REPORT OF

**SUBSURFACE EXPLORATION
AND GEOTECHNICAL ENGINEERING ANALYSIS**

**VAMC RICHMOND CANCER CLINIC ADDITION
CITY OF RICHMOND, VIRGINIA
ECS PROJECT NO. 03:12393**

FOR

**MR. JASON SMITH, P.E.
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155 CLARKESVILLE STREET
P.O. BOX 331
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December 7, 2016

December 7, 2016

Mr. Jason Smith, P.E.
J.M. Smith Engineering, LLC
155 Clarkesville Street
P.O. Box 331
Cornelia, Georgia 30531

ECS Project No. 03:12393

Reference: Report of Subsurface Exploration and Geotechnical Engineering Analysis
VAMC Richmond Cancer Clinic Addition
City of Richmond, Virginia

Dear Mr. Smith,

ECS Mid-Atlantic, LLC (ECS) has completed this report of subsurface exploration and geotechnical engineering analysis for the referenced project. This study has been completed in accordance with our proposal No. 03:13050-GP-R1 dated 09/23/16 and authorized by you on 09/26/16.

We have enjoyed being of service to you during the design phase of this project. If you should have any questions regarding the information and recommendations contained in the accompanying report, or if we can be of further assistance, please do not hesitate to contact us.

Respectfully,

ECS Mid-Atlantic, LLC

COMMONWEALTH OF VIRGINIA
ROBERT C. MOSS, III
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REPORT

Subsurface Exploration and
Geotechnical Engineering Analysis

PROJECT

VAMC Richmond Cancer Clinic Addition
City of Richmond, Virginia

PREPARED FOR

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ECS PROJECT NO.

03:12393

DATE

December 7, 2016

SUBSURFACE EXPLORATION AND
GEOTECHNICAL ENGINEERING ANALYSIS

VAMC RICHMOND CANCER CLINIC ADDITION
CITY OF RICHMOND, VIRGINIA
ECS MID-ATLANTIC, LLC PROJECT NO. 03:12393

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1.0 PROJECT OVERVIEW

1.1 Purposes of Exploration

The purpose of this exploration was to investigate the soil and groundwater conditions at the site to develop geotechnical engineering recommendations to guide design of the addition's foundations, floor slabs, and building retaining walls and to develop earthwork specifications for the project. We accomplished these purposes by drilling soil test borings, completing laboratory testing on select samples, and analyzing the soil samples to evaluate pertinent engineering properties. On this basis we developed our geotechnical engineering recommendations. No warranties are expressed or implied.

1.2 Scope of Work

To complete this investigation, ECS Mid-Atlantic, LLC (ECS) discussed general project characteristics with you and received and reviewed a drawing entitled *Option 4 – Courtyard B* (undated) depicting proposed boring locations. We have also reviewed the Scope of Work Geotechnical Report prepared by Miller-Remick LLC. We also received a document entitled *Revised Scope of Work for Excavate/Relocate Unforeseen Sanitary Pipes* depicting the approximate locations of untraceable utilities in the project area.

The conclusions and recommendations contained in this report are based upon a total of three (3) soil test borings drilled to a depth of 25 feet below the existing grades and boring data obtained from the Linear Accelerator Addition geotech report prepared by Froehling & Robertson, Inc. on January 5, 2015; a site reconnaissance performed by ECS personnel; and laboratory test results of select borings. The borings were located in the field by ECS personnel utilizing the drawings referenced and measuring from existing site features. No investigation for the presence of contamination of the soil, water, or air at or around this site was performed as part of this study.

The recommendations contained herein were developed from the data obtained in the soil borings, which indicate subsurface conditions at these specific locations at the time of the field exploration. Conditions may vary between borings. If during the course of construction variations appear evident, the Geotechnical Engineer should be informed so that the conditions can be addressed. Design recommendations were developed based on building and site design criteria considered typical for this type of facility. Should structural loading or other project characteristics differ from those discussed herein, this company should be informed such that a review of these conditions can be performed.

1.3 Project Characteristics

The project will include the following aspects relative to our scope of services:

- The new addition will be one-story in height and of steel frame and masonry bearing wall construction containing 17,500 square feet. First level floors will be supported as a slab-on-grade. It is anticipated that the foundation will support maximum wall and column loads of 3 kips/foot and 120 kips, respectively. Maximum floor slab loads are anticipated to be 200 psf.

- It is anticipated that maximum cuts and fills of 2 or 3 feet will be required to establish finished grade. The finished floor elevation for the addition will match that of the adjacent areas of the existing building.
- No investigation for site retaining walls, pavements, or stormwater management facilities is included with this report.

2.0 EXPLORATION PROCEDURES

2.1 Subsurface Exploration Procedures

A total of three (3) soil test borings were performed with a truck-mounted auger drill rig that utilized continuous-flight, hollow-stem augers to advance the boreholes. Drilling fluid was not used in this process. The borings were extended to a depth of 25 feet below existing surface elevations. Drilling services were provided by Scott Drilling Services, LLC of Richmond, Virginia. The approximate boring locations are indicated on the Boring Location Diagram included as Appendix II.

Representative soil samples were obtained by means of the split-barrel sampling procedure in accordance with ASTM Specification D-1586. In this procedure, a 2-inch O.D., split-barrel sampler is driven into the soil a distance of 24 inches by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler through the middle 12-inch interval is termed the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring logs. This value can be used as a qualitative indication of the in-place relative density of cohesionless soils and, in a less reliable way, the relative consistency of cohesive soils. These indications are qualitative, since many factors such as drill crews, drill rigs, drilling procedures, and hammer-rod-sampler assemblies can affect the Standard Penetration resistance value and prevent a direct correlation between blow counts and strength and compressibility of soils. Samples were taken continuously to a 10-foot depth and at 5-foot intervals thereafter.

A field log of the soils encountered in the borings was maintained by the drill crew. After recovery, each sample was removed from the sampler and visually classified. Representative portions of each sample were then sealed in glass jars and taken to our laboratory for further visual examination and laboratory testing.

The group symbols for each soil type are indicated in parentheses following the soil descriptions on the soil test boring logs included as Appendix II. The Geotechnical Engineer grouped the various soil types into the major zones noted on the boring logs. The stratification lines designating the interfaces between earth materials on the boring logs are approximate;

in-situ, the transitions may be gradual. A reference to the boring logs is included in Appendix III.

2.2 Laboratory Testing Program

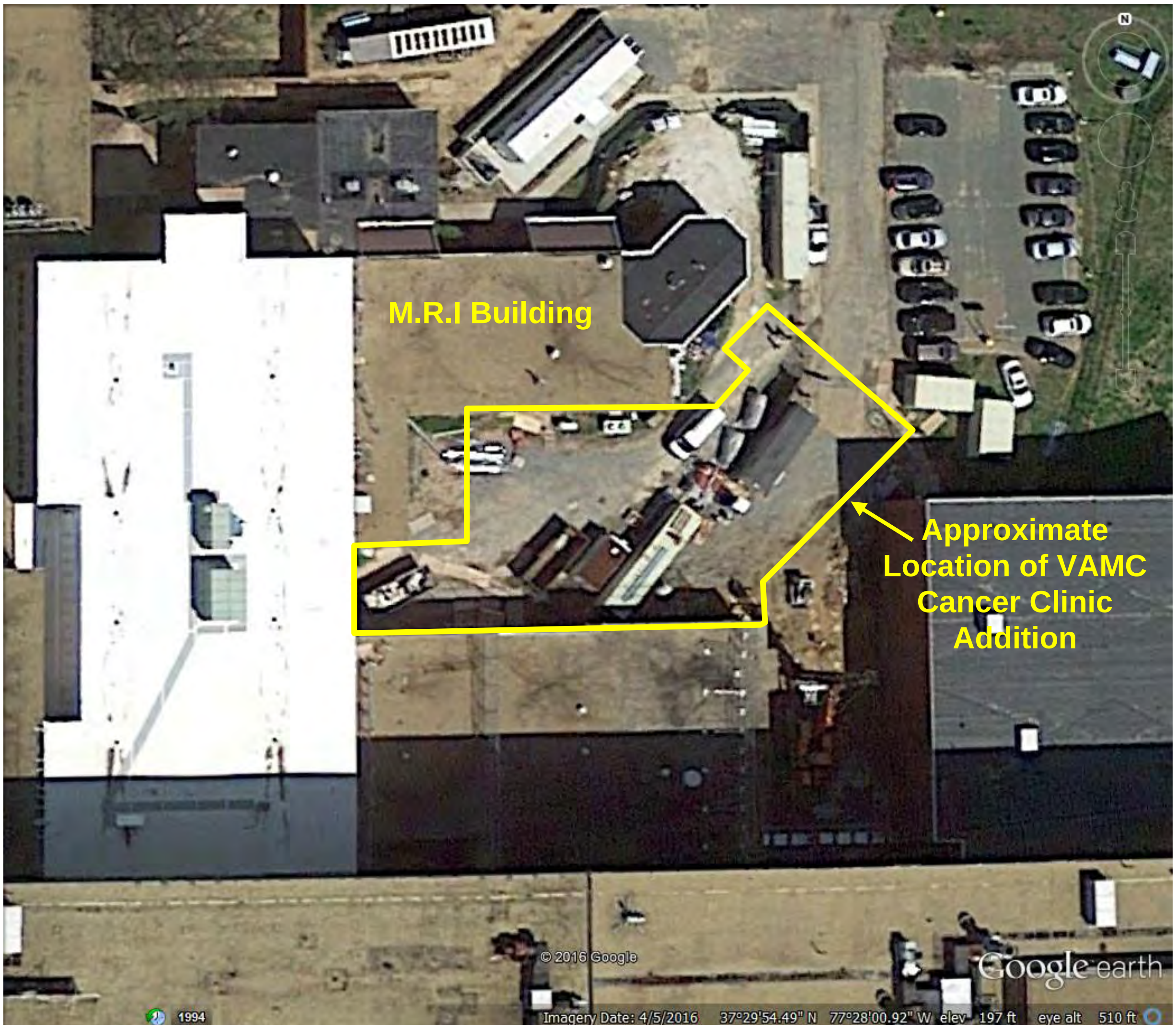
An Engineering Geologist visually classified each soil sample from the test borings on the basis of texture and plasticity in accordance with the USCS and ASTM D2488 (Description and Identification of Soils-Visual/Manual Procedures). Representative soil samples from the test borings were subjected to moisture content, gradation (percent passing #200 sieve), and Atterberg Limits tests to aid in ascertaining pertinent engineering properties.

