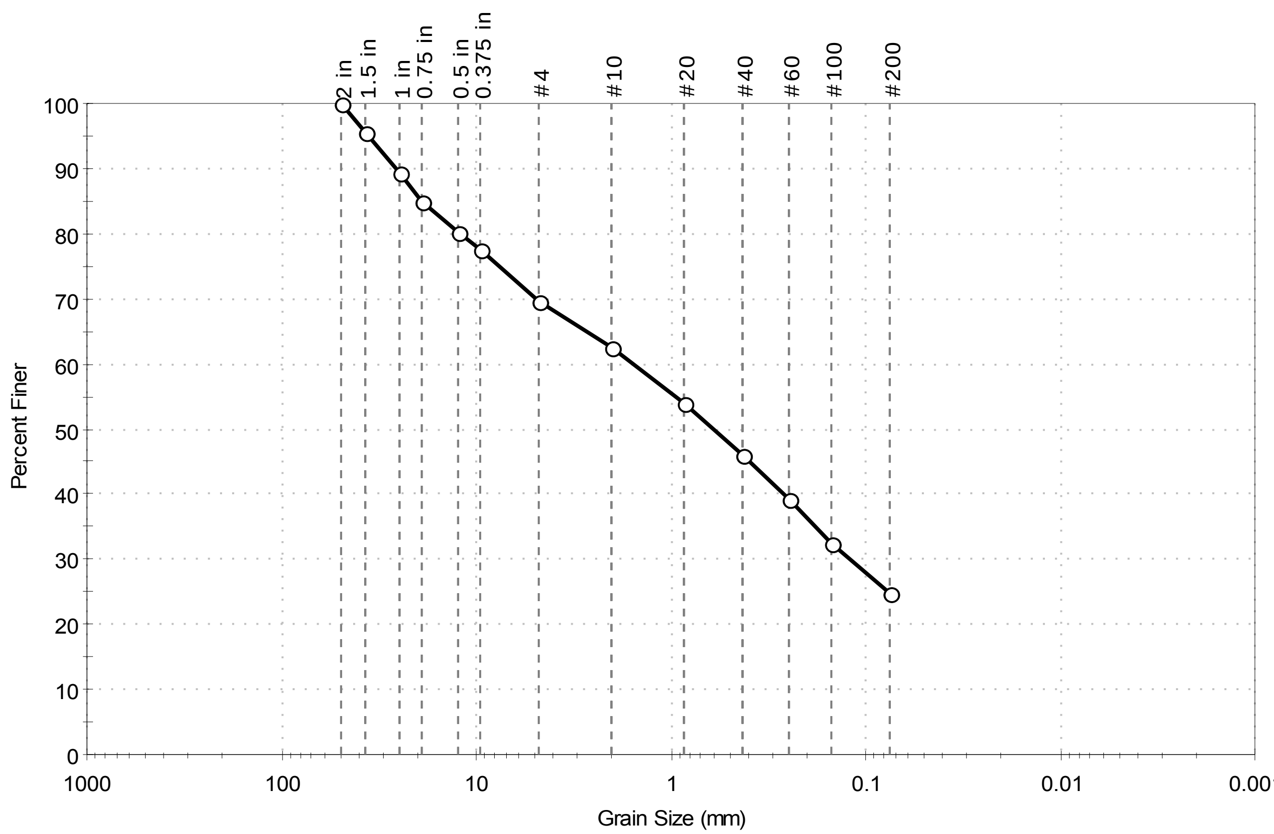
Sand/Gravel Hardness : HARD

printed 12/16/2014 11:50:19 AM

Client: Lahlaf Geotechnical Consulting			
Project: Minuteman High School			
Location: Lexington, MA		Project No:	GTX-302658
Boring ID: TP-4	Sample Type: bag	Tested By:	jbr
Sample ID: ---	Test Date: 12/16/14	Checked By:	emm
Depth : 2-4.5 ft	Test Id: 318525		

Test Comment: ---
Sample Description: Moist, olive brown silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	30.5	44.7	24.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	95		
1 in	25.00	89		
0.75 in	19.00	85		
0.5 in	12.50	80		
0.375 in	9.50	78		
#4	4.75	70		
#10	2.00	63		
#20	0.85	54		
#40	0.42	46		
#60	0.25	39		
#100	0.15	32		
#200	0.075	25		

Coefficients

D_{85} = 18.9804 mm — D_{30} = 0.1198 mm
D_{60} = 1.5328 mm — D_{15} = N/A
D_{50} = 0.6000 mm — D_{10} = N/A
C_u = N/A — C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

printed 12/16/2014 11:50:19 AM