Geotechnical Engineering Report

Fort Greble Recreation Center
Martin Luther King Jr. Avenue, SW
Washington, DC

“Delivering right solutions through quality services and engineering excellence”

Prepared for

HRGM Corporation
April 19, 2013
(Revised April 30, 2013)

DMY

April 19, 2013
(Revised April 30, 2013)

Ms. Anita Butani
HRGM Corporation
2021 Shannon Place SE
Washington, DC 20020

Reference: Geotechnical Engineering Report
Fort Greble Recreation Center
Martin Luther King Jr. Avenue SW
Washington, DC
DMY Project No. 1371.01

Dear Ms. Butani:

DMY Engineering Consultants, LLC (DMY) is pleased to submit this report of our geotechnical exploration and infiltration testing for the above-referenced project. This report presents a review of the information provided to us, a discussion of the site and subsurface conditions encountered, and our geotechnical recommendations.

We appreciate the opportunity to be of service to you on this project and would be happy to discuss our findings with you. We look forward to serving as your geotechnical engineer on the remainder of this project and on future projects.

Respectfully,

DMY ENGINEERING CONSULTANTS, LLC

Peng "Paul" Zhang, PE
Principal Engineer

Weiyi "Wayne" Ma, PE
Principal Engineer

TABLE OF CONTENTS

1.0 PROJECT OVERVIEW

The project site has a physical address of Martin Luther King (MLK) Jr. Avenue SW, Washington, DC and is located at west of MLK Jr. Avenue SW and about 500 feet south of Chesapeake Street SW. The site is currently occupied by Ft. Greble Recreation Center. A Site Location Map showing the approximate location of the project is included in Appendix A.

It is our understanding that the proposed development will consist of potential stormwater management (SWM) facilities, retaining walls, a greenroof pavilion, a concrete pad, and a paved parking area.

The purpose of this study was to obtain the subsurface soil and groundwater as well as the in-situ soil infiltration data for the proposed construction. Our scope of services included the following:

- Reviewing the project information provided to us.
- Advancing hand auger borings at five locations to evaluate the subsurface soil and groundwater conditions for the proposed construction.
- Advancing hand auger borings at three locations and conducting field infiltration tests in the cased boreholes to support SWM facilities design.
- Performing laboratory tests on select soil samples.
- Evaluating field and laboratory data.
- Performing engineering calculations and analyses and preparing this geotechnical engineering report.

The description of the proposed project given above is based on the information provided to us by you and information gathered during our site reconnaissance. If any of the assumptions or project information is incorrect, DMY should be informed so that we may revise our geotechnical recommendations, if necessary.

2.0 FIELD EXPLORATION AND LABORATORY TESTING

2.1. FIELD EXPLORATION

The field exploration consisted of drilling a total of eight hand auger borings to explore the subsurface soil and groundwater conditions. Five of the borings were drilled in the areas of the proposed concrete pad, retaining walls, pavilion and paved parking. These borings were designated as B-1 through B-5 and were advanced to 5 to 10 feet below existing ground levels. The rest of borings were drilled at the potential SWM facility locations. These borings were designated as I-1 through I-3 and were advanced to 8 to 10 feet below existing ground levels. All borings were drilled using hand augers and Dynamic Cone Penetrometer (DCP) tests were conducted in the hand auger boreholes to check for soil strength. The exploration procedures of the soil borings are included in Appendix B.

Additionally, solid PVC pipes were installed in the boreholes drilled at Borings I-1 through I-3 for field infiltration testing. The infiltration test holes were presoaked for 24 hours prior to the infiltration tests. Following the presoak, each infiltration test was performed over a four-hour test period in accordance with the procedures specified in the DDOE Stormwater Handbook. The results of the infiltration tests are included in Appendix B.

The infiltration test boring locations were selected by the Project Civil Engineer (AMT) and the structural boring locations were selected by DMY based on a site plan prepared by Land Design. All test locations were located in the field by DMY personnel based on visual reference to existing site features. The approximate locations of the borings and the field infiltration tests are shown on the Boring/Infiltration Location Plan included in Appendix A.

2.2. LABORATORY TESTING

Following field operations, representative soil samples were selected and tested in our laboratory to verify field classifications and to determine pertinent engineering properties. The laboratory testing program included the following:

- USCS Visual Classification (ASTM D 2488) 29 Tests
- Sieve Analysis (ASTM D422) 3 Test
- Atterberg Limits of Soils (ASTM D4318) 3 Test
- Moisture Content (ASTM D2216) 3Test

The laboratory testing procedures and results are presented in Appendix C of this report.

3.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

3.1. SITE GEOLOGY

The project site is located within the Coastal Plain Physiographic Province of Washington, DC. The near surface soils in the Washington, D.C. area typically consist of man-placed fill soils or natural soils that have been disturbed by previous construction. In this particular vicinity, the natural Coastal Plain soils consist of the Upland Deposits of gravel, sand, silt, and clay.

3.2. SUBSURFACE CONDITIONS

The subsurface conditions encountered at the locations explored are shown in the boring logs in Appendix B. The records represent our interpretation of the subsurface conditions based on visual observations of the soil samples collected. The lines designating the interfaces between various strata on the boring logs are approximate, as the actual transitions between soil strata are often gradual.

Topsoil was encountered at all boring locations with thickness varying from 4 to 7 inches.

Beneath the surficial topsoil, existing fill was encountered in Borings B-1, B-3 and I-1. The fill extended from 2 to 5 feet below the existing grade and consisted mostly of silty SAND, clayey SAND, poorly-graded SAND, sandy SILT, and sandy LEAN CLAY with varying amounts of gravel. Some fill soil samples contained small amounts of debris and roots. Dynamic Cone Penetrometer (DCP) test results ranged from 6 to 25+ blows per 1.75 inches of penetration. Based on ASTM Special Technical Publication #399, the DCP results roughly correspond to soft to firm in terms of consistency for cohesive soils and loose to medium dense in terms of relative density for cohesionless soils. The presence of gravel and debris in some samples may have amplified the DCP blow counts.

Natural Coastal Plain soils were encountered beneath the fill materials or topsoil in each boring extending to boring termination depths. The natural soils consisted of silty SAND (SM), clayey SAND (SC), poorly-graded SAND with silt (SP-SM), and sandy LEAN CLAY (CL). Varying amounts of gravel were present in some samples. The DCP results ranged from 3 to 25+ blows per 1.75 inches of penetration. The test results indicated very loose to medium dense in terms of relative density for cohesionless soils and firm to stiff in terms of consistency for cohesive soils. The presence of gravel in some samples may have amplified the DCP blow counts.

Groundwater was not encountered in any of the borings at the time of drilling or 24 hours after drilling completion. It should be noted that fluctuation of the long-term groundwater table may occur depending on variations in evaporation, precipitation, surface runoff, and other factors not immediately apparent at the time of our exploration.

4.0 GEOTECHNICAL RECOMMENDATIONS

4.1. FOUNDATION DESIGN

No specific structural loading information was available at the time of this report. Based on the results of the subsurface exploration, the anticipated structural loading and our engineering analyses, we recommend that an allowable soil bearing pressure of 2,000 pounds per square foot (psf) be utilized to size the equipment and structure footings.

During construction, the bearing capacity at the final footing excavation should be documented in the field by an authorized representative of the Geotechnical Engineer of Record to confirm that the in situ bearing capacity at the bottom of each footing excavation is adequate for the design loads. The subsurface conditions in the borings suggest that a few feet of undercutting of unsuitable soils should be expected at foundation subgrade at some locations. The unsuitable soils are either too soft or contain excess deleterious materials. The foundation subgrade undercut should be backfilled with engineered fill placed in accordance with the recommendations contained within the Compacted Fills section of this report.

In order to prevent disproportionately small footing sizes, we recommend that continuous footings have a minimum width of 14 inches and that isolated footings have a minimum lateral dimension of 24 inches. The minimum dimensions recommended above help reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" action. Unless expansive soil conditions require a deeper embedment, all footings should be placed at a minimum depth of 30 inches below finished grade to provide adequate frost cover protection acceptable for this region.

Settlement of a structure is a function of the compressibility of the natural soils, the design bearing pressure, structural loads, and the footing embedment depths. For the anticipated loads and bearing conditions, total settlement of less than one inch and differential settlement of less than ½ inches over a 30-foot span are expected.

4.2. GRADE SLABS

The floor slab should be isolated from the footings so that differential settlement of the structure will not induce stress on the floor slab. In order to minimize the crack width of any shrinkage cracks that may develop near the surface of the slab, we recommend that mesh reinforcement be included in the design of the grade slabs. The mesh should be in the top half of the slab to be effective.

Grade slabs should have a minimum thickness of 4 inches. A minimum 4-inch thick washed gravel or crushed stone (DDOT No. 57 aggregate or equivalent) should be placed below the grade slabs to provide uniform bearing support, a vapor break, and drainage of any moisture accumulation. The drainage gravel beneath the grade slabs should be tied into the perimeter drainage lines. A minimum 6-mil thick impermeable plastic membrane should be installed over the gravel layer and serve as a vapor barrier to prevent transmission of moisture through the slab.

4.3. RETAINING WALLS

Retaining walls should be designed to withstand lateral earth pressures and surcharge loads. We recommend that the following parameters be used for retaining wall design:

• Friction Angle for Soil Backfill	28°
• Unit Weight of Soil Backfill	120 pcf
• Coefficient of Sliding Friction	0.35*
• Equivalent Active Fluid Pressure	45 pcf
• Equivalent Passive Fluid Pressure	330 pcf*
• Equivalent At-rest Fluid Pressure	60 pcf

* In the design calculations, the resisting forces computed using the above recommended passive earth pressure coefficient, equivalent passive fluid pressure, and coefficient of sliding friction should be reduced using a safety factor of 1.5.

The above recommended soil parameters assume that the wall backfill consist of properly compacted granular soils. The recommended equivalent fluid pressures assume that constantly functioning drainage systems are installed between the walls and the soil backfill to prevent any accidental buildup of hydrostatic pressures. The wall design should also account for any surcharge loads within a 45 degree slope from the base of the wall. We anticipate that the top of the retaining walls will be relatively constrained and active earth pressure conditions are not likely to develop in the soil backfill behind the walls. Therefore, we recommend that the at-rest pressures be used in the design. A Lateral Earth Pressure Diagram is included in Appendix A of this report, which corresponds to the suggested pressures above.