The results from this testing were used to substantiate the visual classifications and to evaluate the soil's pertinent engineering characteristics. The results of all the laboratory testing are included in the summary sheet in Appendix IV of this report. The soil samples will be retained in our laboratory for a period of 60 days, after which they will be discarded unless other instructions are received as to their disposition.

3.0 EXPLORATION RESULTS

3.1 Site Description

The project site is located in the rear (north) side of the Hunter Holmes McGuire VA Medical Center at 1201 Broad Rock Boulevard in the City of Richmond, Virginia. The addition will be located between the existing Linear Accelerator and M.R.I. buildings. At the time of our visit, it appeared the site had been disturbed by grading and utility installation, and aggregate material was spread across the surface in some areas. Small areas vegetated with grass were present in portions of the site. Much of the proposed addition area was occupied by storage containers, trailers, and construction materials. Based on information available in the *Revised Scope of Work for excavate/Relocate Unforeseen Sanitary Pipe* document and our site visit with Accumark (utility locator service), untraceable sanitary lines and storm sewer pipes are present within the addition footprint at depths of up to 14 feet. The site was relatively flat with a few feet change in elevation across the building footprint. Further Detail can be found on the following image courtesy of Google Earth.



3.2 Subsurface Conditions

Soil Stratification

The soil test borings encountered surface cover consisting of organic topsoil material and gravel material. Gravel thickness was measured to be between 1 and 8 inches while topsoil was measured to be 6 inches. Topsoil was only encountered in boring B-2. Underlying the surface cover, the subsurface materials encountered to a depth of 25 feet were generally arranged in a two layer configuration as follows:

Stratum I (Surface to 16.5'] FILL: All of the borings, encountered undocumented FILL to a depth of approximately 16.5 feet below existing grades. The cohesive FILL was generally comprised of brown, red, orange, and gray, Sandy Lean CLAY (CL) containing variable amounts of rock, brick, asphalt fragments, roots, and gravel. The granular FILL was generally comprised of orange, red, brown, and gray, Clayey SAND (SC) containing rock and brick fragments. The FILL is considered undocumented, in that no form of placement quality control is known to exist. Standard Penetration Test Results (N-values) recorded in the cohesive FILL soils ranged from 5 to 51 blows per foot (bpf) indicating medium stiff to hard consistencies. The high N-values recorded in the upper 2 feet of the soil profile are indicative of the surficial gravel and do not accurately represent the underlying soils. The N-value recorded in the granular FILL soil was 7 bpf indicating loose relative density.

Stratum II (from 16.5’ to boring termination at 25 feet): Underlying the FILL, undisturbed soils were comprised predominantly of orange, brown, and tan to mottled orange, red, and gray Sandy Lean CLAY (CL). N-values recorded in the cohesive clays ranged from 12 to 28 bpf indicating stiff to very stiff consistencies.

Groundwater

Observations for groundwater were made during sampling and upon completion of the drilling operations at each boring location. In auger drilling operations, water is not introduced into the boreholes, and the groundwater position can often be determined by observing water flowing into or out of the boreholes. Furthermore, visual observation of the soil samples recovered during the auger drilling exploration can often be used in evaluating the groundwater conditions.

A static groundwater table was not encountered within the maximum explored depth of 25 feet in any of the soil test borings. The groundwater table is estimated to be between about 25 feet and 35 feet, based on previous experience at the site. It is possible that shallow perched water may be encountered within the upper 4 to 10 feet within stiffer clay FILL.

The location of the groundwater table can vary as a result of seasonal fluctuation in precipitation, evaporation, surface water runoff, local topography, and other factors not immediately apparent at the time of exploration. Normally, the highest groundwater levels occur in the late winter and spring and the lowest levels occur in the late summer and fall. We recommend that the contractor evaluate groundwater conditions prior to construction to determine their impact on the project.

Soil Survey

A review of the USDA / NRCS web soil survey indicates the shallower soils on this site are of the Udorthents-Dumps complex. The USDA / NRCS do not describe the Udorthents-Dumps complex or characterize its expansive (shrink-swell) potential. Based on our visual classification of the soils encountered and the laboratory test results, the cohesive Clays (CL) over which floor slabs will bear have a low shrink-swell potential. The subsurface conditions are described in more detail on the boring logs included in Appendix III.

4.0 ANALYSIS AND RECOMMENDATIONS

General

The site contains as much as 16 feet and possibly more of undocumented FILL. This FILL is considered undocumented in that no documentation of quality control during placement is known to exist. Furthermore, we understand the area once contained deep utilities with associated backfill. Therefore, existing FILL is considered unsuitable for support of spread footing foundations. Considering the substantial depth of this FILL, excavation and replacement from below footings is not considered practical. Therefore, we recommend that the building frame be supported by a deep foundation system (piles). Any heavily loaded slab areas, such as support equipment or interior bearing walls, should be designed independent of the floor slab and should be pile supported. Given the proximity of adjacent existing structures which may be sensitive to vibrations from driven pile foundation installation, and considering space limitations for staging of driven piles, an auger cast-in-place (ACIP) pile foundation system is considered appropriate for this project. Relatively lightly loaded floor slabs can be supported as a slab-on-grade over approved existing FILL material. It should be noted that any ancillary structures (stoops, pads, deck piers, etc.) supported by existing FILL materials may be subject to long-term settlement over time due to FILL consolidation. If this is not acceptable, these should be pile supported.

4.1 ACIP Pile Design

1. **ACIP Pile Compressive Capacity:** Submitted in Table 1 below are design capacities for 12-inch ACIP piles. The capacities are based on a minimum pile penetration of 25 feet below an existing ground surface elevation of EL. 197 feet. This minimum pile length is recommended to penetrate existing FILL soils into the natural bearing strata. Based on the existing grade of the proposed addition in relation to adjacent building structures, it is anticipated that cuts or fill of less than 2 to 3 feet would be required to grade the site and establish the design finished floor elevation. If required, ECS can provide higher capacities for larger diameter piles and deeper pile embedment. Pile installation and capacity should be evaluated by installing indicator piles and performing a pile load test prior to installation of production piles.

Table 4.1-1: ACIP Pile Capacities

Pile Type	Pile Length (feet)	Pile Tip Elevation Based on a Surface Elevation of EL. 197 Feet	Allowable Compressive Capacity (tons)	Allowable Uplift Capacity (tons)
12-inch ACIP	25	172	25	10

2. **Minimum Tip Embedment:** The ACIP pile design is based on a minim penetration of 25 feet below a surface elevation of EL. 197 feet but assumes a minimum penetration of 5 feet into stiff Clays encountered below depth of about 20 feet. The depth to the bearing strata will vary across the site.

3. **Lateral Capacity:** The piles can be designed for an allowable lateral capacity of 1.5 tons/pile, based on 0.5 inches of deflection. Passive soil resistance against pile caps can be considered based on a Coefficient of Passive Earth Pressure of 1.8, based on a cap deflection of 0.5 inches.

4. **Pile Spacing:** Piles should be designed with a minimum on-center spacing of 3 pile diameters.

5. **Pile Settlement:** Immediate ACIP pile settlements are anticipated to be less than 0.5 inch; that is, pile movement required to mobilize soil resistance (up to about 0.25 inches) plus pile shortening resulting from longitudinal elastic compression. These settlements will occur more or less immediately upon application of the service loads. Long term settlements are estimated to result in less than 1.0 inch of pile cap displacement.

6. **Seismic Site Class:** The Seismic Site Class, based on International Building Code guidelines, was determined for the site. The Seismic Site Class for the proposed building was determined from soil boring N-Value data and our experience in similar subsurface profiles where seismic site testing has been performed. Based on Section 1615 of the International Building Code and our local experience, the project site has a Seismic Site Class of D.

7. **Grout Material:** The grout used shall consist of a mixture of Portland Cement, fluidifier, retarder, fine aggregate and water so proportioned and mixed as to produce a grout mix capable of being pumped. The pile grout shall have a minimum 28-day compressive strength of 5,000 psi. Mixing time after adding the fluidifier at the site should be no less than 3 minutes. The grout shall be mixed in accordance with the applicable requirements of ASTM C94.

