Geotechnical Engineering Report

Columbia Pike Retaining Wall – Segment H & I
Arlington, Virginia
April 9, 2021
Terracon Project No. JD205193

Prepared for:
Volkert, Inc.
Springfield, Virginia

Prepared by:
Terracon Consultants, Inc.
Ashburn, Virginia

April 9, 2021

Volkert, Inc.
6225 Brandon Avenue, Suite 540
Springfield, Virginia 22150

Attn: Mr. Brian Graham, P.E.
P: (703) 738-8331
E: brian.graham@volkert.com

Re: Geotechnical Engineering Report
Columbia Pike Retaining Wall – Segment H & I
Columbia Pike and South Frederick Street
Arlington, Virginia
Terracon Project No. JD205193

Dear Mr. Graham:

We have completed the Geotechnical Engineering Services for the above-referenced project. This study was performed in general accordance with Terracon Proposal No. PJD205193 dated January 1, 2017. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

COMMONWEALTH OF VIRGINIA
SUSHANT UPADHYAYA
Lic. No. 051941
PROFESSIONAL ENGINEER

Braque D. Mathson, EIT
Senior Project Manager

Sushant Upadhyaya, PhD, PE, PMP, RMP
Principal

REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed RW-3 concrete gravity retaining wall at Segment H and I to be located along at the intersection of Columbia Pike and South Frederick Street in Arlington, Virginia. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundations for the retaining wall
- Lateral earth pressures
- Global Stability analysis of proposed retaining wall

The geotechnical engineering Scope of Services for this project included the advancement of two hand auger borings to depths of approximately 4 and 7 feet below existing site grades on the embankment slope behind the existing retaining wall and 2 soil borings drilled to depths of 32.5 and 35 feet below existing site grades in front of the retaining wall.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the hand auger boring logs and in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located along Columbia Pike and South Frederick Street near the intersection of South Frederick Street in Arlington, Virginia. See **Site Location**

Item	Description
Existing Improvements	Existing buildings, paved roadways, underground utilities, overhead power lines, and sidewalks
Current Ground Cover	Paved roadways, concrete sidewalks, trees, and grass
Existing Topography (from Site Plan)	Existing elevations from south to north are generally between 173 feet to 205 feet.
Geology	The site is located within the Coastal Plain Physiographic Province of Virginia. The Coastal Plain consists of a seaward thickening wedge of unconsolidated to semi-consolidated sedimentary deposits from the Cretaceous Geologic Period to the Holocene Geologic Epoch. These deposits represent marginal-marine to marine sediments consisting of interbedded sands and clays. The Coastal Plain is bordered to the east by the Atlantic Ocean and to the west by the Piedmont Physiographic Province. The dividing line between the Coastal Plain and Piedmont is locally referred to as the "Fall Line". This name comes from the waterfalls that form as a result of the differential erosion that occurs as streams cross the Piedmont/Coastal Plain contact. The Alluvial and Terrace Deposits are granular units dominated by gravels, sands, and silts, with lesser amounts of clay distributed heterogeneously. The Alluvial materials are gray to gray-brown, and poorly stratified, while the Terrace Deposits are more highly oxidized showing lighter colors ranging from light gray to yellow and red. The Terrace Deposits tend to be more stratified than the more recent Alluvial deposits. The Potomac Group sediments are the oldest sedimentary deposits in the Washington, DC area, and date from the Early Cretaceous Period. These sediments are known to be highly over-consolidated as a result of the weight of a substantial thickness of overlying soils that have since been eroded. The bedrock underlying the site is mapped as the Indian Run Formation of the Cambrian geologic period.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Retaining wall plan, dated 11-12-2020, and Roadway Plan and Profiles dated 12-9-2016.

Item	Description
Project Description	The existing retaining is showing signs of distress and a new RW-3 retaining wall is planned approximately at the same alignment as the existing wall. The existing slope has a gradient of about 1.5:1V. The right of way (ROW) appears to be 5 feet behind the existing retaining wall. Based on the plan and sections, the proposed retaining wall extends from the station (Sta.) 0+14 to Sta. 2+00 (186 feet). The bottom of the wall ranges from EL 173.97 (Sta. 0.14) to EL 171.17 (Sta. 2+00). The maximum exposed height of the wall is approximately 5 feet. The proposed RW-3 retaining wall will retain a 26 feet high slope at a 2H:1V slope gradient.
Proposed Structure	Standard VDOT RW-3 gravity retaining wall.
Bottom Footing Elevation (Feet)	EL 173.97 (Sta. 0.14) to EL 171.17 (Sta. 2+00)
Grading/Slopes	2H:1V
Estimated Start of Construction	2021

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. The individual logs can be found in the **Exploration Results** section of this report.

Due to difficult access and a steep slope behind the wall, the subsurface exploration was conducted by performing two (2) hand auger borings on the existing slope. Dynamic Cone Penetrometer (DCP) testing was performed in each hand auger borings. The hand auger borings were completed by Terracon's engineer. Two Standard Test Borings (SPT) in front of the existing retaining wall. The borings were completed by Terracon. The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a Geotechnical Engineer. Also, we observed and recorded groundwater levels during hand auger borings.

Additionally, soil boring information presented in the "*Columbia Pike Multimodal Street Improvement*" Geotechnical Report prepared by GeoConcepts, dated April 27, 2016 was reviewed to characterize the subsurface conditions. It should be understood there is more risk of unexpected subsurface conditions when using the existing borings, which may not be located directly along the wall alignment.

Field boring logs can be found in the attachments, along with asphalt thicknesses. Field logs include visual classifications of materials encountered during drilling and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent the Geotechnical Engineer's interpretation and include modifications based on observations and laboratory tests

Groundwater

Groundwater level observations were made in the field during hand auger boring operations. Also, previously drilled borings were reviewed for groundwater elevations. Groundwater was encountered in RW-2 at about 15 feet below the existing grade.

The groundwater observations presented herein are considered to be an indication of the groundwater levels at the dates and times indicated. Where greater amounts of more impervious silt soils are encountered, the amount of water seepage into the borings is limited, and it is generally not possible to establish the location of the groundwater table through short term water level observations. Accordingly, the groundwater information presented herein should be used with caution. Also, fluctuations in groundwater levels should be expected with seasons of the year, construction activity, changes to surface grades, precipitation, or other similar factors.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

Before placing fill, existing vegetation and root mat should be removed. Complete stripping of the topsoil should be performed in the proposed retaining wall and embankment areas.

The subgrade information along the proposed retaining wall was not obtained during the field investigation. Therefore, the final subgrade must be observed by the Geotechnical Engineer of Record or by his or her representative to confirm that the subgrade appears to be stable before the construction of the RW-3 retaining wall. Since a proofroll cannot be performed, we recommend that a dynamic cone penetrometer (DCP) or geoprobe should be used to evaluate the bearing subgrade. Based on soil boring RW-1, it is expected that ELASTIC SILT (MH), unsuitable, or soft soils may be encountered at the proposed retaining wall subgrade level. We recommend that the retaining wall bearing subgrade be undercut to a depth of 2 to 5 feet and the excavation is filled with lean concrete that has a compressive strength of about 2,000 psi.

Existing Fill

As noted in **Geotechnical Characterization**, borings HA-3, HA-4, RW-1 and RW-2 encountered existing fill to depths ranging from about 2.5 to 4 feet. The fill appears to have been placed in a controlled manner, but we have no records to indicate the degree of control. Support of footings on or above existing fill soils is discussed in this report. However, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill will, not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report.

We have estimated the bottom of the retaining wall to be about EL 170 to EL 171 based on the cross section sheet. We recommend that the retaining wall bearing subgrade be undercut to a depth of 2 to 5 feet however additional undercut may be needed to remove the ELASTIC SILT (MH) layer. The excavation should be filled with lean concrete that has a compressive strength of about 2,000 psi. The existing and undocumented fill that was removed can be evaluated for reuse as structural fill.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 5 feet of structures, pavements, or constructed slopes. General fill is material used to achieve grades outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity Cohesive	CL, CL-ML ML, SM, SC	Liquid Limit less than 40 Plasticity index less than 20
Granular	GW, GP, GM, GC, SW, SP, SM, SC	Less than 10% Passing No. 200 sieve
Select Type I Material,	VDOT 21A	As per VDOT Road and Bridge Specification 2016
Porous Backfill	No. 78 or No. 8	VDOT Specification Reference No. 506

1. Structural and general fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as Structural Fill
Minimum Compaction Requirements [1, 2]	95% of maximum above foundations	Same as Structural Fill
Water Content Range [1]	Soils: ±20% of optimum moisture content Aggregate: ±2% points of optimum moisture content	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the standard Proctor test (VTM-1).
2. If the granular material is coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 95% relative density VTM-1.

Grading and Drainage

All grades must provide effective drainage away from the structures during and after construction and should be maintained throughout the life of the structure. Water retained next to the structure can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential movement.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations. A shoring system consisting of trench boxes and appropriate bracing should be designed by a professional engineer registered in the State of Virginia.

The groundwater was encountered in RW-2 at a depth of 15 feet. The groundwater table could affect over-excavation efforts, especially for over-excavation and replacement of lower strength soils. Due to limited groundwater information, we recommend that the contractor be prepared for a temporary dewatering system. A temporary dewatering system consisting of sumps with pumps.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts must be monitored under the direction of the Geotechnical Engineer of Record or his/her representative. Monitoring should include documentation of adequate removal of vegetation and topsoil and mitigation of areas delineated by the visual observation, DCP, or geoprobe.

Each lift of compacted fill must be tested, evaluated, and reworked, as necessary until approved by the Geotechnical Engineer of Record or his/her representative before placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency as per VDOT Road and Bridge Specification 2020.

In areas of foundation excavations, the bearing subgrade must be evaluated under the direction of the Geotechnical Engineer of Record or his/her representative. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

RETAINING WALL

It is our understanding the proposed site retaining wall will be designed as a VDOT RW-3 concrete gravity retaining wall with a maximum exposed height of 5.0 feet, and an embedment of about 2.0 to 2.5 feet.

Lateral Earth Pressure Coefficients

The shear strength of the subsurface materials was evaluated from laboratory test data, published correlations of Liquid Limit, Plasticity Index, and SPT-N values. Soil design parameters for sound barrier walls and non-critical slopes, dated April 14, 2011 by VDOT was also used to evaluate the shear strength values. The proposed RW-3 retaining wall must be designed to resist lateral pressures developed from the surrounding soil and surcharge loads. A summary of our design lateral earth pressure recommendations are presented in the table below.

Material	Unit Weight (γ) pcf	Angle of Internal Friction (ϕ) degrees	Cohesion (psf)	Coefficient of Friction (μ)	Lateral Earth Pressure (LEP) Coefficients[1]			Equivalent Fluid Pressures (EFP)[5]		
					Active (K_a)	At-Rest (K_o)	Passive (K_p)	Active (K_a)	At-Rest (K_o)	Passive (K_p)
New Compacted Fill[1]	125	30	0	0.55	0.54	0.72	3.00	67H	90H	375D
Embankment Backfill (Fine)[1]	110	30	50	0.55	0.54	0.72	3.00	59H	79H	330D
Potomac Group – Coarse Grained[2]	125	32	50	0.60	0.46	0.68	3.25	58H	85H	406D
Potomac Group - CH (*Residual Strength*) (Fine)[2]	110	22[3]/10[4]	0	0.40	--	1.20	1.42	--	120H	156D
Potomac Group – CL (*Fully Softened Strength*) (Fine)[2]	110	22	0	0.40	--	0.91	2.20	--	100H	242D

1. Lateral earth pressures are for the backfill slope of 2H:1V.
2. Lateral earth pressures are for horizontal ground surface.
3. Fully Softened Shear Strength is used for the coefficient of friction and lateral earth pressure.
4. Residual Shear strength for CH soils is used for slope stability analysis.
5. H = height of the structure, D = embedment depth below frost zone.

The lateral earth pressures shown in the table above apply only to cases where a subdrainage system is installed as per VDOT RW-3 standard. Hydrostatic pressures are not included in the lateral earth pressures assuming the use of relatively granular or free-draining backfill, and subdrainage (weepholes) at the base of walls below grade.

Equivalent fluid pressure factors presented in the table above are for the respective backfill conditions. Where applicable, the design should consider surcharge loads using a rectangular earth pressure distribution. The surcharge pressure ordinate should be obtained by multiplying the surface surcharge pressure (q) by the lateral earth pressure coefficient for the respective backfill condition. In addition to static earth pressures, the structural designer should consider dynamic earth pressures due to seismic loading, as applicable.

Bearing Resistance

As mentioned in the Site Preparation section, the bearing soils at the proposed RW-3 retaining wall are not suitable for direct support of the retaining wall. Therefore, we recommend that the retaining wall bearing subgrade be undercut to a depth of 2 to 5 feet, and the excavation is filled with lean concrete that has a compressive strength of about 2,000 psi. All footing subgrades must be observed and approved by the geotechnical engineer of record or by his/her representative before placement of concrete.

For concrete RW-3 gravity walls, backfill against the wall (i.e., specified backfill) should be backfilled and constructed in accordance with specification reference VDOT 506.

We have computed the bearing resistance for the proposed RW-3 concrete gravity retaining wall when supported on natural soils. The factored bearing resistance at the strength limit state is calculated using a resistance factor of 0.55. The retaining wall engineer should check the internal stability (sliding, overturning, ect.). A summary of factored resistance for service, strength, and extreme event limits, and estimated wall settlement, are presented in the table below. Calculations are presented in the **Calculations** section of this report.

Retaining Wall Station From	Est. Bottom of Footing Elevation (ft)	Approximate Footing Width (ft)[1]	Service Limit State Resistance $\Phi_b = 1.00$ (ksf)[2]	Strength Limit State Factored Resistance $\Phi_b = 0.55$ (ksf)[2]	Extreme Event Limit State Nominal Resistance $\Phi_b = 1.00$ (ksf)[2]	Expected Footing Subgrade Material	Estimated Settlement (inch)	Remark[3]
0+14 to 2+00	171 to 169	4.5	2.5	5.3	9.6	FAT CLAY (CH), Potomac Group - Coarse or Existing Fill	1.0	2 -5 feet undercut and replacement with lean concrete

1. Footing width B = 0.6H; H is the maximum height of the wall.
2. Bearing resistance value was calculated without eccentricity.
3. For bearing capacity and settlement.

Footing subgrades should be observed and approved prior to placement of concrete, to ascertain that footings are placed on suitable bearing soils as recommended herein. Footings should be excavated and concrete placed the same day in order to avoid disturbance from water or weather. Disturbance of footing subgrades by exposure to water seepage or weather conditions should be avoided. Any existing fill, disturbed, frozen, or soft subgrade soils should be removed prior to placing footing concrete. It may be desirable to place a 3 to 4-inch thick "mud mat" of lean concrete immediately on the approved footing subgrade to avoid softening of the exposed subgrade. Forms may be used if necessary, but less subgrade disturbance is anticipated if excavations are made to the required dimensions and concrete placed against the soil. If footings are formed, the forms should be removed and the excavation backfilled as soon as possible. Water should not be allowed to pond along the outside of footings for long periods of time.

We recommend that the proposed walls for this project be provided with a drainage system to prevent a buildup of hydrostatic pressures in the walls' specified backfill. Drainage behind the retaining walls should be in accordance with the VDOT Road and Bridge Standard RW-3. Drainage behind the CIP concrete retaining walls may be provided by means of a 12-inch wide drainage layer, placed directly behind the wall facing. The drainage layer may consist of open-graded crushed stone (i.e., VDOT No. 78 or No. 8 crushed stone), washed gravel, or other acceptable free-draining material, as approved by the geotechnical engineer. Weepholes (3-inch) should be provided through the wall facing at 8-foot centers, to provide an outlet for water collected in the drainage layer. Alternatively, water collected in the drainage panel/layer may be an outlet to a continuous toe drain installed at the base of the wall behind the facing.

Global Stability

Global stability analysis has been performed for the proposed RW-3 retaining wall. We have only analyzed the global stability analysis for the retaining walls and not the stability of the slopes above the retaining walls. Also, temporary stability conditions during wall construction have not been addressed herein and should be evaluated by the Specialty Contractor based on their proposed construction sequence.

Slope stability analyses were performed using the limit equilibrium slope stability program Slope/W version 10.2, developed by Geo-Slope International. This computer program was used to generate potential failure surfaces with randomly selected radii and centers. The stability analysis was performed assuming static loading for drained (long-term) soil conditions. A search for the most critical potential failure surfaces occurring within earth materials in the proposed slopes was performed using optimized failure mode as calculated by the Spencer method. A minimum required factory of the safety of 1.5 was targeted for the global stability analysis.

We believe the distress of the existing retaining wall is due to lateral earth pressure behind the wall and it is not due to a global stability failure. We did not see any indication of slope failure on the site. It is our professional opinion that a lower factor of safety (1.3) should be a reasonable factor of safety against global failure when using residual shear strength. We understand that the existing vegetation will be removed and the embankment behind the retaining wall will be regraded to a 2:1 slope. Global and slope stability calculations are presented in the **Calculations** section of this report, and calculated factors of safety (FOS) are summarized in the table below. Global stability factors of safety for the retaining walls are unsatisfactory for long-term conditions. Recommended remedial measures to enhance global stability are presented below:

Retaining Wall Station No.	Approximate Exposed Wall Height /Back Slope Height (ft)	Failure Type	FOS Proposed Condition without Undercut	FOS Proposed Condition with Undercut	Remarks	Slope Stability Measure
1+75	5.5/26	Block	1.5	1.7	Residual Shear Strength (CH) – Global Failure	We recommend undercut depth of 2 to 5 feet. The excavation is filled with lean concrete that has a compressive strength of about 2,000 psi.
		Circular	1.4	1.5		

CORROSIVITY

The table below lists the results of laboratory sulfate and chloride. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction. The test results are listed below and are in the **Exploration Results** section of this report.

