GEOTECHNICAL ENGINEERING REPORT

New Boiler Building,
Veterans Administration Medical Center
Salem, Virginia

Schnabel Reference No. 14616014.00
May 6, 2014

Schnabel
ENGINEERING

May 6, 2014

Mr. Robert L. Smith, RA
Harrell, Saltrick & Hopper, P.C.
8016 Tower Point Drive
Charlotte, NC 28227

Subject: **Project No. 14616014.00, Geotechnical Engineering Report, New Boiler Building, Veterans Administration Medical Center, Salem, Virginia**

Dear Mr. Smith:

SCHNABEL ENGINEERING CONSULTANTS, INC. (Schnabel) is pleased to submit our geotechnical engineering report for this project. This study was performed in accordance with our proposal dated June 10, 2013, as authorized by you on February 24, 2014.

EXECUTIVE SUMMARY

This report presents the results of subsurface exploration, laboratory testing, and geotechnical engineering analysis for the proposed New Boiler Building at the Veterans Administration Medical Center in Salem, Virginia.

The project site is underlain by existing fill, natural residual soils, and disintegrated rock. We anticipate that excavated on-site soils should generally be suitable for re-use as compacted structural fill. Very dense disintegrated rock was encountered in five of the borings at approximately El. 1,081 feet to 1,064 feet. Some rock excavation may be required to achieve design grades, particularly at the service tunnel.

Based on the site plans provided to us by your office on April 28, 2014, the proposed boiler building has a finished floor elevation of 1,083 feet. A portion of the structure contains a basement level with a lowest level at 1,065 feet. Considering the existing site grades, we anticipate the building will be founded mostly in cut with some limited fill required. We consider shallow spread footings designed for a net allowable soil bearing pressure of 3,000 psf appropriate for support of the proposed building for foundations founded on suitable natural residual soils, disintegrated rock, or properly compacted structural fill. The existing fill soils are not considered suitable for foundation support and should be undercut and replaced with compacted structural fill where encountered below design bearing grades. Exterior footings should bear at least 24 inches below final exterior grades for frost protection. Floor slabs-on-grade may be designed using a modulus of subgrade reaction, k, of 100 pci. Walls below grade should be backfilled with free draining VDOT No. 57 stone.

We are providing this executive summary solely for purposes of overview. Any party that relies on this report must read the full report. This executive summary omits several details, any one of which could be very important to the proper application of the report.

SCOPE OF SERVICES

Our proposal dated June 10, 2013 defines the scope of services for this project. The scope of services included the following:

- Estimated subsurface conditions and groundwater levels within the area explored based on data collected in the subsurface exploration
- Foundation recommendations for spread footings including a net allowable soil bearing pressure, bearing grades, estimated settlements, minimum dimensions and frost depth
- Recommended Seismic Site Class in accordance with IBC 2009 for use in foundation design based on an extrapolation of data collected in the subsurface exploration
- Recommendations for floor slab support, including a recommended modulus of subgrade reaction for use in slab design
- Earthwork recommendations for construction of load-bearing fill including an assessment of site soils for use as fill, subgrade preparation, and compaction criteria
- Recommended earth pressures, subdrainage, and backfill requirements for basement walls
- Evaluation of rock excavation considerations including a sample definition for rock
- Construction considerations related to the implementation of our recommendations

PROJECT DESCRIPTION

Site Description

The project site is located in the southern portion of the Veterans Administration (VA) Medical Center located on Roanoke Boulevard in Salem, Virginia. Currently, a paved driveway, several parking spaces, and grassy lawn with numerous trees occupy the area of proposed development. An existing building is situated approximately 40 feet away adjacent to the northwest corner of the proposed building. Numerous underground utilities are shown on the site plan provided by your office in the near vicinity of the proposed development including water, gas, electric, and sewer lines. Existing ground surface grades are relatively level in the pavement areas and then slope down to the east. Within the proposed development area, existing ground surface grades vary from about El. 1,085 feet to El. 1,070 feet.

We obtained the site information from the site plan (Sheet AS001) you provided dated April 28, 2014, a publicly available aerial photograph of the site, and through our site visit. A Site Vicinity Map is included as Figure 1.

Proposed Construction

We understand that the project consists of constructing a new boiler building at this site to replace the existing aging boiler building. The main building will be approximately 153 ft by 68 ft in plan dimensions.

The eastern, triangular portion of the building will have a basement level with a finished floor elevation of El. 1,065 ft requiring approximately 5 to 15 feet of cut. The rectangular portion has a finished floor elevation of El. 1,083 ft requiring cuts and fills of 8 feet or less. A service tunnel will extend westward from the basement of the new boiler building.

Column loads generally range from 34 kips to 215 kips, wall loads are on the order of 5 kips per foot, and the slab load is anticipated to be 200 pounds per square foot.

The description of the project as given above is based on the information provided to us at the time this report was prepared. If any changes in the plans for construction occur during the course of the project and if the structural loading varies from what we assumed, we recommend that we be given the opportunity to review these changes in order to determine if modifications to our recommendations are necessary.

We obtained the project information from conversations with your office and the 60% Design Development Submittal plans (Sheets SS101 and SS102), dated April 28, 2014.

Regional Geology

Salem is located within the Appalachian Valley and Ridge Province of Virginia. The exposed rocks of the area consist of Cambrian age sedimentary rocks including shale, siltstone, carbonates and fault breccias. The major structural feature of the area is the Max Meadows Thrust Sheet, where rocks of the Rome formation have been thrust faulted over rock of the younger Elbrook formation. The Rome Formation in the Salem area consists of complexly folded, faulted and fractured shale, siltstone, dolostone and limestone. Residual silt and clay soils overlie these rocks, with alluvial deposits located in the stream valleys and a few isolated occurrences of terrace deposits.

Based on our review of existing geologic data and information in our files, we believe the underlying bedrock across most of the project area consists of interbedded Cambrian-aged shales, siltstones, calcareous shales, and carbonate rock including limestone and dolostone of the Rome formation. Carbonate rocks are prone to dissolution and form a topography widely referred to as karst.

Karst Discussion

The term karst is widely used to describe terrain produced by ground subsidence associated with the dissolution of carbonate rocks. Many karst regions of the world have their distinctive characteristics. The study area is situated in the Appalachian valley karst region. Characteristics of the Appalachian valley karst include sinkholes, sinking streams, underground drainage, caves, highly variable bedrock surface with pinnacles/ledges and troughs, exposed expanses of solution-etched bedrock called karren, linear ledges of bedrock, and high plasticity residual soils. Sinkholes are closed contour depressions formed by subsidence or collapse of soil overburden or bedrock caused by dissolution of the underlying bedrock.

As carbonate rock dissolves, the soluble minerals are carried away by the groundwater, leaving behind the insoluble materials (clay minerals and silicates). The process reduces hard rock into soft soil with the consistency of paste. The rate of rock dissolution is rapid relative to geologic time, but very slow on a human time scale, at only about 2 to 4 mm per century in the Eastern United States (Sowers, 1996). Rock dissolution occurs primarily from the surface downward, and along the surfaces of fissures (joints, bedding planes and fractures) in the rock. The rock fissures are enlarged, creating soil filled troughs and channels surrounded by hard rock. The soil filling is often eroded by flowing groundwater and the troughs and channels become open cavities. These cavities can develop and become interconnected to form caves, which are open conduits for groundwater flow and sediment transport.

As a cavity in the rock grows and expands, the tensile stresses in the roof of the cavity increase, and occasionally the roof will spall slabs of rock and the cavity grows upward toward the ground surface. When a cavity in the rock grows to the point that the roof of rock is too thin or too weak to span the void and support the overburden, the cavity can collapse and form a sinkhole at the ground surface. This type of sinkhole development is a relatively rare occurrence because it is a slow process in terms of human time.

The more common mechanism for sinkhole development is through the erosion of soil overburden into cavities in the underlying rock. This erosion starts at the soil-rock interface over an opening in the bedrock. As soil is carried into the opening by percolating groundwater, a cavity is formed in the soil. This cavity grows as the result of raveling of soil from the roof, and can eventually collapse to the surface causing a sinkhole. This collapse can be caused by the soil overburden weight, new structural loads, vibrations, construction equipment weight and changes in the groundwater levels. Subsurface soil erosion is aggravated by the following hydrologic factors: 1) increasing the infiltration of water at the ground surface; 2) lowering of the groundwater level so as to increase the vertical flow gradient and erosion potential at the critical soil-rock interface; and 3) alternately draining and saturating the soil at the critical soil-rock interface by repeatedly fluctuating the groundwater level from above to below the interface.

Non-carbonate rocks, such as sandstone, granite and schist, weather through chemical and mechanical mechanisms, and leave behind residual soil overburden that decreases in density and hardness with distance from the parent rock. Carbonate rocks, on the other hand, weather predominantly through dissolution, a process that removes a portion of the rock mass and leaves behind only the insoluble material which occupies less volume than the parent rock and as such lacks stiffness, density and structure. Therefore the soils adjacent to the rock surface are soft and paste-like. These soils gain strength over time through the processes of desiccation and consolidation. As discussed previously, carbonate rocks dissolve along joints and fissures, leaving a rock surface that is erratic, with pinnacles of rock cut by soil-filled troughs. Between the pinnacles, soil desiccation and consolidation are inhibited and the soil remains soft and paste-like.

Engineering and Development Implications of Karst

The impact of karst conditions on construction can include: differential settlement of structures due to an irregular bedrock surface blanketed by soft soils; subsurface erosion of soil leading to gradual surface settlement; sudden collapse of soil or rock cavities leading to rapid loss of structural support. The primary potential impact of latent karst features on the proposed development at this site is the loss of structural support beneath the building. The potential for loss of ground support can be reduced by controlling surface runoff during construction and during the life of the structure. By implementing the recommendations included in this report and controlling runoff, the risks can be reduced.