4.2 ACIP Pile Installation:

1. **Grout Injection:**

   The contractor shall provide the inspecting engineer with the calibrated pump rate (in cubic feet per stroke) for the grout injection system so that grout volumes can be tracked, per pile. It is critical that a sufficient volume of grout be continuously pumped at sufficient pressure to prevent suction from developing as the augers are withdrawn. Such suction can cause the soil to mix with the grout, the bearing soils to be disturbed, and the drilled hole to collapse. A pressure head of at least 10 feet of grout above the injection point shall be maintained at all times during auger pulls so that the grout has a displacing action and resists the movement of loose material into the hole. The auger withdrawal rate shall be steady and not exceed 10 feet per minute. Modification to the pumping and withdrawal rates may need to be made or re-drilling of the pile performed should grout head loss occur. Improper grout injection and auger withdrawal techniques often result in a reduction in the capacity of the pile. Therefore, the use of proper construction procedures is extremely important.

The piles shall be installed by the rotation of the continuous flight auger into the ground to the tip elevation as outlined in this report. Once the tip elevation has been attained, a slow positive rotation shall be maintained and the auger initially withdrawn 0.5 ft to 1 ft. Grout shall then be pumped through the auger tip until a minimum grout head of 10 ft is achieved. This will be estimated based on the pump calibration performed prior to pile installation. The auger shall then be advanced back to the tip elevation and steadily withdrawn in a continuous operation while grout is being injected without interruption. The rate of auger withdrawal and that of grout injection shall be coordinated such that the amount of grout pumped per foot of pile during auger retrieval is at least 115% of the theoretical volume per foot of pile. A positive grout pressure head above the tip of the auger shall be maintained at all times as verified by the return of slurry/grout from around the auger flights. If the auger jumps during withdrawal, if the pump skips a stroke, or if there is a break in the slurry/grout return as observed from the top of the augered shaft, the auger shall be lowered a minimum of 5 feet below the depth of questionable area and the pile regrouted. The rate of auger withdrawal shall not be increased once grout return is observed at the ground surface. If the auger is withdrawn too rapidly, suction within the pile shaft could occur, exacerbating the potential for pile necking. If the minimum 115% grout volume is not achieved, the pile shall be redrilled and regrouted at the affected depths.

Installed piles shall be periodically checked by the Contractor to determine if the grout in the piles has settled. If the grout level drops more than about 1 ft, the top of the pile shall be purged and fresh grout shall be added to the top of the pile prior to the grout reaching its initial set.

A minimum grout set time of 12 hours shall be allowed before any adjacent piles are installed unless otherwise directed by the Geotechnical Engineer. No piles closer than 8 ft center to center shall be installed the same day. If grout loss is experienced in a completed pile while drilling an adjacent pile, the construction of the adjacent pile shall be ceased and the completed pile shall be redrilled and regrouted. The adjacent pile shall not be installed until the next day.

2. **Grout Evaluation:**

The Contractor shall not use any grout older than the maximum time specified by the supplier. If the pre-approved maximum time limit is in excess of 120 minutes, the supplier shall provide adequate documentation that the grout does not become detrimentally affected beyond this general local industry accepted standard time limit. The Contractor shall coordinate the grout delivery to meet the above requirement and to assure continuity of the work.

The viscosity of the grout should be controlled with a grout cone. This will reduce the variability of the grout and result in a more uniform compressive strength. It is recommended that the flow cone requirement be specified as a range rather than as a single value.

The grout shall be sampled and tested by an independent Testing Laboratory retained by the Owner. During indicator and test pile installation, sampling and casting of a set of six 2-inch cubes shall be made from each truck of grout delivered to the site. During production pile installation, sampling and casting of a set of six 2-inch cubes shall be made for every 50 cubic yards of grout delivered to the site and no less than once per day. Grout cubes shall be made and tested in accordance with ASTM C31, C109, and C469. The test results shall be submitted to the Owner, the Structural Engineer, and the Geotechnical Engineer for review within 3 days of completion of the testing.

3. **Reinforcing:**

   The piles shall have reinforcing steel cages as shown on the Structural Plans. Additionally, the steel cages should have #3 bars spacers, or pre-approved equal, so as to maintain the cages centered within the pile shaft. The spacers should be located at the tip and the top of the cages, with additional spacers located not more than 15 ft on-center for the full embedded length of the pile. The spacers should be attached so as to prevent bending prior to placement in the pile shaft, and should be approved by the Geotechnical Engineer prior to use. The size of the spacers should be such that a minimum 3-inch grout cover inside the pile shaft is maintained.

   Immediately upon completion of the grouting operation of each pile, the specified reinforcement shall be installed. Care shall be taken not to contaminate the pile grout with soil or other foreign material during reinforcing steel cage installation. The steel cages shall be maintained at the center of the grout-filled augered pile shaft at all times. If difficulty is encountered during installation of the reinforcement, the pile shall be redrilled and regrouted. If problems are still encountered, then the shaft shall be filled with grout and abandoned, and alternate pile location(s) shall be determined by the Structural Engineer.

4. **Obstructions:** The site contains as much as 16 feet and possibly more of undocumented FILL. Obstructions could potentially be encountered within this FILL. The contractor should be prepared to remove any obstructions which interfere with pile installation. Where this is done by excavation, the soil material replaced in the excavation shall be suitable material, moisture conditioned to within +/-3% of the soil's optimum moisture content, placed in

maximum 8-inch loose lifts, and mechanically compacted to a dry density of at least 95% of the soil's Standard Proctor maximum dry density (ASTM D698).

5. **Indicator Piles and Load Testing:** At least two (2) indicator piles should be installed to the design tip elevation to evaluate installation procedures for the auger cast in place piles. These should be installed in the immediate vicinity of borings B-1 and B-2. At least one (1) pile should be statically load tested under the observation of the Geotechnical Engineer to determine adequate capacity. The indicator piles should be installed prior to installation of the production piles at permanent pile locations. If the test pile "fails" during the load test, it will have to be abandoned in place and replaced with additional pile(s). Alternatively, the test piles can be considered sacrificial and installed at non-permanent locations. The purpose of the test pile program is to determine/confirm the production pile tip elevations (pile lengths), confirm our assumption of pile capacity (which is related to our design safety factor), to allow observation of the subsurface conditions encountered by the augers, and to provide the drilling contractor with an opportunity to determine the equipment required to efficiently achieve the design tip elevations. The load test should be performed in accordance with ASTM D 1143, Section 8.1.2 Procedure A: Quick Load Test.

6. **Pile Installation Monitoring:** The Geotechnical Engineer should observe the installation of the all piles. The purpose of the Geotechnical Engineer's observations is to ascertain that installation is being performed in accordance with the previously described criteria. Continuous installation records should be maintained for all piles. The field duties of the Geotechnical Engineer (or their representative) should include the following:

    a. Be knowledgeable of the subsurface conditions at the site and the project-specific criteria.

    b. Be aware of aspects of the installation including type of pile equipment and pile installation tolerances.

    c. Keep an accurate record of pile installation and procedures.

    d. Document that the piles are installed to the proper depth indicative of the intended bearing stratum.

    e. Perform flow cone testing to insure specification requirements are met.

    f. Generally confirming that the pile installation equipment is operating as anticipated.

    g. Mold grout compressive strength test specimens.

    h. Informing the contractor and Geotechnical Engineer of any unusual subsurface conditions.

i. Notifying the contractor and Structural Engineer when unanticipated difficulties or conditions are encountered.

j. Document quantity of grout pumped into each pile hole.

4.3 Floor Slab Design

1. **Floor Slab Support:** The relatively lightly loaded floor slabs can be supported as a slab-on-grade bearing on existing FILL that is observed by the Geotechnical Engineer to be stable at the time of slab placement. Any heavily loaded slab areas, such as support equipment or interior bearing walls, should be pile supported.

2. **Underslab Moisture Protection:** A minimum of a 4-inch thick layer of VDOT Size No. 57 Stone will serve as a capillary break to help reduce the rise of water to the bottom of the slab (capillary action). A polyethylene vapor barrier should be employed on top of the Aggregate Base Material in heated areas to provide additional moisture protection.

3. **Subgrade Modulus:** Provided the placement of Engineered Fill and Aggregate Base material is per the recommendations discussed herein, the floor slab may be designed assuming a Modulus of Subgrade Reaction, K_S, of 150 psi per inch.

4. **Slab Subgrade Preparation:** For the design and construction of all slabs-on-grade for the proposed building, all topsoil or other deleterious material, debris, and soft or unstable subgrade should be removed from within the 2-foot expanded slab limits. The Geotechnical Engineer should be called on to observe exposed subgrades to assure that adequate subgrade preparation has been achieved. A proofroll using a drum roller or loaded dump truck should be performed in their presence at that time. Any FILL or subgrade soils determined to be unstable during proofrolling operations should be removed and replaced with Engineered Fill. Once subgrades have been approved, subgrades should be properly compacted and new Engineered Fill can be placed. Existing subgrades to a depth of at least 10 inches and all Engineered Fill should be moisture conditioned to within +/- 3 percentage points of optimum moisture content then be compacted to a dry density at least 95% of that soil's Standard Proctor maximum dry density (ASTM D698).