Unless the walls are designed to account for hydrostatic pressures, proper drainage measures should be provided to minimize any hydrostatic pressure build-up (from ground water and/or seeping rain water) behind the walls. Adequate drainage can be accomplished if a blanket of select granular backfill, such as DDOT No. 57 aggregate, is used behind the walls. To prevent migration of fines into the select granular backfill, a layer of filter fabric should be installed around the select granular backfill where it comes in contact with the general wall backfills. The filter fabric should have an apparent open size (AOS) of no greater than 0.21 mm (#70 sieve). Geocomposite drainage panel may be used in lieu of the select granular backfill adjacent to the walls. Examples of the geocomposite drainage materials include Enkadrain®, MiraDRAIN®, and Geotec drains. The select granular backfill or geocomposite drainage panel should be extended from the bottom to approximately two feet below the final grade behind the walls. The remaining 2 feet should consist of a clayey material to reduce the amount of surface water infiltration into the drainage system. The ground surface adjacent to the below grade walls should be kept properly graded to prevent ponding of water adjacent to the walls.

For retaining walls, we recommend that a perforated collector pipe be installed at the base of the walls to gravity drain any water from the drainage blanket behind the wall to daylight. The collector pipe should be surrounded by a minimum of 6 inches of drainage gravel wrapped in filter fabric. Alternatively, weep holes may be provided for the retaining walls every 8 feet with outlet at a height of 6 inches above the ground surface in front of the wall.

4.4. SLOPES

A slope stability analysis was performed and the results are attached. The slope stability analysis was performed using a two-dimensional computerized slope stability method based on a limit equilibrium analysis. The GSTABL7 computer program was utilized to perform these computations. The factor of safety against slope instability computed by the program is defined as the ratio of the sum of the moments (or forces) resisting failure divided by the sum of the moments (or forces) causing failure along a specified potential failure surface. Hence, a factor of safety greater than 1.0 indicates a marginally stable slope, while a factor of safety less than 1.0 indicates a potentially unstable or failed slope. During this analysis, numerous conditions and potential failure surfaces were analyzed; however, the computer outputs included in the attachment show only the most critical conditions.

A safety factor of 1.3 is considered to be the minimum adequate factor of safety for evaluation of slope stability, not considering seismic loading conditions. A maximum side slope of 2:1 (Horizontal to Vertical) was used in our analysis and the results showed that a minimum safety factor of 1.44 would be available. Therefore, it is our opinion that a 2:1 slope should be globally stable at the site. Please note that the slope stability analysis and our conclusion were based on the available subsurface information and the assumption that the berm will be constructed using engineered fills in accordance with the requirements outlined in the Compacted Fills section of this report.

It should be noted that a steeper slope will require more active maintenance of the slope surface to protect from erosion and damage, which may cause localized distresses on the slope surface. A proper slope maintenance program should be provided to ensure the long term functionality of the slope.

4.5. INFILTRATION TESTING

The field infiltration test results and soil classifications at the proposed infiltration facility locations are summarized in the following table.

Test Location	Boring Depth (ft)	Infiltration Test Depth (ft)	Field Infiltration Rate (in./hr.)	Soil Classification at Proposed Infiltration Stratum
I-1	10	8	1.172	Clayey SAND with gravel
I-2	8	6	0.078	Sandy LEAN CLAY
I-3	8	6	0.125	Sandy LEAN CLAY

Groundwater or bedrock was not encountered within 2 feet below the infiltration test depths. Based on these data, it is our opinion that the subsurface soil at the tested stratum is suitable for infiltration practice in the area of I-1. The soils are NOT suitable for infiltration practice in the areas of I-2 and I-3; the SWM facilities at these locations should be daylighted by gravity or tied into a nearby stormwater drain.

5.0 CONSTRUCTION RECOMMENDATIONS

5.1. SITE PREPARATION

Subgrade preparation operations should consist of removing any existing underground utilities and structures, old pavement elements, topsoil and vegetation, and any other soft or unsuitable material from the proposed construction areas. The resulting excavations should be brought back to proposed elevations using structural fill placed as detailed herein. Underground utilities and structures such as pipes and vaults should be removed entirely or abandoned by filling with grout to prevent future migration of soils. Disposal of demolition debris should be performed in accordance with local, state and federal regulations.

After stripping to the desired grade and clearing the site as noted above, we recommend that the exposed subgrade within 10 feet of the proposed structure and pavement should be carefully examined to identify any localized loose, wet, yielding or otherwise unsuitable conditions by an experienced Geotechnical Engineer or his authorized representative. Where feasible, unsuitable conditions should be further identified by proofrolling the exposed subgrade with an approved piece of equipment, such as a loaded dump truck having an axle weight of at least 10 tons. Any areas identified to be pumping or rutting encountered during the proofroll should be undercut and re-examined. The resulting excavations should be brought back to proposed elevations using engineered fill placed as detailed herein.

An authorized representative of the Geotechnical Engineer of Record should be present on-site working with the contractor to aid in determination of the required depth of undercut and to observe and evaluate the exposed subgrades. The preparation of subgrade for the proposed structures and pavements should be observed on a full-time basis. Soil bridging lifts should not be used to span over soft fill subgrade soils within the structure footprint. All soft areas shall be excavated and removed.

5.2. COMPACTED FILLS

Engineered fill should be used in all structural areas including wall backfill and utility backfill. All engineered fill should have a maximum particle size of 3 inches and contain minimal amount of organic matter or debris. The engineered fill should also have a Liquid Limit less than 40, a Plasticity Index less than 15, and a Standard Proctor (ASTM D 698) maximum dry density of at least 90 pounds per cubic foot (pcf). Based on the subsurface conditions observed in our exploration, the onsite natural soil and clean fill meeting the requirements herein can be re-used as engineered fill. Before field operations begin, a representative sample of each proposed engineered fill or wall backfill should be collected and tested to determine its Atterberg Limits, gradation, maximum dry density, optimum moisture content, and natural moisture content. The test results will be used to evaluate the suitability of each proposed engineered fill or wall backfill for quality control purposes during fill placement.

Engineered fill materials should be placed in lifts not exceeding 8 inches in loose thickness and moisture conditioned to within 2 percentage points of the optimum moisture content. The engineered fill should be compacted to a minimum of 95% of the maximum dry density obtained in accordance with ASTM Standard D 698, Standard Proctor Method. The top 1 foot of soil supporting pavements, sidewalks, or gutters should be compacted to a minimum of 100% of the maximum dry density in accordance with ASTM Standard D 698. Heavy earthwork equipment should maintain a minimum horizontal distance away from the walls of 1 foot per foot of vertical wall height. Lighter compaction equipment should be used close to the walls.

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

All fill operations should be observed on a full-time basis by an authorized representative of the Geotechnical Engineer of Record to determine that compaction requirements are being met. All fill should be periodically tested to confirm that compaction is being achieved. A sufficient number of tests shall be taken in each lift before the next lift is placed, on the order of at least three tests per lift. The elevation and location of the tests should be clearly identified and recorded at the time of fill placement.

5.3. FOUNDATION CONSTRUCTION

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

The Geotechnical Engineer of Record should document the type and competency of the soils exposed with those documented in the nearby hand auger probes. Any significant difference should be brought to the attention of the owner along with recommendations by the Geotechnical Engineer of Record.

5.4. CONSTRUCTION WATER CONTROL

It is not anticipated that the permanent groundwater table at the site will be encountered above the design subgrade levels. However, excavations performed at this site may encounter perched groundwater conditions or surface water flowing from the higher elevations of the site. We anticipate that some localized areas within the excavations may not be completely dry and may require the use of trenches and sump pits to facilitate the placement of foundations.

Although a totally dry subgrade should not be anticipated, the surface of the subgrade should be sufficiently dewatered to provide an adequate surface on which to construct the footings and pavement.

The surface of the site should be properly graded to keep drainage of the surface water away from the proposed construction areas. The actual extent of the dewatering system will need to be determined at the time the excavation is performed.

