Geotechnical Engineering Report

Storm Water Management Pond

Goddard Space Flight Center

Greenbelt, Maryland

GeoConcepts Engineering, Inc.

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March 7, 2006

Ewing Cole
100 North 6th Street
Federal Reserve Bank Building
Philadelphia, Pennsylvania 19106-1590
Attention: Mr. James A. Wolters

Subject: ***Geotechnical Engineering Report, Storm Water Management Pond, Goddard Space Flight Center, Greenbelt, Maryland (Our 24151)***

Dear Mr. Wolters:

GeoConcepts Engineering, Inc. (GeoConcepts) is pleased to present this geotechnical engineering report for the above referenced project. These services have been performed in accordance with our proposal dated February 17, 2005.

1.0 Scope of Services

This geotechnical engineering report presents the results of the field investigation, soil laboratory testing, and engineering analysis of the geotechnical data. This report specifically addresses the following:

- An evaluation of subsurface conditions within the proposed storm water management pond (SWMP).
- Recommendations regarding the construction of the SWMP including embankment and outlet works foundation support, embankment fill construction, and internal seepage devices.

Services not specifically identified in the contract for this project are not included in the scope of services.

2.0 Site Description and Proposed Construction

The site is located at the northeast corner of Soil Conservation Road and Explorer Drive at Goddard Space Flight Center in Greenbelt, Maryland. A site vicinity map is presented as

Figure 1 at the end of this report. The SWMP site is gently sloping down towards the northeast, with a topographic high at about EL 215 on the southwestern portion and a topographic low at about EL 195 on the northeast portion. The approximate southern one-half of the SWMP area is an area of an old soil landfill, with fill depths up to about 13 feet based on the test borings.

We understand that the SWMP will have a proposed bottom elevation of EL 190, with a maximum cut of about 20 feet required to reach the proposed SWMP bottom. The top of embankment will be at EL 205, which will require a maximum embankment fill height of about 10 feet. The SWMP will have a normal pool elevation and 10-year flood water surface elevation of EL 196.7 and EL 202.7, respectively. The top of the embankment will also serve to support the proposed Loop Road.

3.0 Subsurface Conditions

Subsurface conditions were investigated by drilling five soil test borings in the proposed SWMP area. Test boring logs and a boring location plan are presented in Appendix A.

3.1 Stratification

The subsurface materials encountered have been stratified for purposes of our discussions herein. These stratum designations do not imply that the materials encountered are continuous across the site. Stratum designations have been established to characterize similar subsurface conditions based on material gradations and parent geology. The subsurface materials encountered in the test borings completed at the site have been assigned to the following strata:

Stratum A (Existing Fill)	generally firm sandy lean clay, silty sand and clayey sand FILL, with gravel, organics, asphalt, concrete fragments, and brick fragments, moist, gray, black, tan, brown, red-brown.
Stratum B1 (Potomac Group)	medium stiff to stiff sandy SILT (ML) to sandy LEAN CLAY (CL), with lignite, moist, gray, red-brown, brown.
Stratum B2 (Potomac Group)	generally firm silty SAND (SM) to clayey SAND (SC), moist, red-brown, brown, white, gray.

Topsoil was encountered to depths ranging from about 4 to 11 inches below the existing ground surface. Topsoil depths presented herein should not be considered as stripping depths, as topsoil depths may vary widely across the site, particularly in wooded or previously cultivated areas.

The two letter designations included in the strata descriptions presented above and on the test boring logs represent the Unified Soil Classification System (USCS) designations for the samples based on visual classifications conducted in the field during the subsurface investigation. Visual classifications were made using the methods described in ASTM D-2488, and may not match classifications determined by laboratory testing per ASTM D-2487.

3.2 Geology

The site lies within the Coastal Plain Physiographic Province of Maryland. The Coastal Plain consists of a seaward thickening wedge of unconsolidated to over-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 the 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 soils assigned to Stratum A are believed to be existing fill associated with previous site grading and soil landfill activities. The Stratum B1 clays and Stratum B2 sands are believed to be fluvial to marginal-marine sediments belonging to the Potomac Group. Potomac Group sediments were deposited during the Cretaceous Geologic Period. The Potomac Group sediments are the oldest sedimentary deposits in the Washington, D.C. area. These soils are known to be highly over-consolidated as a result of the weight of substantial thickness of overlying soils that have since been eroded away. As a result of over-consolidation, Potomac Group soils have been pre-loaded and are capable of supporting substantial loads where undisturbed.

3.3 *Ground Water*

Ground water level observations were made in the field during drilling and up to 24 hours after the completion of borings. Ground water was encountered at depths of about 3 to 6.5 feet below the existing ground surface, or at about EL 198 to EL 200.

The ground water observations presented herein are considered to be an indication of the ground water levels at the dates and times indicated. Where impervious Stratum B1 clay 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 ground water table through short term water level readings. Fluctuations in ground water levels should be expected with seasons of the year, construction activity, changes to surface grades, precipitation, or other similar factors.

3.4 *Soil Laboratory Test Results*

Selected soil samples obtained from the field investigation were tested for grain size distribution, Atterberg limits, and natural moisture contents. A summary of soil laboratory test results is presented as Appendix B. The results of natural moisture content tests are presented on the boring logs in Appendix A.

One sample tested from Stratum A classified as silty clayey SAND (SC-SM) in accordance with the USCS, with about 30 percent fines passing the U.S. Standard No. 200 sieve. The liquid limit and plasticity index were 27 and 7, respectively. The natural moisture content was 15.5 percent.

One sample tested from Stratum B1 classified as sandy SILTY CLAY (CL-ML) in accordance with the USCS, with about 54 percent fines passing the U.S. Standard No. 200 sieve. The liquid limit and plasticity index were 20 and 4, respectively. The natural moisture content was 17.9 percent.

Samples tested from Stratum B2 classified as silty clayey SAND (SC-SM) and clayey SAND (SC) in accordance with the USCS, with about 38 to 49 percent fines passing the U.S. Standard No. 200 sieve. Liquid limits and plasticity indices ranged from 23 to 29, and 6 to 11, respectively. Natural moisture contents ranged from 15.6 to 32.0 percent.