4.4 Rigid Retaining Wall Design

1. **General:** It is anticipated that building foundation walls may act as rigid retaining walls supported by pile-supported grade beams.

2. **Wall Design Parameters:** Retaining walls should be designed to withstand the lateral earth pressures exerted upon them. For rigid walls restrained from rotation, the "At Rest" soil condition should be used in the wall design and evaluation. In the design of rigid retaining walls, the following soil parameters can be utilized. These parameters assume granular soils or gravel satisfying the requirements of Section 4.6.7 for Retaining Wall Backfill will comprise the wall backfill. In this regard, Clay and Silt should **not** be used as backfill in the Backfill Zone extending the wall height behind the wall.

Table 4.4-1 Retaining Wall Design Parameters

Coefficient of Earth Pressure at Rest (K_o)[1]:	0.45
Retained Soil Moist Unit Weight (δ)[1]:	125 pcf
Cohesion (C)[1]:	0 psf
Angle of Internal Friction (ø)[1]:	30^o
Coefficient of Passive Earth Pressure (K_p)[2]:	2.5
Restraining Soil Moist Unit Weight (δ’)[2]:	120 psf
Friction Coefficient [Concrete on Soil] (μ)[2]:	0.3

Note 1: Granular Retaining Wall Backfill
Note 2: Existing Subgrades

It is noted that increased lateral pressures generated by surcharge loads should be considered in the design.

3. **Backfill Zone:** The Backfill Zone is considered that zone directly behind rigid retaining walls extending a horizontal distance equal to the wall height behind the wall. Backfill used within the Backfill Zone must satisfy the requirements for Retaining Wall Backfill defined in Section 4.6.7 of this report. In this regard, on-site excavated Clays and Silts are **not** suitable for use as backfill in the Backfill Zone.

4. **Retaining Wall Drainage:** Retaining walls should be provided with foundation and wall drains to remove excess moisture from the wall backfill. This drainage system may consist of drain lines located above the retaining wall footings which discharge to a suitable outlet. These drain lines should consist of perforated pipe surrounded by a minimum of 6 inches of free-draining granular filter or by No. 57 Stone wrapped in filter fabric. A suitable wall drain product should be employed on the back face of the retaining walls. Examples of suitable wall drain materials include Enka Mat, Mira Drain, or Geotec Drains. The material should be placed in accordance with the manufacturer’s recommendations and should be hydraulically connected to the foundation drainage system, which in turn should be properly drained.

5. **Retaining Wall Backfill Compaction:** The fill placed adjacent to rigid retaining walls should not be over-compacted. Backfill compacted behind rigid retaining walls and within the Backfill Zone should be compacted to a minimum of 95% of that soil's Standard Proctor maximum dry density (ASTM D698). Backfill materials should consist of soil material meeting the specifications for Retaining Wall Backfill. Heavy earthwork equipment should maintain a minimum horizontal distance away from the walls of 1 foot per foot of vertical wall height. Lighter compaction equipment should be used close to the walls.

4.5 Drainage Considerations

Positive drainage away from the proposed addition is an essential element in minimizing the adverse effects that water might have on the foundation soil's bearing quality. Positive drainage should be provided around the perimeter of the addition to minimize moisture infiltration into the foundation and/or subgrade soils. Landscaped areas adjacent to the building should be provided with a fall of at least six inches for the first ten feet outward from the building. Gutters should be employed on the building and gutter effluent should be discharged away from the building or into the storm sewer system. Based on the anticipated finished grade elevations, underdrains for slabs and foundation drains for footings are not considered necessary for this project.

4.6 Subgrade Preparation and Earthwork Operations

1. **Stripping:** The subgrade preparation should consist of removing all deleterious material to include topsoil, rootmat, asphalt, concrete debris, foundations, slabs, underground utilities not to be incorporated into the new construction, and soft or unstable subgrade from the proposed 5-foot expanded building and 2-foot expanded pavement limits. For planning purposes, a stripping depth on the order of about 6 inches to remove localized areas of topsoil can be considered.

2. **Existing FILL Removal:** It appears that an observed 16.5 feet (+/-) and possibly more of FILL are present across the building and pavement areas. It is the intent of this report to allow compacted, suitable and stable FILL to remain in place below floor slabs. Existing unsuitable or unstable FILL should be removed from within the 5-foot expanded building limits so as to expose stable FILL or natural subgrades, as determined by the Geotechnical Engineer. The FILL should be evaluated by the Geotechnical Engineer during construction through the observation of the excavation of test pits, subgrade proofrolling, and foundation excavations.

3. **Subgrade Restoration:** It should be contractually incumbent of the contractor to maintain or restore subgrades during clearing, stripping, and construction phases. Old foundations, slabs, or pavements which may be encountered within the subgrade should be removed and replaced with well compacted Engineered Fill. Subsurface utilities that may interfere with foundation installation should also be removed and re-located and the excavations replaced with well compacted Engineered Fill. Subgrades disturbed by subsurface

structure installation, grading activities, and other contractor operations shall be moisture conditioned and recompacted to the specifications of this report. Subgrade soils which are excessively wet and unstable but otherwise consist of suitable materials (inorganic soil) are not considered unsuitable by definition and shall be moisture conditioned and recompacted to the specifications of this report. The Geotechnical Engineer should be called on during excavation work to make site visits in order to assure proper replacement of disturbed subgrades.

4. **Subgrade Proofrolling Inspection:** After stripping and cutting to the desired grade, and prior to footing construction or Engineered Fill placement, the cut surface should be observed by an experienced Geotechnical Engineer or his authorized representative. Proofrolling using a 5-ton drum roller or a loaded tandem axle dump truck having an axle weight of at least 10 tons should be performed at this time to aid in identifying localized soft or unsuitable material. Any soft or unsuitable materials encountered during this proofrolling should be moisture conditioned and compacted or removed and replaced with an approved Engineered Fill material compacted to the criteria outlined in the following paragraphs. Existing subgrades should be moisture conditioned and compacted at this time.

5. **Subgrade and Engineered Fill Compaction:** Existing subgrades as well as subsequent layers of Engineered Fill should be properly compacted. Existing subgrades to a depth of at least 10 inches and all Engineered Fill shall be moisture conditioned to within +/- 3 percentage points of optimum moisture content then be compacted to a dry density at least 95% of that soil's Standard Proctor maximum dry density (ASTM D698). Engineered Fill lifts should be a maximum of 8 inches in loose thickness. Field density testing of subgrades and each lift of fill should be performed at a rate of no less than one test per 2,500 square feet in the building area and no less than one test per 10,000 square feet in pavement areas, but not less than 2 tests per lift. Compaction of natural subgrade surfaces may be waived by the Geotechnical Engineer if they are observed to be stable during proofrolling inspection.

6. **Utility Trench backfill Compaction:** All utility trench backfill should be adequately compacted. Utility trench backfill, as well as backfill above footings and below slabs, should be moisture conditioned to within +/- 3 percentage points of optimum moisture content then be compacted to a dry density at least 95% of that soil's Standard Proctor maximum dry density (ASTM D698). Field density testing of trench backfill should be performed at a rate of no less than one test per 50 linear feet of trench, but not less than 1 test per lift. Based on the soil boring data, the groundwater table is not expected to impact utility or other excavations. Perched water may be encountered within the soil profile in isolated areas from 2 to 10 feet deep and may be encountered at other areas of the site depending upon weather and seasonal conditions at the time of construction.

7. **Engineered Fill:** The following Engineered/Structural Fill types are recommended for use on this project:

   On-Site Borrow Engineered Fill: Soil Material classified as CL, SM, SC, SP, or better which is free of organics and debris. Maximum aggregate size should be limited to 4 inches. Maximum Liquid Limit should be less than 50. Inorganic soil materials excavated from the top several feet are expected to be suitable for reuse. Dark colred, organic or debris laden soils would not be suitable. Fat CLAY (CH) and Elastic SILT (MH) with a maximum Liquid Limit of 60 may be used as Engineered Fill in paved areas 2 or more feet below design subgrade elevations. Soils with a Liquid Limit greater than 60 should be wasted. It is possible that some existing FILL may contain organic matter and/or debris rendering it unsuitable for reuse as Engineered Fill. Lean Clay (CL) removed from excavations can be stockpiled for re-use as Engineered Fill if it is free of organic material and deleterious material and if kept free of contamination by other materials.

   Imported Engineered Fill: Soil Material classified as SM, SC, SP, or better containing less than 35% by weight Silt or Clay and free of organics and debris. Maximum aggregate size should be limited to 4 inches. VDOT Size No. 10 Stone Screenings is considered a suitable Imported Engineered Fill material.

   Retaining Wall Backfill: Fill placed in the Backfill Zone, considered that zone directly behind rigid retaining walls extending a horizontal distance equal to the wall height behind the wall, should consist of a granular soil material satisfying the specification for Imported Engineered Fill. Alternatively, VDOT Size No. 57 Stone or No. 10 Stone Screenings can be employed.

   Porous Fill: A minimum 4-inch layer of VDOT Size No. 57 Stone or approved alternate. Alternatively, Aggregate Base Material, VDOT Type I, Size 21A employed in a 6-inch layer is acceptable to help protect slab subgrades from deterioration during inclement weather.

   Backfill in areas which compaction equipment cannot access: VDOT Size No. 57 Stone or approved alternate placed only under the advisement of the Geotechnical Engineer.

