



**REPORT OF PRELIMINARY SUBSURFACE EXPLORATION AND
GEOTECHNICAL ENGINEERING ANALYSIS**

**ACADEMY HILL TOWNHOMES
TOWN OF WARRENTON, VIRGINIA**

FOR:

**N.V.P. INC.
9300 GRANT AVENUE
SUITE 300
MANASSAS, VIRGINIA 20110**

PROJECT NO. 5929

**August 19, 2016
WWW.DEA-INC.NET**



August 19, 2016

Mr. Matt Sealy
Land Development Manager
9300 Grant Avenue
Suite 300
Manassas, Virginia 20110

Re: Preliminary Subsurface Exploration and Geotechnical Engineering Analysis
Academy Hill Townhomes
Town of Warrenton, Virginia
Project No. 5929

Mr. Sealy:

Dominion Engineering Associates, Inc. (DEA) is pleased to present this preliminary report of subsurface exploration and geotechnical engineering analysis for the above referenced project.

The following report describes the project characteristics, subsurface exploration, data obtained from the exploration and laboratory services, and provides preliminary geotechnical evaluations and recommendations. Soil samples obtained from the current study are stored in DEA's Fredericksburg Soils Laboratory and will be discarded after 60 days unless requested otherwise.

If any questions should arise regarding the information and/or recommendations contained within this report, or if DEA can be of further assistance, please do not hesitate to call.

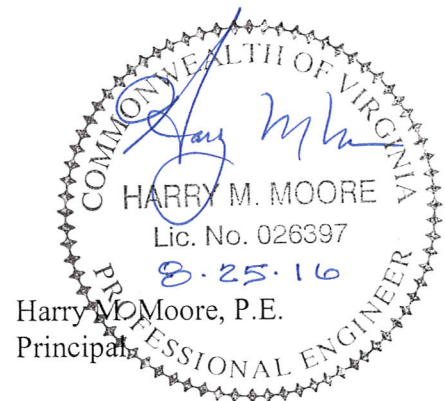
Respectfully,
Dominion Engineering Associates, Inc.

A handwritten signature in blue ink, appearing to read "W. T. Griffith, III".

William T. Griffith, III, C.P.G.
Project Geologist

Attachments: Soil Classification Chart
Boring Logs
Laboratory Test Results
Boring Location Plan

S: Geotech reports\2016\5929 Academy Hill Townhomes Preliminary Report



Dominion Engineering Associates, Inc. (DEA) is pleased to present this preliminary report of the subsurface exploration and geotechnical engineering analysis for Academy Hill Townhomes, a proposed residential development in the Town of Warrenton, Virginia. This report presents the findings of the subsurface exploration along with a preliminary evaluation and recommendations regarding general geotechnical-related design and construction considerations for the site.

Purpose

The purpose of this study was to explore the general subsurface conditions across the property and to provide preliminary geotechnical recommendations for residential land development and building construction. More specifically, a subsurface exploration consisting of 13 widely spaced soil borings was performed at the property in June of 2016. The exploration was performed to acquire information that would allow DEA to make preliminary geotechnical recommendations for building pad preparation, foundations, basement walls, slab-on-grade, retaining wall design, utility installation, pavement areas, and stormwater management facilities. The findings of the exploration and preliminary recommendations are provided within this report.

Drilling Procedures

DEA's fieldwork included a site visit by DEA personnel and drilling thirteen (13) hollow stem auger borings at the site. Generally, the borings were performed along proposed roadways, within various building pads, and in areas where retaining walls may potentially be required. Boring locations for the subsurface exploration were selected by DEA based on existing site features and the Conceptual Layout Plan #1 prepared by Bowman Consulting, dated May 16, 2016. This plan depicted a preliminary site layout with the general location of townhouse lots, access roadways, parking areas, and a stormwater management pond (SWMP). The location of retaining walls was not depicted on the plan. The approximate boring locations for the subsurface exploration are shown on the attached Boring Location Plans.

The soil borings were performed by Stevens Drilling utilizing a CME-45 ATV-mounted drill rig. The borings were drilled using continuous-flight, hollow-stem augers to advance the boreholes. The drill crew maintained a field log of the soils encountered during the drilling of each boring. After recovery, each sample was removed from the sampler and visually classified. Representative portions of each sample were then sealed in glass jars and brought to DEA's soils laboratory in Fredericksburg, Virginia for further visual observation and laboratory testing.

Soil samples were obtained by means of the split-barrel sampling procedure in accordance with ASTM Specification D1586. In this procedure, a 2-inch outside diameter split-barrel sampler is driven into the soil a distance of 18 inches by a 140-pound hammer falling 30 inches. After an initial 6-inch seating interval, the number of blows required to drive the sampler through the next 12-inch interval is termed the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring logs. This value can be used as a qualitative indication of the in-place relative density of cohesionless soils. The N-value can be also used as an indication of the in-place consistency of cohesive soils. These indications are qualitative, since many factors such as drill crews, drill rigs, drilling procedures, and hammer-rod-sampler assemblies can affect the N-value and correlation between blow counts and strength and compressibility of soils.

The drill crews maintained a field log of the subsurface conditions encountered at each of the boring locations during drilling. The soil samples recovered during the drilling process were visually classified by the drill crew. Representative portions of the recovered samples were placed in a jar and sealed. These samples were returned to the DEA laboratory for further examination and laboratory testing to determine pertinent engineering properties.

Laboratory Testing Program

The laboratory testing program consisted of visual classifications of the soil samples and data obtained from the laboratory testing including moisture content tests, percent passing the No. 200 sieve, and Atterberg limits. All data obtained from the laboratory tests are included on the respective boring logs and on data sheets in the Appendix to this report. The soil samples collected for subsurface exploration will be retained at our laboratory for a period of 60 days. After this time, they will be discarded unless other instructions are received as to their disposition.

Visual Classification

DEA personnel classified each soil sample on the basis of texture and plasticity in accordance with the Unified Soil Classification System (ASTM D 2488). The group symbols for each soil type are indicated in the parentheses following the soil descriptions on the boring logs. A brief explanation of the Unified Soil Classification System is included with this report. The stratification lines designating the interfaces between earth materials on the boring logs are approximate; in-situ, the transitions may be gradual and/or at slightly different levels.

Moisture Content Tests

ASTM Designation D2216 gives the standard procedure for determining the moisture content of soil. The moisture content is defined as the ratio of the weight of water to the weight of

solids in a given soil mass and is usually expressed as a percentage. The moisture content is determined by weighing a soil sample, thoroughly drying it at a specified temperature, and weighing it after drying.

Liquid Limit Test, Plastic Limits Test, and Plasticity Index

ASTM Designation D4318 gives the standard procedure for determining the Plastic and Liquid Limits of soil. The sample for the Plastic and Liquid Limit tests is prepared by removing all material larger than the #40 (425 μ m) sieve.

The Liquid Limit test is determined by performing multiple trials in which a portion of the prepared sample is spread in a cup (of specified material and dimensions) and divided by a grooving tool. Then the soil is allowed to flow together, a distance of 1/2 inch, by the force of repeatedly dropping the cup in a standard mechanical device. Data from the multiple trials is plotted with the water content on the y-axis and the number of drops required closing the groove on the x-axis. The Liquid Limit is defined as the water content at which 25 drops are required to close the groove made in the soil.

The Plastic Limit is determined by rolling a small portion of the prepared soil sample into a thread with a uniform diameter of 1/8 inch. The thread is rolled into a ball and rerolled into a thread with a uniform diameter of 1/8 inch. The process is repeated until the thread crumbles and can no longer be rolled into a 1/8-inch thread. The water content of the soil at this point is the Plastic Limit. The Plasticity Index is defined as the difference between the Liquid Limit and the Plastic Limit.

Washed Sieve Analysis

ASTM Designation D1140 gives the standard procedure for determining the amount of material finer than a No. 200 sieve by washing. The percent finer than the No. 200 sieve is found by washing a soil specimen over a No. 200 sieve. Clay and silt, as well as other water soluble materials, are removed from the soil during the test. The percent finer than the No. 200 sieve is found by subtracting the dry mass of the specimen retained on the No. 200 sieve from the original dry mass of the specimen and dividing the result by original dry mass. The washed sieve analysis gives the percentage of fines (Clay and Silt) in a given sample or, conversely, the percent granular material (Sands and Gravel).