Corrosivity Test Results Summary								
Boring	**Sample Depth (feet)**	**Soil Description**	**Resistivity (ohm/cm)**	**Redox Potential (mV)**	**pH**	**Soluble Chloride (mg/kg)**	**Soluble Sulfate (mg/kg)**	**Soluble Chloride (mg/kg)**
RW-1	5-10	clayey SAND (SC)	2300	315	3.7	28	< 5	< 1.2
RW-1	10-15	silty SAND (SM)	3000	291	3.7	26	7.1	< 1.2

- Results of water-soluble sulfate testing indicate that samples of the on-site soils have an exposure class of S1 when classified in accordance with Table 19.3.1.1 of the American Concrete Institute (ACI) Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 19.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
2 – Hand Auger (HA-01 and HA-02)	4 to 7	Embankment
2 - SPT	32.5 to 35	Retaining wall

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout for the two new hand auger borings. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) Elevations were not recorded. If elevations and a more precise boring layout are desired, we recommend borings be surveyed for as-drilled coordinates and elevation.

Subsurface Exploration Procedures (Hand Auger): We advanced hand auger borings with a 3 ¼ inch auger attached to steel rods and handle extensions. The auger is manually advanced from the ground surface with excavated soil removed from the borehole with each pass of the auger. In the Kessler Dynamic Cone Penetrometer (DCP) sampling procedure, a standard 5/8-inch diameter rod was driven into the ground by a 17.6-pound hammer falling a distance of 22.6 inches. The DCP values are indicated on the DCP Test Data logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We advanced the borings with a track-mounted rotary drill rig using continuous hollow stem flight augers. Five samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings and grout after their completion. Pavements were patched with cold-mix asphalt.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include the reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D3080 Standard Test Method for Direct Shear of Soils Under Consolidated Drained Conditions
- ASTM D698 Standard Test Method for Laboratory Compaction Characteristics of Soil
- ASTM G187 Standard Test Method for Resistivity
- CA-643 Standard Test Method for Determing pH
- CA-422 Standard Test Method for Determing Chloride (Water Soluble)
- EPA 375.4 Test Method for Determing Sulfate (Water Soluble)
- EPA 376.2 Test Method for Determing Sulfide (Water Soluble)

The laboratory testing program often included an examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Columbia Pike Retaining Wall – Segment H & I ■ Arlington, Virginia
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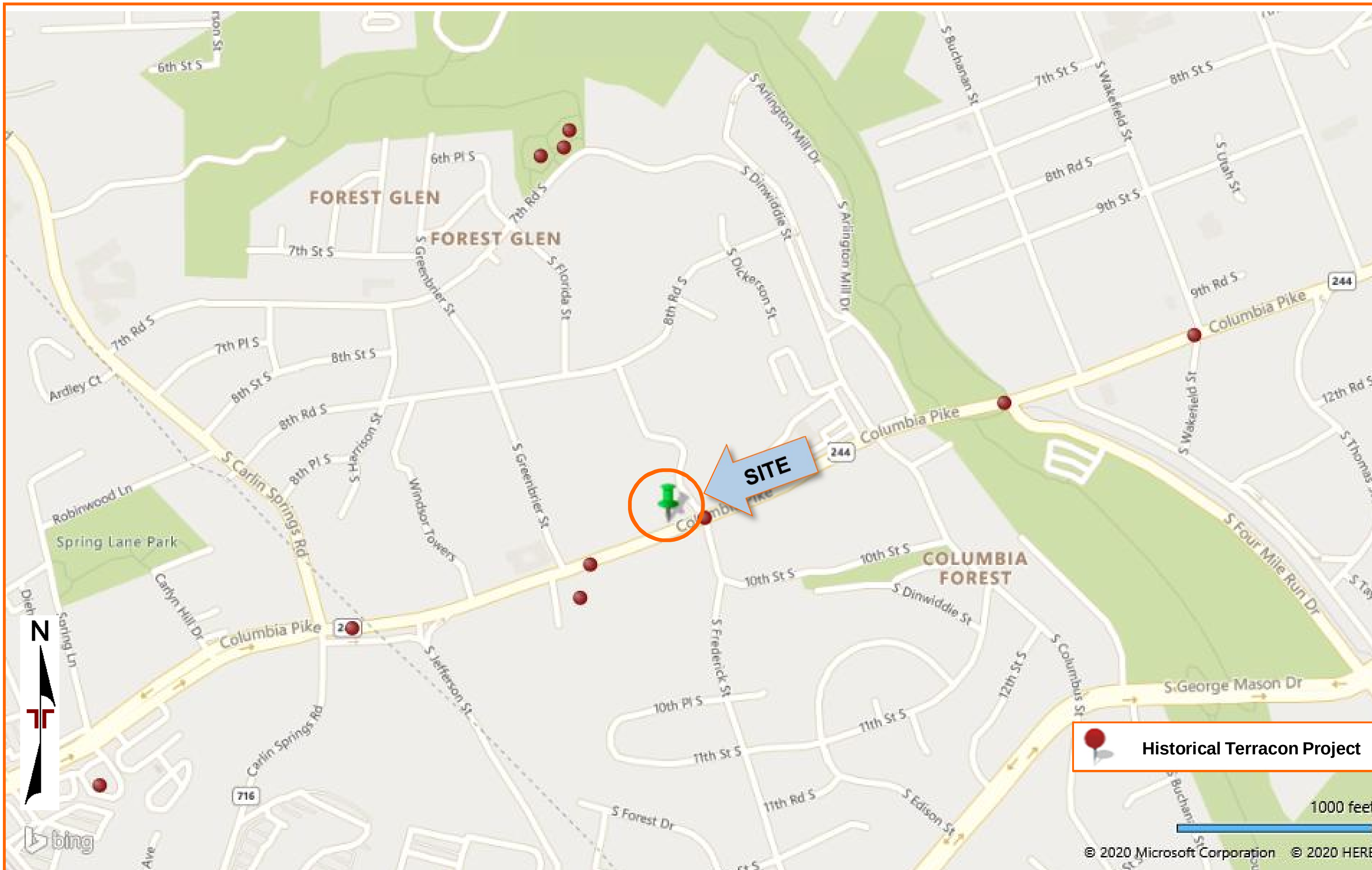

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Columbia Pike Retaining Wall – Segment H & I ■ Arlington, Virginia

April 9, 2021 ■ Terracon Project No. JD205193

Terracon GeoReport

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

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Moisture-Density Relationship (2 pages)
Direct Shear Test Report (3 pages)
Corrosion (2 pages)

Note: All attachments are one page unless noted above.

Virginia Department of Transportation

PROJECT #:	JD205193
LOCATION:	Arlington, Virginia
STRUCTURE:	RETAINING WALL

RW-1

STATION: 11+68 OFFSET: 40 ft. right
LATITUDE: 38.854556° N LONGITUDE: 77.115972° W
SURFACE ELEVATION: 172.0 ft COORD. DATUM: NAD 83

Date(s) Drilled: 02/23/2021 - 02/23/2021
Drilling Method(s): 3.25" ID HSA
SPT Method: Automatic Hammer
Other Test(s): Not Applicable
Driller: Terracon (C. Guidel)
Logger: GeoConcepts (A. Garden)

GROUND WATER
NOT ENCOUNTERED DURING DRILLING
NO LONG TERM MEASUREMENTS TAKEN

FIELD DATA / LAB DATA

PKT. PENETROMETER (tsf)	DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA DIP °	JOINTS DIP °	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
	2	170	2-3-4-4	20	1 - 3							7.6	
2.5	4		4-5-5-8	100	3 - 5					73	35	39.7	85.9
	6	165	6-10-12-15	100	5 - 7							16.5	
	8		5-10-15-18	20	7 - 9							17.3	
	10		5-10-11-14	100	9 - 11					40	14	12.9	22.5
	12	160											
	14		4-8-10	100	13.5 - 15					52	28	22.5	20.0
2.5	16	155		100	15 - 17								
	18												
	20		18-18-23	100	18.5 - 20							13.7	
	22	150											
	24		12-16-20	100	23.5 - 25					44	13	14.1	24.9
4.5	26	145		100	25 - 27								
	28												
	30		14-18-29	100	28.5 - 30							14.6	
	32	140	50/1"	100	32.5 - 32.58								

FIELD DESCRIPTION OF STRATA

0.0 / 172.0
Asphalt = 12 in. **ASPH**

1.0 / 171.0
Crushed stone = 12 in. **CRA**

2.0 / 170.0
Fill, brown-gray, coarse, CLAYEY SAND, loose, moist **FL**

3.0 / 169.0
Potomac Formation, brown-gray, ELASTIC SILT, stiff, moist **MH**

6.0 / 166.0
Potomac Formation, brown-gray, coarse, CLAYEY SAND, very stiff, moist **SC**
SAME: below 7 ft. hard

9.0 / 163.0
Potomac Formation, brown-gray, coarse, SILTY SAND, very stiff, moist **SM**

13.5 / 158.5
Potomac Formation, brown-gray, coarse, CLAYEY SAND, very stiff, moist **SC**

15.0 / 157.0
Potomac Formation, brown-gray, GRAVELLY FAT CLAY WITH SAND, very stiff, moist **CH**

17.0 / 155.0
Potomac Formation, brown-gray, coarse, CLAYEY SAND, micaceous, very dense, moist **SC**

23.5 / 148.5
Potomac Formation, gray, coarse, SILTY SAND, micaceous, dense, moist **SM**

SAME: below 28.5 ft. very dense

Auger and spoon refusal at 32.5 ft.
Bottom of borehole at 32.5 ft.

REMARKS: Rig Type: CME 550. Cave-in Depth at 24.5 ft. A borehole that was 3 ft offset from RW-1 was performed to collect an undisturbed sample from 3 to 5 ft.

SPT_LOGAB:COLUMBIA PIKE LOGS VDOT.GPJ:10.01.00.11:021011:4/9/21

VDOT Virginia Department of Transportation

PROJECT #: JD205193
LOCATION: Arlington, Virginia
STRUCTURE: RETAINING WALL

RW-2

PAGE 1 OF 1

STATION: 12+61 | OFFSET: 43 ft. right
LATITUDE: 38.854650° N | LONGITUDE: 77.115633° W
SURFACE ELEVATION: 174.0 ft | COORD. DATUM: NAD 83

Date(s) Drilled: 02/23/2021 - 02/23/2021
Drilling Method(s): 3.25" ID HSA
SPT Method: Automatic Hammer
Other Test(s): Not Applicable
Driller: Terracon (C. Guidel)
Logger: GeoConcepts (A. Garden)

GROUND WATER
FIRST ENCOUNTERED AT 10.0 ft DEPTH
STABILIZED AT 15.0 ft AFTER 0 HOURS

Depth (ft)	Elevation (ft)	SPT Hammer Blows	Soil Recovery (%)	Sample Interval	Field Description of Strata	LL	PI	Moisture Content (%)	Fines Content -#200 (%)
0.0	174.0				0.0 / 174.0 Asphalt = 12 in. **ASPH**				
1.0	173.0	9-8-3-5	65	1-3	1.0 / 173.0 Crushed stone = 12 in. **CRA**			7.3	
2.0	172.0				2.0 / 172.0 *Fill*, gray, fine to medium, SILTY SAND WITH GRAVEL, medium dense, moist **FL**				
3.0	171.0	8-10-3-2	5	3-5	3.0 / 171.0 *Fill*, gray, fine to medium, SILTY GRAVEL WITH SAND, medium dense, wet **FL**			4.4	
5.0	169.0	3-5-7-10	40	5-7	5.0 / 169.0 *Potomac Formation*, gray-brown, coarse, CLAYEY SAND, medium dense, moist **SC**	116	94	22.2	16.8
7.0	167.0	28-23-17-10	25	7-9	7.0 / 167.0 *Potomac Formation*, gray, medium to coarse, SILTY GRAVEL WITH SAND, very dense, wet **GM**			25.0	
9.0	165.0	10-11-14-18	65	9-11	9.0 / 165.0 *Potomac Formation*, gray-brown, coarse, POORLY GRADED GRAVEL WITH CLAY AND SAND, dense, wet **GP-GC**			20.1	
13.5		8-10-12	47	13.5-15	SAME: below 13.5 ft. medium dense	48	30	27.5	11.2
18			80	18-19					
19		20-50/4"	100	19-19.8	SAME: below 19 ft. very dense			11.4	
23.5		5-23-37	300	23.5-24				13.5	
28.5	145.5	25-50/4"	100	28.5-29.3	28.5 / 145.5 *Potomac Formation*, gray, coarse, SILTY SAND, micaceous, very dense **SM**				
33.5		50/4"	100	33.5-33.8				9.6	
35		50/0.5"	100	35-35.04				2.3	
35.0					Auger and spoon refusal at 35.0 feet. Bottom of borehole at 35.0 ft.				

REMARKS: Rig Type: CME 550. Cave-in Depth at 22 ft.

PAGE 1 OF 1
RW-2

BORING LOG NO. HA-01

PROJECT: Columbia Pike Seg H & I Retaining Wall

CLIENT: Volkert, Inc.
Springfield, VA

SITE: Columbia Pike and S. Frederick St
Arlington, VA

GRAPHIC LOG	LOCATION Latitude: 38.854848° Longitude: -77.11603° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	FILL - SANDY LEAN CLAY (CL), fine to medium, orange brown, moist						
		1					
		2					
						23.2	
		3					
	4.0	4					
	Boring Terminated at 4 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

Elevations were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

Boring Started: 09-23-2020	Boring Completed: 09-23-2020
Drill Rig: Hand Auger	Driller: Adam Seip
Project No.: JD205193	

BORING LOG NO. HA-02

PROJECT: Columbia Pike Seg H & I Retaining Wall

CLIENT: Volkert, Inc.
Springfield, VA

SITE: Columbia Pike and S. Frederick St
Arlington, VA

LOCATION

Latitude: 38.854748° Longitude: -77.11588°

GRAPHIC LOG DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	FILL - SANDY FAT CLAY WITH GRAVEL (CH), fine to medium, brown orange, moist						
		1					
		2					
						28.0	
		3					
		4					
						25.4	
5.0	**FILL - CLAYEY SAND (SC)**, fine to coarse, brown, moist	5					
		6					
						10.7	
7.0	***Boring Terminated at 7 Feet***	7					

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

Elevations were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

Boring Started: 09-23-2020	Boring Completed: 09-23-2020
Drill Rig: Hand Auger	Driller: Braque Mathson
Project No.: JD205193	

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth (Ft.)	Soil Classification USCS	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Fines	Proctor Dry Density (pcf) / Opt. Moisture (%)
HA-01	0 - 4	SANDY LEAN CLAY(CL)	8.8	37	23	14	8.2	31.4	60.3	109.0 / 16.2
HA-02	0 - 5	SANDY FAT CLAY with GRAVEL(CH)	8.9	54	26	28	16.7	30.1	53.2	112.5 / 15.4

PROJECT: Columbia Pike Seg H & I Retaining Wall

SITE: Columbia Pike and S. Frederick St
Arlington, VA

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA
PH. 703-726-8030 FAX.

PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc.
Springfield, VA

EXHIBIT: B-1

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth (Ft.)	Soil Classification USCS & AASHTO	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Fines
RW-1	9-11	SILTY SAND(SM) / A-2-6 (0)	12.9	40	26	14	0.2	77.3	22.5
RW-2	5-7	CLAYEY SAND(SC) / A-2-7 (2)	22.2	116	22	94	1.4	81.8	16.8
RW-2	13.5-15	POORLY GRADED GRAVEL with CLAY a	27.5	48	18	30	58.3	30.4	11.2

PROJECT: Columbia Pike Seg H & I Ret Wall

SITE: Columbia Pike and S. Frederick St
Arlington, VA

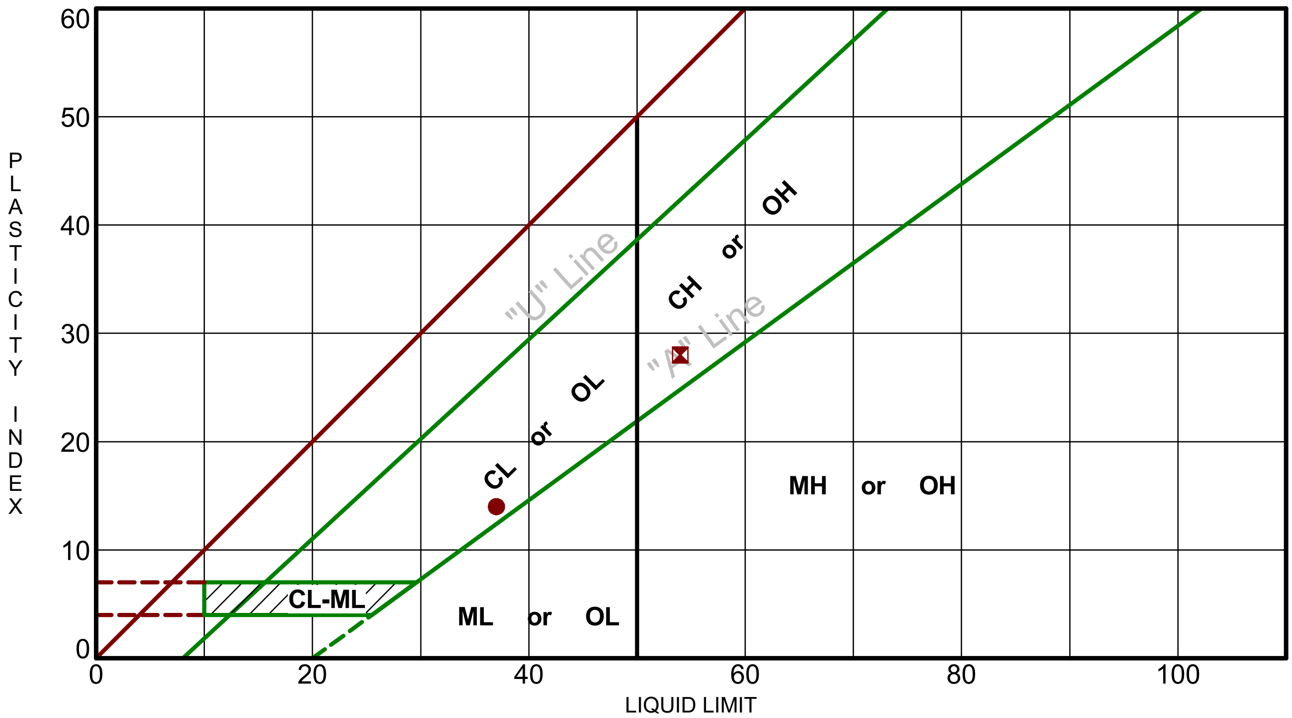
Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA
PH. 703-726-8030 FAX.

PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc.
Springfield, VA

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**HA-01**	**0 - 5**	**37**	**23**	**14**	**60.3**	**CL**	**SANDY LEAN CLAY**
⊠	**HA-02**	**0 - 5**	**54**	**26**	**28**	**53.2**	**CH**	**SANDY FAT CLAY with GRAVEL**

PROJECT: Columbia Pike Seg H & I Retaining Wall

SITE: Columbia Pike and S. Frederick St Arlington, VA

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

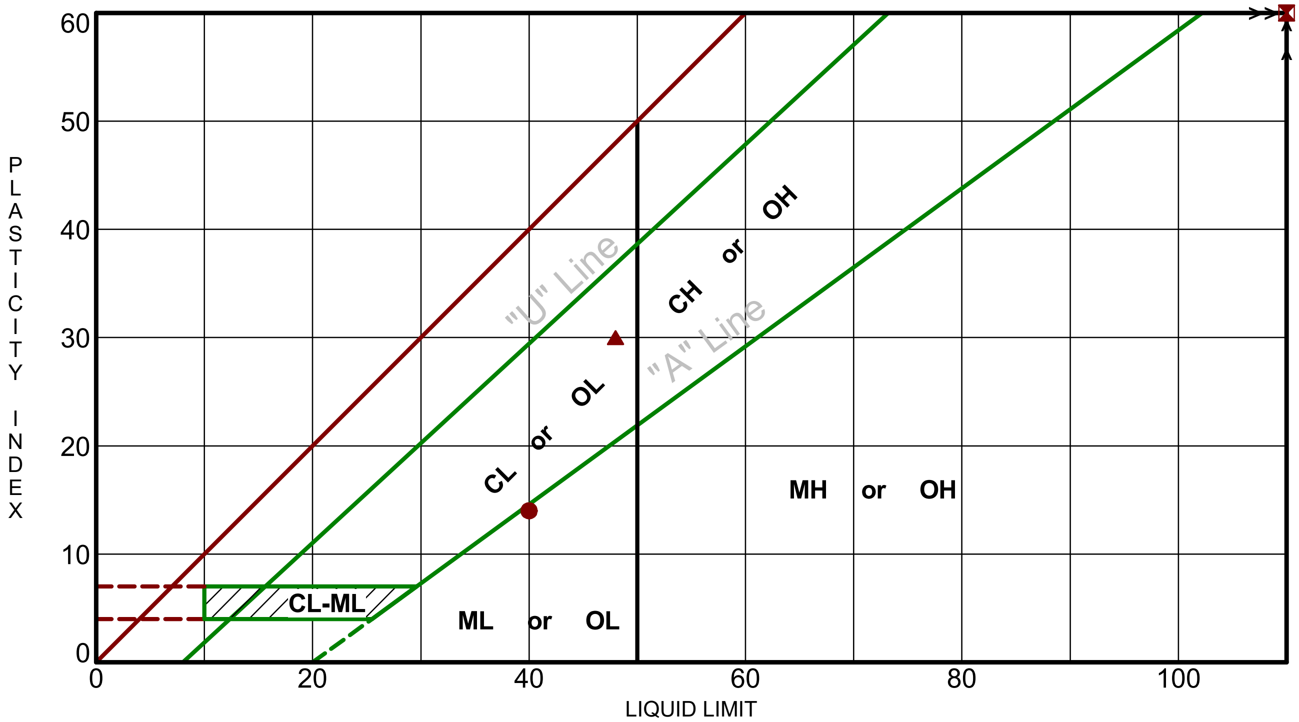
PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc. Springfield, VA

EXHIBIT: B-1

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**RW-1**	**9 - 11**	**40**	**26**	**14**	**22.5**	**SM**	**SILTY SAND**
⊠	**RW-2**	**5 - 7**	**116**	**22**	**94**	**16.8**	**SC**	**CLAYEY SAND**
▲	**RW-2**	**13.5 - 15**	**48**	**18**	**30**	**11.2**	**GP-GC**	**POORLY GRADED GRAVEL with CLAY and SAND**

PROJECT: Columbia Pike Seg H & I Ret Wall

SITE: Columbia Pike and S. Frederick St
Arlington, VA

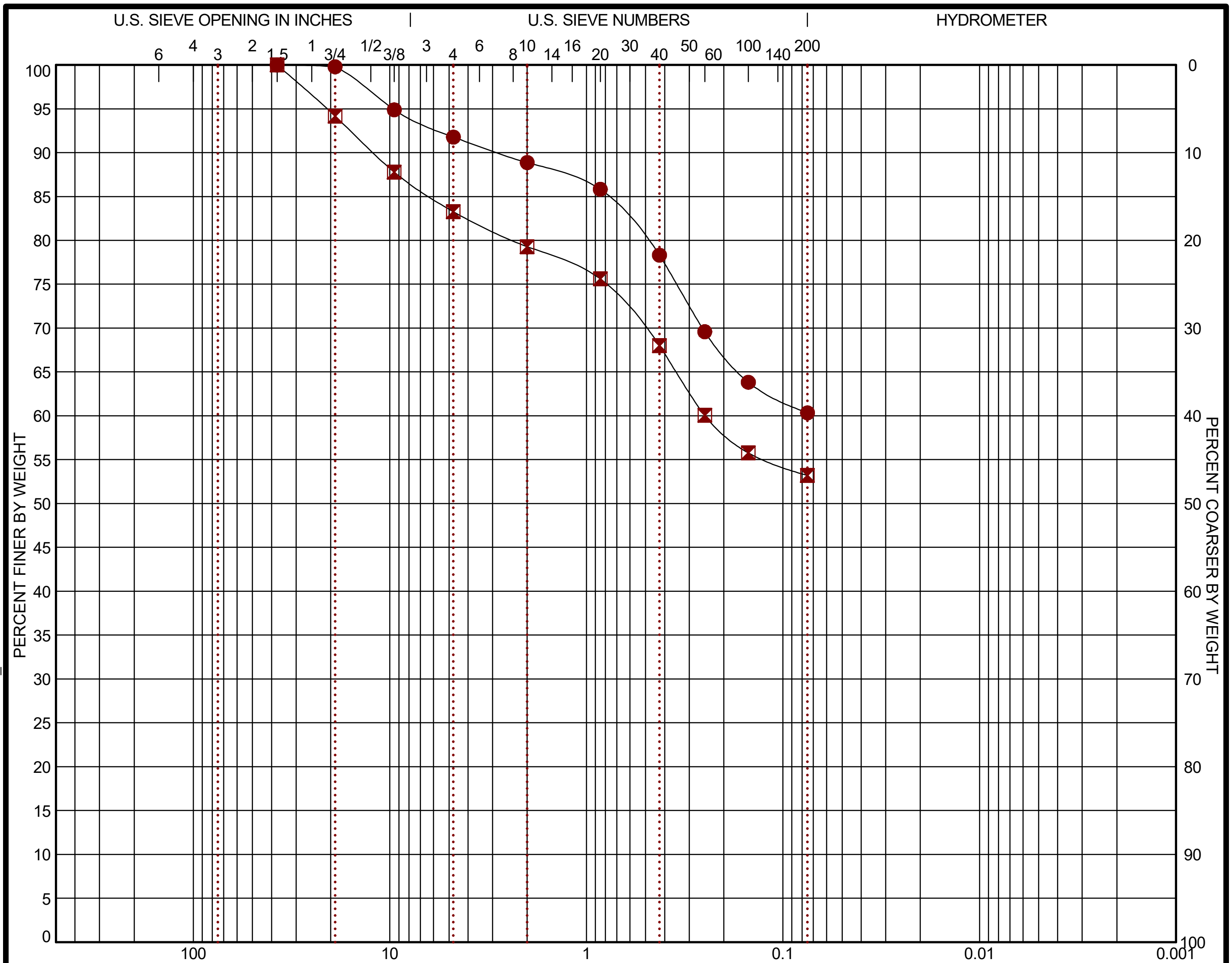
Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc.
Springfield, VA

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**HA-01**	**0 - 5**	**0.0**	**8.2**	**31.4**		**60.3**		**CL**
⊠	**HA-02**	**0 - 5**	**0.0**	**16.7**	**30.1**		**53.2**		**CH**

	GRAIN SIZE	
	●	⊠
D_{60}		**0.249**
D_{30}		
D_{10}		
	COEFFICIENTS	
C_C		
C_U		

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	Sieve	% Finer
1 1/2"	**100.0**	**1 1/2"**	**100.0**		
3/4"	**99.78**	**3/4"**	**94.16**		
3/8"	**94.88**	**3/8"**	**87.77**		
#4	**91.77**	**#4**	**83.27**		
#10	**88.86**	**#10**	**79.28**		
#20	**85.82**	**#20**	**75.61**		
#40	**78.31**	**#40**	**68.0**		
#60	**69.58**	**#60**	**60.05**		
#100	**63.82**	**#100**	**55.77**		
#200	**60.34**	**#200**	**53.19**		

SOIL DESCRIPTION

● SANDY LEAN CLAY (CL)

⊠ SANDY FAT CLAY with GRAVEL (CH)

REMARKS

●

⊠

PROJECT: Columbia Pike Seg H & I Retaining Wall

SITE: Columbia Pike and S. Frederick St Arlington, VA

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

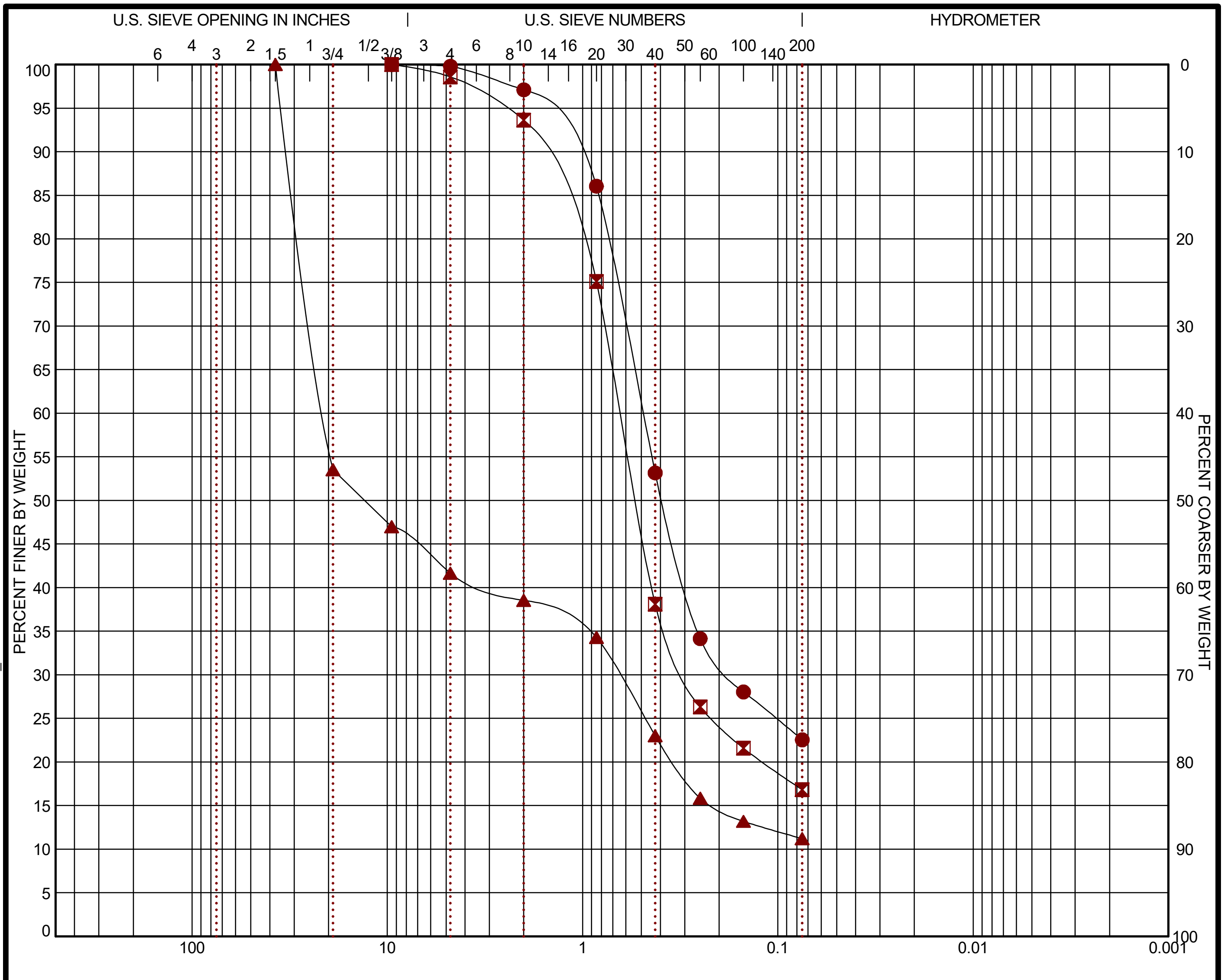
PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc. Springfield, VA

EXHIBIT: B-1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**RW-1**	**9 - 11**	**0.0**	**0.2**	**77.3**		**22.5**		**SM**
⊠	**RW-2**	**5 - 7**	**0.0**	**1.4**	**81.8**		**16.8**		**SC**
▲	**RW-2**	**13.5 - 15**	**0.0**	**58.3**	**30.4**		**11.2**		**GP-GC**

	GRAIN SIZE		
	●	⊠	▲
D_{60}	**0.491**	**0.641**	**20.888**
D_{30}	**0.177**	**0.295**	**0.653**
D_{10}			
	COEFFICIENTS		
C_C			**0.42**
C_U			**425.13**

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
3/8"	**100.0**	**3/8"**	**100.0**	**1 1/2"**	**100.0**
#4	**99.8**	**#4**	**98.58**	**3/4"**	**53.52**
#10	**97.09**	**#10**	**93.61**	**3/8"**	**46.99**
#20	**86.04**	**#20**	**75.1**	**#4**	**41.66**
#40	**53.15**	**#40**	**38.09**	**#10**	**38.54**
#60	**34.15**	**#60**	**26.31**	**#20**	**34.28**
#100	**28.03**	**#100**	**21.58**	**#40**	**23.0**
#200	**22.54**	**#200**	**16.81**	**#60**	**15.85**
				#100	**13.19**
				#200	**11.21**

SOIL DESCRIPTION
- ● SILTY SAND (SM)
- ⊠ CLAYEY SAND (SC)
- ▲ POORLY GRADED GRAVEL with CLAY and SAND (GP-GC)

REMARKS
- ●
- ⊠
- ▲

PROJECT: Columbia Pike Seg H & I Ret Wall

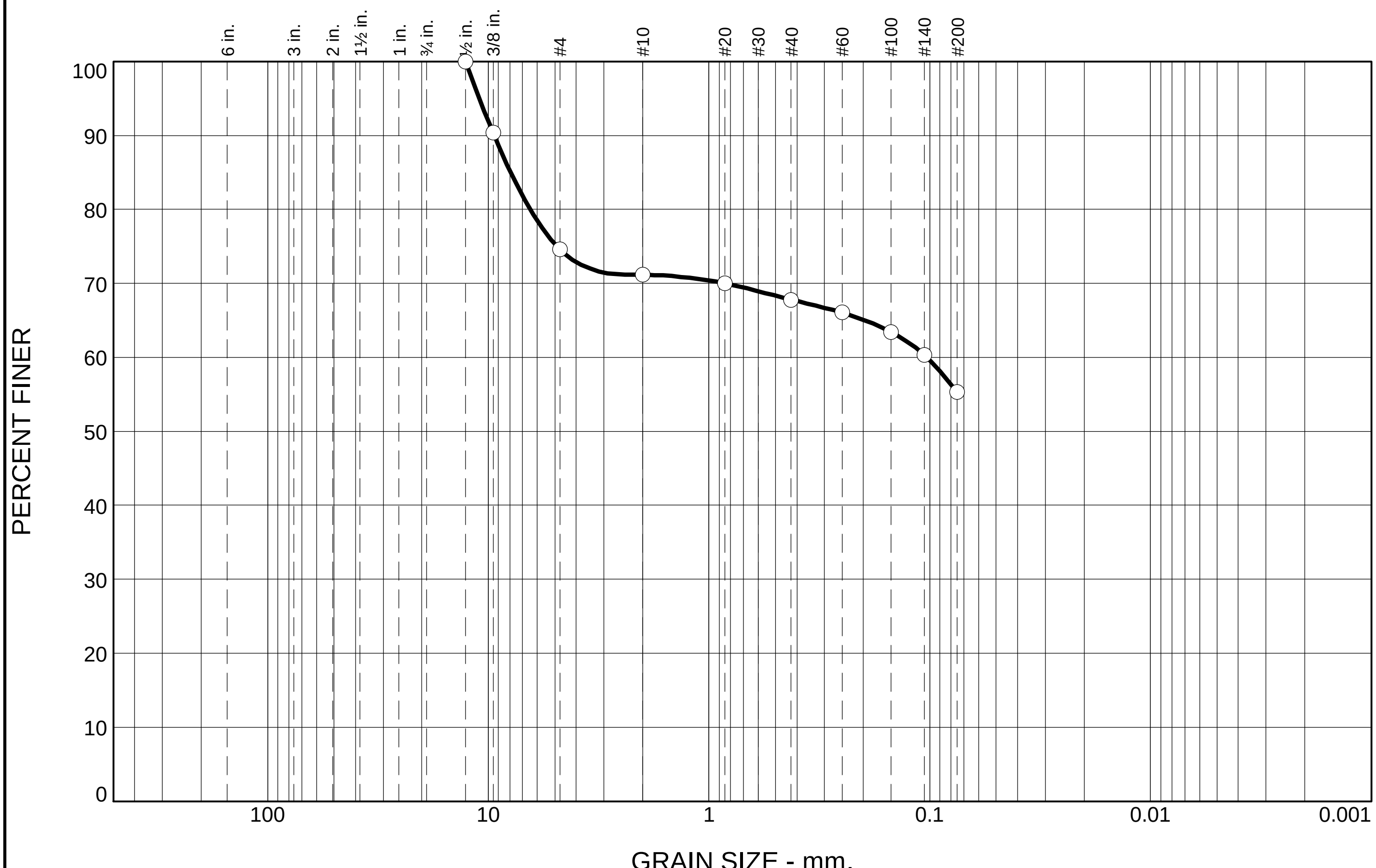
SITE: Columbia Pike and S. Frederick St
Arlington, VA

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA

PROJECT NUMBER: JD205193

CLIENT: Volkert, Inc.
Springfield, VA

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	25.4	3.4	3.4	12.5	55.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	90.4		
#4	74.6		
#10	71.2		
#20	70.0		
#40	67.8		
#60	66.1		
#100	63.4		
#140	60.3		
#200	55.3		

* (no specification provided)

Material Description

gravelly fat clay with sand

Atterberg Limits

PL= 28 LL= 57 PI= 29

Coefficients

D_{90}= 9.4095 D_{85}= 7.9250 D_{60}= 0.1032
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO= A-7-6(13)

Remarks

Source of Sample: RW-1 **Depth:** 15.0-17.0 ft
Sample Number: N/A **Date:** 3/31/21

Terracon Consultants, Inc.