   Utility Excavation Backfill: Soils used to backfill utility excavations within the expanded building limits should satisfy the requirements of On-Site Borrow Engineered Fill or better. Material used to backfill utility excavations outside the expanded building limits should satisfy the requirements of On-Site Borrow Structural Fill or better, except that on-site excavated Fat CLAY (CH) with a maximum Liquid Limit of 60, if encountered, may be used as Utility Excavation Backfill in pavement areas 2 or more feet below design subgrade elevations.

   Aggregate Base: Aggregate Base Material, VDOT Type I, Size 21A.

All materials to be used for Engineered Fill should be analyzed and approved by the Geotechnical Engineer prior to their use on the site.

8. **Unit Rates:** We recommend that favorable sitework unit rates be established in the construction contract for undercutting and backfilling and subgrade stabilization. Unit rates could be established as follows:

   a. Undercut and backfill with Imported Engineered Fill, per cubic yard in place;
   b. Undercut and backfill with On-site Borrow Engineered Fill, per cubic yard in place;
   c. Undercut and backfill with Aggregate Base Material, per cubic yard in place;
   d. Undercut footing trenches and backfill with Foundation Excavation Backfill (wet areas and below footings), per cubic yard in place;
   e. Undercut trenches and backfill with minimum 200 psi Flowable Fill (if approved for below footings), per cubic yard in place;
   f. Dispose of undercut material off site, per cubic yard in place,
   g. Place medium duty, woven and non-woven geotextile fabrics, per square yard. Suitable non-woven fabric for use in stabilization and separation would include Mirafi 160N or equivalent. Suitable woven fabric for use in stabilization would include Mirafi 600X or equivalent.
   h. Place medium duty geogrid, per square yard. Suitable geogrid for use in stabilization would include Tensar TX160 or equivalent.

   The Geotechnical Engineer should be called on to recommend and/or approve material type and placement procedures where subgrade remediation is required.

4.7 <u>Construction Considerations</u>

1. **Subgrade Protection:** The contractor should exercise care during grading to reduce subgrade disturbance and deterioration. The use of tracked equipment should help reduce subgrade deterioration during wet conditions. As the shallower soils of this site are sensitive to deterioration in the presence of water, with or without exposure to construction traffic, exposure to the environment and construction activity may weaken the subgrade soils if stripped subgrade surfaces or excavations are exposed to inclement weather or trenches remain open for too long a time. Therefore, Engineered Fill and Aggregate Base Material should be placed as early in the construction stages as practical to minimize subgrade exposure. If subgrades are softened by surface water intrusion or exposure, the softened soils must be dried out and recompacted or removed and replaced as deemed necessary by the Geotechnical Engineer. We recommend the site be proofrolled immediately after clearing and stripping to document the condition of the subgrade. Repair of subgrade deterioration caused by contractor operations during clearing and stripping or which occurs thereafter should be the responsibility of the contractor.

2. **Existing FILL and Unsuitable Subgrades:** While we expect existing subgrades to be generally suitable for slab and pavement support following subgrade compaction, areas of unsuitable FILL and soft subgrade may be encountered. A contingency for undercut and replacement beyond the design subgrade cut elevations should be included in the construction contract.

3. **Site Drainage:** Positive site drainage should be maintained during earthwork operations so as to help maintain the stability of the subgrade. The contractor should use additional depths of stone or employ geotextile fabrics or geogrids to protect subgrades from damage due to temporary construction traffic, if necessary.

4. **Dewatering:** Based on the soil boring data, the groundwater table is not expected to impact utility excavations; however, seepage from shallow perched water could still occur. For excavations encountering groundwater, aggressive sump pumping or well pointing may be required, depending on excavation depth and location on site, to achieve a stable excavation.

5. **Borrow Fill Suitability:** Most soils available from within the top several feet on this site will consist of soils comprised of Lean CLAY (CL) that should be suitable for re-use by classification.

6. **Borrow Fill Sensitivity:** Clayey soils, present within the top several feet of subgrade, could be difficult to work and compact when not near their optimum moisture content. The contractor should be prepared to moisture condition on site soils prior to compaction.

7. **Engineered Fill Compaction:** Engineered Fill materials should be placed, compacted, and tested in accordance with the recommendations contained in this report. We recommend that all cut and fill operations be observed full-time by a representative of the Geotechnical Engineer to determine if minimum earthwork and compaction requirements are being met.

8. **Foundation Subgrade Evaluation:** All foundation excavations should be observed by a representative of the Geotechnical Engineer to determine that existing FILL soils have adequate bearing and are free of organic matter and deleterious material prior to the placement of reinforcing steel or backfilling with Foundation Excavation Backfill.

9. **Seasonal Considerations:** It would be most desirable to perform initial earthwork operations on this site during the drier seasonal conditions that typically extend from May through October. In this manner, material that otherwise will require removal or drying and reworking could possibly be left in place below new fills.

5.0 CLOSING

If changes are made in the overall site layout or design or location of the structures or if the previously described project characteristics differ significantly from the actual design characteristics, the recommendations presented in this report must not be considered valid unless the actual project characteristics are reviewed by ECS and our recommendations are modified or verified in writing. We request the opportunity to review the foundation plan, grading plan, and applicable portions of the project specifications when the design is finalized. This review will allow us to ascertain whether these documents are consistent with the intent of our recommendations.

This report has been prepared for the exclusive use of the client for specific application to the project described herein. Our conclusions and recommendations have been rendered in a manner consistent with the level and skill ordinarily exercised by members of the geotechnical engineering profession in the Commonwealth of Virginia. No warranty is expressed or implied.

Our conclusions and recommendations are based on subsurface information obtained from the borings. This information does not necessarily reflect variations in the subsurface conditions which can occur between borings or in unexplored areas of the site due to geologic characteristics of the region or past land use. Should such variations become apparent during construction, it will be necessary to reevaluate our conclusions and recommendations based upon site observations and additional investigation, if required.

Field observations, monitoring, and quality assurance testing during earthwork and foundation installation are an extension of and integral to the geotechnical design recommendation. We recommend that the owner retain these services and we be allowed to continue our involvement throughout these phases of construction. ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

APPENDICIES

I. Boring Location Diagram

II. Soil Test Boring Logs and Generalized Subsurface Soil Profile

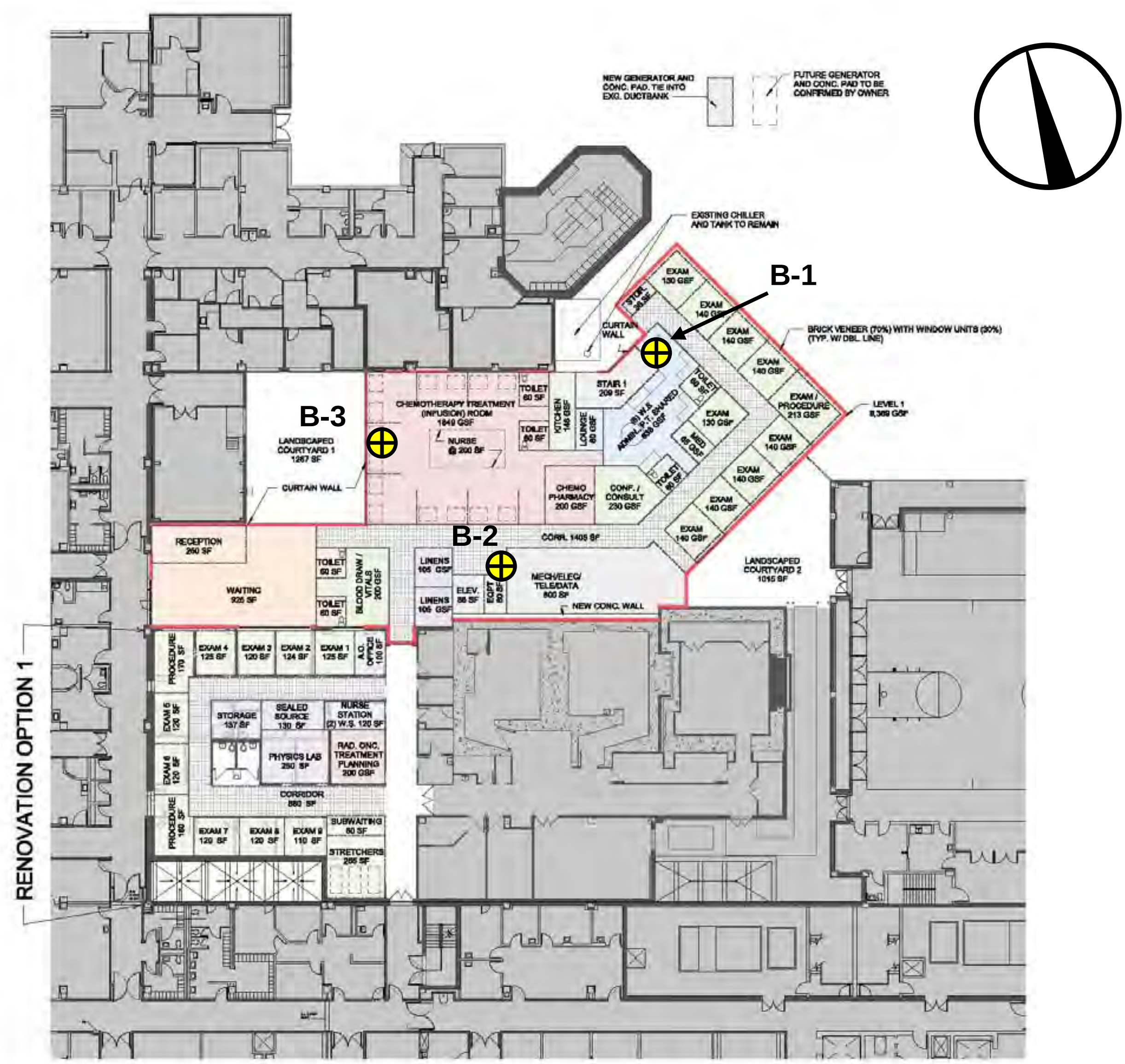
III. Reference Notes For Boring Logs

IV. Summary of Laboratory Test Data

APPENDIX I

BORING LOCATION DIAGRAM

APPENDIX I
BORING LOCATION DIAGRAM
VAMC Richmond Cancer Clinic Addition
City of Richmond, Virginia
ECS Project No. 03:12393