Proposed Construction

Based on the Conceptual Layout Plan #1, prepared by Bowman Consulting dated May 16, 2016, improvements at the site shall consist of grading to prepare subdivision roadways, SWMPs, townhouse building pads, and utilities. Specific structural information was not provided at this time; however, for report purposes, we anticipate that the building

construction will consist of two-story townhouses with both walk-out and in-ground basements. We anticipate wood-frame construction above grade and concrete construction below grade with concrete floor slabs. Each townhouse unit will be serviced by public water and utilities. Based on the above noted plans, a general area for stormwater management facilities is outlined at the southeast corner of the site; however, the number, layout, and type of facilities proposed to provide stormwater management was not known at this time. In addition, based on the existing site topography, we anticipate that retaining walls will be incorporated into the site layout; however, at the time that this report was written, the location of retaining walls was not known.

Site and Subsurface Conditions

The site is located on the south side of Academy Hill Road, at its intersection with Boundary Lane in the Town of Warrenton, Virginia. The site is generally a wooded parcel of land with moderate to steeply sloping topography directing drainage downhill toward a swale at the southeast side of the site. At the central area of the site, the site topography changes to a relatively flat area oriented in a northeast to southwest direction. Considering the relatively steep topography immediately uphill and downhill of this flat area, it is possible soil was borrowed from this property in the past. Elevations across the site range from a high of about EL 621 feet at the northwest corner of the property to a low of approximately EL 541 feet at the southeast corner of the property.

The project site is geologically mapped within the Catoclin Formation of the eastern Blue Ridge Physiographic Province of Virginia. The Catoclin Formation is thought to have formed from ancient lava flows and eruptive material associated with a continental rifting event. The volcanic material and surrounding sedimentary material underwent metamorphism during later continental collisions. The rocks of the Catoclin Formation consist primarily of greenstone (meta-basalts) and associated meta-rhyolite, tuffaceous phyllite, meta-basalt breccia, and associated meta-sedimentary rocks. Greenstone is the generic term utilized to categorize these rocks consisting primarily of green minerals such as chlorite, actinolite, and epidote. Soils formed from the Catoclin parent rock are typically fine grained, micaceous or rich in chlorite (mica-like mineral), and are often times highly plastic. The project site appears to be underlain by chlorite schist (greenschist) formed by the metamorphism of amphibole rich mafic basalt. The higher peaks in and directly outside of Warrenton area are typically underlain by greenschists. These materials weather into fine grained soil that often times are micaceous and/or highly plastic.

Natural soils were encountered at each boring location drilled as part of this study. Topsoil thicknesses at the boring locations ranged from one (1) to four (4) inches. Considering this, and the mature tree cover at the site, a topsoil depth of at least ten (10) inches should be estimated. Along drainage swales, thicker stripping depths due to accumulated topsoil and alluvial materials should be anticipated. Below the topsoil layer, the natural soils at our

boring locations consisted of fine grained soil classified as SILT (ML) and Elastic SILT (MH). In most borings, weathered rock was encountered. The samples of the weathered rock recovered in our borings was classified as SILT (ML). Standard Penetration Test (SPT) N-values ranging between 5 blows per foot (bpf) and 50 blows in 0 inches of penetration. These SPT N-values corresponded to consistencies of medium stiff to very hard for fine grained cohesive soil. Even if sampled as SILT, materials with SPT N-values greater than 65 bpf are considered weathered rock for the purposes of this study.

Weathered rock was encountered in all of the borings performed at this site, except at B-5, B-8, B-9, and B-12. These materials were encountered between 2 feet and 18 feet below existing grades, corresponding to elevations between EL. 550 feet and 594 feet. Auger refusal upon rock was encountered in Borings B-3, B-7, and B-10 between 4.7 feet and 19.2 feet below existing grades, corresponding to elevations between EL. 570 feet and 579 feet.

Groundwater was encountered Borings B-1, B-2, B-6, B-8, B-10, and B-11 between 10 feet and 18.6 feet below existing grades, corresponding to elevations between EL. 567 feet and 593 feet. Generally, these borings were performed at the west half of the site. Otherwise, groundwater was not encountered at the locations drilled. Groundwater on sites with shallow rock is commonly perched at the soil and weathered rock interface or within cracks within weathered rock/rock itself. When rainfall, surface flow, or groundwater enters the site it will continue to infiltrate downwards until it reaches virtually impermeable layers of cohesive soil or weathered rock materials. It will continue to flow along the impermeable layer until it encounters areas where downward infiltration is possible or until it daylight at the surface as a spring or intermittent stream. The position of the groundwater table or perched water condition is anticipated to fluctuate depending on variability in the amount of precipitation, surface runoff, evaporation, and similar factors. Sometimes gray colorations in the soils samples suggest an indication of slow internal drainage or perched water conditions that may occur during wet times of the year. It should be expected that the groundwater level around the existing swale will remain high throughout the year.

The following table summarizes the locations of groundwater, weathered rock, and auger refusal at our boring locations:

Boring Number	Existing Elevation	Shallowest Recorded Groundwater Depth (ft/Elevation)	Depth to Very Dense Materials (ft/Elevation)	Auger Refusal (ft/Elevation)	Notes
B-1	612	18.6' (593.4')	18' (594)	-	-
B-2	590	15.5' (574.5')	8' (582)	-	-
B-3	593	Dry	8' (585)	13.4' (579.6)	-
B-4	578	Dry	8' (570)	-	MH Soil 0-2'
B-5	576	Dry	-	-	-
B-6	605	16.2' (588.8')	13' (592)	-	MH Soil 0-2'
B-7	579	Dry	4.7' (574.3)	4.7' (574.3)	-
B-8	576	14' (562)	-	-	-

Boring Number	Existing Elevation	Shallowest Recorded Groundwater Depth (ft/Elevation)	Depth to Very Dense Materials (ft/Elevation)	Auger Refusal (ft/Elevation)	Notes
B-9	580	Dry	-	-	MH Soil 0-2'
B-10	590	15.5' (574.5)	5' (585)	19.2' (570.8)	MH Soil 0-4'
B-11	577	10' (567)	2' (575)	-	-
B-12	570	Dry	-	-	-
B-13	553	Dry	8' (550)	-	MH Soil 0-2'

RESULTS AND RECOMMENDATIONS

Dominion Engineering Associates, Inc. (DEA) has completed the preliminary subsurface exploration and geotechnical engineering analysis for Academy Hill, a proposed residential subdivision in the Town of Warrenton, Virginia. If the site geometry, proposed road, SWMP, and building locations are different than described within this report, we request the opportunity to review our recommendations in light of the new information and revise them, as necessary. This report is preliminary in nature and written without the benefit of proposed site grades and without location and layout of stormwater facilities and retaining walls. DEA should be allowed to review our boring information once grading plans are prepared to determine if additional recommendations or additional borings would be prudent.

Seismic Recommendation

Based on the soil boring data and the 2012 International Building Code, the site should be considered Seismic Site Classification D.

Site Preparation and Clearing

The first phase of earthwork operations should include stripping and grubbing of any debris, vegetation, topsoil, and organic matter from the areas to receive fill and within the extended building and pavement limits. Stripping should be accomplished to a distance of at least 10 feet beyond building lines, or the toe of fill embankments, and two (2) feet beyond the edge of curbs. For planning purposes, we anticipate a stripping depth of at least 8 inches for vegetated areas with deeper stripping depths necessary within the base of drainage swales. The geotechnical engineer should evaluate topsoil depth further during construction to determine if the stripping depth can be reduced. If site development commences during typically seasonal wet weather, stripping operations could disturb soils that would normally be considered suitable during drier months of the year, potentially increasing the quantity of soils removed and subsequently increasing construction cost. After clearing/grubbing/stripping and prior to

fill operations in the areas of the building pads, proposed pavement areas, and other structural elements, the soil subgrade should be proofrolled.

The proofroll evaluation should be performed prior to any cuts/fills throughout the entire site. Proofrolling should be performed utilizing a loaded dump truck having an axle weight of at least 10 tons, and observed by an experienced Geotechnical Engineer or his/her authorized representative. The proofrolling should be performed by driving the loaded dump truck in tightly spaced parallel runs on the subgrade being evaluated to ensure full coverage of the subgrade area. Any soft/very loose or unsuitable materials encountered during this proofrolling should be removed and replaced with Engineered Fill; test pits may be recommended to evaluate the depth of undercuts (if needed) as recommended by the Geotechnical Engineer. If the depths of the soft/loose soils are shallow (less than one foot), it may be possible to scarify and recompact the soils in place. Prepared pavement subgrades should also be proofrolled to evaluate suitability prior to both placements of aggregate base course and asphalt/concrete pavement materials.

After proofrolling and any performed undercuts, we recommend that the exposed subgrade in areas to receive fill be compacted with a heavy roller. This typically requires at least three (3) passes performed across the site followed by at least three (3) more passes perpendicular to the initial passes. This will aid in densifying the surficial soils and providing more uniform support of the slabs-on-grade and pavement areas. This should also help reduce potential building movements during and after construction. Cut areas should be rolled similarly after completion of any performed cuts.