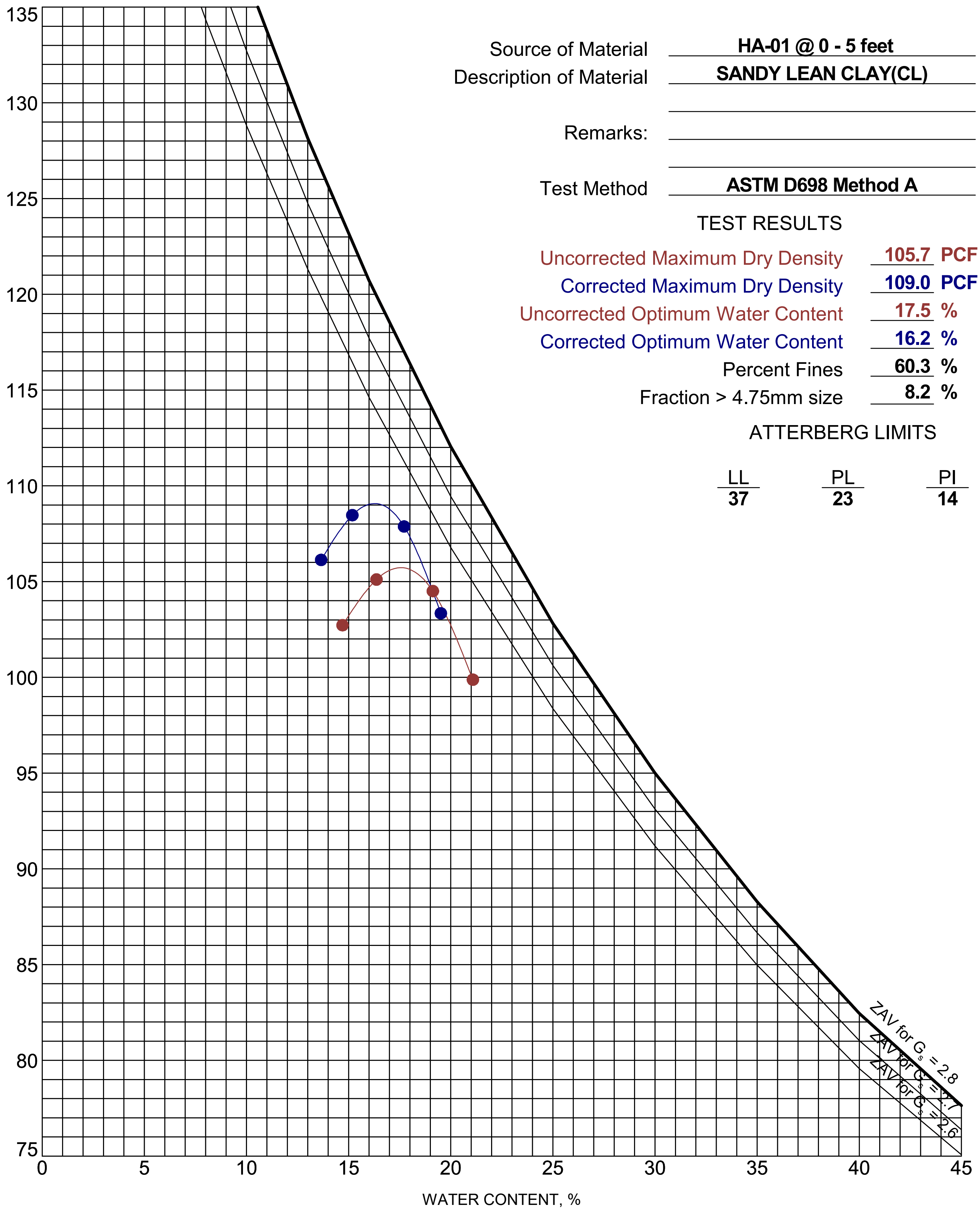
Chattanooga, TN

Client: Volkert, Inc
Project: Columbia Pike Seg H & I Retaining Wall

Project No: JD205193

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**HA-01 @ 0 - 5 feet**
Description of Material	**SANDY LEAN CLAY(CL)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

Uncorrected Maximum Dry Density	**105.7**	**PCF**
Corrected Maximum Dry Density	**109.0**	**PCF**
Uncorrected Optimum Water Content	**17.5**	**%**
Corrected Optimum Water Content	**16.2**	**%**
Percent Fines	**60.3**	**%**
Fraction > 4.75mm size	**8.2**	**%**

ATTERBERG LIMITS

LL	PL	PI
37	**23**	**14**

PROJECT: Columbia Pike Seg H & I Retaining Wall	Terracon 19955 Highland Vista Dr Ste 170 Ashburn, VA	PROJECT NUMBER: JD205193
SITE: Columbia Pike and S. Frederick St Arlington, VA		CLIENT: Volkert, Inc. Springfield, VA
		EXHIBIT: B-1

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

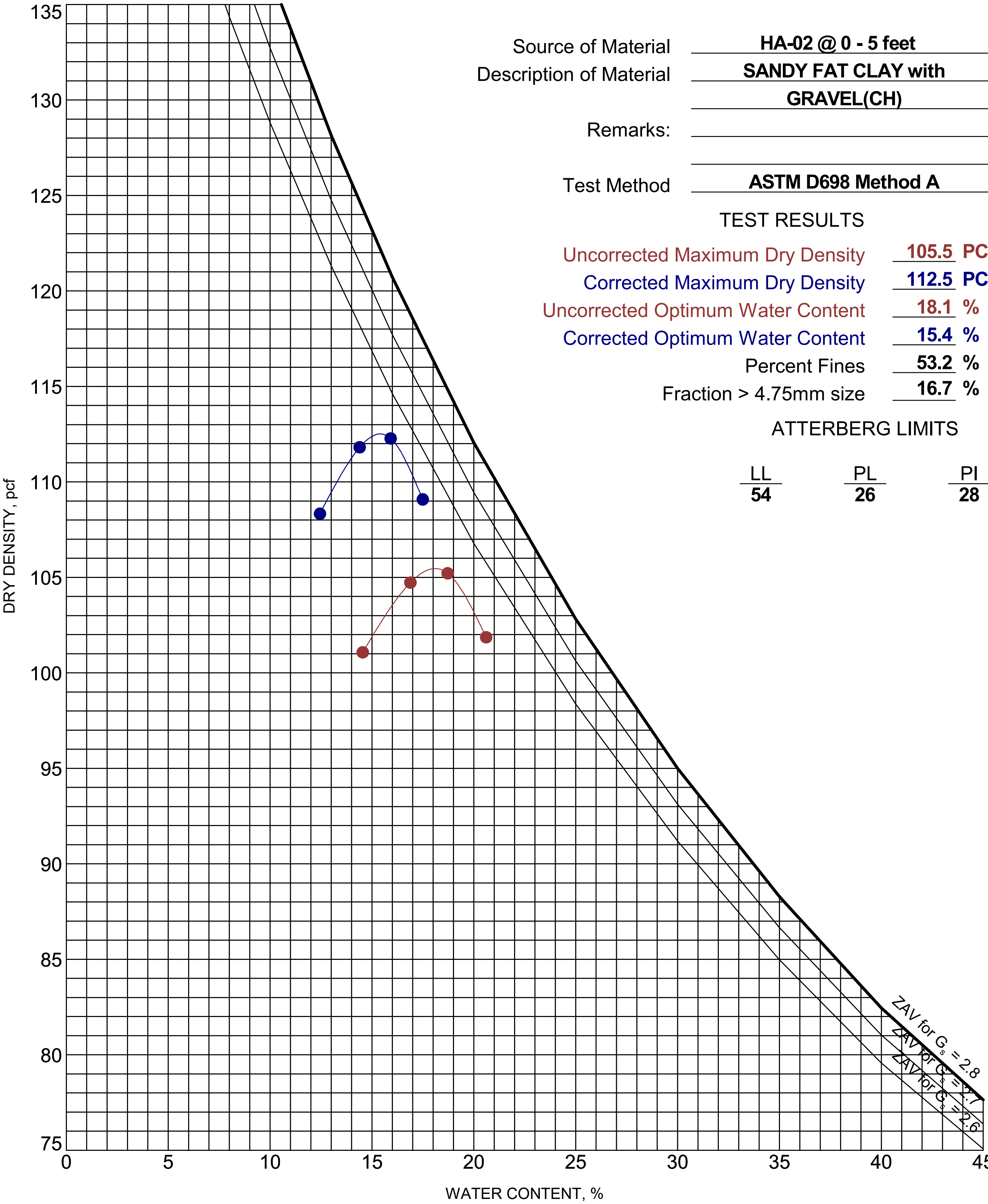
Source of Material	**HA-02 @ 0 - 5 feet**
Description of Material	**SANDY FAT CLAY with GRAVEL(CH)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

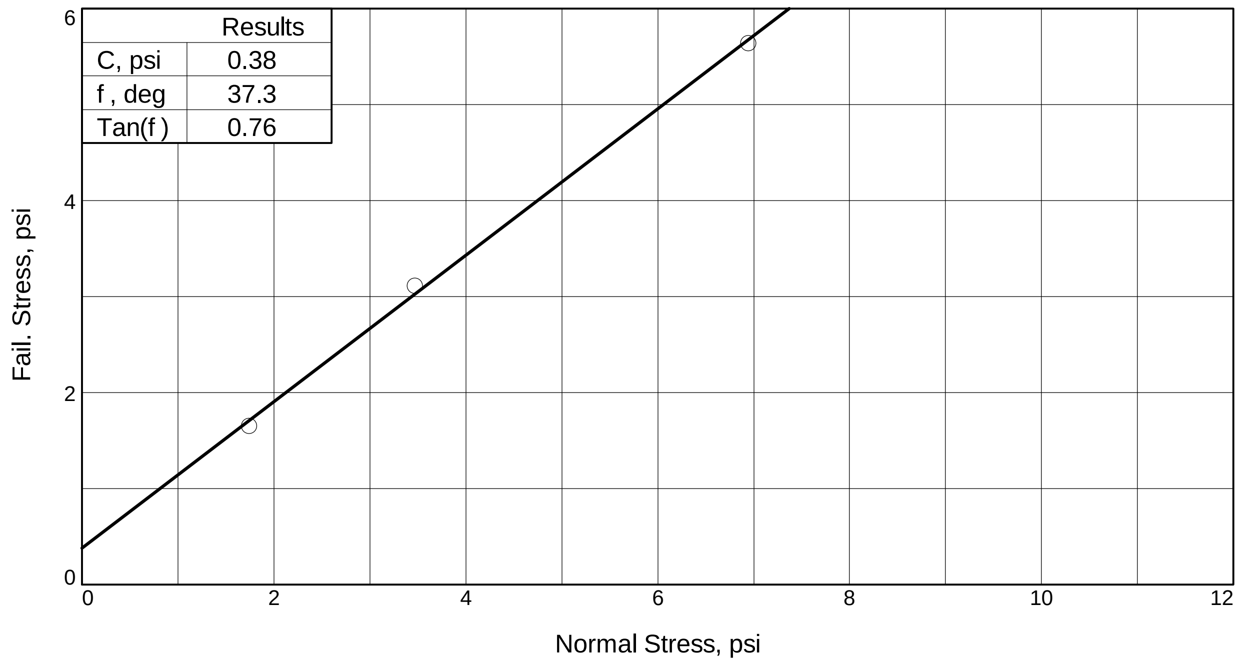
Uncorrected Maximum Dry Density	105.5	PCF
Corrected Maximum Dry Density	112.5	PCF
Uncorrected Optimum Water Content	18.1	%
Corrected Optimum Water Content	15.4	%
Percent Fines	53.2	%
Fraction > 4.75mm size	16.7	%

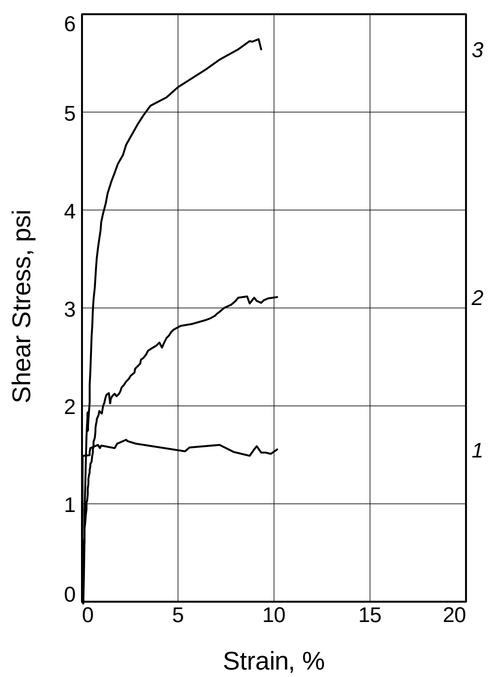
ATTERBERG LIMITS

LL	PL	PI
54	**26**	**28**



PROJECT: Columbia Pike Seg H & I Retaining Wall	**Terracon** 19955 Highland Vista Dr Ste 170 Ashburn, VA	PROJECT NUMBER: JD205193
SITE: Columbia Pike and S. Frederick St Arlington, VA		CLIENT: Volkert, Inc. Springfield, VA
		EXHIBIT: B-2





Sample No.		1	2	3
Initial	Water Content, %	17.5	17.5	17.5
	Dry Density, pcf	101.4	101.4	101.4
	Saturation, %	71.3	71.3	71.3
	Void Ratio	0.6625	0.6625	0.6625
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	23.3	23.1	22.5
	Dry Density, pcf	102.3	102.3	104.2
	Saturation, %	97.2	96.3	98.4
	Void Ratio	0.6477	0.6474	0.6171
	Diameter, in.	2.500	2.500	2.500
	Height, in.	0.991	0.991	0.973
Normal Stress, psi		1.74	3.47	6.94
Fail. Stress, psi		1.65	3.11	5.64
Strain, %		2.3	10.2	9.3
Ult. Stress, psi				
Strain, %				
Strain rate, in./min.		0.005	0.005	0.005

Sample Type: Remold
Description: Brown Sandy Lean Clay (CL)

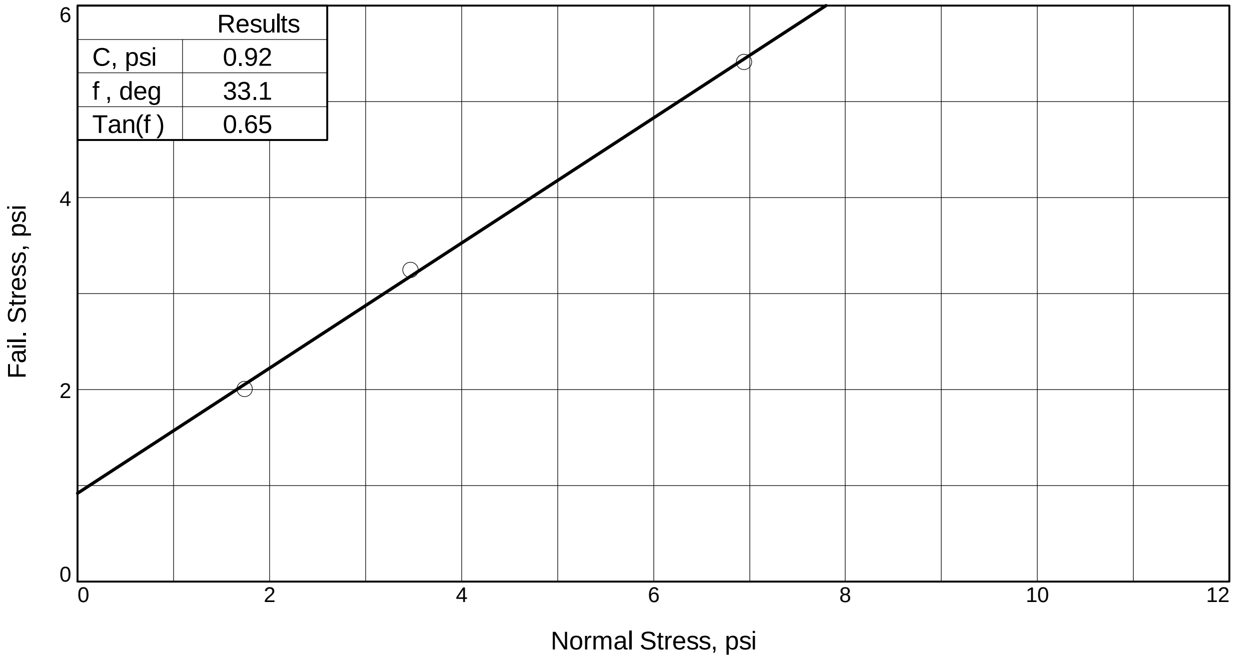
LL= 37 **PL=** 23 **PI=** 14
Assumed Specific Gravity= 2.7
Remarks: Remolded sample.