SUBSURFACE EXPLORATION AND LABORATORY TESTING PROGRAM

We performed a subsurface exploration and field testing program to identify the subsurface stratigraphy underlying the site and to evaluate the geotechnical properties of the materials encountered. This program included test borings. Exploration methods used are discussed below. The appendices contain the results of our exploration.

Subsurface Exploration Methods

Test Borings

Schnabel's subcontractor, Blue Ridge Drilling, drilled 10 test borings (including offsets) under our observation between April 14 and April 18, 2014. Boring B-3, the final boring drilled, was abandoned after the drill rig experienced serious mechanical issues. In Boring B-7 and offset Borings B-7A and B-7B, we encountered an obstruction at approximately 14.5 feet (El. 1,065.5 ft). Veteran's Administration personnel were notified and after reviewing the situation, they told our field representative that they were unaware of any underground structures or utilities in this location. As a precaution, we did not attempt to advance past the obstruction in B-7, B-7A, or B-7B.

The Standard Penetration Test (SPT) was performed at selected depths in the borings. Appendix A includes specific observations, remarks, and logs for the borings; classification criteria; drilling methods; and sampling protocols. Figure 2 (included at the end of this report) indicates the approximate test boring locations. We will retain soil samples up to 45 days beyond the issuance of this report, unless you request other disposition.

Soil Laboratory Testing

Our laboratory performed tests on selected samples collected during the subsurface exploration. The testing aided in the classification of materials encountered in the subsurface exploration and provided data for use in the development of recommendations for design of foundations, earthwork, and below-grade walls. The results of the laboratory tests are included in Appendix B and are summarized (for each stratum) in the Site Geology and Subsurface Condition section of this report. Selected test results are also shown on the boring logs in Appendix A.

Index Testing

We performed index testing on samples collected as part of the exploration to provide soil classifications and to provide parameters for use with published correlations with soil properties. Index testing included performing natural moisture content, Atterberg Limit, and gradation tests on select jar samples of soil representing Stratum B, Residual soils.

SITE GEOLOGY AND SUBSURFACE CONDITIONS

Site Geology

During our exploration, we encountered the following stratigraphy:

Generalized Subsurface Stratigraphy

We characterized the following generalized subsurface stratigraphy based on the exploration and laboratory test data included in the appendices.

Surface Cover

Approximately 1 to 6 inches of topsoil was encountered in the grassed areas. In the asphalt parking lot approximately 4 to 11 inches of asphalt and 1.5 to 7 inches of crushed stone were encountered.

Stratum A – Existing Fill

We encountered existing fill soils in each of the borings from the ground surface to depths between 1.5 feet and 14.5 feet below existing grades. These existing fill soils were composed of lean clay and fat clay. Standard Penetration Test N-values ranging from 1 blow per foot (bpf) to 38 bpf were recorded in this stratum with a median value of 6 bpf. Existing fill represents material placed at the site during prior site development.

Moisture contents varied from 16.7% to 37.3% within the fill.

Stratum B – Residual

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. We encountered SILT (ML), SILT WITH GRAVEL (ML), ELASTIC SILT (MH), and FAT CLAY (CH) in all of the borings, with the exception of Boring B-7, beneath the topsoil, pavement, and existing fill materials at the surface to depths of up to 23 feet. SPT N-values ranged from 6 bpf to 47 bpf. The median value was 17 bpf.

Moisture contents varied from 19.2% to 40.2% within Stratum B.

Liquid Limits (LL) and Plasticity Indices (PI) ranged from 49 to 70 and 29 to 38, respectively. The Atterberg limits results generally indicate these soils exhibit a moderate to high potential for moisture-related volume change (shrink/swell behavior).

Strata C – Disintegrated Rock

Disintegrated rock was encountered in five of the borings as summarized below in Table 1.

Table 1: Disintegrated Rock Summary

Boring Number	Disintegrated Rock Depth (ft)	Disintegrated Rock El. (ft)
B-1	4.0	1,081.0
B-2	6.0	1,078.0

Boring Number	Disintegrated Rock Depth (ft)	Disintegrated Rock El. (ft)
B-4	6.0	1,072.0
B-5	9.5	1,067.5
B-8	6.0	1,076.0

Disintegrated rock is defined by Schnabel as residual material with SPT N-values between 60 blows per foot and sampler refusal. Sampler refusal is defined as an equivalent N-value of 50/1" or less. We recorded sampler refusal in Borings B-2, B-4, and B-8 at depths of 14.1 feet to 22.0 feet (El. 1,067.9 to El. 1,057.1 ft.).

Auger refusal on bedrock was recorded in four borings at depths ranging from 13 to 22.9 feet below existing grades (El. 1072 feet to El. 1057.1 feet).

Groundwater

We did not observe groundwater in the borings performed at the site. The borings caved dry at depths of 4.5 to 30.5 ft.

Schnabel's drilling subcontractor installed a water observation well in Boring B-5. We did not observe groundwater in this well 24 to 72 hours after completion of the borings. We did not obtain long-term water level readings in the remaining borings since we backfilled them upon completion for safety.

The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. The final design should anticipate the fluctuation of the hydrostatic water table depending on variations in precipitation, surface runoff, pumping, evaporation, leaking utilities, stream levels, and similar factors.

Seismic Site Classification

We evaluated the Seismic Site Class and Seismic Site Coefficients for this project according to the International Building Code (IBC) Section 1615 (2012). Our analysis indicates Site Class C for this location. This Site Class was evaluated based on SPT values.

For Site Class C, seismic site coefficients of Fa = 1.2 and Fv = 1.7 may be considered in the design

GEOTECHNICAL RECOMMENDATIONS

We based our geotechnical engineering analysis on the information developed from our subsurface exploration and soil laboratory testing, along with the project development plans, site plans, and structural loading furnished to our office. We recommend shallow spread footings for support of the proposed building based on our analysis. The following sections of the report provide our detailed recommendations.

Site Grading and Earthwork

Proposed building and site grades will require placement of up to 8 feet of compacted structural fill at the southeast corner of the new boiler building. Cuts of up to 15 ft are also anticipated to achieve the lowest level finished floor of El. 1,065 feet. Disintegrated rock and/or rock is expected to be encountered in these cuts.

Boring B-7 and two offset borings (B-7A and B-7B) performed along the proposed steam tunnel alignment, encountered an obstruction approximately 14.5 feet below existing grades. Although not marked or shown on any VA personnel's plans or files, we did not attempt to auger beyond the obstruction over concerns that it could be an underground steam tunnel. Project planning should consider the potential for removal of an obstruction in this area.

Recommendations for compacted fill subgrade preparation fill soil requirements, placement and compaction criteria, and evaluating rock excavation are presented in subsequent sections.

Compacted Fill Subgrades

Subgrades to receive compacted structural fill for building support should be stripped of vegetation, topsoil, existing fill soils, existing asphalt pavement, and organic matter. Schnabel's subsurface exploration indicated topsoil to depths of 1 to 6 inches below the ground surface. The existing pavement section encountered varied from 4 to 11 inches of asphalt over 1.5 to 7 inches of road subbase stone.

Compacted structural fill subgrades should be excavated to the depth necessary to expose suitable residual soils of Stratum B or disintegrated rock of Stratum C. These soils are expected to be encountered at shallow depths beneath the topsoil and root mat and existing fills. At the borings drilled in the building area, existing depths varied from 1.5 feet to 4 feet.

The existing fill soils of Stratum A are not considered suitable for support of compacted structural fills. These soils should be excavated to expose suitable subgrade soils.

The Geotechnical Engineer should evaluate the suitability of the fill subgrades. The stripped subgrades should be proofrolled with a loaded dump truck to evaluate the subgrade suitability for support of the compacted structural fill prior to any undercutting or initiation of fill placement. Areas that exhibit excessive pumping, weaving, or rutting should be scarified, dried and recompacted, or undercut and replaced with compacted structural fill as recommended by the Geotechnical Engineer. Subgrade evaluation techniques complementary to proofrolling could include a combination of probing with a penetrometer, drilling hand augers, or observing test pits.

If stripping and earthwork operations are performed during an extended period of warm, dry weather, the non-organic portions of the undercut materials may be reused as compacted structural fill. The use of these materials as compacted structural fill will depend on the soil moisture content, and the Contractor's ability to limit contamination of these materials with organic matter during stripping and undercutting.

When removal of unsuitable materials is required, the excavation should be performed in a manner to limit disturbance of the underlying suitable material. The excavation should be performed under the observation of the Geotechnical Engineer to evaluate required excavation depths.

Undercut volumes should be evaluated by cross sectioning. Other methods of calculating volumes of undercut, such as counting trucks, are less accurate and generally result in additional expense.

Compacted structural fill subgrades should be kept free of ponded water. If springs or other flowing water is present at the compacted structural fill subgrade level, the Contractor should direct water to discharge beyond the fill limits. Recommendations for discharging springs should be provided by the Geotechnical Engineer.

Compacted structural fill subgrades should be free of snow, ice, and frozen soils. If snow, ice, or frozen soils are present at subgrade levels, these materials should be removed as recommended by the Geotechnical Engineer.

Some existing structures, such as buried utilities or structures, present on site will need to be removed before earthwork construction. Existing utilities and drainage structures within the building area should be removed and replaced with compacted structural fill.

Compacted structural fill subgrades should not be steeper than about 4H:1V. If steeper slopes are present, subgrades should be benched to permit placement of horizontal lifts of fill.