Any fill operations in the building pad and paved areas should be performed in accordance with the recommendations of the Engineered Fill section of this report. If earthwork commences during the wetter months and during periods of wet weather, surface water control measures to dewater the site may be required.

At this time, proposed grades were not known; therefore, it is difficult to determine if groundwater will affect earthwork operations, basement excavations, utility installation, and storm sewer installation above these depths. Once grading plans are prepared, DEA should be allowed to review and evaluate the proposed grades compared to the water levels observed in the borings. Contractors should also examine the water levels to determine if groundwater will affect mass grading and utility installation at the site. It should be expected that dewatering of excavations will be necessary in some areas. The geotechnical engineer should be contacted during construction if groundwater is encountered to provide appropriate recommendations. Final site grading should be designed to allow for positive drainage away from building pads. Dewatering and on-site drainage should be the responsibility of the contractor.

Weathered rock and auger refusal on rock was encountered in many of the borings performed at the site. As noted above, proposed grades were not known at this time; therefore, the

impacted of rock on mass grading and utility installation was not known at this site. The depth of very dense materials and auger refusal upon weathered rock should be reviewed by the Civil Engineer to determine if grading adjustments are warranted. Contractors should also closely review the depth of rock materials noted on our logs to determine if rock removal through ripping, hoe-ramming, or blasting will be necessary. If blasting is deemed necessary, it will be the contractors responsibility to determine if blasting will be allowed in the area of this project site.

Rock Materials

The rock encountered at this site will typically excavate in relatively large cobble to boulder sized round to flat tabular slabs that are difficult to compact. Without specific testing, these larger cobbles and boulders should be considered non-durable in nature. Larger rocks, which break into smaller fragments in the initial excavation, must be compacted with a sufficient compaction energy to substantially break them down into soil size particles during construction.

Rock removed during blasting and ripping operations may be reused as fill once broken down by mechanical compaction effort or crushing. For the purposes of this report, rock at this site will be considered nondurable. The durability of the rock is the ability of a rock or rock-like material to withstand long term chemical or mechanical weathering without size degradation. Any rock materials excavated from the site and reused as fill should be blended with finer grained materials to create a well-graded material with the rock having a maximum size of 4-inches in lateral dimension and 2-inches in thickness. Larger rock should be mechanically broken down with earthwork equipment or crushing equipment to achieve the desired grain size distribution. The resulting fill material should have a "soil skeleton" with rocks evenly dispersed within a matrix of finer grained materials (clay to sand). Laboratory testing including Standard proctor, Atterberg limits, and gradation testing shall be performed on these materials broken down by compaction equipment prior to being reused as engineered fill, to determine if the materials are broken down and blended suitably.

Rock Excavation and Blasting

Depending on proposed grades at the site, ripping, hoe ramming, and/or blasting may be required to reach design grades. If blasting is deemed necessary, the contractor should determine if blasting is allowed in the area of this project site. If blasting is not allowed, the contractor will have to determine alternative methods to reach design grades or possibly the site grading will have to be altered to reduce the amount of rock removal necessary.

Generally, rock materials can be excavated in mass grading operations where rippers are used to a depth of less than 1 foot below the boring refusal depths, or within 2 to 3 feet below materials that have SPT N-values greater than or equal to 50 blows per 3 inches of penetration. Below these depths, hoe-ramming and/or blasting is normally required. In trench

excavations, the maximum depth of excavation with conventional excavation equipment is normally to the depth of boring refusal, and hoe ramming is often employed to extend excavation farther, regardless of the type of rock. In this area, contractors often drill holes in the rock prior to hoe-ramming to help remove the rock.

If blasting of rock is deemed necessary, there is the potential for over-blasting the rock. Over-blasting can significantly impact the budget. If the rock is blasted too deep below planned excavation, some blasted and loosened rock may remain after grading. This remaining blasted material can be highly fractured and/or loosely compacted. Once loads are placed on the loosened over-blasted materials, then the open fractures can close, resulting in settlement. Where over blasting occurs, the disturbed materials must be completely removed.

Foundation Recommendations

The subsurface conditions encountered in our borings indicate that the proposed structures may be supported on conventional shallow footings with a ground-supported floor slab. Footings supported by natural firm soils or on newly Engineered Fill over firm materials may be designed for a net allowable bearing pressure of 2,000 pounds per square foot (psf). For footings that bear on CL, ML, MH or CH soils (generally anticipated) may also be designed for a net allowable bearing pressure of 2,000 psf provided bearing capacity is verified during construction.

Footings bearing on these soils types (CL, ML, MH, CH) should have at least 8 blows per foot when tested at actual bearing elevations with a Dynamic Cone Penetrometer (DCP). If less than 8 blow per foot, bearing may need to be lowered to 1,500 psf and/or footings can be widened or an undercut performed to material meeting this criteria to achieve 2,000 psf. The structural engineer should be consulted for approval if bearing is less than footings are designed for or if footings are altered (widened).

Ideally, the home builder should have footing designs on their plans for both anticipated allowable bearing capacities of 1,500 and 2,000 psf. For these soils types, 1,500 psf is prescriptive with respect to the building code. This would alleviate costly delays during foundation construction when soil conditions are less than 2,000 psf.

If a structure supported on shallow foundations is partially bearing over rock and partially over soil, this could create intolerable differential settlement. Along the foundation excavations, at the transition between soil and weathered rock, areas of rock should be over excavated approximately 12 inches and replaced with lightly compacted fill to create a buffer between the structural element and the rock. This should be performed at least 10 feet beyond the soil rock interface into the rock area, potentially more depending on the separation distance of largely loaded areas. Additional reinforcing steel may be required in these transition areas, if directed by the Structural Engineer. If this condition is encountered at the

time of construction, DEA reserves the right to review the above recommendations based upon actual site conditions encountered in the field. Revision to these recommendations may be necessary at that time.

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. Based on footings designed and constructed herein utilizing a net allowable bearing pressure of 1500 to 2,000 psf, the total long term settlements of the buildings are estimated to be less than one (1) inch with differential settlements between similarly loaded columns or along equal lengths of wall estimated to be less than half the total settlements.

In order to increase the factor of safety against bearing failure, we recommend that continuous (wall type) footings and column footings have minimum dimensions of 18 and 24 inches, respectively. Footings should be placed at a minimum depth of 18 inches below finished grade to satisfy bearing capacity and frost depth considerations. Due to shrink-swell soils being present, foundations may need to bear at lower elevations. The excavation below design bearing grades may be restored as described in the following paragraphs of this report.

A Geotechnical Engineer should observe the foundation subgrade to verify that conditions exposed at the bottom of footing are suitable for the design bearing pressures. Hand augers and/or test pits should be performed within the footing excavation to aid in the evaluation of soil conditions below footing subgrades. If unsuitable materials such as soft/loose or shrink-swell soils (CH, MH) are encountered at the base of a foundation excavation, it will be necessary to lower the base of the footing through the unsuitable materials or to undercut the unsuitable soils and restore the original bearing levels with Engineered Fill, flowable fill, lean concrete, or additional footing concrete as recommended by the Geotechnical Engineer. If undercuts are performed due to unsuitable materials, the undercuts should be over-excavated one (1) foot wider for each one (1) foot below design bearing grade. Where foundations are lowered due to shrink-swell soils, only flowable fill, lean concrete or the concrete foundation mix should be used to replace undercut materials. Typically, foundations lowered due to shrink-swell soils need to bear four (4) feet below finished grades.

Exposure to the environment may weaken the soils at the footing bearing levels if the foundation excavations remain open for too long a time. Therefore, foundation concrete should be placed during 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 excavations prior to placement of concrete. Re-evaluation of bearing soils should be made by the Geotechnical Engineer when these soils have been subject to softening. Foundations should also be backfilled as soon as possible to reduce water infiltration to the bottom of the foundations during construction. Water should not be allowed to pond or collect adjacent to the foundations. Control of surface water and dewatering should be the responsibility of the contractor.

The building footings should be evaluated as an independent system, which are not rigidly connected to the floor slab. In addition, we recommend that the footings be adequately reinforced and be of sufficient thickness so as to better distribute the foundation structural loading.

Foundation Wall Recommendations

The design of the below grade foundation walls should account for the loading imposed by the lateral earth, water, and surcharge pressures. Adequate drainage must be provided to relieve hydrostatic pressures on the foundation walls. These recommendations assume adequate drainage such that hydrostatic pressures do not develop behind the walls.

It has been assumed that the foundation walls are braced, will experience at-rest soil conditions and are adequately drained. Soil types classified as SM, SC, ML, and CL are generally expected to be present within the basement excavations. Wall heights, thicknesses, and steel reinforcement should be based on wall designs specific to the house types, soil conditions, and site grading. Considering the soil types which are present, an earth pressure of 60 psf should be used, which is in accordance with the 2012 International Residential Code.