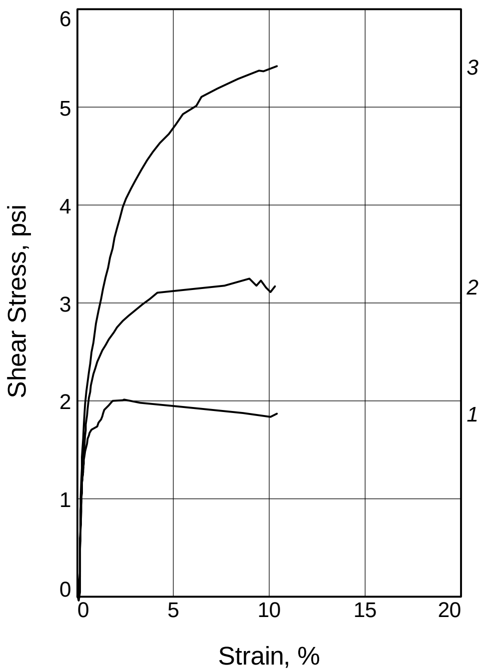
Client: Volkert, Inc

Project: Columbia Pike Seg H & I Retaining Wall

Source of Sample: HA-01 **Depth:** 0.0-5.0 ft
Sample Number: 1
Proj. No.: JD205193 **Date Sampled:** N/A

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN





Sample No.		1	2	3
Initial	Water Content, %	18.1	18.1	18.1
	Dry Density, pcf	101.2	101.2	101.2
	Saturation, %	73.4	73.4	73.4
	Void Ratio	0.6656	0.6656	0.6656
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	26.4	24.5	23.8
	Dry Density, pcf	98.4	101.0	102.0
	Saturation, %	99.8	99.0	98.7
	Void Ratio	0.7127	0.6686	0.6521
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.028	1.002	0.992
Normal Stress, psi		1.74	3.47	6.94
Fail. Stress, psi		2.01	3.24	5.42
Strain, %		2.4	9.0	10.4
Ult. Stress, psi				
Strain, %				
Strain rate, in./min.		0.006	0.006	0.008

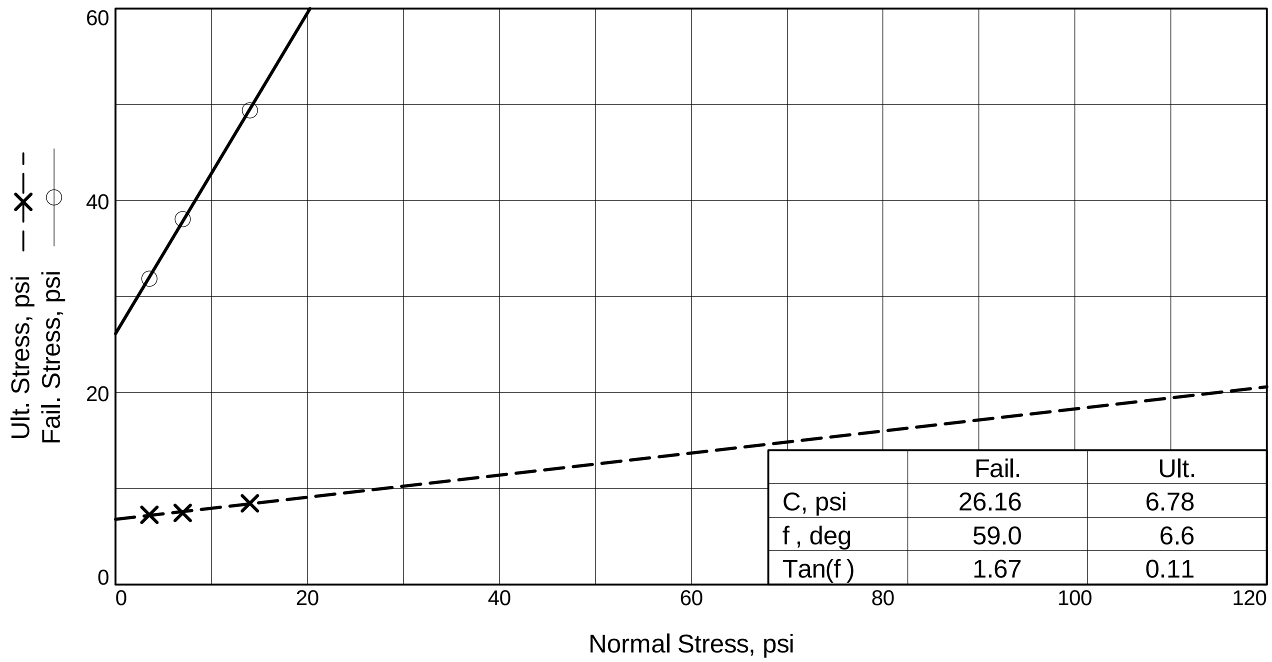
Sample Type: Remolded
Description: Red-Brown Sandy Fat Clay with Gravel (CH)
LL= 54 **PL=** 26 **PI=** 28
Assumed Specific Gravity= 2.7
Remarks: Remolded sample.

Client: Volkert, Inc

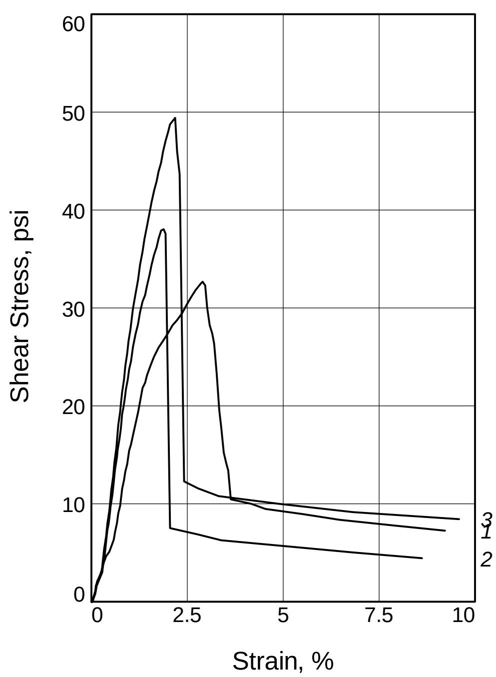
Project: Columbia Pike Seg H & I Retaining Wall

Source of Sample: HA-02 **Depth:** 0.0-5.0 ft
Sample Number: 2
Proj. No.: JD205193 **Date Sampled:** N/A

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN



	Fail.	Ult.
C, psi	26.16	6.78
f , deg	59.0	6.6
Tan(f)	1.67	0.11



Sample No.		1	2	3
Initial	Water Content, %	34.9	35.8	33.7
	Dry Density, pcf	84.0	85.4	88.1
	Saturation, %	93.4	99.1	99.8
	Void Ratio	1.0073	0.9743	0.9126
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	36.2	34.7	31.8
	Dry Density, pcf	84.9	86.9	90.6
	Saturation, %	99.2	99.7	100.0
	Void Ratio	0.9860	0.9400	0.8604
	Diameter, in.	2.500	2.500	2.500
	Height, in.	0.989	0.983	0.973
Normal Stress, psi		3.50	7.00	14.00
Fail. Stress, psi		31.85	38.04	49.42
Strain, %		2.7	1.9	2.2
Ult. Stress, psi		7.25	7.49	8.43
Strain, %		9.2	2.1	9.6
Strain rate, in./min.		0.007	0.007	0.007

Sample Type: Tube
Description: gravelly fat clay with sand

LL= 57 **PL=** 28 **PI=** 29
Assumed Specific Gravity= 2.7
Remarks: Three Specimen Series
Specimens Were Blocky

Client: Volkert, Inc

Project: Columbia Pike Seg H & I Retaining Wall

Source of Sample: RW-1 **Depth:** 15.0-17.0 ft
Sample Number: N/A
Proj. No.: JD205193 **Date Sampled:** 3/31/21

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN

HP ENVIRONMENTAL INCORPORATED

Certificate of Laboratory Analysis

Terracon Consultants Inc.
Braque Mathson
19955 Highland Vista Dr., Suite 170
Ashburn, VA 20147

Report Number: **213433**
Date Received: 03/09/21 14:30
Date Reported: 03/11/21 12:00
Project Location: Columbia Pike

Client Sample No: **RW-1**
Sample Matrix: Soil
Sample Description: 5.0-10.0 ft
Lab Sample No.: 213433-01
Collection Date/Time:

Soil Corrosion Potential Tests

Parameter	Method	Result	Units	Limit	Dilution	Qualifier	Cont.	Analysis Date	Analyst
Resistivity	ASTM G187	**2300**	ohm-cm	N/A	1		A	03/11/21	JMP
Redox Potential	Electrode	+ **315**	mV	N/A	1		A	03/11/21	JMP
pH	CA-643	**3.7**	pH	N/A			A	03/11/21	JMP
Chloride (Water Soluble)	CA-422	**28**	mg/Kg	2.5	1		A	03/11/21	JMP
Sulfate (Water Soluble)	EPA 375.4	< 5.0	mg/Kg	5.0	1	U	A	03/11/21	JMP
Sulfide (Water Soluble)	EPA 376.2	< 1.2	mg/Kg	1.2	1	U	A	03/11/21	JMP

Client Sample No: **RW-1**
Sample Matrix: Soil
Sample Description: 10.0-15.0 ft
Lab Sample No.: 213433-02
Collection Date/Time:

Soil Corrosion Potential Tests

Parameter	Method	Result	Units	Limit	Dilution	Qualifier	Cont.	Analysis Date	Analyst
Resistivity	ASTM G187	**3000**	ohm-cm	N/A	1		A	03/11/21	JMP
Redox Potential	Electrode	+ **291**	mV	N/A	1		A	03/11/21	JMP
pH	CA-643	**3.7**	pH	N/A			A	03/11/21	JMP
Chloride (Water Soluble)	CA-422	**26**	mg/Kg	2.5	1		A	03/11/21	JMP
Sulfate (Water Soluble)	EPA 375.4	**7.1**	mg/Kg	5.0	1		A	03/11/21	JMP
Sulfide (Water Soluble)	EPA 376.2	< 1.2	mg/Kg	1.2	1	U	A	03/11/21	JMP

HP ENVIRONMENTAL INCORPORATED

Certificate of Laboratory Analysis

Terracon Consultants Inc.		Report Number:	**213433**
Braque Mathson		Date Received:	03/09/21 14:30
19955 Highland Vista Dr., Suite 170		Date Reported:	03/11/21 12:00
Ashburn, VA 20147		Project Location:	Columbia Pike

Qualifier Codes:

U = Analyte was not detected at or above reporting limit

Sample Container Codes:

Plastic Bag	A	Soil

Notes:

Soil Results are reported on a wet weight basis (as received) unless stated as "dry".
The lab results reflect the measurement of the sample received only and may not be completely representative of the sampled site.
The Client has the responsibility for assessing risk and appropriate data interpretation of the results contained herein.
Laboratory reports issued are intended for the exclusive use by the Client and shall not be reproduced except in its entirety.
The chain-of-custody is a part of the entire analytical report.
Residual sample(s) will be disposed of in three months unless otherwise notified.

Laboratory Report Approved by:

J Pfaff 03/11/21

Laboratory Director, Chemistry Date

CALCULATIONS

Contents:

Note: All attachments are one page unless noted above.

BEARING RESISTANCE OF RW-3 WALL (LRFD)

Computed by: BM
Checked by: SU

Project Info:	Columbia Pike
Project Number:	JD205193
Structure:	RW-3 Cast-In-Place Gravity Wall
Design Condition:	Drained Condition

Footing Dimensions

B =	4.5	ft	Width of Footing
L=	25	ft	Length of Footing
D_f =	2	ft	Depth from ground surface to bottom of footing
H =	0		Horizontal component of load acting on footing (enter zero if load is vertical)
V =	0		Vertical component of load acting on footing (enter zero if load is vertical)

Soil and Groundwater Parameters

phi =	30	deg	Note: Insert zero for no friction angle
phi =	30	deg	Not Reduced for punching shear
c =	0	psf	Note: Insert zero for no cohesion
g moist =	115	pcf	
g saturated =	115	pcf	
Depth to GW =	10.0	ft	Measured below the bottom of footing

Slope at the Footing Level

Slope inclination (°)		deg	For footings located on slopes or within 3B of a slope crest, Meyerhof (1957) charts are used. These charts are provided in page 4.4.7.1.1.5, Figures 4.4.7.1.1.4A and 4B. Slope inclination should be set to zero (0) for horizontal slope in front.
Height of Slope, H_s =		ft	
Distance, b =		ft	Distance of foundation from edge of slope.
b/B =	0.00		
Df/B =	0.44		
N_{gq} =			Modified Bearing Capacity Factor from Figure 10.6.3.1.2c-2.
N_{cq} =			Modified Bearing Capacity Factor from Figure 10.6.3.1.2c-1.
N_s =	0.00		Section 10.6.3.1.2c
Resistance Factor =	0.55		Table 11.5.7-1: Resistance Factors for Permanent Retaining Walls
RC_{BC} =			

THEORETICAL ESTIMATION OF BEARING CAPACITY (MUNFAKH, et. al. 2001)

AASHTO, 2014 (Section 10.6.3.1.2a, Page 10-69)	$q_n = c\, N_c\, s_c\, i_c + N_q\, s_q\, d_q\, i_q\, C_{wq} + 0.5\, g\, B\, N_g\, s_g\, i_g\, C_{wg}$	Flat ground
AASHTO, 2014 (Section 10.6.3.1.2c, Page 10-73)	$q_n = c\, N_{cq} + 0.5\, g\, B\, N_{gq}$	When slope is present

Correction Factors (For no slope condition)

Groundwater Table

C_{wq}	1
C_{wg}	1

Shape

s_c	1.00
s_q	1.00
s_g	0.93

Depth

d_q	1.00

Inclination

i_c	1.00
i_q	1.00
i_g	1.00

Soil and Foundation Properties

0

a	0.00 degrees
N_g	22.40
N_c	30.14
N_q	18.40

SOLUTION:

Nominal bearing resistance (q_n) =	9.6	ksf
Resistant factor (y) =	0.55	
Factored bearing resistance (q_R) =	5.3	ksf

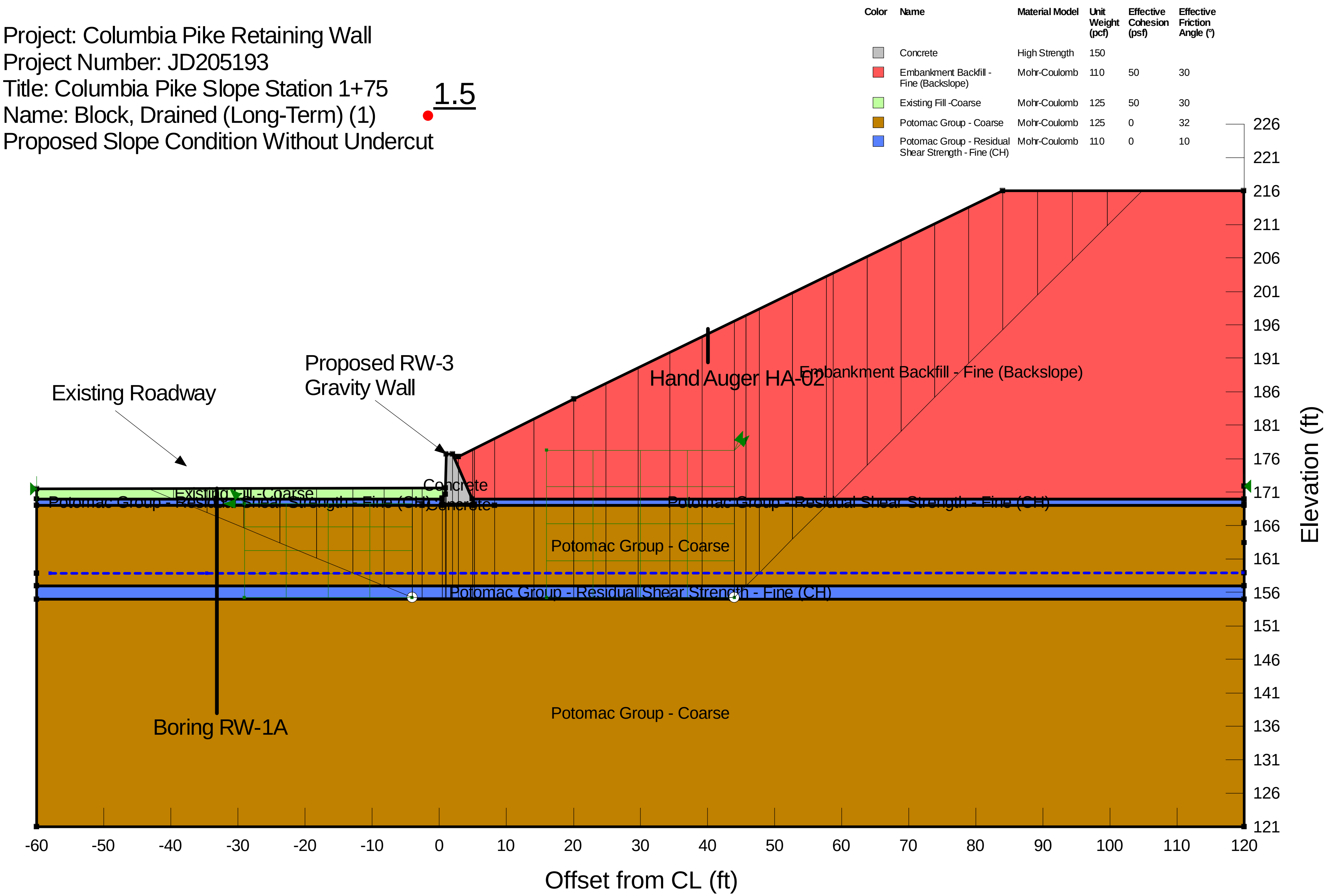
Terracon

Bearing Capacity Service Limit and Elastic Settlement

AASHTO LRFD Bridge Specifications

Project Number: JD205193	**Calculated by: BM**
Project Name: Columbia Pike Retaining Wall	**Checked by: SU**
Project Location: Arlington, VA	**Date: April 2020**

