GEOTECHNICAL STUDY

AT

Proposed East Point Fire Station No. 4
2222 Ben Hill Road Drive
East Point, Georgia

Submitted to

Brown Design Group

Mr. Coy Cooper, Jr. RA
Brown Design Group
3099 Washington Road
East Point, Georgia 30344

PROJECT NUMBER: MEG301949
February 2017

Matrix
Engineering
Group, Inc.
engineers | special inspectors | construction consultants

Matrix
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February 14, 2017

Ms. Audra Cooper
Brown Design Group
3099 Washington Road
East Point, GA 30344

Re: ***Geotechnical Study for the Proposed East Point Fire Station #4***
East Point, Georgia
Matrix Engineering Group's Project No. 301949

Dear Ms. Cooper:

Matrix Engineering Group, Inc. has completed the authorized Subsurface Exploration for the proposed East Point Fire Station No. 4 in East Point, Georgia. The scope of this work included the drilling of six (6) soil test borings to evaluate the subject site for the proposed development. This report describes our investigative procedures and presents our findings, conclusions and engineering recommendations.

Additionally, a Multi-Channel Analysis of Surface Waves (MASW) was performed in order to determine the in situ Shear Wave Velocity profile for the upper 100 ft of subsurface. The weighted average Shear Wave Velocity was used to determine the IBC 2012 seismic site class and provide recommended Design Accelerations (S_{DS} & S_{D1}).

This report describes our investigative procedures and presents our findings, conclusions and engineering recommendations.

Matrix Engineering Group, Inc. appreciates the opportunity to have worked with the Brown Design Group on this project and looks forward to our continued association. If you have any questions or need further assistance, please do not hesitate to call.

Best Regards,

MATRIX ENGINEERING GROUP, INC.

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EXECUTIVE SUMMARY

The following summarizes our findings and recommendations for the proposed development. For detailed information, references and context, refer to the appropriate section in the body of this report.

- The project is located at 2222 Ben Hill in East Point, Georgia. The proposed construction is new Fire Station facility with parking areas, driveways, and sidewalks. Demolition of the existing improvements including the existing fire station will be required to facilitate the construction of the proposed Fire Station.

- The site has been developed in the past and is currently occupied by the existing Fulton County Fire Station Number 4. The existing development includes a split-level building, a baseball/athletic field including an ancillary structure which appears to be associated with the baseball field, a power substation, and asphalt, as well as concrete-paved driveways/parking areas. The site slopes from the northeastern areas of the site in a west to southwesterly direction from elevations on the order of 1,000 feet Mean Sea Level (MSL) to elevations of 980 feet MSL along the southern and western boundaries of the site.

- A total of six (6) soil test borings, designated as B1 to B6, were performed throughout the subject site to explore the subsurface conditions and provide specific geotechnical recommendations for the proposed development.

- Man-made fill or possible man-made fill was encountered at test borings B1, B4 and B5. The fill thickness at these borings was approximately 3.5 feet BGS. The fill material generally consisted of stiff, silty clay (ML-CL) with varying amounts of sand. The consistency of the fill material ranged between 10 blows/ft (bpf) and 14 bpf.

- Residual soils were encountered at each of the soil borings below the encountered fill and/or surface layer. The residual soils generally consisted of interbedded layers of loose to medium dense, silty coarse to fine sands (SM) and firm, sandy silts (ML). The soil consistency of the residual material ranged between 6 and 25 bpf, but was typically observed to be between 11 and 20 bpf. **Partially Weathered Rock (PWR)** was not encountered at any of the test borings. Auger refusal was not encountered at any of the test borings. All borings were advanced to their planned depths. Groundwater was not encountered at any of the test borings at the time of drilling.

- Based on the subsurface conditions encountered at the test borings, the building may be supported on shallow foundations. Based on the anticipated building elevations, the foundations should be situated in well compacted and properly tested soils, and be designed for a maximum net allowable soil bearing pressure **<u>not to exceed 2,500 pounds per square foot (psf)</u>.**

- Subgrade preparation for the proposed development should be the stripping of vegetation, root systems, topsoil, and other deleterious matter, when encountered. **Any deleterious materials or buried debris, such as underground utility lines, septic tanks, or trash pits that may be encountered during the grading operation should be treated on an individual basis. T**he suitability of all other areas of the exposed subgrade needs to be confirmed by proofrolling at the time of construction, after any unsuitable or softened materials are removed. The proofrolling should be observed by the geotechnical engineer.

- Based on the Multi-Channel Analysis of Surface Waves (MASW) technique and the resulting V_{s100} of 1,105 ft/sec, we recommend that a *<u>Site Class “D”</u>* be used for seismic design purposes per IBC2012.

TABLE OF CONTENT

1.0 INTRODUCTION

Matrix Engineering Group, Inc. (Matrix) has completed the authorized Subsurface Exploration and Geotechnical Engineering Evaluation for the proposed East Point Fire Station No. 4 at 2222 Ben Hill Road Drive in East Point, Georgia. The objective of this exploration was to perform six (6) soil test borings to explore the subsurface conditions, and provide the findings and recommendations regarding the geotechnical aspects of the proposed development. This report describes our investigative procedures and presents our findings, conclusions and engineering recommendations.

This work was authorized on January 27, 2017 and performed in general accordance with our proposal for Geotechnical Services which was issued on October 12, 2016.

2.0 PROJECT DESCRIPTION

- The proposed project consists of the demolition of the existing structures to facilitate the construction of a new Fire Station facility with parking areas and driveways, and sidewalks. Additionally, a tower and a fire burn room are proposed on the southern area of the site. Refer to Figure 2 for the proposed site layout.
- The proposed finished floor elevations are not provided, it appears that the finished floor elevations will be near the elevation of the existing ground. Therefore, minimal cut and fill are proposed to achieve the proposed grades.
- Anticipated column loads were not available at the time of writing this report.
- Proposed underground utility locations, or elevations thereof, were not provided at the time of this exploration.

3.0 SCOPE OF WORK

The scope of work for this project consisted of:

- Drilling and sampling a total of six (6) soil test borings located throughout the site to explore the subsurface conditions and provide geotechnical recommendations for the proposed development. Six (6) of the borings were drilled mechanically and extended to a maximum depth of 20 feet below the existing ground surface (BGS).
- Field and laboratory testing to determine the engineering characteristics of the soils encountered in the soil borings.
- Performing a Seismic Site Classification per Chapter 16 of the 2012 International Building Code (IBC2012) utilizing the measured average shear wave velocity for the upper 100 feet of subsurface ($V_{s,100}$).

- Providing recommended short (0.2 second) and 1-second Design Response Accelerations (S_{Ds} & S_{D1}) for seismic events having a 2% probability of exceedance in 50 years.
- Performing a geotechnical engineering analysis for the proposed development.
- Preparation of this geotechnical report based on the data gathered during the exploration.

The purpose of this report is to document the site subsurface conditions, to analyze and evaluate the data obtained, and to provide recommendations regarding the geotechnical aspects of the proposed development.

4.0 EXPLORATION AND TESTING PROGRAM

4.1 Subsurface Exploration

The geotechnical exploration program consisted of the drilling and sampling of a total of six (6) soil test borings located throughout the project site. Boring locations were designated and located in the field by Matrix staff. The approximate locations of the soil borings are shown on Figure 2 presented in the Appendix of this report. For exact locations, the owner may elect to survey the boring locations. Matrix should be informed of any deviations to evaluate and modify our recommendations, if necessary.

Six (6) of the test borings, designated B1 through B6, were performed using a truck-mounted CME 55 drill rig equipped with an automatic hammer in general accordance with ASTM D1586 standards. The borings were advanced to depths of up to 20 feet BGS. Borings were advanced by augering through the soils with continuous flights of 3 inch augers. At regular intervals, the auger flights were removed from the bore hole, and soil samples were obtained through the center of the bore hole with a standard 1.4-inch I.D., 2.25-inch O.D., split-tube sampler. The sampler is first seated 6 inches to penetrate any loose cuttings, and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is recorded and is designated as the Standard Penetration Resistance (N-Value). The penetration resistance, when properly evaluated, is an index of the soil strength, consistency and ability to support foundations.

Representative soil samples were obtained using split-spoon sampling techniques. The samples were classified in the field in general accordance with ASTM D2488 (Visual-Manual Procedure for Description of Soils). Representative portions of the soil samples were placed in sealable, plastic bags and transported to our laboratory. During the field operations, Matrix staff maintained a continuous log of the subsurface conditions including changes in the stratigraphy and any observed groundwater levels. Soil descriptions and penetration resistance values are presented graphically on the Soil Boring Records included in the Appendix of this report.