= Approximate Location of Soil Test Borings

APPENDIX II

SOIL TEST BORING LOGS AND
GENERALIZED SUBSURFACE SOIL PROFILES

CLIENT	JOB #	BORING #	SHEET
J M Smith Engineering, LLC	12393	B-1	1 OF 1

PROJECT NAME: VAMC Richmond Cancer Clinic Addition

ARCHITECT-ENGINEER:

SITE LOCATION: 1201 Broad Rock Boulevard, City of Richmond, Virginia

NORTHING: | EASTING: | STATION:

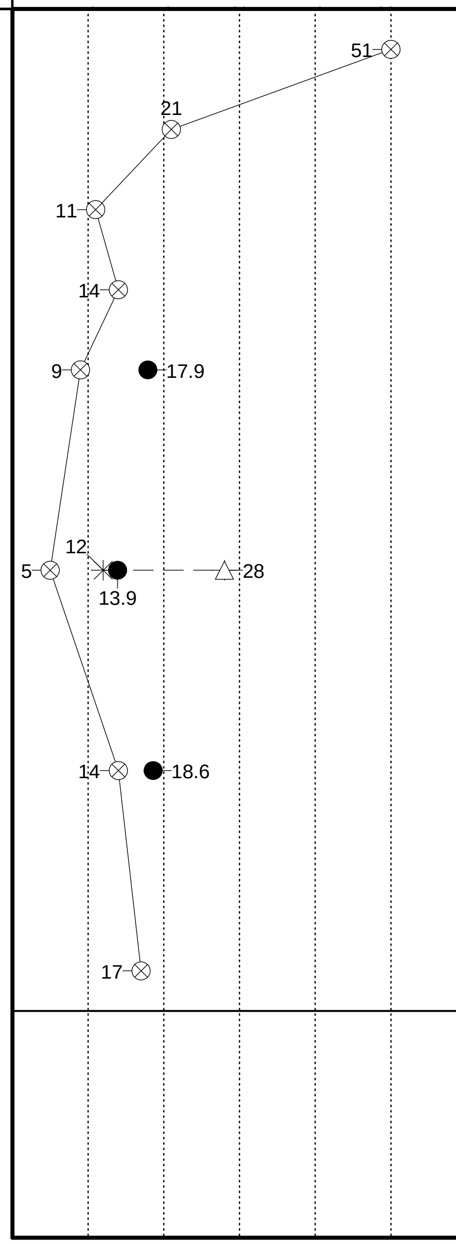
DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION 100%

SURFACE ELEVATION 197 FT +/-

Legend: CALIBRATED PENETROMETER TONS/FT^2; ROCK QUALITY DESIGNATION & RECOVERY (RQD% – – –, REC% ———); PLASTIC LIMIT% — WATER CONTENT% — LIQUID LIMIT%; ⊗ STANDARD PENETRATION BLOWS/FT

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Gravel Depth [4"]			
	S-1	SS	24	6	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments, Dark Brown and Dark Gray, Moist, Hard to Very Stiff		195	19 30 21 31
	S-2	SS	24	16				7 10 11 12
5	S-3	SS	24	20	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments, Orangish Red, Brown, and Gray, Moist, Stiff			4 5 6 6
	S-4	SS	24	12	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments, Red, Orange, and Gray, Moist, Stiff		190	5 8 6 7
	S-5	SS	24	16	(CL FILL) SANDY LEAN CLAY, Contains Roots and Rock Fragments, Dark Brown and Dark Gray, Moist, Stiff to Medium Stiff			4 4 5 6
10							185	
	S-6	SS	24	21				2 2 3 3
15								
					(CL) SANDY LEAN CLAY, Brown and Tan, Moist, Stiff		180	
	S-7	SS	24	21				4 6 8 8
20								
					(CL) SANDY LEAN CLAY, Mottled Red, Orange, and Gray, Moist, Very Stiff		175	
	S-8	SS	24	24				5 7 10 13
25					END OF BORING @ 25'			
							170	
30								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL Dry WS ☐ WD ☒	BORING STARTED 11/10/16	CAVE IN DEPTH None
WL(SHW) WL(ACR)	BORING COMPLETED 11/10/16	HAMMER TYPE Manual
WL	RIG Truck FOREMAN Rob Scott	DRILLING METHOD 2 1/4"HSA

CLIENT	JOB #	BORING #	SHEET
J M Smith Engineering, LLC	12393	B-2	1 OF 1

PROJECT NAME: VAMC Richmond Cancer Clinic Addition

ARCHITECT-ENGINEER:

SITE LOCATION: 1201 Broad Rock Boulevard, City of Richmond, Virginia

NORTHING: | EASTING: | STATION:

CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY — RQD% - - - REC% ———

PLASTIC LIMIT% — WATER CONTENT% — LIQUID LIMIT%

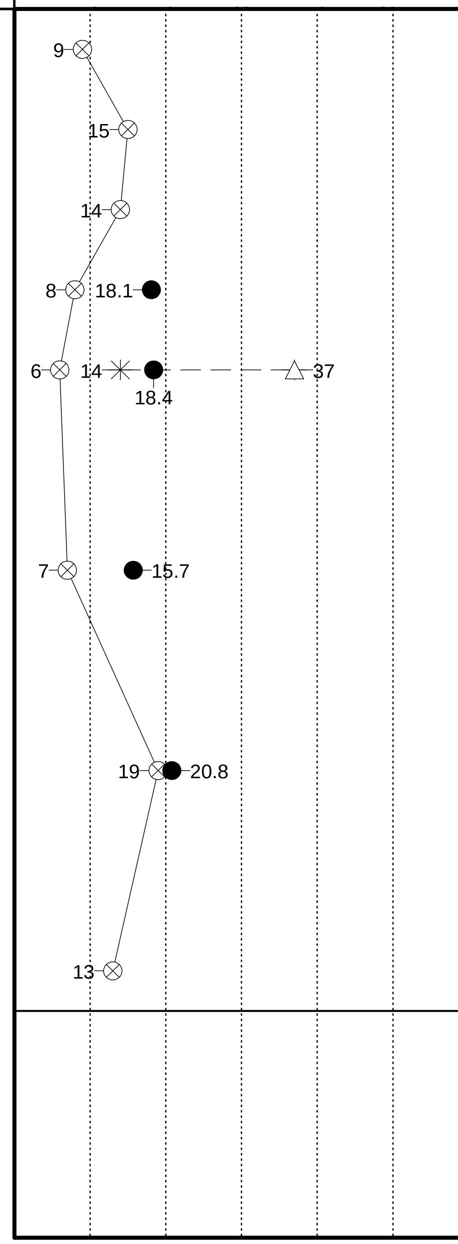
STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 197 FT +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Gravel Depth [1"]			
	S-1	SS	24	20	Topsoil Depth [6"]			4 4 5 7
	S-2	SS	24	14	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments Asphalt and Roots, Dark Brown, Orange, Red, and Gray, Moist, Stiff		195	4 7 8 11
5	S-3	SS	24	24	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments Asphalt and Roots, Dark Brown, Orange, Red, and Gray, Moist, Stiff			5 8 6 11
	S-4	SS	24	20	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments and Brick, Red, Orange, Brown, and Gray, Moist, Medium Stiff		190	3 4 4 5
	S-5	SS	24	21				4 3 3 4
10								
					(SC FILL) CLAYEY FINE TO MEDIUM SAND, Contains Rock Fragments and Brick, Red, Orange, Brown, and Gray, Moist, Loose		185	
	S-6	SS	24	22				5 3 4 4
15								
					(CL) SANDY LEAN CLAY, Orange and Gray, Moist, Very Stiff to Stiff		180	
	S-7	SS	24	16				6 8 11 15
20								
							175	
	S-8	SS	24	21				7 6 7 7
25					END OF BORING @ 25'			
							170	
30								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL Dry — WS ☐ — WD ☒	BORING STARTED 11/10/16	CAVE IN DEPTH None
WL(SHW) — WL(ACR)	BORING COMPLETED 11/10/16	HAMMER TYPE Manual
WL	RIG Truck — FOREMAN Rob Scott	DRILLING METHOD 2 1/4"HSA

