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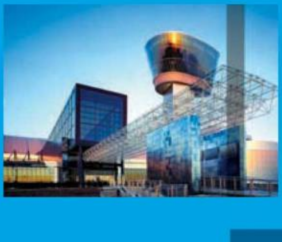
# REPORT OF SUBSURFACE EXPLORATION AND GEOTECHNICAL ANALYSIS
## VAMC SALEM – EMERGENCY DEPARTMENT EXPANSION & RENOVATION – BUILDING 2A
## SALEM, VIRGINIA

ECS REPORT NO. 12:7952





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# TABLE OF CONTENTS

## Report of Subsurface Exploration and Geotechnical Analysis
## VAMC Salem – Emergency Department Expansion & Renovation – Building 2A
## Salem, Virginia

## ECS Project No. 12:7952

ECS MID-ATLANTIC, LLC
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December 31, 2014

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ECS Project No. 12:7952

Reference: Report of Subsurface Exploration and Geotechnical Analysis
VAMC Salem – Emergency Department Expansion & Renovation – Building 2A
Salem, Virginia

Dear Mr. Marvin:

ECS Mid-Atlantic, LLC (ECS) respectfully submits this Report of Subsurface Exploration and Geotechnical Analysis for the above-referenced project. Our services have been provided in accordance with revised ECS Proposal No. 10964-PR, dated November 18, 2014. This report includes the results of the soil test borings, laboratory analysis, and geotechnical recommendations for this project.

## SCOPE OF SERVICES

The conclusions and recommendations contained in this report are based upon the results of our field exploration. Our exploration consisted of a site visit by an engineering geologist and five soil test borings drilled to depths of up to 30 feet below the existing ground surface. Laboratory testing performed on several representative samples obtained during the field exploration aided in the evaluation of the field data. The borings were located in the field by an engineering geologist from our office by measuring distances and estimating angles from existing site features. The boring locations shown on the diagram provided in the Appendix of this report should be considered approximate.

The recommendations contained herein were developed from our interpretation of the subsurface data obtained from the soil test borings. The borings indicate subsurface conditions at specific locations at the time of the exploration. 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 design criteria considered typical for this type of structure and the specific information provided. Should structural loading characteristics differ from those discussed herein, ECS should be contacted for review of these conditions and possible revisions to the recommendations of this report.

## PROJECT CHARACTERISTICS

To-date, project information has been provided by you via a telephone conversation and various emails containing attachments depicting the proposed building addition construction limits relative to Buildings 2A and 143 on the existing Salem VAMC property. We recently received a CAD drawing file depicting the proposed ER expansion footprint, which more than doubled in area from that of the original footprint.

Based on the current information provided, we understand that the project will consist of the construction of a one-story, approximately 9,600-square foot addition to Building 2A's Emergency Department. However, there is the potential for a second story addition in the future. Currently, plans suggest the expansion will occur on the north side of Building 2A and will occupy much of the existing parking lot. We anticipate that the building addition will either consist of wood or light metal (aluminum) frame construction and will bear on step-down spread footings about 8 feet below existing grades with a slab-on-grade. Based on our experience, maximum anticipated column and wall loads for two-story structures may be on the order of 300 kips and 6 kips per linear foot (klf), respectively.

## EXPLORATION PROCEDURES

### Subsurface Exploration Procedures

To characterize the general subsurface conditions, five soil test borings (B-1 through B-5) were performed within the limits of the proposed construction. The borings were performed with truck-mounted drilling equipment utilizing continuous-flight, hollow stem augers (HSA) to advance the boreholes to their scheduled depths or auger refusal. Drilling fluid was not used in this process.

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 18 inches by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler through a 12-inch interval is termed the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring logs. This N-value can be used as a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, it also indicates the consistency of cohesive soils. This indication is qualitative, since many factors can significantly affect the Standard Penetration resistance value and prevent a direct correlation between drill crews, drill rigs, drilling procedures, and hammer-rod sampler assemblies. Samples were obtained at 2.5-foot intervals in the upper 10 feet of the borings, and at 5-foot intervals thereafter.

After recovery, representative portions of each soil sample were removed from the sampler and sealed in glass jars. The samples were taken to our laboratory in Roanoke, Virginia for visual classification and laboratory testing.

## Laboratory Testing Program

Representative soil samples were selected and tested in our laboratory to substantiate visual classifications and to aid in the estimation of pertinent engineering properties. The laboratory testing program included natural moisture content tests (ASTM D 2216), percent fines passing the No. 200 sieve tests (ASTM D 1140), Expansive Index of Soils tests (ASTM D 4829), and Atterberg Limits tests (ASTM D 4318). Standard Proctor testing (ASTM D 698) and California Bearing Ratio (CBR) testing (D 1883) were performed on a composite bulk soil sample obtained from the upper 10 feet in Boring B-4. The results of all laboratory testing conducted are included in the Appendix of this report.

An experienced engineering geologist visually classified each soil sample on the basis of texture and plasticity (ASTM D 2488) and identified each soil sample using the classification group symbols and names as prescribed in the Unified Soil Classification System (USCS) (ASTM D 2487). A brief explanation of the USCS is included with this report. The geologist grouped the various soil types into the major strata 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.

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.

# SITE AND SUBSURFACE CONDITIONS

## Site Conditions

The subject site is located on the north side of Building 2A of the VAMC, located at 1970 Roanoke Boulevard, in Salem, Virginia. Specifically, it is located in the existing parking lot in front of the Emergency Department, adjacent to the ambulance drop off area. At the time of our visit, the site was cordoned off with construction chain linked fencing, due to the renovations being done on Buildings 2A and 143.

Topographically, grades appeared to fall gradually from the existing buildings toward Patriot Boulevard, south to north, on the order of 1 to 2 feet across the anticipated construction limits.

## Site Geology

The project site is located within the Salem Quadrangle of the Valley and Ridge Physiographic and Geologic Province in Southwestern Virginia. Specifically, the site area is located within the Roanoke Valley, which is a northeast-southwest trending lowlands extending for some 20 miles around the City of Roanoke and whose floor is characterized by easily eroded mudstones (siltstones and shales) and carbonates (limestones and dolostones).

The site is located approximately 2 miles southeast of the Max Meadows Thrust Fault, which is bordered further to the north/northwest by the Salem Fault, which comprises the Salem Thrust Sheet. These are low angle overthrust faults that brought the older Rome and Elbrook

Formations of Cambrian Age into contact with younger Ordovician Age rock in this area. The site is underlain by the Rome Formation (€r), which weathers to residual soils consisting of orange-brown and maroon silts, clays, and saprolites (literally, rotten rock) of variable thickness. The Rome Formation is known for its potential sinkhole development, subsidence, and cave openings in some areas within the Roanoke Valley. However, it is noted that our borings did **not** appear to encounter potential karst conditions.

Less than one-quarter of a mile south of the project area, the Roanoke River flows eastward through a flood plain containing a thick veneer of alluvial material overlying the Rome Formation. Recent alluvium is present in the current stream channel and flood plain. The transition from these young alluvial materials to hard rock is often times abrupt, with little or no residual soil or saprolite present.

In non-carbonate materials such as those encountered in the borings, the boundary between soil and rock is not sharply defined. A transitional zone termed "highly weathered rock" (HWR hereafter) is normally found overlying the parent bedrock. HWR is defined, for engineering purposes, as residual material with Standard Penetration resistance greater than 100 blows per foot (bpf). Because weathering is facilitated by fractures, joints, and the presence of less resistant rock types, the profile of the HWR and hard rock is typically irregular and erratic, even over short horizontal distances. Also, it is not unusual to find natural lenses and boulders of hard rock “floating” in zones of HWR within the soil mantle, well above the general bedrock level.

## Soil Conditions

Based on the borings, the subsurface conditions at the site primarily consist of existing fill overlaying natural clays, silts, and HWR.

Asphalt depths at the boring locations were measured to be on the order of 4 inches in thickness. Underlying stone subbase depths were measured to range from approximately 5 inches to 7 inches in thickness. Depths of surficial materials may vary in unexplored areas.

Possible/probable existing fill, which generally consists of LEAN to FAT CLAY (CL to CH) and ELASTIC SILT (MH), containing varying concentrations of sand, rock fragments, and/or roots, was encountered to approximate depths ranging from 5.5 feet to 8 feet below existing grades in the borings. *No other foreign debris was observed in the samples*. SPT N-values in these materials ranged from 4 bpf to 13 bpf, indicating soft to stiff consistencies. The samples obtained appeared to be good quality material; however, pockets of unsuitable material may be present in unexplored site areas.

Below the fill materials, natural soils of similar types and compositions were encountered until either the HWR surface, auger refusal on bedrock, or termination. SPT N-values in these soils ranged from 6 bpf to 25 bpf, with an approximate average N-value of 15 bpf.

HWR, which has been defined previously, was encountered at approximate depths ranging from 14 feet to 17.5 feet below existing grades in Borings B-3 through B-5. Hard rock, which we define by the depth of auger refusal on naturally-occurring mass stratigraphy not deposited by man or stream processes, was encountered in all of the borings except B-1. There is the potential that natural hard rock ledges, pinnacles, or floating boulders could be encountered at shallow depths in unexplored areas, which could require blasting or use of a pneumatic hoe ram for removal.

### Rock Contact Summary

| Boring No. | HWR Depth (ft) | AR Depth (ft) |
|---|---|---|
| B-1 | N.E. | N.E. |
| B-2 | N.E. | -22.0 |
| B-3 | 14.0 | -20.0 |
| B-4 | 17.5 | -21.0 |
| B-5 | 14.0 | -17.0 |

AR: Auger Refusal
HWR: Highly Weathered Rock
N.E.: Not Encountered

Atterberg Limits testing performed on representative soil samples indicated Liquid Limits ranging from 51 to 65, with corresponding Plasticity Indices ranging from 27 to 31. Percent fines passing the No. 200 sieve ranged from 74% to 83%. Natural moisture contents varied from 18.8% to 38.8%. Standard Proctor testing of the composite bulk soil sample obtained from the upper 10 feet within Boring B-4, yielded a maximum dry density of 102.7 pounds per cubic foot (pcf), with a corresponding optimum moisture content of 21.6%. CBR testing of the same bulk sample yielded percentage values of 4.7 and 4.0 at 0.1 inch and 0.2 inch of penetration, respectively.

The laboratory testing program also included the testing of the Expansive Index of Soils (ASTM D 4829), which was performed on a representative portion of the composite bulk soil sample taken from Boring B-4. The results of this testing are as follows:

| Boring | Depth (ft) | Molding Moisture Content, % | Final Moisture Content, % | Initial Dry Density, lbs/ft$^3$ | Expansion Index |
|---|---|---|---|---|---|
| B-4 | 5.5 - 10.0 | 17.7 | 17.7 | 93.1 | 19 |

Based on laboratory testing, the on-site soils possess a very low potential for moisture-related volume change (shrink-swell).

Boring logs describing the subsurface conditions encountered in the soil test borings are included in the Appendix of this report.