Soils classified as MH and CH are not permitted to be used as backfill of basement walls. When these soils are present in the basement excavation of a specific lot, soils may need to be imported to backfill and the MH or CH soils may need to be re-spread on the lot or hauled off.

Basement and Garage Floor Slab (Slab-On-Grade)

We understand the basement slab shall be constructed as ground-supported. Basement and Garage floor slabs should bear on firm, natural soils or on newly placed engineered fill soils over natural soils. Garage slabs, depending on final grading plans may need to be designed as "Structural Slabs". We recommend that the slab-on-grade be underlain by four (4) inches of compacted porous fill (VDOT No. 57 stone). This porous fill will facilitate the fine grading of the subgrade and help reduce the capillary rise of water to the floor slab. The porous fill should be compacted in place by at least two (2) passes with suitable vibratory compaction equipment. Before the placement of concrete, a minimum 6-mil poly vapor barrier should be placed on top of the porous fill to provide additional moisture protection. Based on the soil boring data, we recommend the floor slabs be designed assuming a Modulus of Subgrade Reaction (k) of 75 psi.

Utility excavations beneath the floor slab should be backfilled with Engineered Fill and/or open graded aggregate such as VDOT No. 57 stone. The stone should be placed in maximum 12-inch lifts and compacted with at least two (2) passes of suitable vibratory equipment. If shrink-swell soils are present, utility excavations should be backfilled with Engineered Fill (not No. 57 Stone) or dense graded aggregate such as VDOT No. 21A/B. When Engineered

Fill for backfilling utilities consists of soil or VDOT No. 21A/B, the compaction required is a minimum 95% of maximum dry density per ASTM D698 (Standard Proctor).

We recommend that the floor slab be isolated from the foundation footings to reduce shear stresses on the floor slab from differential settlements of the structure. Also, to reduce the width of any shrinkage cracks that may develop near the surface of the slab, we recommend reinforcement be included in the design of the floor slab.

Asphalt Pavement Recommendations

A design CBR value of 4 is recommended for the onsite ML soils. This value is 2/3's of the estimated CBR value of 6 based on our experience with similar soil types. If expansive soils are present at final pavement subgrades, it may be necessary to undercut these soils (up to 1 foot) or stabilize with lime. Based on the soil borings, MH soils are located at this site and could be exposed at the roadway/parking lot subgrade. For the estimated volume and type of traffic (primarily automobiles) noted below, the following preliminary pavement section is recommended for consideration:

(0-200 vpd)

Surface Asphalt (SM 9.5A)*	1.5"
Base Asphalt (IM -19.0)	2.0"
Base (Compacted 21 A/B Stone)	8.0"

*If roadways will be turned over to VDOT and incorporated into the VDOT roadway system, VDOT will likely require the surface mix to be SM 12.5 instead of SM 9.5A.

It is DEA's belief that the three-layer pavement section is superior to a two-layer system and worth the initial investment. The individual layer thicknesses listed above are considered minimum compacted thicknesses for the different materials.

For the design and construction of the asphalt and concrete pavements, the subgrade should be prepared as outlined in this report. 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 reduce the possibility of the subgrade materials becoming saturated over a long period of time. The groundwater table should not affect the performance of pavements in the remaining areas. Reduction of the soil bearing capacity could result from surface runoff water that is trapped during construction on exposed subgrade soils. Another source of potential soil bearing capacity reduction is water that seeps under pavement from irrigation systems. These methods of bearing capacity reduction could create localized deterioration of the pavement system. Therefore, the earthwork Contractor and Civil Designer should consider the crowning

of pavement subgrades. This will promote the positive drainage of water that could otherwise enter the pavement base and subbase materials.

Standing water that tends to develop within the base course layer may be reduced by the following methods: installing temporary weep holes in drainage structures, construction of drainage swales/diversion ditches, and proper backfill/grading behind curbs to reduce water intrusion from behind the curbs. Pavement subdrains (VDOT UD-4 or similar) or drainage ditches should be provided behind curbs in areas where the grades slope toward the pavements. The invert grade of swales should be at least two (2) feet below the pavement section subgrade level. Pavement subdrains should be daylighted or connected to a storm sewer.

It should be noted that pavement sections subjected to construction traffic (e.g. concrete trucks, tractor trailers, forklifts, etc.) may experience premature deterioration, especially in the sections not constructed to full depth. Pavement failure could result in the need to remove asphalt, subbase stone, and/or subgrade soils in order to replace them with new materials. Re-use of the in-place materials may be possible if they are suitable to meet the pavement design requirements.

Stormwater Management

Stormwater management facilities are proposed at the southeast area of the site. At the time that this report was written, only the general area of the stormwater facilities is known. The type of facilities, layout, and orientation of facilities was not known. The following general recommendations have been provided to help guide the design of the stormwater management facilities.

Pond Embankment Construction

We recommend that the side slopes of any embankments be constructed of cut-slopes or compacted fill to grades no steeper than 3H:1V. The embankment portions may be constructed as homogenous sections provided the proper cohesive materials are used to construct them. If suitable cohesive soils are not available to construct the embankment dam as a homogenous section, a zoned dam with a clay core could be constructed. The Geotechnical Engineer should pre-approve the fill materials used for construction. The geotechnical engineer should also provide dimensions for the clay core during construction if a zoned dam is constructed in lieu of a homogenous dam.

Embankment Fill Type

Soils classified MH or CH per ASTM D-2487 may be used within the embankment as long as the materials are not used within 4 feet of the embankment slope surfaces. We recommend a

lower plasticity soil such as silt (ML), lean clay (CL), or clayey Sand (SC) for the embankment. During excavation, the following soil types: CL, MH, or MH and possibly CH or SC soils, if encountered, should be stockpiled for use in the embankment fill. The SM soils encountered throughout the site may also be considered for use as embankment fill, however these soils should be tested further during construction to evaluate if the “Fines” content is acceptable and approved by the geotechnical engineer.

Fill Compaction Requirements

Compacted fill in the embankments should be placed in horizontal loose lifts, 8 inches thick prior to compacting and moisture conditioned to permit compaction to at least 95% of the maximum dry density determined in accordance with ASTM D-698, Standard Proctor Method. To reduce the seepage through the embankment it is preferable to compact the fill layers on the wet side of optimum at a moisture content between the soils optimum moisture content and no greater than the moisture that would preclude proper compaction. The surface of each lift should be scarified (roughened) before placement of a subsequent fill lift to better bond the soils together. This helps to reduce potential planes of horizontal seepage.

Furthermore, fill areas should be properly roughened or scarified using a sheepsfoot roller or similar equipment prior to the placement of the next fill layer. Although it is desirable to seal fill operations on a daily basis using a steel drum or rubber tire roller, these surfaces should be scarified the following day prior to fill activities to minimize the creation of planes of seepage within the embankment structure.

In general, granular soils (Unified Soil Classification System SC, SM or more granular) should not be used in the cut-off trench or dam core if applicable. Elsewhere, the granular soils could be compacted with a smooth drum vibratory roller or rubber-tired compactor. Cohesive soils should be compacted with a sheepsfoot roller.

In order to facilitate the establishment of grass on the pond embankment slopes, it is considered acceptable to place a 6 to 12-inch thick layer of topsoil on the faces of the embankment slopes. The topsoil materials should be placed in maximum 6-inch loose fill lifts and should be compacted with at least four passes of a tracked dozer. It should be noted that proper vegetative cover is necessary to reduce potential surficial sloughing. Vegetative cover should be established as soon as possible after final grades are achieved.

All fill operations should be observed on a full-time basis by a qualified soil technician to evaluate soil type and whether minimum compaction requirements are being met. A minimum of three compaction tests per lift (fill layer) should be performed within the core trench, embankment core, and embankments. The elevation and location of the tests should be clearly identified at the time of fill placement.

Fill materials should not be placed on frozen soils. All frozen soils should be removed prior to continuation of fill operations. Borrow fill material shall not contain frozen materials at the time of placement. All frost-heaved soils should be removed prior to placement of fill, stone, or concrete.

Cut-Off Trench

A cut-off trench should be located along the centerline of soil embankments, directly under their centerlines to reduce seepage if suitable soils are not present below the proposed embankment. The geotechnical engineer should perform test pits along the centerline of the embankment dams during construction to evaluate that the actual subsurface conditions and provide recommendations with respect to the need for a cut-off trench if subsurface soil conditions are not appropriate.