All borings were backfilled with the soil cuttings by Matrix Engineering approximately 24 hours after the conclusion of the drilling operations. Some consolidation of the backfilled soil column should be expected.

4.2 Laboratory Testing

The laboratory testing program for this project consisted of performing soil classifications in accordance with ASTM D2488 (Visual-Manual Method for Identification of Soils). The soil samples were examined in the laboratory by a geotechnical engineer and visually classified based on texture and plasticity in accordance with the Unified Soil Classification System (ASTM D2487).

The soil samples are kept in sealed plastic bags and will be stored for a period of 60 days and then disposed of unless otherwise instructed by the owner or the engineer.

5.0 SITE DESCRIPTION AND GENERAL SITE GEOLOGY

5.1 Site Description

The site is located at 2222 Ben Hill Road in East Point, Georgia. The site is bordered along the northeastern boundary by Ben Hill Road. Residential properties surround the site on the southern boundaries and power sub-stations are located along the western boundaries of the site. A tributary of North Fork Camp Creek is located along the western boundary of the site.

Based on our site visit and reconnaissance, the site has been developed in the past and is currently occupied by the existing Fulton County Fire Station Number 4. The existing development includes a split-level building, a baseball/athletic field including an ancillary structure which appears to be associated with the baseball field, a power substation, and asphalt, as well as concrete-paved driveways/parking areas. The proposed fire station facility is planned for the southern areas of the site which are presently occupied with the baseball field. Underground utilities and/or other unknown structures may be present that are not in the scope of this exploration.

Based on information obtained from the Fulton County Tax Assessor's website, as well as our visual observations, the site slopes from the northeastern areas of the site in a west to southwesterly direction from elevations on the order of 1,000 feet Mean Sea Level (MSL) to elevations of 980 feet

MSL along the southern and western boundaries of the site. Topographical relief from the site is on the order of 20 feet.

A tributary to Camp Creek runs along the western boundary of the site. The creek flows in a southwesterly and southwesterly direction. Flood plains are typically present around creeks that potentially includes alluvium and colluvium deposits, as well as shallow groundwater elevations.

5.2 General Site Geology

The subject site is located in the Piedmont Geologic Province, which contains the oldest rock formations in the Southeastern United States. The parent rocks in the region are primarily comprised of the unconsolidated mass of quartz, feldspar, mica, and a wide variety of dark minerals such as hornblende and amphibole.

The proportion of felsic and mafic minerals in these parent rocks, as well as of quartz that is very resistant to weathering, limits the amount of clay in the soils. Therefore, these soils are sandy and have faint horizons, and in small-scattered areas, hard rock is exposed.

Chemical decomposition initially occurs along the boundaries of individual mineral crystals. Thus, partially weathered rock has the appearance of dense sand (SM, SP). With further weathering, the individual crystals other than quartz are attacked and the mass becomes a micaceous silty sand (SM) or micaceous sandy silt (ML). In this stage, the original banding of the parent rock is apparent, but the original crystalline structure is not observed. Reflecting the composition of the original rock, mica flakes, rather than the quartz grains, often comprise the majority of the sand-size particles. Finally, in the more advanced stages of chemical weathering, the material is changed into a red or reddish-brown silty clay (CL or CH) or clayey silt (ML or MH). Depending on the quartz content, a sandy fraction will be present. In this weathered stage, the banding and crystalline structure of the parent rocks is lost.

6.0 GENERAL SUBSURFACE CONDITIONS

The subsurface conditions were characterized by visual-manual examination of the soils obtained from the split-spoon sampler and observation from the auger's cutting during the drilling operation. The soil boring logs, designated as B1 to B6, are provided in the Appendix of this report. The test borings were extended to a maximum depth of 20 feet below ground surface (BGS) elevations. The subsurface conditions within the drilled borings are characterized as follows:

6.1 Surface Materials and Man-Made Fill

Based on the existing development, the site has been graded in the past and is currently improved by the existing Fulton County Fire Station Number 4. Although a topsoil layer with a consistent thickness of approximately 6 inches was encountered within the test boring locations, topsoil thicknesses may vary in between the boring locations and at other unexplored areas of the site. The soils below the existing structures and pavements were unexplored and cannot be ascertained without proper testing.

Man-made fill or possible man-made fill was encountered at test borings B1, B4 and B5. The fill thickness at these borings was approximately 3.5 feet BGS. The fill material generally consisted of stiff, silty clay (ML-CL) with varying amounts of sand. The consistency of the fill material ranged between 10 blows/ft (bpf) and 14 bpf.

6.2 Residual Material

Residual soils are those which have weathered in place from the parent rock. Residual soils were encountered at each of the soil borings below the encountered fill and/or surface layer. The residual soils generally consisted of interbedded layers of loose to medium dense, silty coarse to fine sands (SM) and firm, sandy silts (ML). The soil consistency of the residual material ranged between 6 and 25 bpf, but was typically observed to be between 11 and 20 bpf.

6.3 Partially Weathered Rock and Bedrock

Partially Weathered Rock (PWR) is a regionally used term for residual material with a Standard Penetration Resistance of 100 bpf or more, but which can be penetrated by the soil drilling equipment. Neither PWR, nor shallow auger refusal in rock material, were encountered at any of the borings performed within the drilled residual soil depths.

6.4 Groundwater

Groundwater readings were obtained at the time of drilling and after completion of the drilling operation to obtain a stabilized groundwater levels. The test borings were backfilled after the drilling operations. Groundwater was not encountered within any of the test borings at the time of drilling. Groundwater elevations do fluctuate with seasonal changes and typically vary on the order of 4 to 8 feet.

6.5 Summary of Test Boring Records

The geologic profile described generally represents the conditions encountered in the soil borings. Some variations in the description should be expected. The stratification lines designating the interfaces between earth materials shown on the boring logs are approximate; in-situ transition may be gradual.

Table 1 below summarizes the field findings from the soils test borings.

Table 1: Summary of test boring records.

Boring No.	Planned Depth (ft)	Groundwater Depth (ft)	PWR Depth (ft)	Auger Refusal Depth (ft)
B1	20	N/E	N/E(1)	N/E
B2	20	N/E	N/E	N/E
B3	20	N/E	N/E	N/E
B4	20	N/E	N/E	N/E
B5	20	N/E	N/E	N/E
B6	20	N/E	N/E	N/E

(1): *N/E: Not Encountered*

7.0 FINDINGS AND RECOMMENDATIONS

The following recommendations are based on the information furnished to us, the data obtained from the subsurface exploration, and our experience with similar projects. They were prepared in general accordance with established and accepted professional geotechnical engineering practice in this region. Our recommendations are based on findings from the dates referenced within this report and do not reflect any variations that would likely exist at later dates or between the pre-designated borings or unexplored areas. Depths and/or thicknesses are approximate and should not be used for estimating quantities during construction, specifically as it relates to topsoil or other surface materials.

If information becomes available which may impact our recommendations, Matrix Engineering Group shall be afforded the opportunity to review this information and re-evaluate the recommendations contained within this report and make any alterations deemed necessary by a Georgia Registered professional engineer. This report is intended for the use of Brown Design Group and its current design *team. No other warranty is expressed or implied. Matrix Engineering Group, Inc. is not responsible for conclusions, opinions, or recommendations made by others based on this report.*

It should be noted that the soils below the existing structures were unexplored. We assume that the soils below the existing structures are at least as suitable as the soils encountered at the test boring locations, however, the condition of these soils cannot be ascertained without proper testing.

The following recommendations present general guidelines for the proposed development.

7.1 Excavation Considerations

The recommendations provided in this Section are based on the Proposed Site Plan designated as ‘Exhibit D’ provided by Brown Design Group. It is our understanding that the planned construction is to include demolition of the existing facility following the construction of the proposed fire station facility within the southern areas of the site which are presently occupied by the baseball/athletic field. Due to the presence of underground utilities and fill materials within the proposed building area, we recommend that any material which is excavated and planned for re-use as structural fill be examined by the geotechnical engineer of record at the time of excavation to determine its suitability.

PWR was not encountered at any of the test borings, therefore, we do not anticipate difficult excavation to be encountered for the preparation of the proposed building. Depending on the final design elevations and trench excavation of new utility lines, some amount of non-conventional grading, such as localized blasting or hammering may be required near these areas. Accordingly, we recommend that the following general specifications for rock excavation, or a variation thereof, be incorporated into the project documents:

<u>General Recommendations for Rock Excavation</u>:

Rock excavation shall consist of all material which can not be excavated except by drilling, blasting or wedging. It shall consist of un-decomposed stone hard enough to ring under a hammer, and the amount of solid stone shall be not less than one (1) cubic yard in volume. Rock is further defined as follows:

(1) General Excavation: Any material occupying an original volume of more than one cubic yard which cannot be excavated with a single-tooth ripper drawn by a crawler tractor having a minimum draw bar pull rated at not less than 80,000 pounds (caterpillar D-8 or larger)

(2) Trench Excavation: Any material occupying an original volume of more than one cubic yard which cannot be excavated with a backhoe having a bucket curling force rated at not less than 40,000 pounds, using a rock bucket and rock teeth (a John Deere 790 or larger).