## Groundwater Observations

Groundwater observations were made during soil sampling and upon completion of the drilling operations at each boring location. In standard soil auger drilling operations, water is not introduced into the borehole, and the groundwater position can often be evaluated by observing water flowing into or out of the borehole. Furthermore, visual observations of the soil samples retrieved during the auger drilling exploration can often be used in evaluating the groundwater conditions.

Generally, the soil samples were moist, and observable groundwater was not encountered in the borings. However, perched water could be encountered at the interface between higher and lower permeability soils, such as at the transition from residuum to the HWR surface. If perched water is encountered in the foundation and utility excavations, we anticipate that seepage will be slow enough to control with submersible pumps.

# ANALYSIS AND RECOMMENDATIONS

## Foundations

Prior to the start of foundation construction, any existing surface structures should be demolished and the debris removed from the site. Demolition should include removal of any existing foundations, slabs, underground utilities, and associated loose or soft backfill.

Based on the results of our exploration, and provided marginally soft or loose existing fill materials are undercut and replaced, it is our opinion that the proposed emergency department structure can be supported by shallow spread footings bearing in suitable natural soils or properly compacted, engineered fill. Based on the information provided, we anticipate that nominal depths of new engineered fill may be required to achieve design grades within the proposed building addition footprint. All new fill, which will support the foundations, should be placed in accordance with the recommendations provided in the section of this report entitled Subgrade Preparation and Earthwork Operations.

We recommend that a net allowable soil bearing pressure of 3,000 pounds per square foot (psf) be utilized for design of wall and column footings, assuming that the foundations will bear at or near 8 feet below existing grades and penetrate through the possible fill materials. The net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. Suitable natural bearing soils can be identified on our boring logs as those soils having a minimum SPT N-value of 9 bpf. The bearing capacity at the final footing elevation should be verified in the field by the geotechnical engineer to assure that the in-situ bearing capacity at the bottom of each footing excavation is adequate for the design loads.

To attain this allowable capacity, minimum footing widths of 18 inches and 24 inches should be maintained for wall and column footings, respectively. These minimum dimensions will help reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" action in potentially soft surficial soils.

As stated previously, based on laboratory classification testing, the on-site soils generally possess a low potential for moisture-related volume change (shrink-swell). Therefore, we recommend that all footings bear a minimum of 24 inches below finished grade (or fully penetrate the existing fill materials, whichever depth is greater), to provide adequate frost protection. Footings beneath interior, heated spaces may bear at nominal depths.

Any excessively soft or wet soils encountered in the footing excavations should be removed from below all footings. In areas where soft or unsuitable material is undercut, the footing could be lowered or the excavation may be backfilled to re-establish the desired footing elevations. We recommend that a crushed angular gravel (VDOT No. 57 Stone) be used for backfilling. This gravel can be placed readily with minimal compactive effort and will not be susceptible to deterioration from moisture. As an alternative, cementitious, flowable fill or compacted VDOT No. 21-A Stone may be used as backfill.

Provided the foundation design and construction recommendations discussed herein are employed, the maximum total settlement for the individual proposed building addition is estimated to be less than about 1 inch, with differential settlements of less than approximately one-half this amount. The structural design and specification of architectural finishes should consider the potential aesthetic impact of these settlements.

## Floor Slab Design

For the design and construction of the interior slab-on-grade for the proposed building addition, it is recommended that all asphalt, topsoil, and any soft or unsuitable materials be removed from this area prior to fill placement or slab construction. Any stone subbase beneath existing asphalt areas that will remain parking areas may remain in-place, provide it is stable.

Slab subgrades should be prepared in accordance with the Subgrade Preparation and Earthwork Operations section below. Based on the soil type(s) and range of natural moisture contents anticipated to be at or near the design subgrade elevation, floor slabs should be designed assuming a Modulus of Subgrade Reaction ($K_s$) of 75 pounds per cubic inch (pci).

We recommend the slab-on-grade be underlain by a minimum of 4 inches of clean, angular gravel (crushed stone) having a maximum aggregate size of 1.5 inches. VDOT No. 57 Stone is considered suitable for this purpose. This porous fill layer will facilitate the fine grading of the building pad, provide more uniform bearing conditions, and help prevent the rise of water to the bottom of the slab (capillary action). As an alternate, the porous fill layer can consist of 6 inches of Aggregate Base Material. Before placement of concrete, a polyethylene vapor barrier should be placed on top of the granular material in finished building areas to provide additional moisture protection.

We recommend that the floor slab be isolated from the foundation footings so differential settlement of the structure will not induce shear stresses in the floor slab. Also, to reduce the appearance of shrinkage cracks that may develop near the surface of the slab, we recommend that slab reinforcing and control joints be installed in accordance with current American Concrete Institute (ACI) guidelines.

Based on the anticipated finished grade elevations, underdrains for slabs are not considered necessary.

## Drainage

Positive drainage should be provided around the perimeter of the building addition and pavement structures to reduce moisture infiltration into the foundation and/or subgrade soils. We recommend landscaped areas adjacent to the building addition be provided with a fall of least 6 inches for the first 10 feet outward from the building addition. The parking lot, sidewalks, and paved areas should be sloped away from the proposed building addition.

## Seismic Considerations

The 2012 Edition of the International Building Code (IBC) requires that a seismic Site Class be assigned for new structures. The seismic Site Class may be evaluated by calculating a weighted average of the SPT N-values of subsurface materials to a depth of 100 feet. For the evaluation, the N-values recorded in the borings are used for overburden soil, and then, typically, all materials below the depth that HWR or hard rock is encountered (to a depth of 100 feet) are assigned an N-value of 100 bpf.

For this report, the seismic Site Class was evaluated using the SPT N-value method. HWR was encountered in four of the five borings within or immediately adjacent to the proposed building addition footprint, at approximate depths ranging from 14 feet to 17.5 feet below existing grades. Based on this data and that obtained within the overburden soils, along with our experience in the area, we have estimated an average depth to HWR of approximately 15 feet across the site. With this information, a weighted average N-value of less than 50 bpf was calculated, indicating a seismic Site Class D.

Although the SPT N-value method can be relatively conservative, we do not anticipate the seismic Site Class could be improved through the use of alternate methods on this site due to the conditions encountered in the borings.

## Below-Grade Walls

Below-grade walls should be designed to withstand the lateral earth pressures exerted upon them. We recommend that the “At Rest” soil condition be used in the design and evaluation of rigid walls. Site retaining walls which can tolerate free movement at their tops can be designed using “Active” soil conditions. If a keyway is incorporated into the footing design, the “Passive” soil condition can be used for passive resistance; however, any passive resistance acting on the front of the footing should be ignored for design purposes.

In the design of the retaining wall type structures, the following parameters should be utilized for the design of below-grade walls. Two (2) sets of parameters have been provided to allow substitution of compacted stone for the on-site soils if lower earth pressure parameters are required.

| | On-Site Soils | VDOT No. 57 Stone |
|---|---|---|
| Coefficient of Earth Pressure at Rest ($K_o$): | 0.66 | 0.40 |
| Coefficient of Passive Earth Pressure ($K_p$): | 2.04 | 2.04* |
| Coefficient of Active Earth Pressure ($K_a$): | 0.49 | 0.25 |
| Moist unit weight of compacted backfill, $\gamma$: | 125 pcf | 105 pcf |
| Cohesive Strength (C): | 2,000 psf | 0 psf |
| Angle of Internal Friction (Ø): | 20 degrees | 38 degrees |
| Sliding Friction Resistance (Concrete on Soil) | 0.36 | 0.36* |

*Indicates that the parameter is not affected by backfill material.

These soil parameters are considered typical for the existing site soils which would be encountered in excavations and/or utilized for backfill. It is noted that increased lateral pressures generated by surcharge loads should be considered in the design.

The footings for retaining walls can be evaluated using a net allowable soil pressure of 3,000 psf. Maximum toe pressures should not exceed 3,500 psf. Furthermore, the resultant of the soil pressure distribution across the width of the footing should pass through the center third of the footing cross section.

Drainage behind retaining walls is considered essential towards relieving hydrostatic pressures. Drainage can be established by providing a perimeter drainage system located just above the retaining wall footing with discharge by gravity flow to a suitable outlet. This system should consist of a perforated pipe or porous-wall, closed-joint drain tiles. These drain lines should be surrounded by a minimum of 6 inches of free-draining, granular filter material having a gradation compatible with the size of the openings utilized in the drain lines and the surrounding soils to be retained, or by gravel wrapped in filter fabric. The space between the face of the retaining wall and the original earth face should be backfilled with a granular material of porous fill quality or better extending from the perimeter drainage system to near the top of the wall. In order to prevent frost heave effects from acting against these walls, the granular backfill should extend horizontally a minimum of 18 inches behind the wall. In landscaped areas, the upper 18 inches of backfill behind the retaining wall should consist of a relatively impermeable compacted clay cap. Prefabricated wall drainage products, which satisfy the drainage criteria outlined above, are considered an acceptable alternative to granular backfill.

## Subgrade Preparation and Earthwork Operations

The near-surface clays and silts at the site are moisture-sensitive, will be difficult to adequately compact, and are subject to excessive deflection under wheel loads when they are wet. To reduce the potential for moisture-related soil problems, we recommend that site grading operations be performed during the typically drier months of the year (May through October). If this is not possible, substantial undercutting of these soils could be required to achieve stable subgrade conditions.

Prior to proceeding with construction, all topsoil and asphalt should be stripped from the proposed construction limits. Stripping should be accomplished a minimum distance of 5 feet outside the building lines and 2 feet beyond curb lines. As stated previously, any stone subbase beneath existing asphalt areas that will remain parking areas may remain in-place, provide it is stable.

After stripping to the desired grade and prior to fill placement or foundation and new pavement construction, the stripped surface should be observed by an experienced geotechnical engineer or his authorized representative. Proofrolling using a 10-ton drum roller or a loaded, tandem-axle dump truck having an axle weight of at least 10 tons should be used at this time to aid in identifying localized soft or unsuitable material. Any soft or unsuitable materials encountered during this proofrolling should be removed and replaced with engineered fill. The excavation and backfilling should be observed by a representative of the geotechnical engineer so that excessive or inadequate removal of material can be avoided.

Following stripping, proofrolling, and subgrade preparation procedures, engineered fill can be placed. Fill used to support buildings and pavements should be placed in lifts not exceeding 8 inches in loose thickness, moisture conditioned to within +/- 3% of the optimum moisture content, and compacted to at least 95% of the maximum dry density obtained in accordance with ASTM Specification D 698, Standard Proctor Method.

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 5,000 square feet in pavement areas.

The following fill types are recommended for use on this project:

**Engineered Fill:** All low-plasticity on-site soils which are free of organics and other deleterious, non-soil materials. If off-site borrow is required, imported material should classify as CL, ML, SM, SC, SP, or better. Suitable imported material should have a maximum Liquid Limit of 50 and maximum Plasticity Index of 25. Maximum aggregate size for all materials should be limited to 4 inches. It is noted that some of the on-site soils are above optimum moisture, which will require significant drying methods (i.e. scarifying, placing lime, etc.) to facilitate proper compaction.