Compacted Fill

Compacted structural fill and backfill should consist of non-organic on-site soils. If off-site borrow materials are needed, these soils should classify CL, ML, SC, SM, SP, SW, GC, GM, GP or GW according to ASTM D2487. Fill materials should not contain particles larger than 3 inches.

Compacted structural fill should be placed in maximum 8-inch thick horizontal, loose lifts. Fill should be compacted to at least 95 percent of the maximum dry density per ASTM D698 Standard Proctor. Soil moisture contents at the time of compaction should be within 2 percentage points of the soils' optimum moisture content.

Backfill placed in excavations, trenches, and other areas that large compaction equipment cannot access should be placed in maximum 6-inch thick lifts. Backfill should meet the material, placement, and compaction requirements outlined above.

Successful re-use of the excavated, on-site soils as compacted structural fill will depend on their natural moisture contents during excavation. Laboratory test results indicate soils encountered in proposed borrow areas are wet of the estimated optimum moisture content. Scarifying and drying of these soils should be anticipated to achieve the recommended compaction. Drying of these soils will likely result in some delays, and may not be possible during cooler, wetter weather. We recommend that the earthwork be performed during the warmer, drier times of the year.

Rock Excavation

Test boring data, when compared to planned foundation grades, indicate that hard disintegrated rock and/or rock may be encountered during excavation. Conditions encountered during excavation may be different than those observed in the test borings.

The boring data indicate rock excavation methods may be needed. Table 2 provides our estimate of elevations where rock excavation methods, such as hoe-ramming or blasting, may be required at specific boring locations:

Table 2: Estimated Top of Rock Elevations

Boring Number	Estimated Elevation Below Which Rock Excavation Methods may be Required (EL)*
B-1	1,072.0
B-2	1,067.3
B-4	1,057.1
B-5	1,064.0
B-8	1,065.3

*Based on an N-value of 100 or greater

Some rock excavation technique may also be needed in the disintegrated rock. Variations in rock conditions should be expected since the rock surface can fluctuate across the site. Also, the extent of rock excavation will depend on the Contractor's methods, rock jointing, and rock foliation. The above elevations apply for mass excavation of rock on the site. Rock excavation methods may be needed at higher elevations in footing and utility excavations.

A sample definition of rock for excavation specifications is provided below:

> *For mass excavation, rock is defined as any material that cannot be dislodged by a Caterpillar Model No. D-8 heavy-duty tractor, or equivalent, equipped with a hydraulically operated, single-tooth power ripper without the use of hoe-ramming or blasting. For trench, footing and pit excavations, rock excavation shall be defined in terms of a Caterpillar Model No. 330 hydraulic excavator, or equivalent. This classification does not include material such as loose rock, concrete, cemented gravel, or other materials that can be removed by means other than hoe-ramming or blasting, but which for reasons of economy in excavating, the Contractor chooses to remove by hoe-ramming or blasting. Rock does not include boulders less than one cubic yard in volume. Boulders larger than one cubic yard in volume will be considered rock for payment purposes.*

Where the rock cannot be removed with conventional excavation equipment, special means of excavation may be needed. Removal of rock may require the use of blasting, air-powered tools, rock splitters, or large hoe rams.

Spread Footings

We consider spread footings suitable for support of the proposed structure. Footings should be founded on suitable natural soils and disintegrated rock of Strata B and C or on properly compacted structural fill. We do not consider Stratum A existing fill soils suitable for foundation support and these soils should be undercut and replaced with compacted structural fill where encountered below design bearing grades. Compacted structural fill should meet the requirements outlined in the Site Grading and Earthwork section of this report. We recommend footings supported on these materials be designed for a net allowable soil bearing pressure of 3,000 psf. This bearing pressure provides a factor of safety against general bearing capacity failure of at least 3.0.

The above allowable soil bearing pressure may be increased by 33 percent for wind and seismic loads when used in conjunction with load combinations defined in IBC 2009 Section 1605.3.2, Alternative Basic Load Combinations for use with allowable stress design. This increase is not applicable for other allowable stress load combinations, strength design, or load and resistance factor design.

All footing subgrades should be observed by the Geotechnical Engineer prior to placement of concrete to evaluate if subgrade materials are as anticipated.

If unsuitable soils are encountered at the design bearing grade, these soils should be removed and replaced as recommended by the Geotechnical Engineer. Unsuitable soils should be replaced with compacted structural fill, Controlled Low Strength Material (flowable fill), or concrete. Open graded crushed stone such as VDOT No. 57 aggregate should not be used as this can create a reservoir for water, saturating the subgrade, and increasing the possibility of swell below the footing as well as increasing the potential for sinkhole development.

Settlements of shallow foundations supported on suitable natural materials and on properly placed compacted structural fill are not expected to exceed about 1 inch. Differential settlements between similarly loaded footings are not expected to exceed about half this value.

Column and wall footings should be at least 24 and 16 inches wide, respectively, for shear considerations. Exterior footings should be founded at least 2 ft below final exterior grades for frost protection. Interior footings may be founded at nominal depths below the floor slabs. Interior footings subject to freezing should be founded at least 2 ft below slab grade. Where bearing grades between adjacent footings vary, the slope between the bottom edges of adjacent footings should not be steeper than 45 degrees (1H:1V).

To further limit the potential for damage from moisture-related volume change of foundation soils, site grades should be set to permit positive drainage of surface water away from the building. Roof drainage from the building should be collected and discharged at least 25 ft from the building. Trees should not be planted within 25 ft of the building.

Floor Slabs

The proposed floor slabs should be supported on suitable natural materials of Strata B and C or properly compacted structural fill. A modulus of subgrade reaction, k, of 100 pci should be used in the design of floor slabs. The recommended modulus value is for a 1-ft-square plate. Some slab design software may consider different definitions of k for input. The Structural Engineer should contact our office if their software considers a different definition of k.

A 4-inch crushed stone or washed gravel capillary moisture barrier should underlie floor slabs on grade. Moisture barrier material should consist of VDOT No. 57 crushed stone. The Contractor should compact the stone in place with at least two passes of suitable vibratory compaction equipment.

The Contractor should compact floor slab subgrades to repair any disturbance that may occur due to construction operations before placing capillary moisture barrier materials. Since floors will be slab-on-grade, footing and utility excavations should be backfilled with compacted structural fill as defined in the Site Grading and Earthwork section of this report.

Basement Walls

In our analyses, we considered that below-grade building walls will be braced by the structure preventing movement. We have also considered that walls will be backfilled with open graded free draining VDOT No. 57 stone. Braced basement walls should be designed considering equivalent at rest fluid pressure, γ_{ef}, as shown in Figure 3. Equivalent fluid pressure and surcharge factors are presented in Table 3. Where applicable, the design should consider surcharge loads using a rectangular earth pressure distribution as shown in Figure 3. The surcharge pressure ordinate should be obtained by multiplying the surface surcharge pressure, q, by the factor in Table 3. Horizontal forces on the wall should be resisted by friction acting on the base of the wall and passive earth pressure acting on the front of the wall foundation shown on Figure 3.

Table 3: Recommended Design Parameters for Walls

Wall Type	Backfill Materials	Equivalent Fluid Pressure Factor (γ_{ef})	Surcharge Pressure Factor
Braced	Free-draining, VDOT No. 57 Stone	36	0.33

The above parameters consider a horizontal ground surface behind and in front of the walls. We should be contacted to provide alternative parameters if sloping ground surface conditions are anticipated.

These design parameters do not consider hydrostatic pressure since we recommend subdrainage behind the walls. Subdrainage should consist of perimeter subdrains located on top of the wall footing, next to the wall. Subdrains should consist of 4 inch slotted Schedule 40 PVC pipe. Where practical, drain lines should be designed to outlet by gravity to daylight or connected to the storm drainage system. Basement walls should be backfilled as recommended below. Basement walls should be damp proofed.

All wall backfill should consist of VDOT No. 57 open-graded crushed stone. We do not recommend using the on-site soils as wall backfill because they are highly plastic, poorly draining materials that tend to creep and exert high lateral pressures on walls. If the area of backfill is not covered with pavement or sidewalk concrete, then the final 2 ft of backfill should consist of a cap of compacted on-site soils to inhibit surface water infiltration. This soil cap should be placed in maximum 8 inch thick loose lifts compacted to at least 95 percent of maximum dry density per ASTM D-698, Standard Proctor. A layer of geotextile, such as Mirafi 140N or equivalent, should be placed on top of the VDOT No. 57 stone before placing the soil cap. Drainage geotextile should also be used to separate the stone backfill from the earthen slopes. Only light hand-operated equipment should be used to compact backfill against walls. VDOT No. 57 stone backfill should be placed in 2 ft lifts and tamped with the backhoe bucket. Walls below grade should not be backfilled until structurally supported. Free-draining backfill should be placed in the zone extending from the base of the wall footing upwards at 45 degrees.

CONSTRUCTION CONSIDERATIONS

Karst Considerations

As previously discussed, the project site lies within karst geology underlain by carbonate rocks. In some areas, the limestone is susceptible to chemical weathering and the development of voids in the bedrock. Voids and mud seams were not detected in the test borings. However, sinkholes are common in this area. Latent karst features may be present beneath this site. Consequently, we recommend taking preventative measures during construction to reduce the potential for sinkhole development, as summarized below:

1. Positive drainage away from building areas should be maintained during site grading and throughout construction. Upon completion of daily earthwork operations, the ground surface should be sealed by thorough rolling to reduce infiltration of precipitation and to facilitate runoff.
2. During construction, care should be taken to prevent surface water from ponding in and/or adjacent to the construction areas. Foundations should be excavated and poured the same day, if possible. If concrete placement will not occur the same day as excavation, then subgrades should be nominally undercut and backfilled with a mud mat to limit water infiltration.
3. Karst features that are uncovered or that develop during construction should be brought to the Geotechnical Engineer's attention for remedial improvement.
4. Roof drains should be tied directly into storm drains to channel rain water away from the building.
5. Water-tight storm drains should be used.