CLIENT	JOB #	BORING #	SHEET
J M Smith Engineering, LLC	12393	B-3	1 OF 1

PROJECT NAME	ARCHITECT-ENGINEER
VAMC Richmond Cancer Clinic Addition	

SITE LOCATION

1201 Broad Rock Boulevard, City of Richmond, Virginia

NORTHING	EASTING	STATION

CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% - - - REC% ———

PLASTIC LIMIT% — WATER CONTENT% — LIQUID LIMIT%

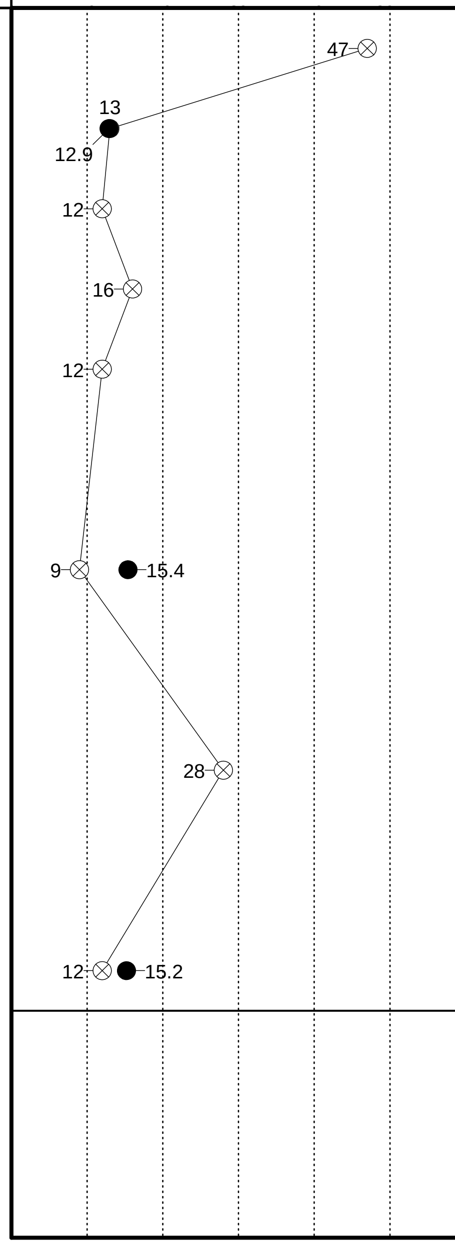
STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 197 FT +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Gravel Depth [8"]			
	S-1	SS	24	22	(CL FILL) SANDY LEAN CLAY, Contains Rock and Asphalt Fragments, Brown, Red, and Gray, Moist, Hard to Stiff		195	18 30 17 8
	S-2	SS	24	21				4 6 7 11
5	S-3	SS	24	20				4 7 5 6
	S-4	SS	24	21	(CL FILL) SANDY LEAN CLAY WITH GRAVEL, Mottled Red, Orange, and Gray, Moist, Very Stiff		190	6 7 9 11
	S-5	SS	24	21	(CL FILL) SANDY LEAN CLAY, Brown, Gray, and Orange, Moist, Stiff			5 7 5 7
10								
					(CL FILL) SANDY LEAN CLAY, Dark Brown and Dark Gray, Moist, Stiff		185	
	S-6	SS	24	20				4 5 4 4
15								
					(CL) SANDY LEAN CLAY, Orange and Gray, Moist, Very Stiff		180	
	S-7	SS	24	22				7 12 16 22
20								
					(CL) SANDY LEAN CLAY, Mottled Orange, Red, and Gray, Moist, Stiff		175	
	S-8	SS	24	20				4 6 6 8
25					END OF BORING @ 25'			
							170	
30								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL Dry WS ☐ WD ☒	BORING STARTED 11/10/16	CAVE IN DEPTH None
WL(SHW) WL(ACR)	BORING COMPLETED 11/10/16	HAMMER TYPE Manual
WL	RIG Truck FOREMAN Rob Scott	DRILLING METHOD 2 1/4"HSA

SOIL CLASSIFICATION LEGEND

ST - SHELBY TUBE
RC - ROCK CORE
PM - PRESSURE METER
- FILL
- POSSIBLE FILL
- PROBABLE FILL

GW - WELL GRADED GRAVEL
GM - SILTY GRAVEL
GP - POORLY GRADED GRAVEL
GC - CLAYEY GRAVEL
SW - WELL GRADED SAND
ML - LOW PLASTICITY SILT
CL - LOW PLASTICITY CLAY
MH - HIGH PLASTICITY SILT
SM - SILTY SAND
SP - POORLY GRADED SAND
SC - CLAYEY SAND
CH - HIGH PLASTICITY CLAY
OH - HIGH PLASTICITY ORGANIC SILTS AND CLAYS
OL - LOW PLASTICITY ORGANIC SILTS AND CLAY
PT - PEAT
WR - WEATHERED ROCK
PWR - PARTIALLY WEATHERED ROCK
HWR - HIGHLY WEATHERED ROCK
DR - DECOMPOSED ROCK

SURFACE MATERIALS

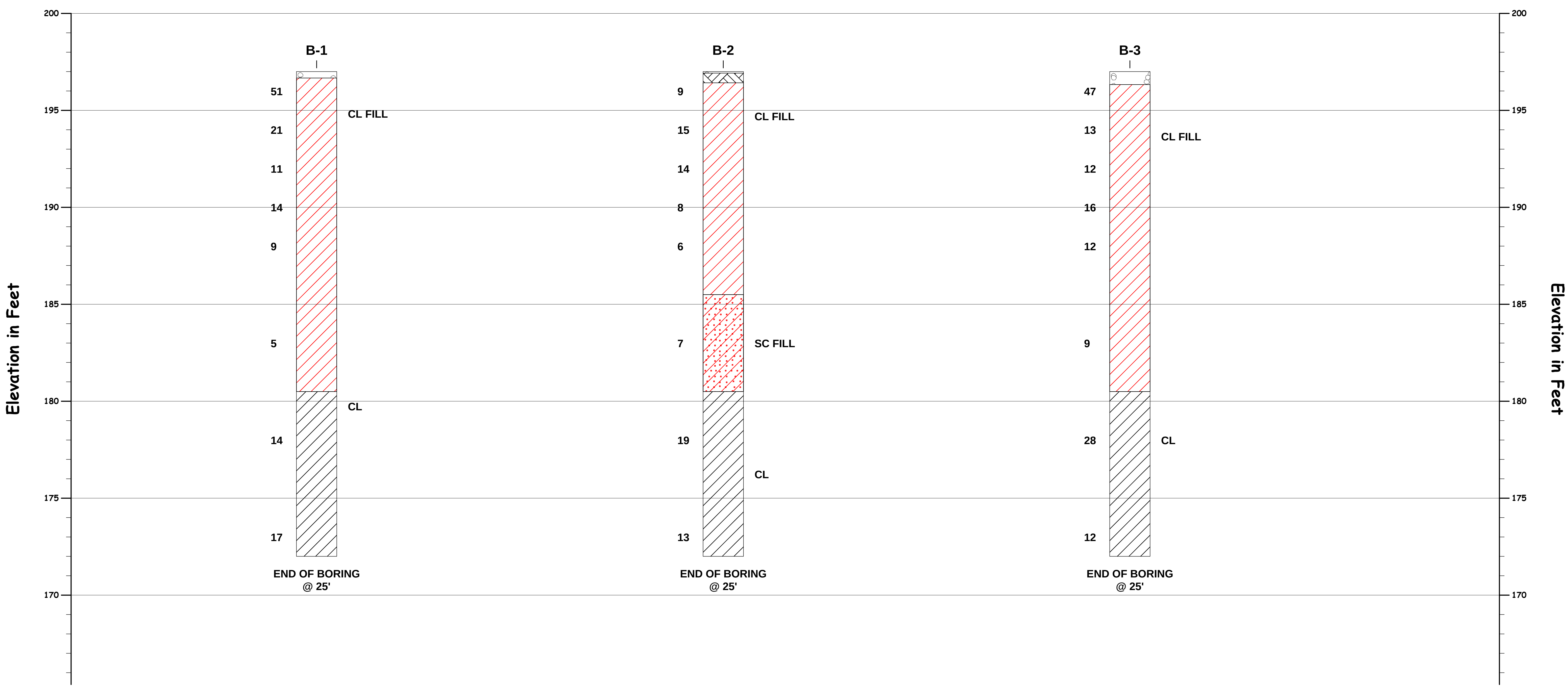
TOPSOIL
CONCRETE
ASPHALT
VOID
GRAVEL

ROCK TYPES

IGNEOUS
METAMORPHIC
SEDIMENTARY

SYMBOL LEGEND

WATER LEVEL - DURING DRILLING/SAMPLING
WATER LEVEL - SEASONAL, HIGH WATER
WATER LEVEL - AFTER CASING REMOVAL
WATER LEVEL - AFTER 24 HOURS



NOTES:
1 SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL REPORT FOR ADDITIONAL INFORMATION.
2 PENETRATION TEST RESISTANCE IN BLOWS PER FOOT (ASTM D1586).
3 HORIZONTAL DISTANCES ARE NOT TO SCALE.