**Porous Fill:** Clean crushed gravel (VDOT No. 57 Stone) with a maximum aggregate size of 1.5 inches placed in a minimum 4-inch-thick layer or Aggregate Base Material placed and compacted in a minimum 6-inch-thick layer.

**Aggregate Base:** Aggregate Base Material Type I, Size 21-A.

## Slope Design and Construction

Our exploration did not include a slope stability analysis. However, in general, we anticipate that the soils available for use as engineered fill will consist of clay and silt. Temporary and permanent cut slopes for the project should be designed at grades no steeper than 2H:1V. If seepage water is noted along slope faces during construction, the geotechnical engineer should be contacted for further evaluation and recommendations for seepage control and possible revisions to these recommendations.

Given the cohesive nature of the on-site soils, fill slopes may be designed for grades no steeper than 2H:1V. If cohesionless materials are used for fill, we recommend that slopes be maintained no steeper than 3H:1V.

It is noted that loose soils along the slope face at these grades will be unstable, increasing the potential for chronic maintenance issues or possible impact to site improvements or structures along the slope crest. In order to reduce the potential for surficial instability, it is critical all soil along the face of the slope be placed and compacted in accordance with our previous recommendations. This is often accomplished by constructing the fill slope on benches to allow safe equipment access. During placement, each compacted lift should extend beyond the design slope face, and then be cut back after compaction to the design grade.

## Exterior Pavements

For the design and construction of exterior pavements, we recommend preparation of the site as outlined in the Subgrade Preparation and Earthwork Operations section of this report. The stripped surfaces should be proofrolled and carefully observed at the time of construction in order to aid in identifying any localized soft or unsuitable materials which should be removed. A geotechnical engineer or qualified soil technician should be present at the time of proofrolling and subgrade inspections.

Some risk is involved in leaving the existing fill in place, although based on our exploration it is our opinion that the risk is relatively low. This risk can be eliminated if the existing fill is completely removed and replaced with engineered fill; otherwise, the Owner must be willing to accept some risk of future pavement distress. In areas where the cost consequences tend to be less (i.e. paved areas), taking the risks associated with undocumented fill and being prepared to make repairs later, if required, is sometimes a cost effective approach. Once the relating facts to undocumented fill are disclosed, the level of risk appropriate becomes a business decision that only the Owner can make.

An important consideration with the design and construction of pavements is surface and subsurface drainage, in particular given the characteristics of the on-site soils. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the deterioration of the pavement can be expected. Furthermore, good drainage should minimize the possibility of the subgrade materials becoming saturated over a long period of time.

The materials which will be present at planned subgrade will likely consist of CH-type soils. Our measured laboratory California Bearing Ratio (CBR) value was 4.7. Based on our experience with similar soils, we recommend utilizing two-thirds of this value, or 3.2, for pavement design. Applying this value and the equivalent 18 kip axle loads ($EAL_{18}$) shown, we recommend the following pavement sections:

**Flexible Pavement**

| | Light-Duty Pavement ($EAL_{18}$= 9,000) | Heavy-Duty Pavement ($EAL_{18}$= 80,000) |
|---|---|---|
| Surface Course | 2” | 2” |
| Intermediate Course | - | 2” |
| Dense Graded Stone | 8” | 8” |

**Rigid Pavement**

| | Light-Duty Pavement ($EAL_{18}$= 9,000) | Heavy-Duty Pavement ($EAL_{18}$=80,000) |
|---|---|---|
| Concrete (f’c = 4000 psi) | 4” | 6” |
| Dense Graded Stone | 6” | 6” |

Materials and placement procedures should be in accordance with current Virginia Department of Transportation (VDOT) Road and Bridge Specifications. Rigid pavement should be provided with adequate joints and reinforcing to prevent distress and minimize shrinkage cracking. Air entrainment should be considered for exterior concrete areas to ensure durability and performance.

Large, front loading trash trucks frequently impose concentrated front-wheel loads on pavements during loading. This type of loading typically results in rutting of the pavement and ultimately pavement failures; therefore, we recommend that the pavement in trash pickup areas consist of an 8-inch-thick concrete slab, underlain by 6 inches of compacted dense-graded aggregate. The slab should be sized to include both the dumpster and the entire truck.

## Rock Excavation

Rock excavation should not be anticipated during mass grading or confined excavations for footings and utilities. As indicated on the enclosed boring logs, none the borings refused on hard rock at or within any anticipated undercut zone, below existing grades. However, subsurface conditions may vary intermediate of the borings and in unexplored areas.

For removal of hard rock, ripping is typically practical with specialized equipment for excavations extending down to levels corresponding to SPT N-values of about 100 bpf of sampler penetration. For general excavations below this level, HWR and hard rock requiring hoe-ramming or blasting for removal is normally required. However, given the proximity of the project to existing development, blasting is not a feasible option.

## Construction Considerations

Exposure to the environment may weaken the soils at the footing bearing level if the foundation excavations remain open for too long a time. Therefore, foundation concrete should be placed the same day that excavations are made. If the bearing soils are softened by surface water intrusion or exposure, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete. If the excavation must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, we recommend that a 1- to 3-inch-thick "mud mat" or "lean" concrete be placed on the bearing soils before the placement of reinforcing steel.

In a dry and undisturbed state, the subgrade soils at the site will provide moderate subgrade support for fill placement and construction operations. However, when wet, these soils will degrade quickly with disturbance from contractor operations. Therefore, good site drainage should be maintained during earthwork operations so as to help maintain the stability of the soils. It should be incumbent on the contractor to protect all subgrades from damage due to construction, or to repair all damaged subgrades.

It is considered essential that any existing fills be evaluated at the time of construction. Where observed to be unstable, they should be undercut from below building and pavement areas at the direction of the geotechnical engineer.

## CLOSING

The recommendations contained herein were developed from the data obtained in the soil test borings, which indicate subsurface conditions at specific locations at the time of exploration. Soil conditions may vary between the 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 the information provided and on building design criteria considered typical for this type of structure. Should structural loading characteristics differ from those discussed herein, ECS should be contacted for review of these conditions and possible revisions to the recommendations of this report.

We have appreciated the opportunity to be of service to you. If you have any questions with regard to the information and recommendations contained in this report, or if we can be of further assistance to you during construction, please do not hesitate to contact us.

Respectfully,

**ECS MID-ATLANTIC, LLC**

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# APPENDIX

Site Location Map (Figure 1)

Boring Location Diagram (Figure 2)

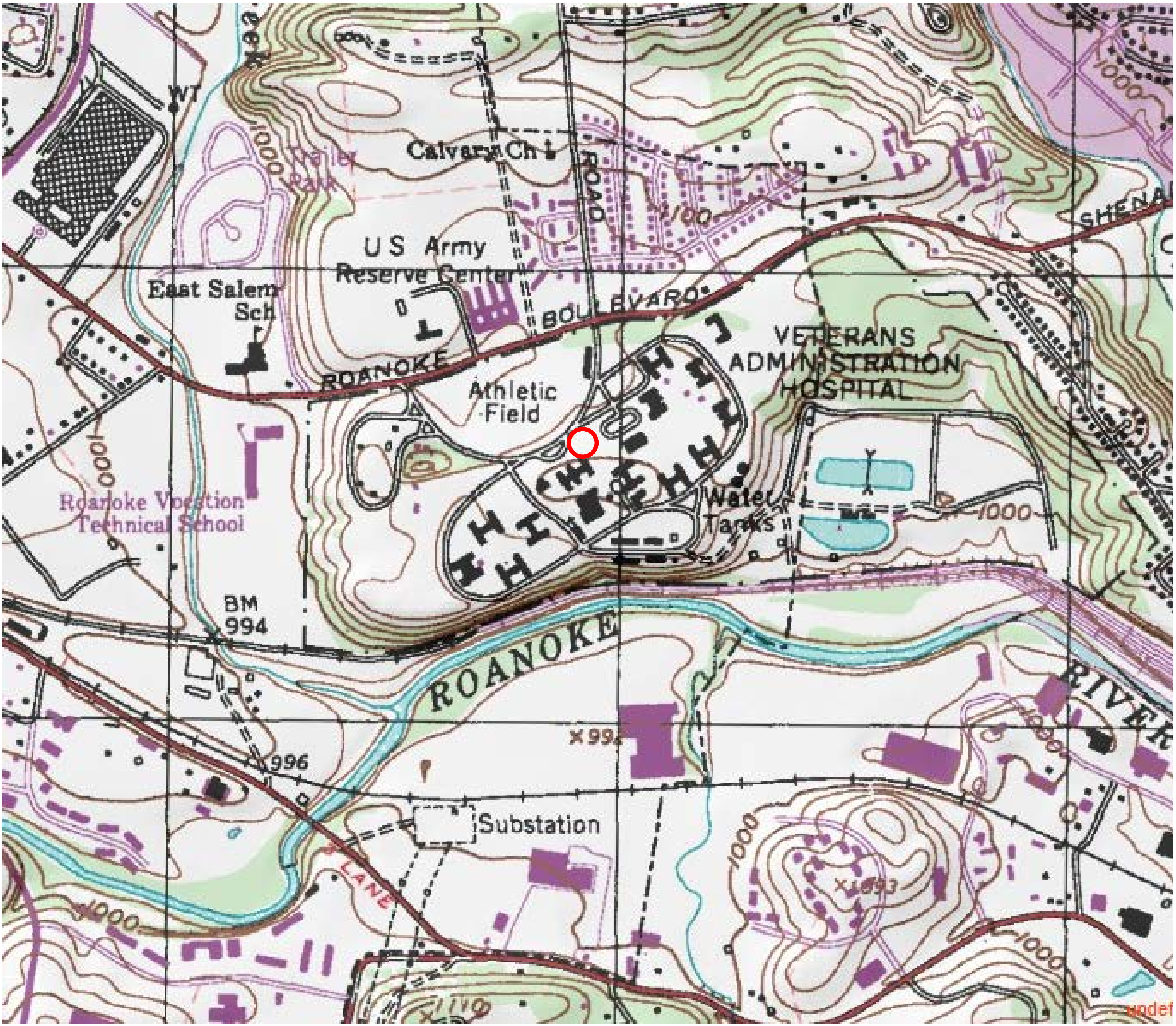
Aerial Boring Location Diagram (Figure 3)

Unified Soil Classification System (USCS)

Reference Notes for Boring Logs

Boring Logs B-1 through B-5

Summary of Laboratory Test Data



**LEGEND**

○ - Approximate Site Location

SCALE (IN FEET)

AS SHOWN

SOURCE:

MYTOPO.COM

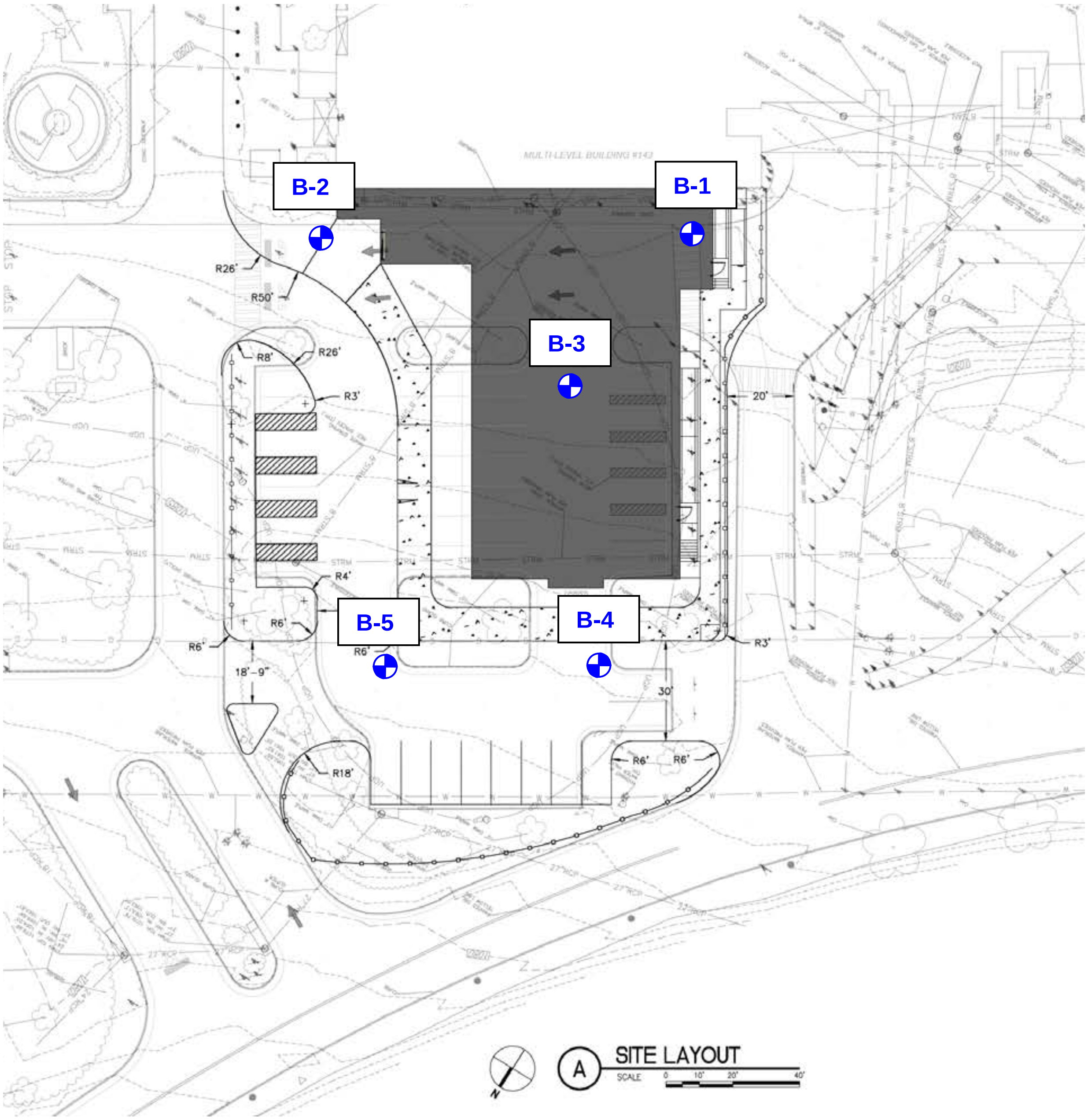
DATED:

2014

FIGURE 1

SITE LOCATION MAP
VAMC SALEM - EMERGENCY
DEPARTMENT EXPANSION &
RENOVATION
1970 ROANOKE BOULEVARD
SALEM, VIRGINIA 24153

ECS PROJECT NO. 12:7952



**LEGEND**

⊕ - Approximate Boring Location

50-SCALE:

1 UNIT ~ 1 FOOT

SOURCE:

ATRIAX GROUP, PLLC

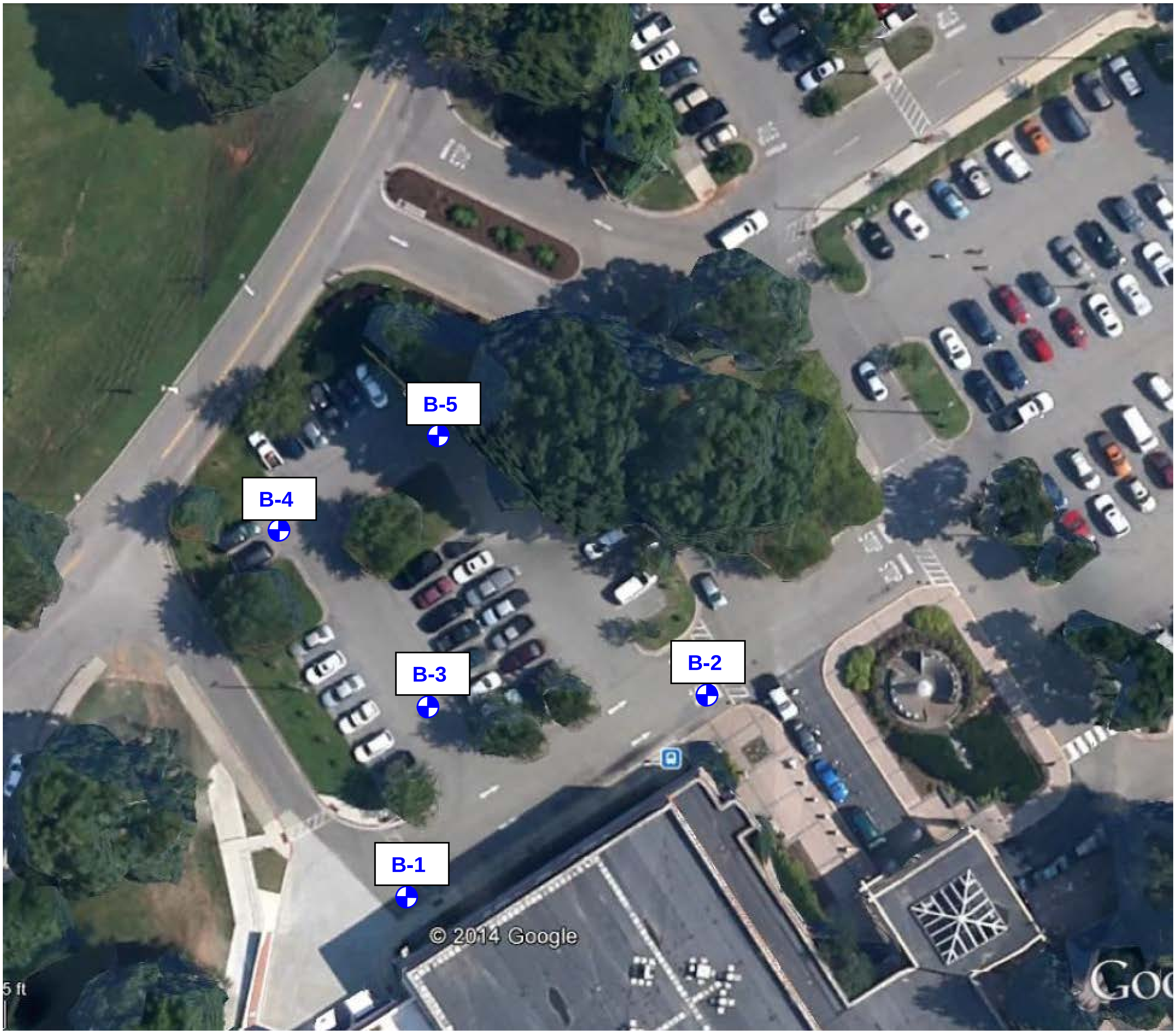
DATED:

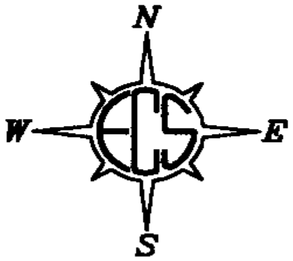
12/03/2014

FIGURE 2

BORING LOCATION DIAGRAM
VAMC SALEM EMERGENCY DEPARTMENT
EXPANSION & RENOVATION
1970 ROANOKE BOULEVARD
SALEM, VIRGINIA 24153

ECS PROJECT NO. 12:7952





**LEGEND**

⊕ - Approximate Boring Location

SCALE:

AS SHOWN

SOURCE:

GOOGLE EARTH

DATED:

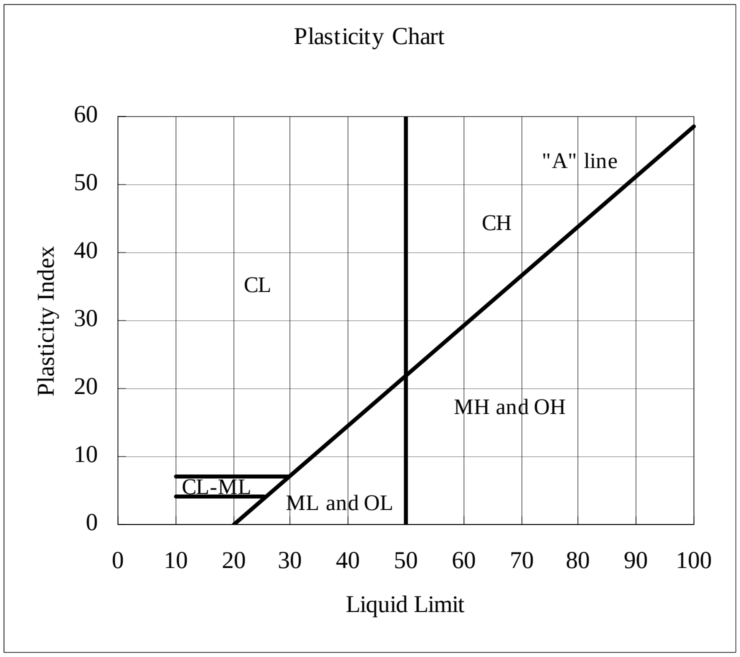
2014

FIGURE 3

AERIAL BORING LOCATION DIAGRAM
VAMC SALEM EMERGENCY DEPARTMENT
EXPANSION & RENOVATION
1970 ROANOKE BOULEVARD
SALEM, VIRGINIA 24153