3.5 *PID Screening*

Soil samples obtained from the Stratum A existing fill were screened with a Photoionization Detector (PID) in an attempt to detect the presence of volatile organic

compounds (VOCs). The PID values ranged from 0.1 to 5.0 ppm, which is generally below significant levels. The PID readings are indicated on the boring logs in Appendix A.

4.0 Engineering Analysis

Recommendations regarding construction of the SWMP facilities including embankment and outlet works foundation support, embankment fill construction, and internal seepage devices are presented herein.

4.1 Riser Foundation Support

The outlet works are expected to consist of precast concrete pipes and a riser structure. Based on the test boring data, the riser foundation is expected to bear on natural soils. Foundations supported by the natural soils may be designed with an allowable soil bearing pressure of 2,000 psf. Foundation subgrades should be observed and approved prior to placement of concrete to ascertain that foundations are placed on suitable bearing soils as recommended herein. Foundations should be excavated and poured the same day in order to avoid disturbance from water or weather. Disturbance of foundation subgrades by exposure to water seepage or weather conditions should be avoided. Any existing fill, disturbed, frozen, soft subgrade soils should be removed prior to placing foundation concrete. 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 foundations are formed, the forms should be removed and excavation backfilled as soon as possible. Water should not be allowed to pond along the outside of foundations for long periods of time.

4.2 Pond Embankment Construction and Internal Seepage Devices

The conditions in the area of the proposed SWMP consist of existing fill material and natural soils. The pond embankment will generally be constructed by placing new compacted fill in the existing swale in the northeast portion of the SWMP. We anticipate that the outlet works installation will require cutting through the embankment, installing the outlet works, and then backfilling to design grades.

To minimize the potential for excess seepage along the exterior of the outlet pipe, we recommend a concrete cradle be placed below the pipe from the riser pipe to a distance of two-thirds of its total length. The cradle should be at least 6 inches thick, and placed directly on top

of undisturbed firm bearing soils up to a level equal to or above the spring line of the pipe. The last one-third of the outlet pipe should be constructed with a 12-inch gravel drainage layer and 12-inch filter layer surrounding the pipe on all sides. The gravel drainage layer should meet the requirements of ASTM C-33 No. 7 crushed stone and the filter layer should meet the requirements of ASTM C-33 fine concrete aggregate. Water that accumulates in the drainage layer should be collected and outletted through perforated, 4-inch diameter PVC pipes, and discharged through the head wall or beyond the downstream toe of the embankment. Details regarding seepage control measures are presented on Figures 2 and 3 at the end of this report.

It is noted that the soils where the embankment is planned may consist of sandy materials, and may also consist of existing fill materials. Accordingly, we recommend a cut-off trench be installed through the subgrade soils along the centerline of the proposed embankment. The trench should extend to a depth of at least 4 feet into natural soils or 4 feet below the cradle, whichever is more. Details of this recommendation are presented on Figures 2 and 3.

Embankment core trench and cut-off trench fill material should consist of soils classifying CL, ML, SC, or GC per the Unified Soil Classification System, with at least 30 percent fines passing the No. 200 sieve. Final embankment slopes should be planted with relatively dense grass vegetation to prevent erosion.

The areas to be filled should be cleared and grubbed prior to placing fill. Unsuitable soft or loose natural soils or existing fill, organic material, etc. should be stripped to approved subgrades as determined by the geotechnical engineer. The actual depth of stripping necessary to provide a suitable base for placement and compaction of earthwork may include topsoil and other soft surficial layers with or without organic matter. Stripping depths will probably extend to greater depths than the topsoil depths indicated herein due to the presence of minor amounts of organics, roots, and other surficial materials that will require removal as a part of the stripping operations. In addition, seasonal soil moisture variations can affect stripping depths. In general, less stripping may occur during summer months when drier weather conditions can be expected. All subgrades should be proofrolled with a fully loaded 10-wheel dump truck or suitable rubber tire construction equipment approved by the geotechnical engineer, prior to the placement of new fill.

Fill material should be compacted in lifts not exceeding 8 inches loose thickness, to at least 95 percent of the maximum dry density per AASHTO T-99. Fill placed along slopes steeper than 5H:1V should be benched into the existing slopes. Benches should consist of

minimum 8 feet wide level cut, and at least one such bench should be used for each 3 feet of vertical rise of fill placed.

It is expected that the soils excavated from Strata A, B1, and B2 will generally be suitable for re-use as fill for the embankment core trench and cut-off trench. However, the Stratum A soils may contain man-made deleterious materials that may make it unsuitable for re-use as fill. In addition, drying of on-site soils by spreading and aerating may be necessary to obtain proper compaction. This may not be practical during the wet period of the year. Accordingly, earthwork operations should be planned for early Spring through later Fall, when drier weather conditions can be expected. Individual borrow areas, both from on-site and off-site sources, should be sampled and tested to verify classification of materials prior to their use as fill.

Fill materials should not be placed on frozen or frost-heaved soils, and/or soils that have been recently subjected to precipitation. All frozen or frost-heaved soils should be removed prior to continuation of fill operations. Borrow fill materials should not contain frozen materials at the time of placement.

Compaction equipment that is compatible with the soil type used for fill should be selected. Theoretically, any equipment type can be used as long as the required density is achieved; however, sheepsfoot roller equipment are best suited for fine-grained soils and vibratory smooth drum rollers are best suited for granular soils. Ideally, a smooth drum roller should be used for sealing the surface soils at the end of the day or prior to upcoming rain events. In addition, compaction equipment used adjacent to walls below grade should be selected so as to not impose undesirable surcharge on walls. All areas receiving fill should be graded to facilitate positive drainage of any water associated with precipitation and surface run-off.