7.2 Groundwater & Dewatering

Since groundwater was not encountered at the time of this study, we do not anticipate groundwater to impact the construction of the proposed development. If encountered, groundwater levels should be lowered and maintained to at least three (3) feet below the bottom of the lowest foundation elevation (only during construction) in order to protect the exposed subgrade's integrity. If groundwater is encountered during the installation of any utility lines, the water should be controlled with a sump and pump system, as warranted at the time of construction.

7.3 Subgrade Preparation

Subgrade preparation for the proposed development should be the stripping of vegetation, root systems, topsoil, and other deleterious matter, when encountered. Topsoil may be stockpiled and later used to dress any proposed landscaped areas. **Any deleterious materials or buried debris, such as underground utility lines, septic tanks, or trash pits that may be encountered during the grading operation should be treated on an individual basis.**

Man-made fill or possible man-made fill materials were observed at test borings B1, B4, and B5. The fill thickness at these borings was approximately 3.5 feet Below Ground Surface (BGS). Due to the nature of the encountered fill materials, it should be noted that unsuitable/unusable fill materials may be present which would need to be addressed and/or quantified during the grading activities.

Once the subgrade has been cleared, the suitability of the exposed subgrade should be confirmed by proofrolling, which will discern any localized soft zones in the subgrade. The proofrolling should be performed by a loaded tandem-wheeled dump truck with an approximate weight of 25 tons. Any material that deflects excessively or ruts under the loaded truck should be densified or removed and replaced with well-compacted material.

Similarly, the suitability of all other areas of the exposed subgrade needs to be confirmed by proofrolling at the time of construction, after any unsuitable or softened materials are removed. The proofrolling should be observed by the geotechnical engineer. Structural fill procedures are provided in Section 8.1 of this report.

7.4 Slab-On-Grade Construction

The concrete slab-on-grade for the proposed structure will be supported on new fill. Provided the fill material is installed to a minimum of 95% of the maximum dry density (standard effort), a modulus of subgrade reaction (k) of 125 pci can be used for designing the floor slab-on-grade. Slab reinforcement and joint spacing should be carefully considered to control random cracking due to slab shrinkage. Slabs should be isolated from the foundations to allow differential movements to take place between the slab and walls. We recommend that at least a 10 mil vapor barrier/retarder (such as polyethylene) be installed below the (slab-on-grade) concrete to limit intrusion of water vapor through the slab. Beneath slab-on-grade areas, a minimum of 4 inches of clean, densely-graded, granular material with a balanced content of fines is recommended to facilitate fine grading and provide stable surface for construction traffic and building loads. Open-graded bases do not meet these requirements because they are relatively incompatible, difficult to trim, and are unstable for construction traffic. It is also difficult to fine grade an open-graded base to a relatively uniform elevation, which can result in restraint to concrete movement as the concrete cools or dries, thus increasing the probability of out-of-joint cracking. If open-graded bases are specified, the surface of these bases should be choked off with a clean fine-graded material with at least 10 to 30% of the particles passing a No. 100 sieve, but not contaminated with clay, silt, or organic material.

7.5 Pavement Design

Based on our experience with projects of similar magnitude and soil conditions, we recommend that a CBR value of 4 be used for pavement design of light and heavy duty pavements. The thickness of the base course material under the pavement is dependent upon the pavement type, magnitude and frequency of loading, and expected pavement life. Based on our experience with projects of similar magnitude and soil conditions, we recommend the following design sections be considered in the design of pavements. These recommendations present a wide range of loading conditions. The architect/engineer should select the pavement section most appropriate to the development. Pavements should be constructed in accordance with all applicable specifications of the Asphalt Institute and the Georgia Department of Transportation:

Heavy Duty Asphalt Pavement:
98% compacted soil subgrade (Standard Proctor – ASTM D698)
6 inches Graded Aggregate Base (GAB), compacted to 100% of maximum dry density (Modified Proctor – ASTM D1557C)
2 inches 19mm SP Asphalt Base

1.5 inches 9.5mm SP II Asphalt Topping
Asphalt layers should be separated by a tack coat.

Light & Medium Duty Asphalt Pavement:
98% compacted soil subgrade (Standard Proctor – ASTM D698)
4 inches GAB, compacted to 100% of maximum dry density (Modified Proctor – ASTM D1557C)
2 inches 19mm SP Asphalt Base
1.5 inches 9.5mm SP II Asphalt Topping
Asphalt layers should be separated by a tack coat.

Heavy Duty Concrete Pavement:
100% compacted soil subgrade (Standard Proctor – ASTM D698)
6 inches GAB, compacted to 100% of maximum dry density (Modified Proctor – ASTM D1557C)
6 inches (4000 psi compressive strength) concrete with Welded Wire Fabric (6x6 – W2.9 x W2.9).

Subgrade preparation should be performed in accordance with our recommendations provided in Section 8.1 and 8.2 of Matrix geotechnical report.

Pavements sub-base (Graded Aggregate Base) should conform to Section 815 of the State of Georgia Department of Transportation Specifications for Road and Bridge Construction. The sub-base should be compacted to 100% of the maximum dry density for crushed stone as determined by the modified moisture-density relationship test (ASTM D1557). Additionally, proofrolling of the sub-base should be performed prior to paving in order to detect any soft areas or excessive rutting which may require stabilization.

Exterior pavements should be provided with the facilities for surface and subsurface drainage. Standing water on the pavement surface eventually may seep into the base course layer and softens the pavement subgrade which leads to premature deterioration of the pavement. In areas where landscape areas slope toward the pavement, a perimeter drain along the back of the curb intercepting migration of surface water should be provided to minimize seepage under the pavement.

7.6 Foundations

The drilled subsurface conditions consisted of residual and man-made fill. Both of which were of adequate consistency and suitability. **However, inherent in man-made fill is the potential for presence of buried deleterious materials.** Therefore, care should be exercised to ensure that adequate foundations testing is performed during construction and that all soils are properly evaluated by a registered Geotechnical Engineer.

Our findings reveal that the building may be supported on shallow foundations. Based on the anticipated building elevations, the foundations should be situated in well compacted and properly tested soils, and be designed for a maximum net allowable soil bearing pressure **not to exceed 2,500 pounds per square foot (psf)**.

A recommended foundation inspection criterion is provided in Section 8.2 of this report. The net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation soils in excess of the final minimum surrounding overburden pressure. We recommend that all continuous footings have a minimum width of 2 feet, and should be a minimum 18 inches below subgrade elevations to prevent shear failure and to minimize the effects of frost.

7.7 Slopes and Vertical Cuts

A common practice in this region has been to limit slopes to 2.0(H) to 1.0(V) or flatter. The soil conditions at this site may tolerate a maximum temporary slope of 1.0(H) to 1.0(V). The soils in this area may contain fissures, foliation planes and other discontinuities that could cause sloughing or possibly a slope failure, even on relatively flat slopes. Therefore, the excavation for the slopes should be monitored by a geotechnical engineer to ensure that soil conditions are similar to those we have encountered. Potential planes of weakness will be more visible at depth as the excavation proceeds. If weak conditions are evident, the engineer can then recommend any necessary remedial actions.

Vertical cuts that exceed 5 feet should be braced or shored as required by OSHA regulations for safety. Additionally, stairways, ladders, ramps or other means of safe access should be made available for any trenches deeper than 4 feet. If any excavation, including a utility trench, is extended to a depth of more than 20 feet, it will be necessary to have the slopes designed by a professional engineer.

7.8 Retaining Walls and Lateral Earth Pressures

The design of any retaining wall is based on the determination of the lateral earth pressures that will act on the wall. These pressures are a function of the retained soils properties, and the structural design of the wall. Three common conditions are considered to exist behind a retaining wall depending on the wall's structural design; namely Active, At-Rest, and Passive earth pressure conditions. Active earth pressures are mobilized when a relatively flexible retaining structure such as a free standing wall is designed allowing for slight movement or deflection. At-rest conditions apply to restrained retaining wall design such as basement or tunnel walls. The passive state represents the maximum possible pressure when a structure is pushed against the soil, and is used in wall design to help resist at-rest or active pressures. Since significant movement has to occur before the passive earth pressure is mobilized, the total calculated passive pressure should be reduced by one-half to two-thirds for design purposes.