Site Grading and Earthwork

The test boring data indicate the approximate depth of topsoil based on our visual identification procedures. The depth of stripping needed to provide a suitable base for placement of earthwork or pavements may include topsoil and other softer surficial layers. Stripping depths in wooded or previously cultivated areas will be greater, particularly during periods of wet weather. The depth of required stripping should be determined by the excavation Contractor prior to construction using test pits, probes, or other means.

The on-site soils are susceptible to moisture changes, will be easily disturbed, and will be difficult to compact under wet weather conditions. Drying and reworking of the soils are likely to be difficult during periods of wet months. We recommend that the earthwork phases of this project be performed during the warmer, drier times of the year to limit the potential for disturbance of on-site soils.

The soils at this site consist primarily of moderately to highly plastic clays and silts. These soils are moisture sensitive, and will become readily disturbed by construction traffic on exposed surfaces of wet subgrades. We recommend avoiding wet weather site preparation and grading activities. If wet weather work is performed, the quantities of disturbed soils to be excavated can be expected to increase.

Traffic on stripped or undercut subgrades should be limited to reduce disturbance of underlying soils. Also, using lightweight, track-mounted dozer equipment for stripping will limit the disturbance of underlying soils, and may reduce the undercut volume needed. The Contractor should provide site drainage to maintain subgrades free of water and to avoid saturation and disturbance of the subgrade soils before placing compacted structural fill, pavement base course or moisture barrier material. This site drainage will be important during all phases of the construction work. The Contractor should be responsible for reworking of subgrades and compacted structural fill that were initially considered suitable but were later disturbed by equipment and/or weather.

Spread Footings

The Contractor should exercise care during excavation for spread footings so that as little disturbance as possible occurs at the foundation level. The Contractor should carefully clean loose or soft soils from the bottom of the excavation before placing concrete. A Geotechnical Engineer from our firm should observe footing subgrades prior to concrete placement to evaluate whether subgrade soils are as anticipated in this report.

Footing subgrades needing undercut should be backfilled to the original design subgrade elevation with compacted structural fill, Controlled Low Strength Material (flowable fill), or concrete. Open graded crushed stone such as VDOT No. 57 aggregate should not be used as this can create a reservoir for water, saturating the subgrade, increasing the possibility of swell below the footing as well as increase the potential for sinkhole development. Placement of concrete should take place the same day as excavation of footings. In the event that these excavations cannot be opened and completed in the same day, a lean concrete “mud mat” should be used to protect the bearing surface.

The potential for variation of moisture content in foundation soils is probably greatest during construction. If the moisture content of foundation soils increases or decreases during construction, a moisture-related change in volume will likely occur as these soils return to their natural moisture content. Therefore, prompt placement of concrete, backfilling, and grading are very important for proper foundation performance.

Engineering Services During Construction

The engineering recommendations provided in this report are based on the information obtained from the subsurface exploration and laboratory testing. However, conditions on the site may vary between the discrete locations observed at the time of our subsurface exploration. The nature and extent of variations between borings may not become evident until during construction.

To account for this variability, we should provide professional observation and testing of subsurface conditions revealed during construction as an extension of our engineering services. These services will also help in evaluating the contractor's conformance with the plans and specifications in accordance with building code requirements. Because of our unique position to understand the intent of the geotechnical engineering recommendations, retaining Schnabel for these services will allow the owner to receive consistent service throughout the project construction.

General Specification Recommendations

An allowance should be established to account for possible additional costs that may be required to construct earthwork and foundations as recommended in this report. Additional costs may be incurred for a variety of reasons including variation of soil between borings, greater than anticipated unsuitable soils, karst activity, obstructions, and rock excavation.

The project specifications should indicate the Contractor's responsibility for providing adequate site drainage during construction. Inadequate drainage will most likely lead to disturbance of soils by construction traffic and increased volume of undercut.

This report may be made available to prospective bidders for informational purposes. We recommend that the project specifications contain the following statement:

> *Schnabel Engineering Consultants, Inc., has prepared this geotechnical engineering report for this project. This report is for informational purposes only and is not part of the contract documents. The opinions expressed represent the Geotechnical Engineer's interpretation of the subsurface conditions, tests, and the results of analyses performed. Should the data contained in this report not be adequate for the Contractor's purposes, the Contractor may make, before bidding, independent exploration, tests and analyses. This report may be examined by bidders at the office of the Owner, or copies may be obtained from the Owner at nominal charge.*

Additional data and reports prepared by others that could have an impact upon the Contractor's bid should also be made available to prospective bidders for informational purposes.

LIMITATIONS

We based the analyses and recommendations submitted in this report on the information revealed by our exploration. We attempted to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction.

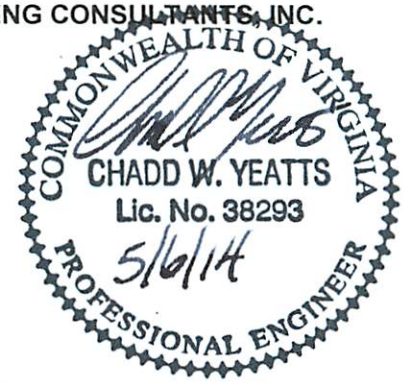
This report has been prepared to aid in the evaluation of this site and to assist in the design of the project. It is intended for use concerning this specific project. We based our recommendations on information on the site and proposed construction as described in this report. Substantial changes in loads, locations, or grades should be brought to our attention so we can modify our recommendations as needed. We would appreciate an opportunity to review the plans and specifications as they pertain to the recommendations contained in this report, and to submit our comments to you based on this review.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING CONSULTANTS, INC.



Chadd W. Yeatts, PE
Project Engineer

Steven J. Winter, PE
Senior Associate

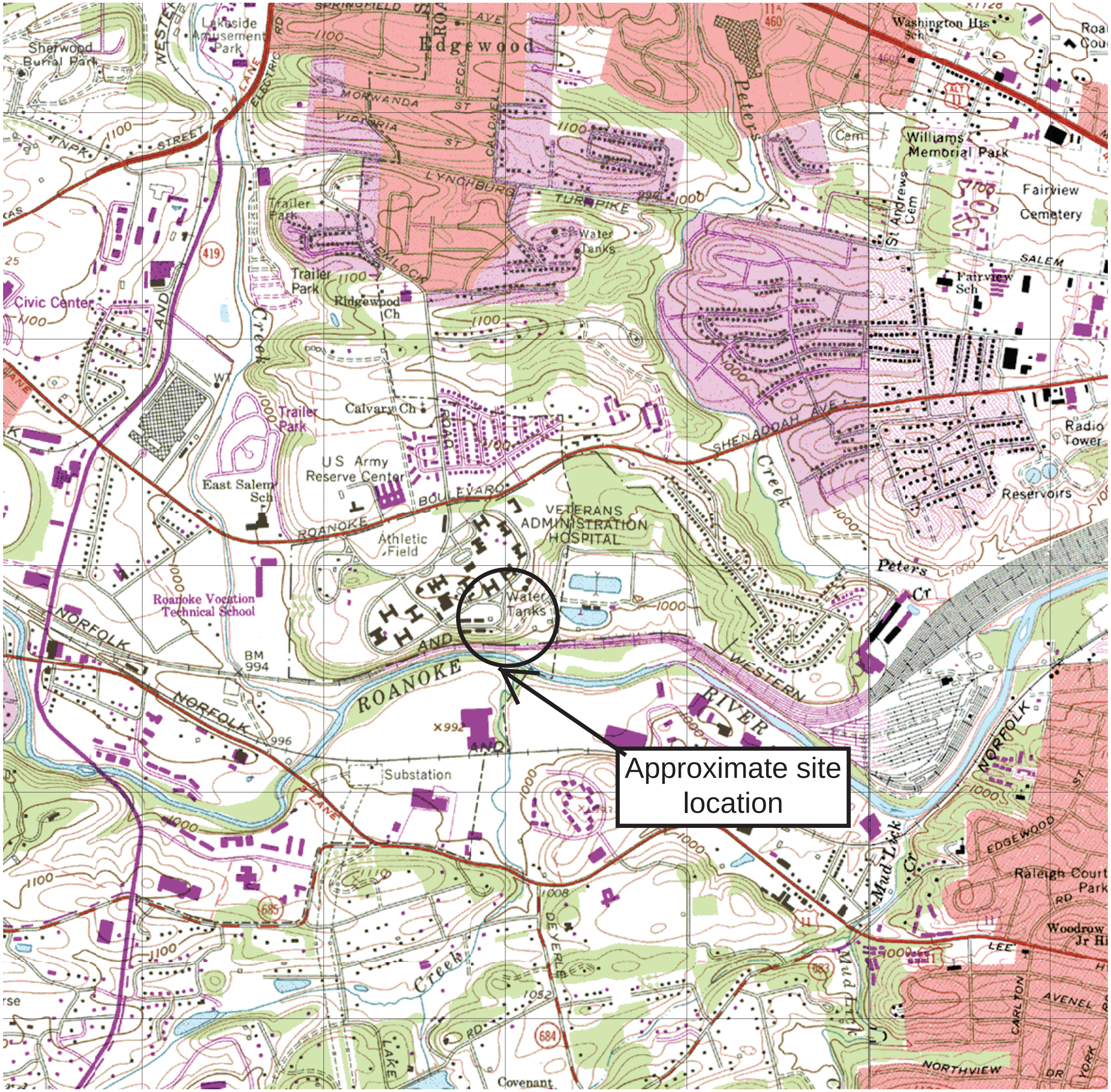
CWY:SJW:rl

Figures
Appendix A: Subsurface Exploration Data
Appendix B: Soil Laboratory Test Data