ECS PROJECT NO. 12:7952

# UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

| Major Divisions | | | Group Symbols | | Typical Names | Laboratory Classification Criteria | | |
|---|---|---|---|---|---|---|---|---|
| Coarse-grained soils (More than half of material is larger than No. 200 Sieve size) | Gravels (More than half of coarse fraction is larger than No. 4 sieve size) | Clean gravels (Little or no fines) | GW | | Well-graded gravels, gravel-sand mixtures, little or no fines | Determine percentages of sand and gravel from grain-size curve.<br>Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:<br>Less than 5 percent GW, GP, SW, SP<br>More than 12 percent GM, GC, SM, SC<br>5 to 12 percent Borderline cases requiring dual symbols [b] | $C_u = D_{60}/D_{10}$ greater than 4<br>$C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3 | |
| | | | GP | | Poorly graded gravels, gravel-sand mixtures, little or no fines | | Not meeting all gradation requirements for GW | |
| | | Gravels with fines (Appreciable amount of fines) | GM[a] | d | Silty gravels, gravel-sand mixtures | | Atterberg limits below "A" line or P.I. less than 4 | Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols |
| | | | | u | | | | |
| | | | GC | | Clayey gravels, gravel-sand-clay mixtures | | Atterberg limits below "A" line or P.I. less than 7 | |
| | Sands (More than half of coarse fraction is smaller than No. 4 sieve size) | Clean sands (Little or no fines) | SW | | Well-graded sands, gravelly sands, little or no fines | | $C_u = D_{60}/D_{10}$ greater than 6<br>$C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3 | |
| | | | SP | | Poorly graded sands, gravelly sands, little or no fines | | Not meeting all gradation requirements for SW | |
| | | Sands with fines (Appreciable amount of fines) | SM[a] | d | Silty sands, sand-silt mixtures | | Atterberg limits above "A" line or P.I. less than 4 | Limits plotting in CL-ML zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols |
| | | | | u | | | | |
| | | | SC | | Clayey sands, sand-clay mixtures | | Atterberg limits above "A" line with P.I. greater than 7 | |
| Fine-grained soils (More than half material is smaller than No. 200 Sieve) | Silts and 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 and 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 of medium to high plasticity, organic silts | | | |
| | Highly Organic soils | | Pt | | Peat and other highly organic soils | | | |

[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

[b] Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC,well-graded gravel-sand mixture with clay binder. (From Table 2.16 - Winterkorn and Fang, 1975)

# REFERENCE NOTES FOR BORING LOGS

## I. Drilling Sampling Symbols

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

## II. Correlation of Penetration Resistances to Soil Properties

Standard Penetration (blows/ft) refers to the blows per foot of a 140 lb. hammer falling 30 inches on a 2-inch OD split-spoon sampler, as specified in ASTM D 1586. The blow count is commonly referred to as the N-value.

### A. Non-Cohesive Soils (Silt, Sand, Gravel and Combinations)

| *Density* | | *Relative Properties* | |
|---|---|---|---|
| Under 4 blows/ft | Very Loose | Adjective Form | 12% to 49% |
| 5 to 10 blows/ft | Loose | With | 5% to 12% |
| 11 to 30 blows/ft | Medium Dense | | |
| 31 to 50 blows/ft | Dense | | |
| Over 51 blows/ft | Very Dense | | |

| *Particle Size Identification* | | |
|---|---|---|
| Boulders | | 8 inches or larger |
| Cobbles | | 3 to 8 inches |
| Gravel | Coarse | 1 to 3 inches |
| | Medium | ½ to 1 inch |
| | Fine | ¼ to ½ inch |
| Sand | Coarse | 2.00 mm to ¼ inch (dia. of lead pencil) |
| | Medium | 0.42 to 2.00 mm (dia. of broom straw) |
| | Fine | 0.074 to 0.42 mm (dia. of human hair) |
| Silt and Clay | | 0.0 to 0.074 mm (particles cannot be seen) |

### B. Cohesive Soils (Clay, Silt, and Combinations)

| *Blows/ft* | *Consistency* | *Unconfined Comp. Strength $Q_p$ (tsf)* | *Degree of Plasticity* | *Plasticity Index* |
|---|---|---|---|---|
| Under 2 | Very Soft | Under 0.25 | None to slight | 0 – 4 |
| 3 to 4 | Soft | 0.25-0.49 | Slight | 5 – 7 |
| 5 to 8 | Medium Stiff | 0.50-0.99 | Medium | 8 – 22 |
| 9 to 15 | Stiff | 1.00-1.99 | High to Very High | Over 22 |
| 16 to 30 | Very Stiff | 2.00-3.00 | | |
| 31 to 50 | Hard | 4.00–8.00 | | |
| Over 51 | Very Hard | Over 8.00 | | |

## III. Water Level Measurement Symbols

| | | | | | |
|---|---|---|---|---|---|
| WL | Water Level | BCR | Before Casing Removal | DCI | Dry Cave-In |
| WS | While Sampling | ACR | After Casing Removal | WCI | Wet Cave-In |
| WD | While Drilling | ▽ | Est. Groundwater Level | ▼ | Est. Seasonal High GWT |

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 a granular soil. In clay and plastic silts, the accurate determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally applied.

CLIENT Atriax Group, PLLC
JOB # 12:7952
BORING # B-1
SHEET 1 OF 1
PROJECT NAME VAMC Salem - Emergency Department Expansion & Renovation
ARCHITECT-ENGINEER Atriax Group, PLLC
SITE LOCATION 1970 Roanoke Boulevard, Salem, Virginia
NORTHING
EASTING
STATION

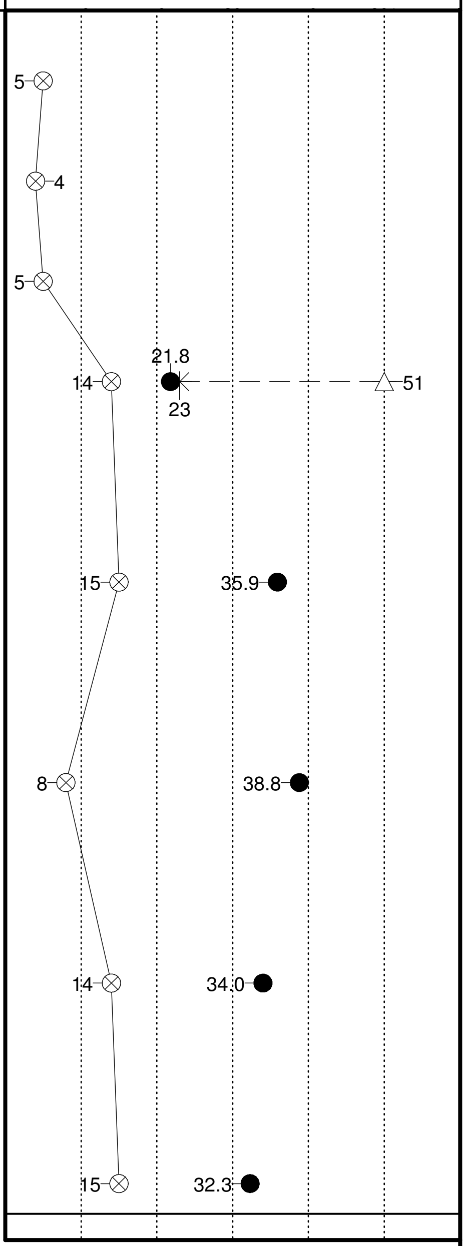
-○- CALIBRATED PENETROMETER TONS/FT²

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 ENGLISH UNITS<br>BOTTOM OF CASING LOSS OF CIRCULATION<br>SURFACE ELEVATION | WATER LEVELS | ELEVATION (FT) | BLOWS/6" |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | Asphalt Depth [4"] | | | |
| | | | | | ABC Stone Depth [7"] | | | |
| | S-1 | SS | 18 | 7 | (MH POSSIBLE FILL) ELASTIC SILT WITH SAND, Trace Clay, Red and Brown, Moist, Medium Stiff to Soft | | | 3<br>2<br>3 |
| | S-2 | SS | 18 | 9 | | | | 2<br>2<br>2 |
| 5 | | | | | | | | |
| | S-3 | SS | 18 | 8 | | | | 2<br>2<br>3 |
| | | | | | (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow, Moist, Stiff | | | |
| | S-4 | SS | 18 | 12 | | | | 5<br>7<br>7 |
| 10 | | | | | | | | |
| | S-5 | SS | 18 | 18 | | | | 3<br>7<br>8 |
| 15 | | | | | | | | |
| | | | | | (MH) ELASTIC SILT WITH SAND, Trace Clay, Orange-Yellow and Brown, Moist, Medium Stiff to Stiff | | | |
| | S-6 | SS | 18 | 18 | | | | 2<br>4<br>4 |
| 20 | | | | | | | | |
| | S-7 | SS | 18 | 13 | | | | 2<br>6<br>8 |
| 25 | | | | | | | | |
| | S-8 | SS | 18 | 10 | | | | 4<br>7<br>8 |
| 30 | | | | | BORING TERMINATED @ 30.0' | | | |



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

WL DRY WS ☐ WD ☐
BORING STARTED 12/12/14
WL(BCR) WL(ACR)
BORING COMPLETED 12/12/14
CAVE IN DEPTH @ 17.2'
WL
RIG BK51 Truck FOREMAN BRD / Smith
DRILLING METHOD 2.25" HSA

| | | | |
|---|---|---|---|
| CLIENT<br>Atriax Group, PLLC | JOB #<br>12:7952 | BORING #<br>B-2 | SHEET<br>1 OF 1 |
| PROJECT NAME<br>VAMC Salem - Emergency Department Expansion & Renovation | ARCHITECT-ENGINEER<br>Atriax Group, PLLC | | |
| SITE LOCATION<br>1970 Roanoke Boulevard, Salem, Virginia | | | |
| NORTHING | EASTING | STATION | |