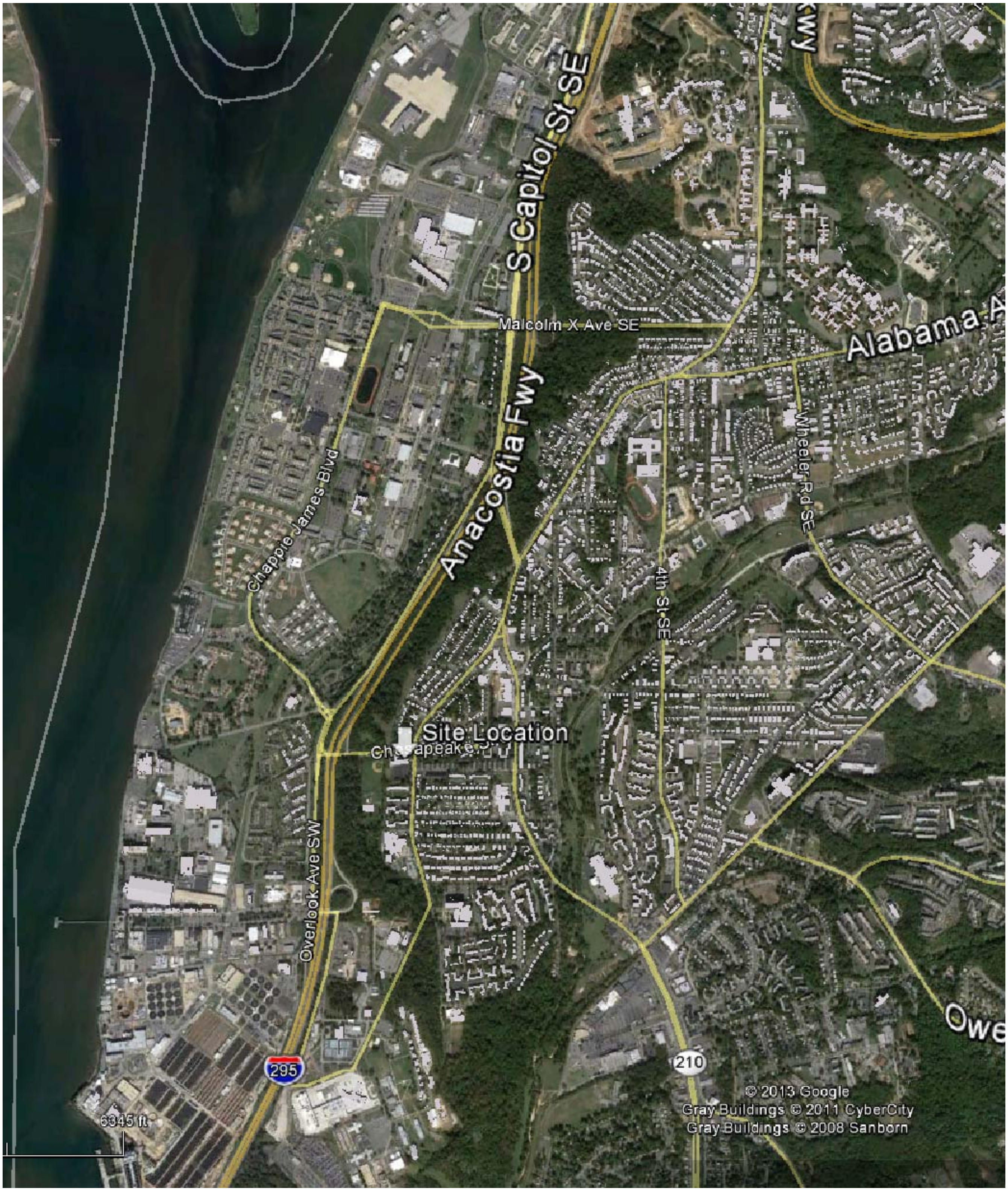
6.0 LIMITATIONS

The recommendations provided are based in part on project information provided to us and are only applied to the specific project and site discussed in this report. If the project information section in this report contains incorrect information or if additional information is available, DMY should be contacted to review our recommendations. We can then modify our recommendations for the proposed project.

Regardless of the thoroughness of a subsurface investigation, there is always a possibility that subsurface conditions may vary from those documented during a subsurface exploration at specific locations. In addition, the construction process itself may alter subsurface conditions. Therefore, experienced geotechnical personnel should be engaged to observe and document the construction procedures used and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team along with timely recommendations. We recommend that DMY be retained to provide this service based upon our familiarity with the project, the subsurface conditions, and the intent of the recommendations.

We have prepared this report for use by the design professionals for design purposes in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made as to the professional advice included in this report.

APPENDIX A – FIGURES



SITE LOCATION MAP

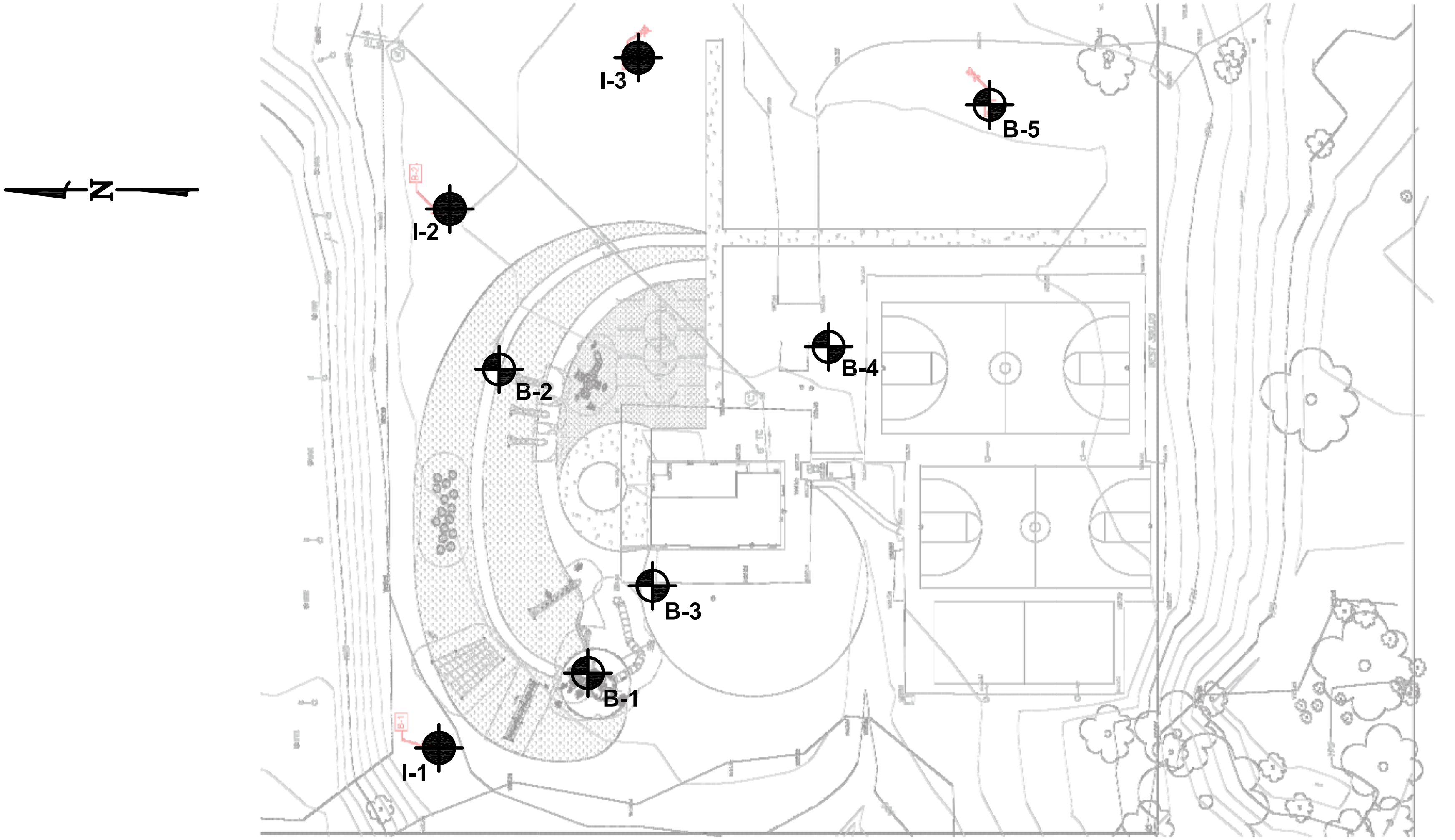
DMY

DMY ENGINEERING CONSULTANTS, LLC
45662 TERMINAL DRIVE, SUITE 110
DULLES, VIRGINIA 20166
PHONE: (703) 665-0586
FAX: (202) 688-1918

FT. GREBLE RECREATION CENTER
WASHINGTON D.C

DATE:	DRAFTED BY:	PROJECT NO.:
4/1/2013	SS	1371.01
SCALE: 1"=2000'	CHECKED BY: PZ	FIGURE NO.: 1

BASE DRAWING PROVIDED BY AMT, LLC

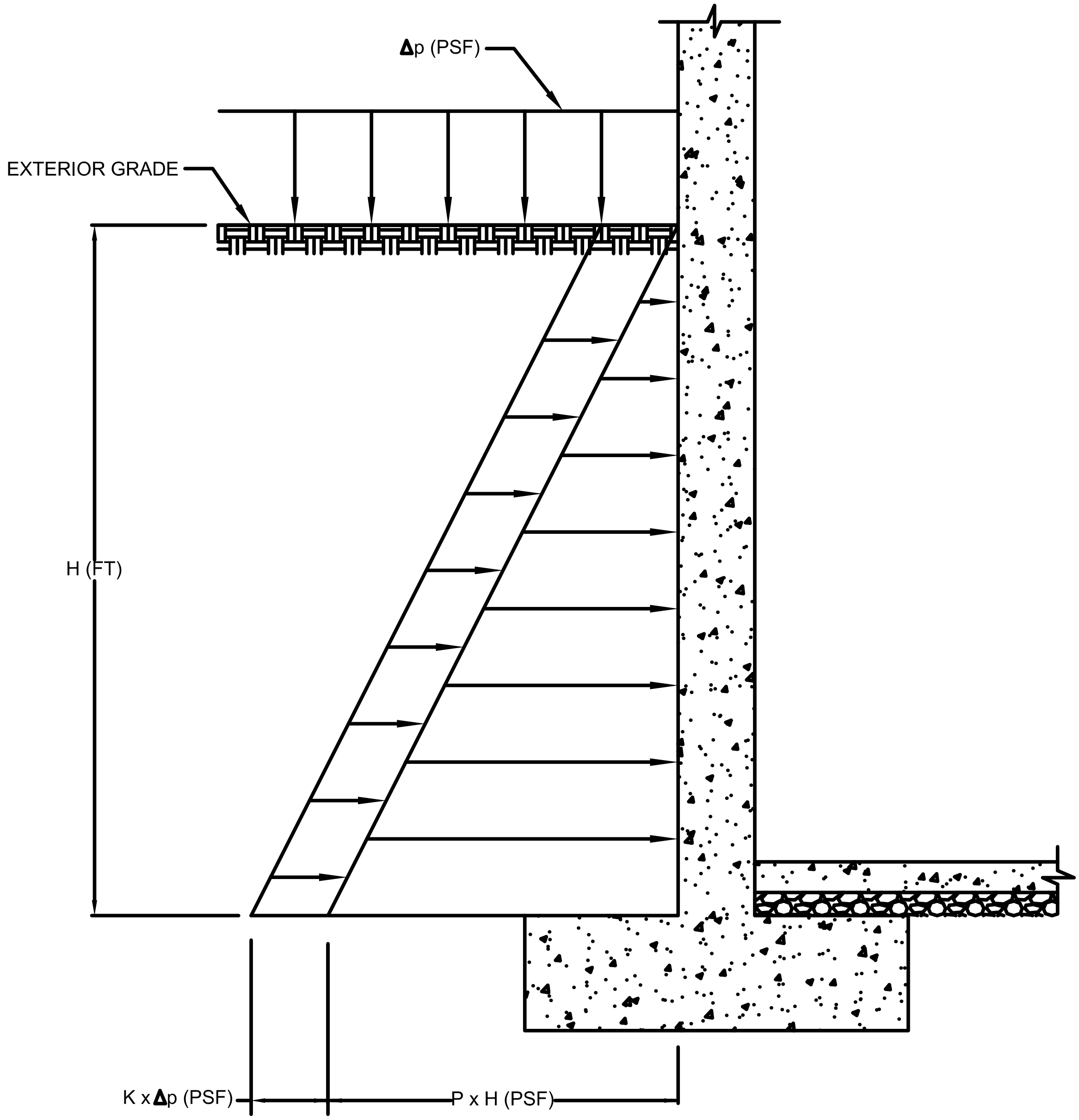


APPROXIMATE HAND AUGER LOCATION

APPROXIMATE INFILTRATION LOCATION

HAND AUGER/INFILTRATION LOCATION PLAN	DMY ENGINEERING CONSULTANTS, LLC 45662 TERMINAL DRIVE, SUITE 110 DULLES, VIRGINIA 20166 PHONE: (703) 665-0586 FAX: (202) 688-1918	FT. GREBLE RECREATION CENTER WASHINGTON D.C.	
		DATE: 04/01/2013	DRAFTED BY: SS
		SCALE: 1 "=60'	CHECKED BY: PZ