Distribution:

Harrell, Saltrick & Hopper, P.C. (2 Copies)
Attn: Mr. Robert L. Smith, RA

FIGURES



VICINITY MAP

FIGURE 1

SCALE: 1"=2000'

Contract # 14616014
Salem VA Medical Center
Boiler Building
Salem, VA

N

SOURCE:

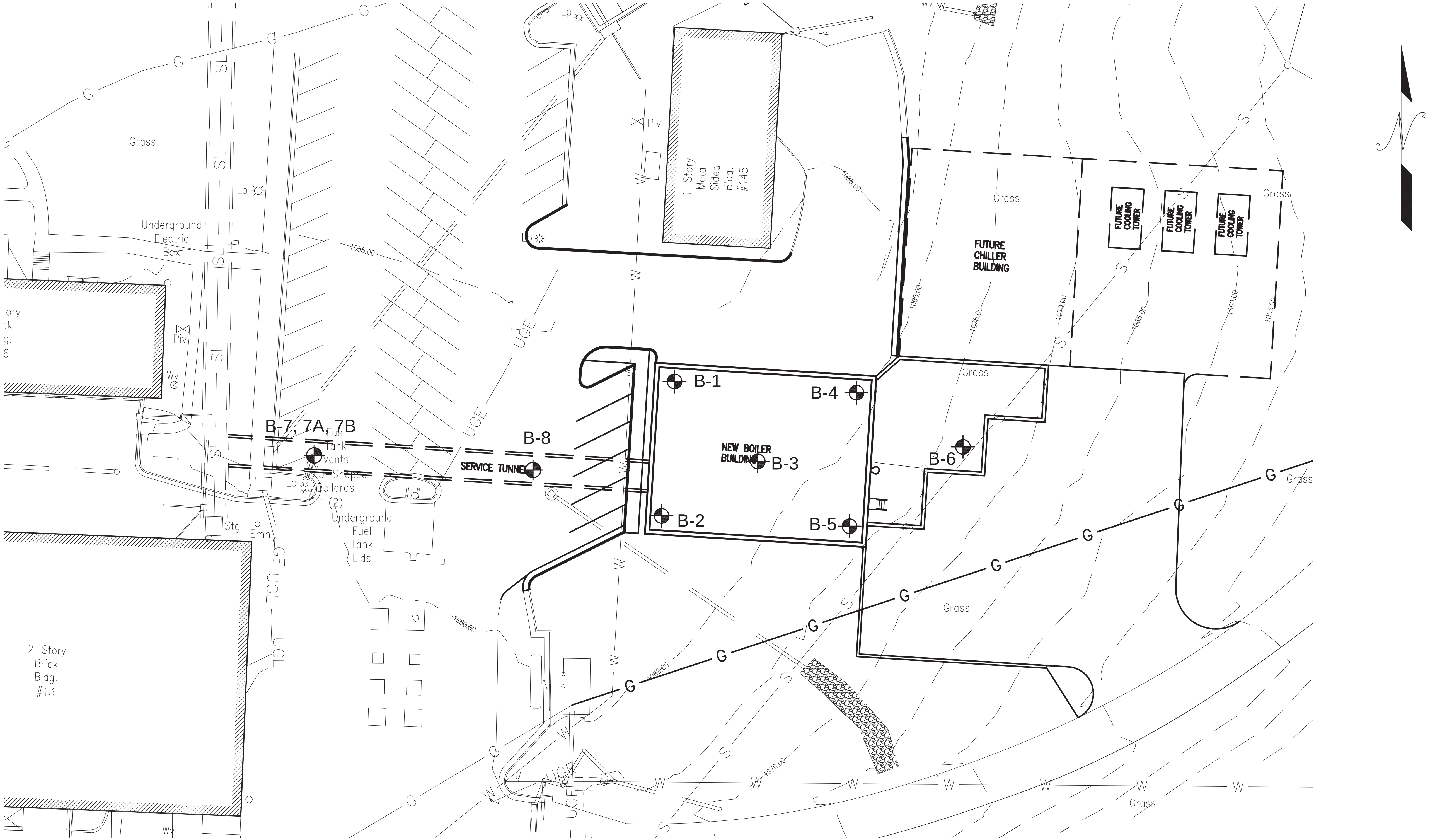
Maptech, Inc. 2006

ALL LOCATIONS ARE APPROXIMATE

Schnabel ENGINEERING

1901 South Main Street, Suite 11
Blacksburg, VA 24060
Phone: 540-953-1239
Fax: 540-953-3863
schnabel-eng.com

05/14



LEGEND

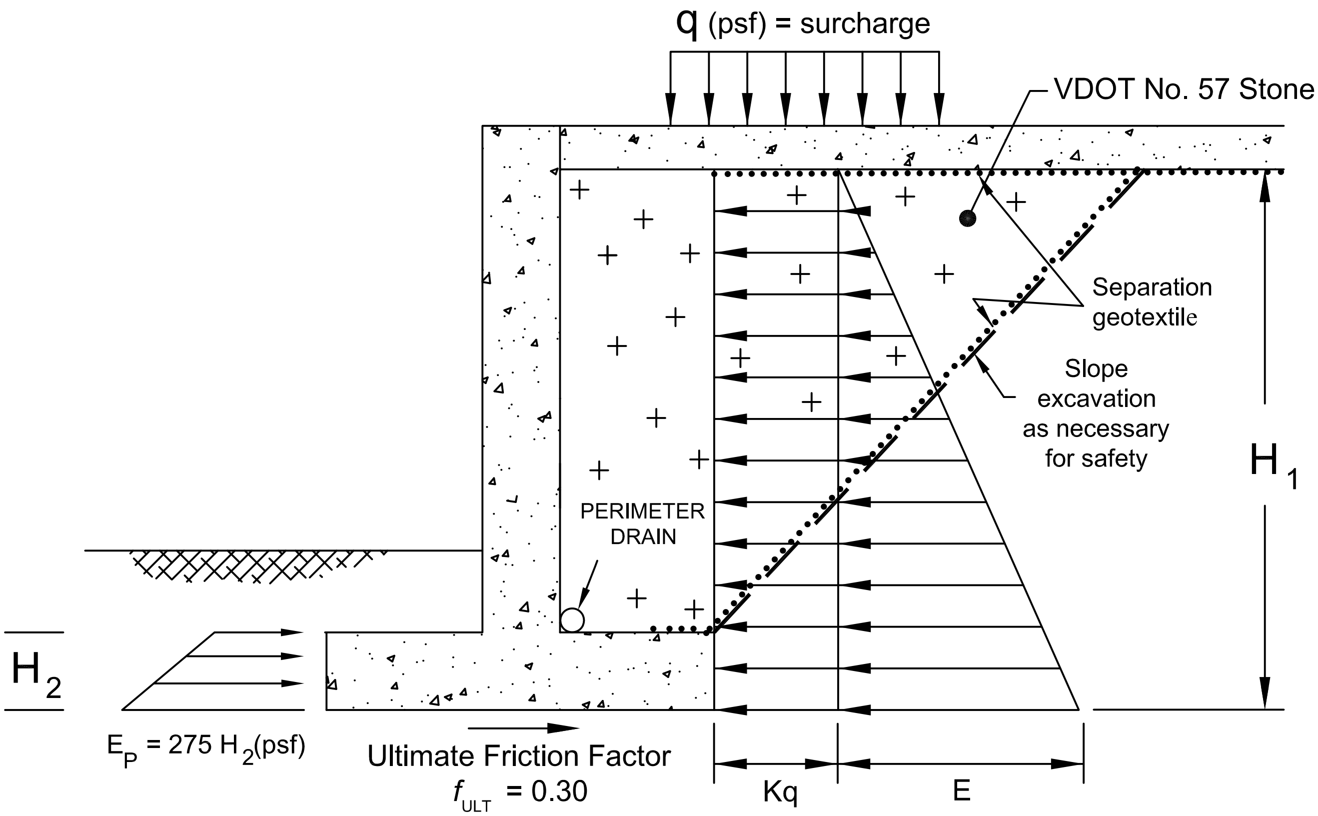
⊕	B-1	Test Boring Number and Approximate Location

0 40' 80'

Schnabel ENGINEERING	SALEM VA MEDICAL CENTER BOILER BUILDING SALEM, VA	Figure Name: Test Boring Location Plan	Done: JAS	Figure Number: 2
		Project Number: 14616014.00	Reviewed: CWY	Date: May 2014

EARTH PRESSURE RECOMMENDATIONS
BELOW GRADE WALLS

NO SCALE



Select Backfill	K	E
VDOT No. 57 Stone	0.4	$43H_1$ (psf)

Unit Weight of local VDOT No. 57 Stone = 110 pcf

Kq = Surcharge Pressure

E = Earth Pressure

Schnabel ENGINEERING
1901 SOUTH MAIN STREET
SUITE 11
BLACKSBURG, VA 24060
540-953-1239
FAX 540-953-3863

New Boiler Building, VA Medical Center	DRAWN BY JAS	SCALE NTS
Salem, Virginia	CHECKED BY SJW	DATE 05/14
Earth Pressure Recommendations - Below Grade Walls	CONTRACT NO. 14616014	FIGURE 3

APPENDIX A

SUBSURFACE EXPLORATION DATA

Subsurface Exploration Procedures
General Notes for Subsurface Exploration Logs
Identification of Soil
Boring Logs, B-1 through B-8

SUBSURFACE EXPLORATION PROCEDURES

Test Borings – Hollow Stem Augers

The borings are advanced by turning a continuous flight auger with a center opening of 2¼ or 3¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

Standard Penetration Test Results

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1⅜-inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 or 24 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value." The SPT is performed according to ASTM D1586.