-○- CALIBRATED PENETROMETER TONS/FT$^2$

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

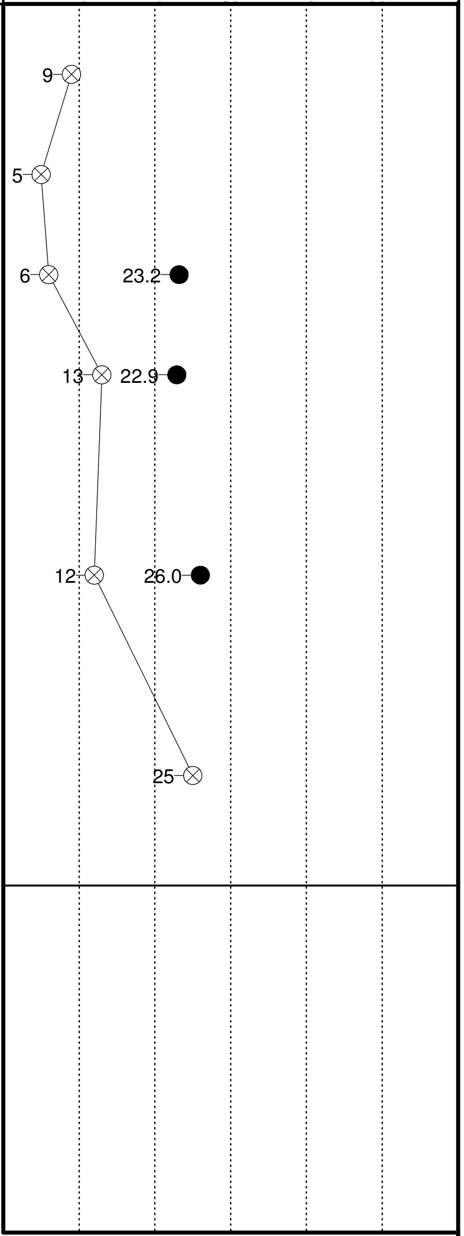
PLASTIC LIMIT% ✕ — WATER CONTENT% ● — LIQUID LIMIT% △

⊗ STANDARD PENETRATION BLOWS/FT

BOTTOM OF CASING ➤   LOSS OF CIRCULATION

SURFACE ELEVATION

| DEPTH (FT) | SAMPLE NO. | SAMPLE TYPE | SAMPLE DIST. (IN) | RECOVERY (IN) | DESCRIPTION OF MATERIAL (ENGLISH UNITS) | WATER LEVELS | ELEVATION (FT) | BLOWS/6" |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | Asphalt Depth [4"] | | | |
| | | | | | ABC Stone Depth [5"] | | | |
| | S-1 | SS | 18 | 9 | (CH POSSIBLE FILL) FAT CLAY WITH SAND, Contains Slight Rock Fragments, Red and Brown, Moist, Stiff to Medium Stiff | | | 8<br>5<br>4 |
| | S-2 | SS | 18 | 7 | | | | 3<br>2<br>3 |
| 5 | | | | | (MH) ELASTIC SILT WITH SAND, Trace Clay, Orange-Brown, Moist, Medium Stiff | | | |
| | S-3 | SS | 18 | 10 | | | | 4<br>3<br>3 |
| | | | | | (CL) LEAN CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow, Moist, Stiff to Very Stiff | | | |
| | S-4 | SS | 18 | 11 | | | | 2<br>5<br>8 |
| 10 | | | | | | | | |
| | S-5 | SS | 18 | 18 | | | | 2<br>5<br>7 |
| 15 | | | | | | | | |
| | S-6 | SS | 18 | 18 | | | | 8<br>12<br>13 |
| 20 | | | | | | | | |
| | | | | | AUGER REFUSAL @ 22.0' | | | |
| 25 | | | | | | | | |
| 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 12/04/14 | |
| WL(BCR)   WL(ACR) | BORING COMPLETED 12/04/14 | CAVE IN DEPTH @ 13.6' |
| WL | RIG BK51 Truck   FOREMAN BRD / Smith | DRILLING METHOD 2.25" HSA |

CLIENT
Atriax Group, PLLC

JOB #
12:7952

BORING #
B-3

SHEET
1 OF 1

PROJECT NAME
VAMC Salem - Emergency Department Expansion & Renovation

ARCHITECT-ENGINEER
Atriax Group, PLLC

SITE LOCATION
1970 Roanoke Boulevard, Salem, Virginia

NORTHING

EASTING

STATION

-○- CALIBRATED PENETROMETER TONS/FT$^2$

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

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

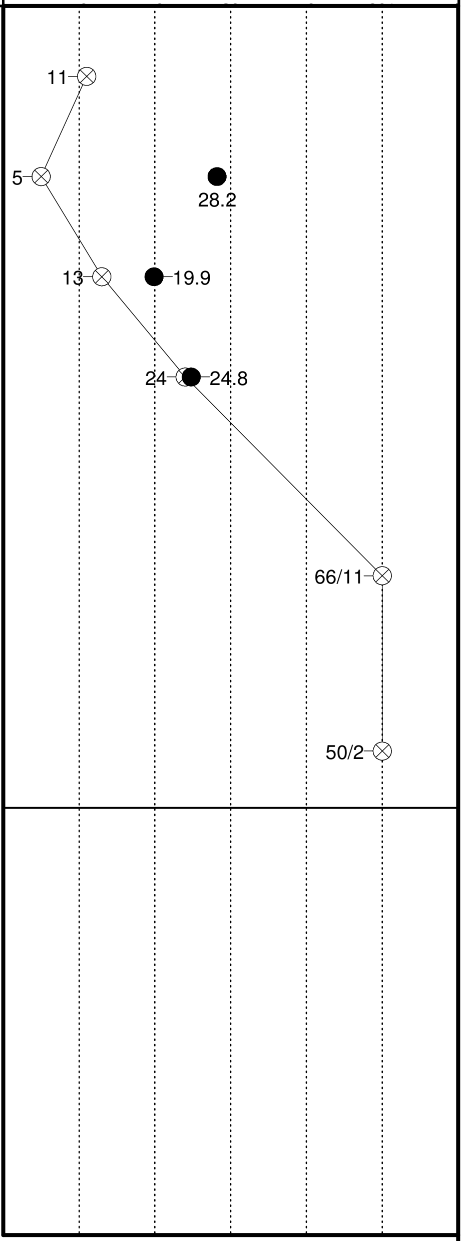
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION

| DEPTH (FT) | SAMPLE NO. | SAMPLE TYPE | SAMPLE DIST. (IN) | RECOVERY (IN) | DESCRIPTION OF MATERIAL | WATER LEVELS | ELEVATION (FT) | BLOWS/6" |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | Asphalt Depth [4"] | | | |
| | | | | | ABC Stone Depth [5"] | | | |
| | S-1 | SS | 18 | 12 | (CH PROBABLE FILL) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Orange, Moist, Stiff to Medium Stiff | | | 5<br>6<br>5 |
| | S-2 | SS | 18 | 10 | | | | 3<br>2<br>3 |
| 5 | | | | | (CL) LEAN CLAY WITH SAND, Trace Silt, Red and Brown, Moist, Stiff to Very Stiff | | | |
| | S-3 | SS | 18 | 13 | | | | 3<br>5<br>8 |
| | S-4 | SS | 18 | 17 | | | | 6<br>10<br>14 |
| 10 | | | | | | | | |
| | S-5 | SS | 17 | 15 | (CL) HIGHLY WEATHERED ROCK SAMPLED AS SANDY LEAN CLAY, Trace Silt, Contains Rock Fragments, Red-Brown and Orange, Moist, Very Hard | | | 6<br>16<br>50/5 |
| 15 | | | | | | | | |
| | S-6 | SS | 2 | 0 | | | | 50/2 |
| 20 | | | | | AUGER REFUSAL @ 20.0' | | | |
| 25 | | | | | | | | |
| 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 12/04/14 | |
| WL(BCR) WL(ACR) | BORING COMPLETED 12/04/14 | CAVE IN DEPTH @ 17.2' |
| WL | RIG BK51 Truck FOREMAN BRD / Smith | DRILLING METHOD 2.25" HSA |

| CLIENT | JOB # | BORING # | SHEET |
|---|---|---|---|
| Atriax Group, PLLC | 12:7952 | B-4 | 1 OF 1 |

PROJECT NAME
VAMC Salem - Emergency Department Expansion & Renovation

ARCHITECT-ENGINEER
Atriax Group, PLLC

SITE LOCATION
1970 Roanoke Boulevard, Salem, Virginia

NORTHING
EASTING
STATION

-○- CALIBRATED PENETROMETER TONS/FT$^2$

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

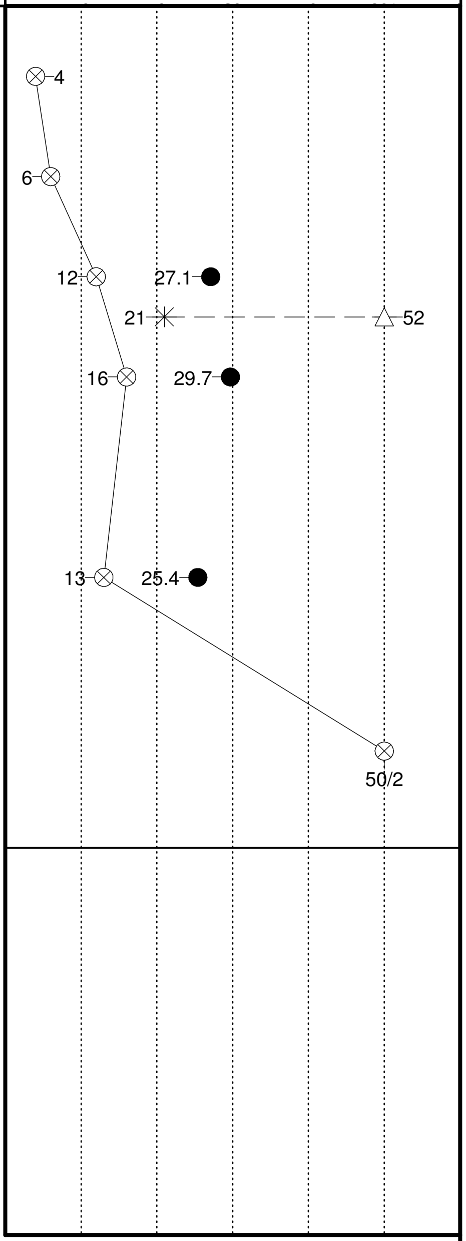
PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS
BOTTOM OF CASING
LOSS OF CIRCULATION 100%
SURFACE ELEVATION

| SAMPLE NO. | SAMPLE TYPE | SAMPLE DIST. (IN) | RECOVERY (IN) | DESCRIPTION OF MATERIAL | WATER LEVELS | ELEVATION (FT) | BLOWS/6" |
|---|---|---|---|---|---|---|---|
| | | | | Asphalt Depth [4"] | | | |
| | | | | ABC Stone Depth [5"] | | | |
| S-1 | SS | 18 | 17 | (CH FILL) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments and Roots, Red and Brown, Moist, Soft to Medium Stiff | | | 3<br>2<br>2 |
| S-2 | SS | 18 | 6 | | | | 2<br>3<br>3 |
| S-3 | SS | 18 | 11 | (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments and Roots, Red and Brown, Moist, Stiff to Very Stiff | | | 3<br>4<br>8 |
| CBR-1 | BLK | 54 | | | | | |
| S-4 | SS | 18 | 10 | | | | 3<br>7<br>9 |
| S-5 | SS | 18 | 14 | (CL) LEAN CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red and Orange-Brown, Moist, Stiff | | | 3<br>7<br>6 |
| S-6 | SS | 2 | 0 | (CL) HIGHLY WEATHERED ROCK SAMPLED AS SANDY LEAN CLAY, Trace Silt, Contains Rock Fragments, Red-Brown and Orange, Moist, Very Hard | | | 50/2 |
| | | | | AUGER REFUSAL @ 21.0' | | | |

DEPTH (FT) 0 5 10 15 20 25 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 12/04/14 | |
| WL(BCR) WL(ACR) | BORING COMPLETED 12/04/14 | CAVE IN DEPTH @ 11.9' |
| WL | RIG BK51 Truck FOREMAN BRD / Smith | DRILLING METHOD 2.25" HSA |

| | | | |
|---|---|---|---|
| CLIENT<br>Atriax Group, PLLC | JOB #<br>12:7952 | BORING #<br>B-5 | SHEET<br>1 OF 1 |
| PROJECT NAME<br>VAMC Salem - Emergency Department Expansion & Renovation | ARCHITECT-ENGINEER<br>Atriax Group, PLLC | | |
| SITE LOCATION<br>1970 Roanoke Boulevard, Salem, Virginia | | | |
| NORTHING | EASTING | STATION | |