PROJECT NO.:	1371.01
FIGURE NO.:	2



LEGEND:

P	LATERAL EARTH PRESSURE, = 60 PCF
H	BACKFILL HEIGHT
Δp	APPLICABLE SURCHARGE
K	AT REST HORIZONTAL EARTH PRESSURE COEFFICIENT, =0.5

LATERAL EARTH PRESSURE DIAGRAM	DMY ENGINEERING CONSULTANTS, LLC 45662 TERMINAL DRIVE, SUITE 110 DULLES, VIRGINIA 20166 PHONE: (703) 665-0586 FAX: (202) 688-1918	FT. GREBLE RECREATION CENTER WASHINGTON D.C.	
		DATE: 4/2/2013	DRAFTED BY: SS
		SCALE: N.T.S.	CHECKED BY: PZ

PROJECT NO.: 1371.01

FIGURE NO.: 3

APPENDIX B – FIELD OPERATIONS

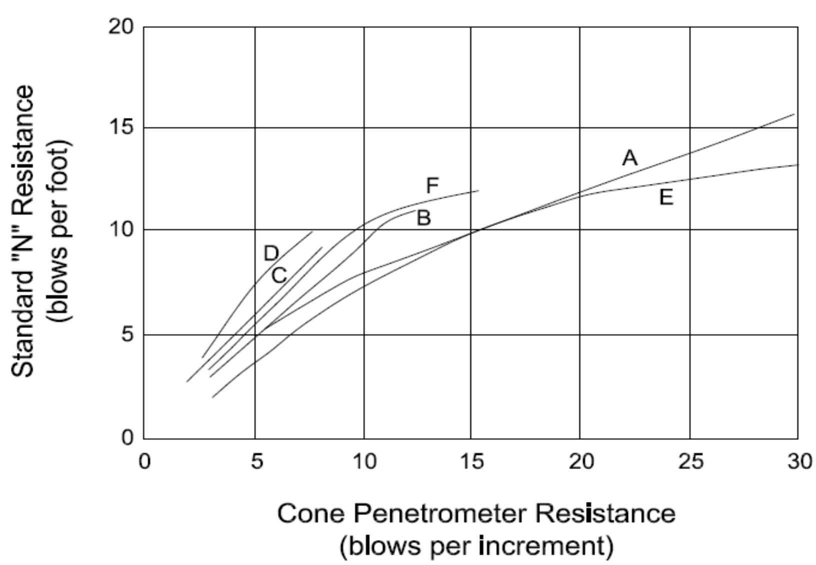
SUBSURFACE EXPLORATION PROCEDURES

Soil Borings – Hand Augers

The hand-auger borings consist of a 4-inch diameter hole drilled with a portable auger bucket. During the auguring procedure, the auger bucket is advanced manually until full. Once full, the bucket is removed, emptied and reinserted to continue the augering excavation for soil profile development. During soil profile development, the auger cuttings are removed from the bucket and visually examined in the field for classification. The soil samples recovered were then classified in the laboratory on the basis of texture and plasticity in accordance with the Unified Soil Classification System (USCS).

Dynamic Cone Penetrometer Tests

The Dynamic Cone Penetrometer (DCP) uses a 15-pound steel mass falling 20 inches to strike an anvil to penetrate a 1.5-inch diameter 45 degree cone that has been seated at the bottom of a hand augered hole. The cone point is driven 1.75 inches using the ring weight which is allowed to free fall 20 inches. The number of blows required to achieve 1.75 inches of penetration are counted and related to SPT results through the following reference: George F. Sowers and Charles S. Hedges, *Dynamic Cone for Shallow In-Situ Testing*, ASTM Special Technical Publication #399 (as shown in the figure below).

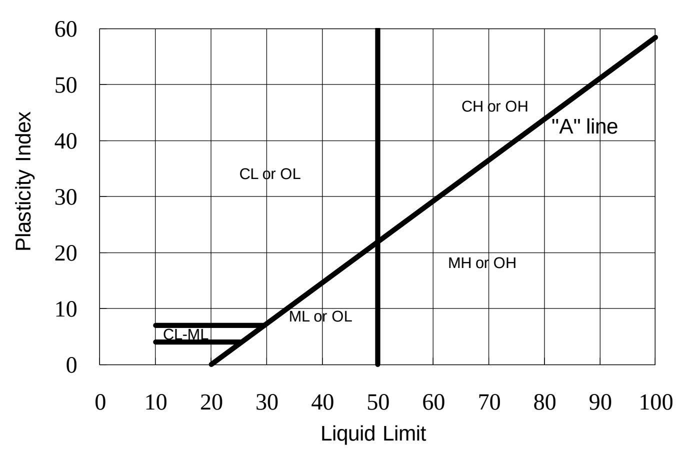


Curve A - Virgin Piedmont soils
B - 95% Compacted soil
C- 90% Compacted soil
D – 85% Compacted soil
E – Coastal Plain soils
F - Piedmont alluvium

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

MAJOR DIVISIONS			GROUP SYMBOL	TYPICAL NAMES	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (Less than 50% passes No. 200 Sieve size)	**GRAVELS** (50% or less of coarse fraction ispasses No. 4 sieve)	**CLEAN GRAVELS** (Less than 5% passes No. 200 sieve)	**GW**	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = D_{60}/D_{10}$ greater than 4 $C_c = (D_{30})^2/(D_{10} x D_{60})$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	**GM**	Silty gravels, gravel-sand mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits below "A" line or P.I. less than 7	
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	**CLEAN SANDS** (Less than 5% passes No. 200 sieve)	**SW**	Well-graded sands, gravelly sands, little or no fines	$C_u = D_{60}/D_{10}$ greater than 6 $C_c = (D_{30})^2/(D_{10} x D_{60})$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	**SM**	Silty sands, sand-silt mixtures	Atterberg limits above "A" line or P.I. less than 4	Limits plotting in CL-ML zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
FINE-GRAINED SOILS (50% or more passes No. 200 Sieve)	**SILTS AND CLAYS** (Liquid limit less than 50)		**ML**	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays		
			OL	Organic silts and organic silty clays of low plasticity		
	SILTS AND CLAYS (Liquid limit greater than 50)		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	HIGHLY ORGANIC SOILS		**Pt**	Peat and other highly organic soils		

PLASTICITY CHART



DEGREE OF PLASTICITY OF COHESIVE SOILS

Degree of Plasticity	Plasticity Index
None to Slight	0-4
Slight	5-7
Medium	8-22
High to Very High	Over 22

DMY

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

B-1

DATE(S) DRILLED:03/30/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 166.5 ft

Ground water was not encountered during drilling

DRY AFTER 24 HRS

FIELD DATA / **LAB DATA**

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)
0.0	166.5									0.0 / 166.5 Topsoil **Tops**			
0.3	166.2									0.3 / 166.2 Light brown, silty sand FILL, trace gravel, loose, moist **FL-SM**			
	165												
2.0	164.5	8 7 8		2.0						2.0 / 164.5 Light brown, sandy lean clay FILL, contains debris and trace roots, firm, moist **FL-CL**			
5	161.5	4 4 4		5.0						5.0 / 161.5 Light brown, clayey SAND with gravel, loose, wet **SC**			
	160												
8.0		4 5 6		8.0									
10	156.5									10.0 / 156.5 Boring Terminated			

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

PROJECT NAME: Ft. Greble Recreation Center PROJECT NO.: 1371.01 LOCATION: Washington DC CLIENT: HRGM Corporation	**B-2** **PAGE 1 OF 1**

DATE(S) DRILLED:03/30/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 166.6 ft

Ground water was not encountered during drilling

FIELD DATA / LAB DATA

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
										0.0 / 166.6 Topsoil **Tops**			
										0.3 / 166.3 Brown, Silty SAND, loose, moist **SM**			
	165												
										2.0 / 164.6 Red and brown, sandy LEAN CLAY, firm to stiff, moist **CL**			
		8 7 7		3.0									
5													
		16 15 17		6.0						6.0 / 160.6 Boring Terminated			

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

DMY

PROJECT NAME: Ft. Greble Recreation Center PROJECT NO.: 1371.01 LOCATION: Washington DC CLIENT: HRGM Corporation	**B-3** **PAGE 1 OF 1**

DATE(S) DRILLED:03/31/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 166.5 ft

Ground water was not encountered during drilling

FIELD DATA / **LAB DATA**

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)
										0.0 / 166.5 Topsoil **Tops**			
										0.5 / 166.0 Brown, sandy silt FILL, soft, moist **FL-ML**			
	165												
										2.0 / 164.5 Brown, Clayey SAND, very loose, moist **SC**			
		3 3 3		3.0									
										4.0 / 162.5 Brown, poorly-graded SAND with silt, trace gravel, loose to medium dense, moist **SP-SM**			
5													
		10 25+		6.0						6.0 / 160.5 Boring Terminated			

REMARKS:

PAGE 1 OF 1
B-3

SPT_LOG:R:\@ PROJECTS\GEOTECHNICAL PROJECTS\1371.01 FT. GREBLE\B-DRILLING\LOGS.GPJ:LOGS.GPJ;4/19/13

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

B-4

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

DATE(S) DRILLED:03/31/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 167.5 ft