Soil Classification Criteria

The group symbols on the logs represent the Unified Soil Classification System Group Symbols (ASTM D2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation can be expected between samples visually classified and samples classified in the laboratory.

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. Disintegrated rock is defined as residual material with SPT N values between 60 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of 1 inch or less.

Water Observation Well

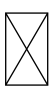
A temporary water observation well was installed in Boring B-5 by inserting a hand-slotted, 1¼-inch PVC pipe in this boring. The pipe was capped and the area surrounding the pipe was backfilled with cuttings from the boring.

Boring Locations and Elevations

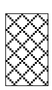
Borings locations were staked by our field personnel by taping and pacing with respect to existing features. Approximate boring locations are shown on Figure 2. Ground surface elevations at the boring locations were estimated from the site topographic plan and are indicated on the boring logs. Locations and elevations should be considered no more accurate than the methods used to determine them.

GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2-inch O.D., 1⅜-inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in general accordance with ASTM D1586.
2. Visual classification of soil is in accordance with terminology set forth in “Identification of Soil.” The ASTM D2487 group symbols (e.g., CL) shown in the classification column are based on visual observations.
3. Estimated water levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.
4. Refusal at the surface of rock, boulder, or other obstruction is defined as an SPT resistance of 50 blows for 1 inch or less of penetration.
5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and water level conditions at the subsurface exploration location.
6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.
7. Key to symbols and abbreviations:



S-1, SPT — Sample No., Standard Penetration Test
5+10+1 — Number of blows in each 6-inch increment



S-1, SAMPLE — Sample No., Hand Auger or Test Pit sample

LL	Liquid Limit
MC	Moisture Content (percent)
PL	Plastic Limit
PP	Pocket Penetrometer Reading (tsf)
%Passing#200	Percent by weight passing a No. 200 Sieve

IDENTIFICATION OF SOIL

I. DEFINITION OF SOIL GROUP NAMES (ASTM D2487)

			SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	WELL GRADED GRAVEL
			GP	POORLY GRADED GRAVEL
		Gravels with fines More than 12% fines	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 10 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	WELL GRADED SAND
			SP	POORLY GRADED SAND
		Sands with fines More than 12% fines	SM	SILTY SAND
			SC	CLAYEY SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	LEAN CLAY
			ML	SILT
		Organic	OL	ORGANIC CLAY
				ORGANIC SILT
	Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic	CH	FAT CLAY
			MH	ELASTIC SILT
		Organic	OH	ORGANIC CLAY
				ORGANIC SILT
Highly Organic Soils	Primarily organic matter, dark in color and organic odor		PT	PEAT

II. DEFINITION OF SOIL COMPONENT PROPORTIONS (ASTM D2487)

			Examples
Adjective Form	GRAVELLY SANDY	>30% to <50% coarse grained component in a fine-grained soil	GRAVELLY LEAN CLAY
	CLAYEY SILTY	>12% to <50% fine grained component in a coarse-grained soil	SILTY SAND
"With"	WITH GRAVEL WITH SAND	>15% to <30% coarse grained component in a fine-grained soil	FAT CLAY WITH GRAVEL
	WITH GRAVEL WITH SAND	>15% to <50% coarse grained component in a coarse-grained soil	POORLY GRADED GRAVEL WITH SAND
	WITH SILT WITH CLAY	>5% to <12% fine grained component in a coarse-grained soil	POORLY GRADED SAND WITH SILT

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS .... Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.

FILL.. Man-made deposit containing soil, rock and often foreign matter.

PROBABLE FILL................... Soils which contain no visually detected foreign matter but which are suspect with regard to origin.

DISINTEGRATED ROCK (DR).. Residual materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2" or less penetration.

PARTIALLY WEATHERED ROCK (PWR)......................... Residual materials with a standard penetration resistance (SPT) between 100 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2" or less penetration.

BOULDERS & COBBLES..... Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12-inch size.

LENSES................................. 0 to ½-inch seam within a material in a test pit.

LAYERS................................. ½ to 12-inch seam within a material in a test pit.

POCKET .... Discontinuous body within a material in a test pit.

MOISTURE CONDITIONS..... Wet, moist or dry to indicate visual appearance of specimen.

COLOR .... Overall color, with modifiers such as light to dark or variation in coloration.

Schnabel ENGINEERING

TEST BORING LOG

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, Virginia

Boring Number: B-1
Contract Number: 14616014
Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: P. Simpson
Schnabel Representative: L. Joyce
Equipment: BK 51 (Truck)
Method: 2-1/4" I.D. Hollow Stem Auger
Hammer Type: Safety Hammer (140 lb)
Dates Started: 4/15/14 **Finished:** 4/15/14
Location: See Location Plan
Plunge: **Bearing:**
Ground Surface Elevation: 1085± (ft) **Total Depth:** 13.0 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/15	---	Dry	13.0'	---
Casing Pulled	4/15	---	Dry	---	5.1'
Completion	4/15	---	Dry	13.0'	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.5	Topsoil		1084.5			SPT 1+2+4+8 REC=20", 83%	MC = 23.1%	Fill
1.5	FILL, sampled as lean clay; moist, yellowish brown, contains root fragments, few gravel	FILL	1083.5	A				
4.0	SILT; moist, purplish brown	ML	1081.0	B		SPT 6+16+31+44	MC = 19.2%	Residual
6.0	DISINTEGRATED ROCK, sampled as lean clay; moist, yellowish brown to purplish brown	DR	1079.0	C	5	SPT 24+54+46/3"		Slower auger advance rate at 4.0 ft
8.0	DISINTEGRATED ROCK, sampled as gravelly lean clay; moist, red brown	DR	1077.0			SPT 22+35+65/6"		Augers grinding at 7.0 ft
11.9	DISINTEGRATED ROCK, sampled as poorly graded gravel with silt; dry to moist, red brown	DR	1073.1		10	SPT 29+71/3"		
13.0	DISINTEGRATED ROCK, sampled as gravelly lean clay; moist, reddish brown	DR	1072.0			SPT 30+55+15/1"		

Bottom of Boring at 13.0 ft.
Auger refusal at 13.0 ft.
Boring backfilled with cuttings upon completion.

Schnabel ENGINEERING	TEST BORING LOG	Project: VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: B-2 Contract Number: 14616014 Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: L. Joyce/J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/15/14 **Finished:** 4/17/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: 1084± (ft) **Total Depth:** 16.8 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/15	---	Dry	16.0'	---
Completion	4/17	---	Dry	16.7'	---
Casing Pulled	4/17	---	Dry	---	4.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	Asphalt; Asphalt 4" Base course 5"							Fill
0.8	FILL, sampled as fat clay; moist, red, trace gravel	FILL	1083.2	A				
2.5	SILT; moist, yellowish red	ML	1081.5	B		SPT 5+8+11+13		Residual
4.0	SILT; moist, yellowish red and tan	ML	1080.0		5	SPT 11+21+18+17	MC = 28.4%	
6.0	DISINTEGRATED ROCK, sampled as silt; moist, yellowish red and tan, trace sand	DR	1078.0	C		SPT 9+36+50/5"		
8.0	DISINTEGRATED ROCK, sampled as silt with gravel; moist, yellowish brown	DR	1076.0		10	SPT 25+54/6"		
					15	SPT 31+69/6"		
16.8			1067.2			SPT 50/1"		

Bottom of Boring at 16.8 ft.
Auger refusal at 16.8 ft.
Boring backfilled with cuttings upon completion.

Schnabel ENGINEERING	TEST BORING LOG	Project: VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: **B-3** Contract Number: 14616014 Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/18/14 **Finished:** 4/18/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: **Total Depth:** 0.5 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.5	Asphalt; Asphalt 6"							

Bottom of Boring at 0.5 ft.
Boring backfilled with cuttings upon completion.
Drill rig had mechanical breakdown. Boring abandoned.

Schnabel ENGINEERING	TEST BORING LOG	Project: VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: B-4 Contract Number: 14616014 Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: L. Joyce/J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/17/14 **Finished:** 4/17/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: 1080± (ft) **Total Depth:** 22.9 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/17	---	Dry	22.8'	---
Completion	4/17	---	Dry	22.8'	---
Casing Pulled	4/17	---	Dry	---	10.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.2	Topsoil		1079.8			SPT 1+2+2+4	MC = 22.4%	Fill
	FILL, sampled as clay; moist, brown, contains root fragments	FILL		A				
2.0	FILL, sampled as lean clay with gravel; moist, brown	FILL	1078.0			SPT 3+4+4+5	MC = 16.7%	
4.0	LEAN CLAY WITH GRAVEL; moist, light brown	CL	1076.0	B	5	SPT 6+8+15+18	MC = 19.1%	Residual
6.0	DISINTEGRATED ROCK, sampled as silt; moist, light brown, trace gravel	DR	1074.0			SPT 14+32+48+50/3"		
8.0	DISINTEGRATED ROCK, sampled as silt; dry to moist, light brown, trace gravel	DR	1072.0		10	SPT 7+31+50/5"		Augers grinding at 10.0 ft.
13.5	DISINTEGRATED ROCK, sampled as gravelly silt; dry to moist, light brown	DR	1066.5	C	15	SPT 18+68+32/2"		
18.0	DISINTEGRATED ROCK, sampled as silt; moist, light brown, trace gravel, pockets of fat clay	DR	1062.0		20	SPT 15+33+30+54		
22.9			1057.1			SPT 50/1"		

Bottom of Boring at 22.9 ft.
Auger refusal at 22.9 ft.
Boring backfilled with cuttings upon completion.