5.0 General Limitations

Recommendations contained in this report are based upon the data obtained from the relatively limited number of test borings. This report does not reflect conditions that may occur between the points investigated, or between sampling intervals in test borings. The nature and extent of variations between test borings and sampling intervals may not become evident until the course of construction. Therefore, it is essential that on-site observations of subgrade conditions be performed during the construction period to determine if re-evaluation of the recommendations in this report must be made. It is critical to the successful completion of this

project that GeoConcepts be retained during construction to observe the implementation of the recommendations provided herein.

This report has been prepared to aid in the evaluation of the site and assist your office and the design professionals in the design of this project. It is intended for use with regard to the specific project as described herein. Changes in proposed construction, grading plans, etc. should be brought to our attention so that we may determine any effect on the recommendations presented herein.

An allowance should be established for additional costs that may be required for foundation and earthwork construction as recommended in this report. Additional costs may be incurred for various reasons including wet fill materials, soft subgrade conditions, unexpected ground water problems, etc.

This report should be made available to bidders prior to submitting their proposals to supply them with facts relative to the subsurface conditions revealed by our investigation and the results of analyses and studies that have been performed for this project. In addition, this report should be given to the successful contractor and subcontractors for their information only.

We recommend the project specifications contain the following statement: "A geotechnical engineering report has been prepared for this project by GeoConcepts Engineering, Inc. This report is for informational purposes only and should not be considered part of the contract documents. The opinions expressed in this report are those of the geotechnical engineer and represent their interpretation of the subsoil conditions, tests and results of analyses that they performed. Should the data contained in this report not be adequate for the contractor's purposes, the contractor may make their own investigations, tests and analyses prior to bidding."

This report was prepared in accordance with generally accepted geotechnical engineering practices. No warranties, expressed or implied, are made as to the professional services included in this report.

We appreciate the opportunity to be of service for this project. Please contact the undersigned if you require clarification of any aspect of this report.

Sincerely,

GEOCONCEPTS ENGINEERING, INC.

June Chokechaitanasin
Project Engineer

Paul E. Burkart, P.E.
Principal

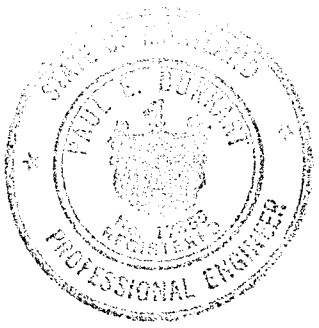

Figure 1: Site Vicinity Map
Figure 2: Embankment Dam Design Recommendations
Figure 3: Embankment Dam Sections

Appendix A: Subsurface Investigation Report
Appendix B: Soil Laboratory Test Report

JC/PEB/dcr
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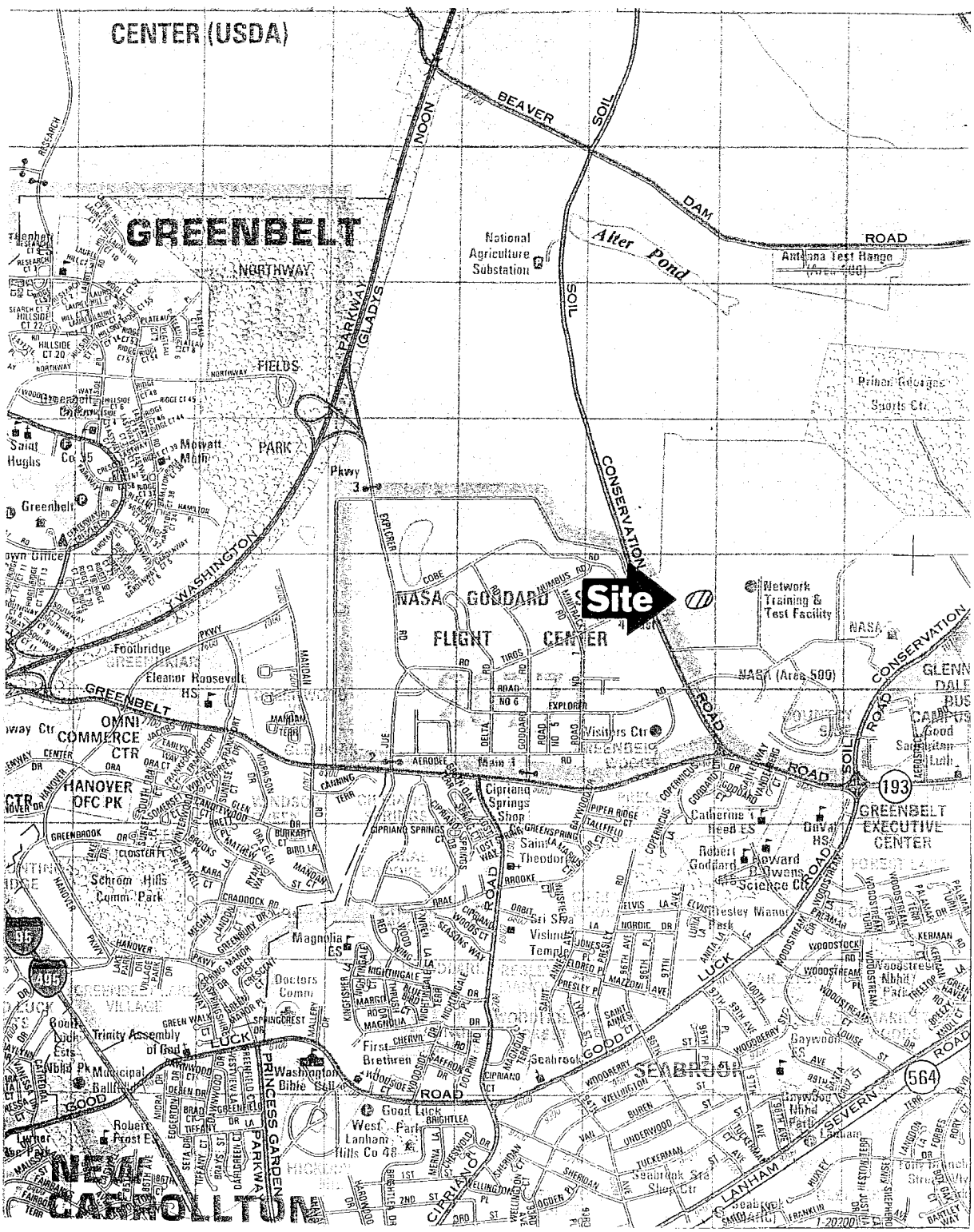