Based on our experience, wall movement (known as tilt), that is necessary for earth pressures to mobilize, range from 0.01H to 0.02H for the Active state and 0.02H to 0.04H for the Passive state. It is assumed that the ground surfaces behind retaining walls will be constructed relatively level and that residual soils like those encountered in our borings will be used for wall backfill. Based on our experience with similar soils and laboratory test data, we recommend that an effective angle of internal friction (ϕ') = 30° and a cohesion c = 200 psf be used as design strength parameters for the silty soils encountered on the site. These strength parameters result in the following earth pressures coefficients and equivalent fluid pressure per foot of depth for compacted fill (based on a total (wet) unit weight (γ_w) of 120 pcf). A coefficient of friction of 0.40 could be used between the wall foundations and the underlying soil. When calculating the resistance to sliding, we recommend using a factor of safety of 1.5.

Table 2

Earth Pressure Condition	*Coefficient*	*Recommended Equivalent Earth Pressure (pcf)*(1)
Active	(K_a) 0.35	42.0
At-Rest	(K_o) 0.5	60.0
Passive(2)	(K_p) 3.0	187.2

(1) *Assumes a constantly functional drainage system*

(2) *Because significant wall movements are required to develop the passive pressure, the design passive pressure should be taken as one-half to two-thirds of the total calculated passive pressure.*

Backfill against the walls should be done carefully to minimize the horizontal load on the wall. Heavy equipment should not be used to compact the soil within 10 feet of the walls. The use of hand-tampers should be sufficient to obtain the required density when working the 10-foot zone adjacent to the wall. Recommended structural fill specifications and procedures are provided in Section 8.1 of this report.

These retaining wall/below grade wall recommendations should not be correlated with soil parameters for use in Mechanically Stabilized Earth (MSE) wall design. We recommend that soil parameters for any MSE retaining wall design be established through appropriate laboratory testing by the wall designer.

7.9 Seismic Site Classification (IBC 2012)

Matrix conducted an analysis, utilizing the Multi-Channel Analysis of Surface Waves (MASW) technique, to determine the Seismic Site Classification for the proposed site. The Probabilistic Ground Motion values were retrieved for a central location within the project site, utilizing the USGS Earthquake Hazards Program, using latitude (N 33.674893) & longitude (W -84.462037). The following are the Spectral Response Acceleration Parameters for a 2% probability in 50 years:

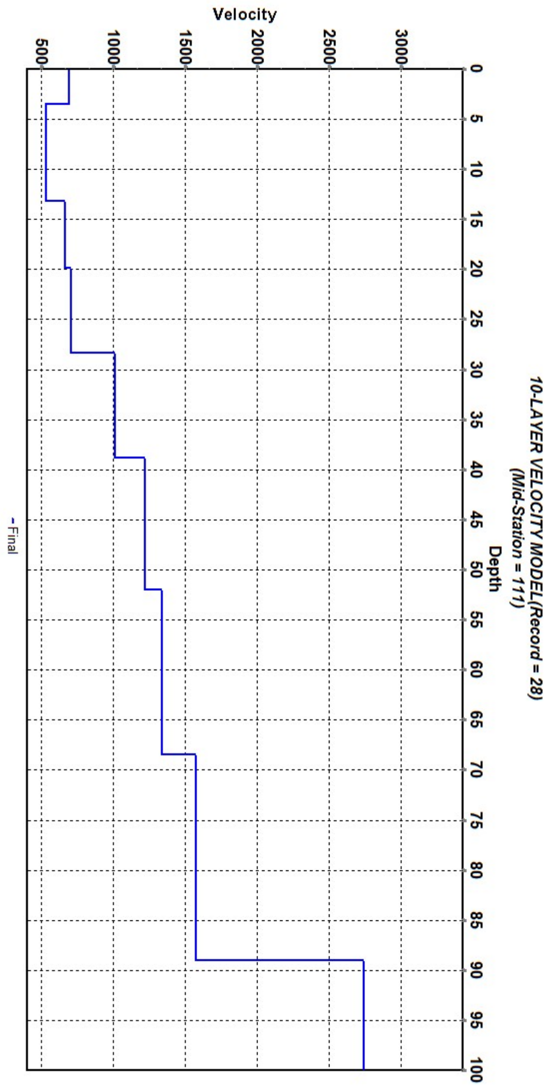
S_s: *Short period (0.2 second), Spectral Response* = **0.180**
S_1: *1-second period, Spectral Response* = **0.089**

The site classification was undertaken in general accordance with the International Building Code 2012 (IBC2012), Table 1613.3.2 and chapter 20 of ASCE 7 by relying on the shear wave velocity for the upper 100 ft of the subgrade.

A site-specific seismic evaluation was carried out by conducting surface velocity testing and performing a Multi-Channel Analysis of Surface Waves (MASW) in order to determine the Seismic Site Classification for the proposed project. One (1) traverse was deployed, as shown on the attached Figure 2. MASW utilizes seismic energy of Rayleigh type surface waves to calculate the shear wave velocity. For this method, the geophones (receivers) remain stationary and data is collected with the source located off the end of the line of geophones. Data is collected at multiple locations (i.e., offsets) in order to obtain the optimal survey settings that would yield the most coherent data set. This data is then processed and inverted to calculate a 1-D shear wave velocity profile.

A weighted average of the 1-D shear wave velocity profile can then be used to get an average shear wave velocity down to the maximum depth of the 1-D shear wave velocity profile. A proprietary pressure-coupled land streamer was deployed in an east-west direction with Geophones spaced 5 ft apart and the source position was located 55 feet off the western end of the transect. The source consisted of a 20 pound hammer striking a steel plate. The surface along which the land streamer was deployed was grass. The data was collected using a 24-channel Geode seismograph, manufactured by Geometrics, Inc., with 4.5 Hz geophones.

The data was processed using the KGS SurfSeis 3 software package, developed by Kansas Geologic Survey. This software is used to process and invert the surface wave data, and produces a 1-D shear wave velocity model, presented below.



The analysis yielded an average shear wave velocity (for the upper 100 ft) **V_{s100} at 1,105 ft/sec.** This value corresponded to a **Seismic Site Class 'D'**. A Site Class C correlates to the following site coefficients adjusted for site class, based on Tables 1613.3.3(1) and 1613.3.3(2) of IBC 2012:

F_a = 1.6

F_v = 2.4

The maximum considered earthquake spectral response accelerations for short periods and at 1-second periods follow:

S_{MS} = 0.289 *Equation (16-37, IBC2012)*
S_{M1} = 0.213 *Equation (16-38, IBC2012)*

This translates to the following Design Spectral Response Acceleration Parameters:

S_{DS} = 0.193 *Equation (16-39, IBC2012)*
S_{D1} = 0.142 *Equation (16-40, IBC2012)*

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Structural Fill

Staged, methodical and well planned grading is key to avoiding unnecessary costs and time delays. Areas should not be stripped or disturbed if the grading contractor is unable to properly seal the subgrade prior to departure each day. Exposure of soils to moisture from direct rainfall or runoff usually renders these soils un-usable for several days. This usually gets mischaracterized as an unsuitable soils condition which is inaccurate. Unsuitable soils are defined as those containing deleterious matter (such as organics, alluvium, debris and/or trash). Moisture problems should be avoided by employing best management practices that involve maintaining positive drainage, placing berms, diversion channels, and/or sealing the subgrade to avoid water infiltration. Other measures involve covering all stockpiled soils with heavy tarps or plastic to avoid saturating the soils in the event of rainfall. Means and methods of construction are certainly the contractor's jurisdiction; however, exposing otherwise suitable soils to excessive moisture or softening of existing subgrades as a result of unscrupulous construction traffic should be avoided and planned for.

We recommend that the following criteria be used for structural fill:

1. Adequate laboratory proctor density tests should be performed on representative samples of the proposed fill materials to provide data necessary for the quality control. The moisture content at the time of compaction should be within 3 percentage points of the optimum moisture content. In addition, we recommend that the fill soils be free of organics and relatively non-plastic with plasticity indices less than 20.

2. Suitable fill material should be placed in thin lifts (lift thickness depends on type of equipment used, but generally lifts of 8 inches loose measurements are recommended). The soils should be compacted

by mechanical means such as sheepsfoot rollers. When placing fill adjacent to an existing sloped grade, proper benching into the existing slope should be employed.