Ground water was not encountered during drilling

FIELD DATA

LAB DATA

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)
										0.0 / 167.5 Topsoil **Tops**			
										0.5 / 167.0 Brown, Silty SAND, moist **SM**			
										2.0 / 165.5 Red and brown, Clayey SAND, medium dense, moist **SC**			
	165												
		18 25+		3.0									
										SAME, with gravel			
5													
		25+		6.0						6.0 / 161.5 Hand Auger Refusal			

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

B-5

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

DATE(S) DRILLED:03/31/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 168.4 ft

Ground water was not encountered during drilling

FIELD DATA / MATERIAL DESCRIPTION OF STRATA / LAB DATA

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
										0.0 / 168.4 Topsoil **Tops**			
										0.6 / 167.8 Brown, Silty SAND, loose, moist **SM**			
										2.0 / 166.4 Red and brown, Clayey SAND, loose, moist **SC**			
	165	10 11 11		3.0									
5		15 14 16		5.0						5.0 / 163.4 Boring Terminated			

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

DMY

PROJECT NAME: Ft. Greble Recreation Center PROJECT NO.: 1371.01 LOCATION: Washington DC CLIENT: HRGM Corporation	**I-1** **PAGE 1 OF 1**

DATE(S) DRILLED:03/30/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 164.5 ft

Ground water was not encountered during drilling

FIELD DATA / **LAB DATA**

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	% Finer than 200
										0.0 / 164.5 Topsoil **Tops**				
										0.3 / 164.2 Light brown, clayey sand with gravel FILL, loose to medium dense, moist **FL-SC**				
		6 25+		2.0						2.0 / 162.5 Light brown, gravelly poorly-graded sand FILL, medium dense, moist **FL-SP**				
	160													
5		25+		5.0						5.0 / 159.5 Light brown, clayey SAND with gravel, loose, moist **SC**				
		6 8 6		8.0							33	18	19.8	38.8
	155													
10										10.0 / 154.5 Boring Terminated				

REMARKS:

PAGE 1 OF 1
I-1

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

DMY

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

DATE(S) DRILLED:03/30/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 166.6 ft

Ground water was not encountered during drilling

FIELD DATA / MATERIAL DESCRIPTION OF STRATA / LAB DATA

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	% Finer than 200
										0.0 / 166.6 Topsoil **Tops**				
										0.3 / 166.3 Light brown, sandy LEAN CLAY, firm to stiff, moist **CL**				
	165													
										SAME, gray and brown				
		25+		4.0										
5										SAME, trace gravel				
		8 20 25+		6.0										
	160													
		20 25+		8.0						8.0 / 158.6 Boring Terminated	28	17	19.6	52.1

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

DATE(S) DRILLED:03/30/13
DRILLING METHOD(S): Hand Augers and DCP
DRILLING EQUIPMENT: N/A
DRILLER: P. Zhang LOGGER: P.Zhang
SURFACE ELEVATION: 167.6 ft

Ground water was not encountered during drilling

FIELD DATA / LAB DATA

DEPTH (FT)	ELEVATION (FT)	DCP BLOW COUNTS	SAMPLE LEGEND	SAMPLE INTERVAL	% RECOVERY	ROCK QUALITY DESIGNATION %	RMR	GEOLOGIC STRATA	GRAPHIC LOG	MATERIAL DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	% Finer than 200
										0.0 / 167.6 Topsoil **Tops**				
										0.5 / 167.1 Light brown, clayey SAND, medium dense, moist **SC**				
		21 25+		2.0										
	165													
		15 18 18		4.0										
5										5.0 / 162.6 Light brown, sandy LEAN CLAY, firm to stiff, moist **CL**				
		12 25+		6.0										
	160													
		18 13 15		8.0						8.0 / 159.6 Boring Terminated	37	17	12.3	68.0

REMARKS:

DMY ENGINEERING CONSULTANTS,LLC
45662 TERMINAL DRIVE, SUITE 110, DULLES, VIRGINIA 20166
PHONE: 703-665-0586 FAX:202-688-1918

FIELD INFILTRATION TESTING SUMMARY

DMY Project No.: 1371.01 **Project Naject Name:** Ft. Greble Recreation Center

Test Date: 3/31/2013 **Tester:** P.Z.

Boring No.: I-1

Infiltration Hole Depth (in.): 97
PVC Pipe Stickup (in.): 11

Reference Depth for Test (24" above bottom) from edge of PVC pipe (in.): 84

	Test 1	Test 2	Test 3	Test 4
Start Time	7:30 AM	8:34 AM	9:38 AM	10:45 AM
Finish Time	8:30 AM	9:34 AM	10:38 AM	11:45 AM
Start Water Depth (in.)	82.13	83.19	83.50	83.50
Start Head (in.)	25.88	24.81	24.50	24.50
Finish Water Depth (in.)	83.19	84.50	84.63	84.69
Fall (in.)	1.06	1.31	1.13	1.19

Calculated Infiltration Rate (in/hr)
Average Fall over 4 hours or last read
1.172

Boring No.: I-2

Infiltration Hole Depth (in.): 72
PVC Pipe Stickup (in.): 12

Reference Depth for Test (24" above bottom) from edge of PVC pipe (in.): 60

	Test 1	Test 2	Test 3	Test 4
Start Time	7:38 AM	8:38 AM	9:40 AM	10:40 AM
Finish Time	8:38 AM	9:38 AM	10:40 AM	11:40 AM
Start Water Depth (in.)	60.25	60.38	60.44	60.50
Start Head (in.)	23.75	23.63	23.56	23.50
Finish Water Depth (in.)	60.38	60.44	60.50	60.56
Fall (in.)	0.13	0.06	0.06	0.06

Calculated Infiltration Rate (in/hr)
Average Fall over 4 hours or last read
0.078

Boring No.: I-3

Infiltration Hole Depth (in.): 71.5
PVC Pipe Stickup (in.): 12.5

Reference Depth for Test (24" above bottom) from edge of PVC pipe (in.): 60

	Test 1	Test 2	Test 3	Test 4
Start Time	7:35 AM	8:35 AM	9:35 AM	10:35 AM
Finish Time	8:35 AM	9:35 AM	10:35 AM	11:35 AM
Start Water Depth (in.)	59.00	59.13	59.25	59.38
Start Head (in.)	25.00	24.88	24.75	24.63
Finish Water Depth (in.)	59.13	59.25	59.38	59.50
Fall (in.)	0.13	0.13	0.13	0.13

Calculated Infiltration Rate (in/hr)
Average Fall over 4 hours or last read
0.125

APPENDIX C – LABORATORY TESTING

LABORATORY TESTING PROCEDURES

SOIL CLASSIFICATION

Soil classifications provide a general guide to the engineering properties of various soil types. Each soil sample was visually classified based on color, texture, and consistency (determined from the 'number of blows per foot in standard penetration tests) according to ASTM D2488.

The group symbols for each soil type are indicated in parentheses following the soil descriptions on the boring logs. A brief explanation of the Unified Soil Classification System is included in Appendix B of this report. Various soil types were grouped into the major zones noted on the boring logs. The stratification lines designating the interfaces between earth materials on the boring logs and profiles are approximate; in situ, the transitions may be gradual, rather than distinct.

The classification system discussed above is primarily qualitative. For detailed soil classification, two laboratory tests are required: grain size analysis and index tests. Using these test results, soil can be classified according to the AASHTO, FAA, or UNIFIED Classification Systems (ASTM D 2487). Soil classifications, along with in-place physical soil properties, provide an index for estimating the behavior of a soil.

GRAIN SIZE ANALYSIS

Grain size analysis (ASTM D 422) is performed to determine the distribution of particle sizes in soil. Samples are prepared for testing according to ASTM D 2217. Particles passing the No. 200 sieve (0.074 mm opening) are labeled as fines (silts and clays). Particles retained on the No. 200 sieve are labeled the coarse fraction of the sample (sands and gravels). Further differentiation is possible by passing the sample through a standard set of nested sieves and/or by performing hydrometer tests, in which particles are suspended in water and the particle size distribution is calculated from the measured settlement rate.

ATTERBERG LIMITS

Atterberg Limits are performed according to ASTM D 4318 to determine the moisture content boundaries between the liquid, plastic, and solid states of soils. These boundaries are called the Liquid Limit (LL) and Plastic Limit (PL). From these we derive the Plasticity Index (PI). Together, the LL, PL, and PI are referred to as the Atterberg Limits. These test methods are used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils and to specify the fine-grained fraction of construction materials.