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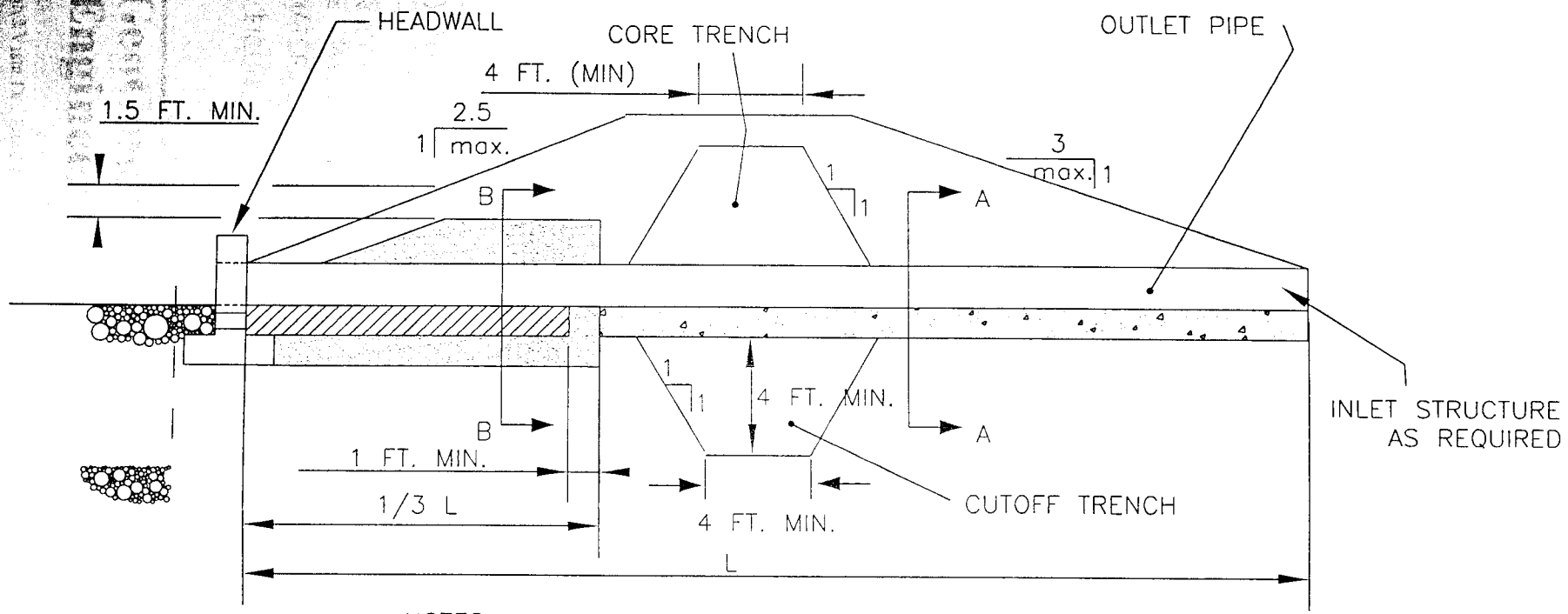
SWMP, GODDARD SPACE FLIGHT CENTER
GREENBELT, PRINCE GEORGE'S COUNTY, MARYLAND

SITE VICINITY MAP		Scale: N.T.S.	Fig. 1
Date: MARCH 2006	Checked By: P.E.B.	Project No.: 24151	



NOTES:

1) CUTOFF TRENCH SHOULD BE INSTALLED ALONG THE PROPOSED EMBANKMENT CENTERLINE AND EXTEND TO AT LEAST 4 FEET BELOW THE CONCRETE CRADLE OR 4 FEET INTO NATURAL SOILS, WHICHEVER IS MORE. THE TRENCH SHOULD EXTEND VERTICALLY TO THE 10-YEAR WATER SURFACE ELEVATION.