3. Any proposed slopes should incorporate only suitable fill, clean of organics or any other vegetative content. Topsoil should only be used to provide a cover over the completed slope so as to promote vegetative growth which in turn protects the slope's surface against scour and erosion. Slopes should be overbuilt and cut back to the proposed grades, exposing the firm compacted inner core. The amount of overbuilding would vary depending on the site conditions, types of soils used and degree of compaction achieved.

4. We recommend that the fill be compacted to a minimum of 95% of the Standard Proctor Maximum Dry Density (ASTM Specifications D 698). The top 2 feet under pavements or structural areas should be compacted to a minimum of 98% of the Standard Proctor Test.

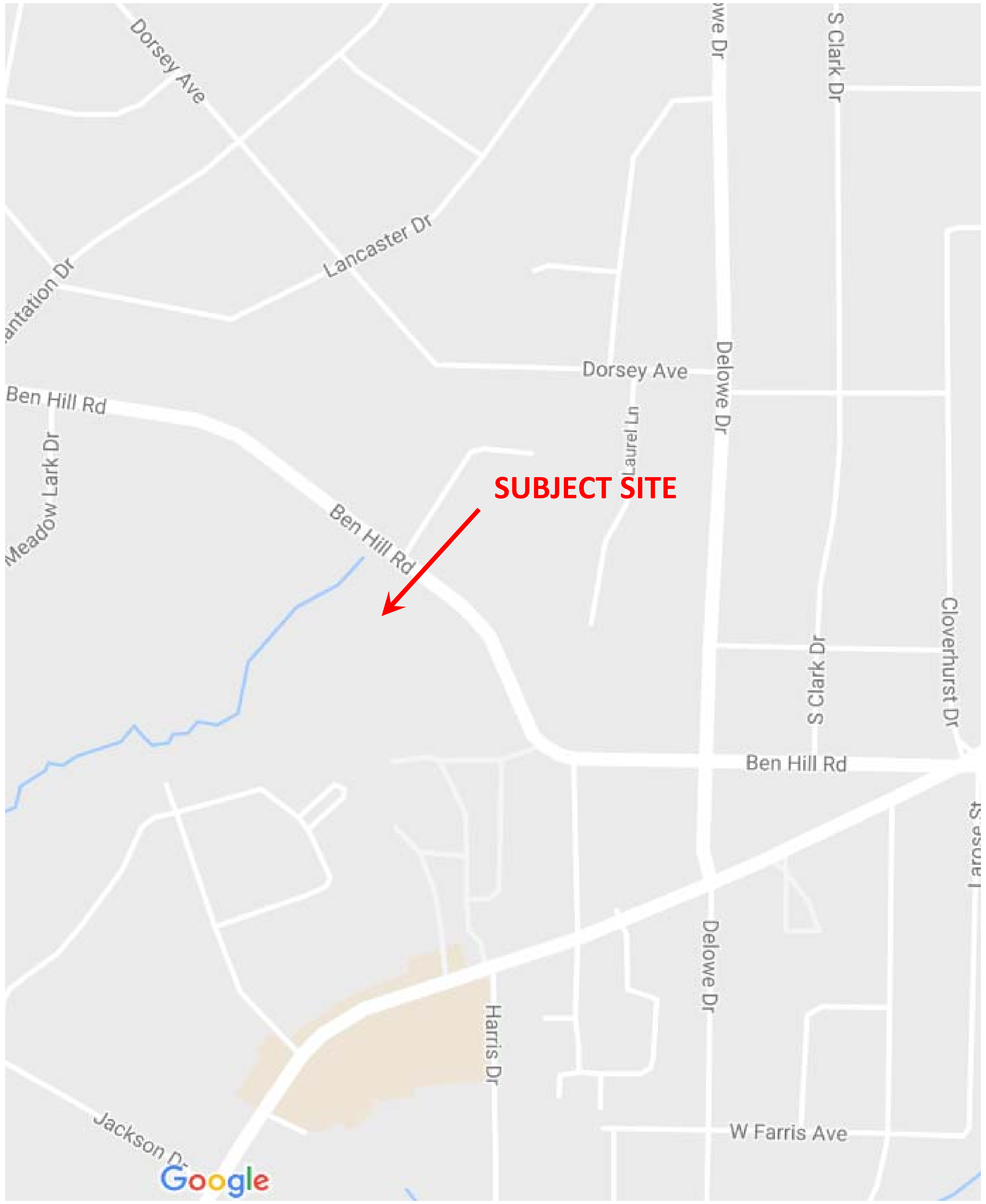
5. An experienced soil engineering inspector should take adequate density tests throughout the fill placement operation to ensure that the specified compaction is being achieved.

8.2 Construction Inspection and Testing

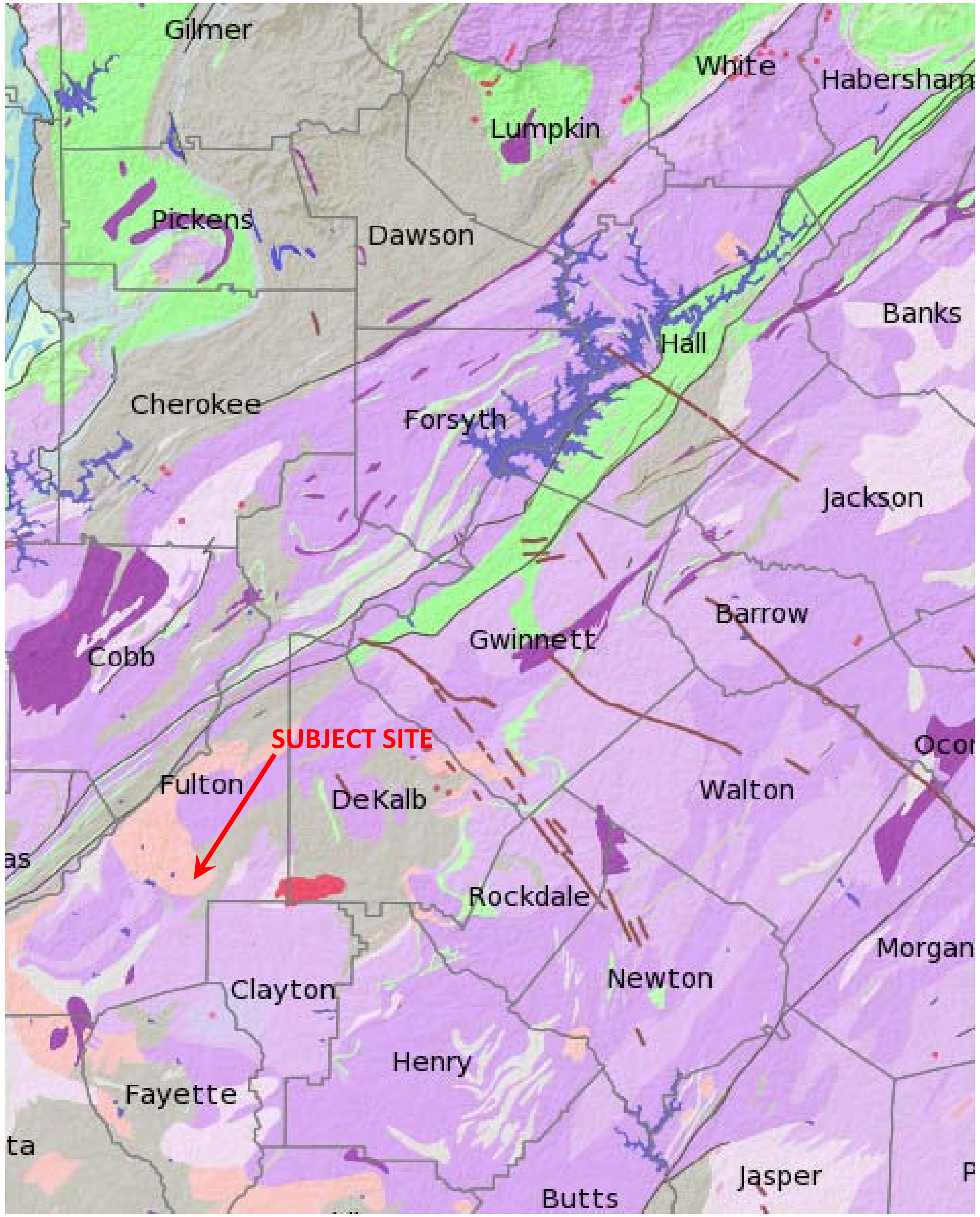
During construction, it is advisable that Matrix Engineering Group inspect the site preparation and foundation construction work in order to ensure that our recommended procedures are followed. The placement of any compacted fill should be inspected and tested. The utilization of acceptable on-site borrow materials, as well as adequate off-site selected fill must be verified.