DMY Engineering Consultants

SUMMARY OF LABORATORY RESULTS

CLIENT HRGM Corporation

PROJECT NAME Ft. Greble Recreation Center

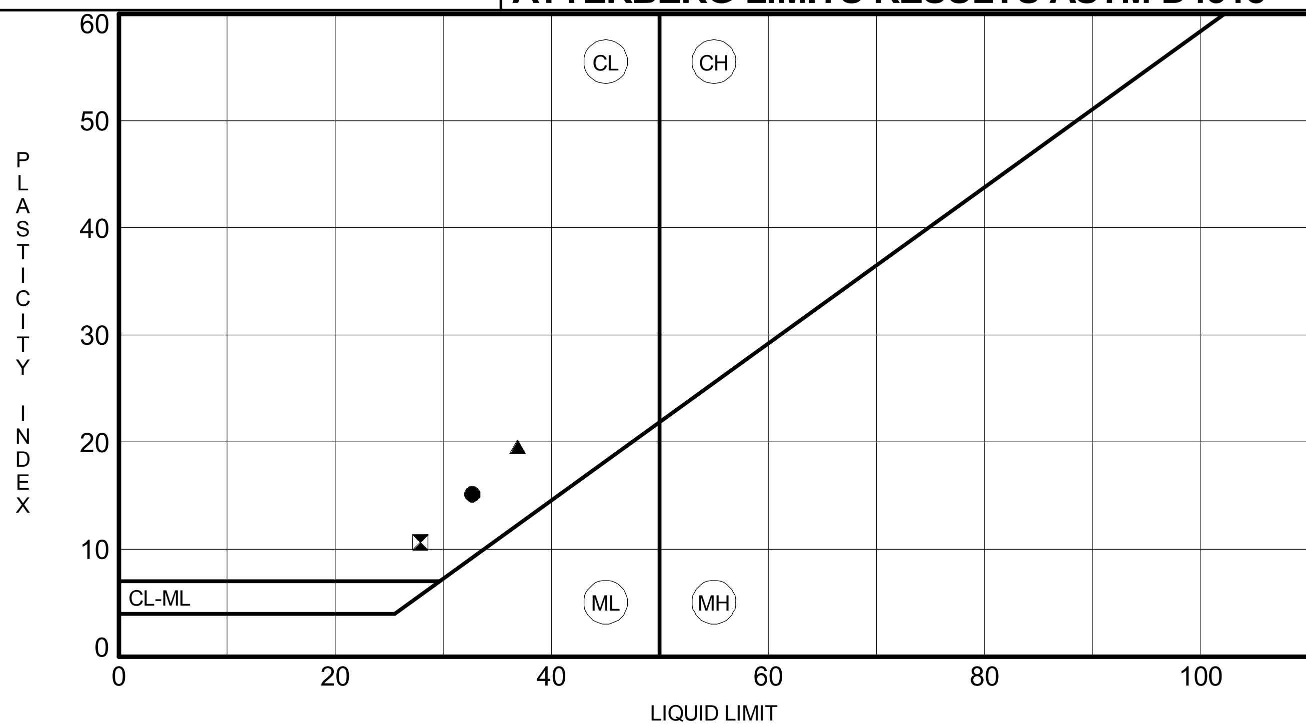
PROJECT NUMBER 1371.01

PROJECT LOCATION Washington DC

Sample ID	Depth (FT)	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Water Content (%)	Proctor Method	Max Dry Density Corrected (pcf)	Optimum Moisture Corrected (%)	Oversize Fraction (%)	Classification
I-1-S3	8	33	18	15	38.8	19.8					brown, Clayey Sand (**SC**)
I-2-S3	8	28	17	11	52.1	19.6					brown, Sandy Lean Clay (**CL**)
I-3-S4	8	37	17	20	68.0	12.3					brown, Sandy Lean Clay (**CL**)

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

ATTERBERG LIMITS RESULTS ASTM D4318

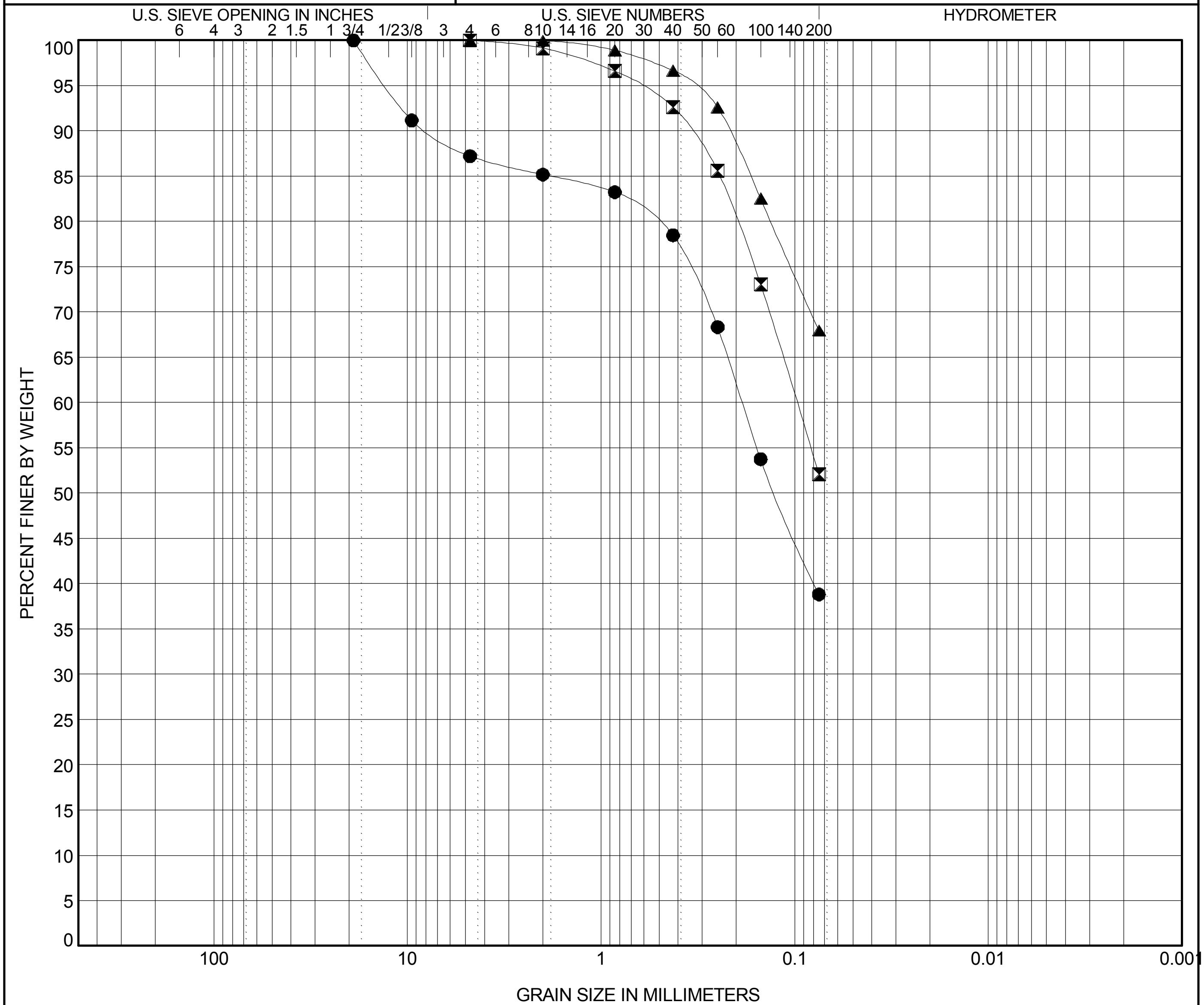


	SAMPLE	DEPTH (FT)	LL	PL	PI	Fines	SAMPLE DESCRIPTION
●	**I-1-S3**	**8.0**	**33**	**18**	**15**	**38.8**	brown, Clayey Sand (**SC**)
⧗	**I-2-S3**	**8.0**	**28**	**17**	**11**	**52.1**	brown, Sandy Lean Clay (**CL**)
▲	**I-3-S4**	**8.0**	**37**	**17**	**20**	**68.0**	brown, Sandy Lean Clay (**CL**)

ATTERBERG LIMITS 4/19/13

PROJECT NAME: Ft. Greble Recreation Center
PROJECT NO.: 1371.01
LOCATION: Washington DC
CLIENT: HRGM Corporation

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

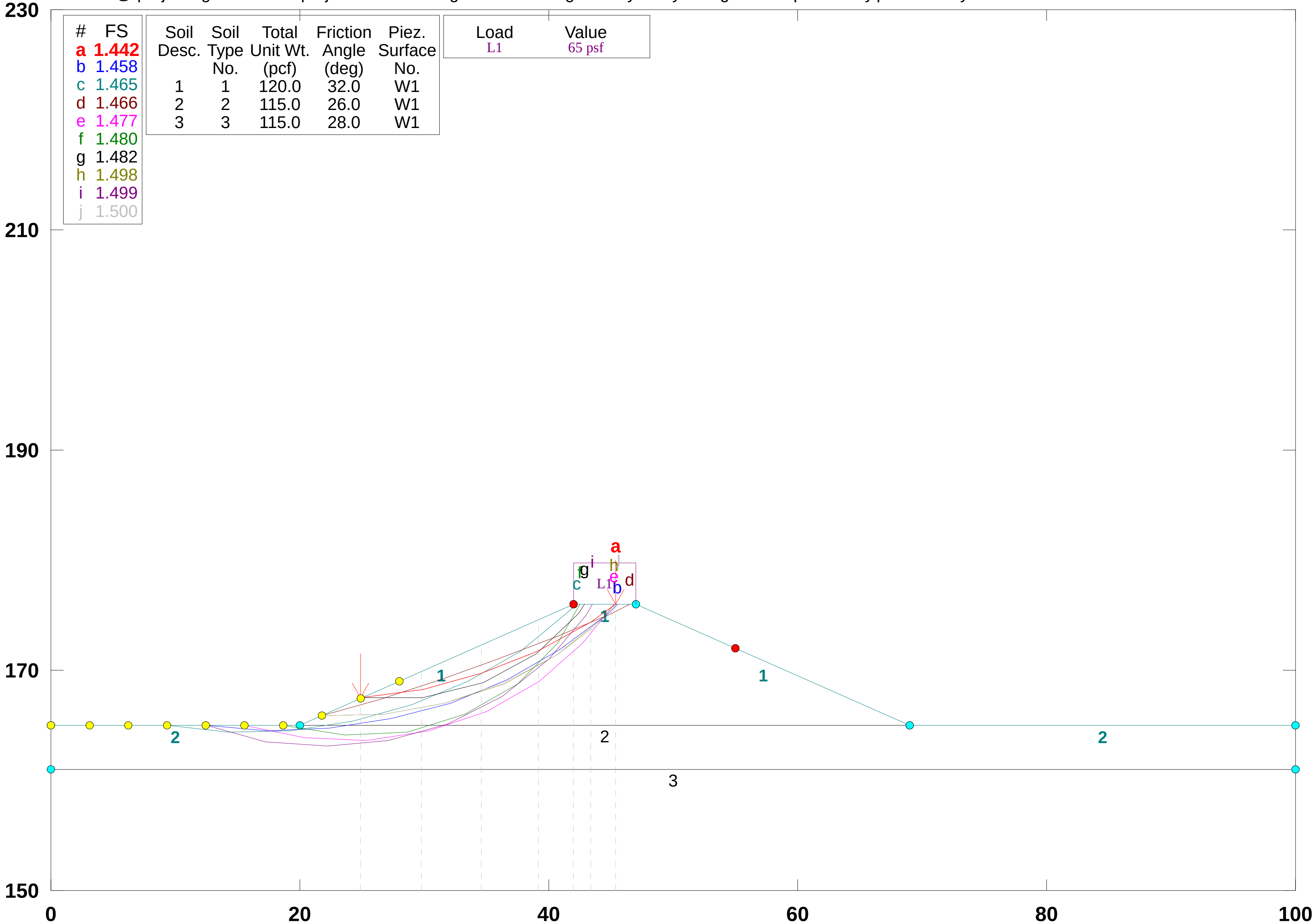
	SAMPLE	DEPTH (FT)	SAMPLE DESCRIPTION	LL	PL	PI
●	**I-1-S3**	**8.0**	brown, Clayey Sand (**SC**)	**33**	**18**	**15**
⧗	**I-2-S3**	**8.0**	brown, Sandy Lean Clay (**CL**)	**28**	**17**	**11**
▲	**I-3-S4**	**8.0**	brown, Sandy Lean Clay (**CL**)	**37**	**17**	**20**