Elastic Half Space Method; Equation 10.6.2.4.2-1				
Parameters		**RW-1**		
q_0	Applied vertical stress (ksf)	2.5		
B	Footing width (ft)	4.5		
Length	Footing length (ft)	25.0		
Es	Young's modulus of soil (ksi)	1.64		
bz	Shape factor (from Table 10.6.2.4.2-1AASHTO LRFD 2014 manual)	1.25		
n	Poisson's Ratio	0.25		
L/B	L/B	5.56		
A'	Effective area of footing (sq. ft)	112.5		
Se	Elastic settlement (ft)	0.08		
Se	**Elastic settlement (inch)**	**1.0**		
Representative Boring		RW-1 and RW-2		
Young's Modulus of Soil (ksi) - Table C10.4.6.3-1 (LRFD 2014)				
Fill Soils - Average SPT (N Value)		20		
Fill - Average N = 20 E = (0.056 x $N1_{60}$) = xx (ksi)		1.64		
Intermediate Geomaterial (IGM) (10 feet)=		0.0	ksi	*Based on our previous experience*
Weighted Average=		1.64	ksi	



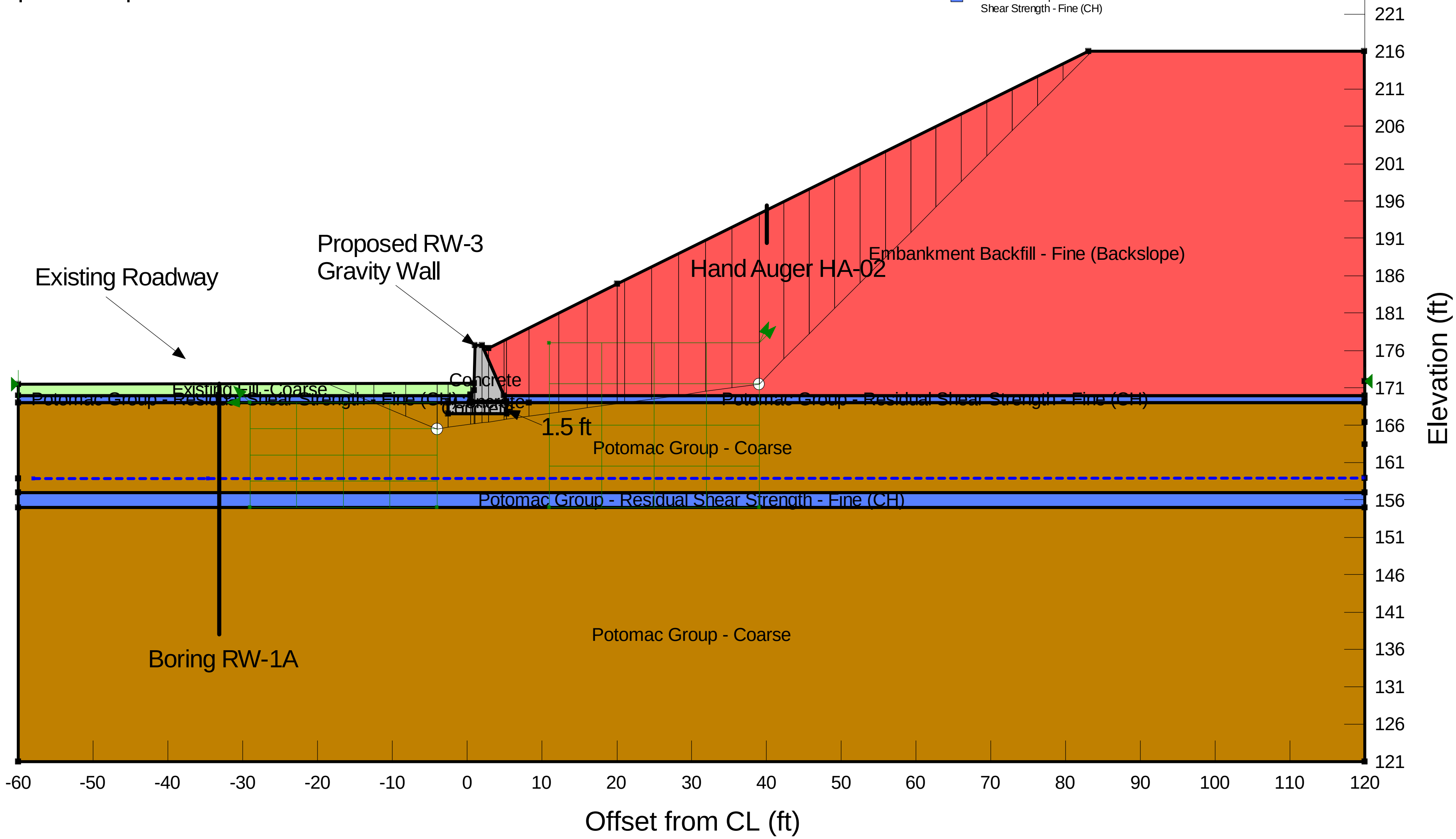
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	Embankment Backfill - Fine (Backslope)	Mohr-Coulomb	110	50	30
	Existing Fill -Coarse	Mohr-Coulomb	125	50	30
	Potomac Group - Coarse	Mohr-Coulomb	125	0	32
	Potomac Group - Residual Shear Strength - Fine (CH)	Mohr-Coulomb	110	0	10

Note: Data point is randomly placed to show factor of safety value only and does not represent the true center of the critical slip surface. Actual coordinates of the center of critical slip surface are: (20.721057, 227.18265) ft

Project: Columbia Pike Retaining Wall
Project Number: JD205193
Title: Columbia Pike Slope Station 1+75
Name: Block, Drained (Long-Term) (2)
Proposed Slope Condition With Undercut

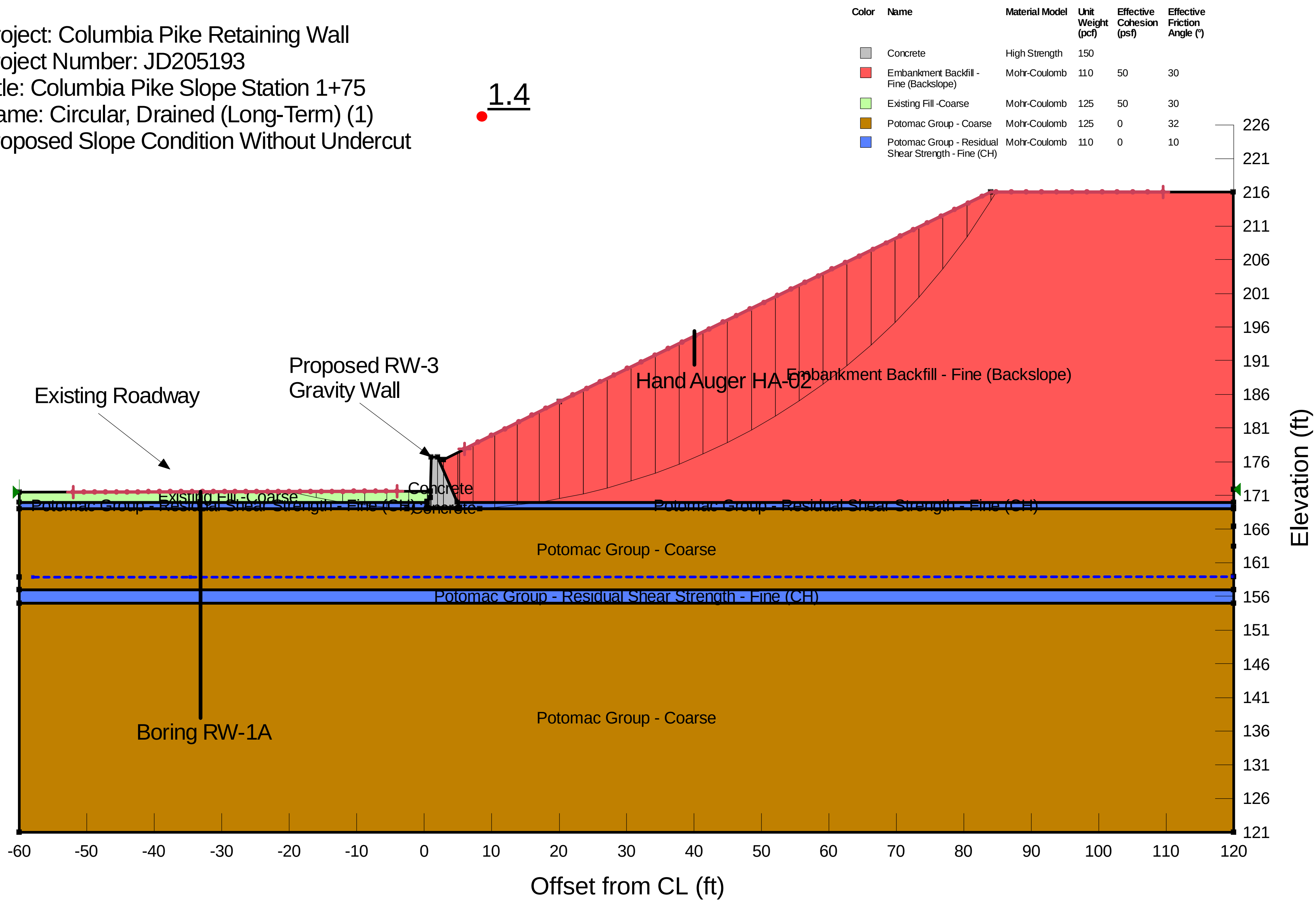
1.7

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	Embankment Backfill - Fine (Backslope)	Mohr-Coulomb	110	50	30
	Existing Fill -Coarse	Mohr-Coulomb	125	50	30
	Potomac Group - Coarse	Mohr-Coulomb	125	0	32
	Potomac Group - Residual Shear Strength - Fine (CH)	Mohr-Coulomb	110	0	10

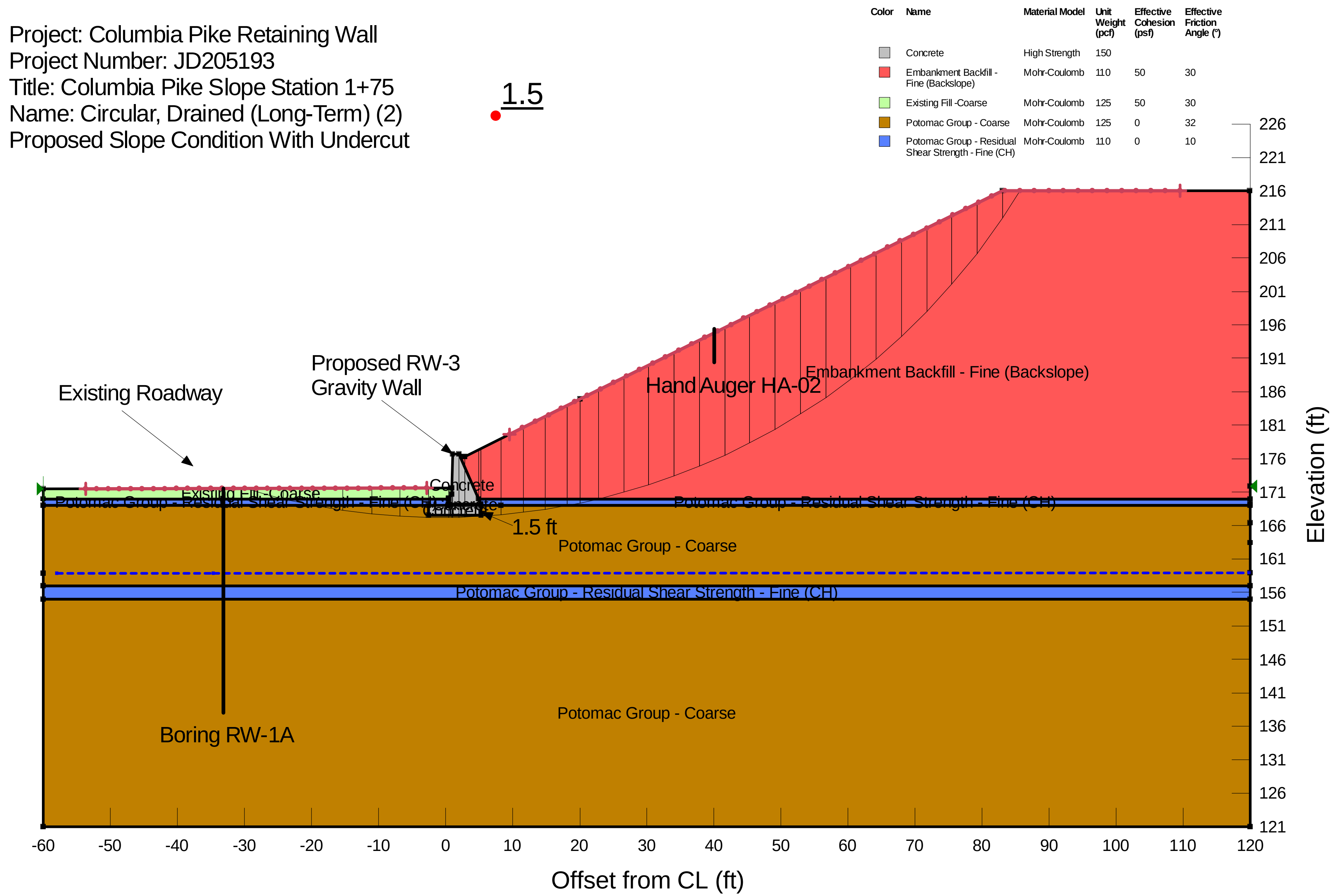


Note: Data point is randomly placed to show factor of safety value only and does not represent the true center of the critical slip surface. Actual coordinates of the center of critical slip surface are: (17.928358, 227.13122) ft

Project: Columbia Pike Retaining Wall
Project Number: JD205193
Title: Columbia Pike Slope Station 1+75
Name: Circular, Drained (Long-Term) (1)
Proposed Slope Condition Without Undercut



Note: Data point is randomly placed to show factor of safety value only and does not represent the true center of the critical slip surface. Actual coordinates of the center of critical slip surface are: (2.5072077, 264.26104) ft



Note: Data point is randomly placed to show factor of safety value only and does not represent the true center of the critical slip surface. Actual coordinates of the center of critical slip surface are: (-0.72491392, 268.02529) ft

Block, Drained (Long-Term) (1)

File Information

File Version: 11.01
Title: Columbia Pike Slope Station 1+75
Created By: Mathson, Braque D
Last Edited By: Mathson, Braque D
Revision Number: 833
Date: 04/08/2021
Time: 08:47:54 AM
Tool Version: 11.1.2.22321
File Name: Columbia Pike RW-3_3 Rev1.gsz
Directory: C:\Users\bdmathson\OneDrive - Terracon Consultants Inc\Desktop\66\JD205193\Working Files\Calculations-Analyses\
Last Solved Date: 04/08/2021
Last Solved Time: 08:48:14 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Block, Drained (Long-Term) (1)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings

  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Existing Fill -Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Concrete

Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Embankment Backfill - Fine (Backslope)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Residual Shear Strength - Fine (CH)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-60, 171.47) ft
Right Coordinate: (119.99, 171.84) ft

Slip Surface Block

Left Grid

- Upper Left: (-29, 169.25) ft
- Lower Left: (-29, 155.25) ft
- Lower Right: (-4, 155.25) ft
- X Increments: 4
- Y Increments: 4
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid

- Upper Left: (16, 177.24924) ft
- Lower Left: (16, 155.24924) ft
- Lower Right: (44, 155.24924) ft
- X Increments: 4
- Y Increments: 4
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-57.94 ft	158.9 ft
Coordinate 2	-34.59 ft	158.9 ft
Coordinate 3	119.89 ft	158.95 ft

Geometry

Name: RW-3 (slope/fill Fully Soften) (1)

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	1.02 ft	176.68 ft
Point 2	1.94 ft	176.68 ft
Point 3	5.28 ft	169.2 ft
Point 4	0.49 ft	169.2 ft
Point 5	0.49 ft	170.08 ft
Point 6	0.92 ft	170.71 ft
Point 7	0.93541 ft	171.63 ft
Point 8	-60 ft	171.47 ft
Point 9	119.99 ft	163.47 ft
Point 10	119.96 ft	216.07 ft
Point 11	84.01974 ft	216.02 ft
Point 12	2.81 ft	176.28 ft