Each footing excavation should be inspected by Matrix Engineering Group, Inc. in order to verify the availability of the required bearing pressure and to determine any special procedures required. At a minimum, Hand Auger and Dynamic Cone Penetrometer testing in accordance with ASTM STP 399 should be performed every 50 feet for wall footing or as directed by the geotechnical engineer.

APPENDIX



Site Plan



Geological Map of Georgia 1976

Reprinted 1997

Matrix Engineering Group, Inc.
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TITLE	Site Map and Geologic Map
PROJECT	East Point Fire Station #4
PROJECT NUMBER	MEG301949
CLIENT	Brown Design Group
SCALE	Not To Scale
REVIEWED	Sam Alyateem, PE
DATE	2/13/2017
FIGURE	1

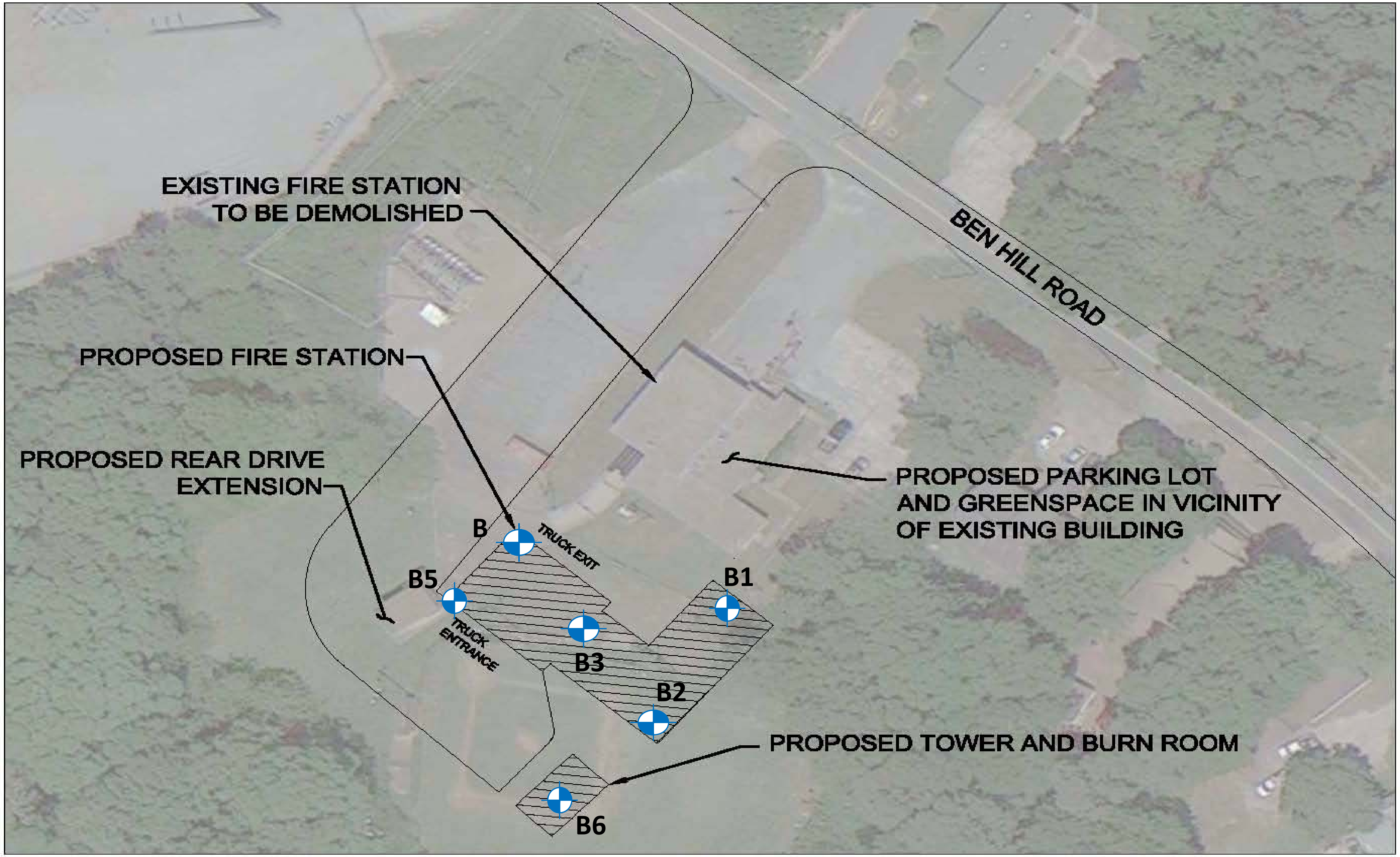
LEGEND

gr1b	PORPHYRITIC GRANITE

EXHIBIT D

PROPOSED AND EXISTING FIRE STATION NO. 4

2222 BEN HILL ROAD



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TITLE

Proposed Soil Test Boring Locations

PROJECT

East Point Fire Station #4

PROJECT NUMBER

MEG301949

CLIENT

Brown Design Group

SCALE

NTS

REVIEWED

Sam Alyateem, PE

DATE

2/10/2017

FIGURE

2

LEGEND

⊕ **B1** Soil Test Borings to 20' deep

CLASSIFICATION CHART

MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (More Than 1/2 of Soil > #200 Sieve)	**GRAVELS** (More Than 1/2 of Coarse Fraction > #4 Sieve)	GW	Well Graded Gravels or Gravel-Sand Mixtures; Little or no fines
		GP	Poorly Graded Gravels or Gravel-Sand Mixtures; Little or no fines
		GM	Silty Gravels, Gravel-Sand-Silt Mixtures
		GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS (MORE Than 1/2 of Coarse Fraction < #4 Sieve)	SW	Well Graded Sands or Gravelly Sands; Little or no fines
		SP	Poorly Graded Sands or Gravelly Sands; Little or no fines
		SM	Silty Sands, Sand-Silt Mixtures
		SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS (More Than 1/2 of Soil < #200 Sieve)	**SILTS & CLAYS** Liquid Limit Less Than 50	ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
		CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
		OL	Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS & CLAYS Liquid Limit Greater Than 50	MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts
		CH	Inorganic Clays of High Plasticity, Fat Clays
		OH	Organic Clays or Medium to High Plasticity, Organic Silty Clays, Organic Silts
HIGHLY ORGANIC SOILS		PT	Peat and Other Highly Organic Soils

Relative Density of Cohesionless Soils from Standard Penetration Test

Very Loose	≤ 4 bpf
Loose	5-10 bpf
Medium Dense	11-30 bpf
Dense	31-50 bpf
Very Dense	> 50 bpf

(bpf=blows per foot; ASTM D1586)

Consistency of Cohesive Soils

Very Soft	≤ 2 bpf
Soft	3-4 bpf
Firm	5-8 bpf
Stiff	9-15 bpf
Very Stiff	16-30 bpf
Hard	30-50 bpf
Very Hard	> 50 bpf

Relative Hardness of Rock

Very Soft	Hard rock disintegrates or easily compresses to touch; can be hard to very hard soil
Soft	May be broken with fingers
Moderately Soft	May be scratched with a nail, corners and edges may be broken with fingers
Moderately Hard	Light Blow of hammer required to break samples
Hard	Hard blow of hammer required to break sample

Particle Size Identification

Boulders	Larger than 12"
Cobbles	3"-12"
Gravel	
Coarse	3/4"-3"
Fine	4.76mm-3/4"
Sand	
Coarse	2.0-4.76 mm
Medium	0.42-2.00 mm
Fine	0.42-0.074 mm
Fines	
(Silt or Clay)	Smaller than 0.074 mm

Rock Continuity

RECOVERY (%) = $\frac{\text{Total Length of Core}}{\text{Length of Core Run}}$ x 100

Description	Core Recovery (%)
Incompetent	Less than 40
Competent	40-70
Fairly Continuous	71-90
Continnuous	91-100

Relative Quality of Rocks

RQD (%) =((Total core, counting only pieces >4" long)/(Length of Core Run)) x 100

Description	RQD (%)
Very Poor	0-25
Poor	25-50
Fair	50-75
Good	75-90
Excellent	90-100

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Correlation of Penetration Resistance with Relative Density and Consistency Sheet and Soil Classification Chart