The cut-off trench (if required) should extend at least 4 feet below the bottom of the embankment (or into cohesive soils) and laterally along the centerline of the embankment up the embankment slopes to the 2 year storm elevation. The cut-off trench should be at least 4 feet wide and soils used in the cut-off trench should consist of cohesive soils such as CL, and ML and/or as approved by the geotechnical engineer.

Principal Spillway

The principal spillway for the SWM facility should consist of the proper class reinforced concrete pipes (RCP) passing through the embankments capable of withstanding the proposed burial depths. Most dams of the type proposed fail due to inadequate seepage control and compaction adjacent to the outlet pipe penetrating the embankments. Anti-seepage collars have been used in the past to control seepage, and have been found to be ineffective. Seepage control should be provided by a concrete cradle and seepage/filter layer around the pipe. To reduce water seepage into or out of the spillway pipe, the pipe should be provided with watertight joints per ASTM C-361.

A concrete cradle should be provided for 2/3 of its length starting at the inlet end of the pipe and extending downstream. The concrete cradle should have a minimum thickness of six inches on the sides and bottom of the pipe and should be placed up to the centerline of the pipe.

The remaining 1/3 of the outlet pipe length should be surrounded with a minimum 12-inch thick layer of open graded aggregate (VDOT No. 78 or 57 stone) wrapped with a suitable non-woven geotextile such as Mirafi 140N to form a seepage collection layer around the pipe. The proper construction of this seepage collection drain is critical since the fabric and stone collect seepage along the pipes and act to resist any piping of fines that might develop along the conduit pipe. The geotextile fabric should extend to at least three feet below the end of the concrete cradle to form a positive connection. It is recommended that the geotextile fabric be

placed before the last section of the concrete cradle is poured. The trench for this 1/3 of the pipe should be excavated to provide a minimum thickness of stone equal to one-fourth the pipe diameter, but not less than 12 inches below the pipe. The thickness of stone along the sides and above the pipe should be at least 12 inches. The exposed subgrade should be observed and evaluated by the Geotechnical Engineer. Any soft or yielding areas should be undercut and replaced with compacted fill.

Seepage collected in the seepage collection layer should be discharged either through or around the end structure using a 4-inch schedule 40 pvc drain tile that is laid at the bottom of the stone a length of approximately 10-feet behind the end wall. The drain tile should be daylighted either through weep holes within the structure or by extending the drains along the back of each wing wall to daylight.

Once all of the conduit pipe, concrete, and the seepage collection layer have been installed, placement and compaction of the general embankment soils may resume. However, care should be taken to ensure that the conduit pipe is not crushed or broken by extreme compactive effort. Backfill over the pipe should be compacted to 95 percent of the soils maximum dry density as determined by the Standard Proctor Method, ASTM D-698. Side slopes, if constructed as the sides of the trench (i.e. open cut), should be benched prior to placement of backfill over the pipe.

Riser Structure

For the proposed riser structure, a net design allowable soil bearing pressure of 1,500 psf should be verified in the field by the Geotechnical Engineer for support of the structure. The foundations should bear on firm, natural undisturbed soils. We also recommend that the foundations be underlain by 4 inches of compacted porous fill (VDOT No. 57 stone). The foundations should bear a minimum of 24 inches below finished adjacent grades. Because of the potential for variable soil conditions to exist, care should be exercised during foundation construction in order to provide for suitable bearing conditions at and below the base levels of foundation excavation. Buoyant conditions should be taken under consideration by the Structural Engineer when designing the riser structure and its foundations.

The Geotechnical Engineer should observe and evaluate the base of riser foundation excavations in order to verify that the exposed conditions are suitable for support of the foundations. If unsuitable bearing conditions are encountered at the foundation level, then the base of the excavation should extend down to suitable materials at a lower elevation and backfilled with Engineered Fill. The original design bearing grade may be restored by the placement of "lean" (2,000 psi) concrete or flowable fill after removal of the unsuitable soils, possibly open-graded stone, or suitable compacted fill approved for use by the Geotechnical Engineer.

General Comments

This preliminary report has been prepared for N.V.P. Inc. to aid in the preliminary evaluation of the Academy Hill Townhomes, a proposed residential subdivision in the Town of Warrenton, Virginia, and to assist the Civil Engineer in the design of this project. The report has been prepared in accordance with generally acceptable geotechnical engineering practices and no other warranties, either expressed or implied, are made.

The scope is limited to the specific project and locations described herein and the description of the project represents DEA's understanding of the significant aspects relative to soil and foundation characteristics. In the event that any changes in the nature or location of the proposed construction outlined in this report are planned, DEA should be informed so that the changes can be reviewed and the conclusions of this report modified or approved.

It is recommended that all construction operations dealing with earthwork and foundations be reviewed by an experienced Geotechnical Engineer to provide information as to whether the design requirements are fulfilled in the actual construction. DEA would welcome the opportunity to provide field construction services during the construction phase.

The analysis and recommendations submitted in this report are based upon the data obtained from the soil borings and tests performed at the locations as indicated on the Boring Location Diagram and other information referenced in this report. This report does not reflect any variations that may occur between the borings. In the performance of the subsurface exploration, specific information is obtained at specific locations at specific times. However, variations in soil conditions exist on most sites between boring locations and from time to time. The nature and extent of variations may not become evident until the course of construction. If site conditions vary from those identified during the exploration, the recommendations contained in this report may require revision.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
<p>COARSE GRAINED SOILS</p> <p>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE</p>	<p>GRAVEL AND GRAVELLY SOILS</p>	<p>CLEAN GRAVELS</p> <p>(LITTLE OR NO FINES)</p>		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		<p>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE</p>	<p>GRAVELS WITH FINES</p> <p>(APPRECIABLE AMOUNT OF FINES)</p>		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			<p>GRAVELS WITH FINES</p> <p>(APPRECIABLE AMOUNT OF FINES)</p>		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
	<p>SAND AND SANDY SOILS</p>	<p>CLEAN SANDS</p> <p>(LITTLE OR NO FINES)</p>		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	
		<p>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE</p>	<p>SANDS WITH FINES</p> <p>(APPRECIABLE AMOUNT OF FINES)</p>		SM	SILTY SANDS, SAND - SILT MIXTURES
			<p>SANDS WITH FINES</p> <p>(APPRECIABLE AMOUNT OF FINES)</p>		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
	<p>FINE GRAINED SOILS</p> <p>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE</p>	<p>SILTS AND CLAYS</p>	<p>LIQUID LIMIT LESS THAN 50</p>		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
<p>SILTS AND CLAYS</p>		<p>LIQUID LIMIT GREATER THAN 50</p>		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS	
				CH	INORGANIC CLAYS OF HIGH PLASTICITY	
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
<p>HIGHLY ORGANIC SOILS</p>				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Reference Notes for Boring Logs/Test Pits

I. Drilling and Sampling Symbols:

SS – Split Spoon Sampler	RB – Rock Bit Drilling
ST- Shelby Tube Sampler	BS – Bulk Sample of Cuttings
RC – Rock Core: NQ, NX, BX, AX	PA – Power Auger (no sample)
PM - Pressuremeter	HAS – Hollow Stem Auger
DC – Dutch Cone Penetrometer	WS – Wash Sample

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

II. Correlation of Penetration Resistances to Soil Properties:

Density of Coarse-Grained Soils

Consistency of Fine-Grained Soils

<u>SPT-N</u>	<u>Descriptive Term</u>	<u>SPT-N</u>	<u>Description of Consistency</u>	<u>Unconfined Compressive Strength, Qp, psf</u>
0 - 4	Very loose	< 2	Very soft	Less than 250
5 - 10	Loose	2 – 4	Soft	250-500
11 - 30	Medium dense	5 – 8	Medium stiff	500-1000
31 - 50	Dense	9 – 15	Stiff	1000-2000
51 and over	Very dense	16 – 30	Very Stiff	2000-4000
		31 and greater	Hard	4000+

III. Unified Soil Classification Symbols: Reference ASTM D2488

GP	Poorly Graded Gravel	SC	Clayey Sand
GW	Well-Graded Gravel	ML	Low Plasticity Silt
GM	Silty Gravel	MH	High Plasticity Silt
GC	Clayey Gravel	CL	Low Plasticity Clay
SP	Poorly Graded Sand	CH	High Plasticity Clay
SW	Well-Graded Sand	OL	Low Plasticity Organic Soil
SM	Silty Sand	OH	High Plasticity Organic Soil

IV. Water Level Measurement Symbols:

WL	Water Level	BCR	Before Casing Removal
WS	While Sampling	ACR	After Casing Removal
WD	While Drilling	WCI	Wet Cave In
		DCI	Dry Cave In

The water levels are those water levels actually measured at the time of the exploration after cave-in has occurred (removing auger bits from borehole) in the borehole/test pit exploration indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils, but fine grained soils may require several days, or even longer, for the water levels to stabilize. The position of the ground water table or perched water condition is anticipated to fluctuate depending on variability in the amount of precipitation, surface runoff, evaporation, and similar factors. To obtain accurate water level readings, a water observation well would need to be installed to measure the ground water levels over a period of time, typically this is beyond the scope of services provided by a geotechnical exploration.