-○- CALIBRATED PENETROMETER TONS/FT$^2$

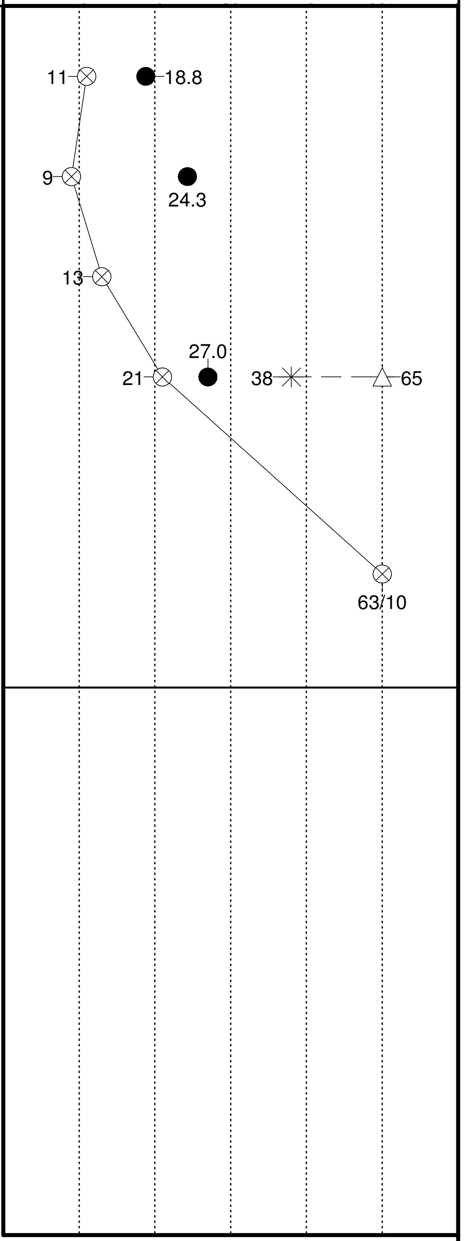
ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –  REC% ———

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL ENGLISH UNITS
BOTTOM OF CASING LOSS OF CIRCULATION
SURFACE ELEVATION

| DEPTH (FT) | SAMPLE NO. | SAMPLE TYPE | SAMPLE DIST. (IN) | RECOVERY (IN) | DESCRIPTION OF MATERIAL | WATER LEVELS | ELEVATION (FT) | BLOWS/6" |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | Asphalt Depth [4"] | | | |
| | | | | | ABC Stone Depth [6"] | | | |
| | S-1 | SS | 18 | 12 | (CL PROBABLE FILL) LEAN CLAY WITH SAND, Contains Slight Rock Fragments and Roots, Red and Brown, Moist, Stiff | | | 7<br>5<br>6 |
| | S-2 | SS | 18 | 9 | | | | 4<br>4<br>5 |
| 5 | | | | | | | | |
| | S-3 | SS | 18 | 1 | | | | 4<br>5<br>8 |
| | | | | | (MH) ELASTIC SILT WITH SAND, Red and Brown, Moist, Very Stiff | | | |
| | S-4 | SS | 18 | 15 | | | | 4<br>8<br>13 |
| 10 | | | | | | | | |
| | S-5 | SS | 16 | 13 | (CL) HIGHLY WEATHERED ROCK SAMPLED AS SANDY LEAN CLAY, Trace Silt, Contains Rock Fragments, Orange-Yellow and Brown, Moist, Very Hard | | | 8<br>13<br>50/4 |
| 15 | | | | | | | | |
| | | | | | AUGER REFUSAL @ 17.0' | | | |
| 20 | | | | | | | | |
| 25 | | | | | | | | |
| 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 12/04/14 | |
| WL(BCR) WL(ACR) | BORING COMPLETED 12/04/14 | CAVE IN DEPTH @ 12.7' |
| WL | RIG BK51 Truck FOREMAN BRD / Smith | DRILLING METHOD 2.25" HSA |

# Laboratory Testing Summary

Page 1 of 1

| Sample Source | Sample Number | Depth (feet) | MC[1] (%) | Soil Type[2] | Atterberg Limits[3] | | | Percent Passing No. 200 Sieve[4] | Moisture - Density (Corr.)[5] | | CBR Value[6] | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | LL | PL | PI | | Maximum Density (pcf) | Optimum Moisture (%) | | |
| B-1 | | | | | | | | | | | | |
| | S-4 | 8.50 - 10.00 | 21.8 | CH | 51 | 23 | 28 | 79 | | | | |
| | S-5 | 13.50 - 15.00 | 35.9 | | | | | | | | | |
| | S-6 | 18.50 - 20.00 | 38.8 | | | | | | | | | |
| | S-7 | 23.50 - 25.00 | 34.0 | | | | | | | | | |
| | S-8 | 28.50 - 30.00 | 32.3 | | | | | | | | | |
| B-2 | | | | | | | | | | | | |
| | S-3 | 6.00 - 7.50 | 23.2 | | | | | | | | | |
| | S-4 | 8.50 - 10.00 | 22.9 | | | | | | | | | |
| | S-5 | 13.50 - 15.00 | 26.0 | | | | | | | | | |
| B-3 | | | | | | | | | | | | |
| | S-2 | 3.50 - 5.00 | 28.2 | | | | | | | | | |
| | S-3 | 6.00 - 7.50 | 19.9 | | | | | | | | | |
| | S-4 | 8.50 - 10.00 | 24.8 | | | | | | | | | |
| B-4 | | | | | | | | | | | | |
| | CBR-1 | 5.5- - 10.00 | | CH | 52 | 21 | 31 | 74 | 102.7 | 21.6 | 4.7 | |
| | S-3 | 6.00 - 7.50 | 27.1 | | | | | | | | | |
| | S-4 | 8.50 - 10.00 | 29.7 | | | | | | | | | |
| | S-5 | 13.50 - 15.00 | 25.4 | | | | | | | | | |
| B-5 | | | | | | | | | | | | |
| | S-1 | 1.00 - 2.50 | 18.8 | | | | | | | | | |
| | S-2 | 3.50 - 5.00 | 24.3 | | | | | | | | | |
| | S-4 | 8.50 - 10.00 | 27.0 | MH | 65 | 38 | 27 | 83 | | | | |

**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.** 12:7952
**Project Name:** VAMC Salem - Emergency Department Expansion & Renovation
**PM:** Trent Fisher, P.G.
**PE:** Stephen Hjelle, P.E.
**Printed On:** Wednesday, December 31, 2014

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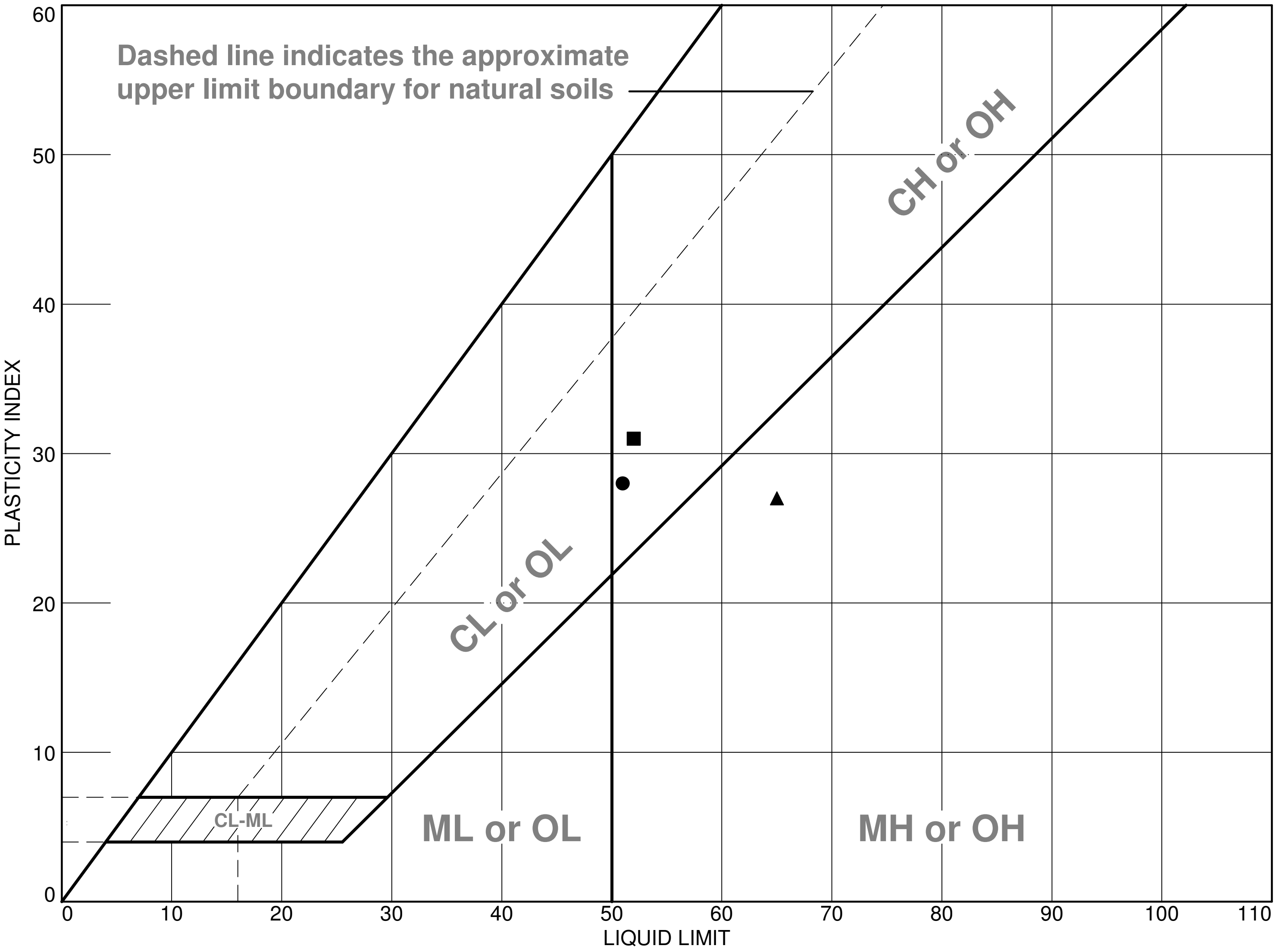
# LIQUID AND PLASTIC LIMITS TEST REPORT



| | MATERIAL DESCRIPTION | LL | PL | PI | %<#40 | %<#200 | USCS |
|---|---|---|---|---|---|---|---|
| ● | (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow | 51 | 23 | 28 | | 79 | CH |
| ■ | (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow | 52 | 21 | 31 | | 74 | CH |
| ▲ | (MH) ELASTIC SILT WITH SAND, Red and Brown | 65 | 38 | 27 | | 83 | MH |
| | | | | | | | |
| | | | | | | | |

**Project No.** 12:7952 **Client:** Atriax Group, PLLC

**Project:** VAMC Salem - Emergency Department Expansion & Renovation

● **Source of Sample:** B-1 **Depth:** 8.50-10.00 **Sample Number:** S-4
■ **Source of Sample:** B-4 **Depth:** 5.5-10.0 **Sample Number:** CBR-1
▲ **Source of Sample:** B-5 **Depth:** 8.50-10.00 **Sample Number:** S-4