GENERALIZED SUBSURFACE PROFILE

VAMC Richmond Cancer Clinic Addition
J M Smith Engineering, LLC
1201 Broad Rock Boulevard, City of Richmond, Virginia

PROJECT NO.: 12393 | DATE: 12/6/2016 | VERTICAL SCALE: 1"=5'

APPENDIX III

REFERENCE NOTES FOR BORING LOGS

REFERENCE NOTES FOR BORING LOGS

MATERIAL[1,2]		
ASPHALT		
CONCRETE		
GRAVEL		
TOPSOIL		
VOID		
BRICK		
AGGREGATE BASE COURSE		
FILL[3]	MAN-PLACED SOILS	
GW	WELL-GRADED GRAVEL	gravel-sand mixtures, little or no fines
GP	POORLY-GRADED GRAVEL	gravel-sand mixtures, little or no fines
GM	SILTY GRAVEL	gravel-sand-silt mixtures
GC	CLAYEY GRAVEL	gravel-sand-clay mixtures
SW	WELL-GRADED SAND	gravelly sand, little or no fines
SP	POORLY-GRADED SAND	gravelly sand, little or no fines
SM	SILTY SAND	sand-silt mixtures
SC	CLAYEY SAND	sand-clay mixtures
ML	SILT	non-plastic to medium plasticity
MH	ELASTIC SILT	high plasticity
CL	LEAN CLAY	low to medium plasticity
CH	FAT CLAY	high plasticity
OL	ORGANIC SILT or CLAY	non-plastic to low plasticity
OH	ORGANIC SILT or CLAY	high plasticity
PT	PEAT	highly organic soils

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS

SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation %
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION

DESIGNATION		PARTICLE SIZES
Boulders		12 inches (300 mm) or larger
Cobbles		3 inches to 12 inches (75 mm to 300 mm)
Gravel:	Coarse	¾ inch to 3 inches (19 mm to 75 mm)
	Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand:	Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
	Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
	Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS

UNCONFINED COMPRESSIVE STRENGTH, Q_P[4]	SPT[5] (BPF)	CONSISTENCY[7] (COHESIVE)
<0.25	<3	Very Soft
0.25 - <0.50	3 - 4	Soft
0.50 - <1.00	5 - 8	Medium Stiff
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

RELATIVE AMOUNT[7]	COARSE GRAINED (%)[8]	FINE GRAINED (%)[8]
Trace	≤5	≤5
Dual Symbol *(ex: SW-SM)*	10	10
With	15 - 20	15 - 25
Adjective *(ex: "Silty")*	≥25	≥30

GRAVELS, SANDS & NON-COHESIVE SILTS

SPT[5]	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

WATER LEVELS[6]

WL	Water Level (WS)(WD)
	(WS) While Sampling
	(WD) While Drilling
SHW	Seasonal High WT
ACR	After Casing Removal
SWT	Stabilized Water Table
DCI	Dry Cave-In
WCI	Wet Cave-In

[1] *Classifications and symbols per ASTM D 2488-09 (Visual-Manual Procedure) unless noted otherwise.*

[2] *To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.*

[3] *Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-**FILL**)].*

[4] *Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).*

[5] *Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf).*

[6] *The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.*

[7] *Minor deviation from ASTM D 2488-09 Note 16.*

[8] *Percentages are estimated to the nearest 5% per ASTM D 2488-09.*

APPENDIX IV

SUMMARY OF LABORATORY TEST DATA

Laboratory Testing Summary

Sample Source	Sample Number	Depth (feet)	MC[1] (%)	Soil Type[2]	Atterberg Limits[3] LL	PL	PI	Percent Passing No. 200 Sieve[4]	Moisture - Density (Corr.)[5] Maximum Density (pcf)	Optimum Moisture (%)	CBR Value[6]	Other
B-1												
	S-5	8.00 - 10.00	17.9									
	S-6	13.00 - 15.00	13.9	CL	28	12	16	56				
	S-7	18.00 - 20.00	18.6					64				
B-2												
	S-4	6.00 - 8.00	18.1					56				
	S-5	8.00 - 10.00	18.4	CL	37	14	23	53				
	S-6	13.00 - 15.00	15.7					49				
	S-7	18.00 - 20.00	20.8					64				
B-3												
	S-2	2.00 - 4.00	12.9					51				
	S-6	13.00 - 15.00	15.4					55				
	S-8	23.00 - 25.00	15.2									

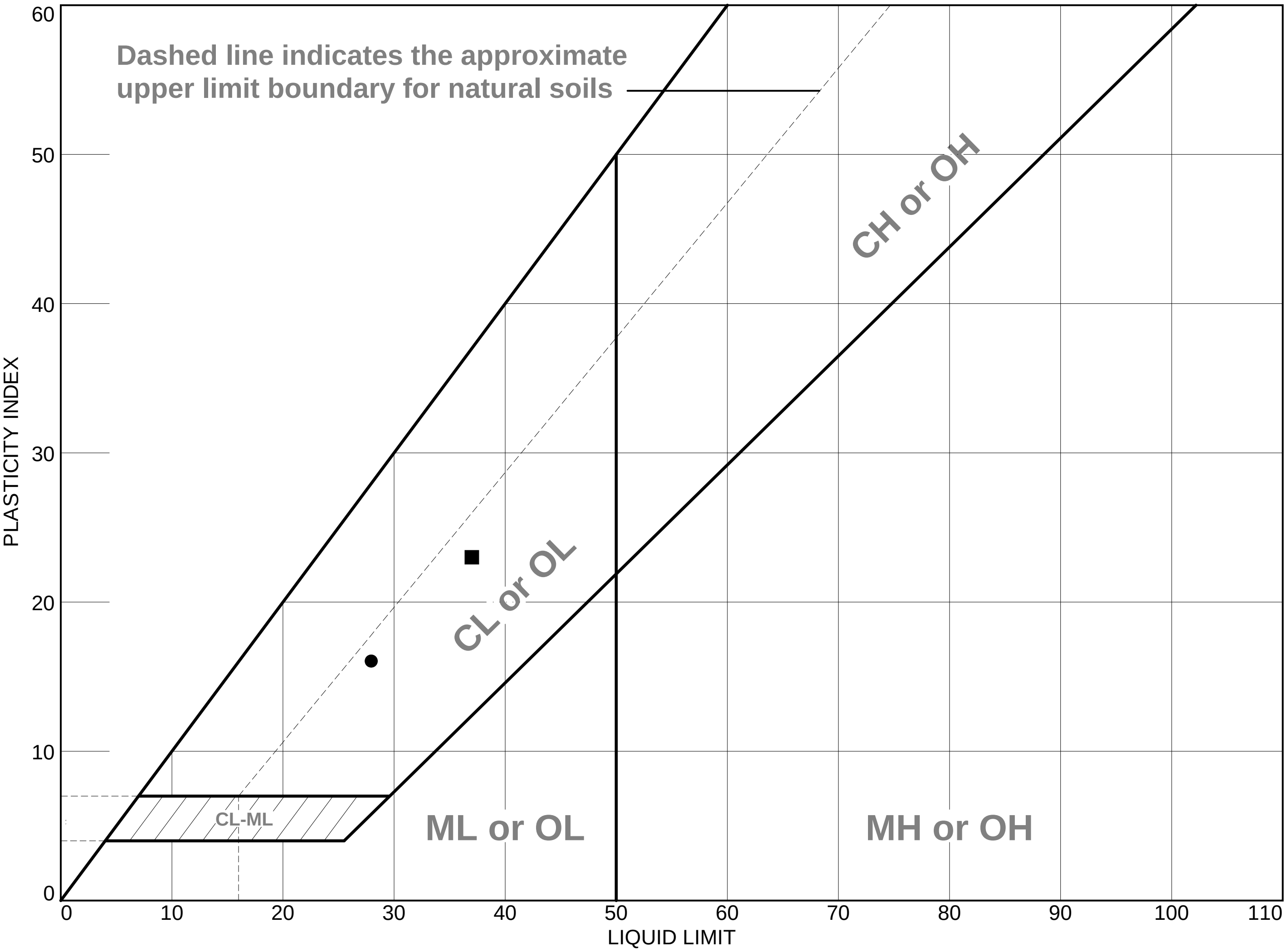
Notes: 1. ASTM D 2216, 2. ASTM D 2487, 3. ASTM D 4318, 4. ASTM D 1140, 5. See test reports for test method, 6. See test reports for test method

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content (ASTM D 2974)

Project No. 12393
Project Name: VAMC Richmond Cancer Clinic Addition
PM: David J. Schlotterer
PE: Robert C. Moss
Printed On: Tuesday, December 06, 2016

ECS MID-ATLANTIC, LLC
2119-D North Hamilton Street
Richmond, VA 23230
Phone: (804) 353-6333
Fax: (804) 353-9478

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	(CL FILL) SANDY LEAN CLAY, Contains Roots and Rock Fragments, Dark Brown and Dark Gray	28	12	16		56	CL
■	(CL FILL) SANDY LEAN CLAY, Contains Rock Fragments and Brick, Red Orange Brown and Gray	37	14	23		53	CL

Project No. 12393 **Client:** J M Smith Engineering, LLC

Project: VAMC Richmond Cancer Clinic Addition

● **Source of Sample:** B-1 **Depth:** 13.00-15.00 **Sample Number:** S-6

■ **Source of Sample:** B-2 **Depth:** 8.00-10.0 **Sample Number:** S-5

Remarks:

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Figure