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BORING NUMBER B-01

PAGE 1 OF 1

CLIENT <u>N.V.P Inc.</u>	PROJECT NAME <u>Academy Hill</u>
PROJECT NUMBER <u>5929</u>	PROJECT LOCATION <u>Town of Warrenton, Virginia</u>
DATE STARTED <u>6/27/16</u> COMPLETED <u>6/27/16</u>	GROUND ELEVATION <u>612 ft</u> HOLE SIZE <u>2.25"</u>
DRILLING CONTRACTOR <u>Stevens Drilling</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>Hollow Stem Auger</u>	AT TIME OF DRILLING <u>Dry</u>
LOGGED BY <u>Richard Paige</u> CHECKED BY <u>Kevin Parris</u>	AT END OF DRILLING <u>Dry</u>
NOTES <u>CAVE-IN DEPTH= 20.1' 20' @ 24 HR</u>	▼ 24 HRs AFTER DRILLING <u>18.6 ft / Elev 593.4 ft</u>

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲											
								20	40	60	80								
								PL	MC	LL	LL								
0		TOPSOIL																	
		Medium stiff, reddish brown fine to medium sandy Silt (ML), moist	SS 1	56	2-2-3 (5)	1.5													
		Very stiff, orangish brown fine to medium sandy Silt (ML), moist	SS 2	78	9-11-12 (23)	1.5													
5		Very stiff, orangish brown fine to medium sandy Silt (ML), trace medium organics, moist	SS 3	94	15-25-29 (54)	2													
10		Hard, orangish brown fine to medium sandy Silt (ML), moist	SS 4	91	21-50/5"	2.5													
15		Hard, orangish brown and gray, Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 5	100	29-50/5"	3.5													
20		Hard, gray and reddish brown Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 6	100	50/4"	2.5													
		Bottom of hole at 23.9 feet.	SS 7	100	50/4"	2													

GEOTECH BH PLOTS 5929 ACADEMY HILL.GPJ GINT US LAB.GDT 8/25/16



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BORING NUMBER B-02

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/28/16	COMPLETED 6/28/16
GROUND ELEVATION 590 ft	HOLE SIZE 2.25"
DRILLING CONTRACTOR Stevens Drilling	GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger	AT TIME OF DRILLING Dry
LOGGED BY Richard Paige	CHECKED BY Kevin Parris
NOTES CAVE-IN DEPTH= 16.2' 16' @ 24 HR	AT END OF DRILLING Dry
	24 HRhrs AFTER DRILLING 15.5 ft / Elev 574.5 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲				
								20	40	60	80	
0		TOSOIL										
0 - 1.5		Medium stiff, reddish brown fine sandy Silt (ML), moist	SS 1	56	2-2-3 (5)	1.5						
1.5 - 5		Medium stiff, reddish brown fine sandy Silt (ML), trace fine to medium gravel, moist	SS 2	72	8-11-25 (36)	1.5						
5 - 2.5		Very Hard, orangish brown and dark gray Weathered Rock sampled as Silt (ML), moist	SS 3	78	11-30-42 (72)	2.5						
2.5 - 2.25			SS 4	100	30-50/3"	2.25						>>
2.25 - 2.25			SS 5	100	50/4"	2.25						>>
2.25 - 2			SS 6	100	50/4"	2						>>
2 - 18.9		Bottom of hole at 18.9 feet.										

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BORING NUMBER B-03

PAGE 1 OF 1

CLIENT <u>N.V.P Inc.</u>	PROJECT NAME <u>Academy Hill</u>
PROJECT NUMBER <u>5929</u>	PROJECT LOCATION <u>Town of Warrenton, Virginia</u>
DATE STARTED <u>6/27/16</u> COMPLETED <u>6/27/16</u>	GROUND ELEVATION <u>593 ft</u> HOLE SIZE <u>2.25"</u>
DRILLING CONTRACTOR <u>Stevens Drilling</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>Hollow Stem Auger</u>	AT TIME OF DRILLING <u>Dry</u>
LOGGED BY <u>Richard Paige</u> CHECKED BY <u>Kevin Parris</u>	AT END OF DRILLING <u>Dry</u>
NOTES <u>CAVE-IN DEPTH= 11.6'</u>	AFTER DRILLING <u>Dry</u>

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲											
								20	40	60	80								
								PL	MC	LL	LL								
0		TOPSOIL																	
		Medium stiff, reddish brown fine to medium sandy Silt (ML), trace fine roots, moist	SS 1	56	2-3-4 (7)	2													
		Very hard, reddish brown and gray fine sandy Silt (ML), moist																	
		Very hard, reddish brown and gray fine sandy Silt (ML), with gravel, moist	SS 2	6	50	2.5													
5																			
		Very hard, orangish brown, gray, and red Weathered Rock sampled as fine to medium sandy Silt (ML), pockets of Elastic Silt	SS 3	0	24-15-25 (40)	2.5													
10		Auger Refusal 13.4'	SS 4	120	50/5"	3													
		Bottom of hole at 13.4 feet.	SS 5		50/0"	2													

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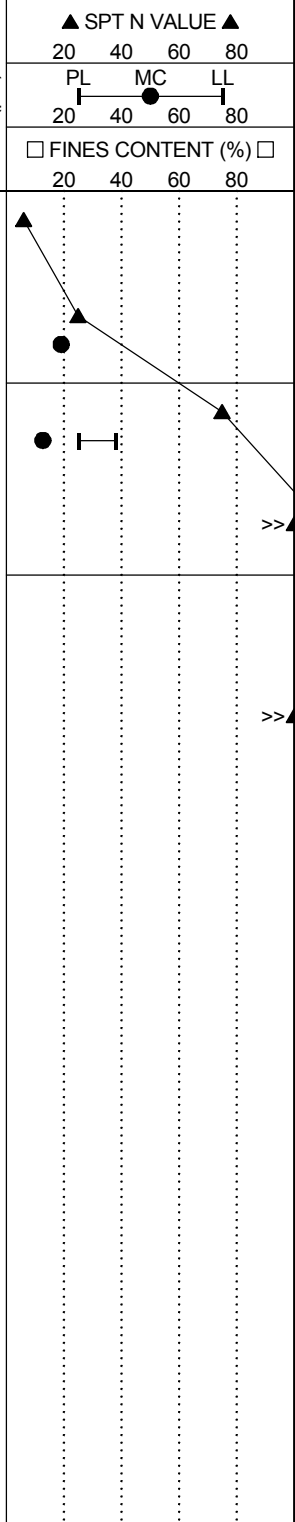
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BORING NUMBER B-04

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/27/16	COMPLETED 6/27/16
DRILLING CONTRACTOR Stevens Drilling	GROUND ELEVATION 578 ft
DRILLING METHOD Hollow Stem Auger	HOLE SIZE 2.25"
LOGGED BY Richard Paige	CHECKED BY Kevin Parris
NOTES CAVE-IN DEPTH= 11.7'	GROUND WATER LEVELS:
	AT TIME OF DRILLING Dry
	AT END OF DRILLING Dry
	AFTER DRILLING Dry

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲		
								20	40	60
0		TOPSOIL								
		Medium Stiff, orangish brown Elastic Silt (MH), moist	SS 1	56	2-3-3 (6)	1.5				
		Very stiff, orangish brown Silt (ML), moist								
			SS 2	83	7-11-14 (25)	2.5				
5		Very hard, orangish brown and gray Silt (ML), moist								
			SS 3	78	14-33-42 (75)	2.5				
		Very hard, orangish brown, gray, and red Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 4	125	50/4"	2				
10										
		Bottom of hole at 13.9 feet.	SS 5	100	50/4"	2.5				



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BORING NUMBER B-05

PAGE 1 OF 1

CLIENT <u>N.V.P Inc.</u>	PROJECT NAME <u>Academy Hill</u>
PROJECT NUMBER <u>5929</u>	PROJECT LOCATION <u>Town of Warrenton, Virginia</u>
DATE STARTED <u>6/30/16</u> COMPLETED <u>6/30/16</u>	GROUND ELEVATION <u>576 ft</u> HOLE SIZE <u>2.25"</u>
DRILLING CONTRACTOR <u>Stevens Drilling</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>Hollow Stem Auger</u>	AT TIME OF DRILLING <u>Dry</u>
LOGGED BY <u>Richard Paige</u> CHECKED BY <u>Kevin Parris</u>	AT END OF DRILLING <u>Dry</u>
NOTES <u>CAVE-IN DEPTH=11.7'</u>	AFTER DRILLING <u>Dry</u>

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲						
								20	40	60	80			
0		TOPSOIL												
		Very stiff, orangish brown and black Silt (ML), moist	SS 1	83	2-8-12 (20)	1.5								
			SS 2	94	7-12-11 (23)	2.75								
5		Stiff, orangish brown and black Silt (ML), moist	SS 3	100	3-4-8 (12)	2.5								
			SS 4	100	6-11-15 (26)	3.75								
10		Hard, orangish brown and red Silt (ML), trace mica, moist	SS 5	100	7-13-16 (29)	3.75								
15		Bottom of hole at 15.0 feet.												