LEGEND

- STONE DRAINAGE MATERIAL
- SAND FILTER MATERIAL
- CONCRETE CRADLE

F:\CAD\ENG DETAILS\EMBANKMENT DAMS\EARTH DAM CROSS-SECTION-NON LINER.DWG

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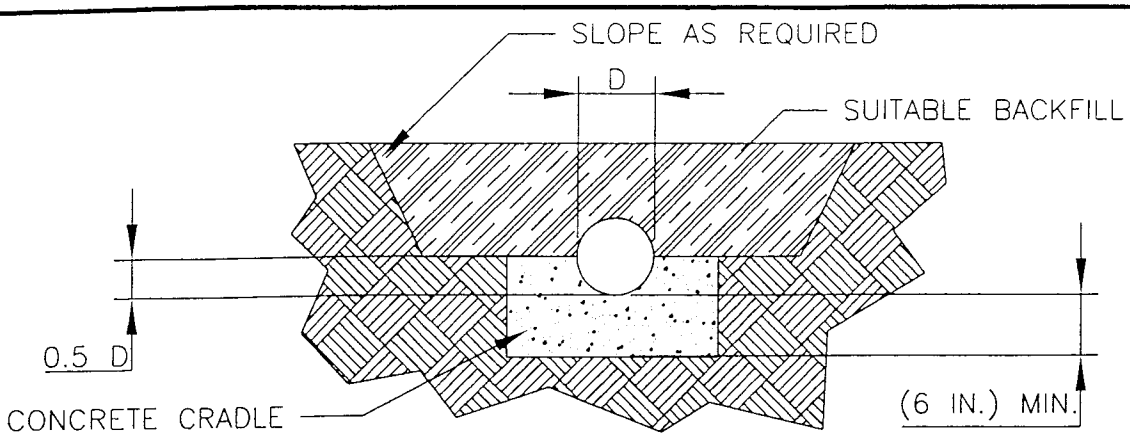
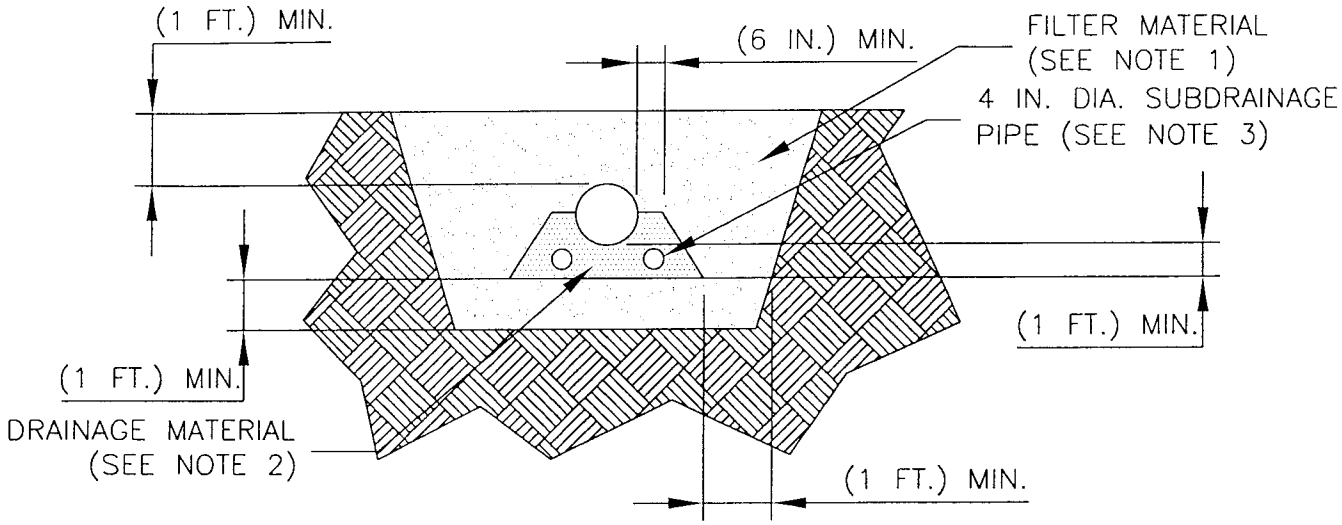
EMBANKMENT DAM DESIGN RECOMMENDATIONS		Scale: N.T.S.	Fig. 2
Date: MARCH 2006	Checked By: P.E.B.	Project No.: 24151	



SECTION A–A



SECTION B–B

NOTES:

1) SAND FILTER MATERIAL SHOULD MEET REQUIREMENTS FOR FINE CONCRETE AGGREGATE PER ASTM C–33.

2) STONE DRAINAGE MATERIAL SHOULD MEET REQUIREMENTS FOR COARSE AGGREGATE NO. 7 PER ASTM C–33.

3) SUBDRAINAGE PIPING SHOULD BE 4 IN. DIAMETER SLOTTED CORRUGATED POLYETHYLENE (PE) TUBING ACCORDING TO ASTM F–405 WITH A MAX. 1/8 IN. SLOT WIDTH FOR AT LEAST THE LOWER 120 DEGREE SECTOR.

4) WATER COLLECTED IN DRAINAGE MATERIAL SHOULD BE DISCARDED BY SUBDRAINAGE PIPE DAYLIGHTING AT THE DOWNSTREAM TOE.

5) ALL MATERIAL SHOULD BE PLACED AGAINST UNDISTURBED FIRM SOILS.

6) SEE FIGURE 2 FOR CROSS SECTION LOCATIONS.

F:\24151\SWMP\\EARTH DAM SECTIONS-DIA.DWG

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SWMP, GODDARD SPACE FLIGHT CENTER GREENBELT, PRINCE GEORGE'S COUNTY, MARYLAND			
EMBANKMENT DAM SECTIONS		Scale: N.T.S.	Fig. 3
Date: MARCH 2006	Checked By: P.E.B.	Project No.: 24151	

Subsurface Investigation Report

Subsurface Investigation Procedures (1 page)
Identification of Soil (1 page)
Test Boring Notes (1 page)
Test Boring Logs (5 pages)
Boring Location Plan, Figure 4 (1 page)

Subsurface Investigation Procedures

1. ***Test Boring – Hollow Stem Augers***

The borings are advanced by turning an auger with a center opening of 2-¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

2. ***Standard Penetration Tests***

Standard penetration tests are performed by driving a 2 inch O.D., 1-⅜ inch I.D. sampling spoon with a 140-pound hammer falling 30 inches, according to ASTM D-1586. After an initial 6 inches penetration to assure the sampling spoon is in undisturbed material, the number of blows required to drive the sampler an additional 12 inches is generally taken as the N value. In the event 30 or more blows are required to drive the sampling spoon the initial 6 inch interval, the sampling spoon is driven to a total penetration resistance of 100 blows or 18 inches, whichever occurs first. The sampling operation is terminated after a total of 100 hammer blows and the depth of penetration is recorded.

3. ***Test Boring Stakeout***

The test boring stakeout was provided by Greenhorne & O'Mara.

GeoConcepts Engineering, Inc.

IDENTIFICATION OF SOIL

I. DEFINITION OF SOIL GROUP NAMES — ASTM D-2487

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

II. DEFINITION OF MINOR COMPONENT PROPORTIONS

Minor Component	**Approximate Percentage of Fraction by Weight**
Adjective Form	
Gravelly, Sandy	30% or more coarse grained
With	
Sand, Gravel	15% or more coarse grained
Silt, Clay	5% to 12% fine grained

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS - Unified Soil Classification Symbols are shown above as group symbols. Use "A" Line Chart for laboratory identification. Dual symbols are used for borderline classification.

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

DISINTEGRATED ROCK/ROCK - Residual rock material with a standard penetration test (SPT) resistance between 60 blows per foot and refusal. Refusal is defined as a SPT of 100 blows for 2" or less penetration.

ROCK FRAGMENTS - Angular pieces of rock, distinguished from transported gravel, which have separated from original vein or strata and are present in a soil matrix.