			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**I-1-S3**	**8.0**	**19**	**0.187**			**12.9**	**48.4**	**38.8**	
⧗	**I-2-S3**	**8.0**	**4.75**	**0.097**			**0.1**	**47.9**	**52.1**	
▲	**I-3-S4**	**8.0**	**4.75**				**0.1**	**32.0**	**68.0**	

APPENDIX D – SLOPE STABILITY ANALYSIS RESULTS

1371.01 Ft. Greble Recreation Center - Drained

r:\@ projects\geotechnical projects\1371.01 ft. greble\e-working\stability analysis\ft greble slope stability.pl2 Run By: Rabih Khouri 4/30/2013 11:32AM



GSTABL7 v.2 FSmin=1.442
Safety Factors Are Calculated By The Modified Bishop Method

```
                         ***  GSTABL7  ***
           ** GSTABL7 by Dr. Garry H. Gregory, Ph.D.,P.E.,D.GE **
     ** Original Version 1.0, January 1996; Current Ver. 2.005.2, Jan. 2011 **
             (All Rights Reserved-Unauthorized Use Prohibited)
*********************************************************************************
                    SLOPE STABILITY ANALYSIS SYSTEM
       Modified Bishop, Simplified Janbu, or GLE Method of Slices.
       (Includes Spencer & Morgenstern-Price Type Analysis)
       Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
       Nonlinear Undrained Shear Strength, Curved Phi Envelope,
       Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
       Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*********************************************************************************
Analysis Run Date:        4/30/2013
Time of Run:              11:32AM
Run By:                   Rabih Khouri
Input Data Filename:      r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability.in
Output Filename:          r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability.OUT
Unit System:              English
Plotted Output Filename:  r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability.PLT
PROBLEM DESCRIPTION:  1371.01
                      Ft. Greble Recreation Center - Drained
BOUNDARY COORDINATES
    5 Top   Boundaries
    7 Total Boundaries
Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
   No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
    1          0.00     165.00      20.00     165.00        2
    2         20.00     165.00      42.00     176.00        1
    3         42.00     176.00      47.00     176.00        1
    4         47.00     176.00      69.00     165.00        1
    5         69.00     165.00     100.00     165.00        2
    6         20.00     165.00      69.00     165.00        2
    7          0.00     161.00     100.00     161.00        3
User Specified Y-Origin =      150.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
  3 Type(s) of Soil
Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
 No.  (pcf)    (pcf)     (psf)     (deg)   Param.   (psf)     No.
  1   120.0      0.0       0.0      32.0    0.00      0.0      1
  2   115.0      0.0       0.0      26.0    0.00      0.0      1
  3   115.0      0.0       0.0      28.0    0.00      0.0      1
BOUNDARY LOAD(S)
    1 Load(s) Specified
Load        X-Left      X-Right     Intensity     Deflection
 No.         (ft)        (ft)         (psf)         (deg)
  1          42.00       47.00         65.0           0.0
NOTE - Intensity Is Specified As A Uniformly Distributed
       Force Acting On A Horizontally Projected Surface.
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
 200 Trial Surfaces Have Been Generated.
  20 Surface(s) Initiate(s) From Each Of    10 Points Equally Spaced
Along The Ground Surface Between  X =   0.00(ft)
                             and  X =  28.00(ft)
Each Surface Terminates Between   X =  42.00(ft)
                            and   X =  55.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is  Y =      0.00(ft)
 5.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
```

Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 200
Number of Trial Surfaces With Valid FS = 200
Statistical Data On All Valid FS Values:
FS Max = 6.108 FS Min = 1.442 FS Ave = 2.560
Standard Deviation = 0.825 Coefficient of Variation = 32.23 %

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.889	167.444
2	29.819	168.276
3	34.603	169.729
4	39.163	171.780
5	43.425	174.396
6	45.415	176.000

Circle Center At X = 21.054 ; Y = 205.544 ; and Radius = 38.292
Factor of Safety
*** 1.442 ***

Individual data on the 6 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.9	483.3	0.0	0.0	0.	0.	0.0	0.0	0.0
2	4.8	1207.4	0.0	0.0	0.	0.	0.0	0.0	0.0
3	4.6	1470.2	0.0	0.0	0.	0.	0.0	0.0	0.0
4	2.8	898.6	0.0	0.0	0.	0.	0.0	0.0	0.0
5	1.4	348.9	0.0	0.0	0.	0.	0.0	0.0	92.6
6	2.0	191.5	0.0	0.0	0.	0.	0.0	0.0	129.3

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	12.444	165.000
2	17.422	164.532
3	22.419	164.723
4	27.346	165.571
5	32.119	167.060
6	36.655	169.166
7	40.873	171.850
8	44.701	175.066
9	45.553	176.000

Circle Center At X = 18.474 ; Y = 202.393 ; and Radius = 37.876
Factor of Safety
*** 1.458 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.333	165.000
2	14.300	164.421
3	19.298	164.541
4	24.231	165.357
5	29.002	166.853
6	33.518	168.999
7	37.690	171.755
8	41.437	175.066
9	42.235	176.000

Circle Center At X = 15.945 ; Y = 200.138 ; and Radius = 35.754
Factor of Safety
*** 1.465 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.778	165.889
2	26.538	167.418
3	31.242	169.114

```
    4         35.883      170.974
    5         40.456      172.996
    6         44.955      175.178
    7         46.508      176.000
Circle Center At X =   -19.303 ; Y =   301.947 ; and Radius =   142.125
       Factor of Safety
      ***    1.466   ***
Failure Surface Specified By  8 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         15.556      165.000
    2         20.415      163.822
    3         25.412      163.643
    4         30.343      164.469
    5         35.008      166.268
    6         39.218      168.965
    7         42.802      172.451
    8         45.216      176.000
Circle Center At X =    23.794 ; Y =   188.273 ; and Radius =    24.688
       Factor of Safety
      ***    1.477   ***
Failure Surface Specified By  7 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         18.667      165.000
    2         23.580      164.071
    3         28.567      164.426
    4         33.299      166.040
    5         37.464      168.806
    6         40.786      172.543
    7         42.537      176.000
Circle Center At X =    24.706 ; Y =   183.492 ; and Radius =    19.454
       Factor of Safety
      ***    1.480   ***
Failure Surface Specified By  6 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         24.889      167.444
    2         29.888      167.515
    3         34.694      168.897
    4         38.967      171.493
    5         42.407      175.121
    6         42.879      176.000
Circle Center At X =    27.176 ; Y =   185.826 ; and Radius =    18.523
       Factor of Safety
      ***    1.482   ***
Failure Surface Specified By  7 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         21.778      165.889
    2         26.777      165.987
    3         31.680      166.966
    4         36.334      168.793
    5         40.593      171.412
    6         44.324      174.741
    7         45.312      176.000
Circle Center At X =    23.723 ; Y =   194.074 ; and Radius =    28.252
       Factor of Safety
      ***    1.498   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         12.444      165.000
    2         17.225      163.535
    3         22.203      163.069
    4         27.173      163.622
    5         31.927      165.170
```

```
    6         36.269      167.649
    7         40.019      170.956
    8         43.021      174.955
    9         43.512      176.000
Circle Center At X =    21.989 ; Y =   187.617 ; and Radius =    24.549
       Factor of Safety
      ***    1.499   ***
Failure Surface Specified By  7 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         21.778      165.889
    2         26.775      166.051
    3         31.676      167.043
    4         36.343      168.836
    5         40.647      171.381
    6         44.468      174.606
    7         45.648      176.000
Circle Center At X =    23.307 ; Y =   195.797 ; and Radius =    29.947
       Factor of Safety
      ***    1.500   ***
          **** END OF GSTABL7 OUTPUT ****
```