**Remarks:**

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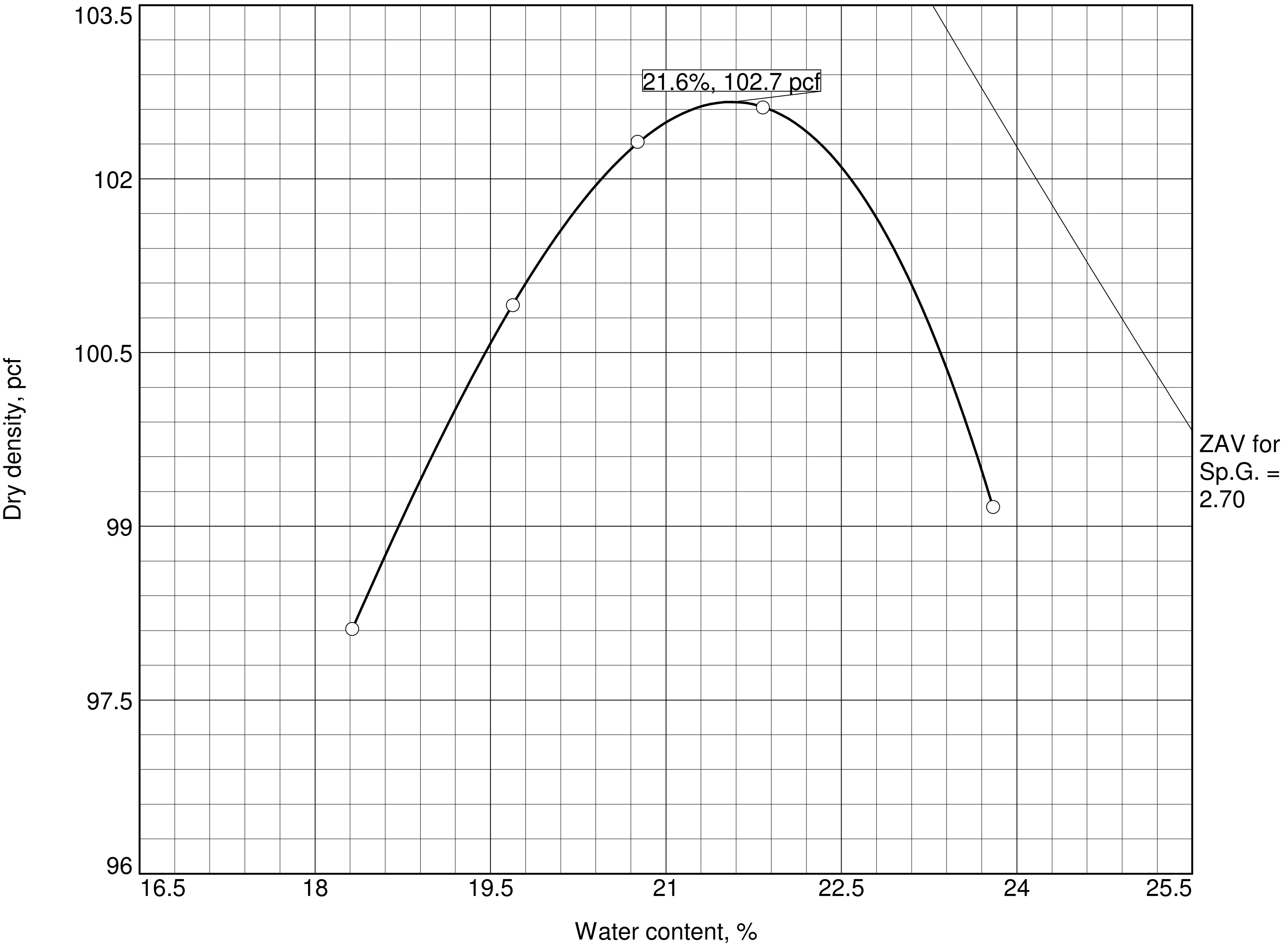
**Figure**



Test specification: ASTM D 698-00a Method A Standard

| Elev/ Depth | Classification |  | Nat. Moist. | Sp.G. | LL | PI | % > #4 | % < No.200 |
|---|---|---|---|---|---|---|---|---|
|  | USCS | AASHTO |  |  |  |  |  |  |
| 5.5-10.0 | CH |  |  | 2.70 | 52 | 31 | 1.3 | 74 |

| TEST RESULTS | MATERIAL DESCRIPTION |
|---|---|
| Maximum dry density = 102.7 pcf<br>Optimum moisture = 21.6 % | (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow |

**Project No.** 12:7952 **Client:** Atriax Group, PLLC

**Project:** VAMC Salem - Emergency Department Expansion & Renovation

**Date:** 12/31/14

○ **Source of Sample:** B-4 **Sample Number:** CBR-1

**Remarks:**

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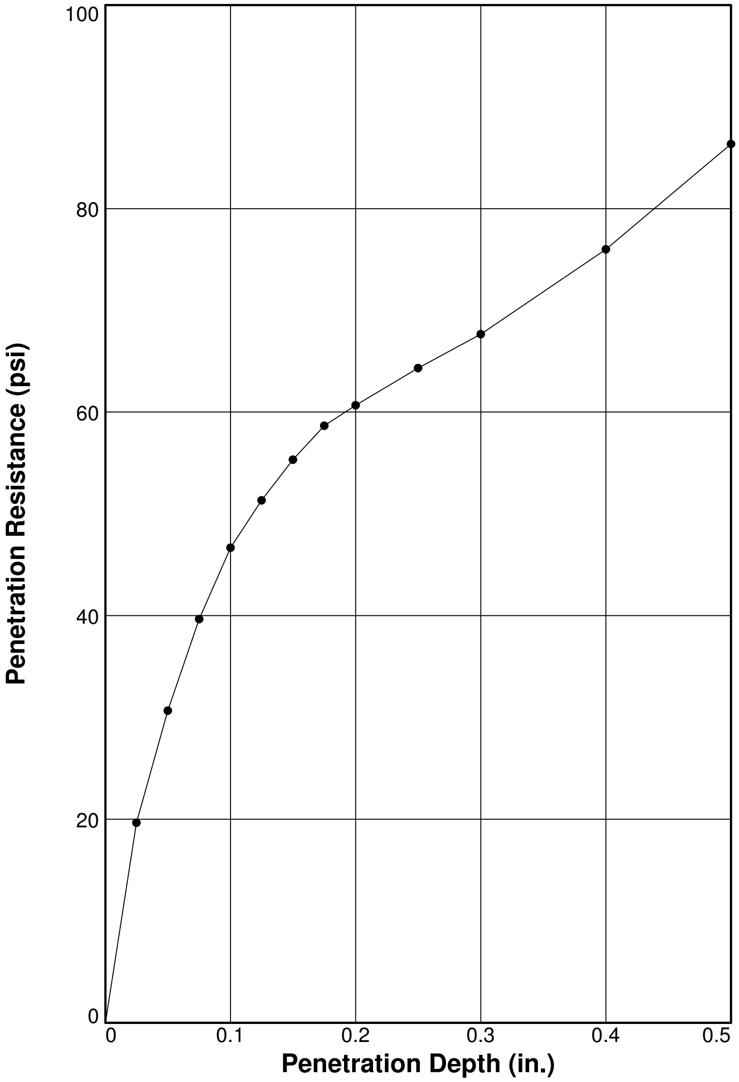
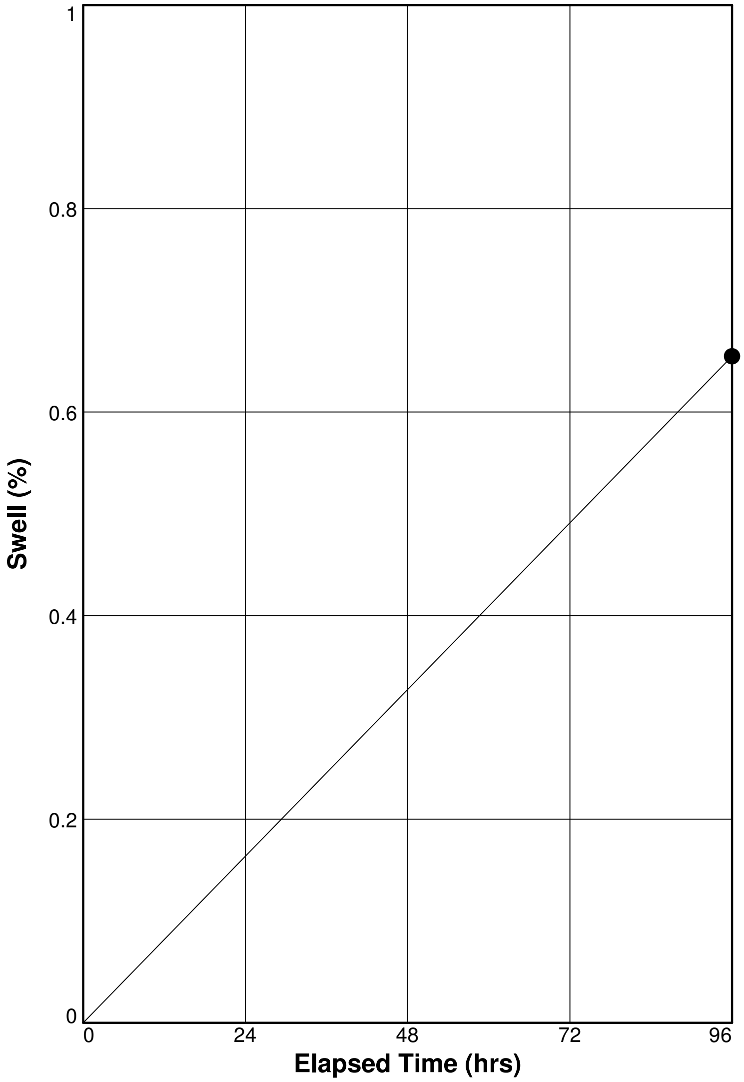
**Figure**

# BEARING RATIO TEST REPORT
## ASTM D 1883-07





| | Molded | | | Soaked | | | CBR (%) | | Linearity Correction (in.) | Surcharge (lbs.) | Max. Swell (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density (pcf) | Percent of Max. Dens. | Moisture (%) | Density (pcf) | Percent of Max. Dens. | Moisture (%) | 0.10 in. | 0.20 in. | | | |
| 1 ● | 100.2 | 97.6 | 19.8 | 99.5 | 96.9 | 43.2 | 4.7 | 4.0 | 0.000 | 10 | 0.7 |
| 2 ▲ | | | | | | | | | | | |
| 3 ■ | | | | | | | | | | | |

| Material Description | USCS | Max. Dens. (pcf) | Optimum Moisture (%) | LL | PI |
|---|---|---|---|---|---|
| (CH) FAT CLAY WITH SAND, Trace Silt, Contains Slight Rock Fragments, Red-Brown and Yellow | CH | 102.7 | 21.6 | 52 | 31 |

**Project No:** 12:7952

**Project:** VAMC Salem - Emergency Department Expansion & Renovation

**Source of Sample:** B-4 **Depth:** 5.5-10.0

**Sample Number:** CBR-1

**Date:** 12/31/14

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**Test Description/Remarks:**

**Figure** ________