QUARTZ - A hard silicate mineral often found in residual soils.

CEMENTED SAND - Usually localized rock-like deposits within a soil stratum composed of sand grains cemented by calcium carbonate, iron oxide, or other minerals. Commonly encountered in Coastal Plain sediments.

MICA - A plate-like phyllosilicate mineral found in many rocks, and in residual or transported soil derived therefrom.

ORGANIC MATERIALS (Excluding Peat) -

Topsoil - Surface soils that support plant life and which contain 8 to 20 % organic matter;
Organic Matter - Soil containing organic colloids throughout its structure;
Lignite - Hard, brittle decomposed organic matter with low fixed carbon content (a low grade of coal).

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

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

LENSES - 0 to ½ inch seam of minor soil component.

LAYERS - ½ to 12 inch seam of minor soil component.

POCKET - Discontinuous body of minor soil component.

COLOR SHADES - Light to dark to indicate substantial difference in color.

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

Test Boring Notes

1. Classification of soil is by visual inspection and is in accordance with the Unified Soil Classification System.

2. Estimated ground water levels are indicated on the logs. These are only estimates from available data and may vary with precipitation, porosity of soil, site topography, etc.

3. Sampling data presents standard penetrations for 6 inch intervals or as indicated with graphic representations adjacent to the sampling data.

4. The logs and related information depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at the test locations. Also, the passage of time may result in a change in the subsurface conditions at the test locations.

5. The stratification lines represent the top of a sample where a different material was encountered. Some variation may be expected vertically between samples taken. The soil profile, ground water level observations and penetration resistances presented on the logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.

6. Disintegrated rock is defined as residual earth material with a penetration resistance between 60 blows per foot and refusal. Spoon refusal at the surface of rock, boulders, or obstructions is defined as a penetration resistance of 100 blows for 2 inches penetration or less. Auger refusal is taken as the depth at which further penetration of the auger is not possible without risking significant damage to the drilling equipment.

7. The information presented in the PID column is the results of photoionization detector (PID) screening of the soil samples obtained in the test boring. The PID is used to provide an indication of the presence of volatile organic compounds (VOCs).

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PROJECT: SWMP, Space Science Building, Goddard Space Flight Center	LOGGED BY: T. North	BORING NUMBER: **B-24**
LOCATION: Greenbelt, Prince George's County, Maryland	DRILLING CONTRACTOR: Connelly and Associates, Inc.	SHEET 1 OF 1
OWNER/CLIENT: NASA/Ewing Cole	DRILLER: Eric B.	DATE STARTED: 11/19/04
PROJECT NUMBER: 24151	GROUND SURFACE ELEVATION (ft): 203.0	DRILLING METHOD: 2.25" I.D. HSA
		DATE COMPLETED: 11/19/04

ELEV. (ft)	DEPTH (ft)	STRATUM	MATERIAL DESCRIPTION	MC (%)	SAMPLE TYPE	BLOW COUNTS	RECOV. (in)
202.7			Topsoil = 4 inches				
		B2	silty, clayey SAND (SC-SM), moist, brown	15.6		2 2 2	18
200.5			sandy SILTY CLAY (CL-ML), moist, brown			3 5 5	18
	5		gray at 5.0 ft.	17.9		4 5 5	18
						5 5 4	5
	10						
189.5		B1	LEAN CLAY (CL), with sand, moist, red-gray			5 8 10	18
	15						
			purple mottled below 18.5 ft.			6 8 13	18
	20						
			purple and yellow mottled below 23.5 ft.			6 13 22	18
178.0	25		Bottom of Boring at 25.0 ft				

PENETRATION RESISTANCE BLOWS/FOOT: 20 40 60 80

GROUND WATER LEVELS:

- ENCOUNTERED: 8.5 ft ELEV. 194.5
- UPON COMPLETION: Dry — CAVED: 6.0 ft ELEV. 197.0
- 11/20/2004: 3.0 ft ELEV. 200.0 — CAVED: 13.0 ft ELEV. 190.0

SAMPLE TYPES: Split Spoon; Bulk; Shelby Tube; Rock Core; Pressuremeter; DCP

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

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Ashburn, VA 20147

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PROJECT: SWMP, Space Science Building, Goddard Space Flight Center	LOGGED BY: R. Hefter	BORING NUMBER: B-106
LOCATION: Greenbelt, Prince George's County, Maryland	DRILLING CONTRACTOR: Connelly and Associates, Inc.	SHEET 1 OF 1
OWNER/CLIENT: NASA/EwingCole	DRILLER: Nick	DATE STARTED: 11/9/05
PROJECT NUMBER: 24151.01 / GROUND SURFACE ELEVATION (ft): 204.0	DRILLING METHOD: 2.25" I.D. HSA	DATE COMPLETED: 11/9/05

ELEV. (ft)	DEPTH (ft)	STRATUM	MATERIAL DESCRIPTION	PID (ppm)	MC (%)	SAMPLE TYPE	BLOW COUNTS	RECOV. (in)
203.1	0		Topsoil = 11 inches	3.0			4 3 5	18
		B1	sandy SILT (ML), moist, gray	3.2			6 7 9	18
	5			3.3			5 6 6	18
195.5								
			sandy LEAN CLAY (CL), with lignite, moist, gray and black	0.4			3 5 7	18
190.5	10							
		B2	silty SAND (SM), moist, gray				6 9 10	18
185.5	15							
184.0		B1	sandy SILT (ML), moist, orange				15 20 24	18
	20		Bottom of Boring at 20.0 ft					
	25							

PENETRATION RESISTANCE BLOWS/FOOT: 20 40 60 80

GROUND WATER LEVELS:

ENCOUNTERED: None

UPON COMPLETION: Dry

CAVED: 13.0 ft ELEV. 191.0

SAMPLE TYPES: Split Spoon, Bulk, Shelby Tube, Rock Core, Pressuremeter, DCP

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

BOREHOLE/TEST PIT: 24151.01 NASA SPACE SCIENCE CENTER.GPJ GEOCONCEPTS.GDT 1/17/06

GeoConcepts Engineering, Inc.