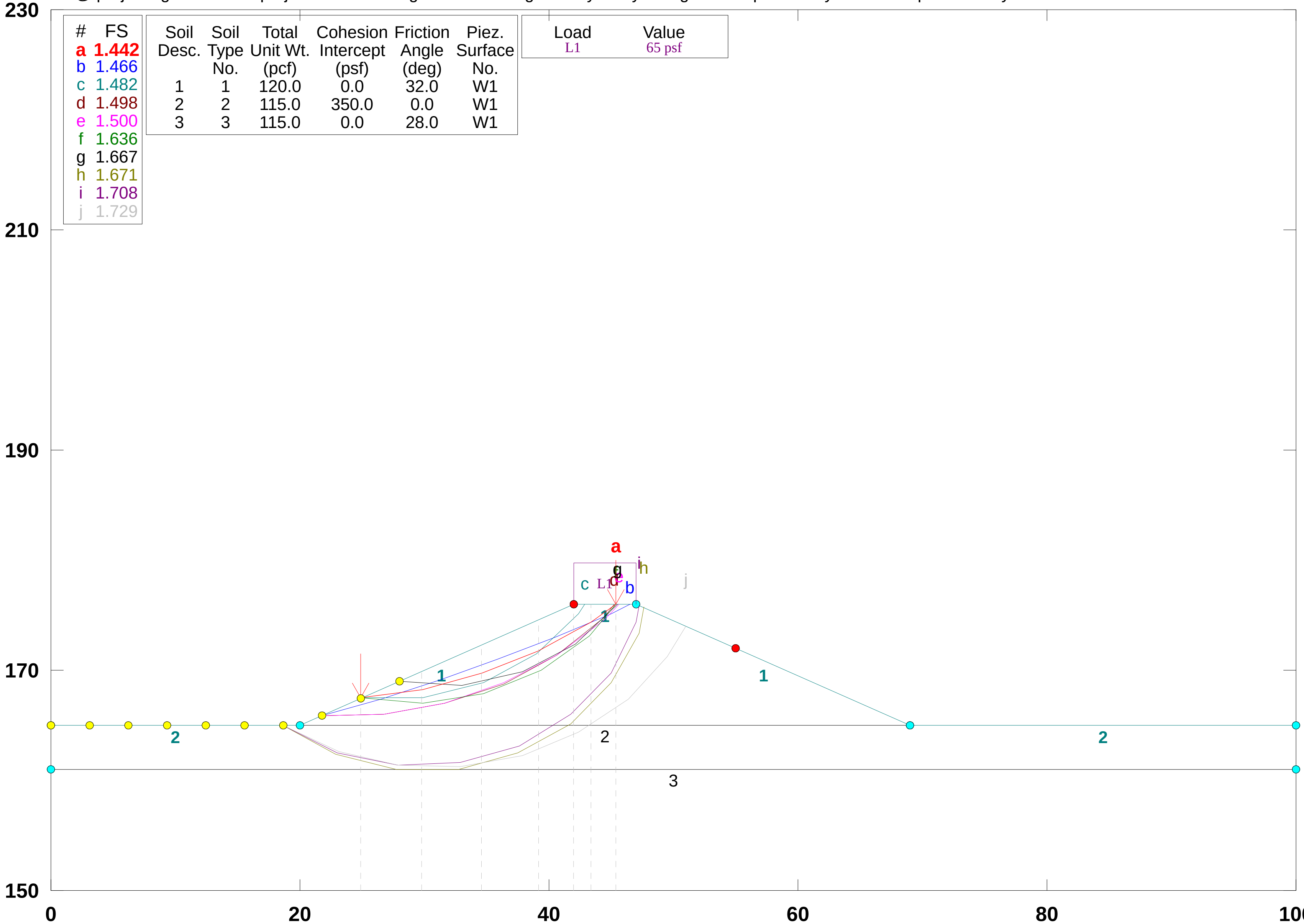
1371.01 Ft. Greble Recreation Center - Undrained

r:\@ projects\geotechnical projects\1371.01 ft. greble\e-working\stability analysis\ft greble slope stability undrained.pl2 Run By: Rabih Khouri 4/30/2013 11:29AM

#	FS
a	1.442
b	1.466
c	1.482
d	1.498
e	1.500
f	1.636
g	1.667
h	1.671
i	1.708
j	1.729

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
1	1	120.0	0.0	32.0	W1
2	2	115.0	350.0	0.0	W1
3	3	115.0	0.0	28.0	W1

Load	Value
L1	65 psf



GSTABL7 v.2 FSmin=1.442

Safety Factors Are Calculated By The Modified Bishop Method

```
                                  ***  GSTABL7  ***
               ** GSTABL7 by Dr. Garry H. Gregory, Ph.D.,P.E.,D.GE **
        ** Original Version 1.0, January 1996; Current Ver. 2.005.2, Jan. 2011 **
                  (All Rights Reserved-Unauthorized Use Prohibited)
    *********************************************************************************
                         SLOPE STABILITY ANALYSIS SYSTEM
           Modified Bishop, Simplified Janbu, or GLE Method of Slices.
           (Includes Spencer & Morgenstern-Price Type Analysis)
           Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
           Nonlinear Undrained Shear Strength, Curved Phi Envelope,
           Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
           Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
    *********************************************************************************
    Analysis Run Date:        4/30/2013
    Time of Run:              11:30AM
    Run By:                   Rabih Khouri
    Input Data Filename:      r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability undrained.in
    Output Filename:          r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability undrained.OUT
    Unit System:              English
    Plotted Output Filename:  r:\@ Projects\Geotechnical Projects\1371.01 Ft.
Greble\e-Working\Stability Analysis\ft greble slope stability undrained.PLT
    PROBLEM DESCRIPTION:  1371.01
                          Ft. Greble Recreation Center - Undrained
    BOUNDARY COORDINATES
        5 Top   Boundaries
        7 Total Boundaries
    Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
       No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
        1          0.00     165.00      20.00     165.00        2
        2         20.00     165.00      42.00     176.00        1
        3         42.00     176.00      47.00     176.00        1
        4         47.00     176.00      69.00     165.00        1
        5         69.00     165.00     100.00     165.00        2
        6         20.00     165.00      69.00     165.00        2
        7          0.00     161.00     100.00     161.00        3
    User Specified Y-Origin =       150.00(ft)
    Default X-Plus Value = 0.00(ft)
    Default Y-Plus Value = 0.00(ft)
   ISOTROPIC SOIL PARAMETERS
     3 Type(s) of Soil
    Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
    Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
     No.  (pcf)    (pcf)     (psf)     (deg)    Param.   (psf)     No.
      1   120.0      0.0       0.0      32.0    0.00       0.0      1
      2   115.0      0.0     350.0       0.0    0.00       0.0      1
      3   115.0      0.0       0.0      28.0    0.00       0.0      1
   BOUNDARY LOAD(S)
        1 Load(s) Specified
    Load        X-Left      X-Right     Intensity     Deflection
     No.         (ft)         (ft)        (psf)          (deg)
      1          42.00        47.00        65.0           0.0
    NOTE - Intensity Is Specified As A Uniformly Distributed
           Force Acting On A Horizontally Projected Surface.
    A Critical Failure Surface Searching Method, Using A Random
    Technique For Generating Circular Surfaces, Has Been Specified.
     200 Trial Surfaces Have Been Generated.
       20 Surface(s) Initiate(s) From Each Of    10 Points Equally Spaced
    Along The Ground Surface Between  X =   0.00(ft)
                                    and  X =  28.00(ft)
    Each Surface Terminates Between   X =  42.00(ft)
                                   and   X =  55.00(ft)
    Unless Further Limitations Were Imposed, The Minimum Elevation
    At Which A Surface Extends Is  Y =      0.00(ft)
     5.00(ft) Line Segments Define Each Trial Failure Surface.
    Following Are Displayed The Ten Most Critical Of The Trial
```

Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 200
Number of Trial Surfaces With Valid FS = 200
Statistical Data On All Valid FS Values:
FS Max = 4.889 FS Min = 1.442 FS Ave = 2.548
Standard Deviation = 0.599 Coefficient of Variation = 23.50 %

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.889	167.444
2	29.819	168.276
3	34.603	169.729
4	39.163	171.780
5	43.425	174.396
6	45.415	176.000

Circle Center At X = 21.054 ; Y = 205.544 ; and Radius = 38.292
Factor of Safety
*** 1.442 ***
Individual data on the 6 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.9	483.3	0.0	0.0	0.	0.	0.0	0.0	0.0
2	4.8	1207.4	0.0	0.0	0.	0.	0.0	0.0	0.0
3	4.6	1470.2	0.0	0.0	0.	0.	0.0	0.0	0.0
4	2.8	898.6	0.0	0.0	0.	0.	0.0	0.0	0.0
5	1.4	348.9	0.0	0.0	0.	0.	0.0	0.0	92.6
6	2.0	191.5	0.0	0.0	0.	0.	0.0	0.0	129.3

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.778	165.889
2	26.538	167.418
3	31.242	169.114
4	35.883	170.974
5	40.456	172.996
6	44.955	175.178
7	46.508	176.000

Circle Center At X = -19.303 ; Y = 301.947 ; and Radius = 142.125
Factor of Safety
*** 1.466 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.889	167.444
2	29.888	167.515
3	34.694	168.897
4	38.967	171.493
5	42.407	175.121
6	42.879	176.000

Circle Center At X = 27.176 ; Y = 185.826 ; and Radius = 18.523
Factor of Safety
*** 1.482 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.778	165.889
2	26.777	165.987
3	31.680	166.966
4	36.334	168.793
5	40.593	171.412
6	44.324	174.741
7	45.312	176.000

Circle Center At X = 23.723 ; Y = 194.074 ; and Radius = 28.252

```
       Factor of Safety
      ***    1.498   ***
Failure Surface Specified By  7 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         21.778      165.889
    2         26.775      166.051
    3         31.676      167.043
    4         36.343      168.836
    5         40.647      171.381
    6         44.468      174.606
    7         45.648      176.000
Circle Center At X =    23.307 ; Y =   195.797 ; and Radius =    29.947
       Factor of Safety
      ***    1.500   ***
Failure Surface Specified By  6 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         24.889      167.444
    2         29.873      167.045
    3         34.798      167.905
    4         39.353      169.969
    5         43.246      173.106
    6         45.400      176.000
Circle Center At X =    28.968 ; Y =   186.529 ; and Radius =    19.516
       Factor of Safety
      ***    1.636   ***
Failure Surface Specified By  5 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         28.000      169.000
    2         32.988      168.660
    3         37.853      169.816
    4         42.157      172.361
    5         45.449      176.000
Circle Center At X =    31.614 ; Y =   185.273 ; and Radius =    16.669
       Factor of Safety
      ***    1.667   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         18.667      165.000
    2         22.913      162.360
    3         27.724      161.000
    4         32.724      161.027
    5         37.521      162.438
    6         41.739      165.123
    7         45.048      168.872
    8         47.188      173.391
    9         47.567      175.717
Circle Center At X =    30.130 ; Y =   178.703 ; and Radius =    17.866
       Factor of Safety
      ***    1.671   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         18.667      165.000
    2         23.026      162.552
    3         27.889      161.389
    4         32.885      161.599
    5         37.632      163.167
    6         41.771      165.974
    7         44.984      169.804
    8         47.028      174.367
    9         47.247      175.876
Circle Center At X =    29.632 ; Y =   179.420 ; and Radius =    18.115
       Factor of Safety
```

```
      ***    1.708   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         18.667      165.000
    2         23.096      162.680
    3         27.934      161.416
    4         32.932      161.275
    5         37.833      162.263
    6         42.386      164.328
    7         46.357      167.367
    8         49.542      171.221
    9         50.945      174.027
Circle Center At X =    31.053 ; Y =   183.257 ; and Radius =    22.062
       Factor of Safety
      ***    1.729   ***
          **** END OF GSTABL7 OUTPUT ****
```