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BORING NUMBER B-06

PAGE 1 OF 1

CLIENT N.V.P Inc. **PROJECT NAME** Academy Hill
PROJECT NUMBER 5929 **PROJECT LOCATION** Town of Warrenton, Virginia
DATE STARTED 6/27/16 **COMPLETED** 6/27/16 **GROUND ELEVATION** 605 ft **HOLE SIZE** 2.25"
DRILLING CONTRACTOR Stevens Drilling **GROUND WATER LEVELS:**
DRILLING METHOD Hollow Stem Auger **AT TIME OF DRILLING** Dry
LOGGED BY Richard Paige **CHECKED BY** Kevin Parris **AT END OF DRILLING** Dry
NOTES CAVE-IN DEPTH=20.1' 19.5' @ 24 HR **24 HRs AFTER DRILLING** 16.2 ft / Elev 588.8 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲						
								20	40	60	80			
0		TOPSOIL												
		Stiff, brown Elastic Silt (MH), with fine to medium organics, moist	SS 1	39	2-7-5 (12)	2								
		Very stiff, orangish brown and gray Silt (ML), with fine to medium roots, moist	SS 2	83	7-10-13 (23)	2								
5		Very stiff, orangish brown Silt (ML), moist	SS 3	78	4-11-17 (28)	2.75								
		Hard, brown and gray fine to medium sandy Silt (ML), moist	SS 4	94	17-23-20 (43)	2								
15		Hard, gray and brown Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 5	100	24-50/5"	3								>>
20			SS 6	75	50/4"	3.5								>>
		Bottom of hole at 23.6 feet.	SS 7	100	50/1"	3								>>

GEOTECH BH PLOTS 5929 ACADEMY HILL.GPJ GINT US LAB.GDT 8/25/16



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BORING NUMBER B-07

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/30/16	COMPLETED 6/30/16
DRILLING CONTRACTOR Stevens Drilling	GROUND ELEVATION 579 ft
DRILLING METHOD Hollow Stem Auger	HOLE SIZE 2.25"
LOGGED BY Richard Paige	CHECKED BY Kevin Parris
NOTES CAVE-IN DEPTH=3.0'	GROUND WATER LEVELS:
	AT TIME OF DRILLING Dry
	AT END OF DRILLING Dry
	AFTER DRILLING Dry

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲	
								20	40 60 80
0		TOPSOIL						PL	MC LL
		Dense, orangish brown fine to medium Silty Sand (SM), with fine to medium gravel, moist	SS	67	1-9-37 (46)			20	40 60 80
		Hard, gray and brown, Weathered Rock sampled as fine to coarse sandy Silt (ML) moist	SS	83	20-34-47 (81)				
		Auger Refusal at 4.7'	SS		50/0"	2.5			
		Bottom of hole at 4.8 feet.							

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BORING NUMBER B-08

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/30/16	COMPLETED 6/30/16
DRILLING CONTRACTOR Stevens Drilling	GROUND ELEVATION 576 ft
DRILLING METHOD Hollow Stem Auger	HOLE SIZE 2.25"
LOGGED BY Richard Paige	CHECKED BY Kevin Parris
NOTES CAVE-IN DEPTH= 10.9'	GROUND WATER LEVELS:
	AT TIME OF DRILLING 14'
	AT END OF DRILLING 14'
	AFTER DRILLING Dry

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲	
								20	40
0		TOPSOIL							
		Very Stiff, orangish brown fine to medium sandy Silt (ML), moist	SS	72	5-6-11 (17)	2			
		Very Stiff, orangish brown and gray fine to medium sandy Silt (ML), moist	SS	100	7-11-14 (25)	2.5			
5									
			SS	94	7-9-15 (24)	2.5			
10		Hard, orangish brown, gray, and red, fine to meduim sandy Silt (ML), moist	SS	89	8-11-20 (31)	3			
15		Hard, orangish brown fine to medium sandy Silt (ML), trace organics, wet	SS	89	21-16-22 (38)	3.5			
		Bottom of hole at 15.0 feet.							

GEOTECH BH PLOTS 5929 ACADEMY HILL.GPJ GINT US LAB.GDT 8/25/16



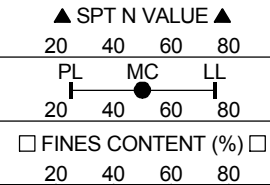
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BORING NUMBER B-09

PAGE 1 OF 1

CLIENT <u>N.V.P Inc.</u>	PROJECT NAME <u>Academy Hill</u>
PROJECT NUMBER <u>5929</u>	PROJECT LOCATION <u>Town of Warrenton, Virginia</u>
DATE STARTED <u>6/30/16</u> COMPLETED <u>6/30/16</u>	GROUND ELEVATION <u>580 ft</u> HOLE SIZE <u>2.25"</u>
DRILLING CONTRACTOR <u>Stevens Drilling</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>Hollow Stem Auger</u>	AT TIME OF DRILLING <u>Dry</u>
LOGGED BY <u>Richard Paige</u> CHECKED BY <u>Kevin Parris</u>	AT END OF DRILLING <u>Dry</u>
NOTES <u>CAVE-IN DEPTH=7.2'</u>	AFTER DRILLING <u>Dry</u>

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲	
								PL	MC
0		TOPSOIL							
		Medium stiff, reddish brown Elastic Silt (MH), moist	SS 1	61	1-3-3 (6)	3.5			
		Very Stiff, orangish brown and black Silt (ML), pockets of Elastic Silt, moist	SS 2	100	4-7-10 (17)	3.75			
5									
		Hard, orangish brown and gray Silt (ML), moist	SS 3	64	4-5-6 (11)	3.75			
10									
		Bottom of hole at 10.0 feet.	SS 4	89	10-17-25 (42)	2.5			



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BORING NUMBER B-10

PAGE 1 OF 1

CLIENT N.V.P Inc. **PROJECT NAME** Academy Hill
PROJECT NUMBER 5929 **PROJECT LOCATION** Town of Warrenton, Virginia
DATE STARTED 6/27/16 **COMPLETED** 6/27/16 **GROUND ELEVATION** 590 ft **HOLE SIZE** 2.25"
DRILLING CONTRACTOR Stevens Drilling **GROUND WATER LEVELS:**
DRILLING METHOD Hollow Stem Auger **AT TIME OF DRILLING** Dry
LOGGED BY Richard Paige **CHECKED BY** Kevin Parris **AT END OF DRILLING** Dry
NOTES CAVE-IN DEPTH= 16.9' 16.5' @ 24 HR **24 HRhrs AFTER DRILLING** 15.5 ft / Elev 574.5 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲		
								20	40	60
0		TOPSOIL								
		Medium stiff, brown and dark gray Elastic Silt (MH), moist	SS 1	61	3-4-4 (8)	1.5				
		Medium stiff, reddish brown and dark gray Elastic Silt (MH), moist	SS 2	67	7-9-12 (21)	2				
5		Very Hard, gray and reddish brown, Weathered Rock sampled as fine sandy Silt (ML), moist	SS 3	100	39-50/3"	1.5				
10			SS 4	100	15-28-50/2"	2.5				
15		Very Hard, gray and yellowish brown, Weathered Rock sampled as fine sandy Silt (ML), moist	SS 5	100	50/4"	3.5				
		Auger Refusal at 19.2'								
		Bottom of hole at 19.2 feet.	SS 6		50/0"	3.5				

GEOTECH BH PLOTS 5929 ACADEMY HILL.GPJ GINT US LAB.GDT 8/25/16



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BORING NUMBER B-11

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/27/16 COMPLETED 6/27/16	GROUND ELEVATION 577 ft HOLE SIZE 2.25"
DRILLING CONTRACTOR Stevens Drilling	GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger	AT TIME OF DRILLING Dry
LOGGED BY Richard Paige CHECKED BY Kevin Parris	AT END OF DRILLING Dry
NOTES CAVE-IN DEPTH= 11.3' 11.1' @ 24 HR	24 HRhrs AFTER DRILLING 10.0 ft / Elev 567.0 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲		
								20	40	60
0		TOPSOIL								
		Stiff, reddish brown clayey Silt (ML), moist	SS 1	78	1-2-9 (11)	1.5				
		Very hard, orangish brown fine to medium Silt (ML), with fine to medium gravel, pockets of Elastic Silt, moist	SS 2	78	22-29-41 (70)	2.5				
5		Very hard, orange and reddish brown and gray, Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 3	67	21-36-50 (86)	2.5				
			SS 4	67	50/3"	2				>>
10										
		Bottom of hole at 13.6 feet.	SS 5	100	50/1"	2.75				>>