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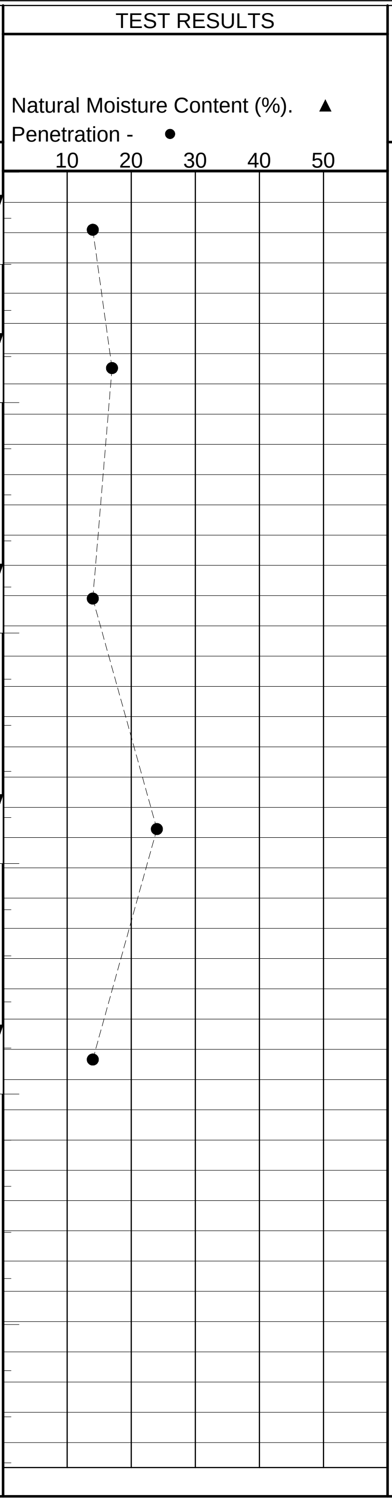
DRILL HOLE LOG

BORING NO. B1

File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ▽ ______ **After 48+ Hours:** ▼ ______ **CAVING>** C

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	SOIL SYMBOL	SAMPLERS	TEST RESULTS Natural Moisture Content (%). ▲ Penetration - ● 10 20 30 40 50	N-Value Blows/ft (ASTM D1586)
	0	Grass layer with topsoil					
	1	Possible Fill - Stiff, Red-Brown, Silty CLAY - low plasticity	FILL				14
	2						
	3						
	4	Residual - Very Stiff, Red-Brown, Clayey SILT with MnO staining	ML				17
	5						
	6						
	7						
	8						
	9	Medium Dense, Tan-Brown, Micaceous, Silty SAND - well graded	SW-SM				14
	10						
	11						
	12						
	13						
	14	Rock fragments observed					24
	15						
	16						
	17						
	18						
	19						14
	20	Boring terminated at 20 feet BGS					
	21						
	22						
	23						
	24						
	25						
	26						
	27						
	28						



This information pertains only tothis boring and should not be interpreted as being indicitive of the site.

DRILL HOLE LOG

BORING NO. B2

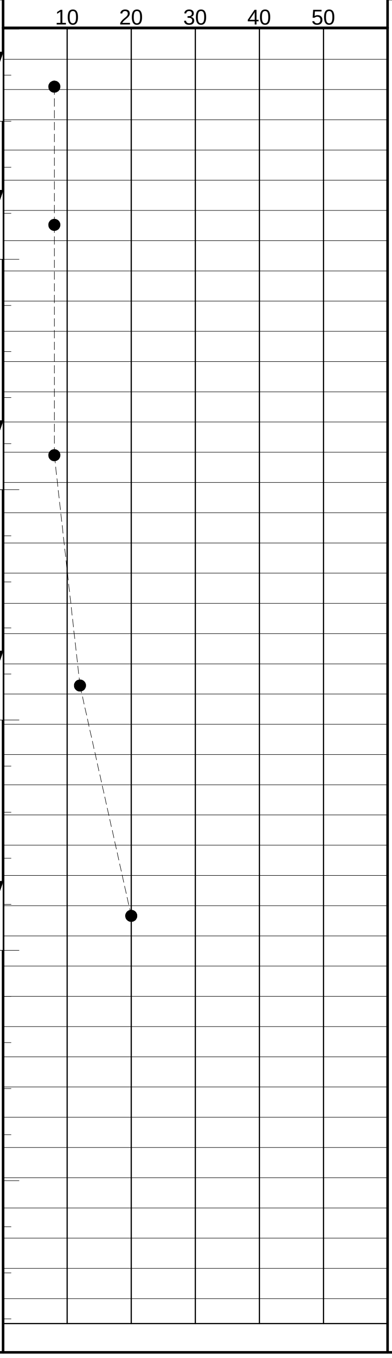
File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ∇ ______ **After 48+ Hours:** ▼ ______ **CAVING>** C

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	N-Value Blows/ft (ASTM D1586)
	0			
	1	Grass layer with topsoil Residual - Loose, Orange-Brown, Micaceous, Silty SAND - poorly graded	SP-SM	8
	2			
	3			
	4			8
	5			
	6			
	7			
	8			
	9			8
	10			
	11			
	12			
	13			
	14	Medium Dense, Tan-Brown, Micaceous, Silty SAND - well graded	SW-SM	12
	15			
	16			
	17			
	18			
	19			20
	20			
	21	Boring terminated at 20 feet BGS		
	22			
	23			
	24			
	25			
	26			
	27			
	28			

TEST RESULTS

Natural Moisture Content (%). ▲
Penetration - ●



This information pertains only tothis boring and should not be interpreted as being indicitive of the site.

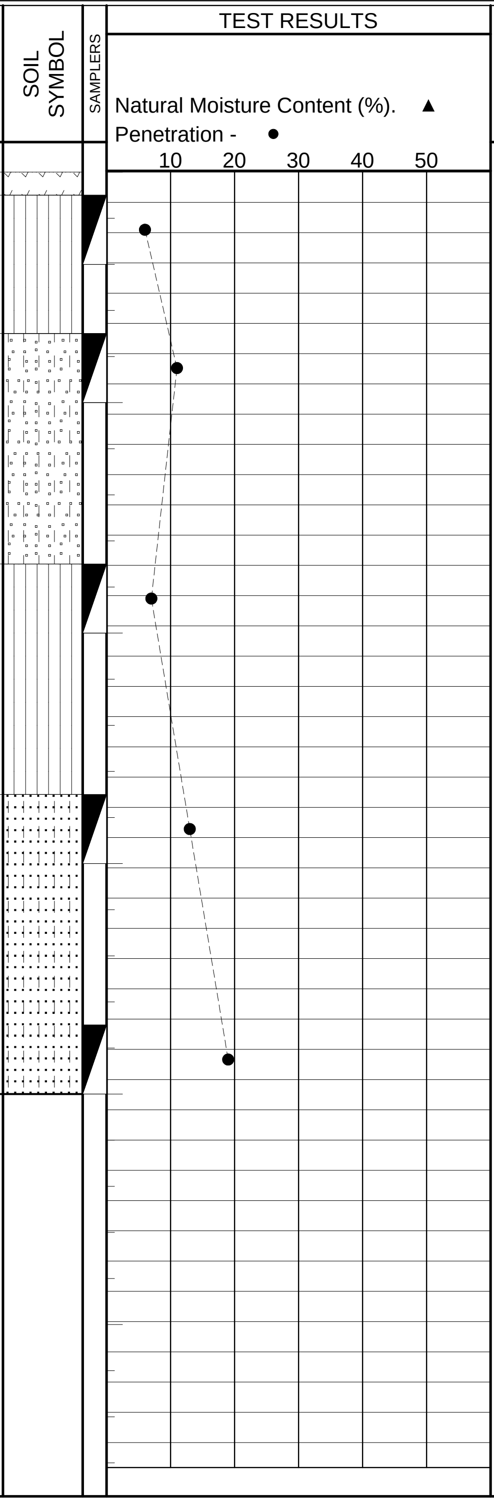
DRILL HOLE LOG

BORING NO. B3

File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ▽ ______ **After 48+ Hours:** ▼ ______ **CAVING>** C

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	N-Value Blows/ft (ASTM D1586)
	0			
	1	Grass layer with topsoil Residual - Firm, Tan-Brown, Moist, Sandy SILT	ML	6
	2			
	3			
	4	Medium Dense, Tan-Brown, Moist, Silty SAND - poorly graded	SP-SM	11
	5			
	6			
	7			
	8			
	9	Firm, Red-Tan-Brown, Moist, Sandy SILT	ML	7
	10			
	11			
	12			
	13			
	14	Medium Dense, Tan-Brown, Micaceous, Silty SAND - well graded	SW-SM	13
	15			
	16			
	17			
	18			
	19			19
	20			
	21	Boring terminated at 20 feet BGS		
	22			
	23			
	24			
	25			
	26			
	27			
	28			



This information pertains only tothis boring and should not be interpreted as being indicitive of the site.