Schnabel ENGINEERING

TEST BORING LOG

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, Virginia

Boring Number: **B-5**
Contract Number: 14616014
Sheet: 1 of 2

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: P. Simpson
Schnabel Representative: L. Joyce
Equipment: BK 51 (Truck)
Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)
Dates Started: 4/14/14 **Finished:** 4/14/14
Location: See Location Plan

Plunge: **Bearing:**
Ground Surface Elevation: 1077± (ft) **Total Depth:** 34.9 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/14	---	Dry	33.0'	---
Completion	4/14	---	Dry	33.0'	---
Casing Pulled	4/14	---	Dry	---	---
Observation Well	4/15	2:30 PM	Dry	34.9'	---
Observation Well	4/17	12:00 PM	Dry	34.9'	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.1	Topsoil		1076.9			SPT 3+31+7+4	MC = 20.8%	Fill
	FILL, sampled as lean clay; moist, brown, contains root fragments	FILL		A				
2.0	FAT CLAY; moist, red brown, contains pockets of silt, and root fragments	CH	1075.0	B		SPT 10+6+7+8	MC = 39.7%	Residual
4.0	SANDY ELASTIC SILT; moist, yellowish brown and red brown, trace gravel	MH	1073.0		5	SPT 6+5+7+10	LL = 70 PL = 38 MC = 37.3% % Passing #200 = 69.9	
6.0	LEAN CLAY; moist, yellowish brown	CL	1071.0			SPT 4+5+7+10	MC = 40.2%	
8.0	SILT WITH GRAVEL; moist, tan	ML	1069.0			SPT 6+9+24+48		Slower auger rate at 9.0 ft.
9.5	DISINTEGRATED ROCK, sampled as gravelly silt; dry to moist, tan	DR	1067.5	C	10			
						SPT 60/5"		Augers scraping and grinding at 13.0 ft.
					15			
						SPT 60/6"		
					20			
23.0	SILT; moist, brown	ML	1054.0	B		SPT 1+2+3+2		

(continued)

TEST BORING LOG 14616014.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 5/7/14

TEST BORING LOG	Project: VA Medical Center Boiler Building, Roanoke Boulevard, Salem, Virginia	Boring Number: B-5
		Contract Number: 14616014
		Sheet: 2 of 2

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	SILT; moist, brown *(continued)*	ML		B				Residual
28.0	SILT; moist, yellowish brown	ML	1049.0	B	30	SPT 2+2+1+2		
						SPT 4+2+36+64/5"		
34.0	DISINTEGRATED ROCK, sampled as silt with gravel; dry to moist, tan	DR	1043.0	C				
34.9			1042.1					

Bottom of Boring at 34.9 ft.
Boring backfilled with cuttings upon completion.
Water Observation Well (W.O.W.) installed to 34.9 ft.

TEST BORING LOG

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, Virginia

Boring Number: B-6
Contract Number: 14616014
Sheet: 1 of 2

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: P. Simpson
Schnabel Representative: L. Joyce
Equipment: BK 51 (Truck)
Method: 2-1/4" I.D. Hollow Stem Auger
Hammer Type: Safety Hammer (140 lb)
Dates Started: 4/14/14 **Finished:** 4/14/14
Location: See Location Plan
Plunge: **Bearing:**
Ground Surface Elevation: 1072± (ft) **Total Depth:** 35.0 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Casing Pulled	4/14	---	Dry	---	30.5'
Encountered	4/14	---	Dry	33.0'	---
Completion	4/14	---	Dry	33.0'	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.2	Topsoil		1071.8	A		SPT 4+2+4+5	MC = 21.8%	Fill
	FILL, sampled as lean clay; moist, brown, contains root fragments	FILL						
2.0	FAT CLAY; moist, yellowish brown, contains root fragments	CH	1070.0			SPT 3+3+5+6	MC = 39.1%	Residual
4.0	ELASTIC SILT; moist, brown, few root fragments	MH	1068.0		5	SPT 4+5+7+9	MC = 40.2%	Relic structure evident in spoon sample
6.0	SILT; moist, yellowish brown	ML	1066.0			SPT 5+7+7+11	MC = 35.7%	
					10	SPT 4+7+10+16	MC = 32.5%	
13.0	SILT WITH GRAVEL; moist, purplish brown to orange	ML	1059.0	B	15	SPT 15+16+25+22		
					20	SPT 6+8+27+22		
23.0	GRAVELLY SILT; moist, purplish brown	ML	1049.0			SPT 4+24+33+30		Slower advance rate at 24.0 ft

(continued)

Schnabel ENGINEERING	TEST BORING LOG	Project:	VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: B-6 Contract Number: 14616014 Sheet: 2 of 2

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	GRAVELLY SILT; moist, purplish brown *(continued)*	ML		B	30	SPT 22+31+22+40		Residual
33.0	SILT; moist, yellowish brown, trace fine grained sand	ML	1039.0			SPT 14+14+15+25		
35.0			1037.0		35			

Bottom of Boring at 35.0 ft.
Boring backfilled with cuttings upon completion.

Schnabel ENGINEERING

TEST BORING LOG

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, Virginia

Boring Number: **B-7**
Contract Number: 14616014
Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: P. Simpson
Schnabel Representative: L. Joyce/J. Krell
Equipment: BK 51 (Truck)
Method: 2-1/4" I.D. Hollow Stem Auger
Hammer Type: Safety Hammer (140 lb)
Dates Started: 4/17/14 **Finished:** 4/17/14
Location: See Location Plan
Plunge: **Bearing:**
Ground Surface Elevation: 1080± (ft) **Total Depth:** 14.5 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/17	---	Dry	14.5'	---
Completion	4/17	---	Dry	14.5'	---
Casing Pulled	4/17	---	Dry	---	9.7'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.4	Asphalt		1079.6	A				Fill
1.0	Crushed stone		1079.0					
	FILL, sampled as clay; moist, reddish brown	FILL				SPT 4+5+6+7		
4.0	FILL, sampled as lean clay; moist, reddish brown	FILL	1076.0		5	SPT 4+3+2	MC = 20.0%	
						SPT 2+2+2		
8.0	FILL, sampled as lean clay; moist, reddish brown to gray	FILL	1072.0			SPT 2+1+2		
					10			
						SPT 4+1/12"		
14.5			1065.5					

Bottom of Boring at 14.5 ft.
Boring backfilled with cuttings upon completion.
Boring terminated on obstruction. Boring offset approximately 2.0 ft. See Boring B-7A for additional strata descriptions. On-site VA Medical Center Personnel were notified and directed to continue boring in an offset. Personnel indicated no known utilites at boring location.

Schnabel ENGINEERING	TEST BORING LOG	Project: VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: **B-7A** Contract Number: 14616014 Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: L. Joyce/J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/17/14 **Finished:** 4/17/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: **Total Depth:** 14.5 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/17	---	Dry	14.5'	---
Completion	4/17	---	Dry	14.5'	---
Casing Pulled	4/17	---	Dry	---	10.9'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	Auger Probe to 14.5 ft. No SPT sampling performed.					AUGER		
					5			
					10			
14.5								

Bottom of Boring at 14.5 ft.
Boring backfilled with cuttings upon completion.
Boring terminated on obstruction. Boring offset 2.0 ft. north. See Boring B-7B for strata descriptions.

TEST BORING LOG	Project: VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	Boring Number: **B-7B** Contract Number: 14616014 Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: L. Joyce/J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/17/14 **Finished:** 4/17/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: **Total Depth:** 15.0 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/17	---	Dry	15.0'	---
Completion	4/17	---	Dry	15.0'	---
Casing Pulled	4/17	---	Dry	---	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	Auger probe to 15.0 ft. No SPT sampling performed.					AUGER		
					5			
					10			
15.0					15			

Bottom of Boring at 15.0 ft.
Boring backfilled with cuttings upon completion.
Boring terminated on obstruction.

Schnabel ENGINEERING	TEST BORING LOG	**Project:** VA Medical Center Boiler Building Roanoke Boulevard Salem, Virginia	**Boring Number:** B-8 **Contract Number:** 14616014 **Sheet:** 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: P. Simpson

Schnabel Representative: L. Joyce/J. Krell

Equipment: BK 51 (Truck)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Safety Hammer (140 lb)

Dates Started: 4/17/14 **Finished:** 4/17/14

Location: See Location Plan

Plunge: **Bearing:**

Ground Surface Elevation: 1082± (ft) **Total Depth:** 16.7 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Encountered	4/17	---	Dry	---	---
Completion	4/17	---	Dry	---	---
Casing Pulled	4/17	---	Dry	---	9.7'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.3	Asphalt		1081.7					Fill
0.8	Crushed stone		1081.2					
	FILL, sampled as silt with sand; moist, yellowish brown	FILL		A		SPT 5+3+3	LL = 49 PL = 29 MC = 37.3% % Passing #200 = 80.2	
4.5	ELASTIC SILT; moist, yellowish brown, few gravel	MH	1077.5	B	5	SPT 2+2+4	MC = 33.6%	Residual
6.0	DISINTEGRATED ROCK, sampled as silt; moist, yellowish brown, contains weathered rock fragments	DR	1076.0			SPT 11+37+51		Slower auger advance rate at 7.0 ft
9.0	DISINTEGRATED ROCK, sampled as silt with gravel; moist, light brown	DR	1073.0	C	10	SPT 34+66/6"		Augers grinding at 10.0 ft
					15	SPT 50/1"		Spoon bouncing at 14.1 ft
16.7			1065.3					

Bottom of Boring at 16.7 ft.
Auger refusal at 16.7 ft.
Boring backfilled with cuttings upon completion.