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BORING NUMBER B-12

PAGE 1 OF 1

CLIENT <u>N.V.P Inc.</u>	PROJECT NAME <u>Academy Hill</u>
PROJECT NUMBER <u>5929</u>	PROJECT LOCATION <u>Town of Warrenton, Virginia</u>
DATE STARTED <u>6/28/16</u> COMPLETED <u>6/28/16</u>	GROUND ELEVATION <u>570 ft</u> HOLE SIZE <u>2.25"</u>
DRILLING CONTRACTOR <u>Stevens Drilling</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>Hollow Stem Auger</u>	AT TIME OF DRILLING <u>Dry</u>
LOGGED BY <u>Richard Paige</u> CHECKED BY <u>Kevin Parris</u>	AT END OF DRILLING <u>Dry</u>
NOTES <u>CAVE-IN DEPTH=14.4' 10.2' @ 24 HR</u>	24 HRhrs AFTER DRILLING <u>Dry</u>

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲						
								20	40	60	80			
								PL	MC	LL				
0		TOPSOIL												
		Medium stiff, reddish brown and gray fine sandy Silt (ML), moist	SS 1	83	2-2-5 (7)	2								
		Medium stiff, orange, reddish brown and gray fine sandy Silt (ML), moist	SS 2	78	9-9-13 (22)	2.5								
5		Medium stiff, orange, reddish brown and gray fine sandy Silt (ML), trace fine to medium gravel, moist	SS 3	56	5-6-10 (16)	2								
			SS 4	0	5-9-18 (27)	3.5								
10														
		Hard, reddish brown and gray fine to medium sandy Silt (ML), moist	SS 5	67	10-14-20 (34)	3								
15		Bottom of hole at 15.0 feet.												

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BORING NUMBER B-13

PAGE 1 OF 1

CLIENT N.V.P Inc.	PROJECT NAME Academy Hill
PROJECT NUMBER 5929	PROJECT LOCATION Town of Warrenton, Virginia
DATE STARTED 6/28/16 COMPLETED 6/28/16	GROUND ELEVATION 553 ft HOLE SIZE 2.25"
DRILLING CONTRACTOR Stevens Drilling	GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger	AT TIME OF DRILLING Dry
LOGGED BY Richard Paige CHECKED BY Kevin Parris	AT END OF DRILLING Dry
NOTES CAVE-IN DEPTH=12.0' 11.2' @ 24 HR	24 HRhrs AFTER DRILLING Dry

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲				
								20	40	60	80	
0		TOPSOIL										
		Medium stiff, brown Elastic Silt (MH), trace medium organics, moist	SS 1	56	1-2-3 (5)	1						
		Hard, reddish brown Silt (ML), moist	SS 2	89	8-14-20 (34)	2.5						
5		Very stiff, reddish brown and gray Elastic Silt (MH), with fine to medium gravel, moist	SS 3	83	6-11-12 (23)	3						
		Hard, brown fine to medium sandy Silt (ML), Weathered Rock sampled as, trace mica, moist	SS 4	100	17-50/3"	2.5						>>
10		Hard, orangish brown and dark gray, Weathered Rock sampled as fine to medium sandy Silt (ML), moist	SS 5	120	50/5"	2.5						>>
		Bottom of hole at 14.0 feet.										

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SUMMARY OF LABORATORY RESULTS

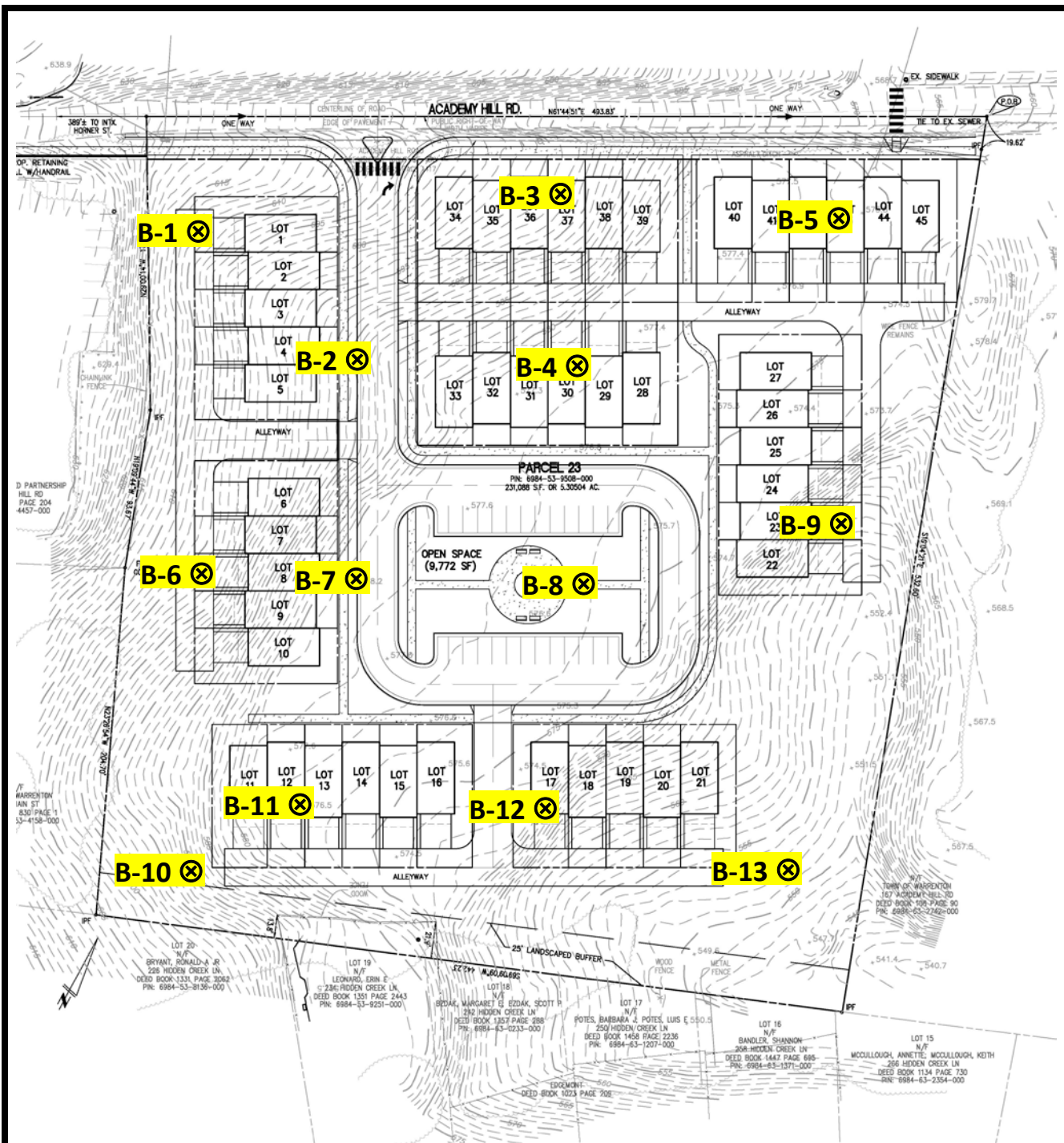
CLIENT N.V.P Inc.

PROJECT NAME Academy Hill

PROJECT NUMBER 5929

PROJECT LOCATION Town of Warrenton, Virginia

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-01	1.5				0.075	77		25.7			
B-02	4.0	41	24	17				18.2			
B-02	6.5							11.2			
B-04	4.0							19.0			
B-04	6.5	38	25	13				12.6			
B-06	4.0							21.9			
B-06	6.5							18.4			
B-06	10.0							9.8			
B-08	1.5							18.0			
B-08	4.0				0.075	77		12.5			
B-09	4.0				0.075	67		23.3			
B-09	6.5				0.075	66		25.5			
B-10	1.5							25.2			
B-12	1.5	46	27	19				22.7			
B-12	4.0							22.5			



Not to Scale

Source:

Bowman Consulting
 Conceptual Layout #1

Figure 1



Boring Location Diagram

Academy Hill Townhomes
 Town of Warrenton, VA

DEA Project No. 5929

August 19, 2016