	X	Y
Point 13	119.99 ft	171.84 ft
Point 14	119.99 ft	158.95 ft
Point 15	-60 ft	158.9 ft
Point 16	119.99 ft	121.03 ft
Point 17	-60 ft	120.98 ft
Point 18	20.03 ft	184.89503 ft
Point 19	119.99 ft	169.28 ft
Point 20	119.99 ft	170 ft
Point 21	-60 ft	170 ft
Point 22	4.92278 ft	170 ft
Point 23	0.49 ft	170 ft
Point 24	-60 ft	157 ft
Point 25	119.99 ft	157 ft
Point 26	119.99 ft	155 ft
Point 27	-60 ft	155 ft
Point 28	-60 ft	169 ft
Point 29	119.99 ft	169 ft
Point 30	0.49 ft	169 ft
Point 31	8.282 ft	169 ft
Point 32	119.99 ft	166.42805 ft
Point 33	-2.55272 ft	169 ft
Point 34	5.28 ft	169 ft
Point 35	5 ft	169 ft

Regions

	Material	Points	Area
Region 1	Concrete	2,1,7,6,5,23,4,3,22	20.337 ft²
Region 2	Concrete	4,30,35,34,3	0.958 ft²

Region 3	Embankment Backfill - Fine (Backslope)	13,10,11,18,12,2,22,20	3,782.5 ft²
Region 4	Existing Fill -Coarse	5,6,7,8,21,23	94.262 ft²
Region 5	Potomac Group - Coarse	16,17,27,26	6,118.8 ft²
Region 6	Potomac Group - Residual Shear Strength - Fine (CH)	24,25,26,27	359.98 ft²
Region 7	Potomac Group - Residual Shear Strength - Fine (CH)	4,23,21,28,33,30	60.49 ft²
Region 8	Potomac Group - Residual Shear Strength - Fine (CH)	29,19,20,22,3,34,31	114.85 ft²
Region 9	Potomac Group - Coarse	30,33,28,15,24,25,14,9,32,29,31,34,35	2,159.9 ft²

Slip Results

Slip Surfaces Analysed: 2537 of 5625 converged

Current Slip Surface

Slip Surface: 988
Factor of Safety: 1.5
Volume: 3,185.9082 ft³
Weight: 365,709.82 lbf
Resisting Moment: 10,470,623 lbf·ft
Activating Moment: 7,005,170.5 lbf·ft
Resisting Force: 121,206.94 lbf
Activating Force: 81,045.205 lbf
Slip Rank: 1 of 5,625 slip surfaces
Exit: (-43.264631, 171.51394) ft
Entry: (104.79967, 216.04891) ft
Radius: 80.752177 ft
Center: (20.721057, 227.18265) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-41.43714 ft	170.75697 ft	-740.23295 psf	179.32099 psf	103.53102 psf	50 psf	0 psf	Existing Fill -Coarse
Slice 2	-38.402543 ft	169.5 ft	-661.76 psf	297.56743 psf	52.469167 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 3	-35.892718 ft	168.4604 ft	-596.85735 psf	584.56184 psf	365.27478 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 4	-31.86986 ft	166.79407 ft	-492.77358 psf	916.52099 psf	572.70588 psf	0 psf	0 psf	Potomac Group - Coarse
						0 psf	0 psf	

Slice 5	-26.429581 ft	164.54064 ft	-351.98113 psf	1,365.4432 psf	853.22364 psf			Potomac Group - Coarse
Slice 6	-20.989302 ft	162.2872 ft	-211.18868 psf	1,814.3655 psf	1,133.7414 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 7	-15.549023 ft	160.03376 ft	-70.396225 psf	2,263.2878 psf	1,414.2592 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 8	-10.526879 ft	157.95352 ft	59.575053 psf	2,652.1113 psf	1,619.9965 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 9	-6.1124369 ft	156.125 ft	173.81921 psf	2,292.9916 psf	373.66728 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 10	-3.27636 ft	155.24999 ft	228.50364 psf	2,055.4583 psf	322.14141 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 11	-1.03136 ft	155.24995 ft	228.55123 psf	2,056.2188 psf	322.26711 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 12	0.712705 ft	155.24993 ft	228.58819 psf	2,108.105 psf	331.40953 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 13	0.977705 ft	155.24992 ft	228.59381 psf	2,529.4711 psf	405.70675 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 14	1.48 ft	155.24991 ft	228.60446 psf	2,919.008 psf	474.39073 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 15	2.375 ft	155.2499 ft	228.62343 psf	2,856.3051 psf	463.33118 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 16	3.905 ft	155.24987 ft	228.65585 psf	2,758.252 psf	446.03604 psf	0 psf	0 psf	Potomac Group -

								Residual Shear Strength - Fine (CH)
Slice 17	5.14 ft	155.24986 ft	228.68203 psf	2,710.8135 psf	437.66674 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 18	6.781 ft	155.24983 ft	228.71681 psf	2,782.5687 psf	450.31299 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 19	11.219 ft	155.24976 ft	228.81087 psf	3,033.762 psf	494.58856 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 20	17.093 ft	155.24967 ft	228.93537 psf	3,366.2337 psf	553.19034 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 21	22.427 ft	155.24958 ft	229.04843 psf	3,664.3754 psf	605.74083 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 22	27.221 ft	155.24951 ft	229.15004 psf	3,928.187 psf	652.24003 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 23	32.015 ft	155.24943 ft	229.25165 psf	4,191.9987 psf	698.73922 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 24	36.809 ft	155.24935 ft	229.35326 psf	4,455.8104 psf	745.23842 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 25	41.603 ft	155.24928 ft	229.45486 psf	4,719.622 psf	791.73762 psf	0 psf	0 psf	Potomac Group - Residual Shear

								Strength - Fine (CH)
Slice 26	44.87538 ft	156.12462 ft	174.87322 psf	3,539.1114 psf	593.20597 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 27	46.714074 ft	157.96331 ft	60.120384 psf	2,942.3794 psf	1,801.0353 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 28	50.19573 ft	161.44497 ft	-157.16975 psf	2,769.9138 psf	1,730.8342 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 29	55.232417 ft	166.48166 ft	-471.50926 psf	2,538.318 psf	1,586.1171 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 30	58.25076 ft	169.5 ft	-659.88401 psf	2,821.1316 psf	497.44162 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 31	61.277658 ft	172.5269 ft	-848.79266 psf	2,314.1222 psf	1,336.0591 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 32	66.331454 ft	177.58069 ft	-1,164.2 psf	2,127.5748 psf	1,228.3559 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 33	71.38525 ft	182.63449 ft	-1,479.6073 psf	1,941.0274 psf	1,120.6527 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 34	76.439046 ft	187.68829 ft	-1,795.0146 psf	1,754.48 psf	1,012.9495 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 35	81.492842 ft	192.74208 ft	-2,110.4219 psf	1,567.9325 psf	905.24628 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 36	86.617231 ft	197.86647 ft	-2,430.235 psf	1,288.2353 psf	743.76301 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 37	91.812213 ft	203.06145 ft	-2,754.4537 psf	915.38827 psf	528.49966 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 38	97.007196 ft	208.25644 ft	-3,078.6725 psf	542.54122 psf	313.23632 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 39	102.20218 ft	213.45142 ft	-3,402.8912 psf	169.69417 psf	97.972977 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)

Block, Drained (Long-Term) (2)

File Information

File Version: 11.01
Title: Columbia Pike Slope Station 1+75
Created By: Mathson, Braque D
Last Edited By: Mathson, Braque D
Revision Number: 833
Date: 04/08/2021
Time: 08:47:54 AM
Tool Version: 11.1.2.22321
File Name: Columbia Pike RW-3_3 Rev1.gsz
Directory: C:\Users\bdmathson\OneDrive - Terracon Consultants Inc\Desktop\66\JD205193\Working Files\Calculations-Analyses\
Last Solved Date: 04/08/2021
Last Solved Time: 08:48:04 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Block, Drained (Long-Term) (2)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings

  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Existing Fill -Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Concrete

Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Embankment Backfill - Fine (Backslope)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Residual Shear Strength - Fine (CH)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-60, 171.47) ft
Right Coordinate: (119.99, 171.84) ft

Slip Surface Block

Left Grid
- Upper Left: (-29, 169) ft
- Lower Left: (-29, 155) ft
- Lower Right: (-4, 155) ft
- X Increments: 4
- Y Increments: 4
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (16, 176.99924) ft
- Lower Left: (16, 154.99924) ft
- Lower Right: (44, 154.99924) ft
- X Increments: 4
- Y Increments: 4
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-57.94 ft	158.9 ft
Coordinate 2	-34.59 ft	158.9 ft
Coordinate 3	119.89 ft	158.95 ft

Geometry

Name: RW-3 (slope/fill Fully Soften) (2)

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	1.02 ft	176.68 ft
Point 2	1.94 ft	176.68 ft
Point 3	5.28 ft	169.2 ft
Point 4	0.49 ft	169.2 ft
Point 5	0.49 ft	170.08 ft
Point 6	0.92 ft	170.71 ft
Point 7	0.93541 ft	171.63 ft
Point 8	-60 ft	171.47 ft
Point 9	119.99 ft	163.47 ft
Point 10	119.96 ft	216.07 ft
Point 11	83.02123 ft	216.02 ft
Point 12	2.81 ft	176.28 ft

Point 13	119.99 ft	171.84 ft
Point 14	119.99 ft	158.95 ft
Point 15	-60 ft	158.9 ft
Point 16	119.99 ft	121.03 ft
Point 17	-60 ft	120.98 ft
Point 18	20.03 ft	184.89503 ft
Point 19	119.99 ft	169.28 ft
Point 20	119.99 ft	170 ft
Point 21	-60 ft	170 ft
Point 22	4.92278 ft	170 ft
Point 23	0.49 ft	170 ft
Point 24	-60 ft	157 ft
Point 25	119.99 ft	157 ft
Point 26	119.99 ft	155 ft
Point 27	-60 ft	155 ft
Point 28	-60 ft	169 ft
Point 29	119.99 ft	169 ft
Point 30	0.49 ft	169 ft
Point 31	8.282 ft	169 ft
Point 32	119.99 ft	166.42805 ft
Point 33	-2.55272 ft	169 ft
Point 34	-2.55272 ft	167.5 ft
Point 35	5.28 ft	169 ft
Point 36	5.27223 ft	167.5 ft

Regions

	Material	Points	Area
Region 1	Concrete	2,1,7,6,5,23,4,3,22	20.337 ft²
Region 2	Potomac Group - Coarse	34,33,28,15,24,25,14,9,32,29,31,35,36	

			2,148.1 ft^2
Region 3	Concrete	4,30,35,3	0.958 ft^2
Region 4	Embankment Backfill - Fine (Backslope)	13,10,11,18,12,2,22,20	3,798.1 ft^2
Region 5	Existing Fill -Coarse	5,6,7,8,21,23	94.262 ft^2
Region 6	Potomac Group - Coarse	16,17,27,26	6,118.8 ft^2
Region 7	Potomac Group - Residual Shear Strength - Fine (CH)	24,25,26,27	359.98 ft^2
Region 8	Potomac Group - Residual Shear Strength - Fine (CH)	4,23,21,28,33,30	60.49 ft^2
Region 9	Potomac Group - Residual Shear Strength - Fine (CH)	29,19,20,22,3,35,31	114.85 ft^2
Region 10	Concrete	30,33,34,36,35	11.743 ft^2

Slip Results

Slip Surfaces Analysed: 2193 of 5625 converged

Current Slip Surface

Slip Surface: 4,408
Factor of Safety: 1.7
Volume: 1,433.2348 ft^3
Weight: 160,182.02 lbf
Resisting Moment: 5,318,956.5 lbf·ft
Activating Moment: 3,212,910.8 lbf·ft
Resisting Force: 80,536.172 lbf
Activating Force: 48,634.739 lbf
Slip Rank: 1 of 5,625 slip surfaces
Exit: (-18.674818, 171.57851) ft
Entry: (88.528214, 216.02745) ft
Radius: 65.033133 ft
Center: (21.1045, 227.13969) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-16.76939 ft	170.78925 ft	-741.8883 psf	225.12376 psf	129.97526 psf	50 psf	0 psf	Existing Fill -Coarse
Slice 2	-13.656854 ft	169.5 ft	-661.33701 psf	340.03167 psf	59.956758 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 3	-10.337311 ft	168.125 ft	-575.42843 psf	795.3551 psf	496.99303 psf	0 psf	0 psf	Potomac Group - Coarse
		166.375 ft				0 psf	0 psf	

Slice 4	-6.1124369 ft		-466.09023 psf	1,212.7999 psf	757.84148 psf			Potomac Group - Coarse
Slice 5	-3.27636 ft	165.59044 ft	-417.05291 psf	780.82335 psf	487.91258 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 6	-1.03136 ft	165.87103 ft	-434.5248 psf	784.16752 psf	490.00225 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 7	0.712705 ft	166.08901 ft	-448.09812 psf	808.6949 psf	505.32866 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 8	0.977705 ft	166.12213 ft	-450.16051 psf	1,237.4593 psf	773.25038 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 9	1.48 ft	166.18491 ft	-454.06966 psf	1,629.5853 psf	1,018.2779 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 10	2.375 ft	166.29677 ft	-461.03506 psf	1,550.3463 psf	968.76388 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 11	3.86639 ft	166.48317 ft	-472.64192 psf	1,422.6714 psf	888.98376 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 12	5.10139 ft	166.63753 ft	-482.25341 psf	1,357.5317 psf	848.27998 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 13	6.781 ft	166.84745 ft	-495.32511 psf	1,362.1242 psf	851.14968 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 14	10.24 ft	167.27977 ft	-522.24504 psf	1,506.2405 psf	941.2035 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 15	14.156 ft	167.76921 ft	-552.72162 psf	1,669.3972 psf	1,043.1551 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 16	18.072 ft	168.25865 ft	-583.1982 psf	1,832.554 psf	1,145.1068 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 17	22.016774 ft	168.75168 ft	-613.89871 psf	1,995.4825 psf	1,246.9159 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 18	26.0038 ft	169.25 ft	-644.92806 psf	2,004.0291 psf	353.36439 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 19	30.004307 ft	169.75 ft	-676.06232 psf	2,163.1629 psf	381.42399 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
	34.0038 ft					50 psf	0 psf	

Slice 20		170.24987 ft	-707.18869 psf	2,494.0162 psf	1,439.9209 psf			Embankment Backfill - Fine (Backslope)
Slice 21	38.00228 ft	170.74962 ft	-738.30717 psf	2,664.2341 psf	1,538.1963 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 22	42.00076 ft	171.24937 ft	-769.42565 psf	2,834.452 psf	1,636.4716 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 23	45.773692 ft	173.27293 ft	-895.681 psf	1,652.0129 psf	953.79009 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 24	49.321077 ft	176.82032 ft	-1,117.0732 psf	1,529.3969 psf	882.99771 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 25	52.868461 ft	180.3677 ft	-1,338.4654 psf	1,406.7809 psf	812.20533 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 26	56.415846 ft	183.91509 ft	-1,559.8576 psf	1,284.1649 psf	741.41295 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 27	59.96323 ft	187.46247 ft	-1,781.2498 psf	1,161.5489 psf	670.62057 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 28	63.510615 ft	191.00985 ft	-2,002.642 psf	1,038.9329 psf	599.82819 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 29	67.058 ft	194.55724 ft	-2,224.0342 psf	916.3169 psf	529.03581 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 30	70.605384 ft	198.10462 ft	-2,445.4264 psf	793.7009 psf	458.24343 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 31	74.152769 ft	201.65201 ft	-2,666.8186 psf	671.0849 psf	387.45105 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 32	77.700153 ft	205.19939 ft	-2,888.2108 psf	548.4689 psf	316.65867 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 33	81.247538 ft	208.74678 ft	-3,109.6031 psf	425.8529 psf	245.86629 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 34	84.397976 ft	211.89722 ft	-3,306.2219 psf	270.60428 psf	156.23345 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 35	87.151468 ft	214.65071 ft	-3,478.0672 psf	82.723028 psf	47.760162 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)

Circular, Drained (Long-Term) (1)

File Information

File Version: 11.01
Title: Columbia Pike Slope Station 1+75
Created By: Mathson, Braque D
Last Edited By: Mathson, Braque D
Revision Number: 833
Date: 04/08/2021
Time: 08:47:54 AM
Tool Version: 11.1.2.22321
File Name: Columbia Pike RW-3_3 Rev1.gsz
Directory: C:\Users\bdmathson\OneDrive - Terracon Consultants Inc\Desktop\66\JD205193\Working Files\Calculations-Analyses\
Last Solved Date: 04/08/2021
Last Solved Time: 08:48:20 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Circular, Drained (Long-Term) (1)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3

  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Existing Fill -Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Concrete

Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Embankment Backfill - Fine (Backslope)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Residual Shear Strength - Fine (CH)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-52, 171.49101) ft
Left-Zone Right Coordinate: (-4, 171.61704) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (6, 177.87593) ft

Right-Zone Right Coordinate: (109.5, 216.05545) ft
Right-Zone Increment: 50
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-60, 171.47) ft
Right Coordinate: (119.99, 171.84) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-57.94 ft	158.9 ft
Coordinate 2	-34.59 ft	158.9 ft
Coordinate 3	119.89 ft	158.95 ft

Geometry

Name: RW-3 (slope/fill Fully Soften) (4)

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	1.02 ft	176.68 ft
Point 2	1.94 ft	176.68 ft
Point 3	5.28 ft	169.2 ft
Point 4	0.49 ft	169.2 ft
Point 5	0.49 ft	170.08 ft
Point 6	0.92 ft	170.71 ft
Point 7	0.93541 ft	171.63 ft
Point 8	-60 ft	171.47 ft
Point 9	119.99 ft	163.47 ft
Point 10	119.96 ft	216.07 ft
Point 11	84.01974 ft	216.02 ft
Point 12	2.81 ft	176.28 ft
Point 13	119.99 ft	171.84 ft
Point 14	119.99 ft	158.95 ft
Point 15	-60 ft	158.9 ft
Point 16	119.99 ft	121.03 ft
Point 17	-60 ft	120.98 ft
Point 18	20.03 ft	184.89503 ft
Point 19	119.99 ft	169.28 ft
Point 20	119.99 ft	170 ft
Point 21	-60 ft	170 ft
Point 22	4.92278 ft	170 ft
Point 23	0.49 ft	170 ft
Point 24	-60 ft	157 ft
Point 25	119.99 ft	157 ft
Point 26	119.99 ft	155 ft
Point 27	-60 ft	155 ft
Point 28	-60 ft	169 ft
Point 29	119.99 ft	169 ft
Point 30	0.49 ft	169 ft
Point 31	8.282 ft	169 ft
Point 32	119.99 ft	166.42805 ft
Point 33	-2.55272 ft	169 ft
Point 34	5.28 ft	169 ft
Point 35	5 ft	169 ft