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Ashburn, VA 20147

703 726-8030
703 726-8032 fax

PROJECT: SWMP, Space Science Building, Goddard Space Flight Center	LOGGED BY: R. Hefter	BORING NUMBER: **B-107**
LOCATION: Greenbelt, Prince George's County, Maryland	DRILLING CONTRACTOR: Connelly and Associates, Inc.	SHEET 1 OF 1
OWNER/CLIENT: NASA/EwingCole	DRILLER: Nick	DATE STARTED: 11/9/05
PROJECT NUMBER: 24151.01	GROUND SURFACE ELEVATION (ft): 206.4	DRILLING METHOD: 2.25" I.D. HSA
		DATE COMPLETED: 11/9/05

ELEV. (ft)	DEPTH (ft)	STRATUM	MATERIAL DESCRIPTION	PID (ppm)	MC (%)	SAMPLE TYPE	BLOW COUNTS	RECOV (in)
205.6	0		Topsoil = 10 inches	2.5	15.5		17 20 22	18
		A	silty clayey sand FILL, with gravel, moist, brown					
			with asphalt below 2.5 ft.	2.3			50/4	4
	5			0.8			5 3 3	18
197.9								
			clayey SAND (SC), moist, gray		32.0		3 5 4	18
	10							
192.9		B2	silty clayey SAND (SC-SM), moist, gray		31.4		7 9 13	18
	15							
186.4							10 13 15	18
	20		Bottom of Boring at 20.0 ft					
	25							

PENETRATION RESISTANCE BLOWS/FOOT: 20 40 60 80

GROUND WATER LEVELS:

▽ ENCOUNTERED: 8.5 ft ELEV. 197.9

▼ UPON COMPLETION: 6.5 ft ELEV. 199.9 CAVED: 10.0 ft ELEV. 196.4

SAMPLE TYPES: Split Spoon, Bulk, Shelby Tube, Rock Core, Pressuremeter, DCP

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

BOREHOLE/TEST PIT 24151.01, NASA SPACE SCIENCE CENTER.GPJ GEOCONCEPTS.GDT 1/17/06

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Ashburn, Va. 20147

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PROJECT: SWMP, Space Science Building, Goddard Space Flight Center	LOGGED BY: R. Hefter	BORING NUMBER: **B-108**
LOCATION: Greenbelt, Prince George's County, Maryland	DRILLING CONTRACTOR: Connelly and Associates, Inc.	SHEET 1 OF 1
OWNER/CLIENT: NASA/EwingCole	DRILLER: Nick	DATE STARTED: 11/9/05
PROJECT NUMBER: 24151.01 / GROUND SURFACE ELEVATION (ft): 212.6	DRILLING METHOD: 2.25" I.D. HSA	DATE COMPLETED: 11/9/05

ELEV. (ft)	DEPTH (ft)	STRATUM	MATERIAL DESCRIPTION	PID (ppm)	MC (%)	SAMPLE TYPE	BLOW COUNTS	RECOV. (in)
211.8			Topsoil = 10 inches					
			sandy lean clay FILL, with concrete, moist, gray	0.1			13 7 5	18
210.1			silty sand FILL, with gravel and concrete, moist, brown	0.1			6 8 8	18
	5	A		0.3			24 50/4	9
204.1			sandy lean clay FILL, moist, black	1.1			2 3 5	18
199.1	10		clayey SAND (SC), moist, gray				7 8 8	18
194.1	15	B2	silty SAND (SM), moist, tan				7 9 11	18
192.6	20		Bottom of Boring at 20.0 ft					
	25							

PENETRATION RESISTANCE BLOWS/FOOT: 20 40 60 80

GROUND WATER LEVELS:

ENCOUNTERED: None

UPON COMPLETION: Dry CAVED: 12.0 ft ELEV. 200.6

SAMPLE TYPES: Split Spoon, Bulk, Shelby Tube, Rock Core, Pressuremeter, DCP

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

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Ashburn, VA 20147

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PROJECT: SWMP, Space Science Building, Goddard Space Flight Center	LOGGED BY: R. Hefter	BORING NUMBER: B-109
LOCATION: Greenbelt, Prince George's County, Maryland	DRILLING CONTRACTOR: Connelly and Associates, Inc.	SHEET 1 OF 1
OWNER/CLIENT: NASA/EwingCole	DRILLER: Nick	DATE STARTED: 11/9/05
PROJECT NUMBER: 24151.01	GROUND SURFACE ELEVATION (ft): 200.7	DRILLING METHOD: 2.25" I.D. HSA
		DATE COMPLETED: 11/9/05

ELEV. (ft)	DEPTH (ft)	STRATUM	MATERIAL DESCRIPTION	PID (ppm)	MC (%)	SAMPLE TYPE	BLOW COUNTS	RECOV. (in)
199.8	0		Topsoil = 11 inches	3.9			6 4 2	18
		A	silty sand FILL, with gravel, moist, brown					
198.2			sandy lean clay FILL, moist, gray	4.2			5 9 11	18
	5			5.0			2 2 4	18
192.2			silty sand FILL, with brick fragments, moist, brown	1.6			4 6 7	18
	10							
187.2		B2	silty SAND (SM), moist, brown				18 14 11	18
	15							
182.2		B1	sandy LEAN CLAY (CL), moist, gray				4 6 5	18
180.7	20		Bottom of Boring at 20.0 ft					
	25							

PENETRATION RESISTANCE BLOWS/FOOT: 20 40 60 80

GROUND WATER LEVELS:

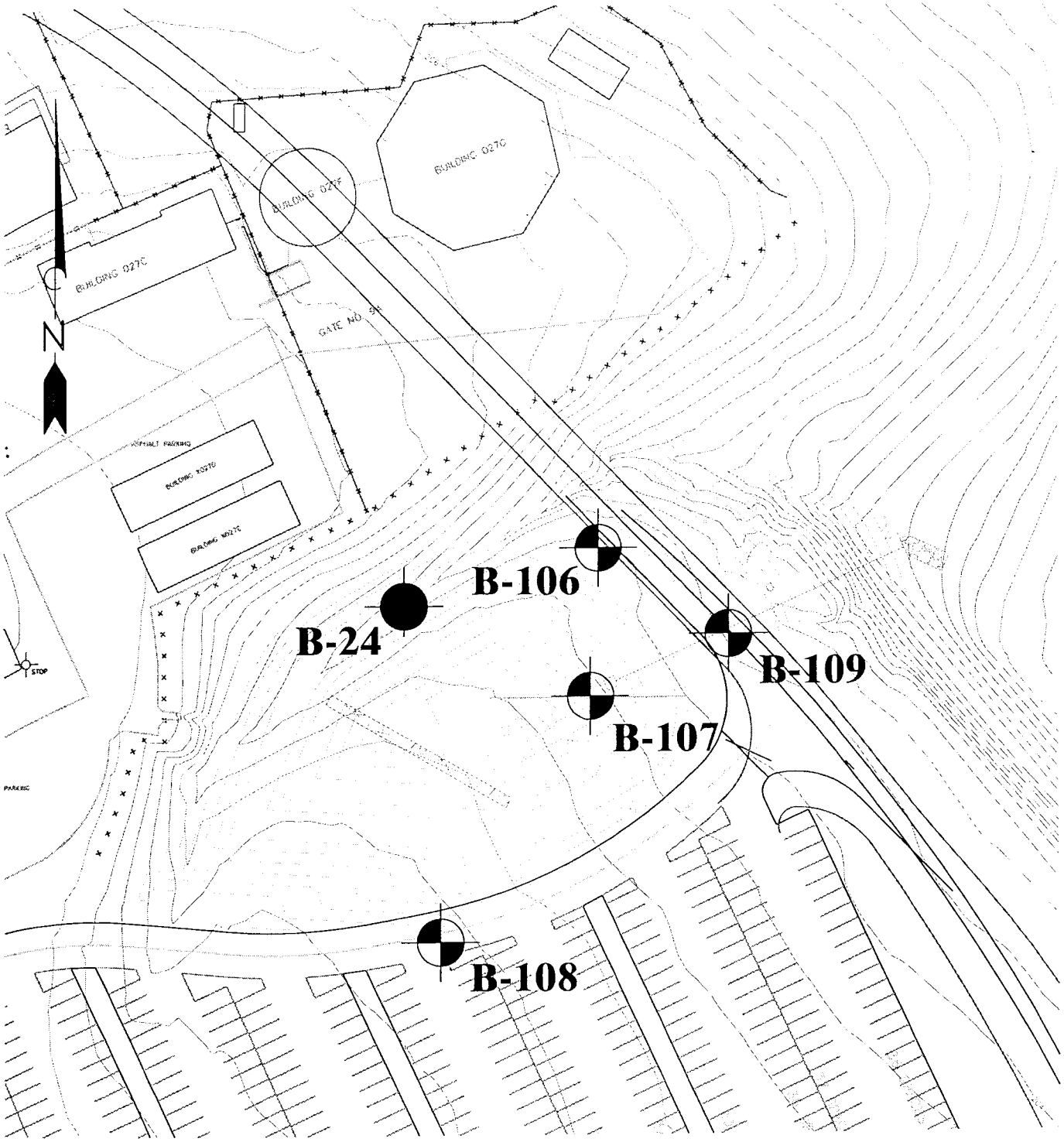
▽ ENCOUNTERED: 13.0 ft ELEV. 187.7

▼ UPON COMPLETION: 3.0 ft ELEV. 197.7 CAVED: 7.5 ft ELEV. 193.2

SAMPLE TYPES: Split Spoon, Bulk, Shelby Tube, Rock Core, Pressuremeter, DCP

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



L E G E N D

APPROXIMATE BORING LOCATION DRILLED NOVEMEBR 2005

PREVIOUSLY DRILLED BORING LOCATION – NOVEMBER, 2004

GeoConcepts Engineering, Inc.

19955 Highland Vista Drive, Suite 170 (703) 726-8030
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SWMP, GODDARD SPACE FLIGHT CENTER
GREENBELT, PRINCE GEORGES COUNTY, MARYLAND

BORING LOCATION PLAN		Scale: 1" = 100'	Fig. 4
Date: MARCH 2006	Checked By: P.E.B.	Project No.: 24151	

Appendix B
Contract No. 24151

Soil Laboratory Test Report

Summary of Soil Laboratory Test Results (1 page)

Summary of Soil Laboratory Test Results

Project: Storm Water Management Pond, Goddard Space Flight Center, Greenbelt, Maryland

Contract No.: 24151

Boring	Depth (ft.)	Sample Type	Stratum	Description of Soil Specimen	Sieve Results (ASTM D 1140)		Atterberg Limits (ASTM D 4318)			Natural Moisture Content (%) (ASTM D 2216)	Remarks
					Percent Retained # 4 Sieve	Percent Passing # 200 Sieve	LL	PL	PI		
B-24	0.0 -1.5	Jar	B2	silty, clayey SAND (SC-SM)	2.7	49.3	26	20	6	15.6	--
B-24	5.0 - 6.5	Jar	B1	sandy SILTY CLAY (CL-ML)	0.0	53.6	20	16	4	17.9	--
B-107	0.0 - 1.5	Jar	A	silty, clayey SAND (SC-SM), with gravel	22.4	29.8	27	20	7	15.5	--
B-107	8.5 - 10	Jar	B2	clayey SAND (SC)	13.3	45.1	29	18	11	32.0	--
B-107	13.5 - 15.0	Jar	B2	silty, clayey SAND (SC-SM)	5.8	37.8	23	16	7	31.4	--

Notes:

1. Soil tests are in accordance with applicable ASTM standards.
2. Soil classification symbols are in accordance with Unified Soil Classification System.
3. Identification of samples are in accordance with ASTM D-2487.
4. Key to abbreviations: LL= Liquid Limit; PL= Plastic Limit; PI= Plasticity Index; NP= Nonplastic; N/T = Not Tested