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DRILL HOLE LOG

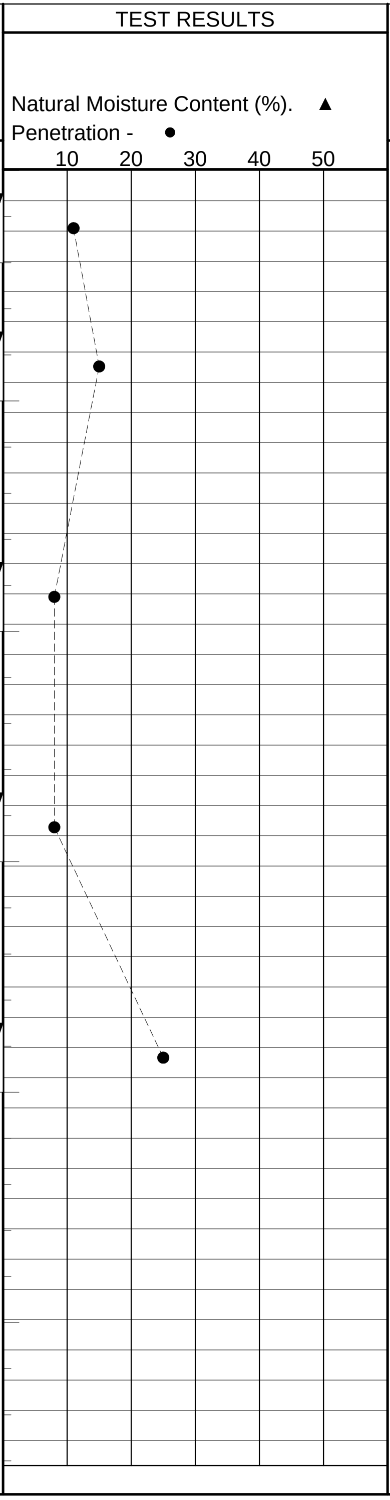
BORING NO. B4

File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ▽ **After 48+ Hours:** ▼ **CAVING>** C

This information pertains only tothis boring and should not be interpreted as being indicitive of the site.

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	N-Value Blows/ft (ASTM D1586)
	0	Grass layer with topsoil		
	1	Fill - Stiff, Red-Brown, Sandy CLAY - plastic	FILL	11
	2			
	3			
	4	Residual - Stiff, Red-Brown, Silty CLAY - plastic	CL	15
	5			
	6			
	7			
	8			
	9	Loose, Red-Brown, Micaceous, Silty SAND - poorly graded	SP-SM	8
	10			
	11			
	12			
	13			
	14			8
	15			
	16			
	17			
	18			
	19	Medium Dense, Olive Gray, Micaceous, Silty Coarse to Fine SAND - well graded	SW-SM	25
	20	Boring terminated at 20 feet BGS		
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			



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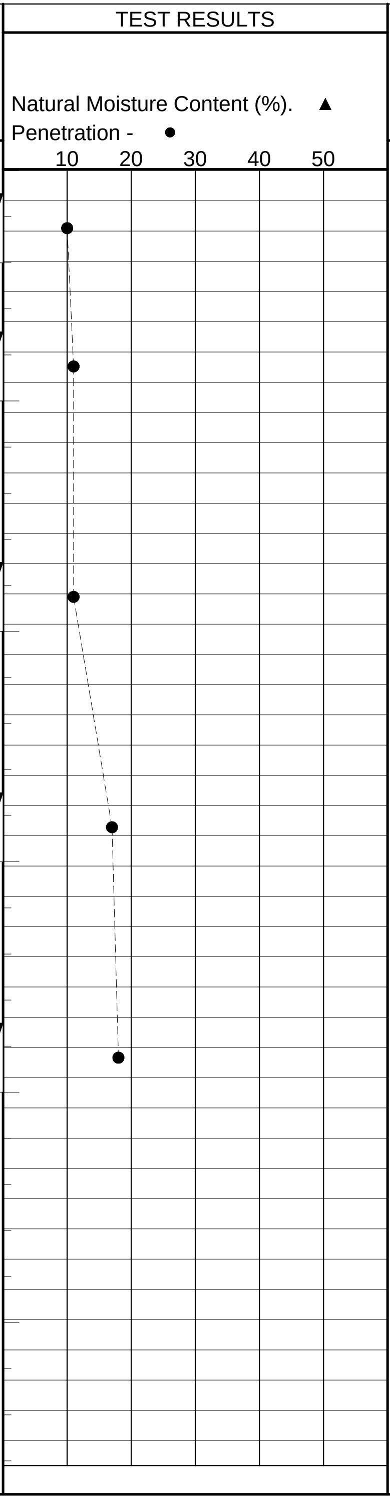
DRILL HOLE LOG

BORING NO. B5

File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ▽ ______ **After 48+ Hours:** ▼ ______ **CAVING>** C

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	N-Value Blows/ft (ASTM D1586)
	0	Grass layer with topsoil		
	1	Possible Fill - Stiff, Red-Brown, Silty CLAY - plastic	FILL	10
	2			
	3			
	4	Residual - Stiff, Red-Brown, Sandy SILT	ML	11
	5			
	6			
	7			
	8			
	9	Medium Dense, Olive Gray, Micaceous, Silty SAND - poorly graded	SP-SM	11
	10			
	11			
	12			
	13			
	14			17
	15			
	16			
	17			
	18			
	19			18
	20			
	21	Boring terminated at 20 feet BGS		
	22			
	23			
	24			
	25			
	26			
	27			
	28			



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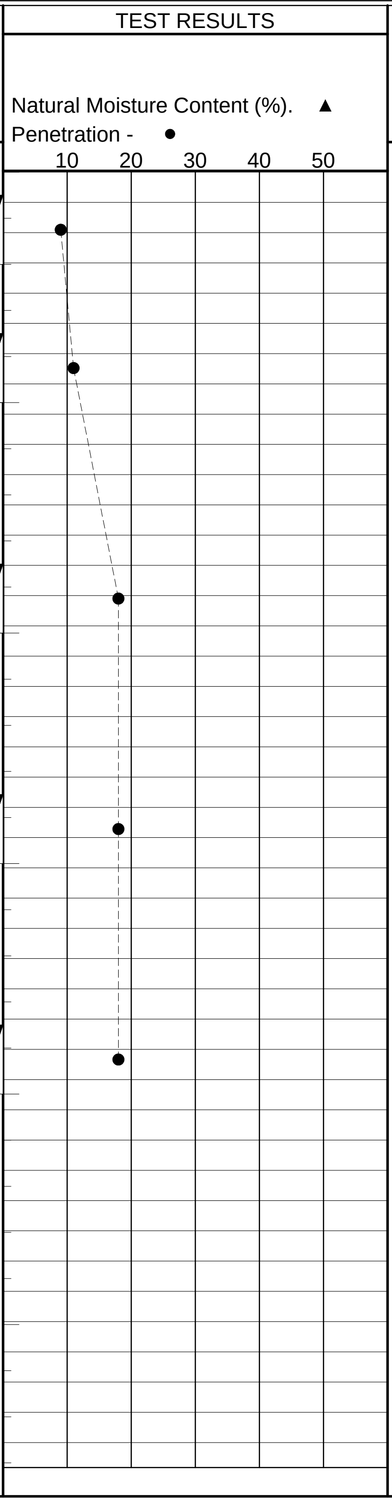
DRILL HOLE LOG

BORING NO. B6

File: Boring Logs
Date Printed: 2/14/2017

PROJECT: East Point Fire Station Number 4
PROJECT NO.: MEG301949
CLIENT: Brown Design Group
DATE: 2/8/17
LOCATION: Refer to Figure 1
ELEVATION:
DRILLER: Kilman Brothers
LOGGED BY: JC Toriz
DRILLING METHOD: ASTM D1586 with Automatic Hammer
STATION:
DEPTH TO - WATER> INITIAL: ▽ ______ **After 48+ Hours:** ▼ ______ **CAVING>** C

ELEVATION (feet)	DEPTH (feet)	Description	SOIL TYPE	N-Value Blows/ft (ASTM D1586)
	0	Grass layer with topsoil		
	1	Residual - Loose, Orange-Brown, Silty SAND - poorly graded	SP-SM	9
	2			
	3			
	4	Stiff, Red-Brown, Sandy SILT	ML	11
	5			
	6			
	7			
	8			
	9	Medium Dense, Olive Gray, Micaceous, Silty SAND - poorly graded	SP-SM	18
	10			
	11			
	12			
	13			
	14			18
	15			
	16			
	17			
	18			
	19			18
	20			
	21	Boring terminated at 20 feet BGS		
	22			
	23			
	24			
	25			
	26			
	27			
	28			



This information pertains only tothis boring and should not be interpreted as being indicitive of the site.