APPENDIX B

SOIL LABORATORY TEST DATA

Summary of Soil Laboratory Tests
Gradation Curves

Summary Of Laboratory Tests

Project Number: 14616014

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Natural Moisture (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Passing No. 200 Sieve	Percent Sand	Percent Gravel
B-5	4.0 - 6.0 / 1073.0 - 1071.0	Jar	SANDY ELASTIC SILT (MH), trace gravel, mottled red brown and light brown	37.3	70	38	32	69.9	25.9	4.2
B-8	2.0 - 3.5 / 1080.0 - 1078.5	Jar	SILT WITH SAND (ML), trace gravel, brown	37.3	49	29	20	80.2	17.4	2.4

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

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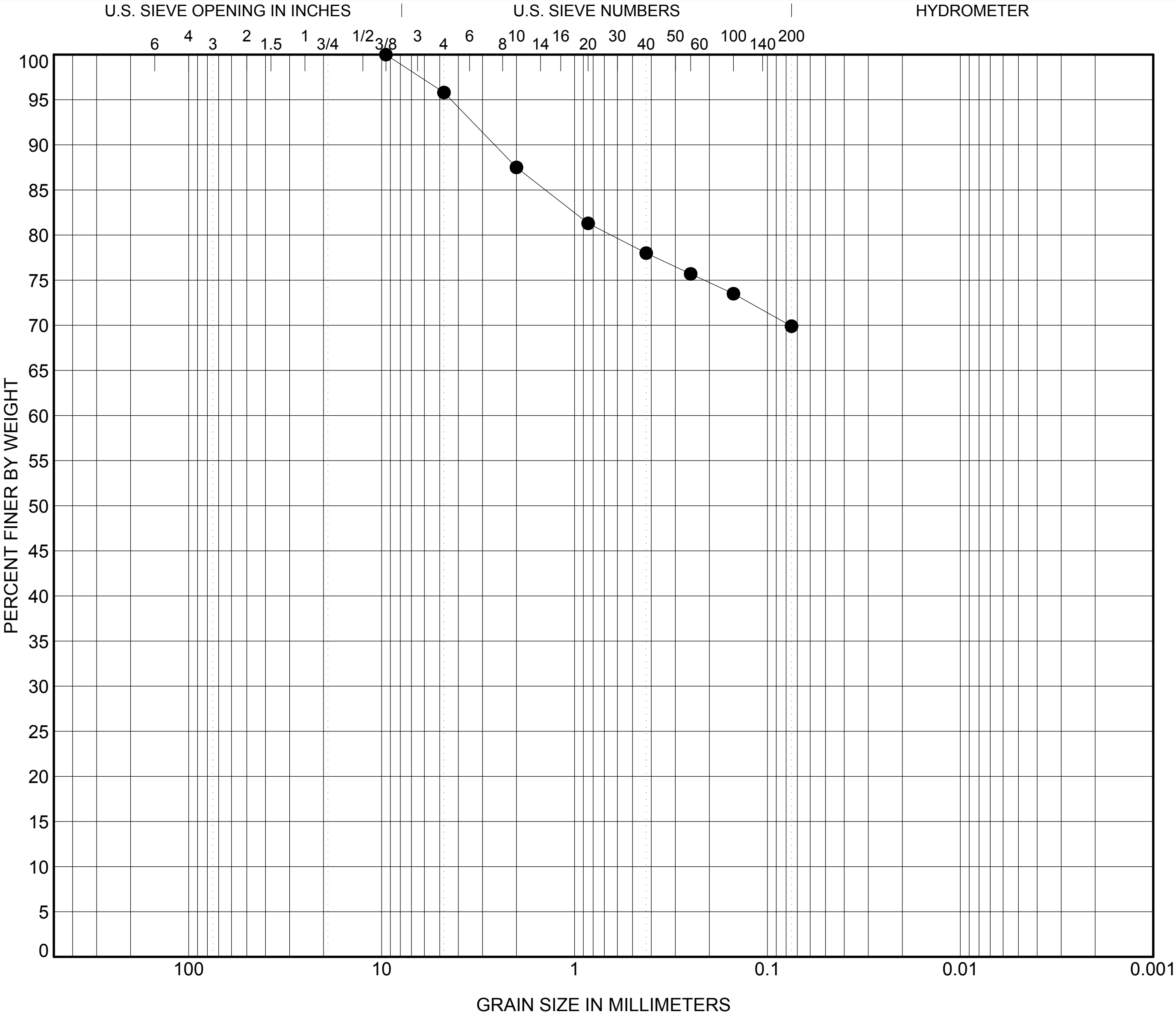
Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, VA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen		Sample Description	LL	PL	PI		
●	B-5	4.0 ft	**SANDY ELASTIC SILT (MH), trace gravel, mottled red brown and light brown**	**70**	**38**	**32**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM D422	**9.5**				**4.2**	**25.9**	**69.9**	

Percent Finer

Sieve Size	No. 200	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4	3/8 in.
% Finer	69.9	73.5	75.7	78.0	81.3	87.5	95.8	100.0

Tested By	Tested Date	Reviewed By	Calc By
MJF	4/22/14	TTM	MJF

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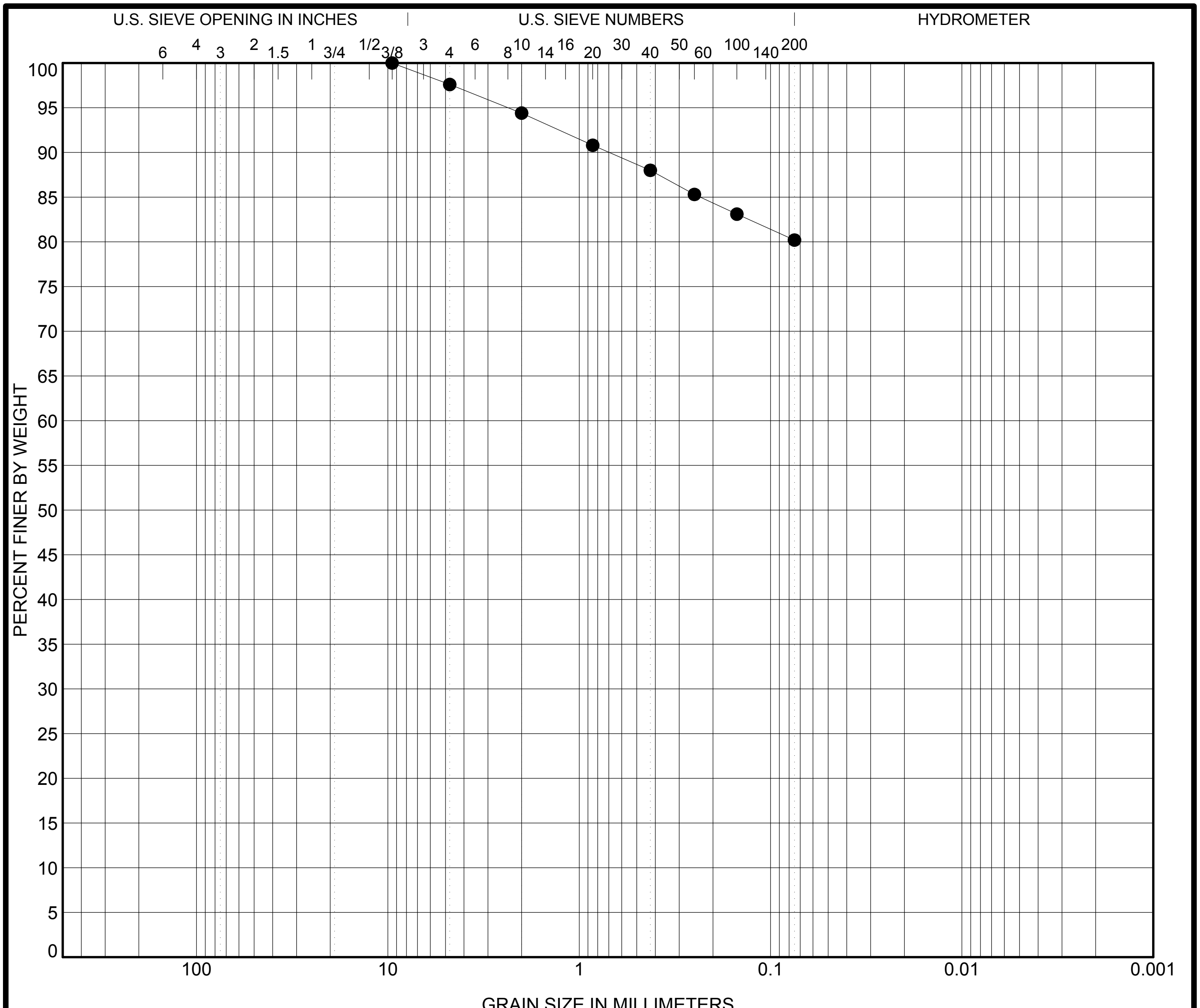
GRADATION CURVE

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, VA

Contract: 14616014



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen		Sample Description	LL	PL	PI		
●	B-8	2.0 ft	**SILT WITH SAND (ML), trace gravel, brown**	**49**	**29**	**20**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM D422	**9.5**				**2.4**	**17.4**	**80.2**	

Percent Finer

Sieve Size	No. 200	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4	3/8 in.
% Finer	80.2	83.1	85.3	88.0	90.8	94.4	97.6	100.0

Tested By	Tested Date	Reviewed By	Calc By
MJF	4/22/14	TTM	MJF

Schnabel ENGINEERING

GRADATION CURVE

Project: VA Medical Center Boiler Building
Roanoke Boulevard
Salem, VA

Contract: 14616014