Regions

	Material	Points	Area
Region 1	Concrete	2,1,7,6,5,23,4,3,22	20.337 ft²
Region 2	Concrete	4,30,35,34,3	0.958 ft²
Region 3	Embankment Backfill - Fine (Backslope)	13,10,11,18,12,2,22,20	3,782.5 ft²
Region 4	Existing Fill -Coarse	5,6,7,8,21,23	94.262 ft²
Region 5	Potomac Group - Coarse	16,17,27,26	6,118.8 ft²
Region 6	Potomac Group - Residual Shear Strength - Fine (CH)	24,25,26,27	359.98 ft²
Region 7	Potomac Group - Residual Shear Strength - Fine (CH)	4,23,21,28,33,30	60.49 ft²
Region 8	Potomac Group - Residual Shear Strength - Fine (CH)	29,19,20,22,3,34,31	114.85 ft²
Region 9	Potomac Group - Coarse	30,33,28,15,24,25,14,9,32,29,31,34,35	2,159.9 ft²

Slip Results

Slip Surfaces Analysed: 3484 of 7905 converged

Current Slip Surface

Slip Surface: 5,298
Factor of Safety: 1.4
Volume: 1,177.2058 ft³
Weight: 130,774.26 lbf
Resisting Moment: 6,708,237.3 lbf·ft
Activating Moment: 4,852,930.7 lbf·ft
Resisting Force: 62,005.656 lbf
Activating Force: 44,861.963 lbf
Slip Rank: 1 of 7,905 slip surfaces
Exit: (-20, 171.57503) ft
Entry: (84.78829, 216.02107) ft
Radius: 95.379619 ft
Center: (2.5072077, 264.26104) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-18.014346 ft	171.13745 ft	-763.65154 psf	123.93982 psf	71.556688 psf	50 psf	0 psf	Existing Fill -Coarse
Slice 2	-14.043038 ft	170.34994 ft	-714.4066 psf	263.05334 psf	151.87392 psf	50 psf	0 psf	Existing Fill -Coarse
Slice 3	-10.422367 ft	169.77626 ft	-678.51859 psf	258.37783 psf	45.558982 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 4	-7.1523356 ft	169.38605 ft	-654.09183 psf	302.21886 psf	53.28934 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 5	-3.8823037 ft	169.10979 ft	-636.77881 psf	330.45614 psf	58.268333 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 6	-0.87864385 ft	168.95138 ft	-626.82831 psf	411.72686 psf	257.2755 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 7	0.712705 ft	168.89857 ft	-623.49912 psf	476.22047 psf	297.57558 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 8	0.977705 ft	168.8937 ft	-623.18979 psf	992.5029 psf	620.18464 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 9	1.48 ft	168.88807 ft	-622.82799 psf	1,462.7736 psf	914.04237 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 10	2.375 ft	168.88251 ft	-622.46296 psf	1,372.9468 psf	857.91239 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 11	3.905 ft	168.89796 ft	-623.3964 psf	1,230.609 psf	768.96986 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 12	5.14 ft	168.91787 ft	-624.61481 psf	1,155.2187 psf	721.86076 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 13	6.2708515 ft	168.96087 ft	-627.27628 psf	1,184.0386 psf	739.86944 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 14	8.896719 ft	169.10979 ft	-636.52059 psf	1,143.448 psf	201.62073 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 15	12.166751 ft	169.38605 ft	-653.70146 psf	1,270.748 psf	224.06716 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 16	15.436783 ft	169.77626 ft	-677.99607 psf	1,380.6984 psf	243.45438 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 17	18.550899 ft	170.25243 ft	-707.66031 psf	1,593.4521 psf	919.98003 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 18	21.807493 ft	170.8722 ft	-746.28707 psf	1,652.1984 psf	953.8972 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 19	25.362478 ft	171.67834 ft	-796.543 psf	1,694.838 psf	978.51517 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 20	28.917464 ft	172.62945 ft	-855.84918 psf	1,718.1418 psf	991.96963 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 21	32.472449 ft	173.73011 ft	-924.49133 psf	1,723.0913 psf	994.82721 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 22	36.027435 ft	174.98584 ft	-1,002.8154 psf	1,710.5065 psf	987.56141 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 23	39.582421 ft	176.40333 ft	-1,091.2373 psf	1,681.0698 psf	970.56608 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 24	43.137406 ft	177.99055 ft	-1,190.2559 psf	1,635.344 psf	944.16632 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 25	46.692392 ft	179.75709 ft	-1,300.4697 psf	1,573.7889 psf	908.62742 psf	50 psf	0 psf	

								Embankment Backfill - Fine (Backslope)
Slice 26	50.247377 ft	181.7145 ft	-1,422.5994 psf	1,496.7731 psf	864.16234 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 27	53.802363 ft	183.87676 ft	-1,557.5179 psf	1,404.5868 psf	810.93857 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 28	57.357348 ft	186.26097 ft	-1,706.2924 psf	1,297.4531 psf	749.08491 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 29	60.912334 ft	188.88826 ft	-1,870.243 psf	1,175.5416 psf	678.69925 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 30	64.467319 ft	191.7852 ft	-2,051.0278 psf	1,038.9862 psf	599.85894 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 31	68.022305 ft	194.98581 ft	-2,250.7703 psf	887.91267 psf	512.63662 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 32	71.577291 ft	198.53474 ft	-2,472.2592 psf	722.4849 psf	417.12685 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 33	75.132276 ft	202.49257 ft	-2,719.2755 psf	542.98794 psf	313.49423 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 34	78.687262 ft	206.94499 ft	-2,997.1688 psf	349.98927 psf	202.0664 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 35	82.242247 ft	212.02049 ft	-3,313.9615 psf	144.6728 psf	83.526878 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 36	84.404015 ft	215.37728 ft	-3,523.4827 psf	11.498556 psf	6.6386947 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)

Circular, Drained (Long-Term) (2)

File Information

File Version: 11.01
Title: Columbia Pike Slope Station 1+75
Created By: Mathson, Braque D
Last Edited By: Mathson, Braque D
Revision Number: 833
Date: 04/08/2021
Time: 08:47:54 AM
Tool Version: 11.1.2.22321
File Name: Columbia Pike RW-3_3 Rev1.gsz
Directory: C:\Users\bdmathson\OneDrive - Terracon Consultants Inc\Desktop\66\JD205193\Working Files\Calculations-Analyses\
Last Solved Date: 04/08/2021
Last Solved Time: 08:48:16 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Circular, Drained (Long-Term) (2)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder

  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Existing Fill -Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Concrete

Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Coarse

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Embankment Backfill - Fine (Backslope)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Potomac Group - Residual Shear Strength - Fine (CH)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-53.71001, 171.48652) ft
Left-Zone Right Coordinate: (-2.8, 171.62019) ft
Left-Zone Increment: 30

Right Type: Range
Right-Zone Left Coordinate: (9.52608, 179.64) ft
Right-Zone Right Coordinate: (109.5, 216.05584) ft
Right-Zone Increment: 50
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-60, 171.47) ft
Right Coordinate: (119.99, 171.84) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-57.94 ft	158.9 ft
Coordinate 2	-34.59 ft	158.9 ft
Coordinate 3	119.89 ft	158.95 ft

Geometry

Name: RW-3 (slope/fill Fully Soften) (5)

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	1.02 ft	176.68 ft
Point 2	1.94 ft	176.68 ft
Point 3	5.28 ft	169.2 ft
Point 4	0.49 ft	169.2 ft
Point 5	0.49 ft	170.08 ft
Point 6	0.92 ft	170.71 ft
Point 7	0.93541 ft	171.63 ft
Point 8	-60 ft	171.47 ft
Point 9	119.99 ft	163.47 ft
Point 10	119.96 ft	216.07 ft
Point 11	83.02123 ft	216.02 ft
Point 12	2.81 ft	176.28 ft
Point 13	119.99 ft	171.84 ft
Point 14	119.99 ft	158.95 ft
Point 15	-60 ft	158.9 ft
Point 16	119.99 ft	121.03 ft
Point 17	-60 ft	120.98 ft
Point 18	20.03 ft	184.89503 ft

Point 19	119.99 ft	169.28 ft
Point 20	119.99 ft	170 ft
Point 21	-60 ft	170 ft
Point 22	4.92278 ft	170 ft
Point 23	0.49 ft	170 ft
Point 24	-60 ft	157 ft
Point 25	119.99 ft	157 ft
Point 26	119.99 ft	155 ft
Point 27	-60 ft	155 ft
Point 28	-60 ft	169 ft
Point 29	119.99 ft	169 ft
Point 30	0.49 ft	169 ft
Point 31	8.282 ft	169 ft
Point 32	119.99 ft	166.42805 ft
Point 33	-2.55272 ft	169 ft
Point 34	-2.55272 ft	167.5 ft
Point 35	5.28 ft	169 ft
Point 36	5.27223 ft	167.5 ft

Regions

	Material	Points	Area
Region 1	Concrete	2,1,7,6,5,23,4,3,22	20.337 ft²
Region 2	Potomac Group - Coarse	34,33,28,15,24,25,14,9,32,29,31,35,36	2,148.1 ft²
Region 3	Concrete	4,30,35,3	0.958 ft²
Region 4	Embankment Backfill - Fine (Backslope)	13,10,11,18,12,2,22,20	3,798.1 ft²
Region 5	Existing Fill -Coarse	5,6,7,8,21,23	94.262 ft²
Region 6	Potomac Group - Coarse	16,17,27,26	6,118.8 ft²
Region 7	Potomac Group - Residual Shear Strength - Fine (CH)	24,25,26,27	359.98 ft²
Region 8	Potomac Group - Residual Shear Strength - Fine (CH)	4,23,21,28,33,30	60.49 ft²
Region 9		29,19,20,22,3,35,31	114.85 ft²

	Potomac Group - Residual Shear Strength - Fine (CH)		
Region 10	Concrete	30,33,34,36,35	11.743 ft²

Slip Results

Slip Surfaces Analysed: 2871 of 7905 converged

Current Slip Surface

Slip Surface: 3,768
Factor of Safety: 1.5
Volume: 1,326.8441 ft³
Weight: 148,432.54 lbf
Resisting Moment: 8,587,524 lbf·ft
Activating Moment: 5,633,118.2 lbf·ft
Resisting Force: 75,812.046 lbf
Activating Force: 49,744.366 lbf
Slip Rank: 1 of 7,905 slip surfaces
Exit: (-29.952005, 171.5489) ft
Entry: (85.633263, 216.02354) ft
Radius: 100.80634 ft
Center: (-0.72491392, 268.02529) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-27.096006 ft	170.77445 ft	-741.17266 psf	182.63356 psf	105.44354 psf	50 psf	0 psf	Existing Fill -Coarse
Slice 2	-21.915236 ft	169.5 ft	-661.50389 psf	295.59089 psf	52.120649 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 3	-17.460747 ft	168.64136 ft	-607.8091 psf	494.94076 psf	309.27331 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 4	-13.201311 ft	168.01704 ft	-568.74626 psf	578.57356 psf	361.53288 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 5	-8.9418745 ft	167.57713 ft	-541.19668 psf	625.74839 psf	391.01099 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 6	-4.6824382 ft	167.31922 ft	-525.00921 psf	641.32918 psf	400.74695 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 7	-1.03136 ft	167.2309 ft	-519.42169 psf	678.61442 psf	424.04535 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 8	0.712705 ft	167.22945 ft	-519.29598 psf	726.94002 psf	454.24254 psf	0 psf	0 psf	

								Potomac Group - Coarse
Slice 9	0.977705 ft	167.23334 ft	-519.53353 psf	1,201.997 psf	751.09106 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 10	1.48 ft	167.24412 ft	-520.19628 psf	1,634.2625 psf	1,021.2005 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 11	2.375 ft	167.26757 ft	-521.64201 psf	1,547.5727 psf	967.03076 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 12	3.86639 ft	167.32912 ft	-525.45445 psf	1,407.653 psf	879.59924 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 13	5.10139 ft	167.38763 ft	-529.08211 psf	1,336.5966 psf	835.19824 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 14	6.781 ft	167.51005 ft	-536.69129 psf	1,333.9429 psf	833.54003 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 15	9.9251063 ft	167.79673 ft	-554.52515 psf	1,445.913 psf	903.50674 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 16	13.211319 ft	168.20071 ft	-579.67939 psf	1,542.6073 psf	963.92802 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 17	16.497531 ft	168.71505 ft	-611.72321 psf	1,619.4594 psf	1,011.9506 psf	0 psf	0 psf	Potomac Group - Coarse
Slice 18	19.085319 ft	169.18935 ft	-641.28132 psf	1,587.8991 psf	279.98946 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 19	21.41009 ft	169.68935 ft	-672.44944 psf	1,637.2285 psf	288.68756 psf	0 psf	0 psf	Potomac Group - Residual Shear Strength - Fine (CH)
Slice 20	24.6724 ft	170.49011 ft	-722.3755 psf	1,746.6972 psf	1,008.4561 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 21	28.43684 ft	171.54916 ft	-788.41619 psf	1,775.5883 psf	1,025.1364 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 22	32.201281 ft	172.76871 ft	-864.47633 psf	1,785.1675 psf	1,030.667 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 23	35.965722 ft	174.15501 ft	-950.94717 psf	1,776.0921 psf	1,025.4272 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
						50 psf	0 psf	

Slice 24	39.730162 ft	175.71559 ft	-1,048.2987 psf	1,748.8945 psf	1,009.7247 psf			Embankment Backfill - Fine (Backslope)
Slice 25	43.494603 ft	177.45949 ft	-1,157.0947 psf	1,703.9964 psf	983.80276 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 26	47.259044 ft	179.39755 ft	-1,278.0122 psf	1,641.7189 psf	947.84686 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 27	51.023484 ft	181.54287 ft	-1,411.8686 psf	1,562.2924 psf	901.98993 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 28	54.787925 ft	183.91134 ft	-1,559.6569 psf	1,465.8642 psf	846.31709 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 29	58.552366 ft	186.5225 ft	-1,722.5959 psf	1,352.5075 psf	780.87058 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 30	62.316806 ft	189.40062 ft	-1,902.2015 psf	1,222.2319 psf	705.65592 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 31	66.081247 ft	192.57641 ft	-2,100.3903 psf	1,074.9992 psf	620.6511 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 32	69.845688 ft	196.08952 ft	-2,319.6385 psf	910.7511 psf	525.82239 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 33	73.610128 ft	199.9926 ft	-2,563.2327 psf	729.45925 psf	421.1535 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 34	77.374569 ft	204.35808 ft	-2,835.6938 psf	531.22528 psf	306.70306 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 35	81.13901 ft	209.29038 ft	-3,143.5422 psf	316.48816 psf	182.72452 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)
Slice 36	84.327246 ft	213.96866 ft	-3,435.5441 psf	91.273503 psf	52.696781 psf	50 psf	0 psf	Embankment Backfill - Fine (Backslope)

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)			
		Clean Gravels (Less than 5% fines)	
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size		GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		Gravels with fines (More than 12% fines)	
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
		Clean Sands (Less than 5% fines)	
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size		SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with fines (More than 12% fines)	
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)			
SILTS AND CLAYS Liquid limit less than 50%		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

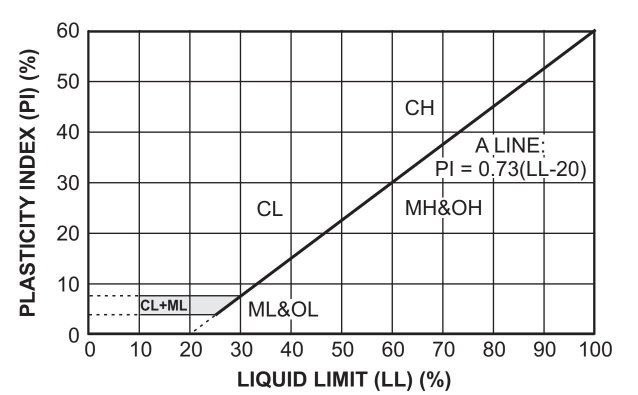
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent .... GW, GP, SW, SP
More than 12 percent .... GM, GC, SM, SC
5 to 12 percent .... Borderline cases requiring dual symbols

PLASTICITY CHART



MATERIAL AND SAMPLE SYMBOLS LIST

MATERIAL AND SAMPLE SYMBOLS LIST

Pavement/Soils	Sedimentary Rocks	Igneous Rocks	Metamorphic Rocks	Sampling
TOPS-TOPSOIL; SC/CH; CH/CL; CH/MH; CH/SC	BLD-Boulder Bed	CHT Charnocktite	MSLS Metasiltstone	
CL/ML; CL/SC; CL/CH; GP/GW; CRA Crushed Aggregate	DLS Dolostone		MSST Metasandstone	
GW/GP; ML/MH; GC/SC; OH/OL; GP/SP	LST-DLS-Interbedded Limestone/Dolostone		QZT - Quartzite	
OL/OH; PT Peat; OH Organic; SC/CL; OL Organic			SPS Soapstone	
SC/GC; SC-SM; SP/SW; SM/GM; SM/MH			MBST Metabasalt	
SM/ML; SM/SC; SP/GP; SW/SP			MBL Marble	